Rob & Smith's

Operative Surgery

Head and Neck Part 1

Fourth Edition

Edited by

Ian A. McGregor ChM, DSc, FRCS(G), FRCS(Eng), Hon FRACS, Hon FRCSI, Hon FRCS(Ed), Hon FACS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

David J. Howard FRCS, FRCS(Ed)
Institute of Laryngology and Otology, Royal National Throat, Nose and Ear Hospital, London, UK

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Pharynx, Larynx and Oesophagus

Illustrations by Ian Ramsden

The surgeon and the pathology department

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Introduction

If the surgeon is to get maximum cooperation from the Pathology Department it is essential that he should appreciate the legitimate requirements of the pathologist. Even in routine clinical situations, with communication between the two limited to the Request Form which accompanies the tissue specimen and the Report which the pathologist issues concerning it, the surgeon should still recognize the need to provide the specimen in the condition which the pathologist requires to carry out his examination, together with the relevant clinical details.

Today, investigative techniques routinely carried out by the pathologist may involve, among others, electron microscopy, aspiration cytology and the use of monoclonal antibodies. It is when such methods seem likely to be required that the surgeon needs to discuss with the pathologist the form in which he requires the tissue specimen – whether fresh, snap frozen or fixed with a special fixative – the appropriate volume of tissue needed for the examination to be carried out, and whether an imprint of the specimen on a slide is required.

When the need for a special investigation seems likely to arise, the surgeon will find his needs best served if he discusses his problem in clinical terms with the pathologist, explaining what questions he wishes to have answered. The questions should be asked in advance, and not once the specimen has been taken, so that the pathologist can decide what his requirements are.

Biopsy

If a biopsy is to be as effective as possible in establishing or confirming a clinical diagnosis, the specimen needs to be taken from the correct site in the lesion, and it must be of an adequate size, with the appropriate tissue content and absence of artefact.

Site

When the biopsy is of an ulcer, the key area is its margin, where surrounding normality is converting into ulcer. This allows samples of the normal, the transitional area, and the frank tumour all to be assessed. Tissue from the depth of the ulcer, as representing the most advanced area of the tumour, should also be included, making sure that it does not consist merely of necrotic tissue near its surface.

Even where there is no ulceration, the sample should straddle the margin of the lesion. When the lesion has multiple foci, more than one sample is desirable, so that representative areas can be assessed. This is particularly so when different foci vary in appearance. Examples of the extremes should be sought, providing a sample of the lesion at its initial stage of development, as well as one at the most clinically active stage. Clinical activity is generally straightforward to assess, both when the lesion is of skin or mucosa, activity usually parallelling the presence and severity of the local inflammatory reaction often associated.

In the oral cavity, when the problem involves the assessment of leukoplakia, the clinician needs to be aware that 'leukoplakia' is merely a clinically descriptive term, and has no place in the vocabulary of the pathologist. For the pathologist, it is the severity of any epithelial dysplasia present in the specimen which he will discuss in his report. For the surgeon, the need in choosing the site to biopsy is to recognize the clinical appearances which are indicative of dysplastic changes, and to grade them in terms of their likely severity, so that he can select the area which will show the most severe dysplastic changes. The choice finally depends on the clinical type of the leukoplakia but, regardless of type, the features on which the surgeon should focus attention as being suggestive of dysplasia are induration, verrucosity, and an inflammatory reaction in relation to the leukoplakic patch.

When the leukoplakic patch as a whole appears quiescent, areas within it should be sought for biopsy where any one of these features is present even in slight degree, as most likely to show dysplastic changes. In the absence of such areas, a representative sample should be taken, but dysplasia is likely then to be minimal or nil.

When the leukoplakic area has an obviously warty appearance, the area of maximal induration, which usually coincides with the site of greatest verrucosity, should be sampled.

The white patch typical of leukoplakia has generally been the lesion considered to have occasional malignant potential, as indicated by the presence of dysplastic changes, but the clinical appearance referred to as 'erythroplakia' has considerably greater significance as regards severity of dysplasia. An area of erythroplakia is recognizable as one where the mucosa appears reddened and 'velvety', with a marginal inflammatory reaction which tails off into normal-looking mucosa. The area is typically slightly depressed in relation to the mucous membrane surrounding it, because of the atrophic state of the involved mucosa. There is no suggestion of induration. Such areas have been amply demonstrated to show at very least carcinoma *in situ*, with early invasive squamous carcinoma as a rule.

Areas of erythroplakia may occur on their own, but they are found more often in association with leukoplakia, i.e. leuko-erythroplakia. In such a mixed area, the erythroplakic element is the more active, and it, rather than the leukoplakic component, should be biopsied.

Probably the most common site for such a mixture of leuko- and erythroplakia, though with the erythroplakic component tending to predominate, is the anterior floor of mouth. Another recognized site is the buccal mucosa adjoining the angle of mouth. Here, the lesion has an appearance specific to the site, due to foci of colonization of the surface with *Candida*, and referred to as 'speckled' leuko-erythroplakia. With this site also, the area to biopsy is the erythroplakic element.

Size

The biopsy should be of sufficient size that the pathologist can identify the various faces of the specimen. This enables him to orientate the tissue properly for cutting, so that the cut section represents a full face of the specimen. Failure to provide an adequate volume of tissue, leaving insufficient to allow a full face to be cut, can result in errors of interpretation. When the biopsy represents curettings, or fragments alone are available, e.g. following laryngoscopy or blind biopsies from the nasopharynx, problems of orientation may be unavoidable, but where the lesion can be visualized directly, generosity of tissue is never misplaced.

Tissue content

In the case of an epithelial lesion, it is essential to include in the tissue sample both the epithelial element and the underlying connective tissue. The difficulty of including both arises most often with verrucous lesions, and in particular where verrucous carcinoma is suspected. A biopsy which includes the underlying connective tissue is absolutely essential to establish the diagnosis and, since it has become recognized that areas of frank invasive carcinoma may be present in predominantly verrucous carcinomas, a search for any area which has the appearance more typical of invasive carcinoma is also worthwhile, so that it can be included as part of the biopsy material submitted.

When osteosarcoma is suspected, an area of active growth should be sought, with both osteoid and soft tissue material. Seeding of the tumour is not a problem. In this respect, osteosarcoma differs from chondrosarcoma, where seeding is a major hazard. In carrying out a biopsy where chondrosarcoma is suspected, dissection of any kind should be avoided if at all possible; if it is unavoidable it should be so organized that any tissue planes opened will be excised at the time of definitive treatment. The growing edge of the tumour should be sampled, heavily calcified material or degenerate cartilage being useless for diagnostic purposes.

Avoidance of artefact

Artefact for which the surgeon must take responsibility is virtually always the result of crushing of the specimen. The use of skin hooks in manipulation of the specimen is preferable to dissecting forceps and, when such forceps are used, it should be with the avoidance of crushing of the tissue always in mind. Crush artefact can make diagnosis difficult; severe crushing can make it impossible. A regular source is biopsy of a lymph node, where there is the temptation to pull the node clear, using dissecting forceps directly applied to it, and squeezing it in the process. Such crushing is most likely to occur when the node is in an awkward site, usually high in the neck, possibly deep to sternocleidomastoid, the biopsy carried out under local anaesthesia, through a 'keyhole' incision, by an inexperienced junior unwisely set the task by his senior. The combination is a recipe at very least for crush artefact. Adequate exposure is essential, and ideally the node should be handled by the loose tissue surrounding it, taking plenty of time for the procedure.

Frozen section

Frozen section is used for diagnostic purposes and in order to establish clearance margins.

Diagnostic usage

The value of the opinion expressed by the pathologist on a frozen section depends very much on his expertise in interpreting such sections. For most pathologists the diagnostic precision possible is less than with formalin-fixed tissue, but the degree of difficulty in interpretation can also vary greatly, depending on the alternative tissue diagnoses involved. Difficulties in histological diagnosis, whether on frozen section or on fixed material, do not necessarily parallel difficulties in clinical diagnosis. Tumours which are readily distinguishable under the microscope, although difficult to distinguish clinically, may present no problems in frozen section, as for example when the distinction is being made between a clinically atypical malignant melanoma and a deeply pigmented basal cell papilloma or angioma. It is when the finer points of histological diagnosis are at issue, for example in distinguishing between a Spitz naevus and a malignant melanoma, that the pathologist may be unable to make a decision on the basis of a frozen section. It is for these reasons that prior enquiry of the pathologist is desirable, explaining the clinical problem, in order to find out whether frozen section is the most appropriate approach.

When such an enquiry is made the degree of diagnostic urgency may also be relevant, since the alternative to a frozen section which a fast paraffin section provides may be an acceptable compromise. A fast paraffin section is capable of providing the extra diagnostic precision possible with fixed tissue in 24 hours, and such a short delay may be entirely acceptable to the clinician if the problem is explained to him and he has time to make the necessary arrangements with the patient. Where the clinical problem is one of suspected malignant melanoma, the use of a fast paraffin section will also permit the pathologist to give a Breslow thickness in addition to a more accurate diagnosis, the standard measurement of Breslow thickness being made on fixed tissue, although a conversion formula to make the reading from a frozen section compatible with that from fixed material is now available.

Clearance margins

The use of frozen section to establish clearance margins is an entirely different matter from its use for diagnostic purposes, and it is one where the technical expertise of both the pathologist and the technician is critical. The manipulation of the specimen, and its alignment for cutting, are more difficult with fresh than with fixed tissue and, for the average pathologist, the degree of precision is a good deal less than the surgeon probably imagines, if he has not watched the various steps involved in preparing the sections. He should also be aware that the sample on which the opinion expressed on adequacy of clearance margins is based on tissue slices at most one or two cells in thickness, selected from a considerable volume of tissue. With such a background, a report that tumour is present has greater significance than a report that none has been found.

In such a situation, the surgeon can improve the degree of accuracy considerably by orientating the specimen properly for the pathologist and indicating as precisely as possible the area which is concerning him most.

It is also important that the surgeon should appreciate how the limitations of frozen section differ in different clinical situations. At one extreme, where the specimen being examined is small in volume and area and the surgeon is able to pinpoint accurately the site which is concerning him, the opinion of the pathologist has correspondingly greater value. At the opposite extreme where, for example, a carcinoma of tongue is being excised and the margins of the resection are 'being monitored by frozen section', the surgeon should exercise caution in blindly accepting a report that the margins are clear of tumour, in view of the minuscule nature of the samples which it is possible for the pathologist to examine, compared with the overall extent of the area which is being sampled.

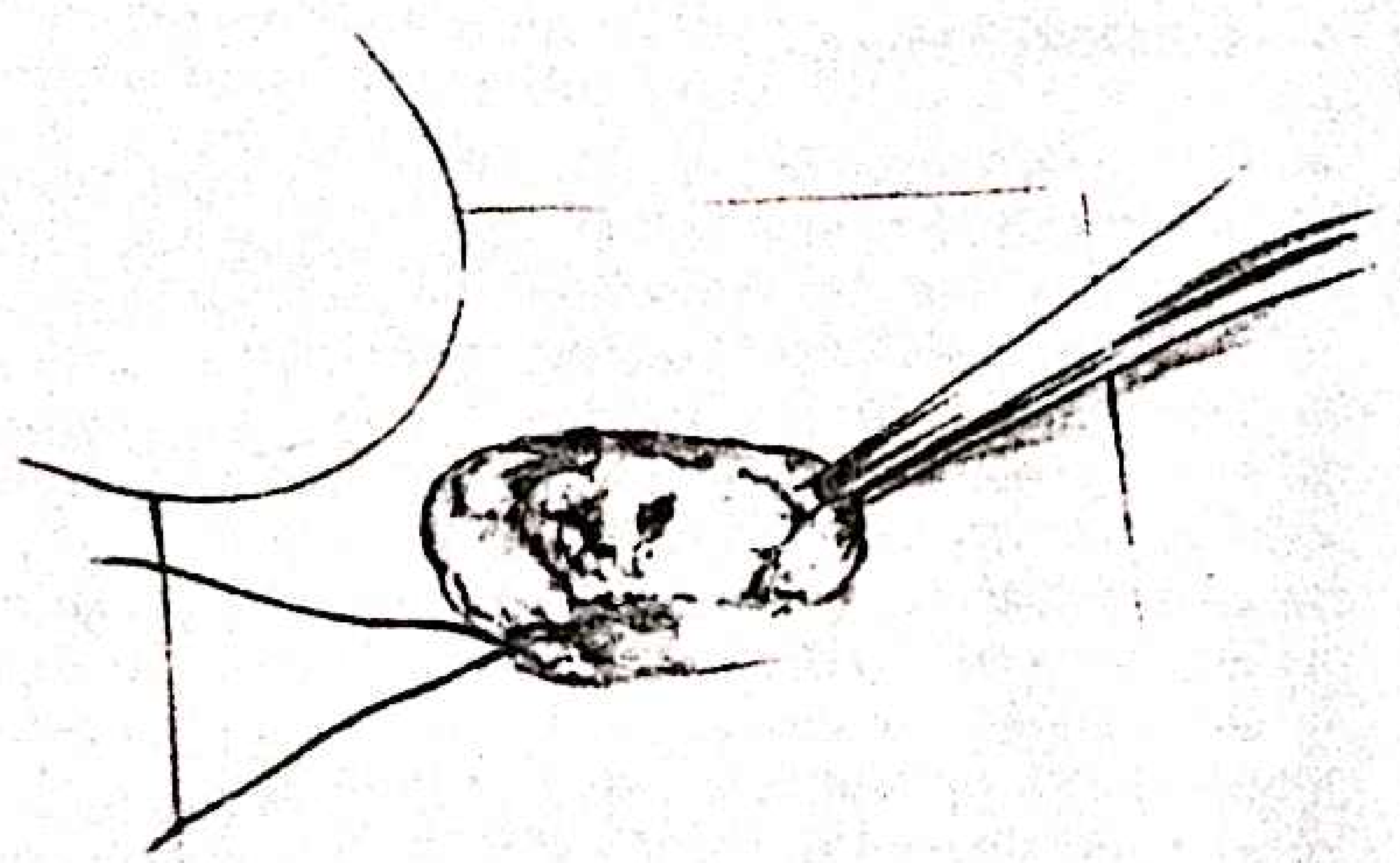
The use of frozen section, and the reliance which appears to be placed on it to confirm clearance margins, varies in different countries and with different surgeons, but no evidence has been produced which indicates that its use, restricted to situations where the answer is regarded by the surgeon as crucial, results in a higher recurrence rate than when it is demanded in a routine manner, without discrimination.

Presentation of specimens

When the excised tumour is submitted for pathological examination, it is generally not merely to confirm the clinical diagnosis but also to estimate the adequacy of local clearance and the extent of spread to regional lymph nodes and other structures which may have been removed as part of the overall resection. The mode of presentation of the range of typical specimens varies according to the type of specimen.

Thin specimen

Thin specimens should ideally be presented to the pathologist in a flat state, and the surgeon can take certain steps to achieve this. When a thin specimen of skin or mucosa is placed in the fixative, it almost invariably becomes distorted in shape, curling up, and once such distortion has taken place it is virtually impossible to undo. For the pathologist to give an opinion on clearance margins when the specimen is in a rolled-up condition, the usual form which the distortion takes, is always difficult and sometimes impossible. The way of avoiding its occurrence is to prevent it from happening at the outset.



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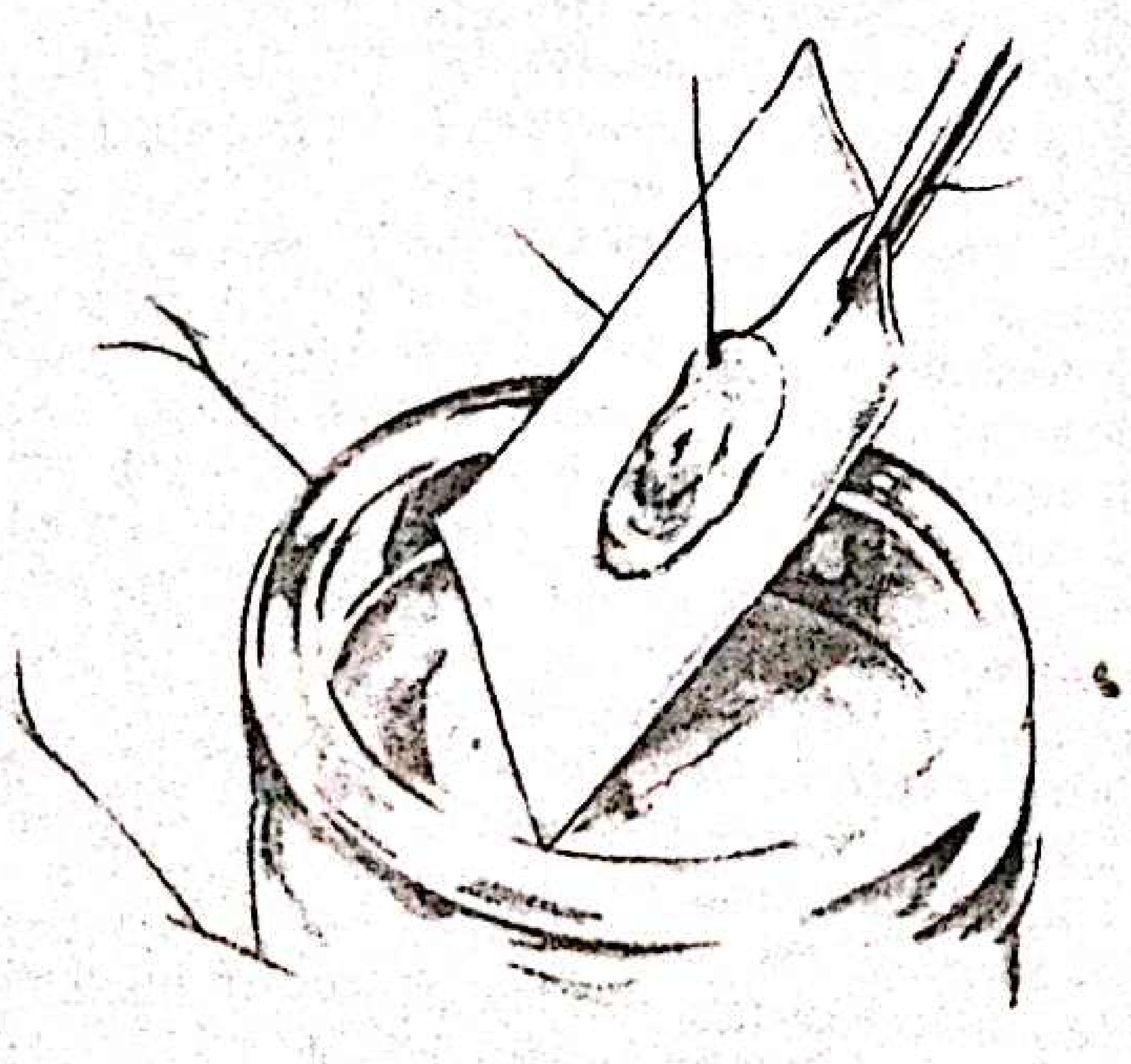
The most generally useful method of preventing distortion, for the standard thin specimen, is to spread it out flat, raw surface down, on a piece of blotting or filter paper.



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The two surfaces adhere, and the combined specimen and paper is carefully lowered into the fixative.

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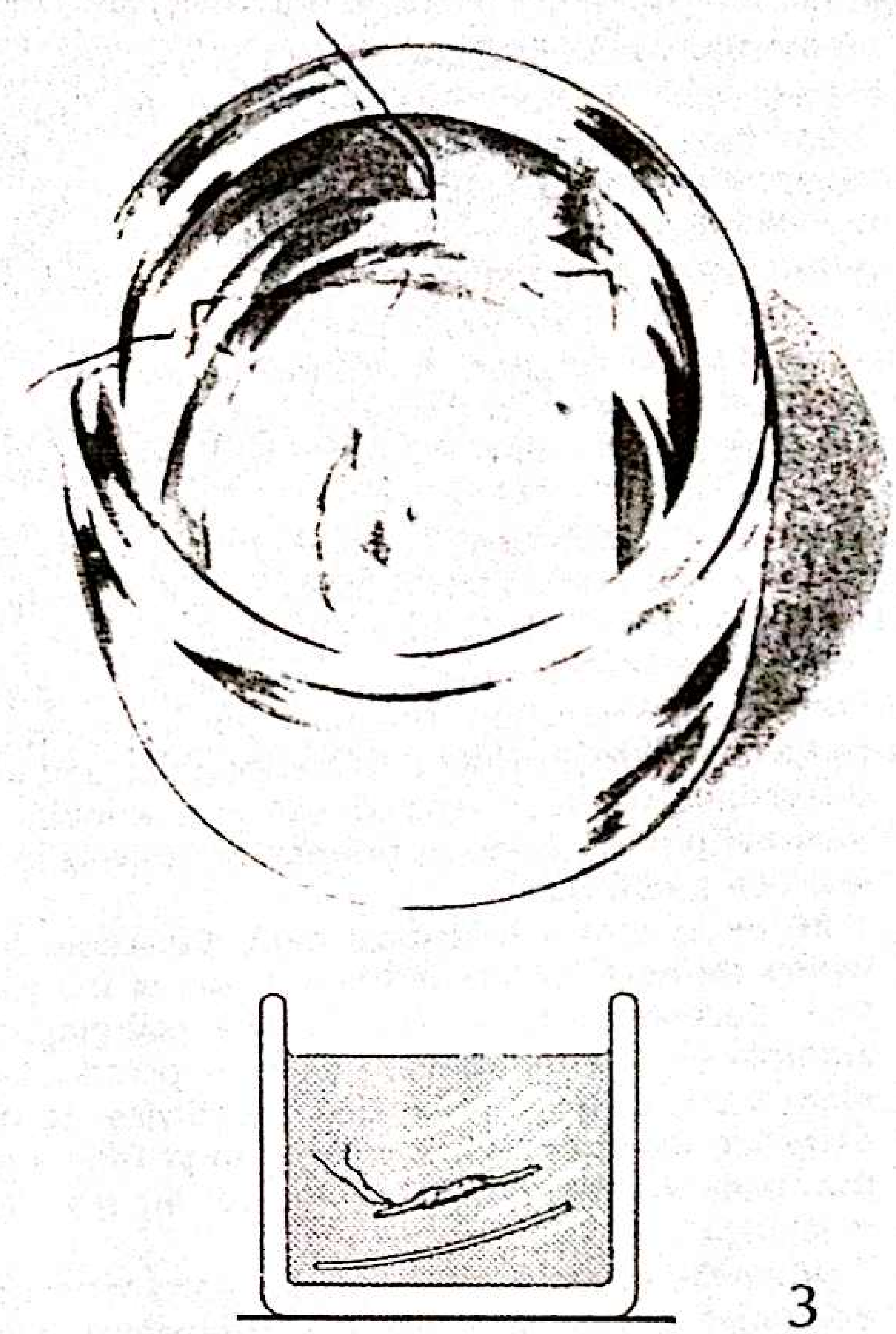
The curling of the tissue which would ordinarily occur is prevented by the adhesion between tissue and paper, and when the two float apart in the fixative, the specimen remains flat, making blocking of the tissue and assessment of clearance margins much easier.



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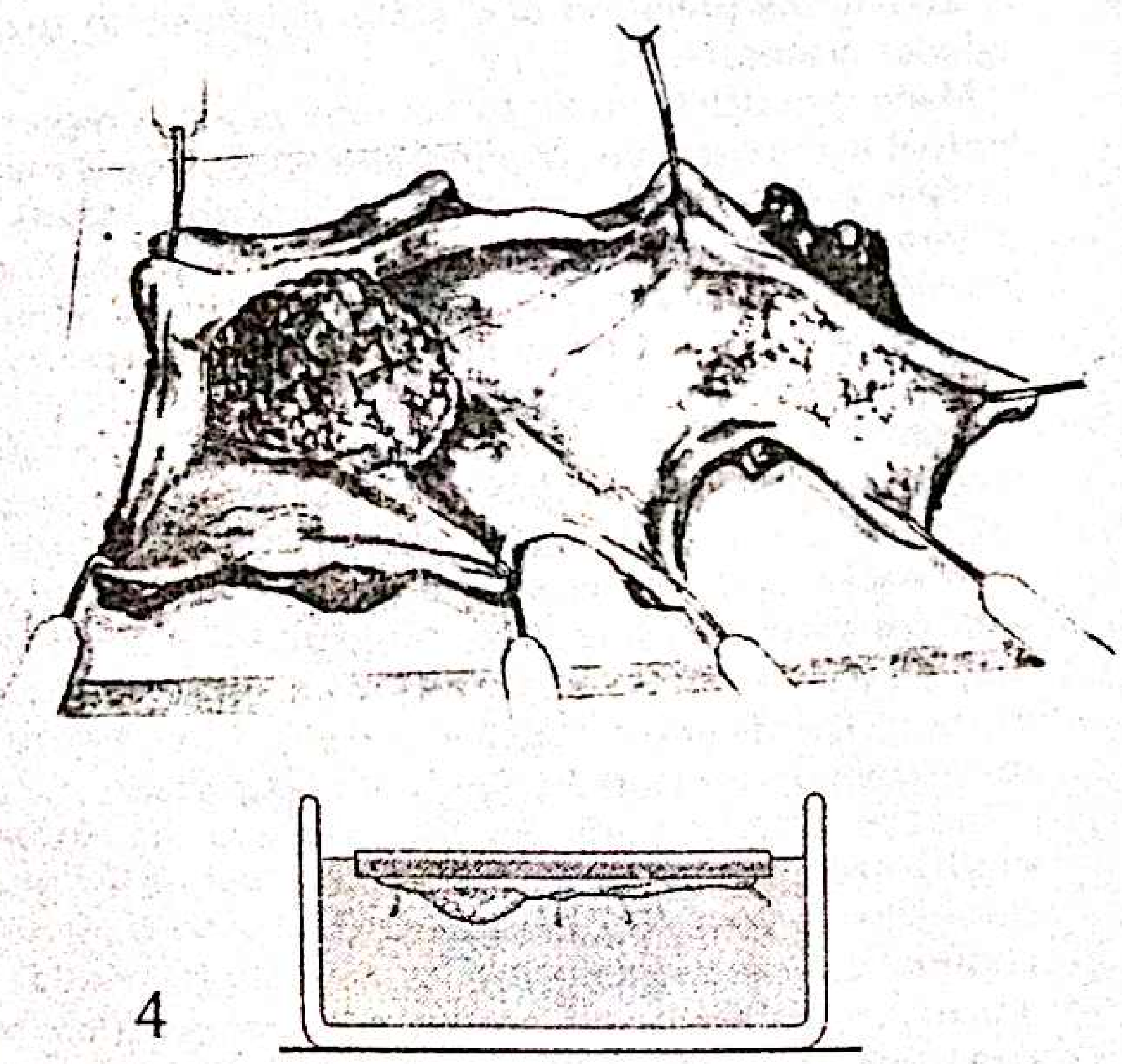

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An alternative method, more suitable when the specimen is thicker and larger in area, is to pin it out on a piece of cork, and place both specimen and cork in the fixative. It is generally necessary to place the cork upside down in the fixative to ensure that the specimen is completely immersed, because the buoyancy of the cork holds it floating on the surface.

The surgeon should also provide reference points on the specimen, such as one or more sutures at specific landmarks, or at '12 o'clock' when the specimen is circular or near circular, with a drawing, where relevant, to indicate how the specimen fits into the adjacent structures, duly recorded both in the clinical record and the request form. Areas of specific concern to the surgeon should also be marked with sutures, and the reason for their importance noted on the request form.

While these steps are the ones most often resorted to in practice, they are no substitute for surgeon and pathologist going over the specimen together, and discussing the areas of concern, particularly if the problem is not a routine one.

Thick specimen

Distortion of the specimen is less of a problem when it is larger and thicker, but here also the surgeon can contribute to making orientation easier for the pathologist. How a thick specimen should be handled depends on whether or not it is fixed before being sent to the pathologist. Pathologists have varying preferences in this respect, but it is up to the pathologist to make his wishes known to the surgeon. A counsel of perfection is for the surgeon to hand over the specimen personally, and make the necessary points himself, but this is not always practicable.

When the specimen is delivered fresh to the Pathology Department, orientation is likely to be straightforward if there are obvious anatomical points of reference. A typical example of such a situation would be the specimen of a radical neck dissection. The presence of the sternocleidomastoid muscle provides a reference point, and where the dissection has been carried out in continuity with an intraoral primary tumour, orientation is likely to be even less of a problem.

In the case of a functional neck dissection, however, where sternocleidomastoid is not part of the specimen, the specimen may appear to the pathologist as an amorphous soft tissue mass with no points of obvious identification. It is then that identifying sutures are essential, together with a drawing to provide a guide, if the pathologist's report is to be in any real way meaningful.

When the surgeon wishes specific parts of the specimen examined, a request to this end is obviously necessary, but it is also essential to tag the structure(s) for identification. Structures which were obvious to the surgeon at time of the resection may be far from obvious to the pathologist examining the excised specimen, even fresh, and the difficulty is increased markedly when the material has been fixed before being sent to the Pathology Department.

A good example of such structures is nerve trunks. The importance of perineural spread of tumour to prognosis is increasingly being recognized, to the extent that the major branches of the trigeminal nerve merit individual examination as a matter of routine. The surgeon cannot reasonably expect specific comment on this aspect unless the nerves are tagged and their examination requested.

When the specimen is being fixed before being sent to the pathology department, the onus is even more on the surgeon to ensure that the pathologist receives it in the best possible state. The most important step is to make sure that fixation leaves the tissue in the shape it had in the patient, with a drawing of the body site and how the tissue fits into it, with points of reference which will allow the pathologist to orientate it. The need for points of reference is greater even than in the non-fixed specimen, since the rigidity of the fixed specimen and the appearance changes created by the fixative make orientation more difficult.

Fixation of tissue takes place from the surface of the specimen to its centre, and in the case of a large volume specimen this may mean 24 hours or longer. Equally important is the volume of fixative, 10 times the volume of the specimen being required for proper fixation. A standard tissue fixative is usually supplied by the Pathology Department, but the surgeon should be aware that it may preclude the use of some of the more recently developed techniques for identifying specific tumours.

If techniques involving histochemistry or immunochemistry are required, snap freezing to −90°C may be required, and for proper categorization of malignant lymphoma, a tumour which regularly presents in the head and neck, the making of imprints of the tissue on a slide are desirable for identification of its cell type, information necessary for appropriate treatment, and probably best carried out by the pathologist personally. These special fixation methods may not often be required, but in specific instances their use may be crucial to establishing the diagnosis.

Aspiration needle biopsy

Biopsy using an aspiration needle to obtain the specimen is being used with increasing enthusiasm by head and neck surgeons, possibly reflecting the general increase in the availability of the service. Its main value is in the diagnosis of solid tumours. The fear of implantation of tumour along the needle track, which existed with the wide bore needle, appears to be baseless with the 22 gauge needle as currently used. The preferred method of presentation of the specimen varies with different cytologists, spreading the aspirate as a smear on a slide like a blood film being the method most commonly used. An alternative is suspension of the specimen in saline, the cell content being obtained by centrifuging the aspirate. More recently, an additional technique has been to fix the centrifuged material as a bolus and section it, with the aim of adding the precision of a tissue diagnosis to that of a cellular diagnosis.

Many cytologists prefer to take the aspirate rather than leave it to the surgeon. Where the site involved is near the surface and is readily accessible it probably makes little difference, but where knowledge of the local anatomy is important, the surgeon is likely to be more effective. Indeed, in such a situation, the cytologist may well be happy to hand over the responsibility.

From the surgeon's point of view, it is important to recognize the value and limitations of the technique and use it in a sensible way, asking questions which are reasonable, and interpreting the report in conjunction with the other evidence. The information which it elicits may be incomplete in itself, but it may provide the final piece in the diagnostic jig-saw, or give direction to the investigation necessary to clinch the diagnosis.

In the diagnosis of thyroid tumours its value is undoubted. Where neck nodes are palpable, and a recognized primary is known to exist, it is likely merely to confirm the clinical diagnosis of a metastatic node, but when the primary is unknown it may narrow the search considerably, depending on whether the cytological appearances suggest a glandular, squamous or lymphomatous lesion.

In parotid swellings, question marks remain regarding its value. These hinge on the smallness of the sample, and how representative it is. In a pleomorphic adenoma, for example, different parts of the tumour frequently vary in their histological appearances, and the specimen may not include cells of a type which allow a clear-cut diagnosis to be made. Salivary tumours can provide diagnostic problems for pathologists even when the entire tumour is available for examination, witness the existence of salivary tumour panels. How much more are problems likely with the tiny sample which an aspiration biopsy provides? In the case of a salivary tumour where the cytological findings are at variance with the clinical findings, the surgeon may legitimately maintain a degree of scepticism regarding the validity of the report, and continue to be ready, as in the past, to modify his surgery to match the findings at operation, along the lines discussed in the chapter on 'Major salivary glands', pp. 326–348.

In all the foregoing, it is apparent that, at all times, the key to a satisfactory relationship between the surgeon and the pathologist is communication between the two. Each has his area of expertise, but he can only exercise it to the full with the help of the other. At the same time the needs of one may not always be immediately apparent to the other, and this is why these needs have to be spelled out on occasion.

From the point of view of the surgeon, greater contact with the pathological department is likely to enhance his knowledge of those aspects of pathology which primarily concern him. From the point of view of the pathologist, greater contact with surgeon is likely to draw him away from those aspects of tumour pathology which interest him as a pathologist, and bring to his notice those aspects which concern the surgeon, aspects which tend to receive little attention in textbooks of surgical pathology. The visit of the surgeon to the pathologist to discuss his pathological problems, and his invitation to the pathologist to discuss them in clinical as well as pathological terms, is likely to enhance their knowledge mutually at a clinico-pathological level, to the ultimate benefit of the patient.

Illustrations by Ian Ramsden

General management and complications

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

A. G. D. Maran FRCS(Ed), FACS
Department of Otolaryngology, University of Edinburgh, Edinburgh, UK

Introduction

The patient with a carcinoma of the upper aerodigestive tract is seldom an ideal subject for the surgery required to treat his disease effectively, and this creates problems for the surgeon in his decision-making. These involve various factors, and it is in the weighing up of them, and the reaching of his final decision on management, that the adequacy of his judgement is crucial.

The age of the patient and his general physical and mental state apart, the surgeon must take account of the natural history of the tumour, as far as this can be established, in relation to its pathological type and anatomical site. At one extreme, it may be apparent that the patient, untreated or treated merely palliatively, will die miserably with local uncontrolled disease; at the other extreme, the natural history of the tumour may be so slowly progressive that death from other causes is probable before the effects of the tumour become overt.

General management

Treatment alternatives

It is becoming increasingly the practice to have the treatment policy for the individual patient discussed by the various specialists likely to be involved in his treatment. In reaching decisions, the probable effectiveness of the various alternative methods, most obviously radiotherapy and chemotherapy, either used as the sole method of treatment, or in combination with surgery, requires to be considered. When decisions are being taken, a degree of candour is highly desirable, although it is not always easy to achieve in face-to-face argument between the practitioners of the various disciplines involved. It is important that the surgeon should be in a position to play a full part, stating his point of view cogently and clearly.

With certain tumour types and tumour sites it may be generally accepted that the tumour will be managed better by one or other of the three treatment modalities, or by a combination of them, but for the patient with squamous carcinoma, the tumour type most often under consideration, the argument regarding the place of each, and its relationship to the others, is far from being resolved. In the arguments which are generally presented, an aspect which is liable to receive inadequate consideration is the effect which each method of treatment has on the others, and failure to address the importance of this aspect tends to work to the detriment of the surgical argument.

In arguing against the use of primary surgery, followed electively by radiotherapy, the statement is still made that surgery reduces the vascularity of the area, reducing in turn the effectiveness of subsequent radiotherapy. It is regrettable that this argument should still be used, since it implies a lack of awareness on the part of the radiotherapists of current surgical practice in head and neck malignancy. It ignores the fact that in carrying out a neck dissection, the surgeon makes use of tissue planes, the superficial plane immediately deep to platysma, the deep plane along the prevertebral muscle layer. Between these two planes the tissue is certainly devascularized, but it is this tissue which is removed as the pathological specimen. It also ignores the fact that, following resection of the primary tumour, the reconstructive techniques, which are now standard world-wide, introduce a fresh blood supply to the resection site, with the transfer of soft tissue and, where necessary, vascularized bone, to the extent that a full dose of 60 Gy of radiation can safely be delivered to the site within 6 weeks of the surgery, regardless of whether the reconstruction has been one of soft tissue alone or includes vascularized bone.

The alternative combined and coordinated approach involves the use of radiotherapy followed electively by surgery 6 weeks later. Although it is advocated in certain centres, this approach has serious adverse factors from the viewpoint of the surgeon. At the end of the 6 weeks, the surface evidence of the tumour may largely have vanished as a result of the radiotherapy, making it impossible for the surgeon, at that time, to estimate suitable clearance margins. This criticism is considered to be adequately met by the carrying out of an examination under general anaesthesia prior to the radiotherapy, at which time the surgeon tattoos with Indian ink the outline of the resection margin around the tumour, which he proposes to use. This may appear to solve the problem of marginal clearance of the tumour, but it fails totally to address the problem of clearance in depth. It also fails to cope with the experience, well recognized by the surgeon who regularly treats tumours of the aerodigestive tract, of the tumour which is found at operation to be more extensive than the preoperative examination indicated. Managed in this way, a tumour is likely to be incompletely excised on the basis of a preoperative assessment of the type described above. These arguments against the use of preoperative radiotherapy apply equally to so-called 'induction chemotherapy', that is chemotherapy used preoperatively.

Surgeons are also acutely aware of the problems which preoperative radiotherapy creates for them as a result of the tissue ischaemia which it produces. Admittedly those ischaemic effects are most severe when the radiotherapy and surgery have not been coordinated in an elective manner, but the problems are still present in some degree even when treatment has been coordinated. They involve the carrying out of the neck dissection and the management of the primary site, in respect of both its soft tissue and bony elements, creating problems of healing and increasing the incidence of mandibular necrosis, particularly when conservative mandibular surgery has been carried out.

These are arguments which the surgeon needs to deploy in discussion if they are to be effective, but he must also appreciate that their acceptance by the radiotherapist is also likely to depend on the consistent ability of the surgeon to present, at the completion of his surgery, a patient whose appearance and function is viewed by the radiotherapist as acceptable.

Preparation of the patient

Preparation of the patient for surgery involves both physical and psychological elements. These, although they appear to be largely independent of one another, inter-relate to the extent that the patient who is psychologically prepared is likely to cooperate more effectively in what for him may be an extremely uncomfortable postoperative period. The discomfort is also likely to be prolonged and frequently considerably increased if, as is often desirable, postoperative radiotherapy is used in an elective role.

Physical preparation

The physical preparation is designed to get the patient as fit as possible on the day of operation. Recognizing that such patients frequently have medical problems relating to alcohol and, more relevant in this context, to tobacco, preparation has a limited objective. Even with such medical conditions as can be treated corrected as far as possible, surgeon and anaesthetist often have to carry out the surgery in the knowledge that the patient has insoluble medical problems. It says much for the skill of the anaesthetists and the techniques which they currently employ, and the effectiveness of postoperative management methods, that the major surgery, excisional and reconstructive, currently carried out, which may extend over many hours, is attended by such a low mortality.

The major problems which arise in the postoperative period most frequently involve the respiratory system. In countering these, the use of preoperative physiotherapy can be very valuable, not merely in improving respiratory reserve, but in familiarizing the patient with the regime of breathing exercises to which he will be subjected postoperatively. The use of antibiotics appropriate to the flora of the sputum may also be helpful during this period, but effective physiotherapy is of much greater value.

The state of the haemoglobin may require correction. A level below 10 g/100 ml should be corrected by transfusion, preferably with packed cells, 2 or more days prior to the surgery, to give the circulation time to stabilize. Above a level of 10 g/100 ml, correction can be carried out during the operation, although anaesthetists currently tend to run their patients with a lower haemoglobin than was usual previously.

If elective postoperative radiotherapy is contemplated, the dental state should be checked, so that any extractions considered necessary can be carried out during the resection, although the routine dental clearance which was once regarded as mandatory is no longer the norm.

The general nutritional state of the patient may create a dilemma for the surgeon. When there has been marked loss of weight, and the patient's skin has the recognizable appearance and feel which denotes a severe loss of subcutaneous fat, the probability of postoperative wound breakdown and, even more significant, necrosis of any flap which makes use of such skin, is sufficiently high to act as an extremely serious deterrent to surgery. Wound breakdown and flap necrosis in such a patient are almost certain to initiate the vicious circle of fistula and carotid exposure, discussed on pp. 18–19, and add to the general emaciation, making the process irreversible.

The question for the surgeon then arises whether or not it would be wiser to postpone the surgical procedure, with the opportunity which the delay creates for continuing growth of the tumour, in order to allow the weight loss to be at least partly corrected. Undue delay in treatment is clearly undesirable, but improvement in nutritional state increases the likelihood of a living patient at the completion of the surgery. A high protein, high calorie diet, preferably administered by nasogastric tube, will give the patient the best opportunity of surviving the operation.

Psychological preparation

How to make the patient mentally prepared is an aspect of management which is fraught with difficulties. It is an aspect which has significant cultural overtones specific to the country and the community in which the patient is being treated. It relates markedly to the manner in which medical practice generally, and the relationship between doctor and patient, have developed in the particular country, as well as the manner in which the problem of cancer in general is discussed between the two.

In the USA, discussion between surgeon and patient is full and open. Treatment options are fully discussed, with the possible complications explained in detail, in an atmosphere of 'informed consent'. In the UK, the situation is managed in a quite different manner. Discussion may have moved marginally in the direction of 'informed consent', but unpleasant facts still tend to be shrouded in euphemisms, and treatment is discussed in very general terms. Surprisingly few questions are asked by the patient as a rule. These differences reflect differences in medical practice generally in the two countries, and neither should be regarded as universally preferable. Each appears to suit the patient–doctor relationship which has developed in the individual community. With either approach, what is essential is that the patient must have the opportunity to ask the questions which he regards as relevant to him, and the surgeon should not shrink from the interview.

In practice, it is remarkable how little the patient absorbs of what he is told at such an interview, and a subsequent discussion is often desirable. Valuable amplification is generally found to have been provided by the nursing staff. When this is the staff who will be looking after the patient pre- and postoperatively, after his initial period of intensive care, the reassurance of such a discussion with the nursing staff is of great value, since it carries with it implied experience, and skill in management, on their part.

When there is the prospect of elective postoperative radiotherapy, it is probably wise to explain this at the outset. To mention it during the postoperative period, apparently as an afterthought, is liable to carry the implication that progress has not been entirely satisfactory, otherwise radiotherapy would not be necessary. The discomfort which is inseparable from radiotherapy must also be explained; the fact that such discomfort is invariable, although its severity varies with different patients for no obvious reason; that it gathers momentum over the period of treatment; and above all that it is temporary, settling when the radiotherapy stops. This aspect of radiotherapy is one which radiotherapists are apt to underplay, even if they do discuss it with the patient. Since many patients find the radiotherapy more of an ordeal than the surgery, this is unfortunate. It is an omission which the surgeon may well feel he has an obligation to correct.

A less immediate side effect of the radiotherapy, but one which the patient finds the more distressing because it is largely permanent, is the production of xerostomia, the dryness of the mouth which results from the incidental radiation of the salivary glands. With care in selecting his portals, it is possible for the radiotherapist to shield one parotid from radiation in the majority of patients, and prevent the 'dry mouth' syndrome. This modification of technique is now a matter of routine with the more progressive radiotherapists, but it is also something which the surgeon can justifiably bring to the notice of his colleague if he finds his patients continuing to suffer from the 'dry mouth' syndrome.

Postoperative care

The way of life of the average patient with an upper aerodigestive tract carcinoma makes him a prime candidate for postoperative chest infection. Avoidance of such infection is primarily a matter of good physiotherapy, coupled with a regime of early ambulation. The patient who is progressing normally should be out of bed and into a chair for a short period within 24 h of recovery from the anaesthetic, and ambulation for increasingly long periods should follow rapidly. A regime of breathing exercises and supervised coughing is essential and if, in the early postoperative period, secretions can only be coughed up as far as the pharynx, regular suction to that site is required. The role of antibiotics is discussed on p. 16.

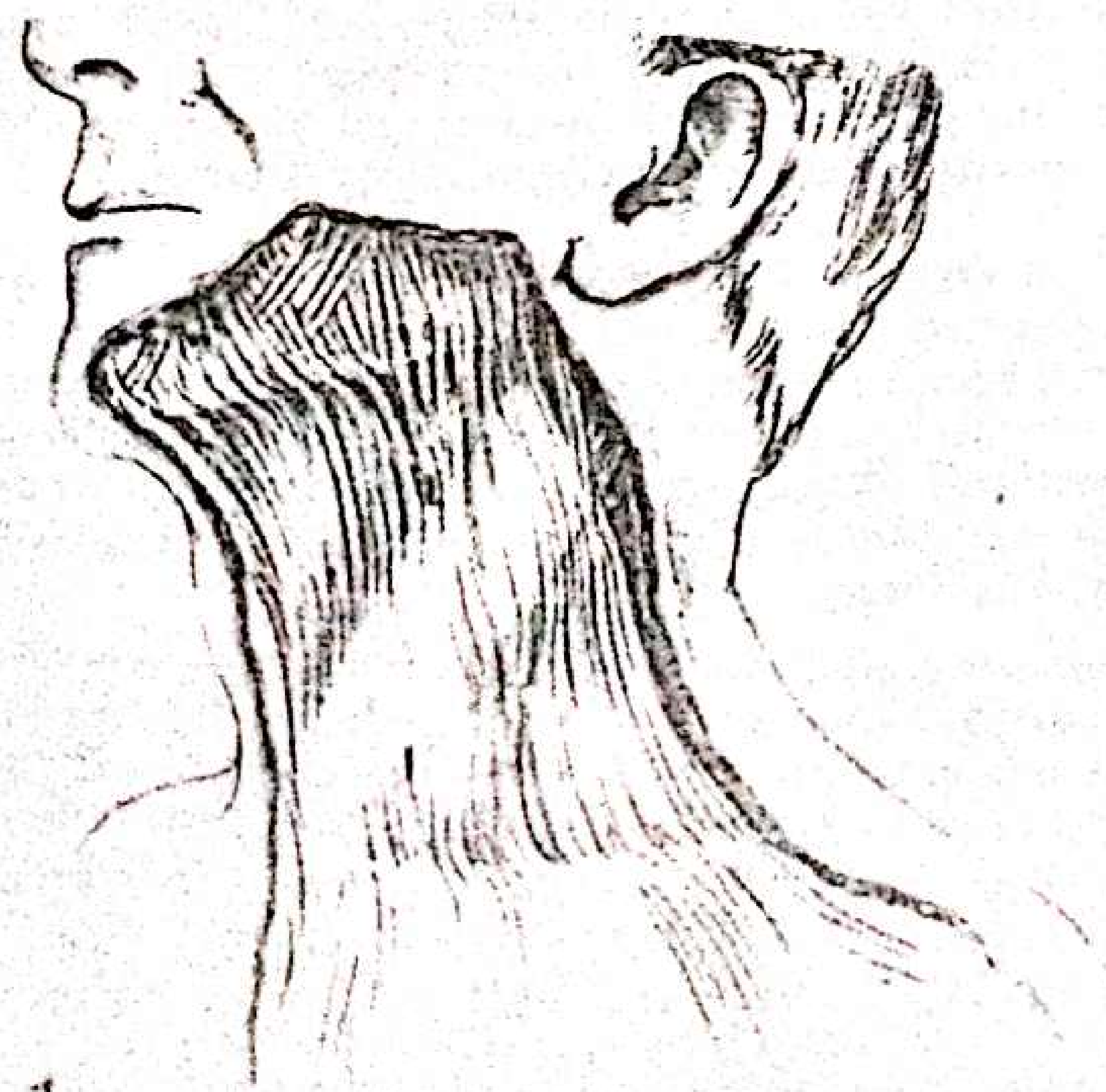
Intravenous fluid replacement can be changed to nasogastric tube feeding as soon as the appearance of the fluid draining from the neck indicates that bleeding has ceased completely. Tube feeding in this way should be continued until the patient has regained control of his swallowing mechanism, and the reconstruction is stable. Blockage of one nostril by the nasogastric tube is unavoidable when a tube of standard calibre is used, and is apt to result in an undesirable degree of mouth breathing, but it can be mitigated by using the fine calibre tubes which are available today.

The difficulty met in maintaining good oral hygiene depends very much on the extent to which the patient is able to keep his mouth closed. Continuous mouth breathing dries moist exudate in the mouth to form a hard adherent crust which is difficult to dislodge. Fortunately, the adverse effects of such crusting on reconstructing flaps, and the mouth generally, are less than one might expect judging by its repulsive appearance. The main virtue of repeated cleansing lies more in the reduction of foetor and in making the patient more comfortable.

Control of pain rarely poses a serious problem but, even so, the analgesic should be chosen to combine maximal analgesic effect with the minimum of depressive effect on respiration. The continuity of control which an intravenous infusion of morphine provides is particularly useful in the immediate postoperative period.

Role of wound suction

The use of dressings applied to the neck following neck dissection has largely been discontinued in favour of suction drainage. The objective of the suction is to prevent fluid accumulating between the skin flaps and the raw surface left when the neck nodes are removed, and encourage rapid adhesion between the two. There are certain sites where fluid is found to accumulate, and these are determined by the alterations in the neck anatomy, resulting from the absence of certain structures in the submandibular and supraclavicular areas which were removed as part of the neck dissection.



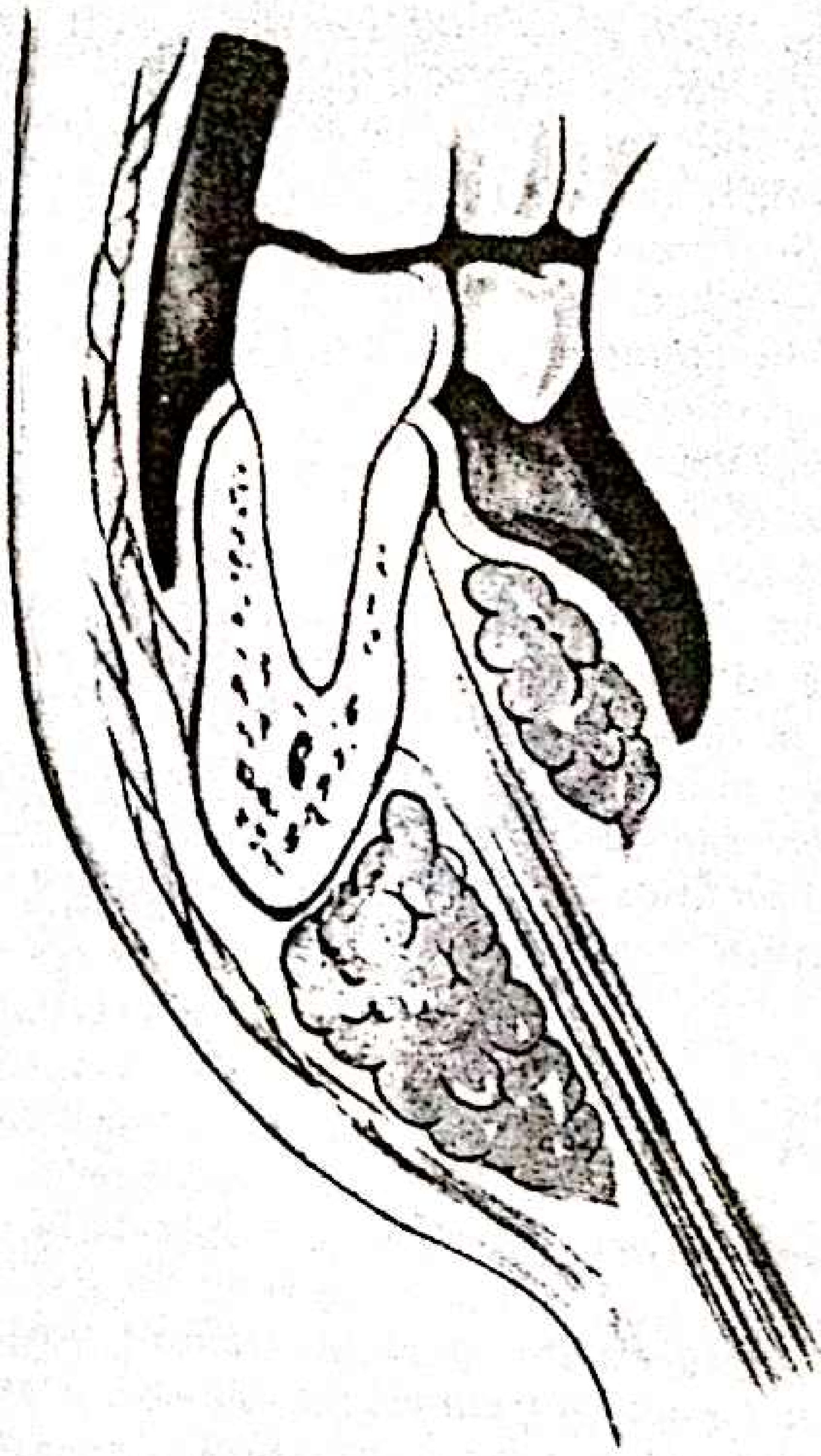
1

1

In the intact neck, platysma lines the neck skin, passing from the outer surface of the mandible down over the clavicle.

2

In the submandibular region, the mylohyoid muscle runs upwards from the hyoid bone to be attached along the mylohyoid line on the lingual surface of the mandible. The wedge-shaped space between platysma and mylohyoid is filled by the superficial lobe of the submandibular salivary gland, and this structure is resected as part of the dissection in this area.



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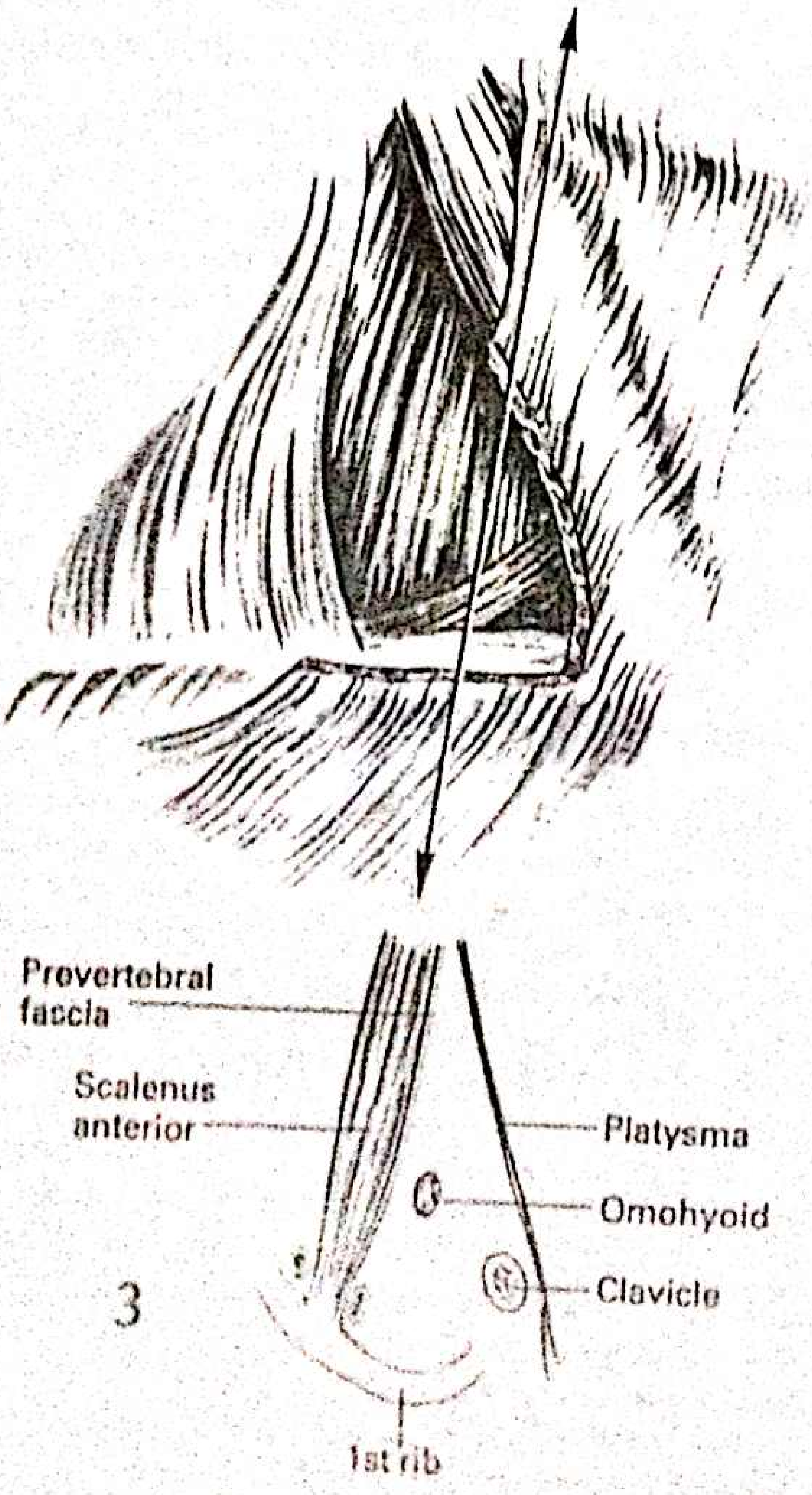

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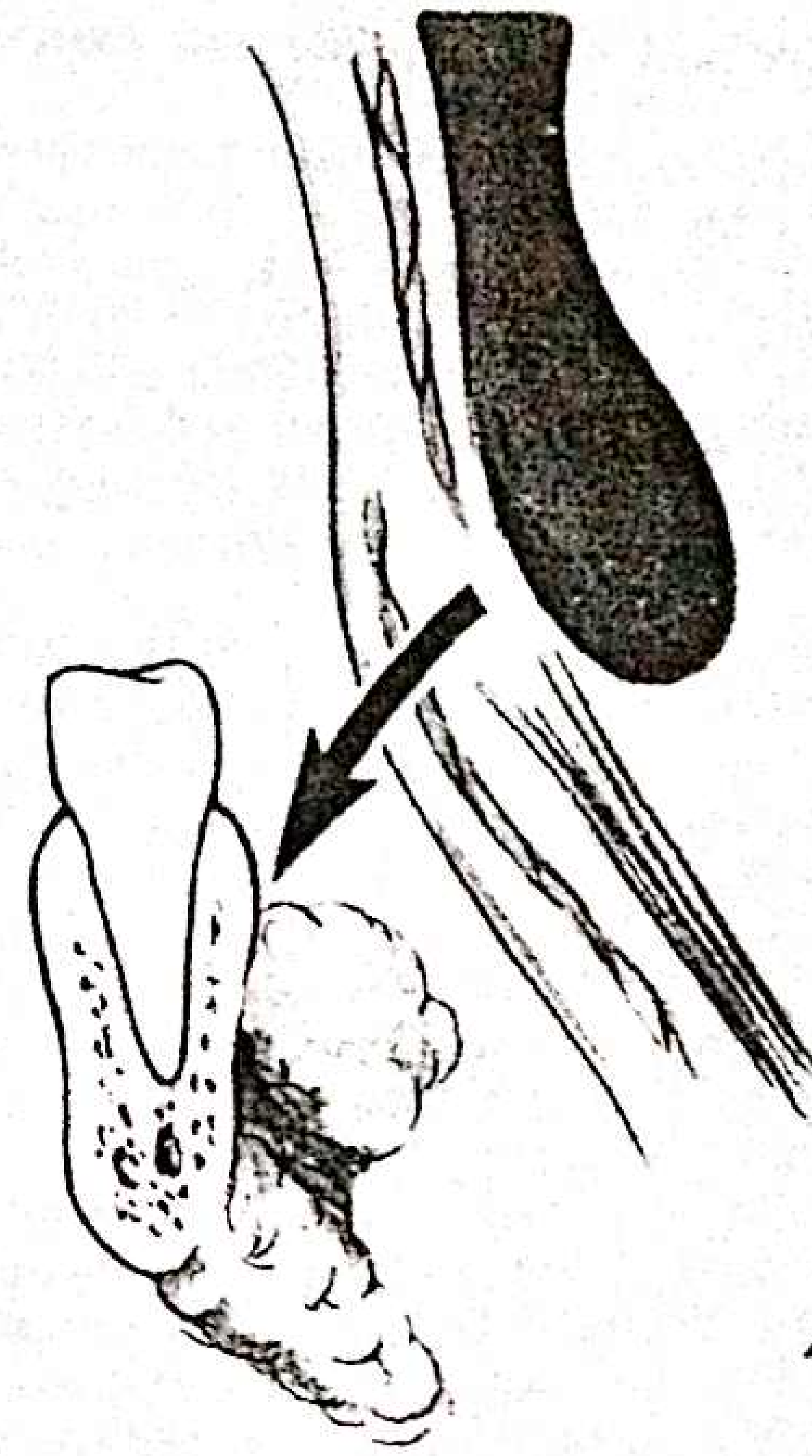
3

In the supraclavicular area, platysma passes over the clavicle to reach the upper chest, while the prevertebral muscles pass deep to the clavicle to be inserted into the first rib and the scapula. The gap between the two is filled by the soft fat of the lower posterior triangle, and this is removed as part of the clearance in this area.

At the completion of the neck dissection, the skin is stretched over the convexity of the neck but, in the submandibular and supraclavicular sites, where floor and skin diverge, the effect of removing the structures which normally fill these areas – the salivary gland from the former, and the fat pad from the latter – is to leave 'dead spaces' there.

4

When the hemimandible has been removed as part of the overall resection, the cheek is able to collapse inward and obliterate the submandibular 'dead space'.



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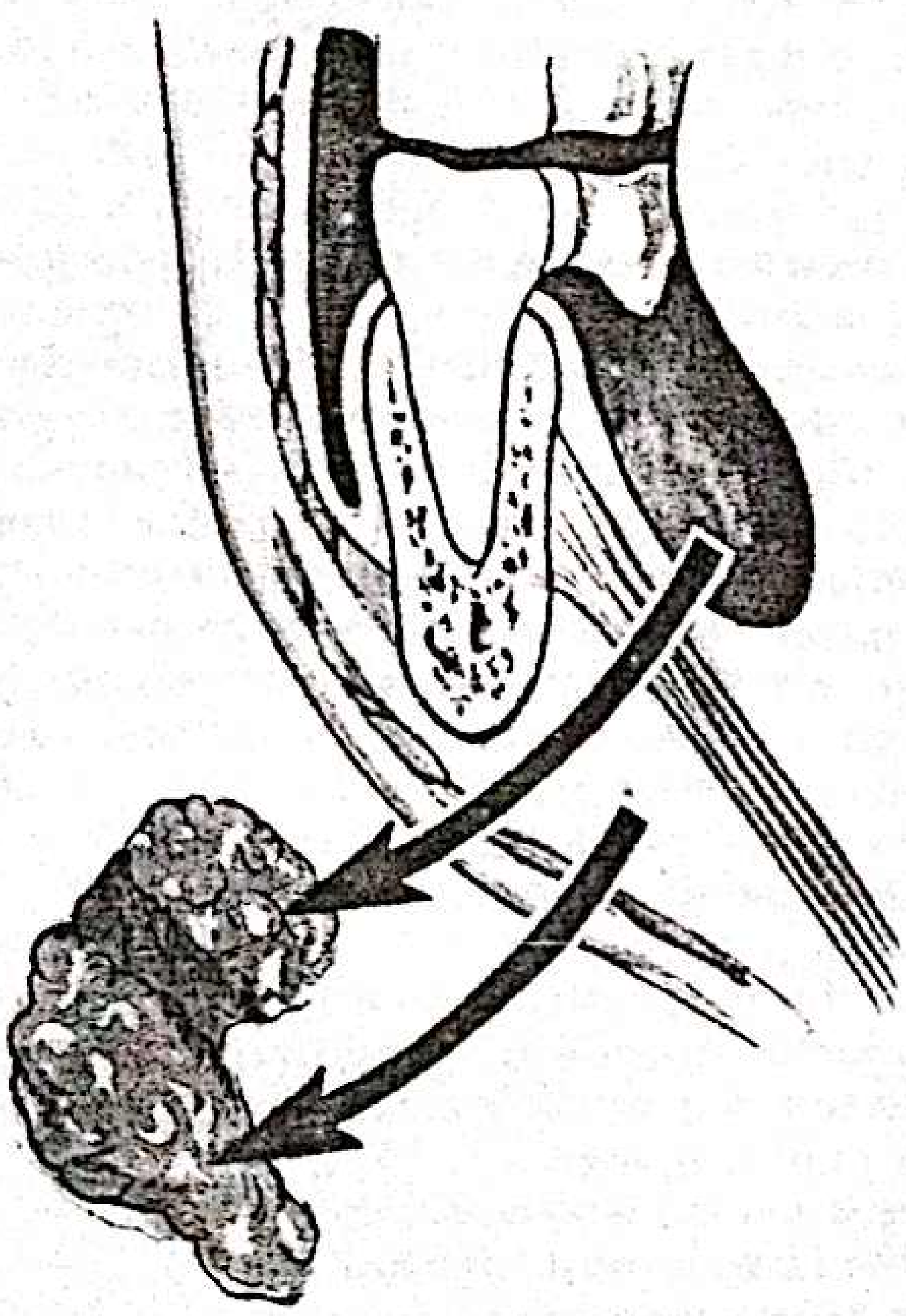

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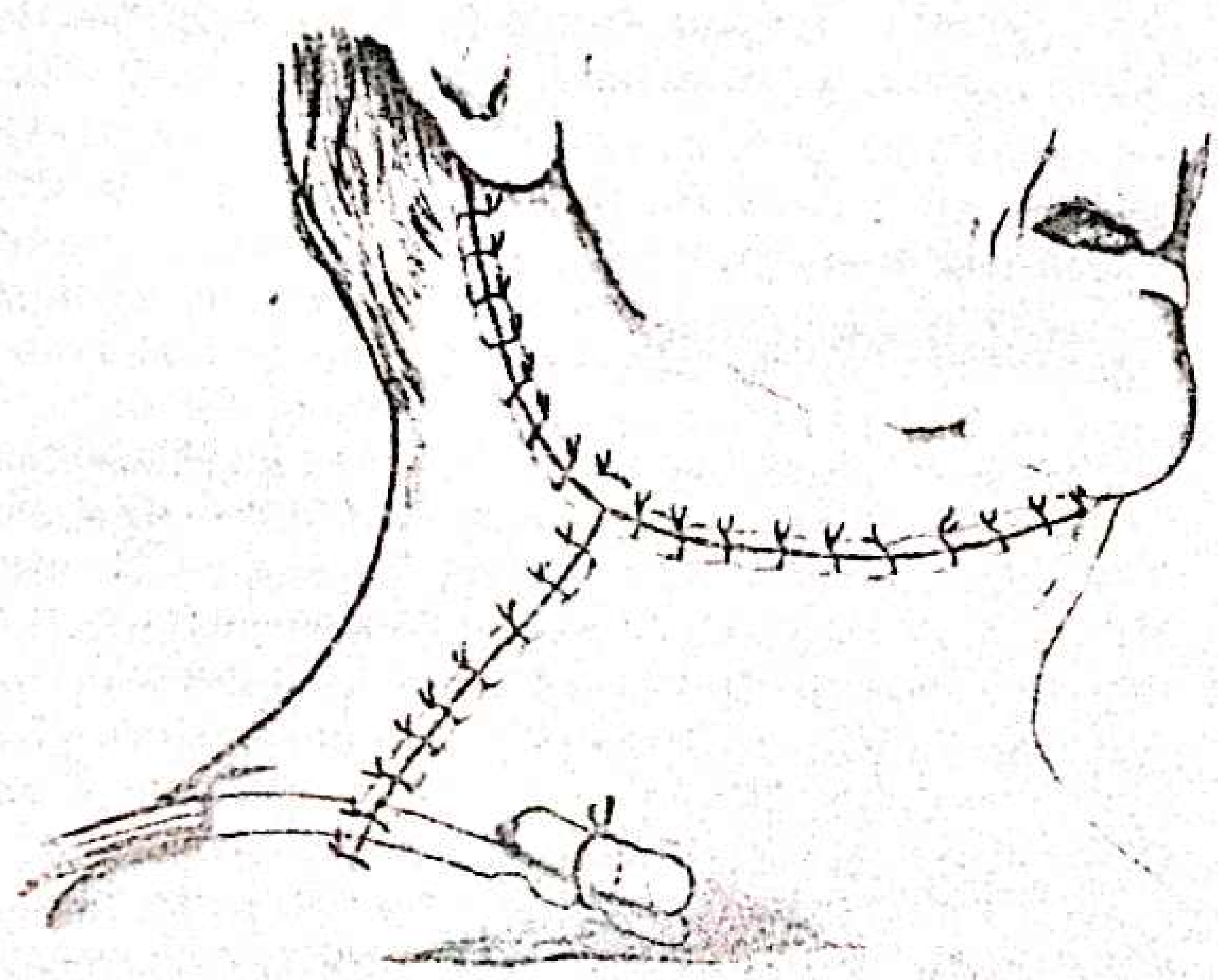
5

When mandibular continuity has been maintained, the space remains.

Because of the presence of a 'dead space' in these two sites, submandibular and supraclavicular, it is there that fluid predominantly collects postoperatively, and it is to them that suction requires to be applied. The two sites require to be drained independently, the form of the drain varying with the local facilities available. If wall suction is available, a 26 French gauge catheter can be used, with additional drainage holes cut in it; in the absence of this facility, one of the finer catheter vacuum suction drainage systems can be used.

6

In the supraclavicular area, the drainage tube is inserted a little above the clavicle, just behind the anterior border of trapezius. It should run horizontally, stopping short of the common carotid artery and the ligated end of the internal jugular vein.



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7

In the submandibular area, an independent drain is only required if mandibular continuity has been maintained. The drainage tube is inserted just below the tip of the mastoid process, and runs forward parallel to, and under, the lower border of the mandible.

In both sites it is desirable that the tip of the drainage tube should not become displaced, in the supraclavicular area because of the presence of the major vessels nearby, in the submandibular area if a microvascular anastomosis has been carried out in the vicinity. In this latter eventuality, the tube may have to be shortened or not used at all, since the demands of the anastomosis take absolute priority. Fixation of the tip of the tube can be ensured by placing a transfixing suture through the skin tied lightly over a cotton wool bolus.

It is in the early postoperative period that the effectiveness of the suction is of particular importance, since the drainage has to match the volume of fluid leaking into the neck, so that the skin will adhere deeply as rapidly as possible. The best clinical evidence of the effectiveness of the drainage is maintenance of the concavity at the suction site. Reduction of the concavity and, even more, conversion to a convexity, is clear evidence of inadequate drainage, and it is generally due to blockage of the tube.

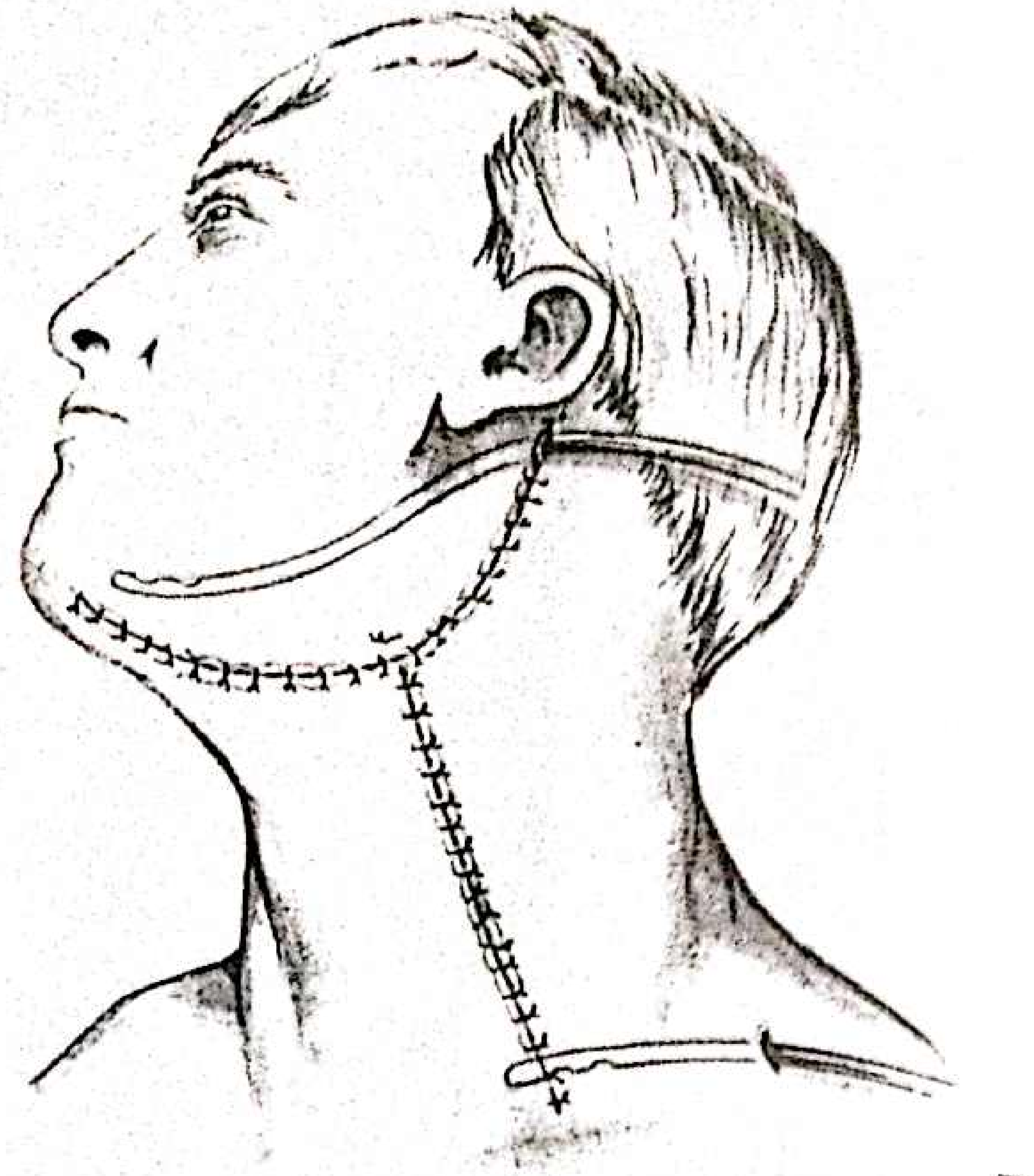
The character of the drainage fluid requires also to be watched. Ideally, it should become relatively clear as it slowly diminishes in volume, with obliteration of the space. In the upper drain, the presence of saliva in the drainage fluid indicates an inadequate seal inside the mouth. With certain reconstructions, mostly the ones which are less often used today, such as the forehead and deltopectoral flaps, an element of salivary contamination is unavoidable but, with the reconstructions in current use, an intraoral watertight seal can be achieved, and contamination should not occur. The supraclavicular drain has to be watched for the development of a creamy consistency in the drainage fluid. This indicates leakage from the thoracic duct, a complication discussed on p. 17.

How long drainage may be expected to continue varies greatly, and there is no set time for removal of the drainage tube. Suction should be maintained for as long as fluid continues to drain.

Control of the airway

Following surgery which involves the upper aerodigestive tract, some patients are unable to control their airway effectively, to the extent that they cannot prevent aspiration of swallowed food and saliva. In such circumstances control has to be taken over from the patient until such time as he is able to exercise it safely. Control takes the form of spatially separating the functions of respiration and swallowing, usually by means of a tracheostomy.

Such a tracheostomy may be temporary, required until the patient has re-established control of his airway and aspiration has ceased to be a hazard, or permanent, when it is apparent that aspiration is going to present a continuing hazard for the rest of the patient's life.



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The operative techniques involved in carrying out both types of tracheostomy, temporary and permanent, in the various clinical situations where the need for the procedure arises, are described in the chapter on 'Emergency and elective airway procedures: tracheostomy, cricothyroidotomy and their variants', pp. 27–44.

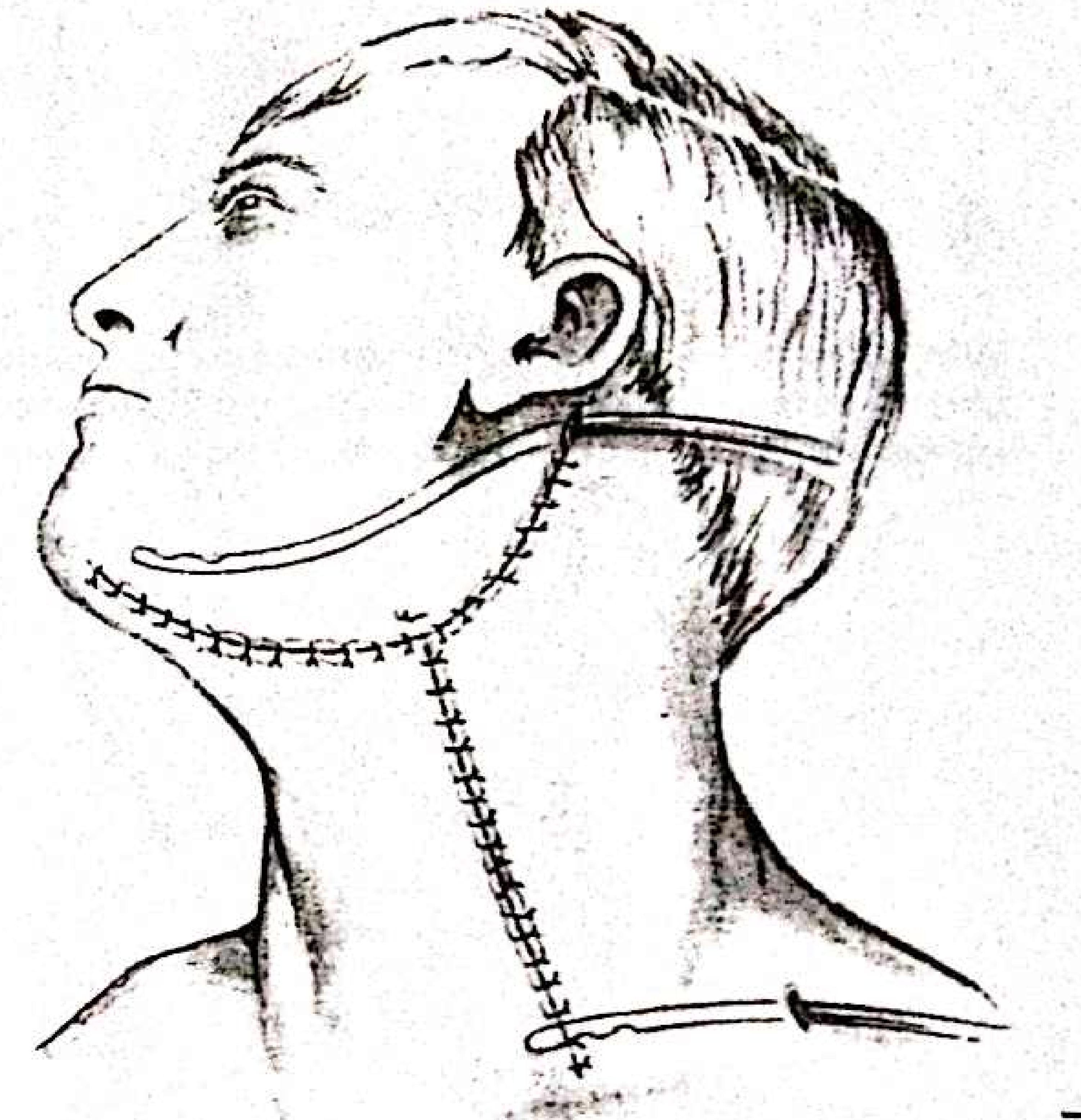
Informing the patient

When the tracheostomy is to be a permanent one, the need for the surgeon to discuss its effects with the patient are so self-evident that it is not an aspect of management likely to be forgotten.

It is when the tracheostomy is to be a temporary one, that the surgeon must not forget to make quite certain that those points concerning its impact on the patient which are needed to reassure him have been explained to him and, equally important, understood by him. To recover from an anaesthetic, unprepared, with a tracheostomy, must be an extremely frightening experience. It is this fact which makes it all the more necessary to see that the patient is fully prepared.

He must be told why the tracheostomy is needed; it must be emphasized that it is strictly temporary, and will be reversed when the local situation has become stable; it must be explained that, although he will be unable to speak while the tracheostomy tube is in place, he will be able to speak when the tube is removed, with little volume at first because of air escape through the tracheostomy opening, but increasing as healing takes place, to a normal volume once healing is complete. An estimate of how long the tracheostomy is likely to be maintained is also desirable.

7



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Indications for tracheostomy

The indications for a tracheostomy are determined by estimating the effect which the resection-reconstruction is likely to have on the patient's control over his swallowing mechanism, and his ability to separate it from his respiratory mechanism.

When the resection involves the laryngeal mechanism, the probability that a tracheostomy will be required is intimately bound up with the extent of the resection and the form of the reconstruction. It is convenient, therefore, to discuss the need for a tracheostomy, temporary or permanent, as part of the chapters in which the various forms which resection-reconstruction of the laryngo-pharyngeal mechanism, partial as well as total, are described.

When the resection is confined to the oral cavity, the tracheostomy is likely to be a temporary one, and the decision as to whether one should be carried out is largely based on the estimated effect of the resection-reconstruction on the function of the tongue. Any surgery which involves the tongue has to be considered from this point of view. The further back in the mouth the resection, the greater the probable effect on swallowing, both in the immediate and short term, and the more imperative the need for a tracheostomy. The ultimate severity of the impact which the surgery has on the swallowing mechanism largely depends on the adequacy of the reconstruction but, in the short term, the degree of discomfort likely to be associated with swallowing is a more reliable guide to the need for a tracheostomy.

The volume of the tissue removed surgically, and the extent to which the origins of the extrinsic muscles of the tongue are disrupted, will also be significant determinants. As a single factor, the size of the area of mucosa resected seems to be less important. The effect of mandibular resection is also largely mediated through its effect on tongue function. In the final assessment, the balance should generally be tipped in favour of tracheostomy if there is any doubt. Correctly performed, and properly managed, it should carry a negligible complication rate.

Management of tracheostomy

The management of a tracheostomy is aimed at reproducing as far as possible the normal physiological environment of the respiratory system, and preventing the occurrence of the sequence of bronchial blockage, collapse and infection. The key to good management is the provision of warm, humidified, inspired air, ensuring that the tracheobronchial secretions are removed effectively, and with these activities carried out in an aseptic manner so that they do not add to any pre-existing infection.

In the context of malignant disease, intraoral resections are regularly carried out in continuity with a neck dissection, and the resection is usually followed by reconstruction of the defect. It is with this as a background that the humidifier should be chosen. The desirable characteristics are that the component in the vicinity of the neck should be light, and capable of being sited so that it exerts a minimum of pressure on the skin flaps of the neck dissection, and on any reconstructing flap.

In the immediate postoperative period, when the dangers of aspiration are at their greatest, an inflated cuffed tracheostomy tube may be needed. Care is then required to ensure that the cuff is not overinflated, and inflation should alternate with deflation at sufficiently short intervals to ensure that tracheal necrosis is avoided. The cuffed tube should also be replaced with a standard one as soon as possible.

While the tracheostomy is open, a regime of bronchial toilet, regularly carried out and involving suction directly applied to the bronchi, is essential. The need for its additional use between the regular suction sessions may be recognized from the sound of secretions moving up and down the bronchi with each breath. The consistency of the secretions is also a good indicator of the adequacy of the humidification.

Prior to each episode of bronchial toilet it may be useful to auscultate the chest. Any area where the sounds are less audible is an indication for the physiotherapist to concentrate attention on that lung segment. The physiotherapist is also responsible for supervising the regime of vigorous breathing exercises and supervised coughing, with simultaneous suction to remove secretions. A soft catheter, introduced into the bronchi through the tracheal opening, induces a bout of coughing, and the suction applied as the catheter is withdrawn removes the secretions along with it. The procedure is repeated until the chest appears clear.

Discontinuation of the tracheostomy

The length of time during which the tracheostomy should be maintained is a matter to be discussed between the anaesthetist and the surgeon, the nursing staff and the physiotherapist.

In reaching a decision, a factor of considerable weight concerns whether or not the reconstruction used has been a single-stage or a multistage one. Today, multistage reconstructions are much less frequent, and the issue is consequently receding in importance, but it may still arise. When a tracheostomy has been allowed to close, the attempted passage of an endotracheal tube by the anaesthetist in preparation for the carrying out of the second stage of a multistage reconstruction is likely to be made difficult, on occasion virtually impossible, because of local anchoring of the trachea and larynx by the recently formed scar tissue. To this may well be added the constraints which the partially completed reconstruction imposes on the anaesthetist in his necessarily forceful manipulations of the laryngoscope as he attempts to intubate the patient. The combination can produce a nightmare situation for the anaesthetist, and it is one which he will wish to avoid by retaining the tracheostomy until the reconstruction is demonstrably complete.

The argument for early removal rests on the undesirability of continuing an abnormal physiological state for longer than is essential, the problems of maintaining satisfactory humidification in a patient whose increasing mobility is being strongly encouraged, and the continuing opportunity for super-added infection of the respiratory tract with organisms which are likely to exhibit hospital resistance to antibiotics. The weight to be given to the two sides of the argument depends very much on the intubating skill of the anaesthetist. The final decision should probably be his.

With the single-stage reconstructions which are more usual today, the tracheostomy tube is best removed as soon as the condition of the patient is reasonably stable. Experience would suggest that the longer the tube remains in position, the more the patient comes to rely on it, becoming afraid that he will choke if it is removed. In any case a trial of removal can be used in the first instance. Particularly if a Bjork flap has been used, reinsertion of the tube should present no problem. Immediately following removal of the tube, coughing forces the tracheobronchial secretions out through the tracheostome, and toilet in this area has to be continued for some time, decreasing as healing occurs. Even with the Bjork flap there is no need to formally close the tracheal opening. Once the sutures joining the tracheal flap to the skin are removed spontaneous healing can be expected. Experience indicates that the flap slowly reverts to its original site in the tracheal wall.

Complications

Postoperative infection

Infection, as it occurs postoperatively, generally involves either the chest or the operative site.

Chest infection

The most important factor in the control of chest infection has already been stressed, namely the use of physiotherapy in the pre- and postoperative situation. Preoperative and regular postoperative sampling of the sputum, to identify organisms and establish sensitivities, may be important to indicate the appropriate antibiotic to administer, but the critical role remains that of the physiotherapist. The postoperative development of a severe chest infection often means that it would have been wiser to carry out a tracheostomy at the outset, with the opportunity which it would have provided for direct suction access to the bronchi. It is striking how often the need for an anaesthetic in a patient with a postoperative chest infection marks the turning point in his progress, because of the opportunity it provides for full and vigorous tracheobronchial suction toilet by the anaesthetist.

Infection of the operative site

When infection of the operative site develops, the significant organisms are generally ones which were present preoperatively in the tumour, particularly those of the *Bacteroides* group. In controlling them, both prophylactically and therapeutically, metronidazole has proved highly effective. Its effectiveness in this role, used as a single antimicrobial agent, has demonstrated that the other organisms found on aerobic culture, and previously regarded as pathogens in this context, are largely commensals. These organisms are not sensitive to metronidazole but, with control of the *Bacteroides* group by the metronidazole, they give little trouble. Administration of metronidazole prophylactically does not appear to be necessary. A single intravenous bolus of 500 mg administered perioperatively has proved effective used alone, but it is more often used as a loading dose, followed by 400 mg three times daily for 5 days, administered orally or by nasogastric tube.

Since the introduction of metronidazole for this purpose, other antibiotic combinations have been developed which are effective not merely against the *Bacteroides* group, but also against a wide spectrum of Gram-positive aerobes and anaerobes, as well as Gram-negative aerobes. One such combination is Augmentin (Beecham) in which clavulanic acid has been used to extend the spectrum of activity of amoxycillin to include the *Bacteroides* group among other organisms. The main limitation to its use would be penicillin hypersensitivity.

Delirium tremens

Alcohol abuse provides a frequent background to oral carcinoma, and the occurrence of delirium tremens must always be watched for. The condition is no respecter of social status, and it should be suspected if the degree of postoperative lucidity is at variance with the norm. Patients are rarely prepared to give an accurate estimate to the doctor of their intake of alcohol. The nursing staff often make a more realistic assessment in this regard, and this places them in an excellent position to give a valuable opinion if there should be erratic behaviour in the early postoperative period. While the use of tranquillizers, particularly chlormethiazole (Heminevrin), regarded as having a specific effect, is generally recommended, personal observation has been that a small dose of alcohol, e.g. 30 ml of whisky, may not merely confirm the diagnosis by its clinical effect, but also control the condition. The therapeutic intent of the surgeon is to control the immediate effects of alcohol withdrawal, not to treat the underlying problem of alcohol abuse.

Acute fibrinolysis

In the past, this was an extremely serious and frequently fatal complication. The initiating factors are not clear-cut, but its occurrence can be recognized when, towards the completion of a surgical procedure, most often involving extensive soft tissue dissection, such as a neck dissection, surfaces which were previously dry begin to bleed from small vessels, and the entire wound becomes a source of haemorrhage. With fresh frozen plasma available today to treat the condition, it is a complication less to be feared, but when the effectiveness of treatment is being recognized by the slowing down of the rate of the blood dripping to the floor of the operating room, the degree of concern on the part of all involved needs no stressing. Even when the condition is treated successfully, it generally leaves problems of multiple haematomas requiring treatment. These are best left alone until the coagulation picture has reverted to normality.

Thoracic duct fistula

Unexpectedly prolonged drainage from the supraclavicular site is of no special moment, other than suggesting that one of the larger lymph channels in the neck has been divided. As long as the drainage fluid remains clear, no special treatment is required, apart from the continuing of suction. When the fluid becomes creamy in consistency, it should be regarded as chyle, and due to a thoracic duct fistula. The diagnosis is usually made clinically, but biochemical analysis of the fluid will provide confirmation. The volume of drainage is variable but it may be quite large.

An immediate step which should be taken is to institute a low fat diet. Adequate intake of fluid, electrolytes and calories, to match that being lost through the fistula, should be ensured, preferably by nasogastric tube, or intravenously if this is not possible.

There are two possible approaches to the local management of the fistula. The neck can be reopened, and the site of the fistula identified and ligated with a non-absorbable suture. Alternatively, the leak can be managed conservatively, waiting for spontaneous closure.

One must presume that the advocates of surgical interference have personal experience of the procedure, but the descriptions which they provide fail signally to emphasize the technical difficulties, and the hazards involved, in reopening a neck dissection wound several days postoperatively, and searching for the opening in the duct, close to the angle between the internal jugular and subclavian veins. The technical problems apart, the fear that the resutured skin flaps may fail to adhere deeply, and the wound may fall apart, exposing the common carotid artery, is sufficient to give the surgeon pause, and make him consider the alternative of a conservative approach. These considerations are likely to have particular relevance if the neck has previously been irradiated.

Conservative management is largely pragmatic, and depends to a considerable extent on whether the skin flaps have or have not adhered deeply. When the flaps have become largely attached deeply, and the leakage is along a fistulous track, it is probably best to discontinue suction and try as far as possible to collapse the walls of the fistulous track by applying pressure externally with pad and elastic adhesive plaster, changed as the pad becomes sodden with the chylous discharge.

When the skin flaps have failed to adhere deeply, the volume of the discharge is usually a causal factor, at least in part, and efficient suction is desirable to limit, as far as possible, wide leakage of the chyle to the lower neck. Effective suction, used in association with local pressure, has the aim in the short term of converting the leakage to a fistulous track by encouraging the adherence of the skin flaps deeply, and then managing the fistula as already described.

Management of a fistula conservatively can be most discouraging in the short term, demanding both patience and persistence by all concerned. Personal experience has been that in every instance the fistula has ultimately closed spontaneously, even if closure has taken place slowly.

A stage in the closure of the fistula is occasionally reached when progress to healing appears to have become completely static because a chyle-derived 'clot' has formed along the sinus track, preventing the development of a granulating surface. Gentle curettage of the track to remove the coagulum may be necessary, in order to expose the underlying granulation tissue before adhesion of the walls with obliteration of the track can take place.

Wound breakdown and fistula

The local complications of wound breakdown and fistula, and the additional complications to which they can give rise, tend to be the ones of most serious concern to the surgeon.

Dehiscence of a suture line, progressing to significant wound breakdown, may involve the skin and/or the mucosa. An associated factor, and one responsible for the dehiscence when it occurs, is flap necrosis, either of a surface flap, replacing resected skin, or a lining flap, replacing resected mucosa. Dehiscence of the suture line, alone or in association with flap necrosis, frequently initiates the sequence which leads to fistula formation.

The seriousness of the problems which these complications, singly or combined, pose for the surgeon can vary from being of nuisance value only to what has aptly been categorized as 'catastrophic postoperative wound breakdown' because of its life-threatening aspects. The sequence can follow resection for intraoral carcinoma, but it arises much more frequently following pharyngolaryngeal resections. In the latter particularly, the breakdown occurs in close proximity to the major vessels in the neck, and it is exposure of these vessels which has the greatest lethal potential, an aspect discussed on pp. 19–21.

Causative factors

Two main factors predispose to these complications and, more significantly, to their lethal potential, namely the medical state of the patient, and the tissue ischaemia which results from radiotherapy.

The necessity of achieving a satisfactory nutritional state prior to surgery has already been stressed. It has special relevance in pharyngeal tumours, where difficulty in swallowing may have been a presenting symptom, and a period of hyperalimentation may be essential prior to surgery.

Radiotherapy has a comparable detrimental influence on wound healing, because of its effect on the vascularity of the tissues which have been irradiated, although in this particular context its effect on the vascularity of the carotids is perhaps ultimately more important. The severity of the adverse effect of radiotherapy depends to some extent on the gap in time between the delivery of the radiotherapy and the surgery. The effects of radiation on the normal tissues are generally considered to plateau at 6 months, although the regular development of radiodermatitis and radionecrosis after a very much longer period of time than this must cast doubt on the accuracy of this statement. Nonetheless, the complication rate, as it relates to previous radiotherapy, has been found to be much greater when the radiotherapy has not been co-ordinated with surgery, compared with the two in a planned sequence.

Mucosal dehiscence and lining flap necrosis

At the stage in postoperative management when these complications occur, a nasogastric tube is likely to be in position, and it should be maintained there until the local situation has become stable.

The two complications, dehiscence and necrosis, present similar problems, differing only in degree. The effect of both is to allow contamination of the operative field with saliva, but management depends very much on whether the complication remains contained within the mouth or pharynx, or whether breakdown of the neck wound also occurs, creating a fistula.

Pharynx. When there is breakdown of a mucosal suture line or necrosis of a lining flap in the pharynx, the likelihood of it progressing to a fistulous connection with the surface is very high because of the closeness between the skin and the mucosa postoperatively, to the extent that with significant wound breakdown or flap necrosis it is almost inevitable. In practice, the development of a fistula is usually the first sign that the integrity of the lining has been breached, mucosal dehiscence which does not progress to fistula formation going unrecognized, and healing spontaneously.

Oral cavity. In the oral cavity, dehiscence of the mucosal suture line and any necrosis is recognized while the problem is still confined within the mouth. In this respect, the pharynx and the oral cavity differ, progress to a fistulous connection being less of an inevitability when the oral cavity is the site involved, reflecting the greater distance between the mucosa and the skin. While the problem remains within the oral cavity, every attempt should be made to manage it conservatively, with regular irrigation to remove any discharge and keep the site as clean as possible.

If necrotic tissue is present, it is often best to allow it to separate naturally rather than carry out a formal slough excision and, with separation complete, to allow spontaneous healing to take place. The result is often surprisingly good in both cosmetic and functional terms. When the reconstruction has made use of a conventional flap, as opposed to a free flap, necrosis when it occurs is often partial, involving only part of the flap. With an island myocutaneous flap, the muscle element often survives, even when the skin island sloughs completely. When this occurs, spontaneous healing can be awaited, with confidence regarding the final result. With a free flap, when necrosis occurs, it is usually total.

It is particularly when necrosis has been total that the general state of the patient, the site of the flap inside the mouth, the probable cosmetic and functional result if healing is allowed to take place after the slough has separated spontaneously, have all to be considered and matched against the consequences of the opening up of the mouth and neck which would be necessary to insert a fresh flap. As with more minor necrotic episodes, the result with spontaneous healing can be surprisingly good, even after loss of an entire free flap.

Skin dehiscence and necrosis

Dehiscence of the skin suture line, when it is minor in extent and not associated with breakdown of a mucosal suture line, creating a fistulous track, is more often a nuisance than a disaster. The problems which it can create, and their seriousness, depend on the structures which are exposed, and their vulnerability. The structures most likely to give rise to concern when they are exposed are the carotids and the perfusion source of a free flap, the former because of the possibility of blowout, the latter because of the very high probability of thrombosis at the site of anastomosis and consequent loss of the flap.

When significant breakdown occurs in the neck without associated mucosal dehiscence or necrosis, it is generally the result of failure of the skin flaps to adhere deeply, either because the suction has been ineffective or because there has been failure to achieve a completely watertight seal of the mucosal lining.

The site and extent of the breakdown depend very much on the skin incision used, to the extent that the proneness of the various incisions to wound breakdown is a significant factor in the choice of which incision to use in a particular clinical situation. Previous radiotherapy is also a recognized causal factor, and it is certainly one which aggravates the problem when breakdown has occurred.

Necrosis which is more than very minor is rare, unless a reconstructing flap has been used to replace resected skin and the flap has necrosed in part or in its entirety. The flaps of skin which are raised in the carrying out of a neck dissection are generally safe from this point of view, their safety being one of the reasons why the skin incisions which are standard today have emerged from the plethora which have been described in the literature. This aspect of neck dissection practice is discussed in the chapter on 'Radical neck dissection'.

Minor wound breakdown is generally allowed to heal spontaneously. If failure of the skin flap(s) to adhere deeply has been a factor in causing the wound to break down, pressure applied to the appropriate area may be desirable. When skin necrosis has occurred, grafting of the defect may be required. The entire approach to management may have to be altered, however, if there is also a breakdown of the intraoral seal, creating a salivary fistula, or if there is exposure of the carotid artery system, a complication discussed below.

Fistula

Communication between the lining of the pharynx or oral cavity and the surface can take different forms, and develops at different stages in the postoperative course of the patient. At one extreme it may consist of a minor salivary leak, the result of a small wound dehiscence; at the other extreme there may be a wide communication between the mucosa and the surface, with the carotids lying exposed in the wall of the fistula, bathed in saliva.

While the occurrence of a fistula of any size is a serious complication, it is important to appreciate that its lethal potential in the short term depends on whether the carotids are exposed and, when they are exposed, whether or not they have been irradiated, and when. It is this aspect which dominates the initial management of the complication, the fear being that exposure will progress to rupture of the vessel wall.

At this stage the over-riding need is to be able to see the arterial segment at risk and monitor the appearance of the vessel wall. If the segment is covered by a necrotic flap, the slough must be carefully removed. If the vessel lies in the wall of the fistula, the wound must be laid open, eliminating any tenting of the skin flaps, so that the full length of the exposed segment can be seen. In either event the wound should be irrigated free of debris and any slough which may still be present, as well as being kept as clear as possible of salivary contamination, although this may be impossible to achieve completely. These steps apart, there is little at this stage that the surgeon can do, other than watch the situation and allow it to stabilize. The management of the exposed carotid and its monitoring are discussed below.

The temptation to proceed to a definitive flap reconstruction, before the situation has become stable along the lines described above, should generally be resisted as 'throwing good money after bad'. This is particularly so when there is salivary contamination. Flaps are tolerant of saliva flowing over them, but they are extremely intolerant of saliva flowing under them, responding to such treatment with suture line breakdown, flap detachment and necrosis.

A stable state can be considered to have been reached when the slough has been completely removed, previously detached skin flaps are beginning to adhere, and raw surfaces, blood vessels included, are developing a cover of granulation tissue. Once this degree of stability has been reached, an assessment becomes possible concerning whether spontaneous closure of the fistula is probable.

Apart from the fistula itself, there may be other unhealed areas which require skin cover. In most instances split-skin grafting is appropriate, and the exposed method is the one to use. Success is most likely with the patient supine, head and neck immobilized as far as possible, salivary contamination minimized by strategic placement of a suction catheter, and the graft, preferably a thin split-skin one, laid in position and left uncovered.

With the important proviso that previous radiotherapy markedly reduces the probability of spontaneous closure, it is generally true that the longer the fistulous track, and the narrower it is, the greater the probability of spontaneous closure, while the shorter and wider the track the less the probability. Allowing for that generalization, and assuming that nasogastric tube feeding is continued and the patient's general condition is maintained and preferably improved, it is remarkable how often, in the absence of previous radiotherapy, even the most apparently unpromising fistula does close spontaneously. This is particularly so if the fistula has resulted from wound breakdown rather than flap necrosis. The fact that the probability of spontaneous closure is greater with the fistula from an oral site than one from a pharyngeal site probably relates to the shortness and frequent width of the pharyngeal fistula compared with the oral fistula.

During the period of waiting and watching, it is important that there should be demonstrably continuing progress towards closure. As soon as it is apparent that progress has ceased, the situation must be assessed afresh. It may be that healing between skin and mucosa has occurred, in which case spontaneous closure of the fistula will not occur. It may also be that the fistulous track, initially a straightforward result of wound breakdown or necrosis, has become lined with residual growing tumour. This can occur in a most insidious manner, and 'granulations' in the track of a fistula, persisting for more than a few weeks, should be biopsied.

The management of a fistula which is considered to be permanent is discussed in the chapter on 'Repair of oral and pharyngocutaneous fistulae'.

Carotid artery exposure

The background to exposure of the carotid artery is wound breakdown in the neck, and the fear is that exposure may be the prelude to rupture of the vessel wall, so-called 'blow-out'. If 'blow-out' occurs, the potential for fatal haemorrhage is obvious; less so is the disastrous effect which ligation of the carotid, required to control the haemorrhage, may have on cerebral circulation and function.

Much of the writing on this subject relates to its occurrence as a complication of pharyngolaryngeal resection in conjunction with neck dissection, generally radical neck dissection. It can also follow similar surgery for tumours of the oral cavity, though the frequency with which it occurs in this site, and the problems which its occurrence creates, are considerably less.

Influence of previous radiotherapy

Given the exposure of a segment of the carotid arterial system, the probability of its progressing to 'blow-out' are related almost entirely to whether or not the vessel has previously been irradiated. In the absence of this adverse factor, it is general experience, as well as a personal one, that the artery, even bathed in saliva, will granulate without untoward incident. It is the previously irradiated vessel which is at real risk, and the risk has been found to be greatest when the radiation was given more than 6 months previously, that is where the radiotherapy and the surgery were uncoordinated.

Protection of the vessels

Awareness of the hazard of exposure has resulted in the devising of methods of avoiding exposure by protecting the vessels, so that, even in the face of extensive wound breakdown in the neck and fistula formation, they would remain covered and protected. The methods of value in current use consist of modifications in the skin incisions used in carrying out the neck dissections, and the use of muscle flaps as cover.

Skin incisions. The various skin incisions used in carrying out neck dissections, particularly radical neck dissections, and the part they may play in vessel protection, are discussed in the chapter on 'Radical neck dissection'.

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Muscle flap cover. Cover of the vessels by a muscle flap is provided in two distinct ways. The muscle flap may be raised and transferred for the specific purpose of providing cover; alternatively, the cover may consist of the muscle which is acting as the pedicle of the myocutaneous flap being used to reconstruct the post-excisional defect.

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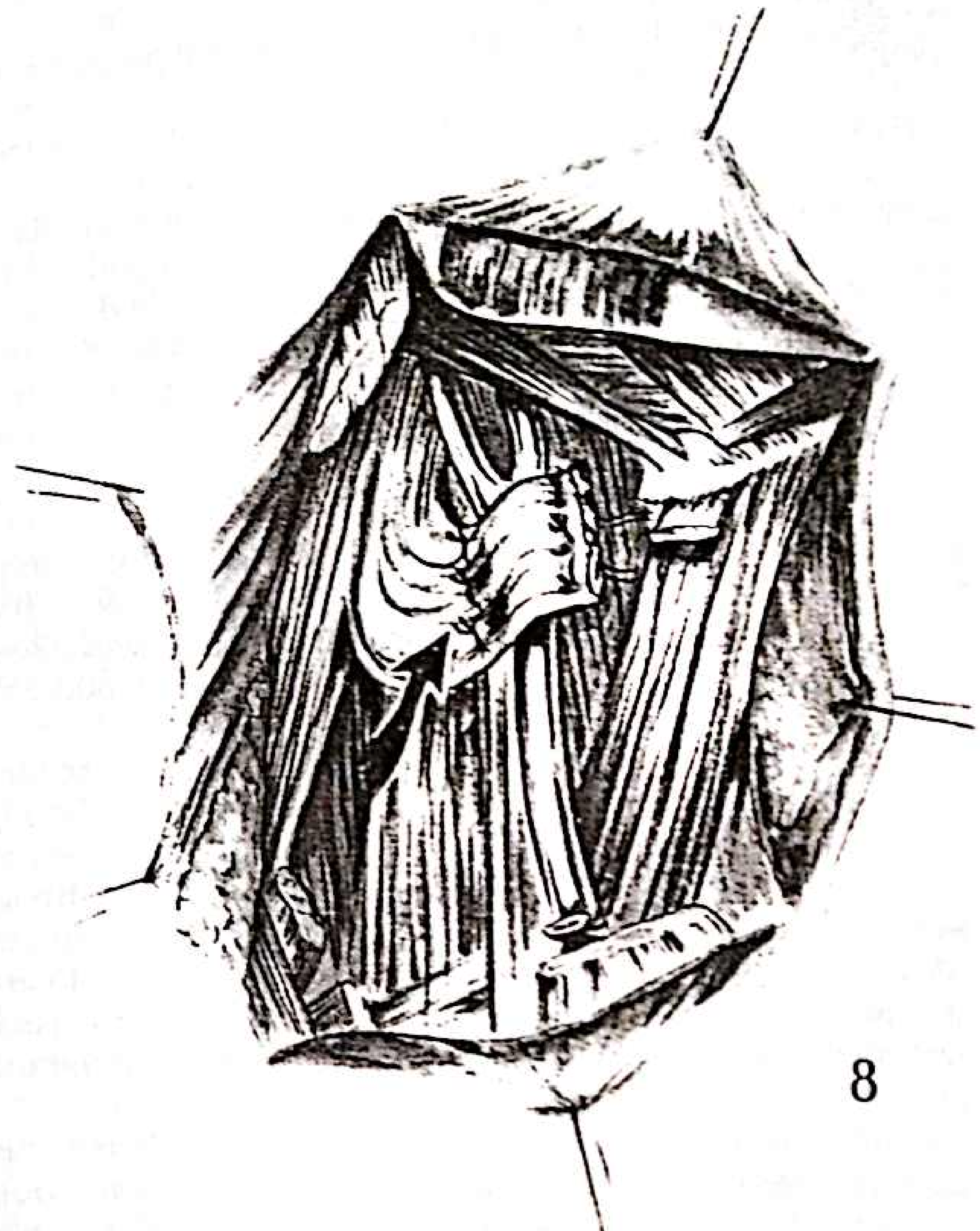
The muscle transferred specifically to provide cover has generally been levator scapulae, transected near its scapular insertion, mobilized, and swung upwards to cover the vessel segment considered to be at greatest risk.



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With the advent of the myocutaneous flaps, cover provided by such a transfer is much less often required. As part of the transfer of their skin islands, the three myocutaneous flaps most commonly used in reconstruction of the pharynx or oral cavity, pectoralis major, latissimus dorsi and lateral trapezius, all end up with their bridge muscle pedicles overlying much of the length of the carotid artery system at risk. When the surgeon is considering the indications for choosing one of these flaps in preference to an alternative technique such as a free flap, the presence of a previously irradiated neck may properly be regarded as a significant factor in favour of using a myocutaneous flap, because of this incidental protective capacity.

Monitoring the vessel state

Carotid exposure, as previously stressed, is an extremely serious complication, and one which requires to be closely monitored to assess whether progress is in the direction of 'blow-out', or towards coverage of the vessel wall by granulation tissue.

The favourable sign to be looked for in the development of granulations is a blurring of the pattern of vasa vasorum on the vessel wall, and their final disappearance with the build-up of granulation tissue.

Failure of these changes to occur in the appearance of the wall is worrying, and of even greater concern is the development of thrombosis of the vasa vasorum. The appearance of anything which could be construed as a slough of the vessel wall is evidence of impending rupture. Small premonitory bleeds are a recognized occurrence, and indicate virtually certain 'blow-out' in the very near future.

Carotid ligation

It is when the appearance of the exposed segment of the artery fails to show signs of cover by granulation tissue, and even more when there are signs of impending rupture, that a decision has to be made regarding whether the artery should be ligated electively rather than waiting until ligation is required as an emergency. It should be borne in mind that ligation carried out electively, as opposed to emergency ligation, doubles the likelihood of both survival and survival without neurological sequelae. That this should be so is not entirely unexpected, having regard to the circumstances attending an elective as opposed to an emergency ligation. When ligation is elective the patient should be normotensive; in an emergency ligation he is likely to be partly exsanguinated, hypotensive, and in greater danger of cerebral thrombosis. It is a difficult decision and one which calls for a nicety of judgement.

Radiotherapy and the head and neck surgeon

Margaret F. Spittle MSc, FRCR
Director, Meyerstein Institute of Clinical Oncology, Middlesex Hospital, London, UK

Introduction

There are few professional relationships so important for the patient as that between the head and neck surgeon and the radiotherapist. Good understanding of the nuances of head and neck surgery – what is possible and when – is vital for the radiotherapist. For the surgeon, some understanding of the technicalities of radiotherapy is essential. In this way the patient gets the best of both worlds. There is a long-standing tradition of joint clinics in the management of patients with head and neck cancers. On these occasions the surgeon, clinical oncologist, reconstructive surgeon, dentist, pathologist and radiologist are able to confer. The nurse, radiographer, speech therapist, oral hygienist, dietician and counsellor will frequently have much to contribute. The development of these joint clinics internationally provides a forum for research and teaching. Their administration and expense must not be allowed to overshadow their importance for patient and staff alike in the management of these rare and complicated malignancies.

Types of radiation

There are some technical aspects of radiotherapy with which the surgical oncologist should be familiar.

Orthovoltage and supervoltage radiotherapy

Orthovoltage radiation is radiation given with X-ray apparatus of 250 kV or less and this apparatus necessarily produces a poorly penetrating beam, but one on which much reliance had to be placed in the past before supervoltage was available. Besides the difference of penetration, there are technical differences between orthovoltage and supervoltage radiotherapy which will be important to the surgeon operating after treatment.

Orthovoltage irradiation gives the maximum dose on the surface of the skin. The traditional severe radiation reactions on the skin are always seen when radical dose orthovoltage irradiation is used. Supervoltage irradiation does not give the maximum dose on the surface of the skin. Due to forward scatter, there is build-up of dose under the surface of the skin which is greater with more energetic beams. A 5 MV linear accelerator gives the maximum dose 1 cm below the incident skin. When treating cancer of the head and neck area the skin, if at risk of involvement by the cancer, must occasionally be treated to the maximum dose. With supervoltage irradiation, a tissue-equivalent bolus is then used to bring the maximum dose back up on to the surface. When using orthovoltage radiation, the dose achieved is often limited by the skin reaction, and poor cosmetic late radiation changes are frequently seen in these circumstances.

An equally important difference between orthovoltage and supervoltage is that with orthovoltage treatment there is a predominance of radiation which is absorbed by the photoelectric effect, which means that a disproportionately high amount of the radiation dose is absorbed in tissues of high density. Bone in the radiation field treated by an orthovoltage beam will receive a relatively higher dose than if the treatment had been given with a supervoltage machine, and this may lead to osteonecrosis. Orthovoltage radiation is almost never used in the head and neck region now and has been superseded by supervoltage irradiation.

Linear accelerator or radioactive cobalt treatment

A long-distance radioactive cobalt machine is a useful addition to a radiotherapist's armamentarium. It produces a beam of supervoltage quality which is sparing of skin and is also absorbed with less dependence on the atomic number of the tissue than an orthovoltage beam, and therefore is relatively sparing of bone. However, the cobalt source is of necessity a finite size and therefore the beam which is produced has a penumbra which is larger than that seen from the point source of a linear accelerator. This leads to a less defined edge to the beam. In the head and neck area, when treating near to such critical sites as the spinal cord and the eye, the sharper edge of the beam from the linear accelerator may be more appropriate. There is no difference between the quality of these beams as far as tumour damage is concerned.

Interstitial irradiation

The inverse square law states that the dose of radiation varies inversely with the square of the distance of the tissue from the source of radiation. It is clear that isodose curves are packed very closely around the source of radiation, but become much wider when at a distance. It therefore follows that when treatment is given by an external source of X-rays placed at approximately 80–100 cm from the skin, a large proportion of the head and neck volume will be treated to the same dose, as it lies within the same isodose. This is useful when treating large tumour volumes, but when the cancer is small, it means that many uninvolved structures will be irradiated if the tumour is treated from an external beam source. Therefore, for small tumours or small areas of residual disease, as in nasopharyngeal carcinoma, there is an advantage in placing the source of irradiation within the tumour and this treatment is called interstitial irradiation or brachytherapy. An early carcinoma of the lateral border of the tongue can be treated by an interstitial implant, and the rapid fall-off of isodoses surrounding the radioactive iridium or caesium sources can give a tumoricidal dose to the cancer, while leaving the contralateral side of the mouth and both parotid glands well below the dose that would lead to permanent damage. To leave functioning parotid glands is a great bonus for a patient with an oral malignancy and is difficult to achieve when treating large volumes of the mouth with external beam radiotherapy.

Interstitial radiation is, however, limited in the volume of tumour that can be irradiated effectively before the implant becomes bulky and obstructive, or areas of inhomogeneity of dose are seen. A major disadvantage of interstitial irradiation is the exposure of patients, relatives and staff that may occur when the isotope is *in situ*, and the consequent limiting of visitors because of the necessary isolation of the patient. Sophisticated afterloading devices are now available where radiation can be given at either a low or high dose rate. If low dose rate is chosen, the isotopes can be intermittently mechanically withdrawn from the patient and put in a protected area. Radium needles are no longer used because of the excessive protection required, but radioactive caesium needles and iridium wire can be used, the latter being more flexible[1].

Electrons

Electrons are produced by a linear accelerator and are high energy particles. The energy of an electron beam can be varied, and with it the depth of penetration. The depth–dose characteristics show a rapid dose fall-off at a depth which depends on the energy of the beam. The beam can therefore be tailored to stop short of critical structures such as the spinal cord, and is often used as a topping-up treatment. This is used when the maximum safe dose to the spinal cord has been achieved by X-rays from a linear accelerator and there is a need to continue to treat the neck overlying the spinal cord to a higher dose. The tolerance of the spinal cord is usually regarded as being approximately 4000 cGy in 4 weeks, and at this dose an electron beam is often employed to increase the dose to the nodes in the neck while sparing the spinal cord.

Apart from its depth–dose characteristics, an electron beam can also produce a superficial beam which, although similar in depth characteristics to an orthovoltage beam, does not have the high dependence of orthovoltage on the density of the material in its path. It is particularly useful for treating areas adjacent to superficial cartilage, such as the nose and ear. Although cartilage is not as dense as bone, it has no blood supply and is thus more vulnerable. There is a little skin sparing associated with an electron beam, but this is very small at low energies and thus the skin reaction must be considered.

The oxygen effect

It has been known for many years that anoxic cells respond much less well to radiation than well oxygenated cells, by a factor of approximately three[2]. It is clear that most tumours contain considerable areas of anoxia, therefore much radiation technology has been directed towards rendering the anoxic areas better oxygenated, or to find some way of circumventing the radio-resistance of poorly oxygenated tumours. The concept of treating the patient in hyperbaric oxygen was a clear attempt to increase the partial pressure of oxygen within the tumour by placing the patient in 3 atm of oxygen before and during the radiotherapy. The therapeutic ratio between the well oxygenated normal cells and the anoxic tumour centre would be increased. There was some encouragement for this technique with results of treatment of cancers of the head and neck area. However, the apparatus is cumbersome and potentially dangerous, and the treatment techniques for irradiating cancers of the head and neck are complicated and therefore difficult to deliver in a hyperbaric oxygen tank. This modality is now rarely used.

Neutron treatment

Neutrons produce a beam of high linear energy transfer radiation, which has greater relative biological effectiveness than a supervoltage X-ray beam. The characteristics of neutrons were thought to be useful for treatment, as the beam is not as dependent on oxygen as a supervoltage beam in mediating damage. As the oxygen enhancement ratio is less, neutron treatment is therefore another way of circumventing the oxygen effect. Considerable radiobiological and clinical research has gone into neutron treatment, both recently and in the distant past, and it is clear that the late effects of radiation with neutrons are different from those produced by radiation by a supervoltage X-ray beam. Although the effectiveness of neutrons is not in doubt, the late tissue tolerance seems poor and the complication rate high[3]. The combination of neutron therapy and subsequent surgery has proved disastrous and salvage surgery has been followed by major complications. It is necessary to resect and replace all neutron-irradiated areas. It may be that the equivalent dose of radiation has not been achieved or that the fractionation technique has not exploited the advantages of neutrons. Certainly the results of treatment of salivary tumours with the neutron beam seem advantageous[4, 5].

Treatment of head and neck malignancy is technically sophisticated because of the many critical sites in the head and neck which must be avoided by the irradiation plan. The limited mechanical flexibility and penetration of available neutron beams may prejudice the results. It may be that treatment by mixed beams will be appropriate.

Hyperfractionation and accelerated fractionation

Traditional radiotherapy treatment is fractionated daily to reduce the size of the tumour during and after the course of the treatment. This may help to overcome the reduced radiosensitivity caused by tumour anoxia by allowing reoxygenation during the course of treatment of parts of the tumour which were initially relatively anoxic. It can therefore be considered that the experience of radiotherapists in evolving a fractionated course of treatment has gone some way to overcoming the oxygen effect. Traditionally radiation has been given daily, with an attempt to allow for recovery of the normal tissue from the radiation damage in the interval between treatments. There is evidence that normal tissue will repair radiation damage quicker than malignant cells, therefore the radiation is given so that enough time is left between fractions of radiation for the therapeutic ratio between the effect of the radiation on the normal cells and that on the malignant cells to be optimized. Repopulation of the tumour will occur if too long is left between small radiation fractions.

Hyperfractionation involves the use of smaller-than-standard doses per fraction. It is usual to give two fractions/day for 5 days/week. Accelerated fractionation involves a shortening of the overall treatment duration and is particularly useful in sparing late-reacting tissues such as the normal tissues and allowing the impact of tumour proliferation during treatment to be minimized. Trials of accelerated and hyperfractionated treatment in head and neck cancers show promising increased local control with minimized normal tissue reaction[6, 7]. Since radiation treatment in the head and neck area has very little margin of security between that dose which will kill the tumour and that dose which will do irreversible harm to normal tissues, the radiotherapist is always at normal tissue tolerance. There is evidence for a dose response curve for epithelial tumours of the head and neck[8]. The author's practice when treating squamous carcinoma of the head and neck is to give doses of 6000–6600 cGy over 6–7 weeks, by shrinking fields if necessary. The surgeon must be aware that radically irradiated tissue in the head and neck area will have received the full impact of irradiation and may heal poorly due to vascular damage, and it is therefore important that the operating surgeon be experienced in this field.

Chemotherapy

Although it is clear that aggressive chemotherapy can certainly affect tumours of the head and neck when used alone and in combination with radiation, it has been very difficult to show the impact of chemotherapy on survival in controlled trials[9, 10]. However, meta-analyses and recent trials continue to hint at the probability of improved tumour control, and possibly survival in some circumstances, with the use of chemotherapy in conjunction with irradiation[11]. The chemotherapeutic agents used in treating head and neck cancer are frequently toxic, which may make it difficult to achieve the full dose of radiotherapy and therefore may prejudice radical treatment. There are some sites, such as carcinoma of the nasopharynx, which seem to be particularly sensitive to chemotherapy treatment[12, 13].

In most Western countries head and neck malignancies are fortunately not numerous and since it is important to define the place of chemotherapy in the management of head and neck tumours, it is vital that the available patients should, if they agree, be put into trials which are attempting to answer this question. Recent work suggests that chemoresponsive tumours may be radiocurable. Response to chemotherapy may indicate those patients who can be successfully treated with less aggressive surgery with organ preservation. This offers new possibilities for choosing treatment options. In a recent trial[14], 332 patients with advanced laryngeal carcinoma were randomized, either to have a laryngectomy and postoperative radiotherapy or to have induction chemotherapy with three cycles of cisplatin and 5-fluorouracil. If tumour response was seen, the patient received radical irradiation after the chemotherapy; if no response was seen, the patient proceeded to surgery. Early results showed no difference in survival, but there was a possibility of organ preservation in 60 per cent of the cases so treated[14]. The substitution of chemotherapy for surgery is a change in the traditional approach of either immediate surgery or radical radiotherapy and salvage surgery in advanced laryngeal disease.

Combined treatment

When combining radiotherapy and surgery, the sequencing of treatment has given rise to much debate and prejudice. The theoretical advantages of preoperative radiotherapy are an intact blood supply and undisturbed tissue planes and lymphatic drainage; also the clinical extent of disease is more obvious and the irradiated skin will be removed at operation. There is also less delay in irradiating the contralateral neck if this is indicated. Smaller fields can also be sometimes used and graft sites are not irradiated. On the other hand, with postoperative radiotherapy the radiotherapist has a knowledge of the extent of the tumour and disease margins. The operative morbidity is less and there is no chance that surgery, which may be the most important part of the combination, will be refused.

The Radiation Therapy Oncology Group has attempted to evaluate these options in 277 patients with tumours of the oral cavity, oropharynx, supraglottic larynx and hypopharynx[15]. Preoperative treatment consisted of 5000 cGy of radiation followed by definitive surgery 6–8 weeks later. The postoperative group received 6000 cGy starting 2–4 weeks after surgery. In all, 74 per cent of postoperative patients and 56 per cent of preoperative patients completed the protocol. The postoperative group had a significant improvement in local or regional control rate ($P = 0.4$). Of those who completed the protocol, 50 per cent of those given preoperative radiotherapy and 74 per cent of those given postoperative radiotherapy had local control at 4 years. There was a difference in survival of 33 per cent in the preoperative group and 38 per cent in the postoperative group ($P = 0.10$). Complications for the combined treatment were similar for the two options.

Prevention of head and neck cancer

In spite of continuing research and experience in the management of advanced head and neck tumours, the outlook for patients with such disease is still very poor. In a sophisticated Western world setting, prevention becomes increasingly important. Clearly tobacco smoking is an overwhelming factor in the aetiology of head and neck cancers, with concomitant high intake of alcohol being a lesser, but also important, factor. A few patients have been occupationally exposed to other carcinogens and this is clearly preventable once the culprit has been identified. Most tumours of the head and neck are squamous cell carcinomas and an attempt has been made to find an agent which will normalize the squamous epithelium in patients with head and neck malignancies. A remarkable improvement in leukoplakia can be seen by giving retinoic acid and β-carotene[16]. If the side-effects can be tolerated and these drugs given early to patients at risk of head and neck cancer, it may be that some are preventable. Head and neck cancer patients who survive have a 25 per cent incidence of second primaries because of smoking and an unstable epithelium. Early trials in the use of adjuvant retinoids suggest that the incidence of a second primary can be significantly reduced[17]. Whether the large studies of cancer prophylaxis now in progress will make an important impact on prevention is as yet unknown, but it is an exciting prospect.

Thus, with improvements in anaesthetics, microvascular and other surgical techniques, and using modern radiotherapy with fractionated treatment, the full armamentarium of local treatments can be pitted against head and neck cancer. However, because of the inherently aggressive nature of many tumours and host factors which are not completely quantified, some patients will fail, either locally or with distant metastases or new primaries. Until what governs these failures has been appreciated, the surgeon and radiotherapist should try to optimize the treatment for each patient, so that if cure is possible it can be achieved with minimal morbidity. This will be more readily achieved if radiotherapists and surgeons are aware of each others' strengths and weaknesses.

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Illustrations by Gillian Lee

Emergency and elective airway procedures: tracheostomy, cricothyroidotomy and their variants

David J. Howard FRCS, FRCS(Ed)
Institute of Laryngology and Otology, Royal National Throat, Nose and Ear Hospital, London, UK

Introduction

This chapter deals with the establishment and maintenance of an artificial airway. Formal elective tracheostomy is the operation against which all other measures must be compared. The various techniques described here each have relative merits and the choice between them will depend on the needs of the patient and the experience of the surgeon. Airway procedures require close cooperation between the anaesthetist, surgeon and nursing staff, and the possibility of complications is much reduced if everyone has an understanding of the anatomical and physiological factors involved in the management of an artificial airway.

Physiological factors

All forms of tracheostomy and cricothyroidotomy bypass the upper airway. This has the following advantages: (*1*) the anatomical dead space is reduced by approximately 50 per cent; (*2*) the work of breathing is reduced; (*3*) alveolar ventilation is increased; (*4*) the level of sedation needed for patient comfort is decreased and, unlike endotracheal intubation, the patient may be able to talk and eat with a tube in place.

However, there are several disadvantages: (*1*) loss of heat and moisture exchange performed in the upper respiratory tract; (*2*) desiccation of tracheal epithelium, loss of ciliated cells and metaplasia to squamous epithelium; (*3*) the presence of a foreign body in the trachea stimulates mucus production. Where no cilia are present this mucociliary stream is arrested; (*4*) the increased mucus is more viscid and thick crusts may form. Both these components may be sufficient to block a tube, particularly those of small calibre used for children; (*5*) while many patients with a tracheostomy are able to feed satisfactorily, there is some splinting of the larynx which may prevent normal elevation during deglutition and this, combined with loss of a positive intralaryngeal pressure on expiration, may lead to aspiration.

TRACHEOSTOMY

This operation has been undertaken since at least the first century BC but before the beginning of the twentieth century its only indication was upper airway obstruction. Nowadays there are multiple indications, but whatever the main reason for the operation it is best performed as an elective procedure under endotracheal anaesthesia in a properly equipped operating theatre. The only exceptions to this, in the author's experience, relate to seriously ill patients on modern intensive care units. If the full facilities to undertake a tracheostomy are available on this type of unit, it may be more satisfactory and less risky to undertake the operation there, rather than move the patient to the operating theatre.

Principles and justification

Indications

An exhaustive list of indications is neither possible nor relevant but in summary there are three main groups:

1. Mechanical obstruction:
   (a) Congenital anomalies, e.g. subglottic stenosis.
   (b) Infection/inflammation causing damage to the mucous membrane of the oral cavity, pharynx, larynx and trachea.
   (c) Trauma, either maxillofacial or direct to the larynx and trachea.
   (d) Inhaled foreign bodies.
   (e) Obstructive tumours involving the tongue, pharynx, larynx, trachea and oesophagus and adjacent associated structures from the base of skull to thoracic inlet.
   (f) Bilateral paralysis and/or fixation of the vocal cords.
2. Retained secretions in the lower respiratory tract. These may occur in a wide variety of diseases such as chronic pulmonary disease, bronchopneumonia, coma from a wide variety of sources, and damage to the thoracic cage and respiratory musculature.
3. As as additional procedure accompanying major head and neck surgery. This is of particular interest to the head and neck surgeon and will be enlarged upon. While absolute indications cannot be given as each patient must be taken on his or her merit, the author suggests the following guidelines.

Operations involving the oral cavity and pharynx

The highly coordinated sequence of events between breathing and swallowing may be significantly disturbed by resection of intraoral tumours. The functional bony attachments of the tongue are largely to the genial tubercles of the mandible in the region of the symphysis. With hemiglossectomy there is complete loss of this attachment on one side and tracheostomy is strongly recommended. With glossectomy it is an absolute indication.

With resection of muscle elsewhere in the tongue the likelihood of tracheostomy depends on the volume resected: resection of the posterior third is of great importance and more likely to require tracheostomy. Isolated resection of the floor of the mouth, even with resection of large areas of mucosa, does not usually require tracheostomy; a nasopharyngeal tube may be used for a period of 24 h. Resection of the faucial region may require tracheostomy, and when it extends posteriorly to involve the lateral and posterior walls of the pharynx, this is a further absolute indication.

With the mandible, resection of the symphysis mentis is an absolute indication for tracheostomy. Partial excision of other components of the mandible may not necessitate tracheostomy unless there is an additional notable component of soft tissue resection.

Maxillary and base of skull procedures

The author does not routinely undertake tracheostomy in patients having partial or total maxillectomy or more major craniofacial procedures. However, the cavities are packed with Whitehead's varnish soaked 2-in gauze and a fully fashioned expertly fitted prosthesis is placed at the end of the procedure. If these measures are not available or there are other circumstances which increase the risk of severe haemorrhage into the airway, then a temporary tracheostomy is indicated.

Laryngotracheal procedures

Most forms of partial laryngeal and upper tracheal surgery, whether for stenosis or for removal of tumours, require a covering tracheostomy, which may need to be placed lower than the classical site outlined below.

Resection of neck structures

Resection of parapharyngeal space tumours may cause vagal nerve palsy, thereby necessitating tracheostomy. Occasionally oedema, haematoma formation or other local factors following thyroid surgery or radical neck dissection may necessitate tracheostomy.

Choice of operation

The degree of urgency in establishing a tracheostomy will determine the method used, but preference should always be for the elective procedure. One of the most appropriate pieces of advice in surgery is 'the time to do a tracheostomy is when you first think about it'.

All of the potential complications of tracheostomy are markedly decreased if a meticulous elective procedure is performed under controlled circumstances by an experienced team. This situation, combined with high quality postoperative nursing care, should reduce the morbidity of the procedure to almost zero. While endotracheal intubation is the procedure of choice to gain control of the airway in most instances, elective tracheostomy has major advantages: the likelihood of laryngeal injury is diminished; the patient is more comfortable and subsequently able to mobilize, talk and eat with the tube in place. In patients with long-term airway problems the length of time to wait after endotracheal intubation before performing tracheostomy is debatable, but with modern high-volume low-pressure cuffed endotracheal tubes many clinicians will wait for up to 3 weeks. This is the absolute upper limit based on the incidence of laryngotracheal stenosis seen with longer periods. If prolonged intubation is expected an earlier tracheostomy at around 10 days is preferable to converting at 3 weeks.

Preoperative

In most cases, with anticipation, emergency tracheostomy can be avoided. If time allows the following should be undertaken: (*1*) inspection and palpation of the neck to assess the laryngotracheal anatomy in the individual patient; (*2*) indirect and/or direct laryngoscopy; (*3*) anterior and posterior tomography of the larynx and upper trachea; (*4*) assessment of pulmonary function.

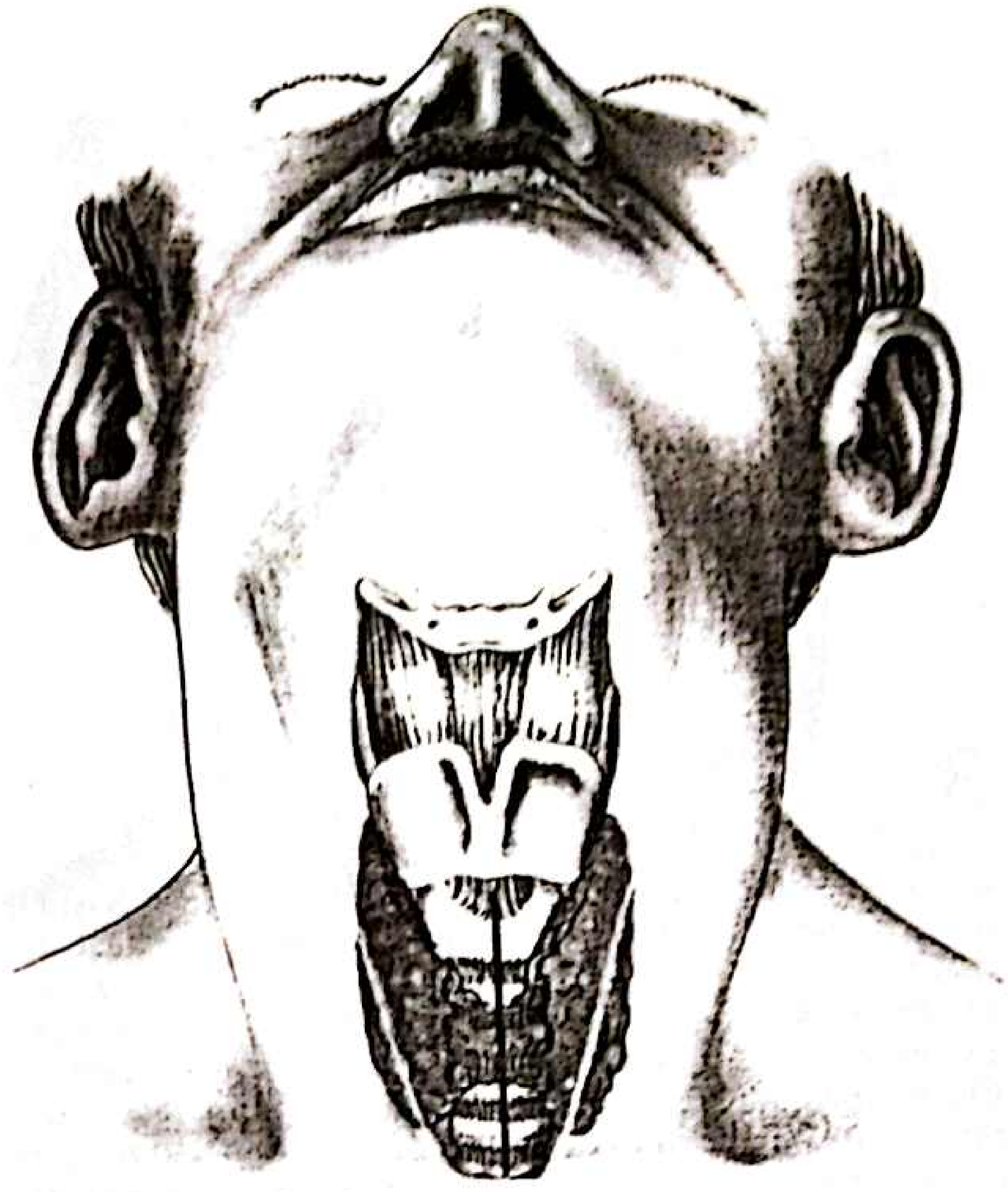
Whenever possible the procedure should be adequately explained to the patient beforehand, with particular emphasis on the inability to speak immediately following the operation and possible difficulties with swallowing. It is extremely disconcerting for a patient to wake from anaesthesia with a tracheostomy if the procedure has not been explained beforehand.

Operations

EMERGENCY TRACHEOSTOMY

If the patient requires immediate establishment of an airway and endotracheal intubation, insertion of a bronchoscope or laryngotomy are not possible, there are no absolute contraindications. The only word of warning would be in those patients who have suffered severe head and neck trauma and may have an unstable cervical spine fracture – cricothyroidotomy may be a more suitable procedure under these circumstances.

If it is possible, the patient should be laid supine with padding placed under the shoulders and the head kept as steady as possible in the midline. This aids palpation of the thyroid and cricoid cartilage between the thumb and index finger of the free hand. The movements of the fingers of the free hand are very important in this technique. The operation is more difficult in small children and thick-necked adults as the landmarks are more difficult to palpate.



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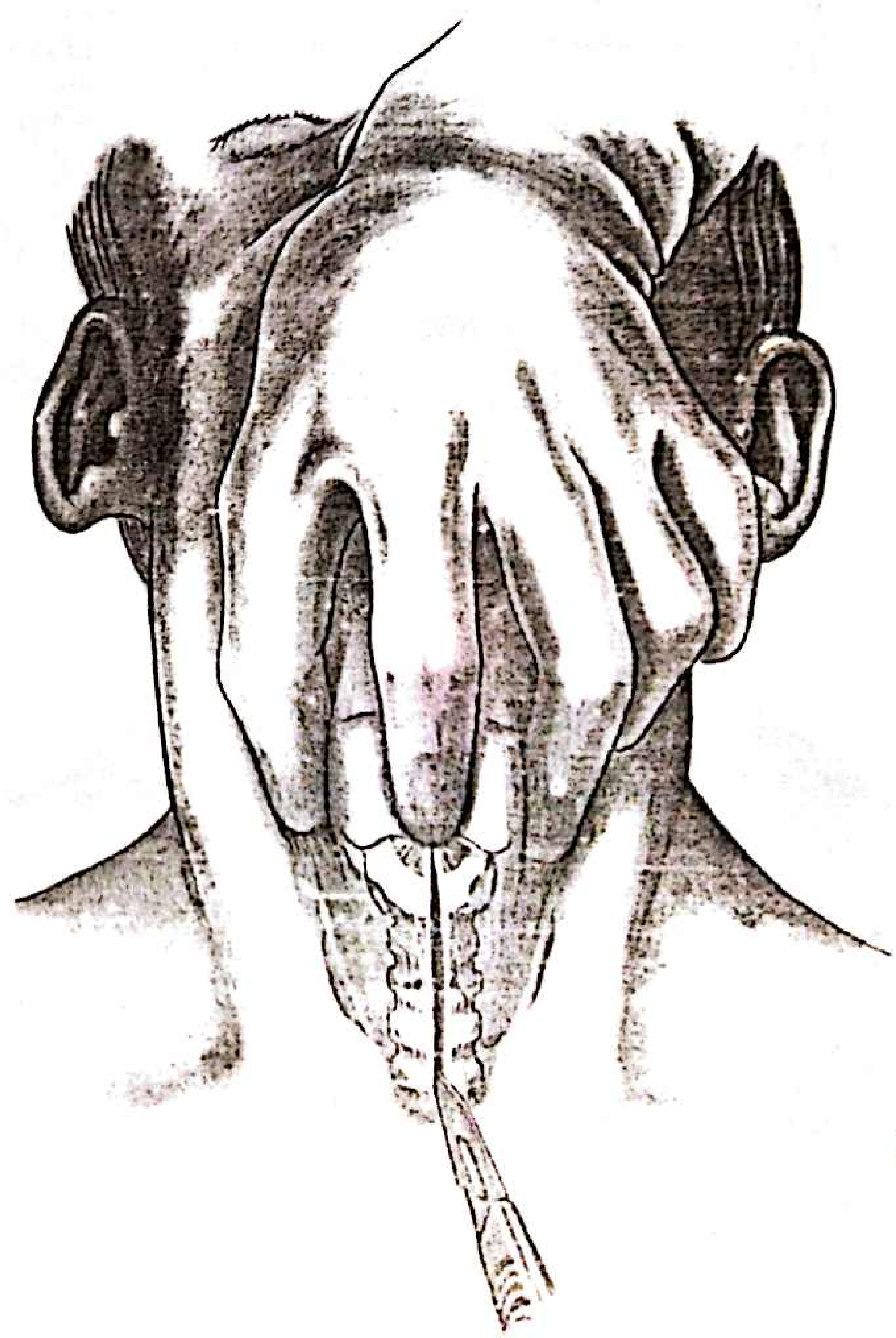
A vertical midline incision is made from the inferior aspect of the thyroid cartilage to the suprasternal notch and continued down through the infrahyoid muscles. There may be heavy bleeding from the wound at this point, particularly if the neck is congested as a result of the patient's efforts to ventilate around an acute upper airway obstruction. No steps should be taken to control this haemorrhage, although an assistant and suction apparatus are valuable if available.



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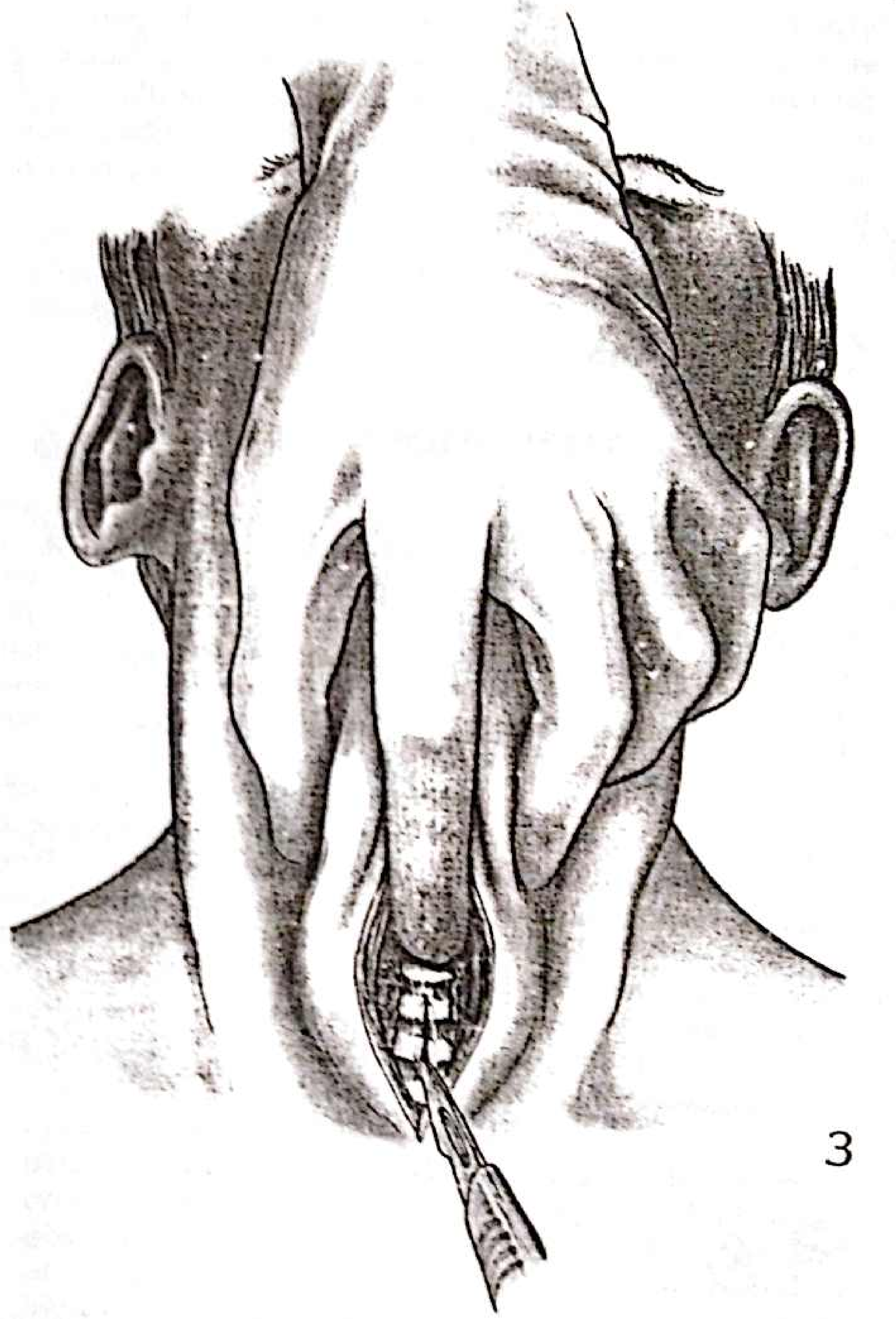
The operator should feel carefully without undue haste for the cricoid cartilage using the index finger of the free hand, while retracting the skin edges by pressure applied by the thumb and middle finger. If the situation is one of extreme urgency, a further vertical incision straight into the trachea at the level of the second, third and fourth rings should be made immediately, without regard to the presence of the thyroid isthmus. The knife blade is rotated through 90°, thus opening the trachea. At this point the patient may cough violently through the blood; the operator should be aware of this possibility to avoid losing the position of the scalpel in the open trachea. Any form of available tube should be inserted into the trachea as soon as possible and blood and secretions sucked out. If no relevant equipment is available, oral suction of the inserted tube and mouth-to-trachea respiration may be necessary.

Once an airway has been established haemostasis is secured. With the emergency under control the tracheostomy should be refashioned as soon as possible.



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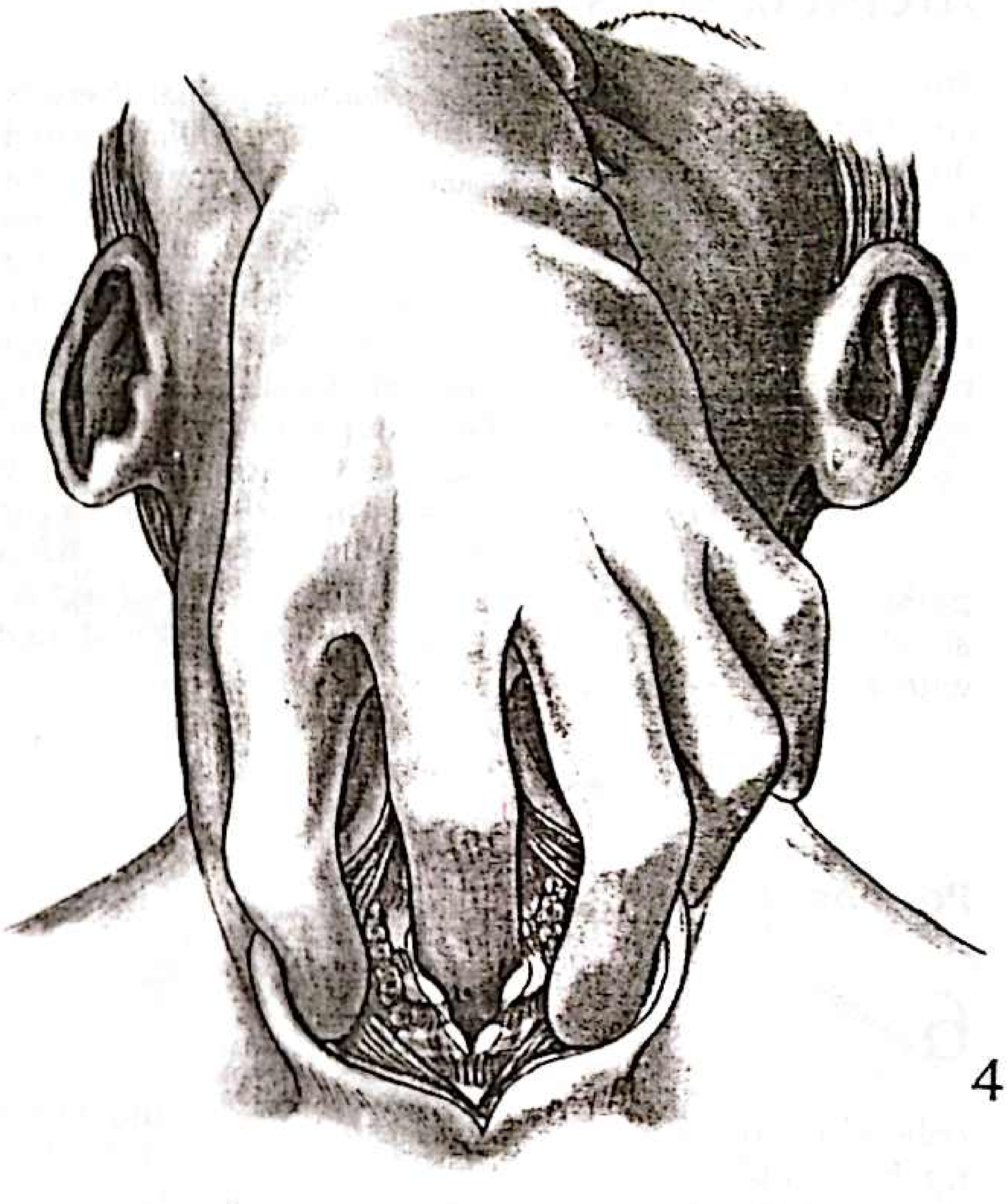
Should additional equipment and a little more time be available during this procedure, once the cricoid cartilage has been identified, blunt finger dissection inferiorly can be used to mobilize the thyroid isthmus down, clearing the trachea before making a vertical incision through the second to fourth rings. The tip of the index finger or an appropriate dilator improves the opening, and a cuffed tracheal tube should be inserted.



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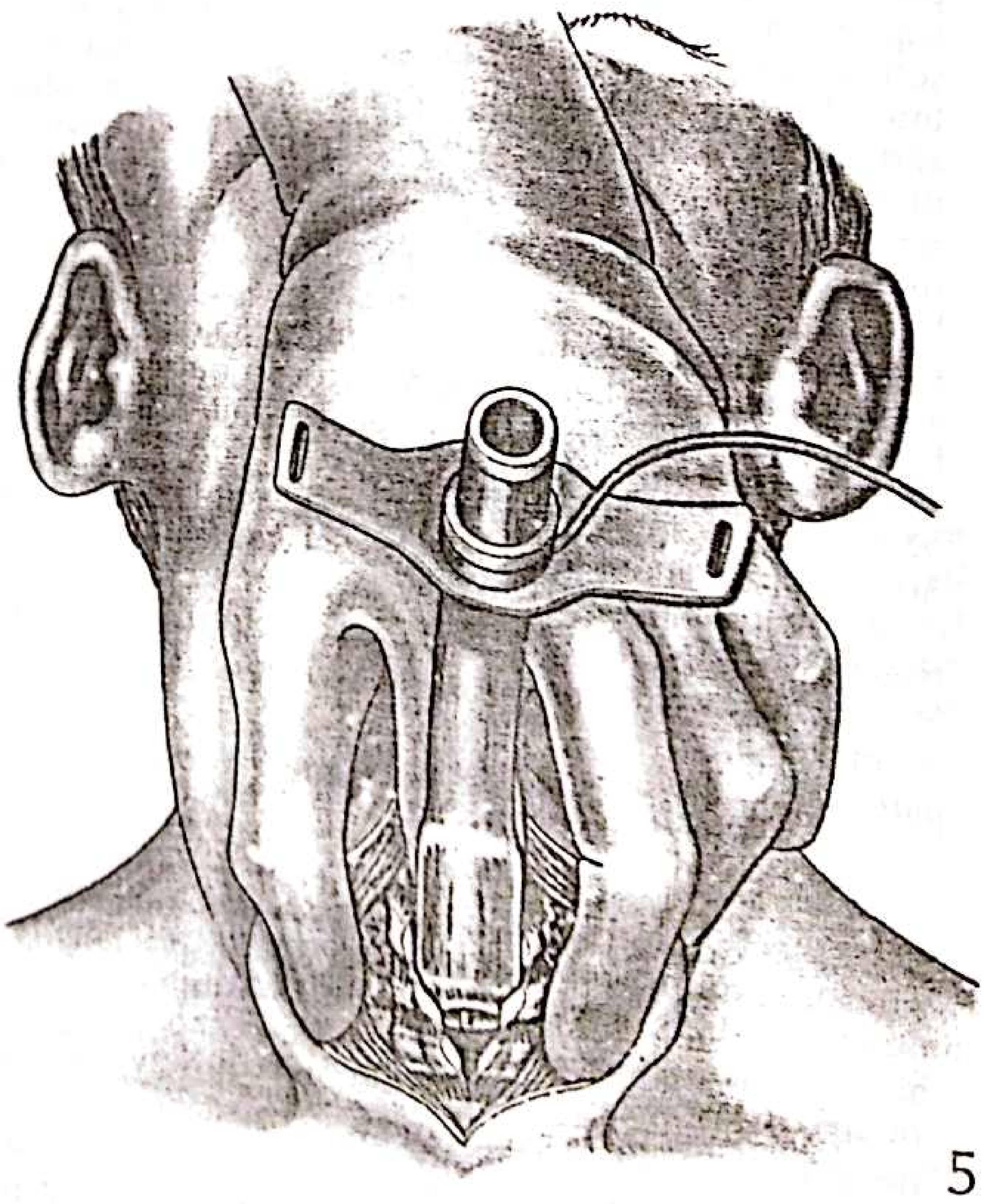
TRACHEOSTOMY UNDER LOCAL ANAESTHESIA

Some patients do not require emergency tracheostomy, but it would be unwise to commence general anaesthesia and attempt intubation for fear of precipitating an emergency airway problem. This situation most commonly occurs in those patients who have large pharyngeal and laryngeal tumours requiring surgery on a highly critical airway, but may occur acutely with an inhaled foreign body.

The respiration of these patients may be markedly improved by the temporary administration of a helium–oxygen mixture, which has an improved flow rate through narrowed airways compared with that of normal air and increases the alveolar Po_2. It can be administered while the patient is being transferred to the operating theatre and optimum conditions for the tracheostomy are established.

These patients in particular need reassurance and explanation as to what is happening. All theatre staff should behave in a calm and organized manner. Patients with severe dyspnoea may not be able to lie flat and the optimum position with a sandbag under the shoulders and extension of the neck may be impossible; a compromise position may have to be found, and infiltration of the neck with local anaesthetic may be more satisfactorily completed while the patient is still upright. Local anaesthesia is obtained by injection of the skin and subcutaneous tissues with 20 ml 1 per cent lignocaine.

Once local anaesthesia is established, the operation is completed in the manner outlined below. Explanation and reassurance should be continually given to the patient, in particular just before incision of the trachea. A further 1–2 ml local anaesthetic may be injected into the tracheal mucosa before incision. The scrub nurse and anaesthetist must be in a position to connect the inserted tracheal tube immediately in order to administer general anaesthesia once entry to the trachea is gained. This will allow further surgery either to remove a foreign body or assess, debulk, or remove the obstructive tumour.



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ELECTIVE TRACHEOSTOMY

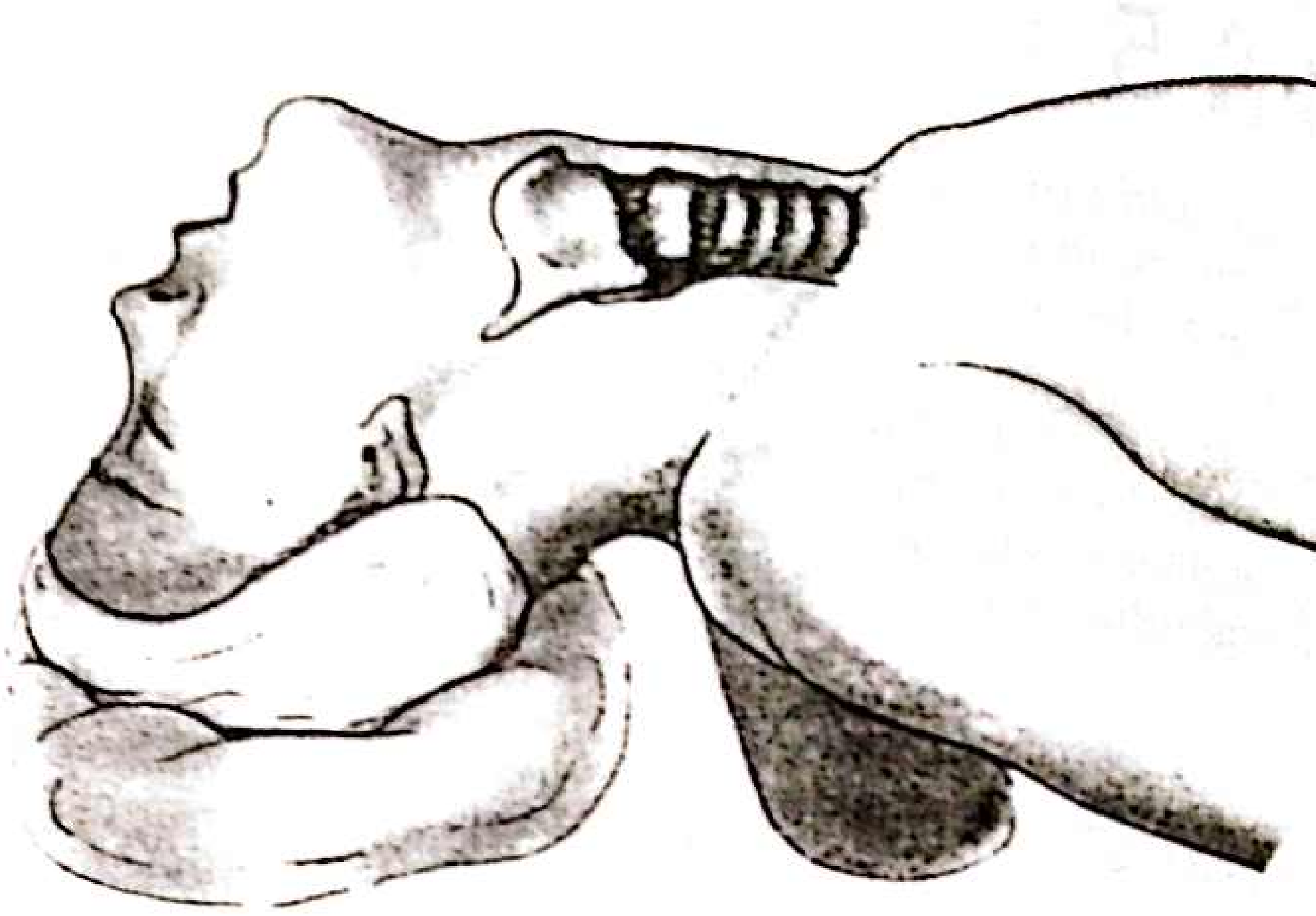
The advantage of the elective procedure is that there is complete airway control at all times and an unhurried dissection and careful placement of an appropriate tube can be carried out. Close cooperation between the surgeon, anaesthetist and scrub nurse is essential, but attention to the details outlined below will markedly reduce possible complications and morbidity from this procedure. Much has been written about tracheostomy, particulary the operative details, and much of it has been biased. There are surprisingly few good prospective studies on the long-term effects of the procedure and its complications. The following measures are based on a personal experience of tracheostomy in general surgery, accident surgery and head and neck surgery, combined with a wide-ranging review of the literature.

Position of the patient

6

Following induction of general anaesthesia and endotracheal intubation the surgeon performing the operation should inspect and palpate the patient's neck with particular reference to the thyroid and cricoid cartilage, suprasternal notch and the distribution and thickness of soft tissues of the neck. There may be marked variation in these landmarks between slim patients with long necks and obese patients with short necks. With a combination of head extension and placement of an appropriate sandbag under the patient's shoulders, a position of reasonable neck extension can be obtained. There should be no rotation of the head. A moderate amount of neck extension helps to keep the chin up and out of the way and to display the cricoid cartilage and anterior trachea. However, if extension is excessive, undue length of trachea may be present in the neck which may produce obstruction or an inadvertently low-placed tracheostomy. An opening made in the fifth or sixth rings may be quite easily undertaken with over-extension but this may then come to lie low in the neck, even behind the manubrium, and make postoperative management of the patient in a normal position difficult. This point is important in young patients, whose neck can be easily overextended.

The most difficult circumstances are a combination of an obese patient with a short neck and displacement of the trachea from the midline by gross pathology. Under these circumstances entry into the airway via the cricothyroid membrane may, in the first instance, be safer. The landmarks are less easily palpable in infants; the larynx lies higher in the neck and the trachea is softer, smaller and relatively deep beneath the skin. If the pathology allows, the inexperienced surgeon may find the insertion of a bronchoscope into the trachea a great help when performing tracheostomy in young children.



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Incision

The debate between the vertical and transverse incision is artificial and unnecessary. In a busy surgical practice both are required under differing circumstances. The oft-quoted statement that the transverse incision heals more satisfactorily and gives an overall better cosmetic result is unsubstantiated; scarring after tracheostomy is more related to the presence of the tracheostomy tube and other general factors related to healing and scar formation in any individual patient. A good cosmetic result often requires re-excision and suturing of a previously healed tracheostomy area, and a more satisfactory result from this revision procedure may be obtained with a transverse scar. The author uses a transverse scar more often in teenagers and young adults, particularly women. However, setting these considerations aside, the most important factor when considering the incision is the access and subsequent management of the tracheostomy.

Vertical incision

This is advocated for all emergency situations, for inexperienced operators, whenever a major additional neck procedure has been undertaken (such as radical neck dissection) and it is preferable that the area of neck dissection and tracheostomy wound do not communicate, or in the difficult neck where anatomical landmarks are not easily palpated.

Transverse incision

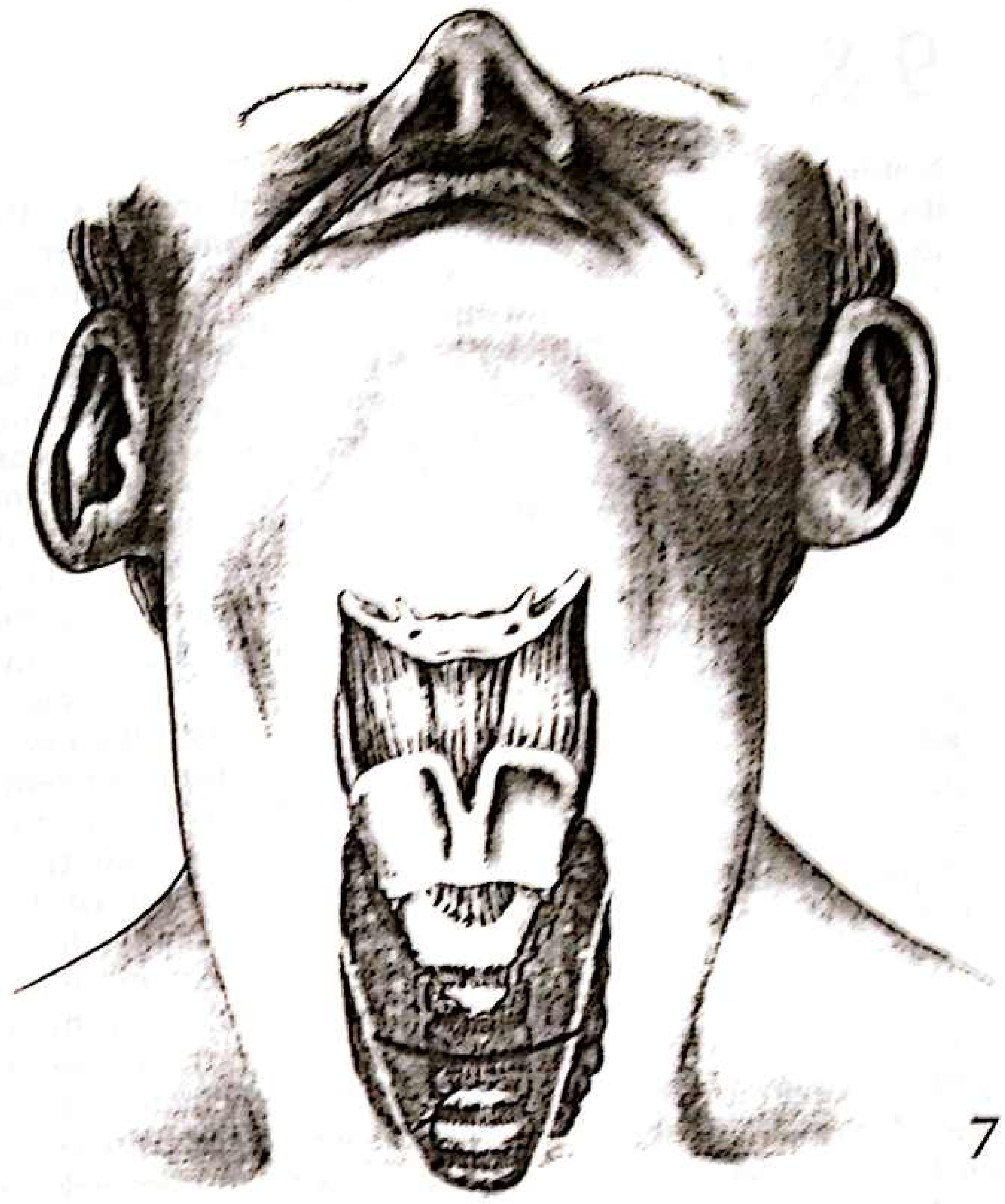
In partial laryngeal surgery when the component of the larynx has been removed through an upper transverse neck incision, a smaller separate transverse incision below for the tracheostomy will prevent communication between the two areas. In all other circumstances where the tracheostomy is expected to be a straightforward procedure and the operator is experienced, the transverse incision is advocated.

7

A transverse incision, approximately 6 cm in length in the adult, is made midway between the cricoid cartilage and suprasternal notch. It is deepened through skin, subcutaneous fat and the cervical fascia. The anterior jugular veins should be exposed laterally and clipped and ligated; it is insufficient in the author's opinion to use diathermy on them. The infrahyoid muscles are thus exposed.

If a vertical incision is used it is carried out in the midline, from the centre of the thyroid cartilage to the suprasternal notch (see *Illustration 1*). The subcutaneous fatty tissue and cervical fascia are divided until the linea alba is visible. Bleeding with the midline incision is less and the anterior jugular veins are usually not encountered.

The operative details are now common to both incisions and the illustrations depict the remainder of the operation through a vertical incision.



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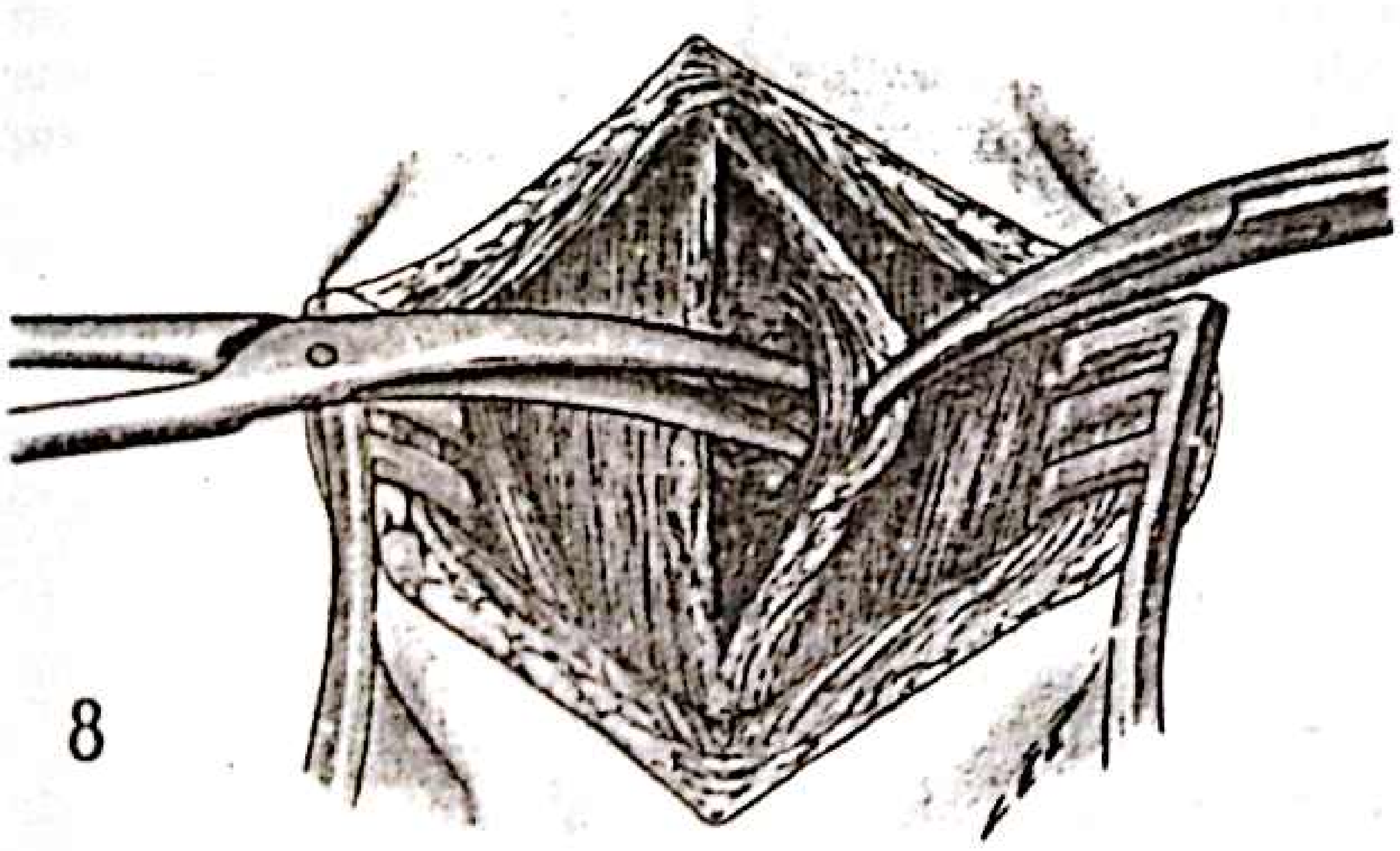
The dissection continues in the midline with division of the interval between the right and left sternohyoid muscles, which are retracted equally and the wound gradually deepened by blunt dissection. Careful retraction and good lighting are essential. Whenever the dissection deepens the retractors must be carefully repositioned.



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Identification of thyroid isthmus

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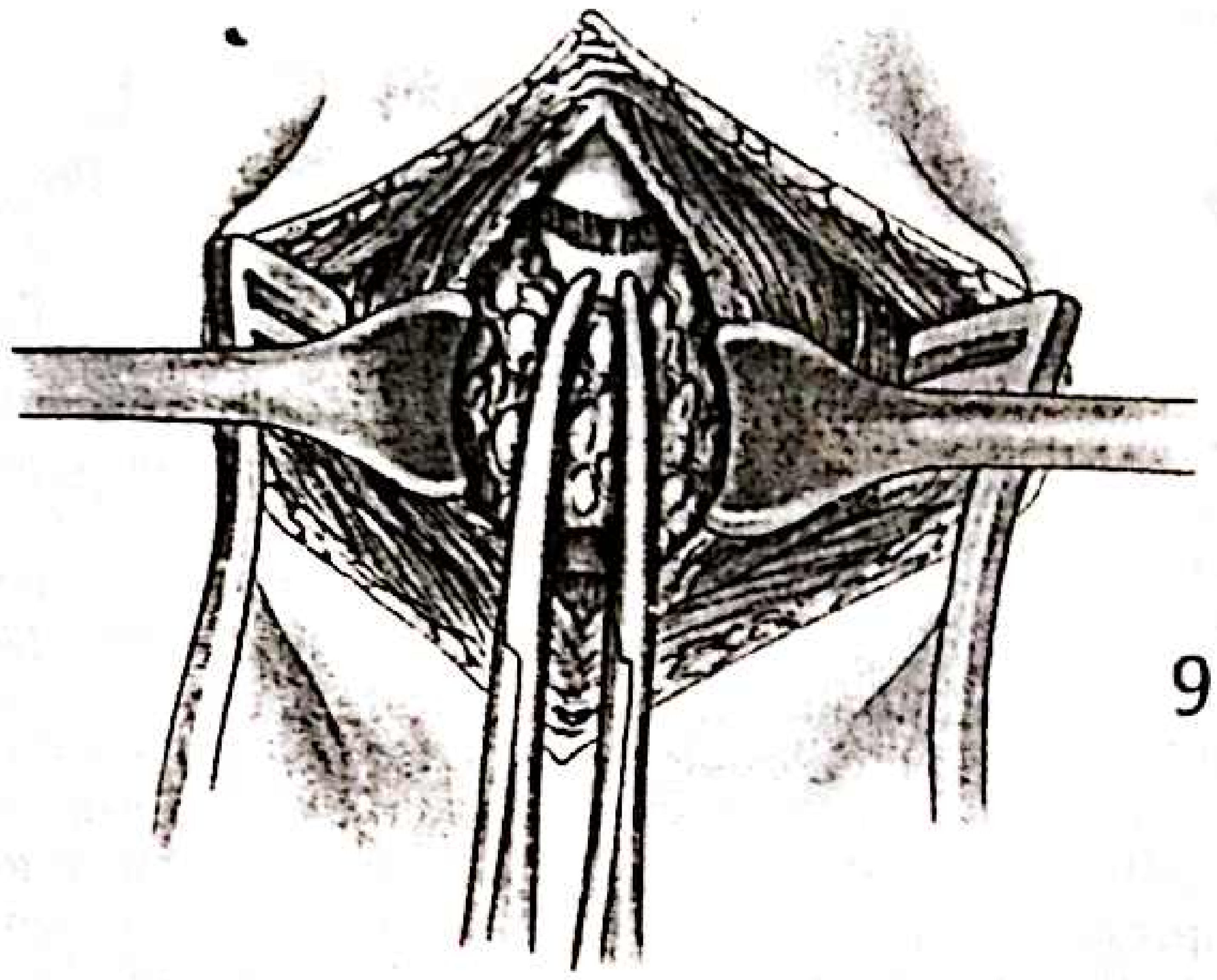
Following separation of the infrahyoid muscles, the thyroid gland and trachea become visible. Anatomical variations in the size and position of the thyroid isthmus are considerable. In some patients the lateral lobes of the thyroid are small and the isthmus narrow so that it may be easily mobilized either superiorly or inferiorly following incision of the pretracheal fascia. However, in most patients the thyroid isthmus lies in front of the second and third rings of the trachea, which are the preferred site of the tracheostomy opening, and the isthmus is of such a size that it could interfere with the tracheostomy. In the author's opinion it is far safer to formally divide the isthmus between forceps and to oversew the edges, providing thorough haemostasis and lessening the likelihood of subsequent bleeding, particularly from the veins of the thyroid capsule. Diathermy of these (sometimes surprisingly large) thin-walled veins is an inferior technique. An inadequate and hurried dissection of the thyroid isthmus combined with poor haemostasis is responsible for many of the haemorrhagic complications in the early postoperative period. With the isthmus formally divided, the anatomy of the underlying trachea is better exposed and there is less likelihood of obstruction of the tracheostomy opening should a tube become displaced later, and also of the tube causing haemorrhage from the adjacent isthmus in the long term.



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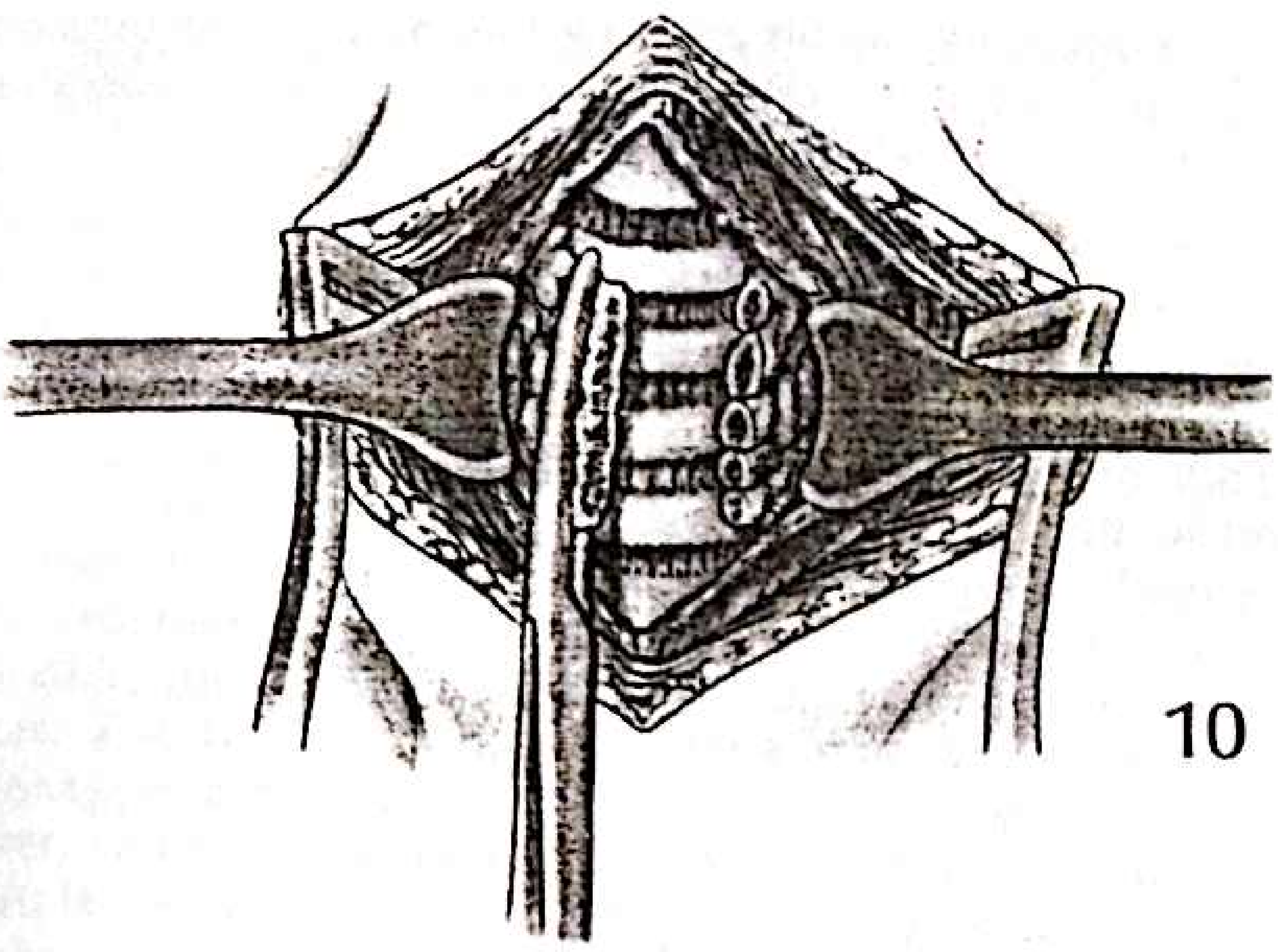

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Opening the trachea

Following division of the isthmus, the first four tracheal rings should be clearly defined, and before the trachea is opened complete haemostasis must be obtained. At this point, the surgeon must check that the anaesthetist is ready to alter the position of the endotracheal tube as necessary and that the scrub nurse has ready an appropriate cuffed tracheostomy tube which has been previously tested for patency of the cuff. Any necessary connections from this tube to the anaesthetic apparatus should also be available. Appropriate suction for aspiration of the trachea should be ready and the trachea may be retracted in an anterosuperior direction by inserting a tracheal hook below the cricoid cartilage. Skin sutures may be placed in the edges of the wound so that they may be tied easily once the tube has been placed.

Type of tracheal fenestration

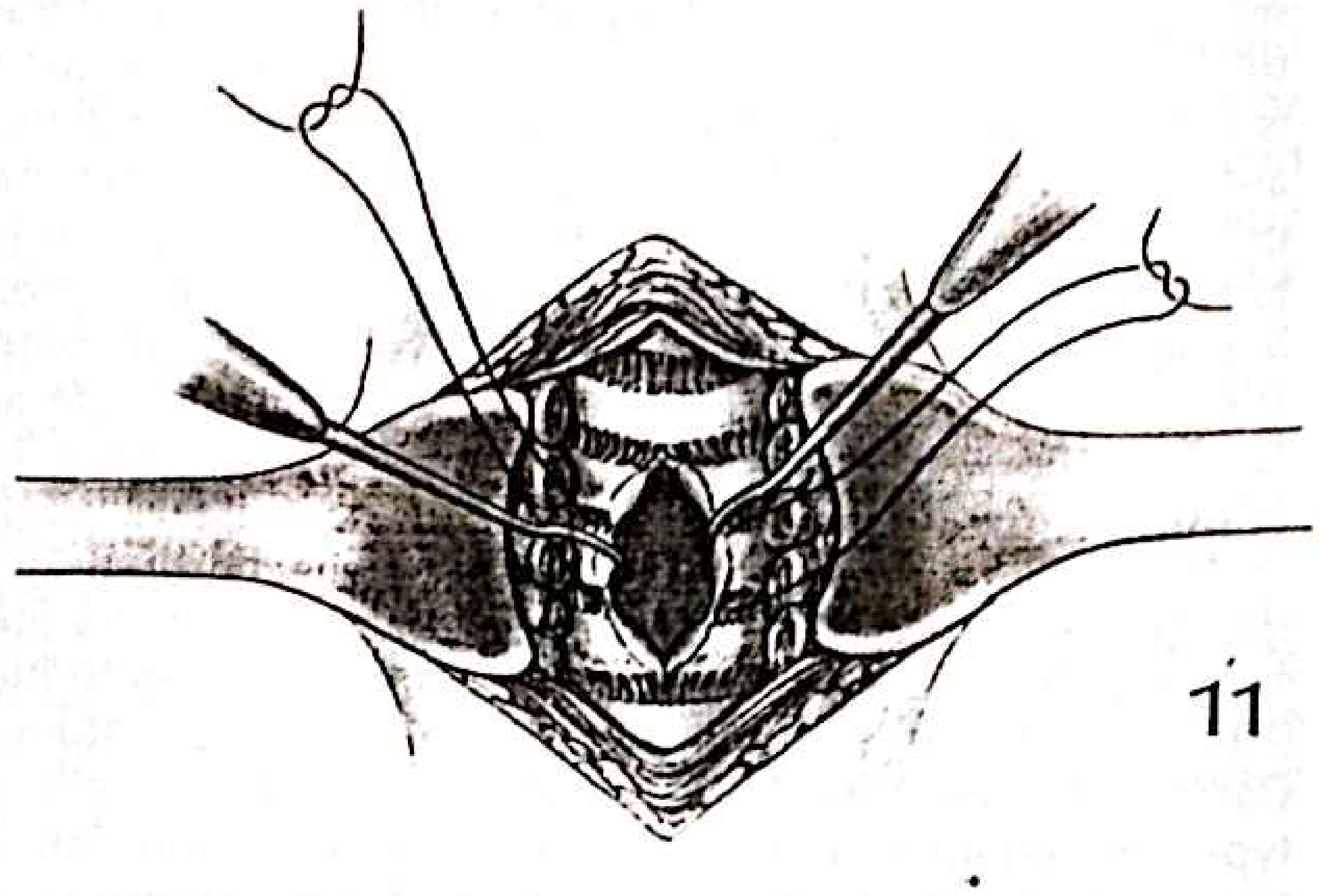
As with the incision, there is no absolute preference here but there are distinct guidelines which should be considered.

Children

In children the cartilages are soft and springy and can be displaced easily to allow insertion of a tube. It is neither desirable nor necessary in the small trachea to remove sections of tracheal rings.

11

Rings two, three and four should be divided in the midline and lateral sutures of 3/0 Prolene inserted. If space is limited and a dilator cannot be inserted, it may be easier to compress the distal end of the plastic tube in curved artery forceps and to insert both into the tracheal lumen, withdrawing the forceps once the position of the tube within the tracheal lumen is satisfactory.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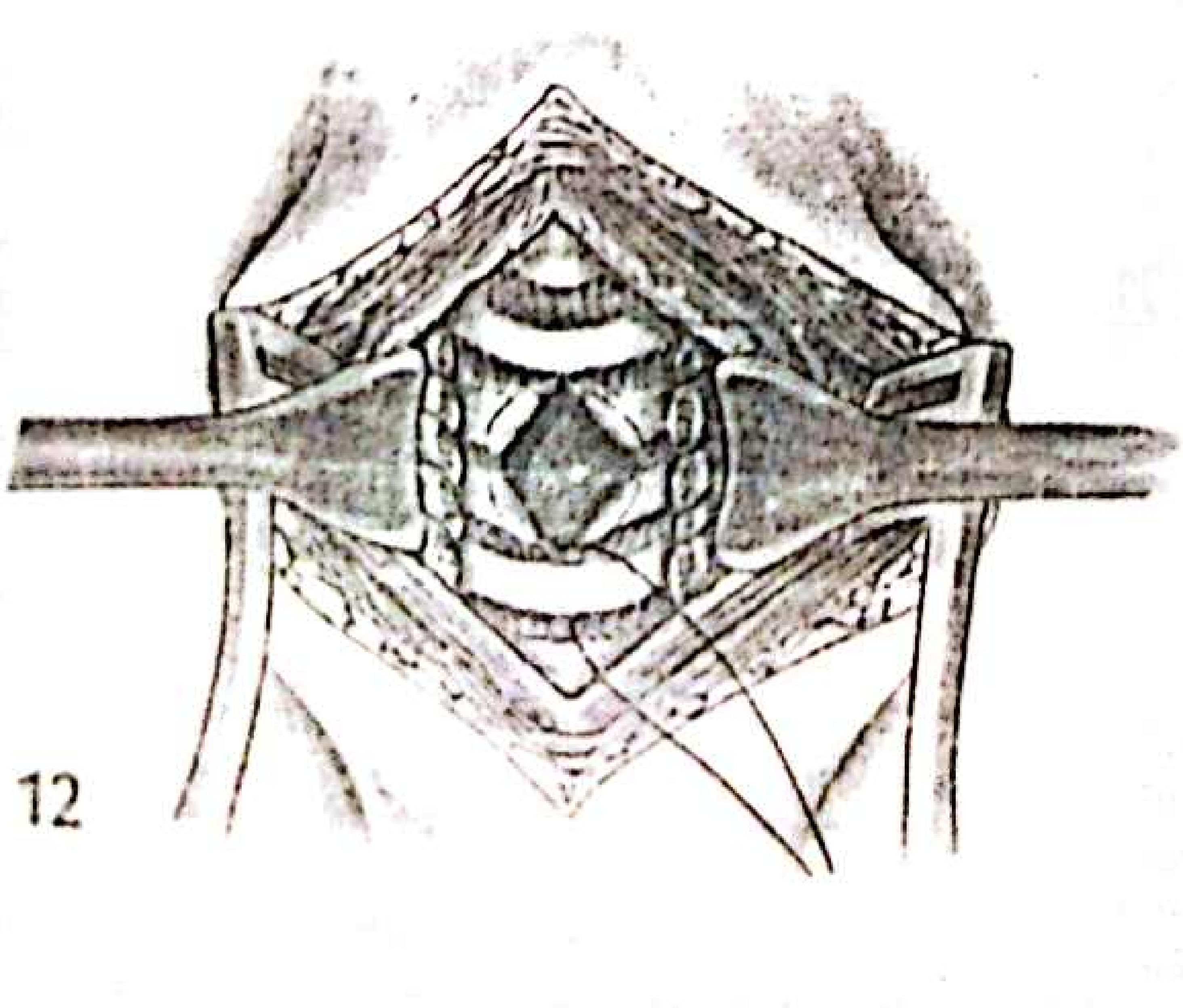
Adults

Vertical incisions, cruciate incisions, a circular window in the tracheal wall and an inferiorly based tracheal flap (Bjork) all have their advocates, but the debate has not been backed up by controlled prospective studies. The most important consideration is that a tracheostomy must provide a trouble-free, safe and easily manageable entry into the airway under a wide variety of circumstances.

Bearing this in mind, the use of a simple vertical incision, cruciate incisions or small windows are not advocated, as there is no good evidence that these prevent tracheal stenosis in the long term. Indeed, the passage of the tracheal tube through the distracted areas of cartilage may give rise to necrosis and/or displacement of portions of the cartilage into the tracheal lumen itself. The over-riding reason is, however, that should a tube become displaced in the early postoperative period, even experienced staff may find it difficult to replace when the edges of the incisions have approximated again. Even the presence of retraction sutures in the edges of the cartilage may not be sufficient to enable return of the tube. The combination of a patient with an obese neck, a retracted rather than divided thyroid isthmus and a vertical incision in the trachea may make it quite impossible to return the tube in an emergency situation.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The author therefore advocates the use of a Bjork flap or the removal of an anterior window of trachea, of the same size as the tracheostomy tube, through the second and third rings. This window is accomplished by first making a transverse incision in the trachea between the second and third rings and then enlarging the opening with a 15-bladed scalpel or, if there is calcification of the tracheal rings, curved heavy scissors or a ring punch. The opening should not be over large as it will allow blood into the trachea or notable amounts of air into the soft tissues of the neck, producing surgical emphysema. In order not to damage the underlying endotracheal tube, in particular to puncture the cuff, the anaesthetist can either push the tube inferiorly so that the cuff lies below the tracheal opening or retract it superiorly to just beneath the vocal cords while the opening is made. The latter position is necessary to introduce the tracheostomy tube, but under no circumstances should the endotracheal tube be fully removed until the tracheostomy tube is correctly placed and can be connected to the anaesthetic apparatus.

Stay sutures

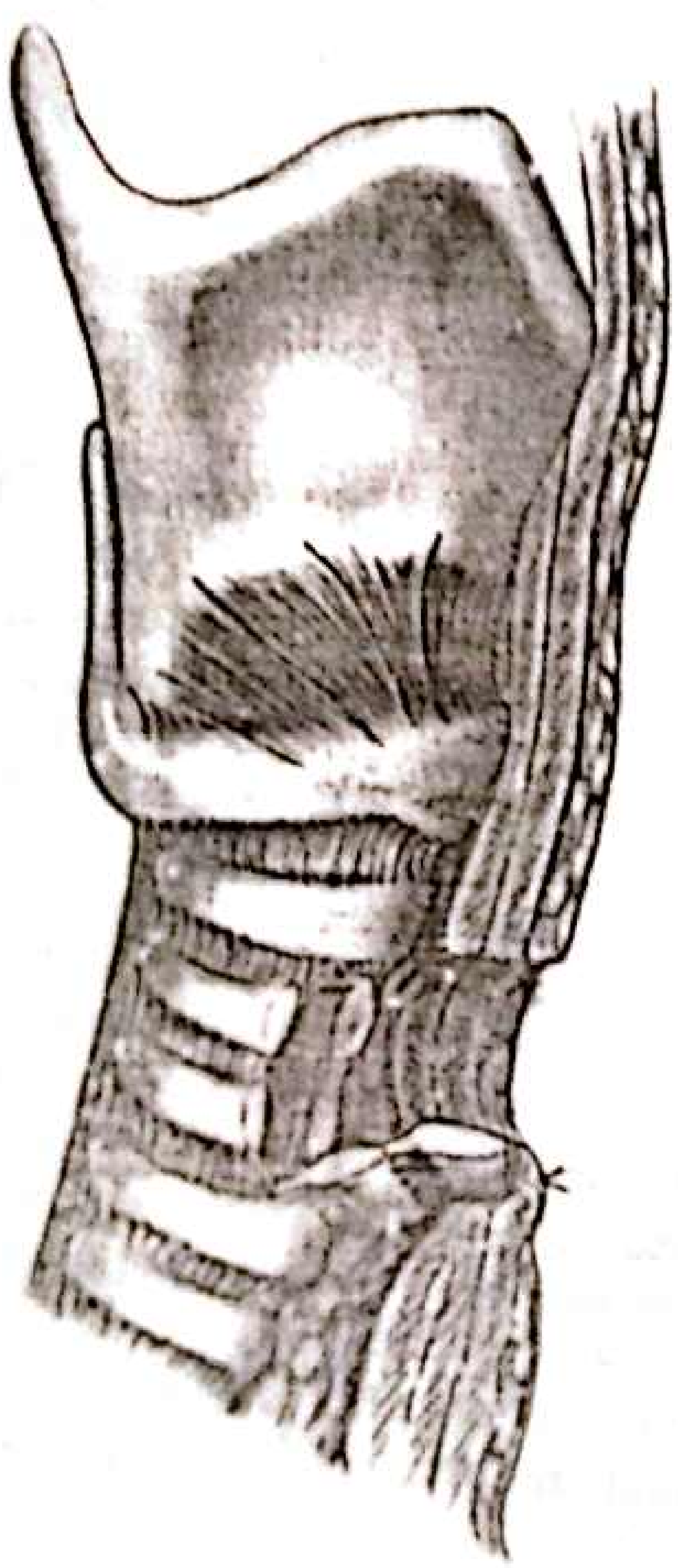
Under most circumstances the anaesthetized patient will be sufficiently oxygenated to allow the placement of stay sutures before the tracheostomy tube is introduced; the endotracheal tube is moved superiorly to make the introduction of the sutures easier. Should circumstances warrant, stay sutures may be placed after insertion of the tube, but with more difficulty. The minimum requirement is for a single strong 2/0 vertical mattress suture into the anterior tracheal wall below the opening, which can be brought out through the incision and the ends securely taped to the skin. In the obese patient where the trachea lies deeply, two retraction sutures placed laterally with substantial bites of the tracheal wall may be preferable to facilitate reintroduction of a displaced tube, bearing in mind the distance from the skin to the tracheal wall. Both methods are satisfactory for short-term tracheostomies; for the longer term tracheostomy many surgeons advocate suturing the inferior aspect of the tracheal opening to the skin, but this is only easily done in the slim patient. Careful placement of these sutures (preferably mattress in type) is required and there should not be too much tension between the trachea and the skin otherwise they may cut out.

Bjork flap

This method of creating the opening in the anterior tracheal wall evokes a surprising degree of debate: there are those who advocate its use on every occasion and those who state that they would never use it under any circumstances. It has two significant potential disadvantages: (*1*) the inferiorly based flap may pull away from the skin if suture placement is inadequate, and may prevent easy access to the trachea should tube displacement occur; (*2*) in a long-term tracheostomy formal closure may be required, but this is occasionally true of all types of tracheostomy, irrespective of the exact method of forming the tracheal opening. In the short-term tracheostomy, so often necessary accompanying head and neck surgery, this second potential complication is extremely rare.

There is a third, oft-quoted, disadvantage of an increased degree of stenosis with this procedure but there is no evidence for this; the recent literature shows the long-term condition of the tracheal lumen to be as good as or better than that associated with other methods.

The advantages of the Bjork method far outweigh the disadvantages and the method is particularly useful for those surgeons who undertake occasional tracheostomy, and where the level of skill and experience of the nursing staff is limited. Performed correctly, it is very safe and allows reintroduction of a displaced tube with the minimum of difficulty.



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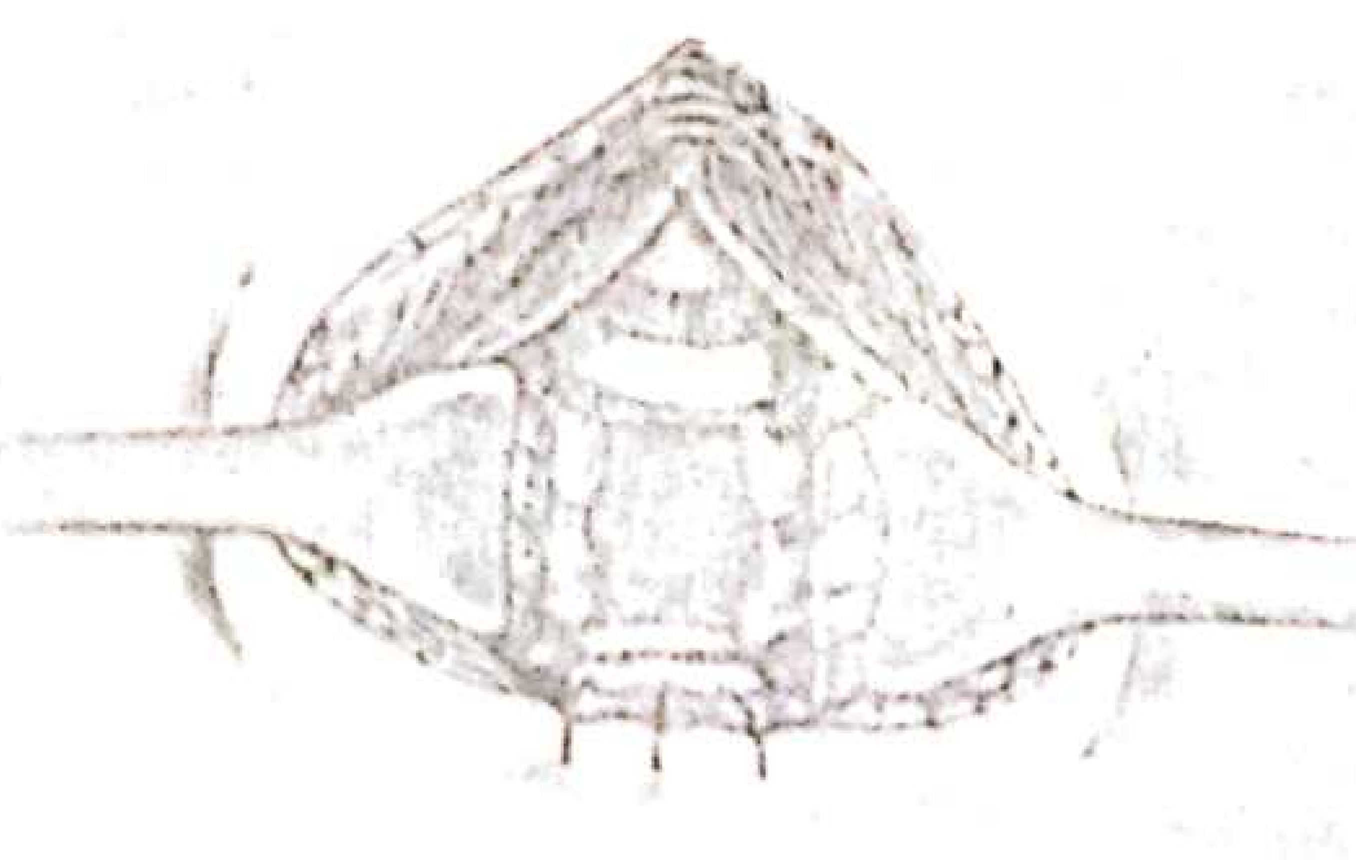
The inferiorly based flap is begun at its apex, with an incision on the superior aspect of the second ring and extends down either side through the second and third rings. In a patient with a thick neck, it may also be necessary to pass through the fourth ring. The flap should not be too narrow as this will limit the blood supply at its tip.



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The tip of the flap should be stitched to the inferior edge of the transverse skin incision or to an appropriate point of a vertical incision. This is best done by horizontal 2/0 mattress sutures through the structure of the second ring, approximating and tying them to the skin edge without undue tension. These sutures should be generous enough that they will not cut out. Three sutures are advocated: one is insufficient. The curve from skin to tracheal lumen created by the position of this inferiorly based flap aids the placement of the tube into the tracheal lumen. Whatever the ultimate choice of opening, the first tracheal ring should not be violated under any circumstances.

Tracheostomy tubes

These are basically made of two materials: silver and plastic. Both materials have been used to make tubes of various sizes and with varying curves, angles, cuffs, inner tubes and speaking valves. An exhaustive review of these is not appropriate here but the surgeon, anaesthetist and nursing staff must be familiar with all aspects of the tube to be used. In the vast majority of situations, a modern high volume, low-pressure, cuffed tracheostomy tube will be inserted at the time of tracheostomy. After 3 days this may be changed to a non-cuffed plastic tube, or silver tube if it appears to offer advantages. The pressure within the tube cuff should be carefully monitored and should be low enough to prevent occlusion of the circulation in the mucosal capillaries. Deflating the cuff for a period of several minutes at hourly intervals is widely advocated but has not been definitively shown to prevent tracheal damage; however, it does have the advantage of repeatedly turning the nursing staff's attention to the cuff pressure.

Fixation of the tube and dressing

When in position, the tube should be retained by double tapes passed around the patient's neck with a reef knot on either side. It is important that the patient's head is well flexed when the ties are knotted, otherwise they may become slack when the patient sits upright, resulting in the possible displacement of the tube if the patient coughs. Alternatively, the flanges of the tube may be stitched directly to the underlying neck skin. This technique is useful when tapes around the neck may impinge on an additional operative site or pedicled flap but it makes dressings beneath the tracheostomy tube flange more difficult to manage. A wide variety of preformed sterile sponge tracheostomy dressings are available but gauze impregnated with antibiotic and antiseptic is also advocated. Whatever the choice of dressing beneath the tracheostomy tube, it should be sufficiently large to allow no possibility of becoming hidden under the flange of the tube or forced into the tracheal lumen if the tube becomes slightly extruded and then pushed back into position. It should not be so large that it displaces the tube from the lumen of the trachea.

Wound closure

Packing of the tracheostomy wound or tight closure of skin around the tracheostomy tube should be avoided, as they may lead to subcutaneous emphysema and pneumomediastinum. Replacement of a displaced tube is also far more difficult if the wound has been tightly closed. One or two skin sutures in each lateral or vertical extremity of the wound are all that is required.

Postoperative management

A knowledge of the physiological changes induced by tracheostomy are an essential requirement for the understanding of postoperative management.

Positioning of the tube and prevention of displacement

The position of the tip of the tracheostomy tube should be checked by a postoperative chest radiograph, as unexpected bronchial intubation or low tracheal placement, with the tip of the tube being obstructed by the tracheal wall, may then be corrected (this may require placement of a more appropriate tube of either different curvature or length). The correct position must be maintained and tension in the securing tapes or skin sutures regularly checked. If the tube tends to displace in the early postoperative period then its suitability must be questioned and a more satisfactory alternative placed immediately. If the methods of introduction and fixation of the tracheostomy tube outline above are used, displacement should be rare and gentle elevation of the trachea towards the surface of the skin with stay sutures will facilitate repositioning of the tube. Tracheal dilators, soft tissue retractors, adequate illumination and a replacement tube should always be available in the early postoperative period.

Changing the tracheostomy tube

The instruments and illumination mentioned above must always be available; after the third day there is usually a good tract and tube changing is relatively easy. If the tube needs to be changed (owing to occlusion with dry secretions, blood or misplacement) it may be more difficult unless the tracheostomy technique outlined is used. In children or patients with obese necks early tube change may be best carried out in theatre with an anaesthetist present.

Care of the tracheostomy

In many units a printed tracheostomy routine is available at the patient's bedside. In the early postoperative period with a cuffed tube the patient is unable to talk, which makes 24-h supervision mandatory as it is in the unconscious patient; high pressure within the cuff should be avoided and the cuff pressure periodically checked. If it is correctly maintained, periodic deflation of the cuff should not be necessary. If intermittent positive pressure ventilation is not required, the cuff can be deflated after 24 h.

Suction

The suction apparatus introduced into the tube and trachea should be sterile and held in a sterile disposable glove. The frequency of suction will vary according to the underlying pathology for which tracheostomy was undertaken; there is no fixed interval and it should be undertaken when required. Suction should be applied only on withdrawl of the catheter, and prolonged suction should be avoided. Most tracheostomy patients produce copious secretions in the initial phase of tracheostomy and swabs should be taken and sent for culture and sensitivity at least twice weekly.

Inner tubes and speaking valves

The frequency of removal and cleaning of an inner tube, with or without a speaking valve, will vary according to the degree of secretion and the underlying pathology. The inner tube may require cleaning every 2–3 h during the first few days. It should be 2–3 mm longer than the outer tube so that the secretions remain within the inner tube and are removed at the time of cleaning. Obstruction of the lumen of the tube by dried secretions may occur, particularly at the distal end, and is an indication of under-humidification or insufficient tracheobronchial toilet.

Humidification and prevention of crusting

Crusting may occur not only in the tube but also in the trachea unless the inspired air is adequately humidified. Tracheal epithelium exposed to dry gases loses its ciliated cells, which are replaced by squamous epithelium. Small calibre tubes used in children easily block with inspissated sputum if there is inadequate humidification. There are many different types of humidification, ranging from a simple gauze swab draped over the external opening of the tracheosotmy tube to the modern ultrasound humidifiers which produce a particle size below 5 μm in diameter. Cold humidity is preferable. Modern humidifiers can be very efficient, and in small children it is important to consider the dangers of hyperthermia and inadvertent water overload due to hyper-humidification. The recent introduction of an effective bacterial filter as an efficient condenser humidifier offers considerable advantages in the management of the patient with a tracheostomy, physiological temperature and humidity in the trachea being combined with positive removal of airborne bacteria.

Complications of tracheostomy

Most complications can be avoided with care and attention to the operative and postoperative details given above.

Intraoperative complications

Haemorrhage. In an urgent situation, hurrying to secure an airway, adequate attention may not be paid to haemostasis. Once the airway is obtained, great attention should be paid to haemostasis: the division and ligation of the anterior jugular vessels, and division and oversewing of the thyroid isthmus are points for particular attention. Coagulation of smaller vessels and occasionally of the tracheal wall itself may be necessary. Blood can be prevented from entering the airway by means of the cuffed tube. Simply packing the wound at the end of the procedure is not satisfactory and should not be used as an alternative to meticulous haemostasis. Significant bleeding at recovery should be managed by return to the operating theatre and re-exploration of the tracheostomy site.

Injury to paratracheal structures. Dissection lateral to the trachea must be avoided so that structures such as the carotid artery, recurrent laryngeal nerves and oesophagus are not damaged. The pleural domes and left brachiocephalic vein are at increased risk in children, particularly so with hyperextension of the neck. In patients with marked emphysema the apex of the lung may extend into the lower neck, and pneumothorax and air emboli are more common in an uncontrolled situation if the patient is struggling and straining. Bradycardia and hypertension may occur following inappropriate vagal stimulation.

Damage to the trachea. An inexperienced operator struggling with poor exposure and haemostasis can cause considerable tracheal damage at both the anterior and posterior wall, with laceration of the first tracheal and cricoid cartilages. If damage to these structures is noted careful tracheostomy at a lower level and reapproximation of the cricoid cartilage is preferable.

Early postoperative complications

Apnoea caused by a fall in P_{CO_2}. In patients who have had prolonged respiratory difficulty, the sudden reduction of carbon dioxide tension consequent on tracheostomy or intubation may cause apnoea. The administration of 5 per cent carbon dioxide in oxygen may be necessary, with the appropriate monitoring of blood gases.

Haemorrhage. Haemorrhage from the same vessels as those mentioned in the intraoperative section is possible in the early postoperative period and, if not already present, a cuffed tube should be inserted and all bleeding points secured once the wound has been reopened. Secondary haemorrhage in association with an infected wound must be treated with antibiotics.

Subcutaneous emphysema, pneumomediastinum and pneumothorax. These may occur for the reasons stated above, but more commonly if the tracheostomy tube or trachea are obstructed and if the skin edges of the wound are closed tightly to each other rather than approximated to the edge of the trachea. Extension of air into the tissues of the neck may cause gross swelling as far up as the lower eyelids and down to the region of the nipples. In severe cases, the swelling may dislodge the tube. Rapid opening of the tracheostomy wound and correct approximation of the tube and soft tissues is a matter of urgency.

Accidental extubation, anterior displacement of the tube, obstruction of the tube lumen and tip occlusion against the tracheal wall. These problems may be prevented by correct siting of the tracheostomy opening, use of an appropriate tracheostomy tube and well-adjusted and secured tapes. Displacement of the tube into the pretracheal space may not be immediately evident; soft tissue prolapse and closure of the tracheal wall may occur slowly, with the patient gradually becoming more dyspnoeic. An emergency situation may then arise in which it is very difficult to replace the tube; this event is responsible for much of the mortality following tracheostomy. It cannot be over-emphasized that correct dissection, removal of a window of trachea or use of a Bjork flap, placement of adequate stay sutures for retraction and appropriate closure of the wound will prevent this disastrous complication.

Infection. Infection may be present in the lower respiratory tract before tracheostomy, and indeed may be the precipitating factor for the procedure. Antibiotics will be required and the secretions should be cultured regularly. Secondary infection following tracheostomy should be prevented by adequate sterile suction of secretions and satisfactory humidification. Pressure necrosis of the tracheal wall will predispose to infection, while pre-existing infection makes ulceration of the tracheal wall due to presence of the tube more likely.

Swallowing dysfunction. In a small proportion of cases the presence of the tracheostomy tube sufficiently disturbs the normal elevation and physiology of the larynx during swallowing to cause aspiration. These patients may occasionally require an additional fine-bore nasogastric tube for feeding until decannulation can be undertaken.

Late postoperative complications

Difficult decannulation. It is rare for adults to be totally dependent on a tracheostomy if it has been established for only a short time. However, after long-term cannulation (and certainly in many children) decannulation can present many problems. A speaking valve tube may aid the situation by restoring expiration and (notably in children) stimulating the reflex for vocal cord abduction. A gradual decrease in the size of the cannula permits the patient to breathe around the tube. In adults, these measures are usually successful; in children, the process may take longer and may in many instances be complicated by residual abnormalities of the upper airway.

Tracheocutaneous fistula. All long-term tracheostomies may become epithelialized, producing tracheocutaneous fistula. The epithelialized tract may require excision and the wound closed properly in layers. An unsightly skin incision can be modified at the same time as this procedure.

Tracheo-oesophageal fistula. Gross damage to the posterior tracheal wall, either at the time of operation or from a malpositioned tube over a prolonged period, may give rise to aspiration of saliva and food. This serious complication should not occur with the care outlined above, but if it does may require open operation for repair.

Tracheo-innominate artery fistula with severe haemorrhage. This dramatic complication usually occurs several weeks after the procedure although it may occur earlier in previously irradiated patients, particularly when a low tracheostomy has been undertaken. Massive haemorrhage may occur without warning; sometimes a small amount of bright red blood appears from the tracheostomy tube as an initial warning. A cuffed tube should be placed quickly and direct pressure applied to the innominate artery through the tracheostomy wound. An endotracheal tube placed with the cuff over-inflated just distal to the tracheostomy opening may be life saving and allows time for resuscitation and direct exploration to control the haemorrhage.

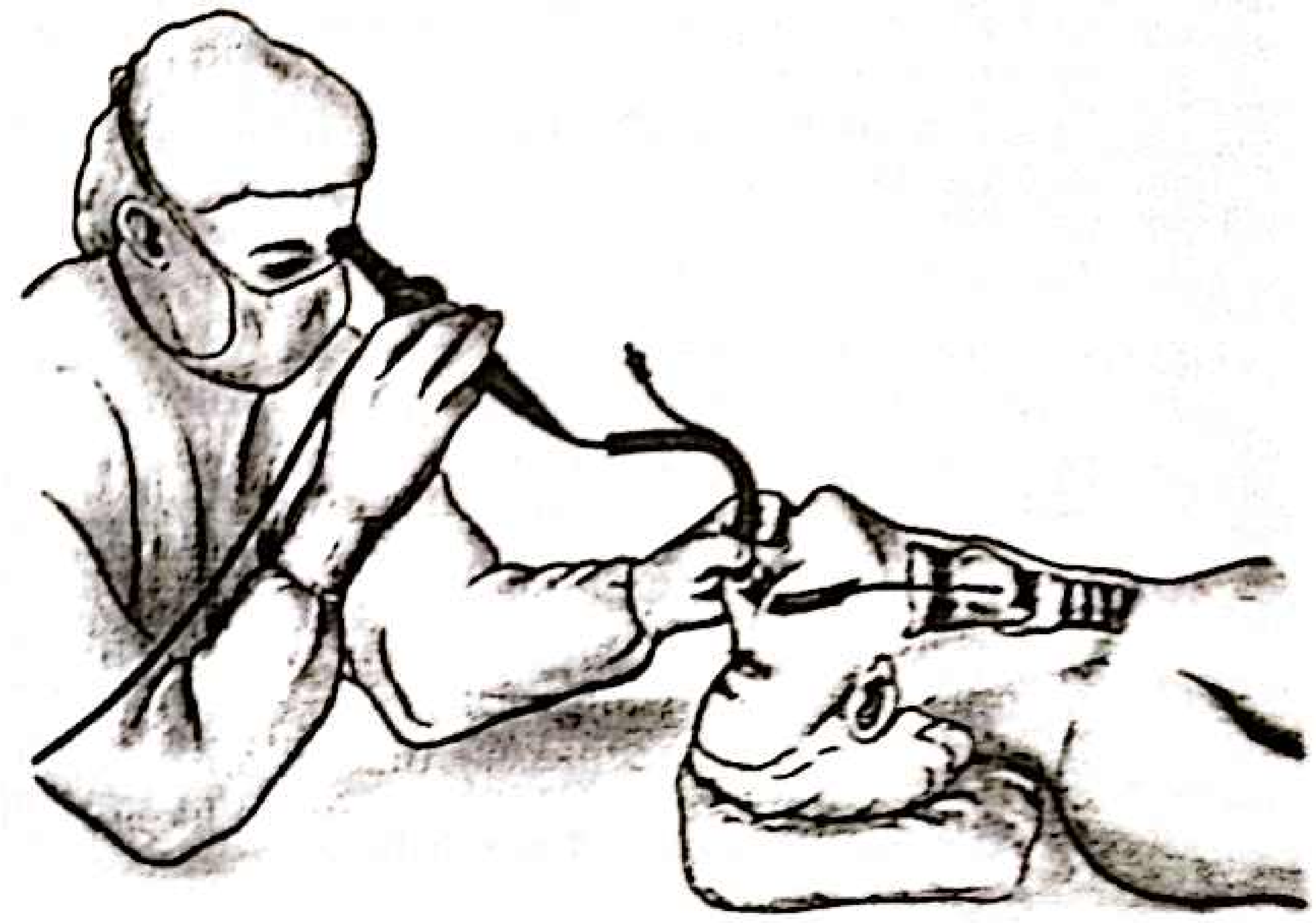
Tracheal stenosis. This may occur consequent upon problems at the stoma or in association with the cuff, the tip of the tube, or injury to the cricoid cartilage. All the factors previously outlined may lead to stenosis, which may occur rapidly within a few weeks of the tracheostomy. Displaced cartilage, prominent granulations and notable necrosis may all produce early stenosis. The ultimate management of stenosis is complicated and depends on many factors. Prevention of stenosis by attendance to detailed technique and postoperative management is infinitely preferable to its treatment.

OTHER EMERGENCY AIRWAY PROCEDURES

FIBREOPTIC ENDOTRACHEAL INTUBATION

15

In most emergency situations endotracheal intubation is the most direct and satisfactory method of securing the airway. Nasotracheal intubation, in expert hands, is also a well established technique and is particularly useful if the patient has trismus, severe mandibular injuries, cervical spine rigidity or an obstructing mass within the oral cavity. Both these forms of intubation can be aided in difficult patients by passing a modern fibreoptic endoscope through the centre of an endotracheal tube, hence guiding it into the larynx and trachea under direct vision. Secretions may be removed with these endoscopes and difficult intubations accomplished with a much improved degree of safety and control. These fibreoptic techniques should be thoroughly practised before using them in emergency situations. In the author's experience they have significantly decreased the need for the other airway procedures included in this section.



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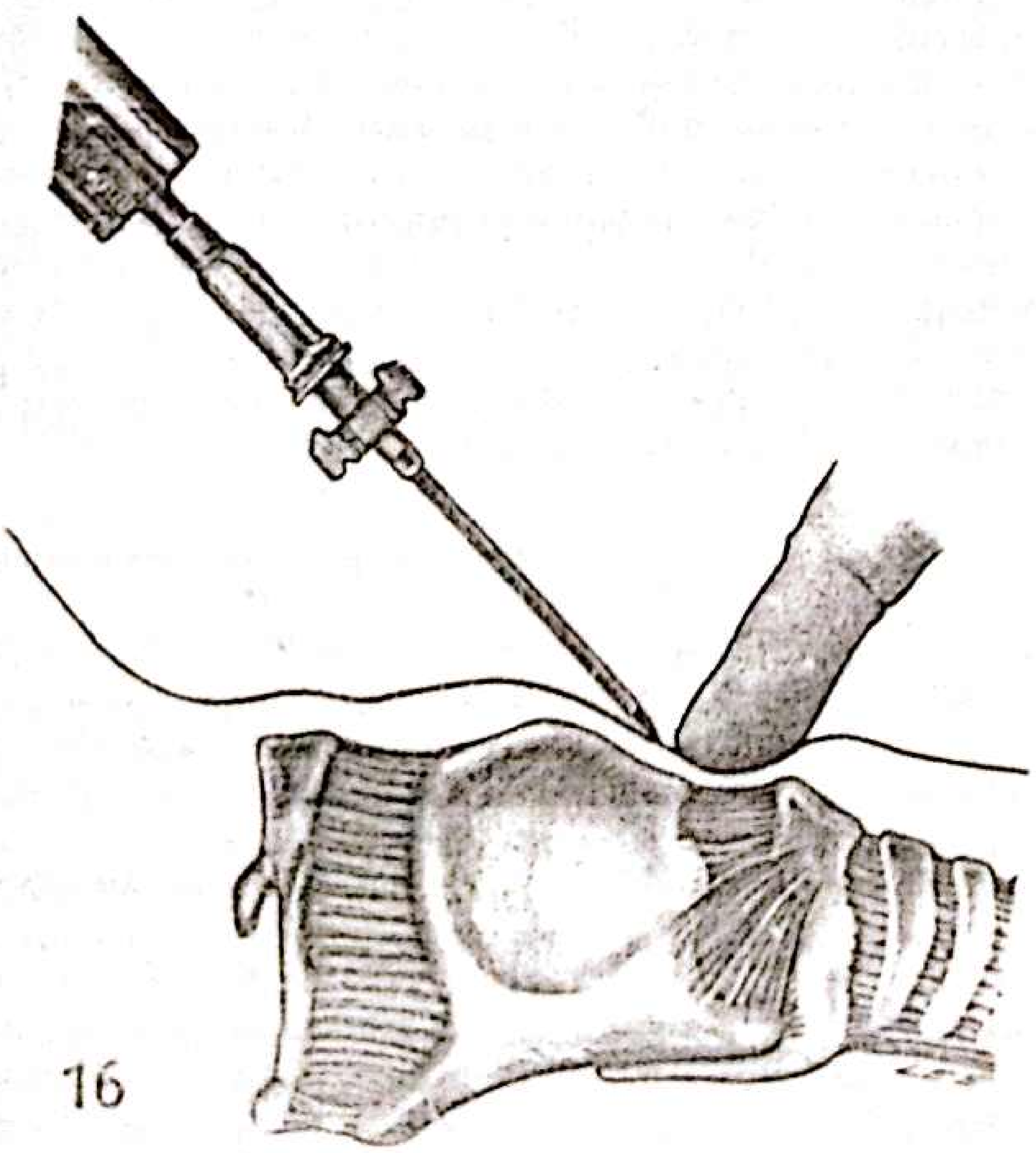
TRANSTRACHEAL NEEDLE VENTILATION

This technique has been increasingly advocated in the last decade, and although some specialist equipment is required, the actual technique is simple and effective. It will allow ventilation of the patient for periods in excess of 1 h, and will often give ample time to allow for a more organized elective procedure.

Equipment

A source of pure oxygen with a delivery pressure of 50–60 p.s.i. (345–415 kPa) is required. Many emergency rooms and operating theatres now have available connecting systems, such as Carden apparatus (Carden Intermittent Jetting Device, Medical Engineering Corporation, Wisconsin, USA) which allow a controlled supply of pressurized oxygen to the airway. Jet ventilation techniques are increasingly used by laryngologists to provide excellent conditions for microlaryngoscopy and laser procedures. A 14 or 16 gauge plastic sheathed intravascular needle and a 10 ml syringe containing a few ml lignocaine are also required.



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Operation

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The cricothyroid membrane is located by palpation of the neck with the index finger and the needle and syringe introduced in the midline and directed downwards and backards into the tracheal lumen.

17

The needle is advanced steadily and negative pressure is placed on the syringe until bubbles of air are clearly seen. The tissues of the neck may be infiltrated with the anaesthetic if desired, and the tracheal mucosa likewise partly anaesthetized by the introduction of 1–2 ml after gaining the tracheal lumen.

18 & 19

The needle is then removed and the plastic sheath cannula remains in the trachea. It is attached by means of a luer connection through the jetting device to the high-pressure oxygen supply. Ventilation may be accomplished in a controlled manner, with the chest being observed for appropriate excursions. Exhalation is accomplished via the elastic recall of the chest wall, but if there is severe obstruction of the laryngopharynx, by either foreign body or tumour, the exhaled outflow of gases can be aided by the placement of one or two further cannulas as exhalation ports.

Advantages

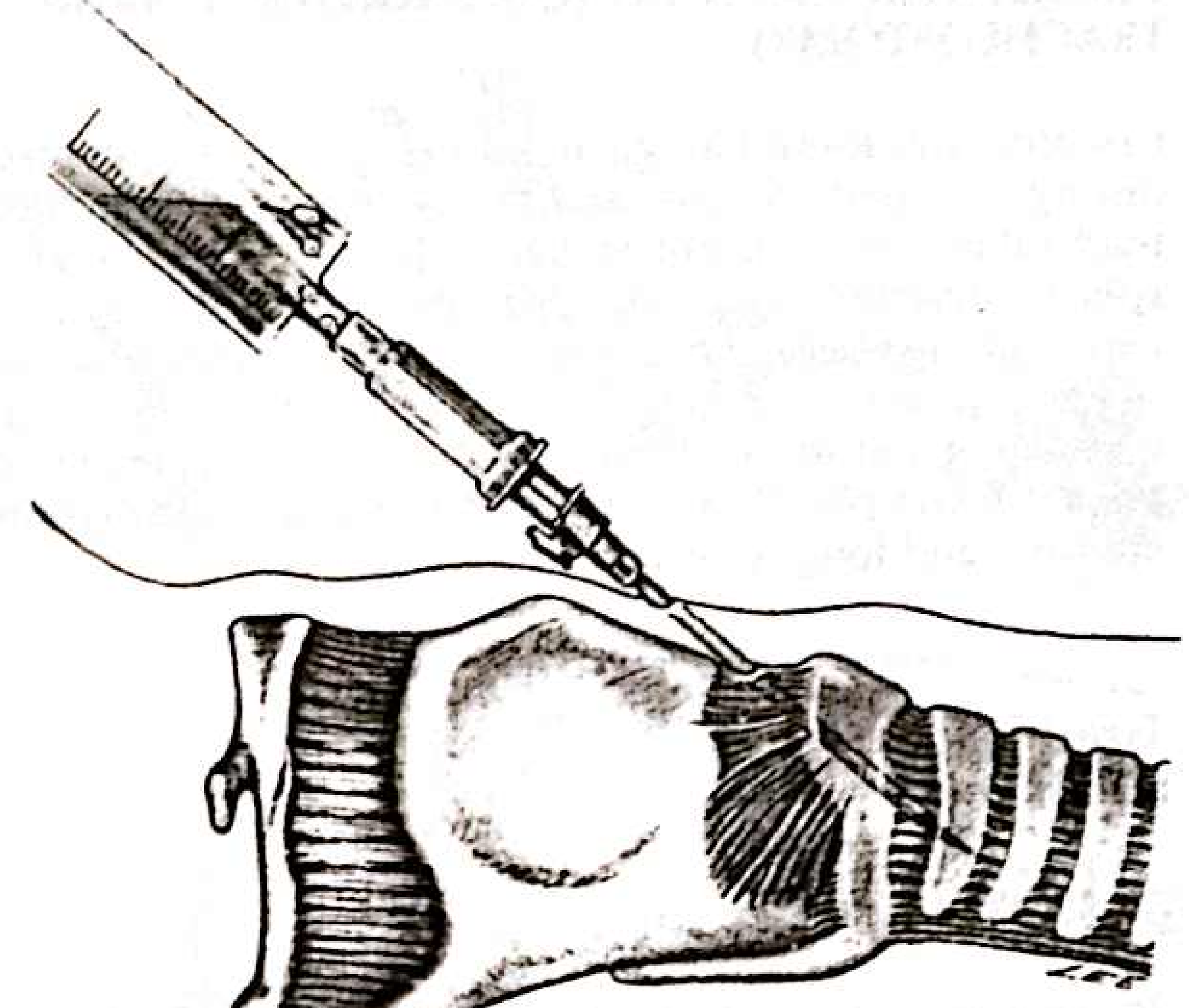
If the equipment is available, no other specific work is required and extremely rapid control of ventilation can be gained. The procedure requires a minimum of technical expertise and is particularly appropriate for the anaesthetist awaiting surgical help after an unsuccessful attempt at endotracheal intubation. Ventilation can be continued for at least 1 h and the technique accomplished with the patient in a variety of positions including sitting upright.

Disadvantages and complications

Specialist equipment is required.

The major complication of this technique is improper placement of the needle outside the trachea or submucosally within the trachea. The pressurized oxygen quickly results in gross distortion of tissues with subcutaneous emphysema which further compromises the patient's airway. The placement of the needle is of paramount importance and great care must be taken to keep the cannula in the correct position. This should be done by the person controlling the Carden apparatus holding and maintaining the cannula in the correct position rather than by the placement of tapes or sutures. A simple oximeter apparatus, available in many modern operating theatres, will aid the monitoring of the ventilation.

As with all procedures related to the cricothyroid membrane, the cricothyroid branch of the superior thyroid artery may be perforated by the needle, particularly if it is placed laterally, and may cause bleeding into the airway. Any haemoptysis related to the transtracheal needle ventilation should be assessed and, if significant, may require direct exploration in order to secure haemostasis. The author has never seen this complication and feels that, of all the cricothyroidotomy type techniques, this is the safest in both the acute and longer term situation.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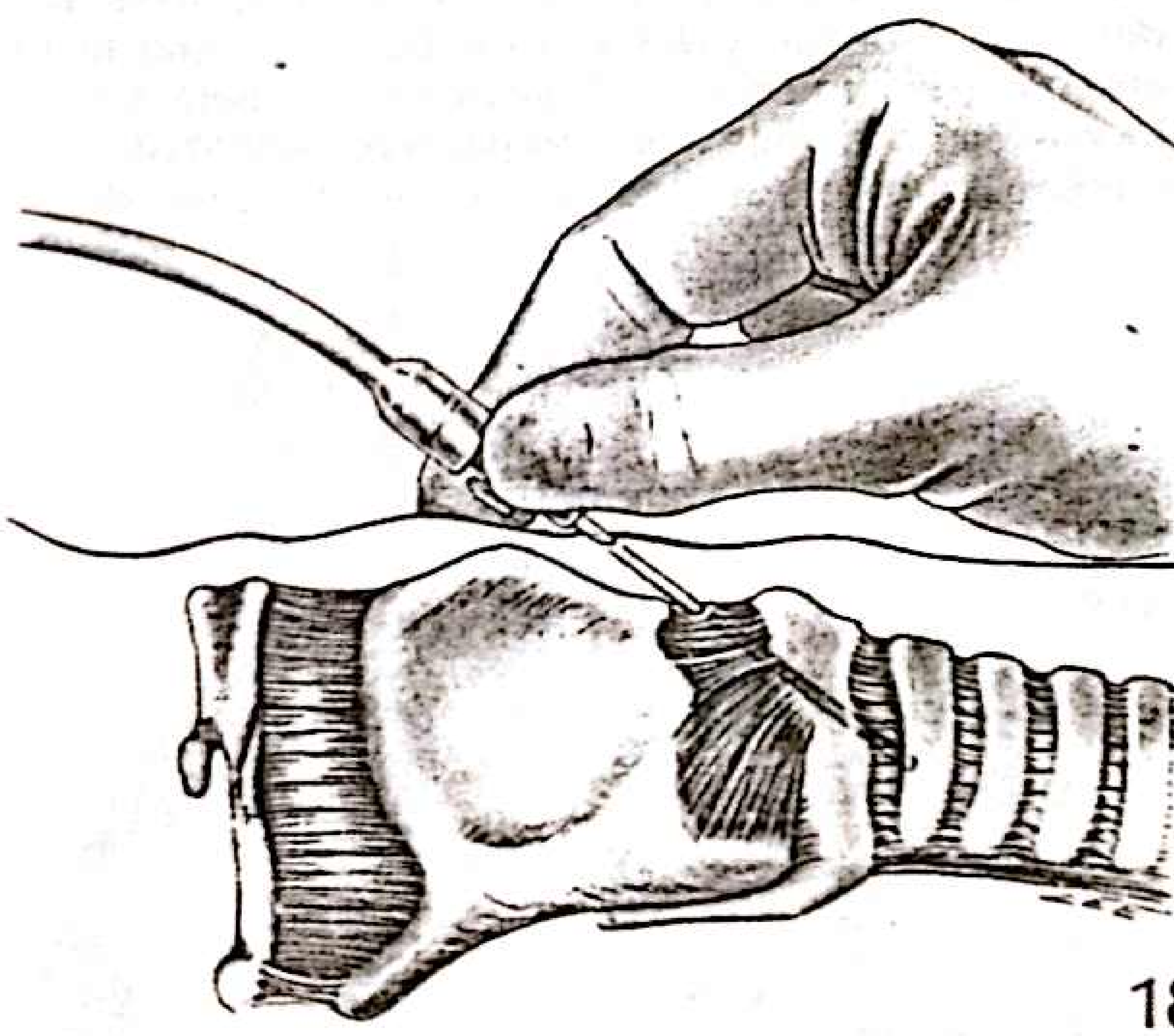
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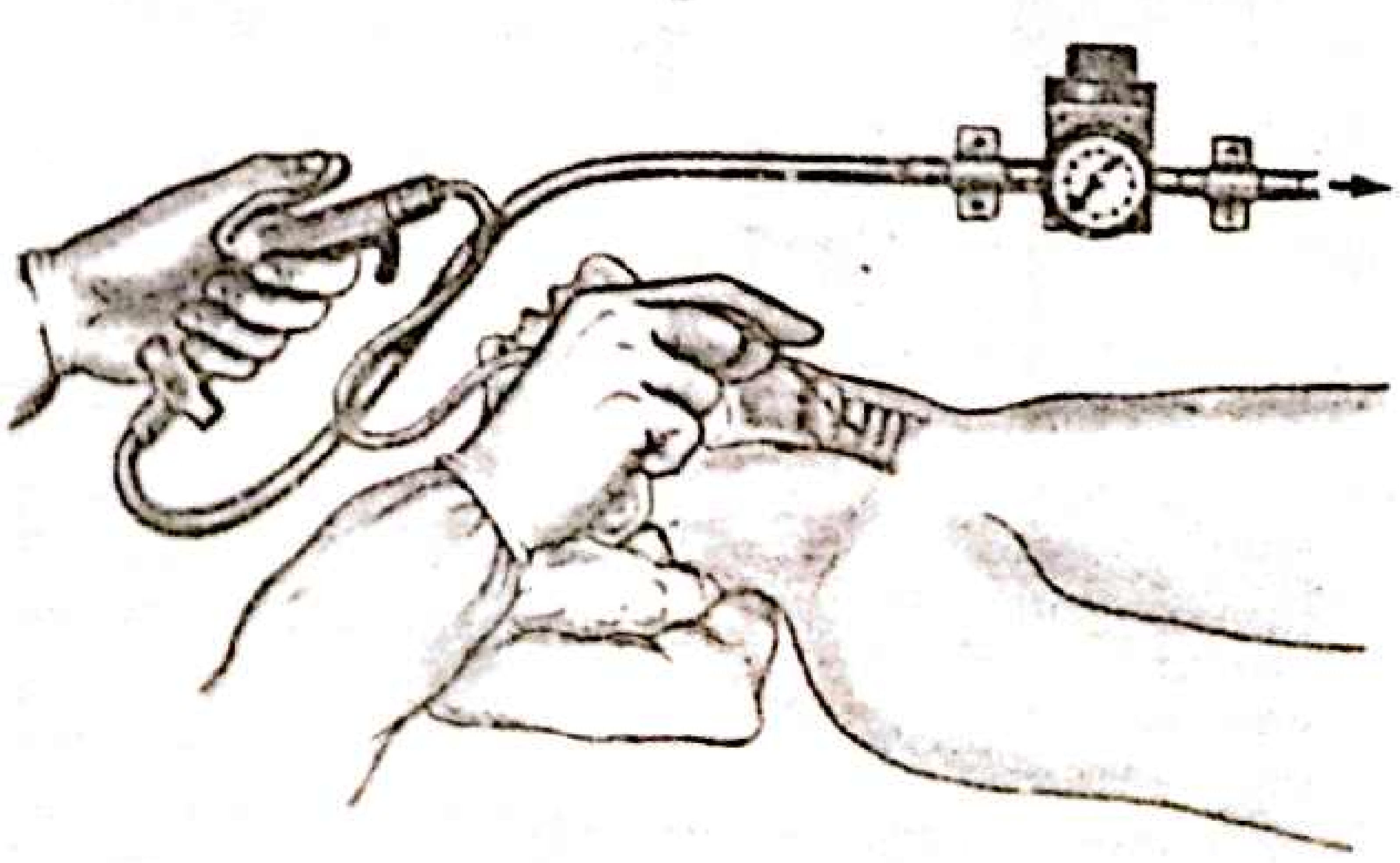
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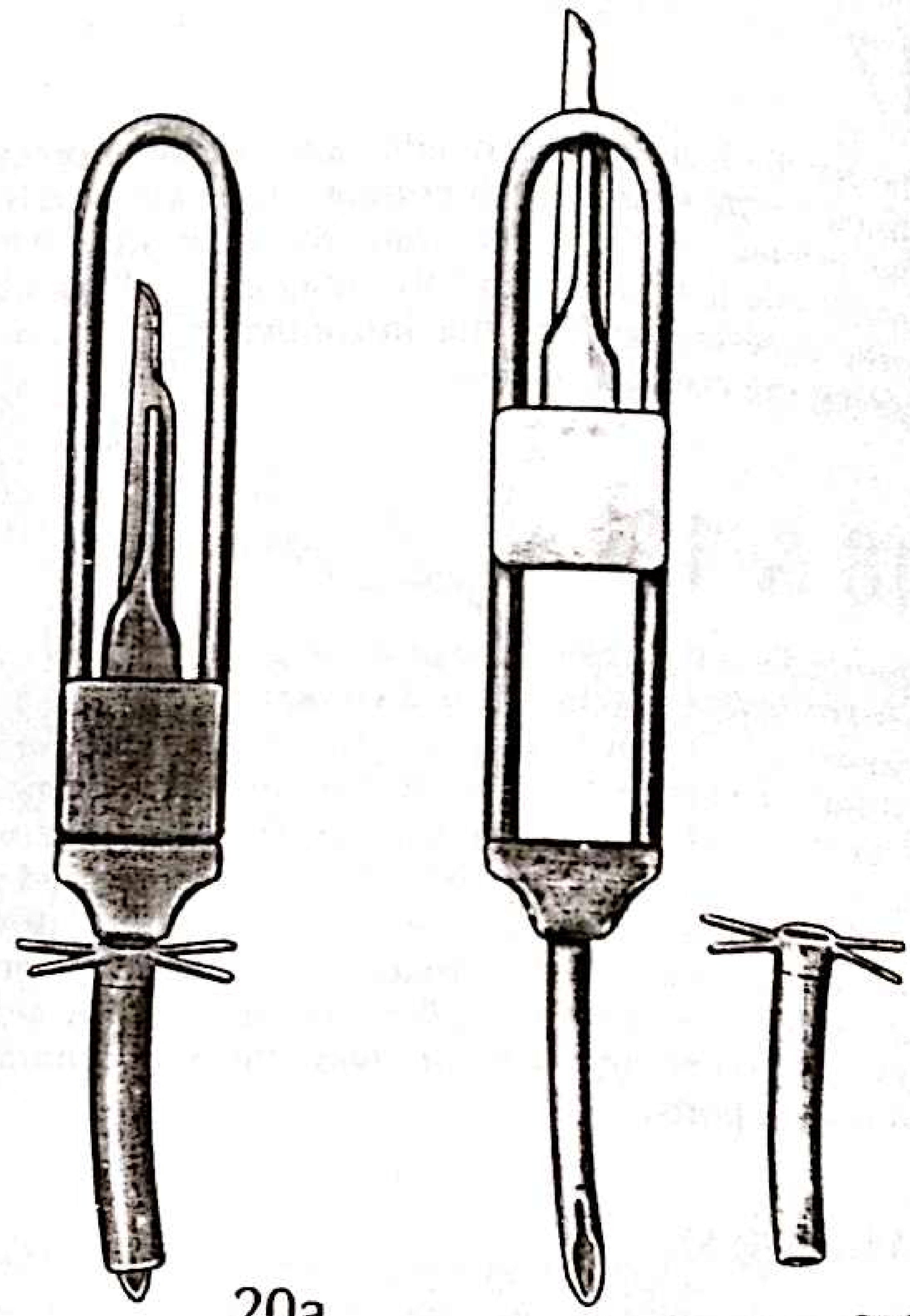
CRICOTHYROIDOTOMY (LARYNGOTOMY, MINI-TRACHEOSTOMY)

Cricothyroidotomy has gained support in some centres during the past decade and is advocated when endotracheal intubation is not possible. It has the advantages of speed and ease, requiring little equipment and surgical expertise. However, its use for all but the briefest access to the airway remains controversial and there are conflicting reports with regard to the subsequent incidence of complications, particularly those of subglottic stenosis and long-term voice changes.



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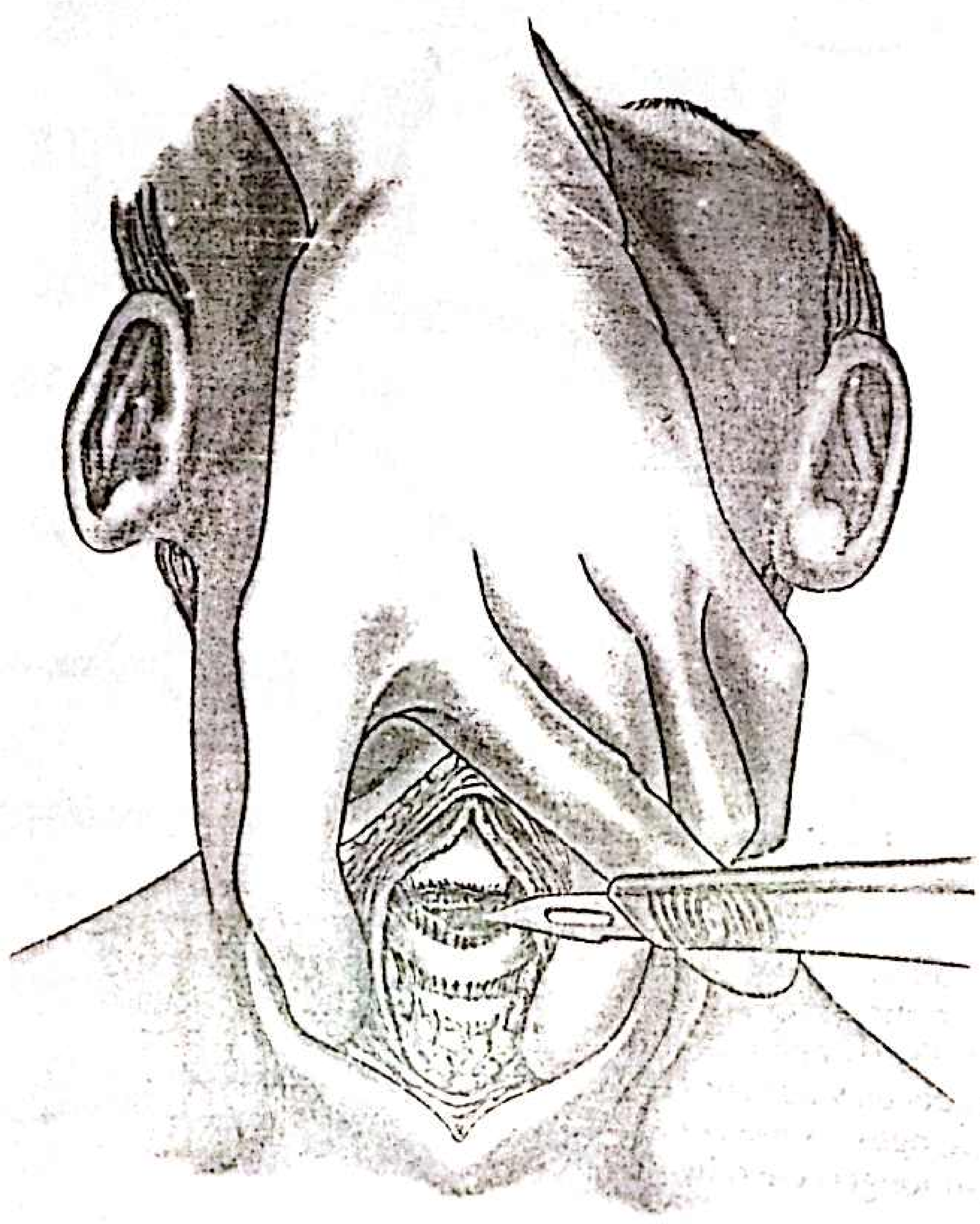
Equipment

20a & b

In an emergency the entire operation can be performed with a scalpel alone, but a pair of curved artery forceps and a small endotracheal or tracheostomy tube are useful. A wide variety of small combined instruments, such as the Cawthorne's laryngotomy knife and tube, have been designed over the years and on occasions and in dire emergencies scissors have been used. There are also increasing varieties of prepacked sterilized mini-tracheostomy sets available to facilitate the procedure.



Operation

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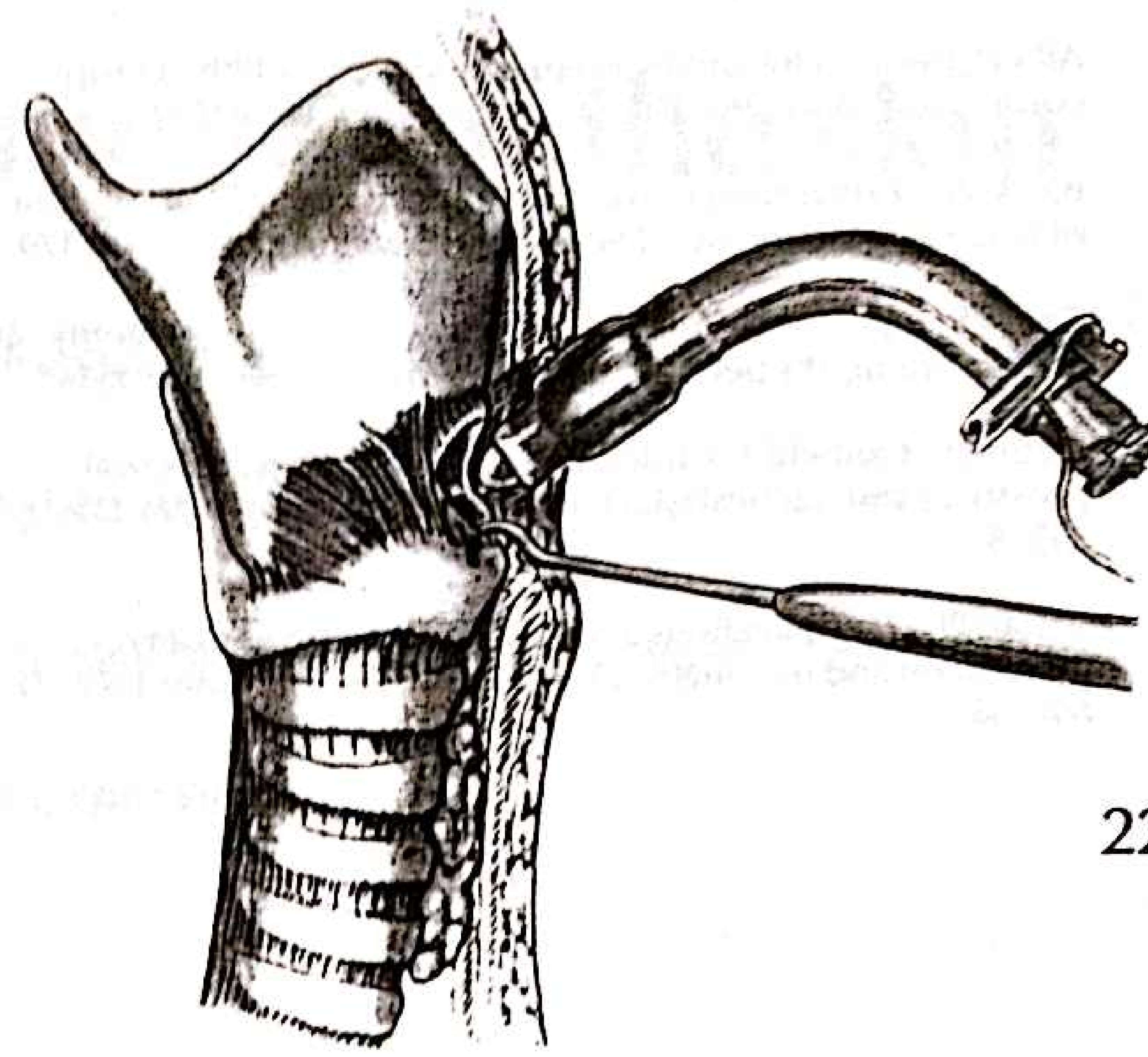
If possible, the patient's neck is extended and the area between the prominence of the thyroid cartilage and the cricoid cartilage below is palpated with the index finger of the free hand. In the emergency situation a vertical skin incision is recommended with dissection rapidly carried down to the cricothyroid membrane. A 1 cm transverse incision is made through the membrane immediately above the cricoid cartilage and the scalpel twisted through a right angle to gain access to the airway.

22

If available, artery forceps, dilator or a tracheal hook will aid in improving the aperture and the insertion of an available tube.



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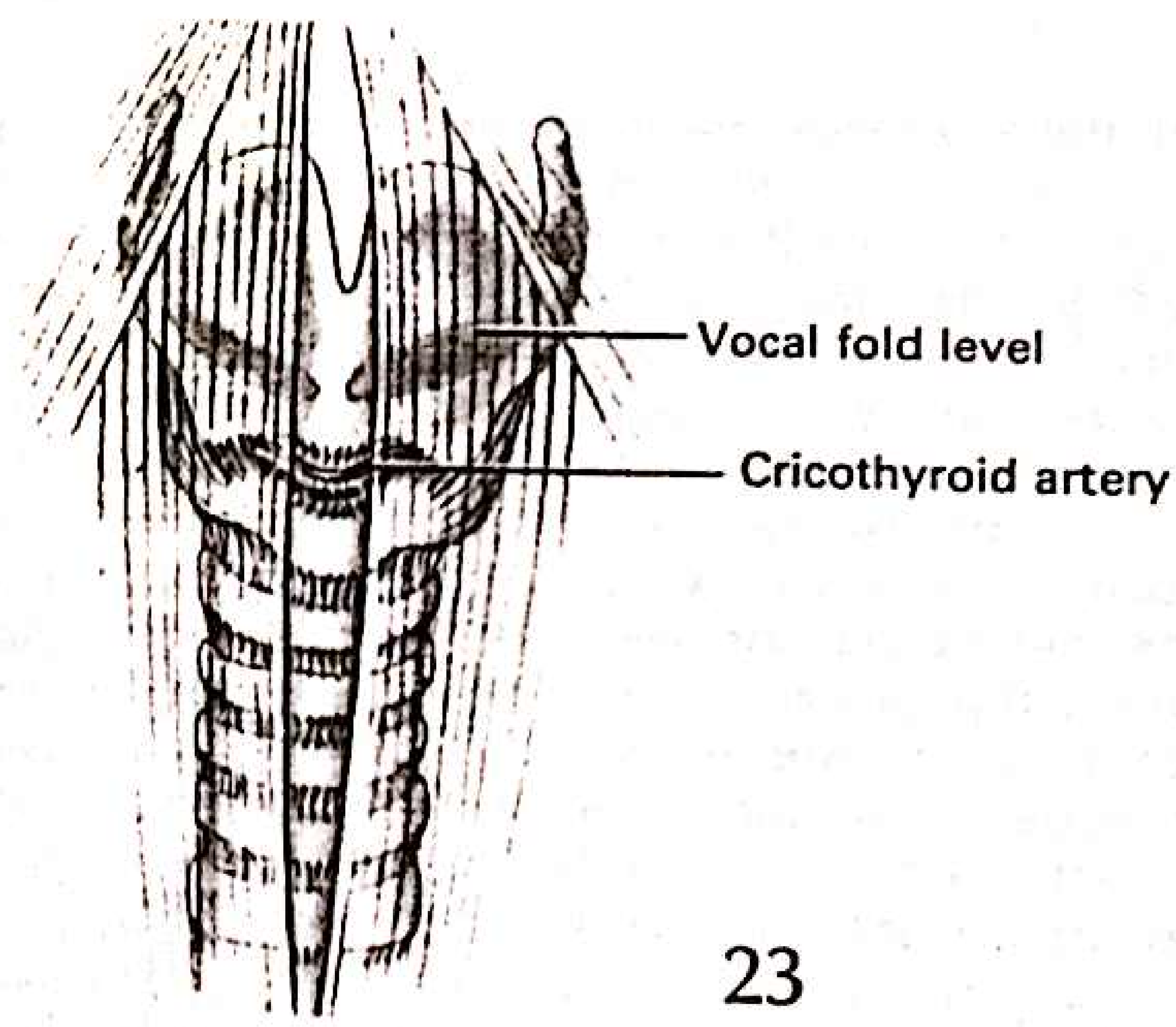
In an elective situation a transverse skin incision may be preferred and a good deal more time given to haemostasis and a more controlled entry through the cricothyroid membrane. The cricothyroid arteries tend to run transversely in the upper part of the membrane.

Depending on the degree of emergency, it may be necessary for the surgeon to assess the results of the procedure by direct laryngoscopy, and the author recommends that careful consideration should be given to conversion of the cricothyroidotomy to a tracheostomy or to the insertion of an endotracheal tube, if this is subsequently possible. Although there is debate about the frequency of subglottic stenosis following this procedure, there is general agreement that it is much increased if any long-term mechanical ventilation is undertaken via a tube placed in this position.



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Advantages

It is an easy and rapid approach to the airway and can be performed by a relatively inexperienced person. It may be the procedure of choice in patients with unstable spinal fractures where extension of the neck for tracheostomy might produce further damage, patients undergoing cardiovascular procedures requiring ventilation through an incision well away from the site of the thoracic surgery, or in individuals with thick necks and a low larynx where standard tracheostomy may be extremely difficult.

Disadvantages

Subglottic laryngeal pathology may prevent its use. There is an increased incidence of subglottic laryngeal stenosis and the procedure is not indicated in children. Perichondritis, subglottic oedema, granulation formation and reduced vocal cord mobility may all cause long-term voice changes. These complications are all more common after prolonged cricothyroidotomy.

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Illustrations by Ian Ramsden

Reconstructive techniques of the skin

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Luis O. Vasconez MD, FACS
Professor and Director, Division of Plastic Surgery, University of Alabama, Birmingham, Alabama, USA

Renato Saltz MD
Assistant Professor, Division of Plastic and Reconstructive Surgery, Medical College of Georgia, Augusta, Georgia, USA

Julio Hochberg MD
Division of Plastic Surgery, West Virginia University, Morgantown, West Virginia, USA

In selecting the method of reconstruction to be used following tumour resection in the face, direct suture, free skin graft, or flap (local or distant), several considerations have to be taken into account.

Pathological factors

High among pathological factors is the certainty of tumour clearance, particularly as it relates to clearance in depth, since this itself may determine whether a graft or a flap should be used. The graft, being thinner, is less likely to hide recurrence of tumour deep to it, compared with the thicker flap which may conceal recurrence until it is disastrously extensive. Whether it has proved possible to make use of 'tumour barriers' in the resection may also be a factor in decision-making. Cartilage and bone, the former particularly, are effective barriers to tumour spreading through them, and the act of removing as part of the overall resection the layer of bone and/or cartilage underlying the tumour may have the effect of converting the probability of deep clearance to a certainty, allowing the safe use of a flap where for other reasons, such as those of cosmesis, it would be preferable.

A further factor which may influence the use of a flap, particularly a local flap, is the pathological state of the surrounding skin. Skin tumours arise either in the midst of skin which is apparently normal, or as the most neoplastically advanced focus in a skin diffusely dysplastic as a result generally of exposure to actinic radiation. Such skin is seldom suitable for transfer as a local flap. Essentially premalignant and therefore unsuitable on pathological grounds, it is frequently also atrophic and this makes it also less than ideal for use on technical grounds. Fortunately most of the tumours which arise in such skin are slow growing and do not infiltrate deeply unless neglected over a long period. Most can be effectively managed by direct suture or free skin graft.

The infiltrative characteristics of the particular tumour type may also influence the form which reconstruction should take, whether the tumour tends to remain superficial or infiltrate deeply. At the opposite ends of this spectrum are the localized basal cell carcinoma with its typically lateral spread and the 'single lesion' squamous carcinoma with its pattern of deep as well as marginal spread.

Anatomical considerations

Anatomical considerations concern such matters as the surface which is exposed when the tumour is excised and whether or not it is readily graftable. Bare cortex of the calvarium and mandible cannot be expected to accept a graft, while the bones of the middle third of the face appear to possess a degree of vascularity which allow them to be grafted with good expectation of take. Less absolute criteria concern the surface left after excision which, although it might be technically graftable, would not allow such a procedure as interpositional grafting of a facial nerve to be used, either at the time or subsequently if a skin graft was used rather than a flap to cover the defect.

Certain resection sites are not capable of being grafted, for example those involving the full thickness of part or all of the nose. Skin–mucosal suture completed by a prosthesis may then provide the answer, followed after a period of waiting by the formal reconstruction, although on occasion the decision may be made that the prosthesis should continue as a permanency to provide the 'reconstruction'.

From the viewpoint of appearance, there is no doubt that, if one excludes the postauricular whole skin graft used in certain sites, most strikingly in the region of the eyelids, local flaps give the best cosmetic results compared both with grafts and flaps brought from a distant source.

When the demands of the pathological situation and those of cosmesis appear to be incompatible, for example where depth clearance is doubtful but a flap is cosmetically desirable, an approach which can provide a useful and effective compromise is to use a graft to provide cover on a strictly temporary basis despite its poor appearance. This manoeuvre allows the site to be watched until cure is regarded as virtually certain, say 12–18 months later, at which time the cover can safely be replaced with the appropriate definitive flap.

The expedient of temporary graft followed subsequently by definitive flap is one which the surgeon is likely to feel the need to resort to less frequently as his assurance grows with experience and he is better able to match pathological requirements with those of cosmesis, but even the most experienced surgeon is likely to have recourse to it on occasion when excision is in particular doubt. The unexpected recurrence, the patient with a history of repeated recurrences, the postradiotherapy recurrence in one of the awkward sites – nasolabial area, inner canthal area, periauricular and acoustic meatal region – these provide the most frequent situations where the problem arises.

1

Direct suture

The use which can be made of this method depends very much on the local availability of skin. This requires to be assessed preoperatively and to be demonstrably present if closure under tension is to be avoided, with spreading of the scar subsequently, or distortion of the nostril, lip, eyelid and eyebrow.

1

Availability runs in parallel with the presence of a wrinkle pattern in the face and how deeply etched the pattern is in the skin. The most striking wrinkle pattern runs at right angles to the underlying muscles of facial expression. Since these are concentrated around the mouth and eyelids the pattern is most marked in relation to these structures – the vertical striations around the mouth, related to the underlying orbicularis oris sphincter, the nasolabial fold in relation to the dilator muscles radiating outwards from the angle of the mouth, the glabellar pattern in relation to the vertical muscles which pass upwards from the glabella into the forehead, and the 'crow's foot' pattern radiating from the lateral canthus, indicative of the orbicularis oculi muscle. These are the most marked examples, but the pattern itself, and its magnitude at the different sites, are indicators of the habitual facial expression which is individual to each patient. As a corollary the surgeon should be wary of the older patient whose face is devoid of wrinkles. Such a face usually has a certain 'rotundity' and the combination indicates that skin availability will be minimal.

A less obvious wrinkle pattern which is also present in most adults is related to the gravitational sagging which results from a loss of dermal elasticity and slackness of the skin generally, most markedly around the eyelids, and the angle of mandible and submandibular area generally.

The fine pattern of wrinkling which is often present in the aged and usually markedly sun-damaged skin is of little use to the surgeon as an indicator of skin availability. It is invariably associated with the other patterns in any case.

2

The wrinkle lines of expression are useful to the surgeon in two ways. Their presence indicates a laxity of tissue on each side of the wrinkle and they indicate also the line along which, or parallel to which, the ellipses of skin excision should be placed so that the scar will be in or parallel to the wrinkle and less conspicuous as a result.

There is one significant exception to this general truth, namely the forehead. There the predominant wrinkle pattern is horizontal, but in excising lesions of the forehead an overriding consideration is the symmetry of the eyebrows. Over the lower two-thirds of the forehead the deep fixity of the scalp is converted to mobility as a result of the change from the galea to the frontalis muscle. The action of this muscle is to elevate the eyebrows. With the scalp fixed in position while the eyebrows are mobile, the effect of a significant horizontal excision on one side of the midline, particularly in the lower two-thirds of the forehead, is to pull up the eyebrow and produce a very obvious asymmetry. Because of this, unless the ellipse of the excision is a narrow one, vertical excisions are generally to be preferred and, unexpectedly, they result in remarkably inconspicuous scars if the lines of the wrinkles are matched on both sides.

The pattern of forehead wrinkling becomes more complex towards the midline, with the intrusion of the glabellar muscles. The pattern of wrinkling which results varies considerably in depth and extent in individual patients, but it can be used to good effect without producing eyebrow asymmetry.

The amount of skin available and whether or not the tissues can tolerate the excision is usually obvious, but where there is doubt the skin can be pinched up between the finger and thumb to mimic the effect of the elliptical excision and give a guide as to whether tension will be too great or distortion will be produced.

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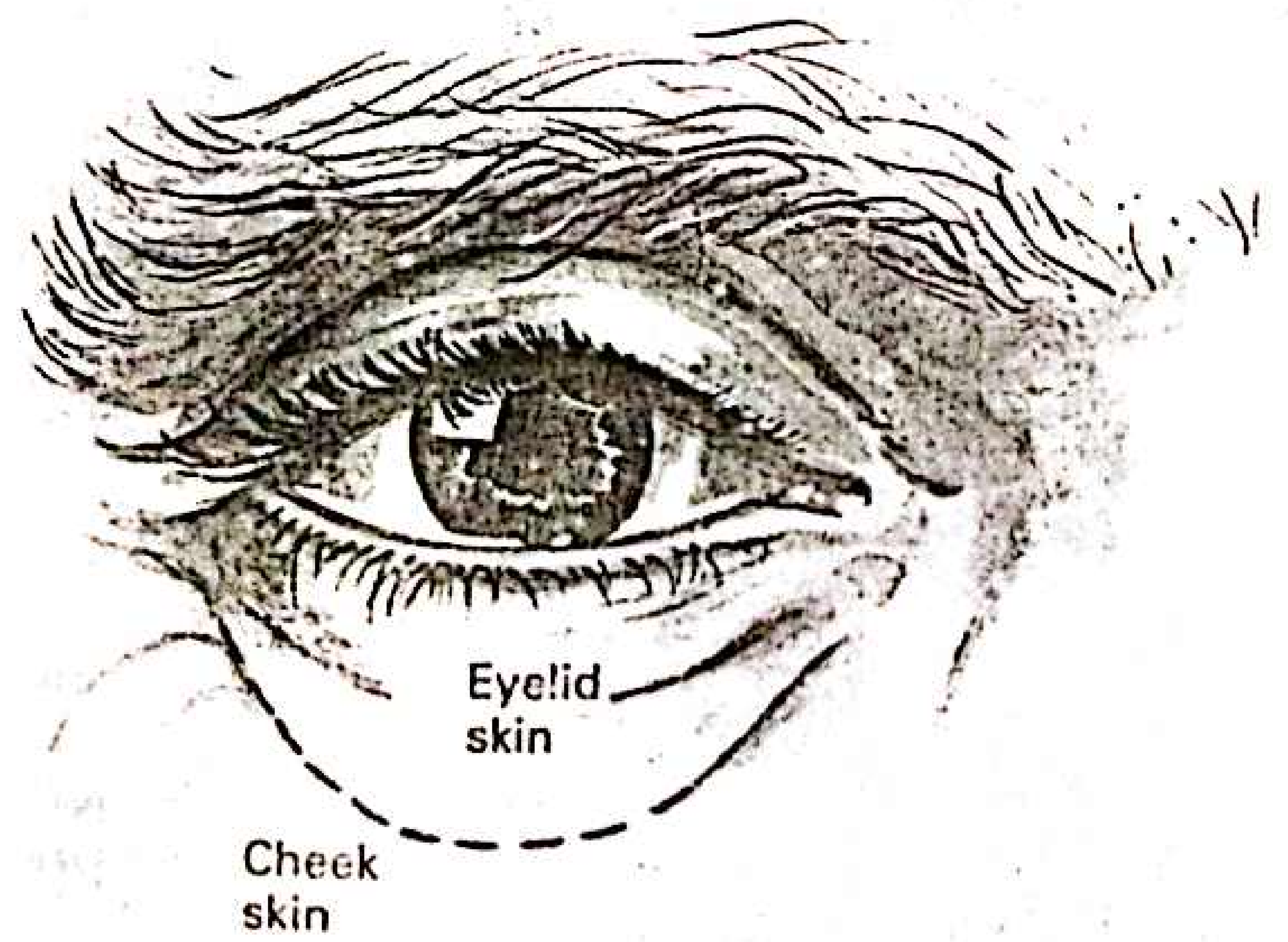

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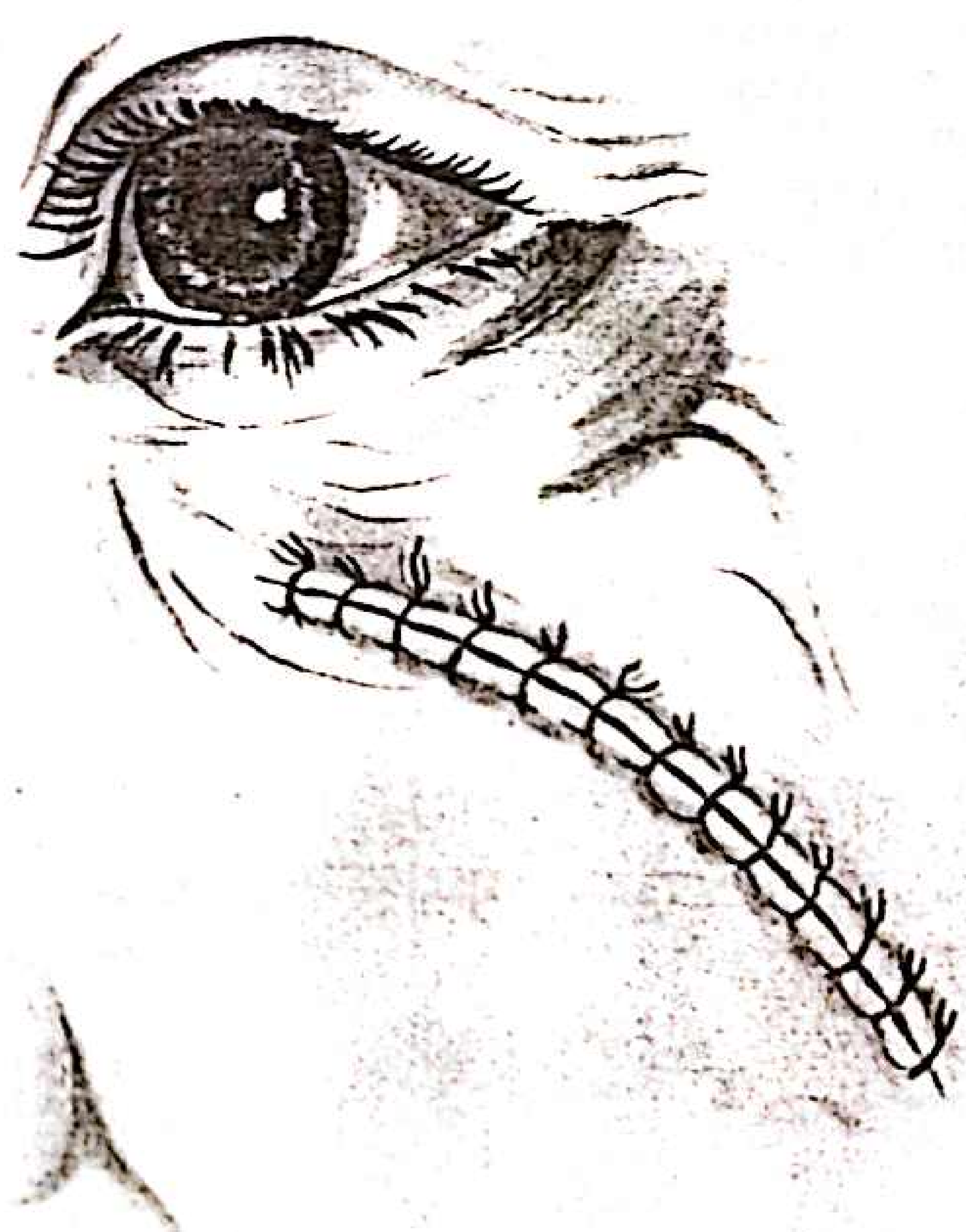
A site where particular care has to be exercised is in the lower eyelid, because of the effect of gravity on the lid and its comparative inability to cope with gravitational forces. This is particularly marked in the older patient whose tarsal plate often tends to be lax in any case. In the normal lower eyelid the skin is loosely attached to the periosteum of the inferior orbital margin, creating the malar furrow. It is this attachment which prevents the gravitational pull on the cheek from being transmitted to the lower eyelid in the normal individual and so prevents ectropion. In assessing the amount of lower eyelid skin which can be excised without producing ectropion, the skin above the malar furrow, that is the eyelid skin, must be carefully distinguished from the skin below, that is the cheek skin. Any encroachment on the latter by pulling it up in the 'pinching' process will result in ectropion.

4

4 & 5

The problem of lower eyelid excision can be resolved on occasion by making the ellipse an oblique one so that the tension of closure passes lateral to the outer canthus, removing the stress from the lid itself. Once in the cheek, the lines of election run obliquely downwards and laterally and the scar which results should be a good one.



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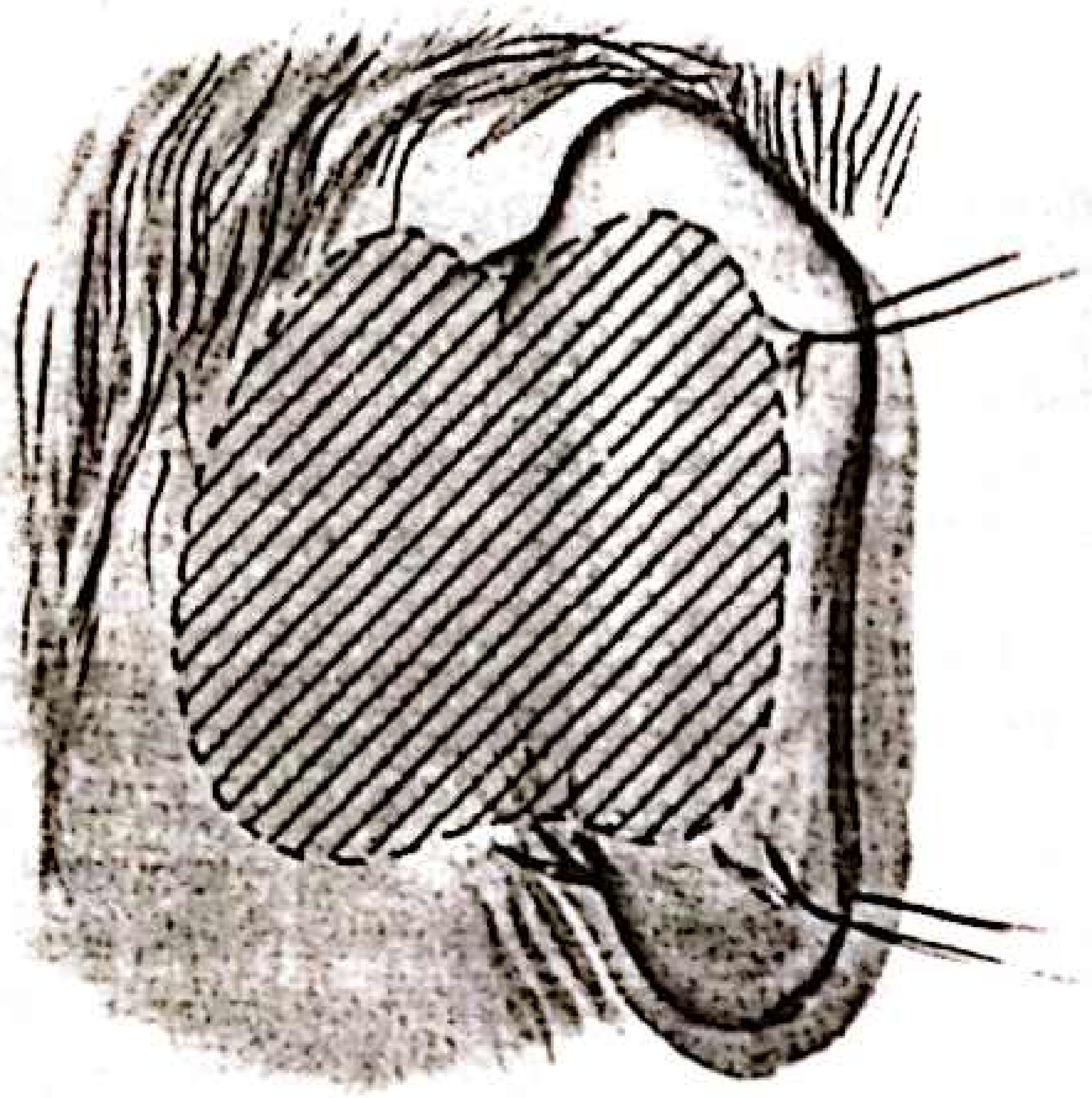
Free skin grafts

A major consideration which determines whether or not to use a whole skin graft or a split-skin graft concerns how essential it is that there should be no subsequent contraction of the graft. If contraction is likely to affect the result adversely to an unacceptable degree, a whole skin graft must be used. The most obvious example of such a situation concerns the eyelid defect. The eyelid, upper or lower, is not capable of withstanding the powerful contractural tendency inherent in all split-skin grafts, and the whole skin graft is virtually mandatory for resurfacing the eyelid defect which results from tumour excision.

The use of large areas of whole skin graft is precluded by the fact that, unlike the split-skin graft which leaves a proportion of the adnexal structures behind in the donor area, from which spontaneous healing occurs, the whole skin graft leaves none. The defect created when it is raised has either to heal from the margins of the donor site, be closed directly, or be covered by a split-skin graft. Direct closure is the method generally used and this limits the size of defect which can conveniently be covered with a whole skin graft in practice.



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The whole skin graft which is used with any regularity is taken from the postauricular site. The redundant skin of the upper eyelid is also used as a source, particularly for defects of the orbital area, but the small amount available limits its usage very materially and the postauricular whole skin graft is used in that site much more often. The eyelid area, especially the inner canthus, is one which regularly provides postexcisional defects and here the postauricular whole skin graft has its most frequent usage. It gives an outstandingly good colour and texture match, better than any other reconstruction in many instances. In other sites on the face its role is restricted by the fact that the area available is limited to the hairless skin behind the ear and on its posterior surface.

7

7

The defect in the donor site is closed directly.

For the larger defect there is no alternative to the split-skin graft, although it seldom provides a good colour and texture match, becoming either paler than the surrounding skin or hyperpigmented. Quite apart from the poor colour match, the split-skin graft tends to produce a flat, rather expressionless, appearance, the normal play of facial expression being largely lost. Considered from a cosmetic point of view it should be avoided if possible.

Grafts, whole skin or split-skin, are largely hairless, even cut from a hairy area, and certainly never match the male beard area in that respect, a characteristic which is liable to detract further from their cosmetic acceptability in certain circumstances.

Flaps

The flaps which are used in reconstructing facial defects can be divided into local flaps, which use as donor sites the adjacent skin of the face, and distant flaps, which involve transfers from donor sites below the clavicle.

Examples of each group are used in reconstructing both surface defects and defects of the upper aerodigestive tract and, in order to avoid duplication, the basic design of those flaps which have such a dual role will be described in relation to their usage in reconstructing surface defects. Their role in reconstruction of the aerodigestive tract will be discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

8

Local flaps

8

The face in most adults, as already stressed, has a degree of laxity of the skin which is concentrated in areas of availability, strikingly in the mandibulomasseteric area, the nasolabial fold, the glabellar area and adjoining forehead, and the temple. They play a significant role in the construction of local facial flaps.

In sites other than the face local flaps usually leave a secondary defect when they are transferred, and this has to be split-skin grafted. In the face, flaps are designed wherever possible in such a way that secondary defects can be closed directly or avoided completely. This is achieved by exploiting the areas of availability. The slack which is present preoperatively in one or other of these sites is either taken up as the flap moves into its transferred position or the defect left by the flap is sited in an area of availability and so can be closed directly.

Many local flaps have been described for use in facial reconstruction, but it is striking how those which have become part of the standard repertoire fill a regularly recurring therapeutic need and also exploit the areas of availability most effectively.

ROTATION FLAPS

The design requirements of these flaps call for a significant area of skin which is not broken by anatomical structures such as the nose, eyes, ears and lips, if a flap is to be designed to reconstruct a reasonably sized defect. In the face such flaps are most often designed on the cheek and submandibular area, occasionally extending onto the neck. In this site they make use of the mandibulo-masseteric area of availability and for their effective use it is essential that a reasonable laxity should be present in that area. Its presence must always be tested for before the procedure is embarked upon.

Rotation flaps are also used in the scalp, but in that site there is no area of availability to be exploited and a secondary defect is often left which has to be grafted. As with rotation flaps in general, the defect to be reconstructed is designed in the form of a triangle, rotation of the flap bringing one side of the defect over to the other, in this way closing it. The consequence of this is that the apex of the triangle adjoins the base of the flap.

Inferiorly based rotation flap

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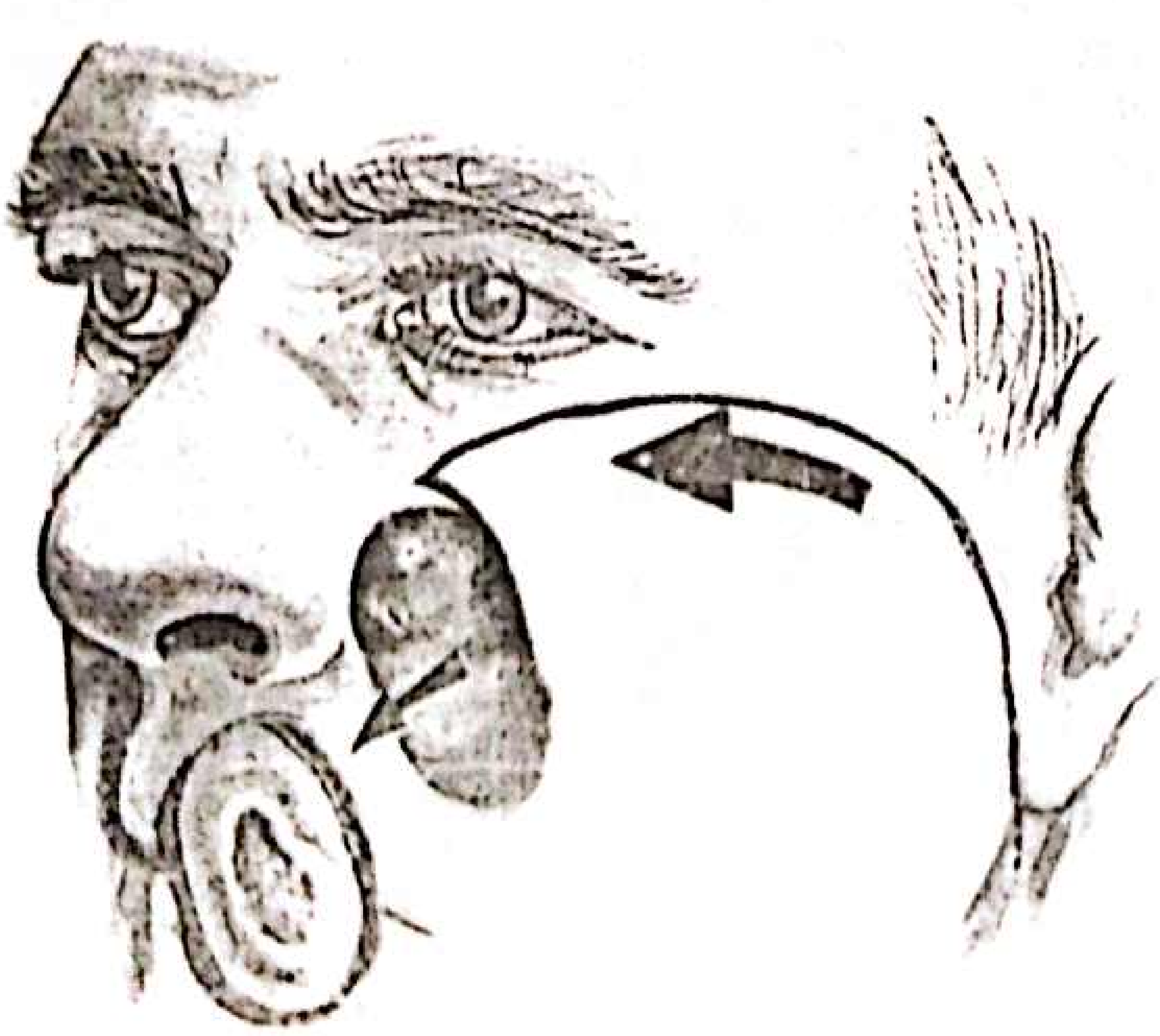
The inferiorly based flap is used to reconstruct defects in the region of the nasolabial fold where it has been possible to design the defect in the form of a triangle with its apex inferior and the long axis parallel to the fold.



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The outline of the flap approximates to a half circle, curving over the malar prominence towards the pre-auricular fold, where it runs down vertically to the ear lobe, extending beyond it for 1–2 cm. An important aspect in the design of the flap concerns its detailed line and the steps which are taken to minimize tension in the flap at completion of its transfer.

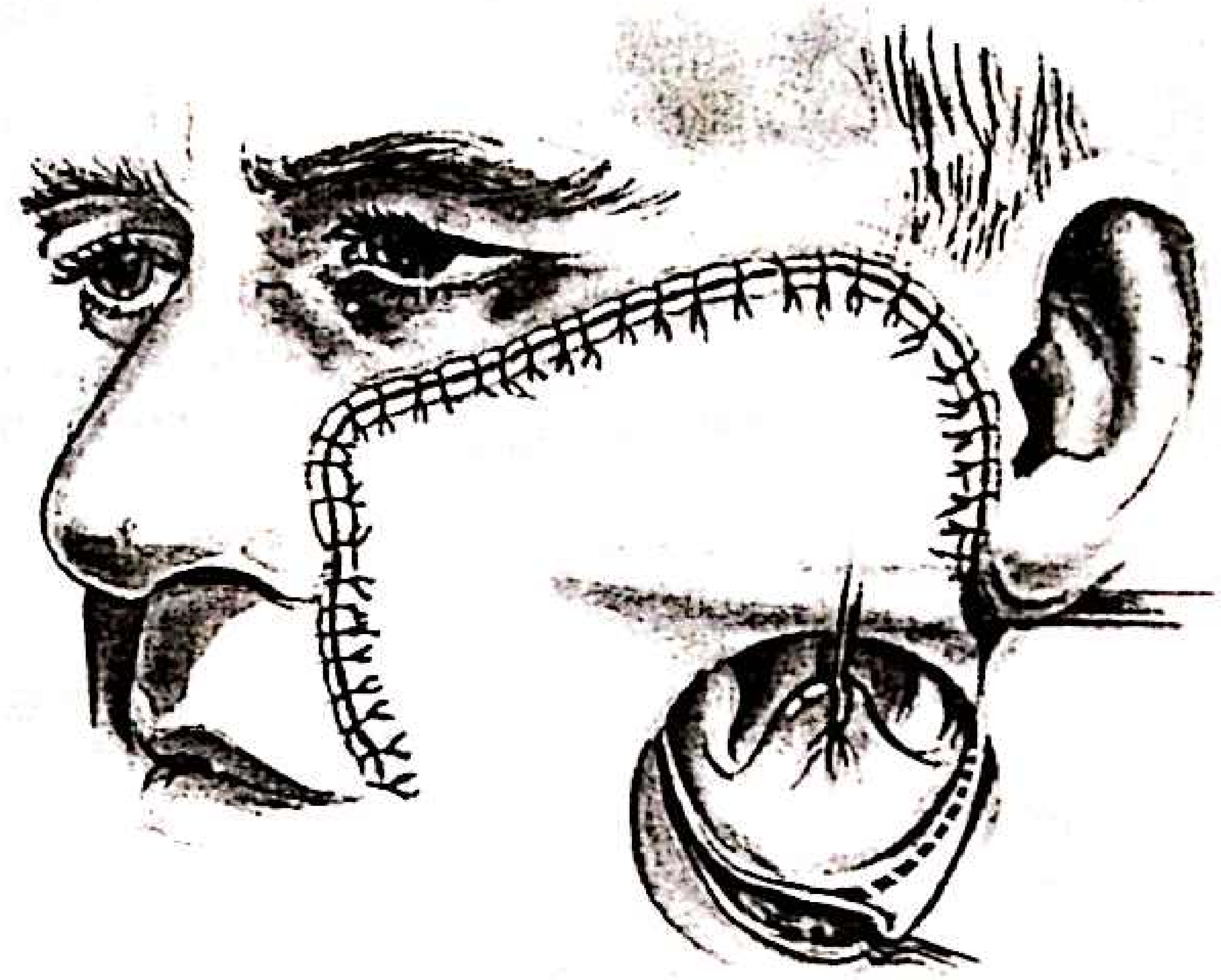
Two such steps are taken – the margin of the flap adjoining the triangular defect is made a little longer than the side of the defect itself, and the line of the flap as it passes back from the defect passes upwards as well as backwards. This latter step has the effect of reducing the tension which might otherwise pull the lower eyelid down and result in ectropion. The flap is raised in the usual 'face-lift' plane, between skin and muscle.

11

With the flap transferred, the discrepancy between the two sides of the line to be sutured is reduced as far as possible by suturing under differential tension. This is only occasionally totally effective on its own and a further step is usually required. As suturing reaches the ear lobule the discrepancy manifests as a 'dog ear' on the postauricular side of the suture line and this is excised, leaving the scar hidden in the postauricular fold.

The main hazard of the procedure is haematoma and steps to prevent it are taken at all stages. Haemostasis must be meticulous throughout, and a suction catheter can be inserted under the flap through the postauricular part of the incision where the scar will be hidden. Suction should be continued until drainage has stopped completely. It is probably wiser to leave the area exposed and allow effective monitoring of the state of the flap.

The rotation flap used in this way gives an excellent final result but it does not have a wide safety margin. It requires to be judged with care and calls for scrupulous technique, both intraoperatively and postoperatively, particularly to ensure that there is no tension build-up from haematoma. A valuable step in raising the flap is to make regular trials of the transfer so that it is not elevated unnecessarily.



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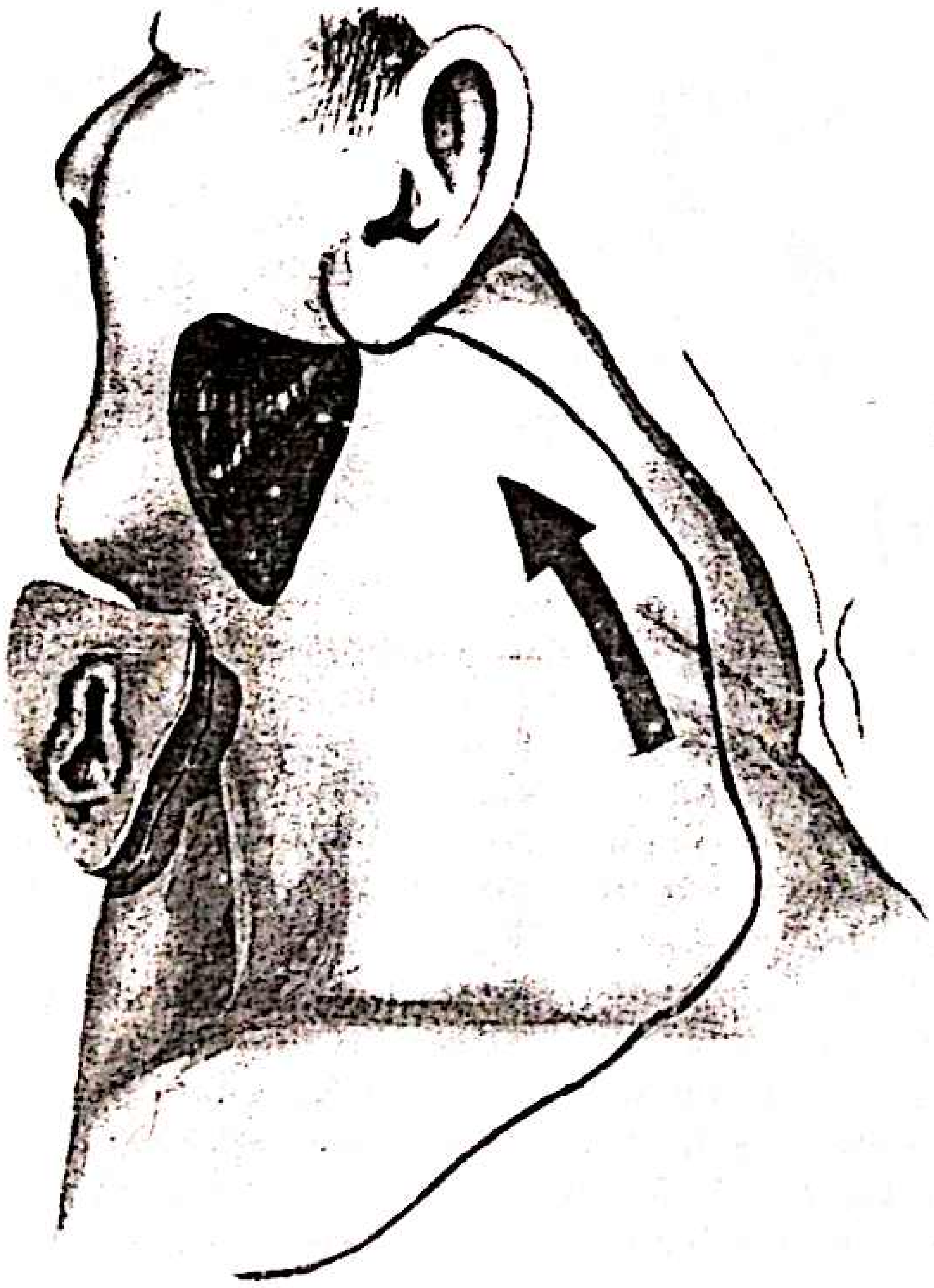

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An alternative form which the rotation flap can take brings the submandibular and neck skin areas into the design. The defect is more vertical than the usual nasolabial defect and the base of the flap becomes vertical rather than horizontal. The line of the flap passes under the lobe of the ear and curves down over the neck skin onto the upper chest.

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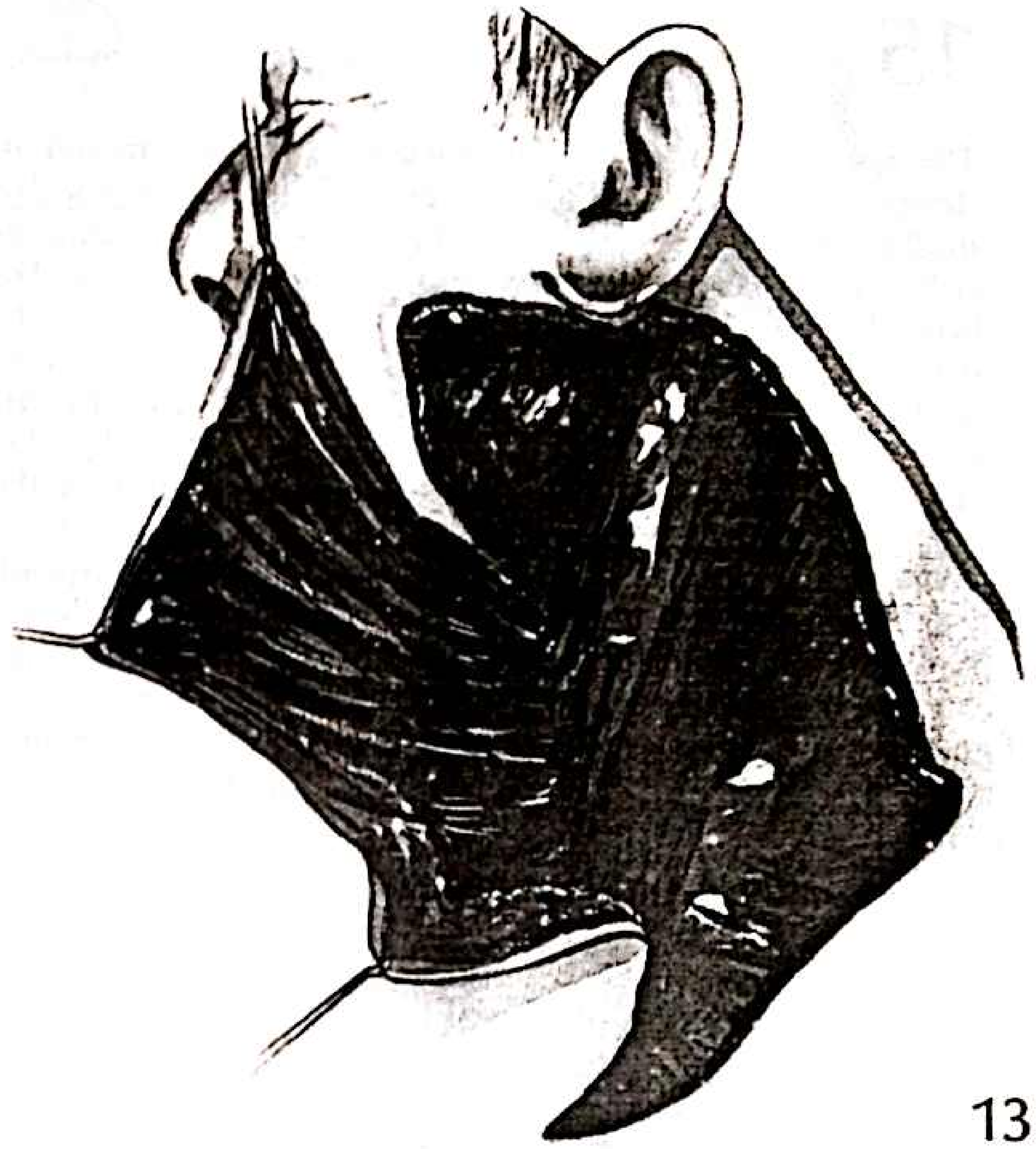
In the neck the flap is elevated deep to platysma so that its vascularity can make a contribution to the blood supply of the flap as a whole.



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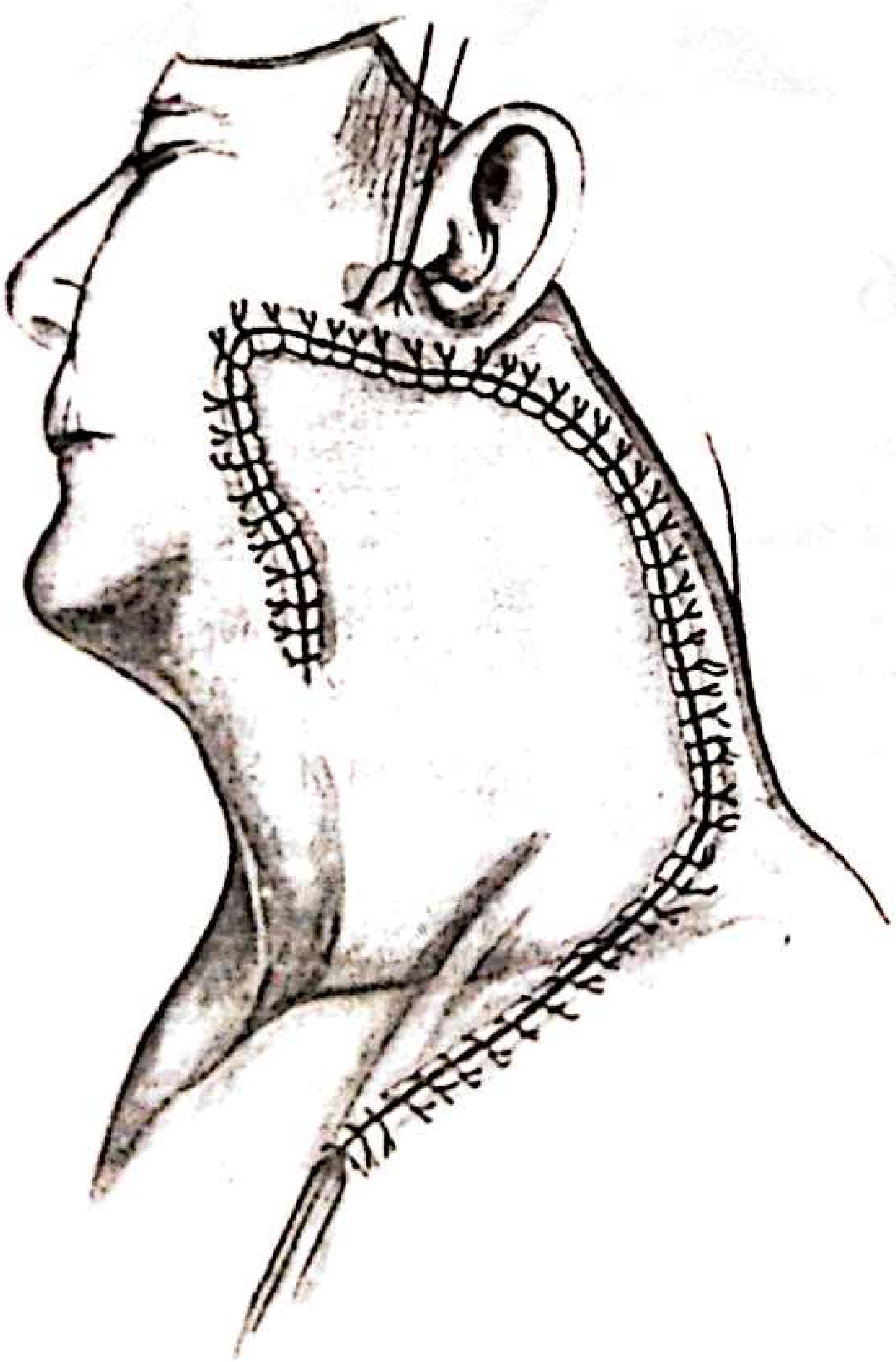

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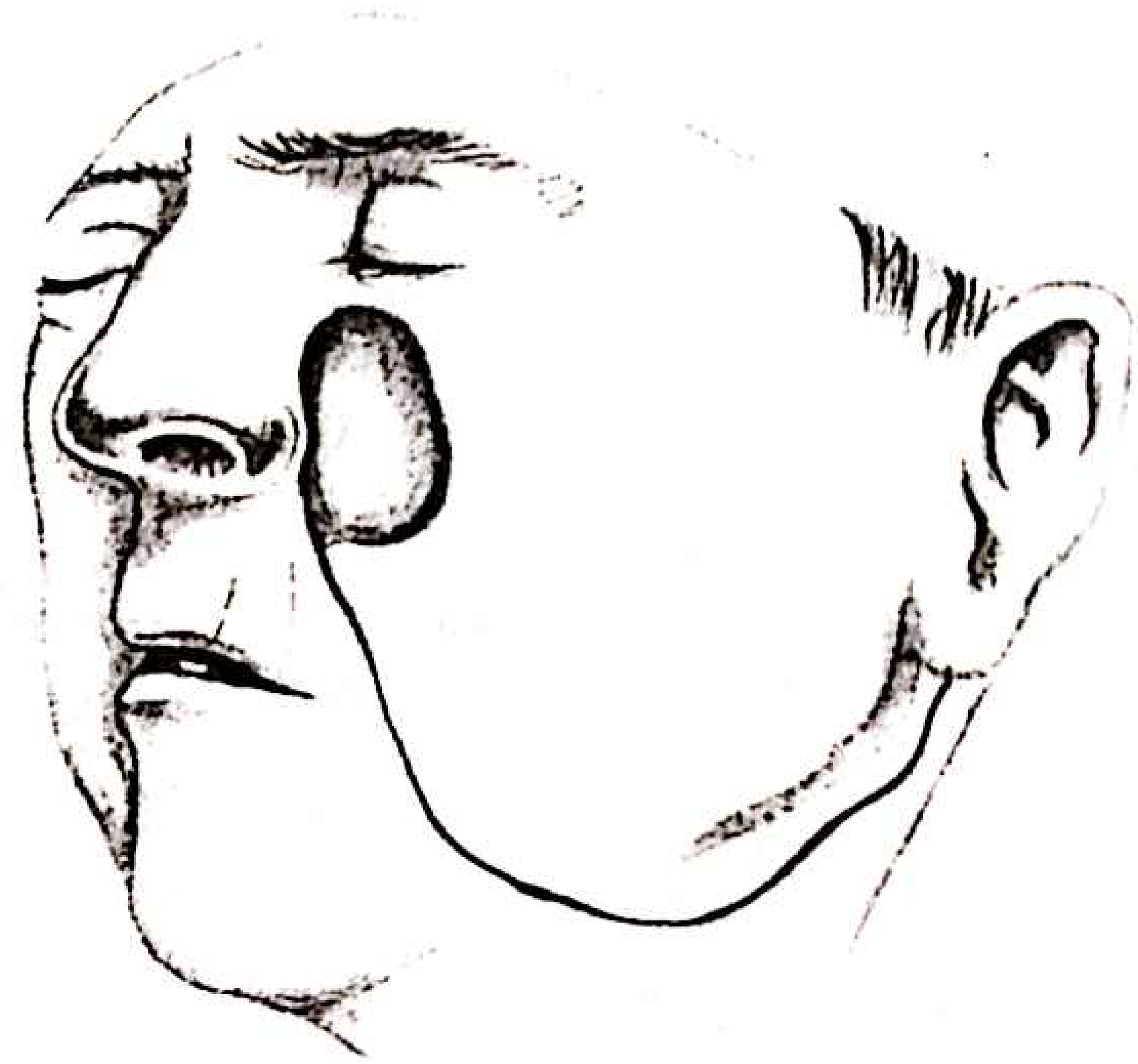
The laxity of the tissues in the area, concentrated in the mandibulomasseteric area, usually allows complete closure of the skin using differential tension in suturing.

Superiorly based rotation flap

15

The superiorly based flap has its main value in managing defects of the cheek, but it has also been described in managing the exenterated orbit. The defect is triangulated with its apex facing laterally and slightly downwards. The line of the flap runs down along the junction between the nose and the cheek, and continues along the nasolabial fold over the lower border of the mandible to the submandibular area. There it follows a suitable skin crease, curving back and finally slightly up towards the mastoid area, stopping about the line of the ear lobe. With a proportion of the defect directly below the lower eyelid, it is important at the design stage to have the defect extend medial to the medial canthus, so that the tendency of gravity to pull the eyelid down and produce ectropion is countered by the support provided by the suture line along the junction between nose and cheek.



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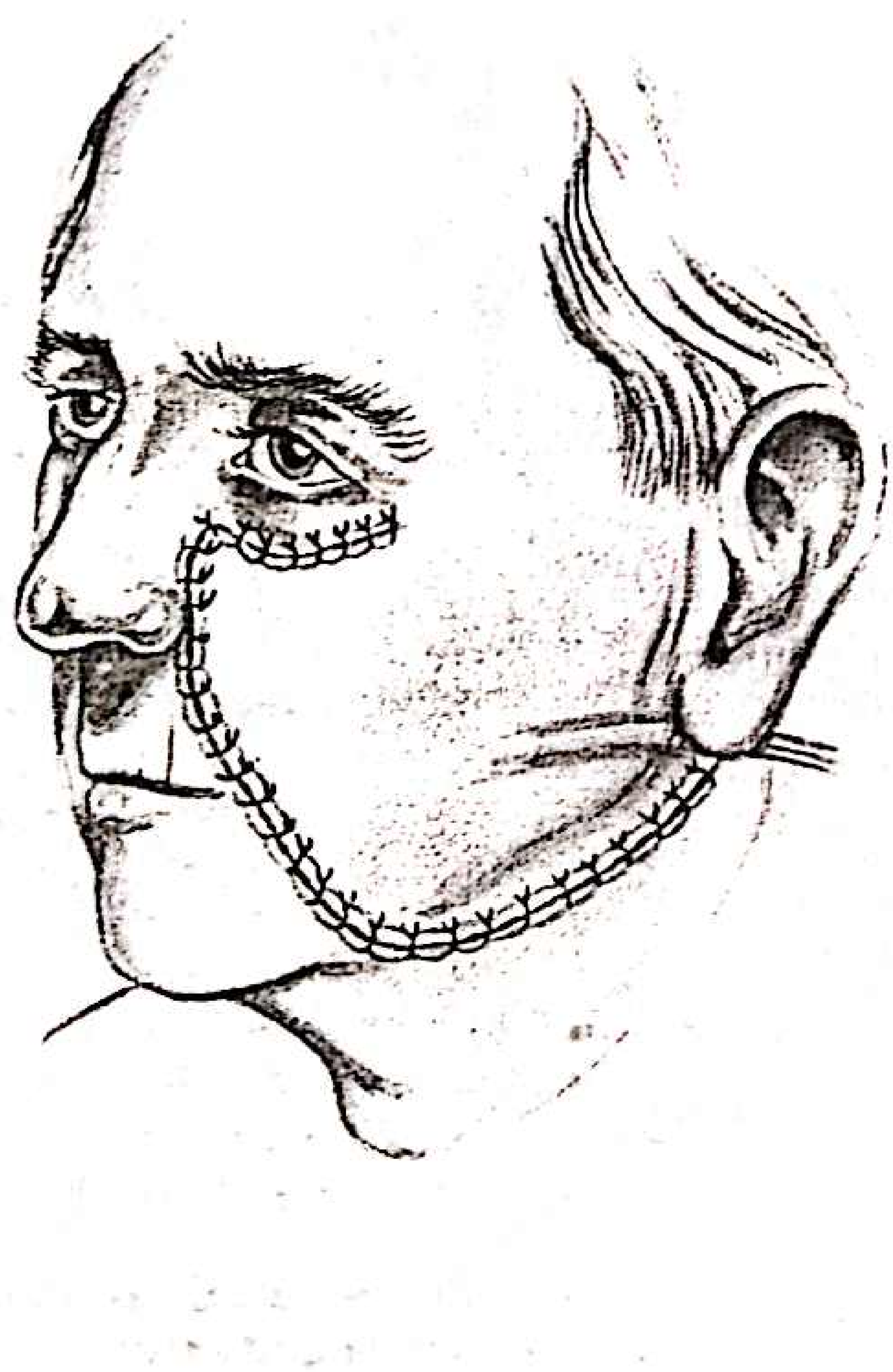

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The success of this flap depends very much on the presence of the mandibulomasseteric area of availability and it is usually possible to achieve complete closure using differential tension suturing. The best cosmetic result is achieved where there is a well developed pre-existing nasolabial fold and the submandibular skin creases are well marked. By raising the lower part of the flap superficial to platysma, problems with the mandibular and cervical branches of the facial nerve are avoided.

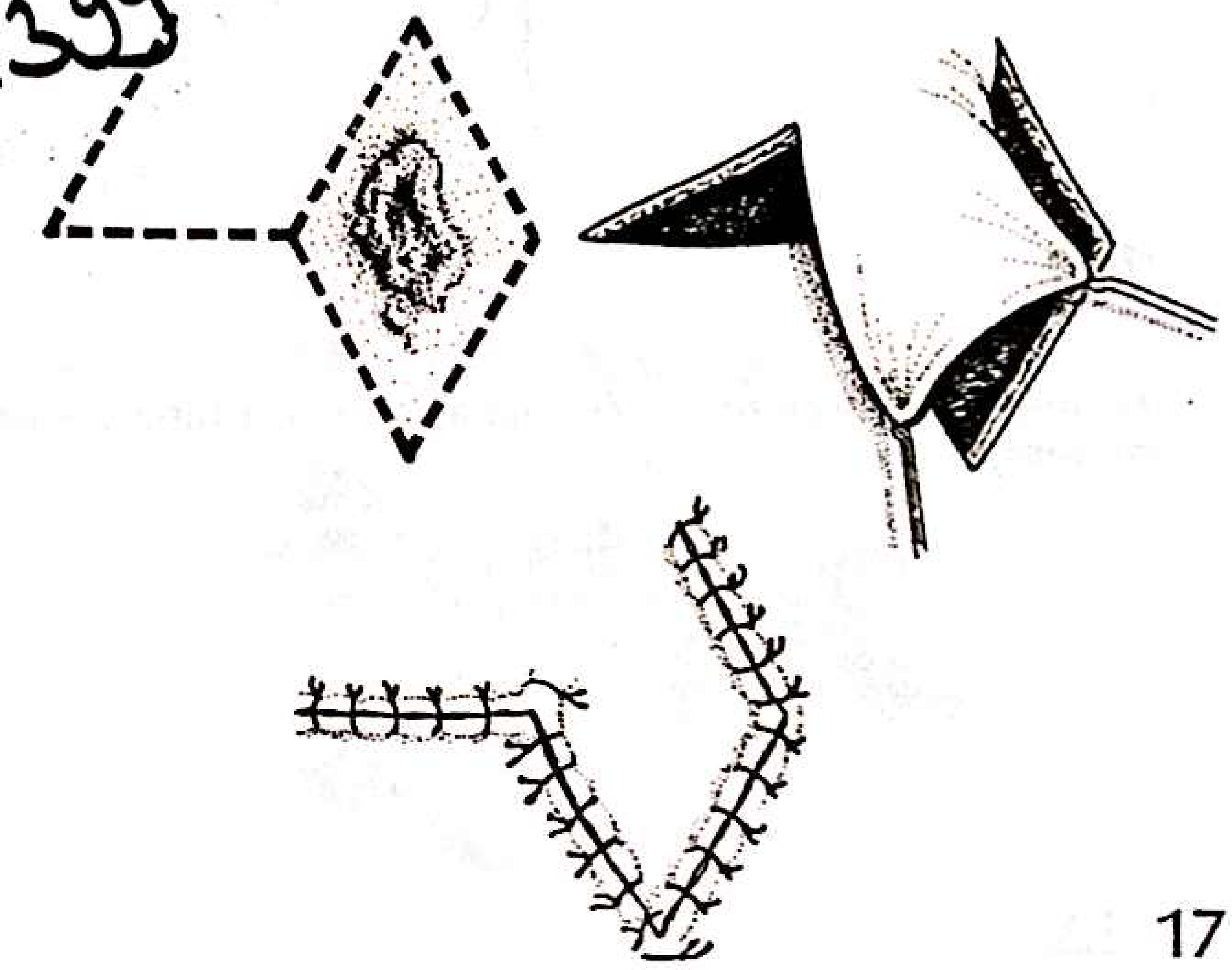
Rhomboid flap

This flap is unusual in having a much more precise design than most other flaps, both in the shape of the defect and the flap which is raised to fill it.

1399

17

The defect is created as a rhombus whose shorter diagonal equals its sides in length, giving an appearance of two equilateral triangles sharing a side. The flap is outlined by extending the shorter diagonal for a length equal to it and from its extremity a back-cut is made at an angle of 60°. The flap enclosed by these lines is raised and transposed into the defect. Having the same shape and dimensions as the defect, the flap fills it exactly. The secondary defect left by the transfer is closed directly.



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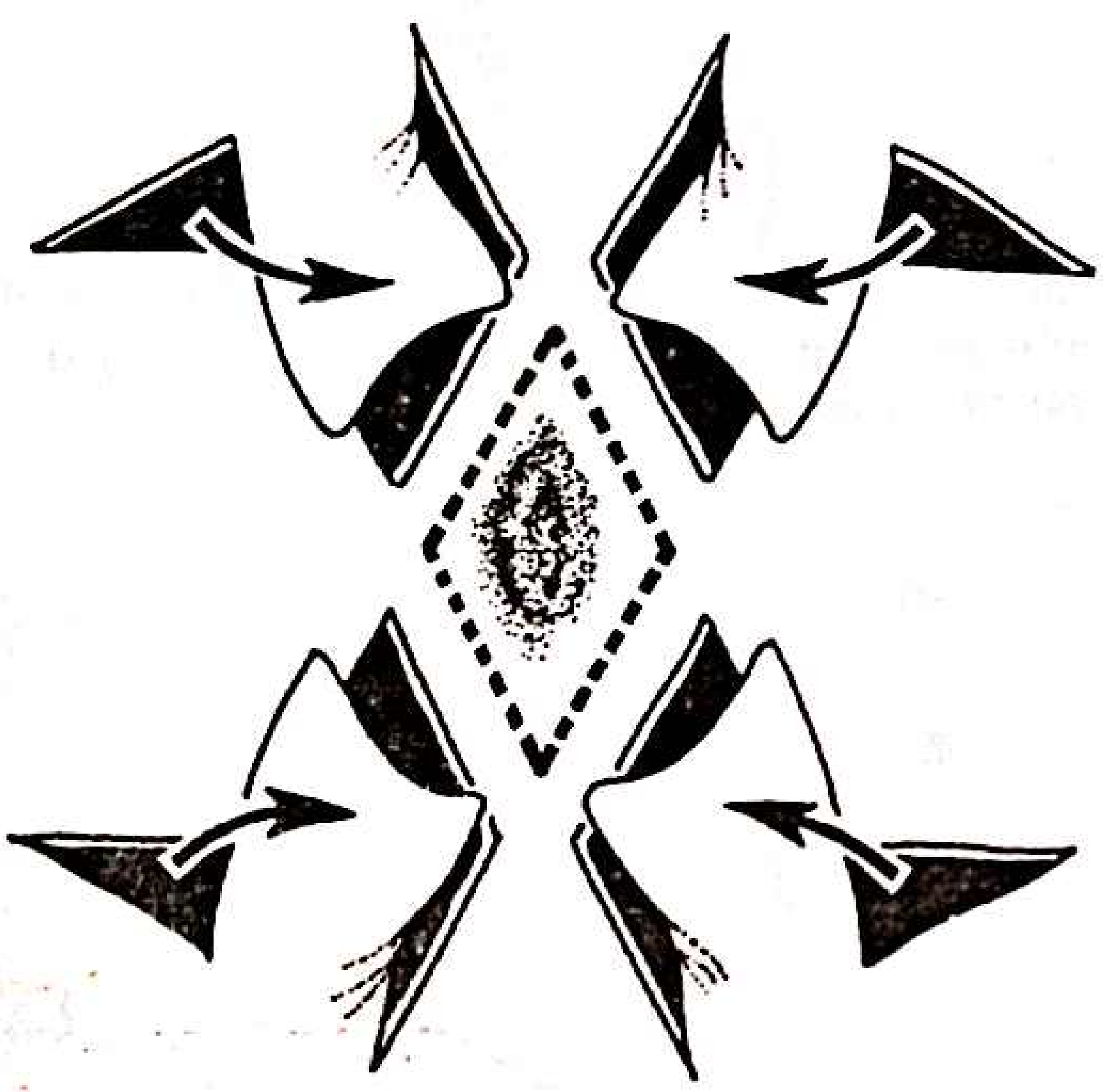

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Using such a design, four flaps are theoretically possible since the shorter diagonal can be extended in either direction and the flap can be designed on either side of it. In practice the flap is positioned on the side of the defect where tissue is available, on which it can be placed. The ease with which the secondary defect is closed is also dependent on the local availability of skin. Together these factors together determine which of the four potential flaps is selected in practice.

The practical consequences of these theoretical considerations are that if the defect left when a lesion is excised cannot be designed as an appropriately sited rhomboid, the method cannot be used. The secondary defect created when the flap is transferred must also be in a site and direction where tissue is available for closure. If the defect in its shape and site permits the axes of the rhomboid to be selected, for example if the lesion is circular, the possibilities of placing the secondary defect in a suitable position for easy closure are greatly increased.

The rhomboid flap can be used in many clinical situations, but a considerable number of these could be managed equally well by excising an ellipse and closing the defect directly.

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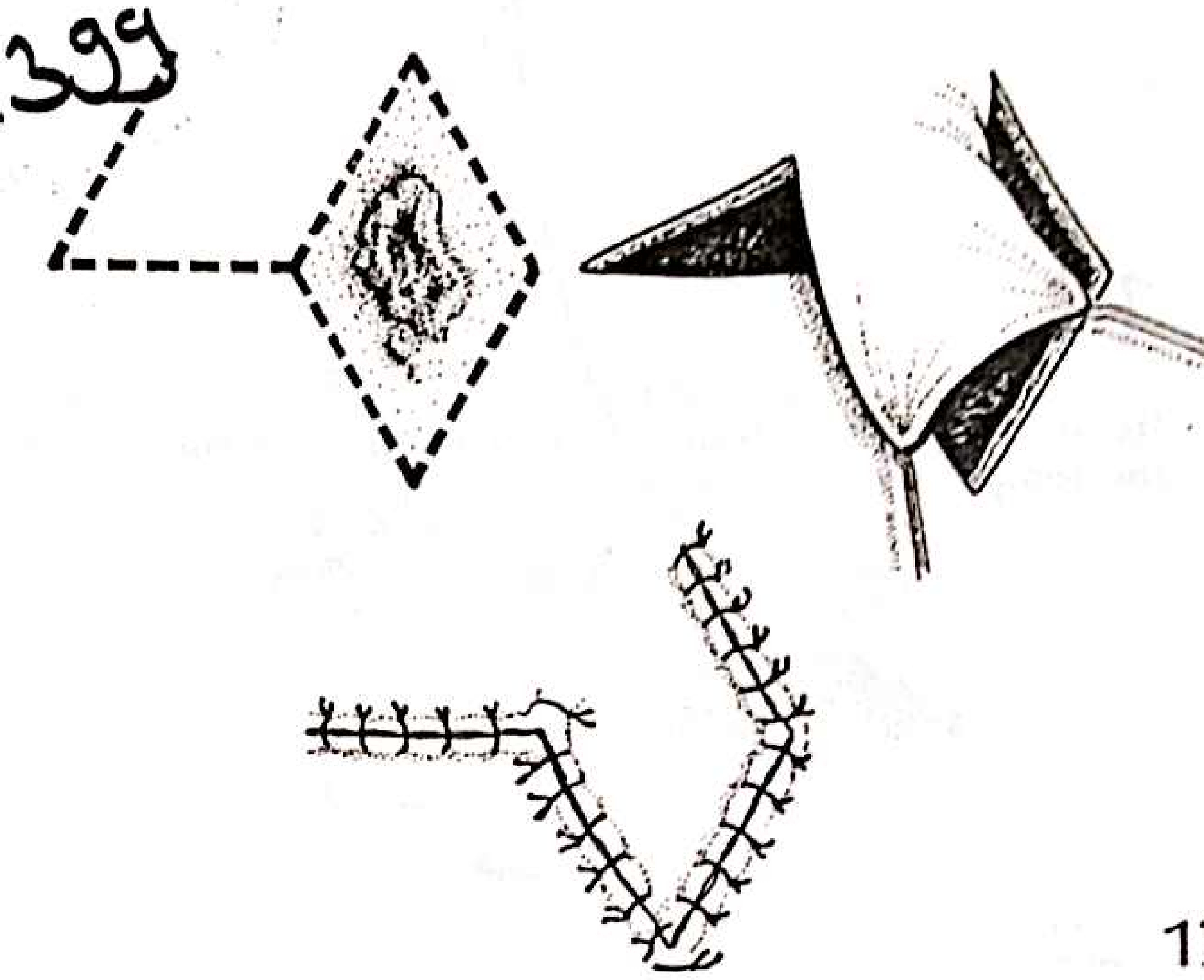

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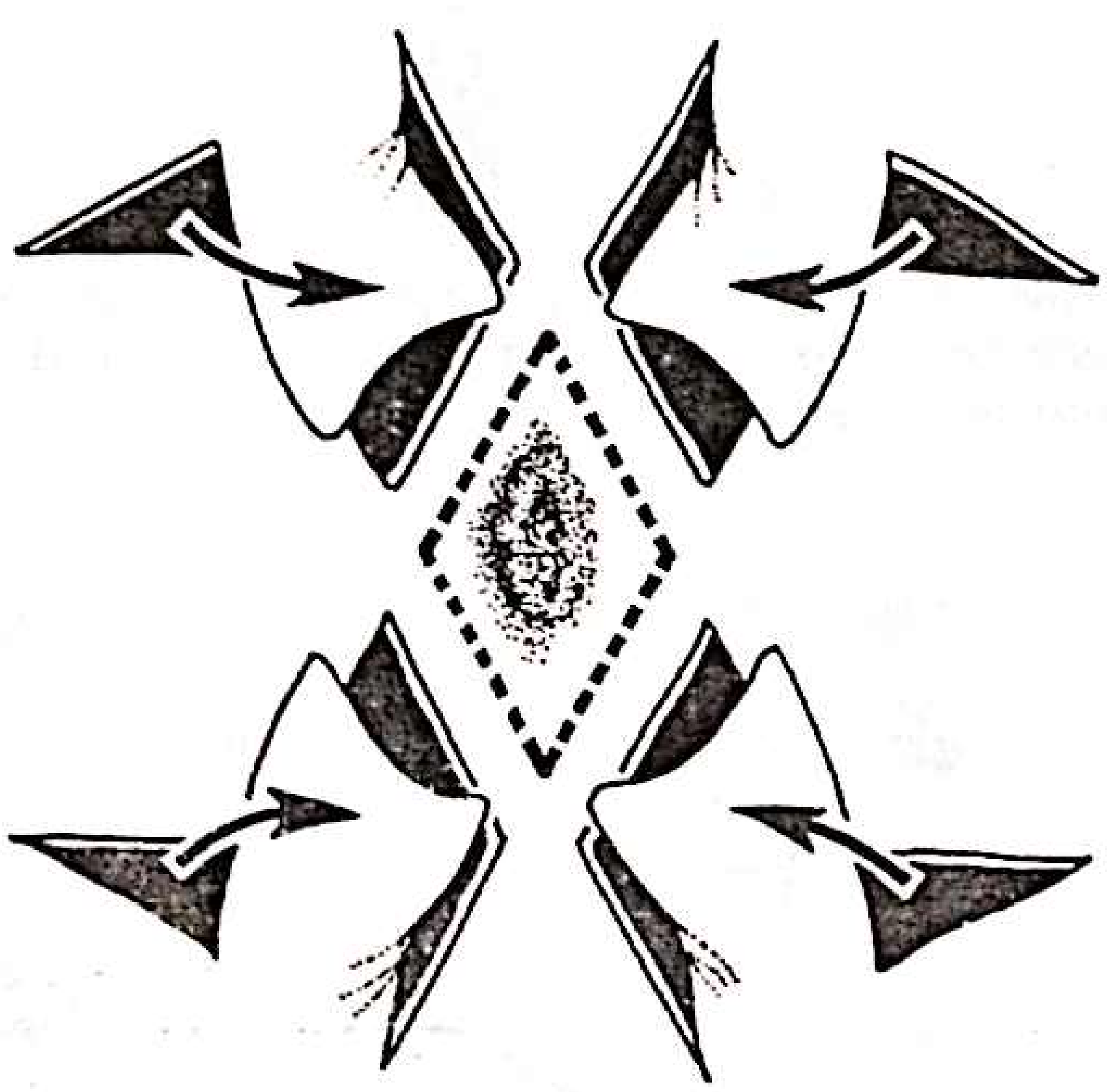

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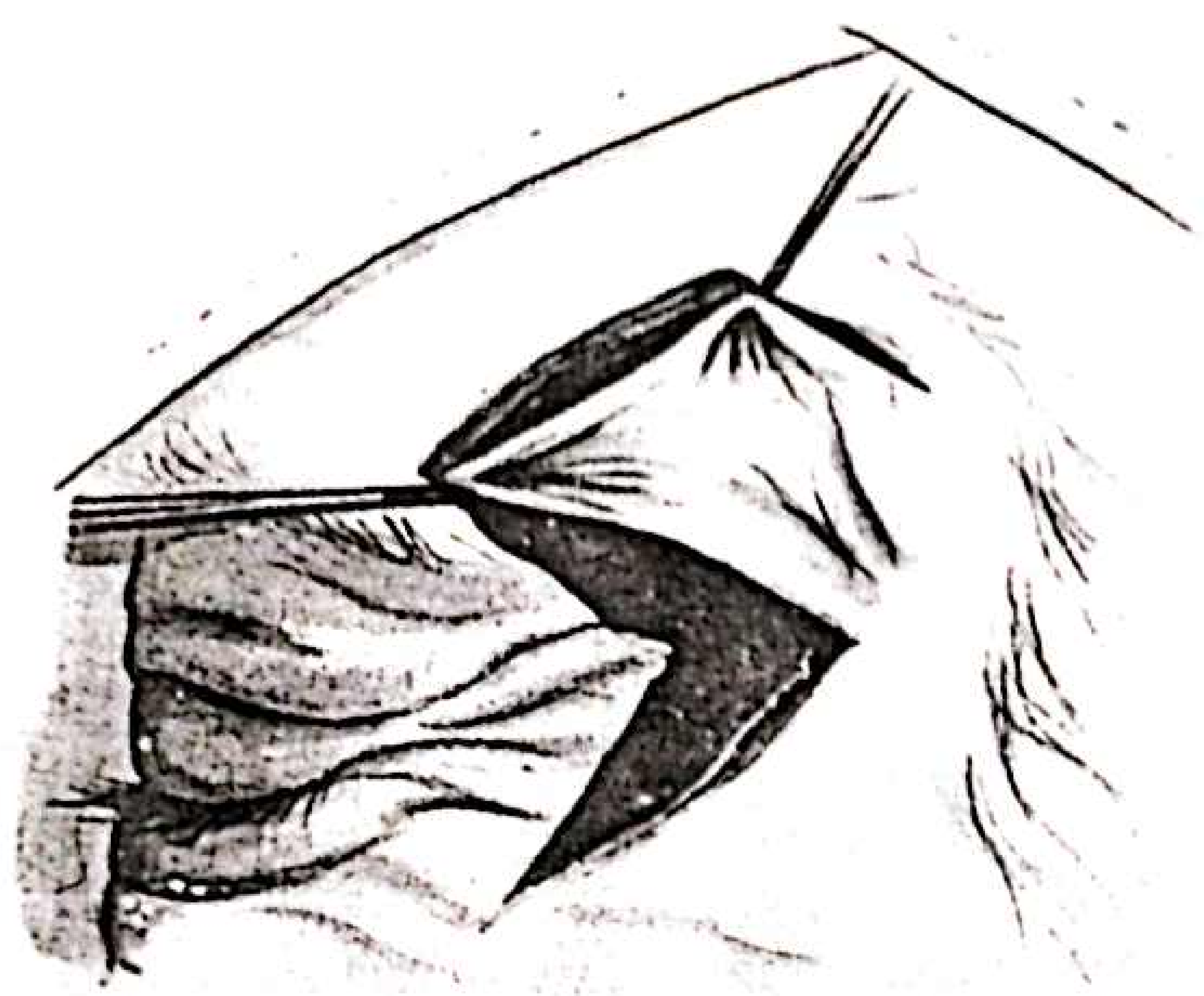
The rhomboid flap can be used in many clinical situations, but a considerable number of these could be managed equally well by excising an ellipse and closing the defect directly.

19

Its unique contribution is in managing small tumours of the temple area.

19



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In this site it is essential to maintain the distance between the eyebrow and the anterior hairline, and avoid distortion of either anatomical landmark.

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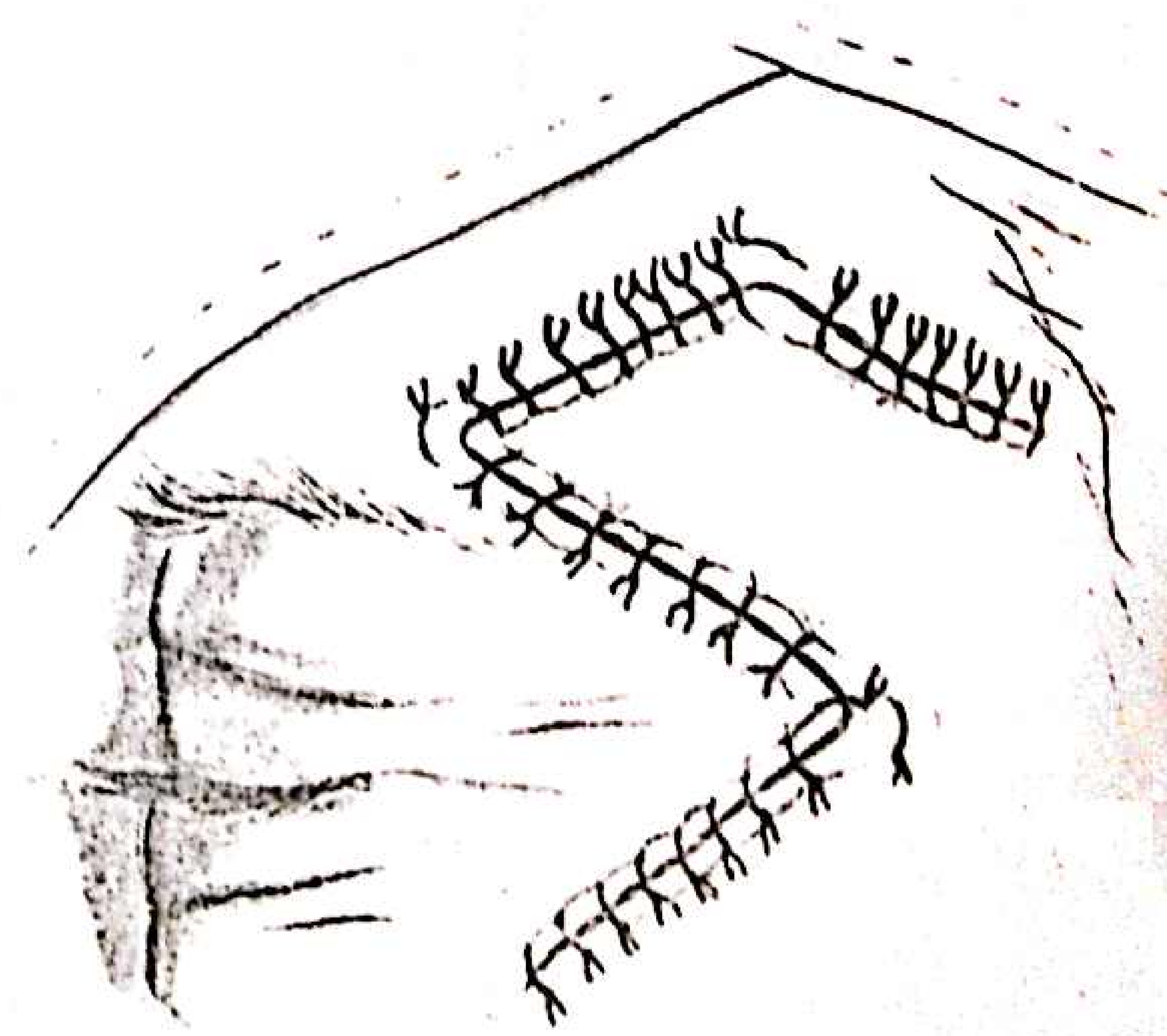
The rhomboid flap achieves this by transferring the defect from one which cannot tolerate the distortion of direct suture into one in a different site where closure does not give rise to distortion.



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The lesion which is suitable for reconstruction with a glabellar flap is one sited in the hollow on the side of the nose below the medial end of the eyebrow, medial to the inner canthus and the cheek just below it, whose resection can be designed to leave a triangular defect with its base towards the canthal area. The flap is constructed on the hairless skin between the eyebrows and the forehead above it, outlined as an inverted V as broad as the distance between the eyebrows, and pedicled on the skin area around the supraorbital foramen on the opposite side of the forehead from the defect. It includes in its pedicle a proportion of the supraorbital and supratrochlear arteriovenous systems. The height of the V is dictated, not by the needs of the reconstruction, since the upper part of the flap is usually removed in the process of trimming it to fit the defect, but by the need to avoid a dog-ear when the secondary defect is closed.

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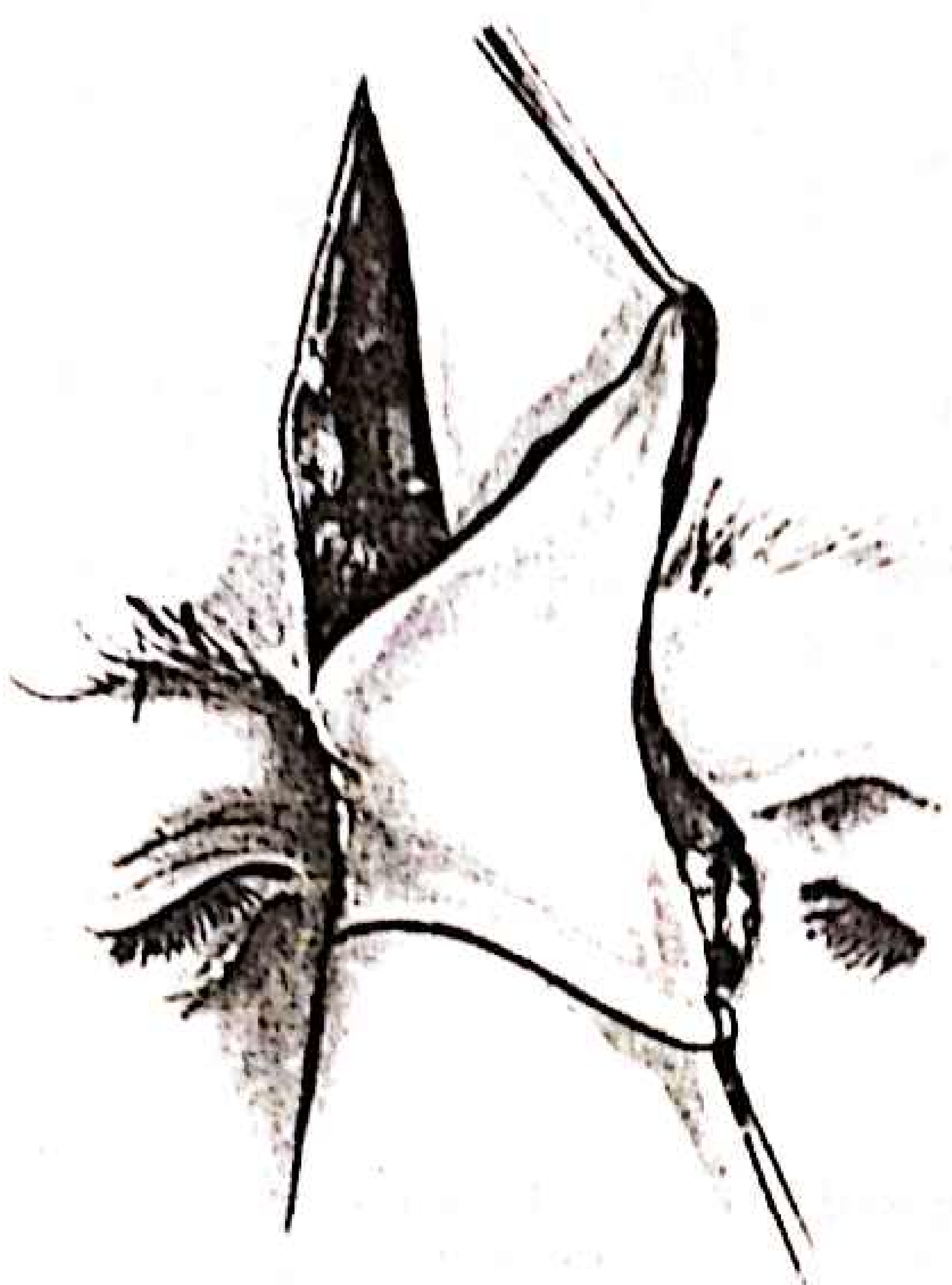

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The flap, outlined in this way, is elevated to its base and rotated into the primary defect, leaving a secondary triangular defect in the centre of the forehead.

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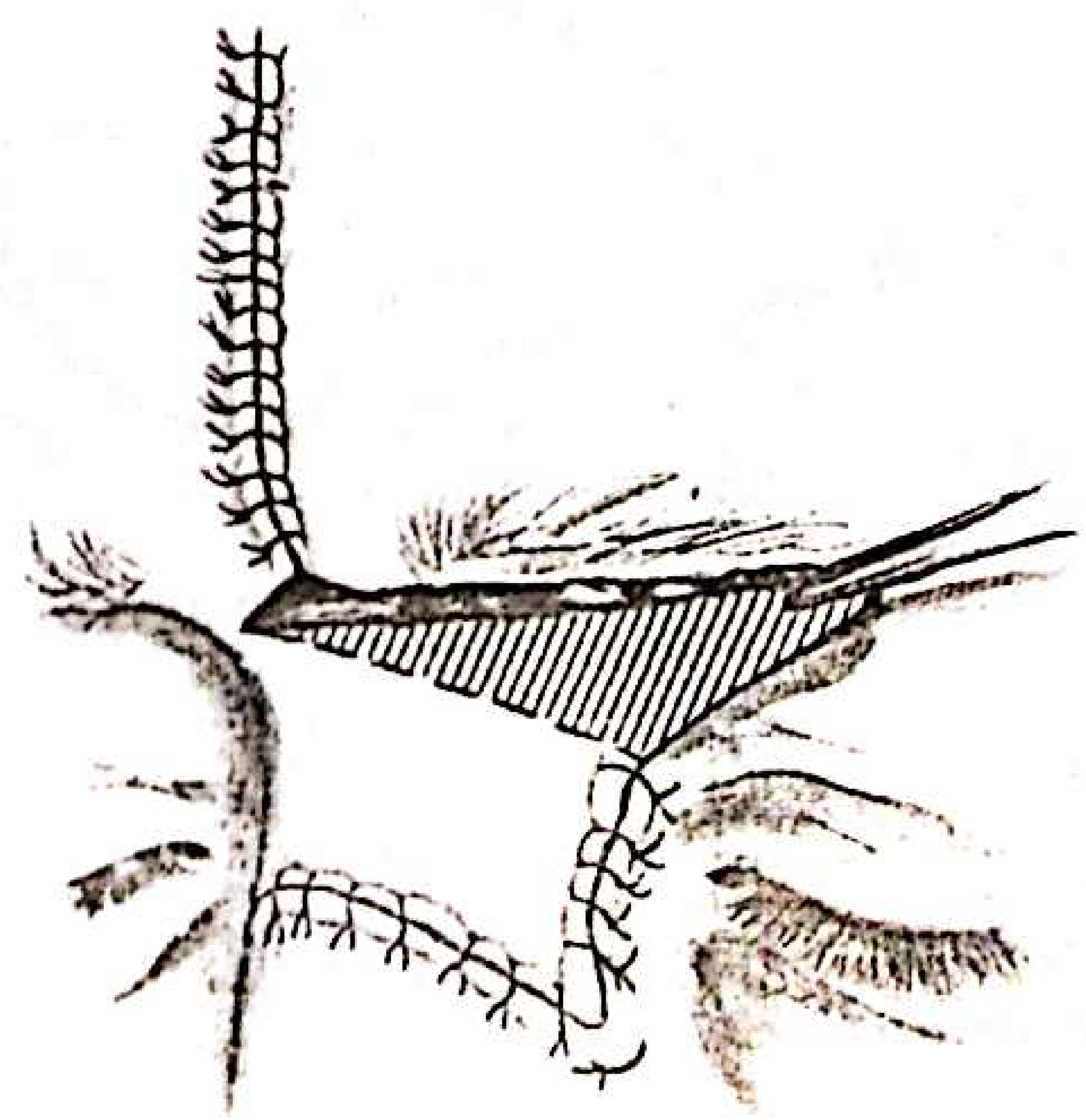
The forehead defect is closed directly. As the flap is sutured in position the skin redundancy corresponding to the upper part of the V becomes defined.



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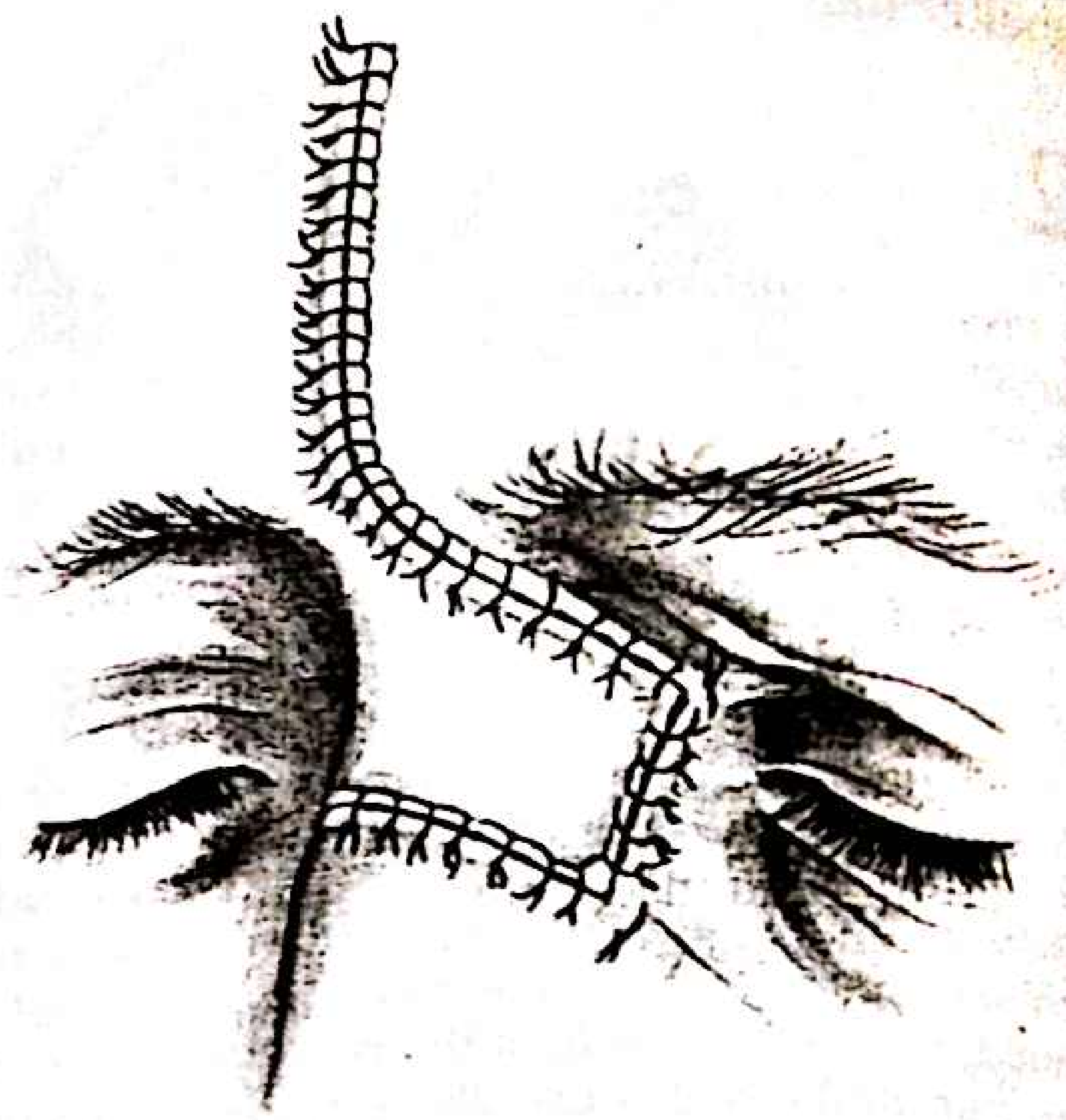

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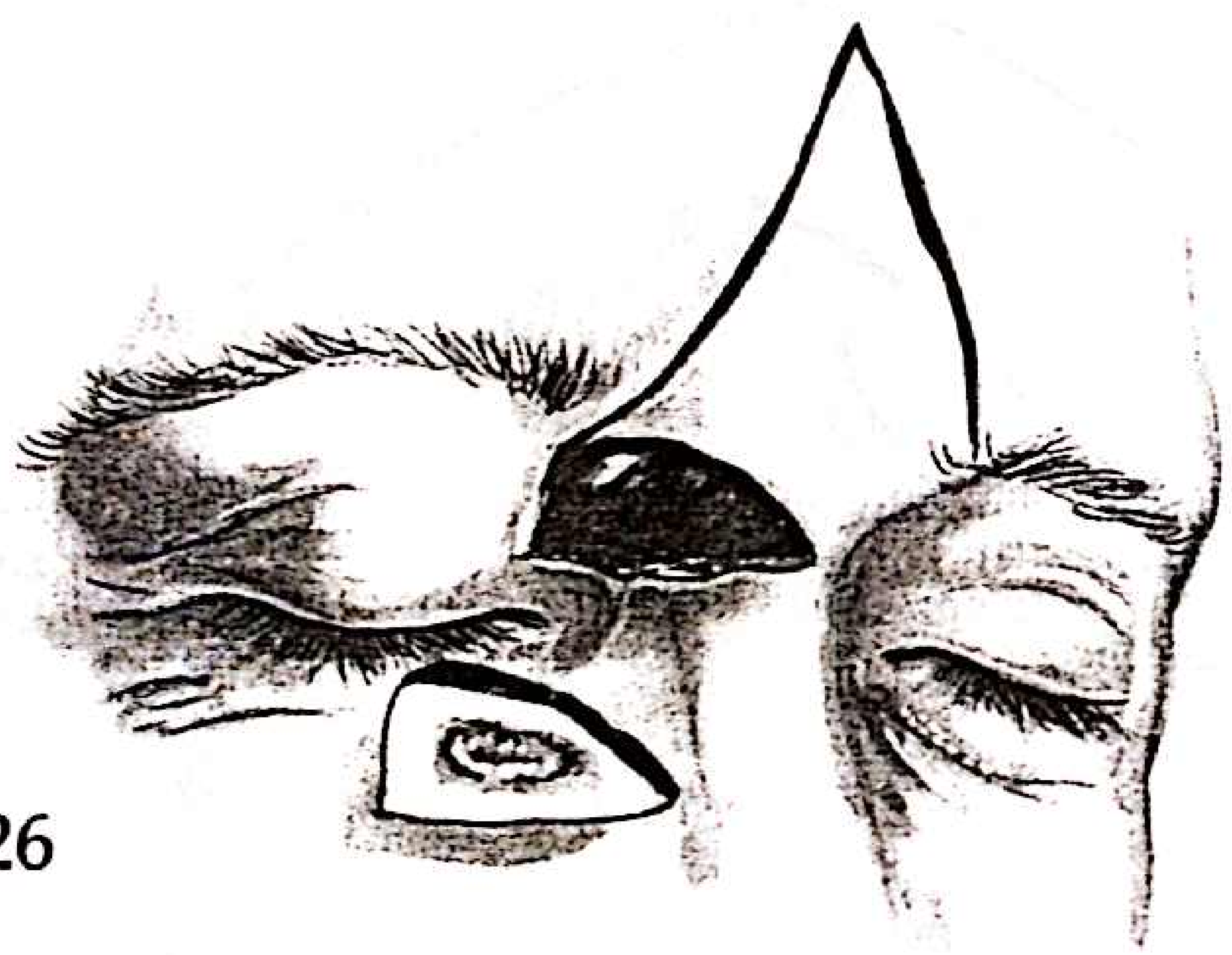
Following its excision, suturing of the flap in its transferred position is completed.

The management of the secondary defect left when the flap is transferred into its new position depends on the degree of laxity of the glabellar skin, as indicated by the presence of a wrinkle pattern, and the breadth of the defect. Closure begins at the upper end and is continued downwards. If skin has been abundantly available, direct suture can be continued down until the entire defect is closed.



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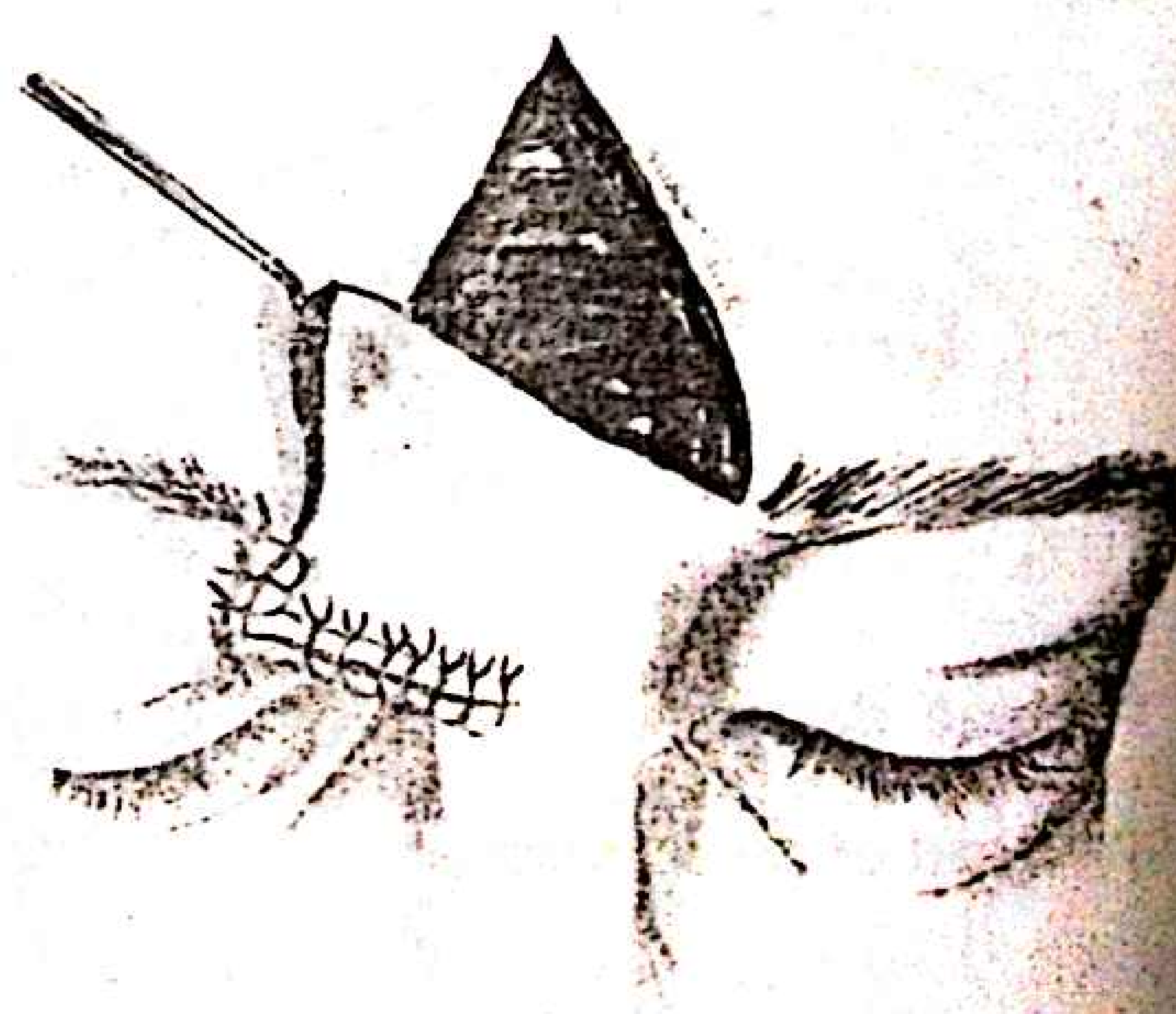
When skin is less widely available, or the flap is broader than usual because of the distance between the eyebrows, an alternative method of managing the secondary defect may be required.



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With the flap transferred it becomes apparent that direct closure will not be possible.

Transfer of the flap will have left its apex pointing obliquely upwards and laterally. With the apex of the flap held in this position with a skin hook, the line of an incision is drawn on the forehead skin along the line of the upper border of the flap.

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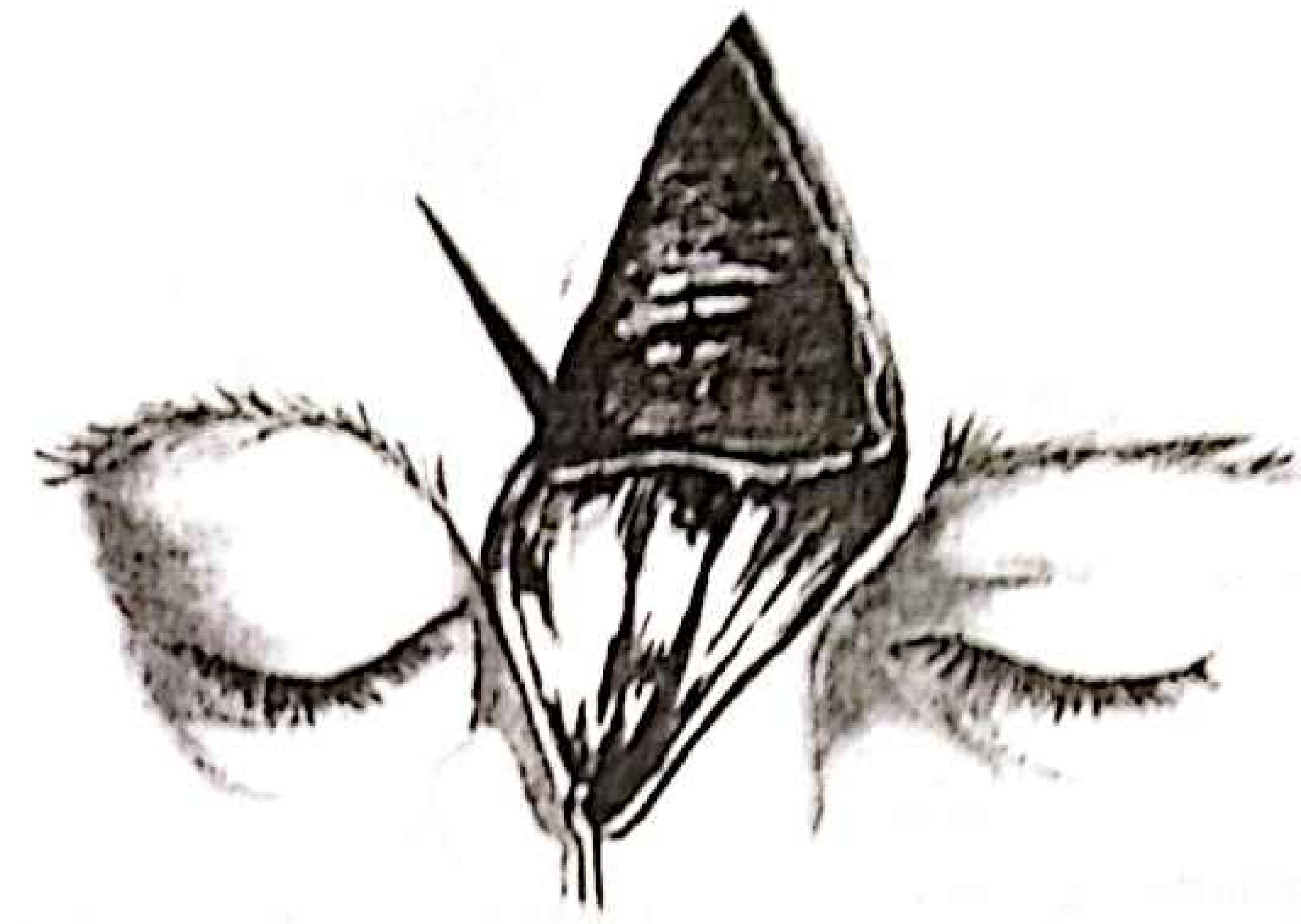
An incision is made along this line.



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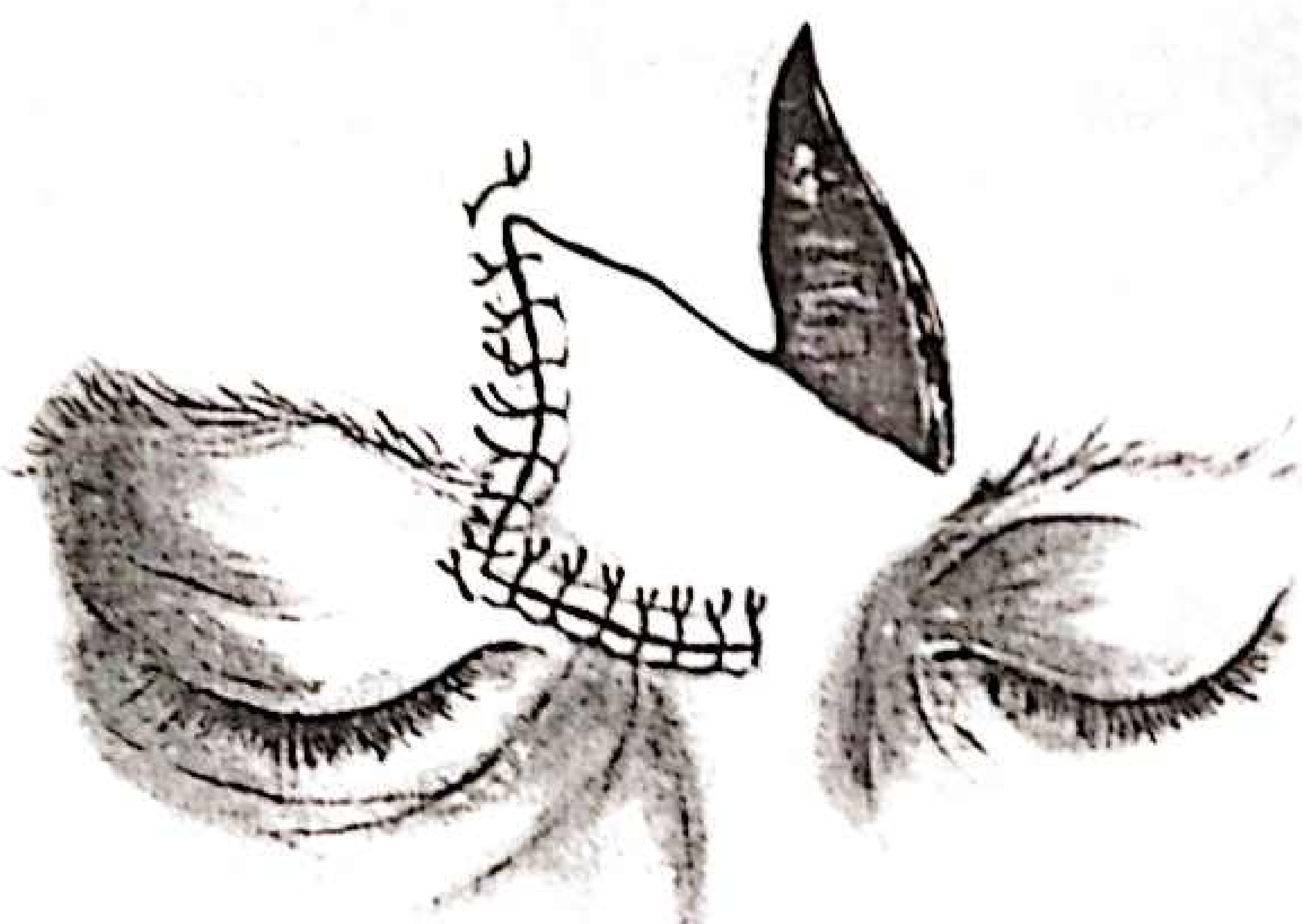

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29

The effect of this incision is to define a small triangular flap which is able to move medially and allow the remainder of the defect to be closed directly.

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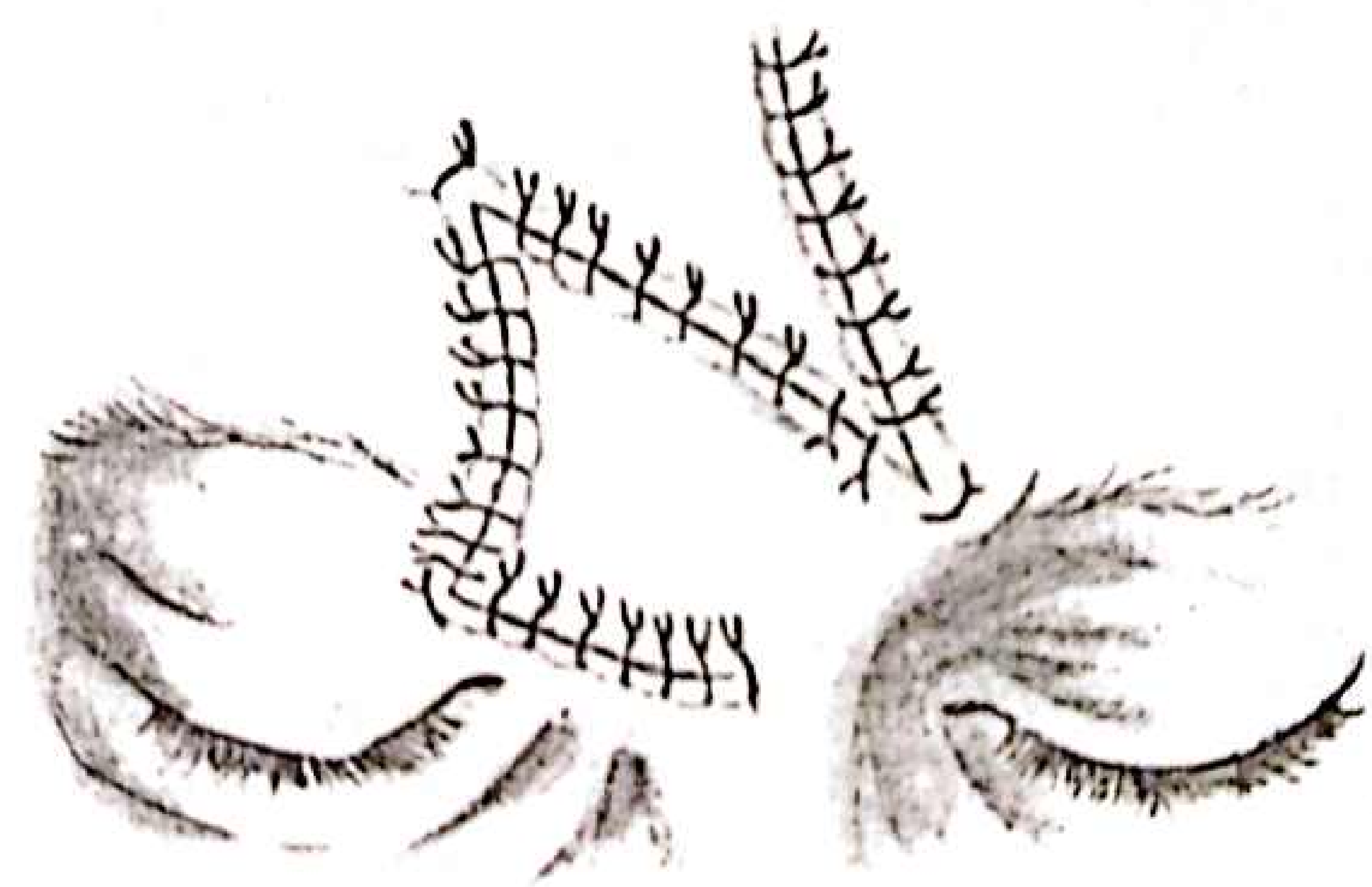
Movement of the flap medially leaves a triangular defect laterally, but it corresponds in shape and size to the apex of the glabellar flap and is filled by it, although some trimming may be required to make it fit.

The defect for which the glabellar flap works well arises relatively frequently, most often following excision of a basal cell carcinoma, a common tumour in this area. The dimensions of the flap, and consequently of the defect which it can reconstruct, are limited by the distance between the eyebrows. Taking account of the flap geometry, the limitation concerns the lateral extent of the defect. More than minimal extension of the defect on to the cheek precludes its use because the flap is unable to reach the defect, particularly its lateral inferior angle. The pivot point of the flap is at the base of the flap opposite the primary defect and measurements should be taken from that point in planning. If there is any doubt, a modified glabellar flap, the finger forehead flap, described on p. 74, should be used instead.



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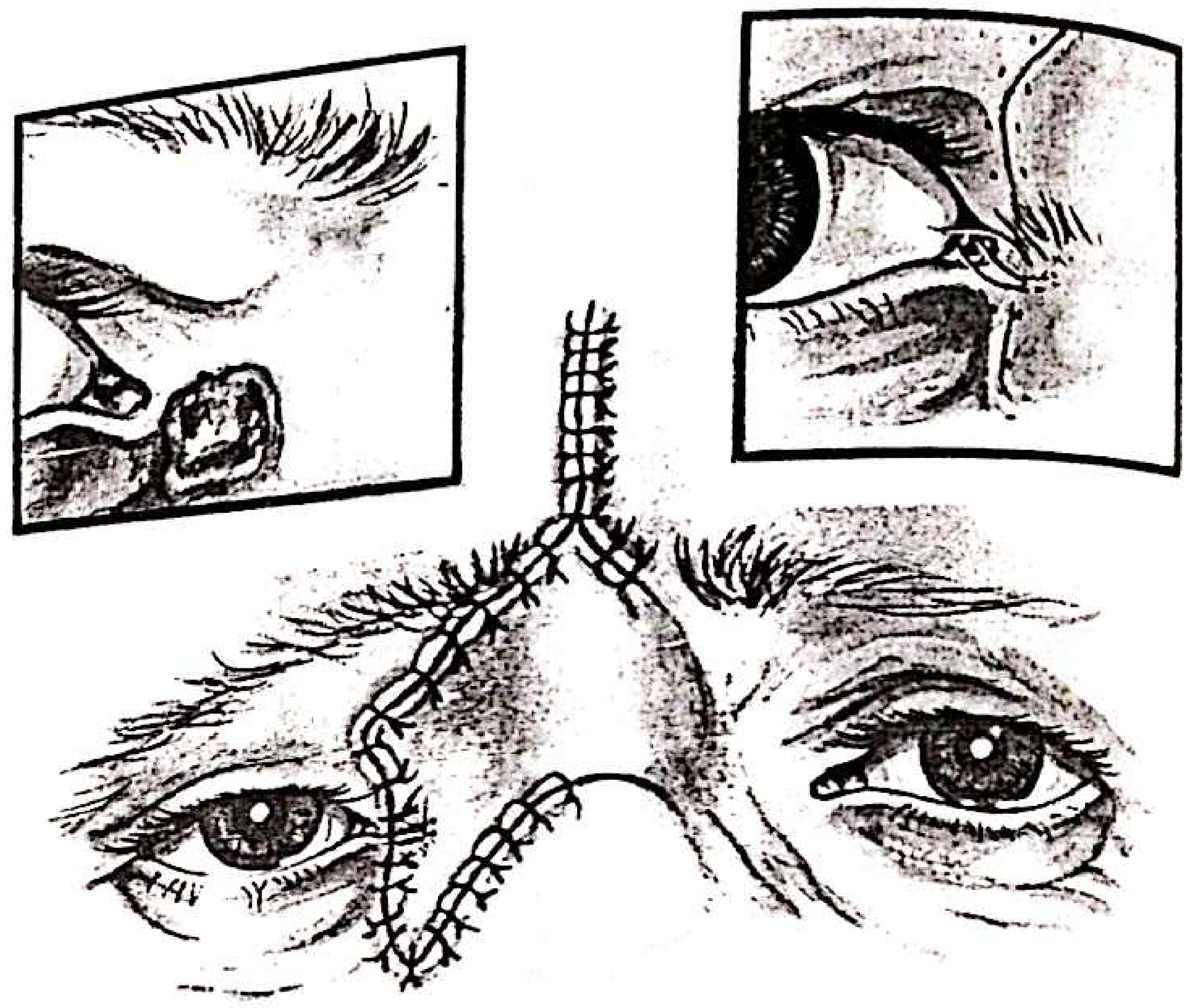
The glabellar flap is of course ruled out completely if the eyebrows meet centrally with an absence of hairless skin between the eyebrows. Even when there appears to be an adequate space between the eyebrows the presence of barely visible fine hairs at the medial end of the eyebrow proper should be looked for. If these are accidentally included in the flap, its transfer changes their direction of growth to become horizontal and they can give rise to troublesome trichiasis if the transfer is to the inner canthal area.



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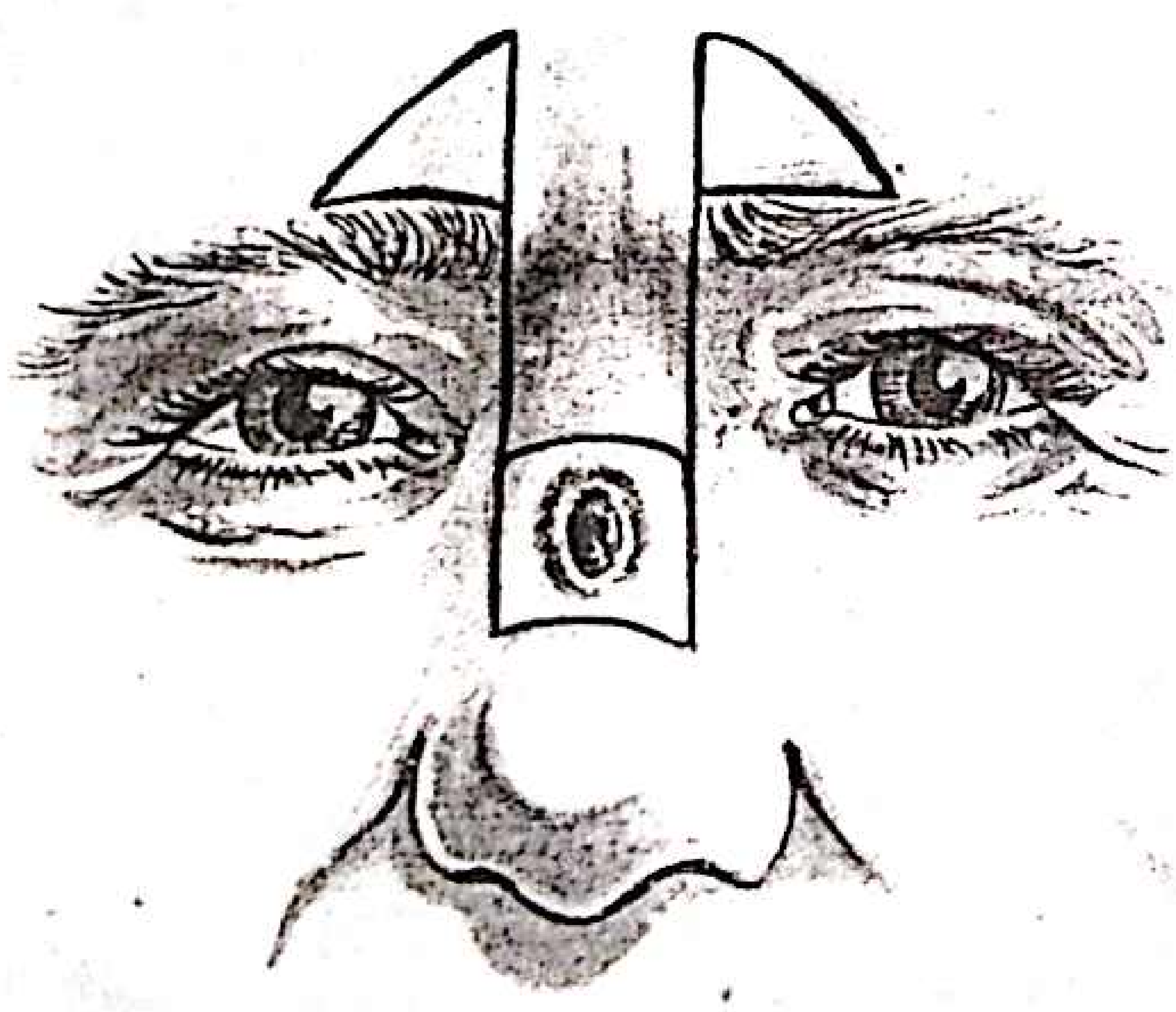

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Median glabellar flap

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This flap has the form of a vertical rectangle passing down between the eyebrows on to the dorsum of the nose from its base, which is approximately 1 cm above the level of the eyebrows.

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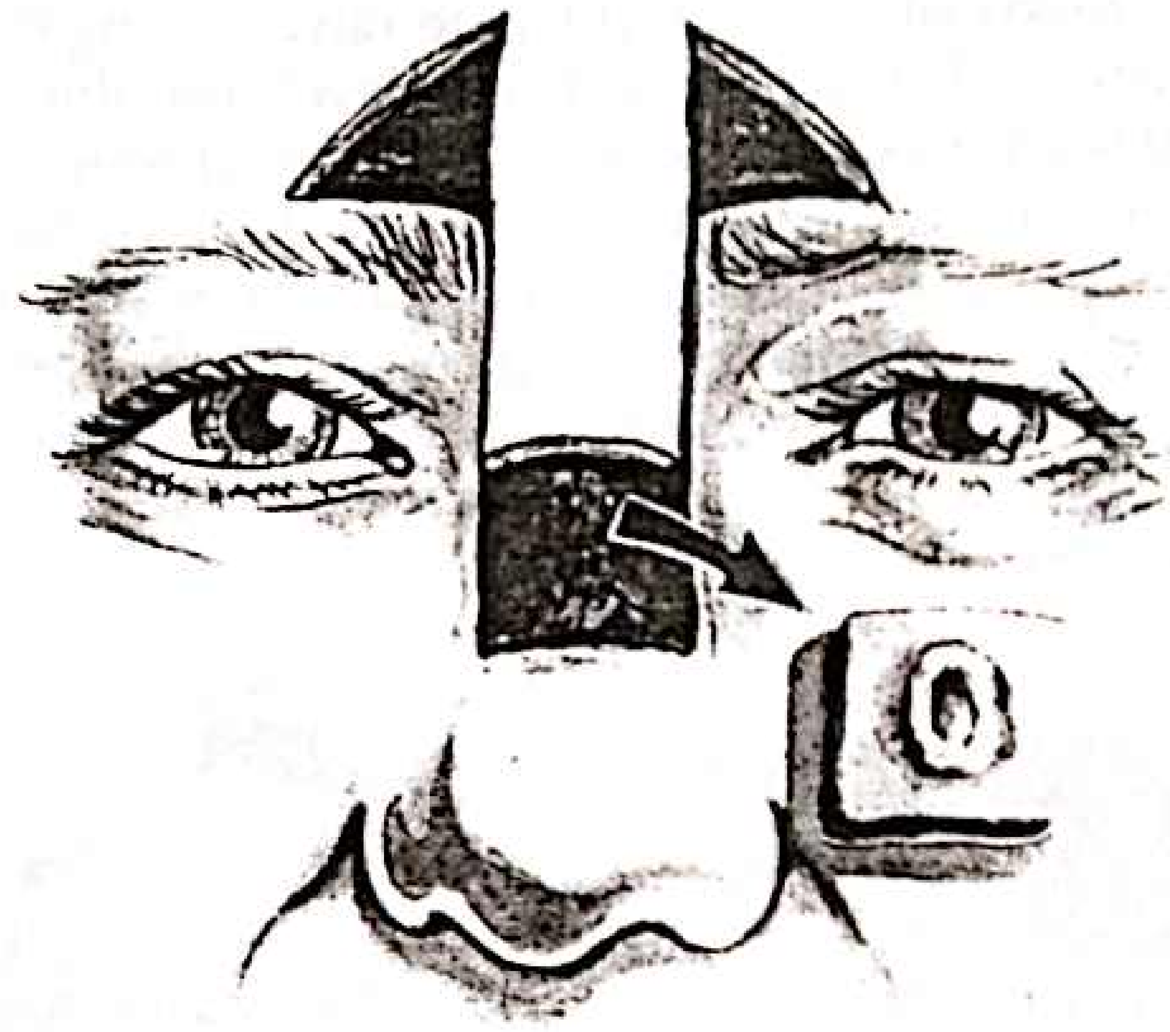
It is advanced downwards to cover small defects in the midline of the upper two-thirds of the nose. The defect is constructed as a square and, when the flap is raised and advanced downwards to cover it, the effect is to create dog-ears at the base of the flap on each side just above the eyebrow.



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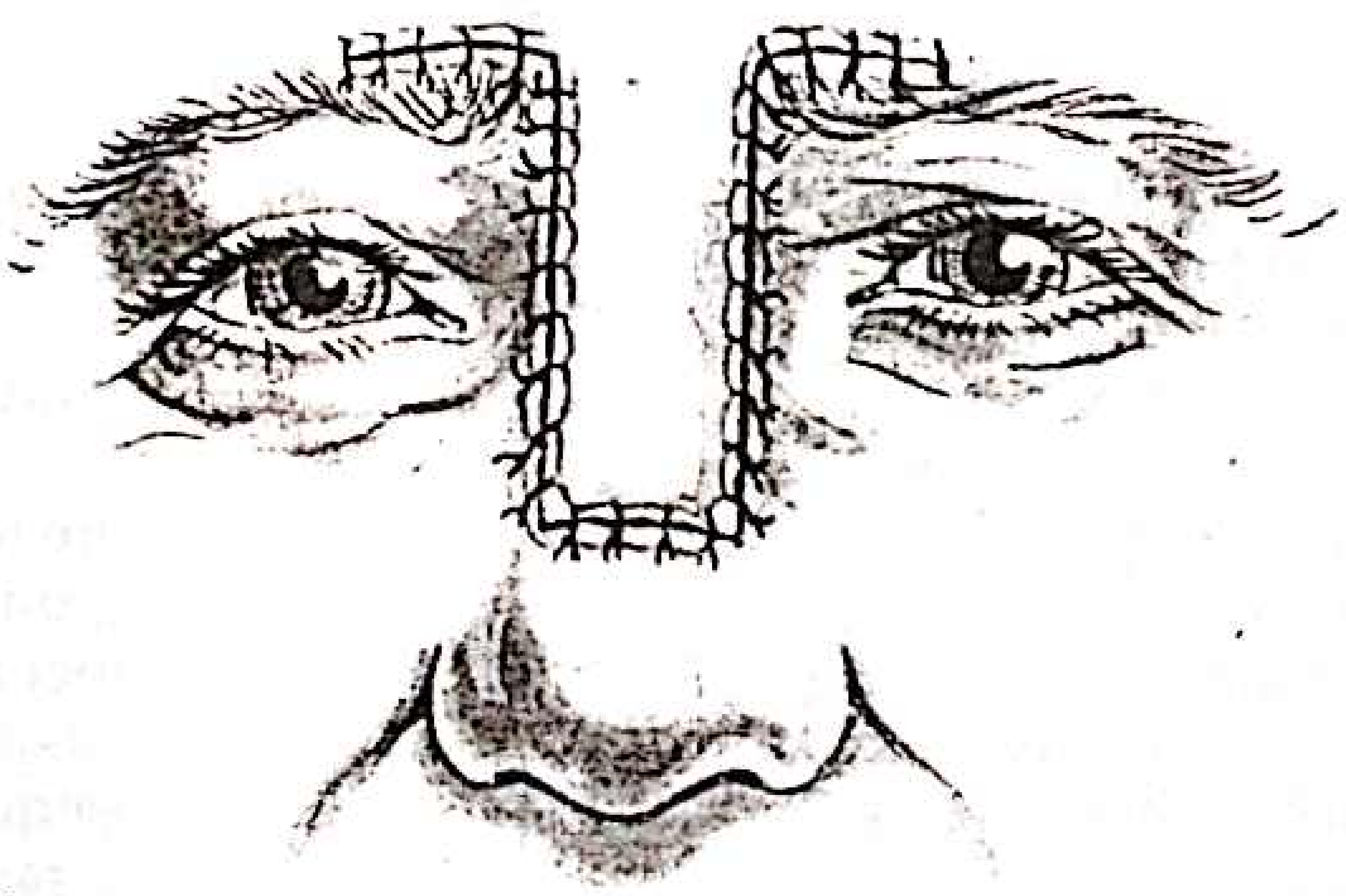

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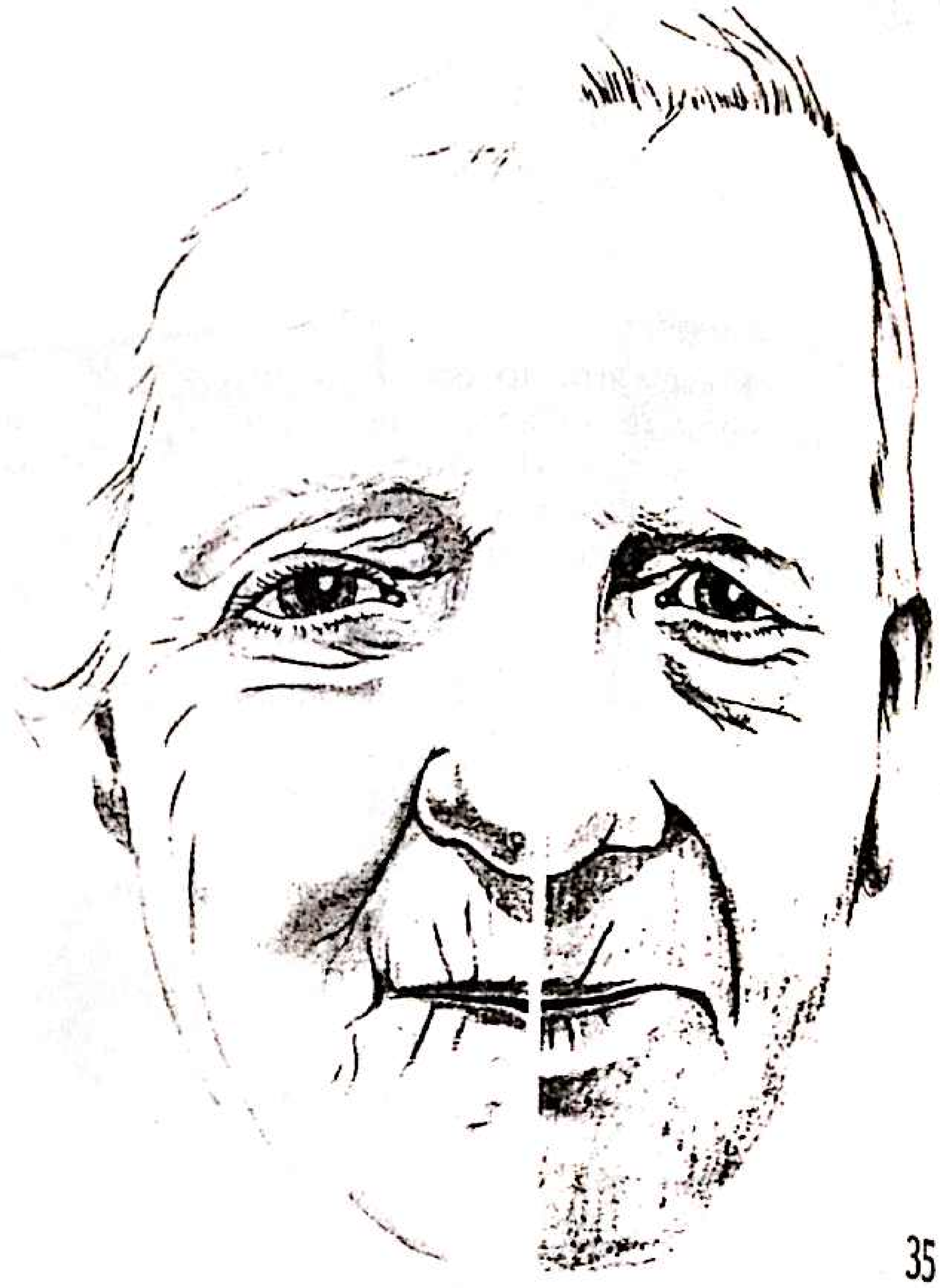
These are excised, leaving a horizontal scar along the upper border of the eyebrow on each side. In the absence of an adequate breadth of hairless skin between the eyebrows on which the flap can be designed, the method cannot be used.

In most clinical contexts advancement flaps are conceded to be unsatisfactory reconstructive procedures, because the local tension created by the transfer markedly limits the amount of advancement which is possible. There is also a tendency for the flap to revert to its original site, making for a poor ultimate result. In the case of the median glabellar flap, these unsatisfactory aspects are concealed in the short term by the presence in most patients of a hollow at the junction of the forehead and nose and a comparative laxity of the tissues on each side of the nose at this site. Together these factors allow the advancement to occur and the immediate result is good. It is as the reaction settles that its less satisfactory aspects appear. These show as a loss of the angle between the nose and forehead which converts to a rather unattractive 'Greek' profile. The method would scarcely be worth including among reconstructive flaps were it not that there are no good alternative single-stage reconstructions for the relatively small midline lesion of the upper two-thirds of the nose.

Nasolabial flap

This flap consists of a finger of tissue raised along the line of the nasolabial fold, its precise level on the cheek depending on the geometry of the transfer. It relies on the richness of the subdermal circulation. It is most often used as a superiorly based transposed flap to reconstruct defects of the nose and upper lip, occasionally the lower lip. An inferiorly based flap of similar design is an occasional alternative form of the transfer. The secondary defect is closed directly.



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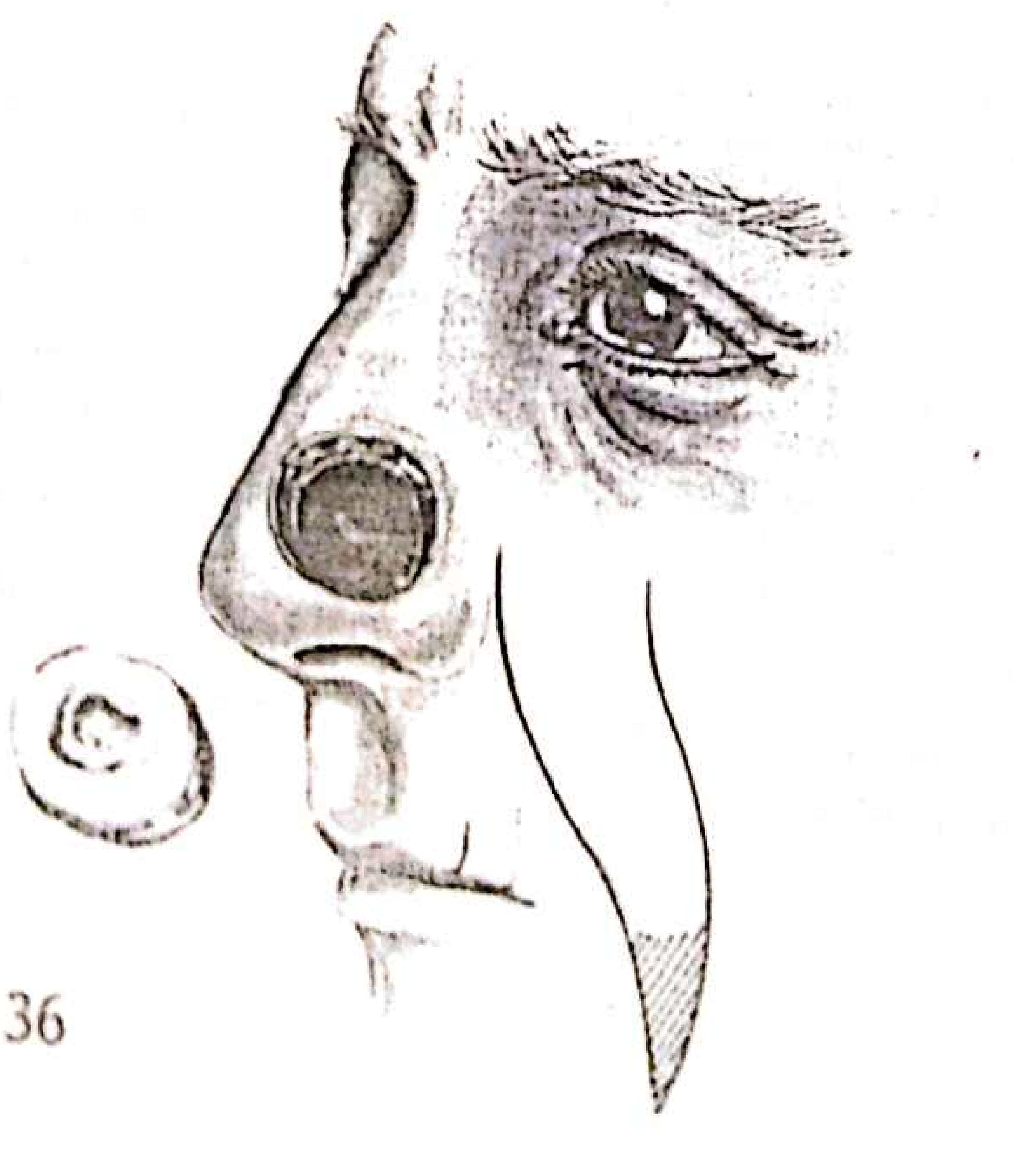
The site of the flap in relation to the nasolabial fold depends very much on the sex of the patient and whether the resection site is hairless. In the female the flap can be raised astride the fold or lateral to it, depending on convenience; in the male the hairbearing skin often lies largely medial to the nasolabial fold and it may be necessary, if the transfer is to a hairless area such as the nose, to place the flap lateral to the hairbearing area. Extension of the flap upwards is limited by the possibility of producing ectropion when the secondary defect is closed as the medial canthus is approached. Downward extension is determined by the geometry of the transfer.

The width of flap which can be raised varies in different individuals and depends very much on the presence of the nasolabial fold and the cheek lateral to it, the tissue available being maximal just above the angle of the mouth. It is generally true that a broader flap can be raised without producing distortion than one might think. It is rare to find an adult in whom the nasolabial area of availability is totally absent.

The fact that the secondary defect is closed directly has an influence on the shape of the flap as raised. It should be narrowed to a point towards its tip so that the defect can be closed easily without creating a dog-ear. The tip is likely to be trimmed off when the flap is being inset into the defect, but it is preferable to have any excess on the flap where it can be discarded if not required than find the flap a little short in the event.

When the flap is used to reconstruct a defect of the nose a superior pedicle is almost invariable. Depending on the site of the defect on the nose the flap and the defect may lie alongside one another, making a single-stage transfer possible although, as discussed below, subsequent revision is generally needed to give the optimal result. When the flap and the defect are separated by a bridge of intact tissue a two-stage procedure is unavoidable.



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With the tumour excised, the flap is outlined, generally straddling the nasolabial fold if the patient is female, more laterally placed to avoid hairbearing skin if the patient is male.

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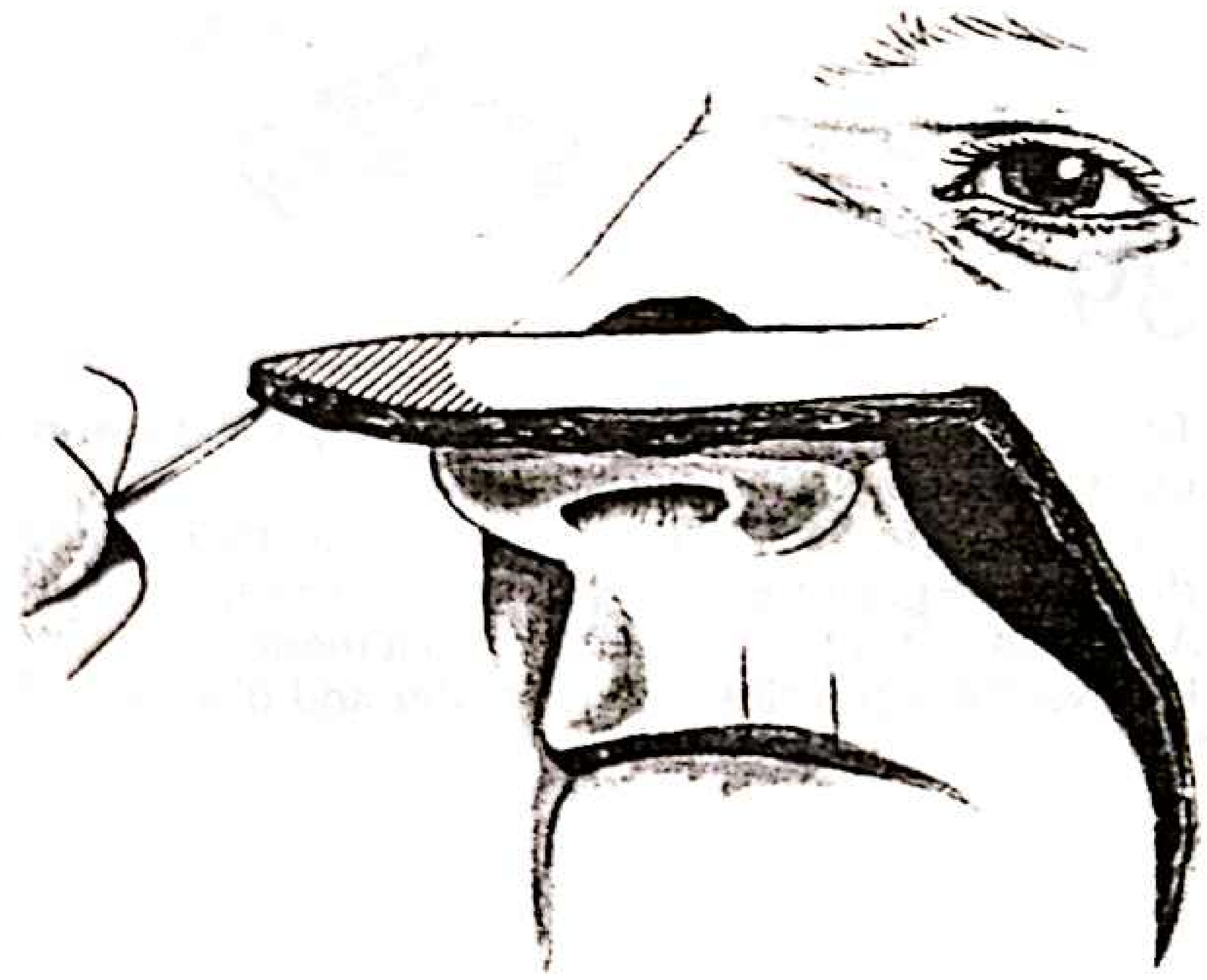
The flap is elevated in preparation for transfer. It can be initially raised at a level which includes some subdermal fat with its skin component, the final level at which it will be sutured to the margins of the defect. Alternatively it can be initially raised at the much deeper plane between the subdermal fat and the underlying facial muscles, and then thinned to the appropriate thickness. There are advantages to this latter method, since the vessels which emerge between the individual muscles to reach the skin are more easily defined, making the elevation of the flap a more bloodless procedure.



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The flap is sutured to the margins of the defect. The raw surface on the deep aspect of the bridge segment can be left without a dressing or covered with a layer of tulle gras. The excellent blood supply of the flap makes it highly resistant to infection, and it is not necessary to eliminate the raw surface by applying a skin graft to it.

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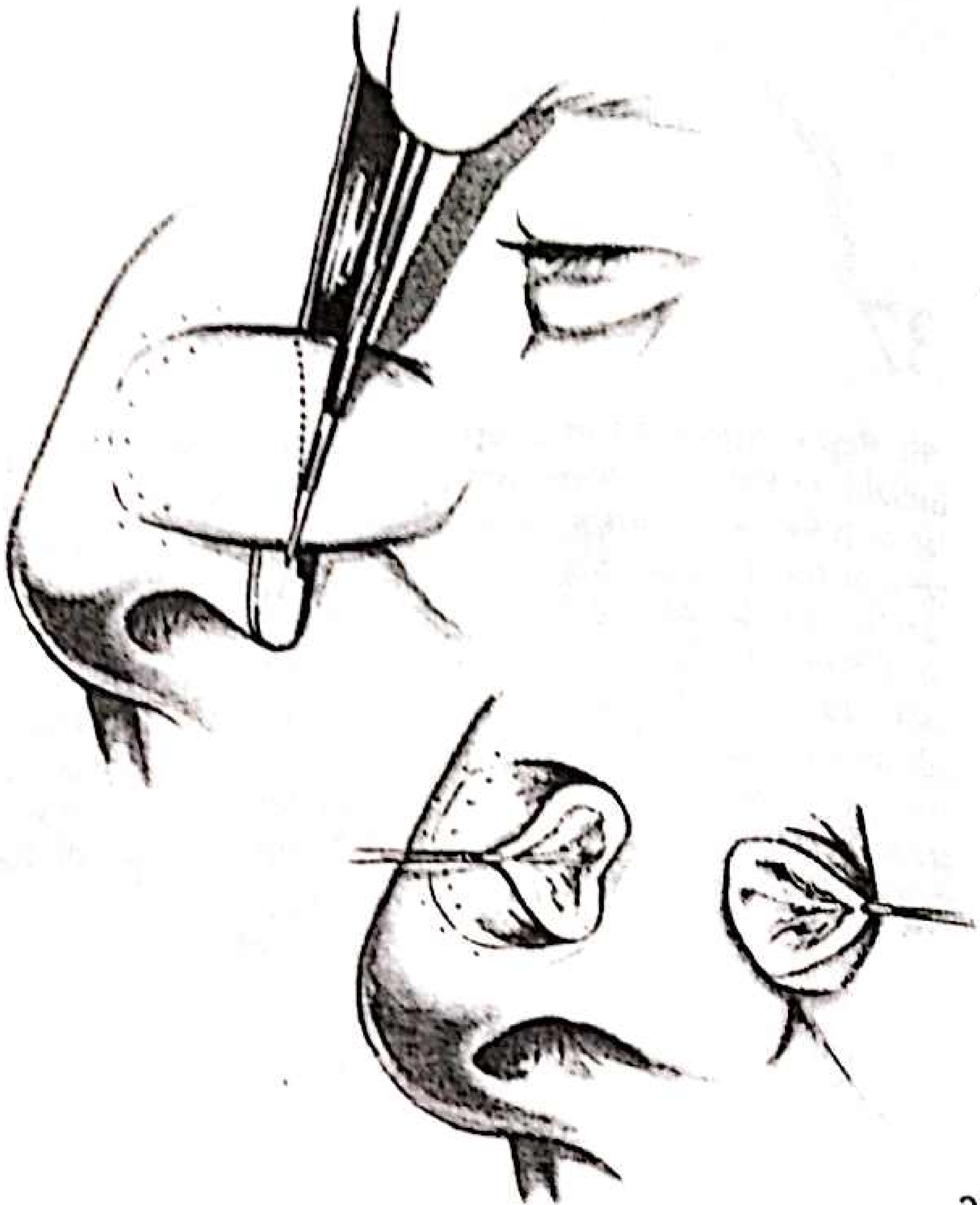
Three weeks later the pedicle is ready for division, with insetting of the flap.

If the best final cosmetic result is to be achieved, division and insetting require to be carried out with care. A degree of tubing of the bridge element develops in the interval between the initial transfer and division.



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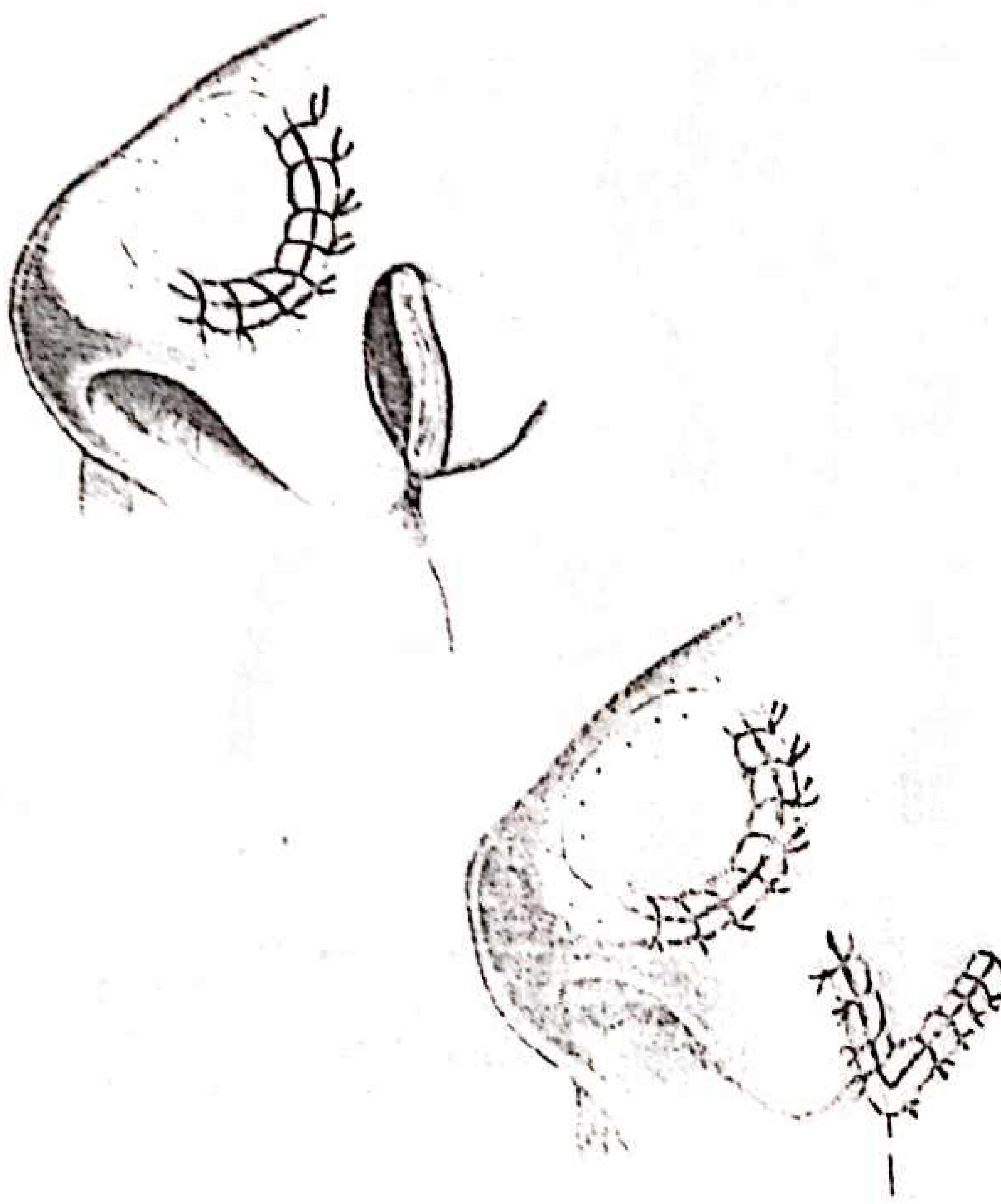
When the pedicle is divided it is important to undo the tubing completely. This involves elevating the pedicle segment onto the part which is already inset, back as far as its broadest segment, to allow the tubing to be undone completely, restoring the flap to its original shape and thickness. The part of the defect which is exposed by this elevation must also be formally restored to its original shape and depth, with a vertical wound margin. The margin of the flap can then be trimmed to fit the shape of the defect so that it is able to sit snugly in position for suturing. A similar degree of care is required in managing the stump of the pedicle, elevating it to its original base, turning it to lie along its original direction, opening up the suture line over sufficient length to allow it, trimmed appropriately, to lie flush with the surrounding skin, to which it is sutured.

In planning nasolabial flaps there are limits to the effectiveness of their detailed planning. It is theoretically desirable to decide how the flap is going to approach the defect, so that its breadth will match that of the defect in the line along which the flap is approaching it. This is easier to say than to do. It is often found that the flap does not approach and fit into the defect quite in the way and from the direction which the plan intended, and if the planning has been too detailed and proves inadequate in the event the result can be disastrous. A useful compromise which can avoid the difficulty is to make the defect as near as possible to a circle in shape whenever possible. The direction from which the flap reaches the defect then becomes immaterial, and the only important flap dimension, other than that of making it long enough to reach the defect, is to provide it with an adequate width. The most important point in planning the length of the flap is that it should be able to reach its destination without tension.



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When the defect extends laterally as far as the junction between the nose and the cheek the reconstruction can sometimes be carried out in a single stage, but the result is liable to be less than completely satisfactory. There tends to be loss of the demarcating line between the ala of the nose and the cheek, the flap bridging the nasolabial hollow and often obliterating it completely. The loss of the hollow is most obvious towards the alar base where the hollow is deepest.

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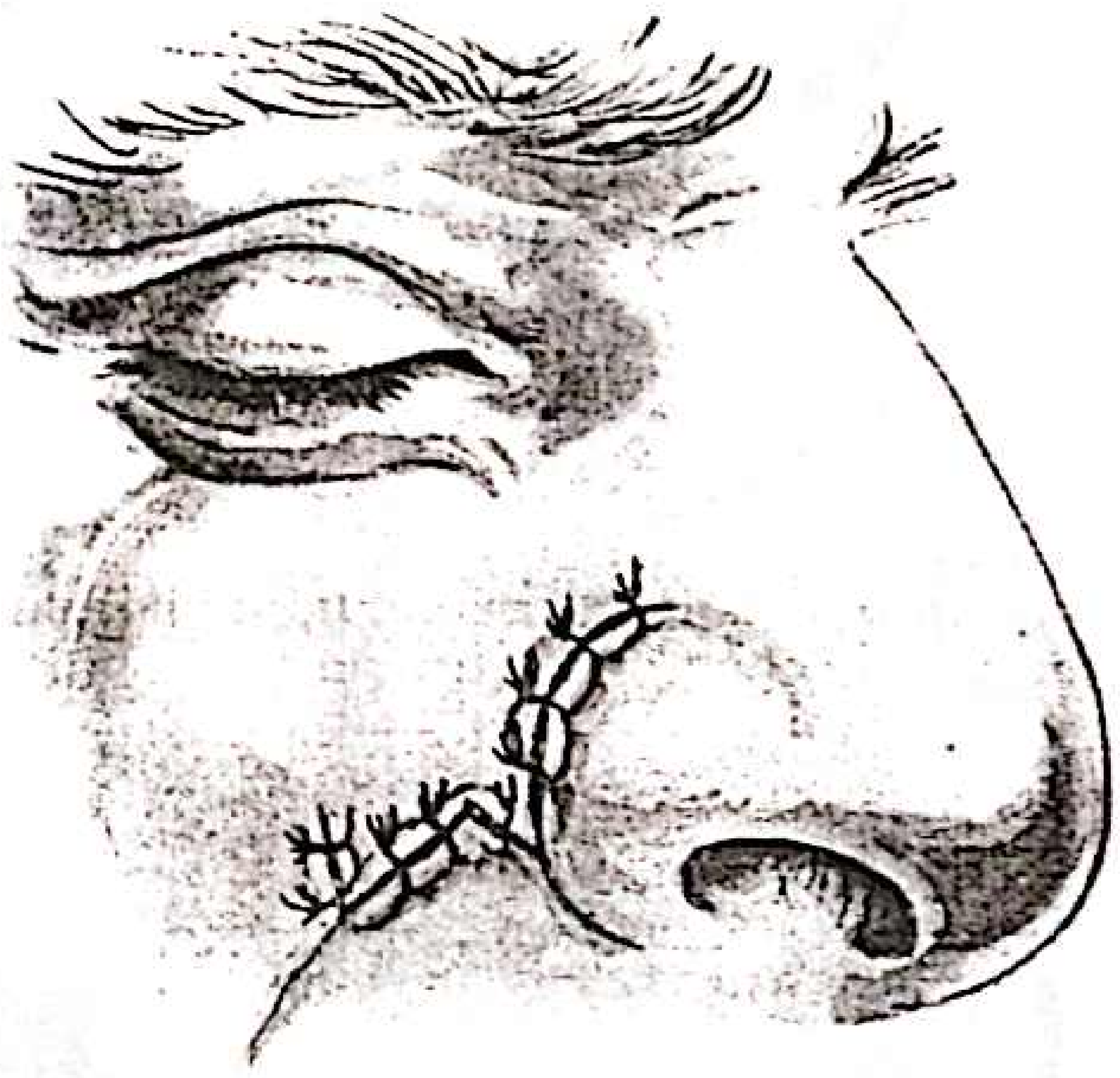

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Its correction, to restore the line of the ala nasi and the nasolabial hollow, requires a further operative procedure.

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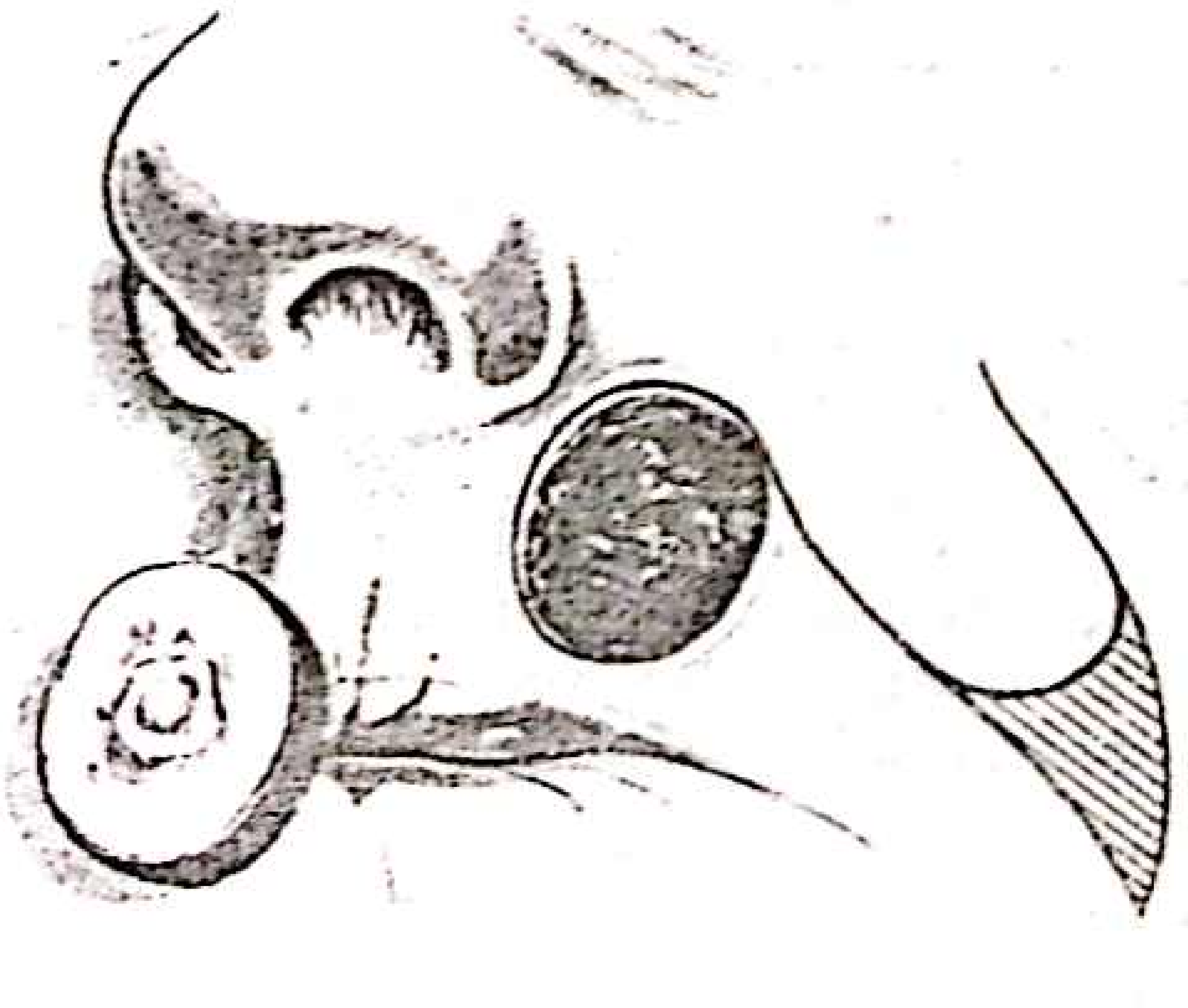
The most frequent usage of nasolabial flaps is to reconstruct nasal defects, nasal skin providing a regular source of suitably sized defects, particularly in its lower third, but partial thickness defects of the upper lip, particularly lateral to the Cupid's bow, are also ones where the flap transposed into the defect works well.



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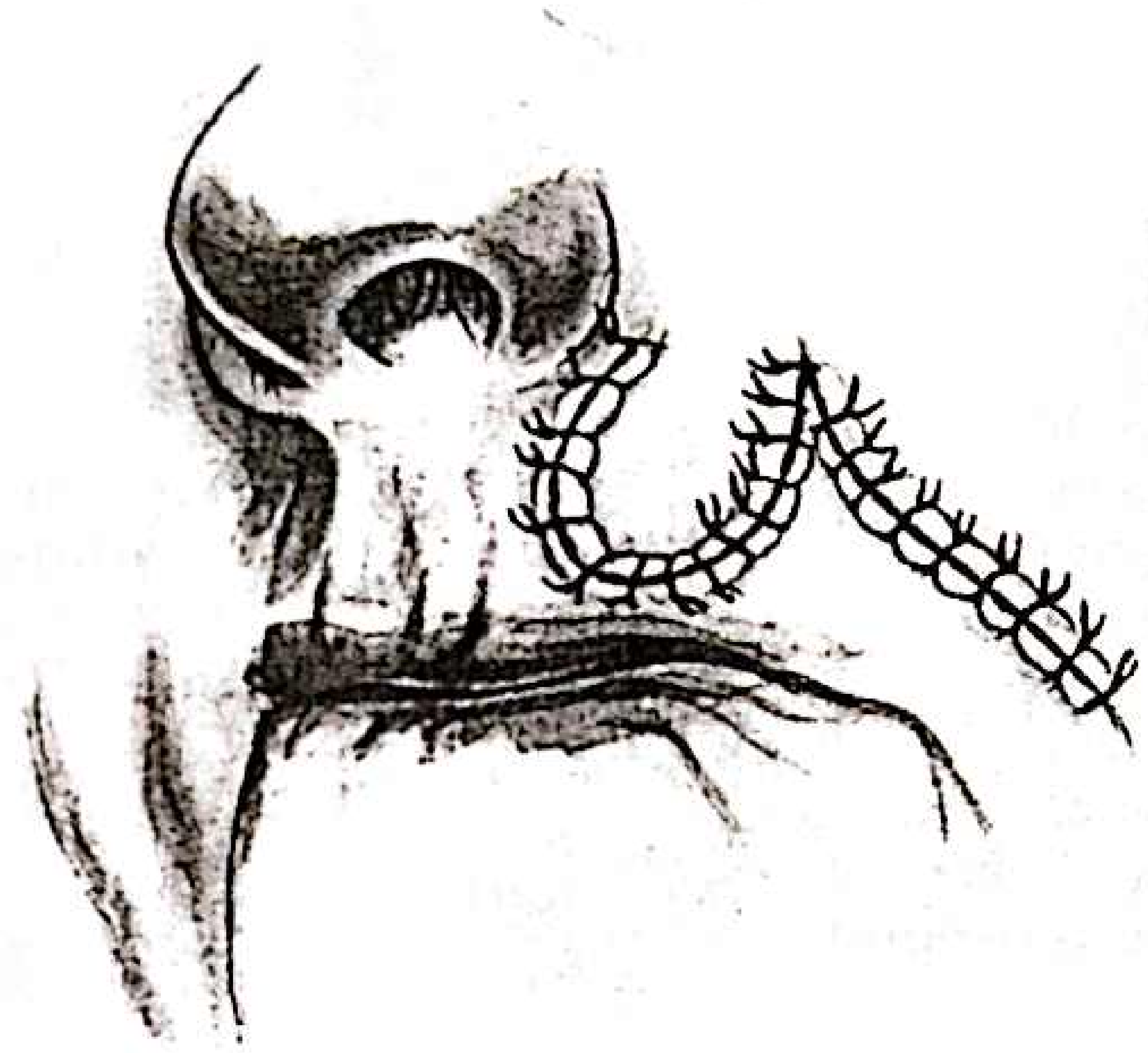
In carrying out the resection there is advantage in deepening it to include the orbicularis muscle. Under the flap, its contraction is liable to produce unsightly pincushioning.



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Larger defects extending across the upper lip can also be resurfaced effectively using a superiorly based nasolabial flap, transposed into the defect.

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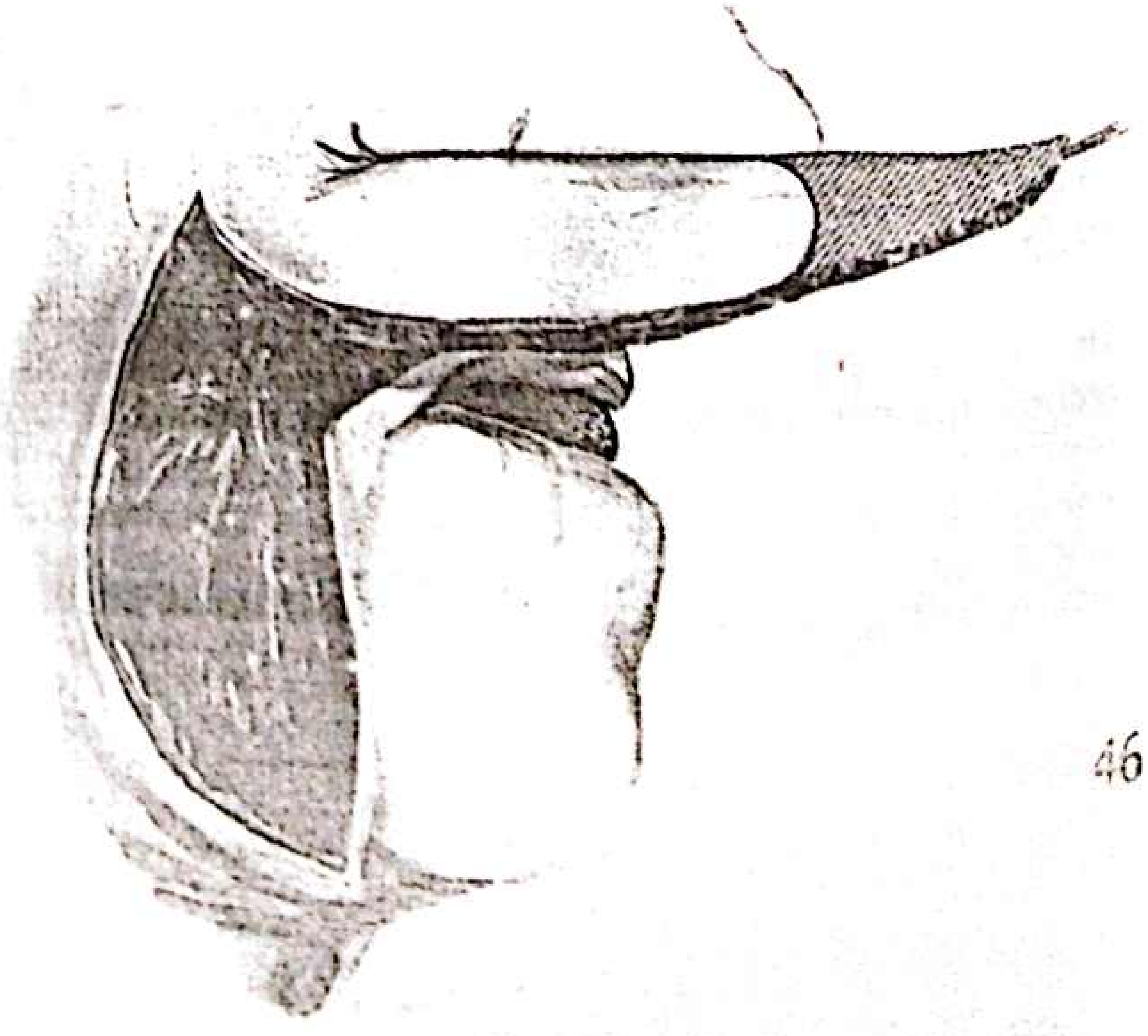
To reach its destination such a flap may have to be extended down to the lower border of the mandible and even into the submandibular triangle.



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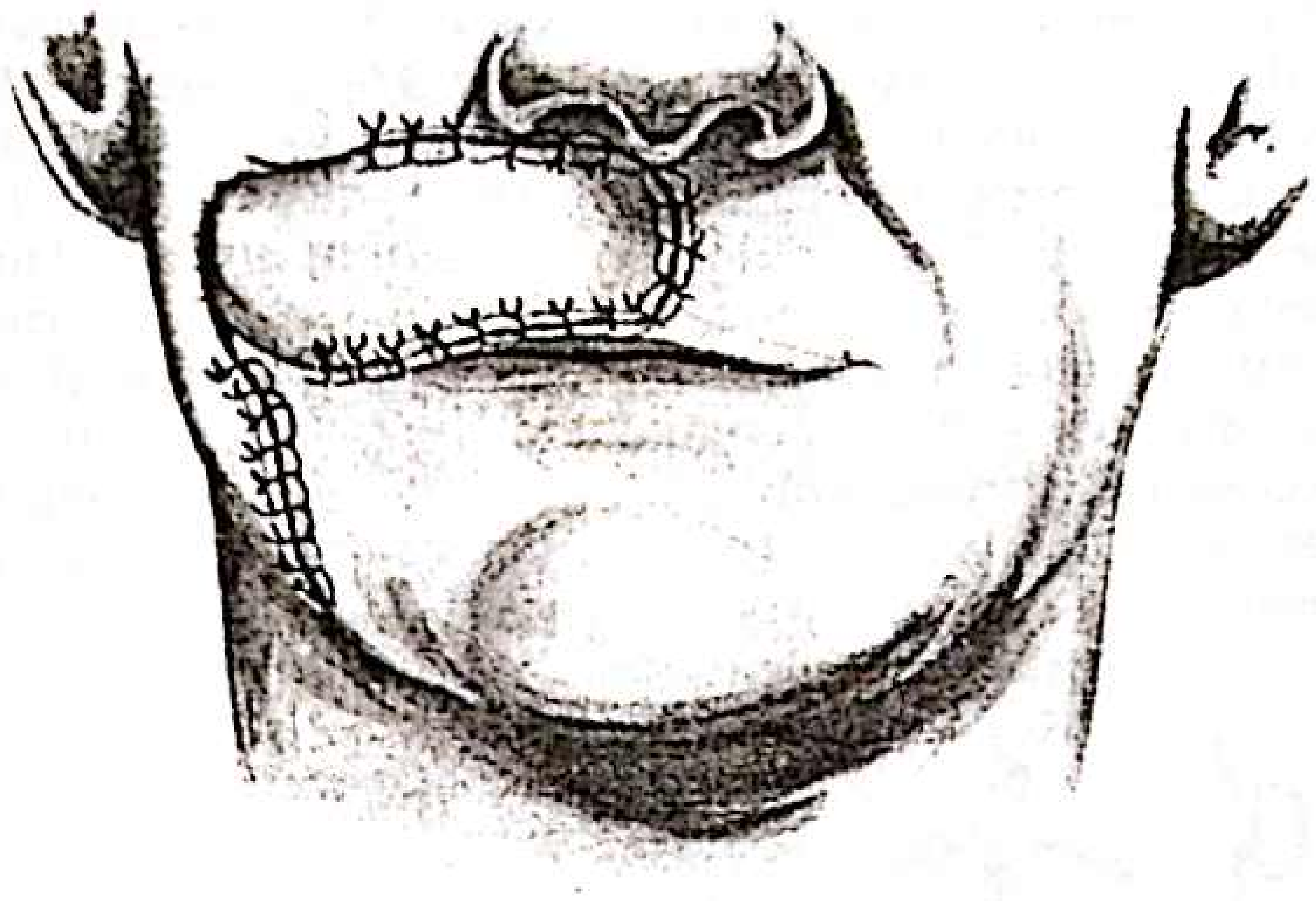
Such a flap carries the unexpected bonus that, in the male, its hair growth in its transposed position matches that of the adjoining normal lip.



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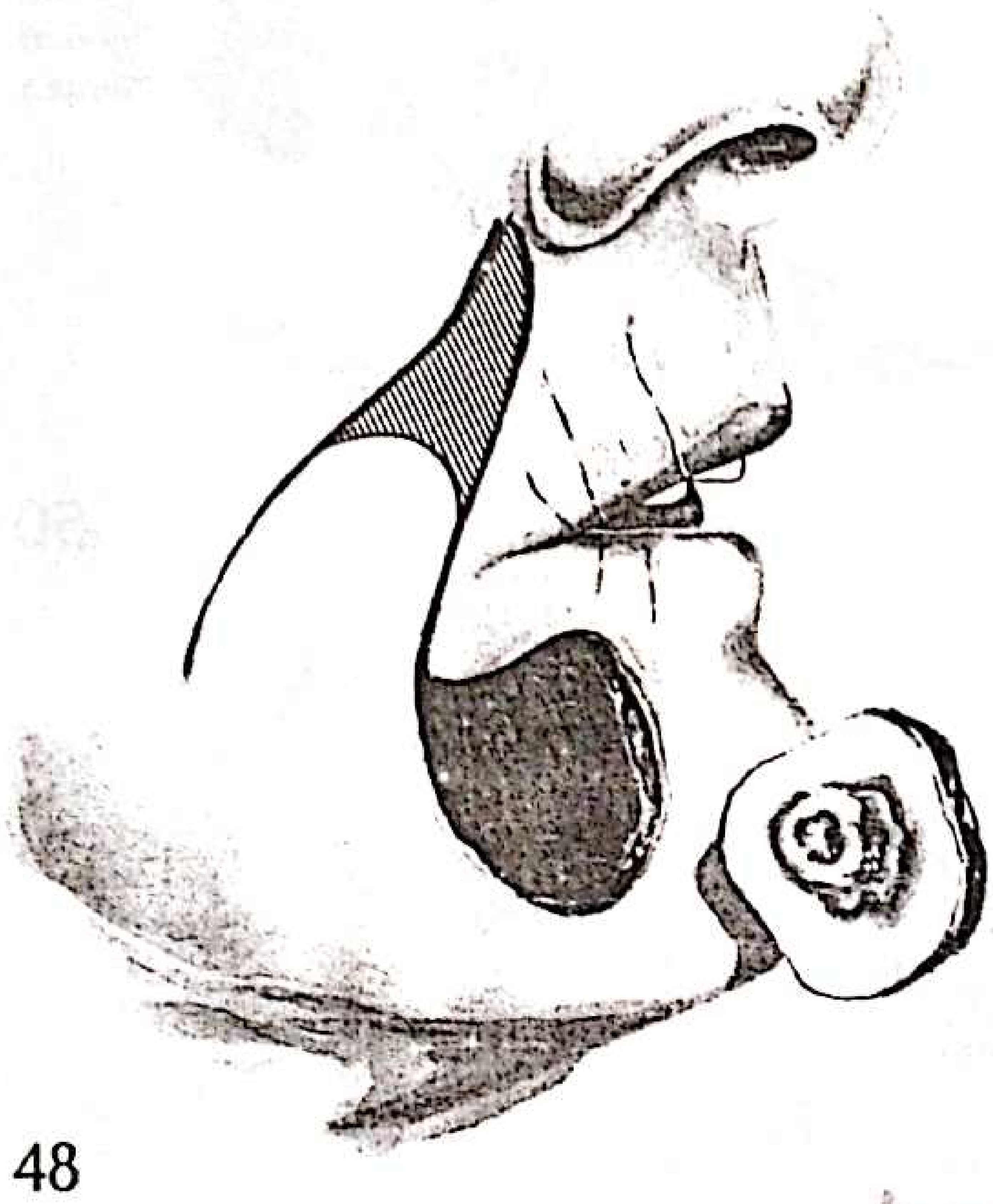

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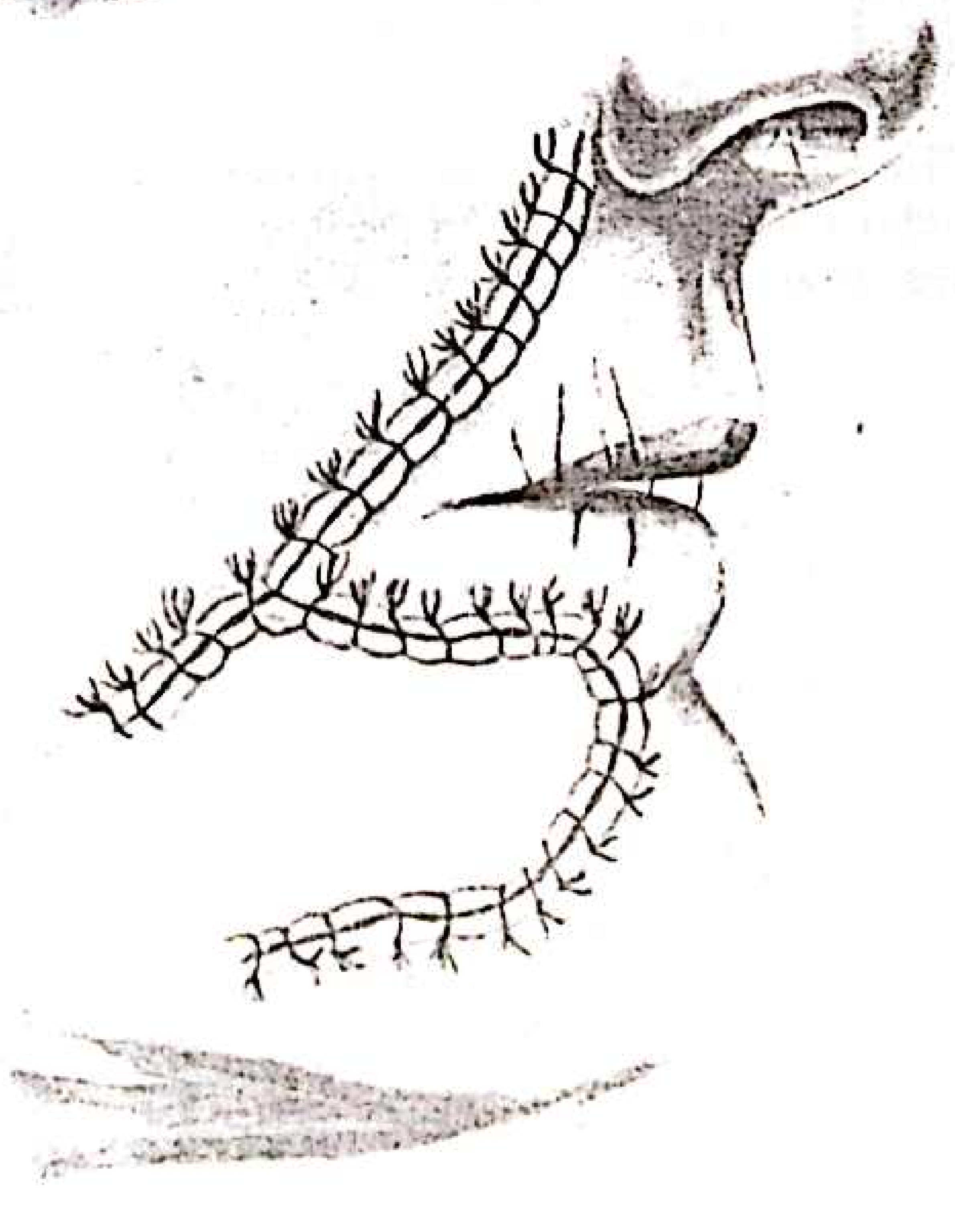
The inferiorly based nasolabial flap also has a place in the reconstruction of defects of the lateral part of the lower lip, adjoining the line of the nasolabial fold.

A problem which can arise in using the nasolabial flap is failure to match the thickness of the flap to the depth of the defect. This is apt to show most strikingly when the defect is a relatively small one, particularly when it is sited on the nose, the site of the transferred flap showing as a local prominence rather than a smooth continuation of the surrounding contour. The avoidance of this is discussed in the chapter on 'Nose', pp. 157–177.



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Perialar rotation advancement flap

A reconstructive problem which can arise concerns the small defect of the upper lip in the vicinity of the alar base. If the defect is created as an ellipse and closed directly, distortion of the lip is produced because the ala is fixed in position and the lengthening or shortening produced as the ellipse is closed cannot be absorbed readily. Horizontal closure results in shortening of the lip and vertical closure results in lengthening, and the presence of the Cupid's bow with its symmetry tends to accentuate the discrepancy. It was with the aim of avoiding asymmetry that the perialar rotation advancement flap was developed.

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The technique involves extending the lip defect by excising a crescent of skin and subcutaneous tissue immediately lateral to the ala of the nose. The skin of the cheek lateral to the excised crescent is mobilized from the underlying muscles and, with advancement and rotation of the cheek skin, the defect of the lip and the perialar crescent close with a minimum of lengthening of the lip scar. It is essential in designing the flap that the medial margin of the total defect, lip and perialar, should equal the lateral margin in length so that the defect will close directly. A factor in designing the defect which influences the result is the degree of obliquity in the long axis of the lip defect. A degree of obliquity reduces the likelihood of some lengthening resulting.

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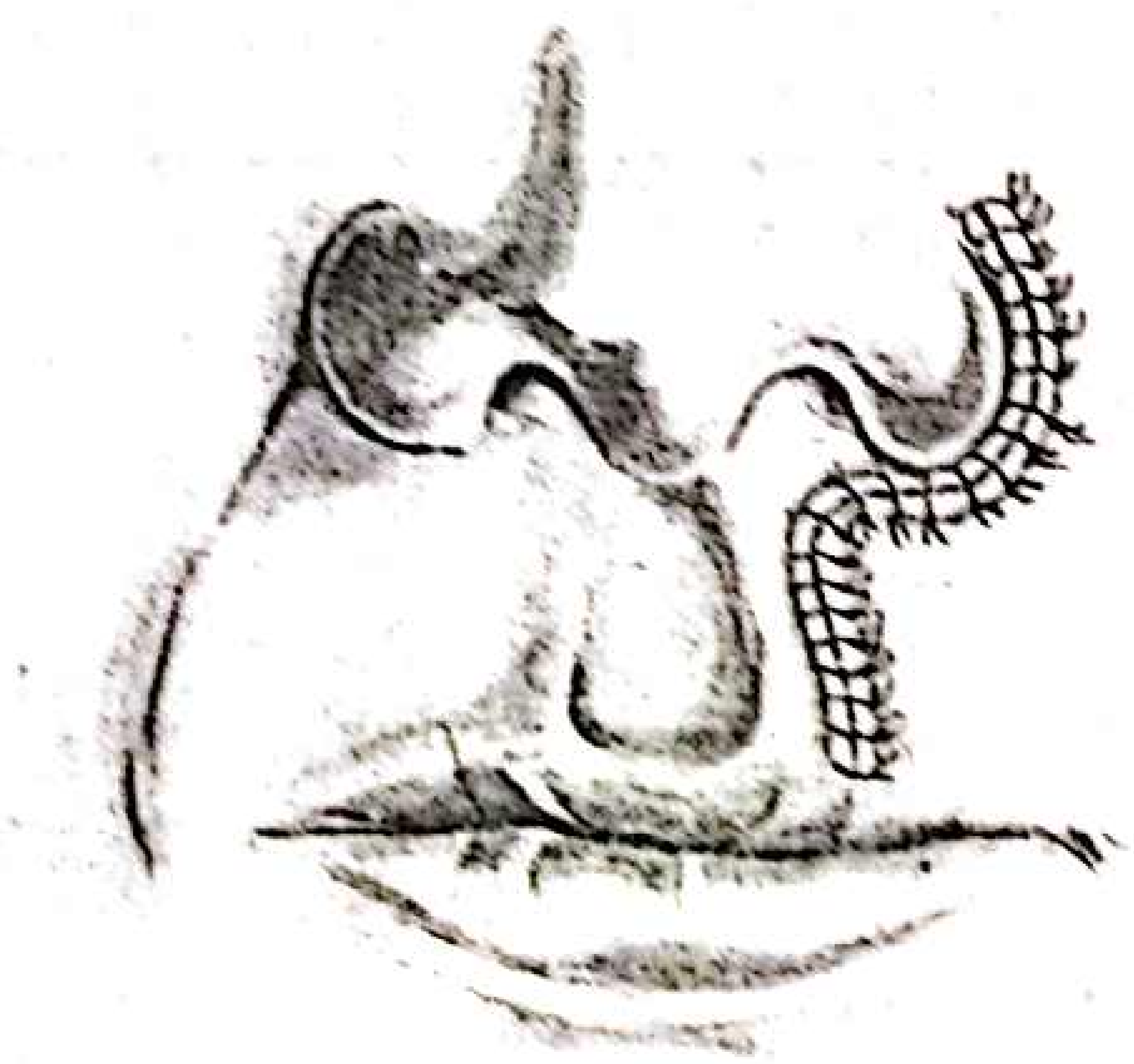

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The ideal of maintaining symmetry of the lip is not always achieved but even so, any asymmetry produced is usually less than that which follows other methods.

Bilobed flap

A problem which occasionally arises in practice is that of the defect which is suitable for cover by a flap but which is too distant from an area of availability to make a single-stage transfer possible. In this situation the bilobed flap can sometimes provide a solution.

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The defect and the flap are designed with the overall outline of a clover leaf, an outer leaf forming the defect, with the bilobed flap sharing a single pedicle providing the other two leaves. In the transfer the 'central leaf' is transferred to fill the primary defect. The effect is to leave a secondary defect. This, not being in an area of availability, is unsuitable for direct suture, and it in turn is closed by transfer of the 'outer leaf'. The defect which this leaves is designed to be in an area of availability and capable of being closed directly.

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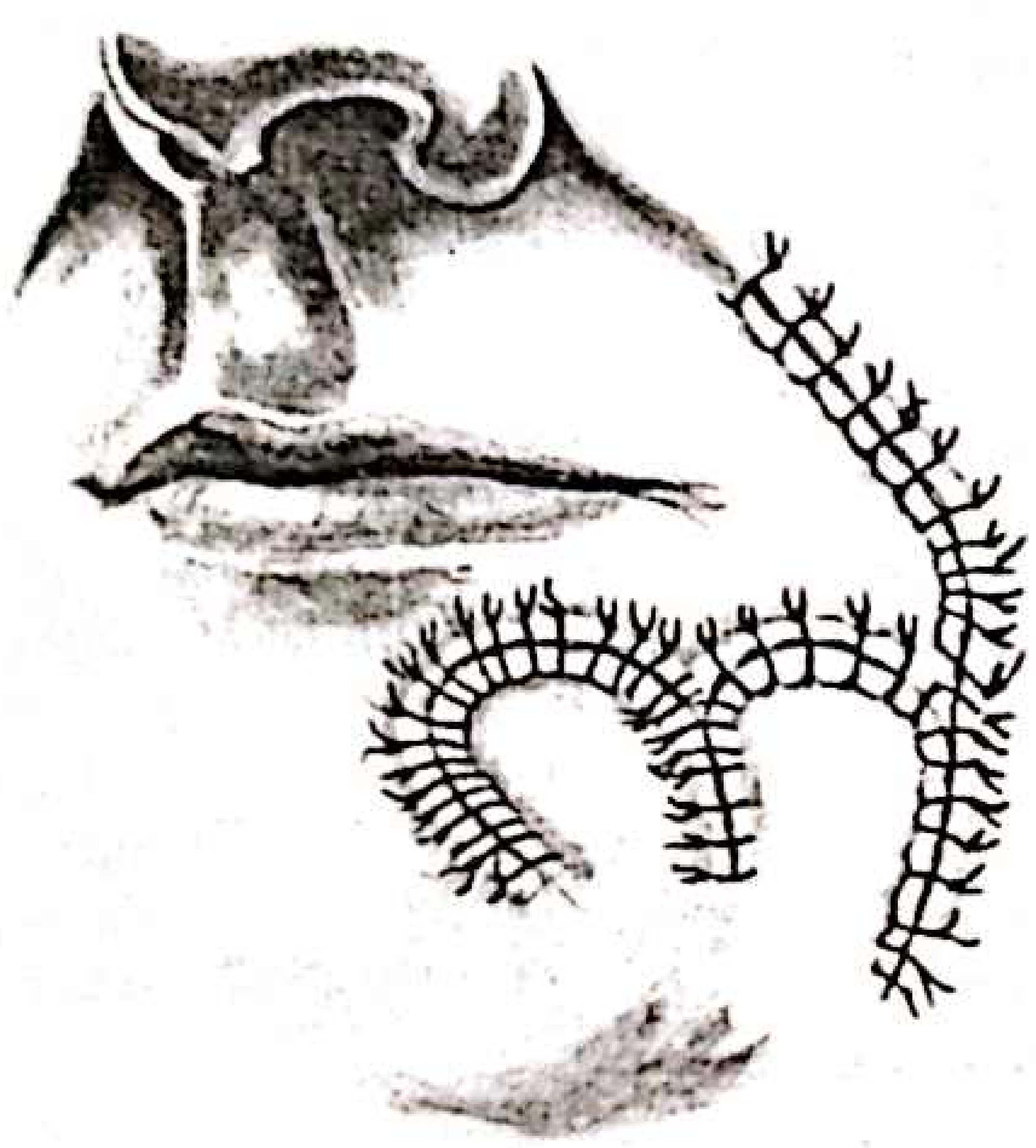

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The dimensions of the primary defect and those of the flaps require to be approximately similar, although with experience it is sometimes possible to make use of tissue elasticity and construct each flap a little smaller than the defect it is designed to fill, reducing the size of the final defect. The oval shape of the flaps has a tendency to result in pincushioning and the smaller each is in size the more obtrusive is this likely to be.

This is a technique with a valuable, even if small, place but it is one which has to be planned with great care and used with considerable judgement. Failure in either of these aspects is liable to produce a disastrous result and one which is unlikely to be readily retrievable. It is a method which should be used sparingly and only by an experienced surgeon.

FOREHEAD FLAPS

54

Many flaps have been developed to make use of the hairless skin of the forehead. They show a wide variation in design but they have in common their vascular background. This is based on the named arteriovenous systems which provide the vascular input–outflow of the area, the supraorbital-supratrochlear systems passing upwards on each side of the glabellar area, and the anterior branch of the superficial temporal artery which, together with its vein, passes horizontally across the forehead towards the midline. In addition to these feeding vessels, however, the entire area has a network of linking vessels whose calibre is such that they are capable of converting what would appear in anatomical terms to be a random pattern flap into an axial pattern flap, measured in terms of its clinical behaviour. The entire network has a virtual absence of deep connections, the overall orientation of the vascular system being horizontal. Together these factors explain why a delay is rarely required in using flaps in this area, and also why on the rare occasions when delay is used it need not include elevation of the flap.

Forehead flaps are most often used to reconstruct defects below the level of the eyes and the presence of a bridge segment is then unavoidable. Many of the flaps used in practice are so narrow that tubing of the bridge segment is not practicable, and even with the broader designs their rigidity makes tubing generally impossible. Fortunately the blood supply of flaps raised from this area is so good that infection of the raw surface which is left exposed in the bridge segment is virtually unknown.

In the case of the smaller and shorter flaps, where the secondary defect is being closed directly, it is often possible to match the thickness of the part of the flap which is being inset into the defect to the depth of the defect, by raising the flap superficial to frontalis and the glabellar muscles. When the secondary defect is extensive enough to require grafting, it is more common to raise the entire flap at its definitive level, that is, deep to the frontalis muscle. To this generalization there is one notable exception, namely in the raising of the forehead flap to reconstruct the nose. In one of the standard methods, the skin overlying the frontalis muscle is the segment used to provide the skin component of the reconstructed nose, and in order to make it as thin as possible this part of the flap is raised superficial to the muscle. The plane between muscle and skin is not a natural one, and requires careful dissection. As soon as the bridge segment of the flap is reached, however, the standard surgical plane, just superficial to the pericranium, is used to ensure the inclusion of the maximum axial vasculature.

Depending on the site of the flap and the direction of the incisions, the raising of the flap at the pericranial level frequently divides nerves, both motor and sensory. Horizontal incisions tend to produce sensory loss above the incision and vertical incisions produce palsy of frontalis medial to the incision. The closer the vertical incision is to the midline, the less is the palsy produced, but as a factor in design neither loss, motor or sensory, rates particularly highly in the surgeon's calculations, other factors being considered more important in most instances.

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The secondary defect

The method of managing the secondary defect generally depends on its breadth. Where possible direct suture is used; otherwise the defect is split-skin grafted.

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The forehead and scalp provide an ideal site for delayed exposed grafting, but if this method is being used it is essential is to make sure that the surface exposed when the flap is raised is not allowed to dry out. Under the heat of an operating lamp the pericranium can mummify with disturbing speed, resulting in graft failure and the exposure of bare calvarium.

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This disaster can be avoided by covering the site with an occlusive dressing as soon as the flap is raised. A 5 mm thick layer of tulle gras, cut to fit the defect and fixed to its margins with tacking sutures, functions well. Removal in 24–48 h allows the surface to be prepared for the application of the graft, cut and stored in the refrigerator at the time of the original procedure.

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With the patient in bed, awake and cooperative, the graft, with a small margin of overlap, is laid on the raw surface, and the patient instructed to be careful. In such a situation, delayed exposed grafting is technically easier, more convenient, and take is more consistent.

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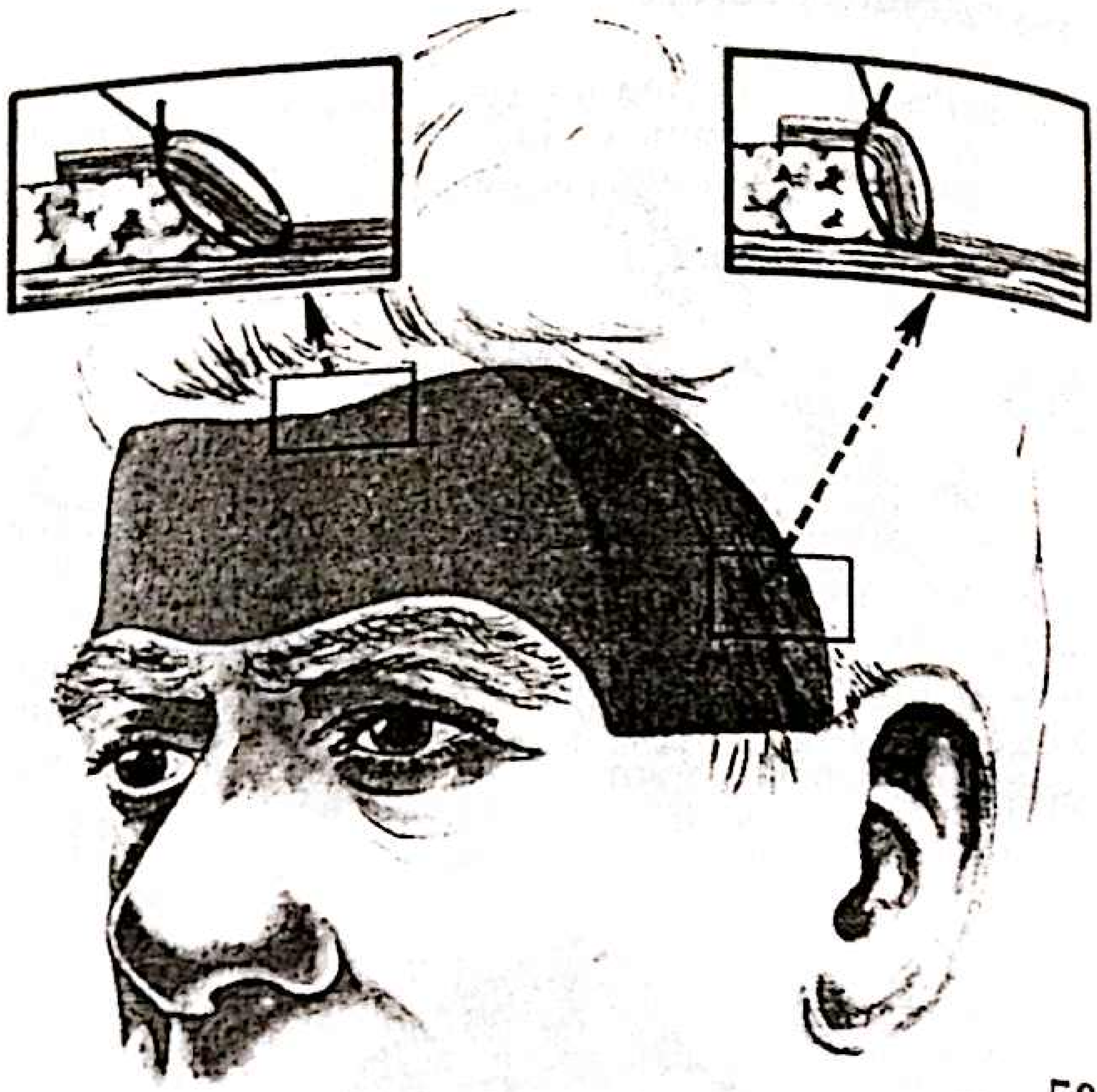

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When a graft has been applied to the forehead defect, the thickness of the flap is not matched by the thinner graft and a localized depression results. The initial 'punched out' appearance at the margin of the graft can be reduced if the flap is bevelled along its margin. Even if this is not done it is found that the initially abrupt change of contour slowly settles and the ultimate result is largely the same, regardless of whether or not bevelling was carried out at the outset.

When the transferred flap has an inset segment and a bridge segment, the management of the latter when the flap is divided 3 weeks after the initial transfer depends on whether the secondary defect has been grafted or closed directly. In the case of the former the bridge segment is usually returned to its original site, a corresponding area of the graft being excised. When the secondary defect has been closed directly, the bridge segment is generally discarded.

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The bridge segment of a forehead flap tends to tube itself spontaneously over the 3-week period between the initial raising and transfer, and division and final insetting.

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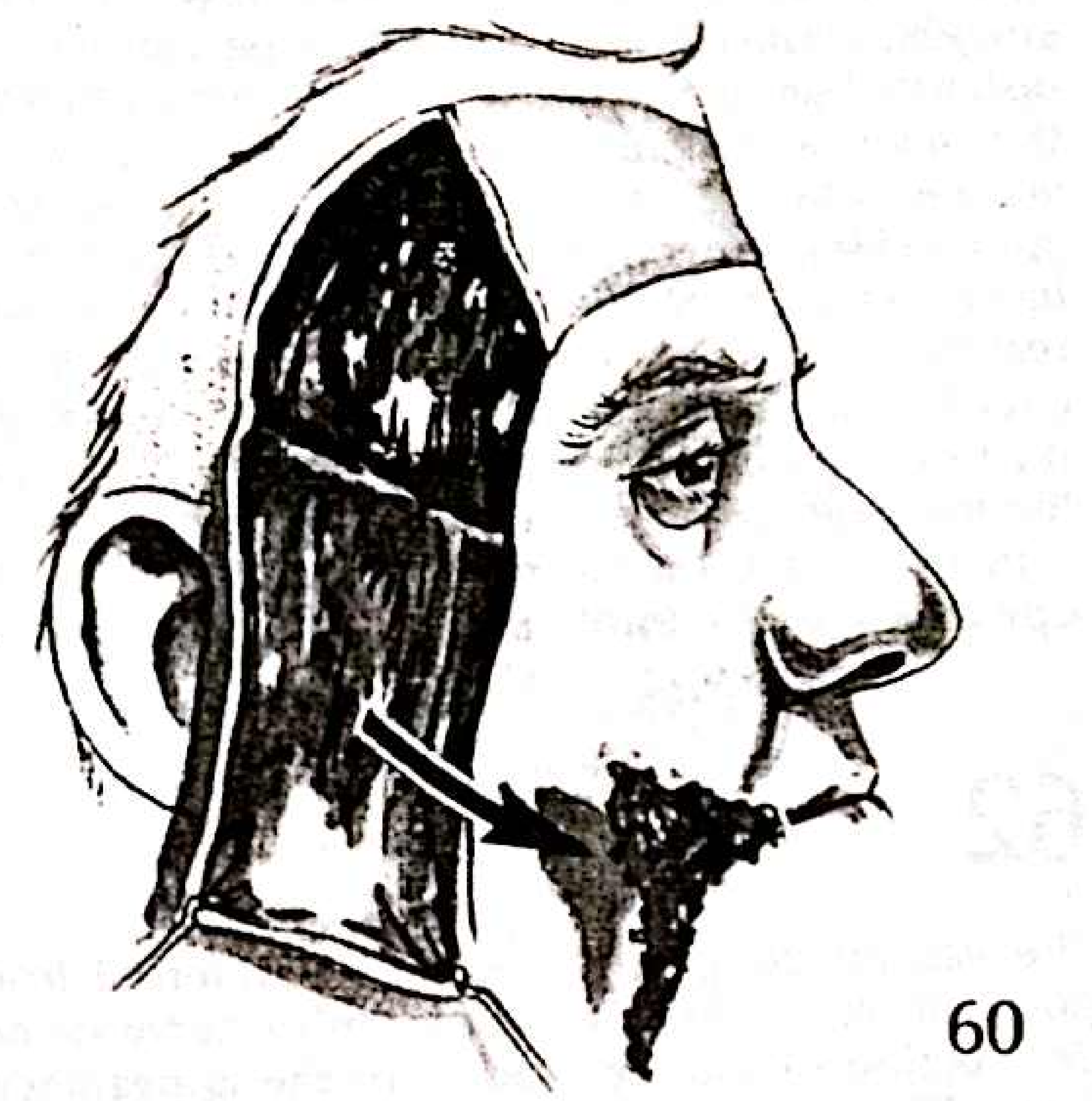
The processes involved in this are fibrotic contraction along the axis of the flap and the growth of spread epithelium from the margins. When the bridge segment is returned to the forehead it is essential to undo the tubing by removing the line of fibrous tissue which has built up along the core of the flap and excising the spread epithelium.



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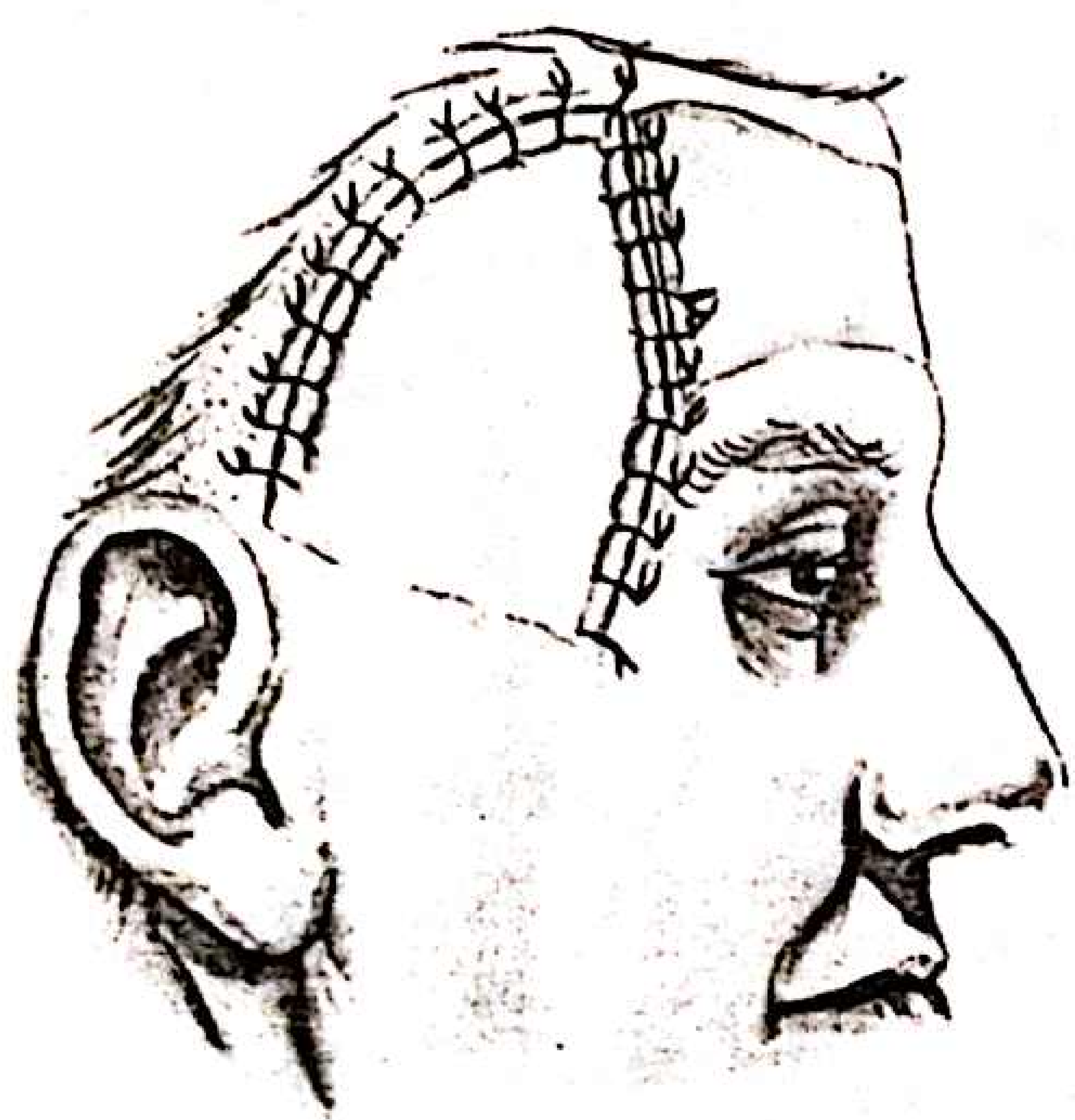

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Unless this is done carefully and thoroughly, difficulty will be encountered in restoring the flap to its original width and fitting it in its original site.

When a forehead flap has been used and the defect has required a graft, one of the less satisfactory but largely unavoidable consequences is a loss of movement of that part of the forehead because of the inclusion of the frontalis muscle in the flap. The graft is also usually very obvious as a patch, either unduly pale or markedly pigmented compared with the surrounding forehead. In contrast, the flap provides an excellent colour and texture match in its transferred site.

Considered as a flap source, the forehead has considerable virtues as well as adverse qualities and in each clinical situation they have to be balanced against one another. The balance is one which is likely to be tilted significantly in its favour with more extensive use of tissue expansion, and the opportunity which it presents to avoid the need to graft the secondary defect. The principles underlying the use of tissue expansion are discussed in the chapter on 'Scalp and forehead', pp. 195–214.

When it has been possible to close the forehead defect directly, care should always be taken to match the transverse forehead wrinkle lines. Mobilization of the forehead skin on each side of the defect to allow closure under less tension is frequently advocated, but the amount of additional advancement which it achieves in practice is disappointingly small. Fortunately forehead skin tolerates suture under considerable tension without adverse effects.

The flaps which are raised on the forehead are either based inferiorly, and make use of the supraorbital-supratrochlear system, or are based laterally, and make use of the superficial temporal system.

Inferiorly based flaps

Inferiorly based flaps most often take the form of a straight, relatively narrow, finger-type flap which passes upwards from the glabellar area. It is most often based on the midline and uses the supraorbital-supratrochlear system. Curving of the flap to one or other side in approaching the glabellar area can be used in order to increase the reach of the flap a little. The sites within the reach of such a flap extend from the lower eyelid, over the cheek, to the nasal tip, but the size of the defect generally regarded as suitable must be sufficiently narrow to allow the forehead defect to be closed directly.

In theory such a flap can pass vertically or obliquely upwards over the forehead.

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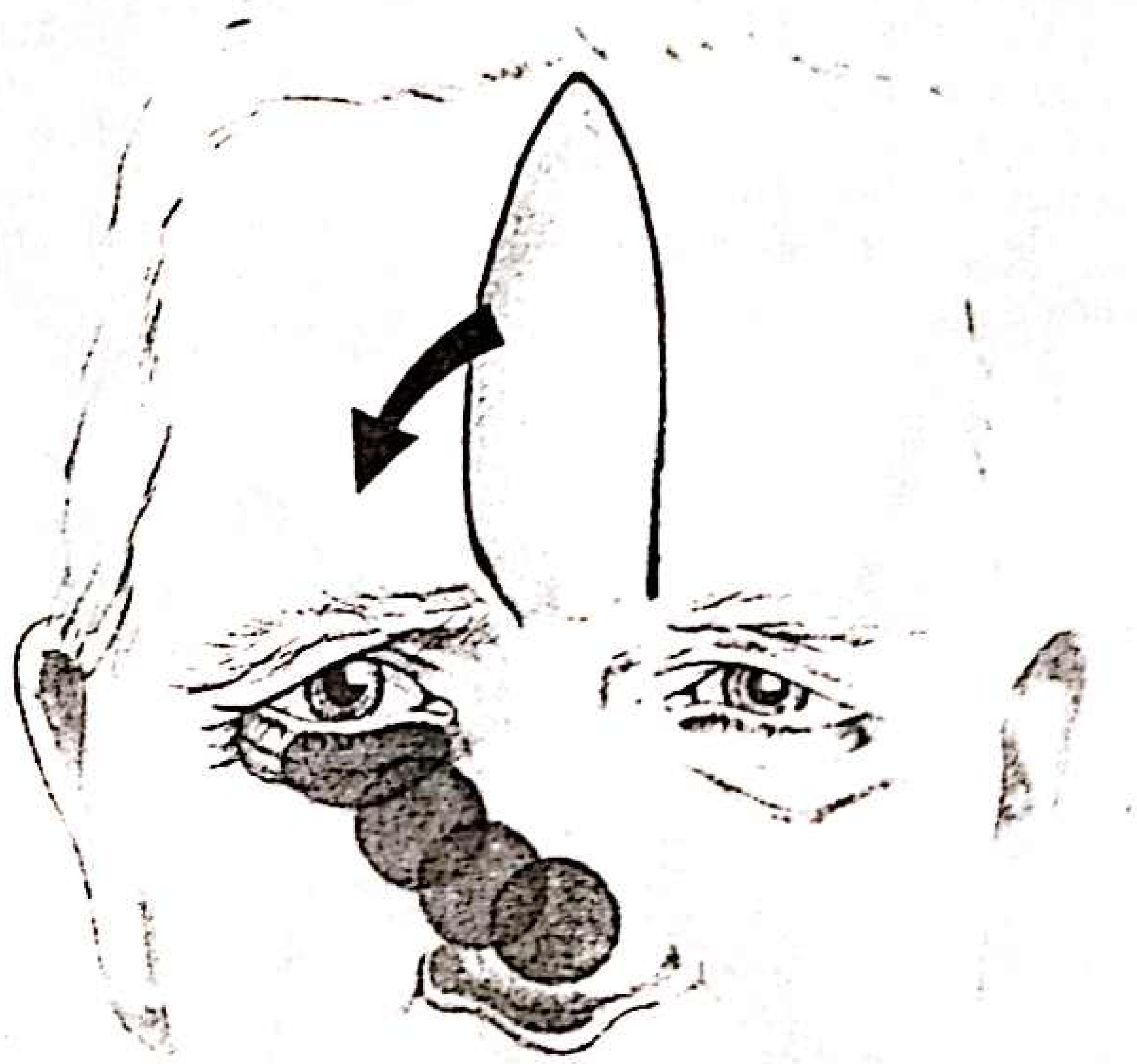
The vertical design is much to be preferred from every point of view – from the absence of nerve damage and destruction of muscle, and from the appearance of the final scar. The factor which limits the vertical construction is the height of the forehead.



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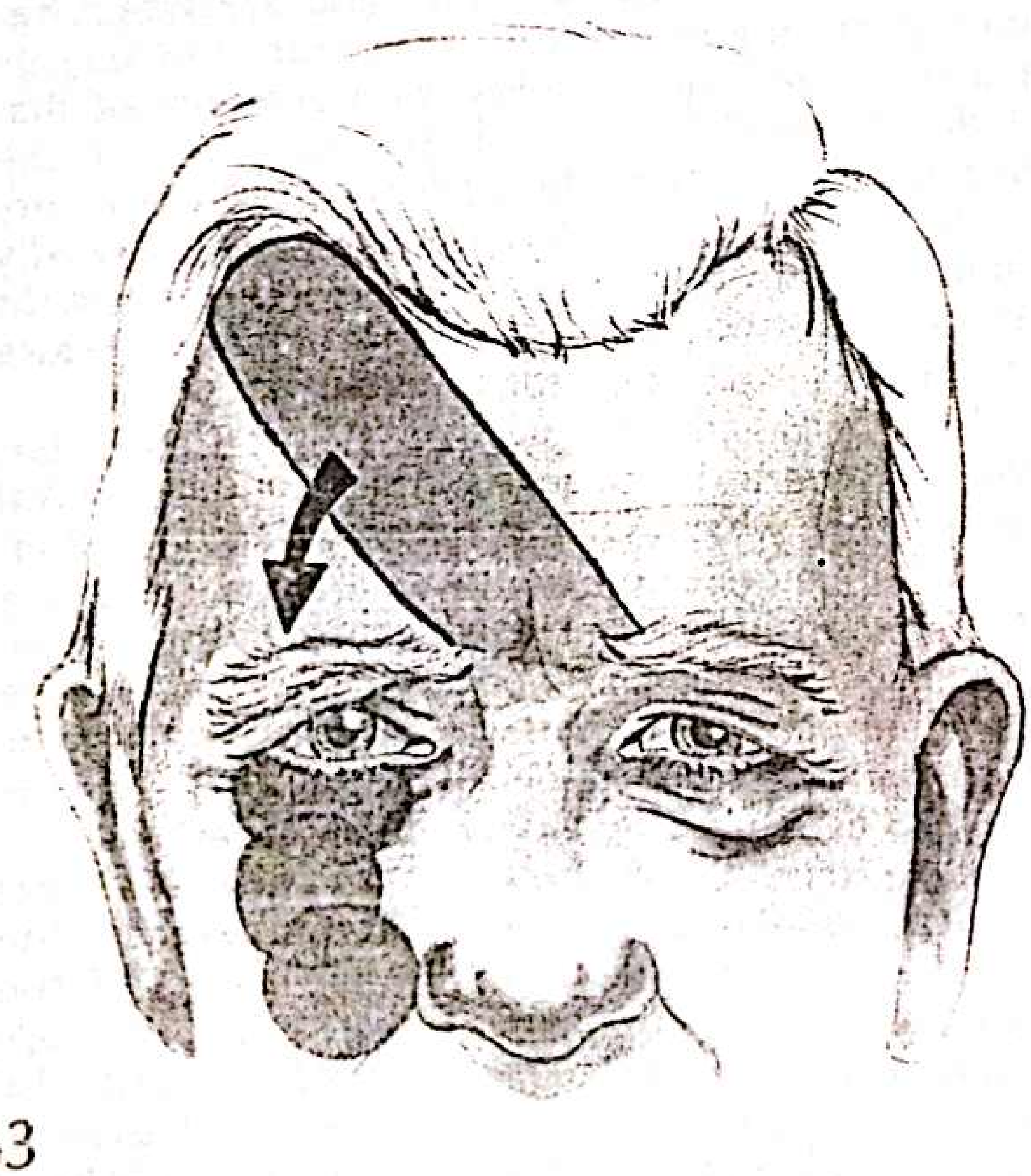

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If this is insufficient to provide an adequate length of flap, an oblique construction may be unavoidable because of the extra length of flap which it makes possible. The secondary defect of the obliquely designed flap has generally to be grafted if eyebrow asymmetry is to be avoided.

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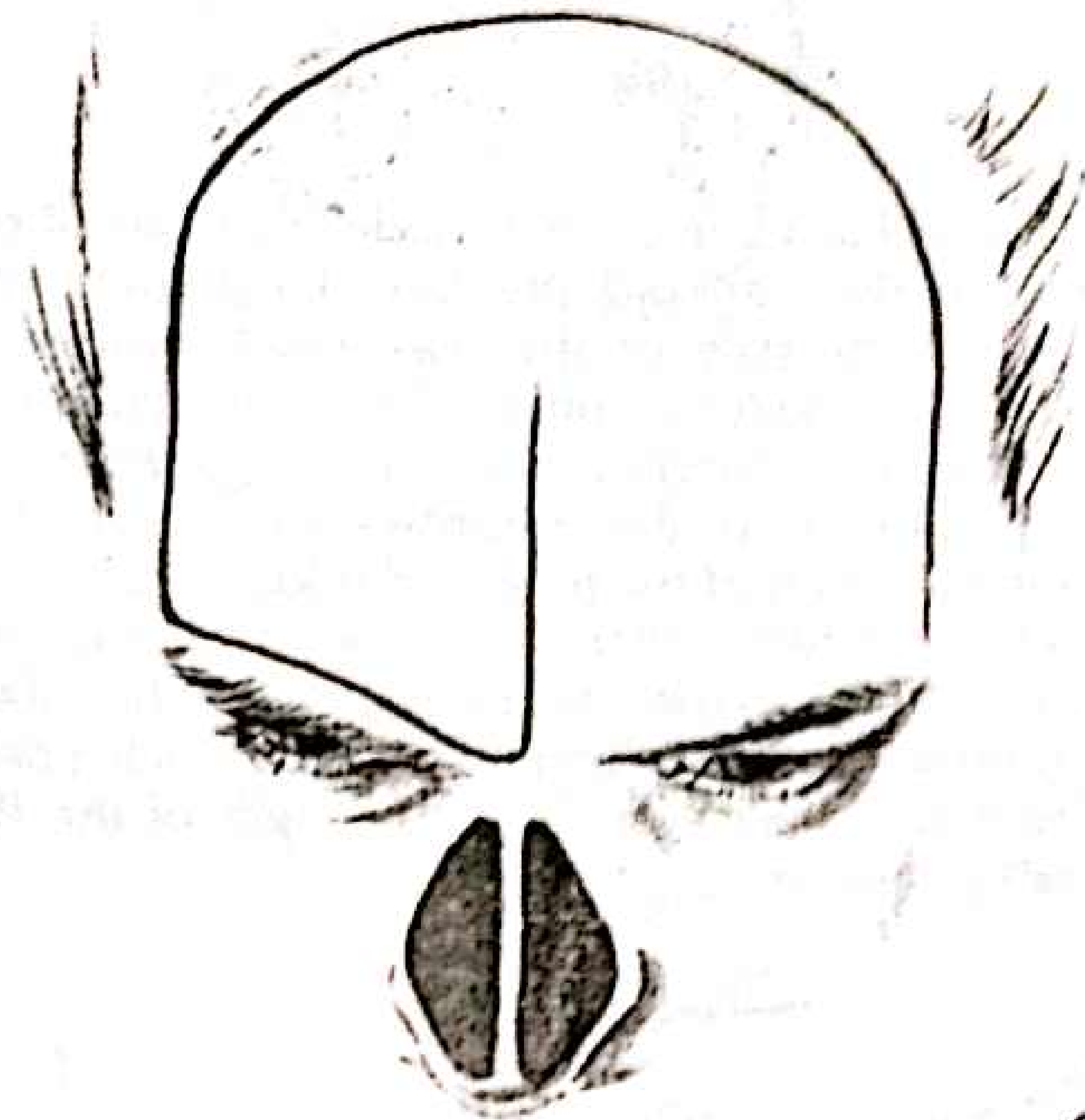
An alternative form which the inferiorly based flap can take is with a 'sickle' shape. With this design its use is virtually confined to providing the skin cover element of a nasal reconstruction following a major resection. The flap is based on one or other eyebrow, extending over its entire width and including the supraorbital-supratrochlear vessels. The flap passes upwards on to the scalp and turns round in a curve to run vertically downwards on to the opposite side of the forehead. It is the hairless forehead segment which is finally transferred, the remainder of the flap acting as its bridge segment.



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The segment of the flap overlying frontalis, as already pointed out, is raised in the plane superficial to the muscle, to give it the necessary thinness to tolerate the folding necessary to reconstruct the nostrils and columella.

Laterally based flaps

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Laterally based flaps use as their pedicle part or all of the skin between the ear and the lateral extremity of the eyebrow, and the part of the flap which provides the transferred tissue extends on to the hairless skin of the forehead. The final forehead defect has generally to be grafted if asymmetry of the eyebrows is to be avoided. If the full vertical width of the forehead is being raised as the flap, it can be safely be extended across the midline to the hairline on the opposite temple despite the obvious reversal of vascular flow which results from such a design. When the flap is narrower the safe length of the flap is considerably shorter.

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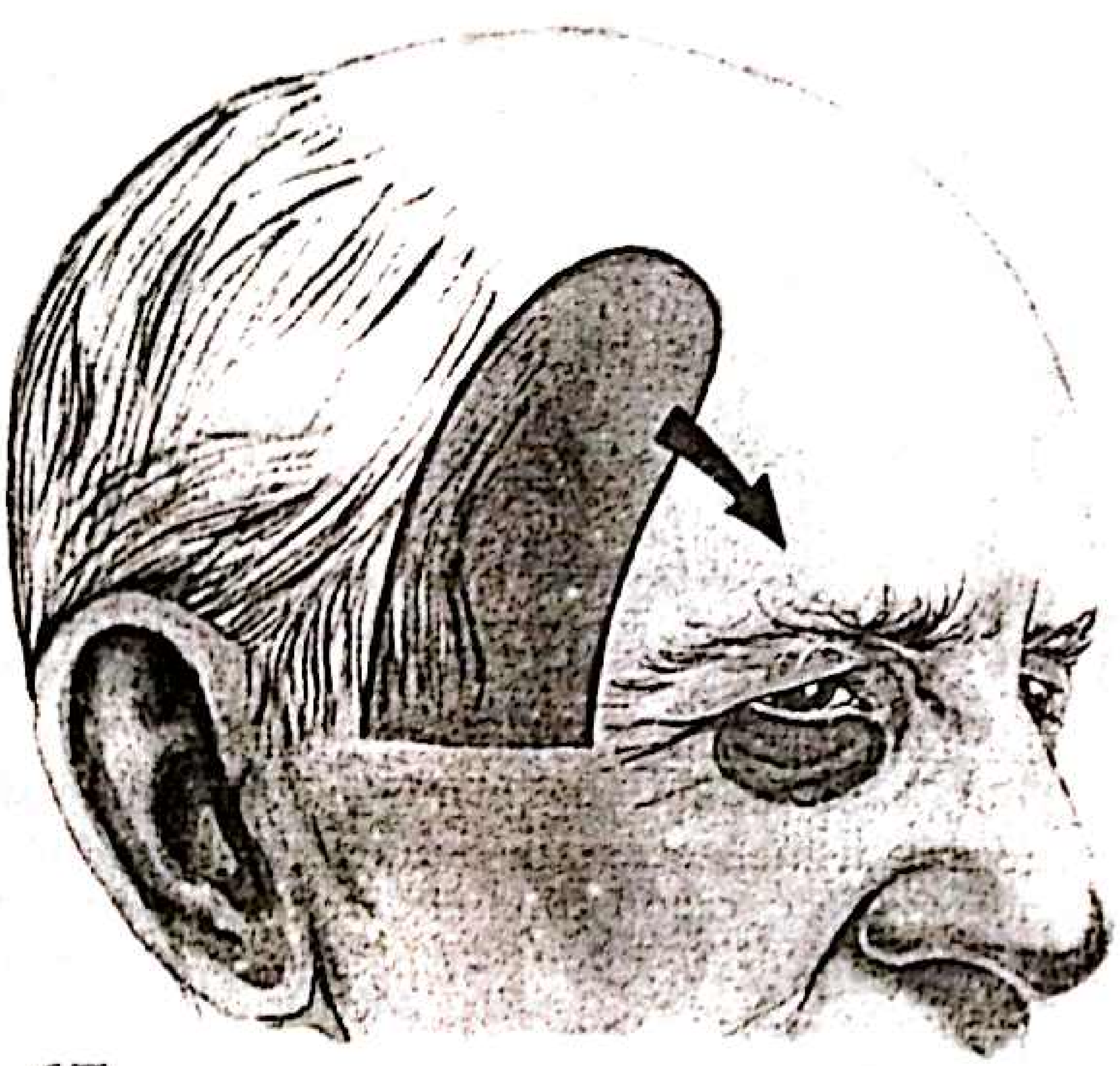

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If only a relatively short flap is required it may be possible to confine the flap to the temple area as the donor site of the flap. This site is frequently hairless as part of the masculine baldness pattern and a graft in that site is generally less conspicuous.

The superficial temporal artery often has a tortuous course in the older age group and it may be wise to map out its line on the skin preoperatively to ensure that it is included in the flap over its entire length. One of the uses to which the laterally based flaps has been put is in intraoral reconstruction. In this role it is discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

While these are the flap designs most often used, alternative shapes to match the outlines of specific defects can also be used, provided always that they are effectively perfused by one or other of the vascular systems which have been described.

Distant flaps

DELTOPECTORAL FLAP

68

This flap extends horizontally across the anterior chest wall towards the tip of the shoulder from a base along the lateral border of the sternum. Its vascular basis is provided by the upper two or three perforators of the internal mammary vessels. The line of the upper border of the flap is made parallel to and just below the line of the clavicle, and the lower border is usually made to run along the anterior axillary fold. Its extreme lateral extent is the midlateral line of the deltoid muscle. The flap designed in this way will include the first two perforating vessels and usually the third also.

The deltopectoral flap has the general reputation of being a reliable flap, but any extension beyond its recognized safe length, that is almost as far as the midlateral line on the deltoid muscle, is unsafe unless preceded by a scrupulous delay, and even then problems of viability of the distal end of such an extended version must be expected. Within its recognized safe length no preliminary delay is required, an attribute which is essential in the context of reconstruction following resection for malignancy, where the extent of the defect cannot be assessed with certainty preoperatively. The flap designed with the full length as described above can generally be expected to reach the level of the zygomatic arch, but this is the limit of its reach if it is to be used with reasonable safety.

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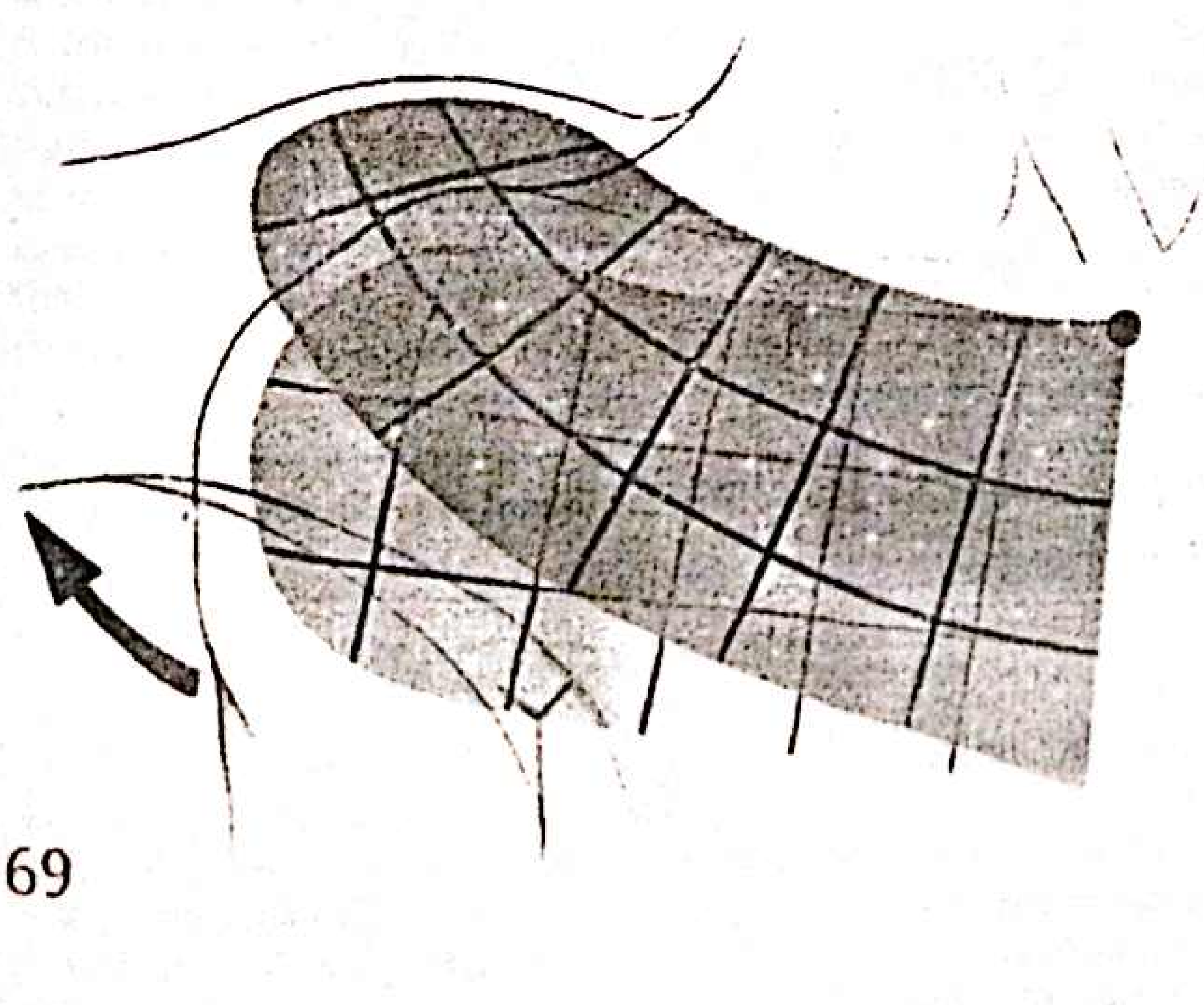

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The pivot point of a flap transposed in this way, and consequently the point from which measurements are made in planning the transfer, should normally be the base of the flap at its inferior border. As a result of the considerable laxity of the skin in its lower part, concentrated most markedly along the anterior axillary fold, and present in order to accommodate free abduction of the shoulder, this flap has an anomalous pivot point. A more accurate measure in planning is provided if the various distances are measured from the upper border of the flap at its base and this extends the reach of the flap considerably. Measurements should also be carried out with the head extended to ensure that, when transferred, the flap has sufficient laxity for safety.

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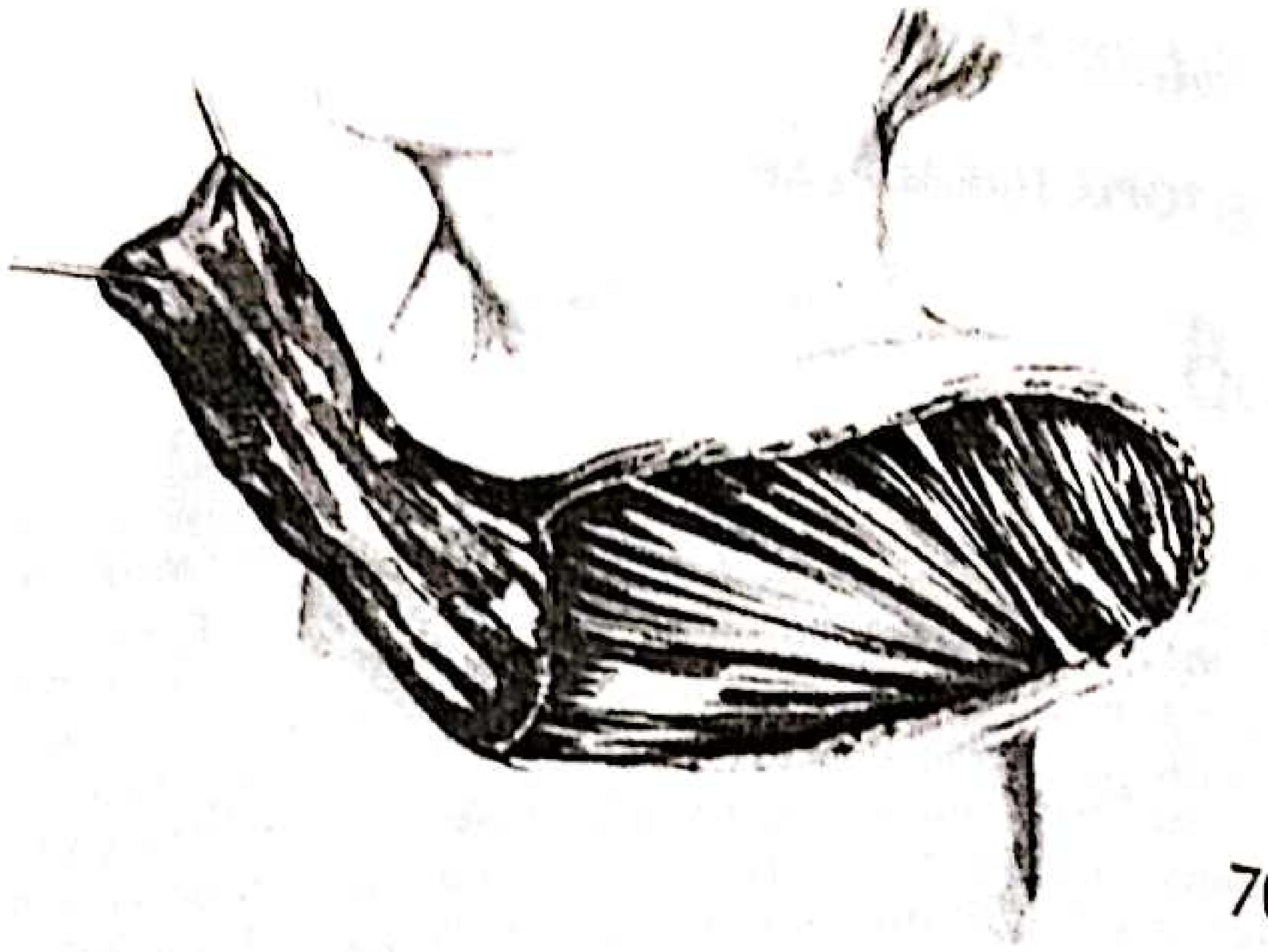
Following the outlining of the flap on the skin, the margins are incised down to the underlying muscles. The plane in which it is raised includes the deep fascial layer, stripping the pectoralis major and deltoid muscles bare. This is a relatively avascular plane, the only vessel of any size regularly encountered being the deltoid branch of the thoracoacromial artery, one which requires ligation or diathermy. The flap is raised almost to the lateral sternal border. As the border is approached the perforating vessels are watched for and preserved, each in its intercostal space in the semicircle formed by the sternal border and the ribs.



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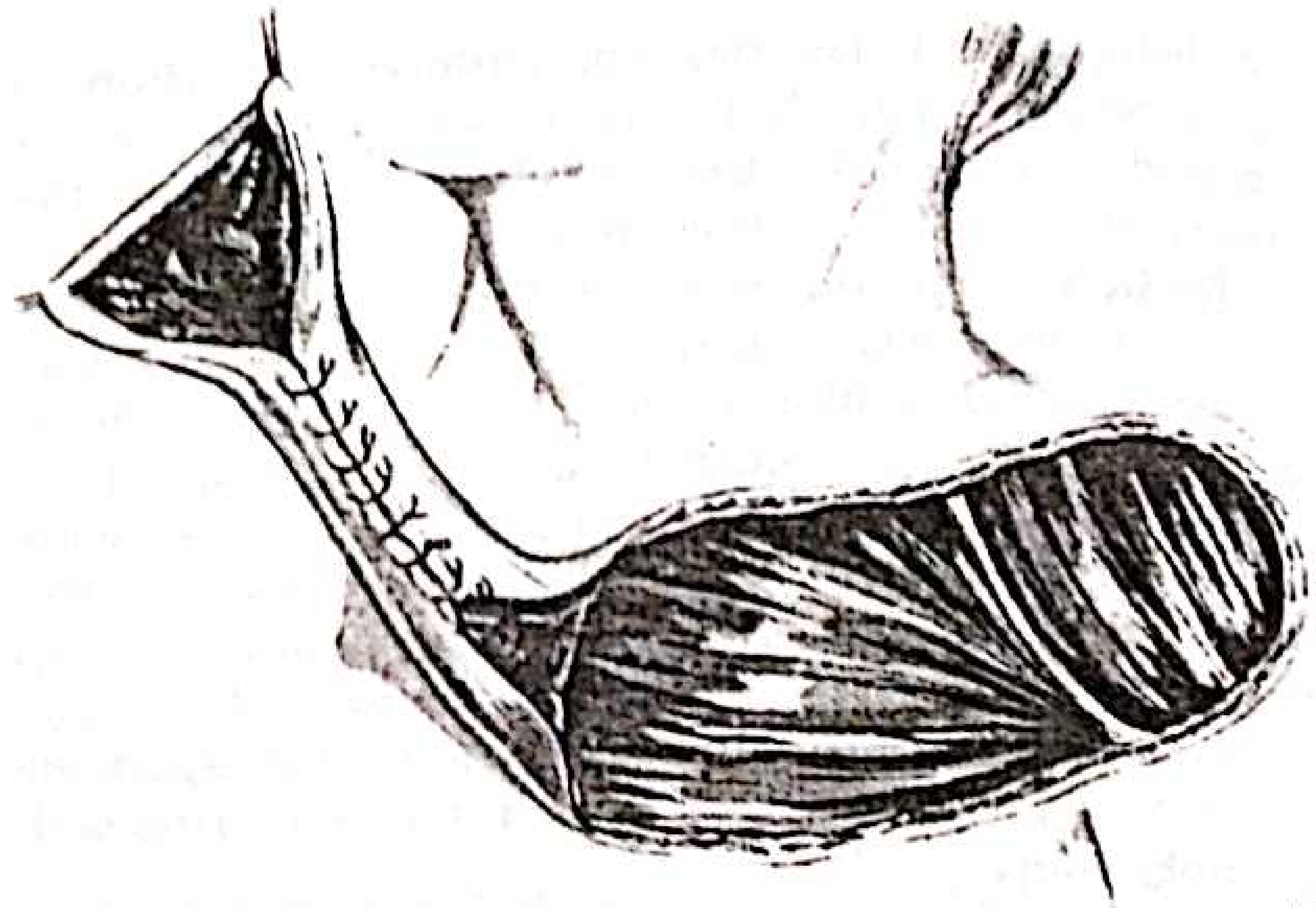
When the flap is being used to reconstruct a surface defect at a distance, it is usual to tube the bridge segment in order to eliminate its raw surface.



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In its transferred position, rapid and effective adhesion between the flap and its bed is essential, and this is best achieved by passing a suction drain along the tubed pedicle to the distal end of the flap. Transfer of the flap in this way leaves a secondary defect on the anterior chest wall which is normally split-skin grafted.

The flap is left for 3 weeks, and the pedicle is then divided, the bridge segment of the flap being untubed and returned to its original site on the chest, excising enough of the graft to accommodate it.

The question of whether or not the flap should be inset immediately following division of the pedicle is a matter of some importance. Insetting the flap involves the elevation of a proportion of the already attached segment, untubing it, trimming the excess and suturing it in position. To carry this out in other parts of the body immediately after dividing the pedicle is to run the serious risk of 'rim necrosis' of the part of the flap being inset. It has been found that, with a reasonably extensive initial attachment of the flap, the overall vascularity of the facial skin and subcutaneous tissue allows division and immediate insetting to be carried out without necrosis resulting. When the area of attachment is less extensive, or if for any other reason the vascular attachment is considered to be less than optimal, it is safer to postpone insetting for a week following the division of the pedicle. In the interval the raw end of the pedicle is dressed.

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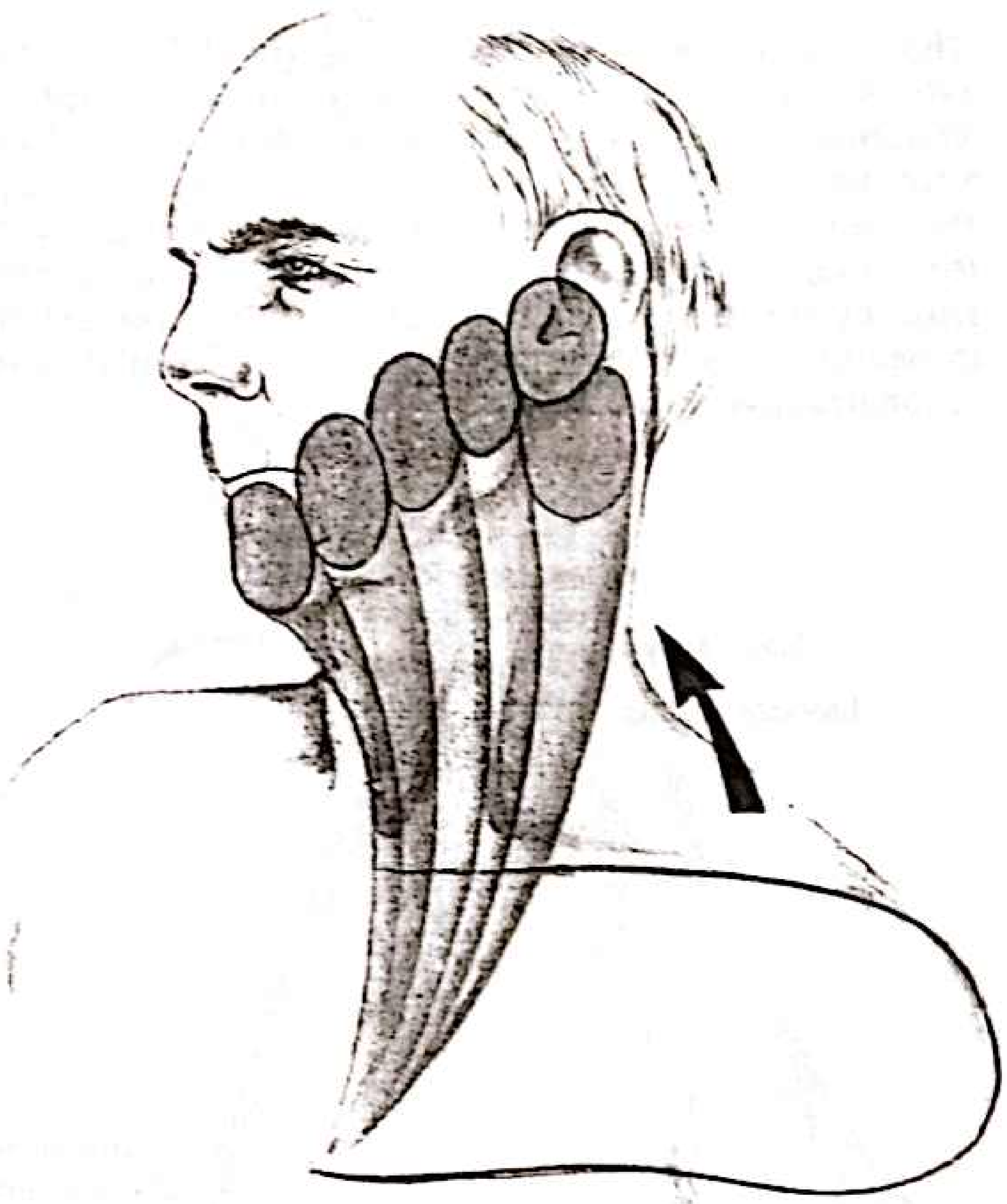
The flap is available to resurface defects within a quarter circle arc – mastoid area, ear, parotid area, cheek, lower lip, chin, and the neck within the arc.



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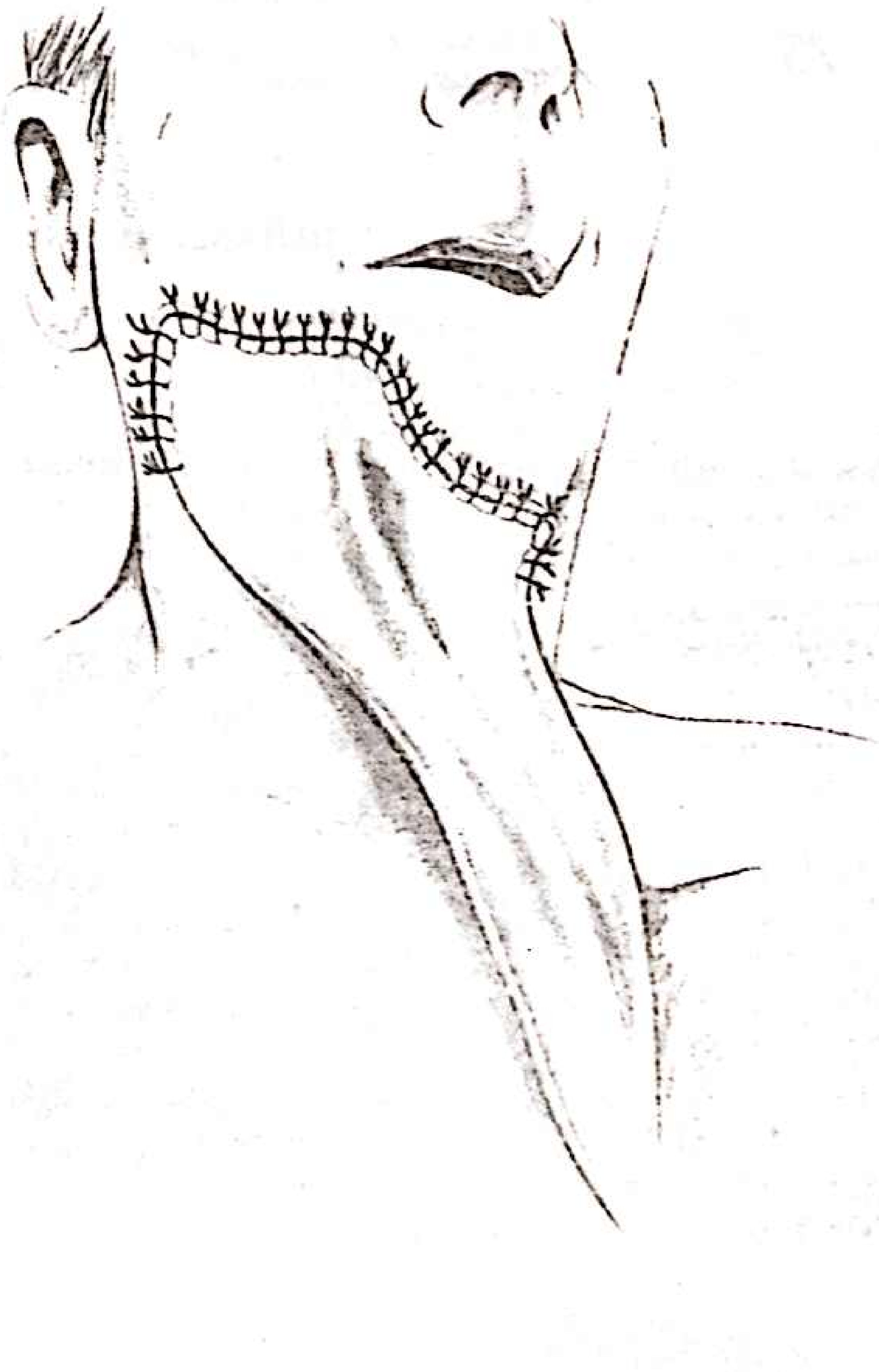
When the flap is used to replace neck skin, it is often technically possible to use either side of the chest as the source. Generally speaking, the position of the flap pedicle and its direction after the transfer should have the effect of pulling the flap on to the defect rather than pulling it off. A similar situation arises when a submandibular defect is being resurfaced, the flap raised on the contralateral side generally being more effective.

The frequency with which this flap is used today depends very much on whether microvascular facilities are available and the surgeon has the necessary expertise. A further factor in deciding its suitability in a particular clinical situation concerns the depth of the defect. The deltopectoral flap has little bulk in relation to its surface area and is at its best where the depth of the defect matches the thickness of the flap. Failure to appreciate this is liable to leave a residual contour defect even though the surface element has been corrected.

The deltopectoral flap is hairless and this may limit its value, although given the size of the defect for which it might be considered suitable, the alternatives also share that deficiency. Initially paler than its surroundings in the face, it generally weathers to an adequate colour match.

Its major deficiency in the current surgical climate is the fact that it is a two-stage procedure. The site of the secondary defect is also viewed by some as an adverse factor. These disadvantages have to be matched against its acknowledged virtues of technical ease, relative safety, and simplicity generally. It has also been used in intraoral reconstruction, as discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240, but its popularity in this role has decreased even more markedly than its use in surface reconstruction.

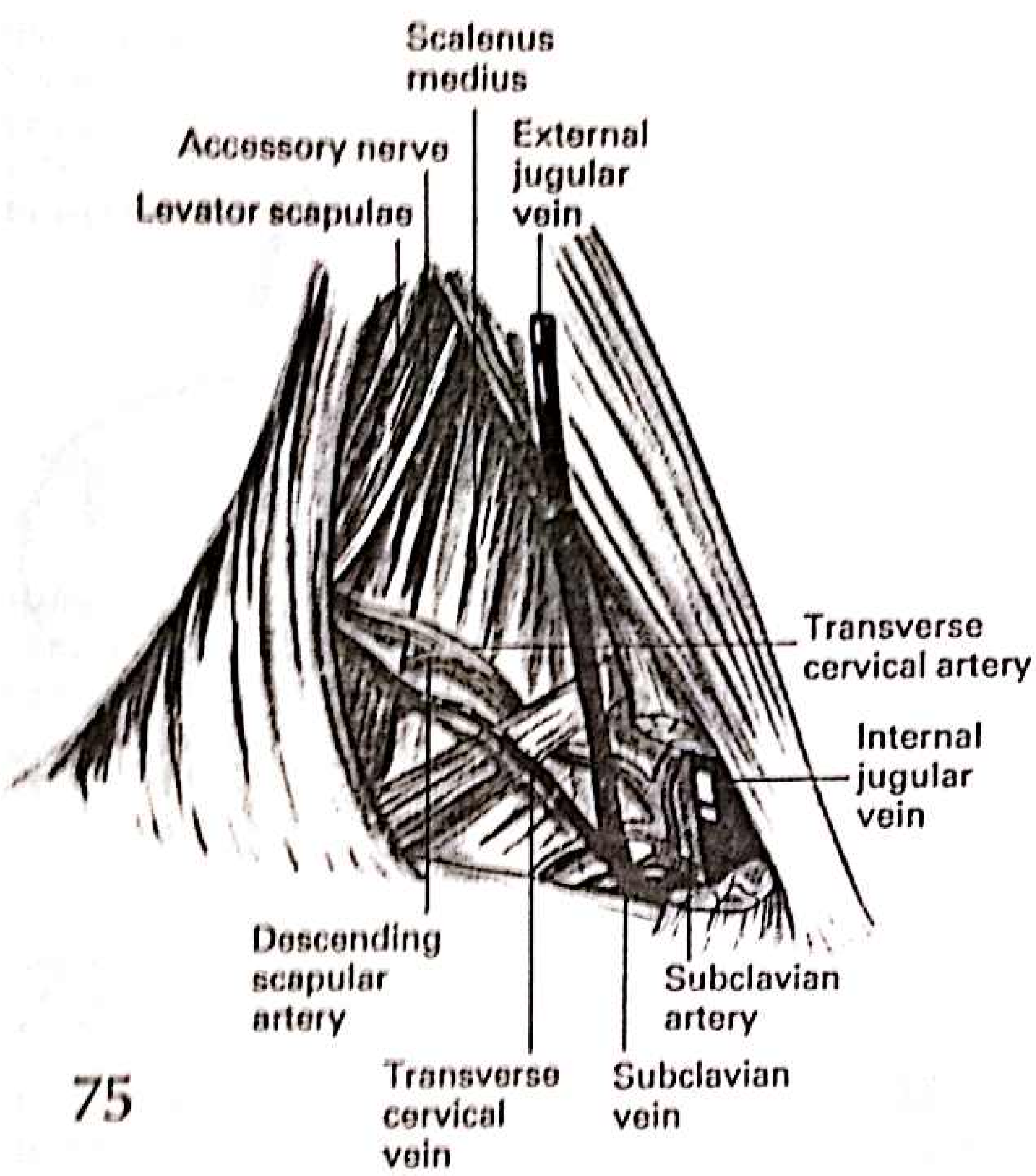


74

TRAPEZIUS FLAPS

The trapezius muscle receives a segmental blood supply which reaches its deep surface along the length of its attachment from the occiput to the lowest thoracic spinous process, but it is the supply provided by the transverse cervical vessels and the descending branch of the occipital artery which are important as perfusion sources of the myocutaneous flaps which make use of the trapezius muscle and which have pôtential use in reconstructive surgery.

The anatomy of these vessels, particularly the transverse cervical, is extremely important with regard both to the basic pattern and the variations which may be present. The variations are sufficiently frequent to create problems of nomenclature in the anatomical texts. Their importance to the surgeon lies in the fact that they may limit or even preclude altogether the use of the flaps which are based on them.



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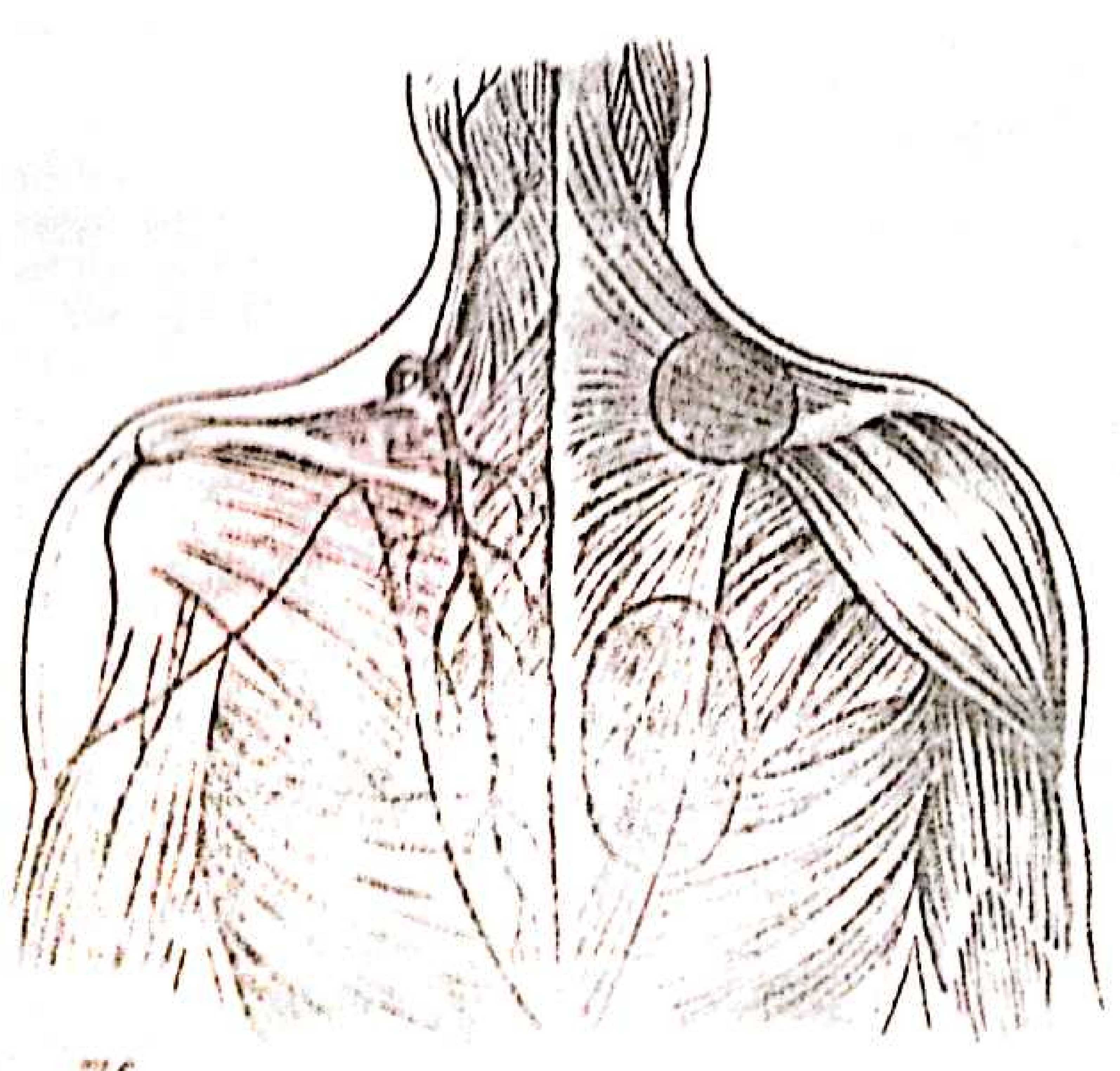
The transverse cervical artery, in the form which enables the lateral trapezius flap to be used, is one of the terminal branches of the thyrocervical trunk, and it passes laterally across the lower part of the posterior triangle towards trapezius. At the anterior border of levator scapulae it divides into superficial and deep branches.

The deep branch passes down as the descending scapular artery, parallel to the vertebral border of the scapula and deep to the levator scapulae and the rhomboids. The superficial branch continues on to reach the anterior border of trapezius alongside the accessory nerve, both then passing under trapezius, between it and levator scapulae.



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There it divides into an ascending branch which forms an anastomosis with the superficial part of the descending branch of the occipital artery, and a descending branch which runs in the general direction of the lowest point of origin of the trapezius muscle.

To this description must be added the variations of importance to the reconstructive surgeon. These concern the occasional total absence of the artery and the relation of the artery to scalenus anterior. In approximately 40 per cent of individuals the artery passes behind scalenus anterior. Equally variable is the pattern of the associated vein. The standard course of the vein is parallel to the artery, in a more superficial plane, sometimes passing superficial, sometimes deep, to the inferior belly of omohyoid, but also the vessel regularly passes down behind the clavicle and empties into the subclavian vein instead of the more usual external jugular.

Three myocutaneous flaps are raised which make use of elements of the vascular pattern which has been described, the upper, lateral and lower trapezius flaps. The upper makes use of the anastomotic connection between the transverse cervical system and the occipital arterial system; the lateral and lower make use of the inferior branch of the superficial part of the transverse cervical artery.

Upper trapezius flap

77

The upper trapezius flap is the myocutaneous version of the 'nape of neck' flap, a relatively narrow flap of neck skin, based on the occipital area and passing downwards with its anterior border along the margin of trapezius. Used as a skin flap it has not had a good reputation for safety, but the effect of incorporating the length of trapezius immediately underlying the skin flap has been to enhance the reliability of the composite to a considerable extent.

The skin and subcutaneous tissue of the neck in this area is relatively rigid, and with the increase in bulk created by the inclusion of the muscle the flap which can be raised is even less flexible. It can only turn in a gentle curve and this has the effect of limiting its safe range and reach to the region of the ear and its surroundings. Even then it would not be regarded as a first choice, being reserved rather for the clinical situation where alternatives have failed.

77

Lateral trapezius flap

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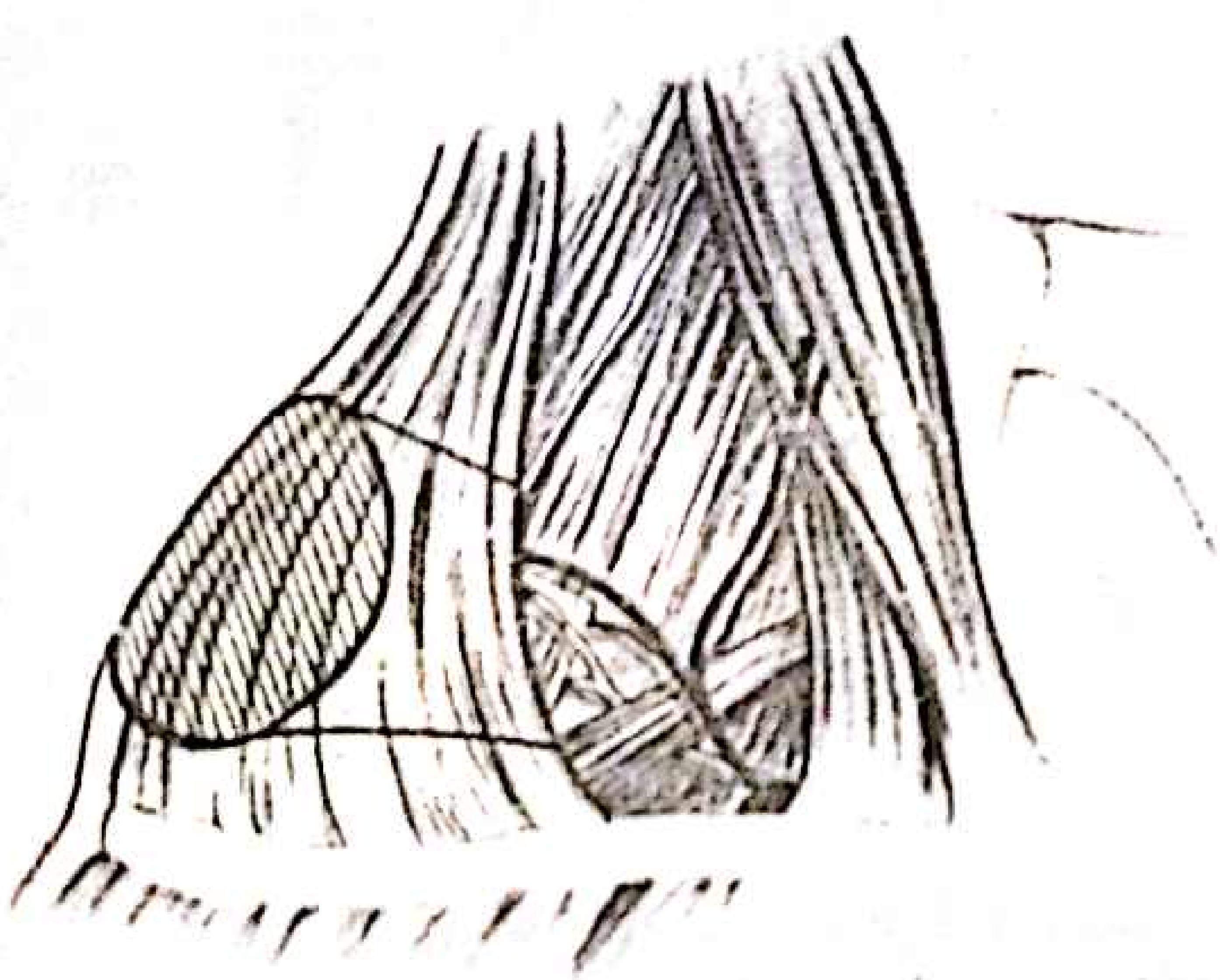
The lateral trapezius flap is based on the transverse cervical arteriovenous system, and its skin island lies astride the line of the artery as it runs from the point where it reaches trapezius 5 cm above its clavicular insertion downwards and medially in the general direction of the spine of the scapula.



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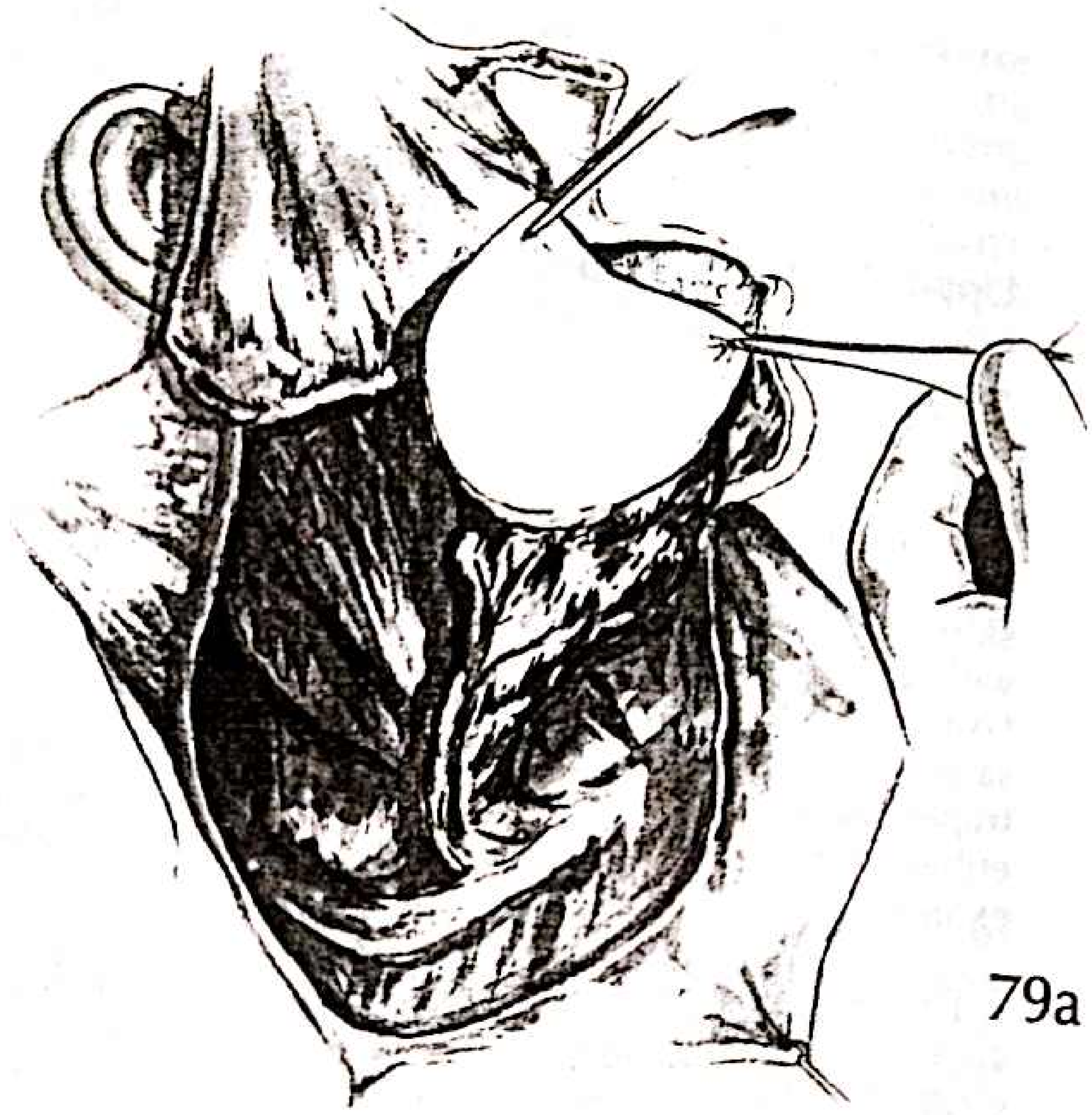

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The flap consists of the skin island with the trapezius muscle immediately underlying it; the pedicle consists of the strip of trapezius muscle passing towards its anterior border at the site of entry of the vessels, and beyond that of the transverse cervical vessels, the flap being elevated as far as the point of origin of the vessels, sacrificing in the process the accessory nerve.

79b

The position of the skin island on the line of the artery, and its dimensions, depend on the geometry of the transfer, taking as its pivot point the site of origin of the vessels in the neck. On the assumption that this is a fixed point, an aspect of planning discussed below, the placing of the island depends on matching the distance between the pivot point and the upper margin of the defect which it is designed to reconstruct, and that between the pivot point and the distant end of the island whose site is being planned.

The problem in planning is that, as a result of the variations in the anatomy of the vessels which have been described above, the pivot point cannot be ascertained with certainty; at worst it may not even be feasible to raise the flap successfully. This fact limits the potential value of the flap to a degree where it should only be considered in certain limited circumstances. These are where the carrying out of a neck dissection is part of the programme of resection, and where in the course of carrying out the neck dissection it becomes possible to explore the lower part of the posterior triangle of the neck and ascertain the anatomical situation as regards the transverse cervical vessels to find out whether the use of the flap is feasible. Only then will it be possible to fix the pivot point and allow accurate planning measurements to be made.

The flap has found its main role, virtually its only role, in intraoral reconstruction and, used for that purpose, it is discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

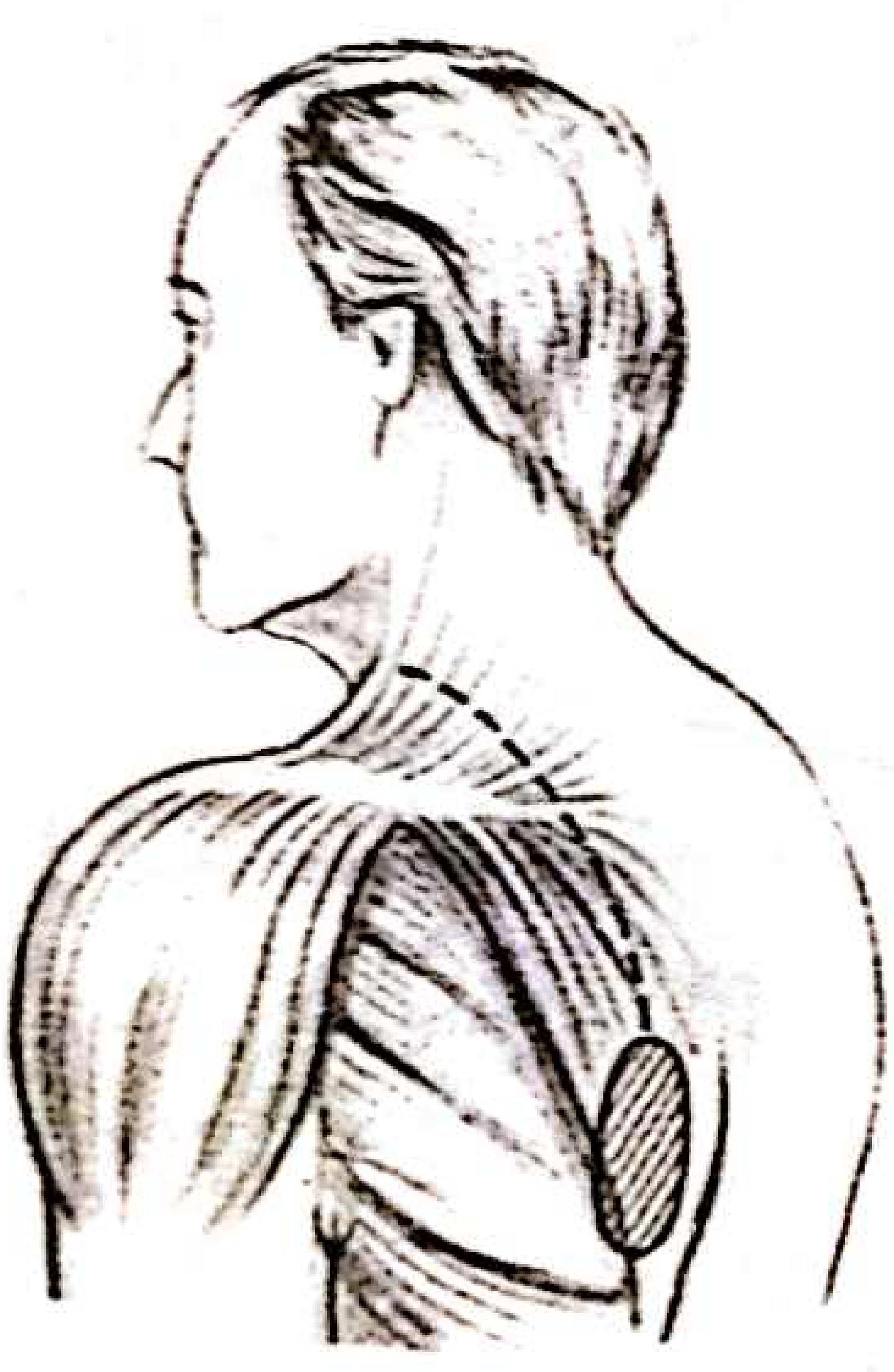
Lower trapezius flap

The lower trapezius flap makes use of the fact that the descending branches of the transverse cervical vessels run from the point at which they pass deep to trapezius in the general direction of the lowest point of origin of the muscle, entering its substance as they go. This determines the line of the muscle pedicle and, if the anterior border of trapezius where the vessels reach it is taken as the pivot point of the flap in planning the transfer, the relevant lengths can be used to calculate the site of the island along the line of the vessels.

Extending the pedicle as far as the anterior border of trapezius is liable to result in division of the accessory nerve with its effect on the shoulder from paralysis of the muscle.

A branch from the descending scapular artery has been consistently found to emerge from deep to the rhomboids. Together with the segmental vessels, it perfuses the lower part of the trapezius muscle. This is capable of providing the vascular basis of a modified version of the lower trapezius flap, in which the muscle is elevated only to the level of the scapular spine. Although the use of the modified flap would limit the reach of the flap and limit its potential role, it has been further advocated on the grounds that its use allows preservation of the function of the upper part of trapezius. However, the flap raised to its originally described length and perfused entirely by the descending branch of the transverse cervical artery has been found in clinical practice to be reliable, and this would suggest that there is sufficient intramuscular anastomosis to provide effective perfusion of an island as far down as 5 cm below the lower angle of the scapula.

The decision regarding which of the two pivot points to use, the upper using the transverse cervical artery alone, or the lower, will clearly depend on the geometry of the transfer, and other considerations may also be important, such as the relative inflexibility of the dorsal skin and subcutis, and the thickness of trapezius. The thickness of the muscle means that the flap, pedicled on the lower site, may only move in a gentle curve with a consequent reduction in its reach. Problems of pressure on the muscle pedicle may also arise, given the inextensibility of the dorsal skin. On all of these grounds it may be advantageous to extend the muscle pedicle to the point at which the transverse cervical vessels reach the muscle, and also to allow an element of reserve at the planning stage.



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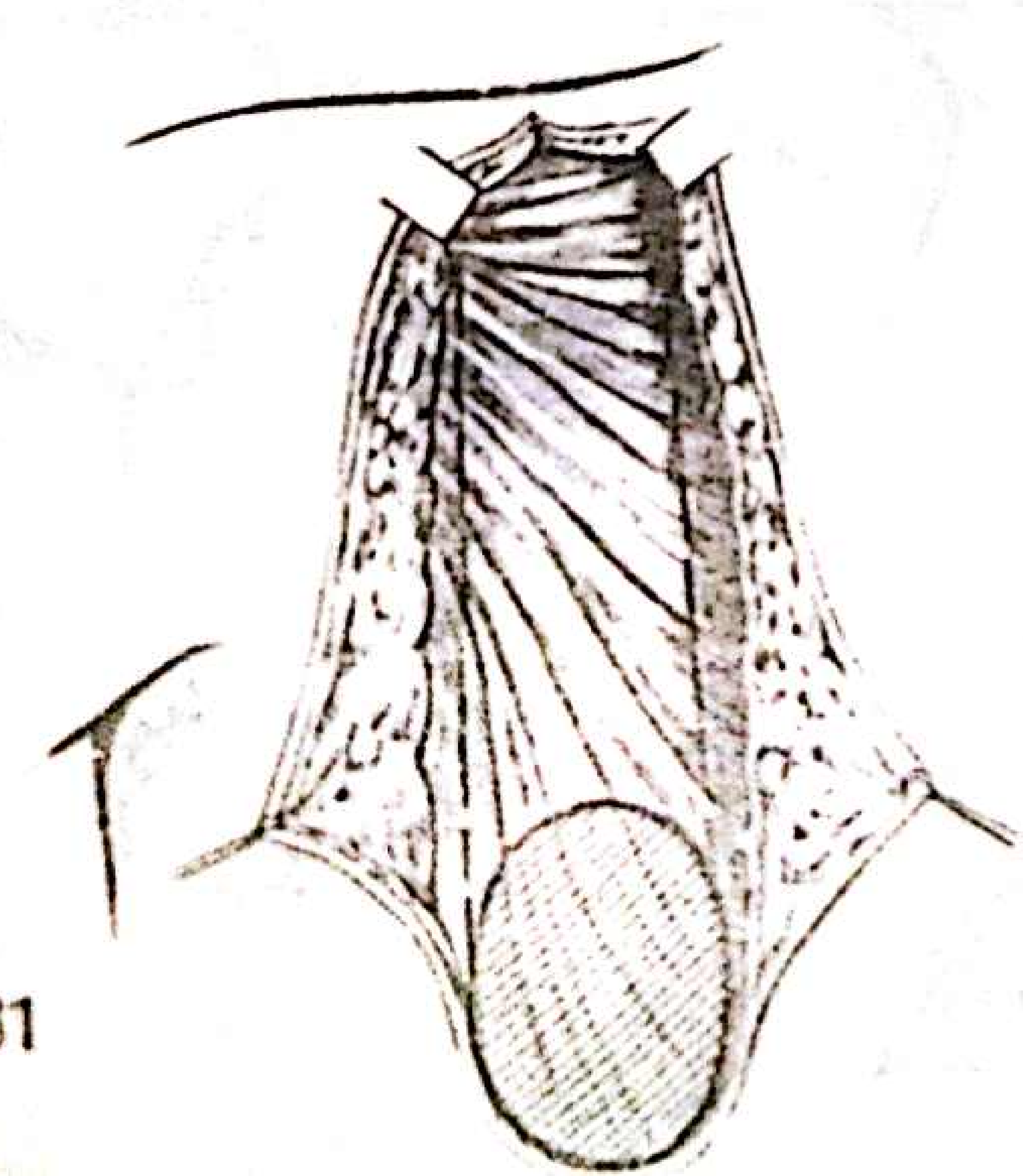
The flap is generally raised as an island, with a skin incision upwards towards the anterior border of trapezius 5 cm above its clavicular insertion, the point at which the transverse cervical artery reaches it.



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An initial encircling skin incision isolates the island. A further skin incision is then made, passing from the island towards the anterior border of trapezius, and elevation of the skin on each side exposes the muscle which will form the pedicle of the flap. The muscle pedicle is generally made as broad as the skin island.

82

Elevation of the island is best begun along its lateral margin until the lateral border of trapezius is reached. This allows the plane of elevation deep to the muscle to be established at an early stage.

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Elevation continues in the plane deep to trapezius up to the anterior border of the muscle. When the level of the rhomboids is reached, care is required to ensure that they are not elevated along with the flap by mistake.

It may be technically possible to tunnel the island to its destination if a neck dissection has not been carried out as part of the resection, but as a rule blind dissection of a tunnel in that area of the neck is probably unnecessarily hazardous. Opening the neck with a zigzag incision along the line of the 'tunnel' is to be preferred. The secondary defect is closed directly, failing which a split-skin graft is applied.

The tissues in the shoulder and posterior triangle of the neck are comparatively inelastic and the skin island should be watched for vascular problems due to compression of the muscle pedicle. If such a problem should arise, it may be necessary to open the neck or shoulder suture line until the vascular state of the island becomes stabilized.

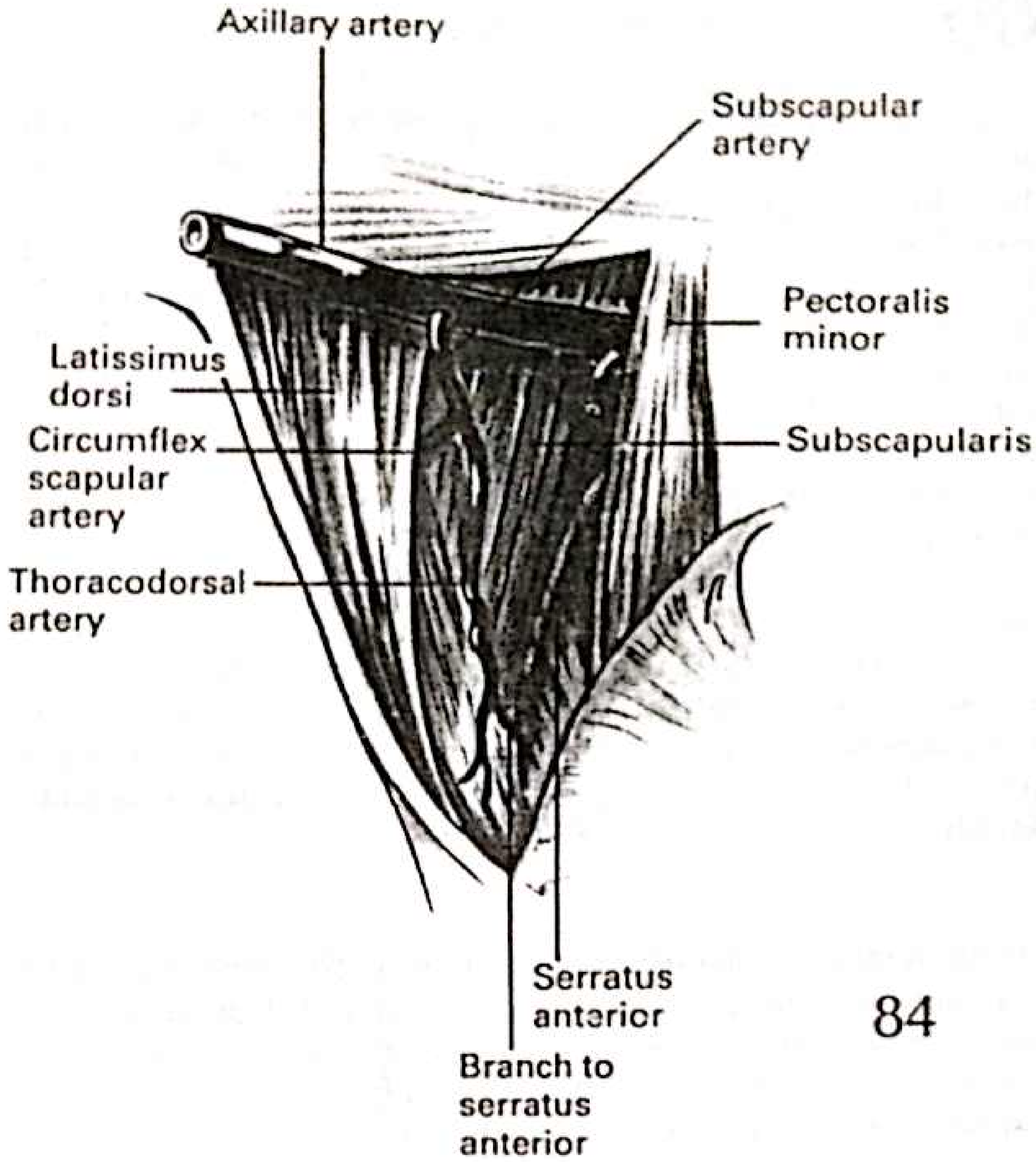
As a potential reconstructive method for the preauricular defect the flap has several virtues. It is not in the vicinity of either the primary tumour site or the site of potential metastasis. It is capable not merely of providing skin cover but also of transferring sufficient bulk to fill the hollow which is often part of the defect within its reach.

The main adverse factor with the trapezius flaps in general is the need to turn the patient on his side at very least in order to raise the flap, and with most surgeons the flap is raised with the patient in the prone position. The carrying out of the resection and the reconstruction with the patient on his side creates for most surgeons an unfamiliar situation, and one which may make him select an alternative reconstruction which allows the entire procedure to be carried with the patient in the more familiar supine position.

83

LATISSIMUS DORSI FLAP

The fibres of latissimus dorsi fan out from its narrow tendinous insertion into the upper humeral shaft to form a flat muscle with a wide origin extending from the midthoracic spinous processes to the posterior part of the iliac crest.



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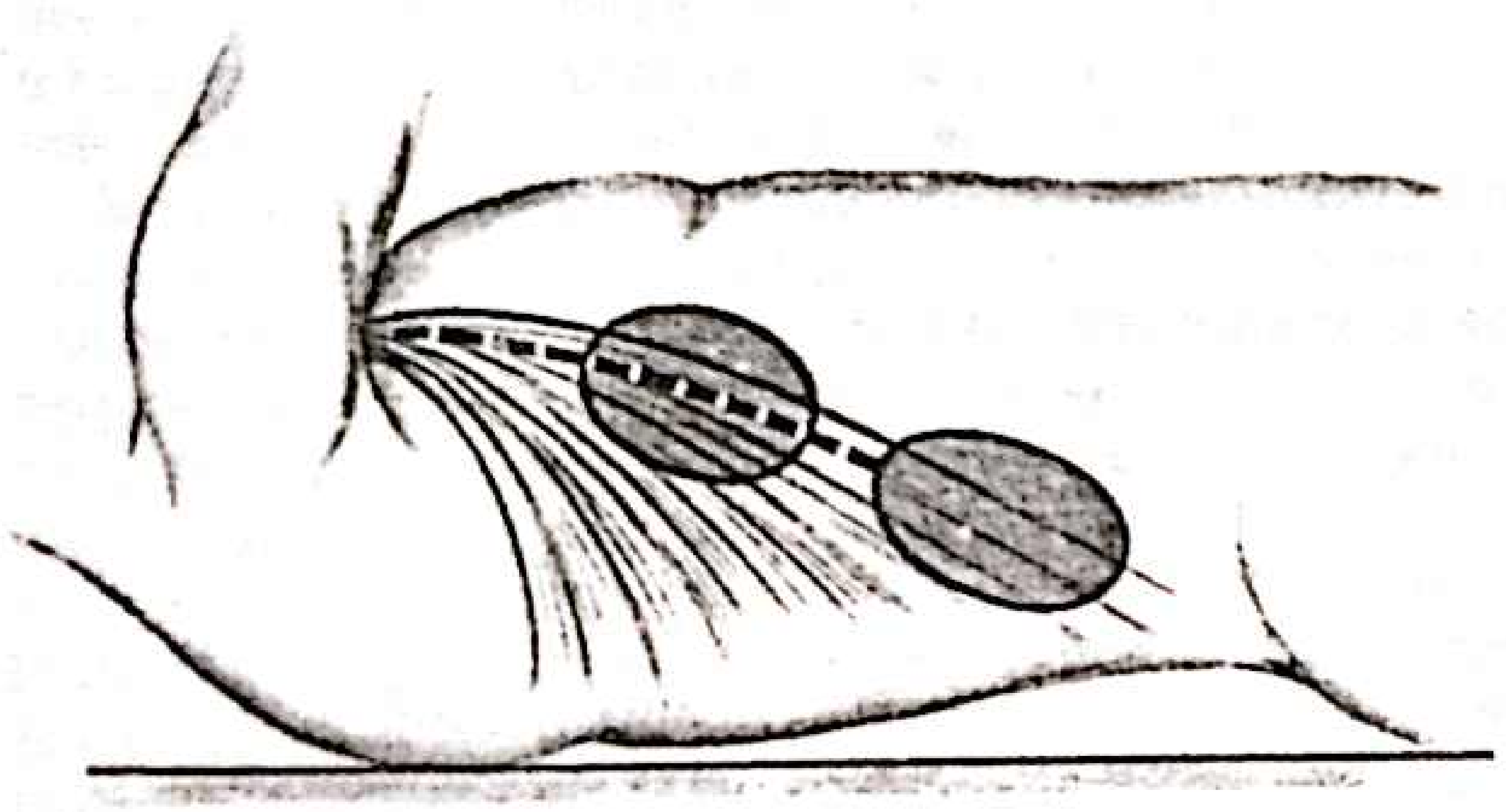
The perfusion source which is used when the muscle is providing the basis of a myocutaneous flap is the subscapular vessels. These arise from the axillary vessels close to the insertion of the muscle and pass down on the posterior wall of the axilla in the direction of the muscle belly; 4 cm from their point of origin they give off the circumflex scapular vessels and continue on as the thoracodorsal vessels, entering the muscle substance 6 cm later. Inside the muscle the artery generally divides into two main branches, one running down parallel to its anterior border, the other parallel to the upper border. The overall direction of vessels within the muscle is along the line of the fibres.



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An island of skin placed virtually anywhere over the muscle is capable of being transferred as an island myocutaneous flap, and the site chosen in a particular clinical situation is dependent on various factors. One such factor is the choice of a site which will allow the flap to be elevated and transferred with the patient supine. A skin island placed along the anterior border of the muscle meets this requirement.

When the transfer is being carried out as a pedicled one, the length of the vascular pedicle is an additional critical factor in selecting the site. A long pedicle can be provided by placing the island near the iliac crest site of origin, the pivot point of the transfer being close to the origin of the subscapular artery. An island in this site can be transferred to the preauricular site with ease.

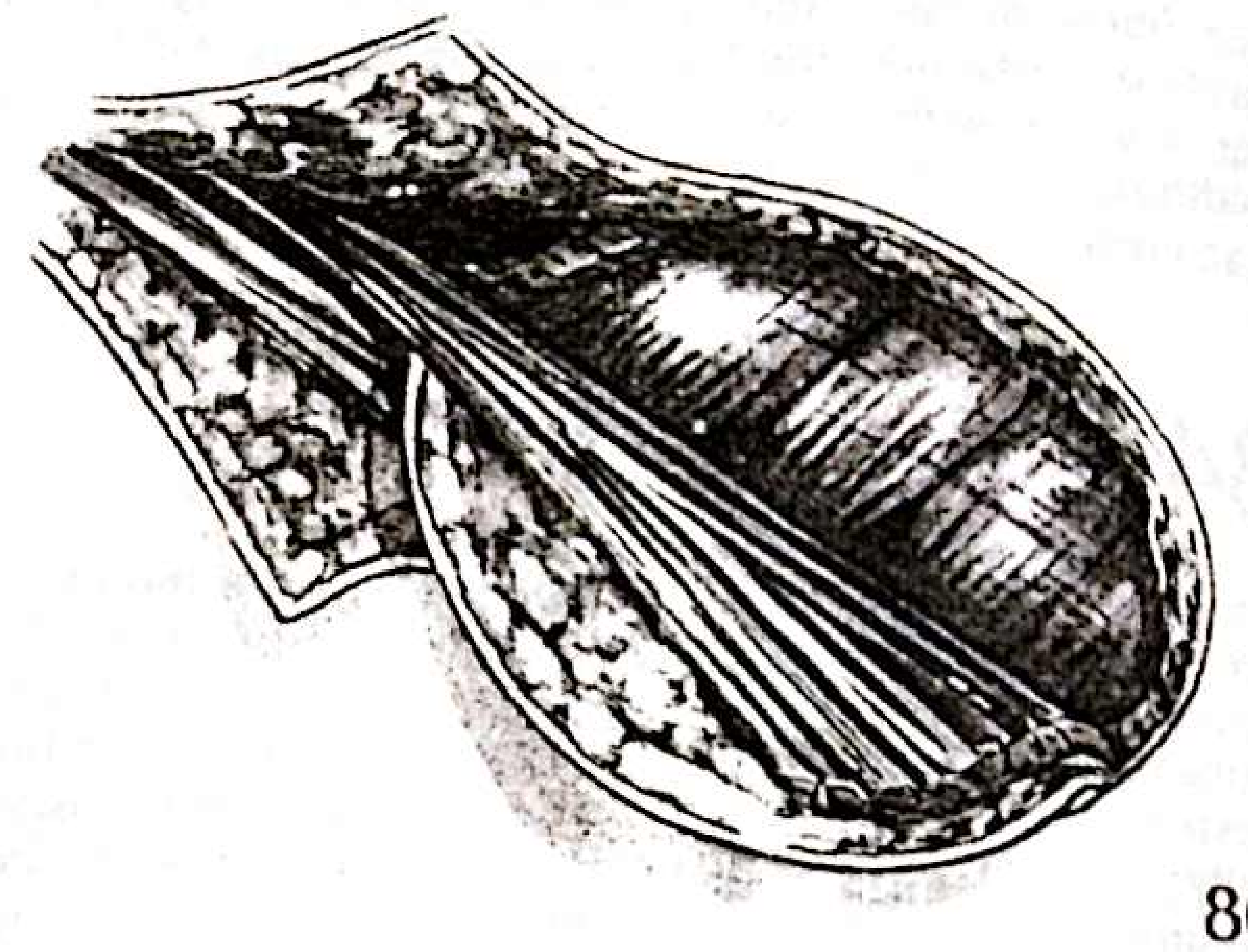
When the transfer is being carried out as a free flap, the island can be placed more proximally along the line of the anterior border of the muscle, the main constraint on the selection of the site being the need to provide a vascular pedicle of adequate length.

Over the initial 10 cm of their course both artery and vein are lying free of the muscle and this makes it possible to reduce the proximal pedicle to the vessels alone if this will make the transfer easier.

The island should lie vertically along the line of the anterior border of the muscle and it may extend anteriorly beyond the margin of the muscle to an extent which depends on the size of the island. In the clinical situation where the use of the flap is being considered, 3 cm would constitute a safe maximum.

86

As a first step in raising the flap the line of the anterior border of the muscle should be marked on the skin and the island positioned in relation to this, predominantly over the muscle but leaving the possibility of extending the skin island beyond the anterior border as already described. From the proximal extremity of the island the skin incision is extended upwards along the anterior border of the muscle. When the skin island has been isolated by an incision around its circumference, elevation is begun anteriorly as far as the anterior border of the underlying latissimus dorsi muscle. Elevation of island and muscle continues thereafter deep to the muscle, and in passing proximally from the island this plane of elevation is continued. The muscle falls back as elevation proceeds, displaying the vessels on its deep surface. With dissection of the vessels proximally, branches to serratus anterior are met and divided, as are also the circumflex scapular vessels.



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From a strictly vascular point of view the pedicle should be approximately as wide as the skin island, but where the requirements of the reconstruction call for added breadth of muscle the pedicle can be widened to allow for this.

When the anatomical point has been reached in the proximal dissection where the vascular pedicle becomes separate from the muscle substance, the latter can safely be narrowed or divided completely, leaving the pedicle confined to its vascular element. When the transfer is a pedicled one, the retention of a musculotendinous component provides a brake on the application of traction to the pedicle, and in its absence greater than usual care has to be exercised to ensure that traction on the pedicle is avoided.

When the transfer is as a free flap, the feeding vessels can be divided at a level which allows an appropriate length for the anastomosis in the transferred site.

Transferred as a pedicled flap, a route has to be tunnelled up into the neck, either under pectoralis major, with a window cut in the muscle to allow passage over the clavicle, or subcutaneously over pectoralis major. Above the clavicle a tunnel has also to be created to allow transfer to the recipient area unless a neck dissection is being carried out simultaneously. The defect left following the transfer is usually closed directly with suction drainage of the track.

The reach of the pedicled flap is considerable if it is designed as described with a very long vascular pedicle. It has been used to cover scalp defects, although such a transfer would stretch the technique to its limit.

The transfer is also regularly carried out as a free flap with microvascular anastomosis. The extensive dissection involved in making the tunnel to allow the transfer as a pedicled flap over the clavicle and in the neck is not altogether desirable and, where the necessary microsurgical expertise exists, the transfer is probably carried out more frequently as a free flap. The vessels involved are relatively large and the transfer is one of the less demanding.

Usage as a free flap also increases to a considerable extent the design options open to the surgeon. It relieves him of the need for a long vascular pedicle and allows him greater freedom to chose the site on the muscle where he places his island. Final selection may still be along the anterior border in order to avoid having to turn the patient, but it need not necessarily be at the lower end of the muscle.

The characteristics of the flap which distinguish it are the large size of the skin island which can be transferred and consequently the size of defect which it can reconstruct. The thickness of muscle incidentally transferred allows it to deal with the contour element of any defect, although in practice it is liable initially to be found to be more bulky than is ideal. Allowance should be made for denervation atrophy to be largely complete before proceeding to definitive thinning.

The use of the flap in reconstructing intraoral defects is discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

PECTORALIS MAJOR FLAP

87

The main vascular basis of this myocutaneous flap is provided by the pectoral branch of the thoracoacromial artery and the veins associated with it. These vessels emerge from the clavipectoral fascia medial to the coracoid process, and in the transfer they are supplemented on occasion by the lateral thoracic vessels which emerge lateral to the tendon of pectoralis minor. The vessels initially run downwards and medially on the deep surface of pectoralis major before penetrating and continuing in its substance.

The pivot point from which measurements are made in planning the transfer is the point of emergence of the vessels from the clavipectoral fascia. This has a surface marking 2–3 cm medial to the coracoid process, the bony point readily palpable below the clavicle.

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The flap is transferred as a skin island below and medial to the areola about the level of the 6th rib. It has been found safe to extend the island beyond the lower border of the muscle, but 3–4 cm beyond is probably the safe limit. In the female, planning may be hampered by the size of the breast, and placing of the island in the inframammary fold has been suggested in such circumstances. The safety of the flap in this site has been questioned, however, and it may be that the flap should not be used at all when the size of the breast creates a planning problem.

In raising the flap the skin island to be transferred is incised down to muscle or the adjacent rectus sheath. The direct line between the pivot point and the island is a straight incision connecting the two, and this incision can certainly be used, but in the context of head and neck reconstruction there are strong arguments for having the deltopectoral flap available at very least as a 'back-up' and such an incision would make its subsequent construction impossible. An incision following the outline of a deltopectoral flap is preferable, turning down to meet the skin island.

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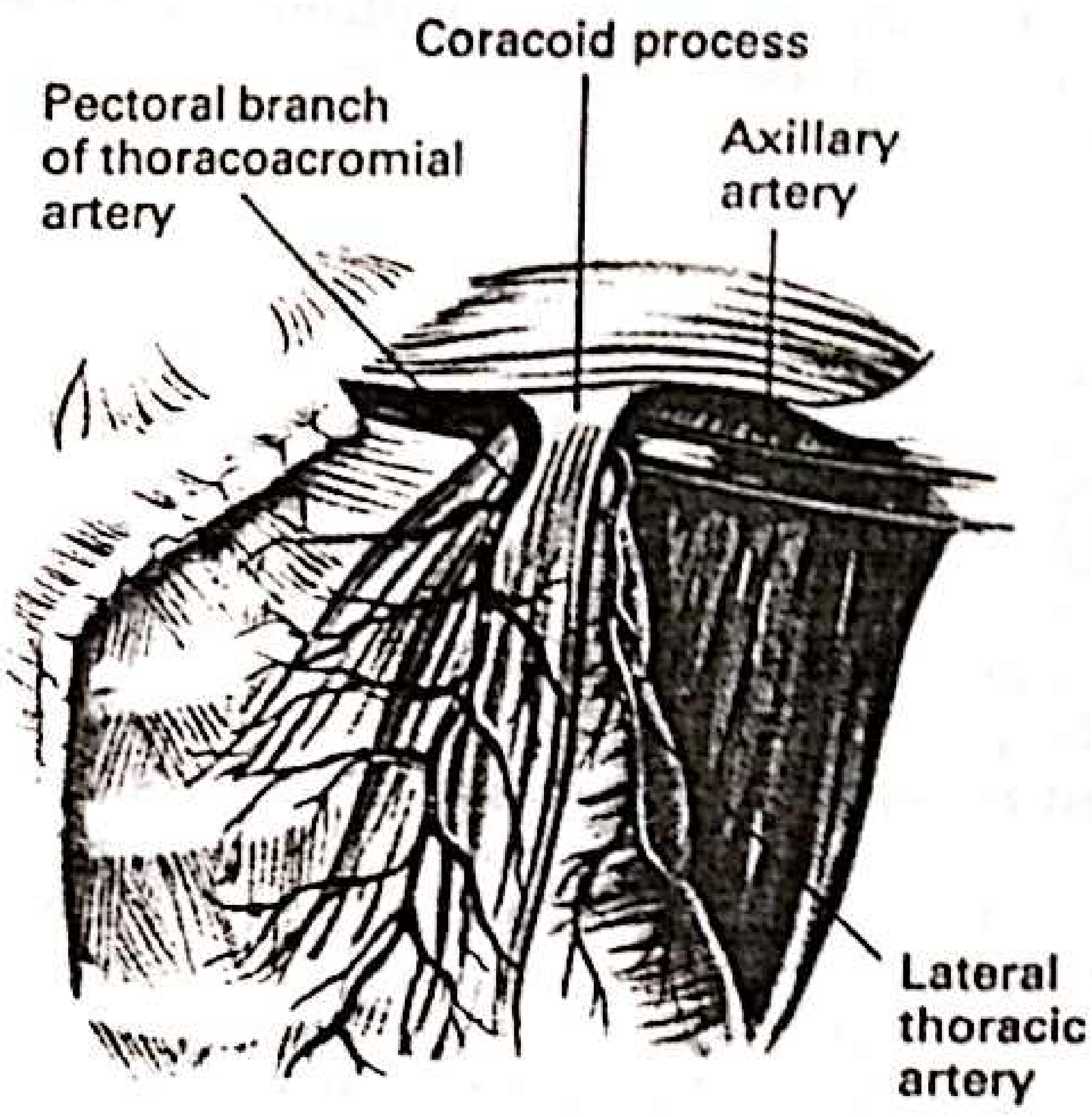
With this approach the pectoralis major is laid bare over the length and breadth of the muscle pedicle.



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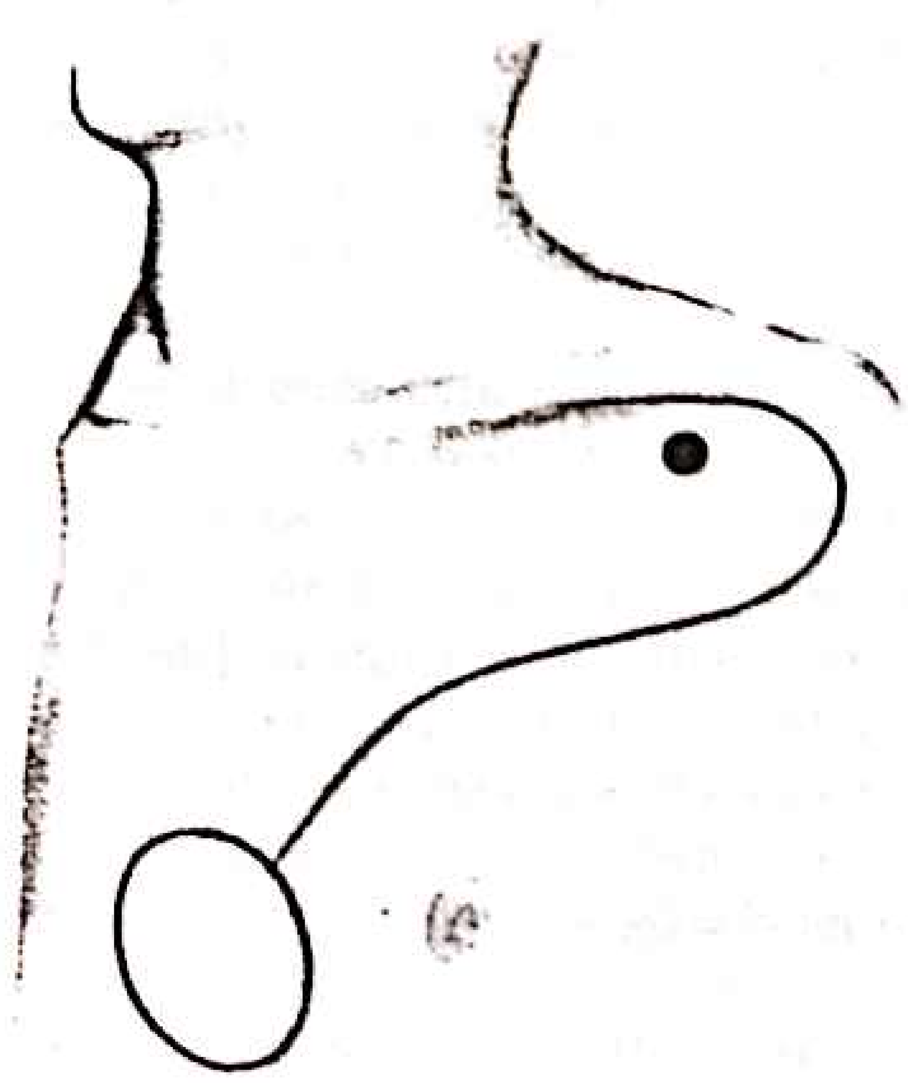

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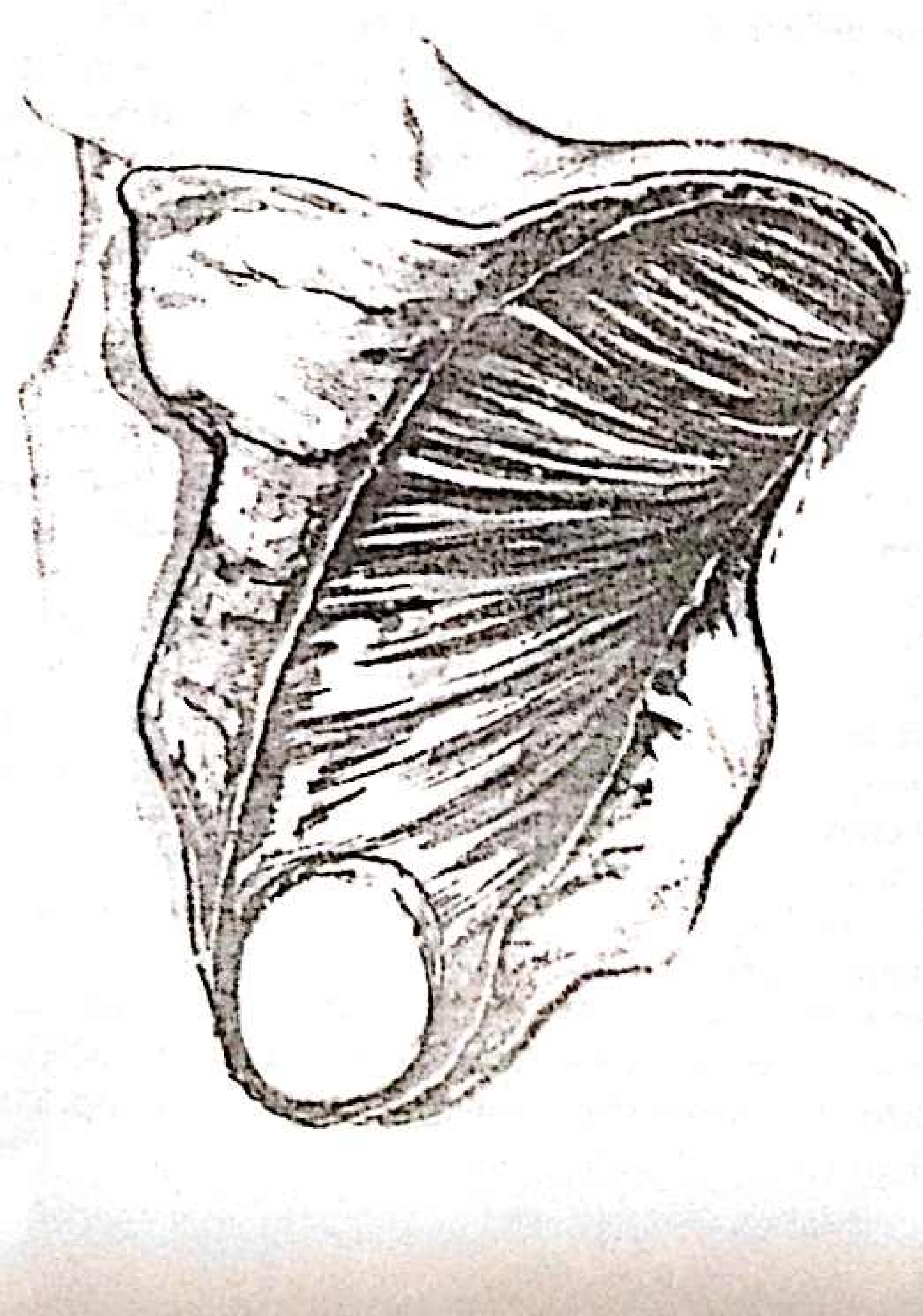

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Incisions are made through the muscle along its margins of the pedicle, towards its lower end at least, made as broad as the skin island.

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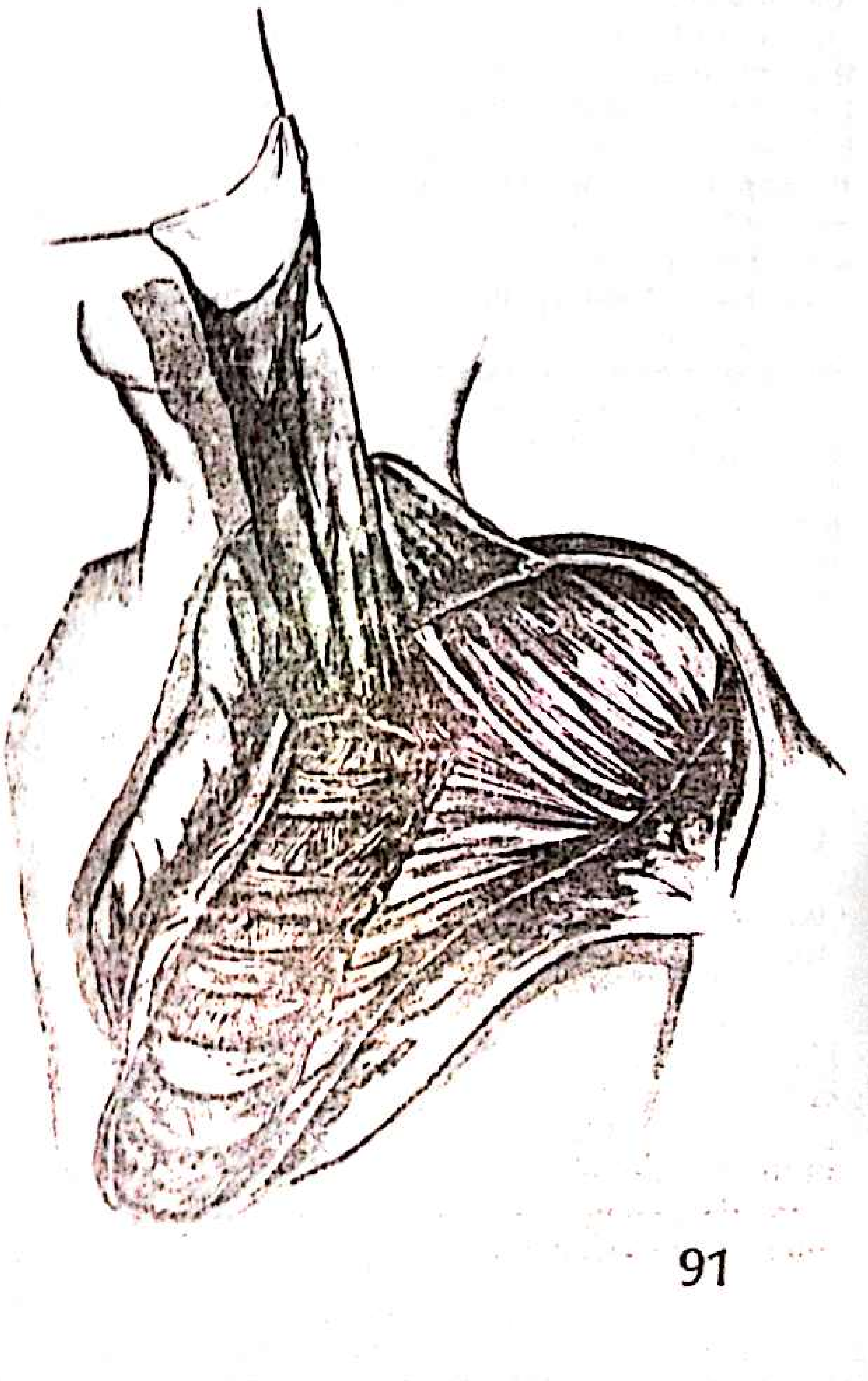
The composite of skin and muscle is then elevated from the chest wall, exposing the ribs with the intercostal muscles and pectoralis minor. As the flap is raised and the arteriovenous network becomes visible, it may be possible to narrow the muscle pedicle somewhat, and when elevation has reached the hilar area a trial of the transfer can be carried out with the lateral pectoral vessels intact. Depending on the tension produced, they can be left intact or divided.

It is often possible to close the secondary defect in the female by moving the breast medially without creating unacceptable deformity, but in the male split-skin grafting of the defect is generally required.

By far the most frequent use of this flap is in intraoral reconstruction, and its usage in that context is discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240. The transfer virtually always involves tunnelling the flap through the neck. In most of these clinical situations a radical neck dissection has been carried out, and the removal of the sternocleidomastoid muscle and the contents of the posterior triangle, which are part of the neck dissection, provides the space which allows the flap to be transferred under the skin flaps while still keeping the pressure on the muscle pedicle within the bounds of safety.

Rarely, the transfer is carried out with the pedicle exposed in the neck, wrapped around with a split-skin graft to prevent infection. Transfer in this way, though technically feasible, is not very satisfactory, patchy take of the graft being typical.

The flap is most often used to replace either a mucosal defect or a skin defect, but when the defect is one which involves both skin and mucosa the skin island has been used to provide both. The problem is usually one which is primarily intraoral, and this is discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.



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Free flaps

The crucial element in the successful transfer of a free flap is the provision of an effective circulation and this in turn means successful anastomosis of the flap vessels to those selected in the recipient site. The key to successful anastomosis is the effecting of a junction between vessels which are correctly aligned, and joined in a manner which results in minimal trauma to their intimal endothelium, the most important factor being the maintenance of intimal continuity across the junction zone.

General considerations

Apart from the technique involved in carrying out the anastomosis, certain basic conditions must be met in order to provide the necessary background for success.

The patient should be kept warm throughout so that vasoconstriction is reduced to an absolute minimum. It is also recognized that rough handling of the vessels will produce local spasm. Even a small reduction in vessel diameter has a disproportionate effect on the rate of flow through it. Good haemostasis is desirable, for larger vessels using ligation, for smaller vessels with bipolar coagulation. Drying of the field must be prevented by regular irrigation with heparinized Ringer's solution (20 i.u./ml), using a 10 ml syringe with a blunted needle, bent if need be, or a fine plastic cannula.

The recipient artery should be inspected for signs of atheroma. Its presence does not preclude the use of the vessel altogether unless it is close to the anastomosis, but it does create turbulent flow, predisposing to thrombosis. Previous radiotherapy to the recipient site should also make the surgeon cautious regarding the use of any vessels which have been in the field of radiation. Thickening of the wall is evidence of damage, and while not an absolute contraindication if the vessel looks and feels reasonably normal, consideration should be given to the use of recipient vessels in the opposite non-irradiated side of the neck, using an interpositional vein graft if necessary to bridge the gap.

The presence of infection in the vicinity of the anastomosis is an absolute contraindication, failure being inevitable.

The free flaps in general use today for head and neck reconstruction have an arteriovenous system whose artery is largely similar in diameter to the facial and superior thyroid arteries, the vessels most frequently used in the recipient site.

Preparation of the vessels

During the dissection to expose the recipient artery and vein which have been selected, their walls should not be handled directly. It is acceptable to strip them of the loose connective tissue surrounding them, mobilizing them by pushing, but without gripping their adventitia. The vessels of the flap are handled in the same way.

In dissecting the recipient vessels, it makes the subsequent anastomosis easier if the vessels are freed over a sufficient length to bring them into the open wound, and if possible reasonably close to the surface, but the periadventitia should not be touched until they are visualized under the microscope.

In preparing the flap for transfer, macroscopic preparation of the vessels, both at the recipient site and the vascular pedicle of the flap, should be demonstrably complete before the flap pedicle is divided, so that the ischaemia time is reduced to an absolute minimum. Before any further anastomotic preparation, the flap should be sutured in its transferred site, either totally, or at least with sufficient sutures to ensure that there will be no subsequent disturbance at the anastomotic site.

As already noted, the flap vessels and the recipient vessels involved most frequently in head and neck reconstruction are of comparable diameter, and end-to-end anastomosis is usual. If there is gross inequality in diameter, as for example where the external carotid artery has to be used as a recipient vessel, there is then no alternative to the use of end-to-side anastomosis.

Finally, the vessels must be brought into position, end-to-end, with correct orientation. Incorrect orientation leads to turbulent flow and an increased risk of thrombosis. In choosing the site on the vessel for the arterial anastomosis, the presence of branches in the vicinity is undesirable, and valves should similarly be avoided in the case of veins. Both lead to turbulent flow.

All the macroscopic preparations should be complete before the microscope is introduced. When working with the microscope the comfort of the surgeon is essential. The table should be at the correct height and the seat stable. Ideally, the surgeon's elbow and wrist should both be supported, but of the two the wrist is the more important. Competent assistance makes the procedure easier and quicker.

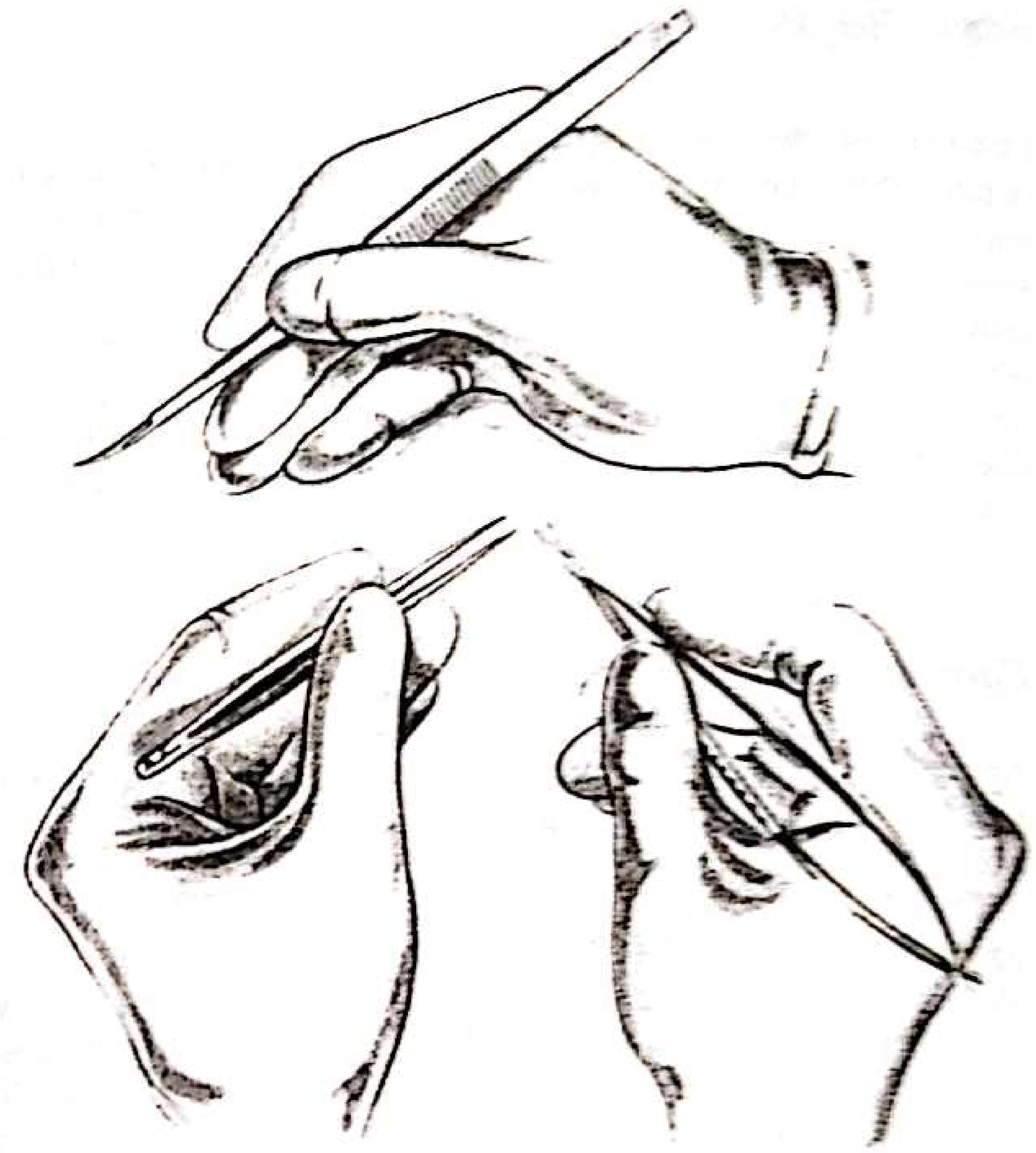
When it has been confirmed under the microscope that an adequate length of each vessel has been exposed, a microclamp is applied. Vessel orientation is rechecked prior to anastomosis.

Instrumentation

The operating microscopes have become increasingly sophisticated, with foot-controlled focusing, zoom magnification facility, fibreoptic light sources, and a dual binocular system. With the increase in the diameter of the vessels of many of the flaps in current use, some surgeons are reverting to the use of loupes, but the majority still use the microscope.

Microinstruments have also been developed to meet the needs of the microvascular surgeon. Initially they were modified versions of instruments developed for other purposes, e.g. jeweller's forceps, or for other surgical disciplines, e.g. ophthalmology.

A relatively small palette of instruments is required; a spring-handled needle holder and spring-handled scissors – straight to cut vessels, curved to dissect and trim off periadventitia and cut sutures – and forceps of different sizes, generally straight, but with a curved version, useful where access to the vessel is awkward. A modified version of the forceps with blunt tips is used as a vessel dilator in order to overcome the spasm which initially develops even with the most gentle of manipulation.



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The instruments are held and manipulated using the 'pencil-holding grip', in the case of the needle holder making sure that the needle is held at its mid-point.

Microclamps of various types are used to occlude the vessel and hold it in position during anastomosis. All share the characteristic of having just sufficient power to maintain the vessel occluded without damaging the intima. Double clamps are also available which hold the ends of the vessels to be anastomosed in position without tension, but many surgeons prefer the greater flexibility of individual clamps on each vessel. The individual clamps also make it easier to control the degree of tension of the suture line and ensure that there is an absence of torsion of either vessel.

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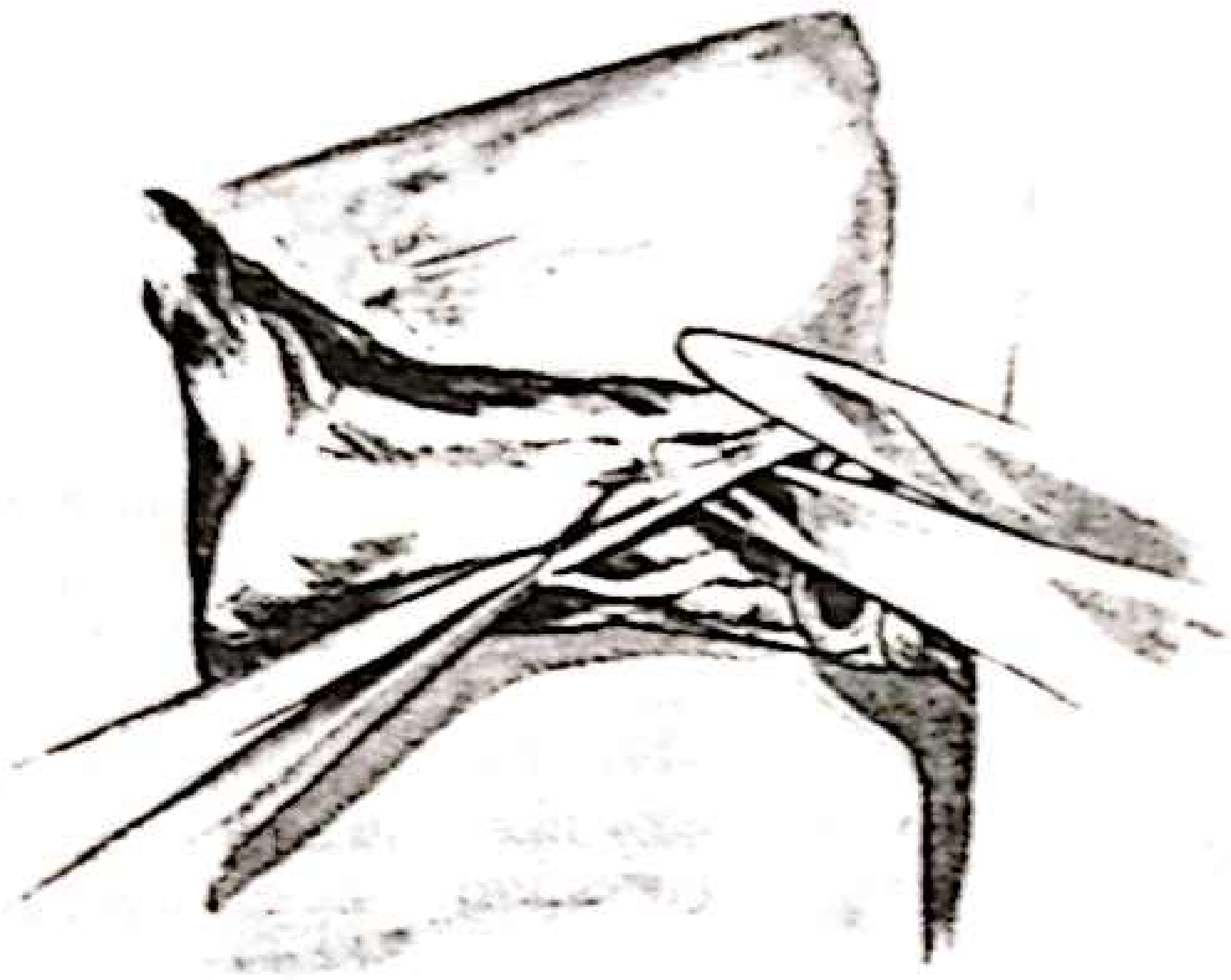
When the microscope is in position and the vessels are in the field of vision, approximated and occluded with microclamps, the field generally is irrigated with warmed heparinized Ringer's solution. The lumen of each vessel is also washed out, both manoeuvres being repeated at regular intervals throughout the procedure. Some surgeons also place a small strip of plastic sheeting behind the vessels at the anastomotic site to provide a contrasting background, against which they feel the vessels, together with the needles and sutures, stand out with greater clarity.

Before any suturing is begun it is axiomatic that microscopic preparation of the vessels must be demonstrably complete. In manipulating the vessels, even under the microscope, the walls may be pushed to and fro with closed forceps, but otherwise they should be handled only via the remaining periadventitia.



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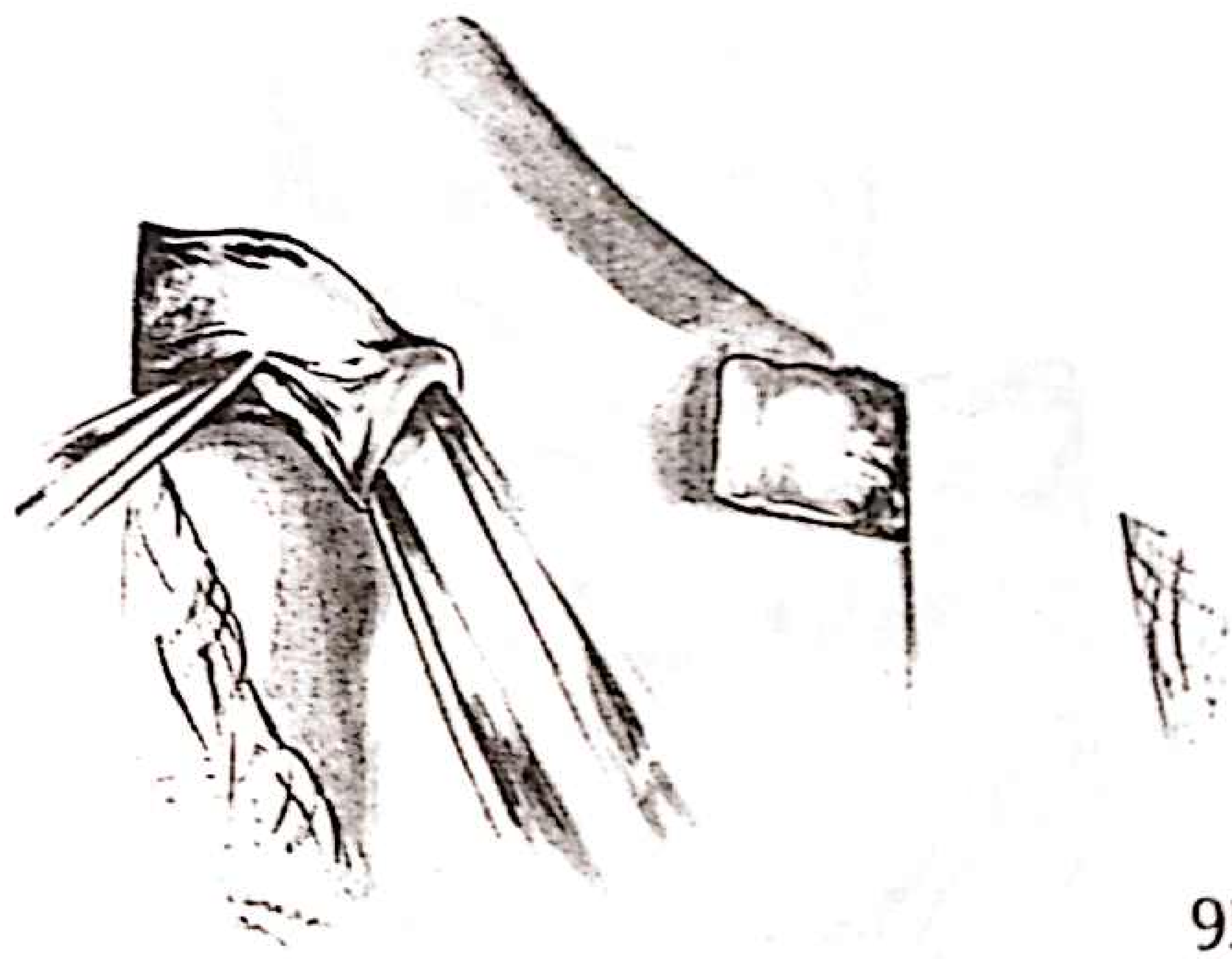
In preparing for end-to-end suturing, the periadventitial tissue is dissected back from the cut end of each vessel for 2–3 mm, making sure that no fragment, loose or attached, is allowed into the lumen, where it will cause thrombosis.



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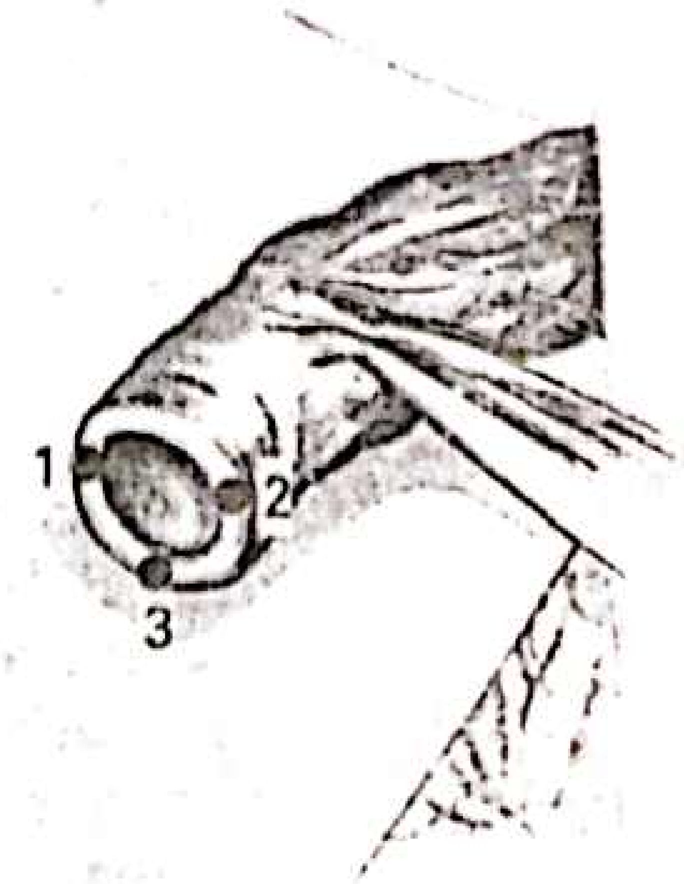
After even the most gentle preparation the vessel is generally in a degree of spasm and this is overcome using the vessel dilator. It is introduced carefully into the vessel lumen with its jaws closed and gently allowed to open. Finally, it is usual to trim the cut end of each vessel to ensure that all traumatized tissue has been removed.



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Suture technique

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With end-to-end anastomosis, three key sutures are placed at equal distances around the circumference of the line of the anastomosis, providing reference points for subsequently filling in the intervening gaps with additional sutures.

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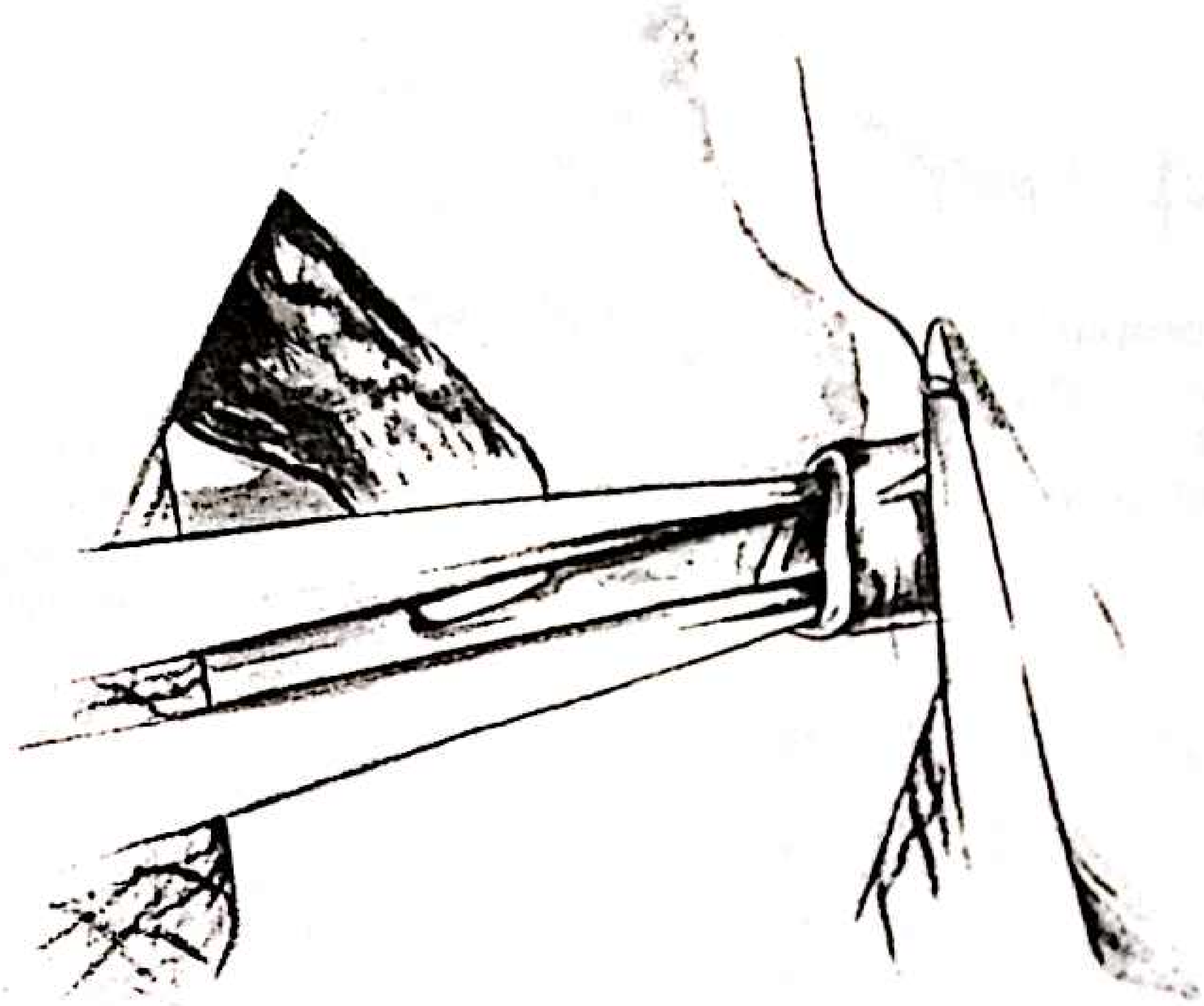
The needle should be inserted vertically through the full thickness of the vessel wall in a single smooth movement, the site of insertion at a point distant from the cut end of the vessel wall roughly equal to twice the thickness of the wall. The first suture is passed from adventitia to lumen, the wall of the vessel being supported by closed forceps inserted into the vessel lumen and opened slightly.



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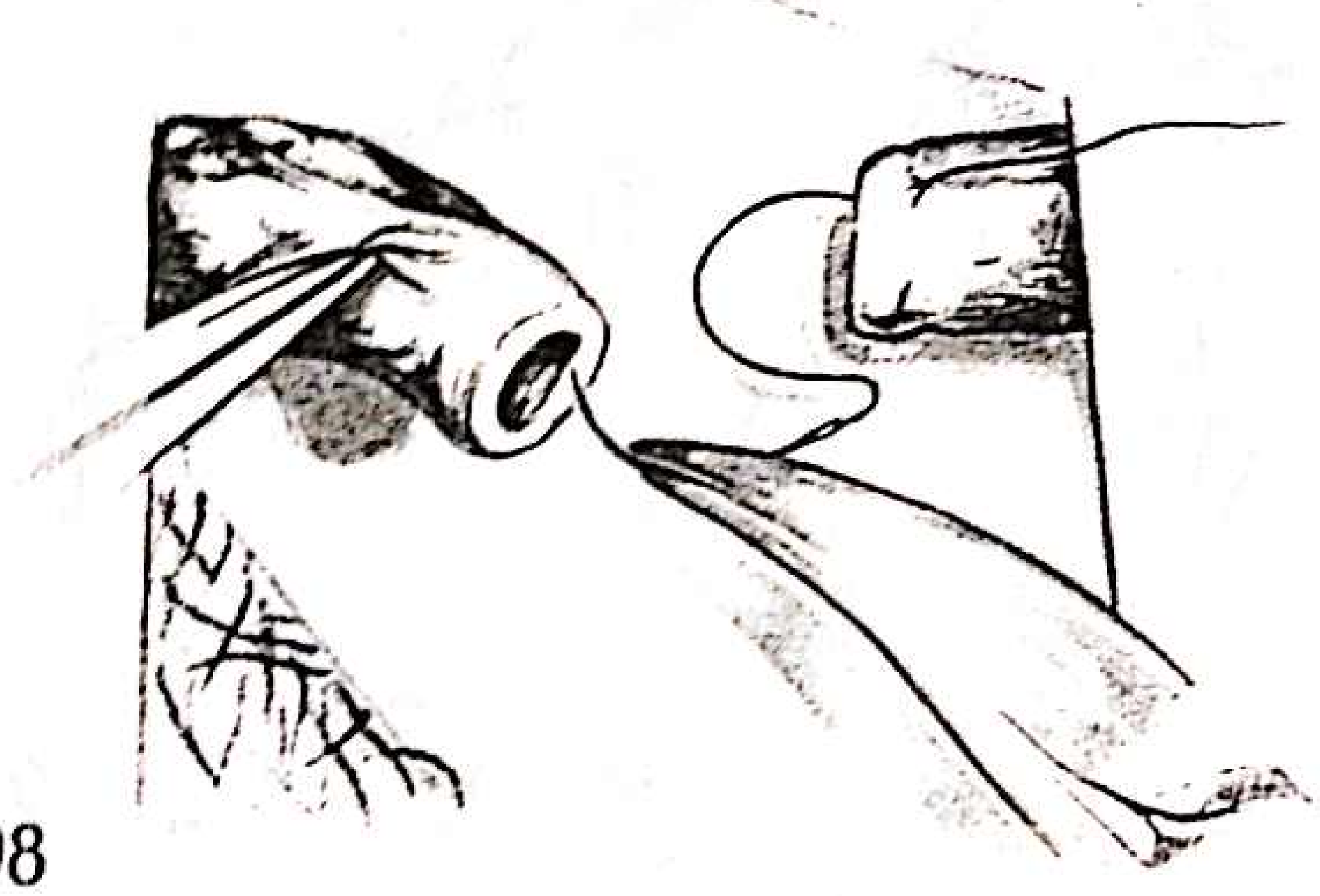

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The needle is then drawn through.

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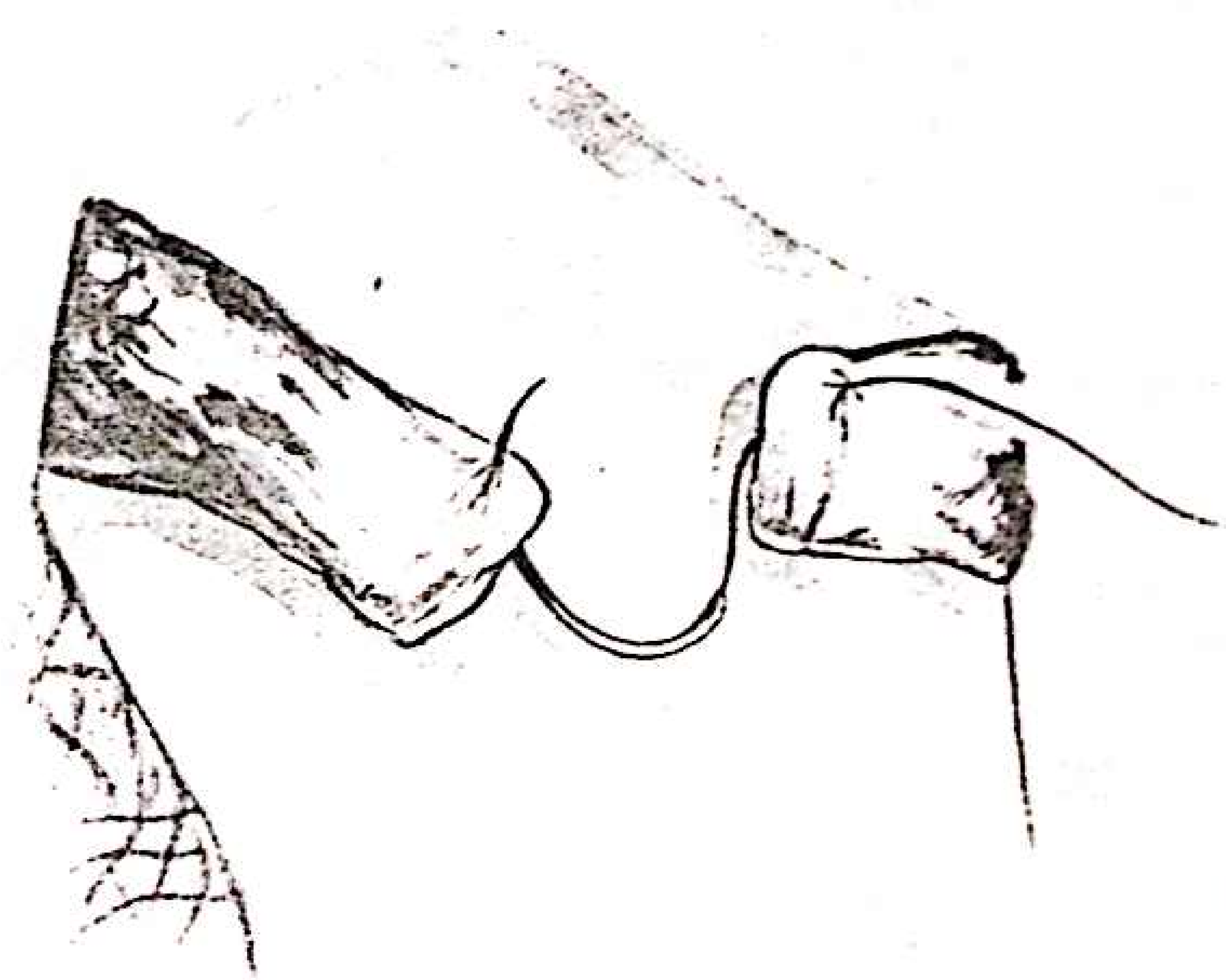
The needle is inserted through the wall of the other vessel from lumen to adventitia and drawn through.



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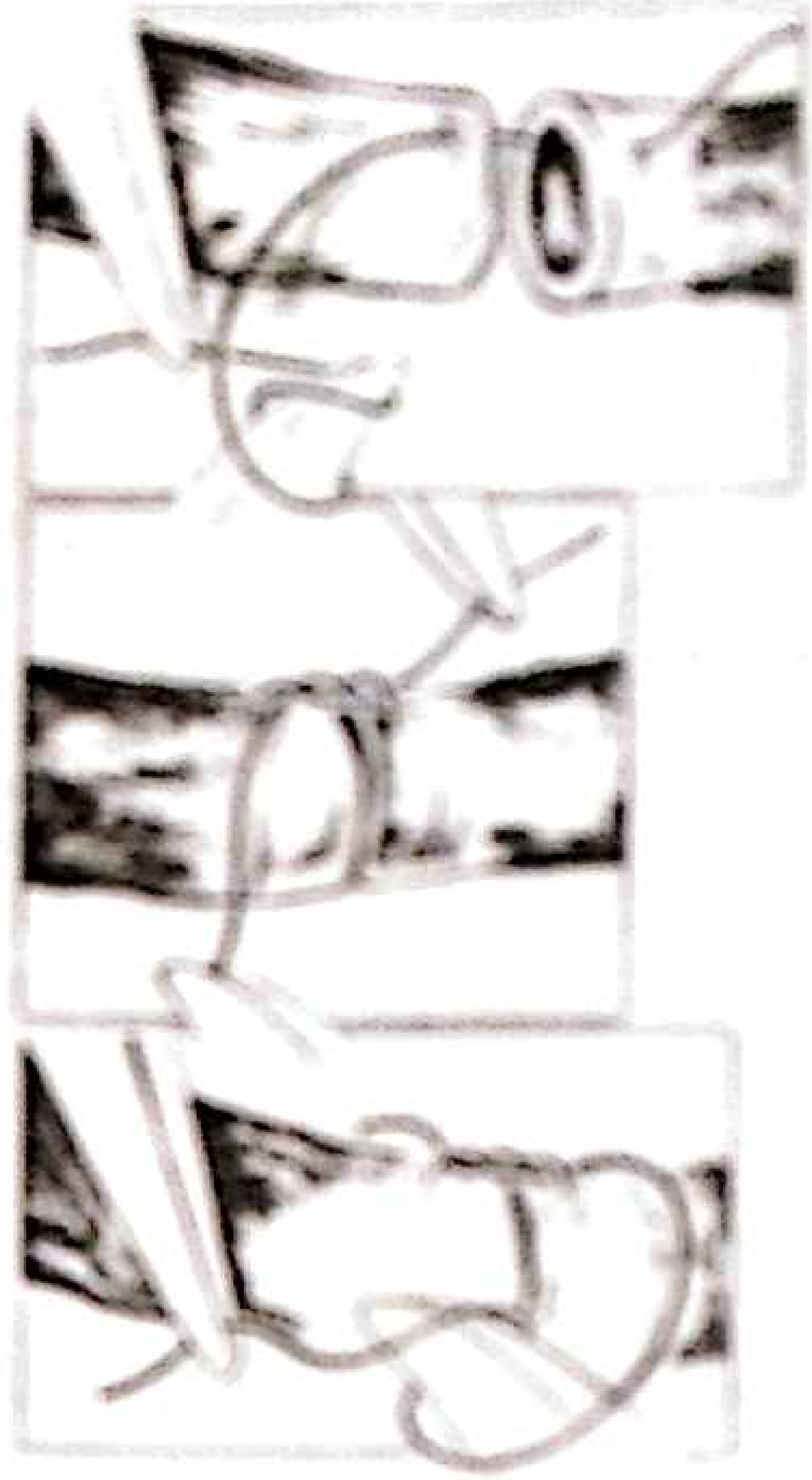

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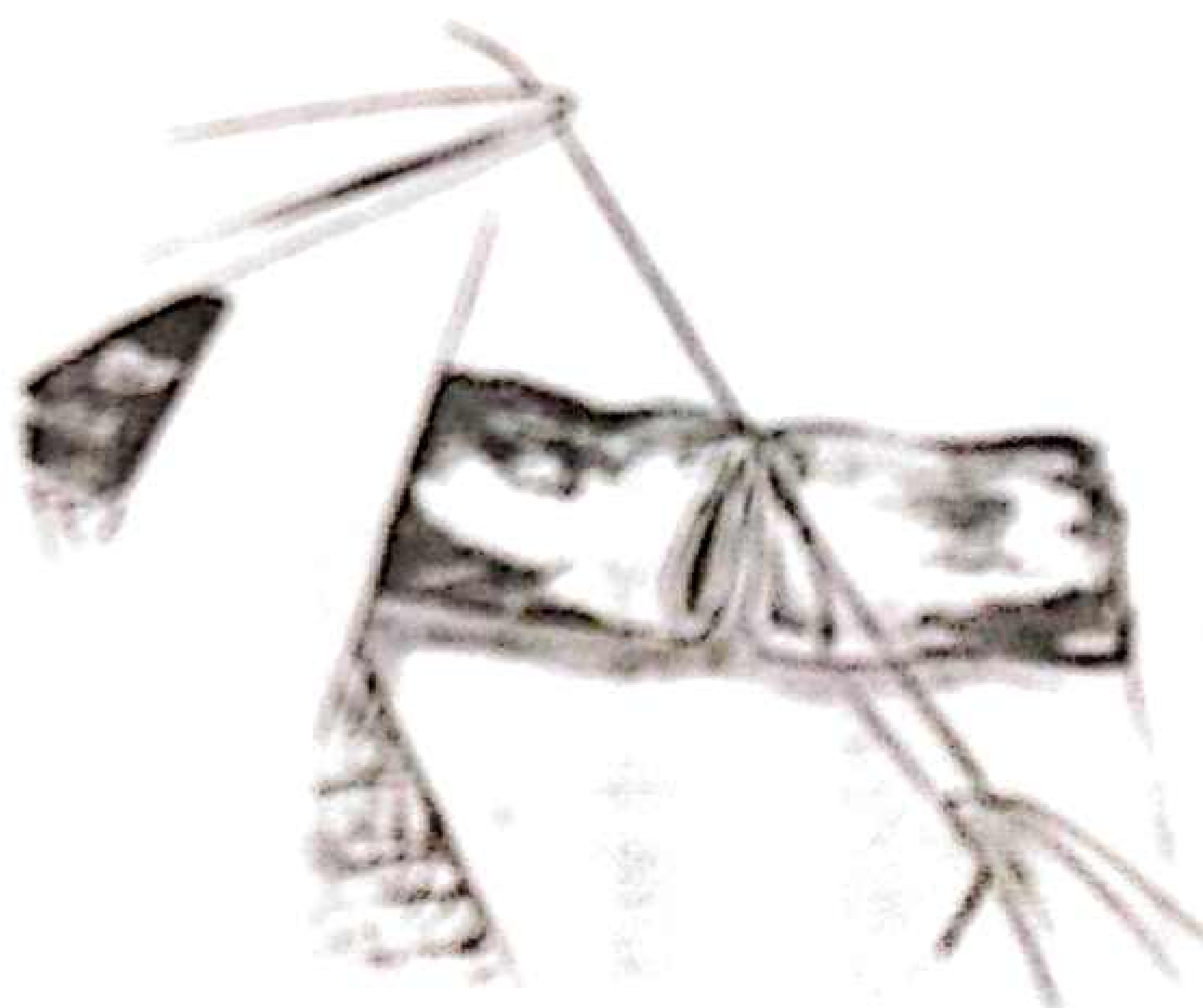
The suture is knotted, usually with a double loop, on the outside of the anastomotic site. Just enough tension should be applied in tying to hold the vessel ends together with a little eversion.



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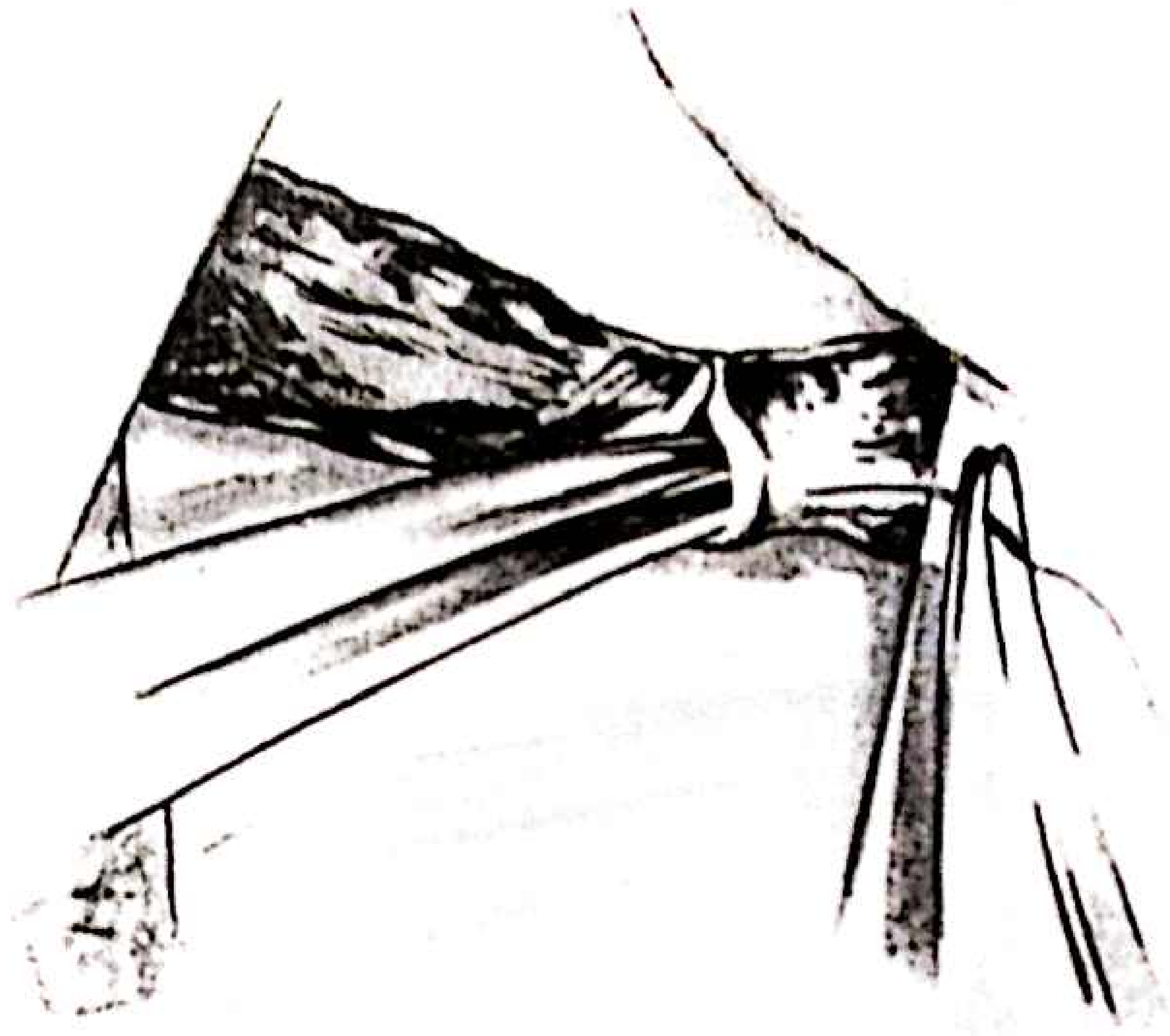

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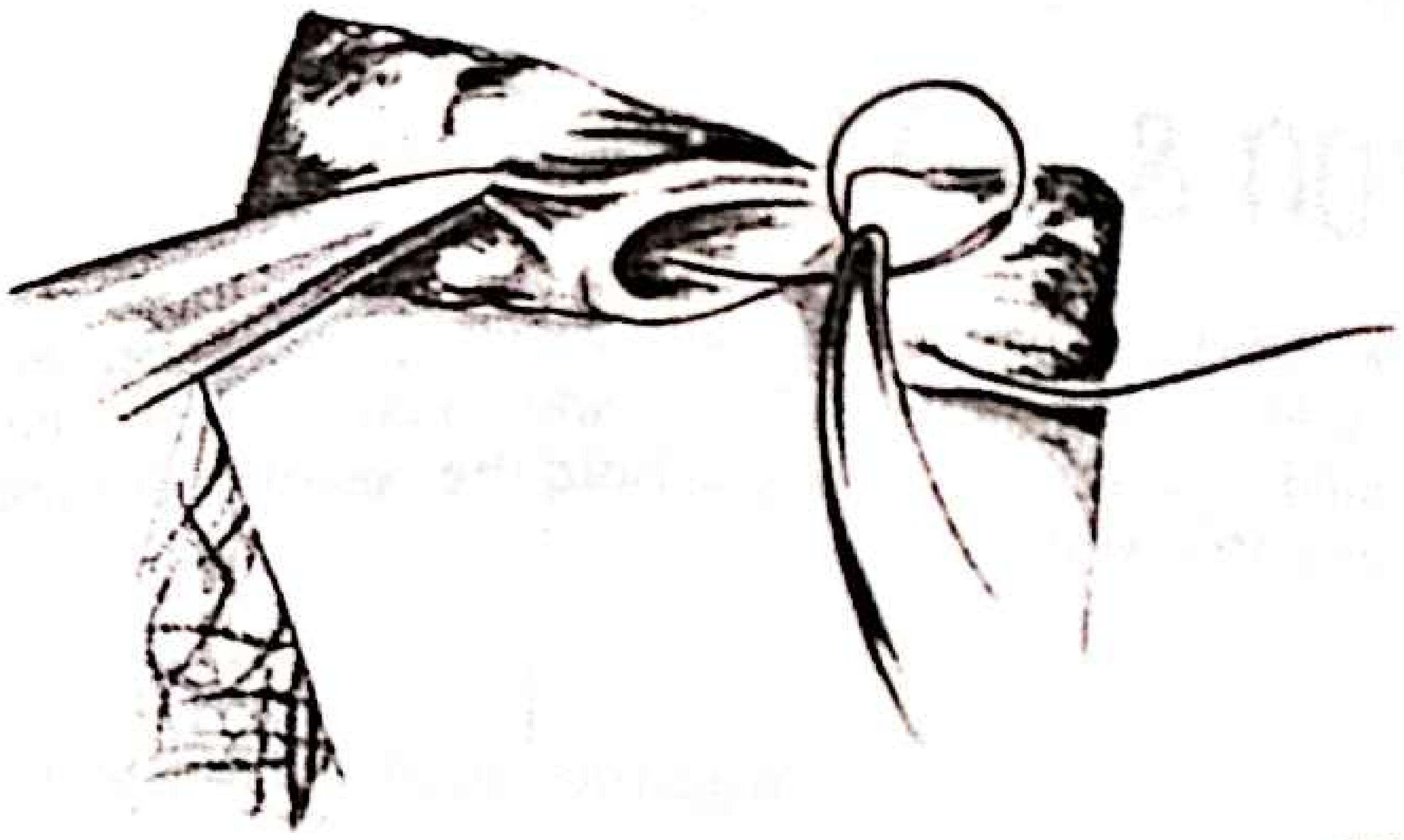
102 & 103

The second key suture is inserted on the surface facing the surgeon, using the same technique as described for the first key suture.



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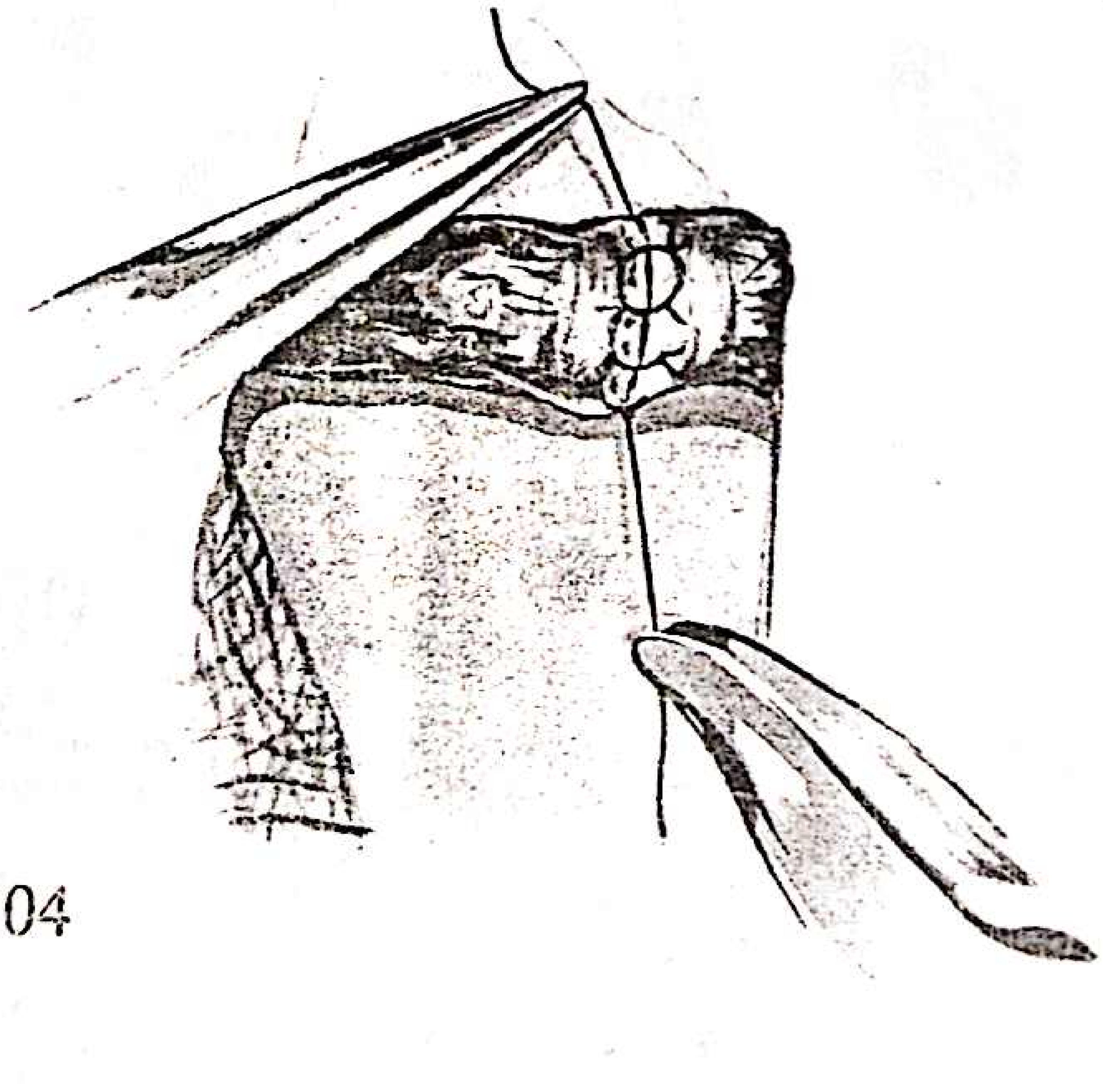

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The intervening sutures between the two key sutures are inserted and tied.

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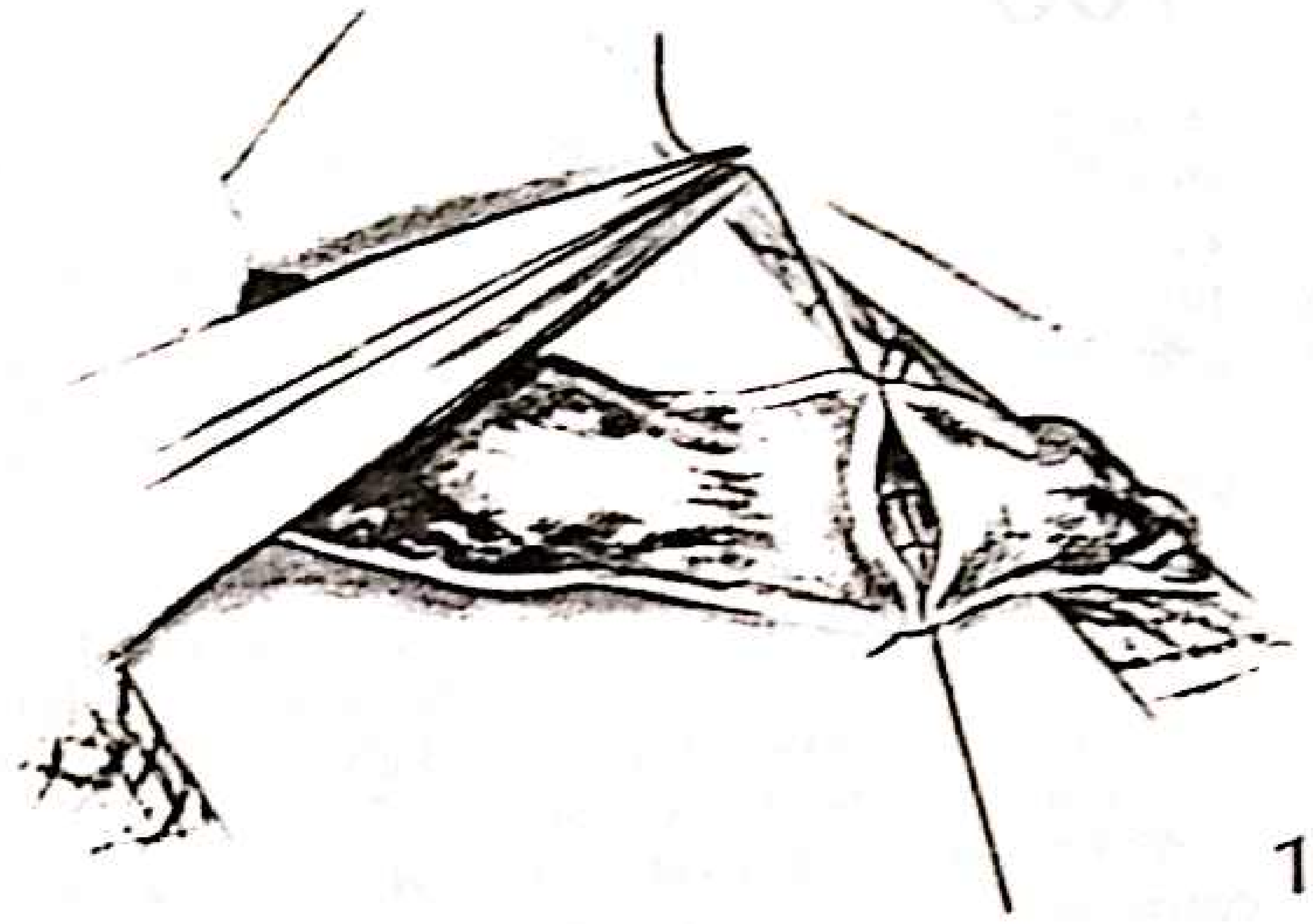
The microclamps are then turned over exposing the under surface of the vessel. The slight retraction of its ends allows the intimal line of the inserted sutures to be inspected to ensure that none have penetrated the posterior vessel wall.



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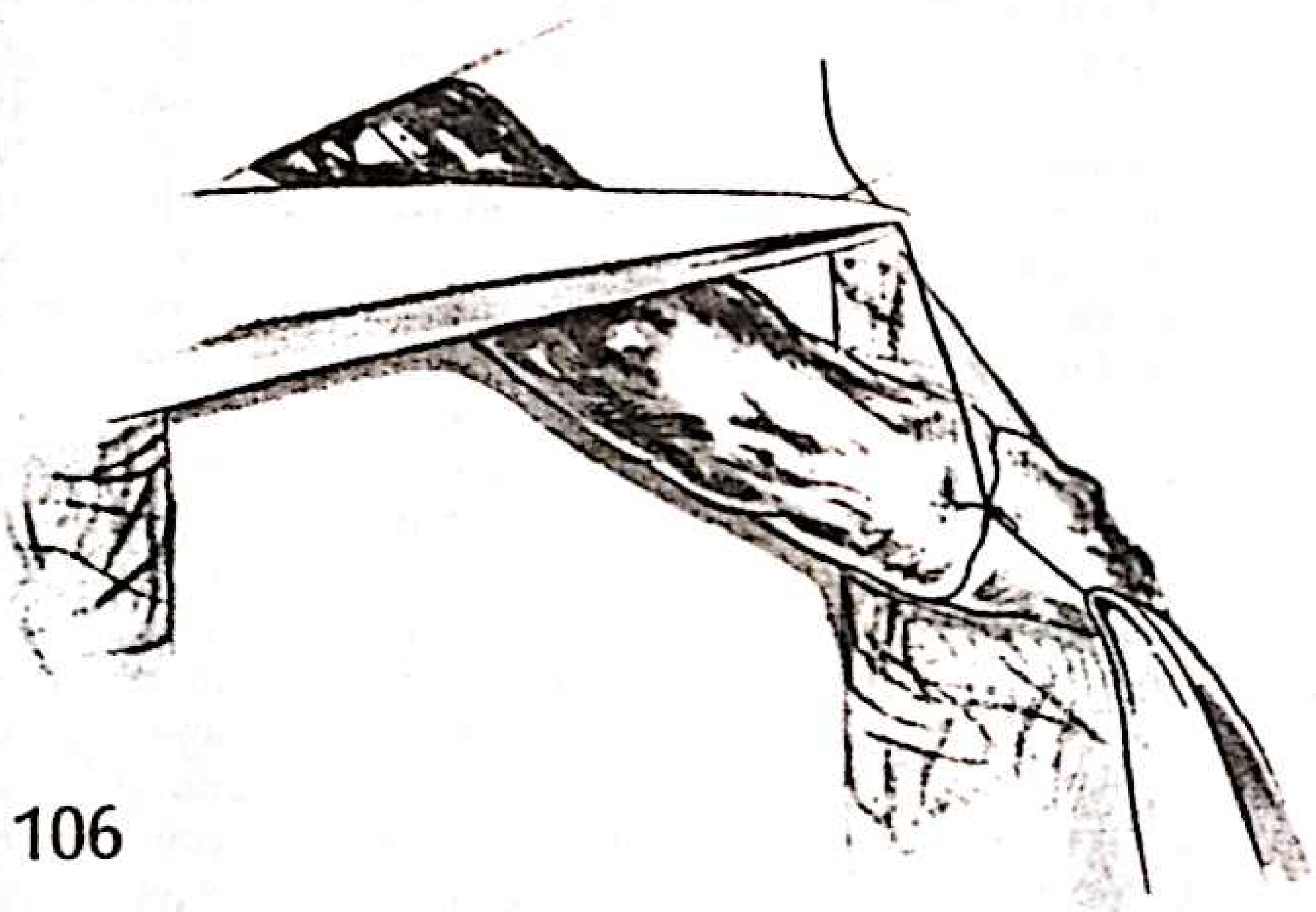

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The third key suture is inserted and tied.

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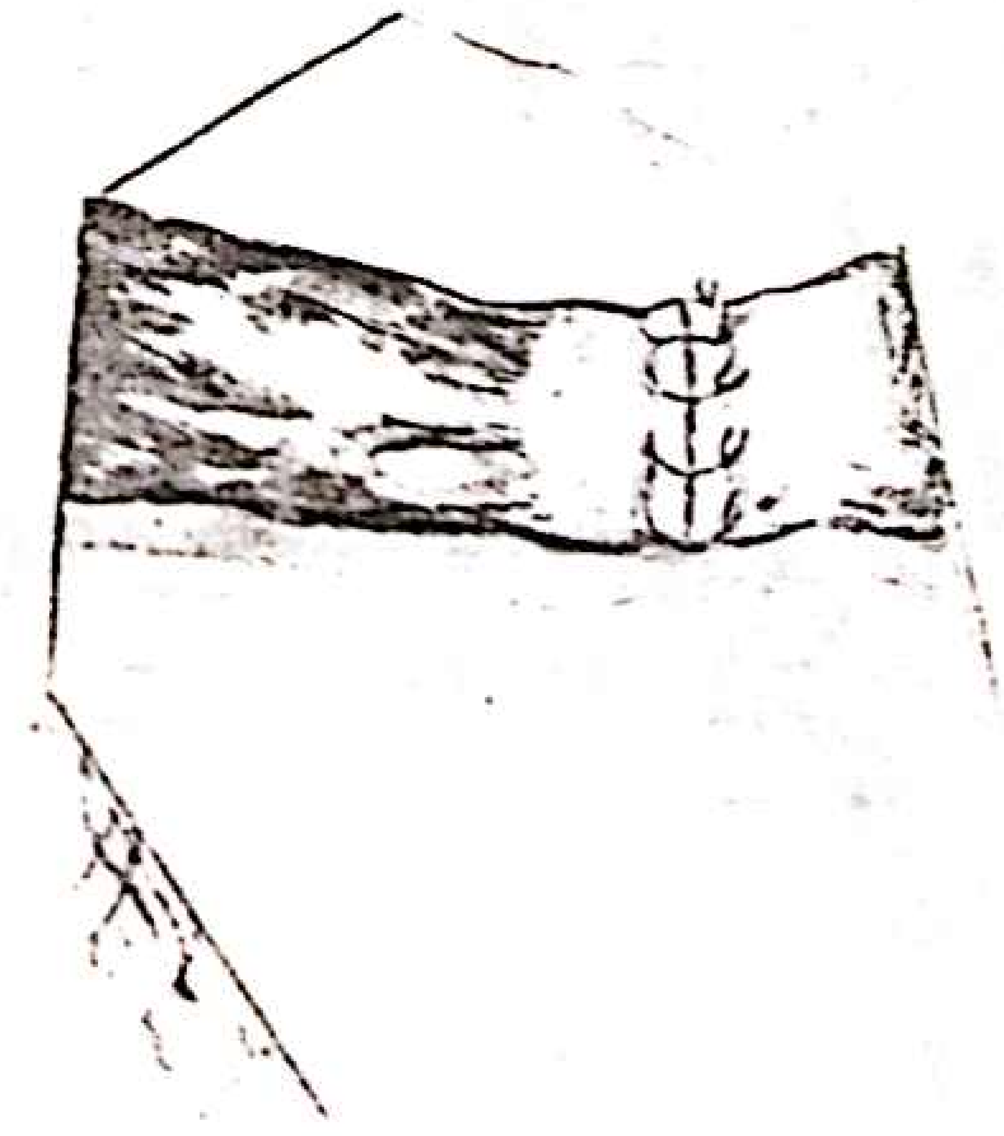
The remaining sutures, which close the intervening gaps, are inserted and tied, completing the anastomosis.

A similar sequence is followed with the vein. The wall of the vein is usually thinner than the arterial wall, so its anastomosis is often more difficult technically.



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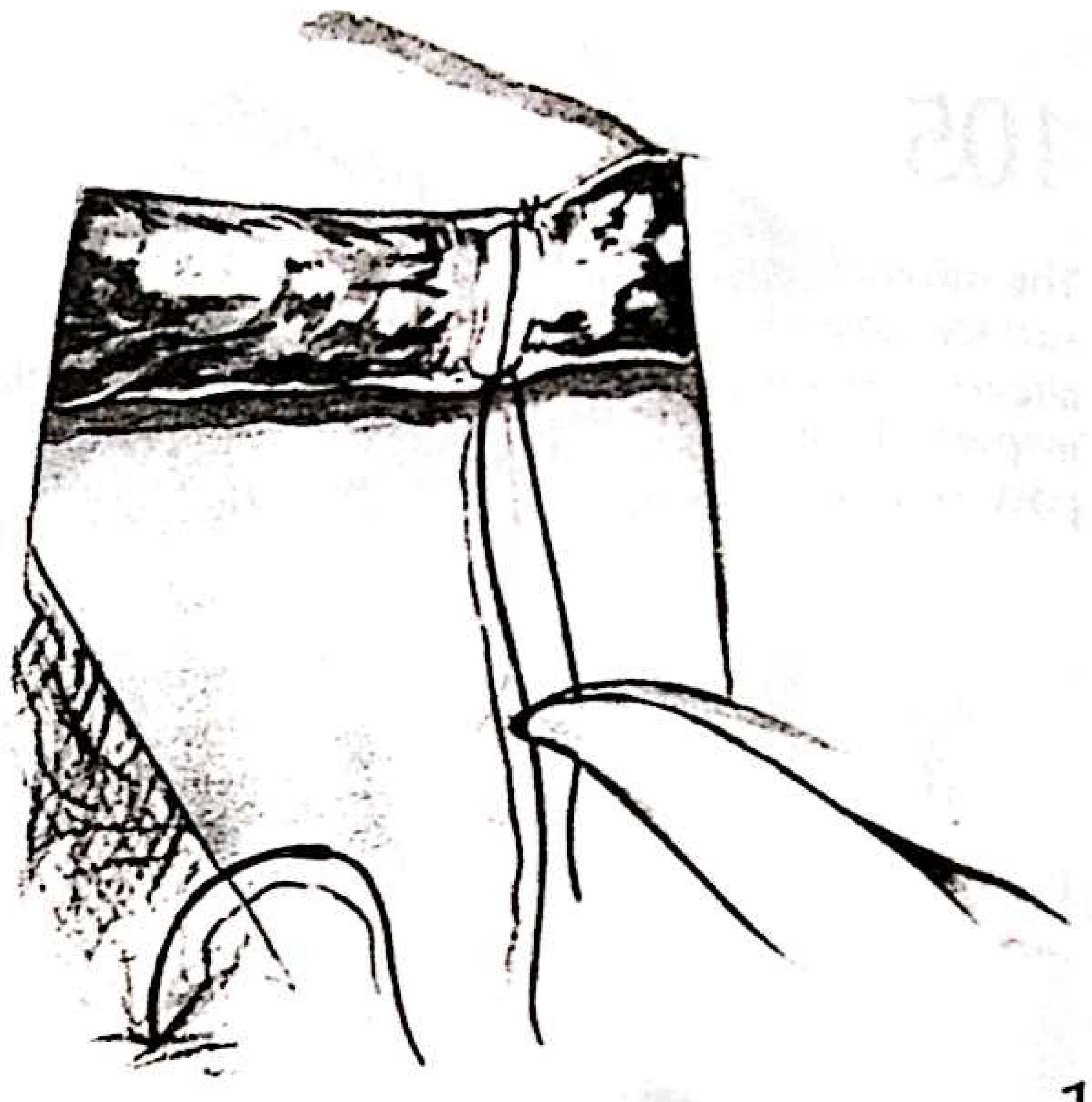
A problem which the surgeon faces is what to do with the needle while he is carrying out the instrumental tying of each suture. It is essential that it should be kept visible in the field, ready to be picked up when the ends of the completed knot are cut. One solution is to insert its tip into the gauze swab usually in the field, present to soak up excess irrigation fluid.

The sequence as described, arterial anastomosis followed by venous anastomosis, is the usual one, but if one or other of the anastomoses is likely to be more difficult it is probably better to complete it first.

When both the arterial and venous anastomoses are complete the microclamps are removed in the following order: distal venous; proximal venous; distal arterial; and proximal arterial. There is often a little initial leakage of blood, which quickly subsides. Any obvious source of leakage calls for the insertion of additional sutures, if necessary with the renewed application of clamps.

It may take some time for the flap to become pink, and filling of the vein may be the first sign that the circulation has been restored. A pulsatile artery with a pink flap and a full vein are good evidence of effective perfusion.



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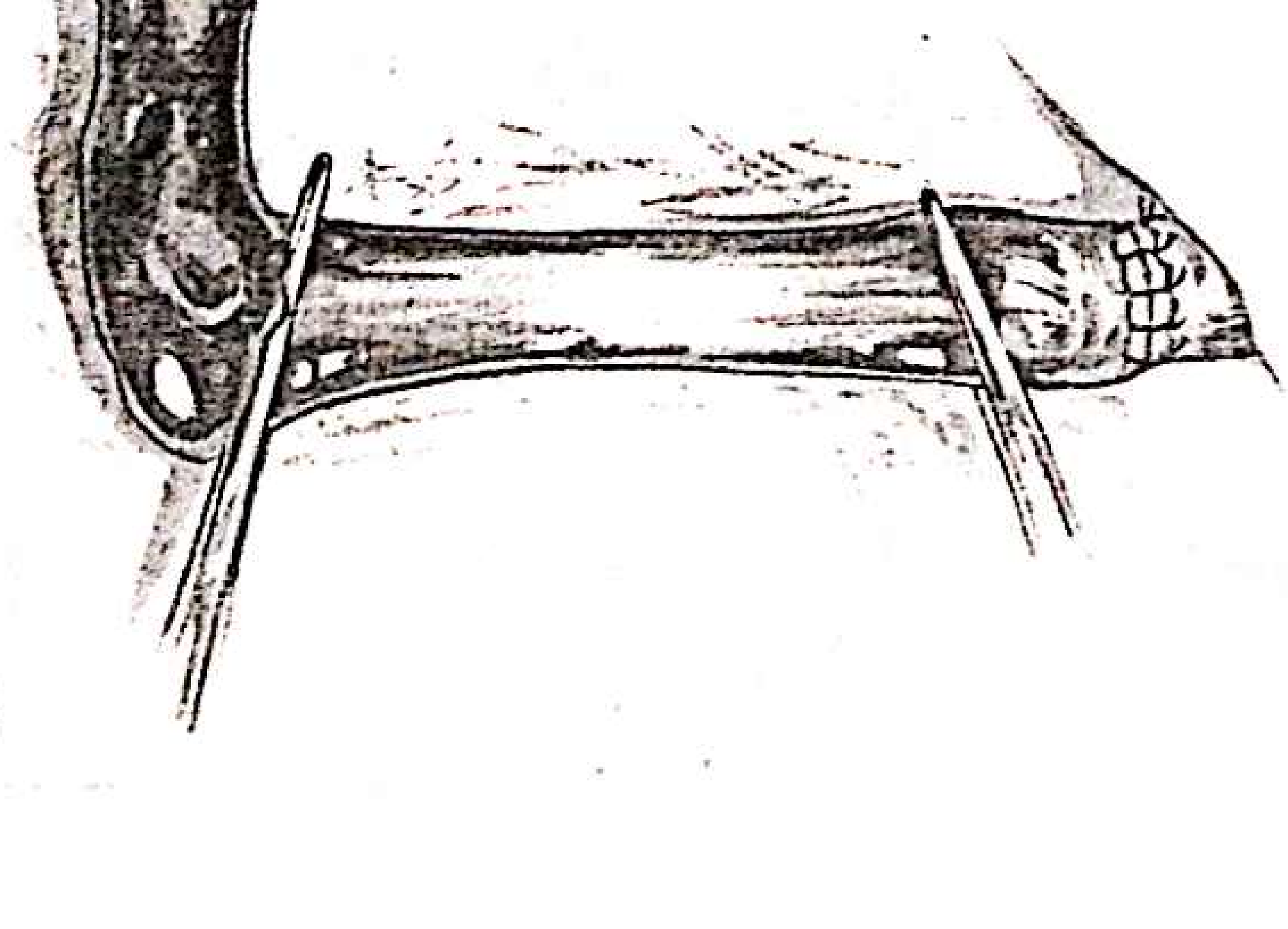
If there is doubt of the arterial patency, the 'milking test' can be used. In this two forceps are applied to the artery, distal to the anastomotic site, side by side.



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The blood in the vessel is milked distally by the distal forceps, leaving a length of empty vessel.

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The proximal forceps is then opened. Filling of the empty length of vessel indicates a patent anastomosis.

111

If there is no effective perfusion after a reasonable period of observation, with the vessels and flap kept warm, and with papaverine and/or local anaesthetic (both vasodilators) applied to the anastomotic site, the anastomoses should be resected and refashioned.

When there are no suitable recipient vessels within reach of the vascular pedicle of the flap it may be necessary to make use of an interpositional vein graft. The vein chosen should have a diameter similar to the vessels to which its ends are to be anastomosed – measured when it is first exposed and before it has developed any spasm. Valves near the site of anastomosis should be avoided as predisposing to turbulent flow and thrombosis. If any valves are present in the graft, care should be taken to ensure that after interposition the direction of flow will hold them in an open position. Tributaries should be carefully ligated or coagulated before the vein is harvested, and prior to insertion it should be irrigated with heparinized Ringer's solution to clear it of blood and, incidentally, to verify that it is leakproof. Once harvested, its length should be made to match the defect; too short will result in tension, too long is liable to result in kinking or twisting.

The final step in the transfer is the insertion of a drain under the flap. If this takes the form of a suction drain, as it frequently does in head and neck reconstruction, it is essential that it is applied at a distance from, and not adjoining, the anastomotic site. A certain way of ensuring that the tip of the drain remains in position is to fix it with a transfixing suture through drain and skin.

Postoperative care

The flap is at its most vulnerable during the first 72 hours following transfer. During this period it requires to be carefully monitored. Various methods of providing a continuous assessment of the state of circulation in the flap have been devised, but none matches experienced clinical observation. The flap which is progressing well has a definite pink colour and blanches on pressure. Any deviation from this norm requires careful assessment.

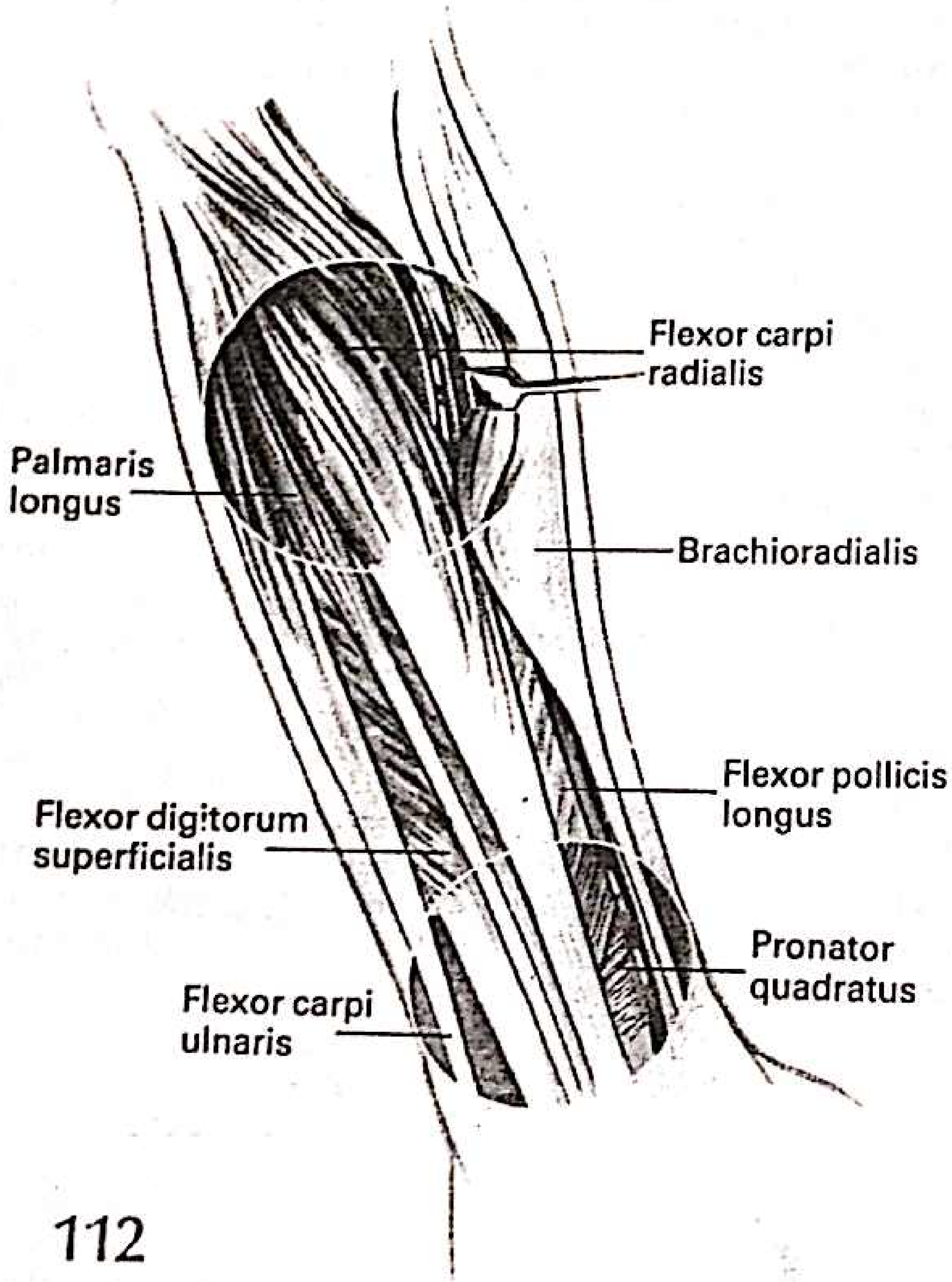
Undue pallor with a 'collapsed and empty' look and failure to blanch on pressure is strongly suggestive of arterial insufficiency. Failure of the flap to bleed when stabbed with a No. 11 blade is indicative of an absence of flow. Minimal bleeding indicates spasm, but the distinction is largely academic since the one so frequently progresses to the other. Venous insufficiency is much commoner than arterial insufficiency, and should be suspected when the flap is cyanosed and venous stasis is apparent on pressure.

The presence of either venous or arterial insufficiency is an indication for re-exploration of the anastomosis. It is striking how an increased readiness to re-explore, and if necessary revise the anastomosis, rather than watch and wait, has resulted in an overall improvement in the flap success rate.

RADIAL FOREARM FLAP

This flap has been used to transfer skin and fascia, and also as a composite along with a vascularized length of radial bone. The latter usage is largely confined to intraoral reconstruction, and is discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

The soft tissue which the radial forearm flap transfers is from the flexor aspect of the forearm, and is perfused through branches of the radial vessels which pass towards the surface in the intermuscular septum between flexor carpi radialis and brachioradialis. This septum becomes continuous with the investing layer of deep fascia which encircles the entire forearm, and the branches of the radial vessels take part in the formation of a plexus of small vessels which ramify over the fascial layer. It is from this vascular plexus that the flap receives its blood supply.



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In the proximal part of the forearm the radial artery lies at a distance from the skin, hidden between the muscle bellies of brachioradialis and flexor carpi radialis. The intermuscular septum which separates them, in which the branches of the radial vessels run in passing to the investing fascial layer, is a definite, if filmy, structure. As the artery passes distally it becomes more superficial, and brachioradialis and flexor carpi radialis, as they become tendinous, separate from one another.

The effect is to make the septum a less clearcut structure, but the concept of branches from the artery passing towards the surface to perfuse the investing layer of deep fascia, and through it the skin, remains totally valid. Indeed the branches are numerically greater in the distal than in the proximal forearm. It is this vascular system, based on the intermuscular septum and the investing layer of deep fascia, which makes it possible to raise the flap from virtually any part of the flexor aspect of the forearm, provided there is an adequate breadth of investing fascia connecting the skin island to the intermuscular septum.

The selection of the site of the skin island on the forearm is determined by several factors. The greater number of branches that reach the surface in the distal than in the proximal forearm might be regarded as a reason for placing the island distally, although there is no evidence that placing the island proximally is less safe in practice. The surface exposed when the flap is raised on the proximal site is mainly muscular, and takes a skin graft readily. In the distal site the tendon of flexor carpi radialis, with its cover of visceral paratenon, is the main structure exposed, and fear of the problems created if the skin graft used to cover the defect fails to take and bare tendon is left exposed has, for some surgeons, proved a deterrent to the use of the distal site. An additional consideration concerns the distribution of any hair present on the forearm, although in fact the hairs concerned are short and in practice give no trouble, even in the oral cavity. The use of the distal site provides the longest pedicle, both of the radial artery and its venae comitantes and a superficial vein, usually the cephalic. The artery is available as far proximally as the vicinity of the bifurcation of the brachial vessels, and the vein for a similar length. Both sites, proximal and distal, have been used successfully and the choice is largely a matter of personal bias. For medicolegal reasons it is probably wise to carry out an Allen test on the hand before embarking on the procedure.

113

When the flap is being raised on the distal site, the radial artery is palpated at the wrist, and the line of its course is marked on the forearm, together with that of a suitably sized superficial vein, generally the cephalic. The limb is exsanguinated, the pneumatic tourniquet inflated, and the outline of the skin island is drawn out on the skin.

The skin is incised down to the layer of deep fascia, and if the island overlies the line of the radial vessels, as it generally does, the incision can be immediately deepened to include the deep fascia. The cephalic vein apart, the superficial veins around the margins of the flap are divided.

The plane of elevation is between the investing layer of deep fascia and the muscle belly of flexor pollicis longus, together with the tendons of brachioradialis and flexor carpi radialis. Dissection can begin at either the radial or the ulnar side of the flap.

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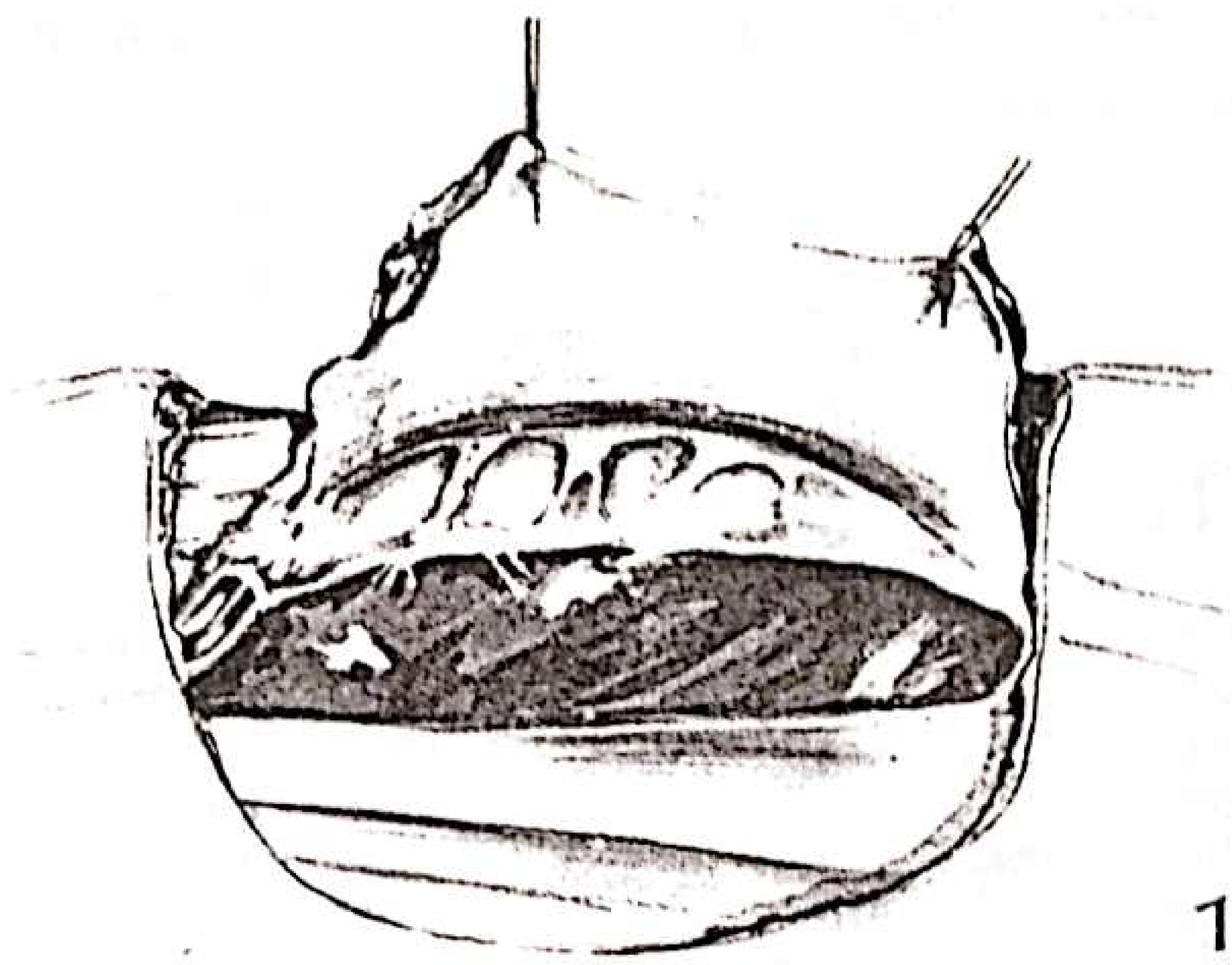
When the flap is raised from the radial side, the radial vessels are identified at an early stage, medial to the tendon of brachioradialis, and their walls are cleared at the distal margin of the flap, ready for subsequent division.



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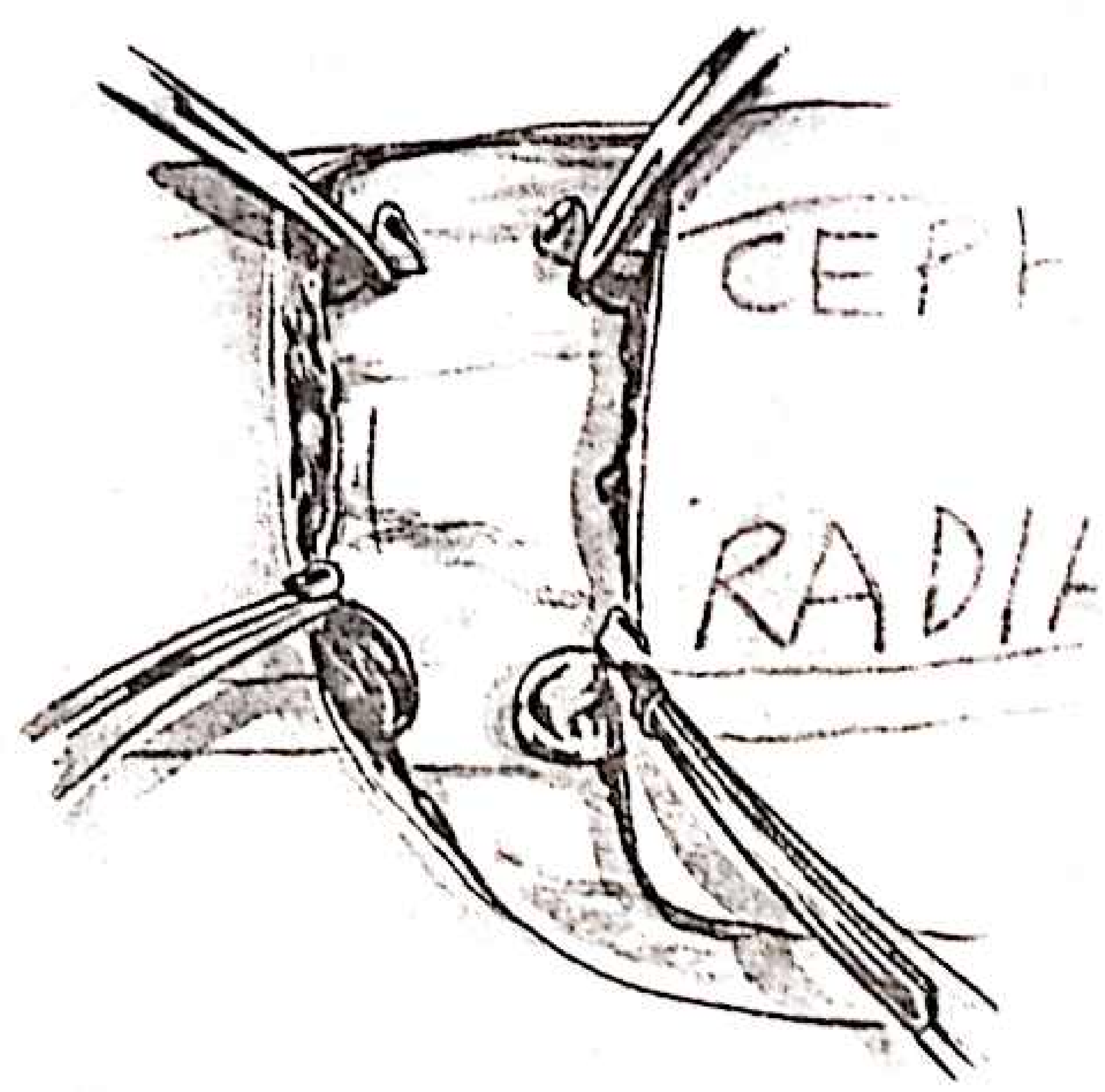
In the course of elevating the distal margin of the flap, the cephalic vein is identified, and both it and the radial vessels are ligated and divided.



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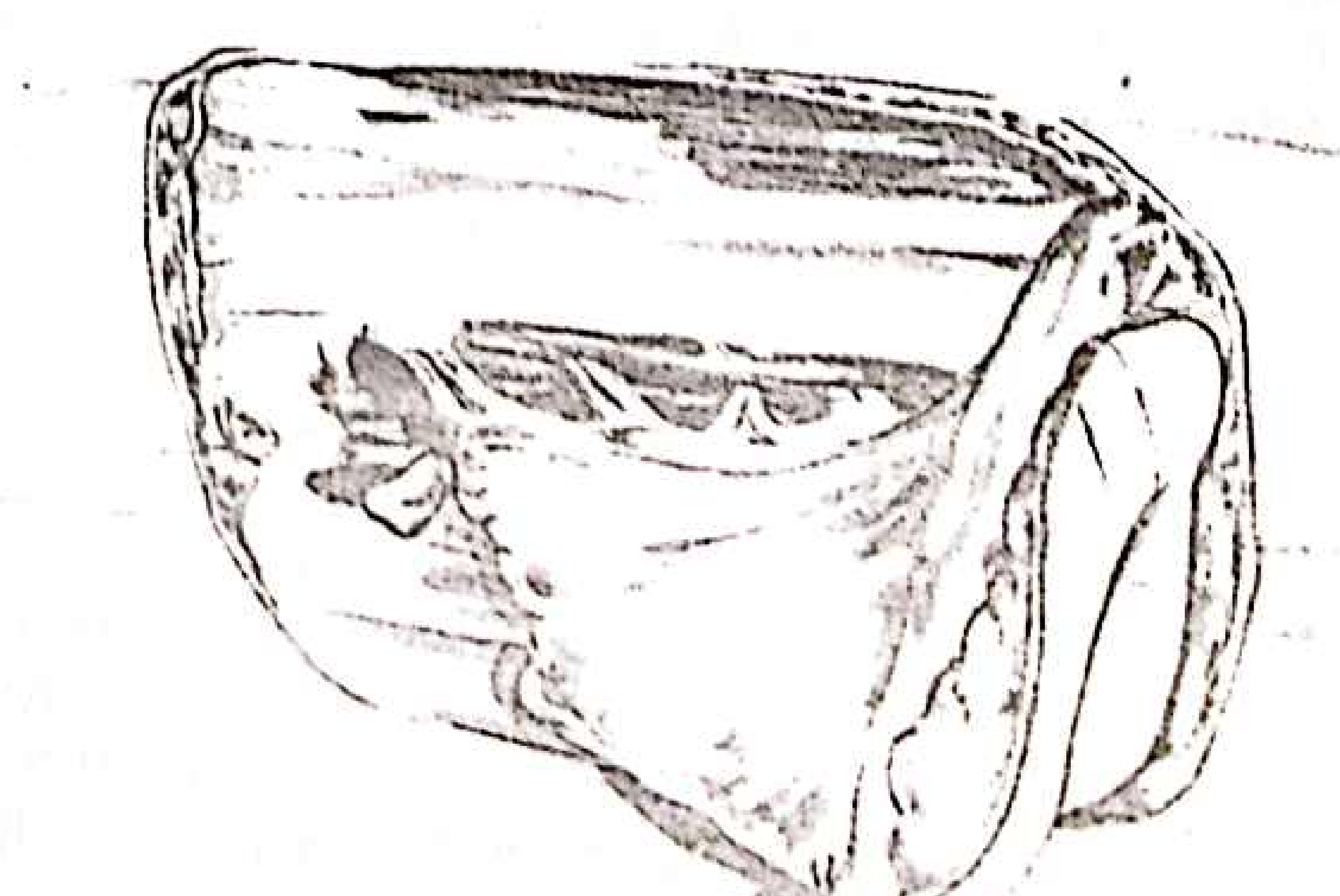
Mobilization of the flap from its ulnar border exposes the flat tendon of flexor carpi radialis, and as the flap is elevated from the three borders, radial, distal and ulnar, the small branches passing from the radial vessels to the flexor muscles are displayed. Their division allows elevation to be continued as far as the proximal border of the flap.



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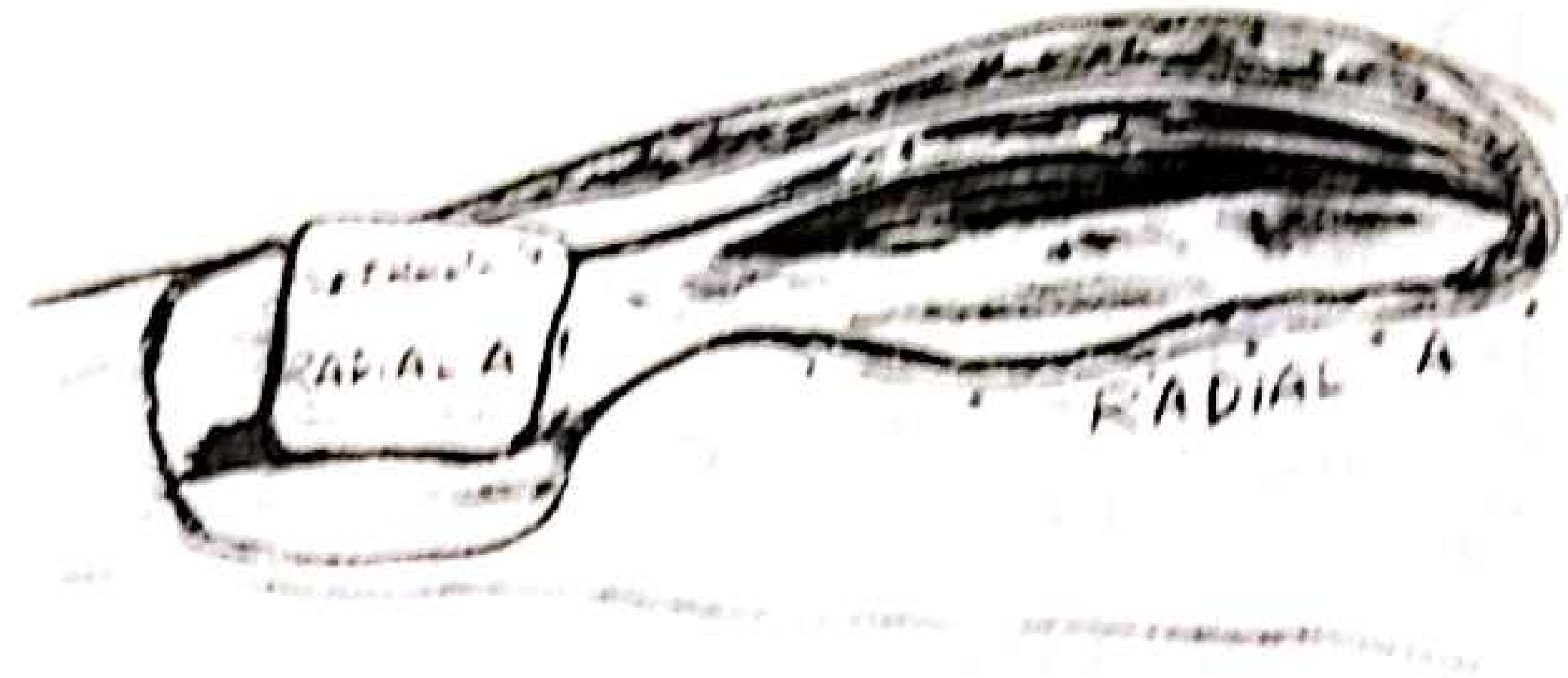
From the centre of the proximal border of the flap a long skin incision is made, passing proximally from the flap in the direction of the elbow, and the radial vessels are mobilized, dividing any branches passing deeply to the surrounding structures and superficially in the direction of the skin, taking care at the same time to avoid dissecting close to the vessels. The cephalic vein is also mobilized, dividing any tributaries which reach it. With its vascular pedicles established, elevation of the flap is completed.



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The proximal limit of the arteriovenous pedicle may be influenced by the vascular anatomy at the brachial bifurcation. The anterior interosseous artery often takes origin from the radial artery, and should be retained as a perfusion source for the distal forearm and hand. In preparation for proximal division of the vessels their walls are cleared at the site of division, but they are left unoccluded until the last moment so that the ischaemia time involved in the transfer is reduced to an absolute minimum.

118

The secondary defect of the forearm is generally split-skin grafted. Care in this aspect of the transfer is essential at all stages, during the raising of the flap, in the application of the graft, and in its postoperative management. The structure in the defect which is particularly at risk is the visceral paratenon which covers the tendon of flexor carpi radialis, because of its vulnerability to drying under the heat of the operating lamp. It must be kept constantly moistened with saline during the raising of the flap.

Careful haemostasis following release of the tourniquet, and prior to the application of the graft, is also essential. The bolus method of grafting is standard and the bolus should be moulded to the defect with more than usual care. A circumferential plaster of Paris cast provides the final immobilization, with the wrist held extended, the position most likely to provide the basis of subsequent good hand function.

A further problem which can arise results from the firm attachment of the visceral paratenon to the underlying tendon. Split-skin grafts are normally left exposed without dressings at 7 days, but in this clinical situation experience has demonstrated that, even with good initial graft take, the attachment of the graft to the paratenon is not sufficiently strong at the end of 7 days to prevent it from becoming detached, as the paratenon moves proximally and distally with the tendon if free wrist movement is allowed, with loss of the graft overlying it. It is desirable to continue immobilization in the plaster of Paris cast for a total of 10–12 days.

The radial forearm flap has an excellent safety record, is among the easier flaps to raise, and has vessels of a good calibre. Its adverse factors concern the secondary defect, its appearance and the problems relating to grafting, referred to above. Fortunately, even if there is failure of the graft over the tendon, and an area of bare tendon of flexor carpi radialis is left exposed, an ultimate deficit in hand function is not inevitable. The bare tendon should be treated conservatively, no matter how great the temptation to interfere operatively and no matter how large the area exposed. With full movement of the wrist and fingers encouraged, and treatment confined to the regular application of bland dressings, the exposed tendon will granulate, albeit slowly, and heal with full hand function. Even the appearance of such a healed donor site settles remarkably well.

Although the flap is available for surface defects, its most frequent use in the head and neck is probably in intraoral reconstruction. In this latter role the transfer can be extended to include part thickness of the radial shaft, as discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

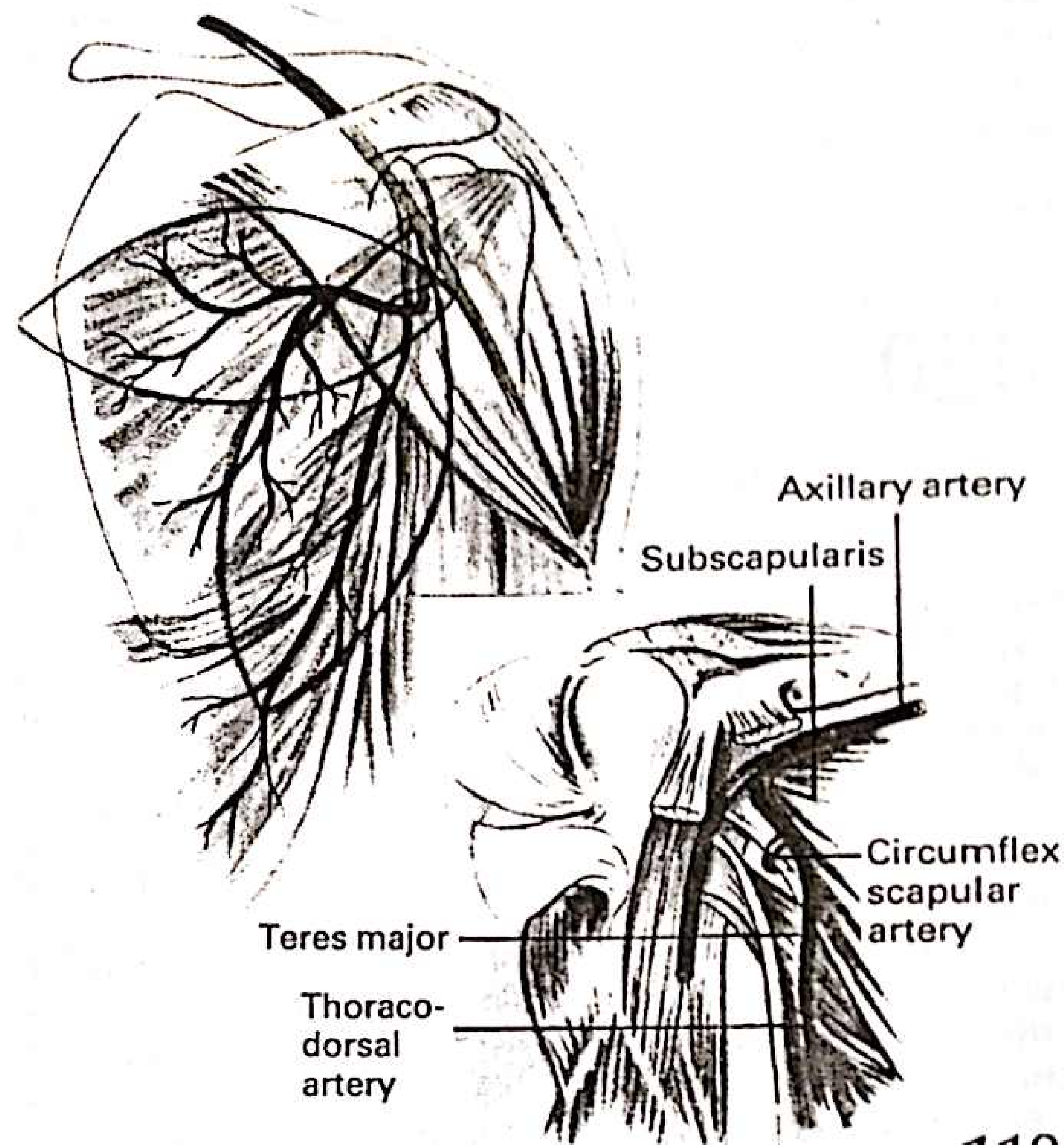
SCAPULAR FLAPS

119

These flaps are raised from the skin which overlies the scapular area, and they receive their blood supply from the cutaneous branches of the circumflex scapular artery and the veins which accompany it, usually two in number, occasionally one. Its parent vessel, the subscapular artery, is a branch of the third part of the axillary artery, and passes down on the posterior wall of the axilla for approximately 4 cm, where it divides into the thoraco-dorsal artery, which continues down to reach the latissimus dorsi muscle, and the circumflex scapular artery, the larger of the two branches. Almost immediately it passes backwards into a triangular intermuscular space, bounded above by subscapularis and teres minor, below by teres major, and laterally by the long head of triceps. While curving round the lateral border of the scapula in the space the artery gives off its musculoskeletal branches, which supply the infraspinous muscles and the associated scapular bone. It then emerges from between teres major and minor into the subcutaneous tissue overlying the scapula and divides into a horizontal branch, running towards the midline approximately 2 cm below the spine of the scapula, and a descending branch, passing obliquely downwards parallel to the lateral border of the scapula and approximately 2 cm medial to it, both in the superficial fascial layer.

These terminal cutaneous branches have both been used as the basis of a free flap, one the horizontal flap, with its skin ellipse approximately midway between the spine of the scapula and its inferior angle, the other the parascapular flap, with its ellipse of skin running obliquely downwards, parallel to the lateral border of the scapula. Both flaps are generally constructed in the form of an ellipse to facilitate direct closure of the secondary defect, and if this is to be achieved the maximum breadth of flap which can be raised is 12 cm.

The two flaps share a common centre, the site where the cutaneous branch of the parent artery emerges from between the teres muscles. With both flaps, the pedicle is a short one, 6 cm at maximum, if it is restricted to the cutaneous branch of the parent artery. It can be lengthened if the artery is traced back to its origin in the axilla.



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To raise the flap the patient can be positioned either prone or in the lateral position. The position of the intermuscular space between the teres muscles is palpated and, with the other relevant landmarks, spine or lateral border of the scapula, depending on which of the two flaps is being raised, is marked on the skin. Identification of the space as the site of emergence of the perfusion source provides the point from which the central line of the ellipse is drawn on the skin, parallel to the line of spine of the scapula in the case of the horizontal flap, parallel to its lateral border in the case of the parascapular flap. The size of the flaps used in practice is limited by the need to be able to close the secondary defect directly, 24 cm × 12 cm being generally considered an absolute maximum. With both flaps the plane of elevation should carry the layer of deep fascia with the flap to ensure the presence of the axial vessels in the flap, laying bare the underlying muscles and identifying each in turn.

120

Accurate identification of the site of the perfusion source is the key to the safe raising of both flaps, making it possible to raise each beginning at its distant end, and continuing towards the point of entry of the vessels, which become visible as the vascular pedicle is approached. As the vessels are entering the intermuscular space, several branches which supply the adjoining muscles and bone are seen and divided. If the length of pedicle which this dissection provides is adequate, the vessels are divided and the transfer proceeded with. If further proximal exposure of the vascular pedicle is required, the dissection should be continued round the anterior free border of the latissimus dorsi muscle to allow the triangular intermuscular space to be approached from both sides, although in the obese patient this part of the dissection is likely to be difficult, but the subscapular artery has a diameter of 2.5–3.5 mm at its origin, and this, together with the increase in the length of the pedicle, adds to the technical ease of the vascular anastomosis when the flap is transferred. The secondary defect on the scapular area is closed directly.

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Used to reconstruct a purely soft tissue defect, neither flap has any real advantage over the other, apart from the fact that the artery perfusing the parascapular flap occasionally emerges below rather than above teres major, a finding which would make the raising of the flap difficult if not impossible. The parascapular flap can be raised in conjunction with a length of scapular bone, as discussed in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240. With both flaps the site is one which is liable to have an undesirable thickness of subcutaneous fat. The skin itself has also the thickness and lack of flexibility typical of back skin generally.

Flap selection

With so many reconstructive techniques available to provide skin cover there are problems of selection. At the outset selection has to be based on whether or not the surgeon has the skills and equipment necessary to carry out microvascular anastomosis. If the reconstructions which require this expertise are not available for one or other of these reasons, the possible methods consist of the pedicled flaps, the deltopectoral flap, one of the trapezius flaps, the pectoralis major flap, and the latissimus dorsi flap.

The deltopectoral flap, although eclipsed at present by the current popularity of the myocutaneous and free flaps, remains a simple and safe technique, and one which does not call for particularly sophisticated surgery. The skin transferred is of excellent quality and weathers to give as good a skin match as any of its rivals. It is comparatively thin and, although it can cope with the minor loss of volume aspect of the defect as well as the skin cover aspect, it may leave a slightly hollow surface contour. It involves a two-stage procedure and this tends to be viewed by the present generation of surgeons as a significant adverse factor.

Of the trapezius flaps the lower has the fewest adverse factors. Given the length of pedicle required to reach those defects for which it might be regarded as appropriate, it is likely to have to be elevated to its full extent, and this makes the loss of accessory nerve function largely unavoidable. The addition of the muscle to its skin–fascial thickness enables it to fill a defect of greater volume than the deltopectoral flap, although the subsequent shrinkage of the denervated muscle is likely to reduce its bulk over a period of months. Its major adverse factor is the need to turn the patient and for some surgeons this may be a decisive factor in selection.

The other trapezius flaps also involve the turning of the patient, but each has further limitations in its role. The 'nape of neck' flap does not turn readily other than in a gentle curve and this substantially limits its potential use. The possibility of the vascular anomalies of the transverse cervical vessels (see p. 80) should deter the surgeon from using the lateral trapezius flap unless the absence of these anomalies has been established during the neck dissection element of the overall resection. The presence of a previously irradiated posterior triangle of the neck is also likely to be viewed as a contraindication to use of the flap.

The pectoralis major flap, although it is the current 'work-horse' for many surgeons in reconstructing defects of the oral cavity and has the virtue of familiarity as a result, has serious disadvantages used for surface reconstruction unless the defect is relatively close to the clavicle. When the defect is in the neck area the transfer can be made leaving the muscle pedicle subcutaneous, but unless a neck dissection is being carried out as part of the resection (and in the case of surface defects this is not common), the use of a subcutaneous tunnel becomes decreasingly feasible the greater the distance to be travelled by the flap. To have the bridging muscle pedicle exposed between the neurovascular hilum is theoretically possible, wrapped around with a split-skin graft, but its use in practice is beset with technical problems.

The latissimus dorsi flap, raised as a pedicled flap, can reach most sites on the head, although the dissection from the axilla to the defect is an arduous one unless a neck dissection has provided a ready-made neck pathway. In practice it is more often used as a free flap, particularly if a neck dissection is not being carried out simultaneously. A problem in practice may be the disproportion between the thickness of the flap and the depth of the defect, an aspect discussed below.

The free fasciocutaneous flaps, radial forearm and scapular, are liable to differ considerably in their thickness of subcutaneous fat, and selection to match the contour component of the defect might be a factor in selection. More important, however, is likely to be familiarity with the particular flap. The scapular flaps require the turning of the patient, unless the surgeon is willing to carry out the entire procedure, resection and reconstruction, with the patient in the lateral position, a position which for most surgeons lacks the virtue of familiarity. The scar of the secondary defect is hidden in most circumstances, compared with the graft which is standard with the radial forearm flap.

Possibly of greatest significance to the surgeon is the technical difficulty of the transfer, particularly the length of the pedicle and the calibre of the vessels involved. The scapular pedicle is short and has a small calibre unless it is extended to the origin of the circumflex scapular vessels, an extension which adds considerably to the technical difficulty of the dissection. The radial forearm flap is technically easy to raise with large calibre vessels and a long pedicle. It has also, for many surgeons involved in reconstruction following head and neck resections, the virtue of familiarity. Its major deficiency concerns the secondary defect, particularly if there has been graft failure.

A problem which arises with certain of the transfers discussed, and which makes revision subsequently necessary, is the disproportion between the volume of the defect and that of the flap. The difficulties are exacerbated by the fact that, with those reconstructions in which muscle is part of the tissue transferred, the volume of the flap as originally transferred changes, becoming less as the denervated muscle atrophies. A period of waiting is therefore desirable until the situation has stabilized before any revisional surgery is begun. Revision is then directed to reducing the volume of the fat. In the past, this involved a staged removal, with half of the flap elevated, thinned appropriately, and resutured in position, followed by similar thinning of the remainder after a suitable gap in time, determined by softening of the site. For some surgeons this is still the procedure which would be appropriate, but it is being increasingly replaced by the use of liposuction.

Illustrations by Ian Ramsden

Lips

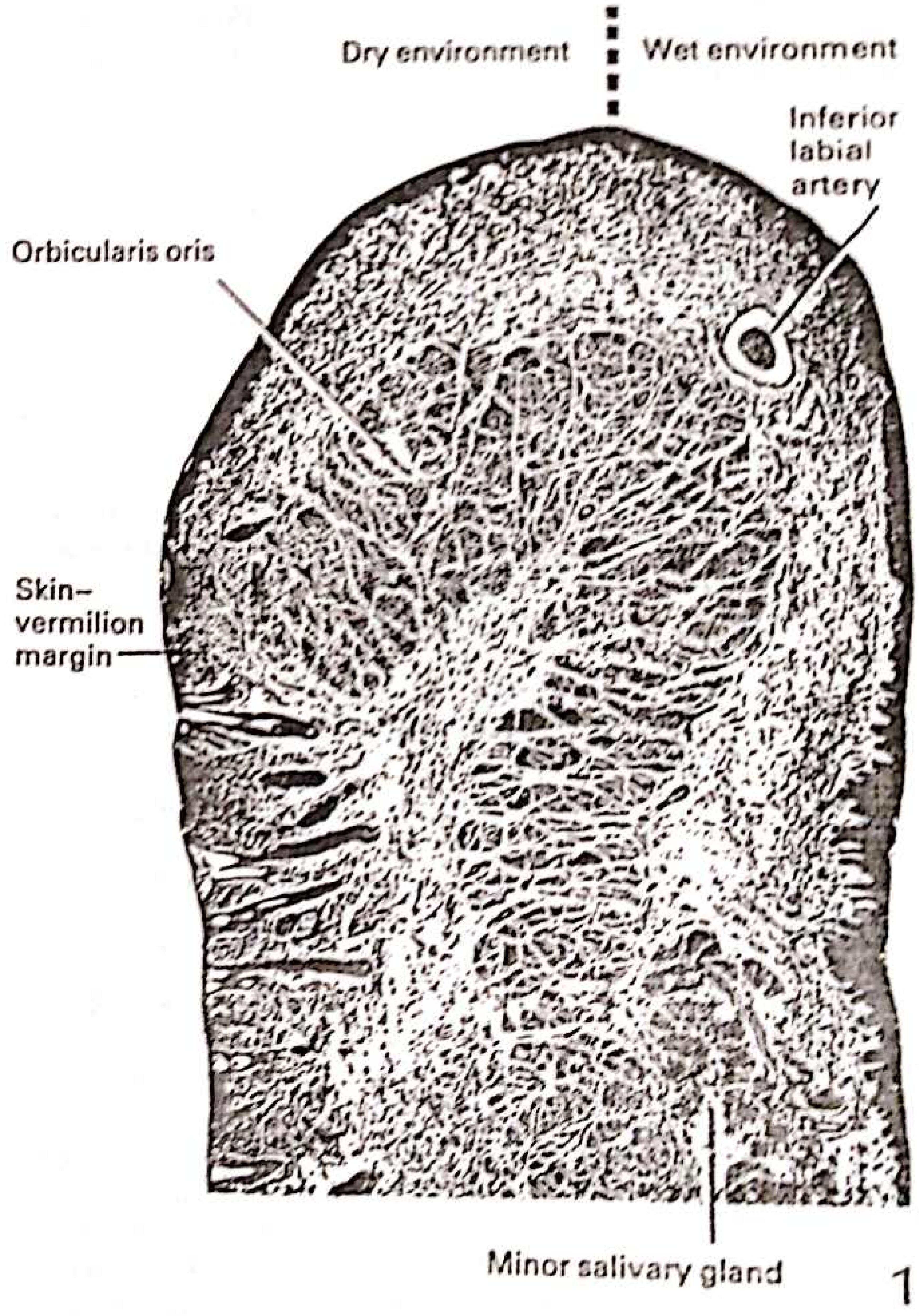
Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Anatomical aspects

1

The two surfaces of each lip, skin and mucosal, become continuous with one another round its red margin, referred to also as the vermilion. On the vermilion of each lip a line is present which marks the site along which the two lips come into contact with one another. It indicates also the transition from a dry to a wet environment: the dry vermilion with a pattern of wrinkles, exposed to sunlight, and with a clear-cut boundary line between it and the skin proper, patterned with the Cupid's bow in the upper lip and a central fullness in the lower lip; the moist vermilion with a smooth surface which merges without obvious surface change with the mucosa lining the lip.

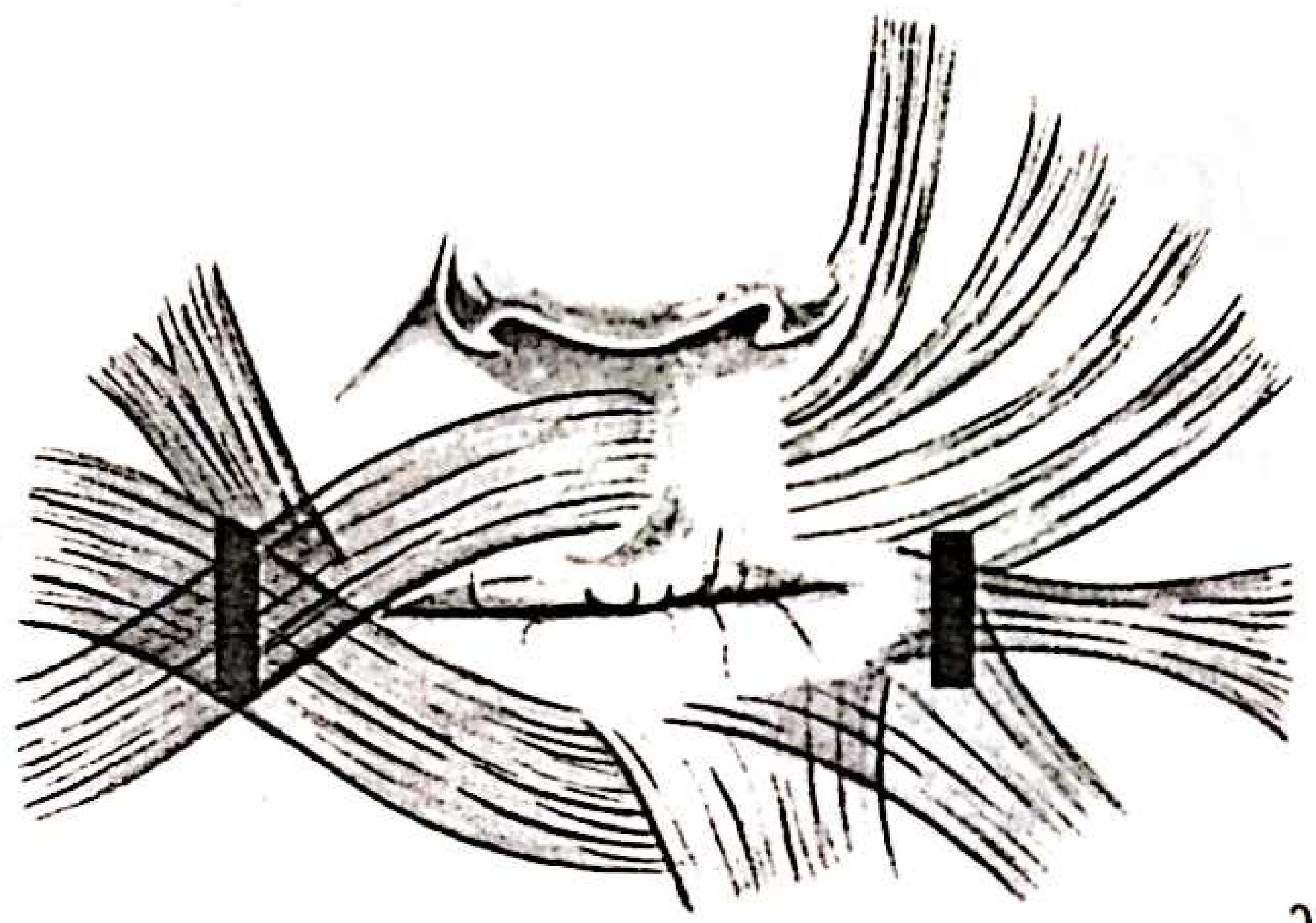
Clusters of minor salivary glands are present in the substance of both lips between the muscle layer and the mucosa, and a clear-cut plane of surgical cleavage is present between them and the muscle. No comparable plane exists between the skin and the muscle.



1

2

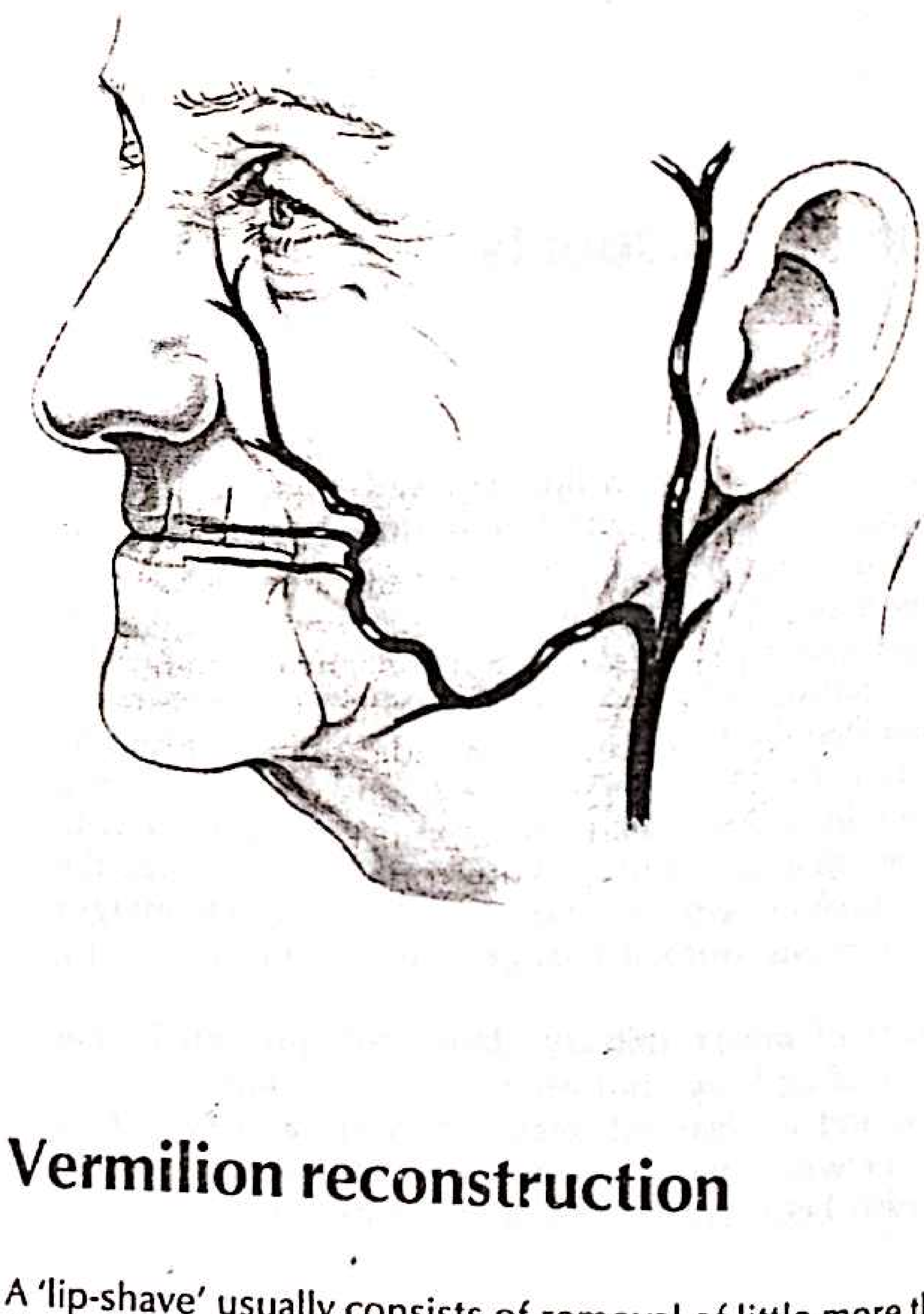
The muscle of the lip, orbicularis oris, acts as a sphincter, functioning in concert with a dilator group of muscles radiating from each angle to produce the movement patterns associated with normal activity. Its sphincteric function, particularly as it involves the lower lip, maintains the continence of the oral cavity, preventing the drooling of saliva. It is this aspect of function which the surgeon is concerned to maintain or restore in his reconstruction.



2

3

Contributing to the rich blood supply of the lips, labial arteries, branches of the facial artery, run horizontally across each lip at the level of the junction between the vermilion and the skin, between the mucosa and the muscle of the lip. It is these vessels which make possible the safe transfer of the large segments of lip tissue used in several of the standard lip reconstructions.



3

Pathological aspects

The vermilion has a distinctive tumour incidence, which differs from that of the adjoining skin and mucous membrane. There is a striking site distribution of the various tumour types. Squamous carcinoma is much the most common tumour and it arises almost exclusively in the vermilion of the lower lip, occurrence in the upper lip vermilion being an extreme rarity. The distribution between the lips parallels the comparative dosage of actinic radiation which each vermilion receives. Squamous carcinoma of the angle is not common, but one of the forms which it takes represents spread onto the vermilion of the angle from the intraoral mucosa adjoining the angle. Naevi and lentigenes of the lower lip are relatively common, but malignant change rarely, if ever, occurs. In contrast, when mucosal lentiginous melanoma arises in the vermilion, it does so most frequently in the upper lip, spreading in a lentiginous manner over the upper lip mucosa.

The lower lip vermilion, exposed along its entire length to actinic radiation, is frequently the site of diffuse premalignant change. It is with this as a background that squamous carcinoma is most frequently seen, making it often desirable to strip the exposed vermilion and resurface the area either in the form of a 'lip-shave', as a prophylactic measure, or as an addition to the resection of a frank squamous carcinoma. Squamous carcinoma with an actinic background of causation is generally slow to increase in size, slow to infiltrate and slow to metastasize, characteristics which influence to a considerable extent aspects of its surgical management. When metastasis occurs it is generally to the submandibular nodes.

Vermilion reconstruction

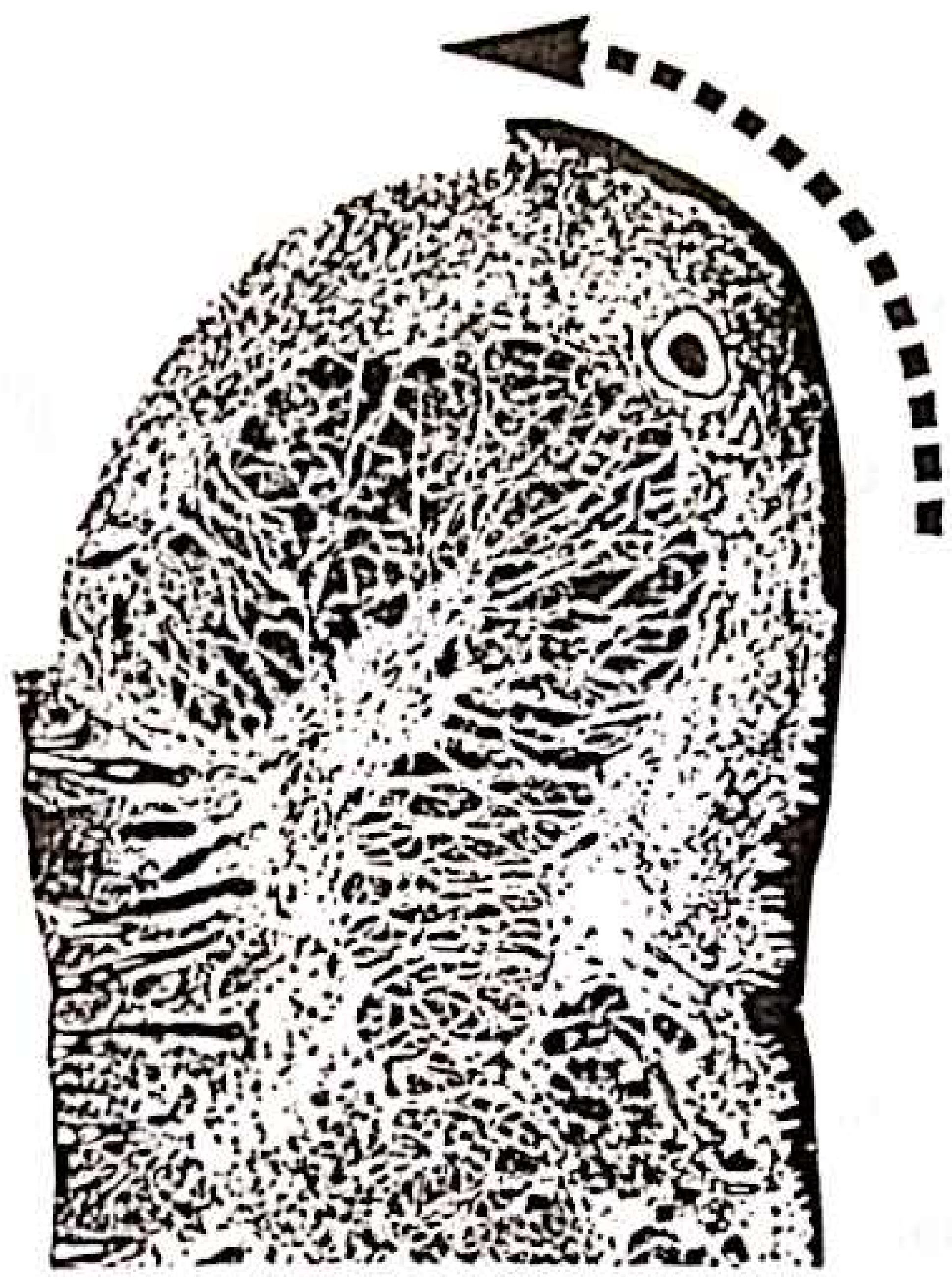
A 'lip-shave' usually consists of removal of little more than the epidermis and dermis, although in some cases it may involve removal of some of the underlying muscle in addition. Vermilion may also be lost as part of the resection of a segment of the full thickness of the lip. The reconstructions which are used in such circumstances restore the oral sphincter, but in certain of the standard reconstructions the restored segment lacks a red margin. In both of these situations it is necessary to reconstruct the red margin and the methods which are used involve advancing the mucosa of the inner aspect of the lip round the margin or the transfer of a flap of the mucous membrane of the tongue.

Mucosal advancement

4–7

When the defect is one of the vermilion alone and does not extend deeply to involve lip muscle, the mucosa lining the lip can be advanced round the margin and the defect directly closed. In advancing the mucous membrane in this way it is not essential to mobilize it preparatory to advancement. The defect is generally one of the exposed vermilion only and this is a comparatively narrow strip lying, as it does, between the lower margin of the vermilion and the line of contact between the lips, the line of demarcation between the dry environment exposed to the sunlight, with its typical wrinkle lines, and the moist intraoral environment with its smooth mucosal surface.

Mucosal advancement can also be used as an element of those lip reconstructions which would otherwise leave the lip margin without a vermilion. At the planning stage of such a reconstruction it is frequently possible to leave the margin of the reconstructing flap which is destined to form the free border of the lip with a fringe of mucosa which can turn over the free border to form the new vermilion. The leaving of a mucosal fringe in these circumstances seldom interferes with the pathological requirements of the resection. When such a method is used the flap margin which will provide the border can also be sculptured with a suitable degree of fullness to mimic the curve of the normal vermilion. Failure to do this usually leaves a red margin which lacks the fullness of the remainder of the lip. This also explains why advancement of the mucosa is less satisfactory when the vermilionectomy has included some of the underlying muscle and leaves a rather square-cut edge. Mucosal advancement is unable to provide the substance of tissue necessary to match the volume which has been lost, and a narrow vermilion is the result.



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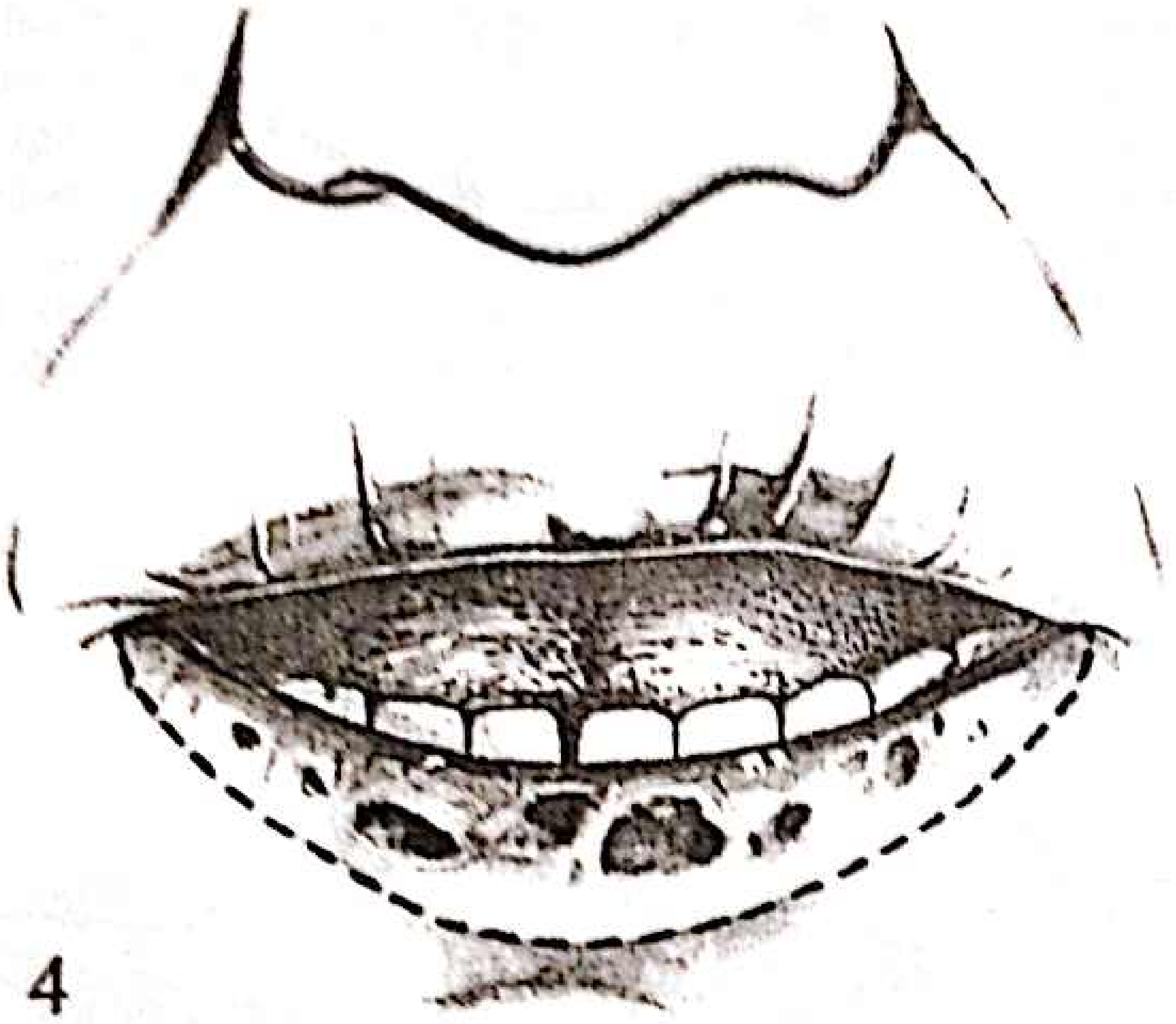

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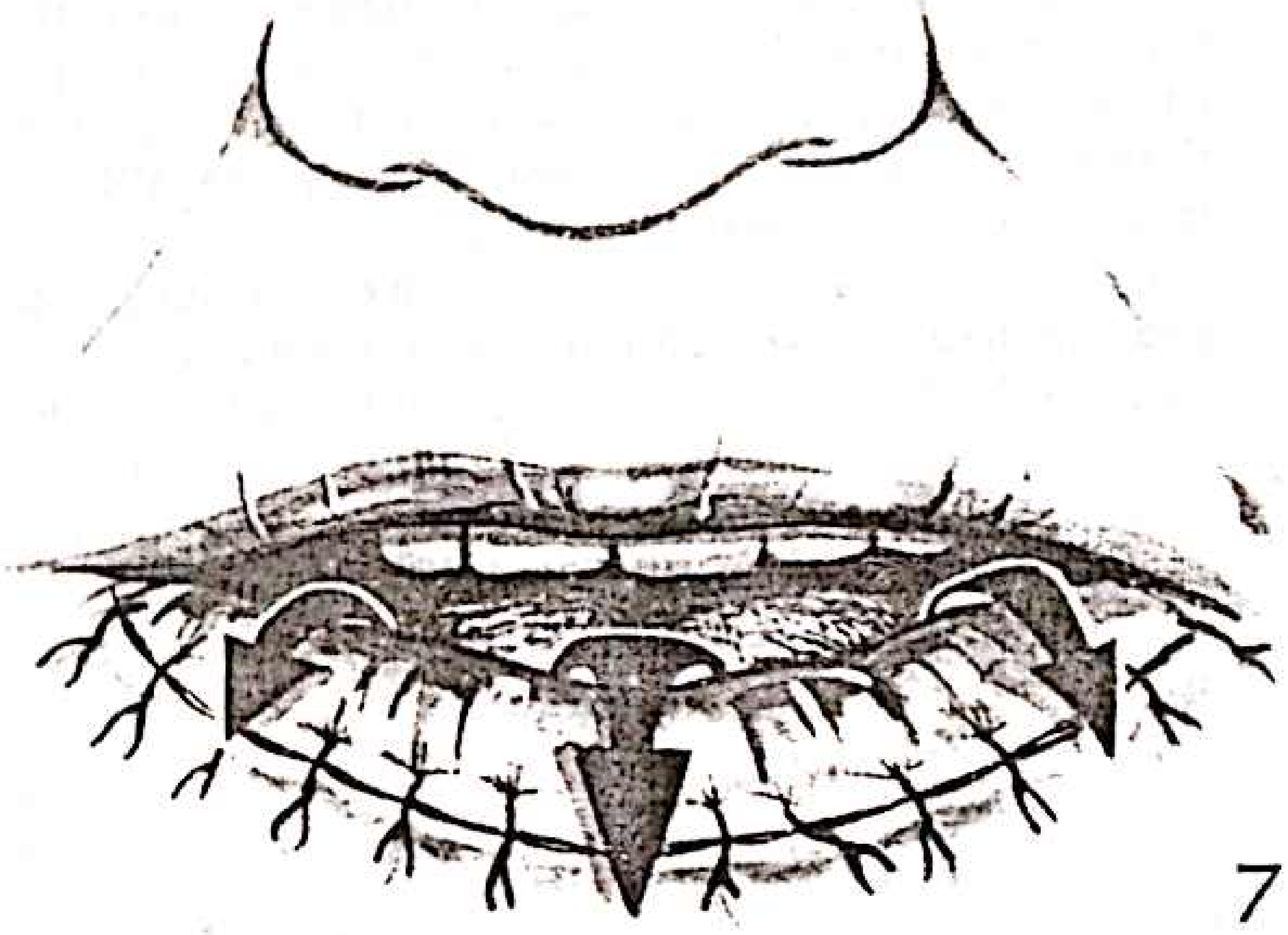

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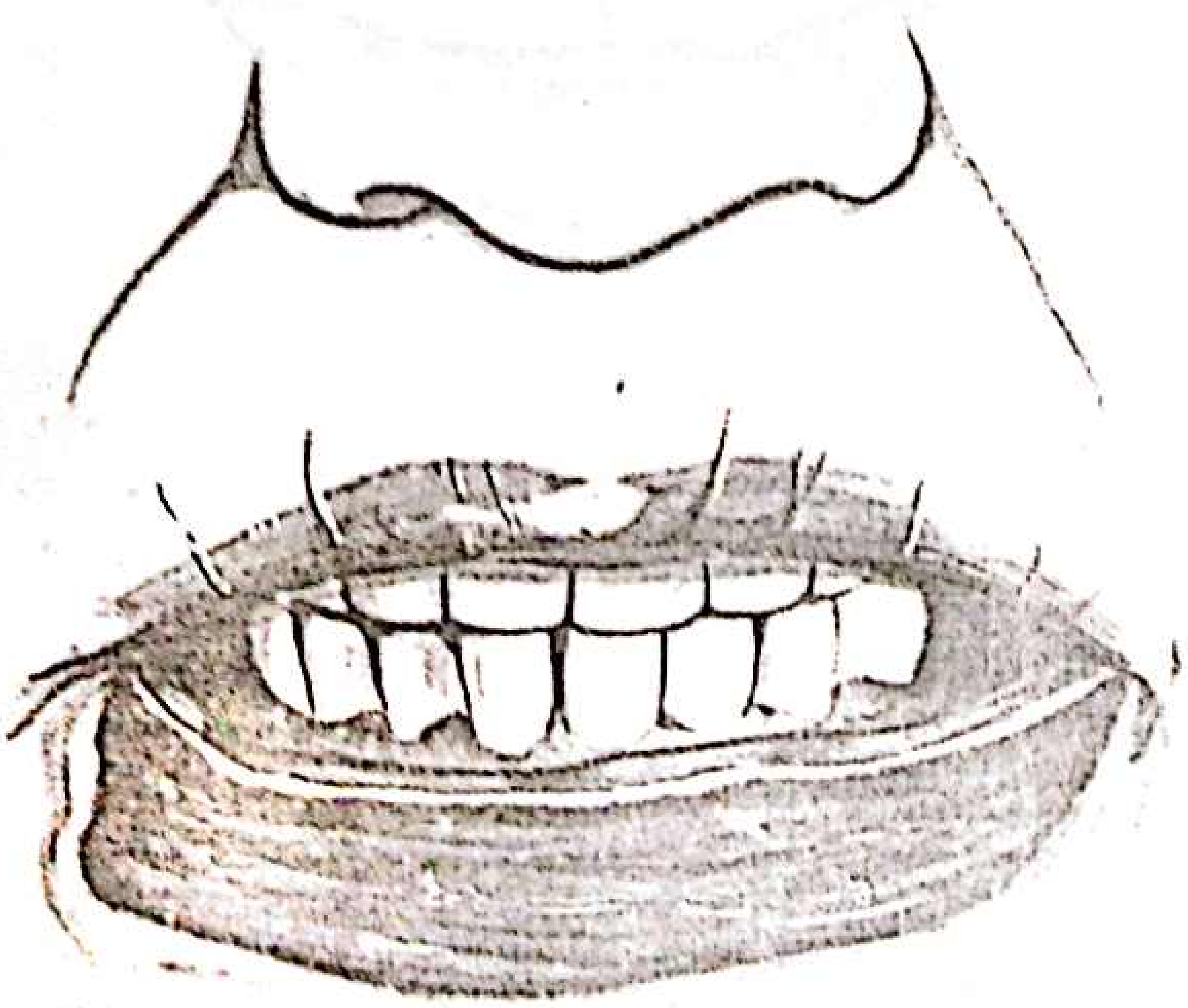


5

Tongue flap

8 & 9

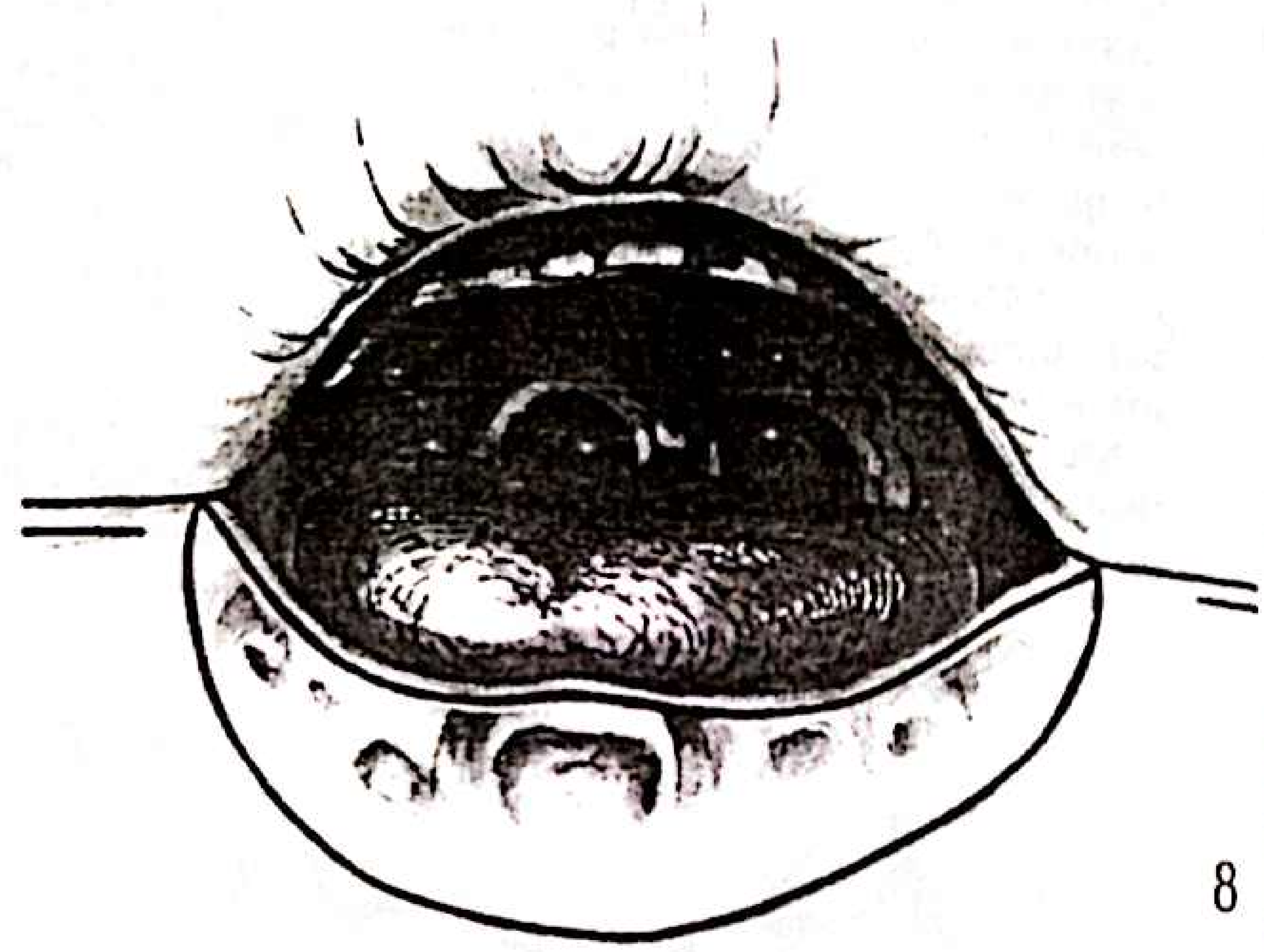
In this method of reconstruction, a flap of tongue mucosa, supported by some of the underlying muscle, is raised, advanced over the lip, and sutured to the margin of the skin along the anterior resection line. The method can be used following a vermilionectomy where muscle as well as vermilion has been removed. It can also be used to complete certain of the techniques used in reconstructing the lips, most often the lower lip, by providing a red margin.

The flap can be designed to use either the dorsal papillated mucosa (*see Illustrations 10* and *11*) or the smooth ventral mucosa (*see Illustrations 12–14*). The decision as to which to use depends very much on the appearance of the mucosa of the tongue. In some patients the dorsum has rugae and is heavily papillated. Such mucosa is not really suitable for transfer to the lip because of its unsatisfactory appearance in that position. It is then that the use of the ventral mucosa is preferable, although in practice it is rarely required.

Often the area requiring to have red margin provided extends from angle to angle and in such circumstances the flap is taken from the anterior tongue on each side of the midline. When the entire red margin is being resurfaced, care should be taken not to stop short of the angle. The flap should be carried onto the angle on each side. Failure to do this will leave the flap forming a very obvious patch on the lip.

As the tongue has no dermis to hold sutures, the flap should be raised with a good content of underlying muscle to compensate for this lack. The thickness of muscle required can be determined when the flap is being raised, to match the volume required to restore a good contour to the lip margin.

The final appearance is adequate, although a degree of scaling usually develops on the mucosa as a result of the transfer from its previous wet intraoral environment to the dry exposed red margin. This is liable to cause the patient concern since scaling is a regular component of the premalignancy syndrome as it occurs in the red margin. Reassured that the scaling is not due to recurrence of the original condition, most patients find that an emollient cream controls the scaling reasonably effectively. The tendency to scaling usually diminishes with time.



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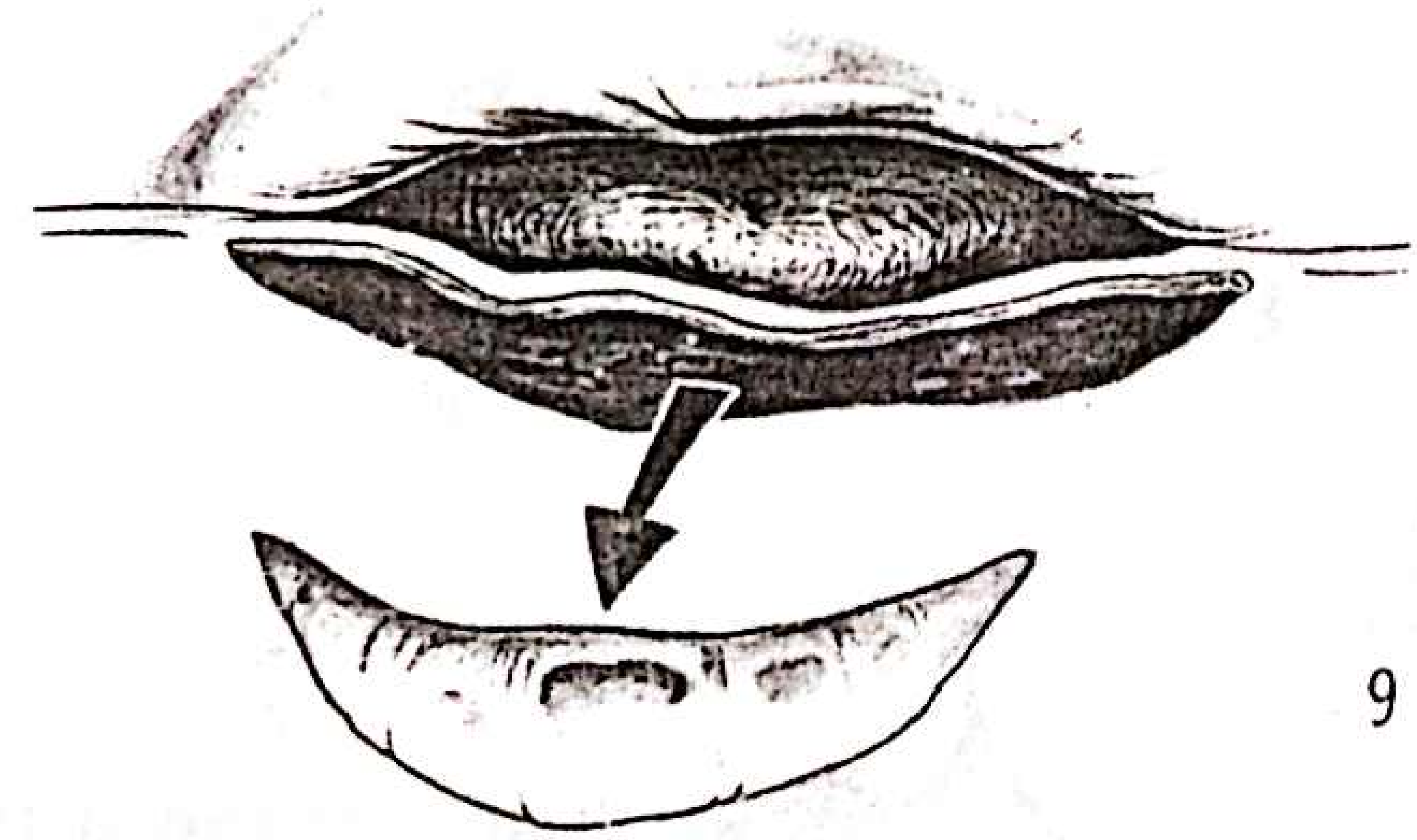

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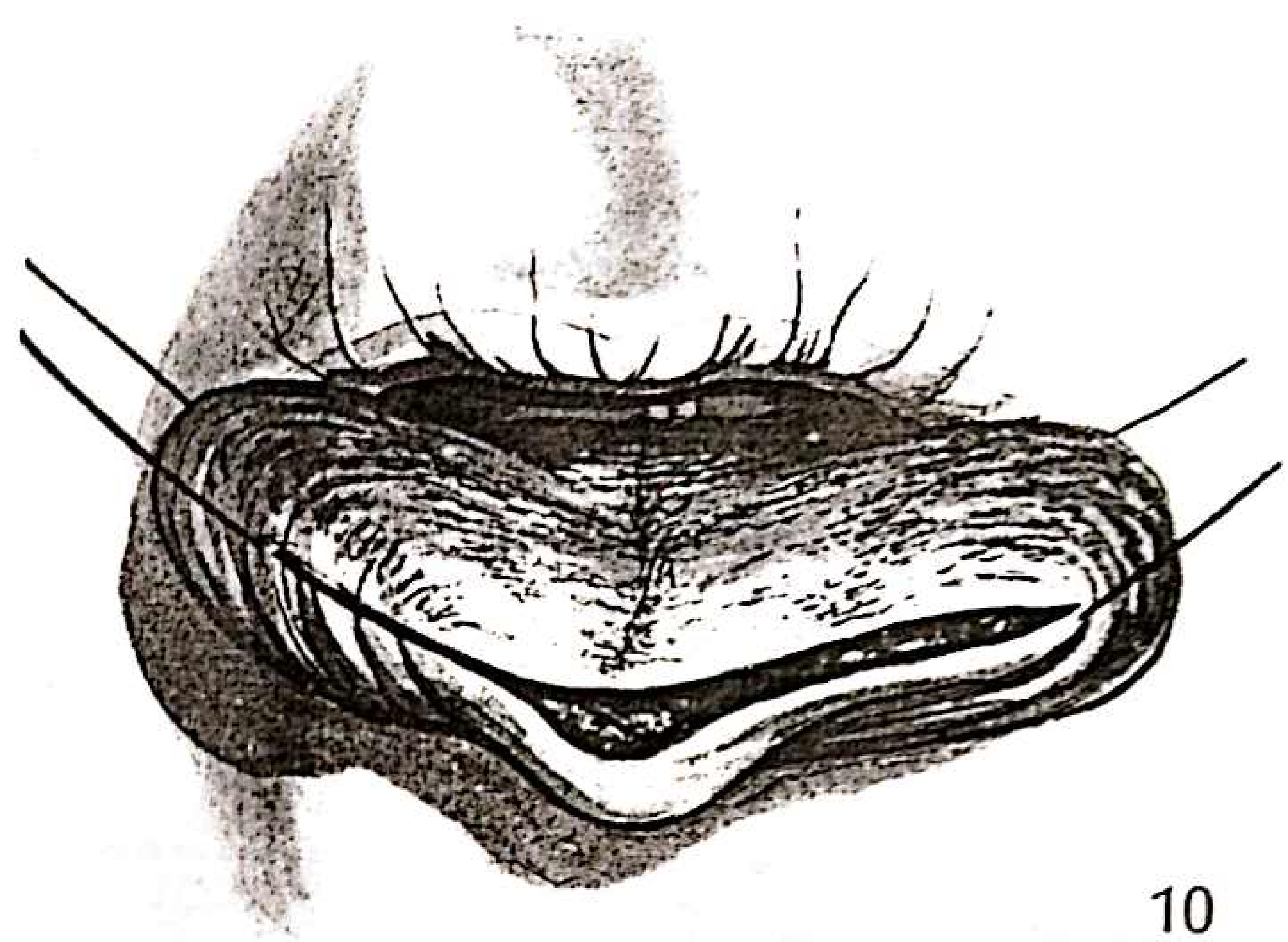
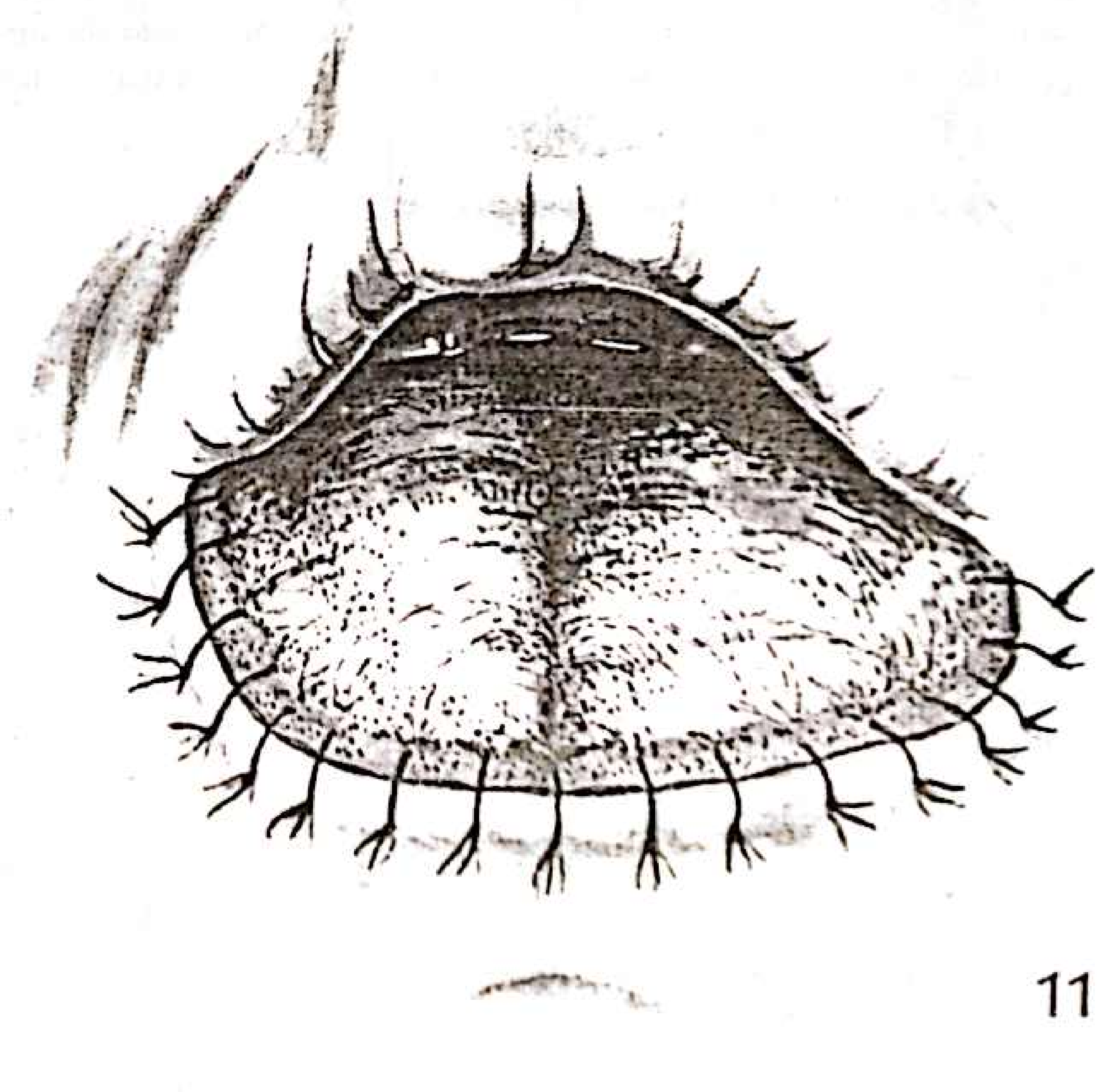


10

Dorsal tongue flap

10 & 11

When the flap is being raised on the dorsal aspect, an incision is made along the line demarcating the dorsal from the ventral surfaces of the tongue, its length designed to match that of the lip defect. It is then deepened for approximately 1.5 cm in a direction which will raise a flap with sufficient muscle substance to match the requirements of the lip defect. When the defect involves the lower lip alone and a dorsal flap is being used, the flap is merely advanced to cover the lip defect. The incision made on the tongue runs along its margin, extending backwards on each side sufficiently far to provide a flap of adequate length to cover the lip defect angle to angle.



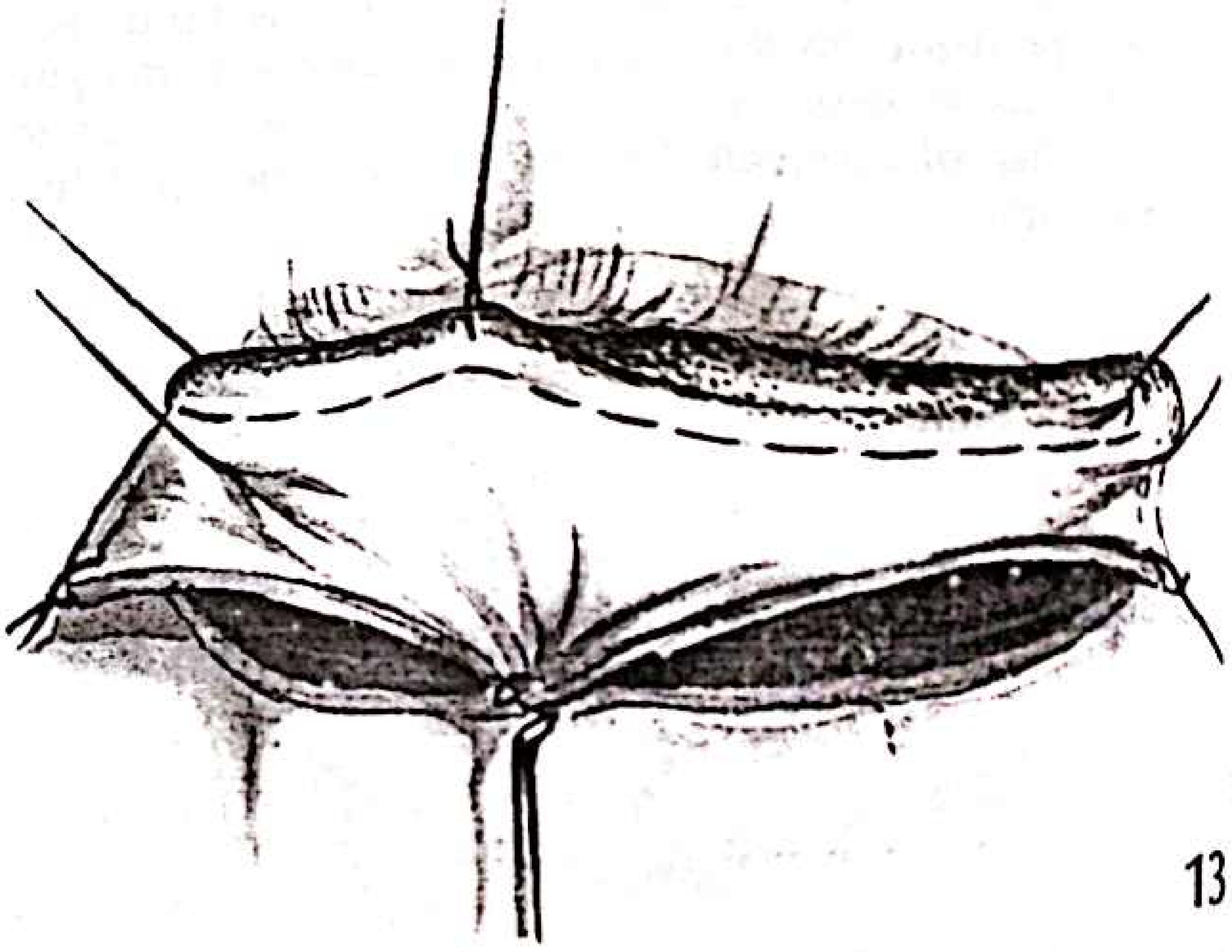
11

Ventral tongue flap

12, 13 & 14

When the flap is being raised on the ventral aspect, a horizontal incision corresponding in length to the lip defect is made approximately 1.5 cm below and parallel to the rim of the tongue. With a back-cut made at each extremity, the flap, based above, is raised with its suitable content of muscle and, hinging forward, is advanced to cover the lip defect.

12



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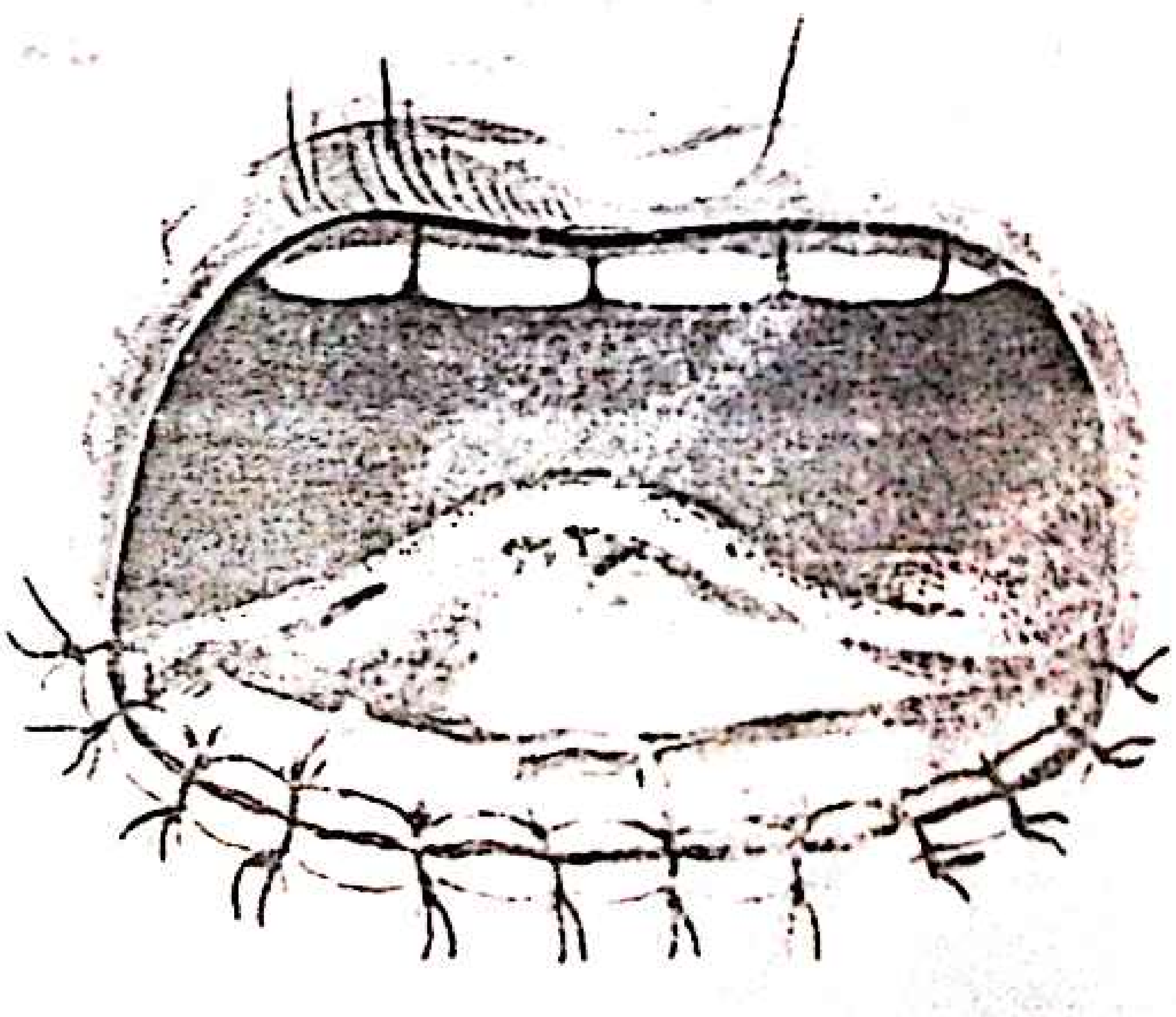


14

15

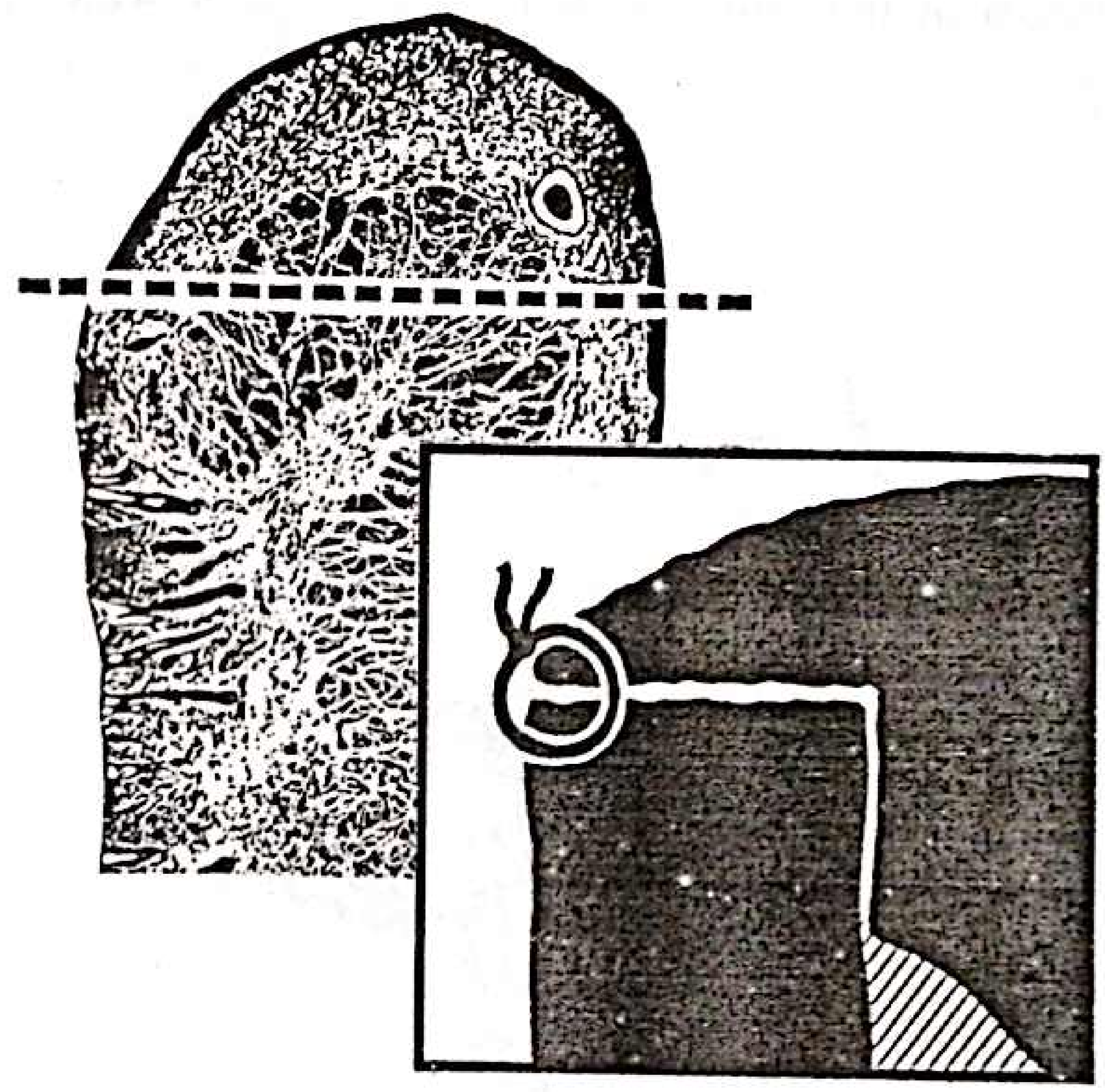
With both flap designs scrupulous haemostasis is essential before the sutures are inserted to attach the flap to the lip. Once the flap has been sutured in position, any bleeding is hidden under the tongue and behind the lip, and is extremely difficult to cope with. Only one line of sutures is used to attach the margin of the flap to the skin edge of the lip defect. A good 'bite' of the sutures on the flap is desirable and there are advantages in leaving the sutures in position for longer than usual. The suture marks which result settle to look like the vertical wrinkling which is normally present along the red margin and the effect is to add to the final normality of the appearance.

When the patient has teeth it is *essential* to fit him preoperatively with an overlay dental splint to hold the mouth sufficiently open to prevent him from inadvertently biting the flap during recovery from the anaesthetic.

The flap beds down very quickly in its lip site and can safely be divided at 2 weeks. Sensation is gradually restored but many patients notice some numbness along the tongue margin, insufficient to be annoying but sufficient for them to be aware of it. The appearance of the lip, while never normal to close inspection, is generally very satisfactory regardless of whether it consists of dorsal or ventral mucosa.

It is possible to design a reconstruction comparable to the dorsal flap as applied to the lower lip, by advancing the ventral mucosa onto the upper lip when such a defect is present. Defects of the upper lip which are suitable for such a reconstruction are fortunately extremely rare, since experience has shown that for some unexplained reason patients who have had such a flap have found the procedure sufficiently uncomfortable to be barely tolerable. In this it contrasts with the situation when the flap is used for the lower lip: such patients are minimally inconvenienced by the anchoring of the tongue to the lower lip.

When the defect involves the angle of the mouth with extension onto both the upper and the lower lip, the tongue flap design can be modified to provide a very adequate vermilion substitute. The flap is raised in the form of a horizontal V on the side of the tongue adjoining the defect of the angle, with one limb of the V above the demarcating line between ventral and dorsal surfaces, and one below, meeting posteriorly. The upper flap hinges down and the lower one hinges up, resulting in a V-shaped flap which matches the angle defect of the lip. The method is illustrated in the chapter on 'Buccal mucosa', pp. 270–282, as part of the reconstruction of the buccal mucosal defect which involves the angle of the mouth.



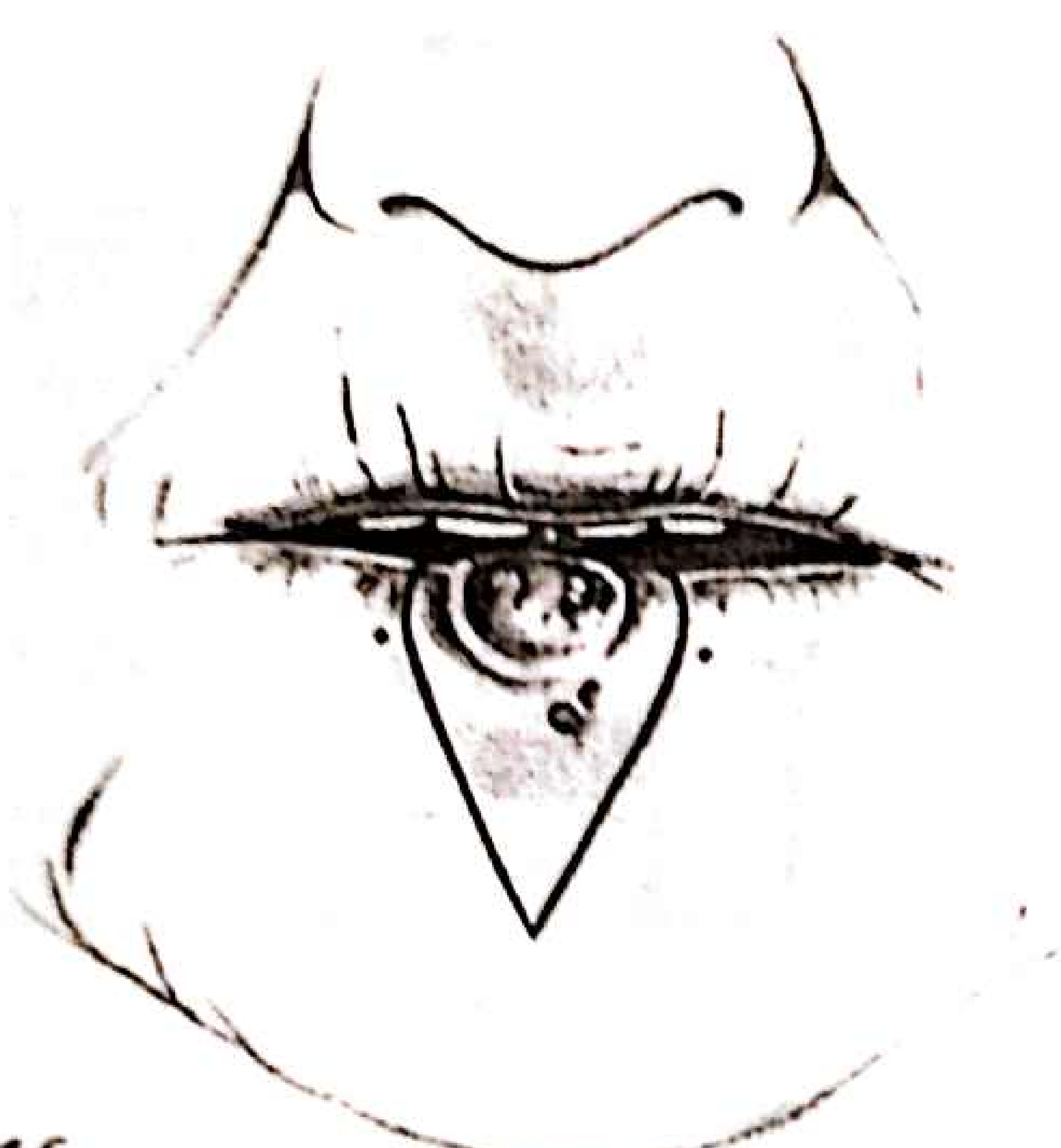
15

Lower lip

Lip-shave

This procedure, in which the vermilion of the lip is stripped, can be managed satisfactorily by mucosal advancement (*see Illustrations 4–7*) in most patients and the resulting appearance with its maintenance of the normal lip curvature is excellent. The pathological background to the great majority of lip-shave procedures is actinically induced premalignancy, and since the entire red margin is exposed and pathologically involved it is usual to strip it from angle to angle.

The progress of premalignancy to invasive squamous carcinoma in the lower lip is usually a slowly evolving process and the occasional patient is seen where there is a little more induration than might be expected from premalignancy alone, yet barely enough to constitute obviously invasive carcinoma. A compromise resection in such circumstances might be a 'deep lip-shave', removing some of the muscle underlying the vermilion. The effect is loss of the curve of the lip and it is in this situation that the muscle substance lost can be restored by using a tongue flap rather than mucosal advancement to provide the new vermilion.

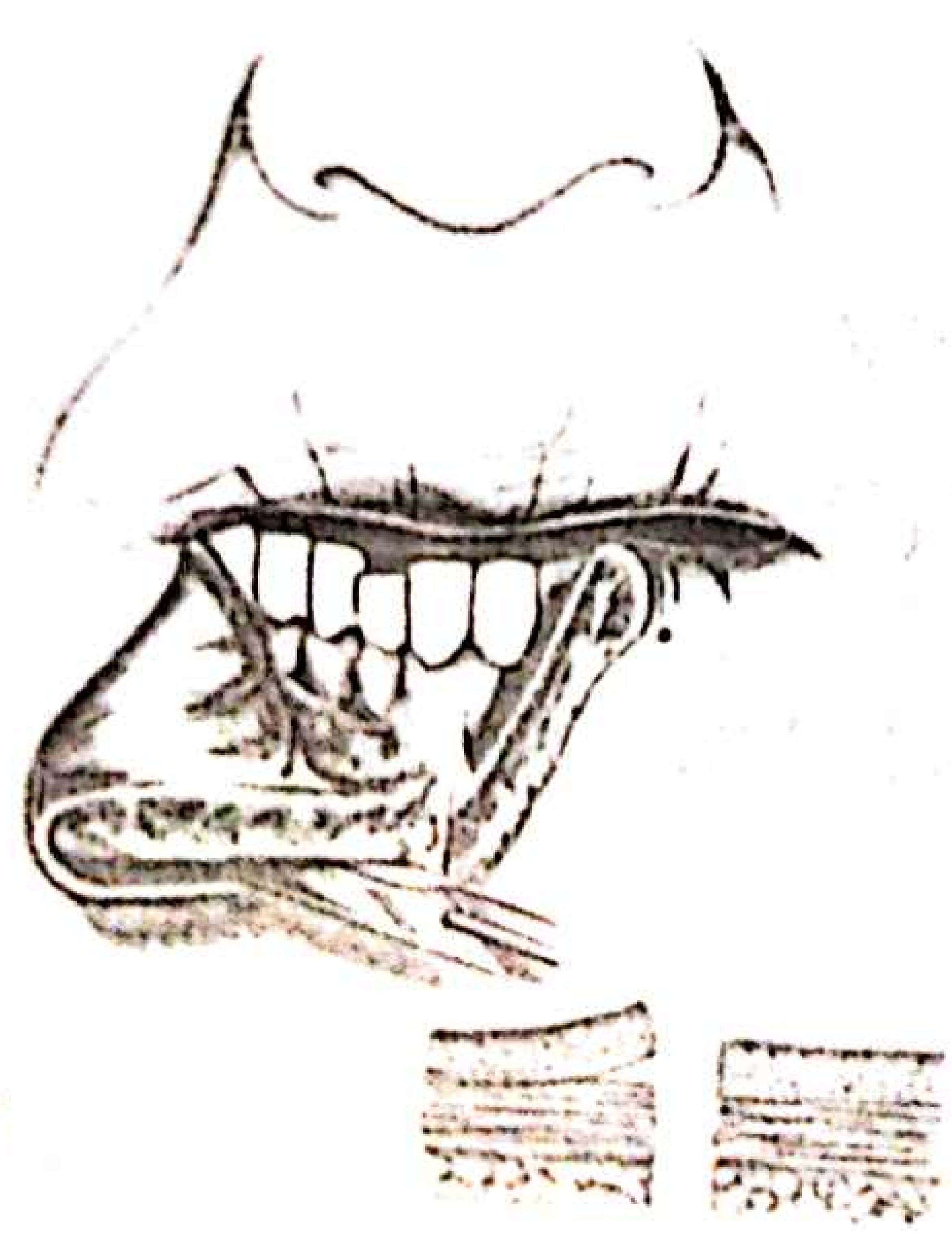


16

V-excision and direct closure

16 & 17

In its basic form this procedure involves the resection of a wedge of the lip and closure of the defect by approximating its two sides. in constructing the V, tattooing of the skin–vermilion junction with Bonney's blue (pigmentum tinctorium BPC) makes for easy matching when the margins are being brought together. The suture techniques used are those which have become standard in closures generally when cut edges of lip are being approximated. The precision of closure can be increased if the skin and muscle layers are clearly defined, and this can be done by mobilizing the skin back from the wound edge for 2–3 mm.

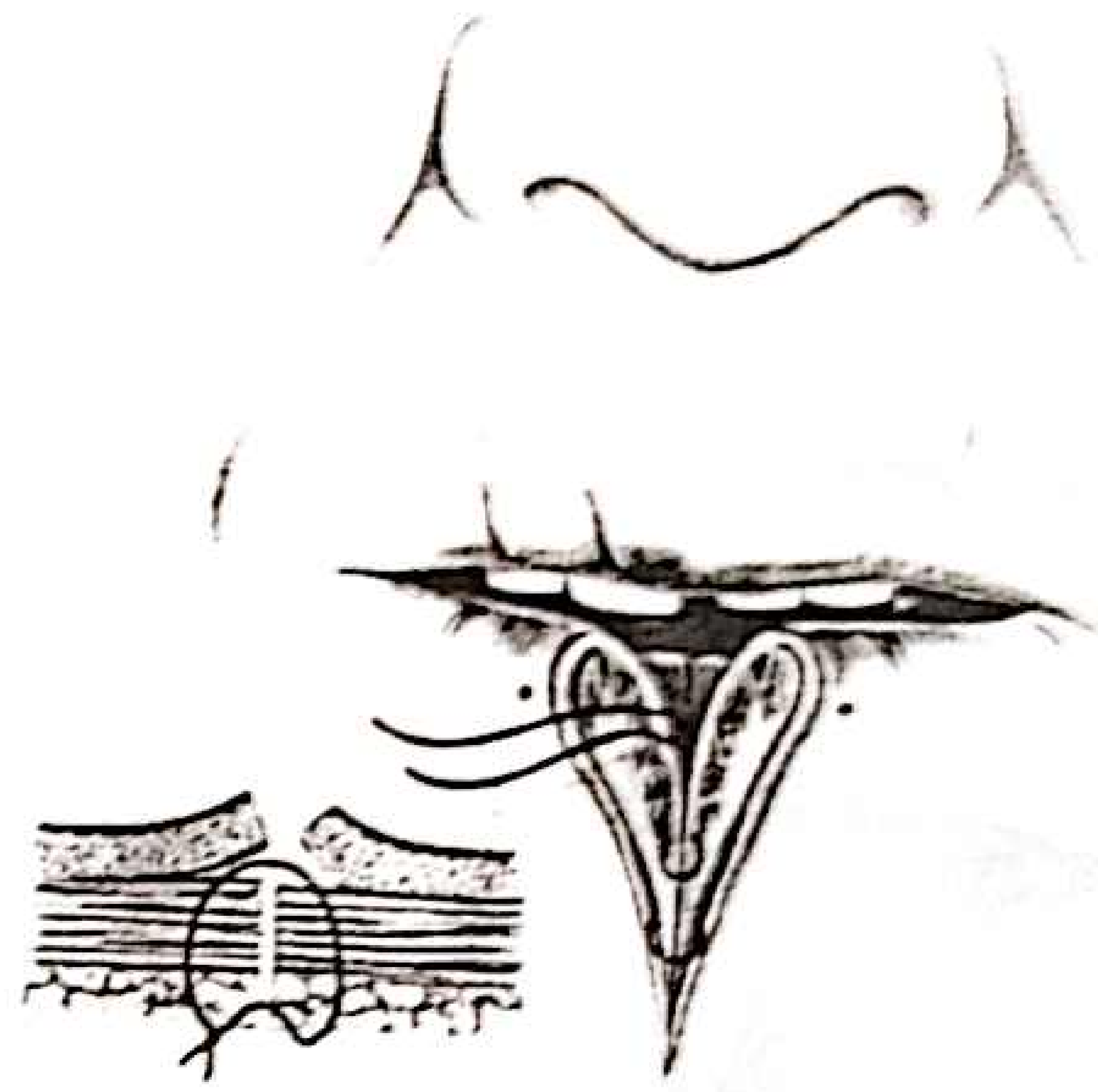


17

18 & 19

The simplest and generally applicable technique uses a two-layer closure. In this the muscle and mucosa are approximated as a single layer using absorbable muco-muscular mattress sutures. These sutures take the strain of closure and they allow the skin to be closed with an absence of tension. The alternative technique makes use of a three-layer closure, mucosa, muscle and skin being sutured independently. There are occasions, even for the surgeon who routinely uses a two-layer closure, to suture the muscle independently. The need arises most obviously during flap reconstructions where suture of the muscle as an independent layer is felt to be necessary to ensure a watertight closure.

The method is appropriate for the carcinoma of the vermilion which can be adequately cleared laterally by such a resection, with the proviso that the distance between the limbs of the V should not exceed one-third of the width of the lip, this being the maximum which the lip can lose without suffering undue tightening. The V can be at any part of the lip and the only design aspect of importance is that the limbs of the V should be equal in length. The length of the V is generally determined by its width. As the V broadens, it has also to lengthen if a dog ear at its apex is to be avoided.



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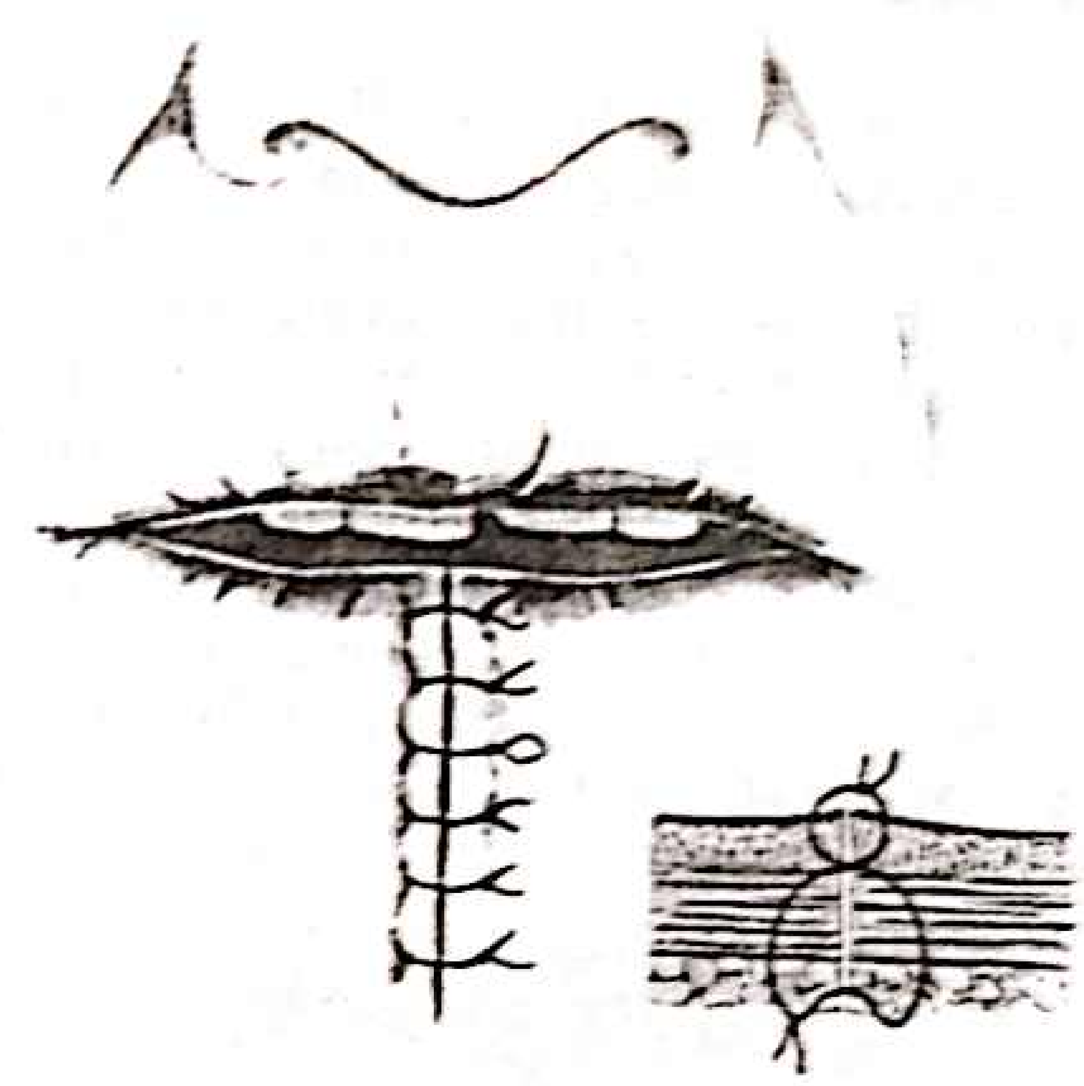

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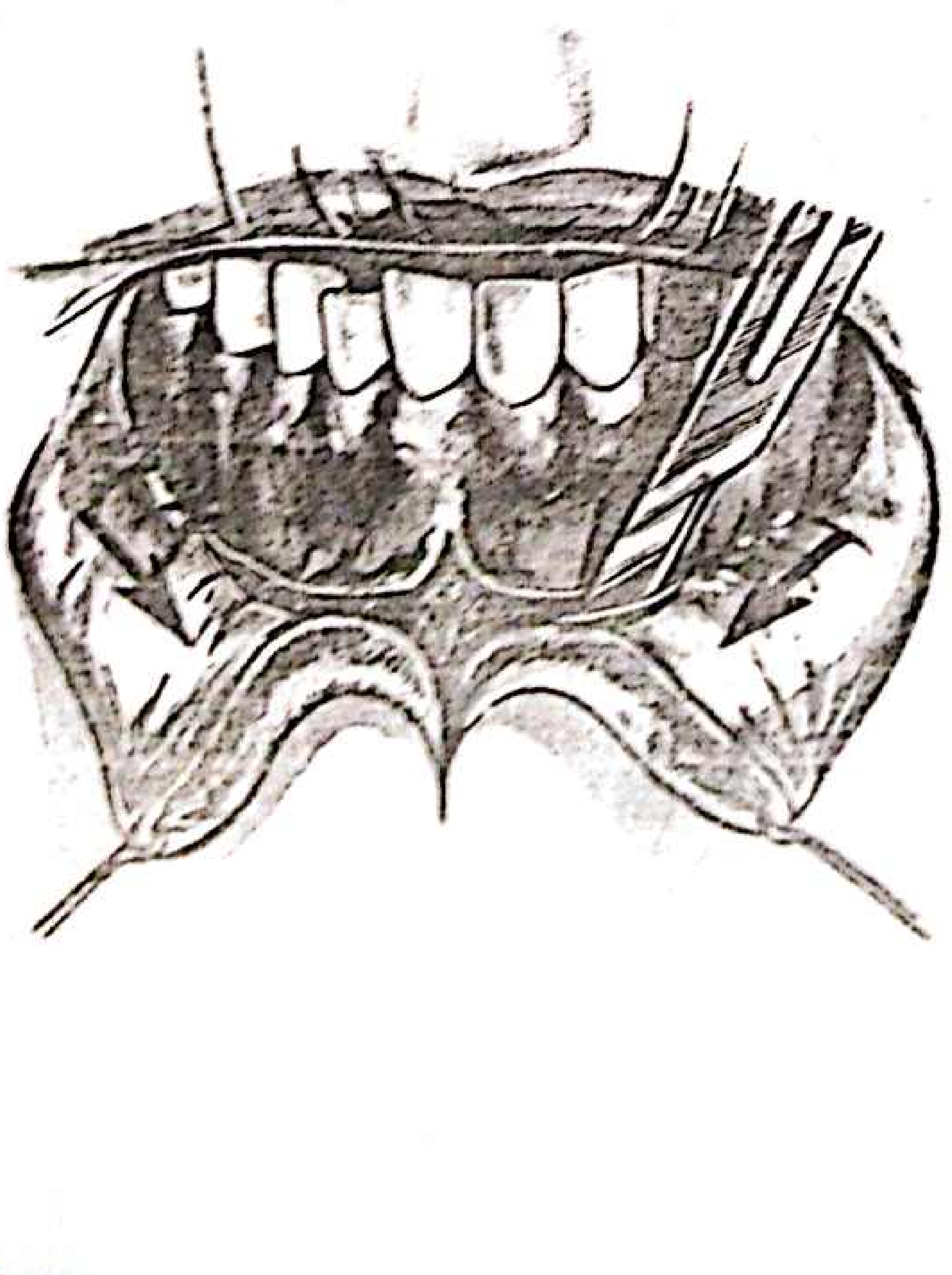


20

V-excision and mobilization of labial sulcus

20

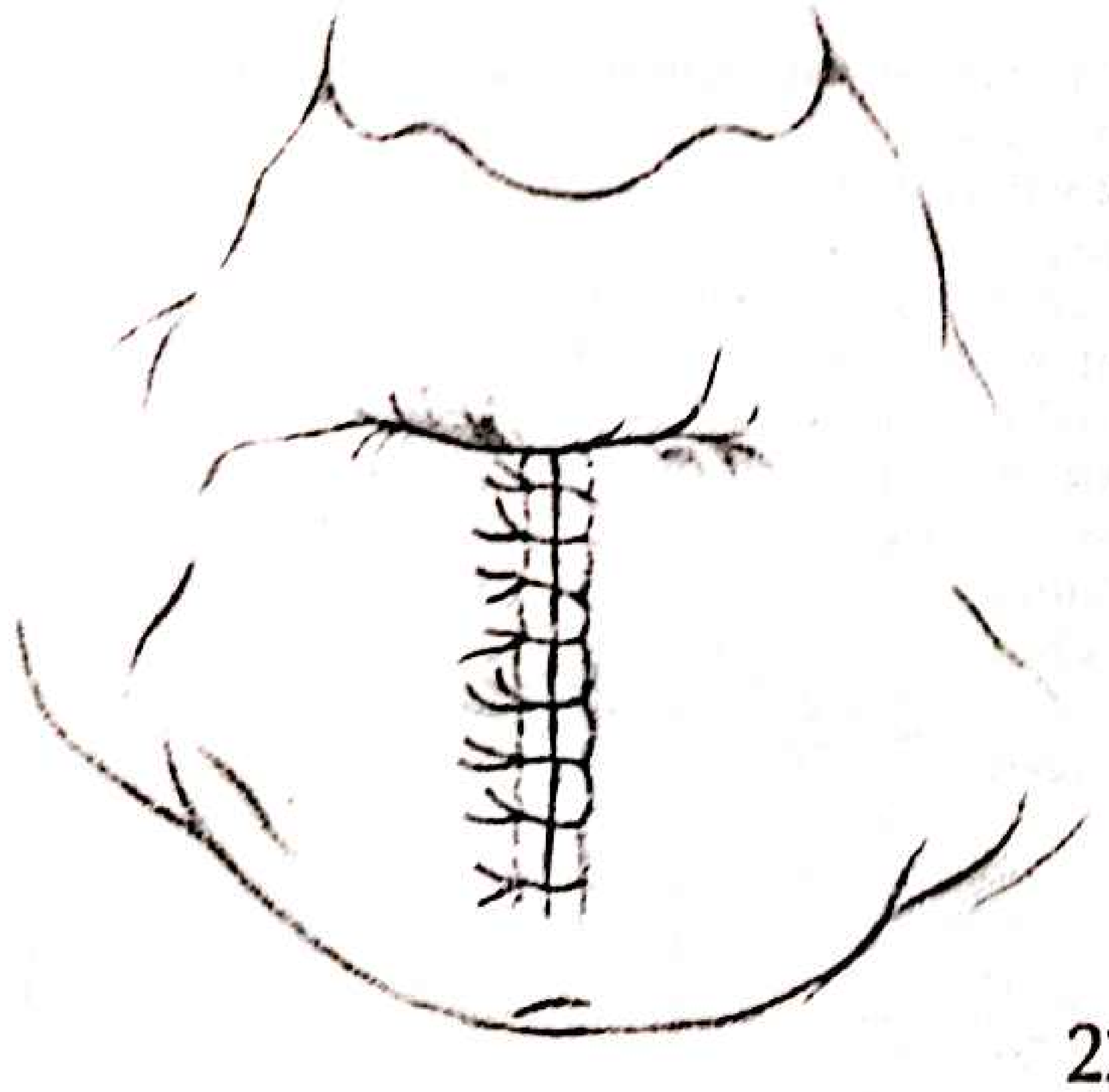
When the apex of the V extends below the lower buccal sulcus, the fixation of the mucoperiosteum to the mandible along the sulcus can prevent the advancement which is required to close the defect. It may then be necessary to make an incision along each lower buccal sulcus so that mobility is restored and closure made possible.

Modified V-excision

21 & 22

A criticism which can be levelled at the standard V-excision is that the wedge of tissue removed begins to narrow in passing downwards and may fail to clear the tumour laterally. This is most likely when there is a significant degree of infiltration into the substance of the lip, and this can be clinically assessed by feeling for deep induration. In such circumstances it may be advisable to make the upper part of the V vertical, passing to the formal V below. The use of a W-excision rather than a V-excision has been described but it has no particular merit and complicates matters without conferring any compensatory advantage.

21

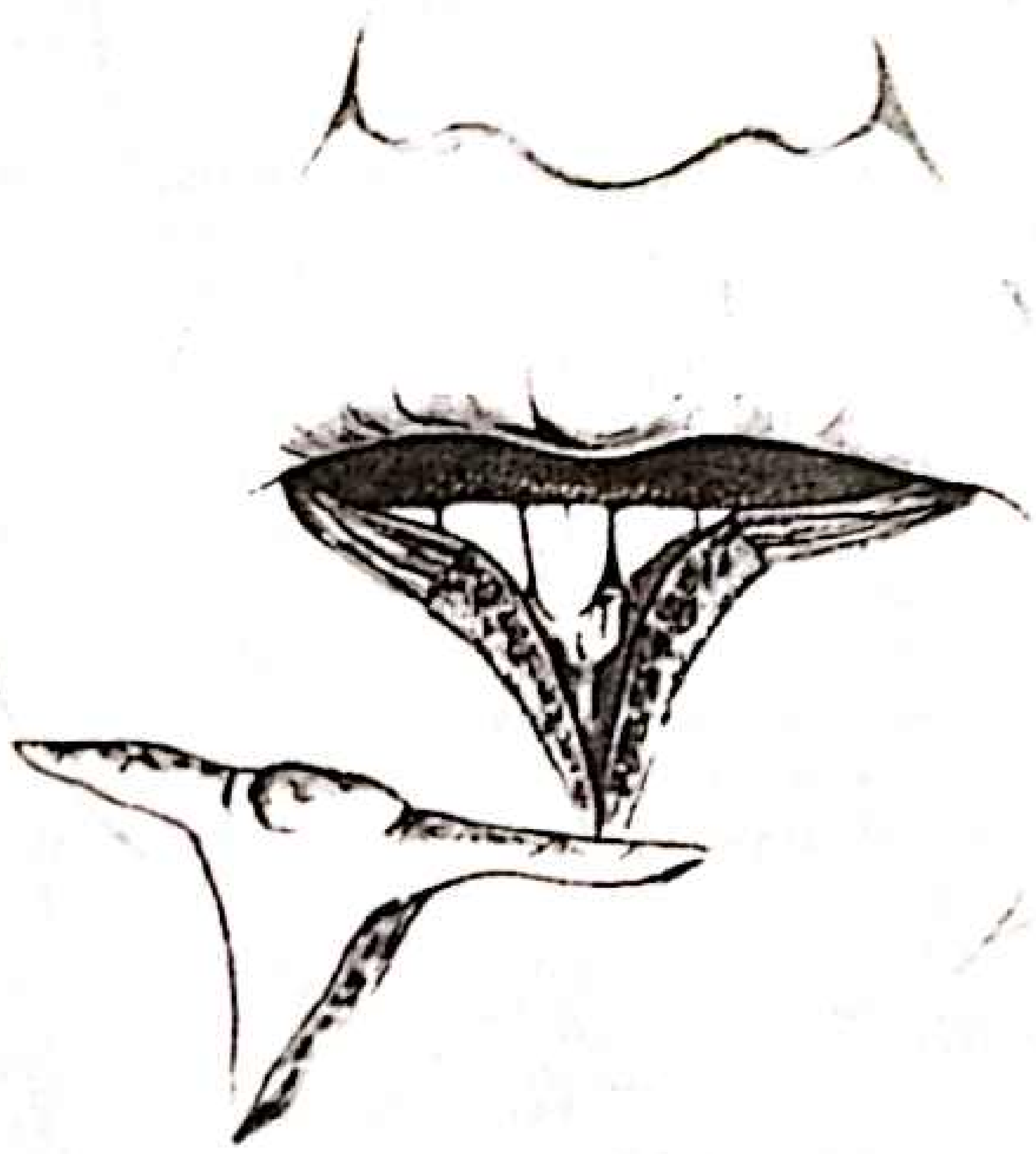


22

V-excision and lip-shave

23 & 24

The place of V-excision is in the lower lip carcinoma where the adjoining red margin is clinically normal. If the adjoining vermilion is showing signs of premalignant change, the question of prophylactic stripping arises. If this is considered necessary, it can be carried out as part of a single combined procedure, V-excision and lip-shave. The defect which results from such an excision is managed by closing the V-defect directly, as in the V-excision and direct suture. The vermilion defect which is left can then be managed either by mucosal advancement or by using a tongue flap. The tongue flap gives a better final result as a rule, although its use does involve a two-stage procedure. Mucosal advancement involves the approximation of four points, two mucosal and two of skin, and it is general experience that a notch often results at the point of approximation. If, despite this, the decision is made to use the mucosal advancement method, it is essential to advance the mucosa *before* closing the V since the mucomuscular mattress sutures used to close the V have the effect of fixing the mucosa along the margins of the V in its non-advanced position, making subsequent attempts to advance it nearly impossible. The considerable virtue of the tongue flap used in this situation is that it resurfaces the lip from angle to angle and in the process bridges the closed V.



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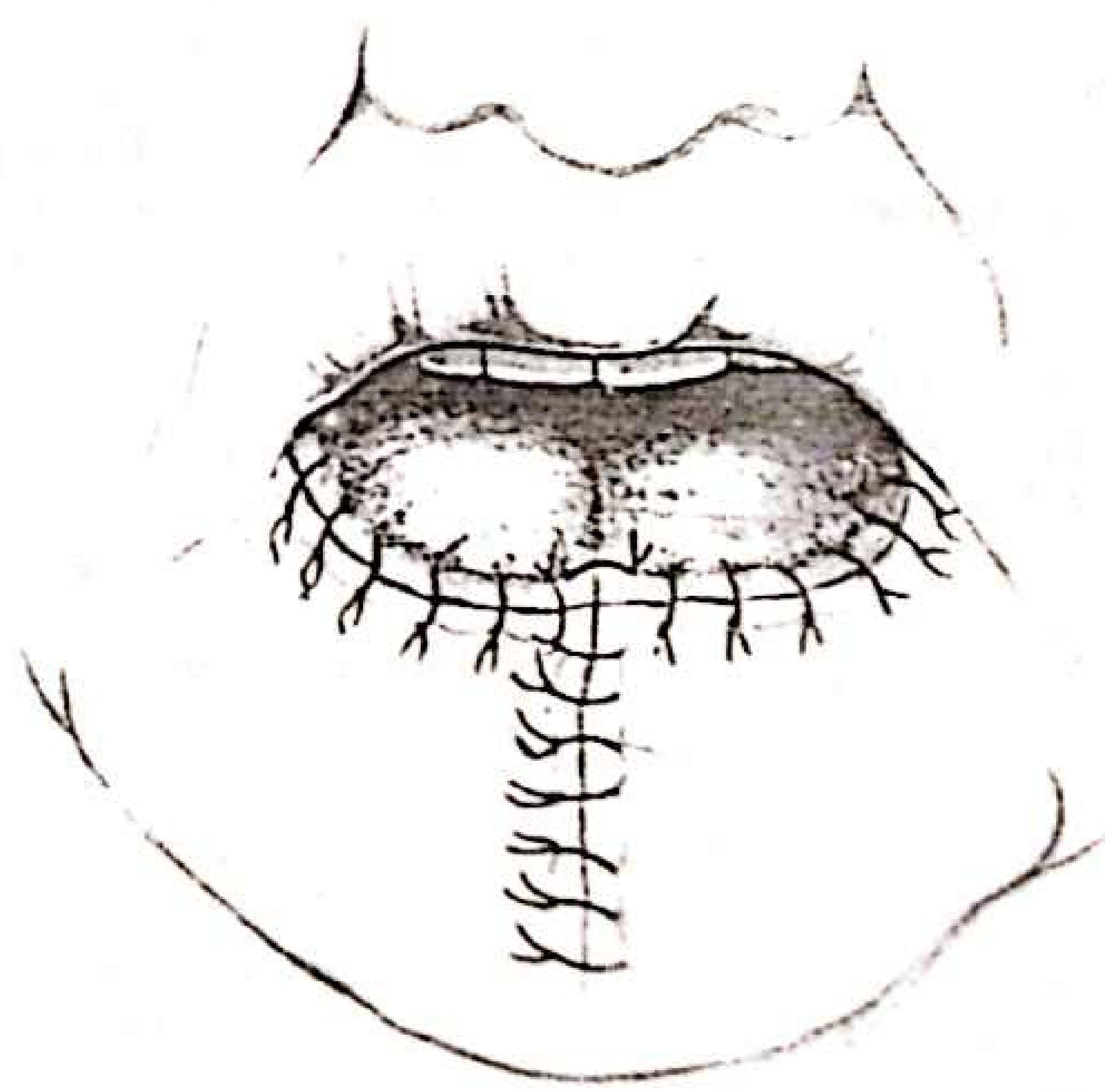


24

Excision and reconstruction

Any defect of the lower lip which involves more than one third of its width requires a formal reconstruction. The reconstructions in common use require the creation of a geometrical shape, either a rectangle or a V. The shape appropriate to the reconstruction selected is created at the outset of the procedure beyond the excision limits necessary to clear the tumour.

The most effective reconstructions make use of the fan flap principle. In this the defect is made in the form of a rectangle, the reconstructing flap being outlined on the cheek lateral to the angle of the mouth and rotated into the defect. Depending on the site of the defect and its breadth, a single flap may be adequate; alternatively two flaps are required, one on each side. The technique makes use of the nasolabial area of tissue availability to allow the successful transfer of the flap into the lip defect, and it is essential in making a clinical assessment at the outset to take account of whether or not such availability exists. Fortunately in the average adult face adequate tissue is available.

Classic fan flap

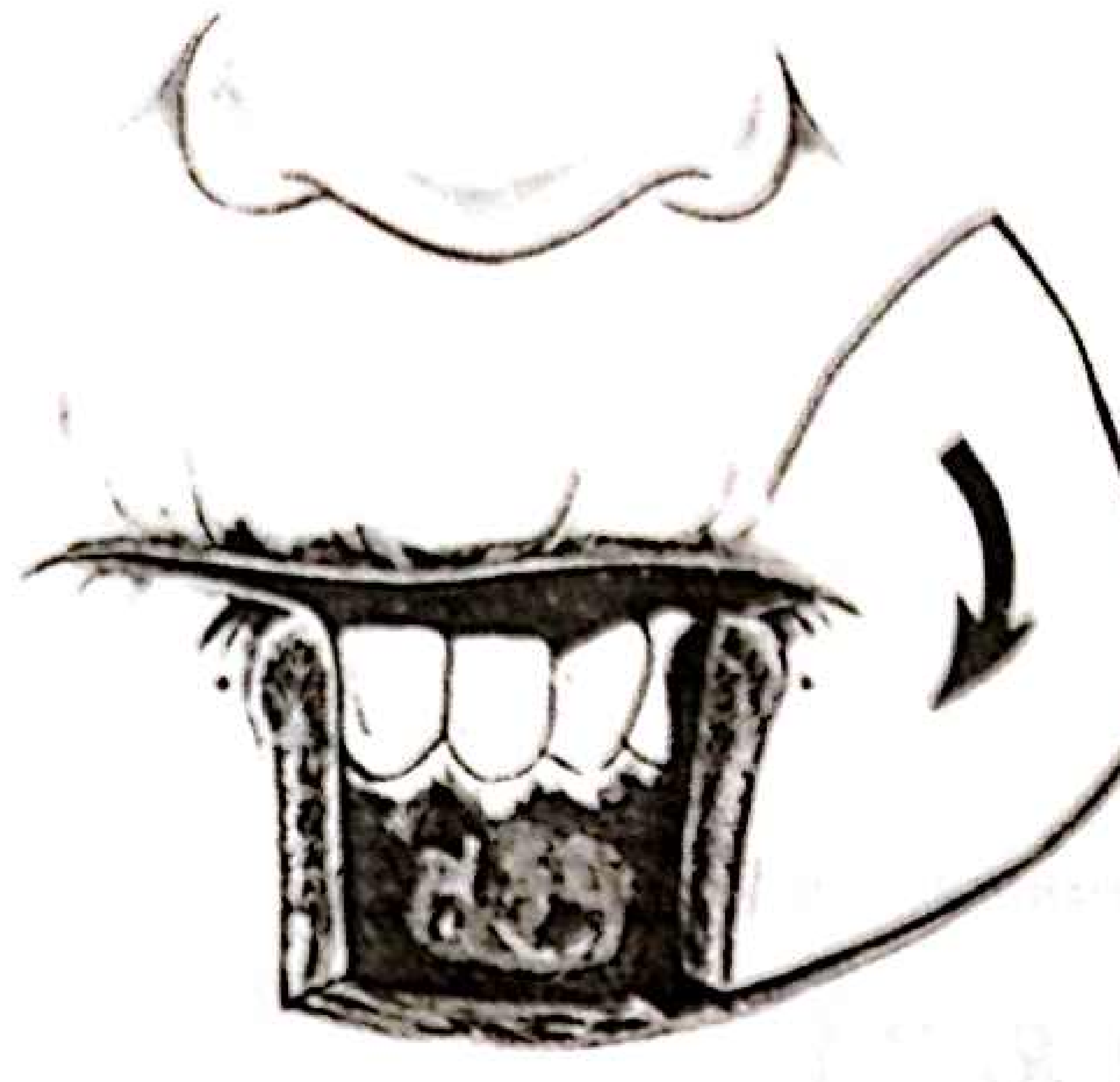
25, 26 & 27

The flap involves the full thickness of the cheek and is constructed on one side of the rectangular defect of the lip. It is transferred by being 'rolled round' to meet the opposite resection margin and so close the lip defect.

The outline of the flap approximates to the arc of a circle with a radius equal to the depth of the lip defect and with its centre at the angle of the mouth. The line of the flap is continued round to the line of the nasolabial fold. A back-cut is then made towards the vermilion, stopping a little short of it in order to leave a pedicle which contains the superior labial vessels. The flap thus raised includes the full thickness of the cheek and it is rotated round the angle of the mouth, moving the angle with it in the process, and sutured to the opposite side of the defect.

In its rotated position the flap is sutured to the surrounding cheek in order to restore the integrity of the oral sphincter. The inequality in the length of the two sides of the defect along the margin of the flap, which is equal to the width of the lip defect, is managed to some extent by suturing the defect under differential tension, by closing the nasolabial defect directly and, if necessary, by incorporating a Z-plasty at a suitable point around the margin of the flap.

In this technique no new vermilion is created and as a result there is a reduction in the width of the mouth, angle to angle. This means that the technique becomes increasingly unsatisfactory as a reconstruction as the width of the lip defect increases. It is best reserved for defects between one-half and two-thirds of the width of the lip. Attempts to open the new angle subsequently and so increase the width of the lip have been described, but they are not satisfactory, the segment which is opened up tending to gape. It is also less effective when one margin of the defect extends to the angle of the mouth and is better reserved for defects of the central area where vermilion is available on both sides of the defect.



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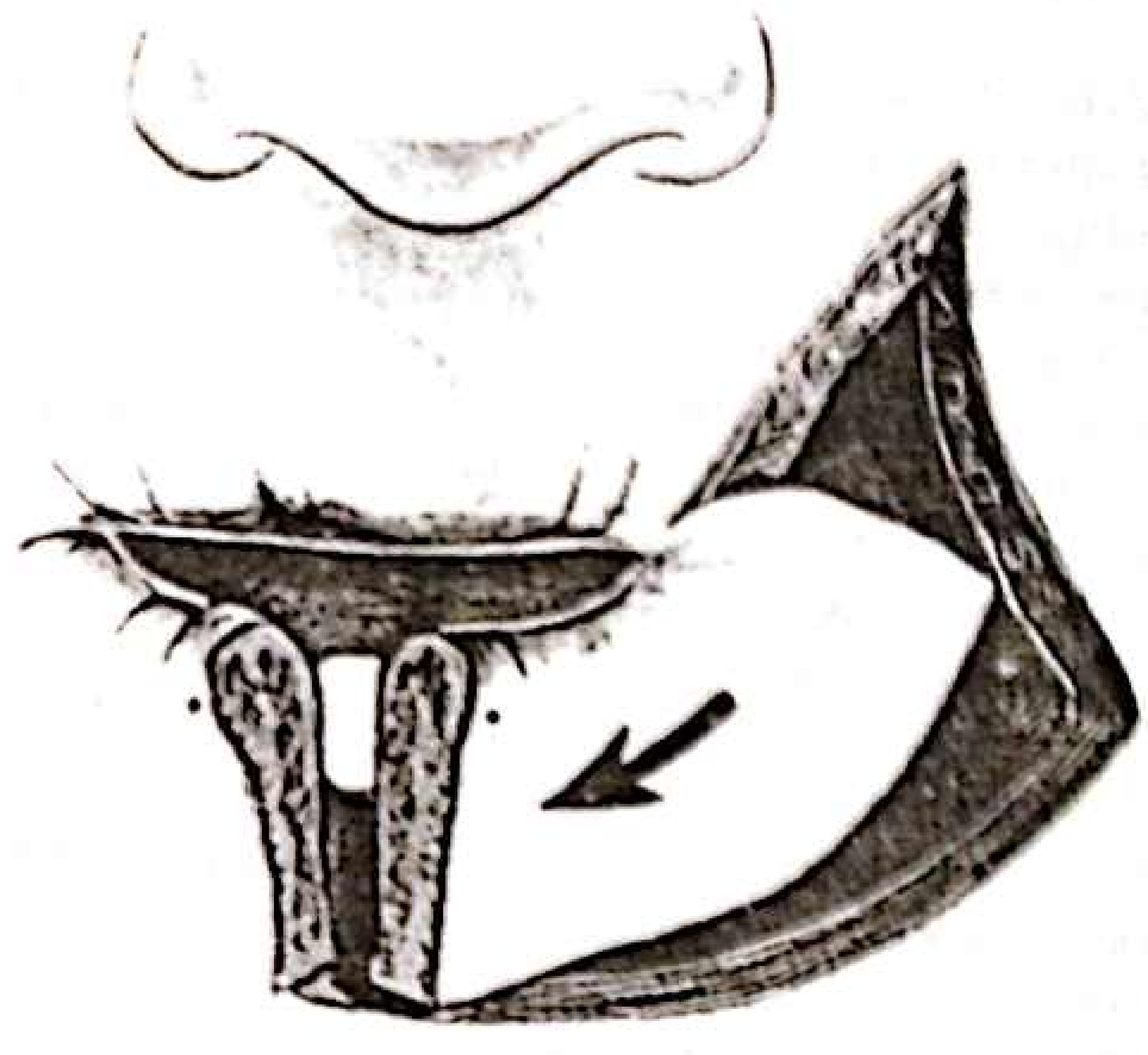

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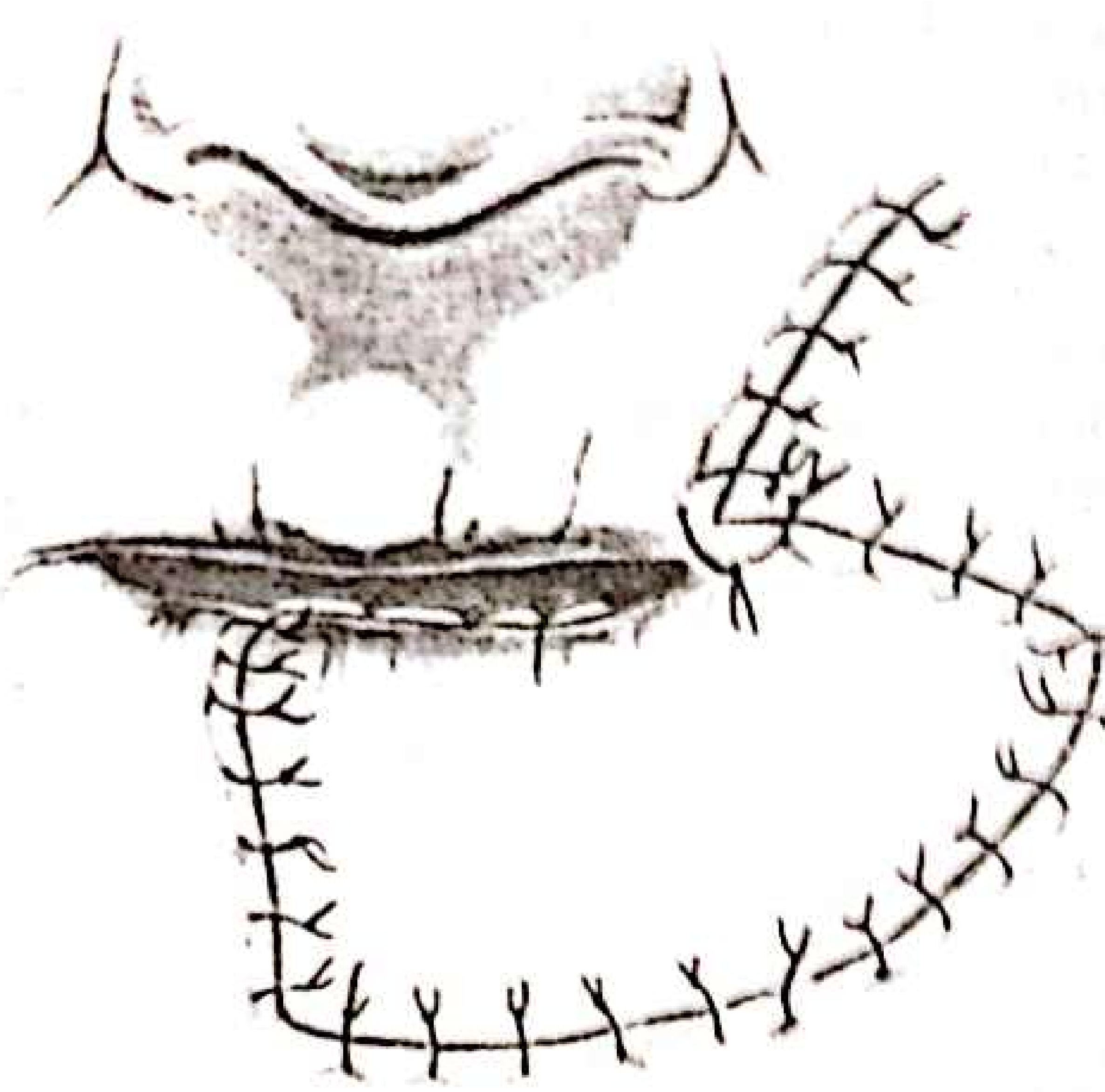


27

The flap is denervated, both motor and sensory, and this is regarded by some as a serious disadvantage of the method. In practice the muscle in the remaining segment of the lip provides adequate function, and both functions, motor and sensory, do recover slowly as a rule. A further unsatisfactory aspect is that the method cannot readily be combined with a lip-shave.

Two modified versions of the flap, each embodying the fan flap principle, have been devised, each of which eliminates one of the deficiencies of the classic version.

Neurovascular fan flap

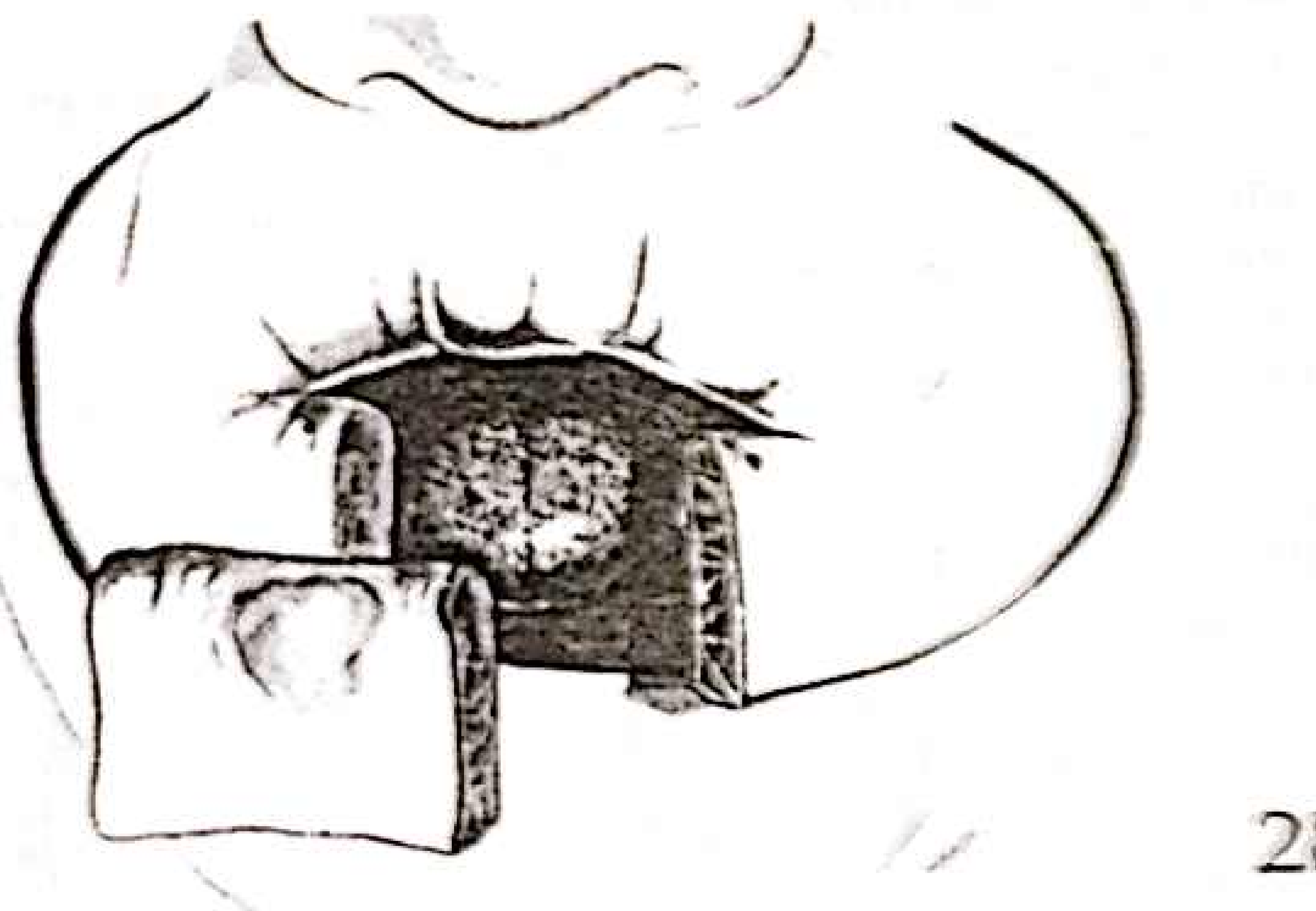
In this modification of the classic fan flap, the blood vessels and nerves, motor and sensory, which reach the flap from the adjoining cheek are maintained as far as possible intact, so that at the end of the procedure the reconstructed lip retains the greater part of its normal function in terms of movement and sensation. Maintaining these structures reduces the amount of rotation which the flap can tolerate and therefore the amount of advancement to close the defect. In order to achieve the necessary advancement it is usual to design two flaps, one on each side of the defect, each rotating and advancing to close its own half of the lip defect as the two meet in the midline.

28, 29 & 30

The defect is made in the form of a rectangle, usually extending down to the lower buccal sulcus. From each side of the defect an approximately circular skin incision is made, centred on the angle of the mouth, round on the cheek as far as the alar base. The incisions are then deepened, in the process dividing the fibres of the muscles which radiate outwards from the orbicularis oris sphincter. During division of the muscle fibres the blood vessels and nerves which cross the incision are watched for and as far as possible individually preserved. The muscle fibres are completely divided except for some fibres of buccinator. It has been found that preservation of buccinator fibres retains the overall slit-like shape of the mouth while total division tends to give rise to a round mouth.

Distinguishing between muscle to be divided and vessels and nerves to be preserved is not always easy, but it helps if the skin edges are forcibly retracted, putting the muscle fibres on the stretch. At the touch of the scalpel they divide while at the same time the mobility of the vessels and nerves allows them to move with the scalpel and escape division. Division is continued until the minor salivary glands which lie between the muscle and the mucosa are exposed. These are left intact, as is the mucous membrane except towards the margin of each flap as it abuts on the lip defect. There the mucous membrane is divided back for 1.0–1.5 cm to allow the flaps on each side to be advanced to the midline. The flaps are advanced towards the midline and sutured together in layers. In the remainder of the incision the skin alone is closed, no attempt being made to suture muscle. With the flaps advanced the two margins of the skin incision are of course unequal in length by approximately half of the width of the original lip defect. If the use of the method has been well judged, the discrepancy is not great and closure is generally possible by using differential tension on the two sides. When the technique has been pushed beyond its wise limit and the advancement required cannot be accommodated by the use of differential tension alone, a 'dog-ear' is liable to develop if the skin is closed. Its correction should be designed to leave the scar which results in the best cosmetic line.

The method is extremely effective and has largely replaced the classic fan flap, since the indications for its use are virtually the same as those for the classic version.



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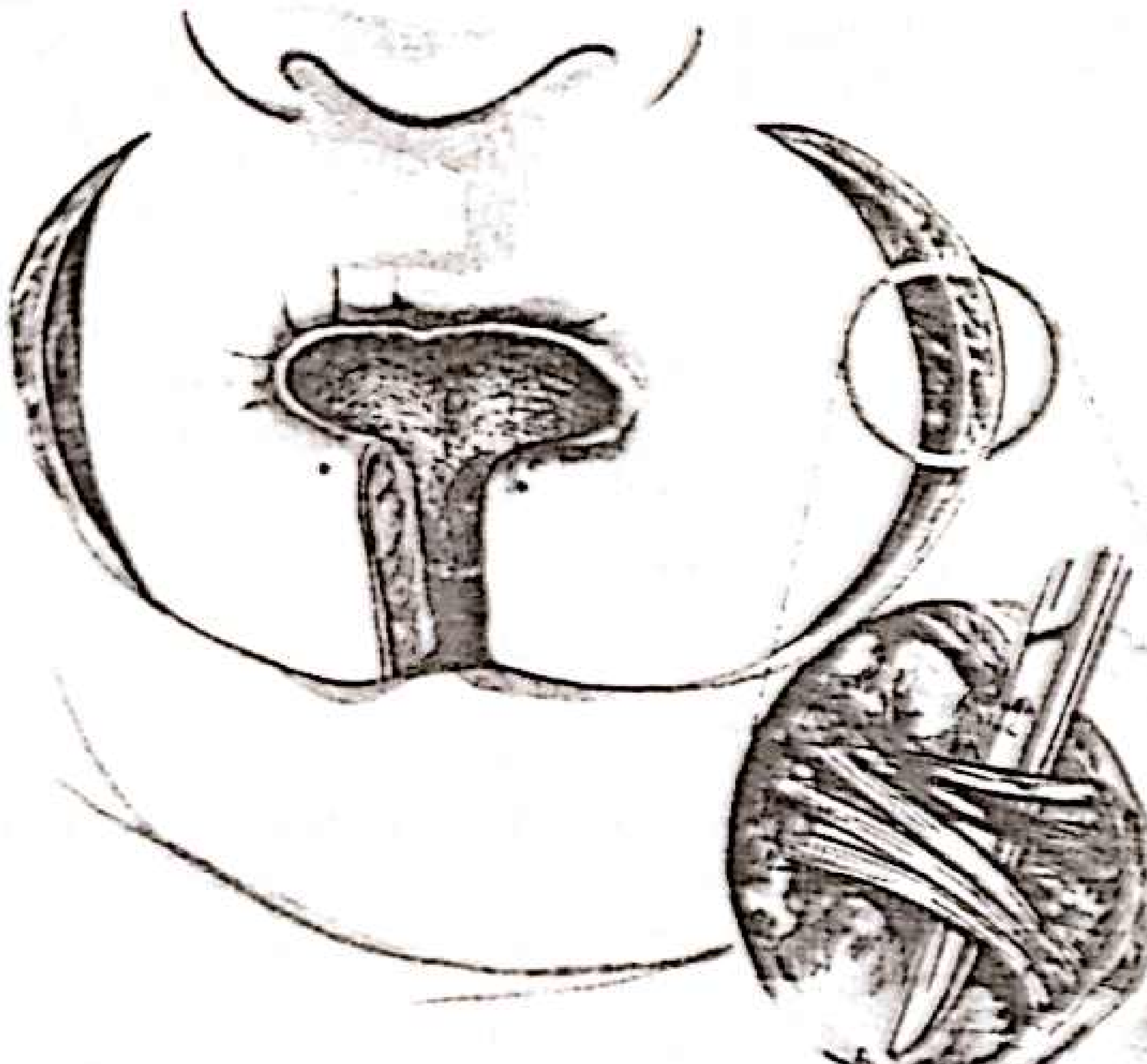

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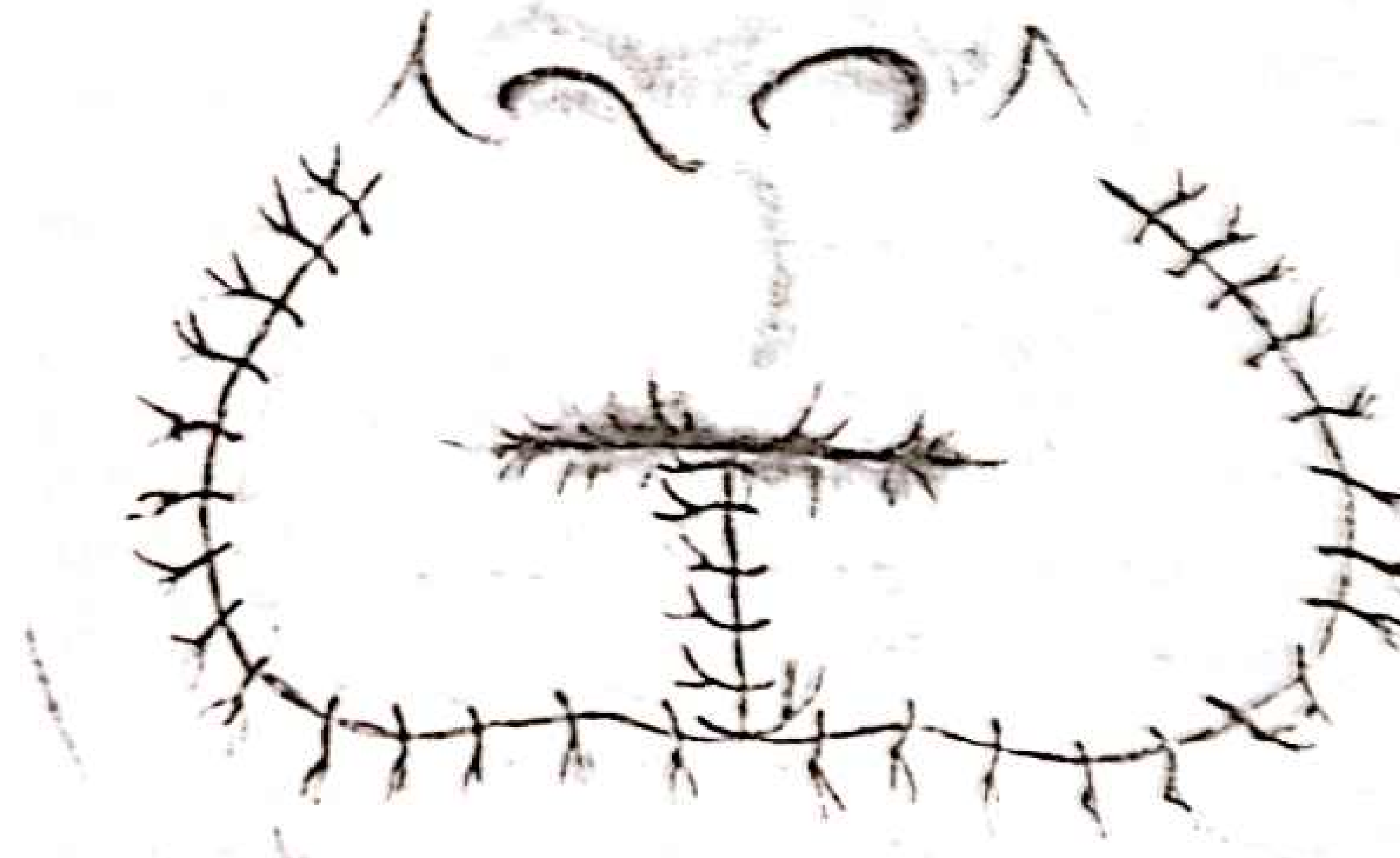


30

It is easiest technically when the defect does not extend to the angle. Like the classic fan flap it does not create fresh vermilion and the lip is reduced in circumference by half of the width of the original rectangular defect. It is this which limits it in its effective usage to defects of up to two-thirds of the lip. A further limiting factor is that it does not readily combine with a lip-shave and because of this it is probably best confined to patients where a lip-shave is not required simultaneously. One of its more dramatic virtues is the speed of rehabilitation of the patient. Excellent function is present virtually from recovery from the anaesthetic. The scars, which might be regarded as not optimally placed in terms of lines of election, nevertheless settle quickly and the cosmetic result is usually excellent.

Modified fan flap

A further modification of the classic fan flap can be used for the defect which extends to one angle of the mouth and involves approximately half of its width. The flap as outlined on the cheek is in many ways similar to the classic fan flap, but instead of being 'rolled round' into the defect, taking the angle of the mouth with it, it is rotated into the lip defect around the angle of the mouth, the latter staying in its original position. The effect is to retain the original width of the lip, but the reconstructed segment lacks a vermilion border and this has to be reconstructed, either by mucosal advancement or by a tongue flap.

31

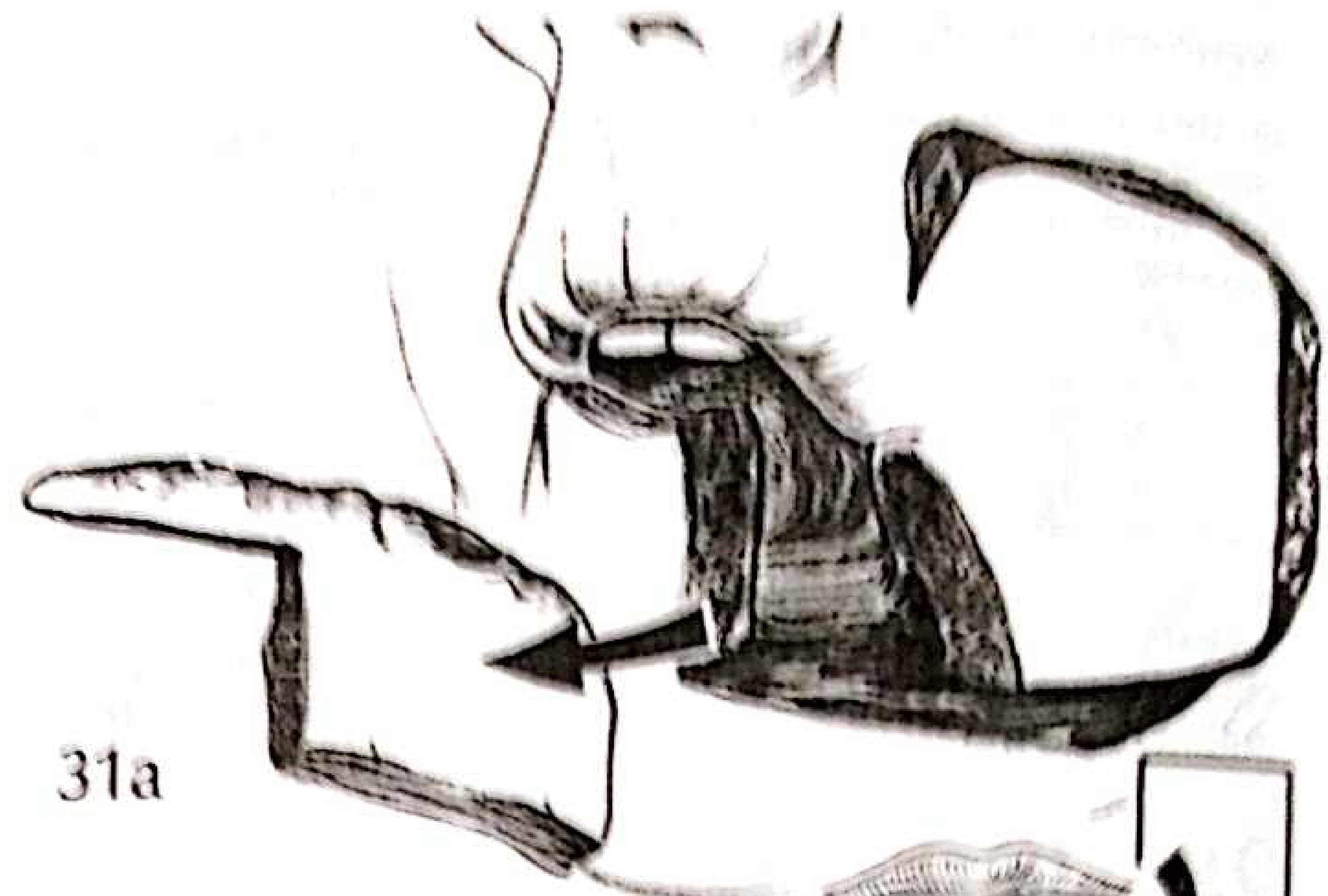
The lip defect approximates to a square and the full thickness flap which is raised on the cheek has the general shape of a vertical rectangle whose width is equal to that of the lip defect and twice its length. The rationale of the method can be more readily understood if one thinks of the rectangle as being two adjoining squares, one above the other (see *Illustration 31b*), with a small pedicle at the angle of the mouth, similar to that of the classic flap in containing the superior labial vessels.

32–33

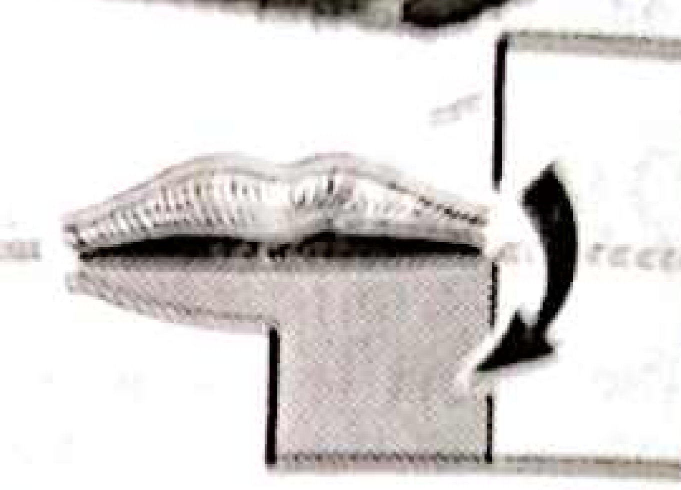
When the flap is rotated into the defect, the rectangle comes to lie horizontally, its lower half filling the original defect and its upper half filling the previous position of the lower half of the flap (see *Illustration 32b*). The effect is to transfer the square defect from the lower lip to the nasolabial area. The nasolabial defect is closed by approximating its upper outer angle downwards and medially towards the angle of the mouth, making use of the nasolabial area of availability to allow the closure (see *Illustration 33b*).

In order to allow the principle of the flap to be more readily understood it has been described in terms of squares and rectangles, but in practice it is possible to round off the angles to curves, making rotation more of a reality. Rounding off the angles has the additional virtue of reducing the amount of advancement required to close the secondary nasolabial defect. The defect and the flap can be further tailored to take account of the curve of the chin prominence.

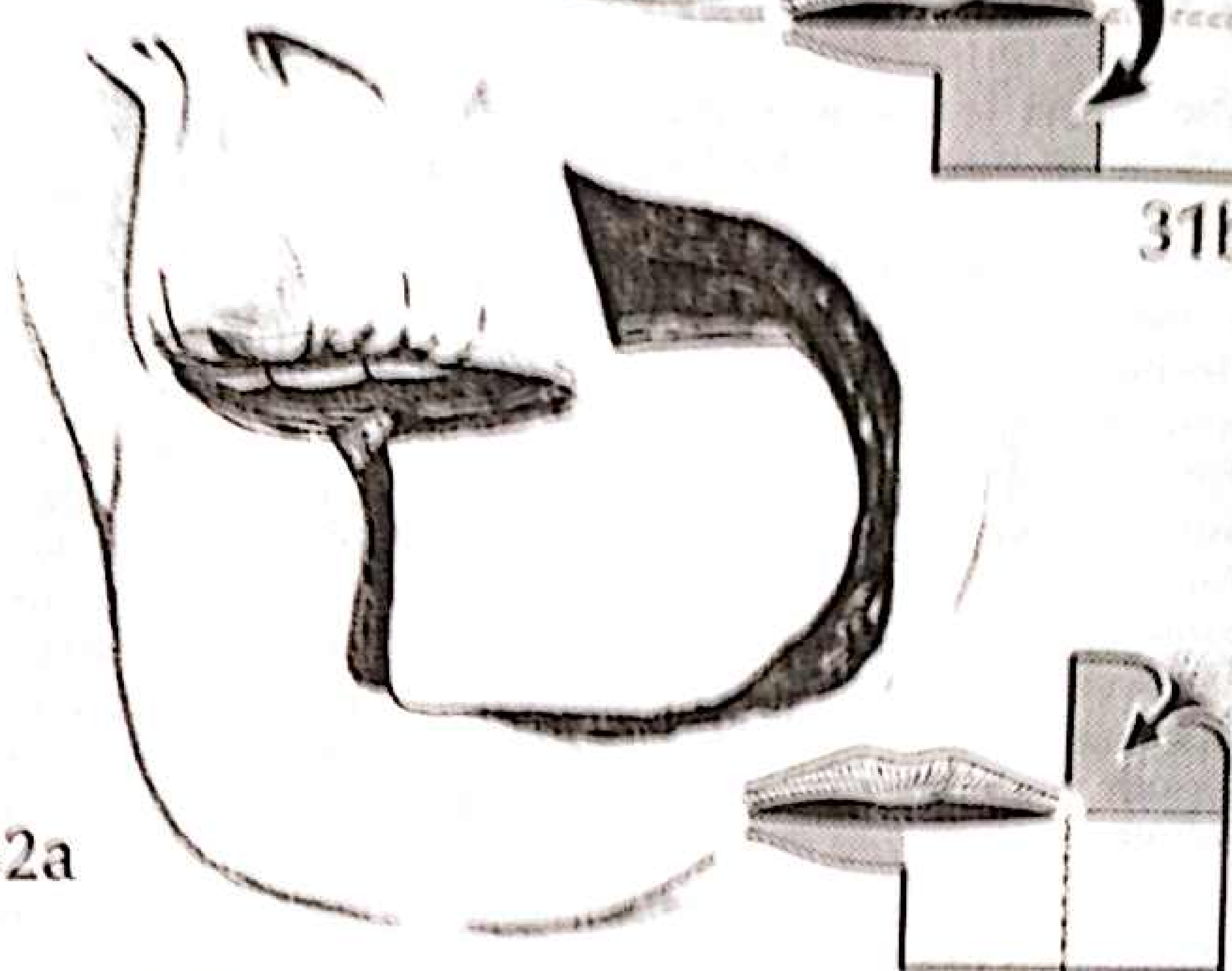
As already pointed out, the flap in its transferred position lacks a red margin. If it is decided to use mucosa to resurface the lip margin, the appropriate margin of the flap should be sculptured to the curve of the vermilion and a fringe of mucosa left to cover it. It is not likely that such sculpturing of the margin and the leaving of a mucosal fringe would contravene the pathological requirements of resection. The generally preferable alternative, however, is to use a tongue flap to resurface the lip margin. One of the virtues of this modifed version of the fan flap is that it can be combined with a lip-shave of the remaining vermilion if this is showing premalignant change, and the combined defect can be handled very effectively by resurfacing the reconstructing flap and the defect left by resecting the vermilion of the remaining lip with the tongue flap.



31a

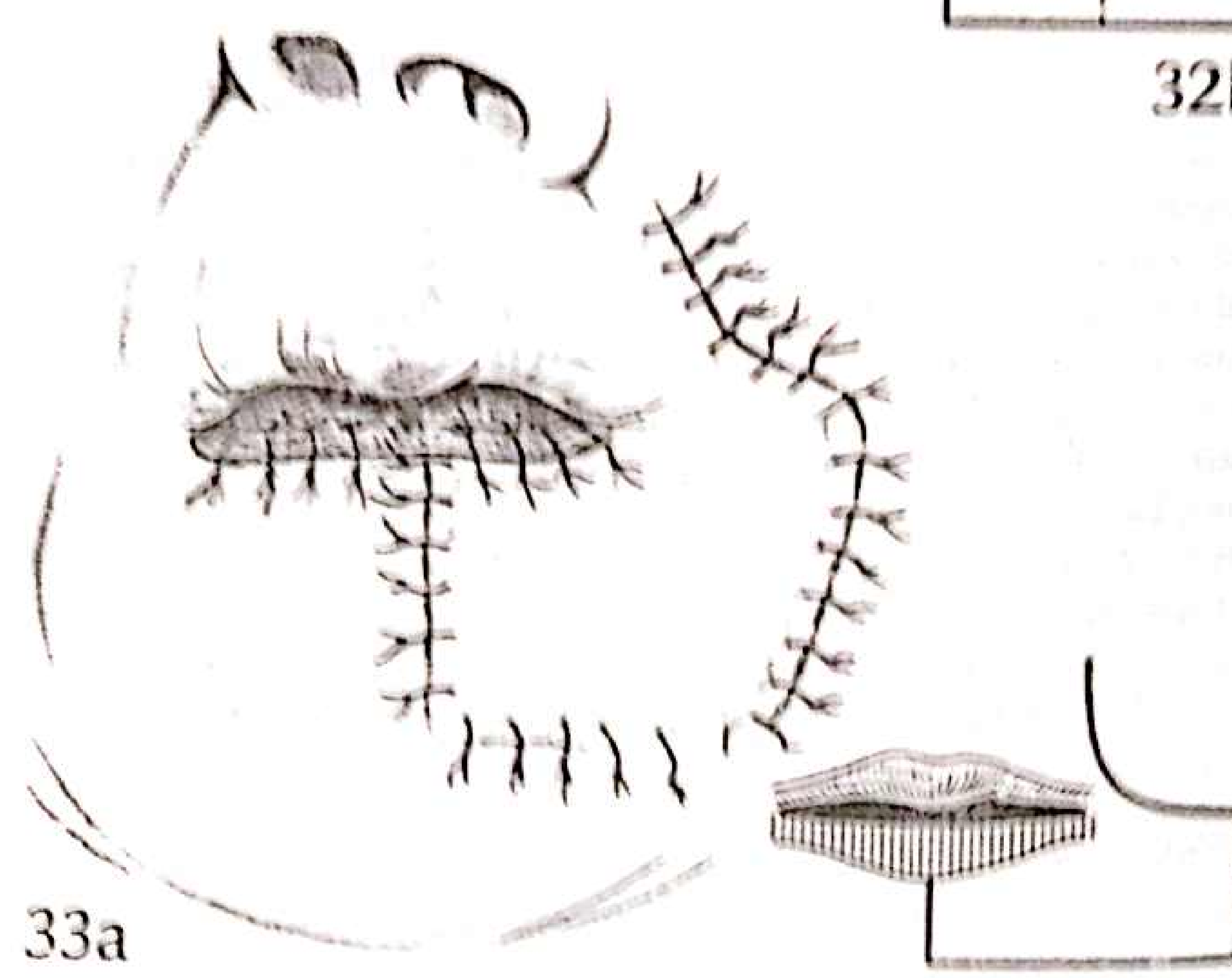


31b



32a

32b



33a

33b

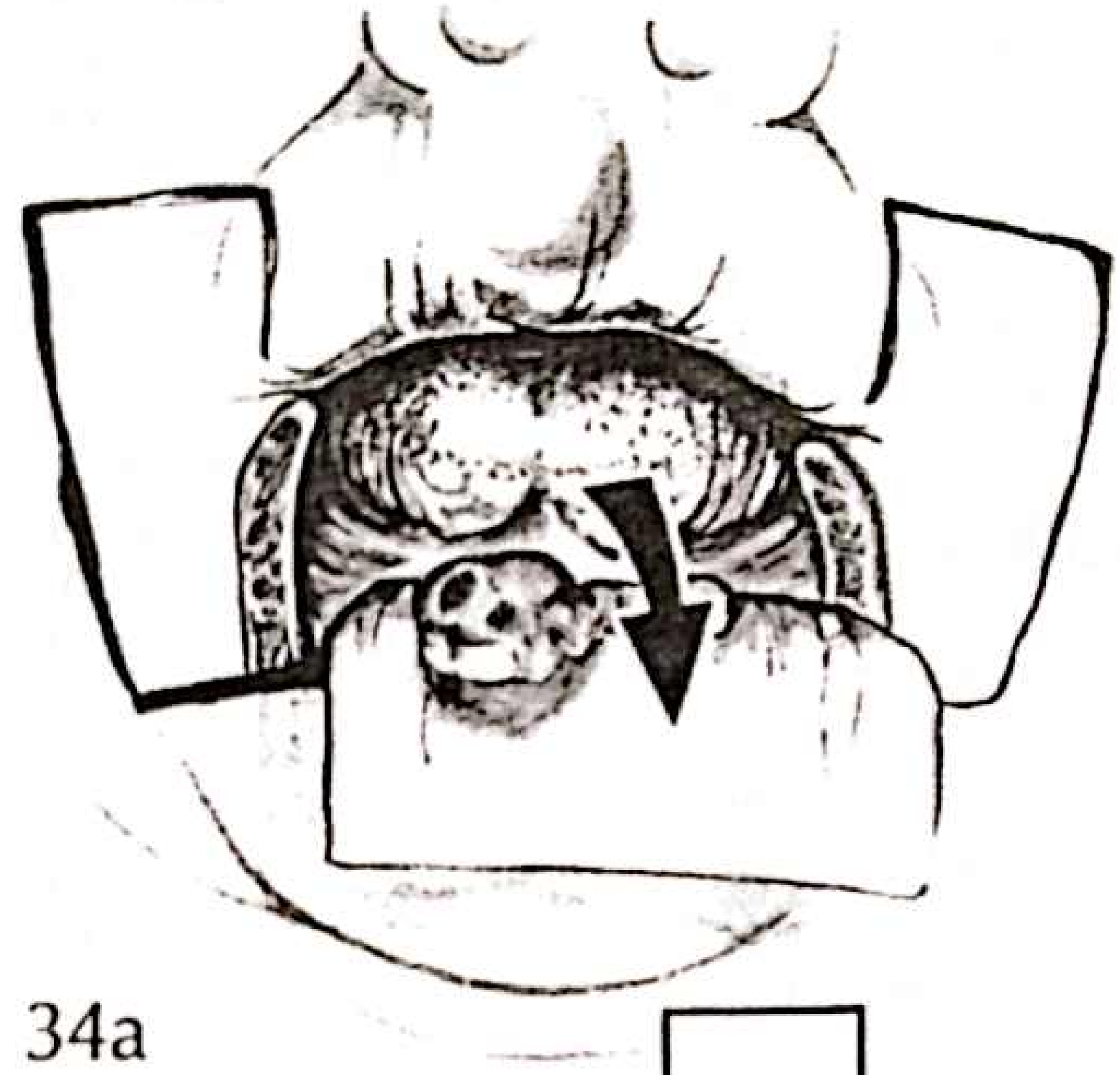
The method shares the disadvantage of the classic fan flap of denervating the reconstructing flap although, as with the classic version, both motor and sensory functions usually recover. The number of occasions on which it is used might well depend on how often a lip shave of the remaining vermilion is felt to be necessary and whether or not the defect extends to the angle, reconstruction of this particular combined defect being one where the alternatives are less effective.

Bilateral fan flap

34–36

The modified fan flap has the virtue of being able to be duplicated on each side when the entire lip requires resection. As shown diagrammatically in *Illustrations 34b, and 36b*, the defect can be regarded as having two squares side by side, each reconstructed with a fan flap, the two meeting in the midline. Although in theory mucosa can be advanced from each flap to resurface the red margin, the surface produced is not good, a notch usually being produced in the centre of the lip where the two flaps meet. A much better result is achieved if the entire margin, angle to angle, is resurfaced using a tongue flap. As with the single flap, motor and sensory recovery in the flap takes place slowly.

In comparing these methods, the neurovascular fan flap is the one recommended for the lesion whose resection does not reach the angle of the mouth and where the defect is not greater than two-thirds of the lip. The modified fan flap is best reserved for the lesion extending to the angle, particularly if a lip-shave is required simultaneously, or used in a bilateral form for total lip resection–reconstruction.



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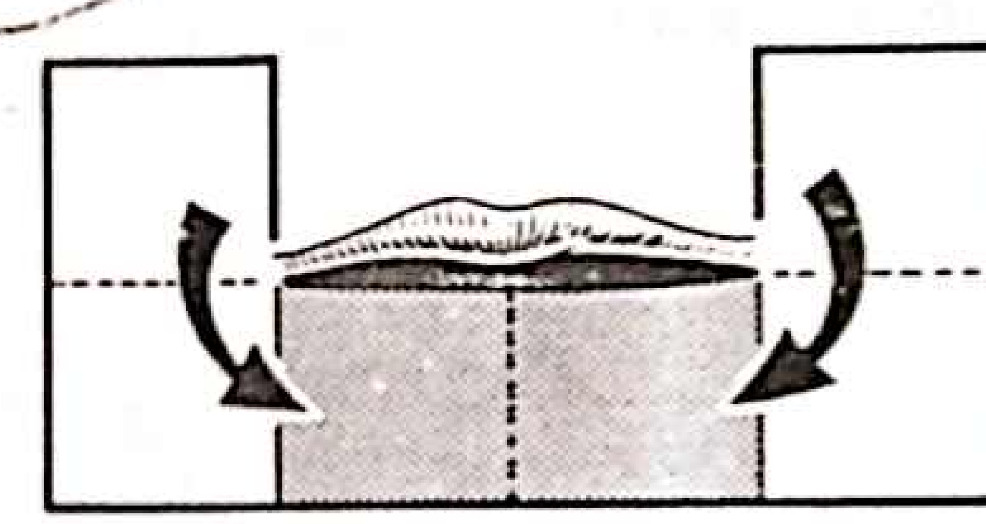

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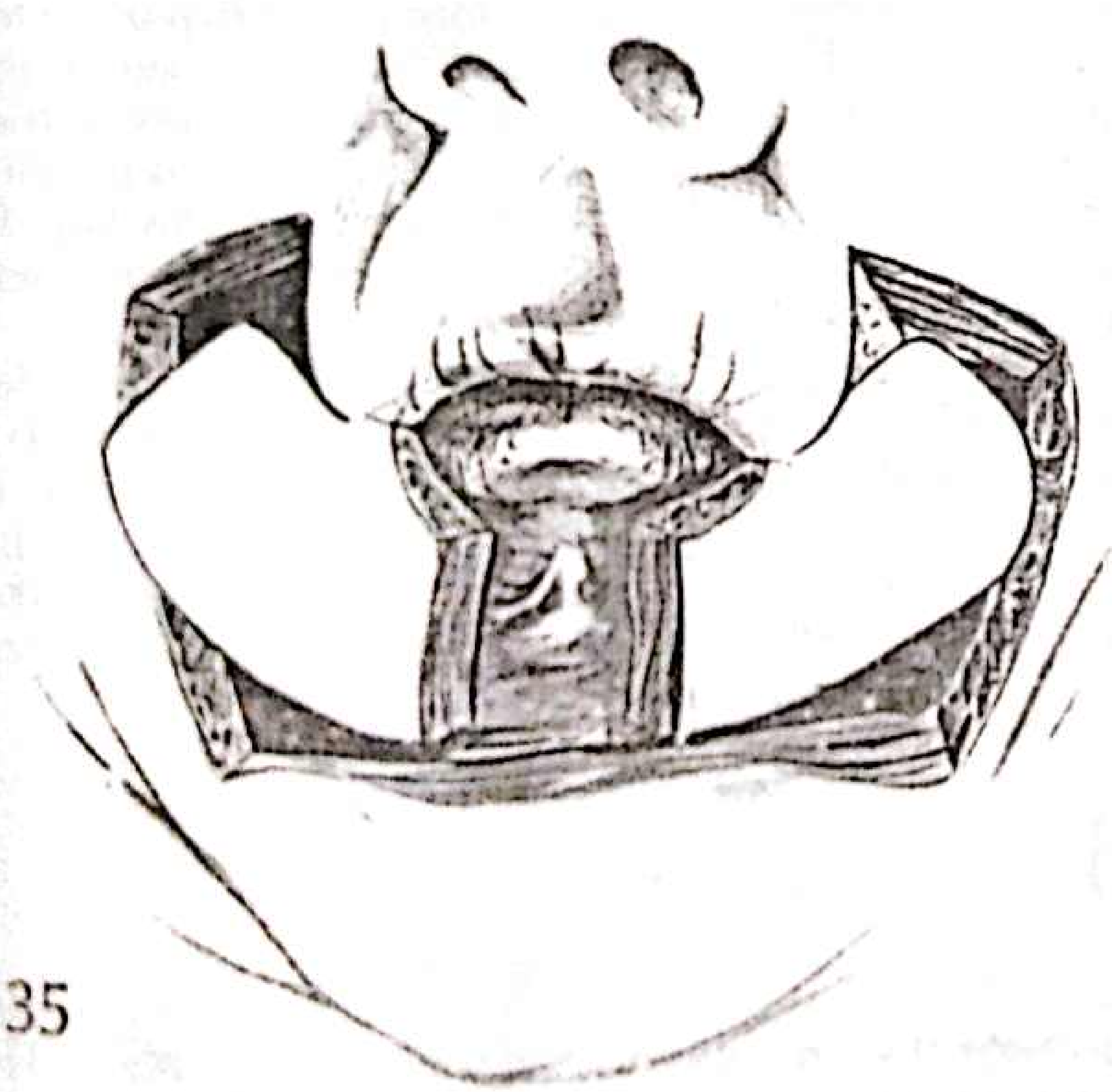

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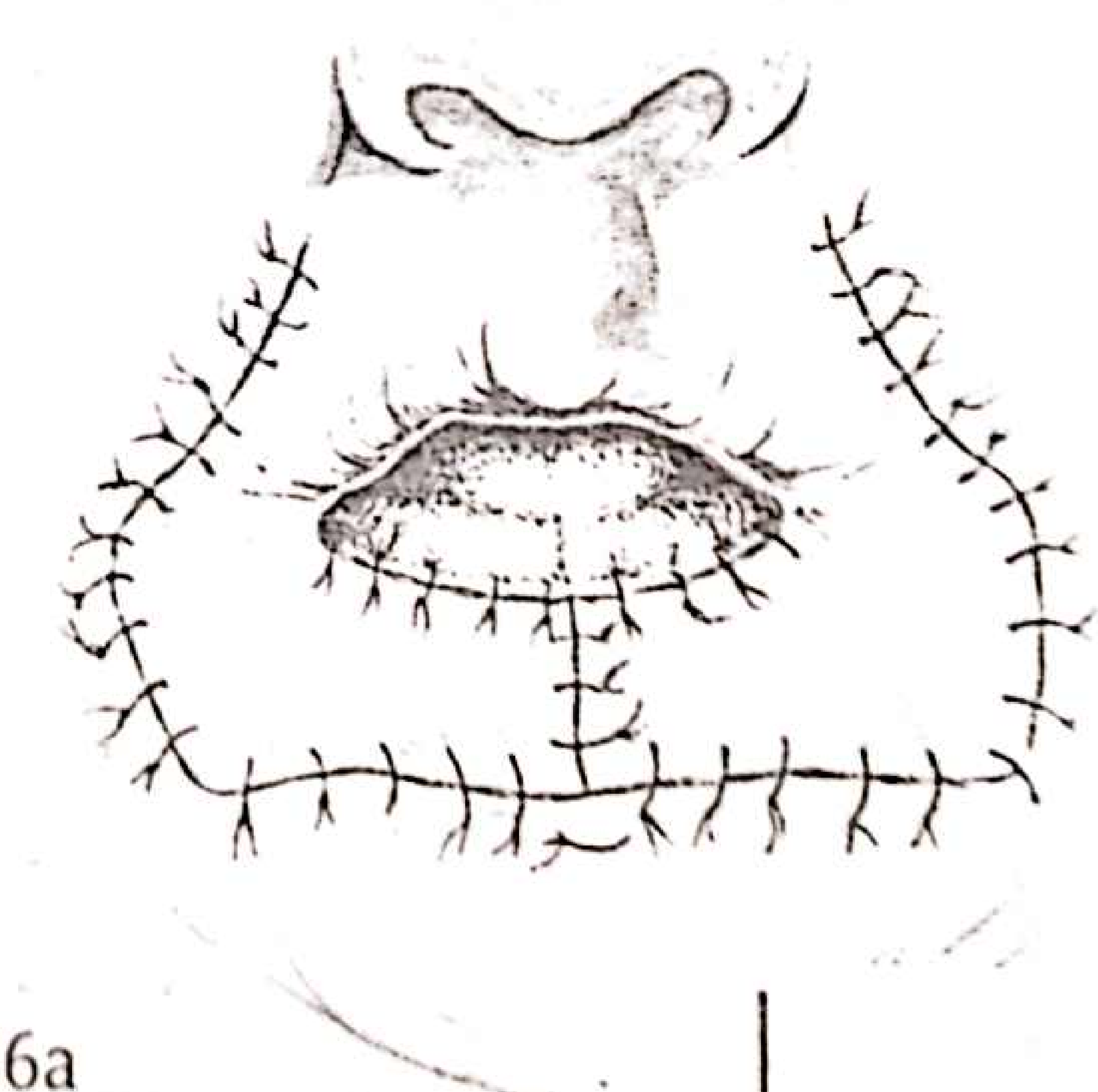
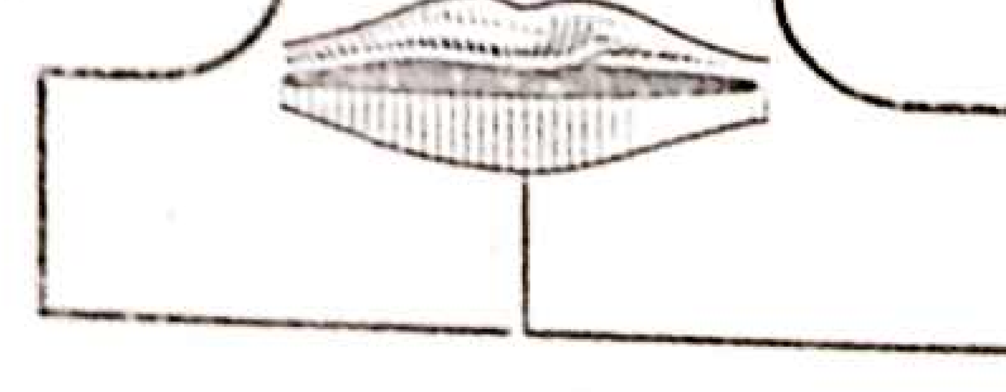


36a

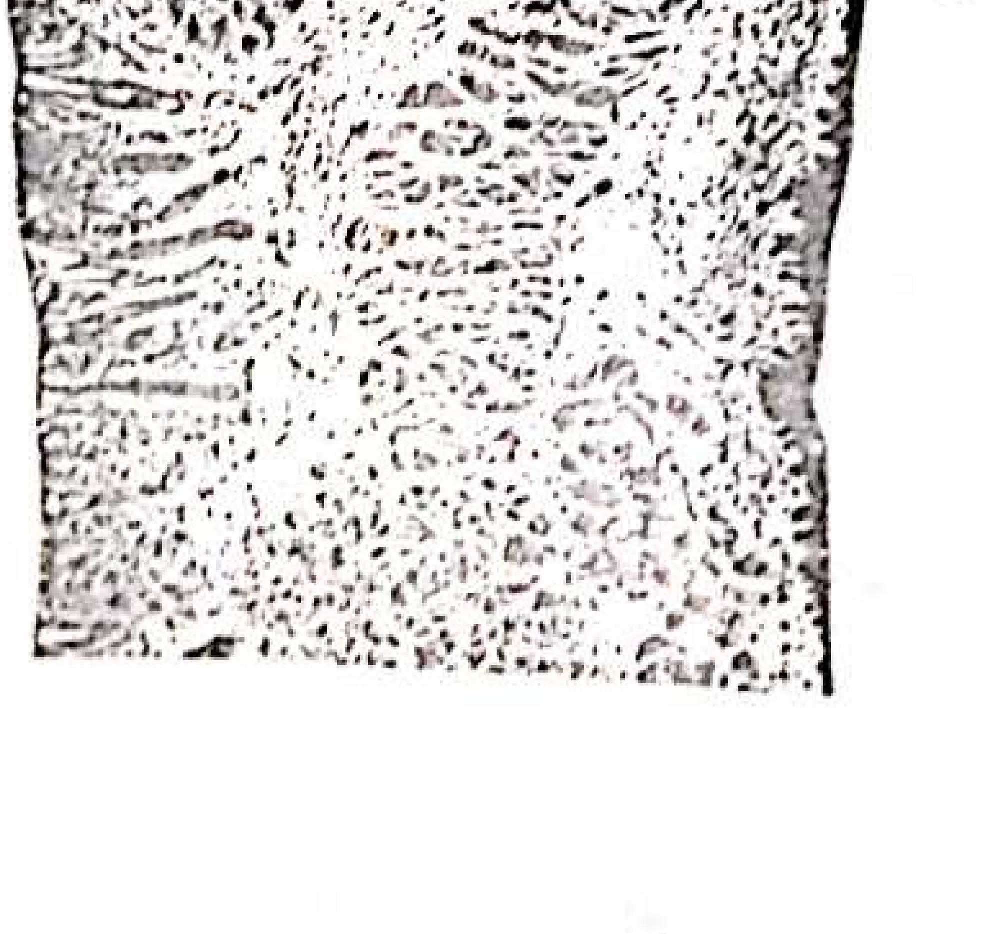


36b

Upper lip

Malignancy of the upper lip which requires a full thickness excision is a rarity. When it does arise it is more often from a tumour of the minor salivary glands of the lip rather than squamous carcinoma of the vermilion or skin. As a result the methods of excision and reconstruction have not been systematized in a manner comparable to lower lip defects, and the methods used are those which were developed for other purposes, particularly cleft lip and trauma. The fact that the lower lip can tolerate excision of up to one-third of its width without undue constriction means that the lower lip can be regarded as an area of availability to reconstruct defects of the upper lip, the tissue usually provided in the form of a full thickness wedge. Indeed, the similarity in structure and content of the two makes it ideal for the purpose. The presence of the labial vessels in the lip margin also allows flaps to be designed with a very small pedicle, provided it contains the vessels. When it is inserted into the upper lip such a wedge of lower lip substance becomes fully integrated into the upper lip, regaining both its sensory and motor functions.

37



38

V-excision

While it is possible to use this method, it is much less effective than the corresponding method in the lower lip and has a very limited role. Its limitations result from the fixation of the central third of the lip to the nasal skeletal structures and the presence of the Cupid's bow. The former prevents any compensatory adjustment taking place after excision and the latter highlights the asymmetry, resection of even a small wedge tending to result in a significant and very obvious asymmetry of the lip as a whole. The skeletal fixation also means that any lengthening of the lip which results from a resection–reconstruction cannot be masked readily. Because of these limtiations, full thickness tissue excisions are generally better reconstructed than closed directly and the reconstruction which is used depends on the site of the defect, whether it is of the central lip or involves the angle.

Abbe flap

Used to reconstruct full thickness defects involving up to one-third of the width of the lip, this flap is the most generally useful. It consists of a full thickness flap of the lower lip, pedicled on the inferior labial vessels and rotated 180° to fit into the upper lip defect. The lower lip defect is closed directly. After 2 weeks the flap pedicle is divided.

37

The flap is probably raised most frequently on the centre of the lower lip, but this is not obligatory. It can be raised from virtually any site on the lip without giving rise to subsequent asymmetry. As already stressed, a flap of up to one-third in width can be used. The flap is generally designed as a V-shaped wedge to allow easy closure of the secondary defect, and the defect of the upper lip is usually also constructed in this shape. Occasionally the flap is designed as a W, usually to fit into the floor of each nostril, but the V design is much more common.

The flap can be positioned on the part of the lower lip which will allow it to rotate into the upper lip defect with a minimum of distortion, although a little distortion is considered acceptable if this will permit the flap to be raised from the centre of the lower lip, closure of the defect to give a midline scar being felt by many surgeons to be likely to give a better final scar.

38

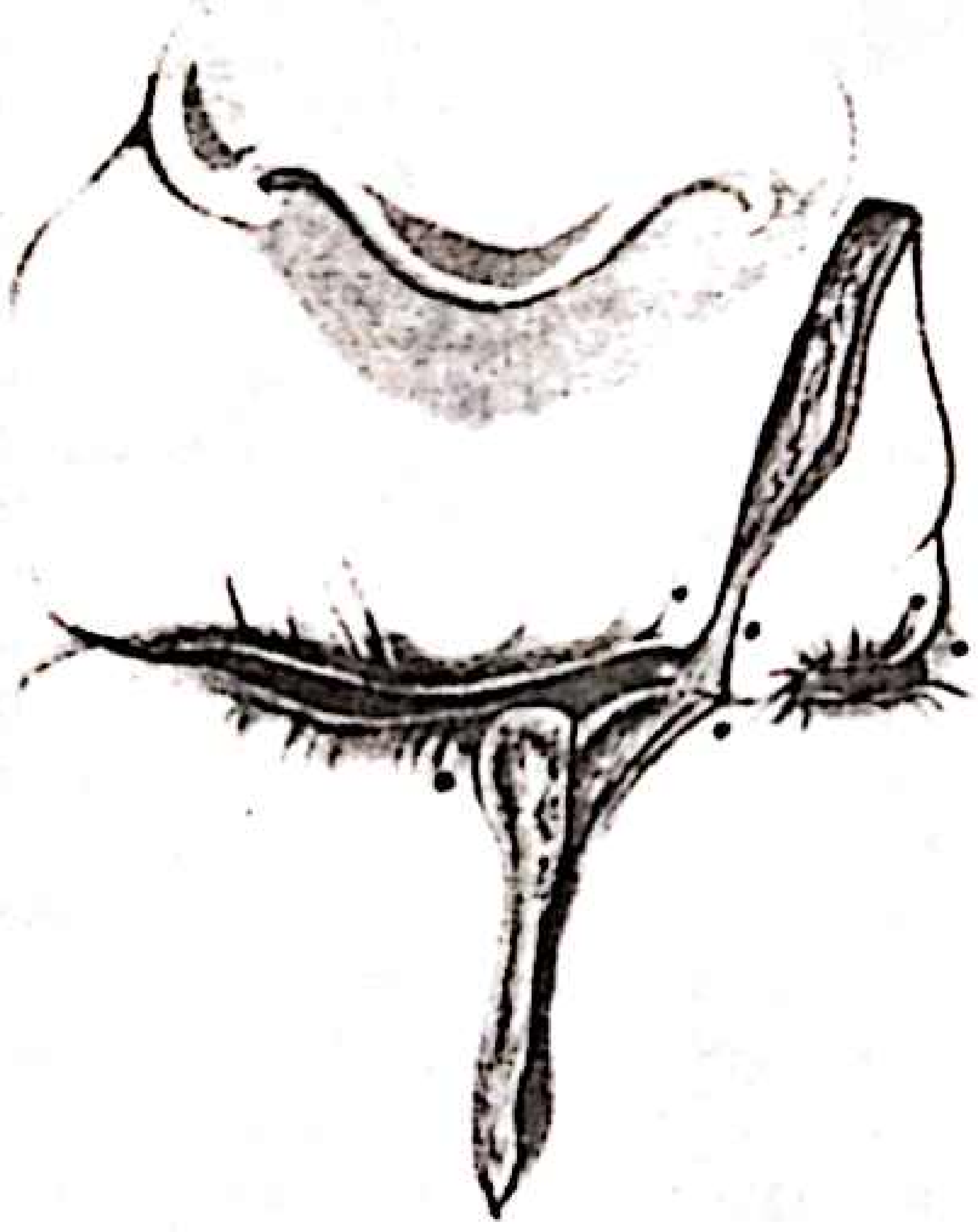
The pedicle is designed to be as small as possible in order to allow rotation of the flap to take place more easily. The method used is determined by the position in the lip substance of the inferior labial vessels which lie behind the muscle layer in the lip, between it and the mucosa at about the level of the skin–vermilion junction. This posterior position makes it possible to design the pedicle entirely on the red margin, and allows the various skin–vermilion junctions to be matched and sutured together at the time of the initial transfer (see below).

39–43

The flap is elevated in the first instance almost as far as the skin–vermilion junction. The skin incision is continued round the curve of the vermilion almost to the line of lip contact with the upper lip. Dissecting more deeply, the muscle is carefully divided, finally leaving a thin layer to protect the vessels lying behind it. The flap is rotated 180° and sutured in position in the usual way, carefully matching the skin–vermilion junctions, tattooed preoperatively with Bonney's blue to make the matching easier. It is essential to make sure that the sutures in the vicinity of the pedicle do not constrict the vessels within it.

If a general anaesthetic has been used, it is wise to apply an encircling bandage to keep the mouth closed until the patient is awake and cooperative. It is safe to divide the pedicle at 2 weeks. The pedicle being entirely on the vermilion, division is straightforward and can be carried out under local anaesthesia.

39



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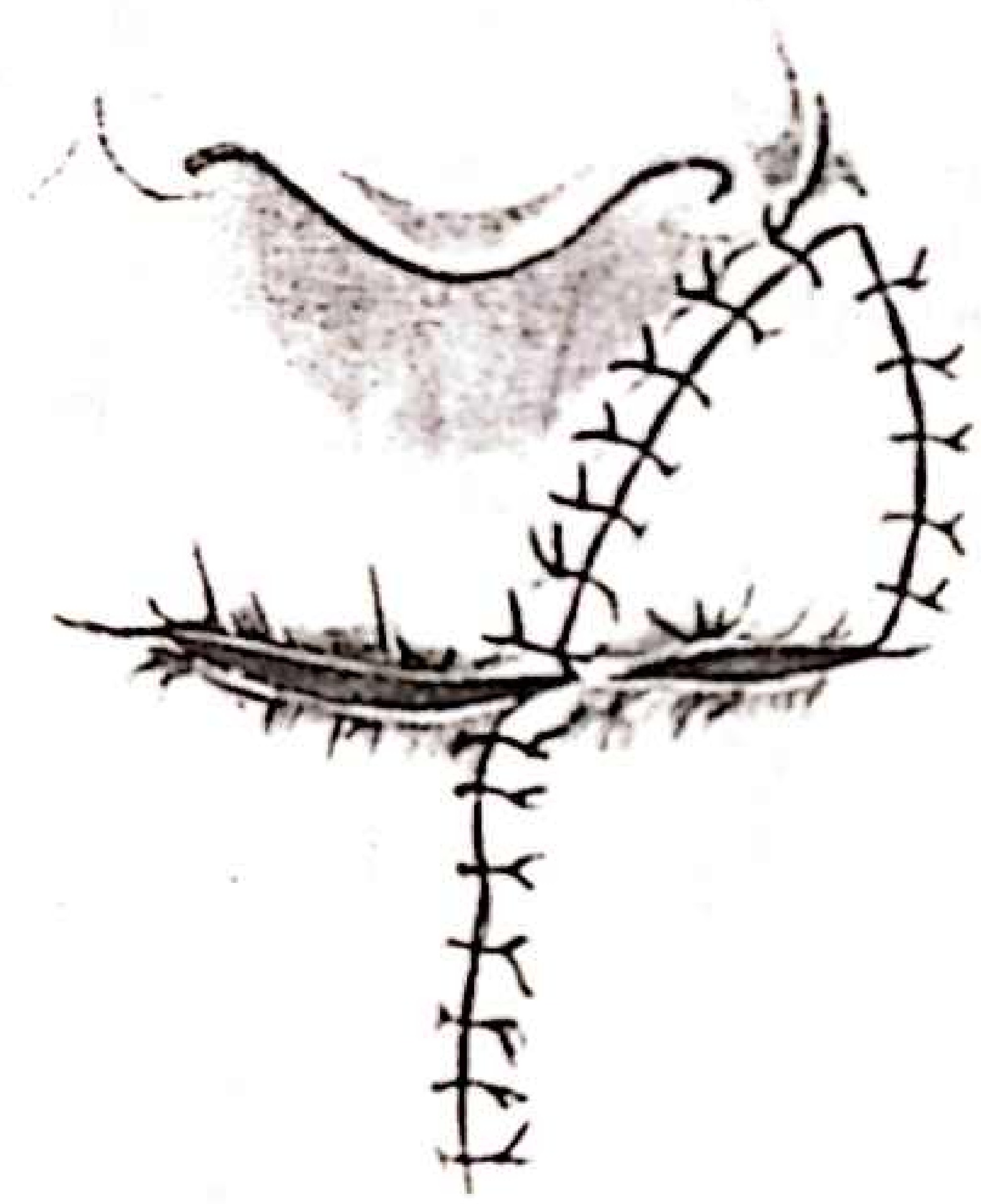

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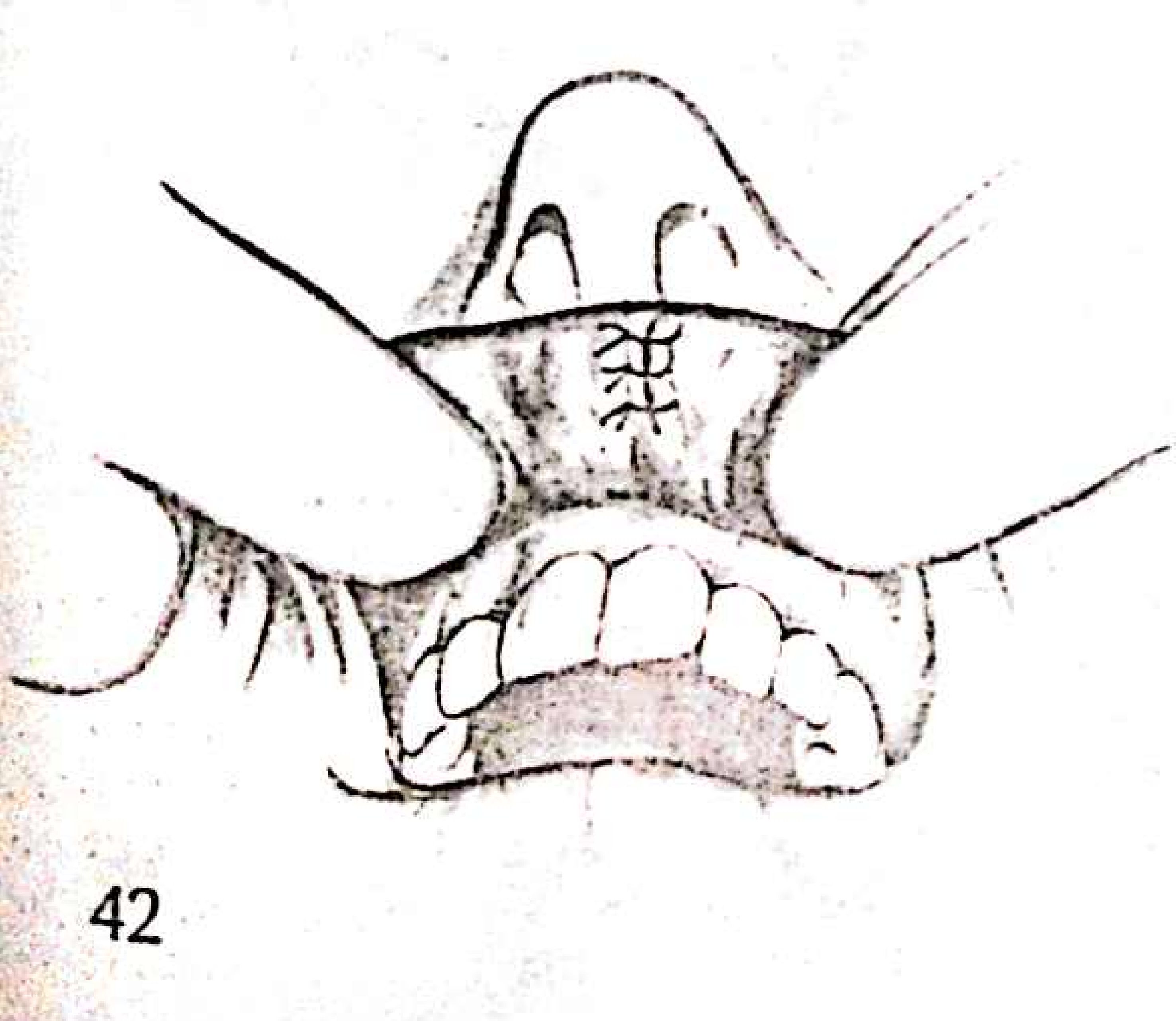

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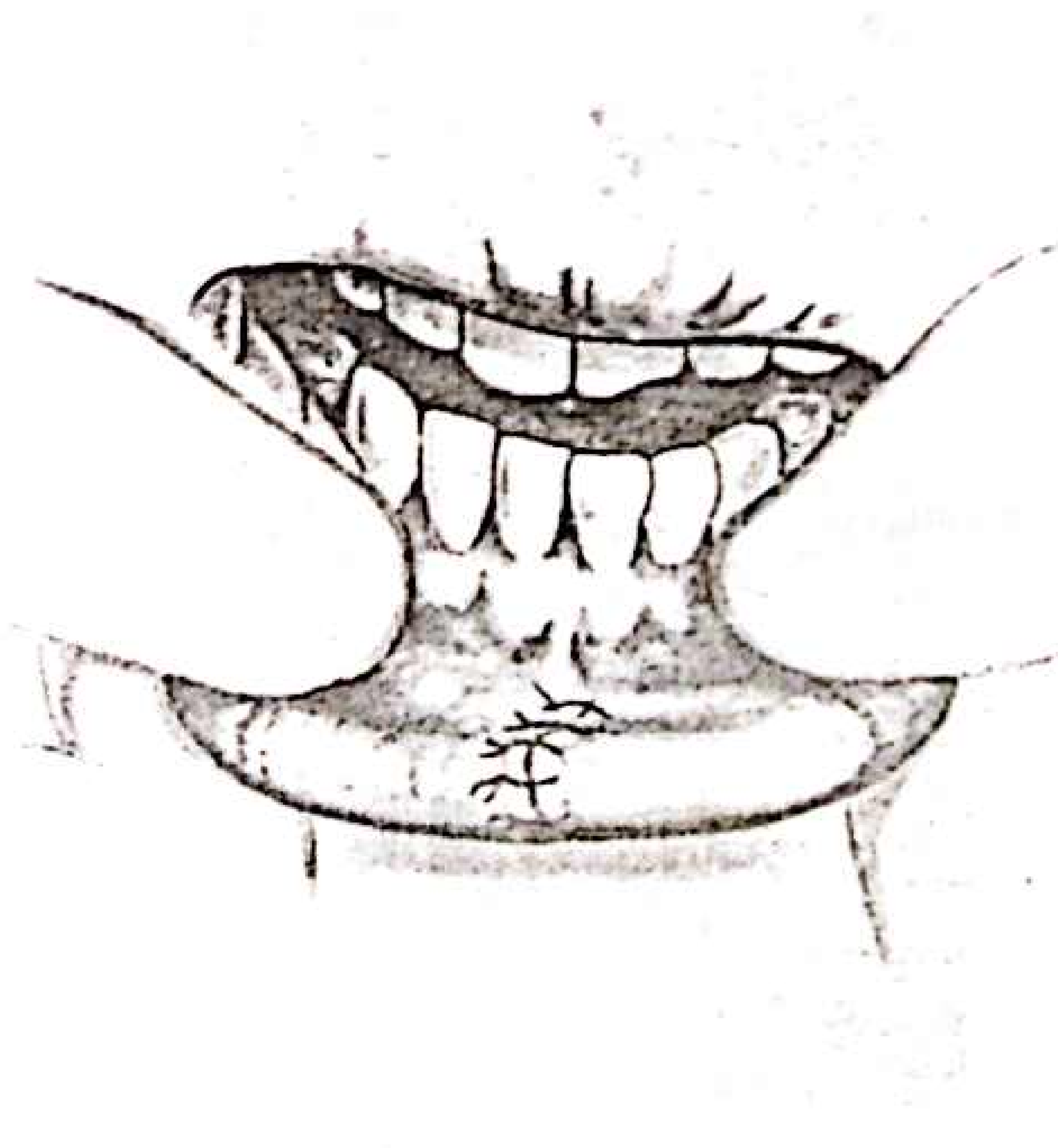

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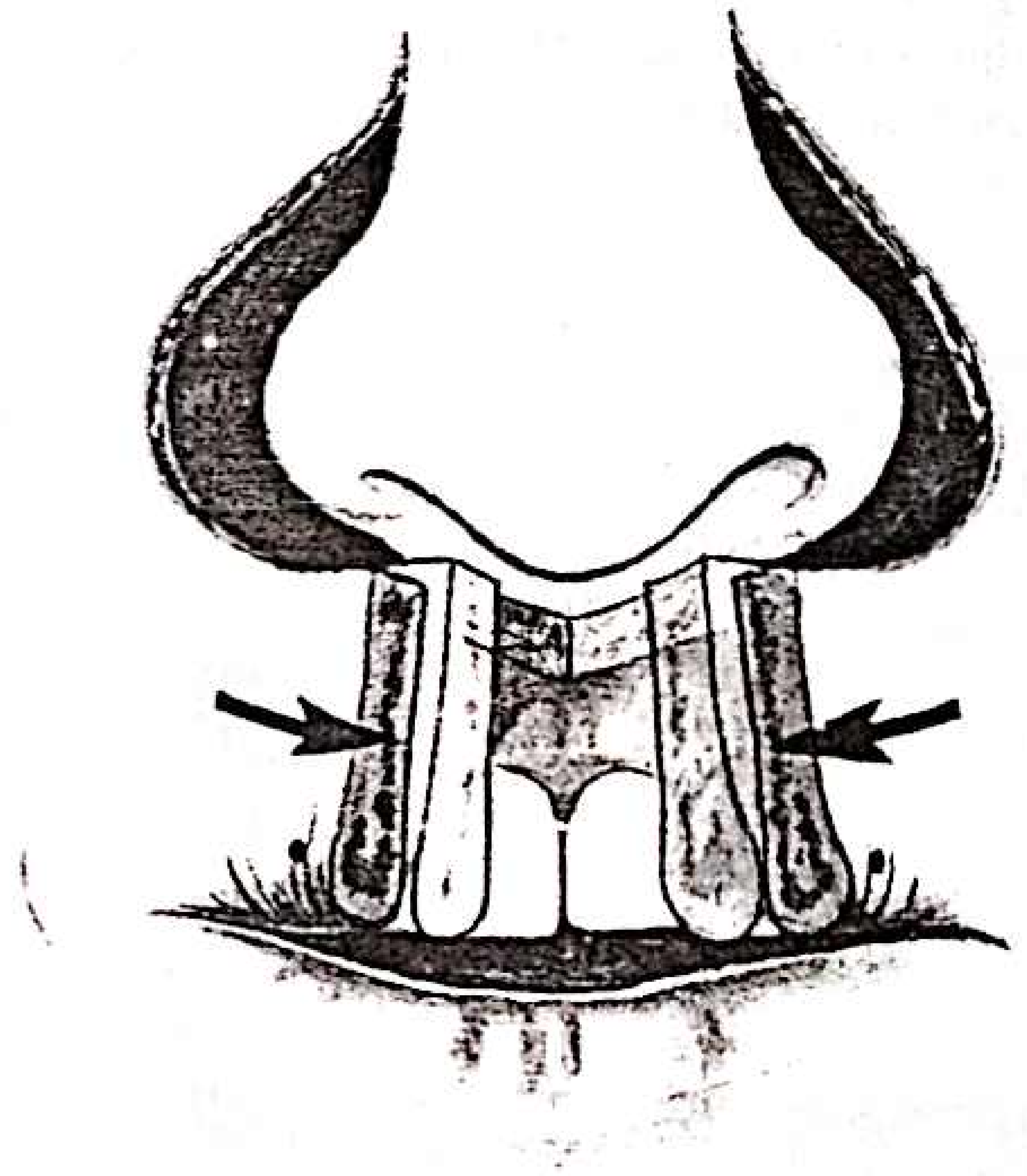
44

Advancement techniques

44–47

The Abbe flap most readily fills a V-shaped defect, and because of this problems can arise occasionally, most often in the philtral area when the defect is rectangular. Useful in this situation, used either alone or in conjunction with an Abbe flap, is a version of the technique of perialar cheek advancement (see chapter on 'Reconstructive techniques of the skin', pp. 45–103). From the upper border of the rectangular defect, on each side as a rule, an incision is made passing round the alar base, along the line separating the nose from the cheek, for approximately 1.5–2.0 cm. Lateral to this incision, a crescent of tissue in depth is excised, allowing the cheek to be mobilized from the underlying maxilla and, with an incision along the upper buccal sulcus, to be advanced medially. The effect is to close the perialar defect and to narrow or completely close the lip defect. If the defect is merely narrowed, the narrowing is still sufficient to allow an Abbe flap to fill the residual gap and complete the reconstruction.



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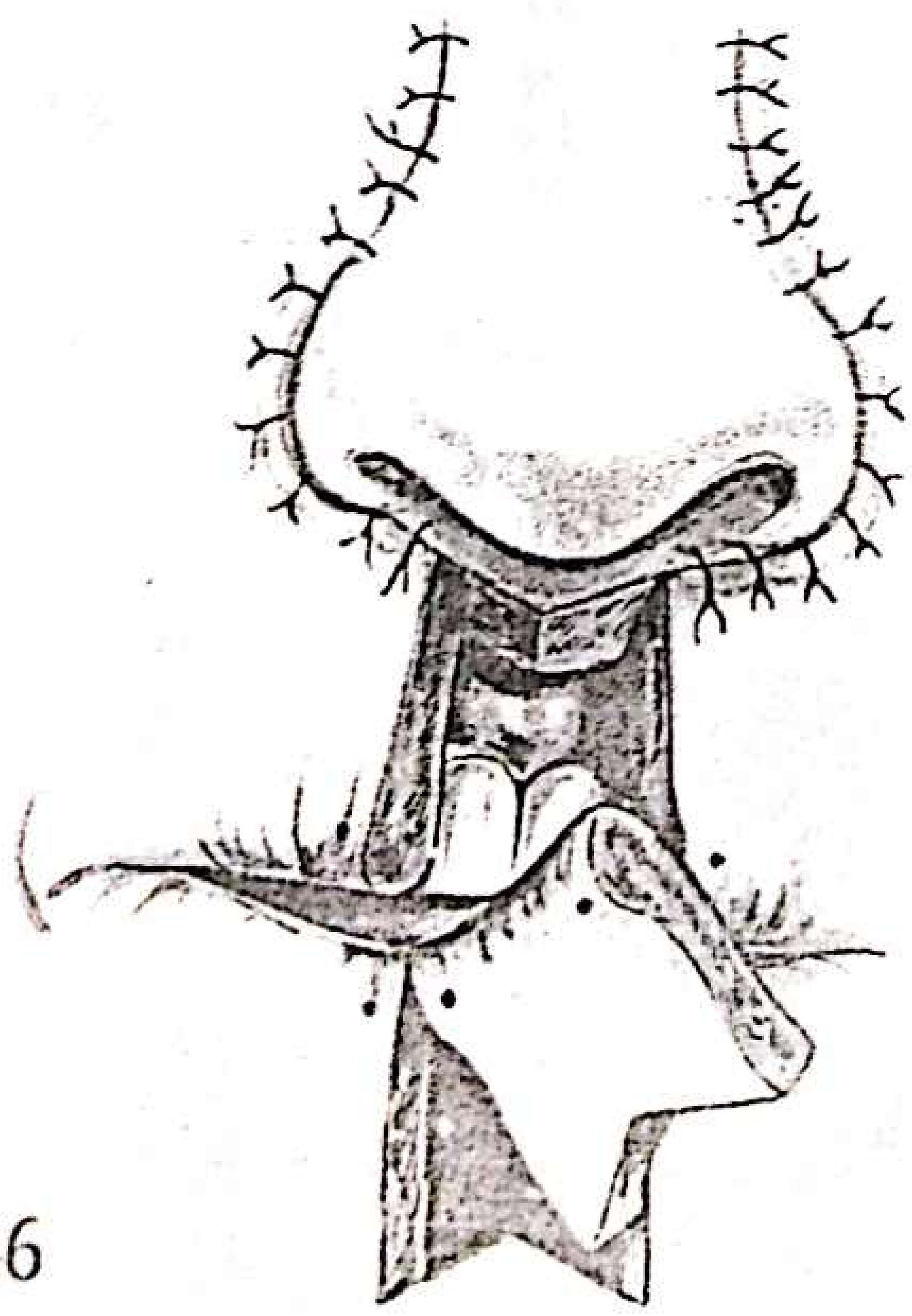

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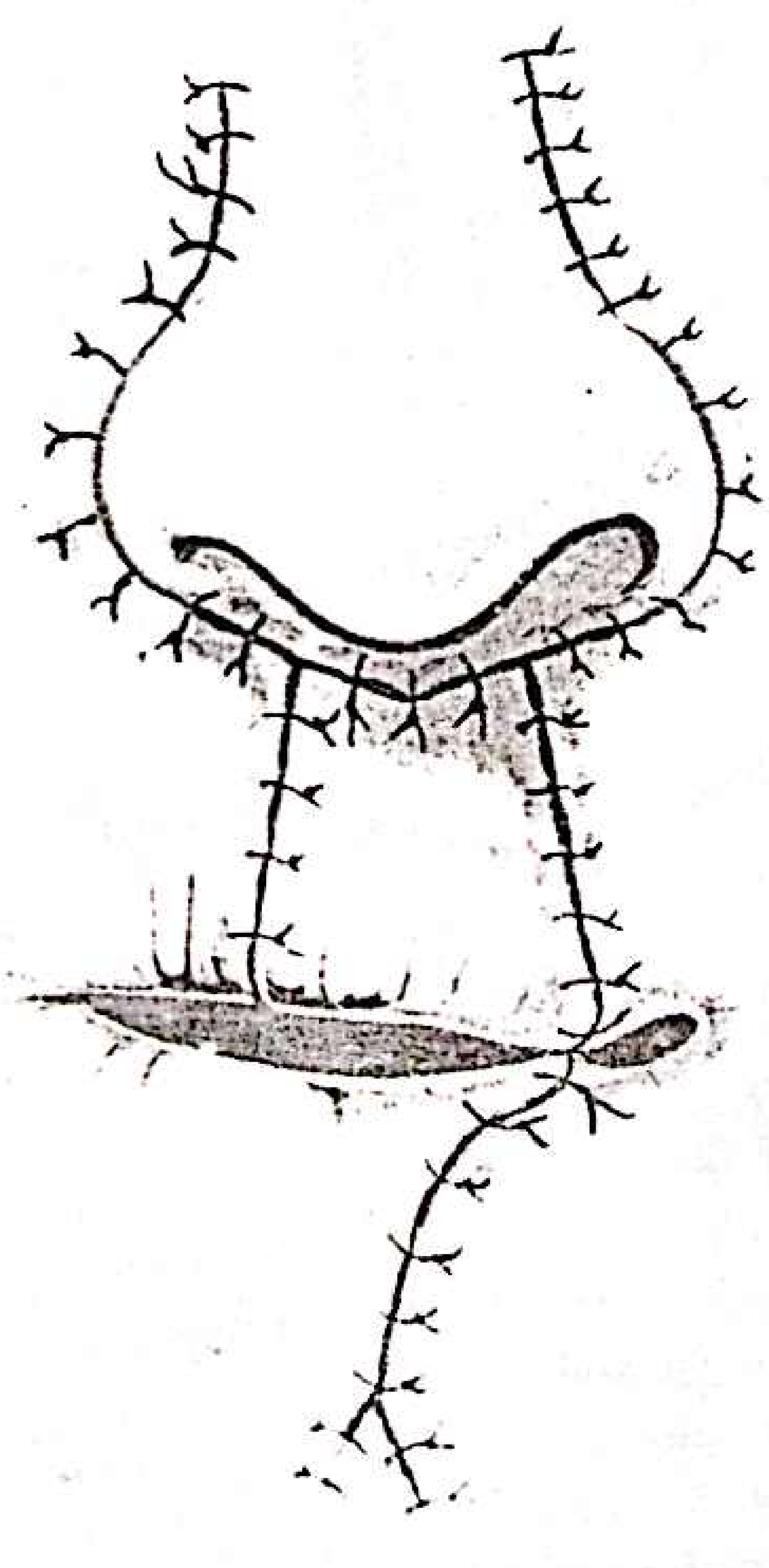


47

Defects of the angle

When the defect of one lip at the angle can be constructed as a V, a modified version of the Abbe flap, the Abbe–Estlander flap, can be used as an alternative to the Abbe flap itself.

48–51

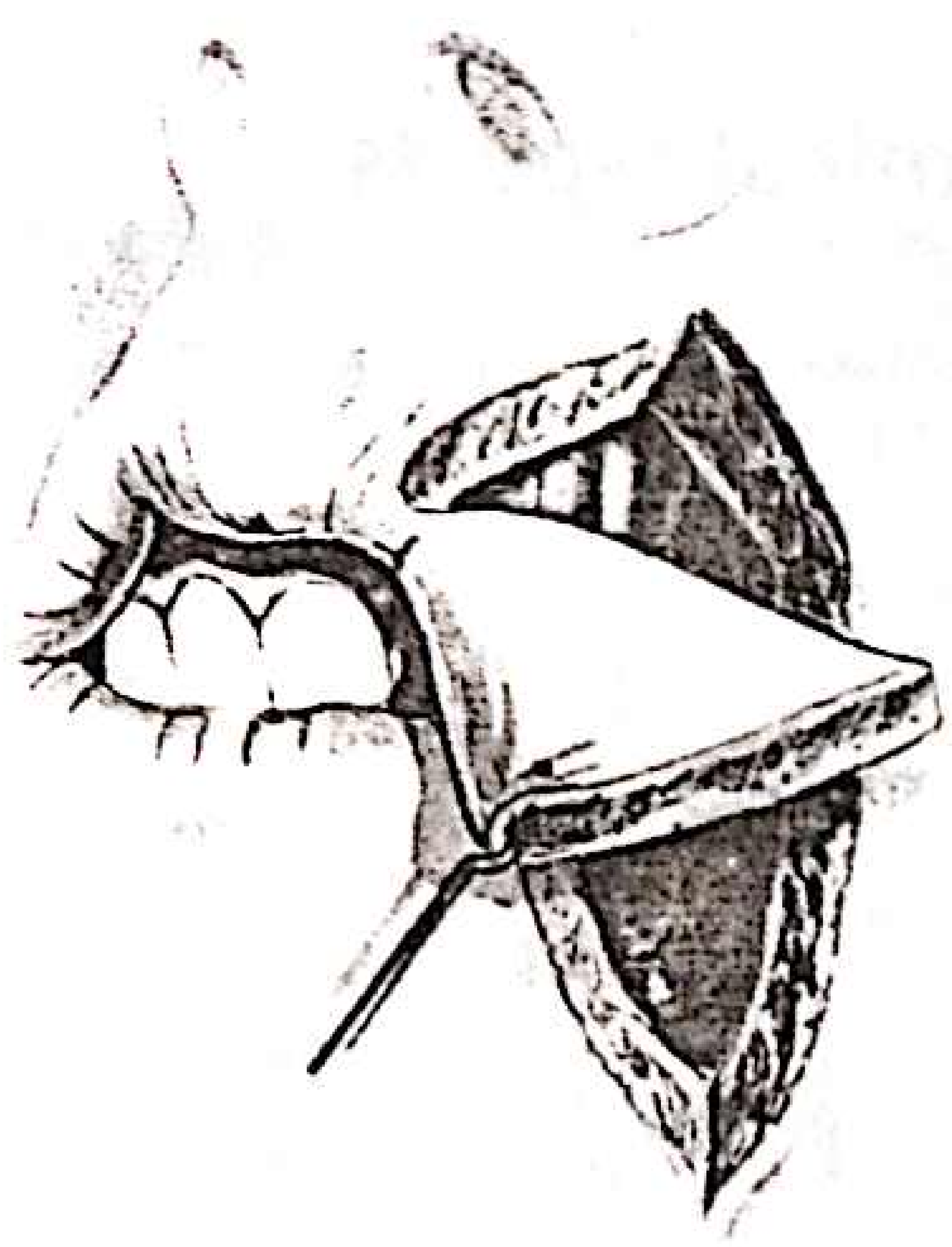
In the Abbe–Estlander version, a flap with similar characteristics to the Abbe flap with a medial pedicle can be raised at the angle of the intact lip. When such a flap is rotated 180°, it can fill the defect of the opposite lip and at the same time the pedicle on which it was rotated becomes the new angle of the mouth. The defect being created by the transfer is closed directly.

Because of the comparative frequency of tumours of the lower lip, the method has been applied more often to defects of the lower lip than the upper lip. It gives an adequate cosmetic result but it does also give rise to an obvious asymmetry of the upper lip in many instances and this detracts from its value. A solution often advocated is to restore symmetry by opening the new angle but the result is seldom good. The angle tends to gape and the new vermilion is narrower than its fellow on the opposite side of the lip.

Transfer from the lower to the upper lip is less likely to result in asymmetry and the result is adequate, though it is generally accepted that a more natural angle is produced by using a standard Abbe flap rather than an Abbe–Estlander flap. The use of an Abbe flap allows a more normal angle to be achieved, although at the expense of a second stage to divide the pedicle. The pedicle of such an Abbe flap is fairly near the angle, and feeding during the period between transfer of the flap and division of the pedicle is less of a problem.

Defects of the angle of the mouth which involve both lips are most frequently due to the extension of tumour which is primarily of the buccal mucosa and which has spread round the vermilion of the angle. This tumour is managed on the basis of its buccal component and is discussed in the chapter on 'Buccal mucosa', pp. 270–282.

48



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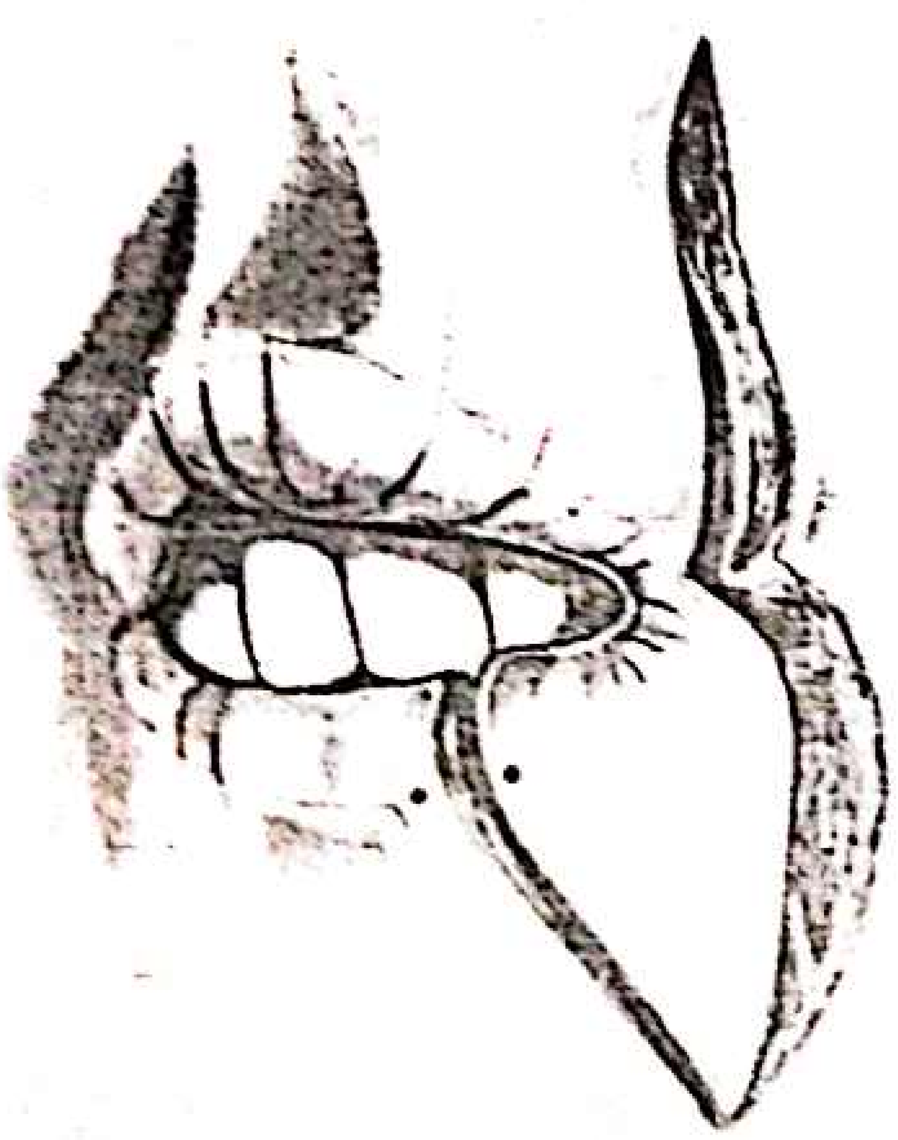

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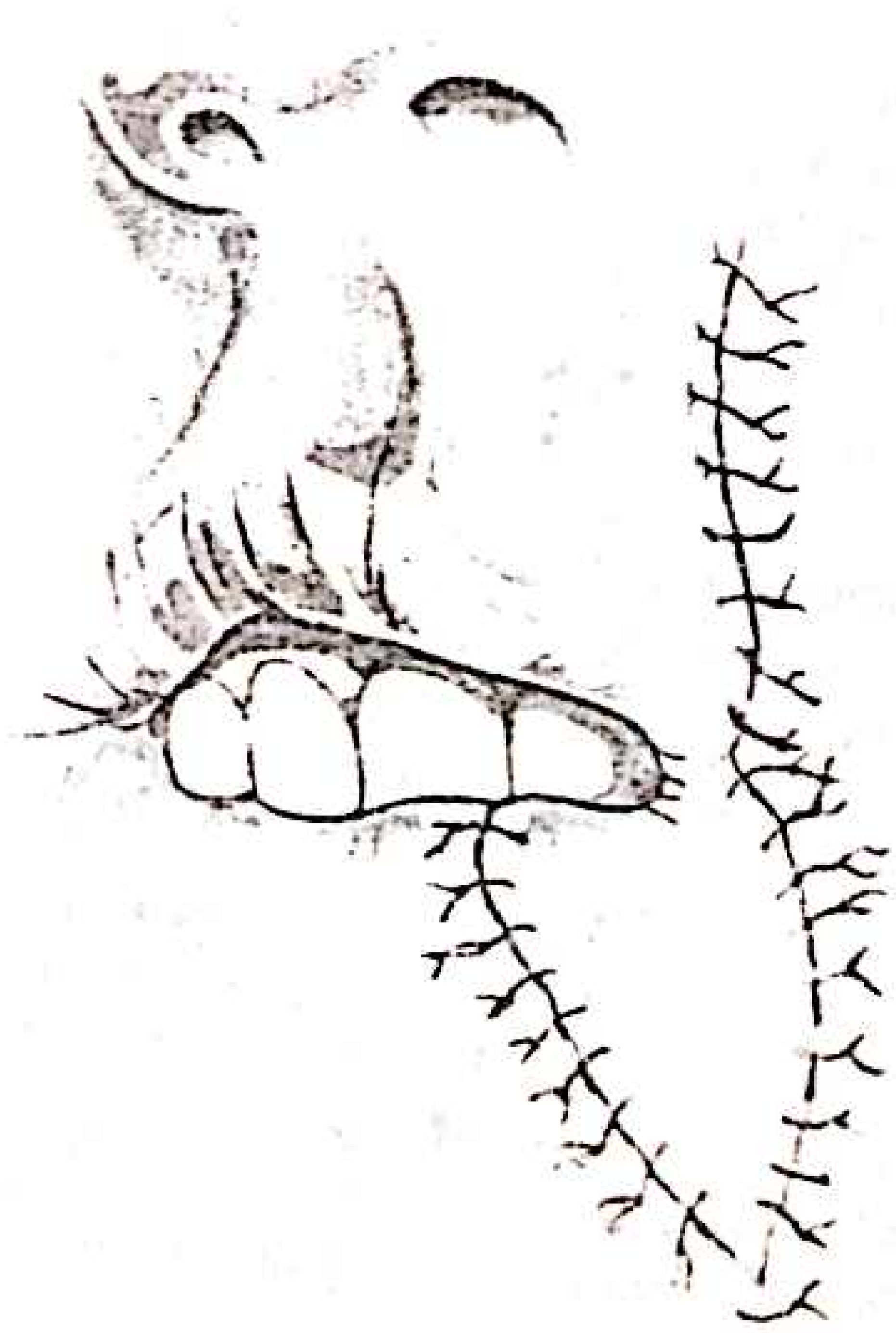


51

Eyelids

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

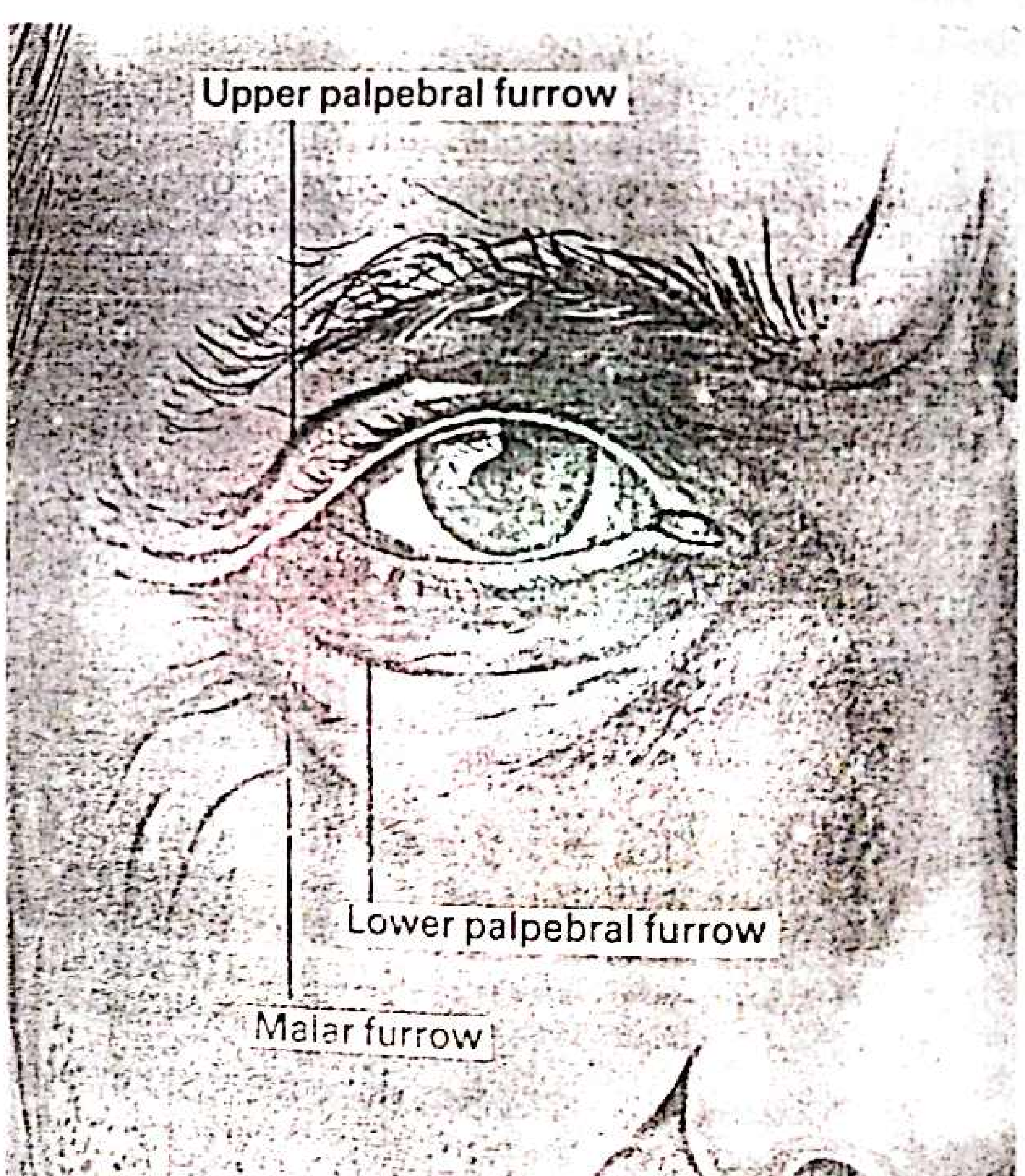
Anatomical aspects

The skin of the eyelids is thin and forms readily into folds. The folds and the pattern of wrinkles which develop as a result are determined by the repeated involuntary movements of blinking and the voluntary movements of opening and closing the eyelids, by the attachments of the skin to deeper structures, and by the effects which each of these have on the other. The pattern becomes increasingly marked with the laxity of the skin which develops in most individuals as part of the ageing process.

1

Over the tarsal plates the skin is less wrinkled, the two structures behaving as a single unit in eyelid movements. The margin of each tarsal plate is indicated on the surface by skin folds, the palpebral furrows. Although they are present in both lids, the furrow in the upper lid is the more marked of the two because of the constant movement of the lid in opening the eye, and the overhang of the skin above the upper palpebral furrow, frequently accentuated in the older patient by skin redundancy in that area.

The skin above the upper palpebral furrow retains its eyelid character almost as far as the eyebrow, and the degree of redundancy which develops there varies markedly in different individuals, in its severest form overhanging the lid margin. The line which indicates transition from lower eyelid skin to the skin of the cheek, the malar furrow, corresponds approximately to the infraorbital ridge. Along thi· line the skin is attached deeply to the periosteum of the ridge. This attachment largely prevents the downward drag of gravity on the cheek from being transmitted to the eyelid and producing ectropion.



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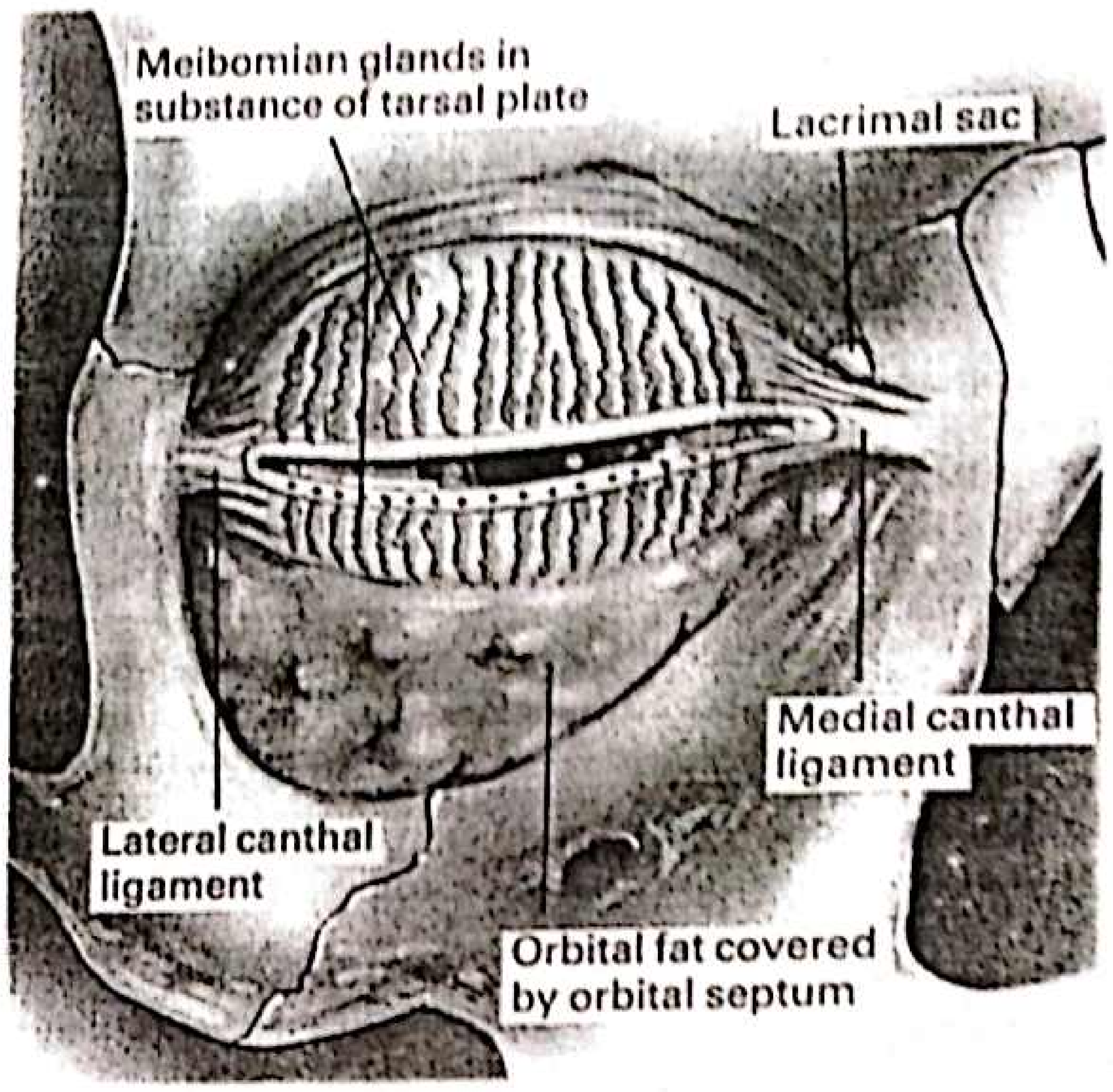
2 & 3



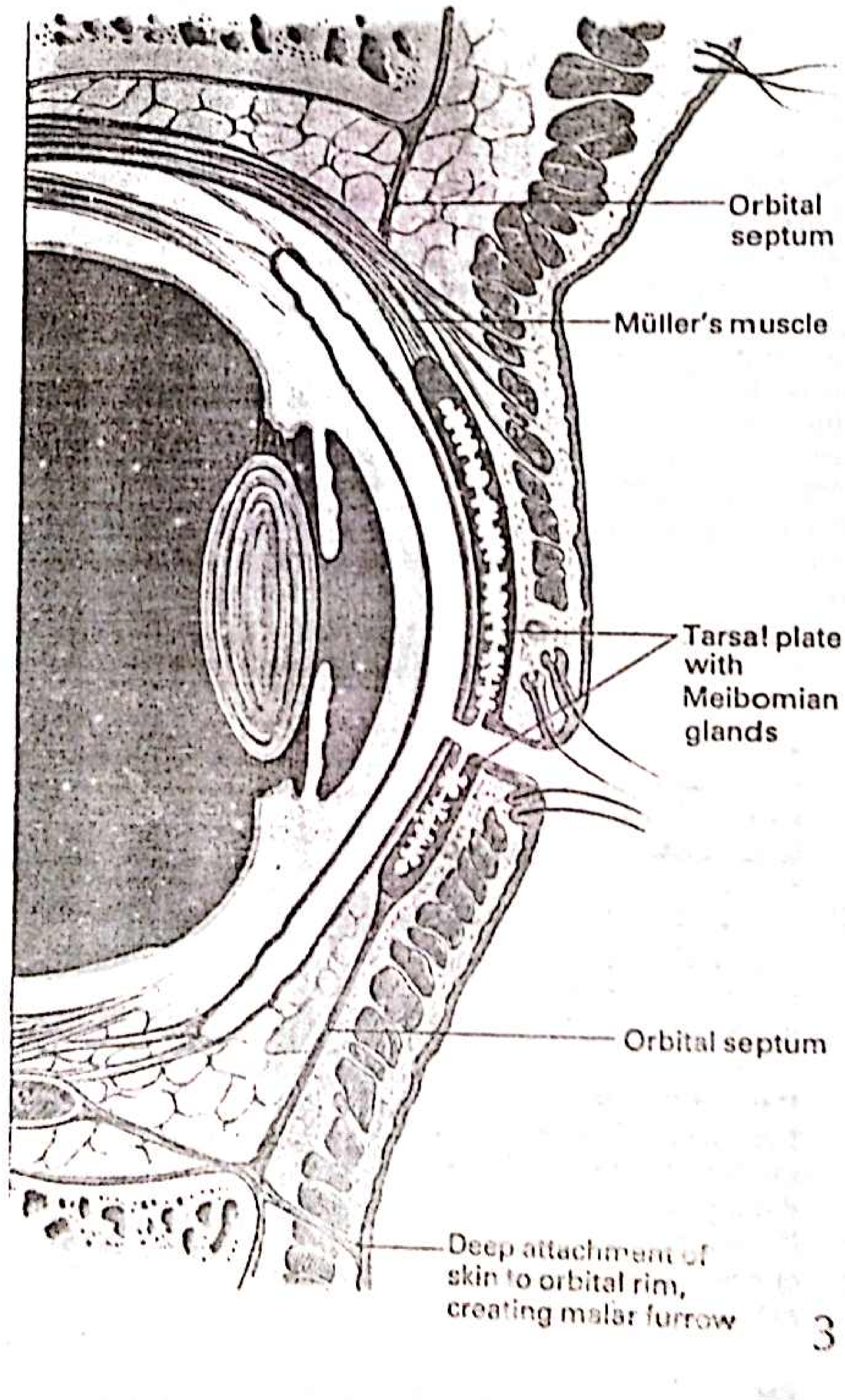
2

The skeletal basis of both eyelids is provided by the tarsal plates, dense fibrous tissue structures which are attached on each side to the orbital margin by the canthal ligaments and which hold the lids in contact with the globe. They contain the Meibomian glands, modified sebaceous glands which are arranged in parallel along the length of each lid and which open on its margin. The canthal ligaments provide the axis around which the lids move, forming most obviously in the upper eyelid the basis of the visor mechanism which protects the cornea. In the lower lid an added function of the tarsal plate is to counter the effect of gravity, providing support for the lid and preventing ectropion. It is this supportive function which reconstruction aims to maintain or restore.

When one or other limb of a canthal ligament is divided or resected the remaining limb maintains the overall position of the canthus. Resection of the entire ligament has quite different effects, depending on whether the lateral or medial ligament is lost. The effect of resecting the lateral ligament is relatively minor; resection of the medial ligament results in significant forward and lateral drift of the canthus, producing the appearance of unilateral telecanthus.

Where it lines the tarsal plates the conjunctiva and the plate are firmly fixed to one another and the two are managed surgically as a single structure. Elsewhere the conjunctiva is mobile on the underlying tissues and can be raised as a flap, delicate and filmy over the sclera, with greater substance in the lower lid and fornices. It is capable of being moved, if necessary, to provide lining in eyelid reconstruction. Along the limbus, the line demarcating the sclera from the cornea, it becomes fixed deeply. In the fornices and canthi there is considerable conjunctival slack which is taken up in part with movement of the globe but along its line of reflection from the globe onto the eyelid the conjunctiva is maintained in position by the presence of fine fibrous strands which attach it to the muscles which move the eyeball.

The orbital septum is a weak membrane deep to the orbicularis oculi muscle, present in both eyelids and separating those structures regarded as being within the orbit from those considered to be outside. In the lower eyelid, where it is a more clear-cut structure, it plays a part in reconstructive surgery, limiting the movement of flaps where mobility is essential to the reconstruction. This is felt as a restriction to movement rather than seen as a definite structure. It can be freely divided without adverse effects.



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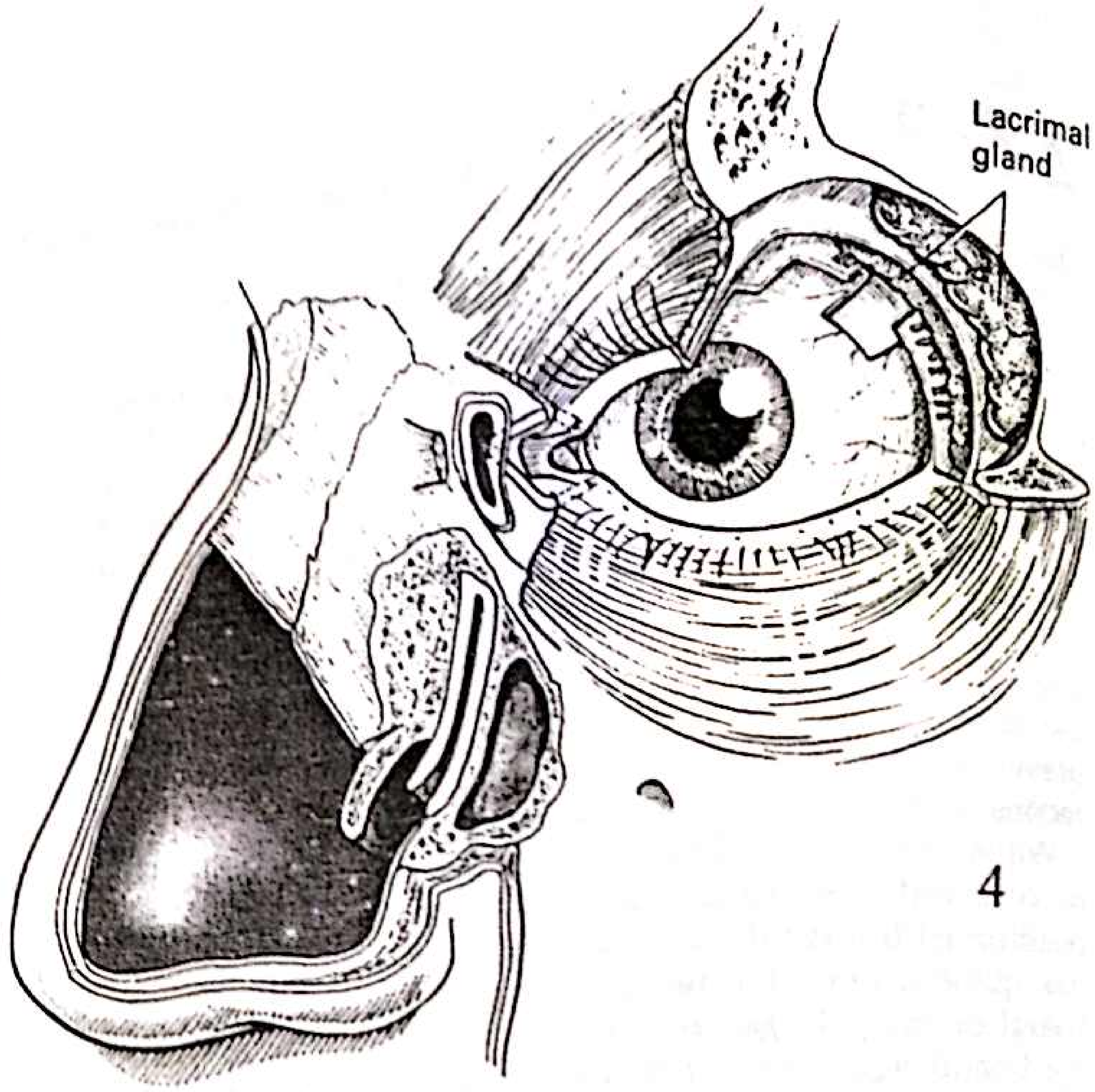
4

The lacrimal gland, deep to the orbital septum and draining into the upper lateral fornix, is rarely involved in eyelid resection or reconstruction. The drainage system is vulnerable to damage or destruction, not in the methods used in reconstructing postexcisional defects, these having been devised to avoid it, but in the excision of the tumour. From a punctum, positioned at the medial end of each lid margin and normally in contact with the globe, a canaliculus connects with the lacrimal sac, which drains via the nasolacrimal duct into the inferior meatus on the lateral wall of the nasal cavity.



4

Drainage problems resulting in epiphora can be caused by loss of contact between the punctum, particularly the lower lid punctum, and the globe, as well as by destruction of the system as a result of the resection. Efforts to reconstruct an alternative drainage system have proved largely ineffective. Their ineffectiveness is a consequence of the flow pattern of the tears in passing from the upper lateral fornix to the lacrimal sac. A narrow line of tear fluid is formed along the margin of each eyelid where it lies against the globe, held in position by the water-repellent secretion of the Meibomian glands, and it moves slowly medially towards the punctum of the lid, into which it drains. Tear fluid present in other sites within the conjunctival sac plays no part in this drainage mechanism. Since it is one of these other sites, the lower fornix, which the reconstructive techniques are designed to drain, it is scarcely surprising that they are not effective.

The clinical effects of loss of the drainage mechanism are very variable. Much of the tear production in the normal eye does not involve the drainage system, being lost by evaporation, and attention directed at preventing overproduction of tears is likely to be a more effective approach than futile attempts to reconstruct a drainage system. Irritation in the conjunctival sac is a regular cause of overproduction of tears and, although elimination of any such sources may be all that the surgeon can do, such steps can be surprisingly effective.

The extreme richness of the blood supply of the eyelids explains why it is possible to raise flaps, whether of skin and muscle or the full thickness of eyelid, with a freedom and safety unmatched elsewhere in the body.

Suture techniques

The suturing techniques used in suturing eyelids and conjunctiva are designed to reduce irritation within the conjunctival sac to a minimum by leaving little or no suture material exposed within the sac, and by taking particular care to avoid having suture material come into contact with the extremely sensitive corneal epithelium. The techniques involved depend on whether closure involves the bringing together of the cut edges of the eyelid to close a full thickness defect or the approximating of the conjunctiva.

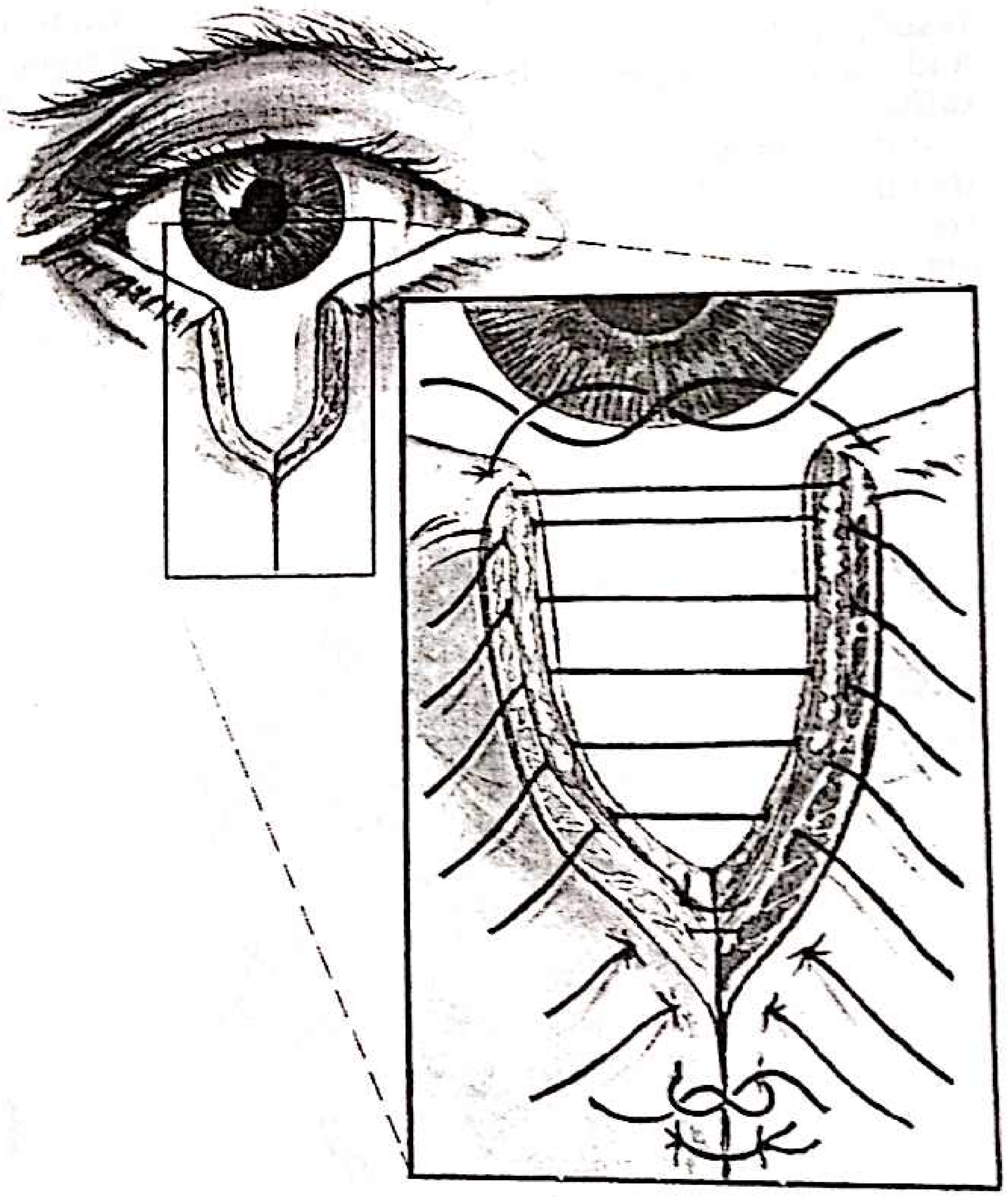
5

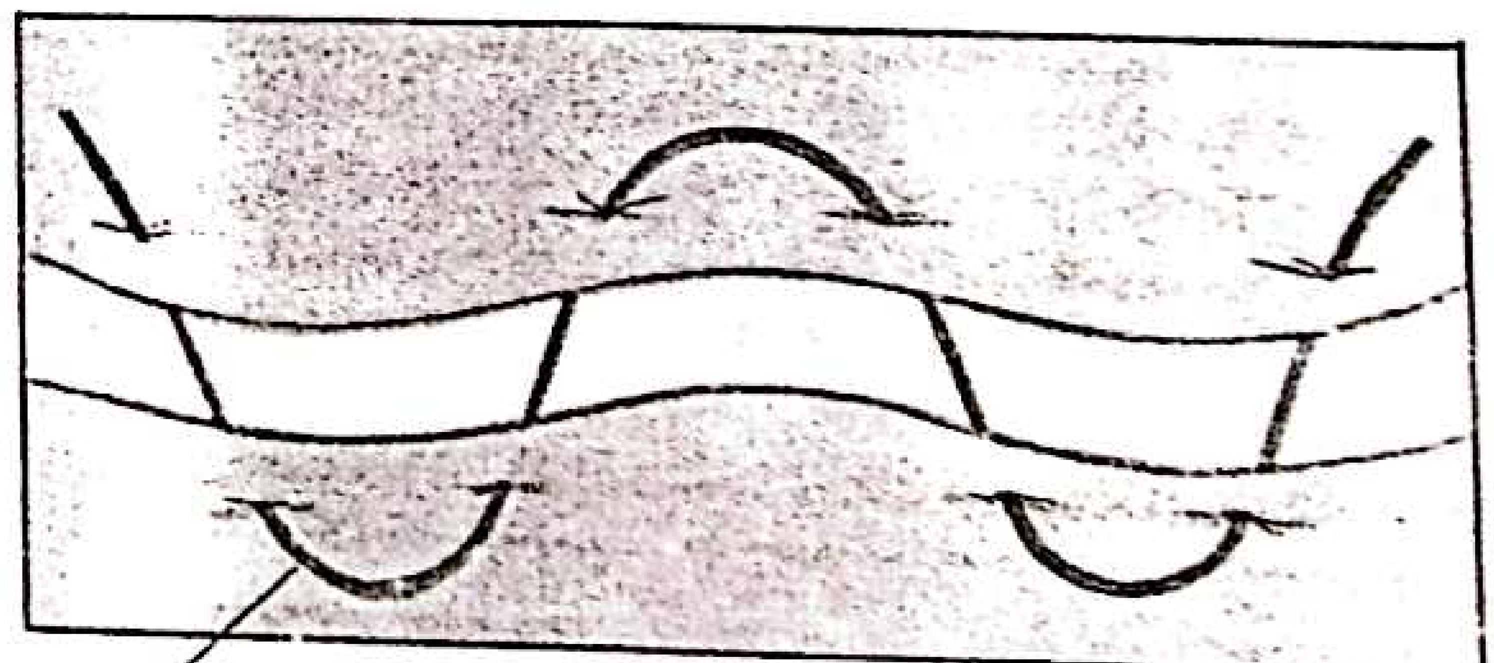
In closing a full thickness eyelid defect, use is made of the fact that in both eyelids the conjunctiva and the tarsal plate behave as a single structure. As a result, approximation of the tarsal plate simultaneously approximates the conjunctiva. If the margins of the tarsal plates are sutured together accurately, the conjunctiva does not require closure as a separate layer, spontaneous healing taking place.

The cut margins of the tarsal plate are approximated using a fine absorbable suture on an atraumatic needle, for example 6/0 chromic catgut. Interrupted sutures are used, placing the knot on the skin side of the tarsal plate, including the full thickness of the tarsal plate, but stopping short of the conjunctiva. Fine sutures of this sort have very little tensile strength and tension across the suture line must be reduced to a minimum. Measures to reduce tension are an integral part of the various reconstructive techniques used. Many postexcisional eyelid defects are V-shaped, with the defect narrowing towards the apex of the V beyond the tarsal plate so that any tension across the suture line decreases rapidly. The orbicularis muscle in this region can be approximated as a distinct layer if desired, but it is usually sufficient to close the skin alone. Over the tarsal plate the skin suture can include the muscle layer. Particular care should be taken to match the lid margin accurately, making use of the several visual aids available: the line of the eyelashes, the grey line, and the junction between skin and conjunctiva. To avoid notching, the suture used in matching the lid margin is best inserted so as to produce a little eversion of the wound edges.

In many patients in the age group prone to tumours of the eyelids, the skin and orbicularis muscle are atrophic and the sutures should not be tied too tightly. Healing is extremely rapid and the skin sutures can safely be removed on the fourth or fifth day if care is taken.

Formal approximation of conjunctiva with sutures within the conjunctival sac is not often necessary, and if the site is likely to come into contact with the cornea, sutures should be avoided if at all possible. If suturing is unavoidable, a continuous interweaving suture of fine monofilament nylon can be used with the ends brought through the skin. The smooth surface of the suture material allows for easy removal.





Interweaving suture of conjunctiva

5

Provision of skin cover

Skin cover can be achieved by direct suture of a defect, failing which it will take the form of a graft or a flap.

The defect to be closed by direct suture should, wherever possible, be constructed as an ellipse whose closure converts into a single line. In the context of tumour the cosmetic aspect may have to take second place to pathological considerations. A simple ellipse closed directly leaves a single scar line to be watched for recurrent tumour, and to incorporate a Z-plasty, for example, which might on occasion improve the cosmetic result, spreads the area of potential tumour recurrence and makes management of such a recurrence much more difficult.

With both grafts and flaps the prime requirements are that they should be thin and mobile but not susceptible to secondary contraction. The tarsal plates have a strictly limited capacity to resist skin contraction and, if that capacity is exceeded, ectropion results. In the older age group, the population most susceptible to malignancy in the eyelid area, the tendency to atrophy of the orbicularis muscle and increased laxity of the tarsal plate reduce further the resistance of the lids to those stresses which are likely to produce ectropion.

How essential thinness and mobility are considered to be depends on the site. It is least at the medial and lateral canthi. In the lower eyelid, which is relatively immobile, and in the upper eyelid directly over the tarsal plate where the skin, tarsal plate and conjunctiva are acting virtually as a single structure, the need for mobility is still not great. It is in the vicinity of the palpebral furrow of the upper eyelid that the need for thinness and mobility is greatest, particularly where the defect which is being reconstructed straddles the furrow, since folding and unfolding of the furrow occur every time the eyelid is opened and closed.

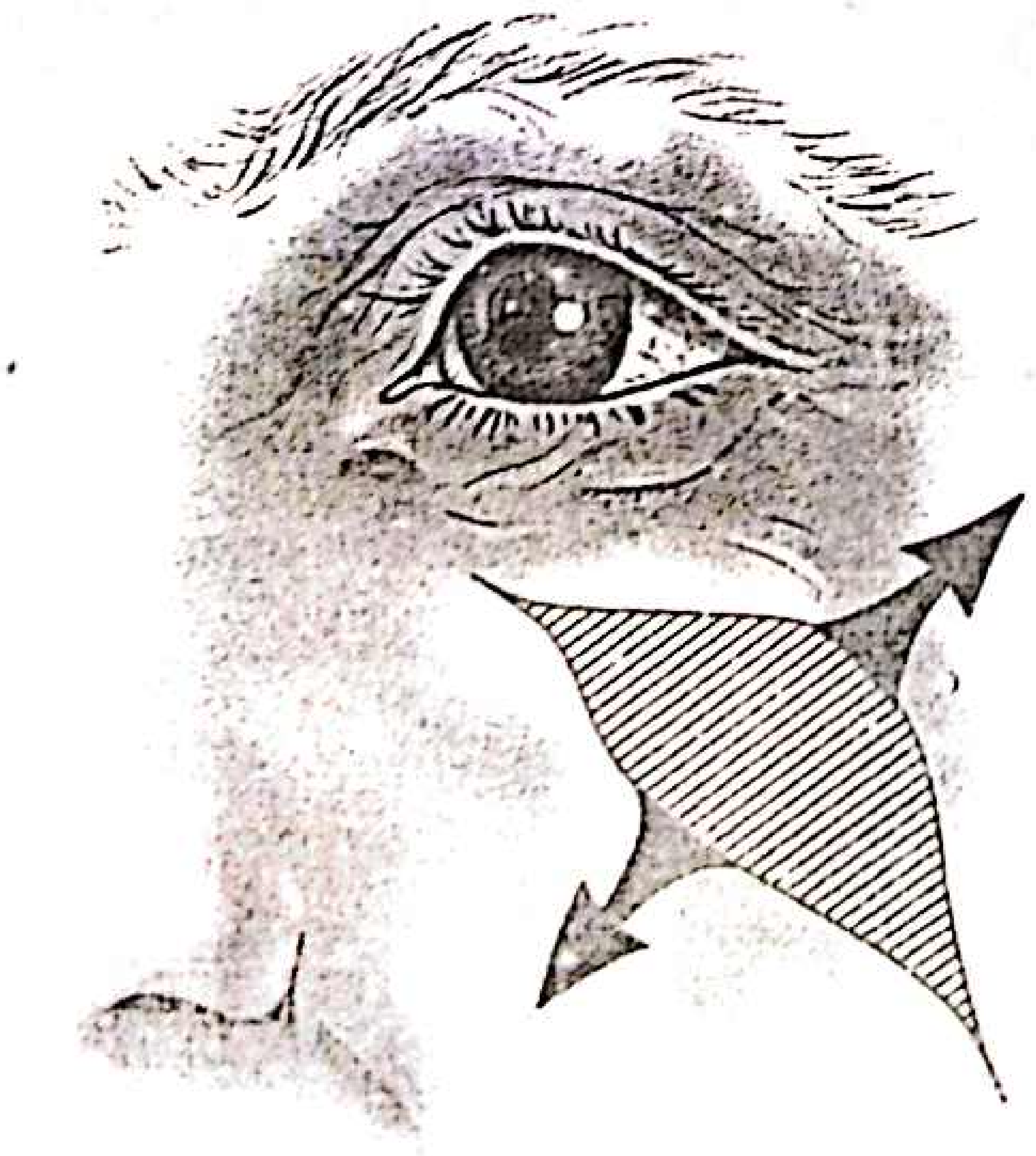

6

Direct suture

The usage of direct suture differs in the two eyelids.

6

In the *upper eyelid* considerable laxity of the skin is usually present above the superior palpebral furrow and quite wide defects can be closed directly. Excision generally takes the form of a horizontal ellipse, lesions which require a vertical excision rarely being suitable for excision and suture. Even when the defect extends onto the skin overlying the tarsal plate it is often possible to advance the lax skin downwards, sometimes as far as the lid margin, to close the defect directly.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7

In the *lower eyelid* the hazard associated with direct suture is ectropion. There is never as much lax skin available as in the upper eyelid, and gravity also acts against the surgeon. Over the lid itself excision of a vertical skin ellipse is rarely possible, and the nearer the ellipse approximates to the horizontal the more directly does closure draw down the eyelid.

As a preliminary to any excision in this area it is essential to estimate whether the excision and direct closure will give rise to ectropion. When making this assessment there must be no encroachment from the skin of the eyelid onto the cheek skin, that is, beyond the malar furrow. In the supine patient, as on the operating table, the assessment is best made with the patient looking upwards and with the mouth wide open to mimic the pull of gravity. Excision of an ellipse which follows the skin creases laterally (as shown), so that maximum tension across the wound is beyond the lateral canthus, occasionally allows closure without producing ectropion.

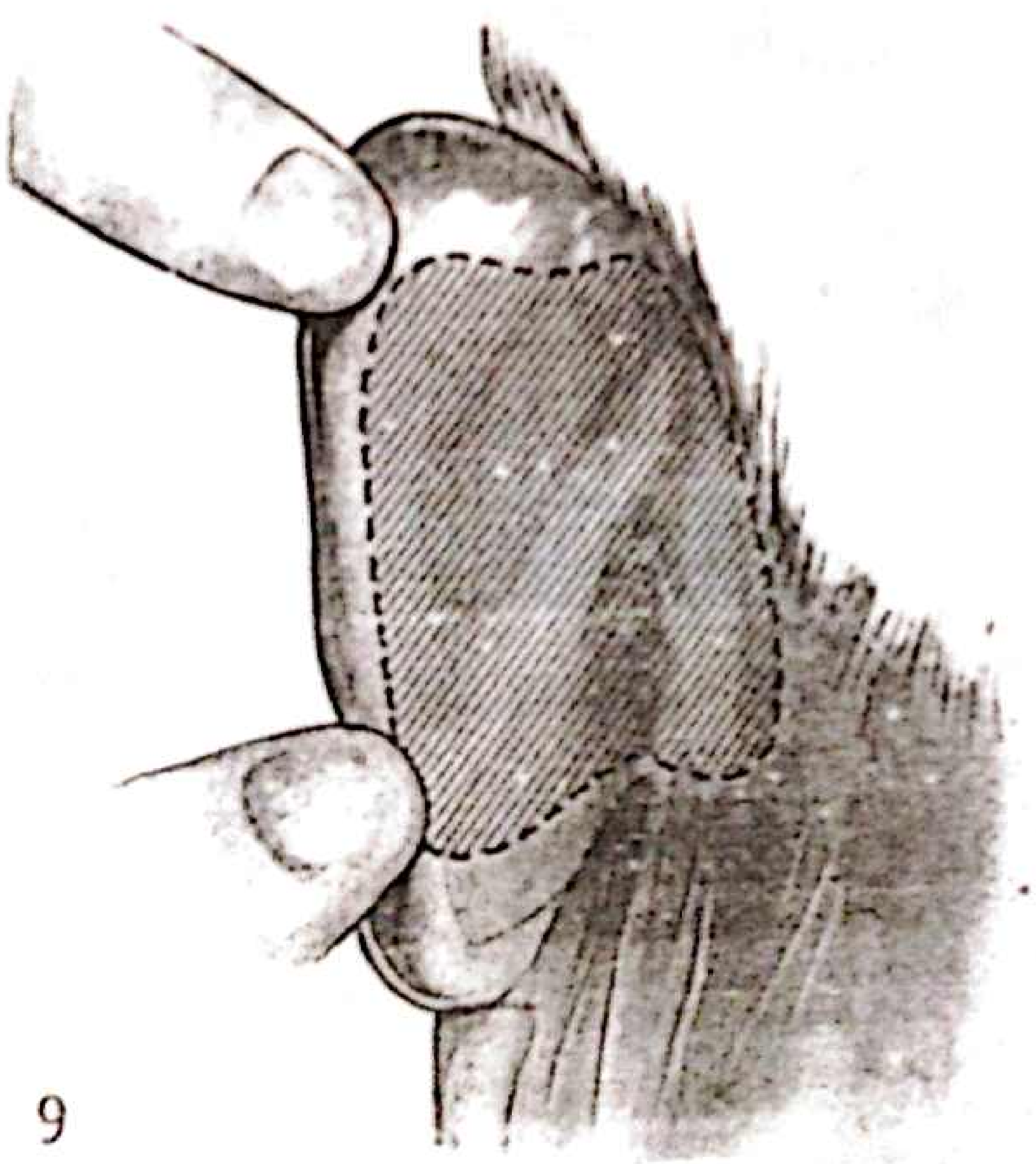
Skin grafts

In using skin grafts, the paramount requirement is that there should be no secondary contraction of the graft. In the context of malignant disease this virtually rules out the use of split-skin grafts. Split-skin grafts have been recommended for upper eyelid defects on the basis of comparative thinness and potential mobility, but their usage in clinical practice has been in severe eyelid burns rather than in managing defects following tumour resection. In burned patients the defects are larger in area and adequate areas of suitable skin of full thickness are not available. In the smaller defects which result from tumour resection the whole skin graft taken from the upper eyelid or postauricular area works extremely well.

8

Upper eyelid skin, harvested from the contralateral eyelid, is ideal but is limited in the area available. Even so, more is often available than would appear at first sight. With advancing age, redundancy of the skin of the upper eyelid increases and in many of the patients being treated for eyelid tumours a sizeable area is present.

8



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9

Postauricular skin is a generally excellent alternative. It is available in adequate quantity for virtually all the eyelid or canthal defects which are suitable for grafting. It is generally accepted as suitable for all the eyelid sites, although some surgeons might consider the defect of the upper eyelid which overlies the upper palpebral furrow an exception. Defects in that site are not common, but when one does occur, it usually results from excision of a skin tumour which has extended upwards from its site of origin over the tarsal plate. Personal experience has been that in practice a postauricular whole-skin graft is sufficiently mobile to give an excellent result, both functionally and cosmetically.

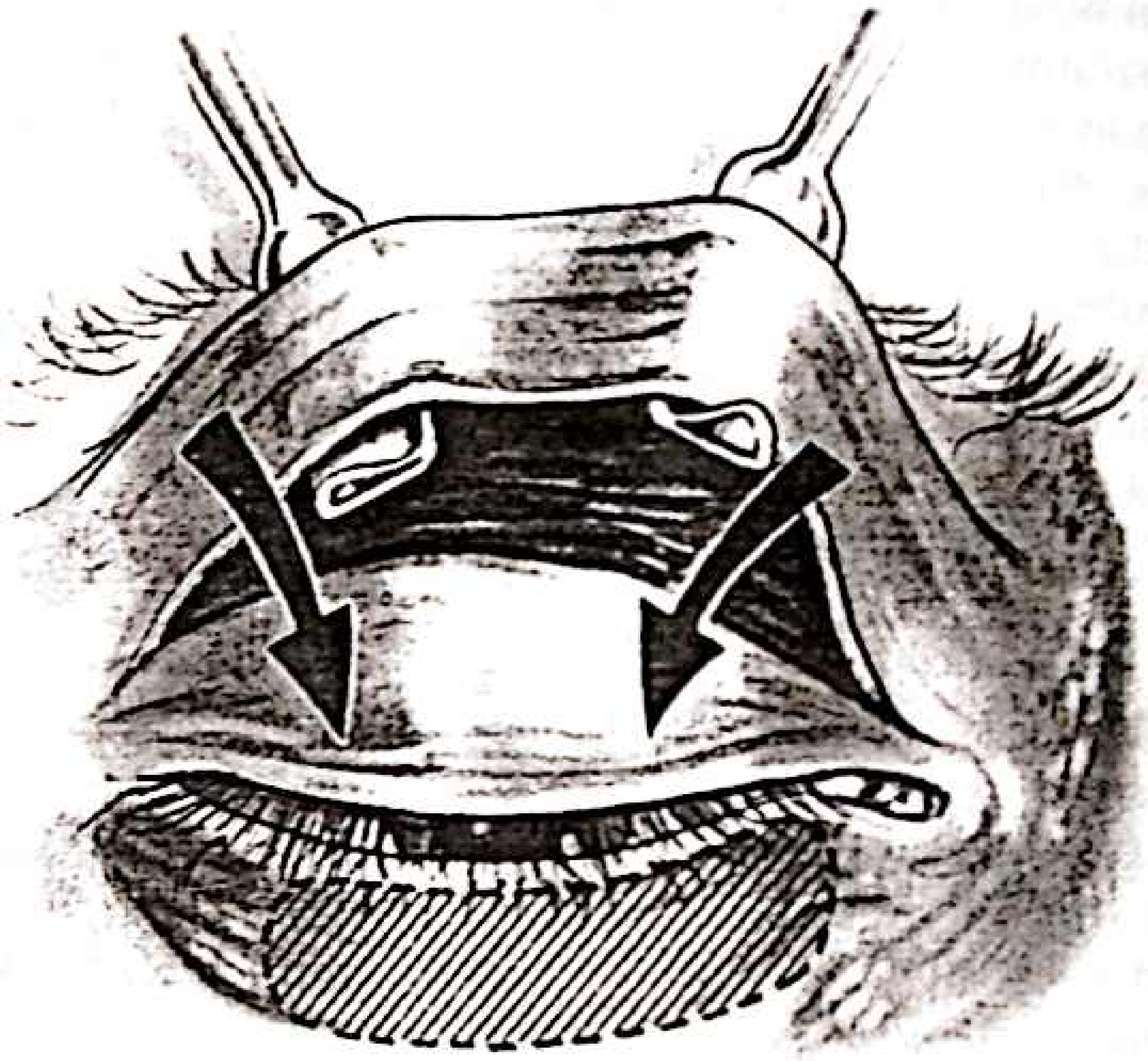
Skin flaps

In designing skin flaps for use in eyelid reconstruction the sites made use of are the upper eyelid, the nasolabial area or the forehead.

Upper eyelid skin

10

The upper eyelid site makes use of the skin area between the superior palpebral furrow and a little below the eyebrow. In its fully developed form the flap is raised as a horizontal flap extending from end to end of the eyelid, pedicled at each extremity (the 'Tripier' flap). It is usually raised at a level which includes the underlying orbicularis muscle, and in providing cover it has all the virtues already ascribed to upper eyelid skin used as a free skin graft.



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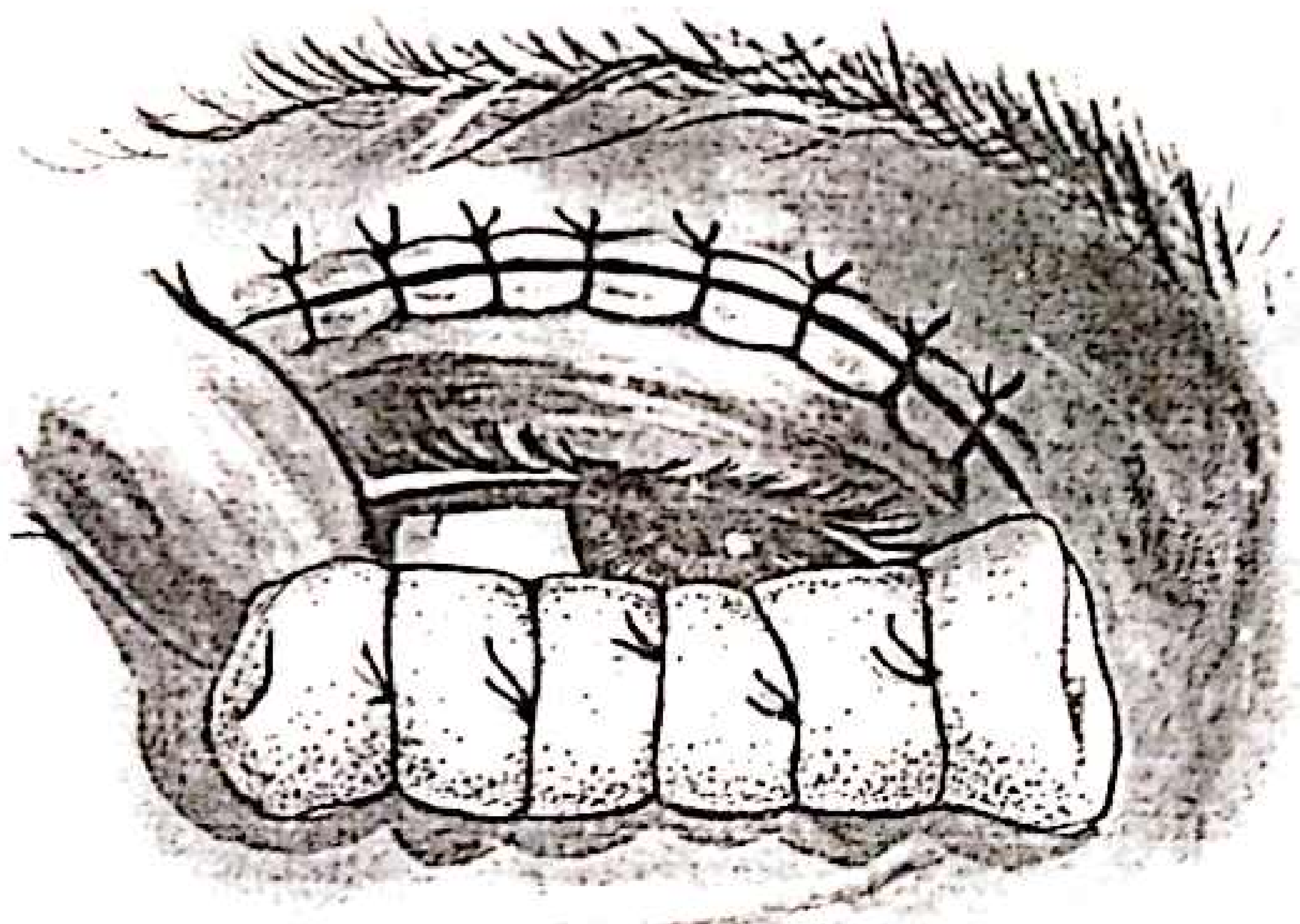
11

Its main use is as a 'bucket handle', swung across the palpebral aperture to provide skin cover for the defect of the lower eyelid which is close to the lid margin. In this form it can provide skin cover from canthus to canthus. The skin raised as the flap is generally lax and transfers readily across the palpebral aperture. The width of flap which can safely be raised depends on the laxity of the upper eyelid skin, and this has to be assessed at the planning stage to allow the secondary defect to be closed directly. Despite its remarkable length:breadth ratio it is an extremely safe flap. In its transferred site the flap tends to tube itself to an undesirable extent but this tendency can be prevented by applying a light 'tie-over' bolus dressing, slightly stretching the flap and at the same time positively untubing it.



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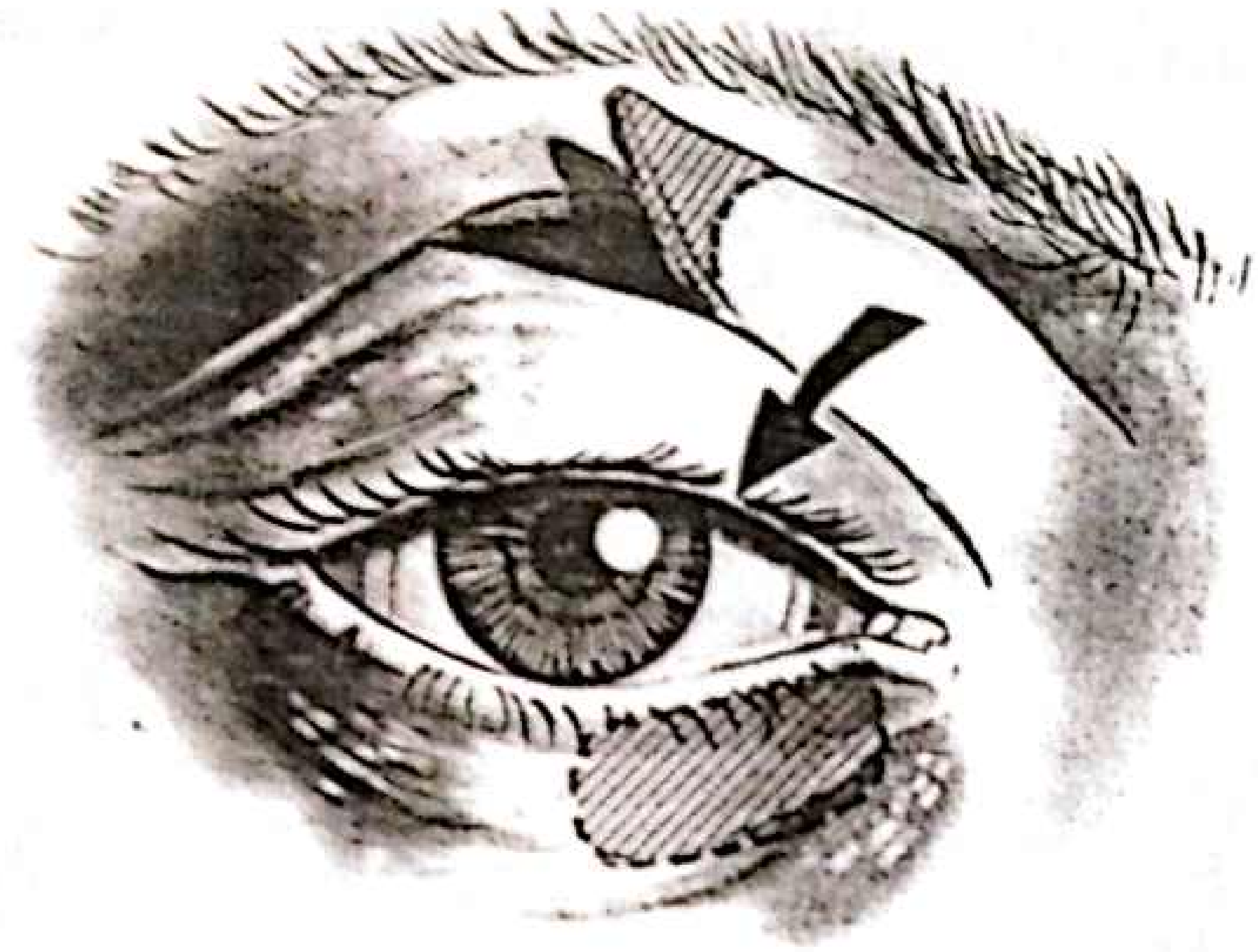

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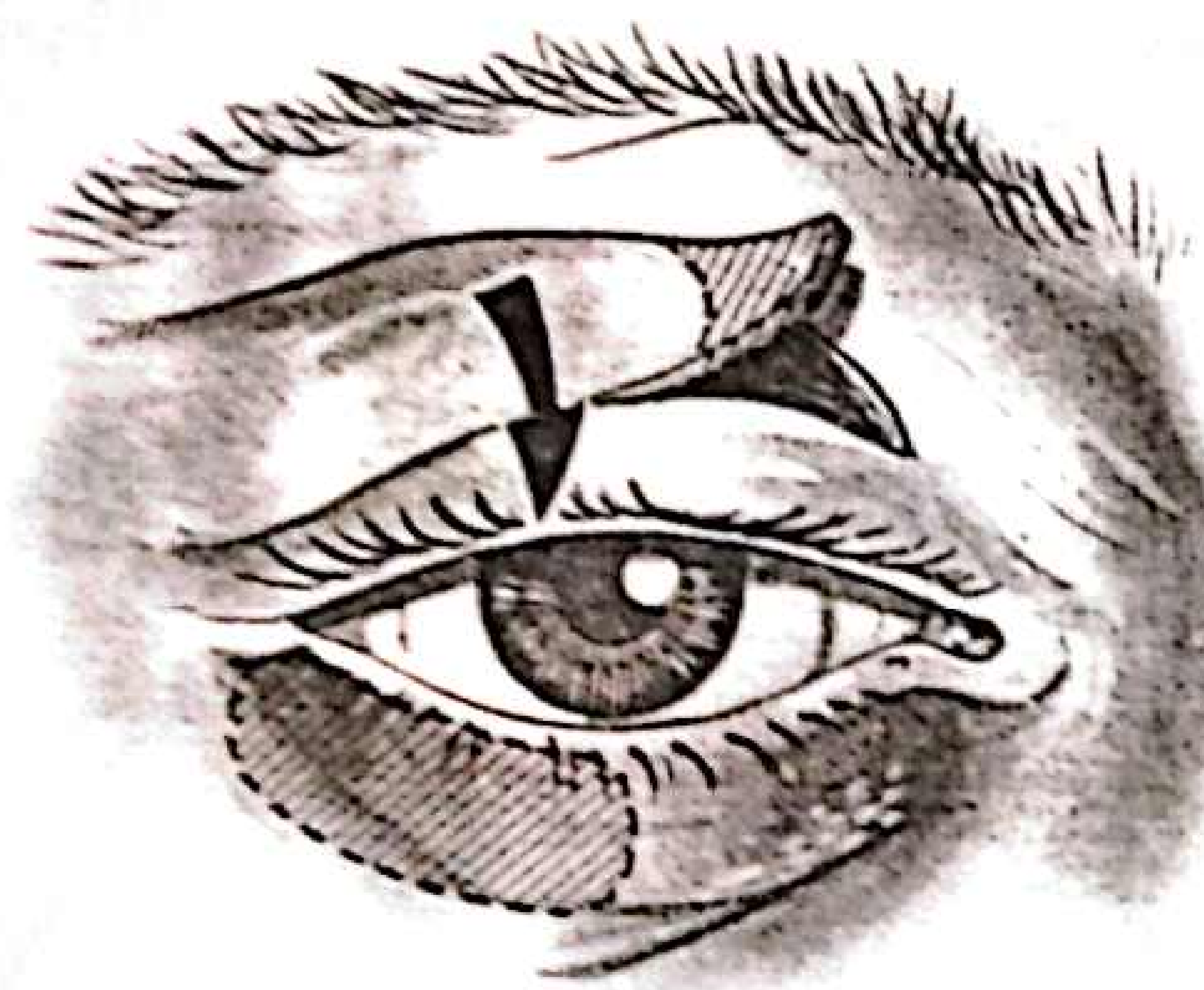

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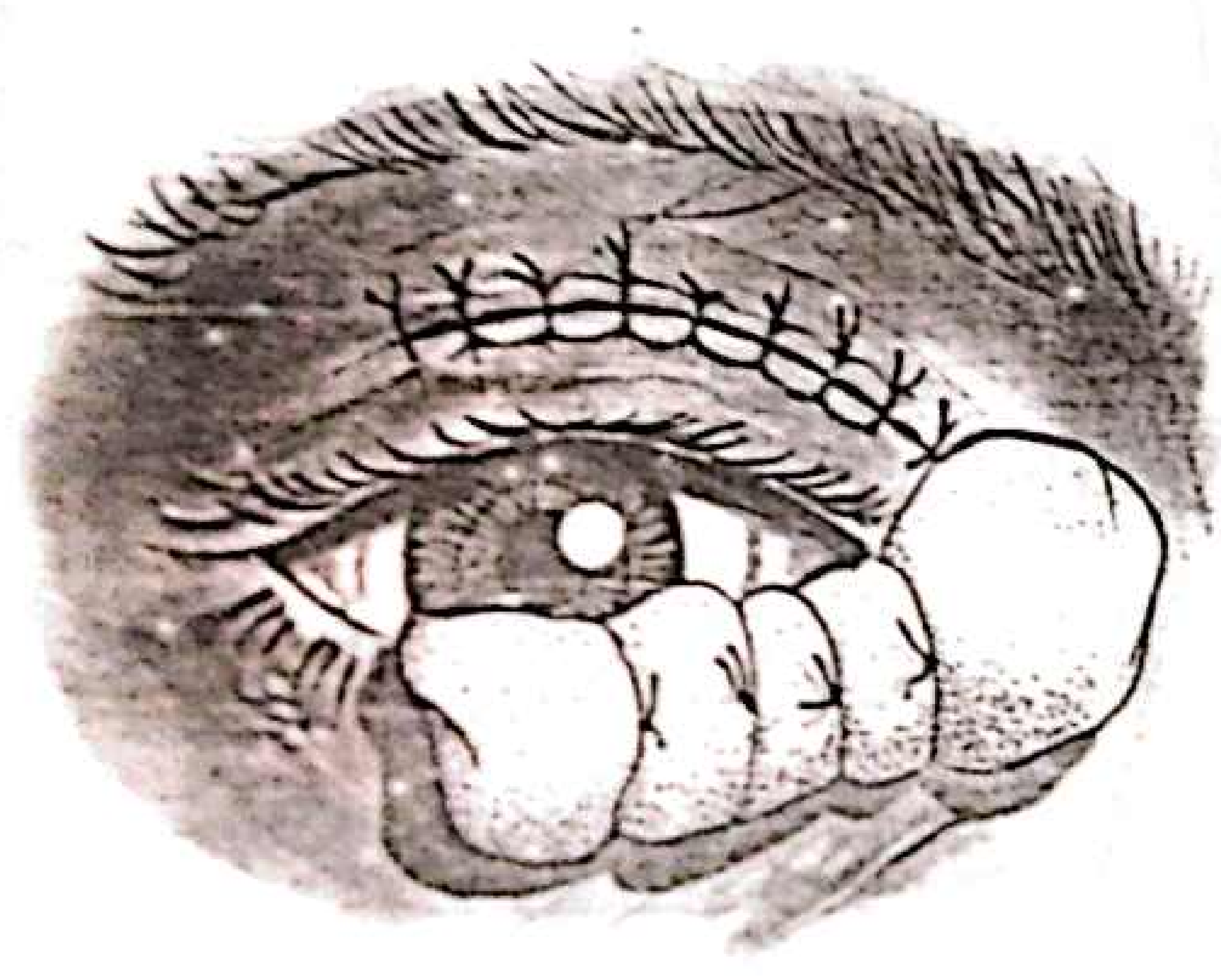

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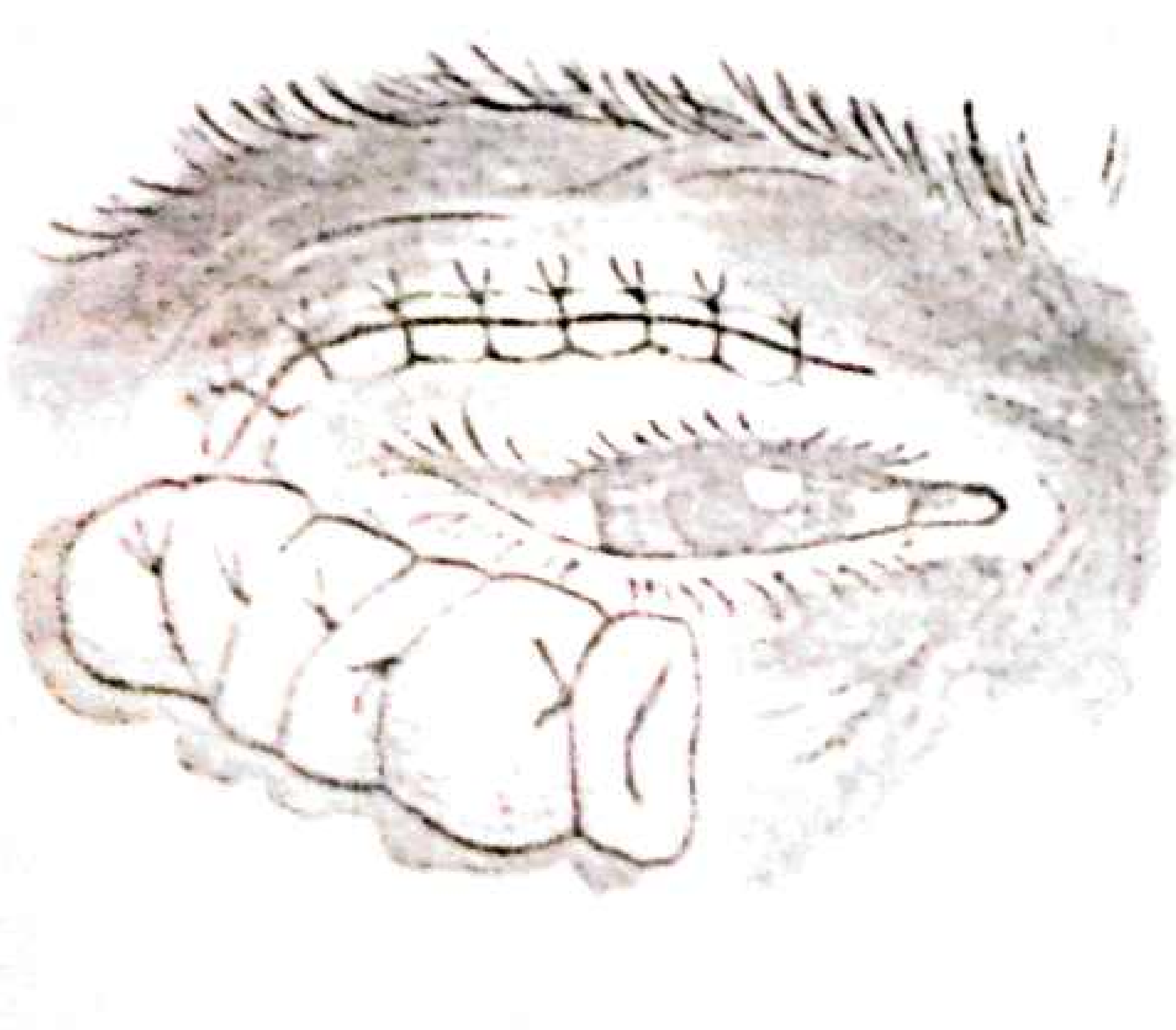

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12–15

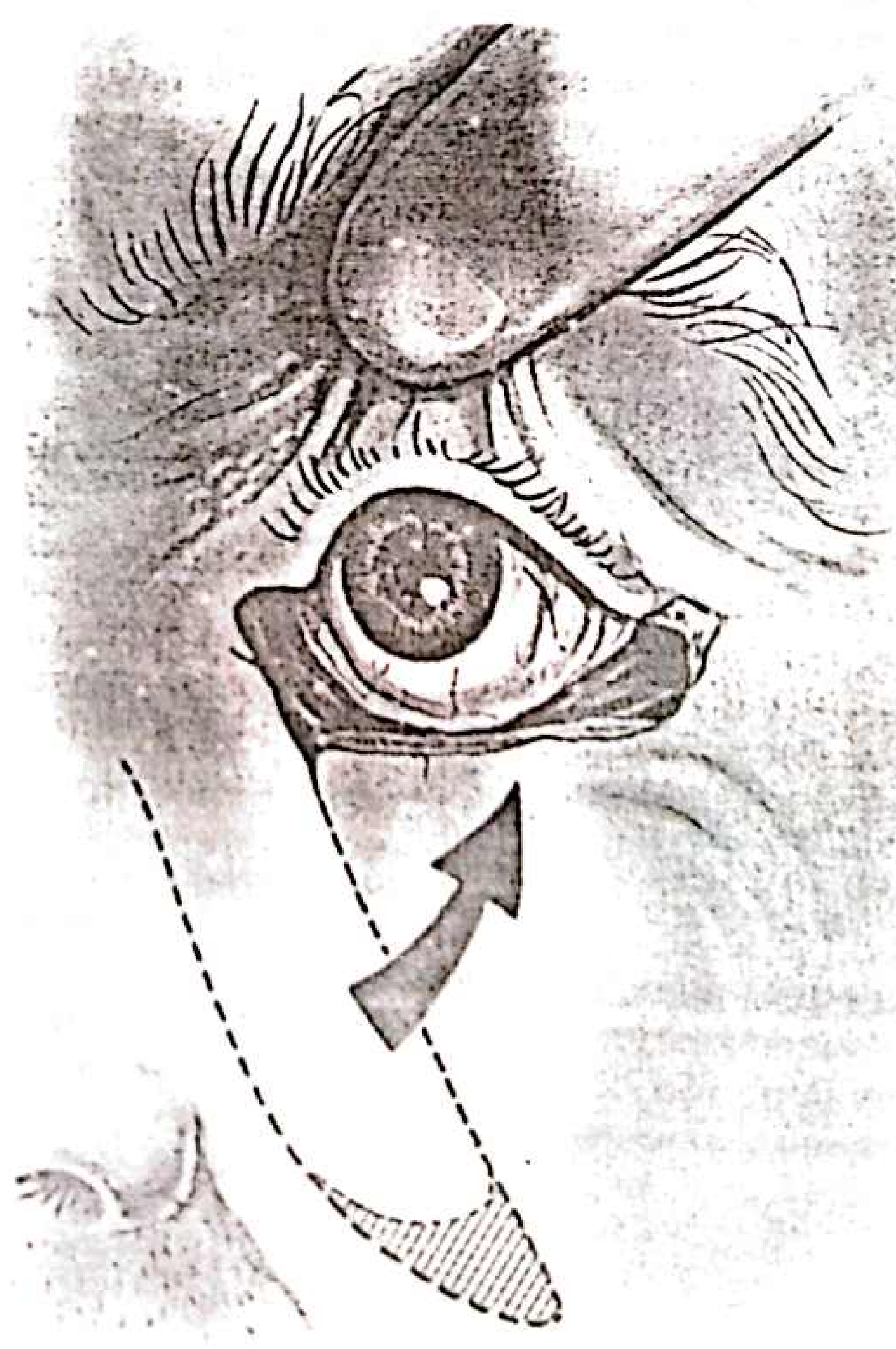
When the defect is limited to one side of the eyelid, medial or lateral, the entire flap length may not be required. In such a situation the flap can be transferred as a 'half' Tripier. A further extension of the technique is as a standard transposed flap. In this last form it is most often used in the medial canthal area, this being the most common site for skin tumours in the eyelid area.

Depending on whether or not the lower lid defect extends to a canthus, the flap may inset entirely into the defect or have a length of non-inset pedicle. The pedicle then tubes itself very rapidly. The pedicle created in this way can be excised secondarily, but it is often unobtrusive and the patient may prefer to leave it alone.

Nasolabial skin

16

The nasolabial area can be used to provide a superiorly based flap using the hairless skin alongside the nasolabial fold. The flap extends upwards towards the medial canthus along the line of the facial artery and angular vein, and is capable of being swung upwards to reconstruct a lower eyelid defect. The flap is a narrow one and the secondary defect can be closed directly.



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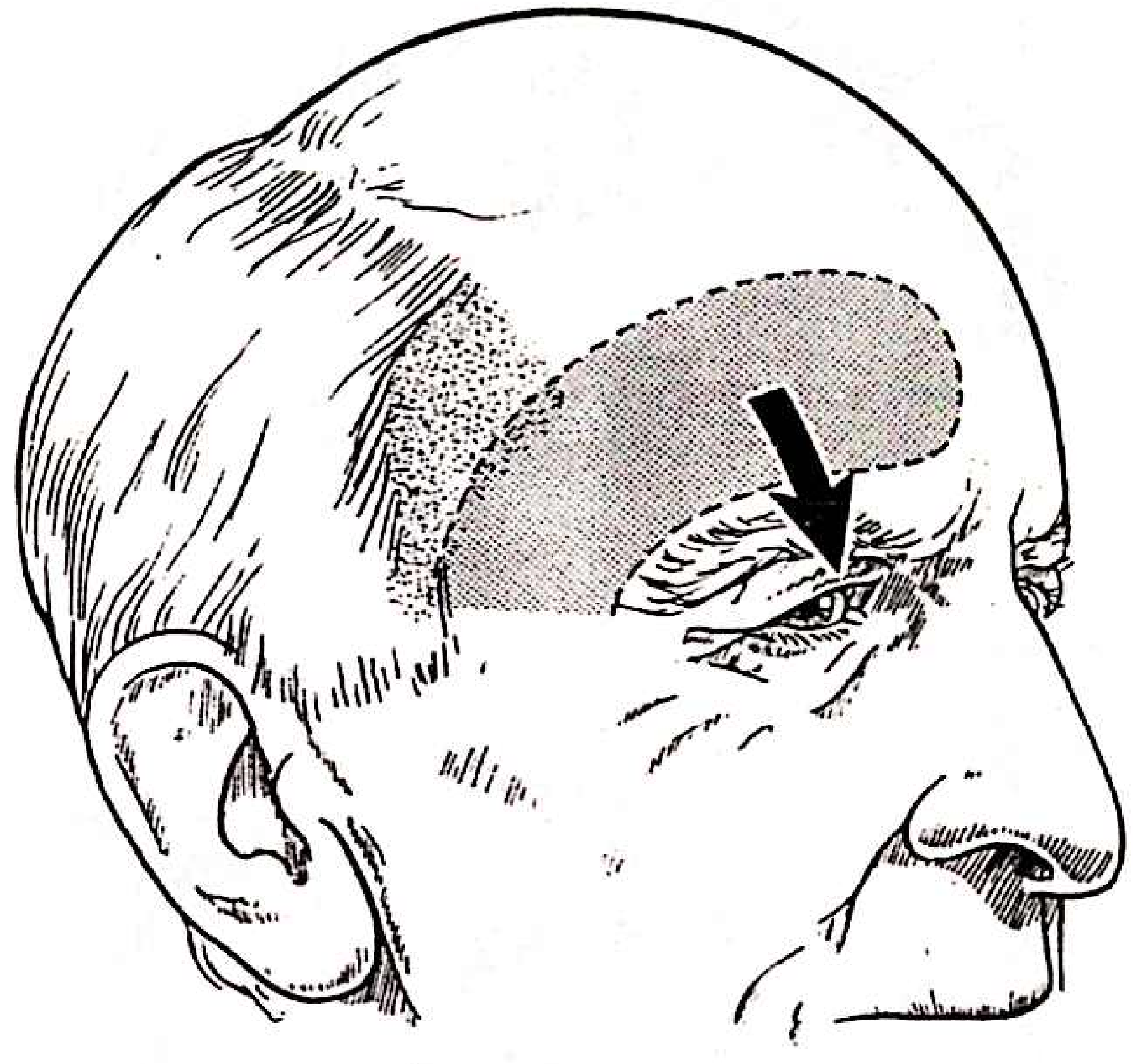
Forehead skin

When the forehead is used as a source of skin to reconstruct defects of the canthi and lower eyelid, the siting and design of the flap vary with the site of the defect.

17

If the defect is predominantly lateral, the flap is based on the temporal area, transferring the hairless skin of forehead or temple. The secondary defect requires a split-skin graft.



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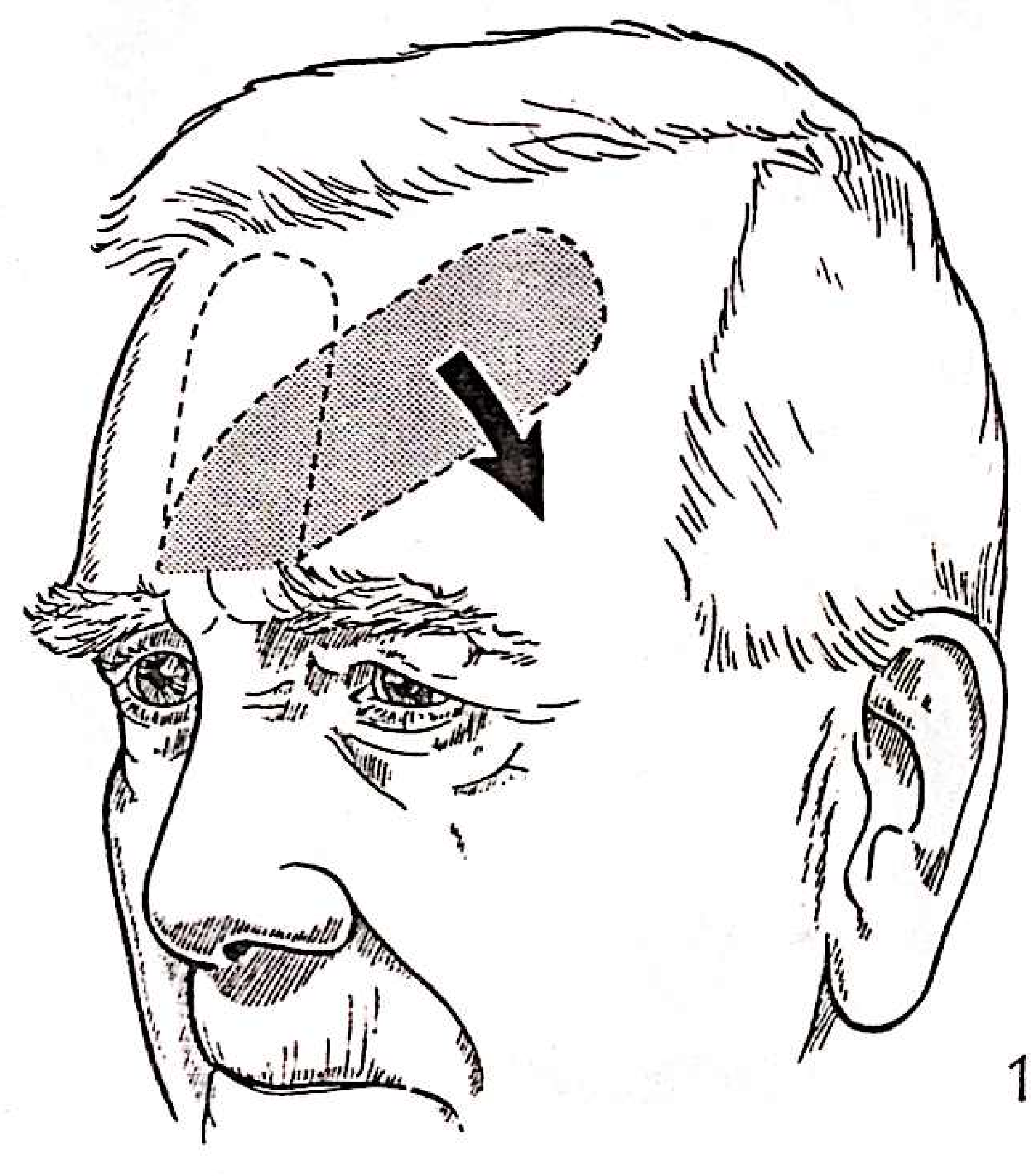
18

If the defect is predominantly medial, a flap based on the glabellar area is used. The flap extends upwards over the forehead and can be either vertical or oblique. The vertical flap is to be preferred, giving a better final cosmetic result as regards the secondary defect on the forehead, but the length of the flap which can be raised is limited by the height of the forehead. The oblique construction is used only when the geometry of the transfer requires a longer flap than the vertical height can provide.



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The secondary defect of the vertical flap is closed directly wherever possible, taking care to match the forehead wrinkle lines. The defect too wide for direct closure is covered with a split-skin graft. The oblique defect cannot be closed directly without distorting the level of the eyebrow, and a split-skin graft is unavoidable.

Division of the pedicle with insetting of the flap and return of its bridge segment, or excision of the pedicle, are nearly always required as a second stage to the procedure. With the oblique construction this involves excision of part of the temporary graft to allow return of the bridge segment; with the vertical construction the greater part of the pedicle is generally discarded.

Both the nasolabial and forehead sources are less than entirely satisfactory when used to reconstruct defects of the lower eyelid. The skin which they provide is thick and immobile, even thinned as much as possible at the time or subsequently. They should only be used in the absence of an alternative, usually when the defect extends beyond the confines of the eyelid and no alternative local source can provide the area of tissue required.

The glabellar-based flap is used most frequently in reconstructing the defect which follows resection of a deeply penetrating tumour of the medial canthal area which involves not merely the canthus but also the eyelids towards their medial extremity. In such circumstances the need for mobility does not assume the importance which it does in the upper lid, and there is rarely any obvious alternative source where the need for a flap arises.

Provision of conjunctival lining

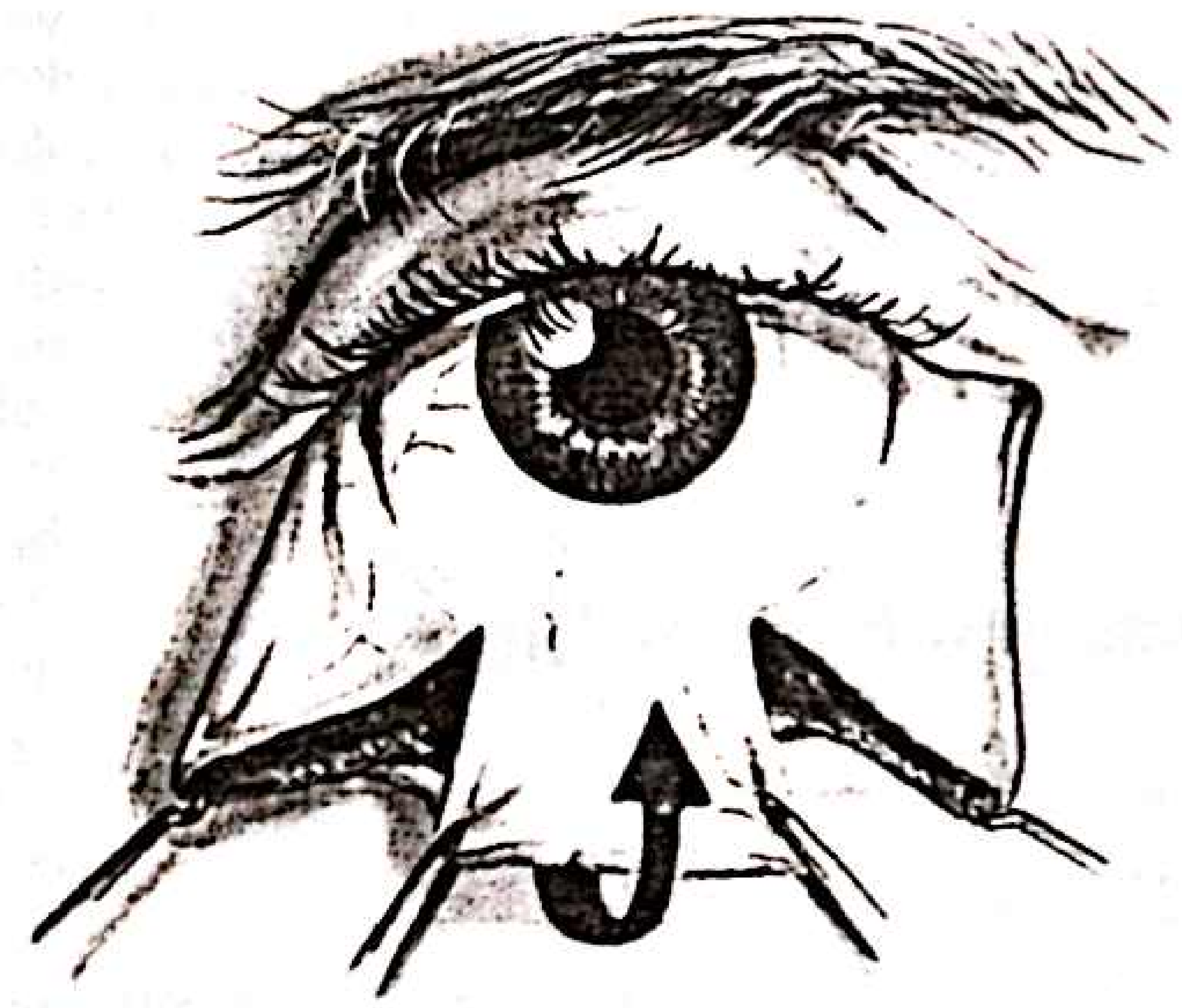
Conjuctiva which is lost in the process of tumour excision is made good either by adjusting the conjunctiva which remains or by replacing it with a mucosal graft.

Conjunctival adjustment

19–22

In adjusting the conjunctiva, use is made of the slack which is present in the inferior and lateral fornices. This slack allows conjunctiva to be advanced to line eyelid surfaces which would otherwise be bare of lining. Outwith the tarsal plate the conjunctiva is only loosely attached deeply and it can be elevated and mobilized as a distinct layer even beyond the fornix, onto the eyeball if necessary (*Illustrations 19, 20* show advancement in the centre of the eyelid; *21, 22* at the canthal area). On the sclera it becomes a filmy tenuous structure, but even there it can be mobilized as far as the limbus. Along the line of the lower fornix fascial strands attach the fornical conjunctiva to the inferior rectus muscle and these may have to be divided to allow advancement to take place. Initially the advancement takes up the fornical slack; further advancement reduces the depth of the fornix.

The extent to which conjunctiva can be advanced is limited, and it does tend subsequently to revert to its original site, reducing the value of the method.



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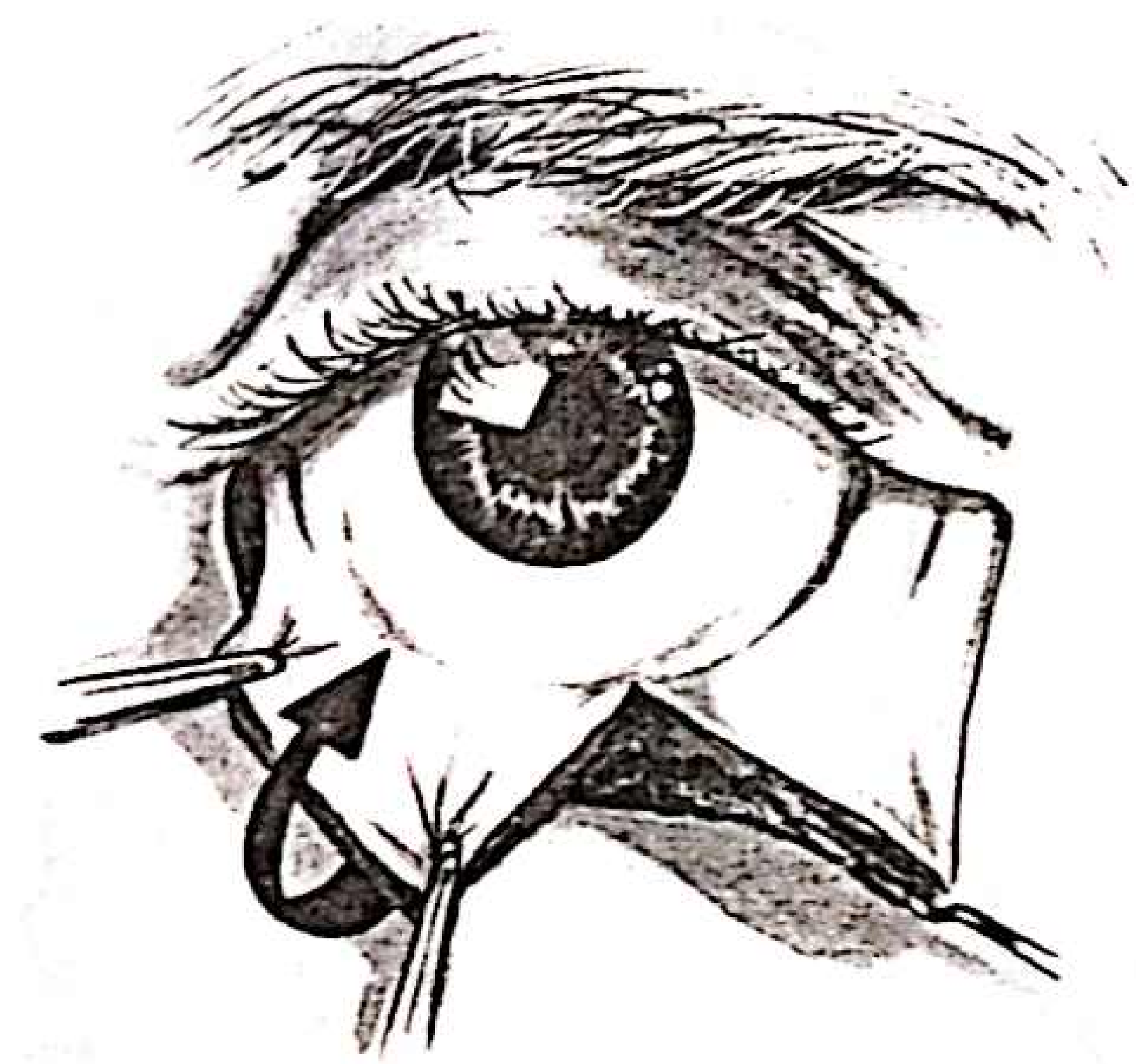

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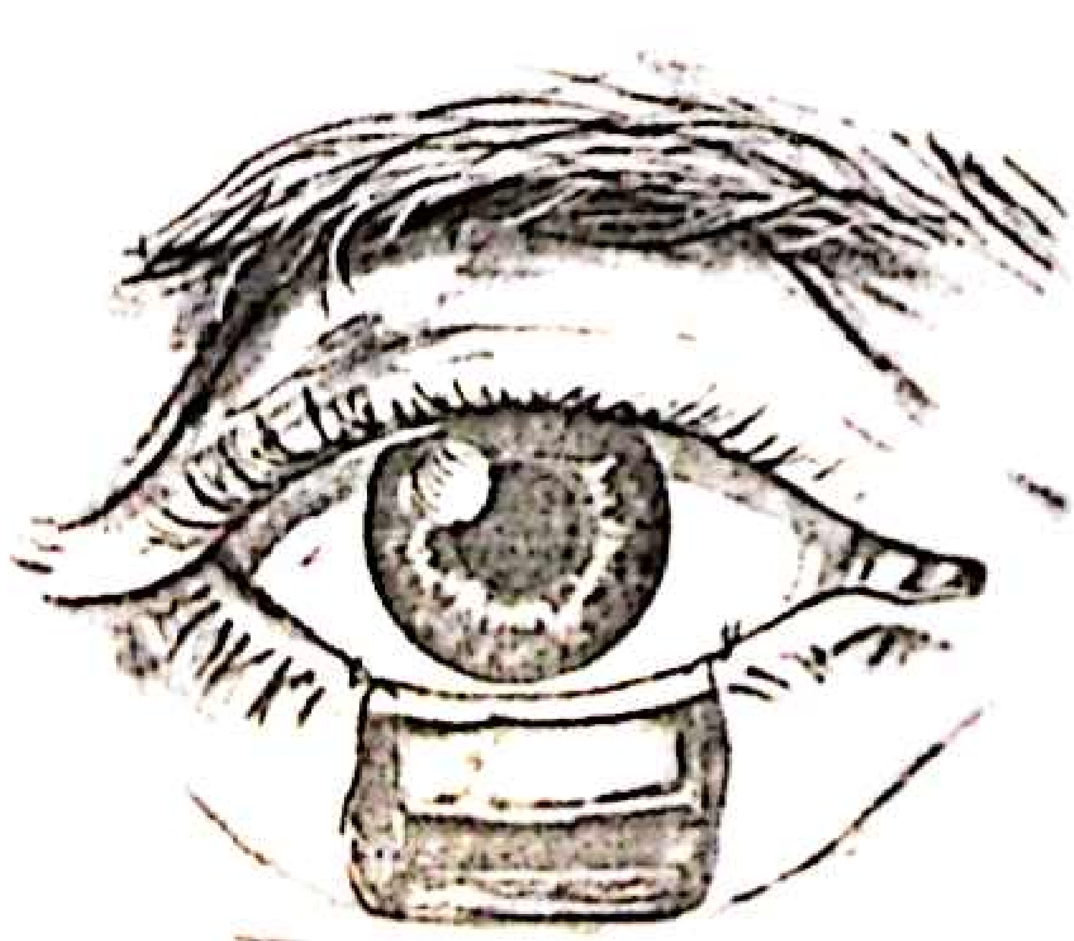

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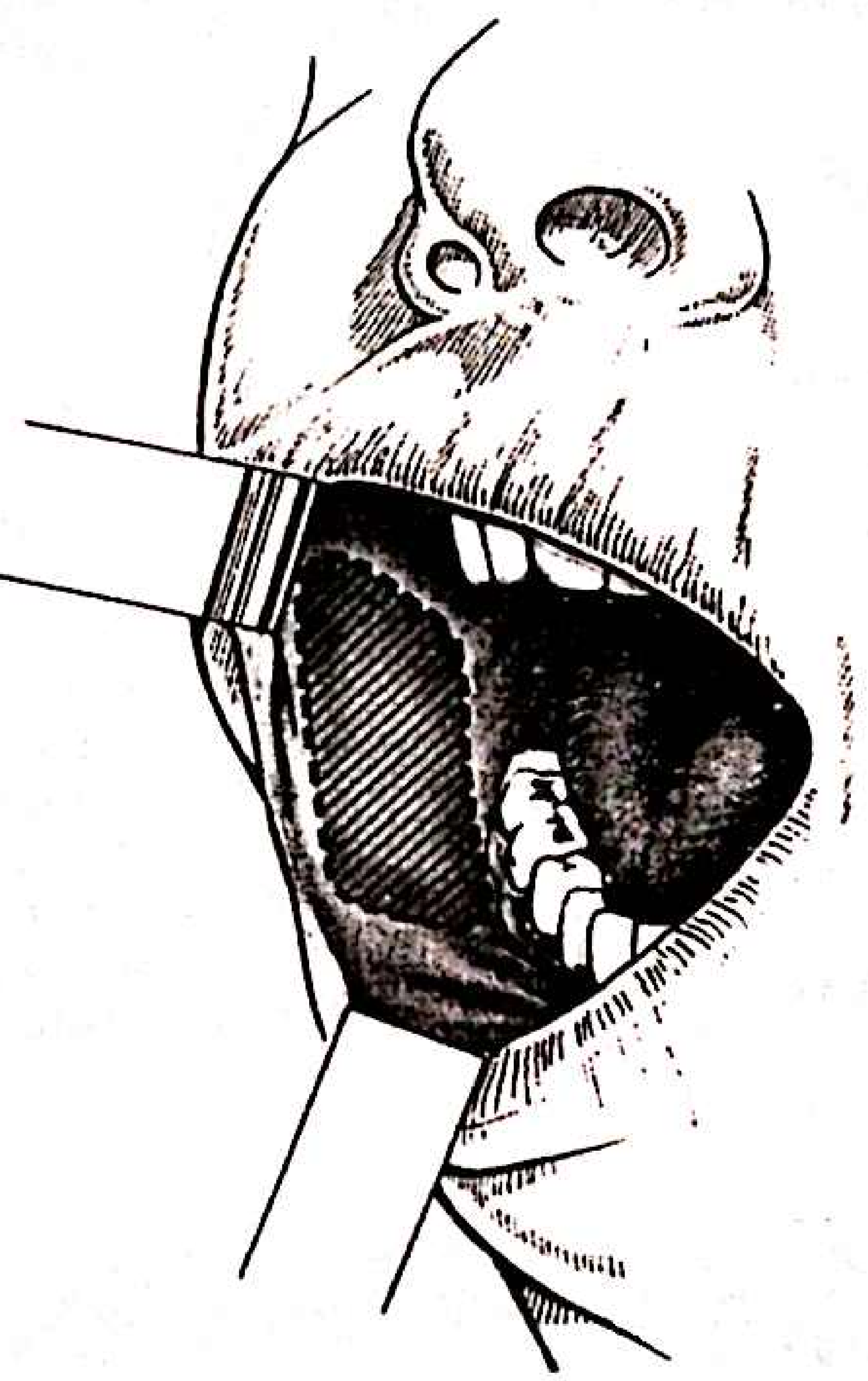
22

Mucous membrane grafting

Mucosal grafts are tolerated well by the cornea, and they can be harvested from the oral cavity or the septal mucosa. They function equally well as replacements for conjunctiva, and selection is based on whether conjunctiva alone requires replacement or conjunctiva together with a supporting structure is required. In the latter instance the two can be transferred together as a chondromucosal graft.

23

When oral mucosa is used as the graft source it is usually taken from the buccolabial area. The graft should be thinned, not to make for easier take, but to provide a more effective colour match for the resected conjunctiva. Unthinned, it retains some of the pink colour of oral mucosa and when exposed on the eyeball looks distinctly odd.



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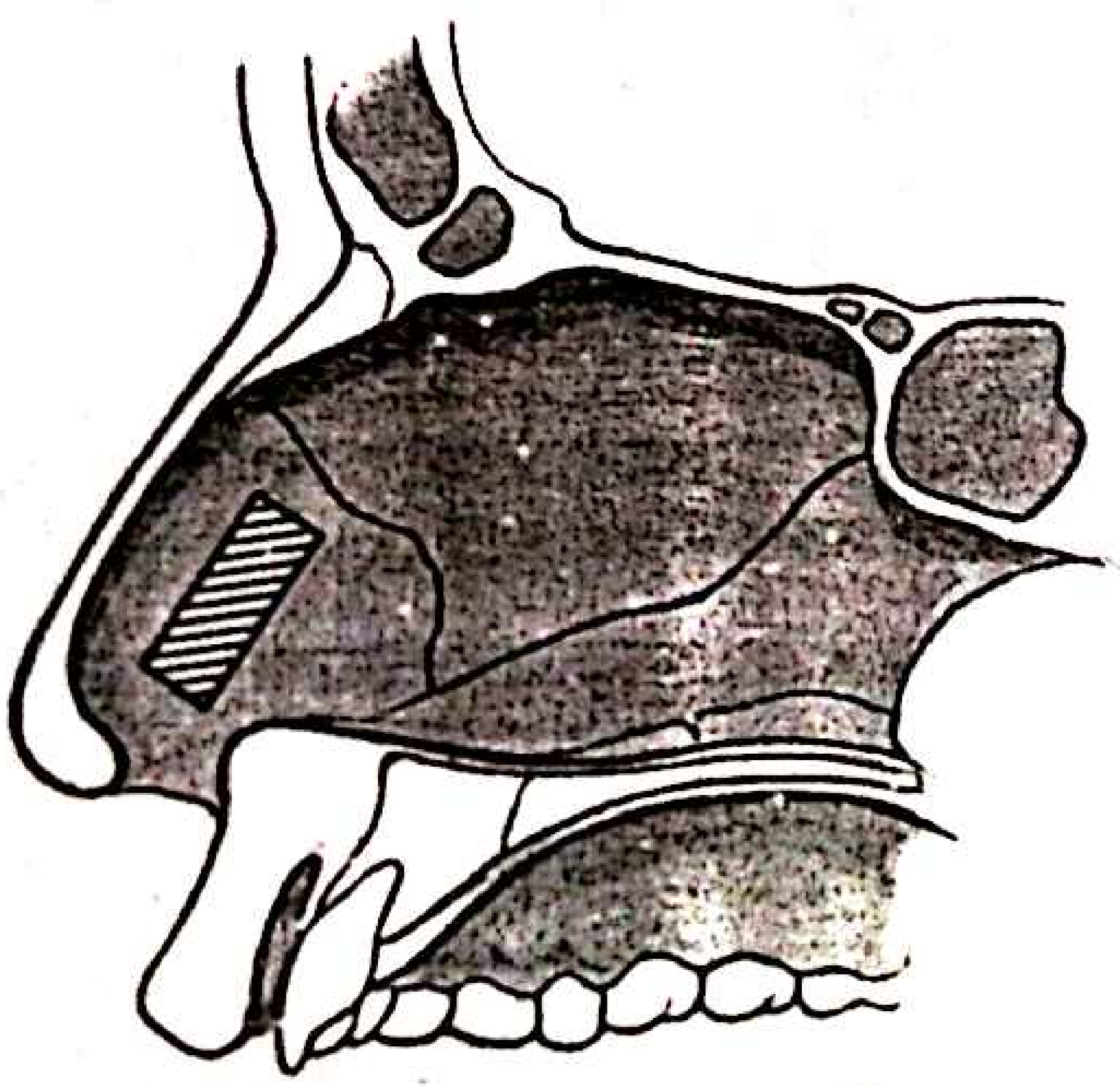


24

Eyelid support with mucosal lining

24

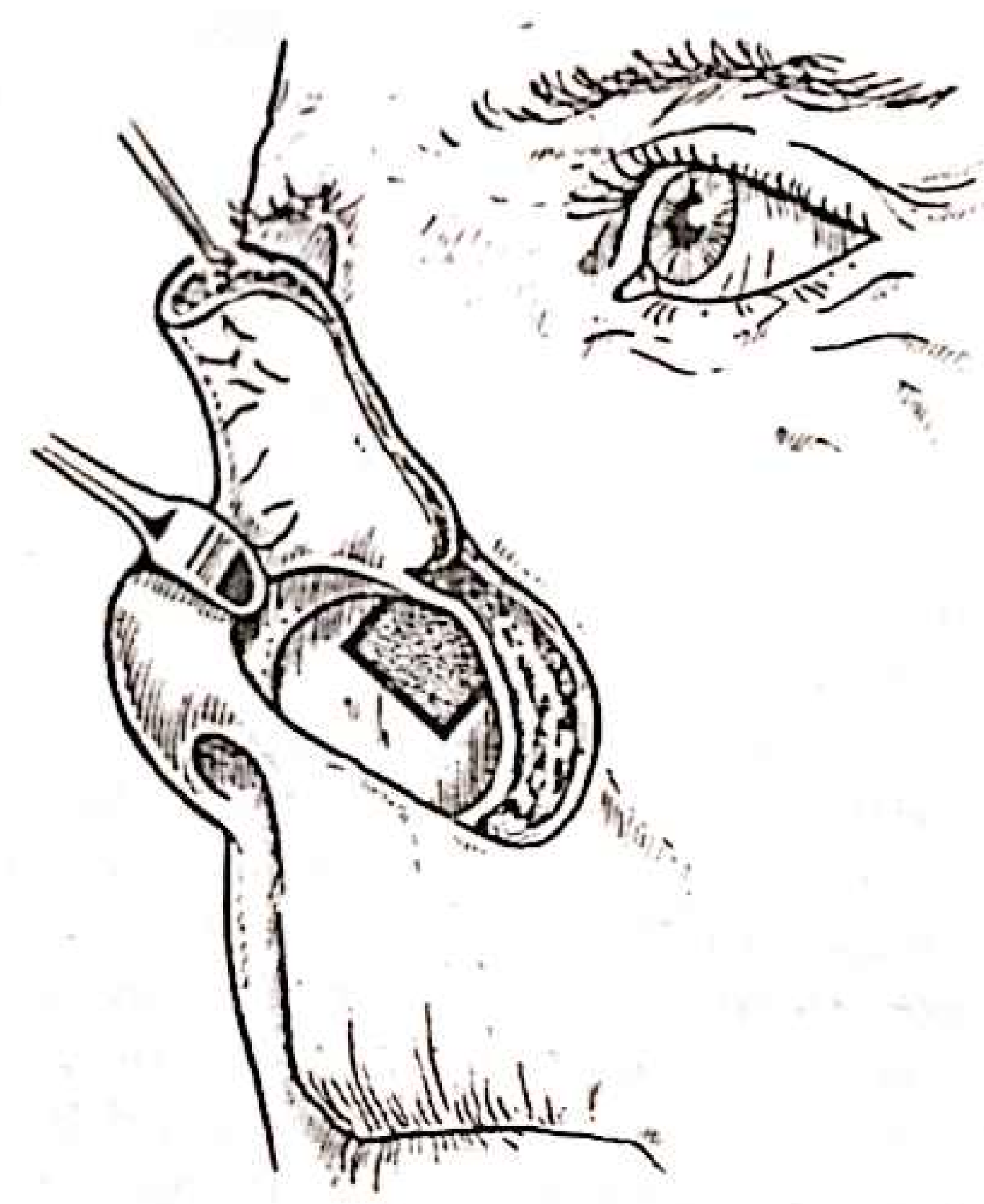
When it is considered that a proposed reconstruction will lack sufficient rigidity to prevent ectropion developing under the influence of gravity, the composite chondromucosal graft harvested from the anterior nasal septum functions extremely well, providing both support and lining simultaneously.

25

25, 26 & 27

Access to the septum is provided by elevating the ala of the nose surgically on the chosen side. The alar base is detached by a full thickness incision which externally follows the line demarcating nose from cheek, and curves anteriorly to follow the hollow created by the gap between the alar and lateral nasal cartilages. Internally the incision follows the shelf between the two cartilages.

Within the area of the cartilaginous nasal septum a site is selected which leaves an adequate width of septal cartilage anteriorly so that continuing nasal support is maintained. At least 1 cm of septum should be left anterior to the donor area. The initial incision in the septum is made through mucosa and cartilage, and the composite of mucosa and septal cartilage is stripped from the mucoperichondrium of the contralateral nostril over the entire extent of the graft. Freed deeply in this way the graft can be removed by making the remaining marginal incisions. The graft, as harvested, consists of a strip a little less than 1 cm wide and as long as is required to match the horizontal width of the eyelid defect. A nasal pack is inserted and the mucosal defect is allowed to heal spontaneously.



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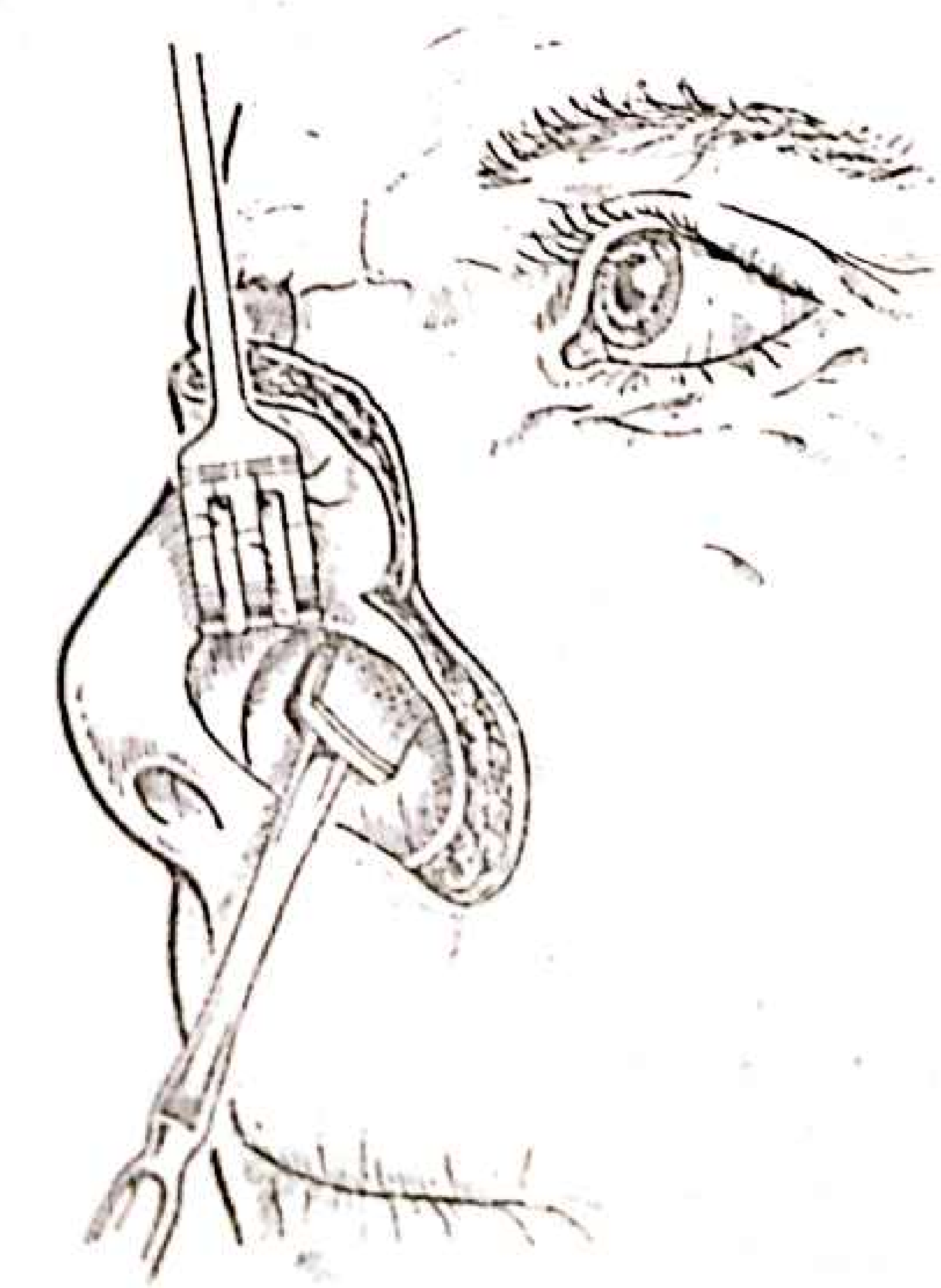

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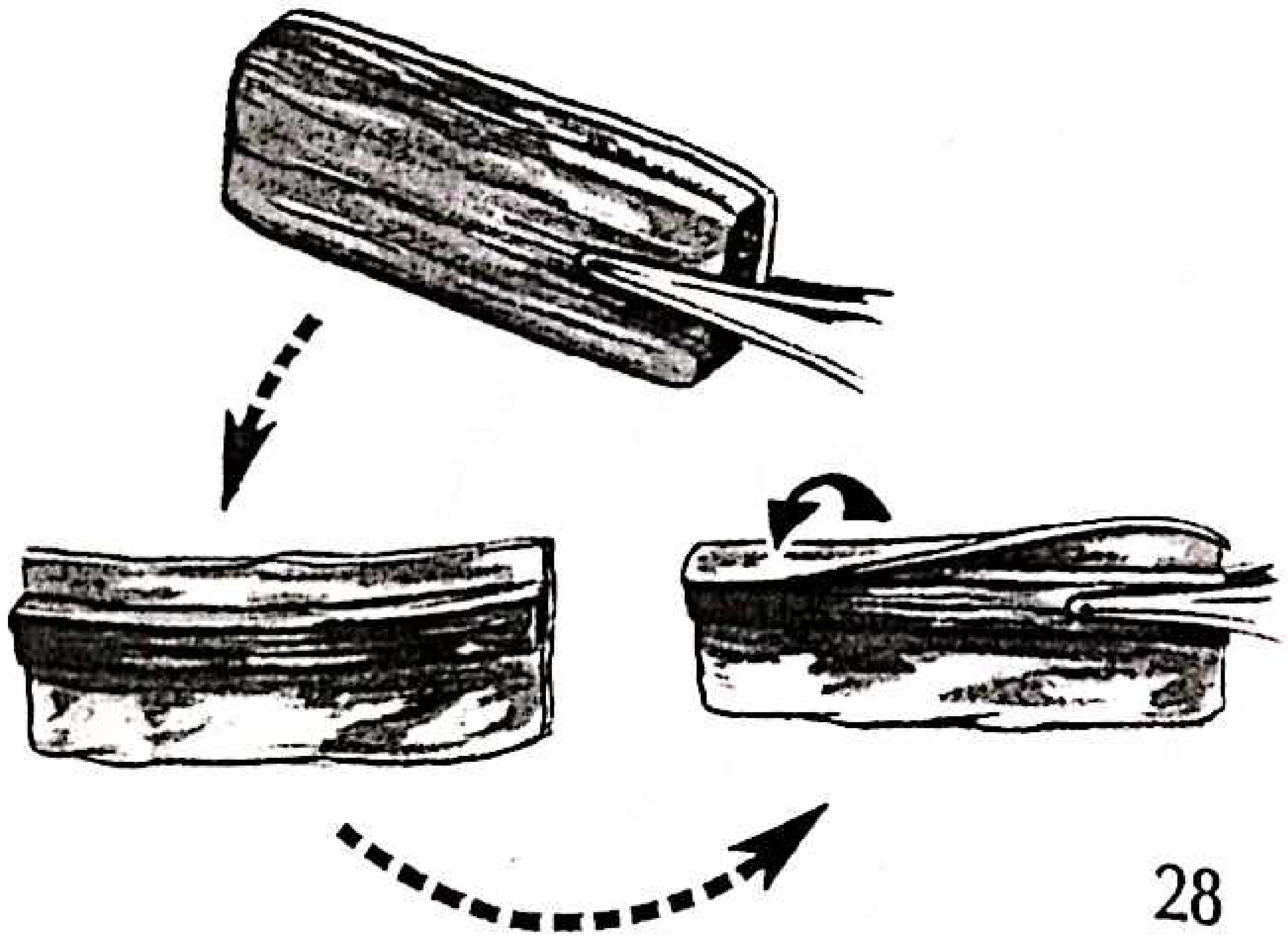

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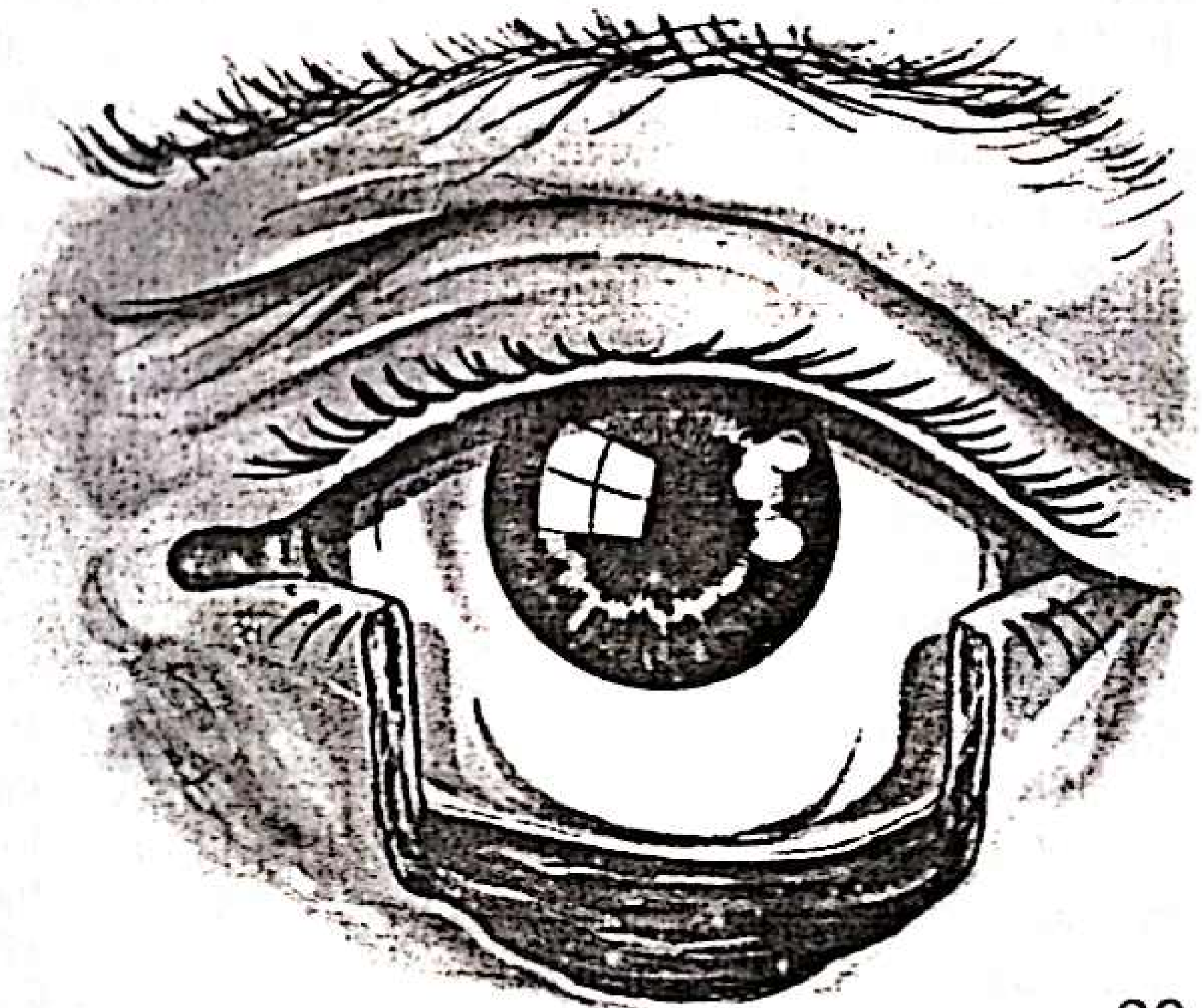
28, 29 & 30

The cartilage component of the graft removed in this way is inappropriate both in area and in thickness, a strip 3–4 mm in width being sufficient to provide support. The unwanted excess should be trimmed away so that a mucosal rim of overlap is left on one side and the bulk of the mucosal graft on the other. The provision of a mucosal rim in this way allows the mucosa to overlie the edge of the cartilage graft in its reconstructing position and provide the margin of the reconstructed eyelid so that the skin component of the reconstruction is kept from contact with the globe. Reduction of the cartilage in this way also increases the area of mucosa available to be revascularized and makes 'take' more certain.

The cartilage is also thinned. The biomechanical properties of cartilage are such that thinning has the incidental, but extremely valuable, effect of creating distortion of its shape. In the process of being thinned the strip of cartilage develops a gentle concavity which matches the curve of the eyeball. This useful distortion develops even when the cartilage was initially distorted in the opposite direction owing to a pre-existing septal deviation.



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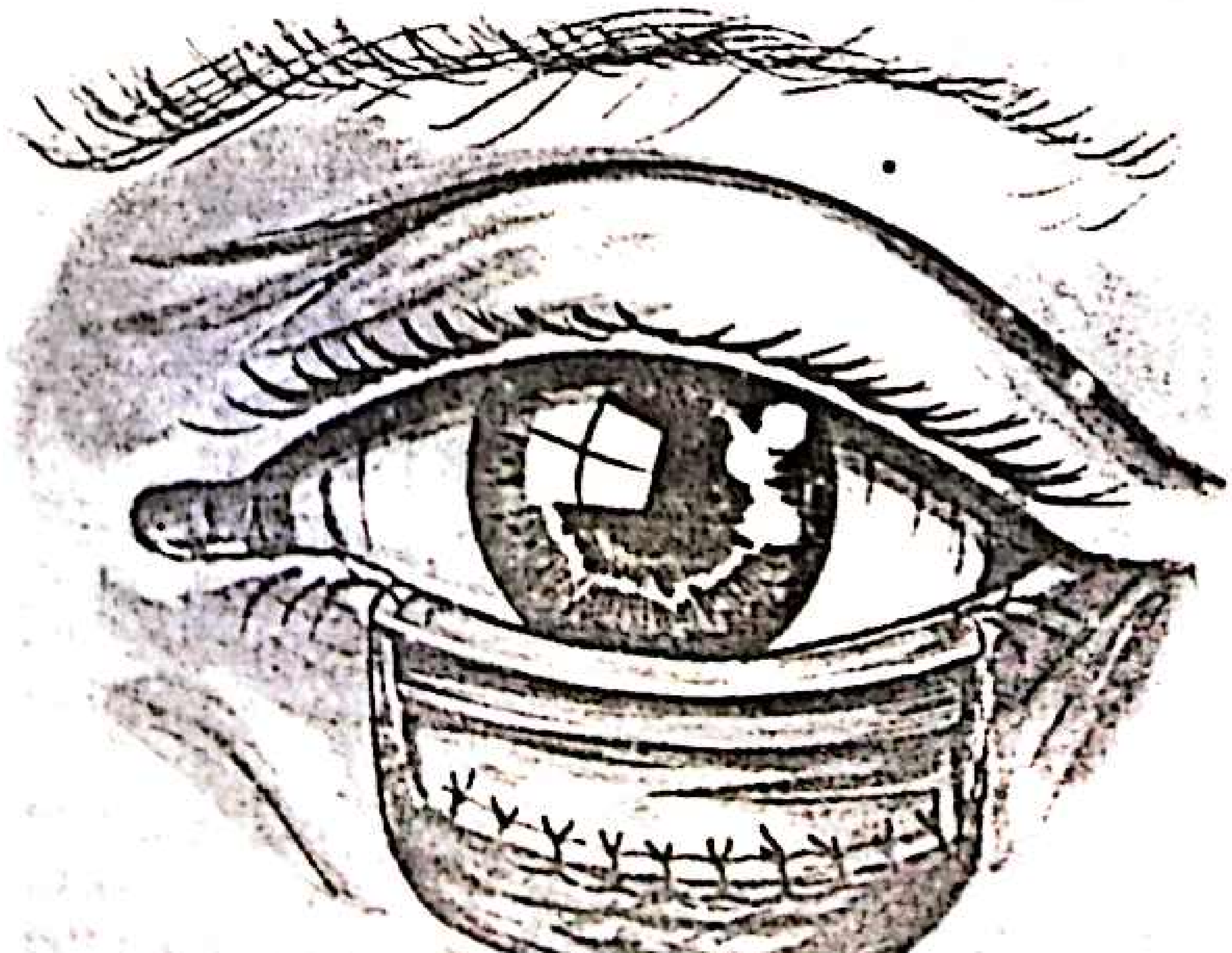

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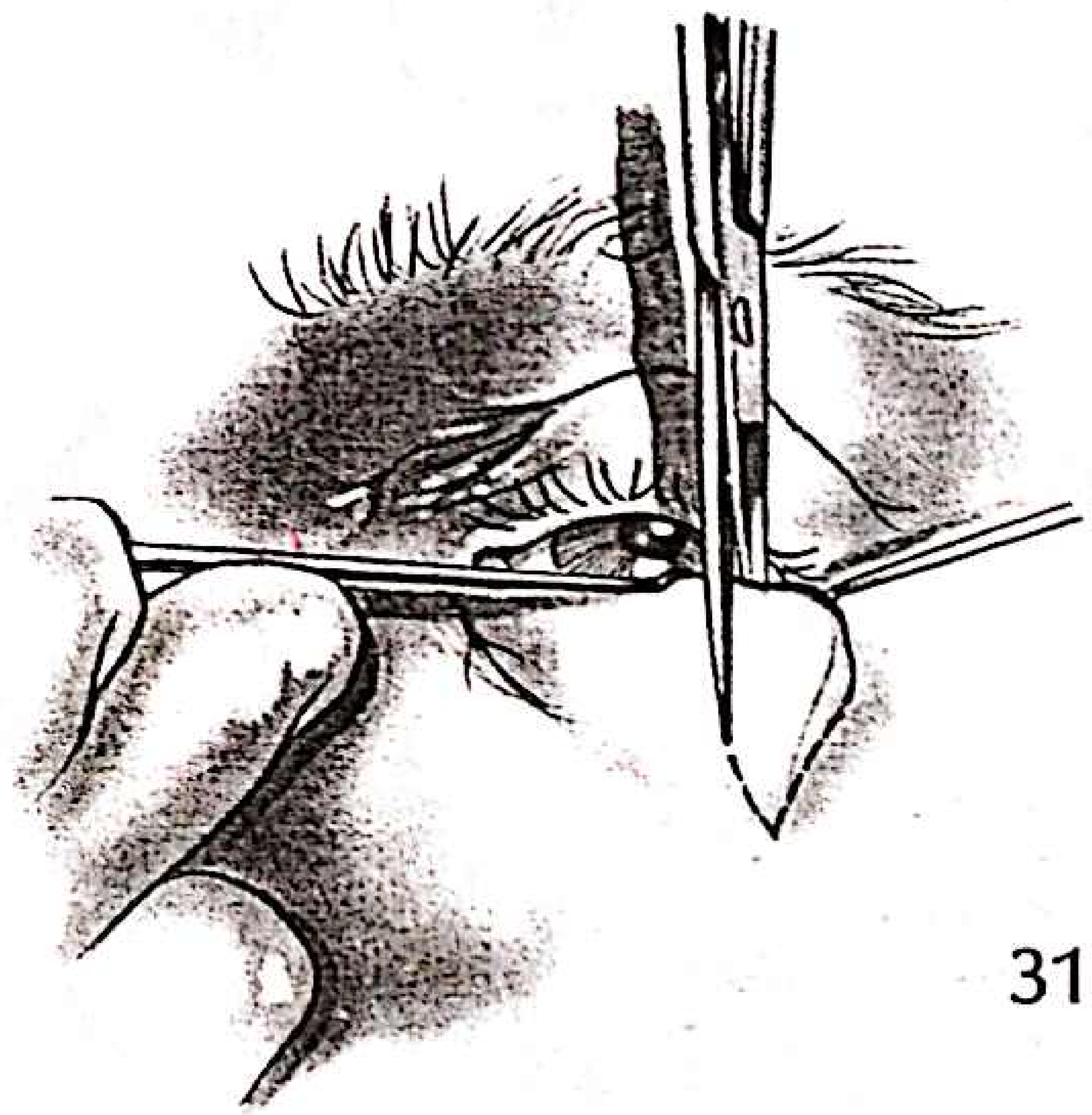
Full thickness defects

The postexcisional defects involving the full thickness of the eyelids which occur with any frequency fall into four groups according to site – the lower and upper eyelids, and the medial and lateral canthi. Occasionally two of these sites are involved simultaneously, but the more important of the two is generally apparent and dictates the type of reconstruction used.

Tumours which involve the eyelids usually spread predominantly either horizontally (parallel to the lid margin) or vertically. The reconstruction developed to manage the defects created by excision of tumours which have spread in these two distinct ways dictate the shape of the defect that the surgeon creates beyond the strict needs of pathological clearance of the tumour. In the horizontally spreading tumour the defect is made in the form of a rectangle; in the vertically spreading tumour it is made in the form of a V. The reconstructions used for the rectangular defect are applicable only to the lower eyelid; those described for the V-shaped defect can be used in both the lower and the upper eyelid.

31

To make the V-defect, which involves dividing the full thickness of the eyelid, a clean cut which severs the conjunctiva, tarsal plate and skin at the same level, is best achieved by using sharp pointed scissors, with the lid on each side of the cut supported with skin hooks. The skin is generally so mobile on the tarsal plate that cutting in the standard way using a scalpel tends to result in a less tidy cut.



31

The lower eyelid

Rectangular defects

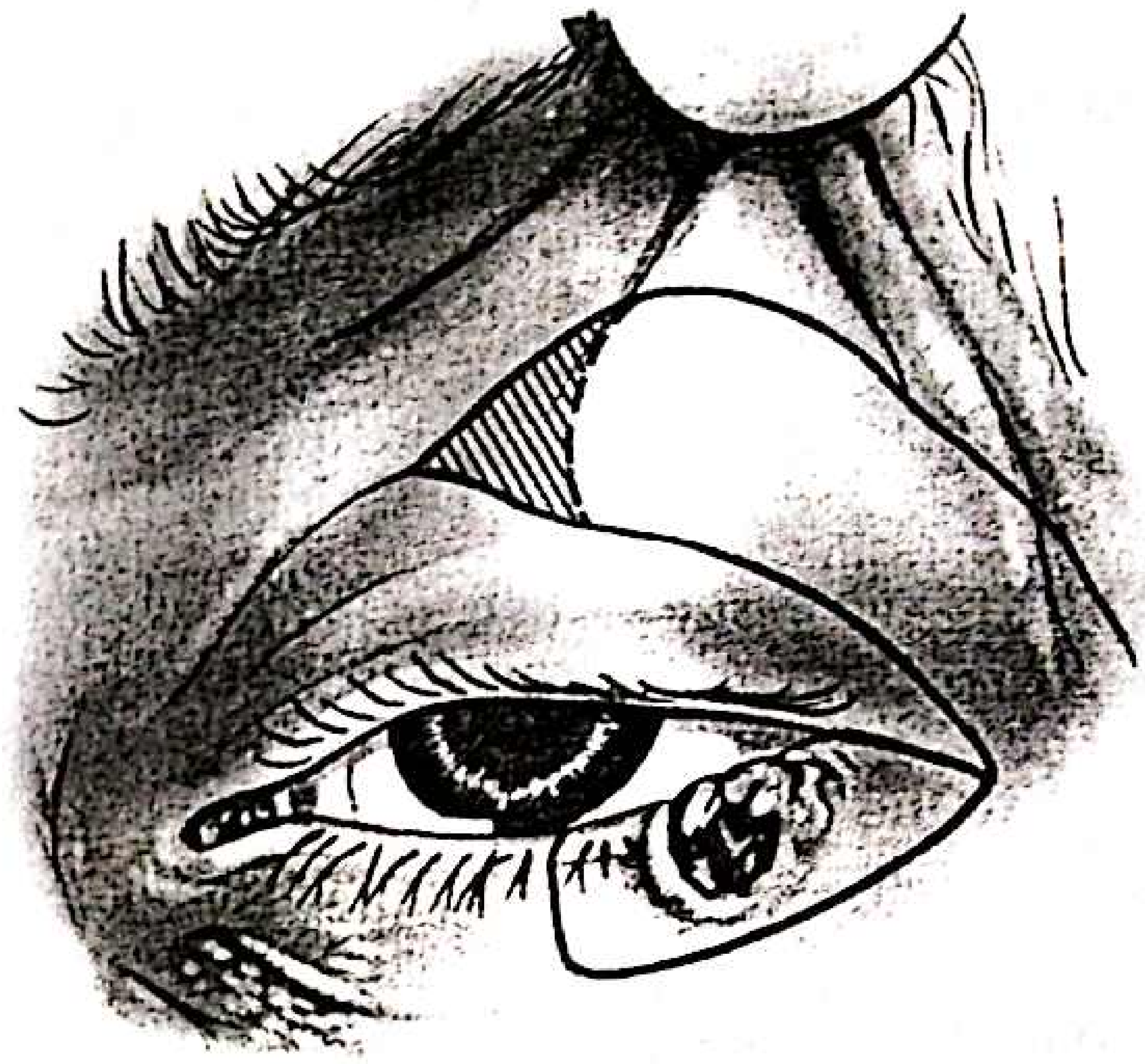
The reconstruction of a rectangular defect involves the provision of conjunctival lining and skin cover. A supporting structure to reproduce the function of the resected tarsal plate may also be required if the skin replacement lacks sufficient inherent rigidity to maintain the lid unaided. The skin provided by forehead and nasolabial flaps has such rigidity; the Tripier flap has virtually no inherent rigidity and when it is used the provision of a supporting structure has to be considered. It must be stressed that, even when a Tripier flap is used, provision of support is desirable rather than essential. However, in its absence drooping of the reconstructed lid is likely to develop once the postoperative reaction has settled and the tissues have softened.

It is not always essential when carrying out the resection to excise conjunctiva at the same level as the skin. Tumours arising in the skin of the eyelids can reach the conjunctiva either by spreading deeply through the substance of the lid or by spreading marginally round the lid margin. In the former mode of spread, skin and conjunctiva generally have to be resected at the same level; in the latter mode, the level of the margin of the tumour on the skin may be quite different from the margin on the conjunctiva. The marginal form of spread is commoner, particularly with basal cell carcinoma, and it is often possible to conserve conjunctiva by resecting skin and conjunctiva at different levels.

Conjunctival lining can be provided by advancing the remaining conjunctiva or by using a mucosal graft. Assuming a reconstruction that makes use of a Tripier flap, deciding which method of providing lining to use depends on how much of the eyelid has been resected horizontally and how much conjunctiva has been resected vertically, although the latter is less significant in practice. The greater the width of eyelid resected, the less tarsal plate is left to provide support and the greater the need to introduce support as an element of the reconstruction. When more than half of the eyelid has been resected, support is desirable; when less than half has been resected, it is less necessary. When doubt exists in the mind of the surgeon concerning whether advancement of the conjunctiva will be adequate to provide lining, it is well to remember that generally a better long-term result will be obtained if the conjunctival defect is reconstructed with a mucosal graft.

32–36

When the decision is made that conjunctival advancement will provide adequate lining, the advancement is carried out as already described (see *Illustrations 19–22*), according to whether the defect is of the central segment of the eyelid or extends to one or other canthus, and a suture is inserted holding the lid conjunctiva in its advanced position to the lid margin at the resection edge. A Tripier flap of appropriate dimensions is designed on the upper eyelid and swung down to provide the skin cover. Some of the sutures holding the flap in position along its upper and lower margins are left long and tied lightly over a bolus of flavine wool.



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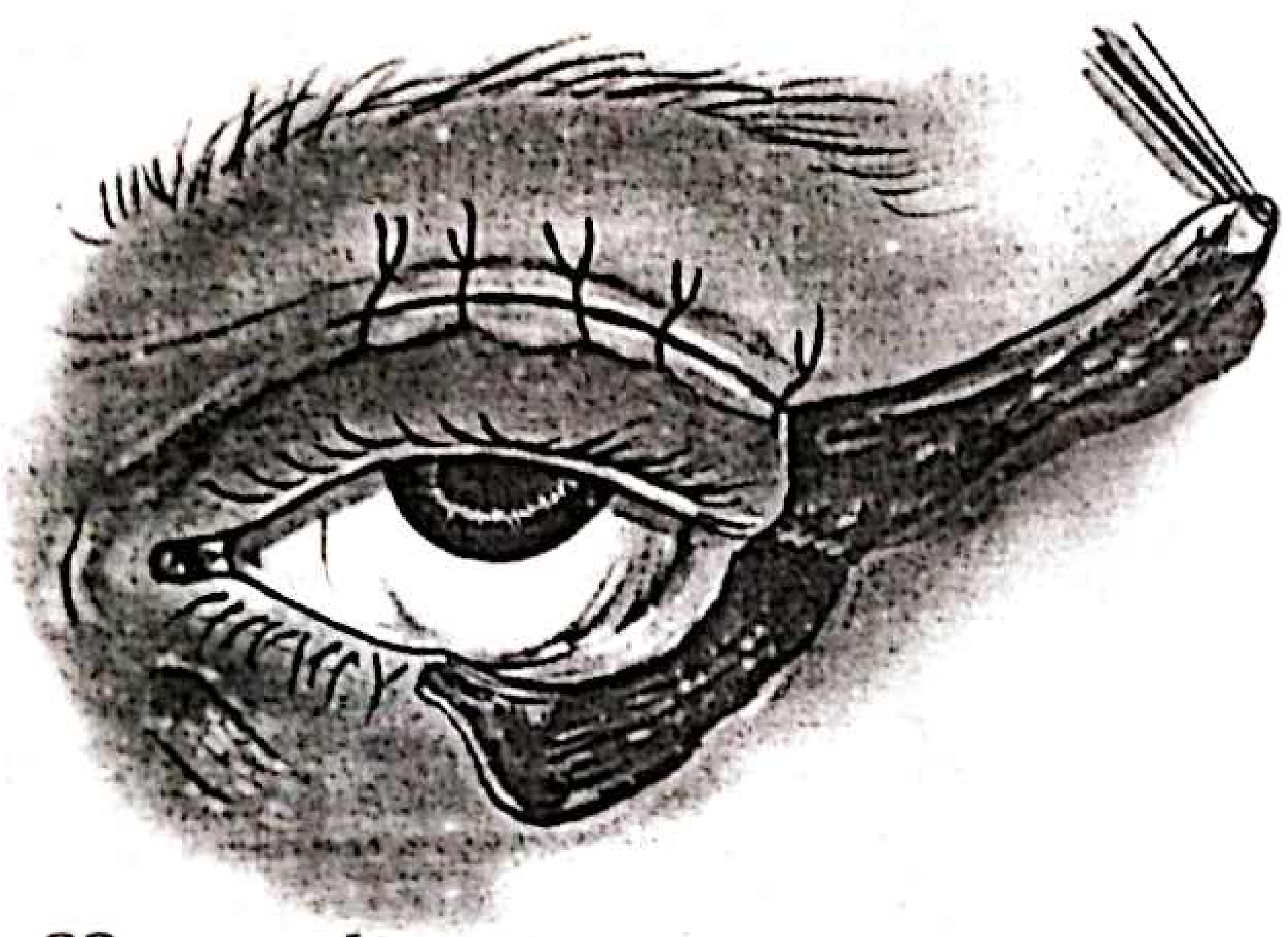

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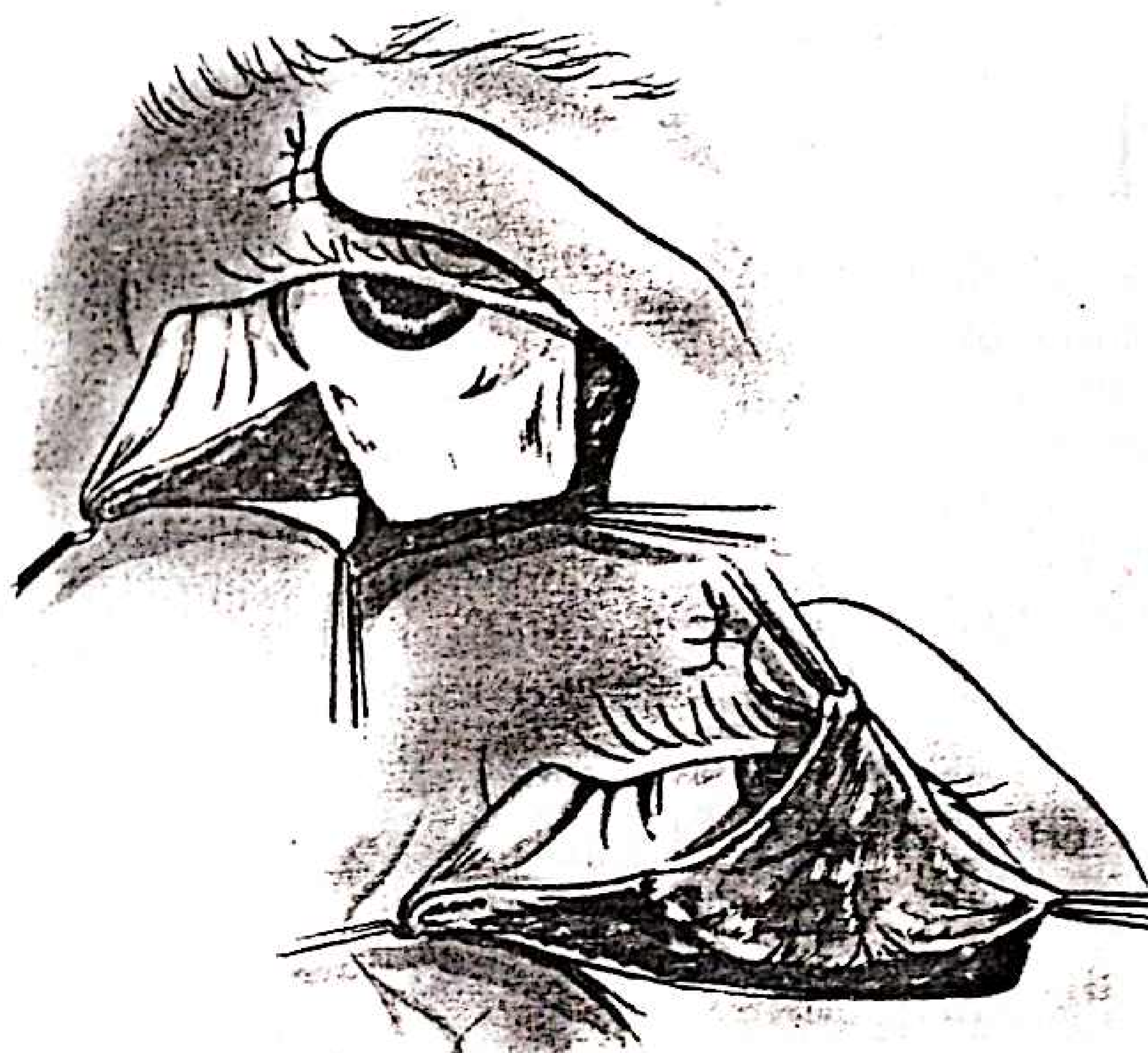

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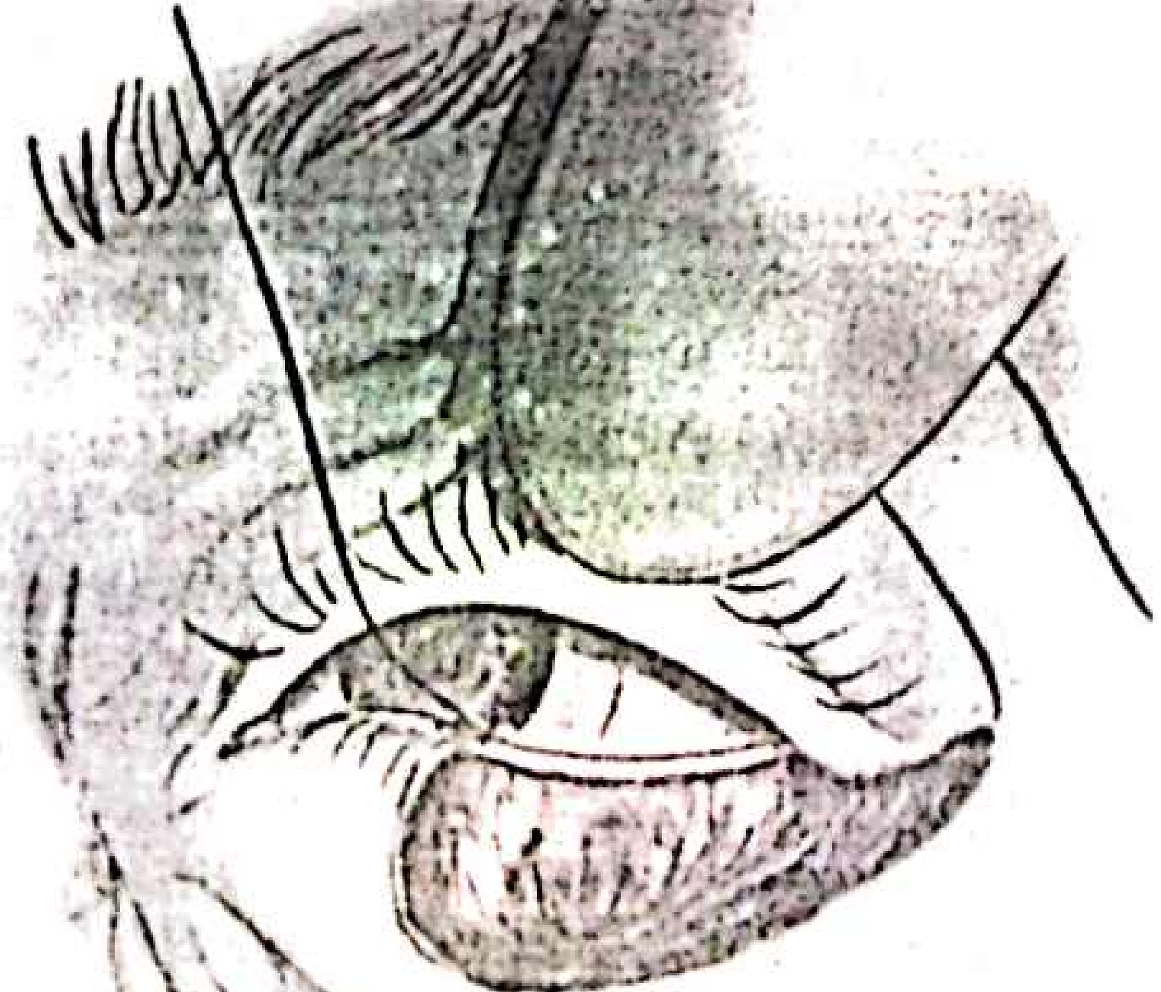

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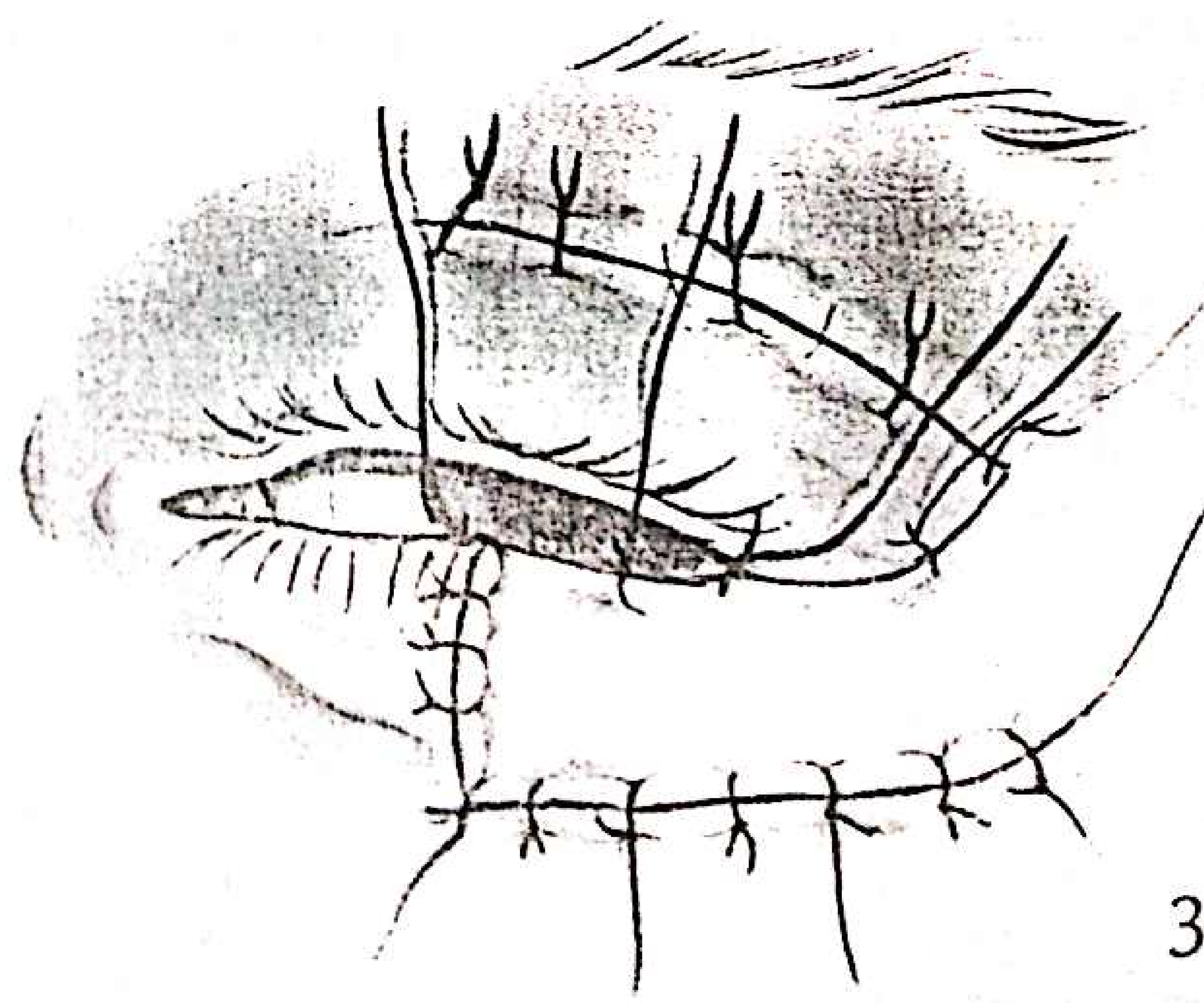

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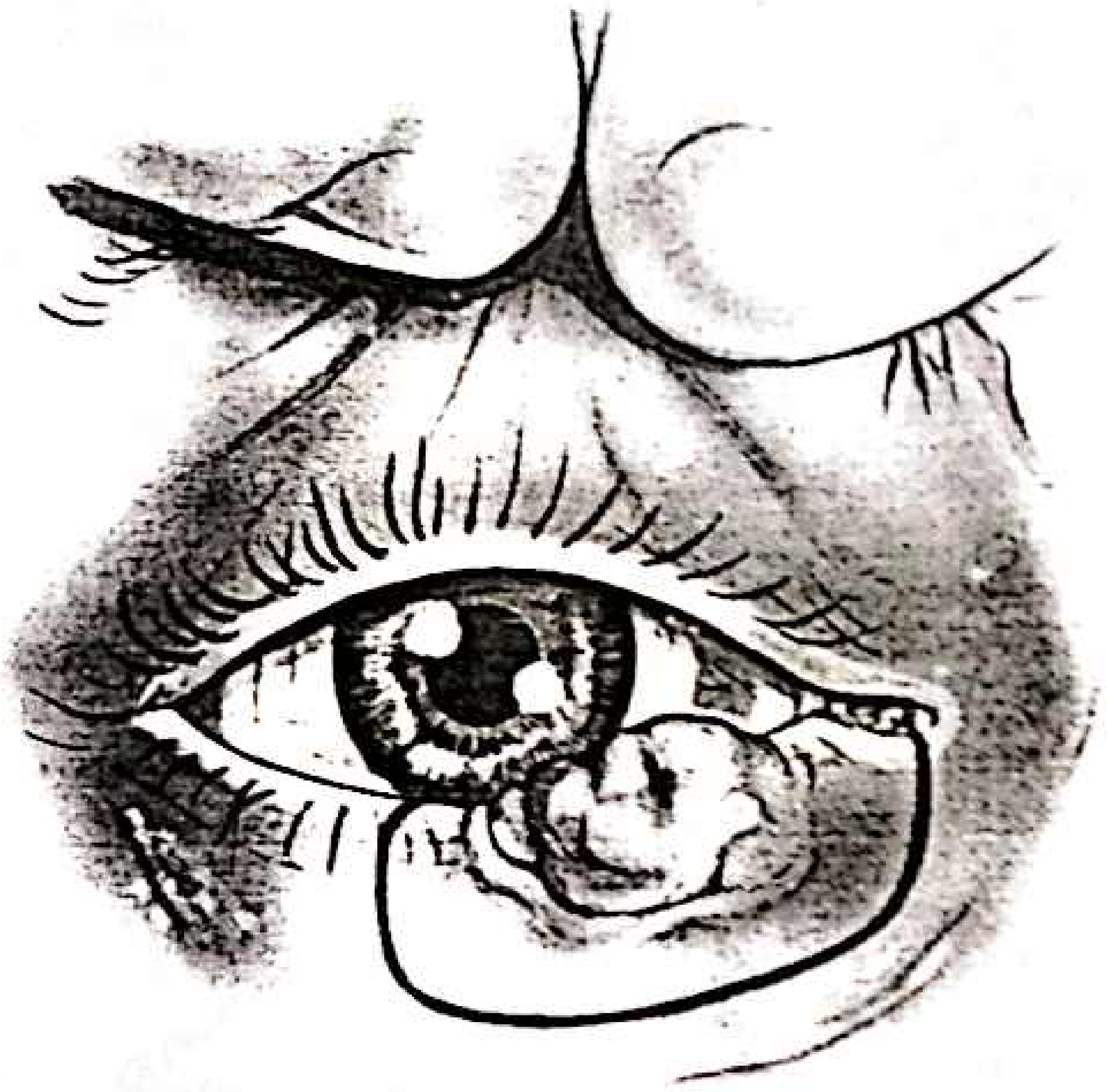
37, 38 & 39

When the decision is made that a mucosal graft is required and the rectangular defect is narrow enough to allow a Tripier flap to provide the skin cover, a chondromucosal graft should be taken from the nasal septum as already described (*see Illustrations 24–27*) and used to provide lining and support simultaneously. When the cartilage has been trimmed, leaving a mucosal fringe, and thinned to match the curve of the eyeball, the composite graft is sutured in position with interrupted 6/0 chromic catgut, knots facing outwards, along its lower border and its medial and lateral margins. There is sufficient thickness of tissue, both on the resected lid margin and on the graft of mucosa, that suture material need not be exposed in the conjunctival sac. When suturing the mucosa to the conjunctiva along the lateral and medial resection margins, care should be taken to approximate mucosa beyond the strict limit of the conjunctiva, over the lid margin as far as the line of the eyelashes, to ensure that the margin of the reconstructed eyelid will be mucosal rather than skin.



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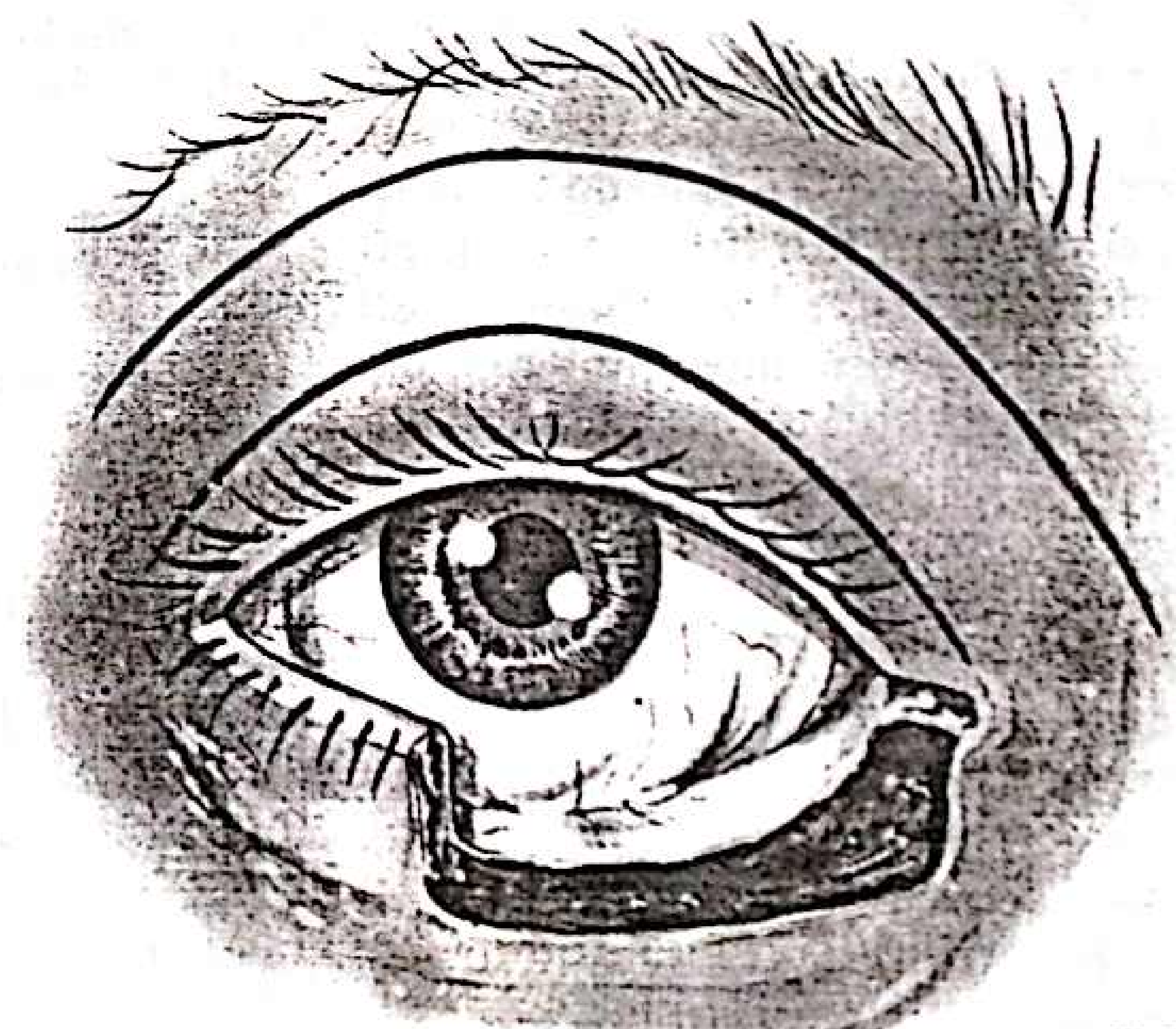

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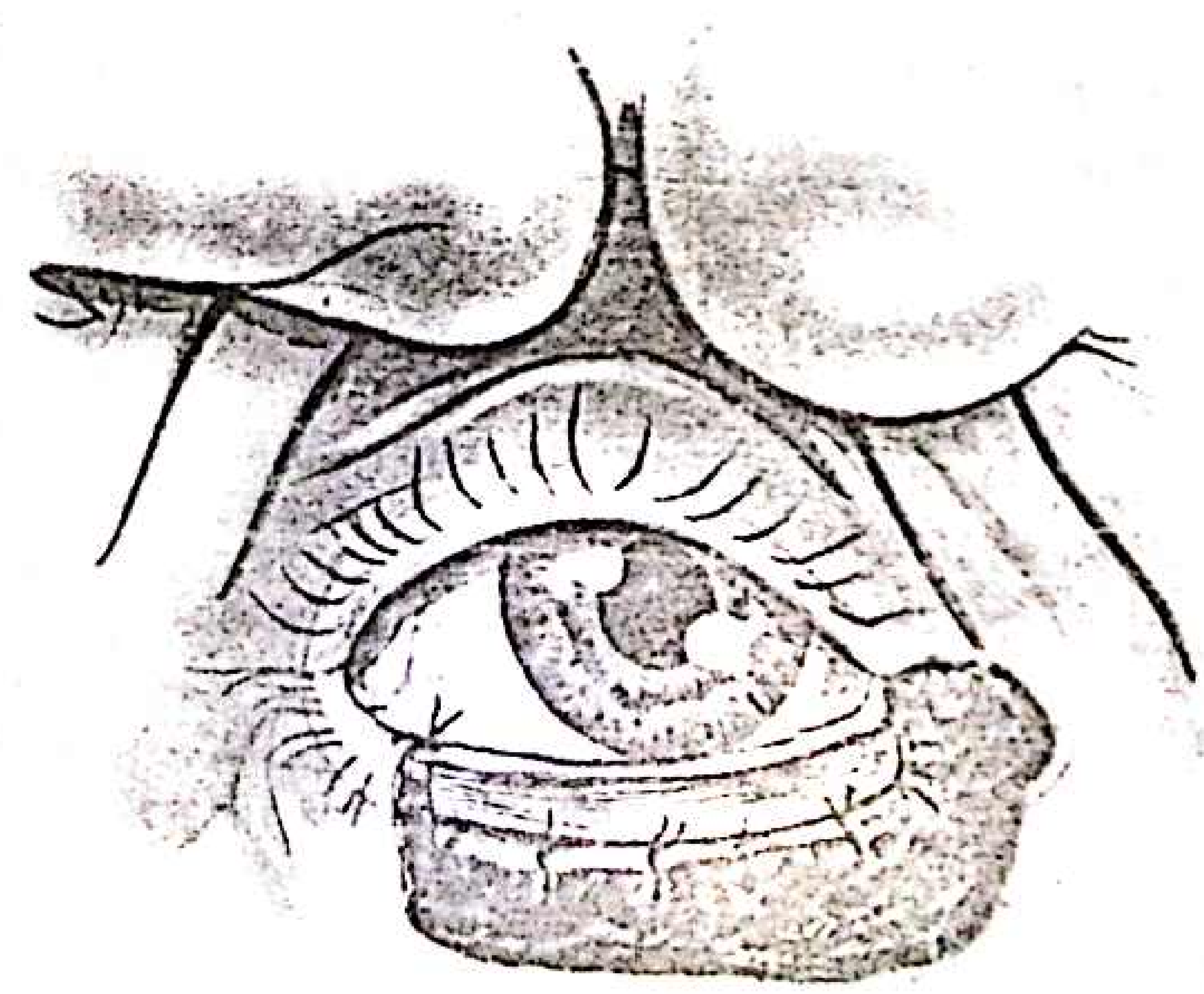

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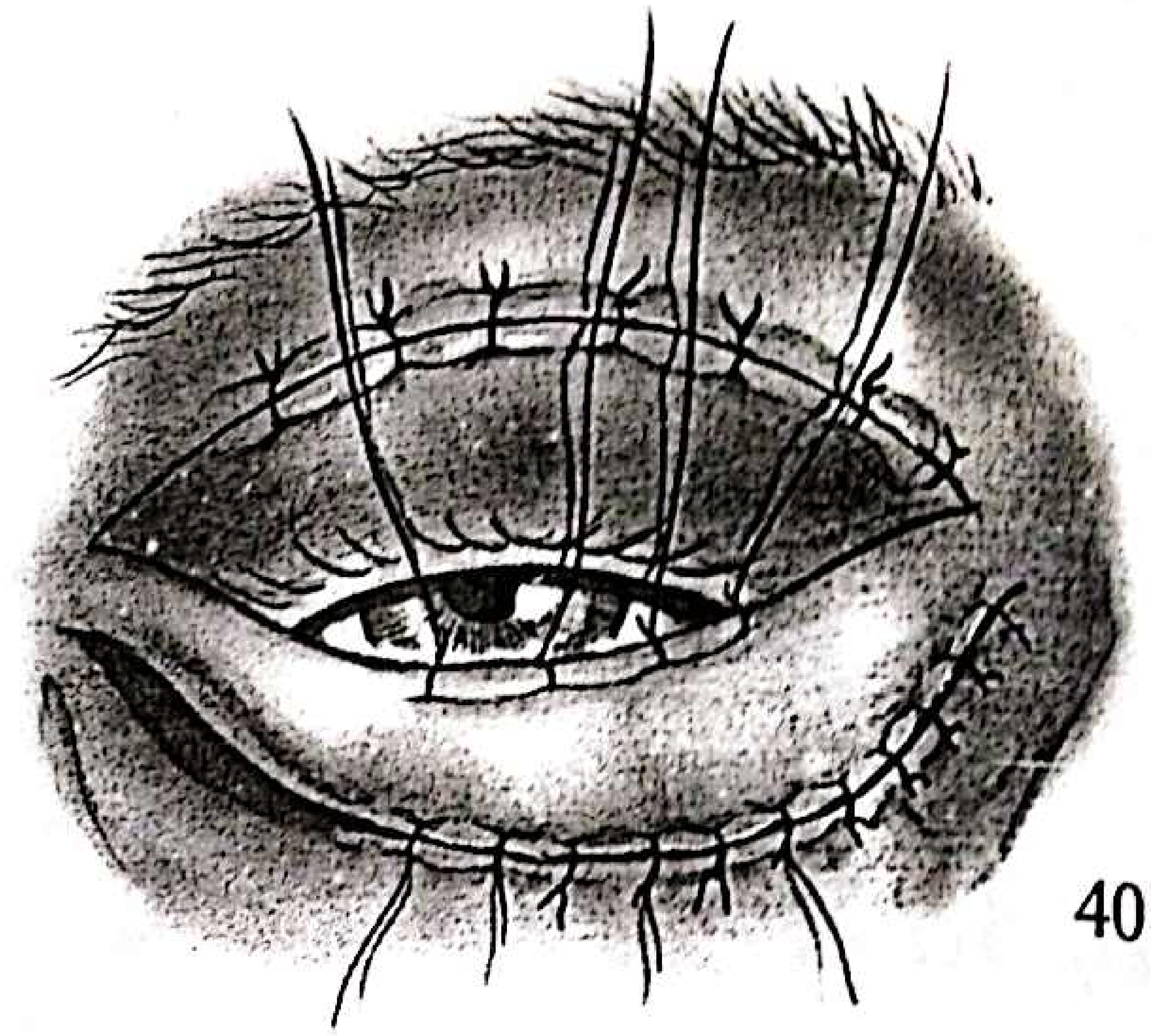

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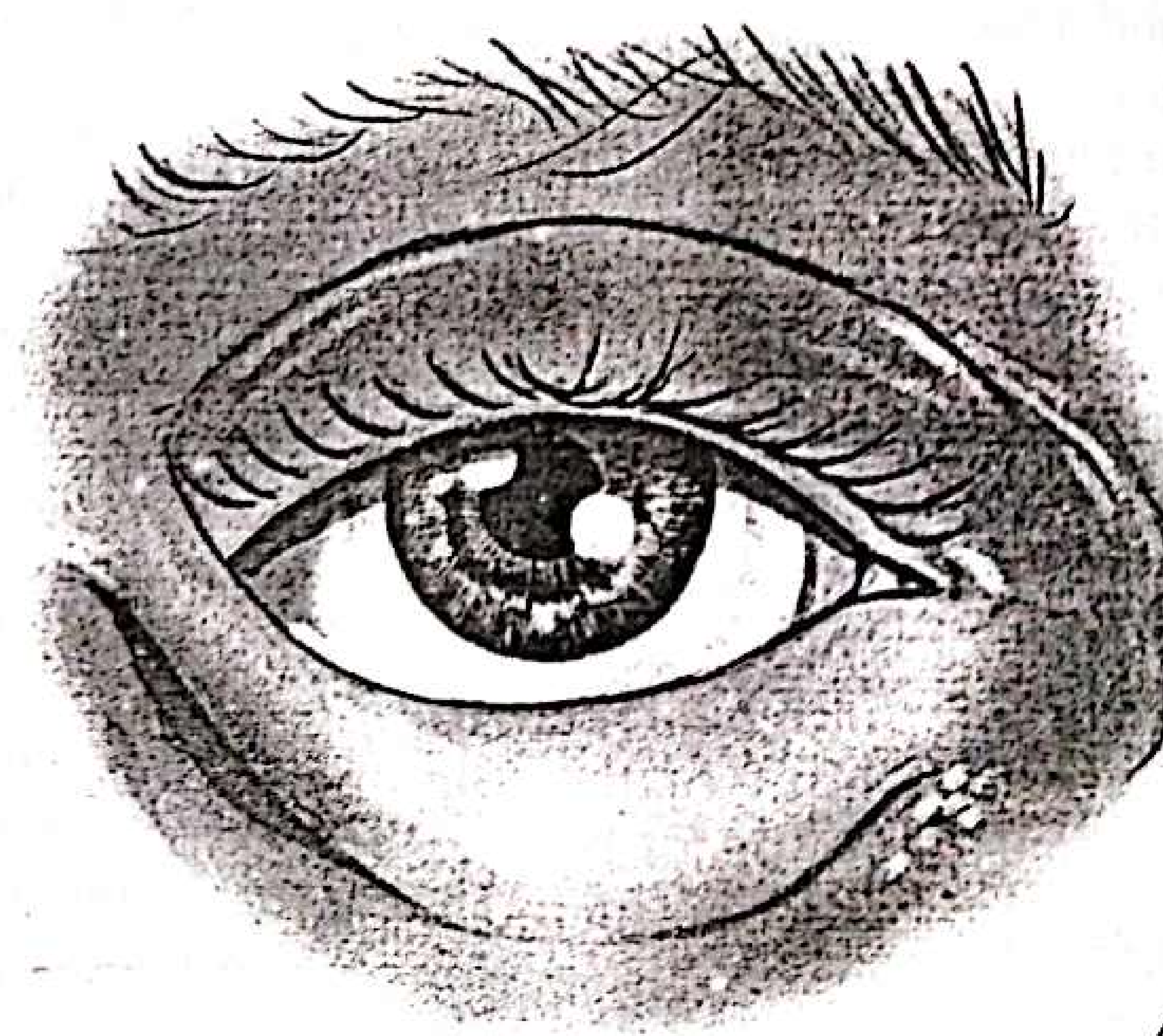
40, 41 & 42

The Tripier flap is then swung across to provide skin cover and sutured along its borders, the lower border to the resection line of the skin, the upper to the mucosal fringe. Along each suture line some sutures are left long to act as tie-overs to hold a flavine wool bolus in position over the flap, anchoring it against the chondromucosal graft and at the same time holding it in an untubed position. The bolus can be removed after 4–6 days.

Depending on the horizontal extent of the defect and the geometry of the Tripier flap, there may be a pedicle at one or other end where the flap has not been inset. This can be divided and insetting completed when the site has softened.



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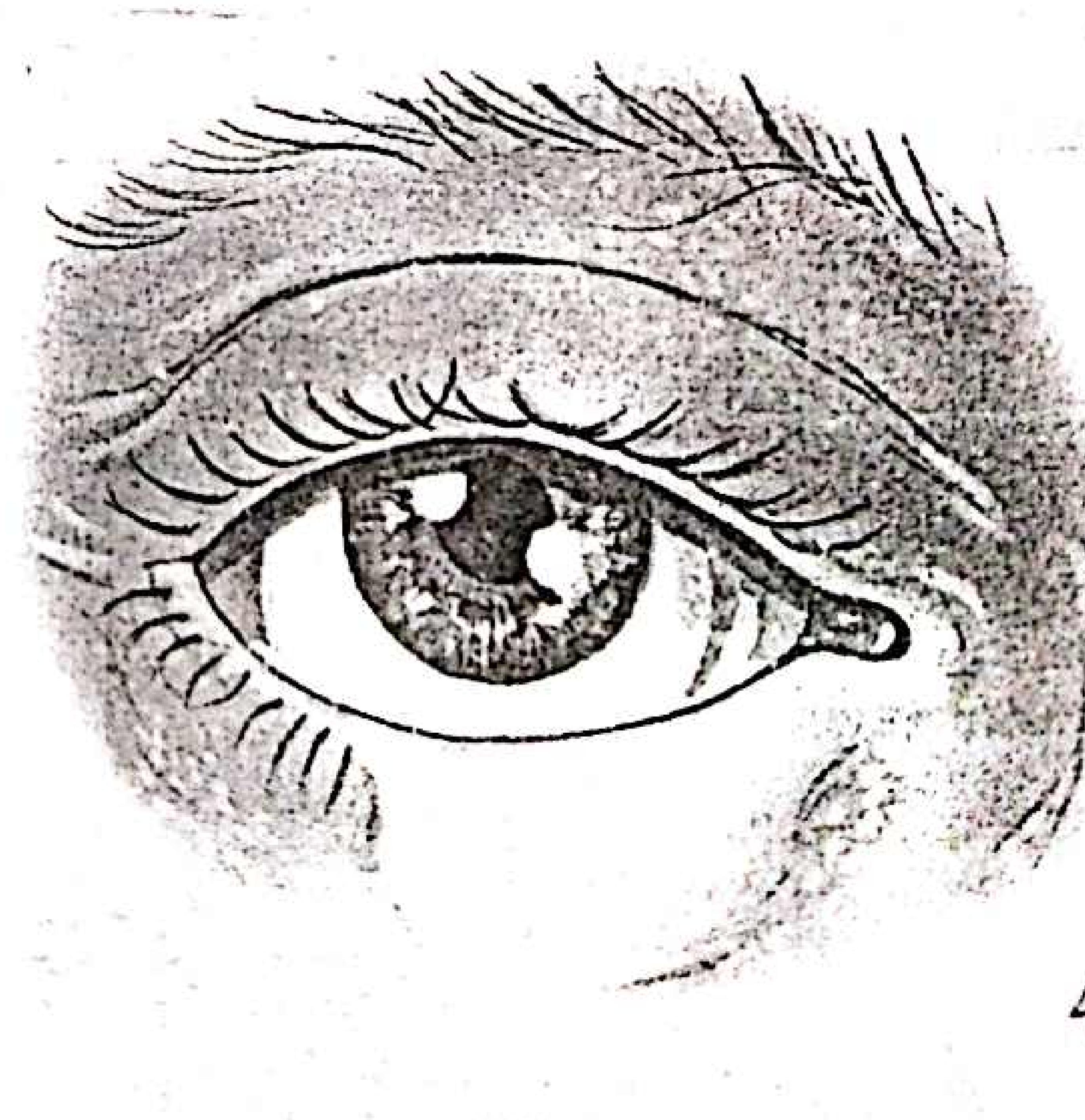
The design of the Tripier flap does mean that extension of the postexcisional defect more than minimally beyond either canthus virtually rules out its use as a source of skin cover. Alternative flap sources such as forehead or nasolabial fold may then have to be used. These sources may also be required when the rectangle of skin resected is too broad for the Tripier flap which it is possible to design on the upper eyelid. If one of these alternative sources is used, oral mucosa provides an adequate substitute for the resected conjunctiva.



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V-shaped defects

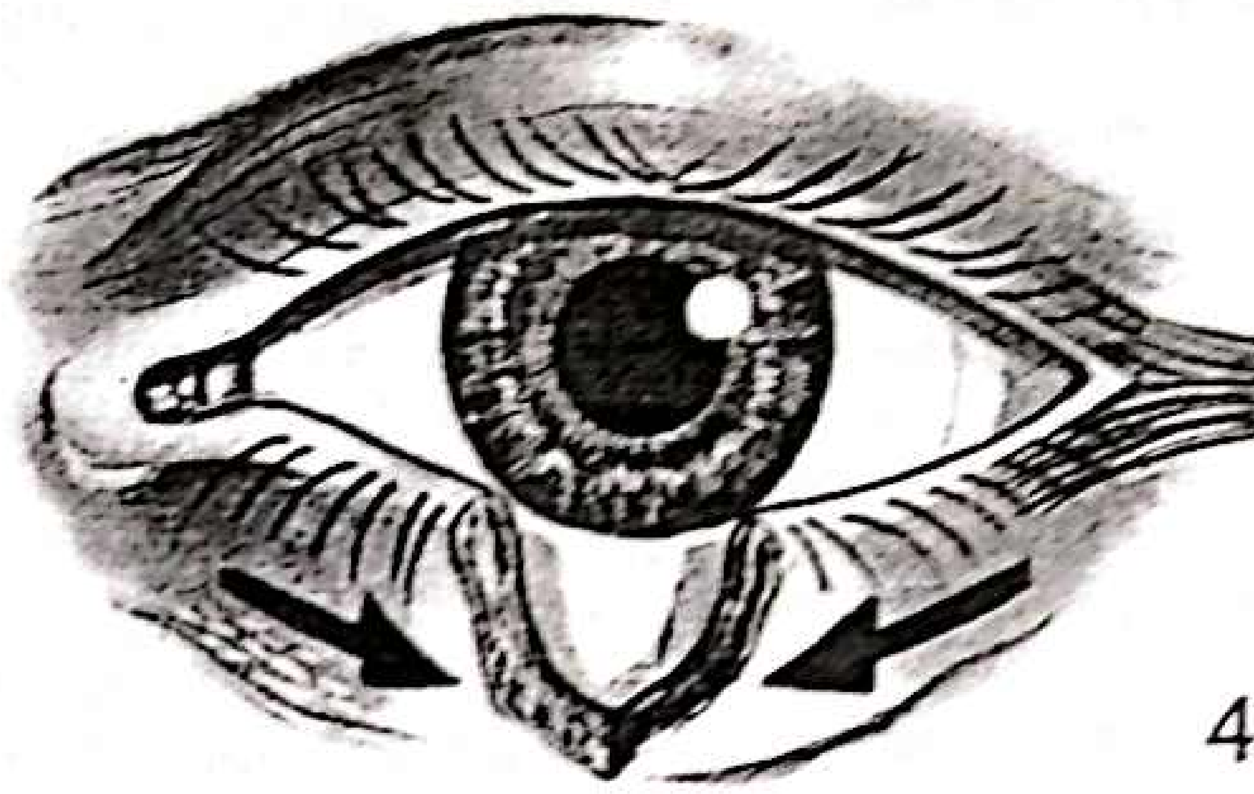
V-shaped defects are closed by approximating the two limbs of the V. The ease with which this can be achieved and maintained without undue tension across the suture line depends on the breadth of the V and the degree of pre-existing laxity of the eyelid.

Depending on these factors, three methods are available to close the V-defect: V-excision and direct suture; V-excision and lateral canthotomy; and V-excision and transposed flap.

V-excision and direct suture

43 & 44

This method can generally be used when the defect extends over a little less than a quarter of the width of the eyelid. Closure of the defect uses the suturing technique already described (see *Illustration 5*).



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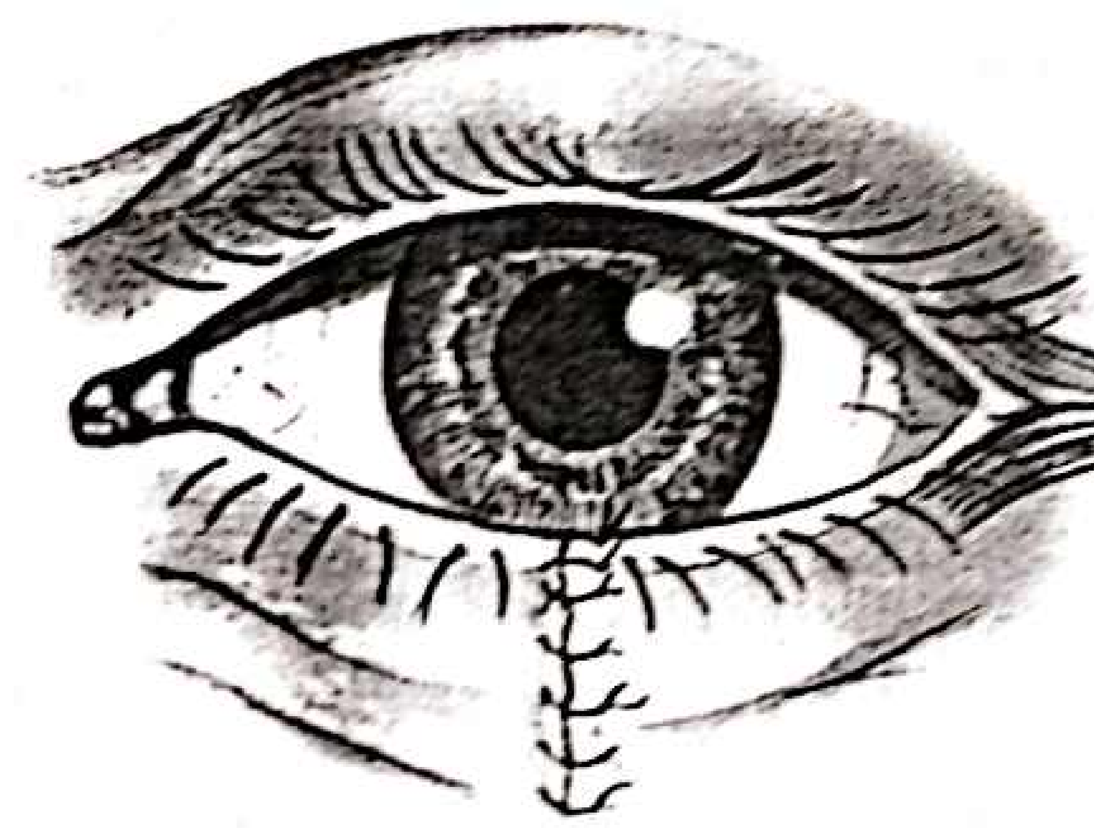

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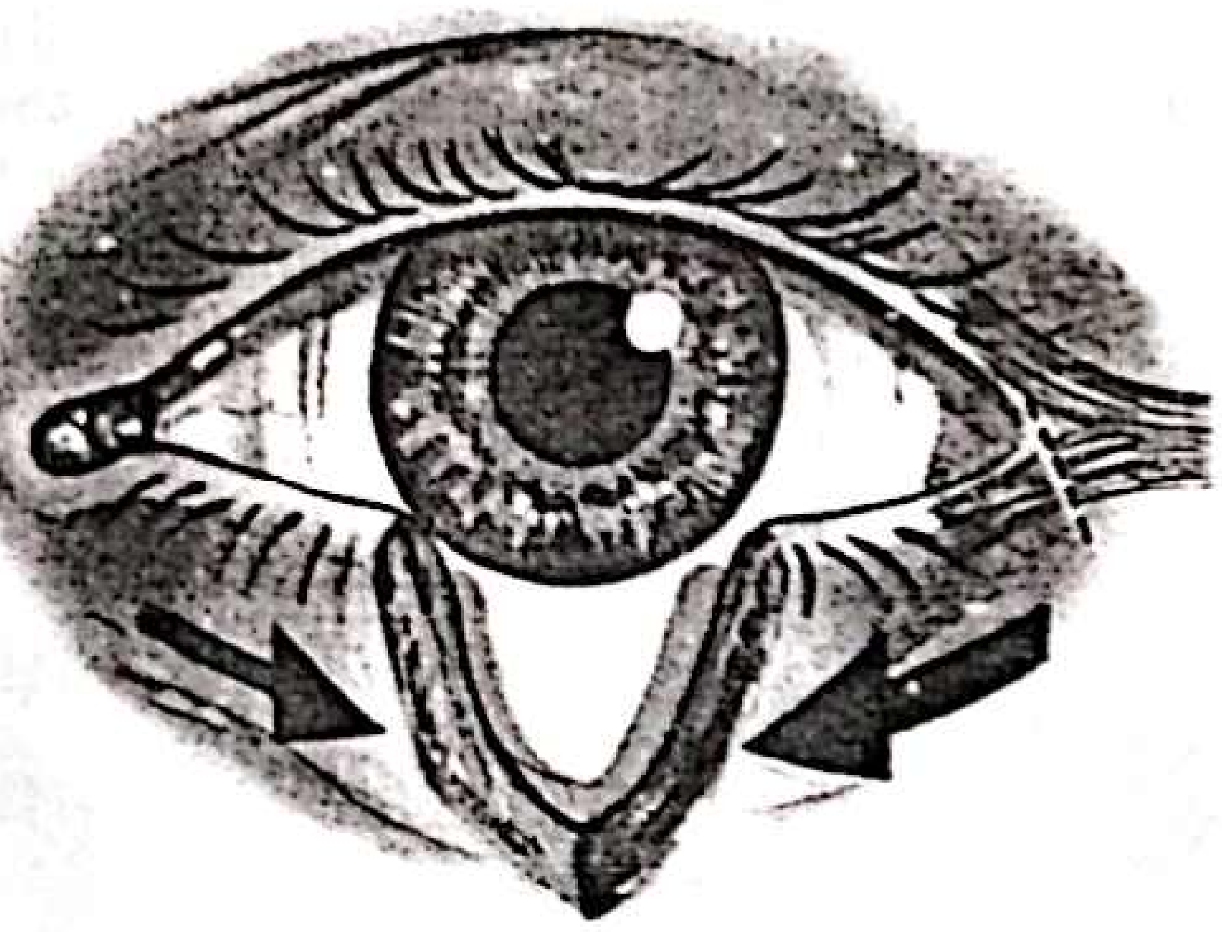

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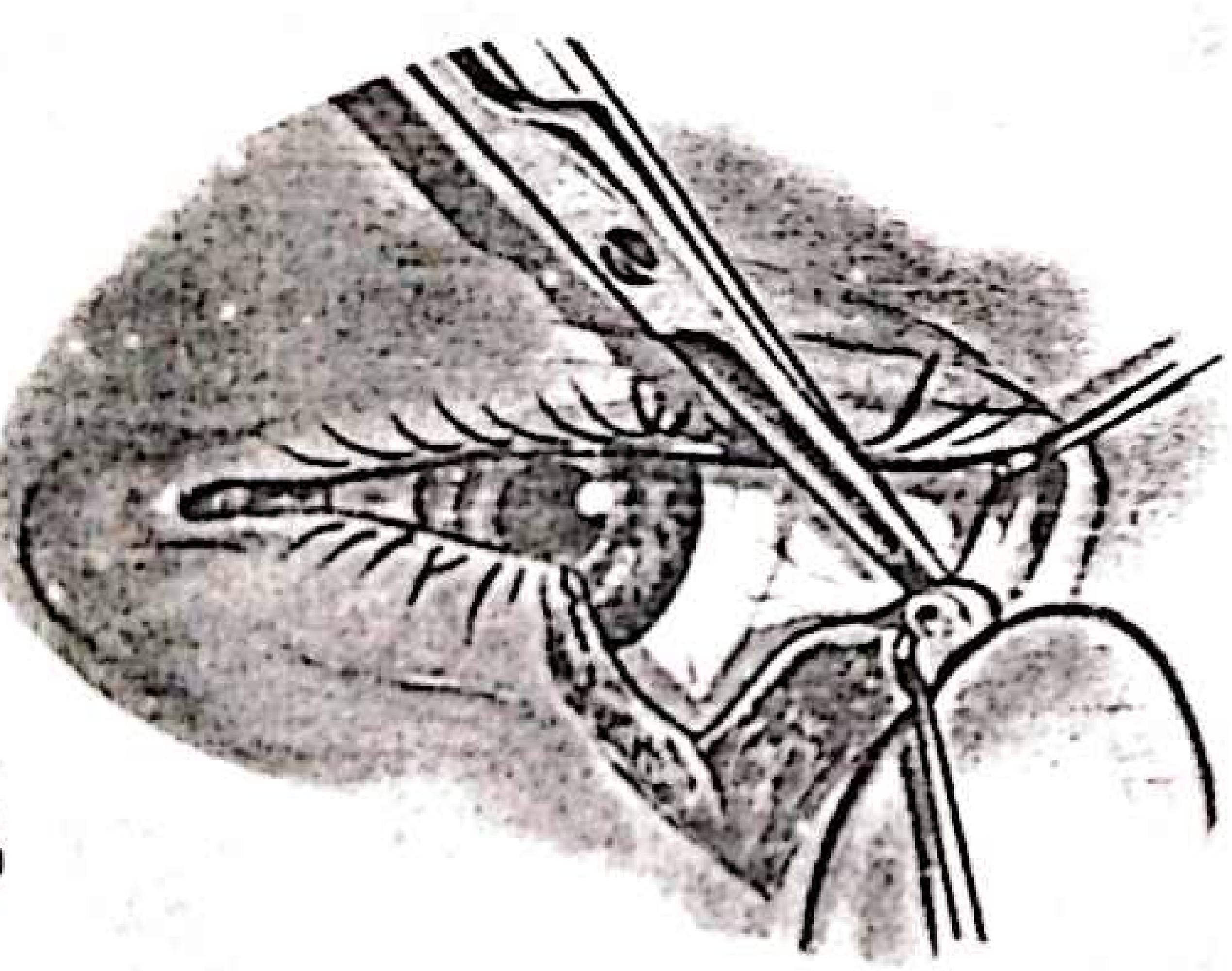

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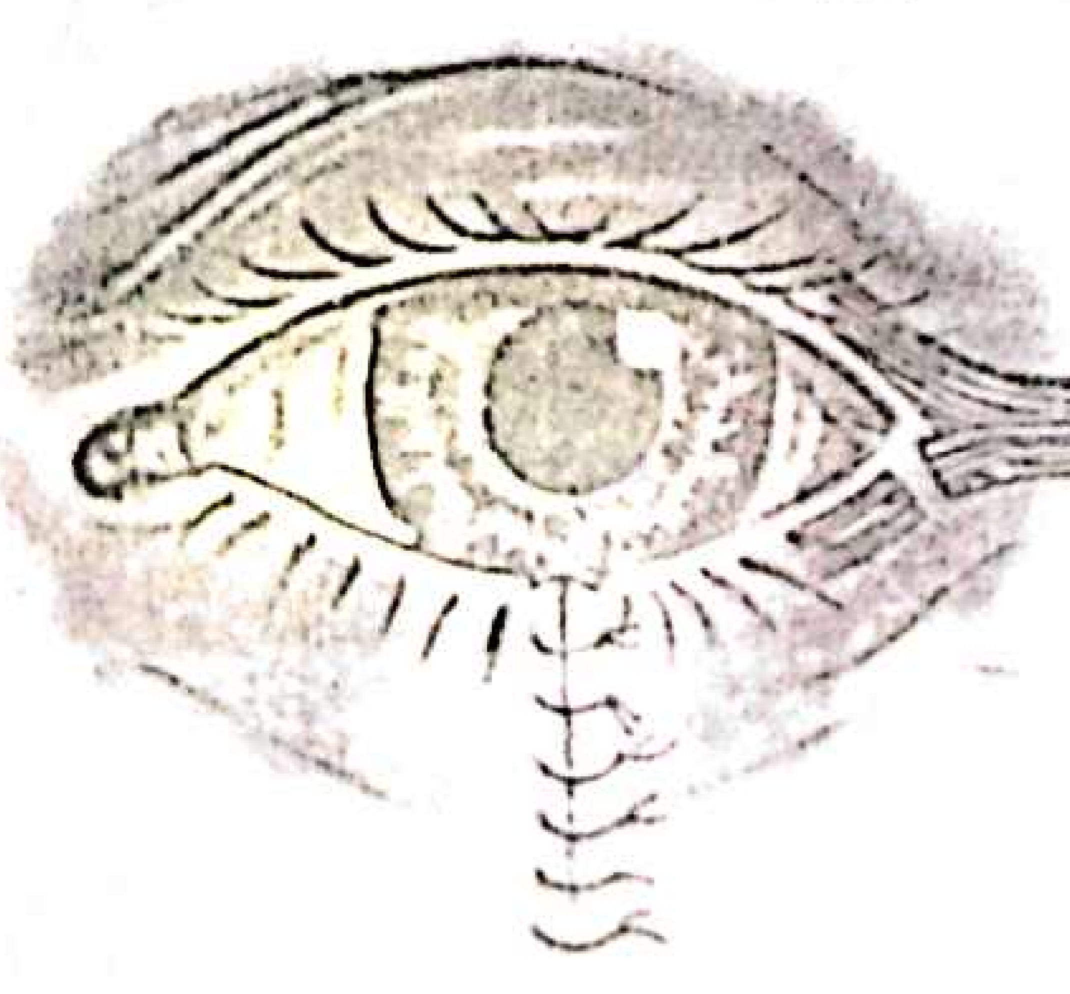

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V-excision and lateral canthotomy

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If the tension on the sutures is felt to be excessive there should be no hesitation in proceeding to V-excision and lateral canthotomy. Division of the limb of the lateral canthal ligament to the eyelid which is the site of the resection reduces the tension materially. The ligament can be divided in a formal manner, using a skin incision, but this can be avoided by carrying out the canthotomy through the conjunctiva, using sharp pointed scissors to divide the ligament. Identification and division are made considerably easier if a little traction is applied to the lid to put the limb of the ligament on the stretch. The ligament is first separated into its upper and lower limbs back to the orbital insertion and the appropriate limb is then divided. To achieve maximum advancement from what is virtually a relaxation incision, it may be necessary also to divide some fibres of the orbicularis muscle and part of the orbital septum. The conjunctival incision heals spontaneously, requiring no suture. Canthotomy used in this way will extend the defect which can be closed directly to a little more than a third of the eyelid.

V-excision and transposed flap

48–52

When the defect cannot be closed without tension even after canthotomy, it is necessary to design a transposed flap on the temple, lateral to the eyelid, and advance it medially to close the defect. In outlining the flap a skin incision is made laterally from the outer canthus along a line which continues the upward curve of the lower eyelid and extends almost to the hairline. From its lateral extremity a back-cut is made parallel to the lateral limb of the V and equal to it in length, making an angle of approximately 60°. The effect is to outline an inferiorly based flap with the approximate shape of a parallelogram, and the principle of the reconstruction is that this flap is elevated and moved medially to close the lower lid defect by approximating the two limbs of the V.

The segment of the flap beyond the lateral canthus is raised at the level of the fat deep to the dermis, but on reaching the orbicularis muscle the level should be deepened so that dissection is deep to the muscle, allowing it to be advanced as part of the flap. At the lateral canthus the slip of the canthal ligament to the lower lid is divided and, with a skin hook in the resection line of the lid, medial traction is exerted on the flap. This allows the structures which are preventing ready movement medially to be identified with the palpating finger. The structures responsible are mainly the orbicularis muscle and the orbital septum, and they are freely divided with scissors until the flap moves medially unimpeded. It is not necessary to divide the conjunctiva in the lateral fornical area as a final step in this process of mobilization and advancement. There is abundant conjunctival slack in the fornix and this is taken up, spreading out to line the reconstructed eyelid as the skin flap is advanced medially. The free margin of the advancing conjunctival layer lies alongside the corresponding margin of the skin–muscle flap. The V is closed, and the skin and conjunctiva are sutured together along the free margin of the reconstructed segment.

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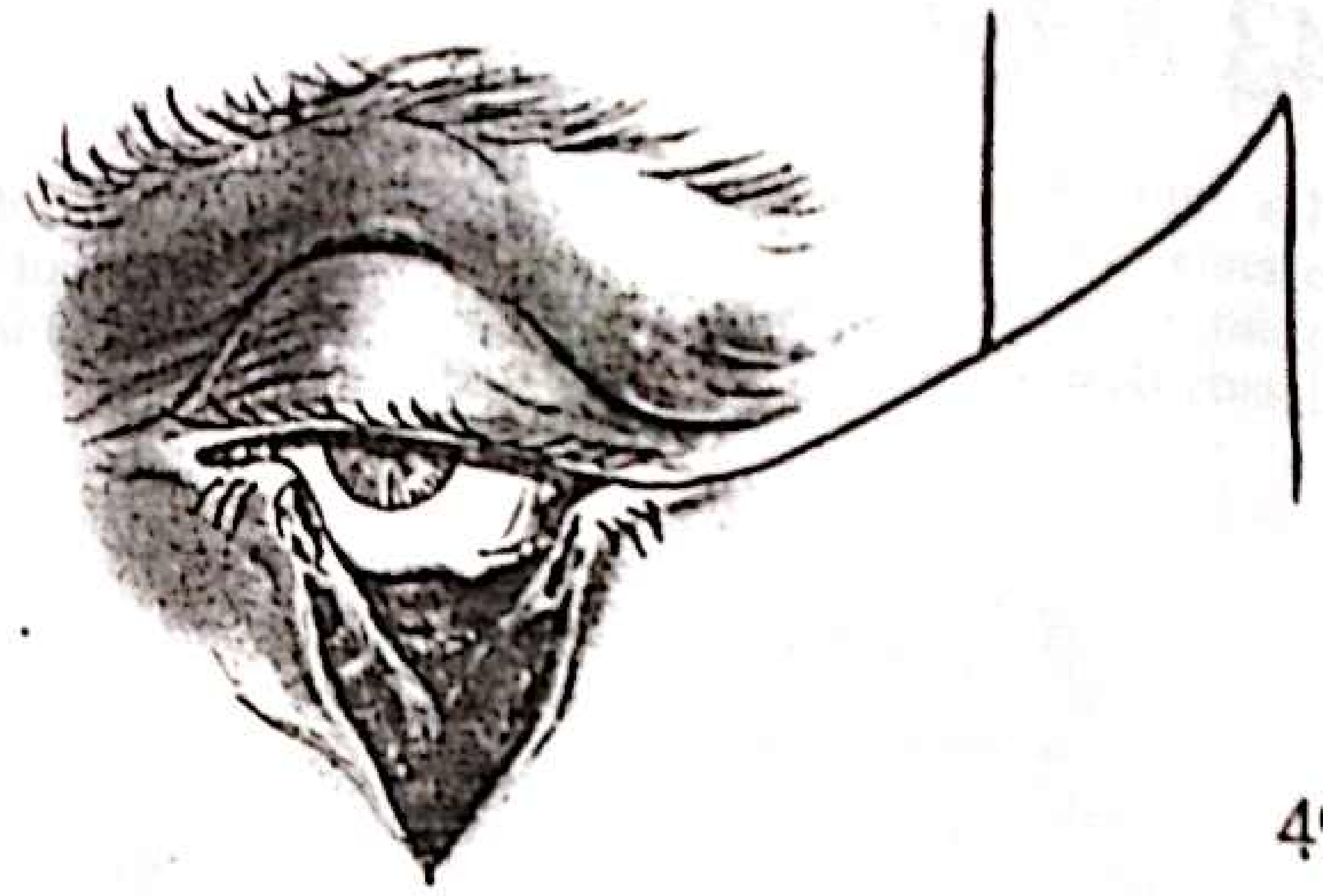

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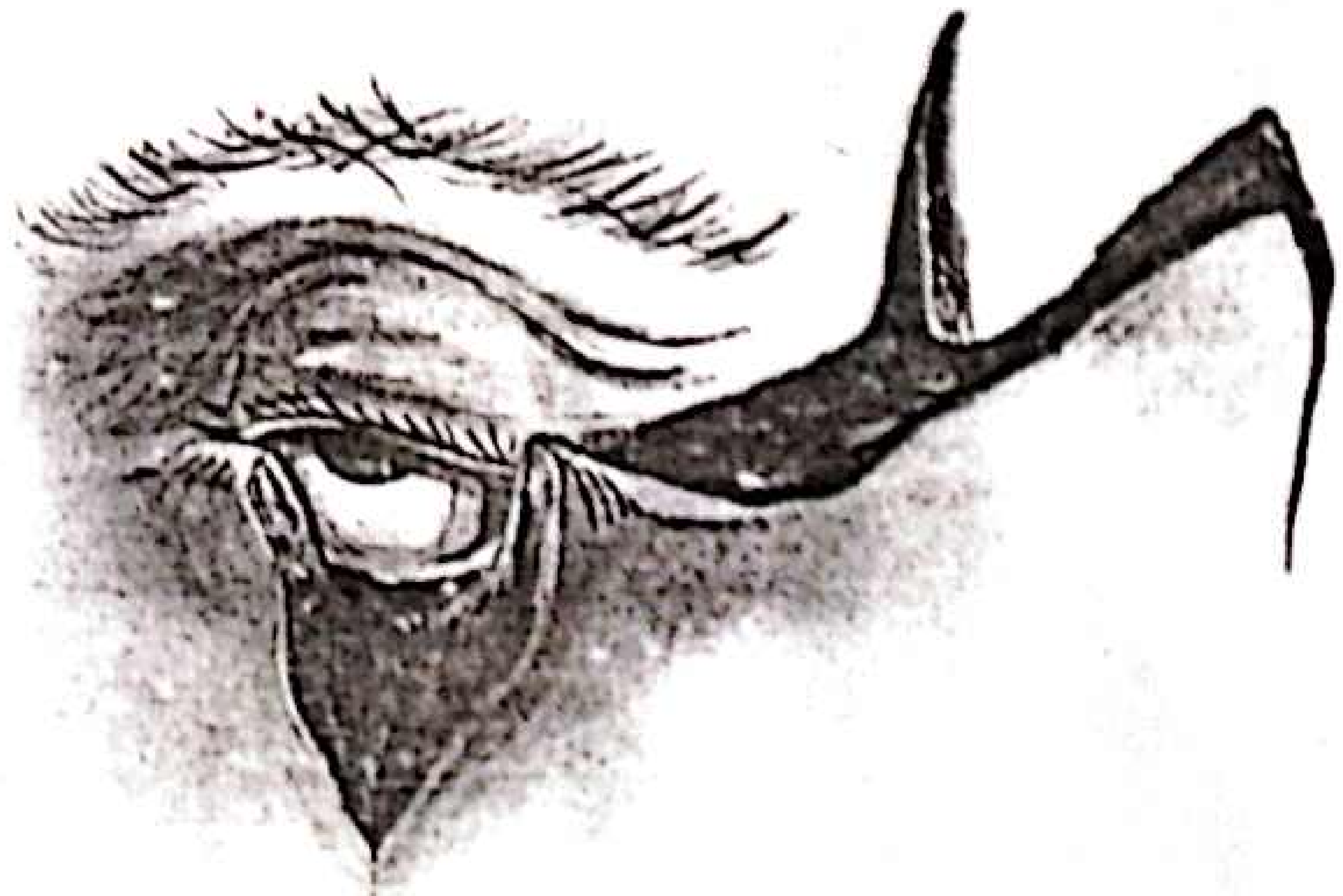

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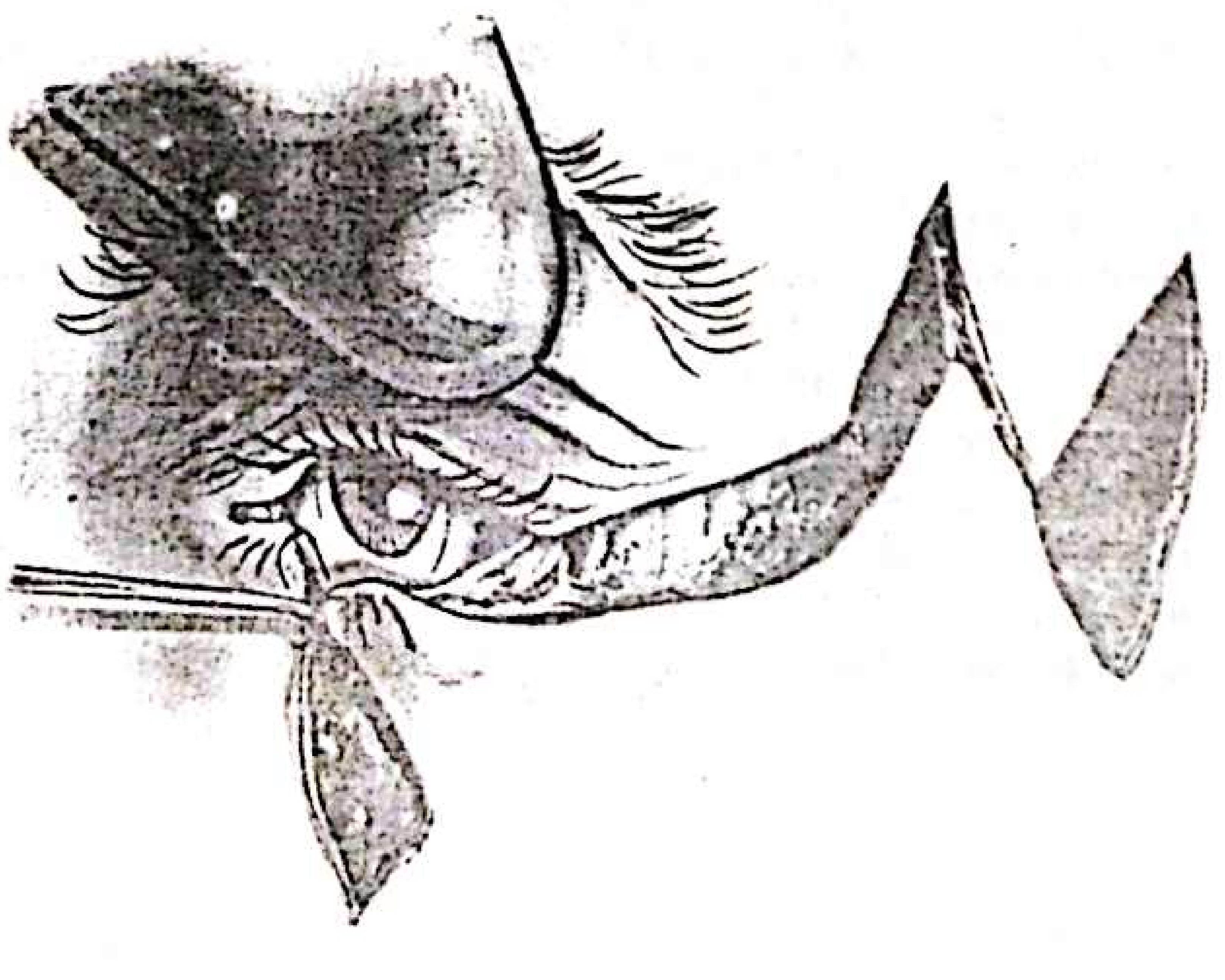

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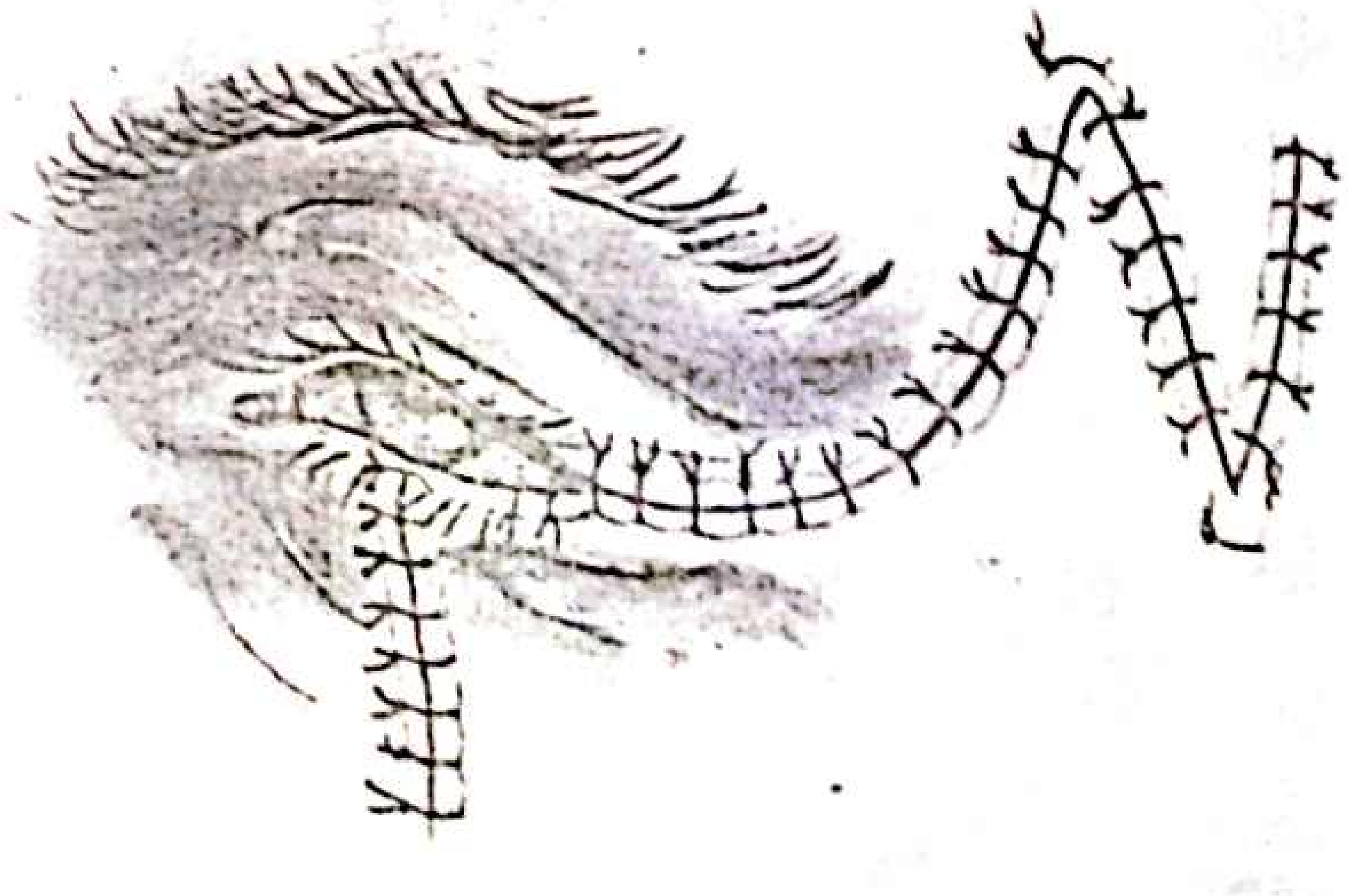

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An effect of closing the V of the lower eyelid in this way is to open up a corresponding V in the temple at the posterior margin of the flap. This is closed using a modified Z-plasty, the design of which is incorporated in the overall planning at the outset of the procedure. The Z is constructed with the posterior part of the curving incision passing back from the lateral canthus as the common limb of the Z and the back-cut as one of the other limbs. The third limb of the Z is constructed above the common limb to make a flap with a 60° angle and this is rotated downwards to fill the triangular defect created by the medial transposition of the main flap.

The upward curve of the incision outlining the transposed flap has the virtue of ensuring that the reconstructed eyelid has adequate vertical height to avoid ectropion. The completion of the lateral Z-plasty also leaves the posterior tip of the transposed flap at a considerably higher level and this has the effect of steepening the initial curve of the flap. The change which results is distinctly advantageous since the rising line of the scar has the effect of providing an upward pull and adding support to the reconstructed lid.

The transposed flap used in this way is suitable for defects extending up to two-thirds of the eyelid. This covers the great majority of the tumours which can be excised to leave a V-shaped defect, and the method has a wide applicability. It is technically easiest when tarsal plate is present on each side of the defect to provide good material for holding a suture. When the defect abuts on one or other canthus it can still be used but the procedure is more difficult technically. The scars on the temple settle to virtual invisibility.

The upper eyelid

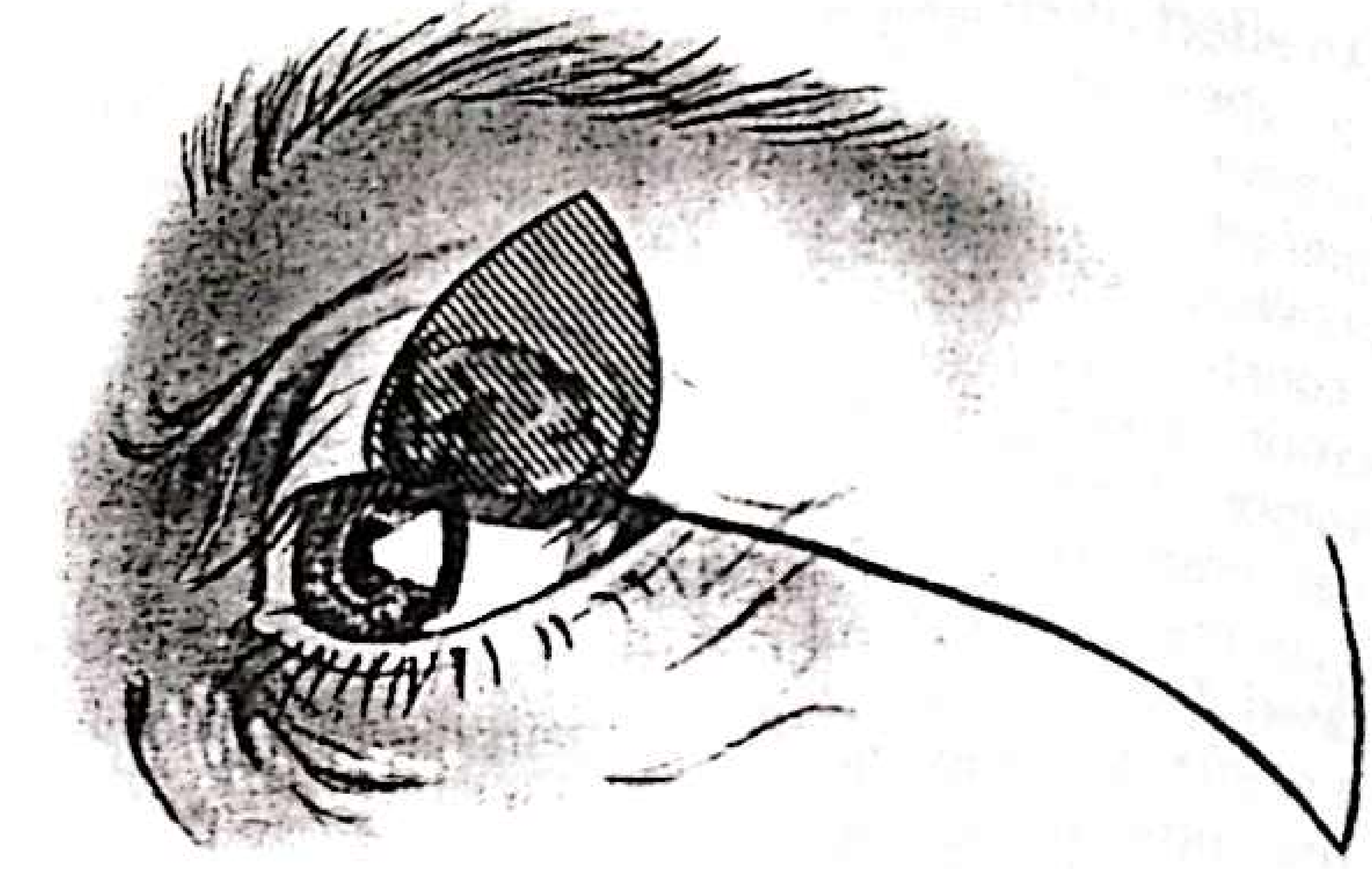
Tumours involving the upper eyelid are comparatively rare and those which require a full thickness excision of the eyelid are very rare. This is fortunate, because the functional results of the possible reconstructions of the upper eyelid after major excisions are poor. It is not possible to reproduce the complex structure of the upper eyelid, particularly the levator muscle with its tendinous insertion along the line of the superior palpebral furrow, and aponeurotic lateral expansions extending to each of the canthi, and Müller's muscle inserted into the upper border of the tarsal plate.

The anatomy of the eyelid also provides an explanation of why extensive tumours which are suitable for excision and reconstruction are rare. A tumour arising in the skin of the upper eyelid, as it spreads marginally upwards, extends in the general direction of the eyebrow along with the orbicularis muscle. The functional basis of the upper eyelid lies very much with the levator mechanism, and above the superior palpebral furrow the levator passes quickly back into the orbital cavity. The distance between the orbicularis and the levator rapidly increases, the two being separated by the fat both in front and behind the orbital septum. Because of this separation it is rare for upper eyelid tumours which arise above the superior palpebral furrow to extend deeply enough to involve the full thickness of the eyelid, and yet be sufficiently localized that a full thickness excision confined to the eyelid will clear the tumour completely.

Tumours requiring full thickness eyelid excision arise almost invariably in the part of the eyelid below the superior palpebral furrow, that is, over the tarsal plate. Such a tumour, if it has spread horizontally along the lid to a significant extent, and particularly if it involves the entire lid from medial into lateral canthus, is likely to have spread upwards as well, involving the lid extensively, and making the patient a potential candidate for orbital exenteration. For these reasons, excision of an entire upper eyelid for tumour is very seldom required, and excisions of more than half of the upper eyelid are almost as rare.

To be suitable for reconstruction, the full thickness defect of the upper eyelid is converted into a V shape, and managed as a mirror image of the lower lid defect of similar shape and comparable size. A V-excision with direct suture, V-excision with lateral canthotomy, or V-excision reconstructed with a transposed flap should be used, depending on the breadth of the V. The main difference from the comparable procedures in the lower eyelid is that the breadth of the V suitable for each is probably less in each instance, up to the V-excision and transposed flap, which is suitable for defects of up to half of the lid only.

V-excision and direct suture and V-excision with lateral canthotomy are carried out in precisely the same way as the corresponding procedure on the lower eyelid.



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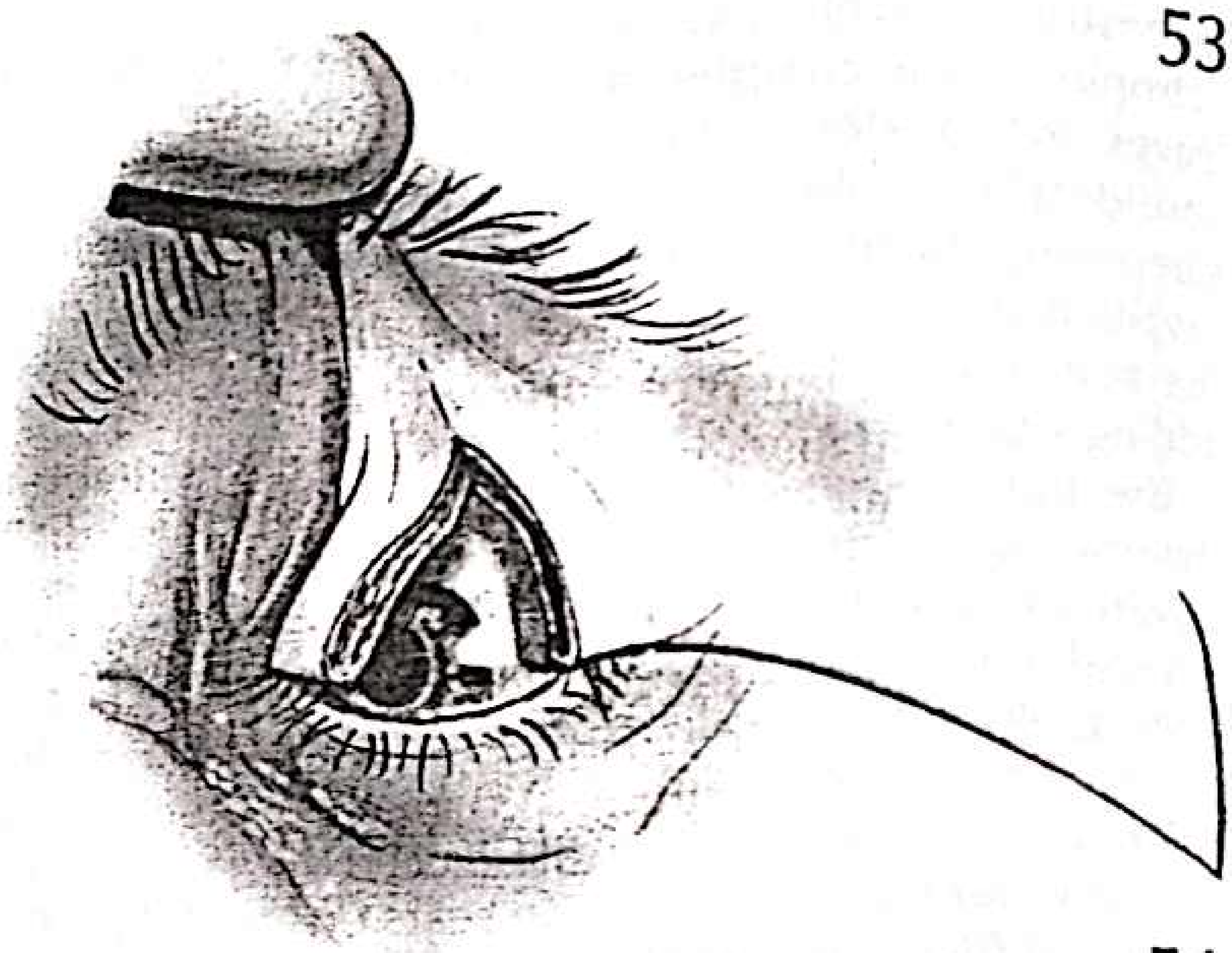

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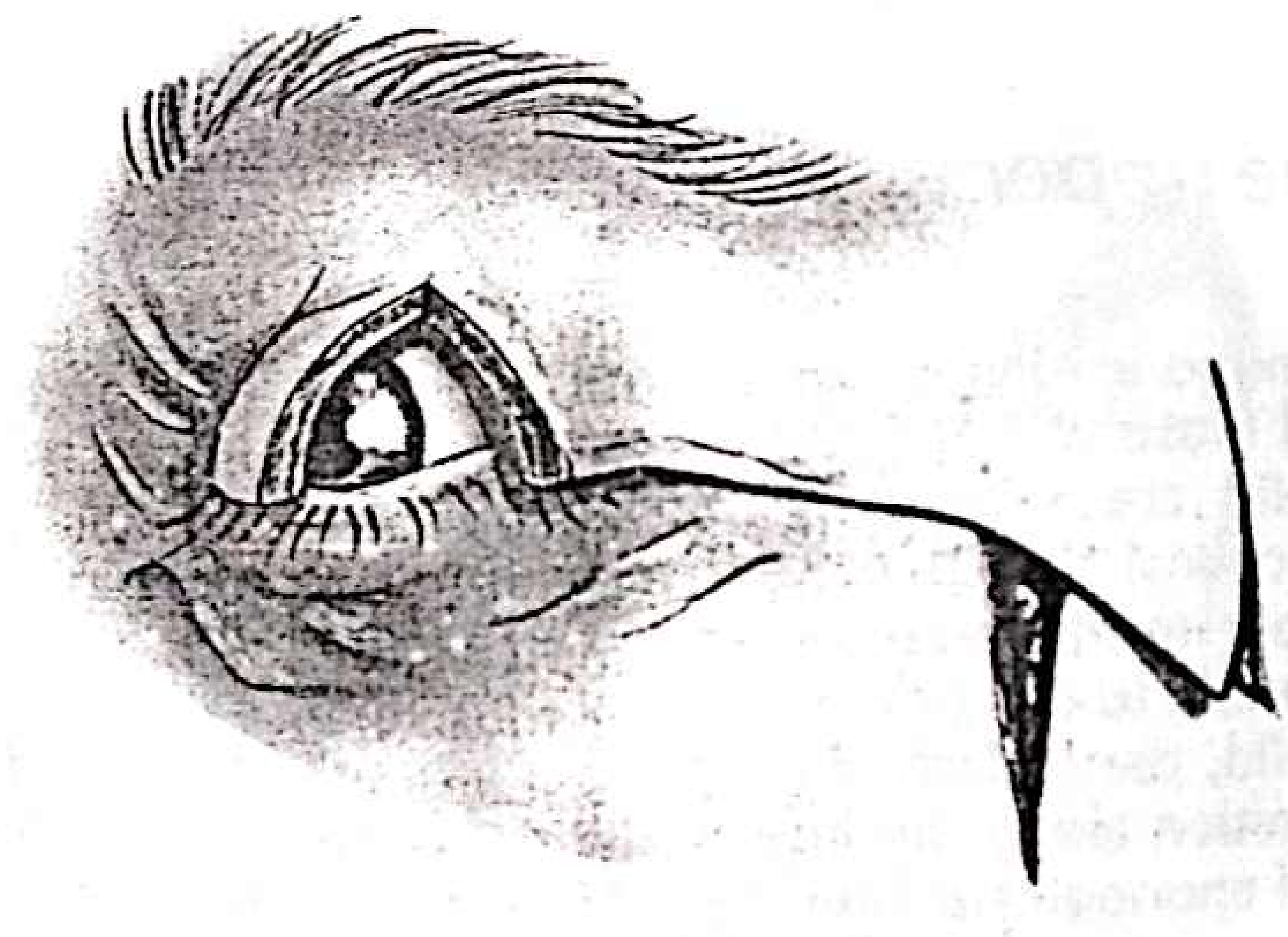

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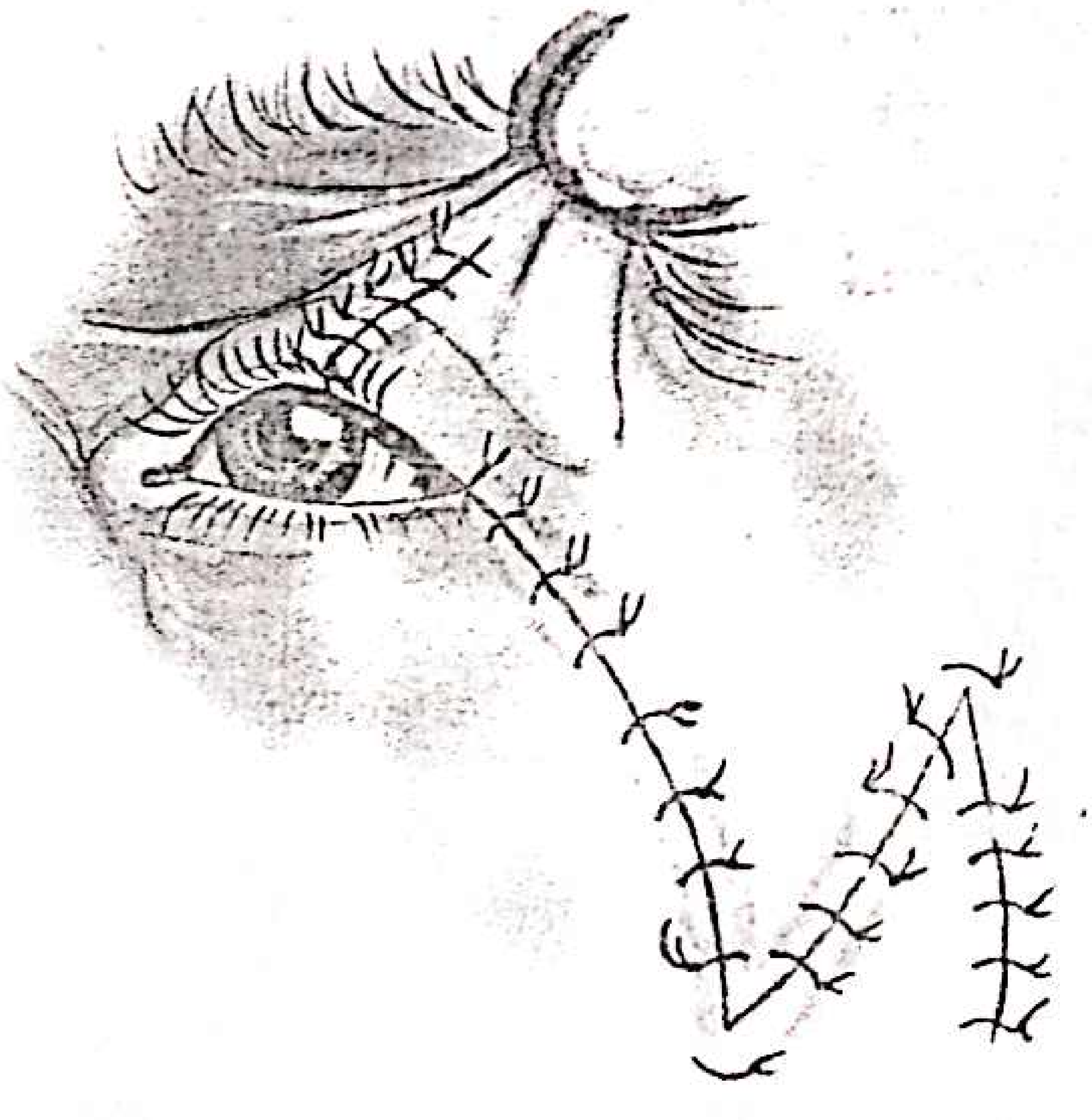

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53–56

V-excision and transposed flap is carried out in a slightly different manner, though in essence it still mirrors the method used in the lower eyelid. The incision beyond the lateral canthus follows the downward curve of the upper eyelid, with an upward back-cut at its posterior extremity. Division of the slip to the upper lid of the lateral canthal ligament allows the lid to advance and division of the orbicularis and orbital septum and the aponeurotic extension of the levator allows the flap to advance further to close the eyelid defect. The plane of dissection is anterior to the lacrimal gland and upper fornix so that the secretion of tears is not affected. Advancement of the flap and closure of the V proceed as with the lower lid, and the resulting defect in the temple is also handled in the same way, with a Z-plasty. Despite the division of the levator expansion lateral to the V, the muscle adjusts surprisingly well with no distortion of the curve of the lid margin. A minor cosmetic deficiency of the reconstruction is the dog-ear which develops at the apex of the V. The skin here is extremely lax and the effect is to accentuate the prominence of the dog-ear. It can readily be excised subsequently if the patient wishes.

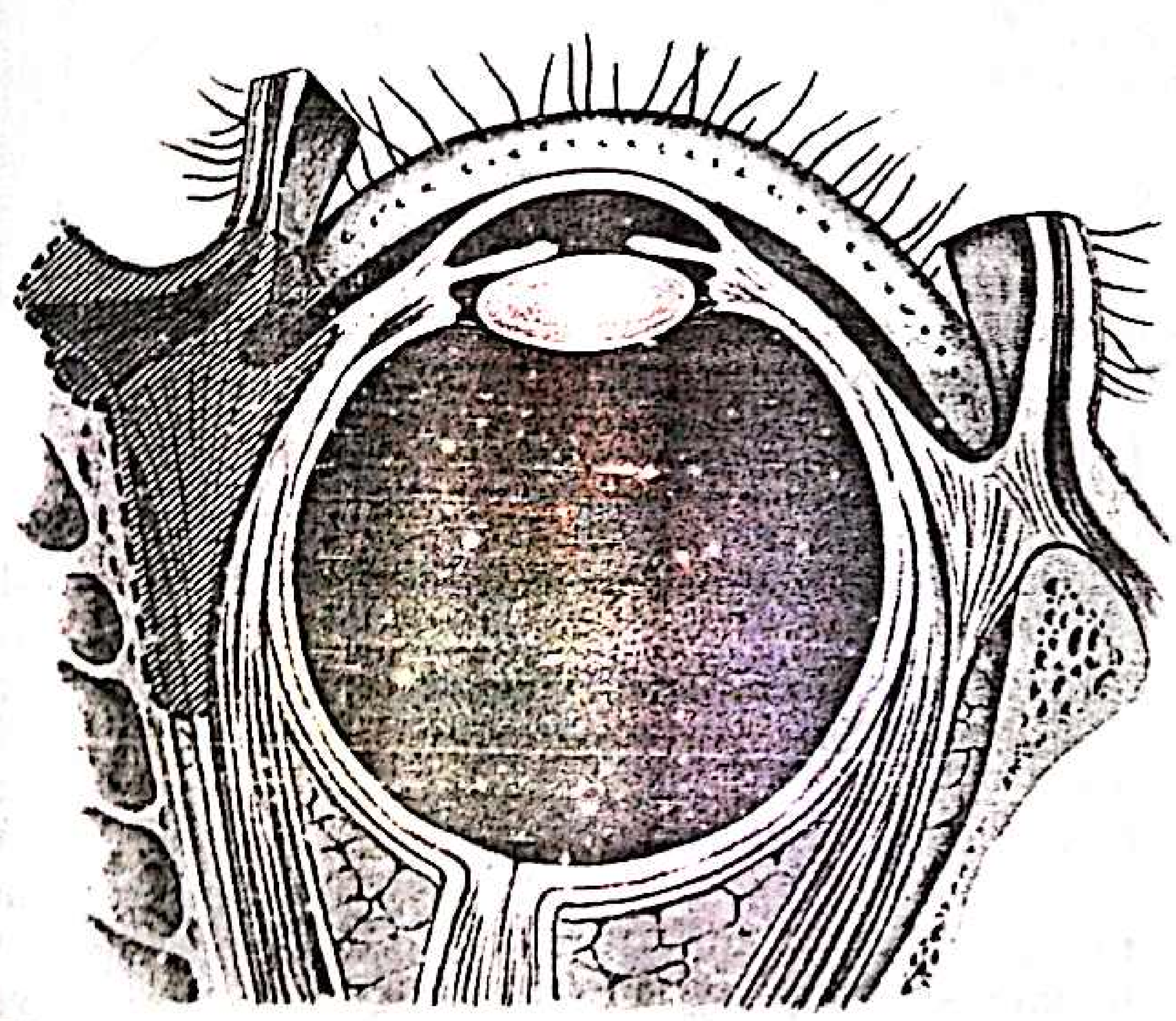
The canthi

Tumours of the medial canthal area are very much commoner than tumours of the lateral area, and the reconstructive problems which the postexcisional defects of the two sites present vary markedly in their difficulty, depending on which canthus is involved and how destructive of the canthal mechanism the tumour has been.

In the medial canthal area the anatomy of the site is a major factor in creating the problems which develop during excision, and even more during reconstruction of the defect. These arise in their most acute form if the medial canthal ligament has to be resected in its entirety and they are the result of the complexity of its attachment to the margin of the orbit. The component of the ligament which is palpable through the skin continues on medially from the tarsal plate to attach to the frontal process of the maxilla in front of the lacrimal sac, but the ligament has additional indirect attachments behind the lacrimal sac. The total effect is to hold the medial canthus backwards as well as medially. Loss of the ligament, for example by resection of a tumour involving it, results in a drift of the canthus forward as well as laterally, giving the appearance of unilateral telecanthus, and when the ligament is lost in this way it is not possible to correct the deformity by attempting to reconstruct it. These problems present in a particularly acute form when a deeply penetrating tumour of the medial canthal area is resected, removing the entire canthal mechanism in the process, and many of the details of the reconstructive technique are designed to minimize them.

The approach to reconstruction following excision in this area depends on the state of the canthal ligament at the completion of resection. If a remnant of the ligament remains, and this will be clinically evident from the maintenance of the canthus in its normal position, a postauricular whole skin graft is the appropriate means of cover in most instances and the result should be satisfactory. Total loss is usually immediately obvious at operation, though in most instances the entire canthal mechanism is formally resected at the outset because the tumour is clearly a penetrating one.

Tumours of the lateral canthal area whose excision requires resection of the canthus are very uncommon. The lateral canthal ligament is less strong than the medial canthal ligament and its line of stress is a continuation of the curve of the eyelids. This makes for fewer problems when the area is being reconstructed.



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Medial canthus

The problems of managing a penetrating tumour of the medial canthus arise both at the stage of resection and during reconstruction.

57

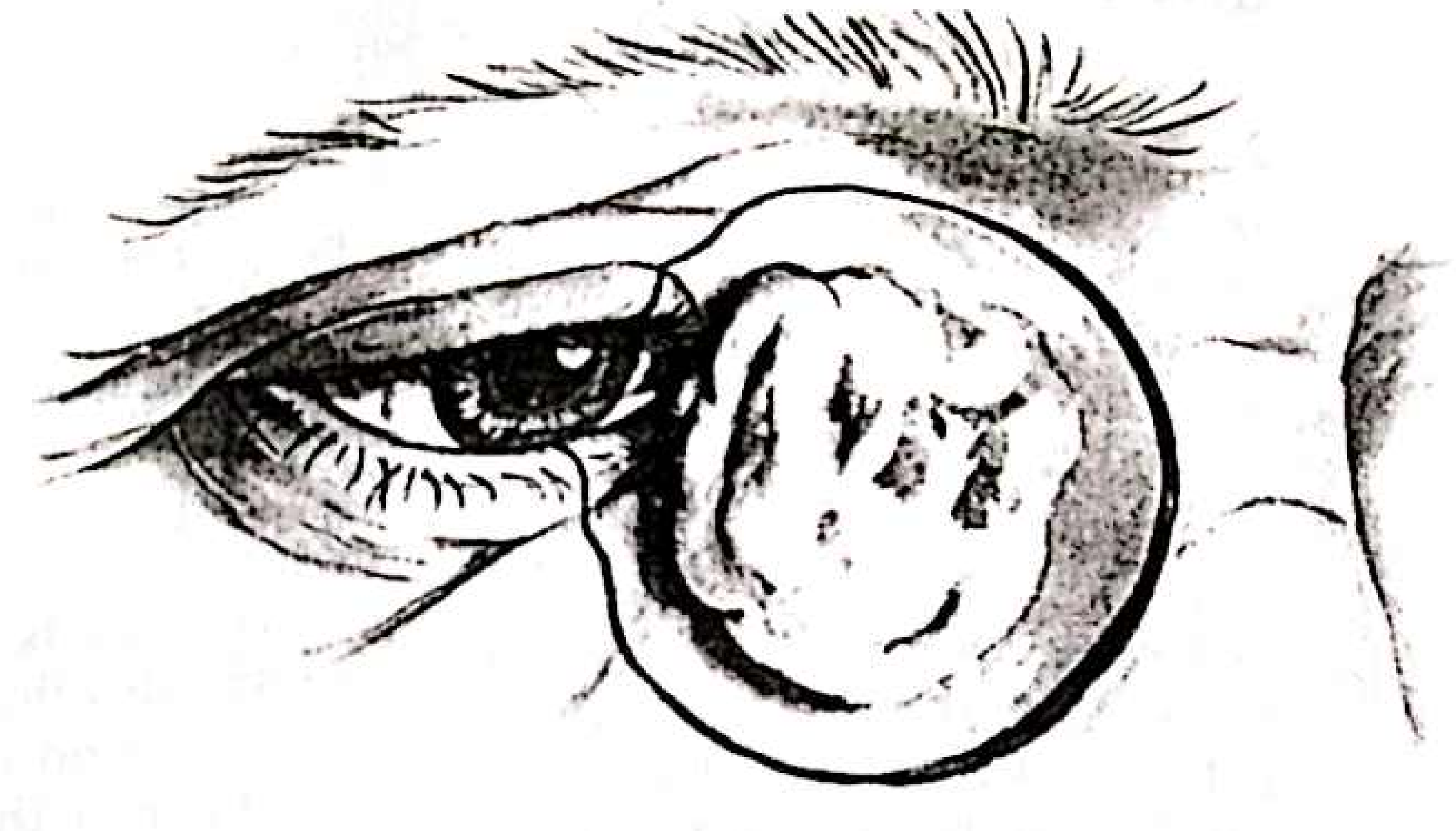
The resection problems concern the structures which are involved by the tumour and the most efficient way of excising them, having regard to the need for effective visualization of tumour extent throughout the excision. The penetrating tumour of the medial canthus extends backwards within the wedge formed medially by the nasal process of the maxilla, the lacrimal bone and the orbital plate of the ethmoid as they pass backwards along the medial wall of the orbit, and laterally by the medial rectus muscle. Involvement by tumour of the medial side of the wedge does not necessarily imply local inoperability since the bone can be excised, together if necessary with the mucosa of the nasal cavity and/or the ethmoidal labyrinth. Involvement of the medial rectus does imply local inoperability and exenteration of the orbit is then unavoidable.

The difficulty in seeing the area clearly during excision arises because of the vascularity of the tissues involved and the way in which the orbital fat obscures the field once the wall of the orbital cavity has been breached. The key to good visibility is to avoid entering the cavity until the posterior extent of the tumour, at least medially, has been defined. This involves staying in the plane between the periorbita and the bony wall of the orbit. This plane is easy to enter and equally easy to maintain by stripping the periorbita off the medial wall of the orbit and retracting the orbital contents laterally. With a penetrating tumour of the medial canthus it can be assumed that a full thickness segment of the medial end of one or other eyelid, usually both, will need to be resected, the line of the lid resection constituting the lateral resection margin.

Resection

58 & 59

The line of resection of each eyelid is drawn on the skin and the line is continued over the rim of the orbit onto the skin overlying the bone adjoining the canthus, encircling the tumour with an adequate clearance margin. Where the line overlies the bone the skin is incised and the incision is deepened to the bone. The soft tissue enclosed by the incision is stripped subperiosteally off the bone, working backwards in the direction of the orbit. In the process the canthal ligament is detached from its bony attachment and the lacrimal sac is lifted out of the hollow in which it lies. Continuing into the orbit, the soft tissue is stripped off the medial wall backwards until it is apparent from the smooth appearance of the bony surface exposed and the clean stripping of the periorbita that the tumour has been cleared posteriorly. The bony surface which is exposed in this way, although it may be involved by tumour, is left temporarily. Along a line which clears the tumour posteriorly, the periorbita is divided vertically, opening into the orbital fat, and a similar horizontal incisions are made along the upper and lower clearance lines, dividing the periorbita.



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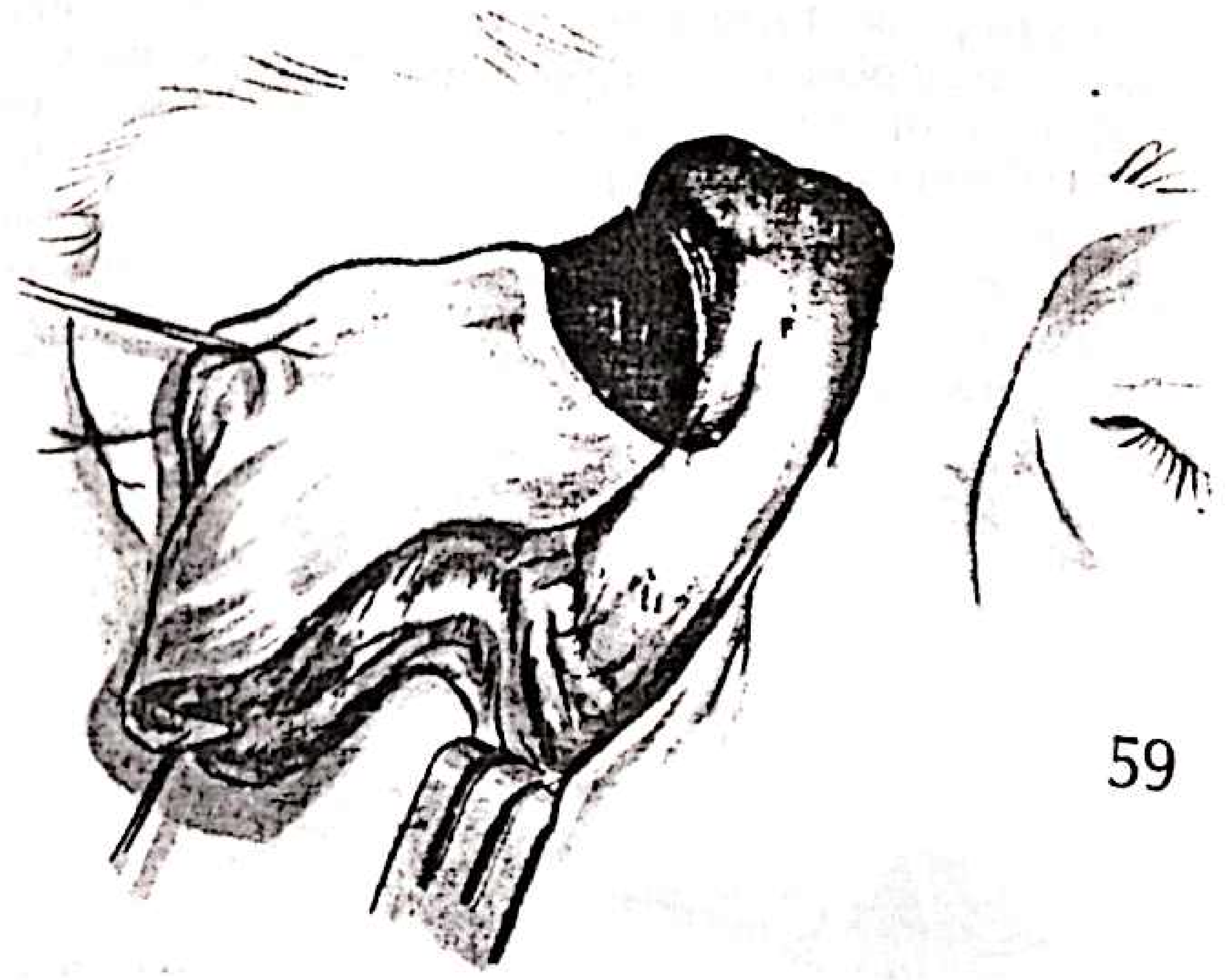

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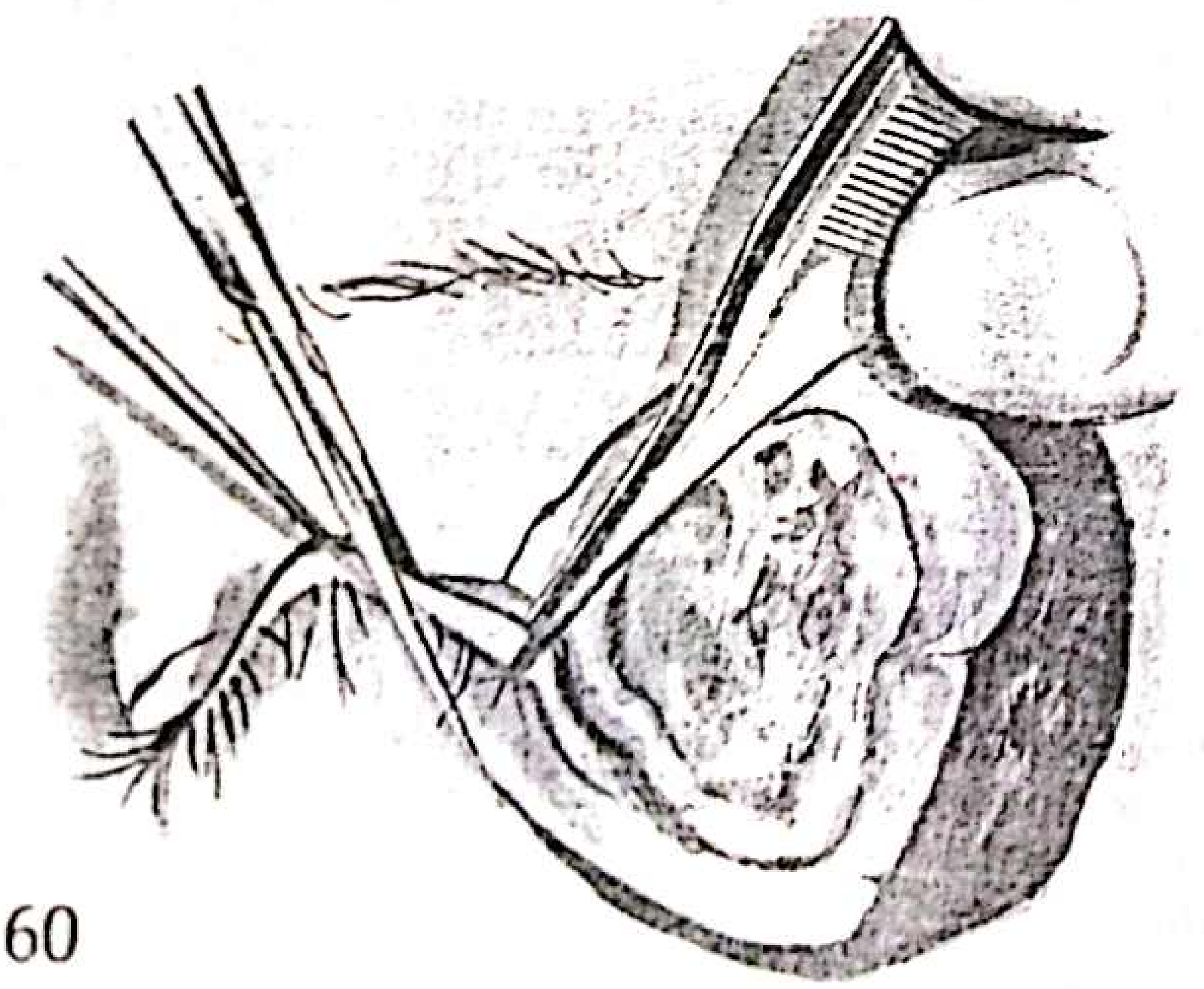

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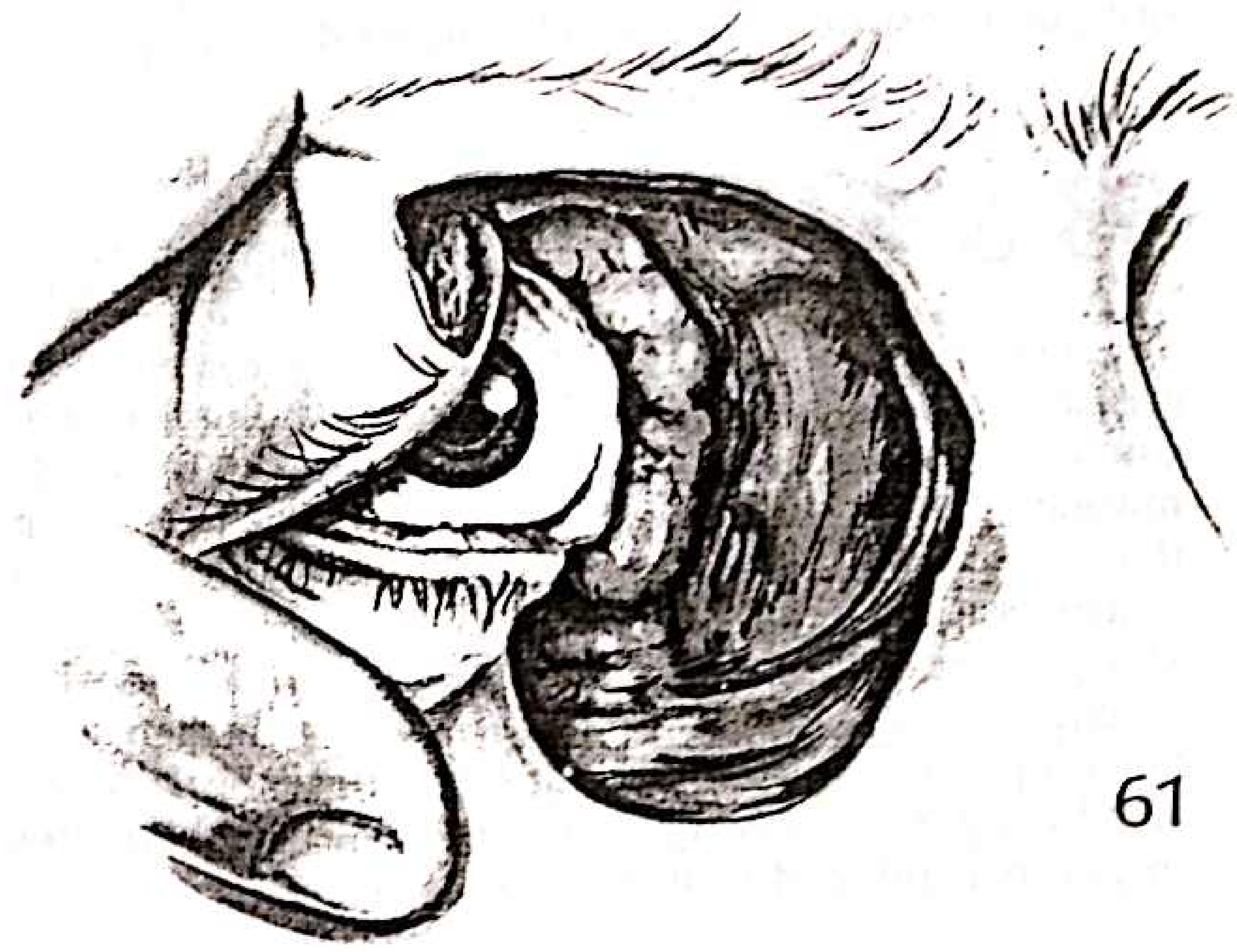
Attention is then turned to clearing the tumour laterally. Each eyelid is sectioned through its full thickness along the line marked out on the skin as far as the fornix, and beyond this the skin incision is continued to the orbital rim, completing the marginal skin clearance of the tumour. The eyelid segments which are part of the resection specimen are retracted medially and separated to expose the medial fornix. Along a line which clears the tumour in the medial fornical region the conjunctiva is divided from upper to lower fornix. The soft tissue is dissected medially off the globe and back into the orbital fat, leaving the medial rectus covered with orbital fat if at all possible. It is now possible to pull the wedge of soft tissue forward and complete the local resection.



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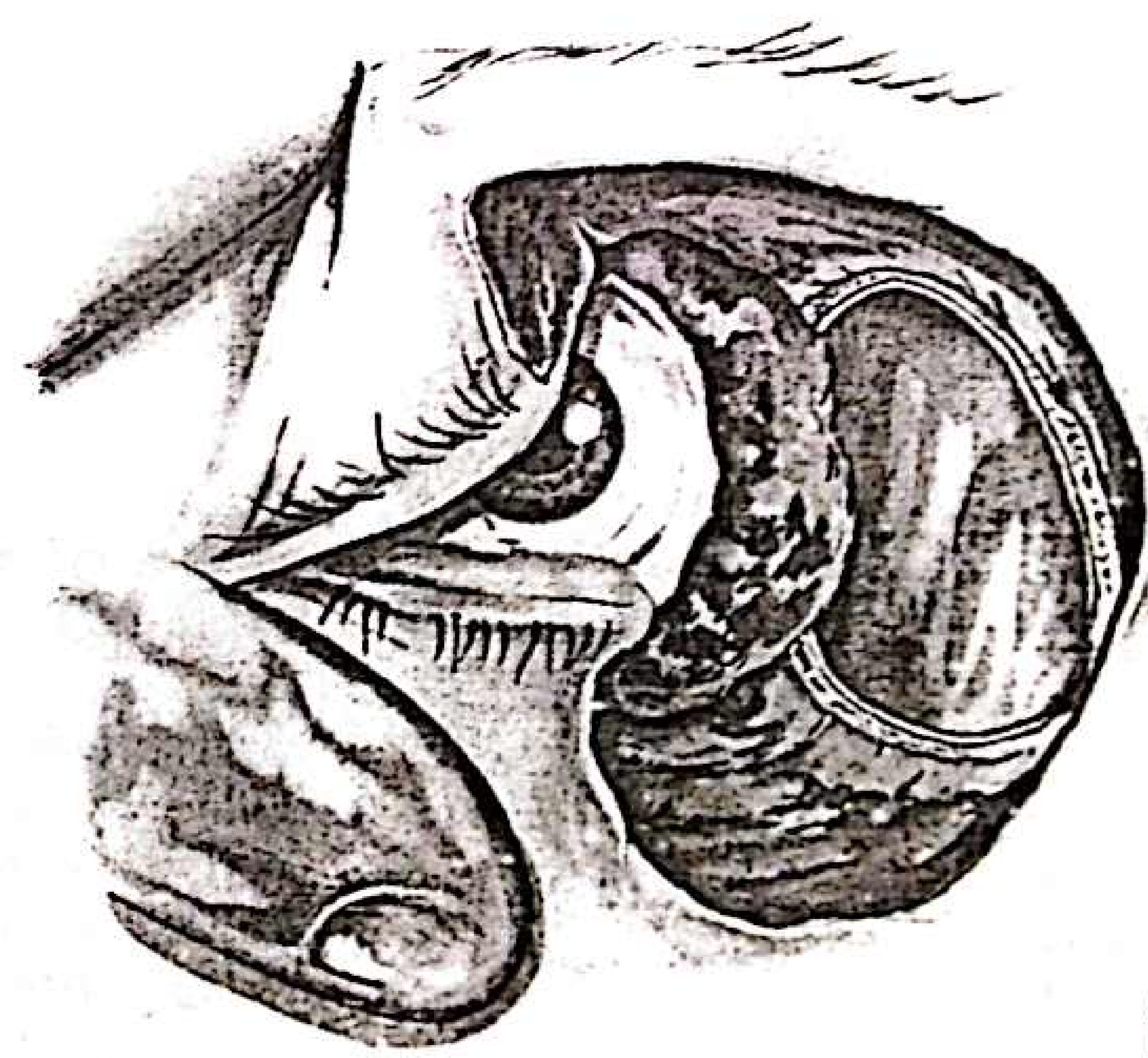
61 & 62

Removal of the soft tissue element of the tumour leaves the bony medial wall of the orbit and canthal area open to be inspected for signs of erosion, evidence of involvement by tumour. Any suspicious sites should be resected radically marginally, removing the full thickness of the bone and exposing the deep surface of the nasal mucoperiosteum and, further back in the orbit, ethmoidal mucosa. If necessary these surfaces can in turn be resected, exposing the nasal septum, and in practice there is much to be said for resecting bone and mucoperiosteum as a routine, this being more radical in pathological terms and likely to give a better ultimate cosmetic result for the reasons discussed below.

Such an approach to excision of the tumour, in which the resection of the soft tissue element and the bony element are separated into two distinct parts, may breach the concept of monobloc resection, but the improvement in visualization of tumour extent and accuracy of resection more than compensates for this.



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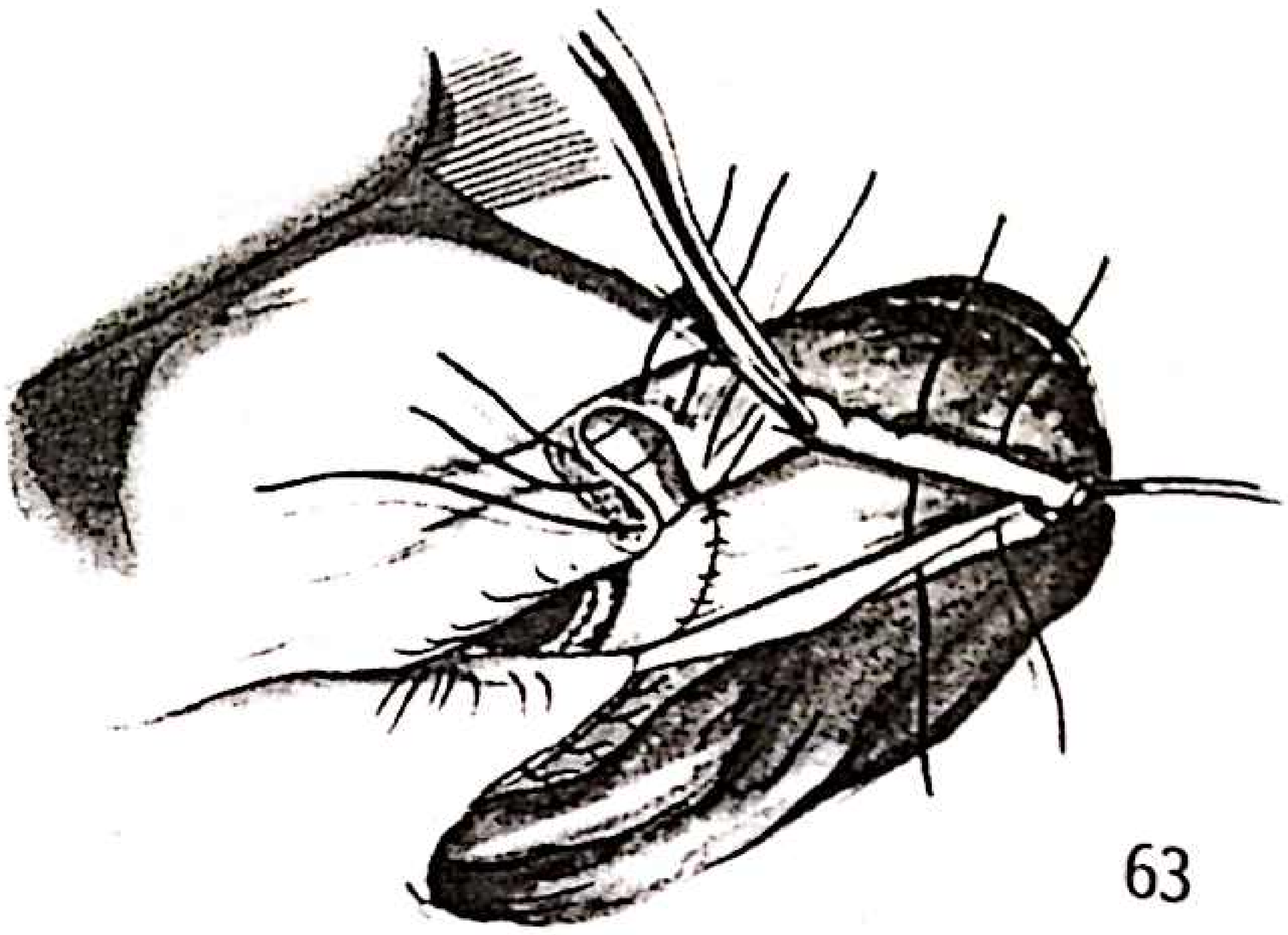
Reconstruction

Reconstruction of the defect which is left requires both skin cover and replacement of the conjunctiva which was resected. The conjunctival loss virtually always has to be made good by using a graft of oral mucosa. Skin cover is provided by a glabellar-based forehead flap, vertical or oblique, depending on the extent of the defect. An oblique construction is usually required.



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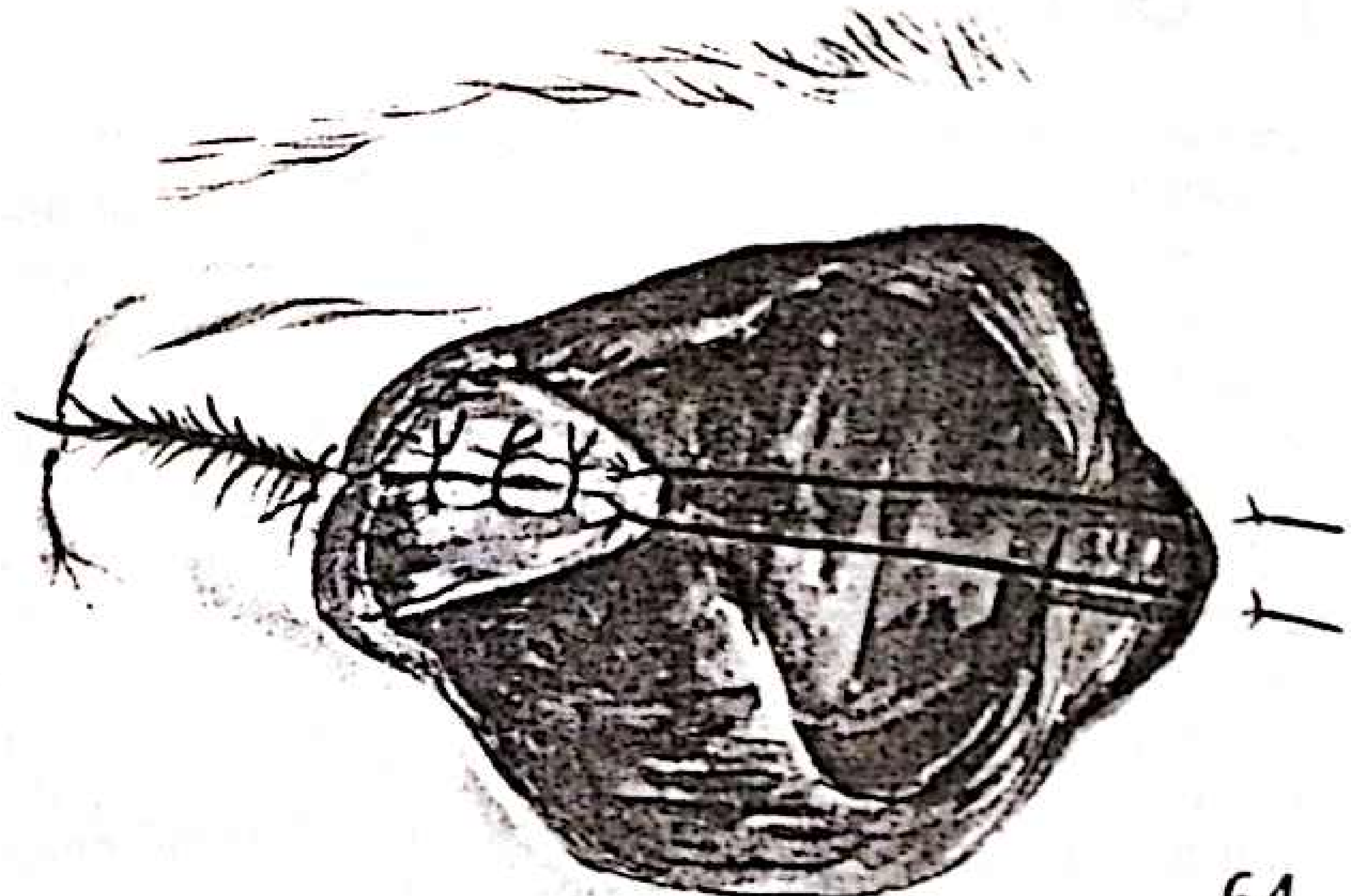
The cut margins of the two eyelids are approximated, creating a temporary new medial canthus, and the graft of oral mucosa is used to reconstruct the medial fornix. One margin of the graft is sutured to the conjunctival layer of the resected lid margins, and the opposite margin is sutured to the conjunctival resection line on the eyeball. The graft margins between are sutured to the remaining resection lines. The mucosal graft should be held in a tented position medially, with a suture through its apex, and brought out through the skin so that a deep 'medial fornix' is produced to line the skin flap.



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The resulting defect is covered by the forehead flap. The distal end of the flap is thinned as much as is safe to match the thickness of the original skin of the medial canthal area as far as possible.

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The reconstruction is completed in the short term by dividing the pedicle of the flap 3 weeks later and returning any bridge segment to the forehead. The reconstruction is then left in this state, with the canthus in its laterally displaced position, to allow the tissues to soften and settle.

It is at this point that the value of the radical resection of the bony wall of the orbit and the mucoperiosteum shows. The generous removal of these tissues allows the flap to sit more readily in the hollow of the canthal area, and the scarring produced during healing in this area 'pulls' the flap even more deeply into the hollow. The effect is to reproduce to a considerable extent the original canthal hollow despite the absence of the canthal ligament.

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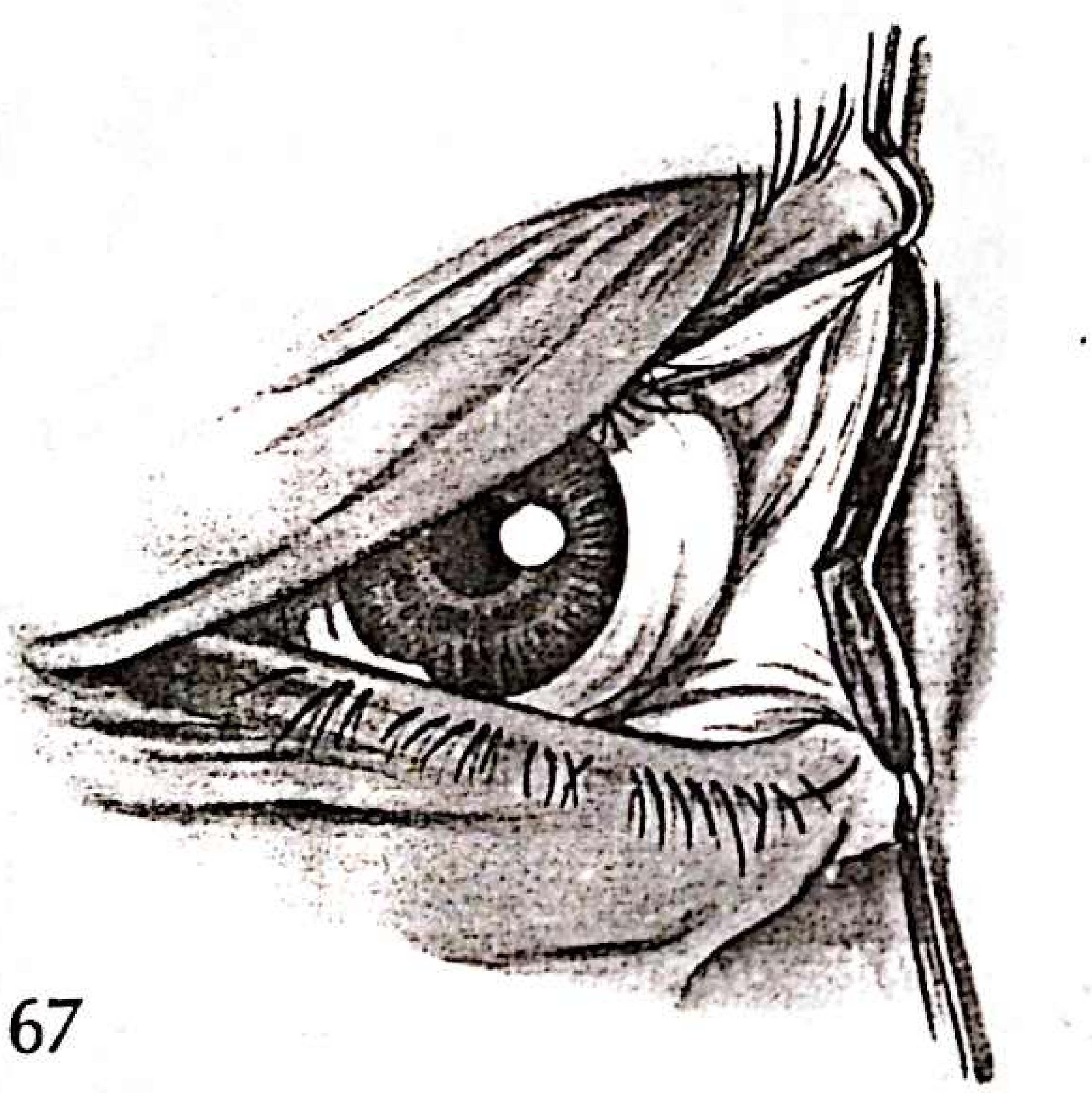

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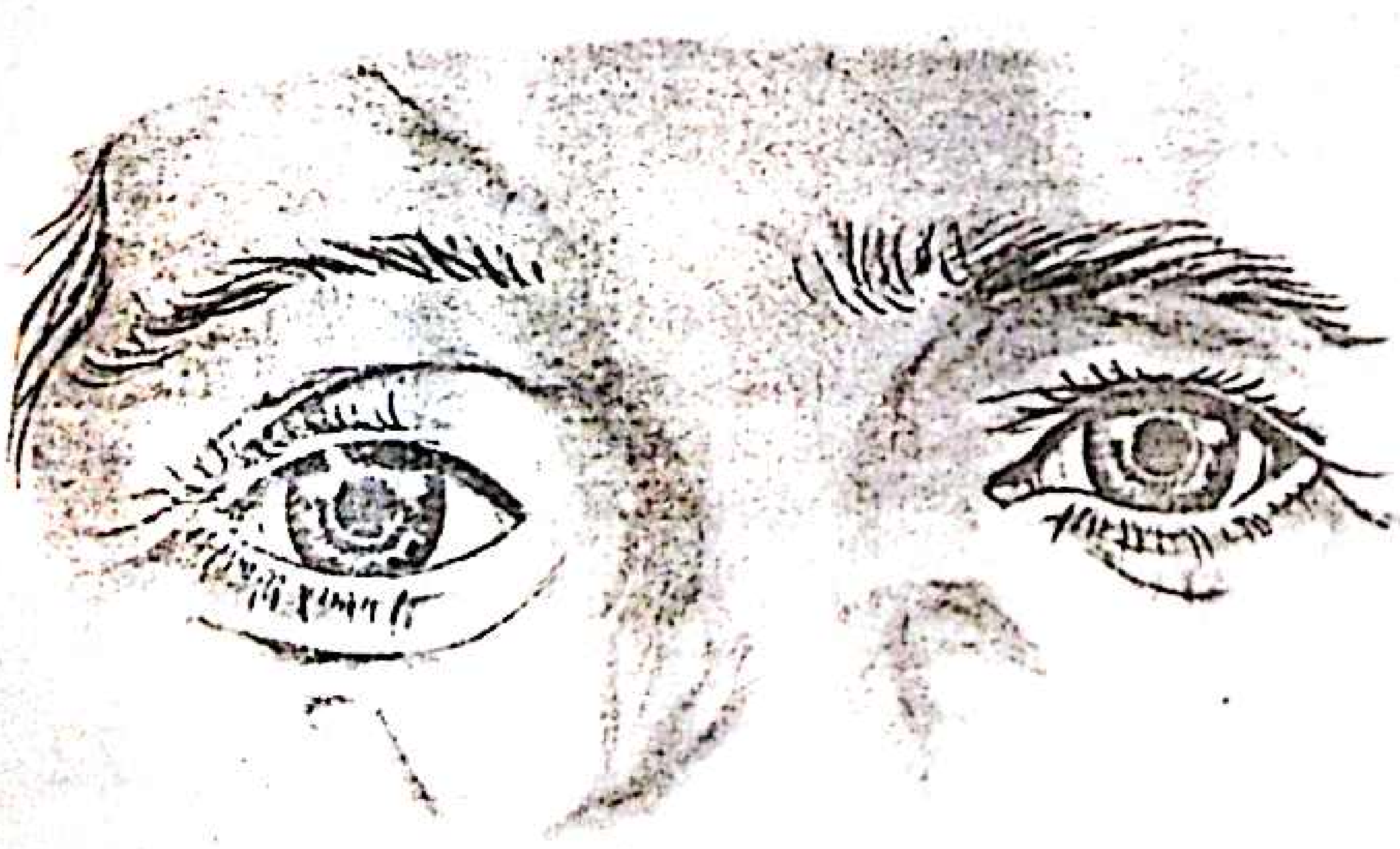
Once the reaction has settled adequately, the reconstruction is completed by carrying out a medial canthotomy which restores the canthus to its original site. For the reasons already discussed on p. 126, no attempt is made to reconstruct a fresh drainage mechanism.



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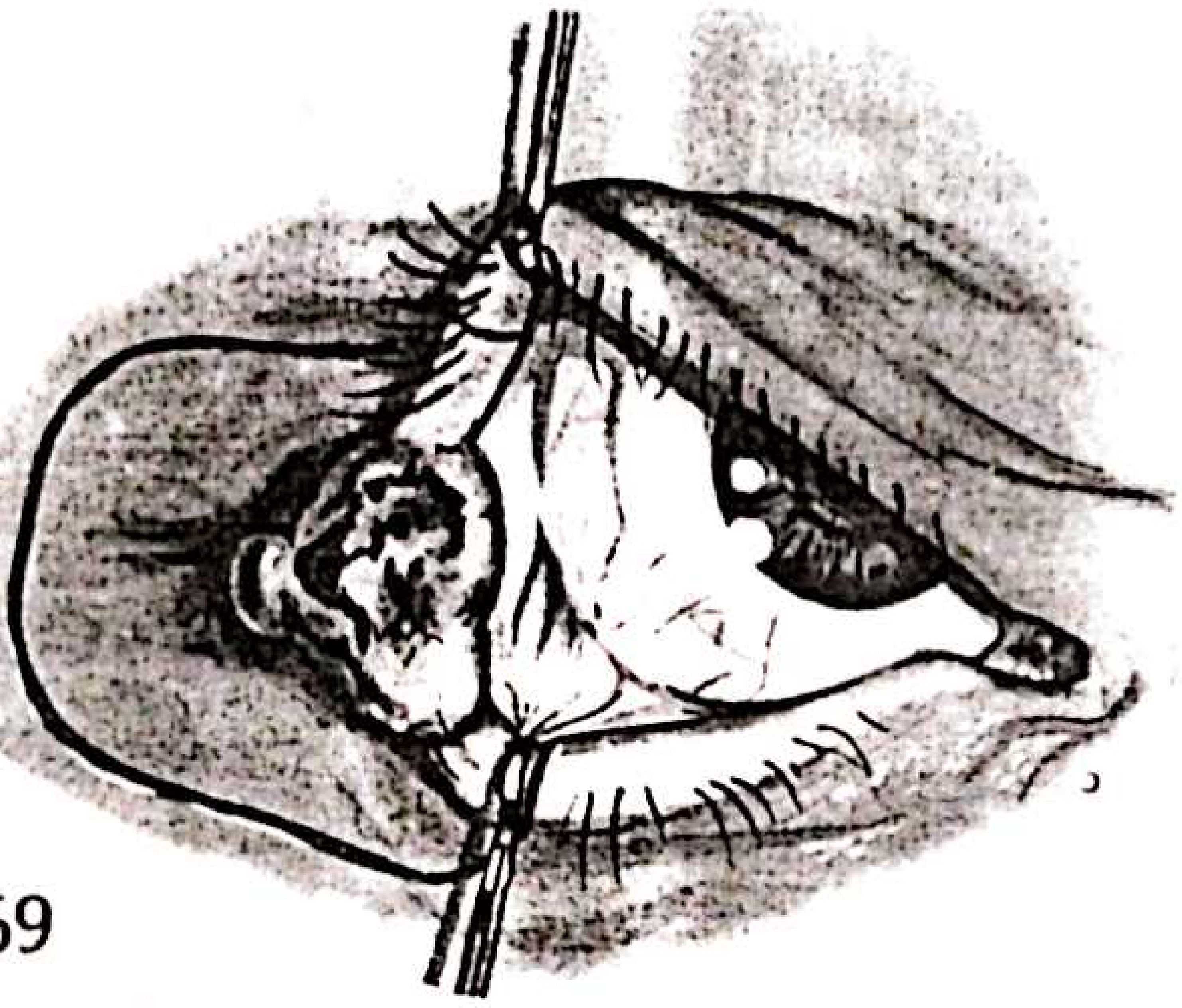
Lateral canthus

The principles underlying resection and reconstruction of the lateral canthus are similar to those of the medial canthus but there are fewer technical problems.

69–72

As with the medial canthus, the resection usually includes full thickness segments of both lids adjoining the canthus. The lid margins are sutured together at the resection line, creating a temporary lateral canthus medial to the original site, and the lateral fornical conjunctiva is advanced to line the reconstructed segment of the eyelid, suturing it to the conjunctiva along the resection line of the eyelids. The amount of conjunctiva resected rarely merits replacement with a mucosal graft, mobilization and advancement of the residual conjunctiva being adequate. Here, as with the medial canthus, the conjunctiva should be 'tented' laterally so that it will line the reconstructed eyelid segment.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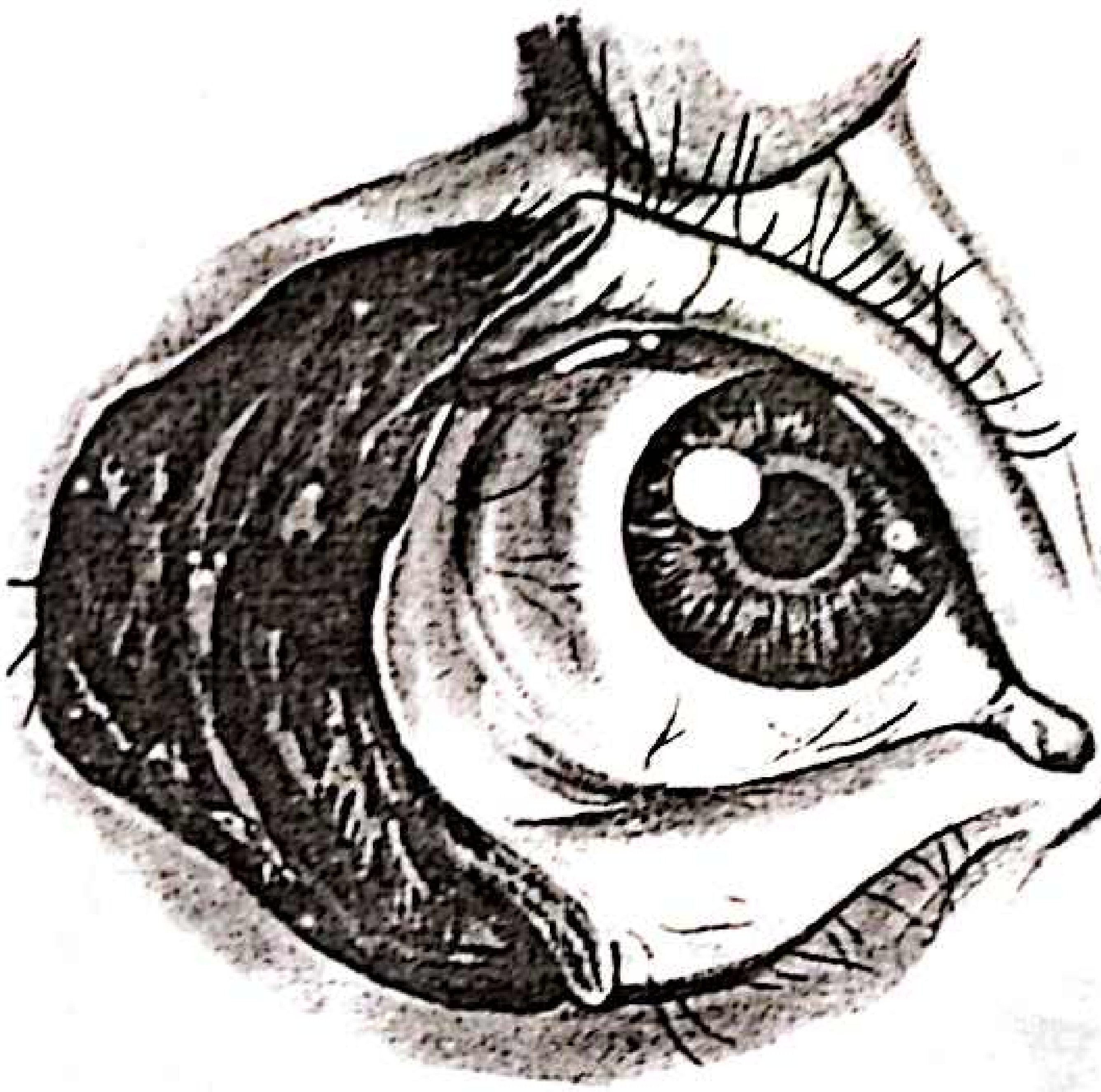
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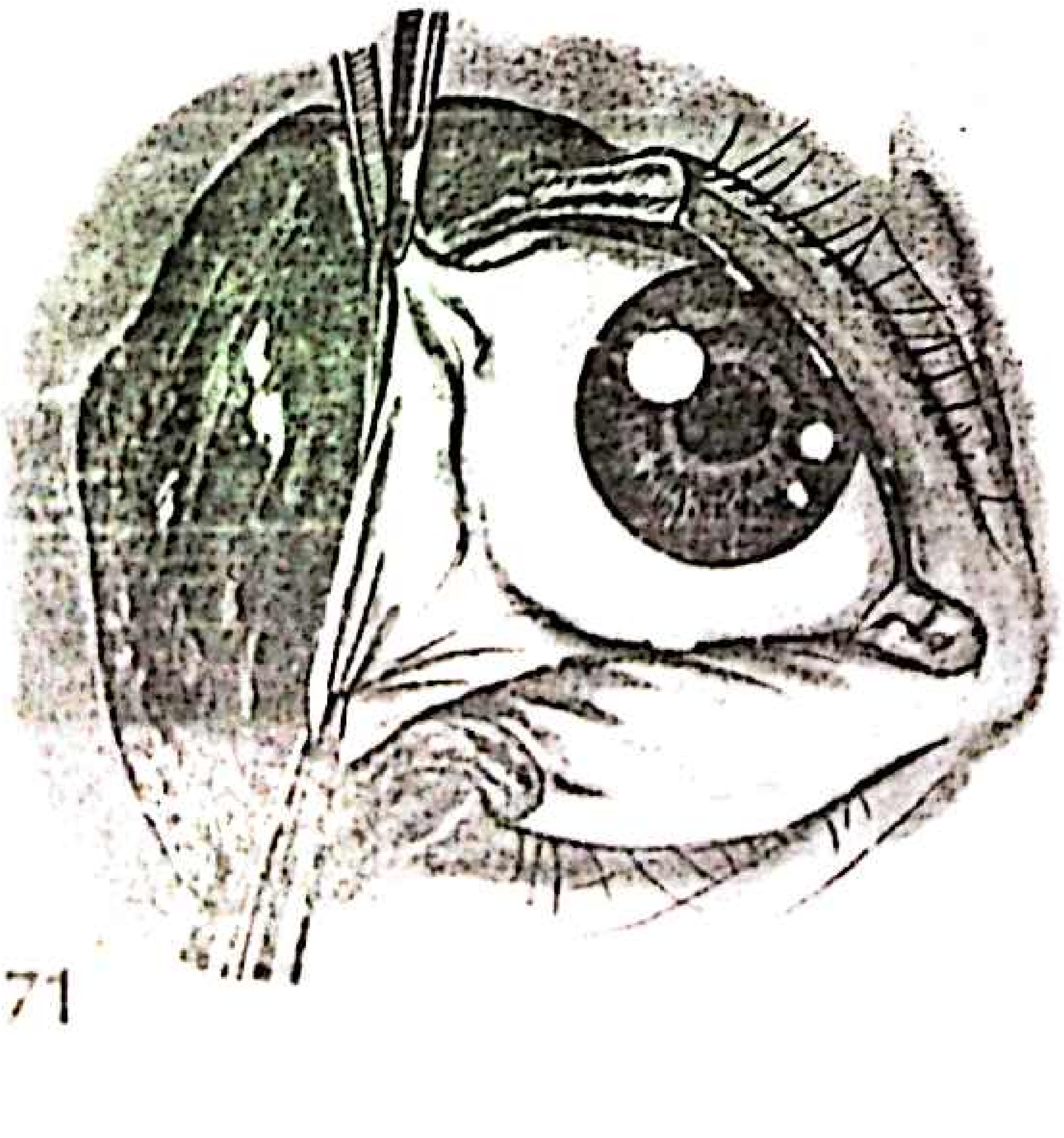
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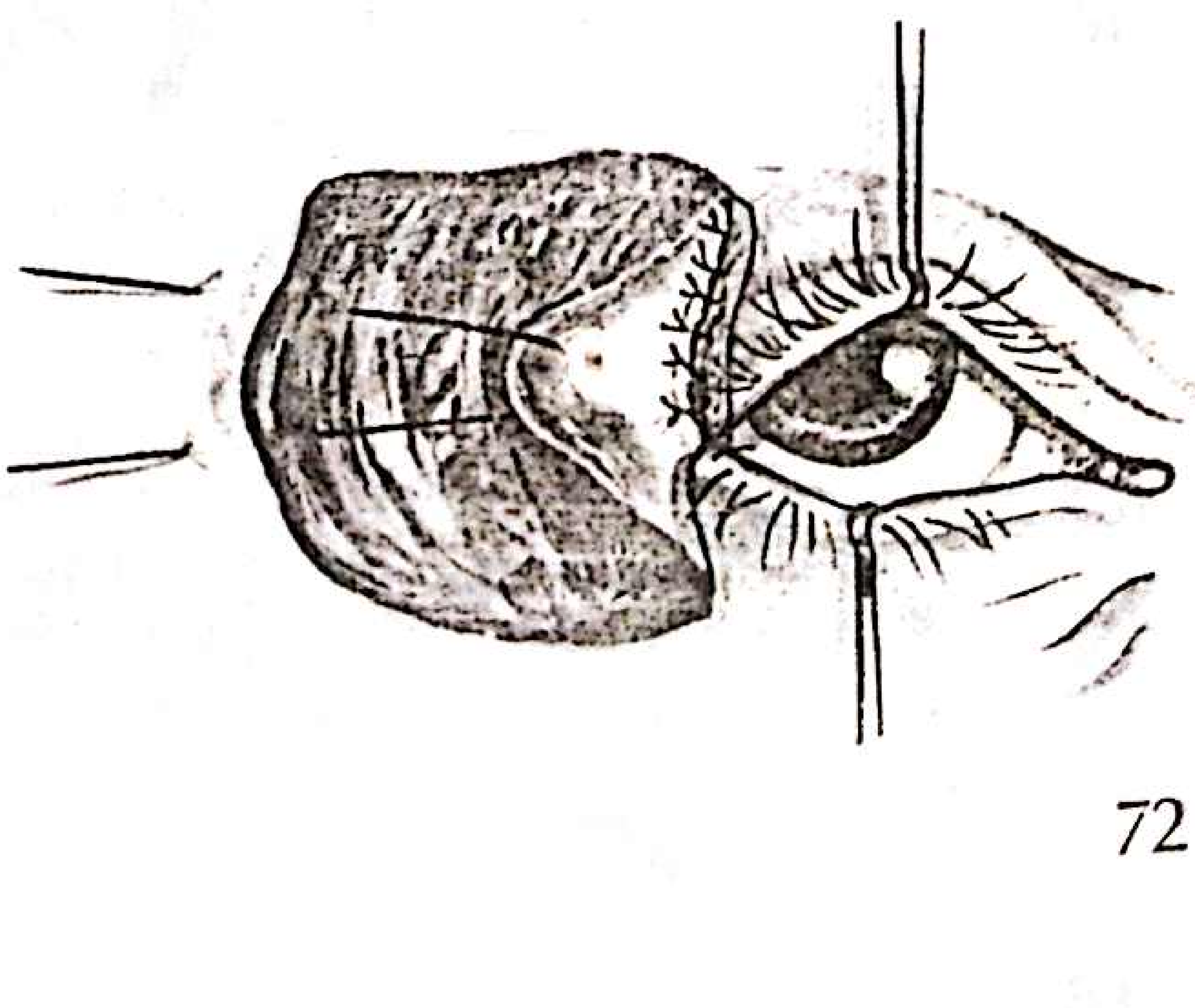
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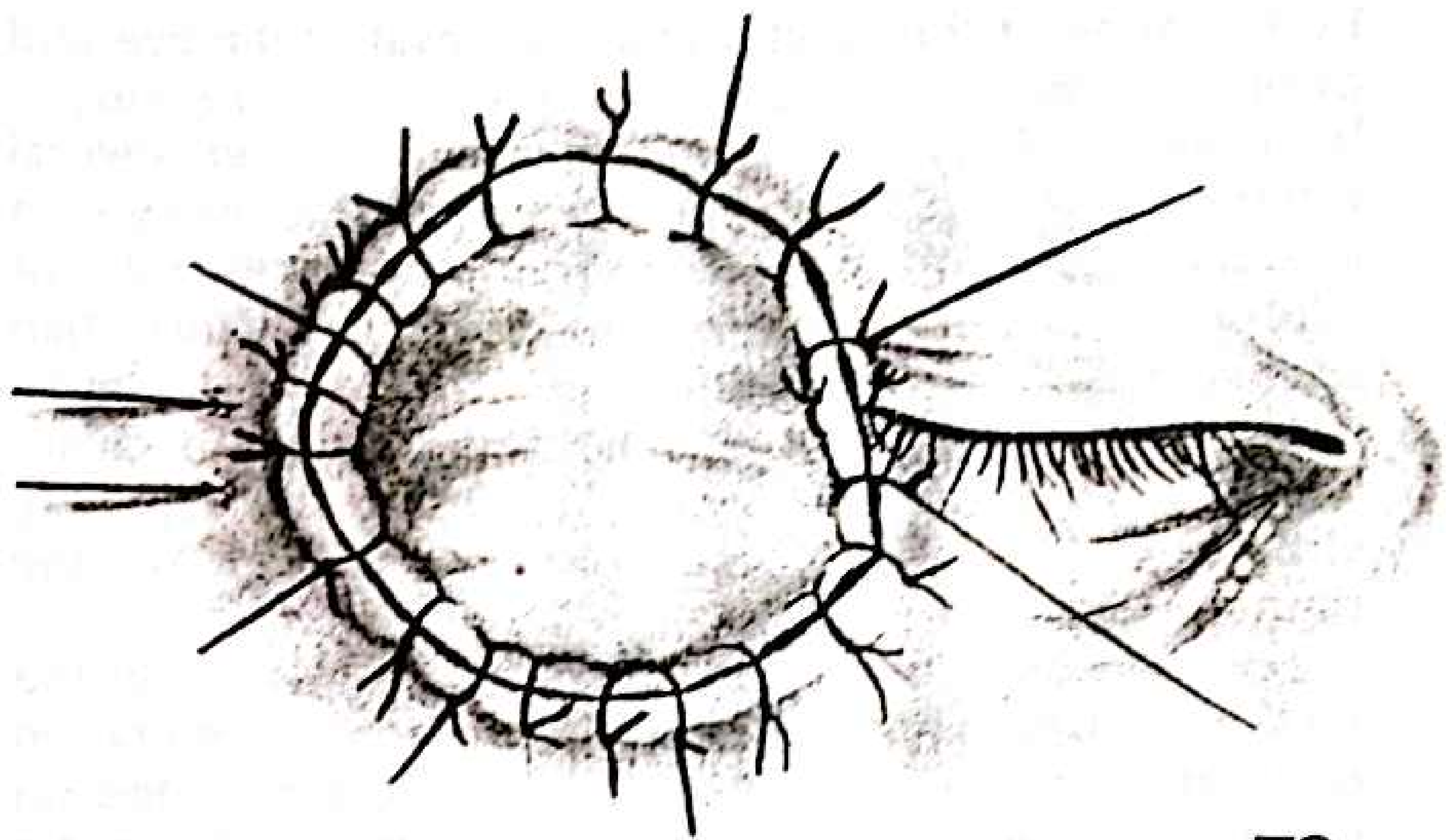
Cover is provided by a postauricular whole skin graft or forehead flap. The advanced conjunctiva provides a graftable surface for the postauricular whole skin graft, and its thinness and mobility give a better result than is generally achieved with the thicker skin of most flaps. If it has proved necessary to resect part of the lateral orbital rim to clear the tumour, a flap is of course required.



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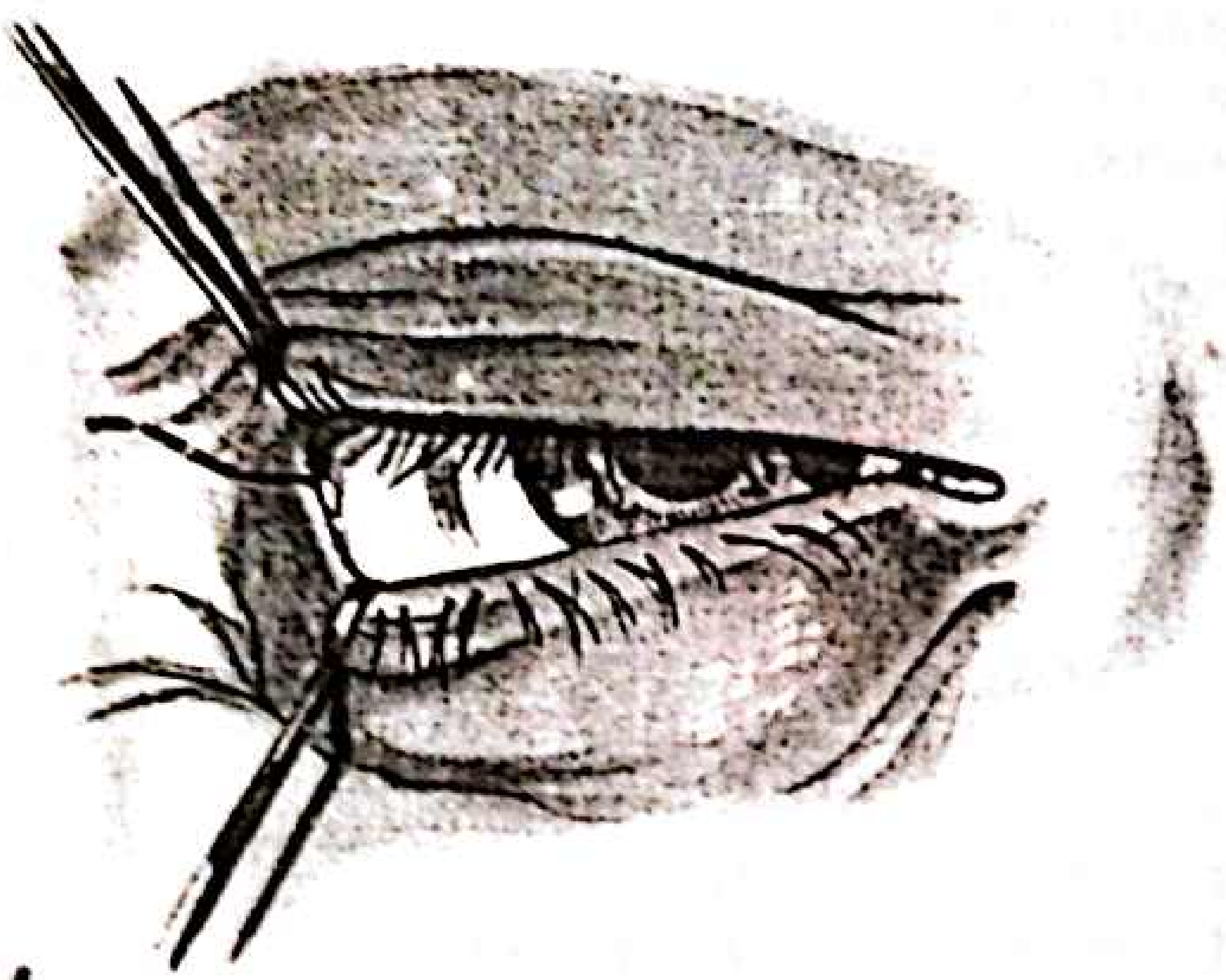

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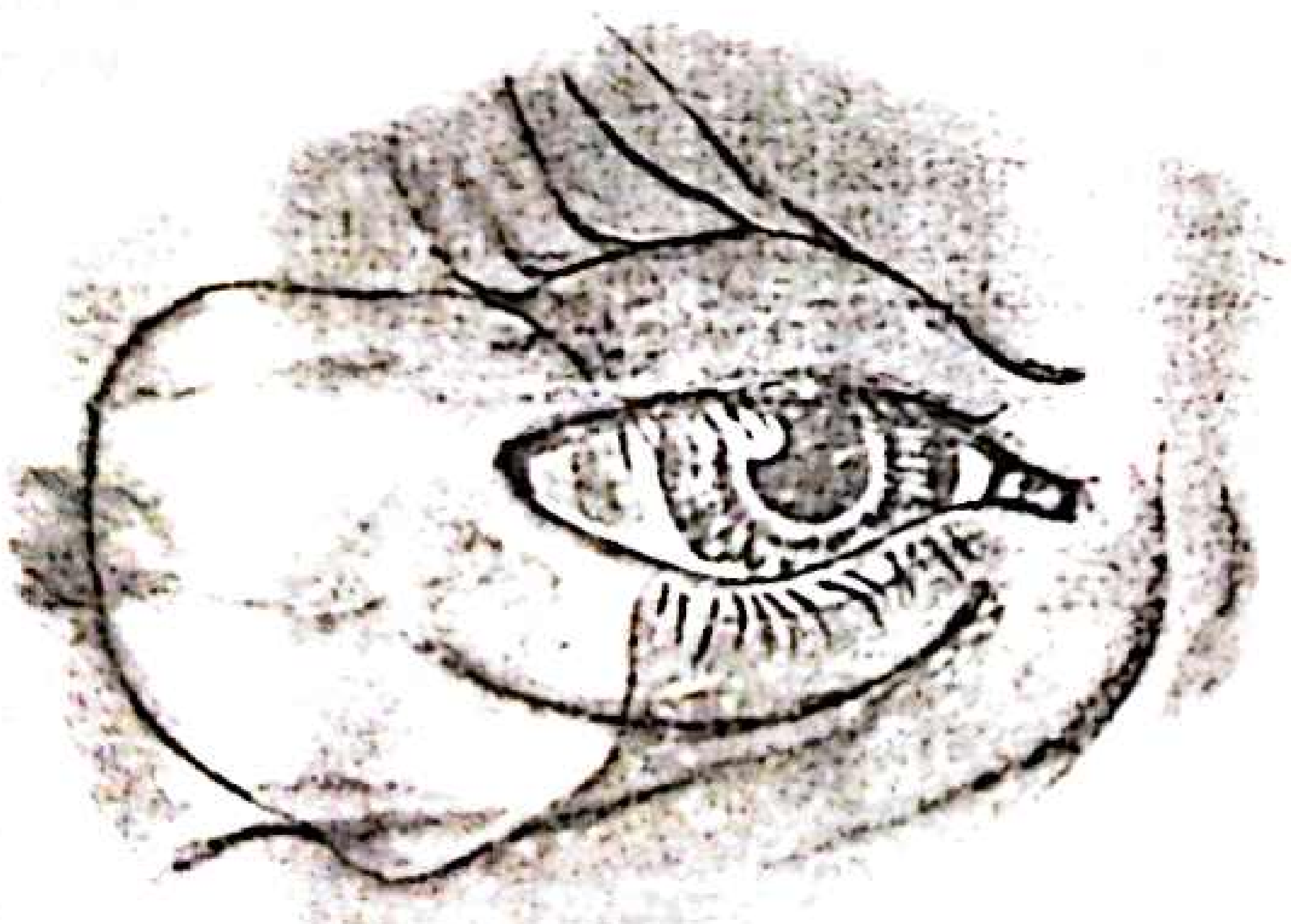
Once the operative reaction has settled, a lateral canthotomy can be carried out to restore the palpebral aperture to its original width.



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Orbital exenteration

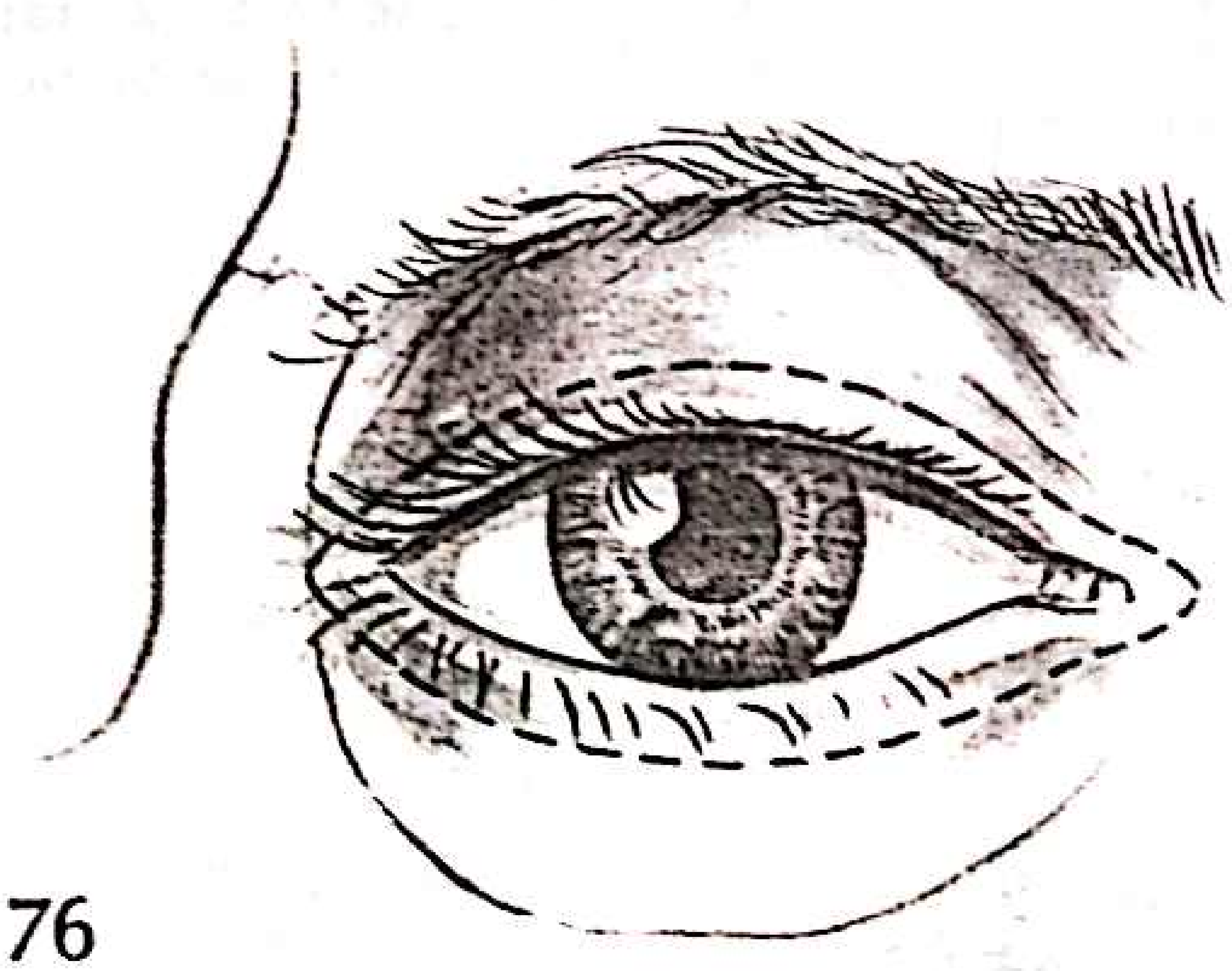
Exenteration of the orbit implies removal of the eye and orbital contents, preferably contained within the periorbital lining. The procedure is carried out in several different circumstances. It may be required to manage an eyelid tumour which has extended deeply into the orbit or where the nature of the tumour demands a more than usually radical surgical approach, as in adenoid cystic carcinoma of the lacrimal gland. It is also carried out where tumour has invaded the orbit from an adjoining structure, most often the maxillary antrum or the ethmoids.

The prosthesis which is typically used to provide the final camouflage after completion of the exenteration consists of an 'eye with eyelids', generally mounted on spectacles (see *Illustration 86*); this abuts directly on the orbital margin. There is consequently nothing to be gained by trying to retain an intact functioning eyelid, even where this would be pathologically acceptable. In the context of exenteration the value of an eyelid lies in its skin element, which can be draped over the orbital rim and make a contribution to the lining of the orbit.

Resection

76

The initial skin incisions are made parallel to, and close to the margin of each eyelid, modifying the line of the incision if necessary to clear any tumour involving the lid.



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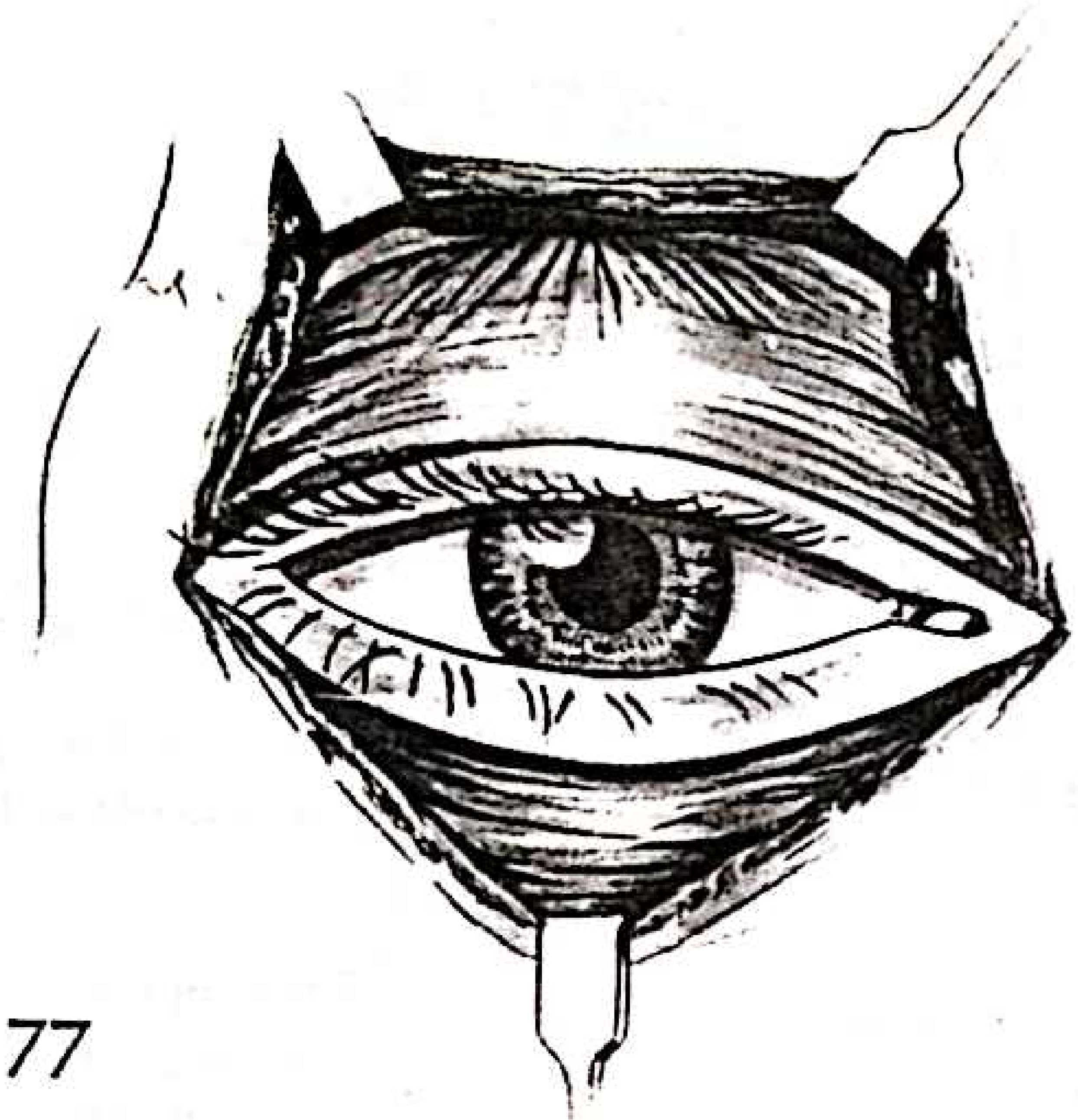
77–81

They are immediately deepened to the plane between skin–muscle and tarsoconjunctiva, and the lids are split in this plane until the orbital rim is reached. Dissection is then deepened to the bone to reach and establish the dissection plane which will be used in the orbit, between the periorbita and the bony walls. The medial and lateral canthal ligaments are stripped off the bone, and stripping of the periorbita is continued back to the apex of the muscle cone all round. The periorbita normally strips readily, and if it fails to do so it is usually because there is local infiltration by tumour, an aspect of the resection whose management is discussed below. When the contents have been freed, the muscle cone with its contained optic nerve is divided and the orbital contents are removed. A temporary pack is inserted and removed after a few minutes to allow any bleeding vessels to be tied off or diathermied.

Periorbita which fails to strip cleanly generally fails because there is local infiltration by tumour. This can be managed by ignoring it temporarily, continuing with the exenteration and carrying out the appropriate additional resection of bone and other involved structures once the orbit is empty of its contents and the area can be seen more clearly, or by resecting the involved segment of orbital wall in continuity with the main tumour. The method which is appropriate depends on the tumour type and the site of involvement of the wall of the orbit. In squamous carcinoma or basal cell carcinoma involving the eyelid area, clearance of the orbital contents, followed by bone resection once the extent of the involvement can be seen, is feasible, and in many maxillary tumours this method is equally satisfactory. Indeed, resection in continuity may be virtually impossible technically because of the difficulty of seeing the site properly until the orbit is empty. It is when the bone involved is of the roof or the lateral orbital wall, and when a craniofacial approach (see chapter on 'Tumours involving the anterior and middle cranial fossae') is being used, that resection in continuity becomes feasible more often. In the case of a malignant lacrimal gland tumour, particularly adenoid cystic carcinoma, resection in continuity is essential because of the known pathological behaviour of the tumour.



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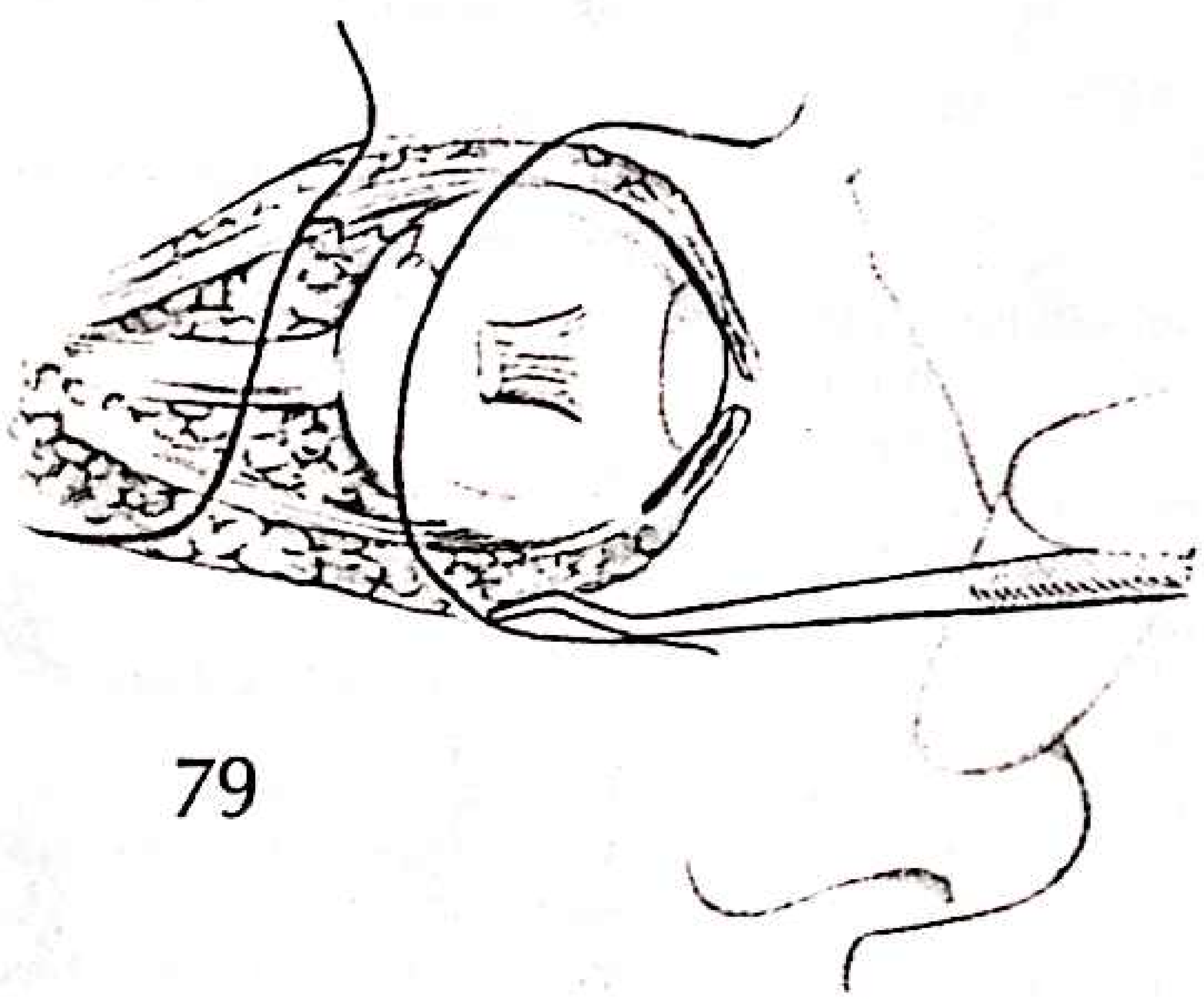

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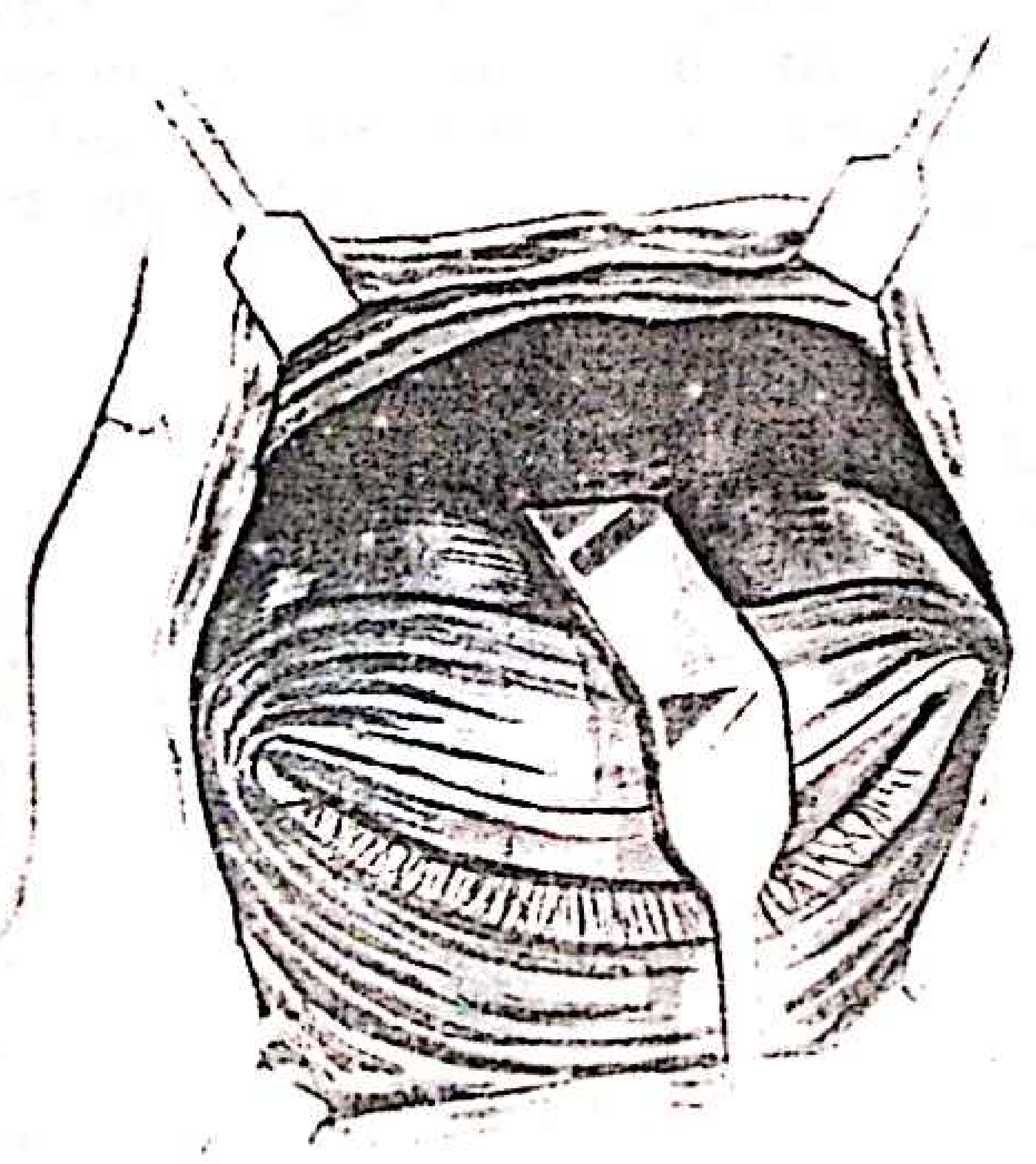

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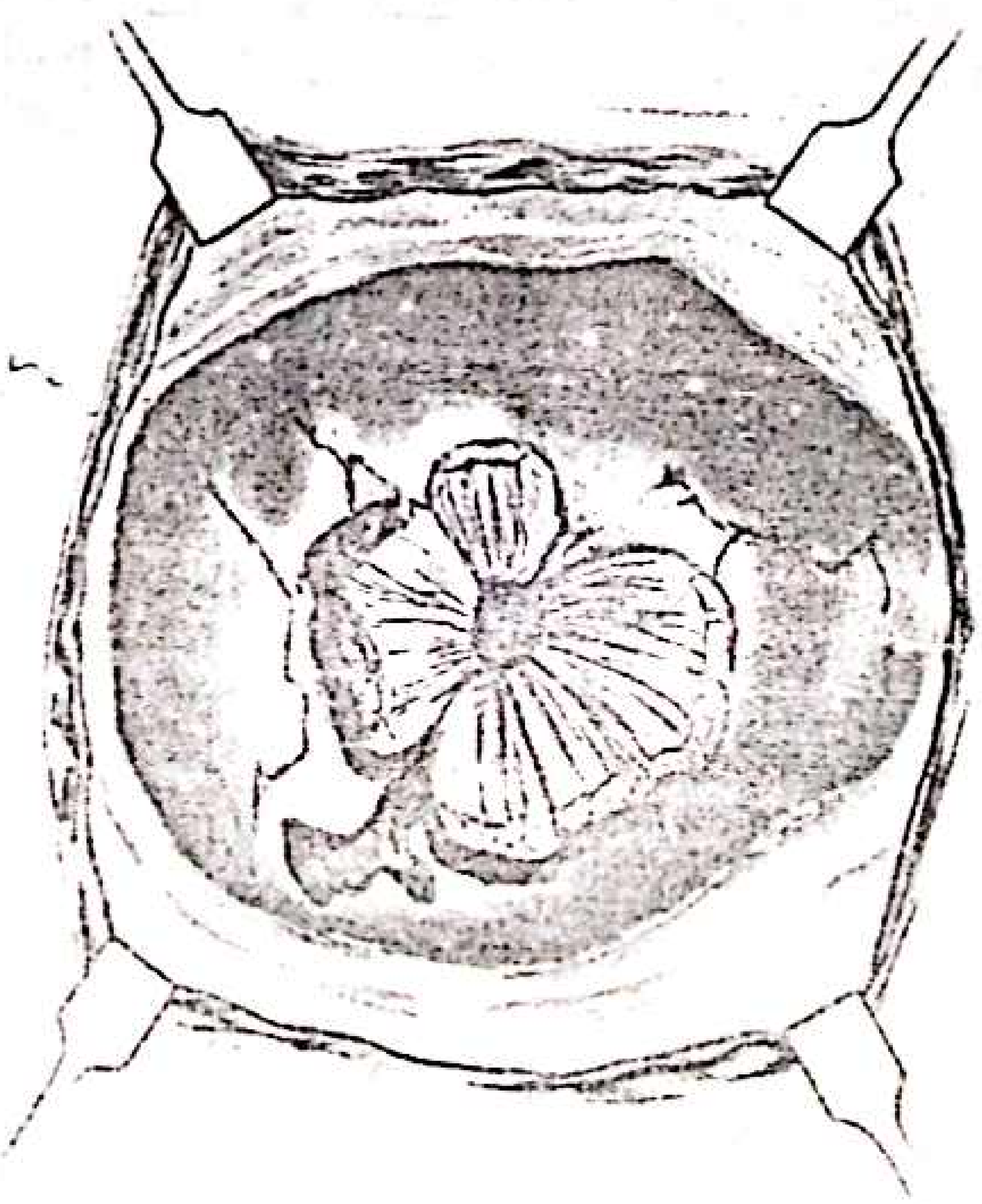

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Reconstruction

Exenteration invariably involves removal of the orbital contents but often has to be extended to include varying amounts of the eyelid and orbital wall. The reconstruction which is then carried out can take various forms, using the eyelid skin, a split-skin graft, skin flap or muscle flap. In each instance the reconstruction is generally completed with a prosthesis.

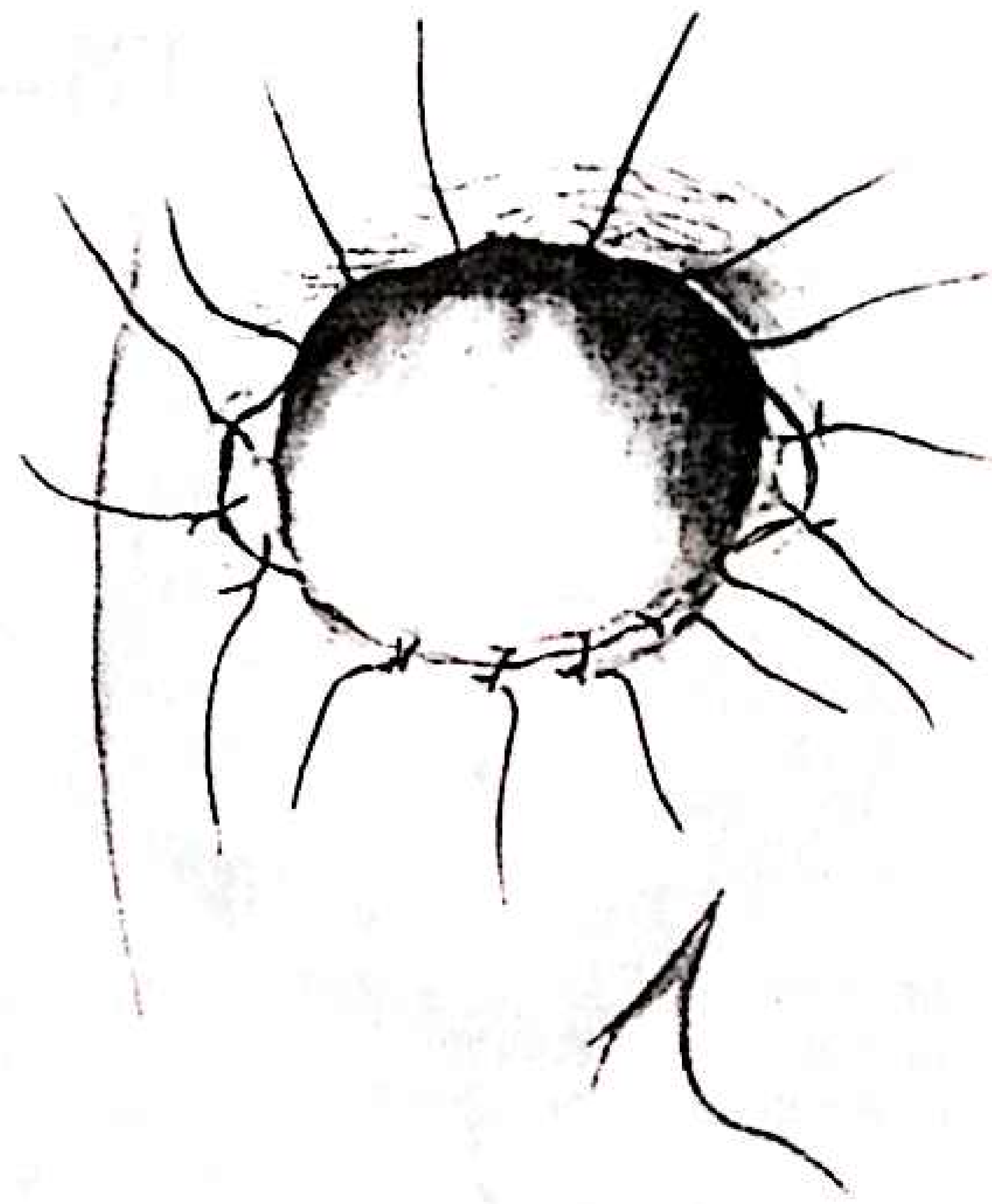
When it has not proved necessary to excise skin of the eyelids they may be capable of lining the greater part of the orbital cavity, or even the entire cavity, depending on its depth. If the eyelid skin is being used in this way the margins of the lids are merely sutured together and a pack is inserted to hold them back against the walls of the cavity.

Split-skin graft

From the viewpoint of suitability for skin grafting, the greater part of the bone of the middle third of the face is sufficiently vascular to accept a split-skin graft and the exenterated orbit generally takes a graft well.

82, 83 & 84

A split-skin graft of generous proportions should be cut so that it will drape itself into the orbital cavity. It is sutured to the margins of the defect, leaving the sutures long to tie over the flavine wool bolus which is packed into the deep hollow to hold the graft against its walls. The graft in draping itself into the cavity develops folds but these are not important in relation to graft 'take'. The graft takes where it lies against a vascularizing surface, and the folds necrose. With the necrotic folds trimmed, the area heals completely.



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85 & 86

The reconstruction is completed by the fitting of a prosthesis, usually attached to spectacles.

The use of a graft to line the orbital cavity in this way has the considerable advantage of allowing the site to be inspected easily, but many patients dislike the skeletal appearance of the cavity, some to the extent of being unwilling to keep the site clean or even to touch it. An alternative method of reconstruction may then have to be considered.

There are two alternative approaches to the problem. In one a skin flap is used to fill the cavity and cover the surface defect; in the other the temporalis muscle is detached from its origin on the skull and used to fill the cavity, the residual surface defect being either split-skin grafted or covered with a skin flap.

Skin flap

The potential sources of a skin flap are the forehead and the cheek. A forehead flap may be based inferiorly on the glabellar area (*see Illustration 18*) or laterally (*see Illustration 17*), but in both instances the secondary defect almost invariably requires to be grafted, and the resulting appearance may well act as a deterrent for many surgeons.

The flap which makes use of cheek skin is designed as a superiorly based rotation flap (as described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103) its outline passing down from the junction between cheek and nose, along the nasolabial fold and over the lower border of the mandible, curving back along a skin fold in the submandibular area to end below the ear lobule. Rotation of such a flap upwards is capable of covering the surface defect, but for it to sit into a deep orbital defect in addition may prove difficult. Its effective use depends very much on the laxity of the cheek and even more on the presence of well marked skin laxity in the mandibulomasseteric area.

Both flaps are capable of covering the surface defect; their ability to fill the orbital cavity, especially if it is deep, is questionable.

Muscle flap

87–90

In using temporalis to cover the posterior part of the defect, the muscle is exposed by a vertical incision directly over it. It is then detached from its origin in preparation for being swung forward into the orbit on its mandibular insertion. To obtain access to the orbit a window is cut in the lateral orbital wall, or the wall itself is hinged back on the temporal fascia which is attached to it. The surface of the muscle which is left within the orbit by the transfer is either split-skin grafted or covered with one of the skin flaps described above. In practice the muscle does not move forward particularly easily and the method is less effective than descriptions of the technique might imply. A significant temporal hollow is also left and patients are apt to comment adversely on this fact.

Both muscle and skin flaps have the serious drawback of covering the site, making inspection for recurrence of tumour impossible. How serious this consideration is depends on the original pathological problem, but it is an aspect which should play a key role in decision-making.

It should also be borne in mind that the final camouflage is with a prosthesis, usually custom-made and consisting of an artificial eye with eyelids, attached to spectacles. It is the effectiveness of this prosthesis which is likely to determine the success of the entire procedure as far as the patient is concerned. The thickness of the flap is liable to make the fitting of the prosthesis more difficult and less effective, while fitting is generally straightforward when a graft has been used.

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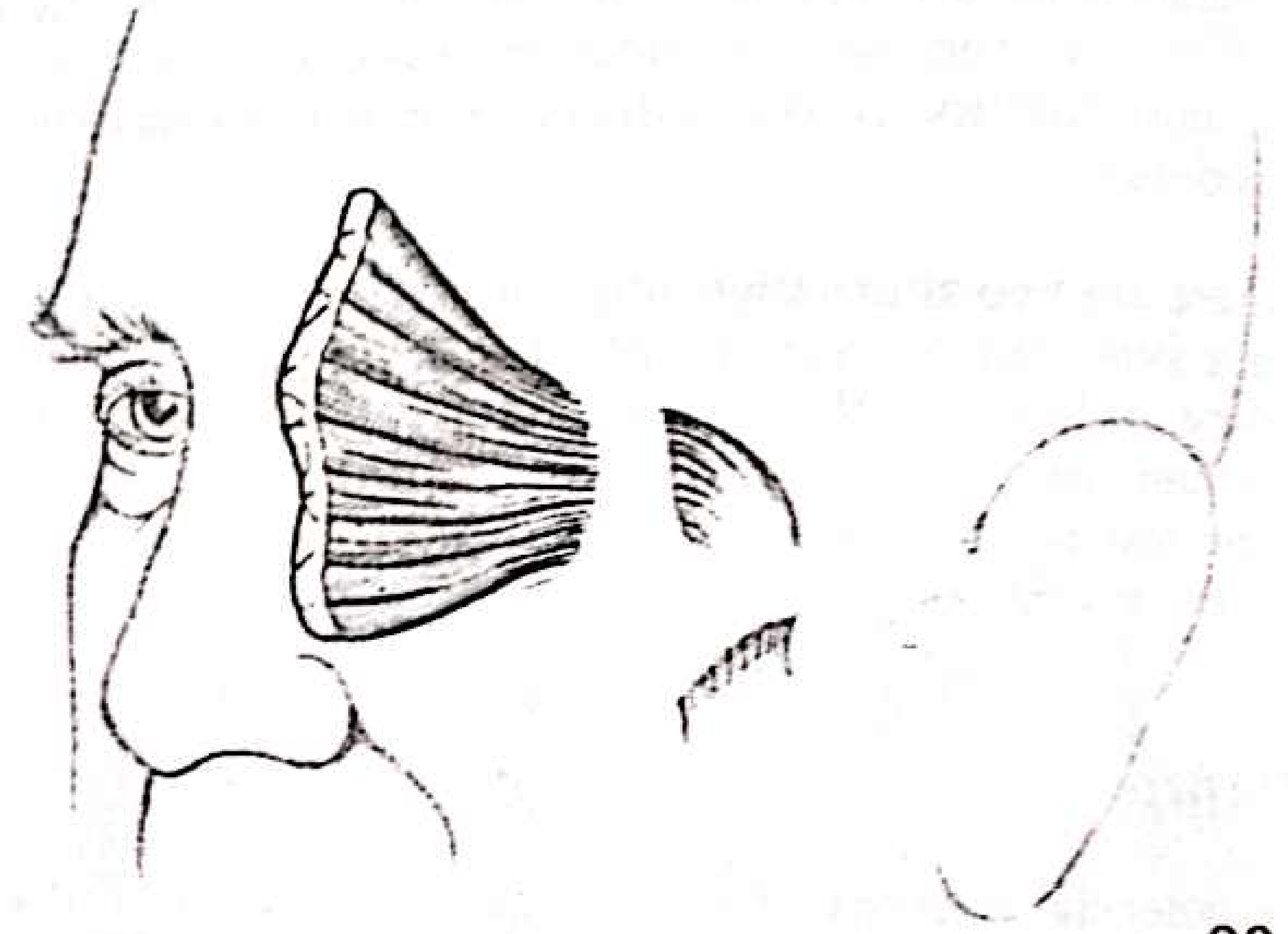

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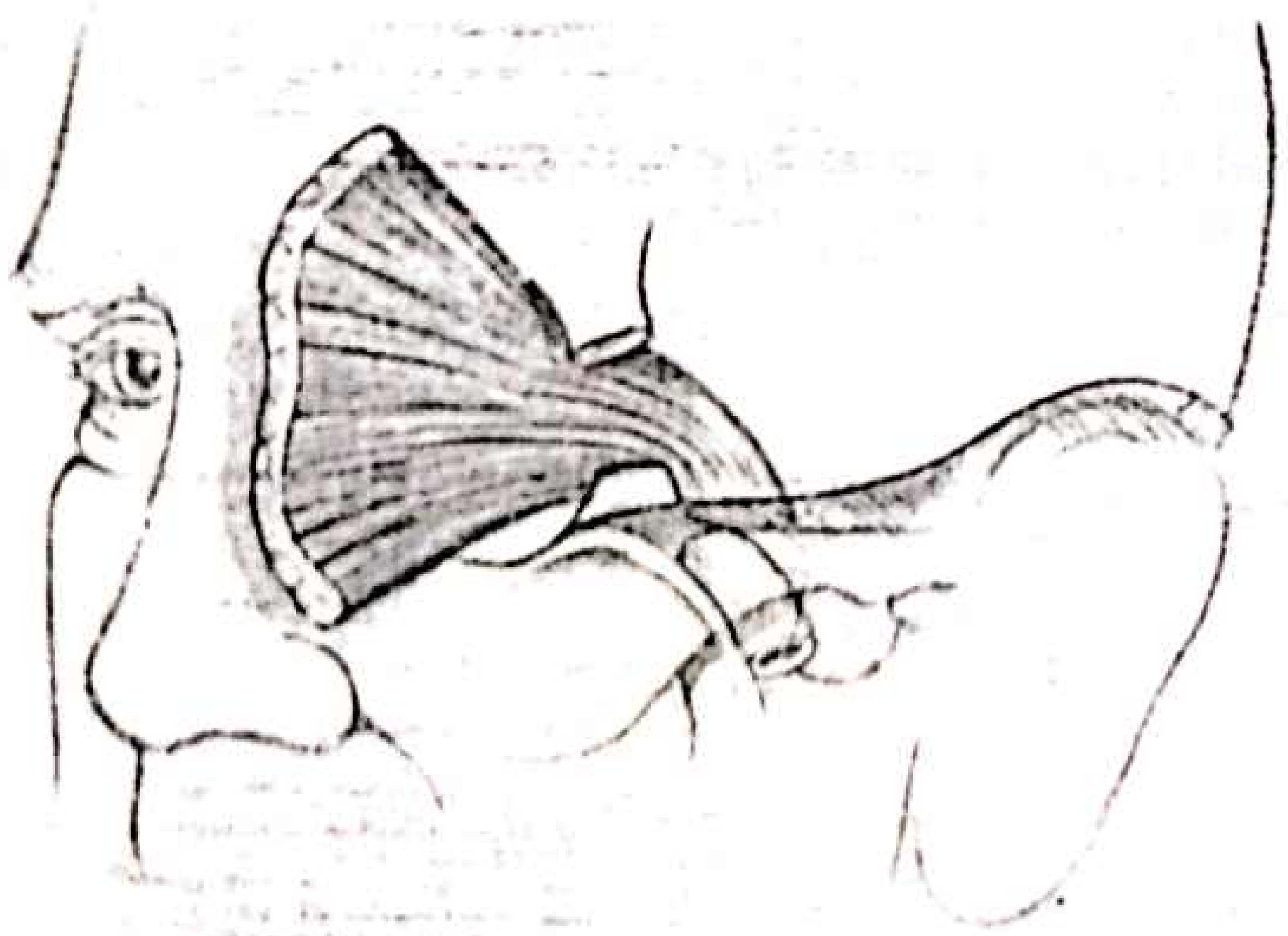

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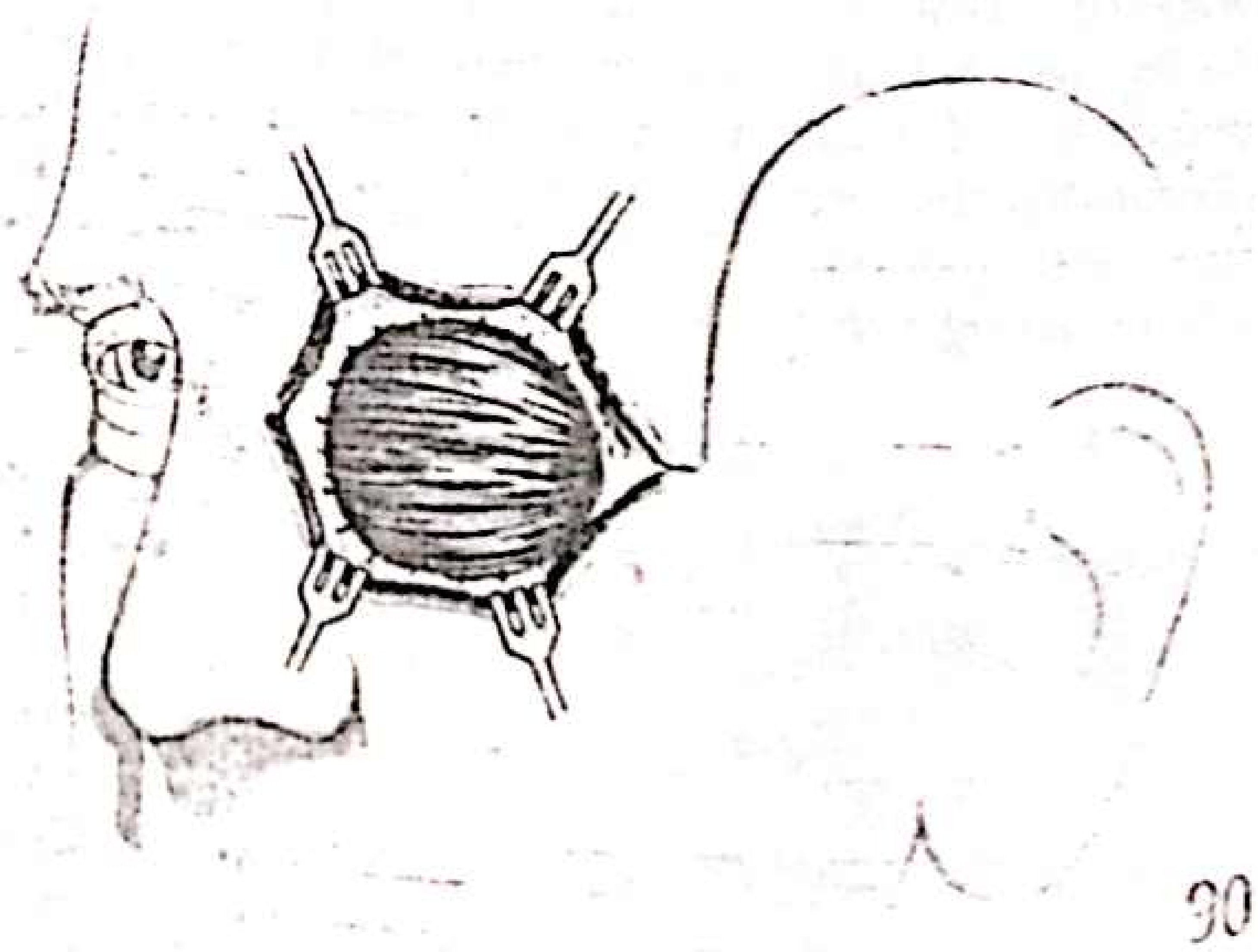

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Illustrations by Ian Ramsden

Nose

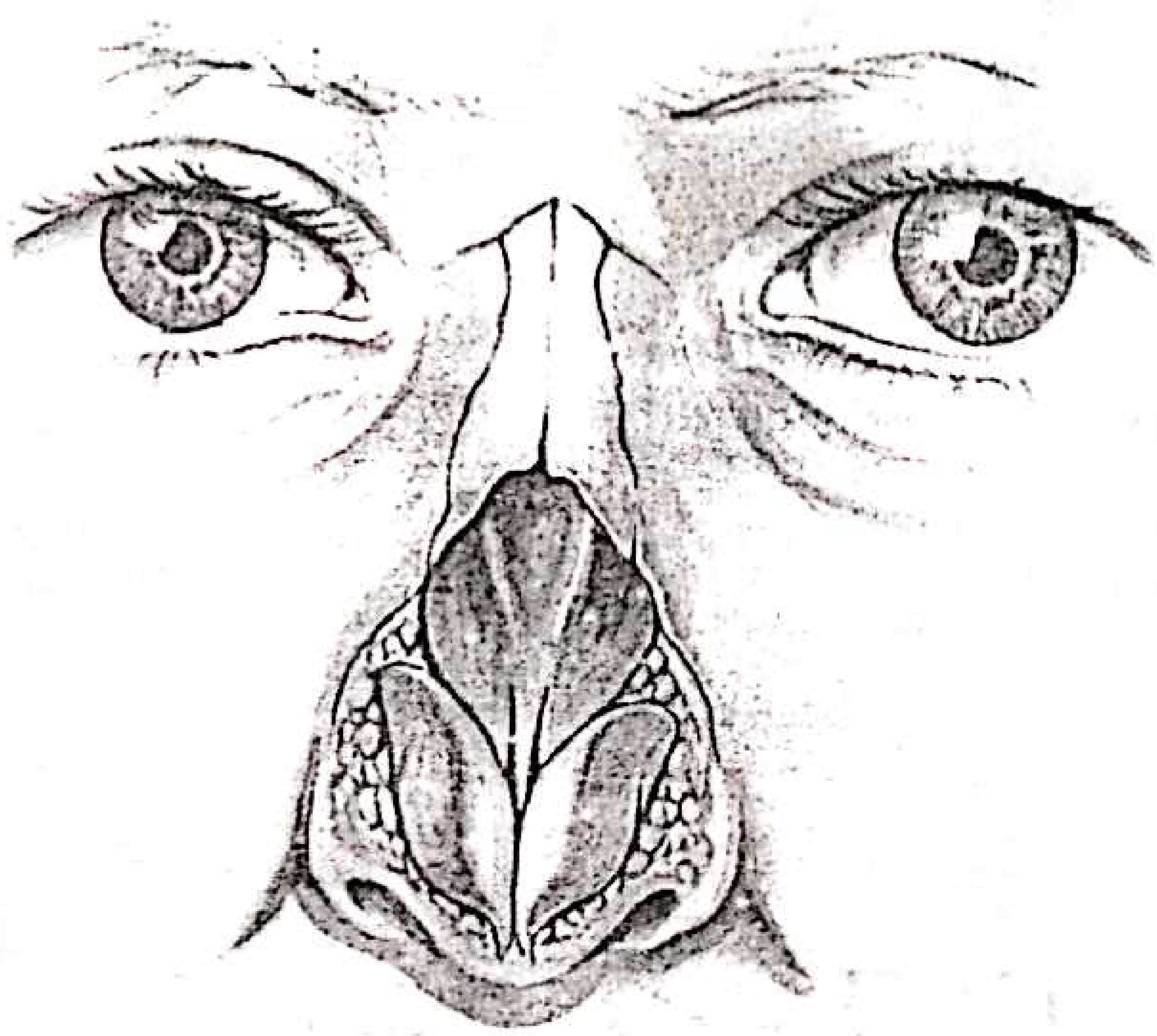
Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Anatomical factors

1

Viewed in relation to tumour excision and reconstruction of the postexcisional defects, the nose is basically a three-layered structure, with an outer cover of skin and a lining which commences as skin along the nostril margin, changing to mucous membrane above, the two surfaces separated in their upper part by the nasal bones, below by the nasal cartilages, lateral and alar. The skin is relatively loosely attached to the nasal bones and the lateral cartilages, and it can be stripped easily to leave a cover of periosteum and perichondrium. Over the alar cartilages fixation is much greater, although it is still possible to strip it surgically leaving perichondrium. Within the nostril the skin is firmly fixed to the deep surface of the alar cartilage, and stripping to leave a graftable surface is not possible.

The quality of nasal skin as surgical material varies greatly, both in different patients and in different parts of the nose, in both instances parallelling the degree of activity of the sebaceous glands locally. Sebaceous activity generally increases with passage from the glabellar area towards the nasal tip, where it is maximal, and skin showing such activity is thick, highly vascular and prone to minor infection, particularly in relation to sutures. It is difficult to work with and totally unsuitable for use in reconstruction.



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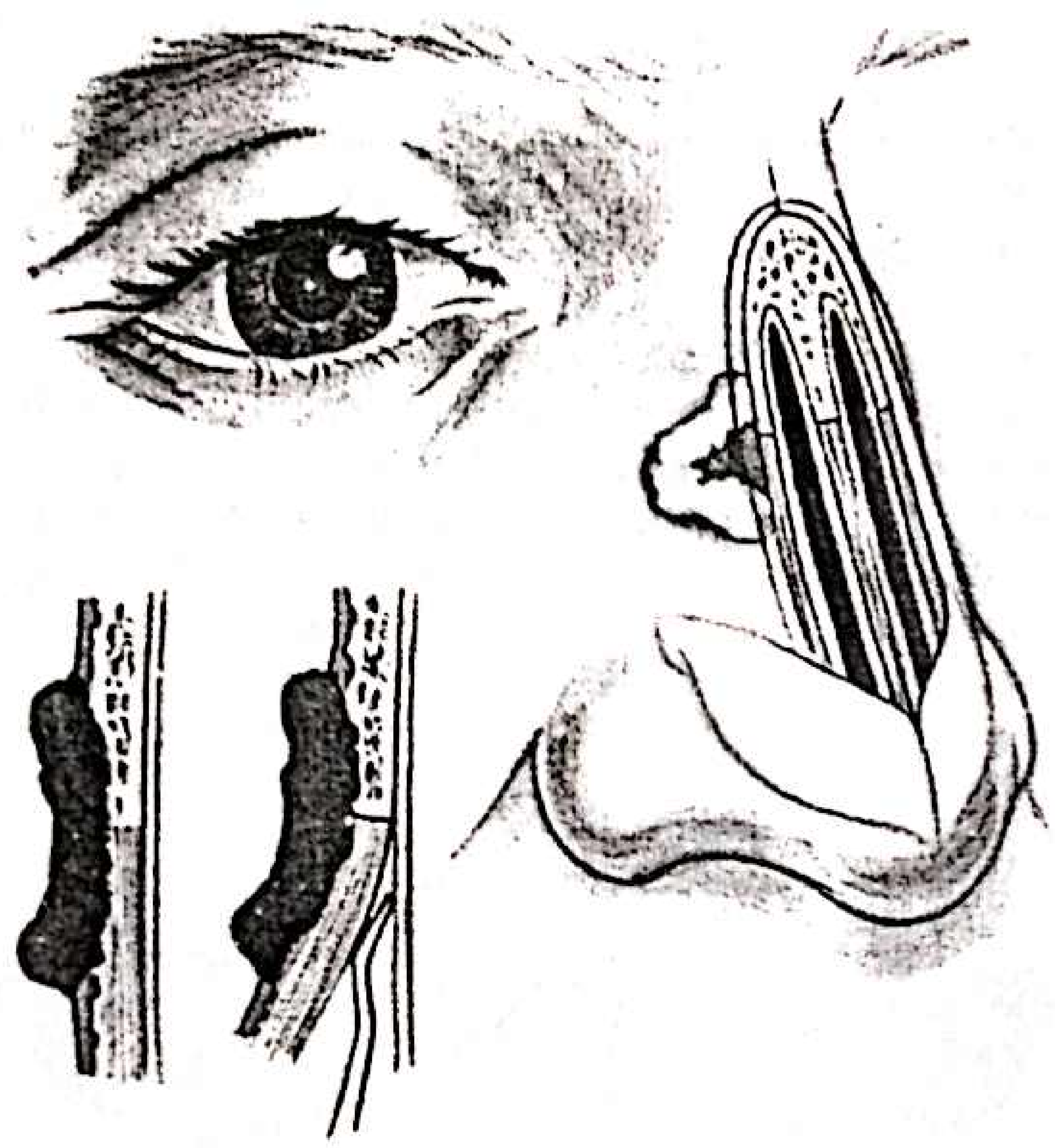
Pathological factors

Skin tumours of the nose vary in the depth clearance which they require from those involving skin alone, through skin and bone and/or cartilage, to those extending deeply to involve the lining also, skin or mucosa, depending on the level. Full thickness defects are generally much more difficult to reconstruct effectively than partial thickness defects, and any steps the surgeon is able to take which avoid the creation of a full thickness defect will make the task of reconstruction much easier. The most generally valuable step which he can take is to make use wherever possible of tumour barriers.

The tumours which commonly arise in nasal skin are generally slow growing, particularly in their deep infiltration through to the lining of the nose. In the sequence of deep infiltration the nasal bones and cartilages act as a significant barrier, and by making use of this barrier it is often possible to square the demands of clearance of the tumour in depth with those of reconstructive convenience by allowing lining to be preserved.



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When the surgeon suspects that tumour spreading deeply from the skin surface involves the underlying bone or cartilage, it may still be possible to strip these structures from the skin or mucosal lining on their deep surface, leaving it intact. In such circumstances it is essential to make a careful assessment as to whether or not the entire thickness of the cartilage or bone has been penetrated. The clinical criteria involved in the assessment are based on whether or not they have stripped cleanly from the lining mucosa or skin and the normality of the appearance of the surfaces exposed, both of the cartilage or bone and the mucosa or skin. In practice it is not a difficult clinical decision, but if any doubt exists excision has to be extended to include the full thickness of the nose.

The pathologist should also be specifically asked to examine the excision specimen for clearance in depth. In the event it is unusual to find the bone or cartilage completely penetrated when the surgeon has considered that it was safe to retain the layer of lining, skin or mucosa.

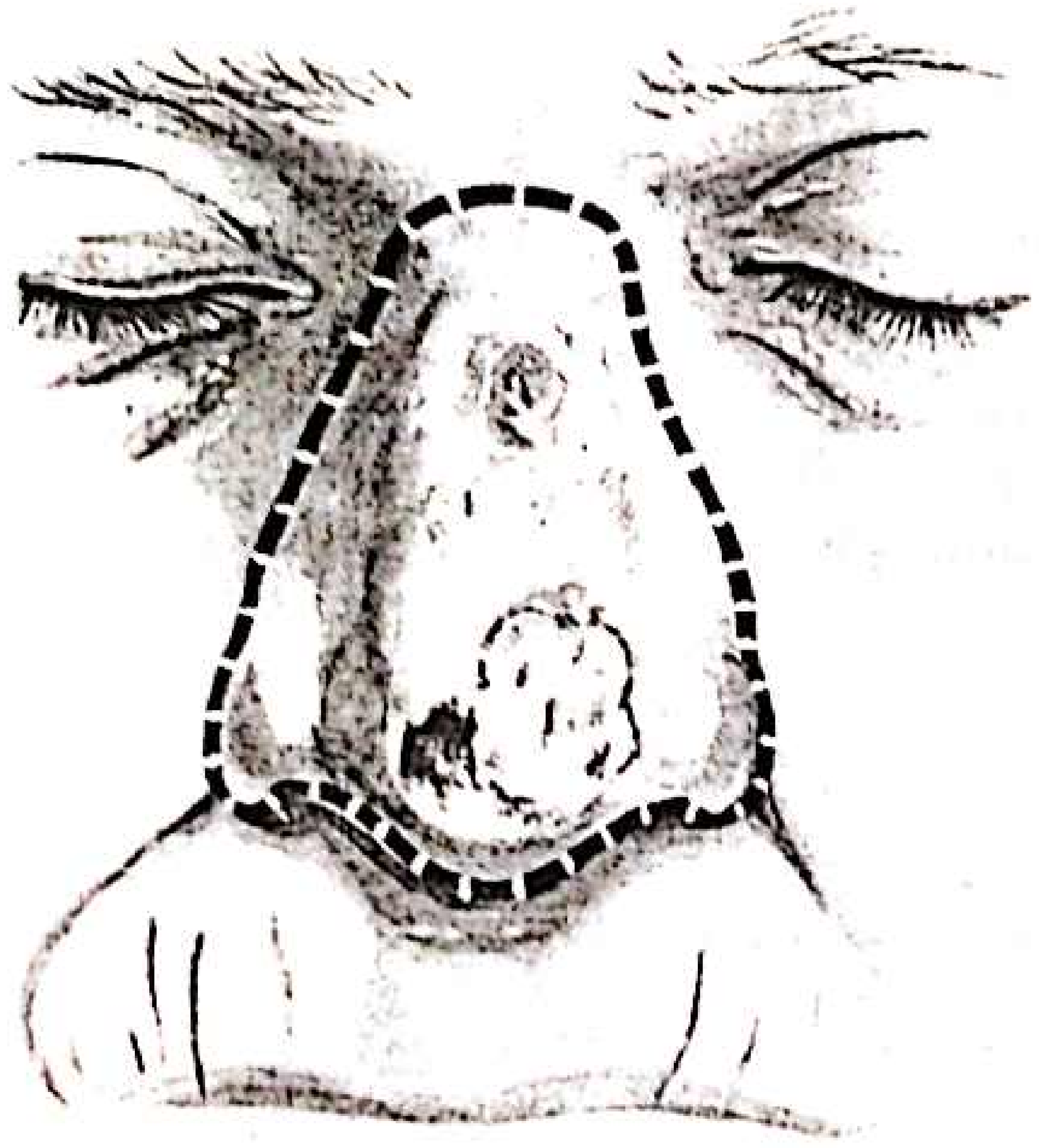
The effectiveness of the cartilage barrier diminishes with passage towards the rim of the ala. A gap is also present between the lateral and alar cartilages but it is not often significant in practice. Of much greater significance is the decreasing mobility of the skin in relation to the underlying cartilage with passage from the lateral to the alar cartilage. The alar cartilage is also thinner than the lateral cartilage and the skin which lines it is firmly adherent to its deep surface. As a result most full thickness defects include the alar segment of the nose.

Direct suture

Defects of the nasal skin which are suitable for direct suture are strictly limited in size, and the value of the method decreases in general with passage towards the nasal tip. The factor responsible is the degree of fixation of the skin to the deep structures, and it applies particularly towards the nasal tip where fixation of skin to cartilage is virtually absolute. A further factor which limits the use of direct suture in many patients in the age group prone to skin tumours concerns the degree of sebaceous activity of the nasal skin. When sebaceous activity is marked the skin is vascular, thickened and immobile, and prone to minor infection with pustule formation and a marked tendency to suture marks and poor scars.

When the lesion is near the nasal tip it is essential, in the process of closing the defect, to avoid as far as possible producing an asymmetry of the tip, particularly the nostril margin, and this aspect must be assessed carefully at the planning stage. The ellipse of the excision should be outlined on the skin surface and the effect of approximating its margins on the overall symmetry of the nostrils estimated. The width of the ellipse which can be closed directly in such circumstances is small and the method is not one which can be used with any frequency.

In the upper half of the nose freedom to excise and close directly is greater but the method has still only a very limited role.



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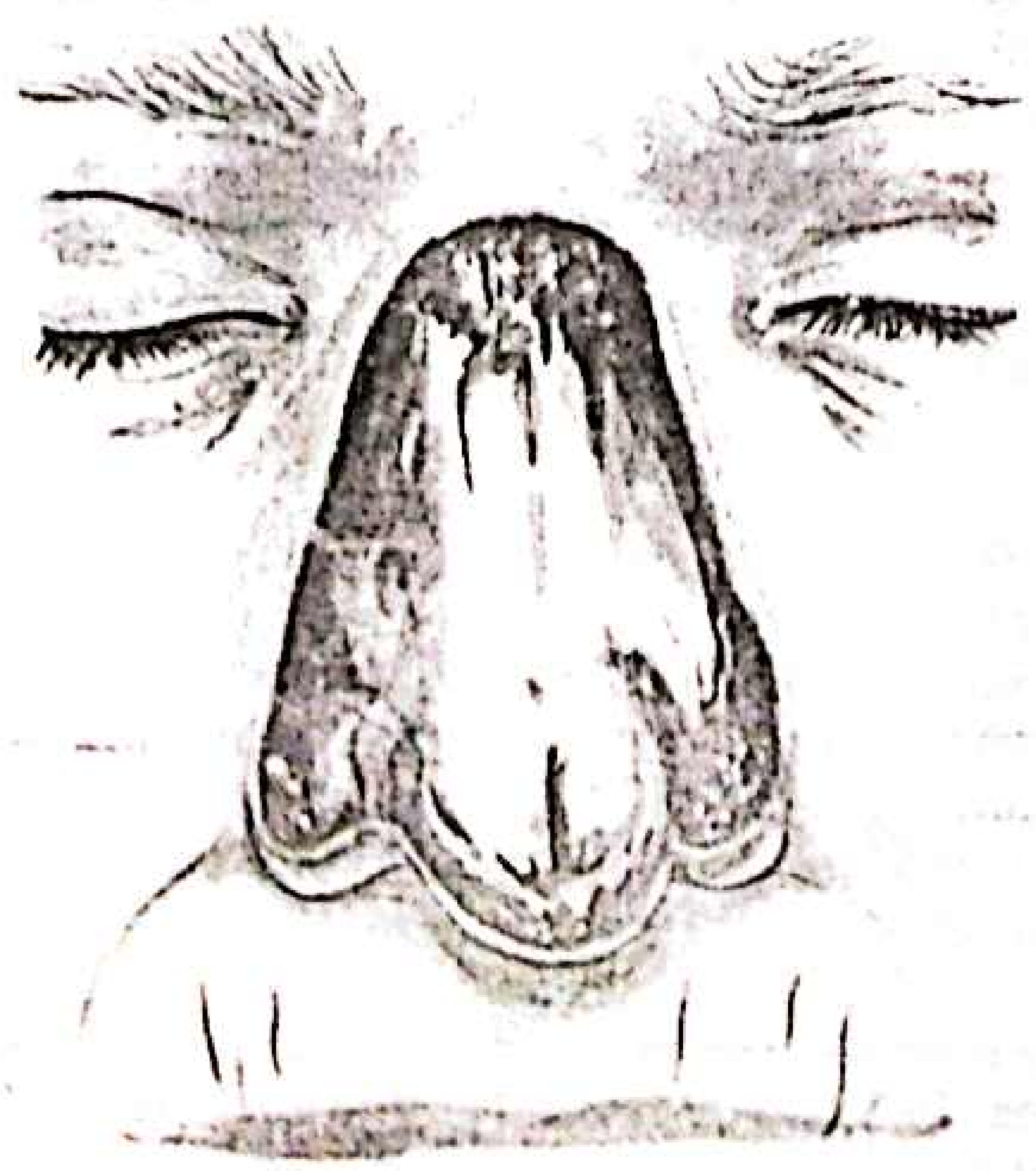

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Free skin grafts

In the clinical situation where the use of a free skin graft might be considered, the degree of sebaceous activity plays a major part in the excellence or otherwise of the cosmetic result which is achieved. The greater the degree of activity, the greater the contrast in the surface appearance of the graft and the skin of the nose in general, and the poorer the cosmetic result. Defects which are considered suitable for grafting do not involve the periosteum or perichondrium as a rule and the thickness of the graft matches that of the defect reasonably well, avoiding a final contour defect.

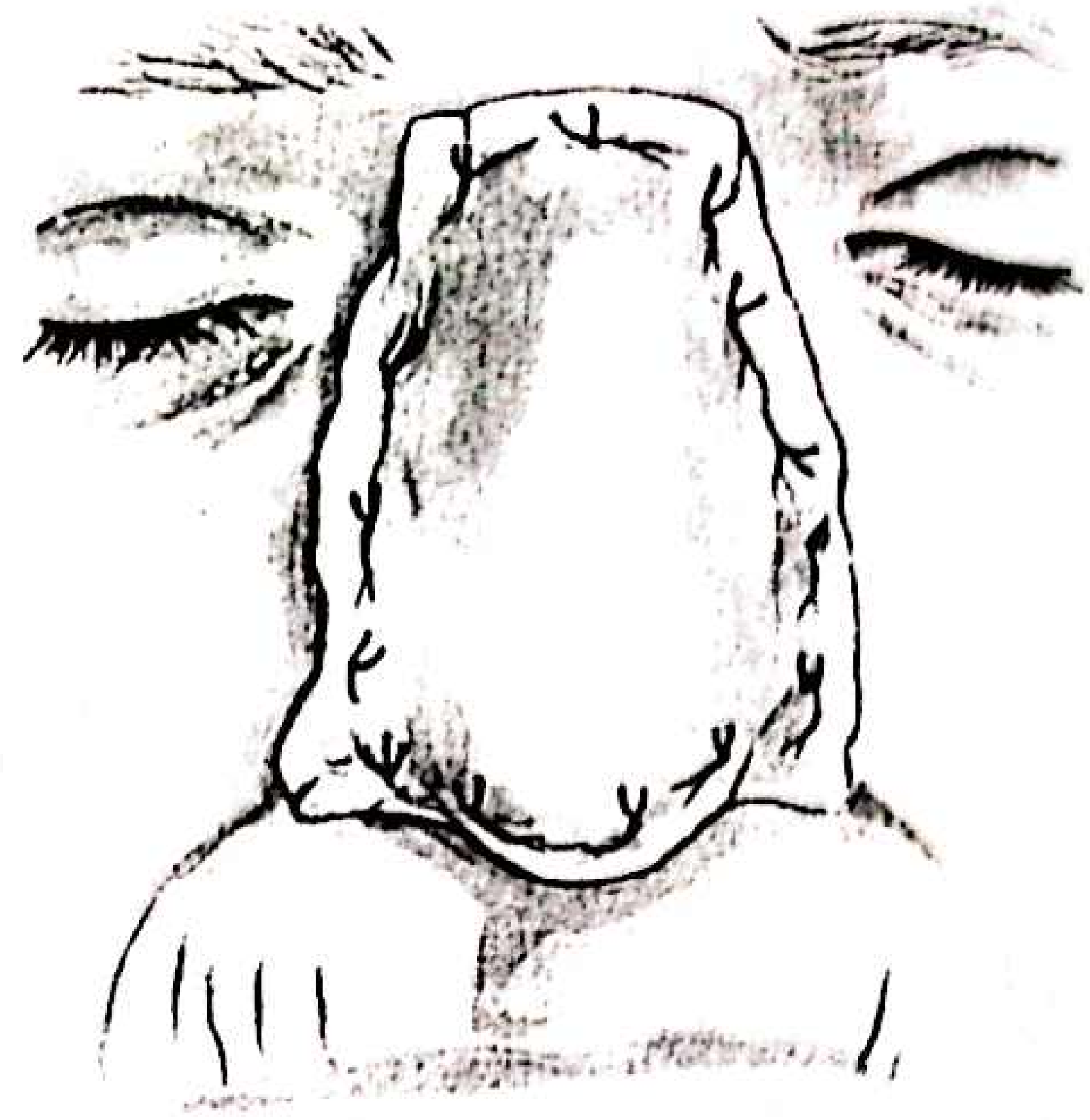
For most small defects the postauricular whole skin graft is standard and it gives a generally good cosmetic result. With the more extensive defects a split-skin graft will be required, but the poor colour and texture match achieved when the average split-skin graft is used limits very much the excellence of the result obtainable, and the poor match is made the more conspicuous by the juxtaposition of the two contrasting surfaces, graft and nasal skin. A possible solution in such circumstances is to treat the nose as a cosmetic unit, and strip its entire surface, covering the defect with a split-skin graft.

3

The method has its most effective role where there is low-grade multifocal neoplasia without any evidence of deep infiltration. In degloving the nose in this way the excision margin on each side is the junction between the nose and the cheek, inferiorly the nostril margin.

4

In stripping the skin it is essential to leave an intact periosteal and perichondrial surface on which to apply the graft. This is not difficult over the nasal bones and the lateral cartilages, but towards the tip considerable care is required to avoid baring the alar cartilages. The amount of bleeding encountered during the stripping procedure is surprisingly small and is largely from the margins of the defect.



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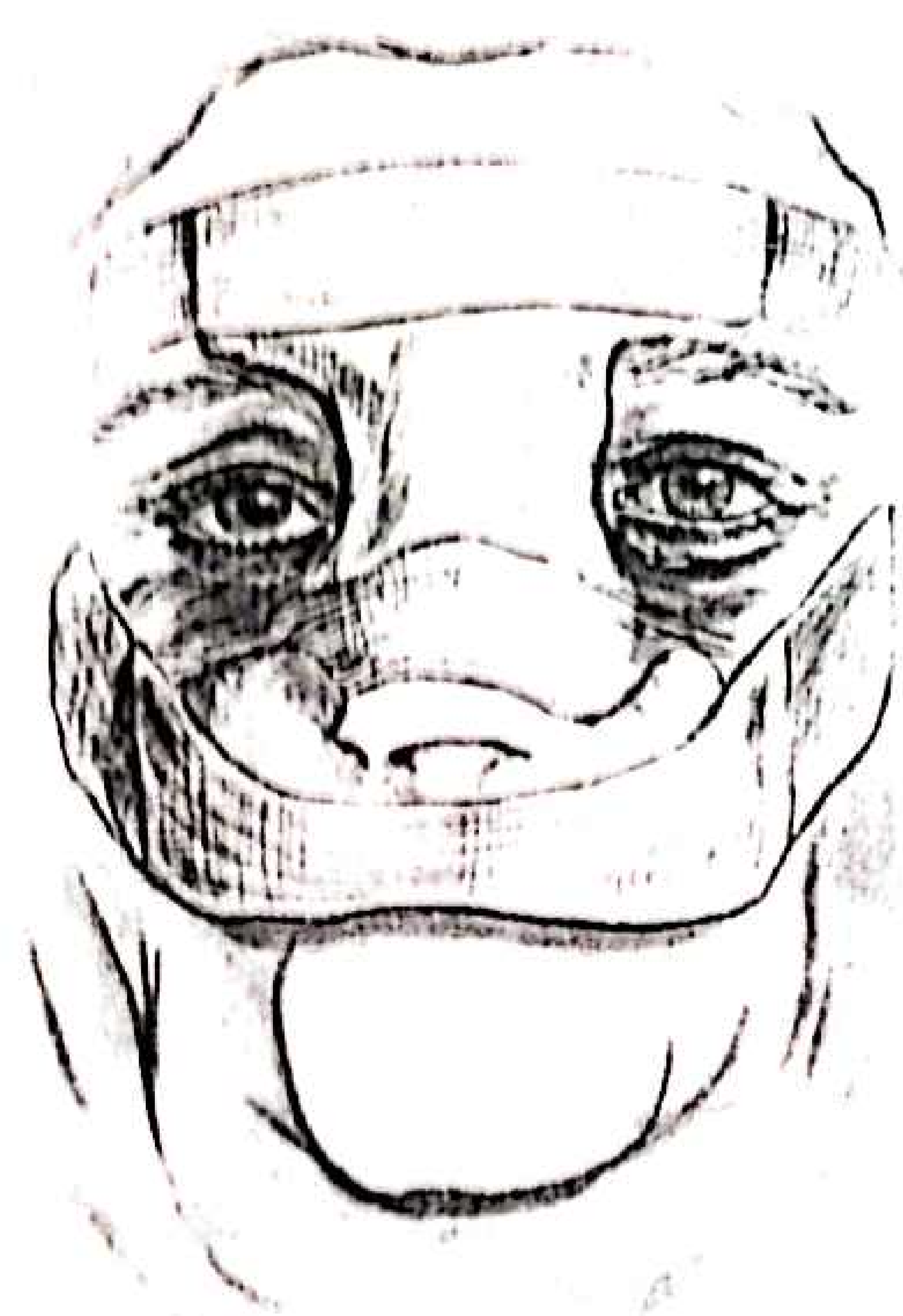
The split-skin graft used is of medium thickness, thickening towards the alar margin in order to minimize subsequent graft contraction in that area. The graft is sutured to the margins of the defect.



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A standard nasal plaster splint, with an intervening layer of paraffin gauze to prevent the plaster from becoming adherent to the graft, is carefully applied to provide a degree of immobilization and pressure. The insertion of a nasal pack provides stability of the tip area against which the pressure is being exerted.

7

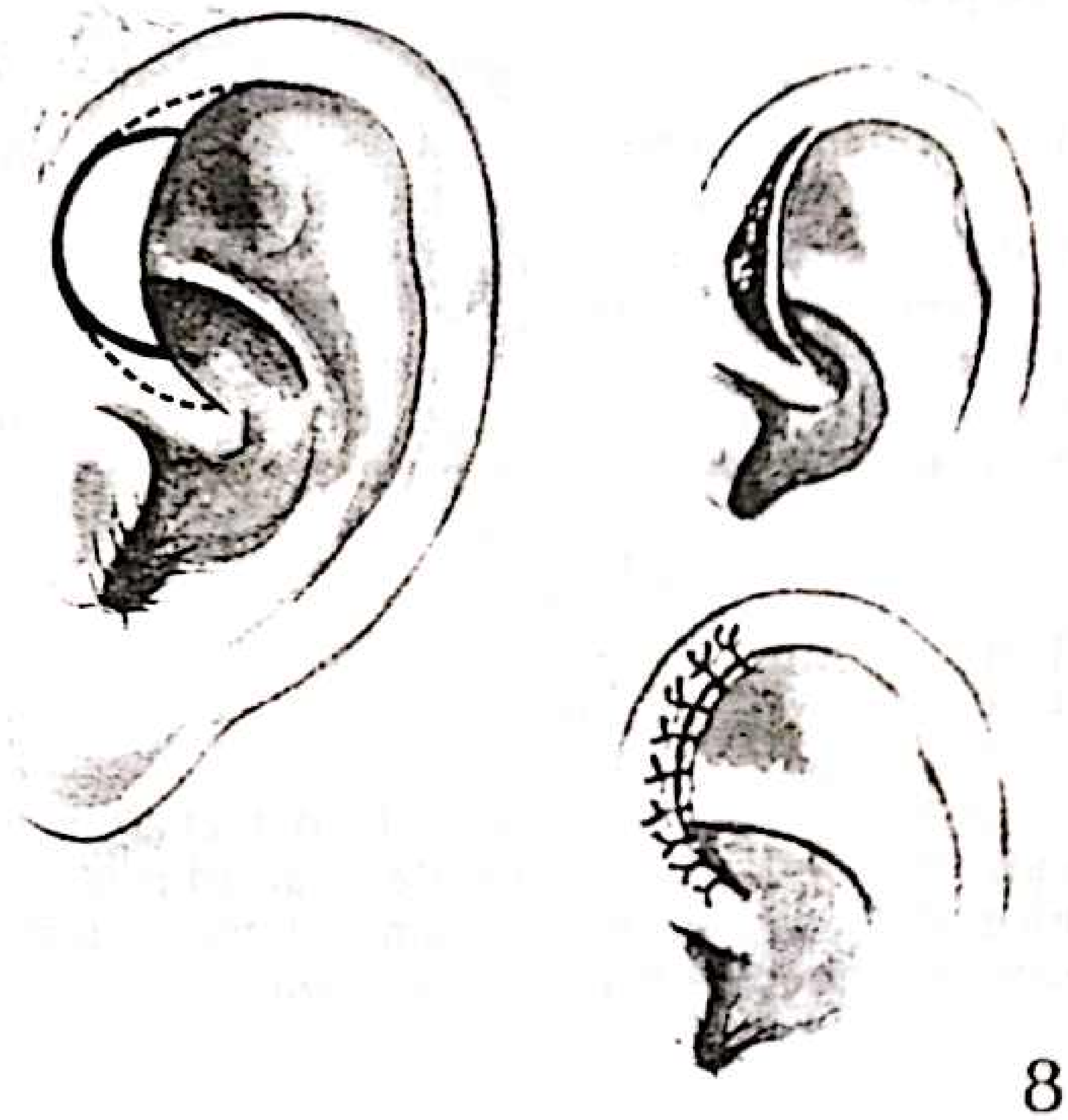
The appearance which results can be surprisingly good, largely because of the uniformity of the appearance of the graft. Close inspection shows it to have the characteristics of the donor site but to the casual observer the appearance is remarkably normal.

7

Composite graft

8

This method is used to reconstruct small full thickness defects of the alar margin. A wedge of the skin and cartilage of the rim of the ear, its site on the ear chosen to match the curve of the alar margin, is transferred as a free composite graft, the secondary ear defect being closed directly.



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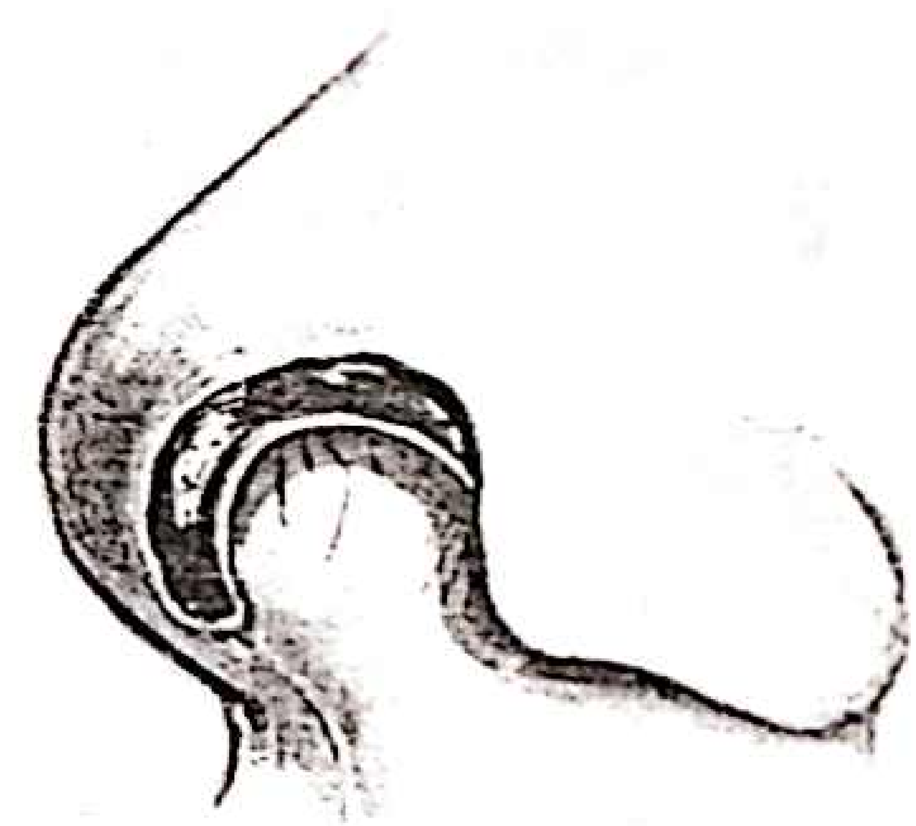
With skin on both sides of the graft, and the rim of cartilage between to provide rigidity, such a graft can replace the two surfaces lost in the full thickness resection. As a graft, however, it presents technical problems in relation to 'take' because the area available for vascularization is restricted to the margins of the skin. In this respect it contrasts with the standard free skin graft where, in addition to the margins, the deep surface of the graft is available for vascular link-up between the graft and the bed. The fact that the composite graft takes at all is an indication of the rich vascularity both of the recipient site and the donor site, the relatively small area of vascular contact still being adequate to allow vascularization to occur.



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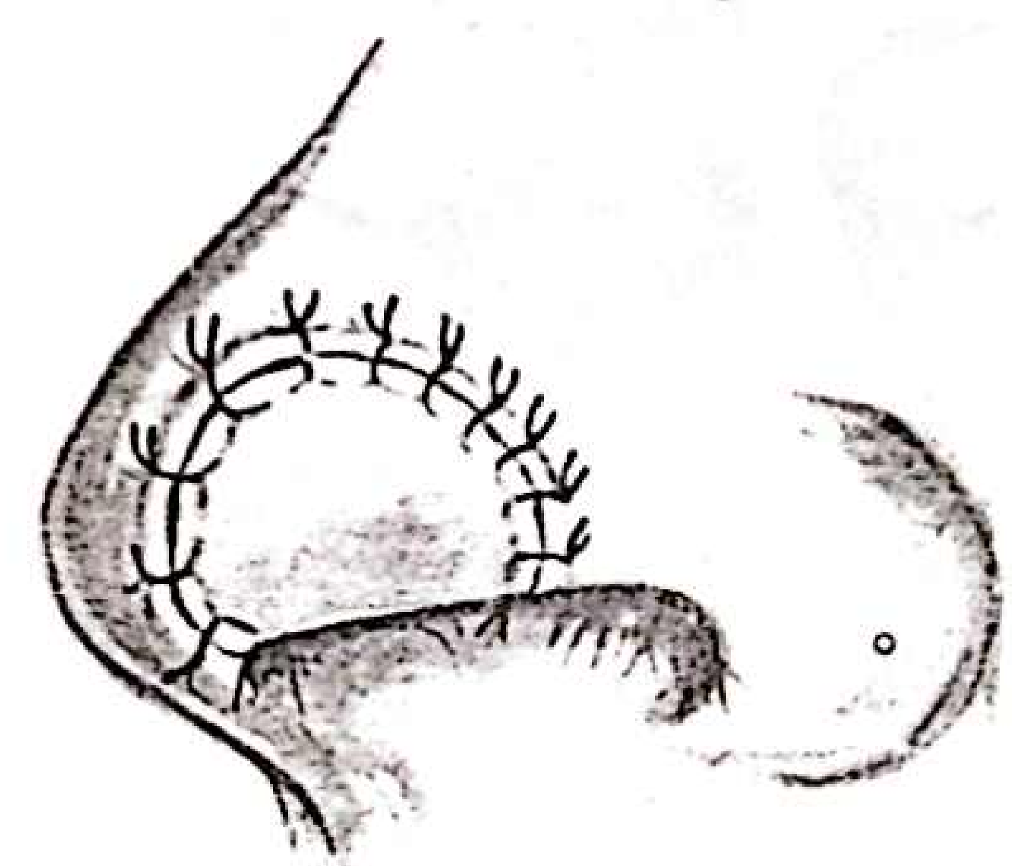
Care taken to avoid unnecessary trauma at all stages of the transfer is essential, and suture of the margins of the graft to those of the bed must be meticulous, so that dermal and hence vascular contact is as intimate as possible. In practice it is sometimes possible to increase the area of dermal contact by excising an additional rim of skin from the nose and adding a corresponding area to the graft. It may be possible also to reduce the rim of cartilage to a narrow strip.



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Any factor which reduces the vascularity either of the graft or the bed will act to slow down or even stop altogether capillary link-up and increase the probability of graft failure. The factors most likely to have this effect in clinical practice are the previous use of radiotherapy to the recipient site or the presence of a pre-existing skin disease, both of which reduce vascularity. Any areas of local scarring must also be ruthlessly excised.

The presence of any adverse factor should be a virtually absolute contraindication to use of the method, and even when everything appears to be favourable a significant failure rate must be expected. The technique is nonetheless a tempting one to use in a suitable clinical situation, since it is a single-stage procedure and when it is successful the result is very good. Even failure does not make the use of alternative and more reliable methods more difficult, although these methods may involve more than one stage and often fail to give such a good ultimate cosmetic result as a successfully used composite graft. In practice, however, suitable defects are rare and it has a very limited role.

Flaps

Reconstruction of the defect which requires a flap reconstruction may involve the provision of lining as well as skin cover. If lining is not provided when it is needed, the deep raw surface of the flap heals by a mixture of fibrous contracture supplemented by marginal epithelialization. The clinical effect is to produce contracture of the reconstructing flap and distortion of the nose.

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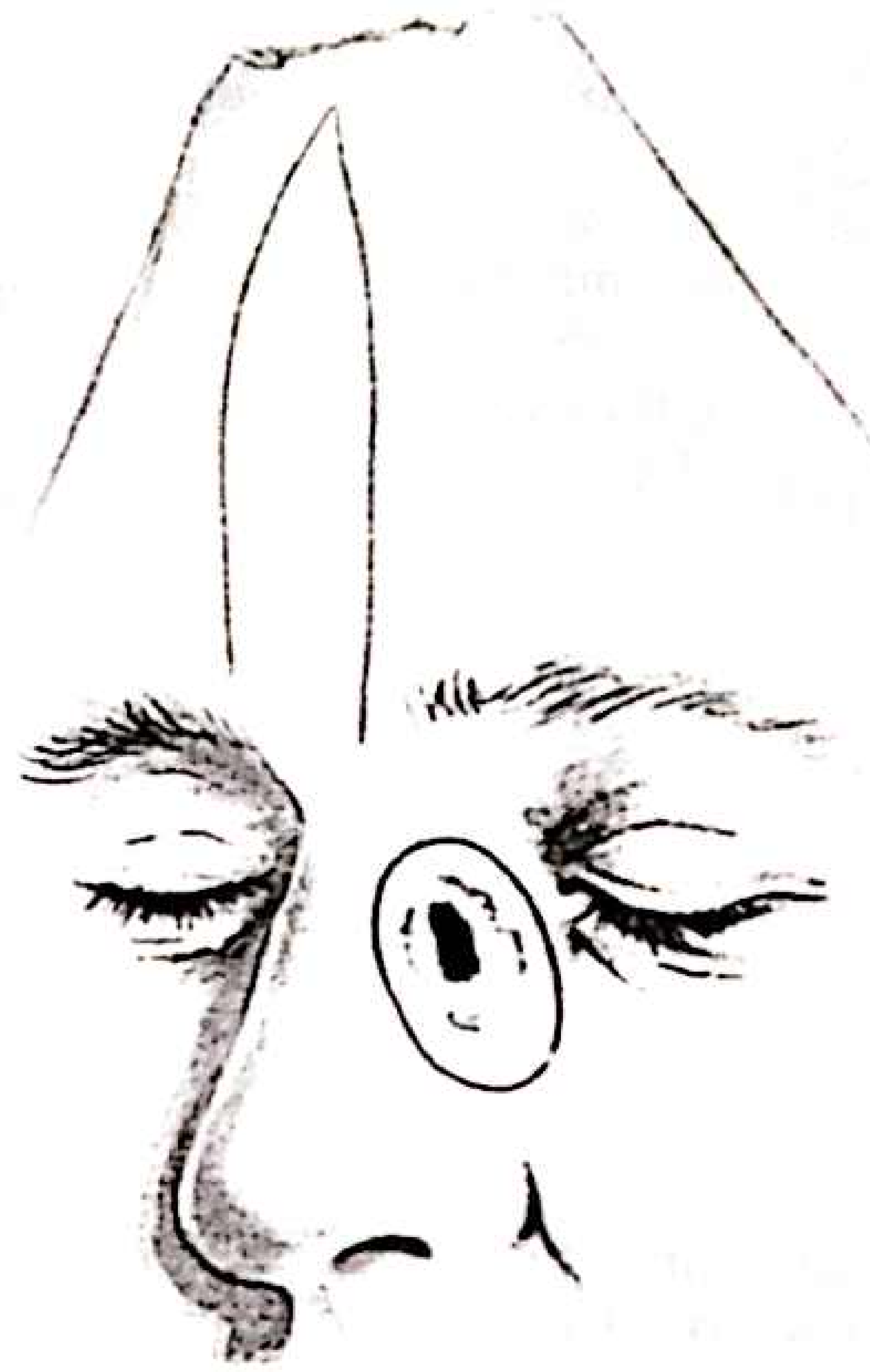
It is only when the margins of the defect are rigid, usually bony, that it becomes possible to avoid providing lining, since the fixity of the margins of the defect prevents contraction of the flap from occurring.



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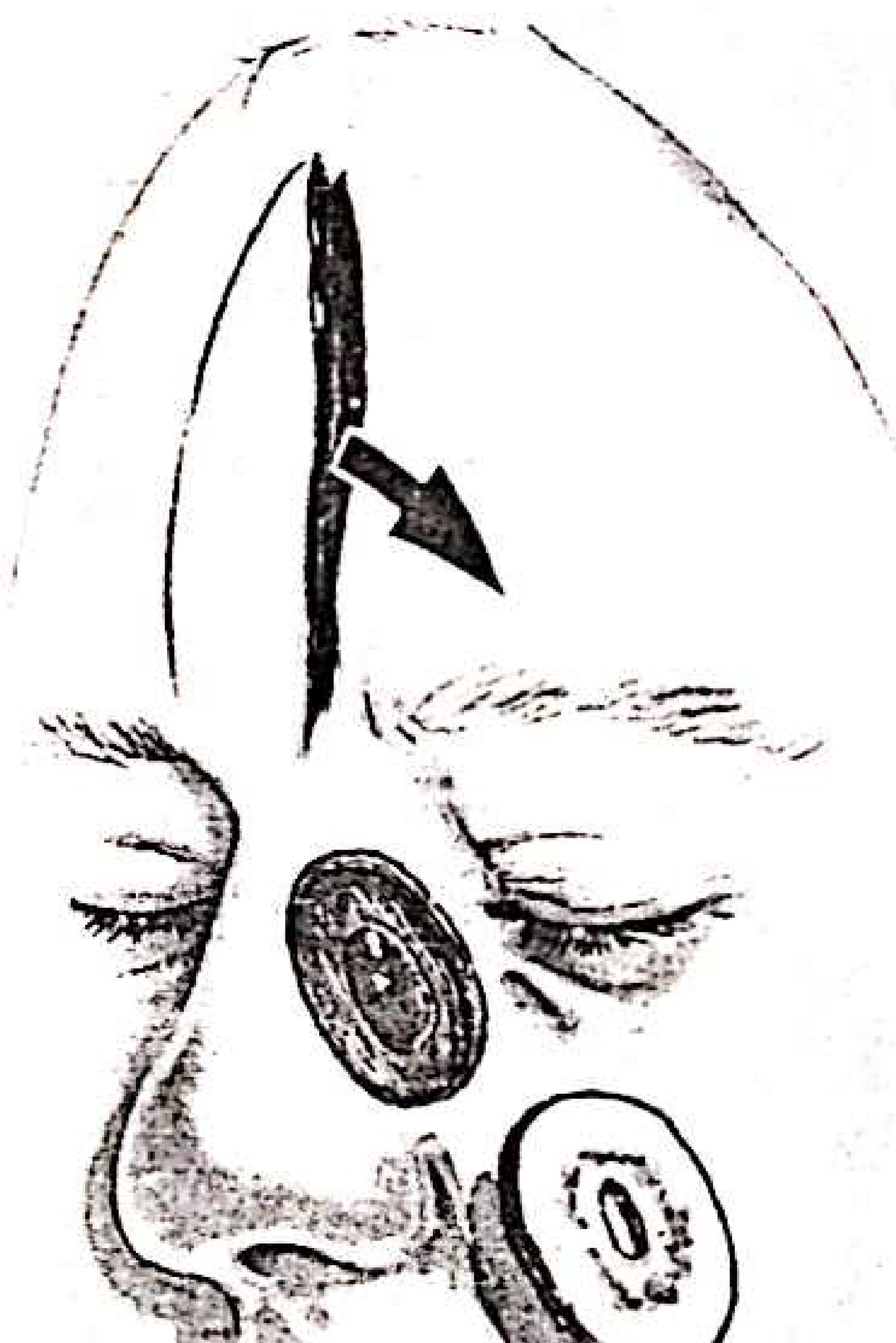

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In such circumstances it is essential to remove a generous rim of skin beyond the margin of the defect so that the flap has sufficient overlap to heal effectively around its entire circumference and not break down to leave a fistula. The deep surface of the flap heals by epithelialization from the edges of the mucosal defect, but without contracting.

When it is necessary to provide lining as part of the reconstruction, it is seldom possible to provide this immediately following on the resection, and it then becomes impossible to reconstruct the defect primarily. The defect is then generally left fully displayed by suturing skin to mucosa, and the definitive reconstruction is postponed until the tissue reaction along the suture line has settled. In the interval, depending on the site and extent of the defect, it may be desirable to provide a temporary prosthesis. This topic is discussed on p. 172.

Provision of lining

The standard techniques of providing lining involve inturning local flaps, or constructing the lining on the flap which is providing skin cover, prior to its transfer. Other methods which are occasionally possible involve transfer of a flap of intraoral mucous membrane to provide lining, or make use of the nasal septum for the same purpose in reconstructing the defect near the alar margin. Mucous membrane, transferred as a flap, is difficult to manipulate and is prone to necrosis; nasal septum, used in this way, is liable to create secondary problems in the nose. Neither method has achieved popularity.

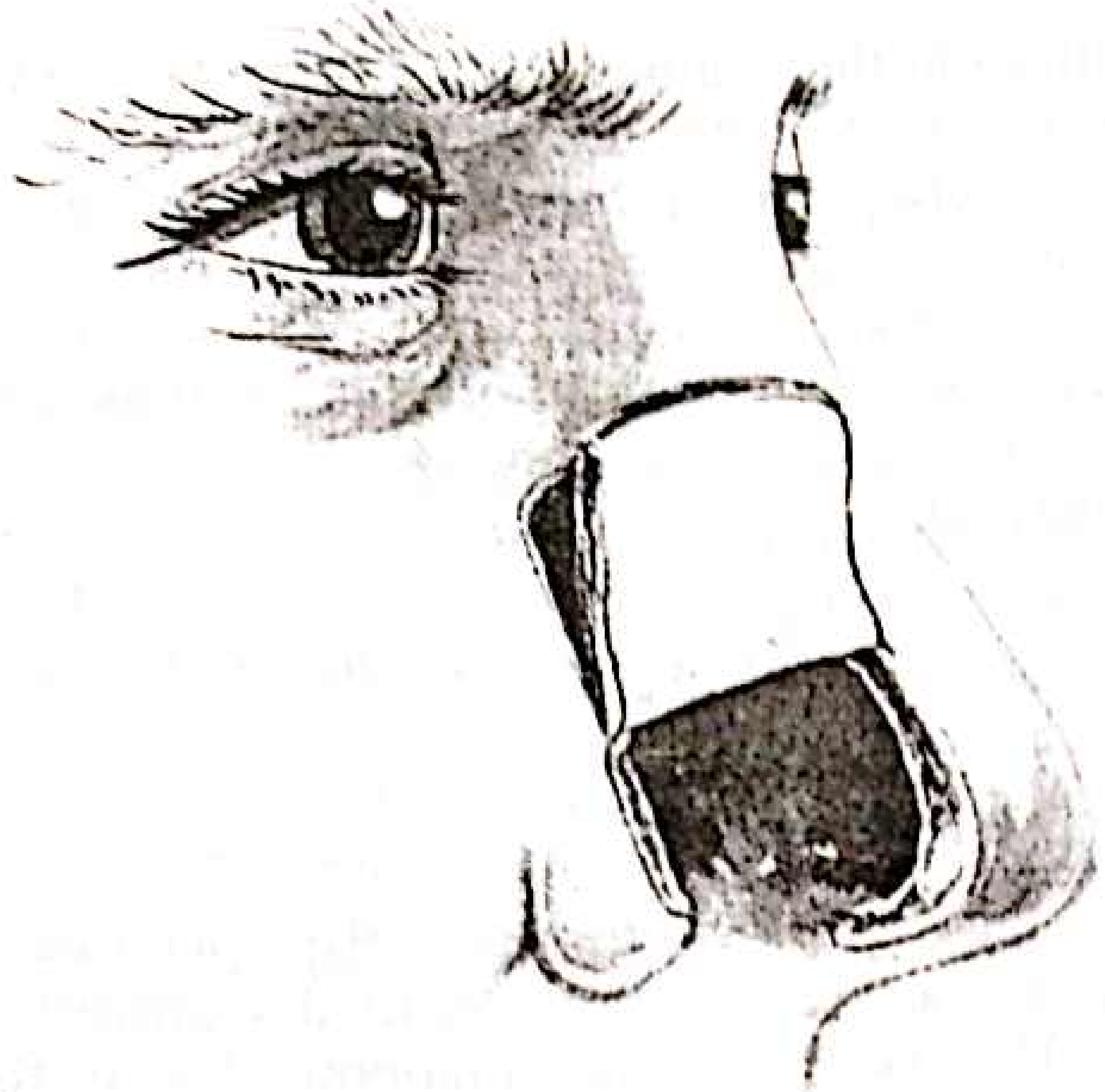
Local inturned flaps

13 & 14

This method of providing lining involves the raising of a flap of skin immediately adjoining the defect, based on the suture line of the skin–mucosal closure of the original defect. Using the skin–mucosal scar as a 'hinge', the flap is turned over to form the lining of part or all of the defect. Several considerations govern the design and placing of such a flap. The 'hinge' around which the flap is turning consists of scar tissue, and the blood supply crossing it, on which it has to rely, is seldom good.

Several steps are regularly taken by the surgeon to improve it. As a first step, an adequate amount of time is allowed to elapse for the tissue reaction to settle before the reconstruction is begun. The use of a prior delay, including at least partial elevation, is also largely routine.

When the defect permits alternative designs, the one which provides the best length:breadth ratio is generally chosen. In raising the flap, dissection is also stopped as soon as the flap is able to turn over, so that the maximum of tissue in addition to the skin–mucosal scar is left intact, augmenting the blood supply of the flap. A further safety device involves the use of two shorter flaps, one from each side of the defect, turned over and sutured to one another, in preference to one longer flap.



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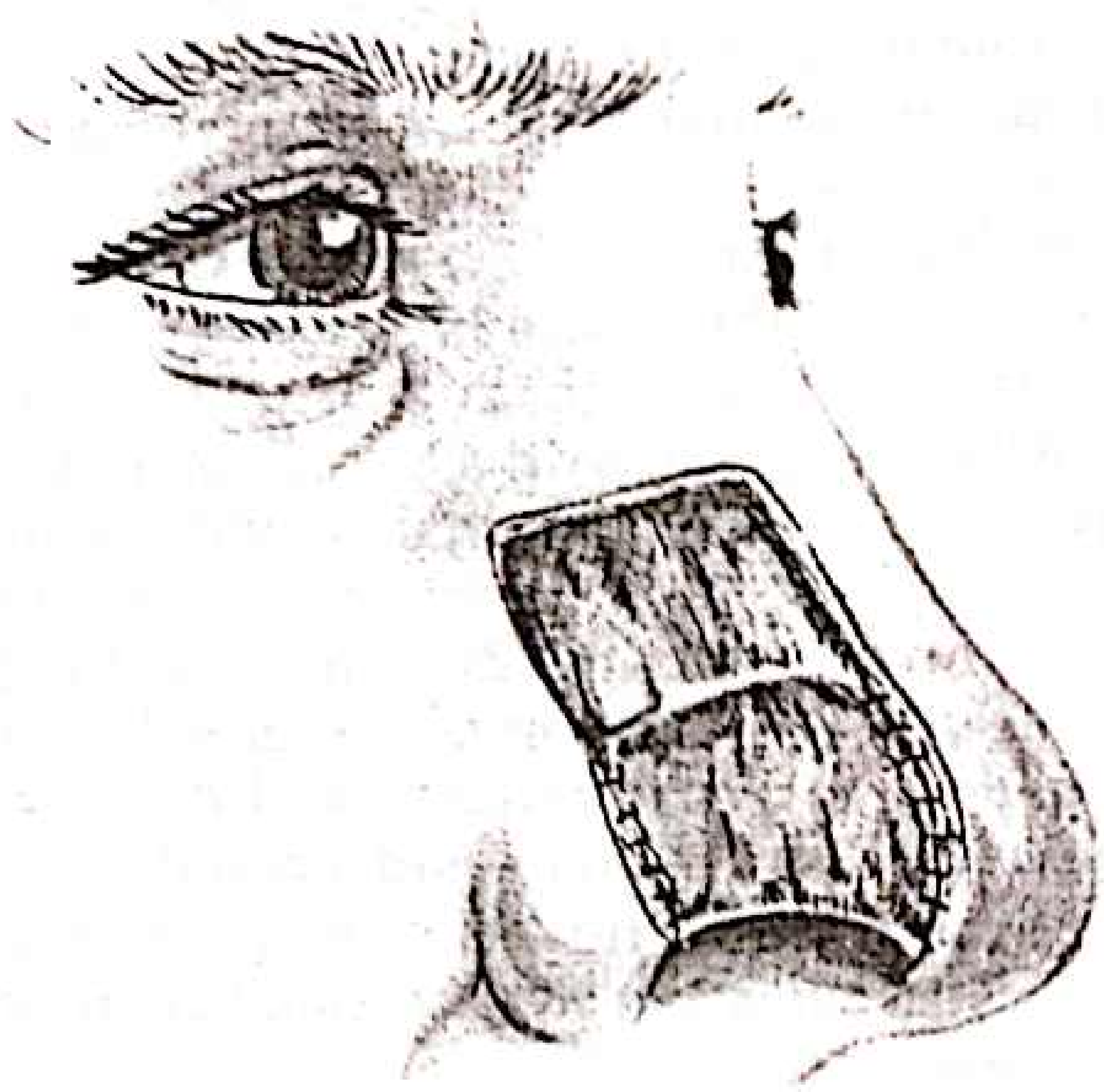

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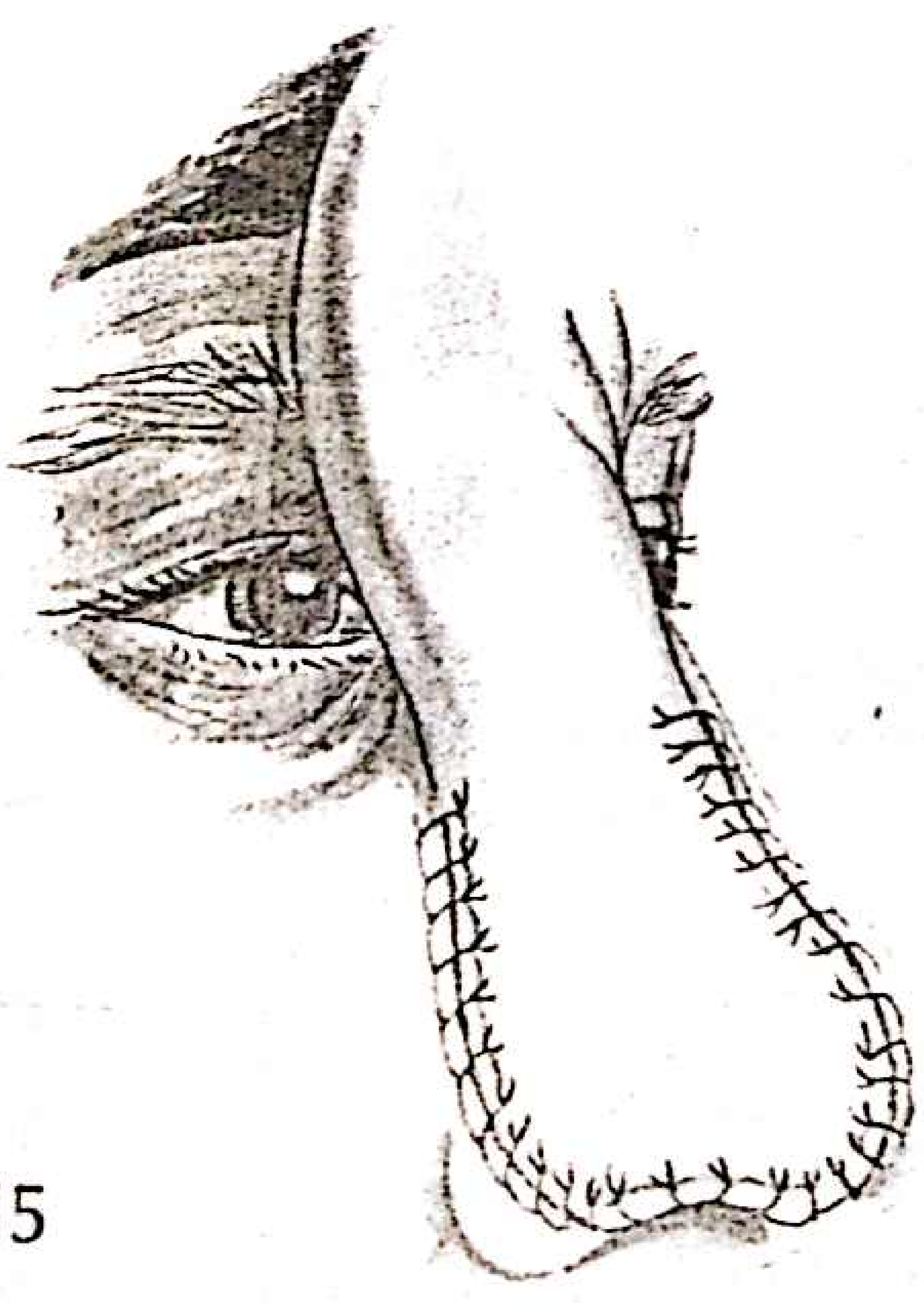

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The selection of lining flaps is also influenced by the direction from which the flap providing the skin cover is going to approach the defect. This aspect of design is of considerable importance, since unless the defect which is left when the lining flap is raised and turned over can be closed directly, its transfer has the effect of adding to the total skin defect. The largest area of relatively flat skin is generally above the full thickness defect involving the nostril margin, the site most often involved, and with the covering flap reaching the defect from above, a lining flap designed to add to the vertical dimension of the defect is the one most often used.

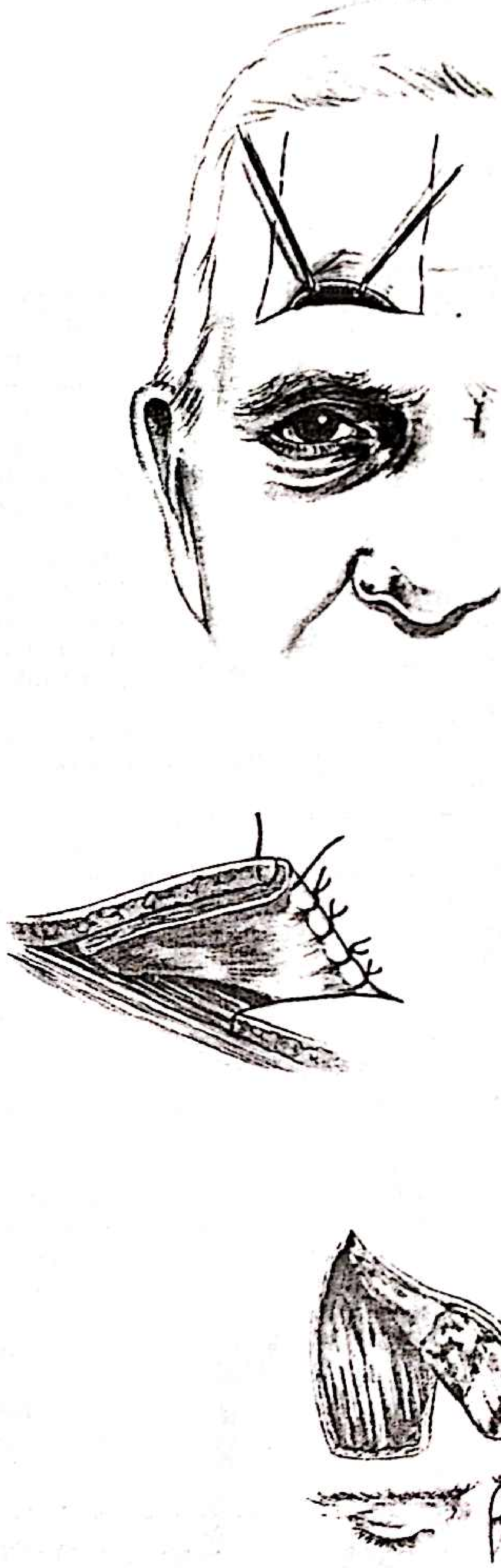
Lined flaps

In this method the segment of the flap which is providing the skin element of the full thickness defect is lined at a preliminary stage with a free skin graft so that, when the flap is raised and transferred, both surfaces, skin and lining, are already present. When this method is chosen the defect is usually of the alar margin, and the junction of the graft and the flap is designed so that it forms the nostril margin.

16

With the flap, usually a forehead flap, planned, the skin incision is made along the line of the projected nostril margin. The skin and subcutaneous tissue above the incision is elevated over the extent of the area to be lined with the graft. Forehead flaps are generally raised deep to frontalis, but the lined component raised in this plane is likely to be thicker than ideal. Because of this it is preferable to raise the segment of the flap which is being lined superficial to the muscle, deepening to the standard level when the remainder of the flap is raised in due course. The thickness of graft generally recommended is split-skin, but there are advantages in using a post-auricular whole skin graft. One of the problems which arise when a split-skin graft is used is its tendency to contract. The whole skin graft is less prone to this. The graft is sutured to the margin of the flap and 'tucked in' under it and a pressure dressing is then applied to the entire area. The elevation of the area being lined by the graft creates two raw surfaces and it is probably better, though not essential, to extend the graft to cover both and have the entire area healed during the period of waiting necessary to allow the graft to stabilize in preparation for its transfer.

Approximately 6–8 weeks following the establishment of the lined element the flap is raised and transferred. In discussing the design of the flap used to reconstruct a defect with bony margins where lining was not required, the need for a generous overlap beyond the full thickness element of the defect was stressed. In designing a lined flap a similarly generous overlap on each side of the graft is equally desirable.



16

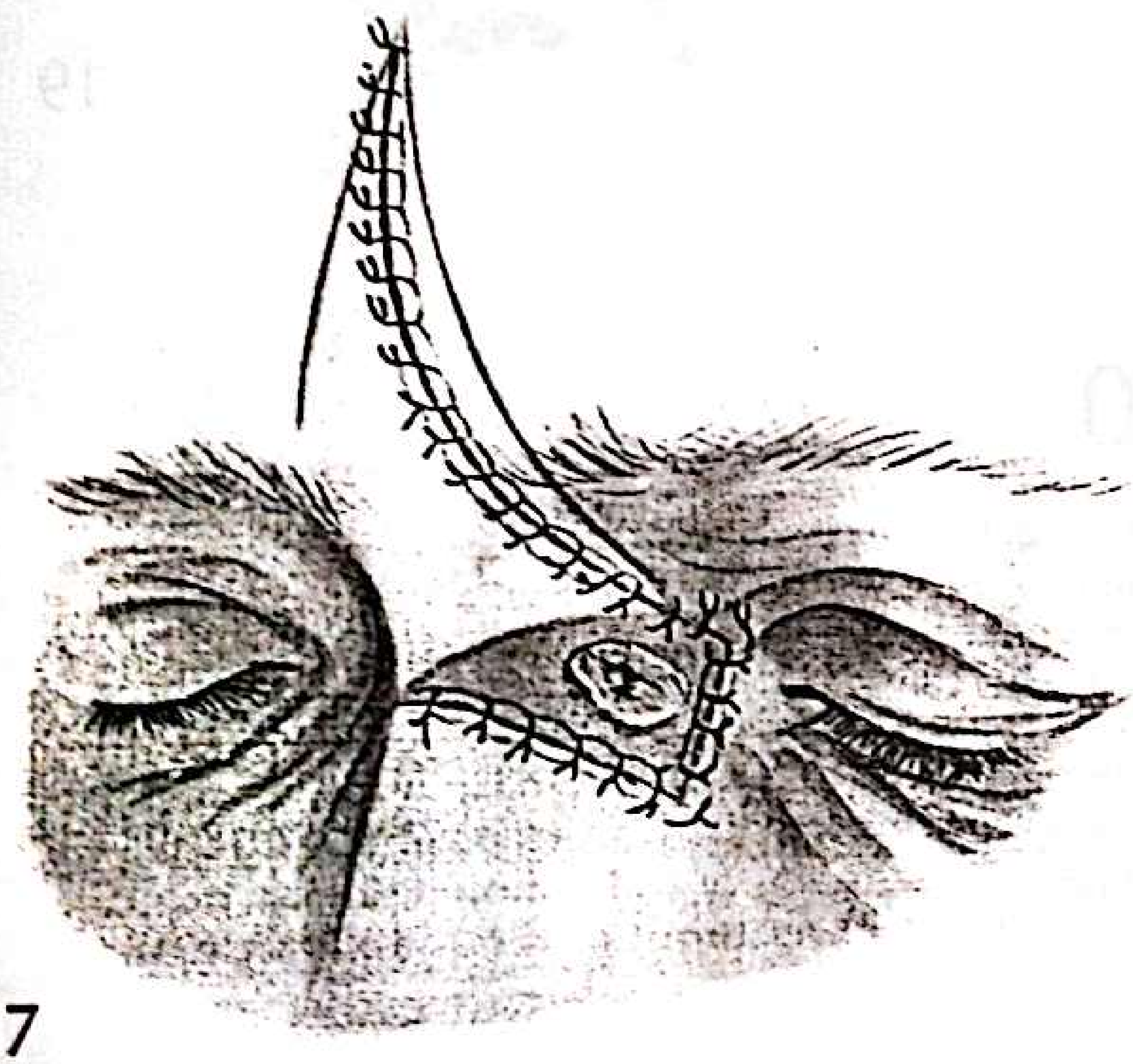
Minor defects

Because of the anatomical characteristics of the nose, with bone and cartilage sandwiched between the skin and mucosa, small defects, with the exception of those reaching to the alar rim, do not often involve its full thickness. It is also not usually necessary with such defects to provide a replacement for any cartilage or bone which may have been resected.

The skin of the lower half of the nose, where it overlies the cartilages, tends to be more rigid than average in many patients in the older age group, making it less than ideal material for use as a flap source, and the added presence of sebaceous gland activity virtually precludes its use for this purpose altogether. In the upper half of the nose the skin is less rigid and more mobile, but the area available on which a flap can be designed is sufficient to provide cover for only a very small defect.

It is for these reasons that the sources which provide the flaps used to reconstruct even comparatively small defects come most frequently from the surrounding area, in each instance using one of the areas of skin availability in the vicinity.

For defects of the upper half of the nose, the forehead provides the best general source.



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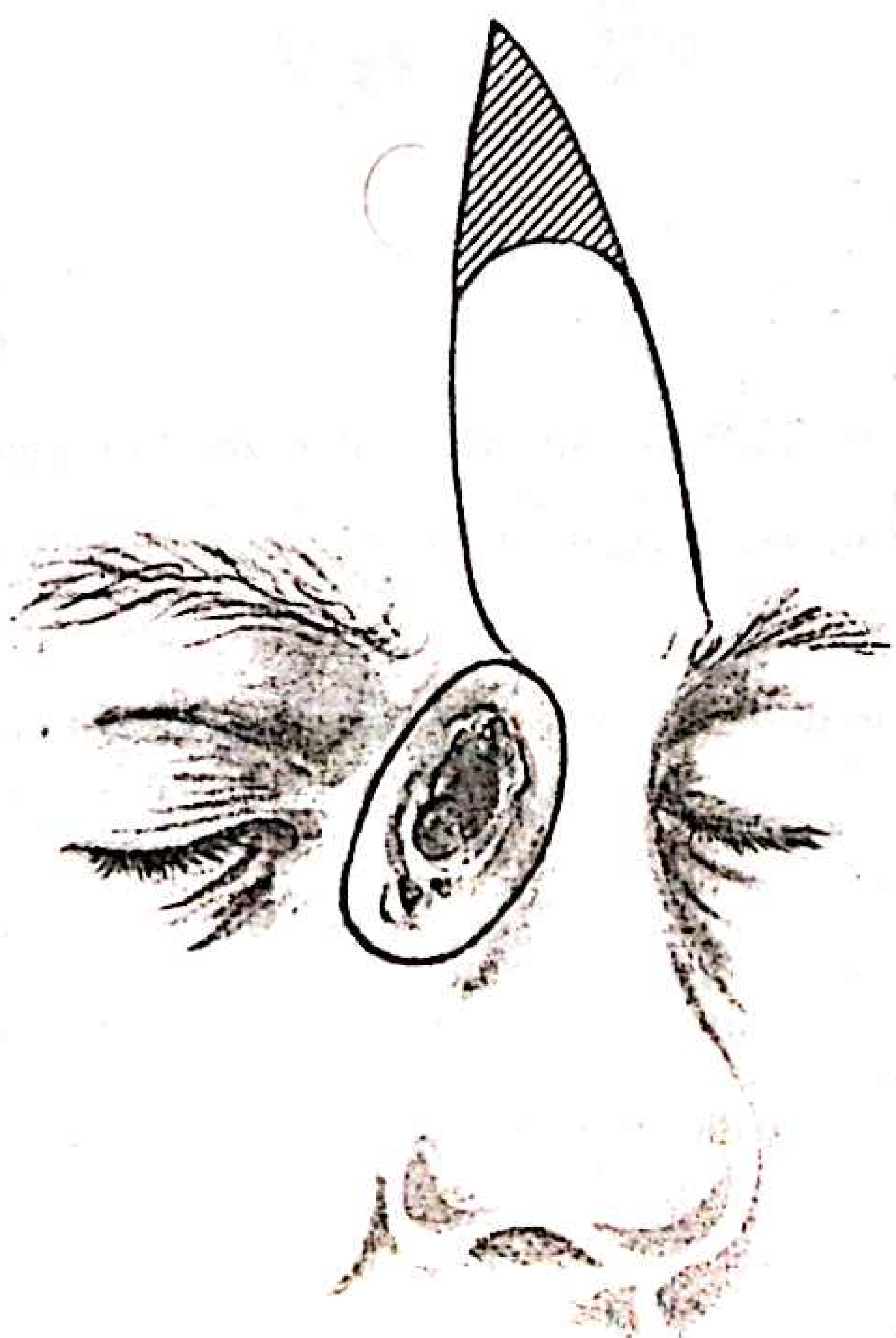
17

The defect of the side, at and a little below the level of the inner canthus, can usually be covered with a glabellar flap, as described on pp. 57–61.

18

If it becomes apparent at the planning stage that the reach of the flap is inadequate, the additional length which the finger forehead flap provides, described on p. 74, may be required.



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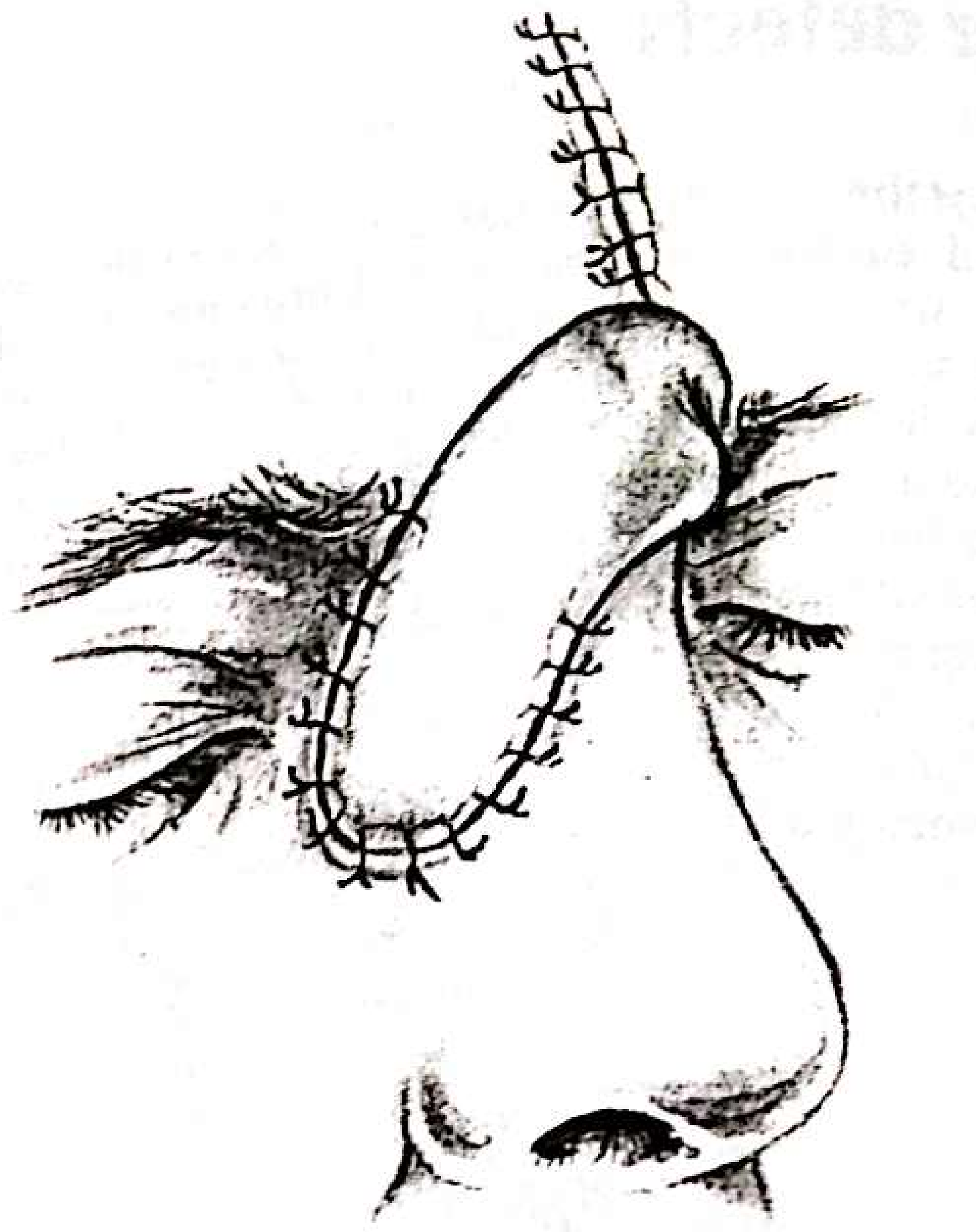
Raised vertically from the centre of the forehead, this flap rotates through a considerable angle to reach its destination and the frequent effect is to create a significant dog-ear. Even if the main transfer has been carried out in a single stage, revision is usually required to remove the dog-ear.

This flap can also be used for the defect which extends on to the middle and lower third of the nose.



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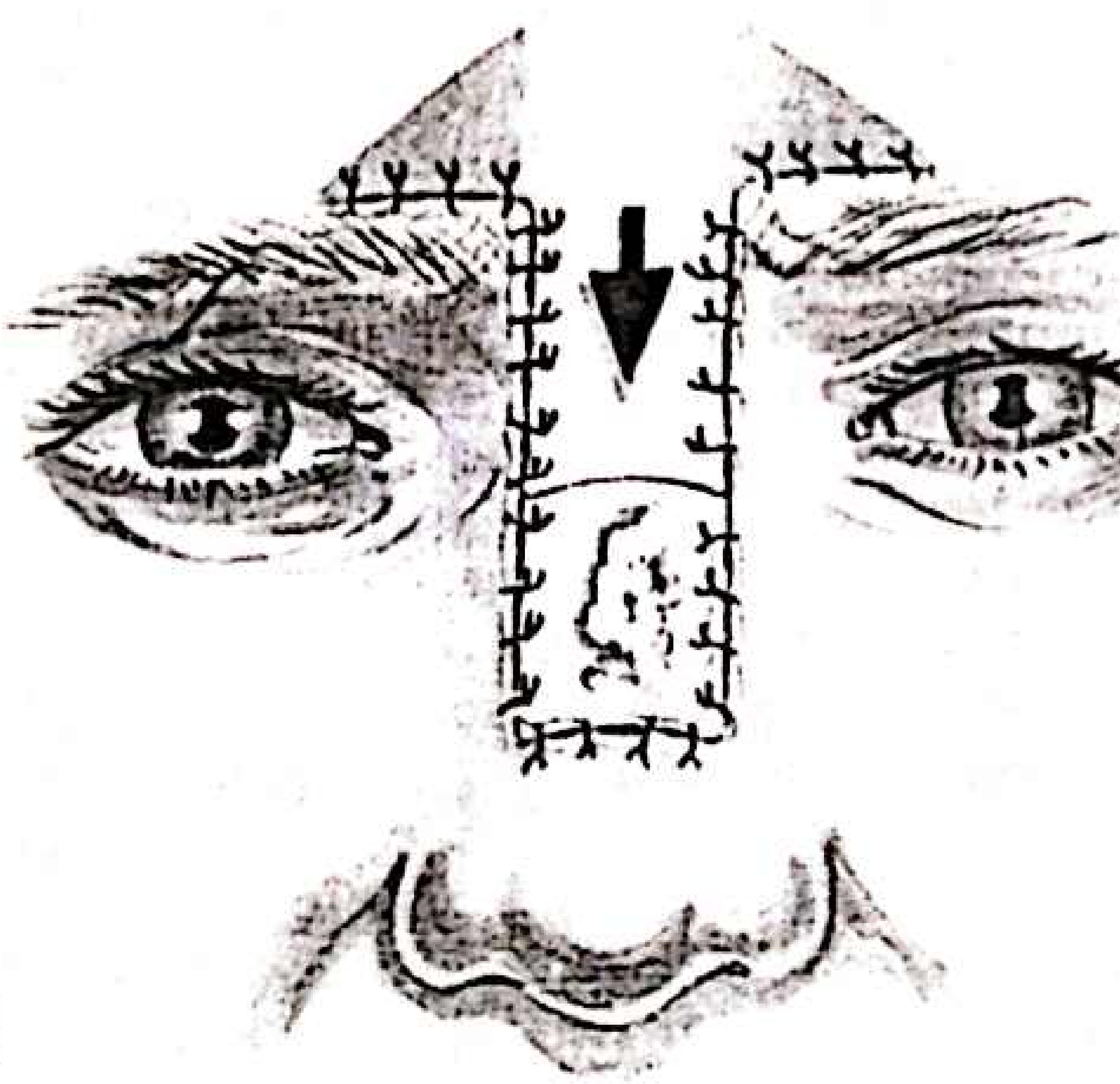
The defect of the midline of the upper half of the nose is probably best managed by the median glabellar flap. Despite its minor disadvantages, already discussed on pp. 60–61, its simplicity and safety, together with the absence of a ready alternative, make it the most suitable. As the defect extends down the nose towards the tip it becomes less satisfactory and it should seldom be made to extend into the lower third.



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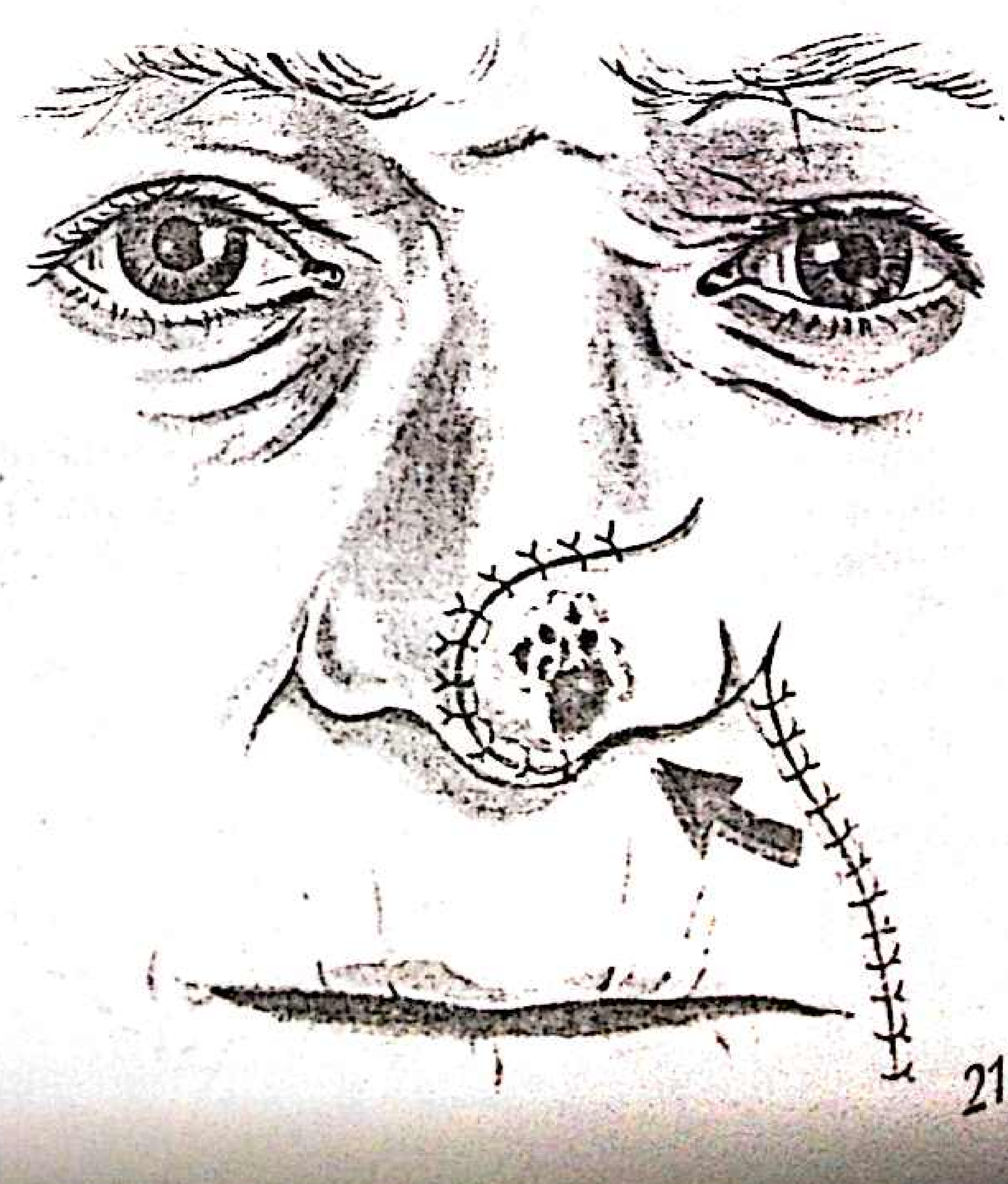
When the defect involves the lower half of the nose the virtues of the nasolabial flap, discussed on pp. 62–67, become more apparent. Used for this purpose it is most often superiorly based. The limiting factor to its use in reconstructing defects which involve the upper part of the nose concerns the site of the secondary defect and the need to close it directly. Extending it upwards beyond a certain height makes ectropion an increasing hazard when the secondary defect is closed.



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When the defect is of the lower half of the nose, particularly in the midline, the finger forehead flap still retains a significant role despite its apparent distance from the defect, its maximum length and the extent of its reach dependent on the height of the forehead.

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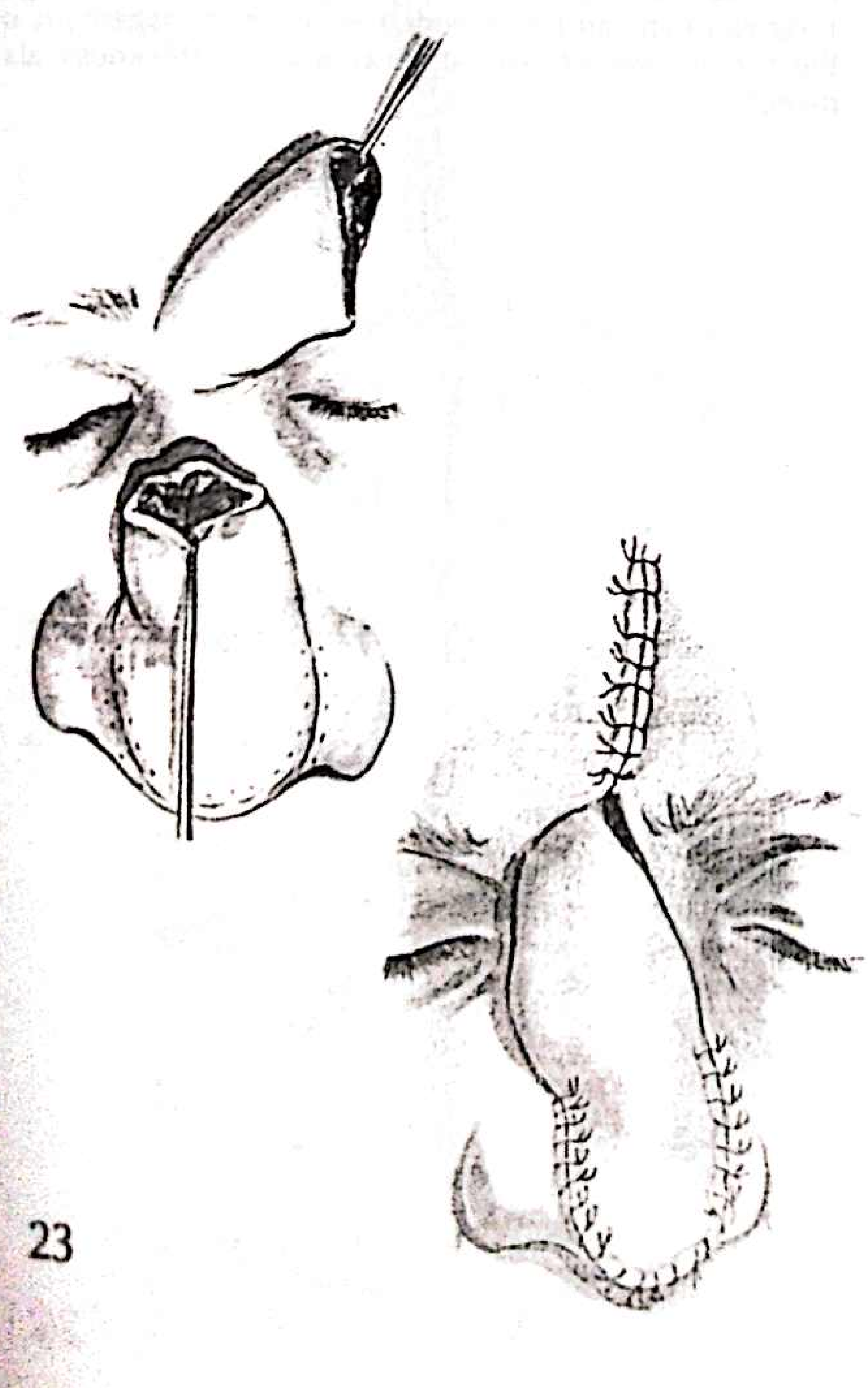
In many patients a flap can be constructed which is capable of reaching the nasal tip, but in any case, preoperative planning to establish the reach of the flap is straightforward.



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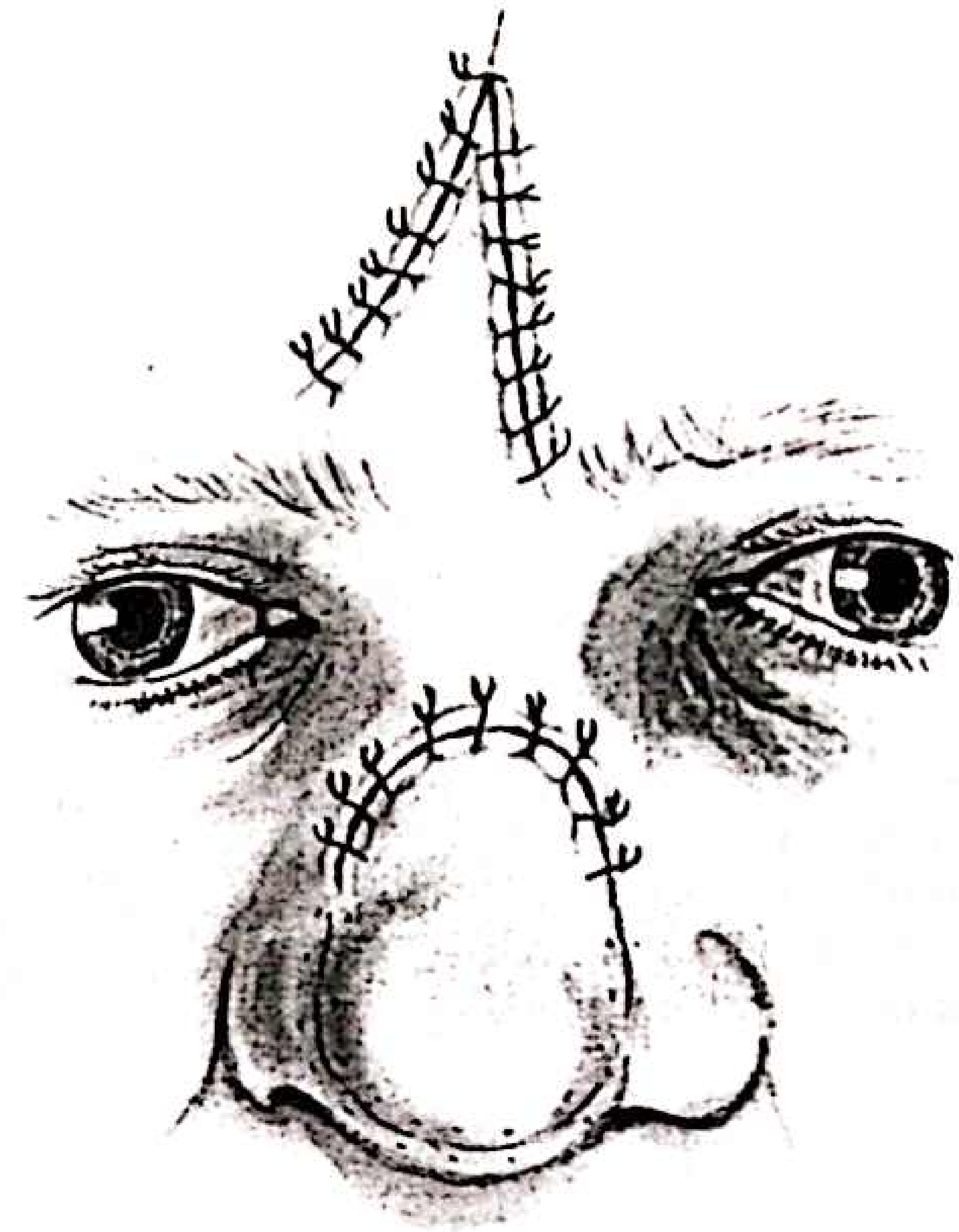
The method is most useful in the defect which extends upwards over the dorsum of the nose and whose extent laterally is limited.



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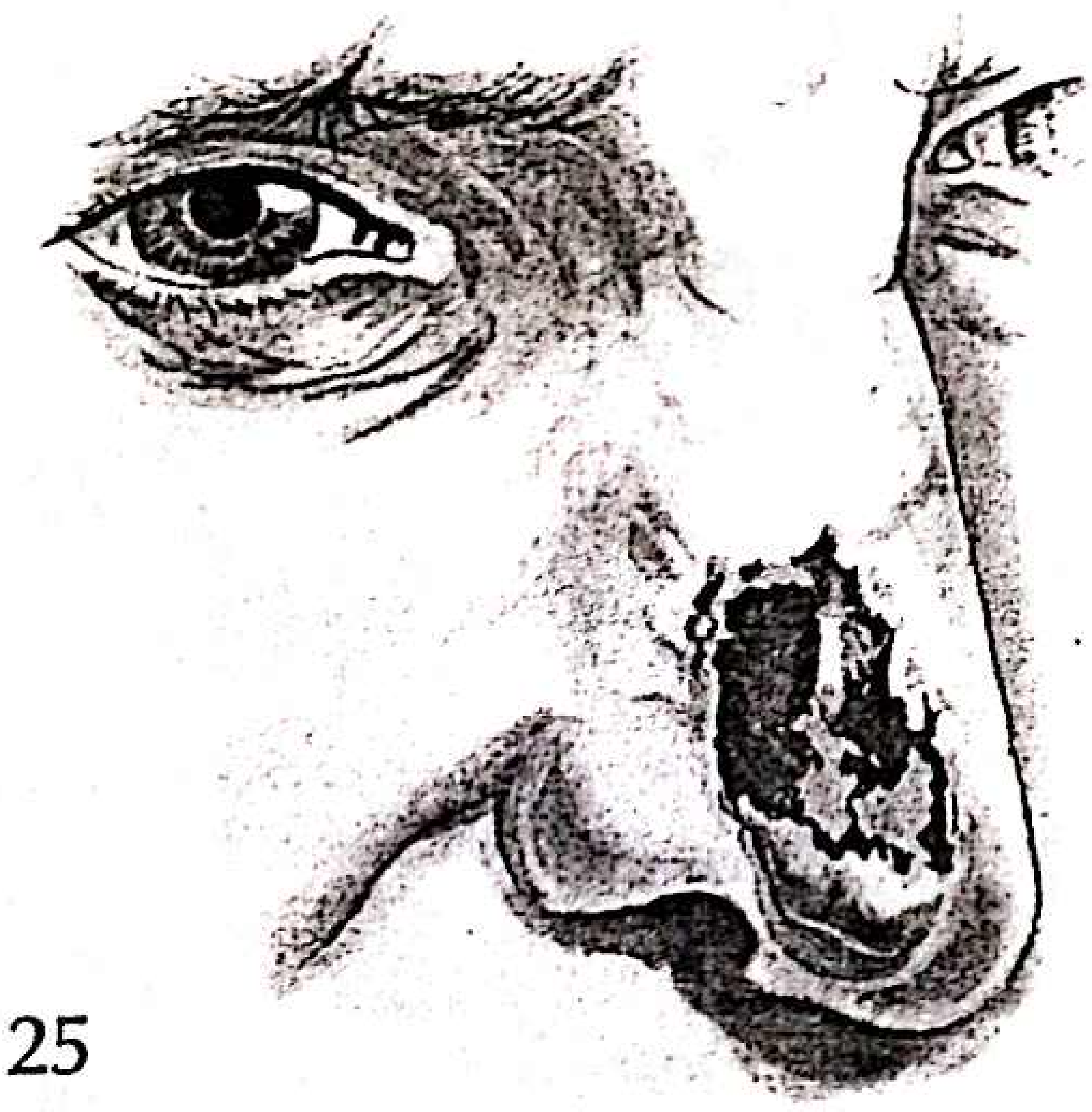

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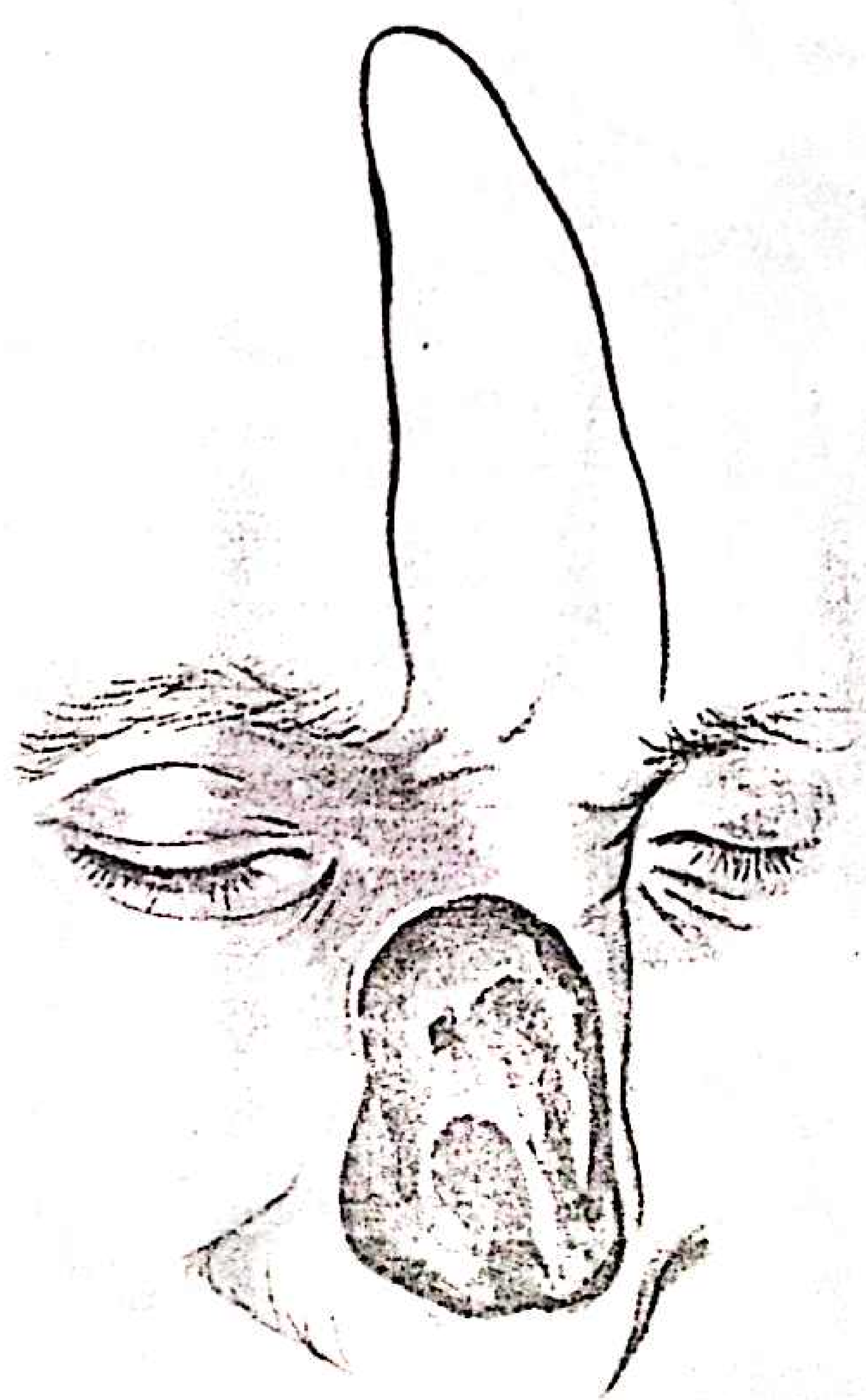
25

An occasional way in which the usage of the vertical finger forehead flap can be extended is in the management of the tumour whose excision leaves a full thickness alar defect.

26

Such a defect often partly involves the skin alone and partly the full thickness of the alar margin.



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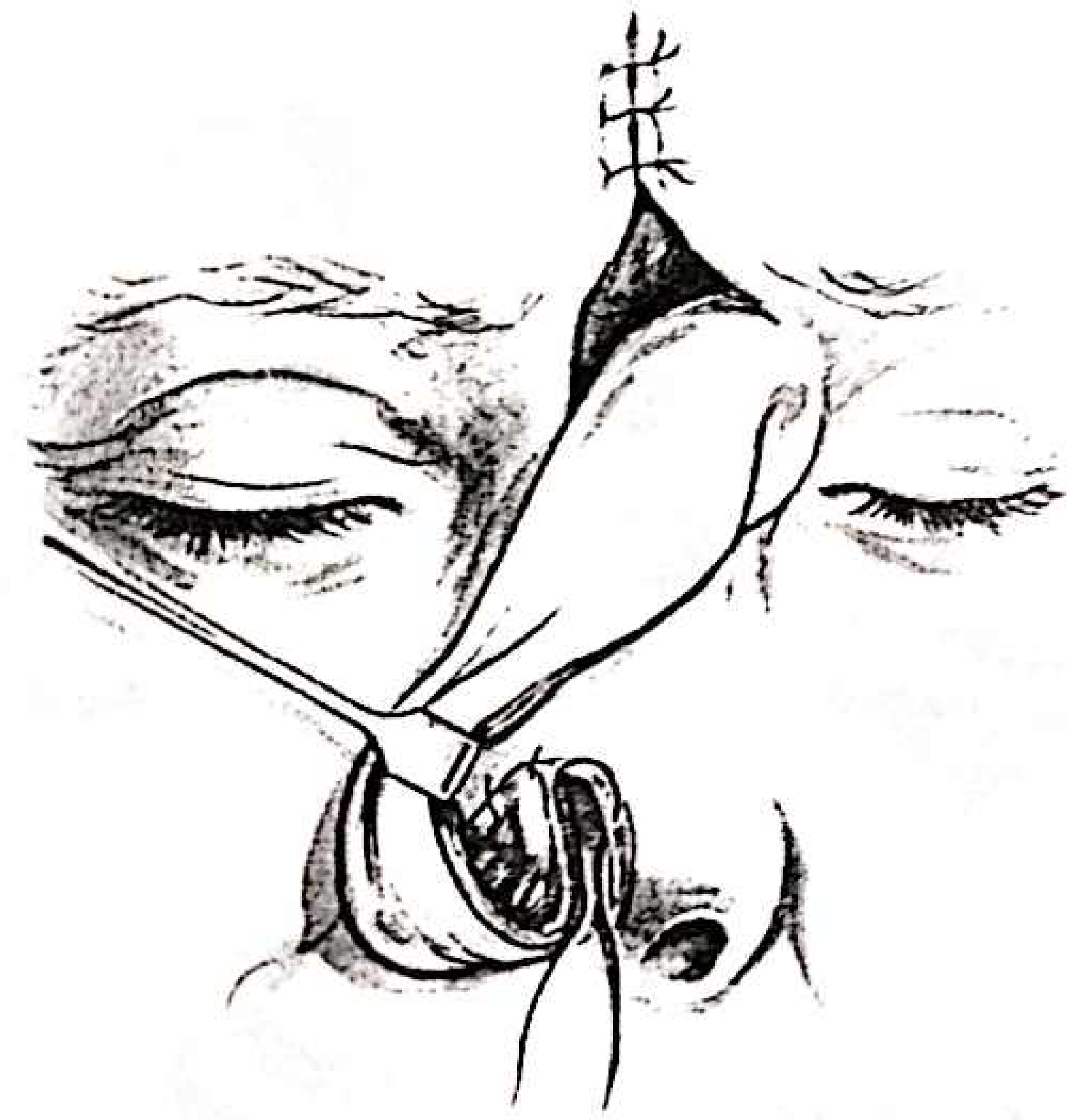
If the tip of the flap is turned in, it becomes possible to provide lining and skin cover simultaneously.



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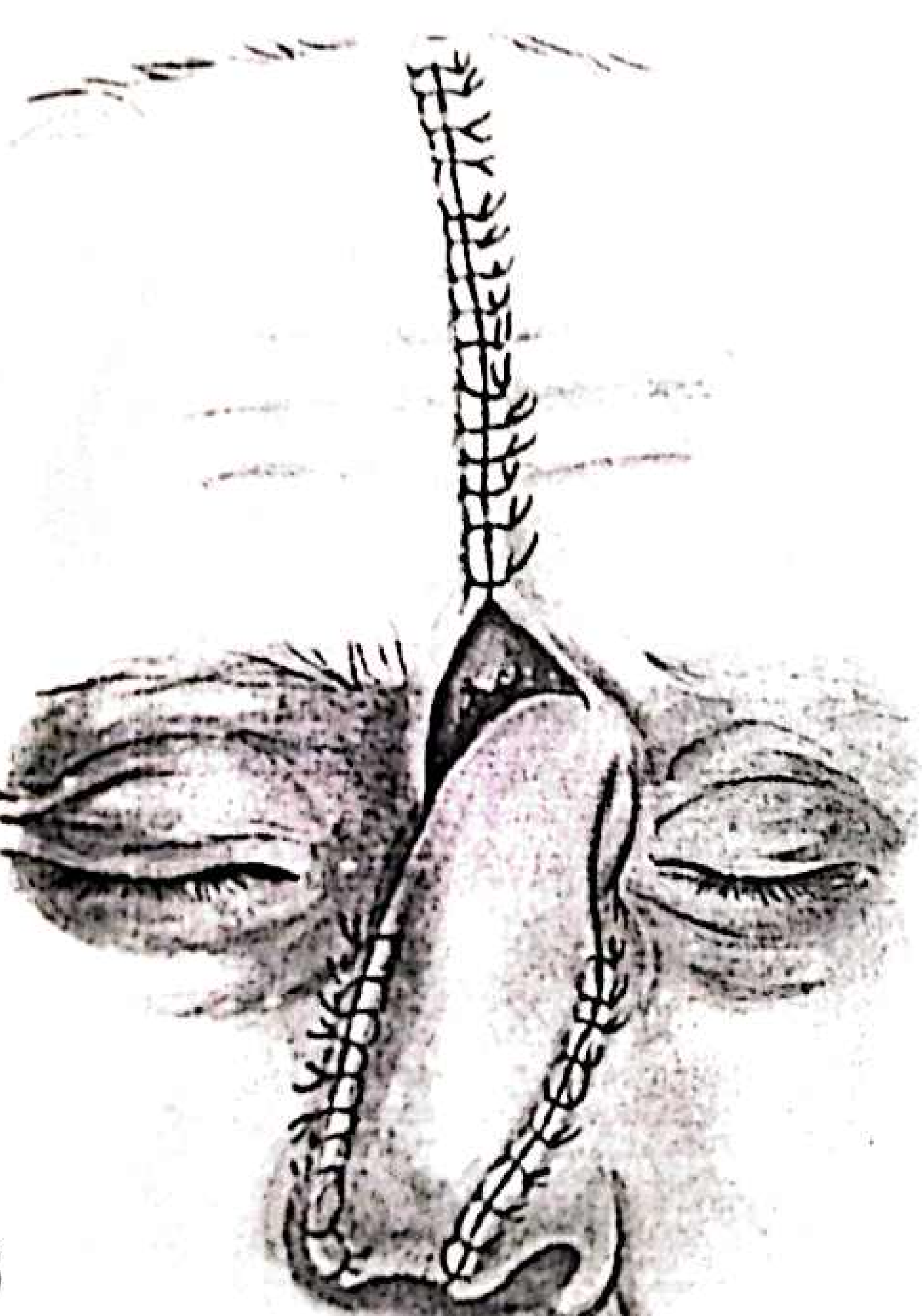

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28

The reconstruction is one which must be used with considerable discretion, although in the suitable case it provides an easy and effective solution to the full thickness defect, and one which can be used as a primary reconstruction. The limiting factors to its use are the height of the forehead and the character of the forehead skin. A high forehead is needed to provide the necessary additional length for the flap, and the forehead skin must be thin and flexible, both characteristics which can be tested for at the planning stage. Used in an unsuitable patient, the flap may not tolerate being bent on itself and, even if the blood supply is adequate, the double thickness of the flap is liable to give an unsatisfactory bulk to its final appearance.

Many of the defects which occur in the lower half of the nose could in theory be managed using either a nasolabial or a finger forehead flap, and the question consequently arises as to which of the two should be preferred in a giveh set of circumstances. The decision frequently depends on the shape and dimensions of the defect. The defect which is predominantly vertical is generally best managed by use of the forehead flap, and the predominantly transverse defect by using a nasolabial flap.

29 & 30

A reconstructive method which has been described for defects of the nasal skin is the bilobed flap, discussed on p. 69. Used in appropriate circumstances, carefully designed and carried out well technically, this flap is capable of giving an excellent result, but the scope for disaster is very much greater than with the methods already described. Its use involves elevation and rotation of the nasal skin and this limits its role to the nose with minimal sebaceous gland activity, in the part where the skin is thin and pliable. The shape of the nose is also important, a prominent bridge line adding to the geometrical hazards of the transfer. Its safe and effective use calls for experience and expertise in the technique. It is not a method for the occasional operator.

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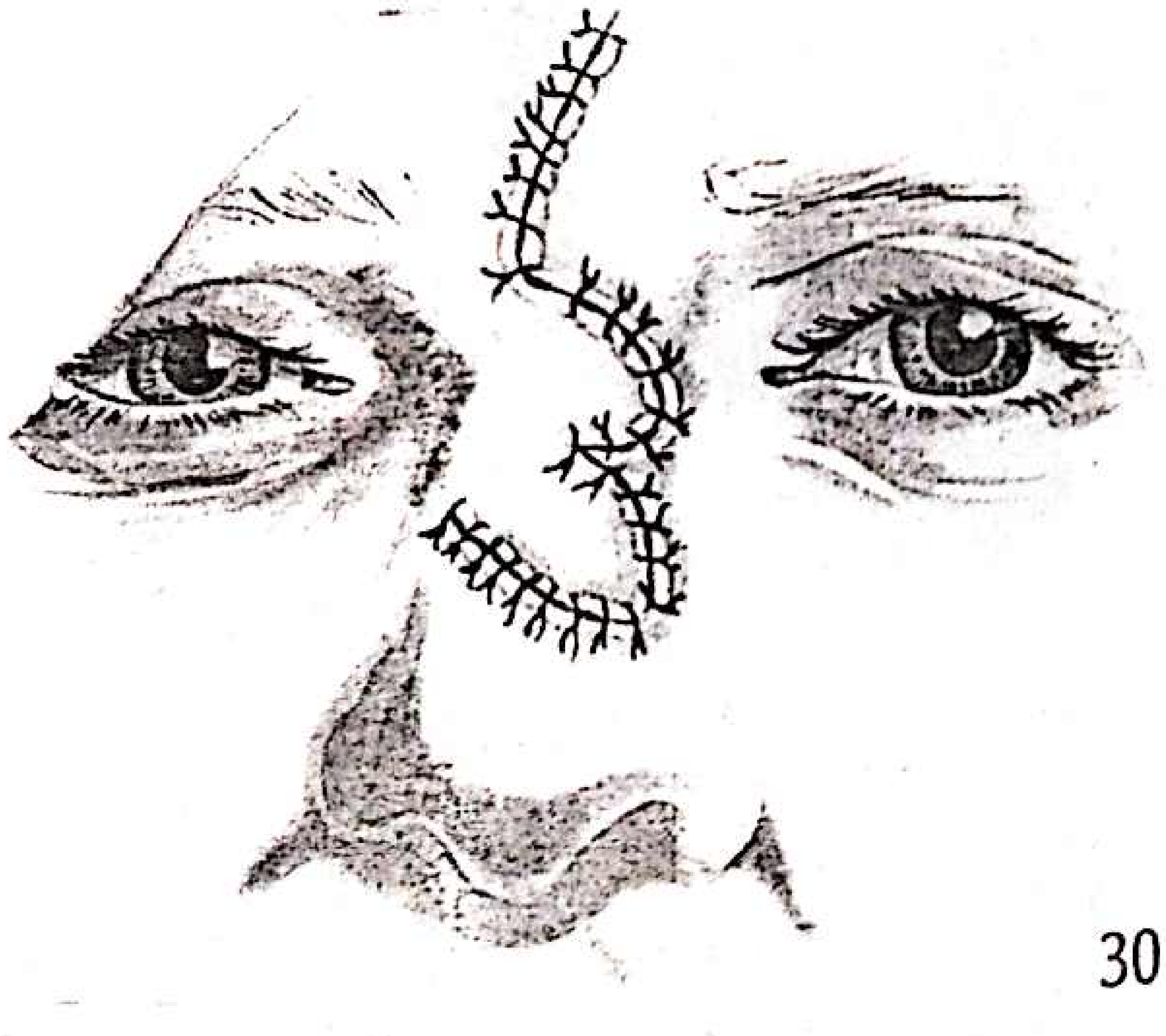

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A technical deficiency regularly seen at completion of the transfer of many of the flaps used in practice to reconstruct minor defects of the nose is that the flap is raised above the level of the surrounding skin, often with a degree of pincushioning of the flap in addition. Both of these deficiencies, but the former particularly, are the result of failure to match the thickness of the flap to the depth of the defect. The extent to which a flap can be thinned is limited if it is to retain an adequate blood supply, although it should generally be thinned as much as is safe.

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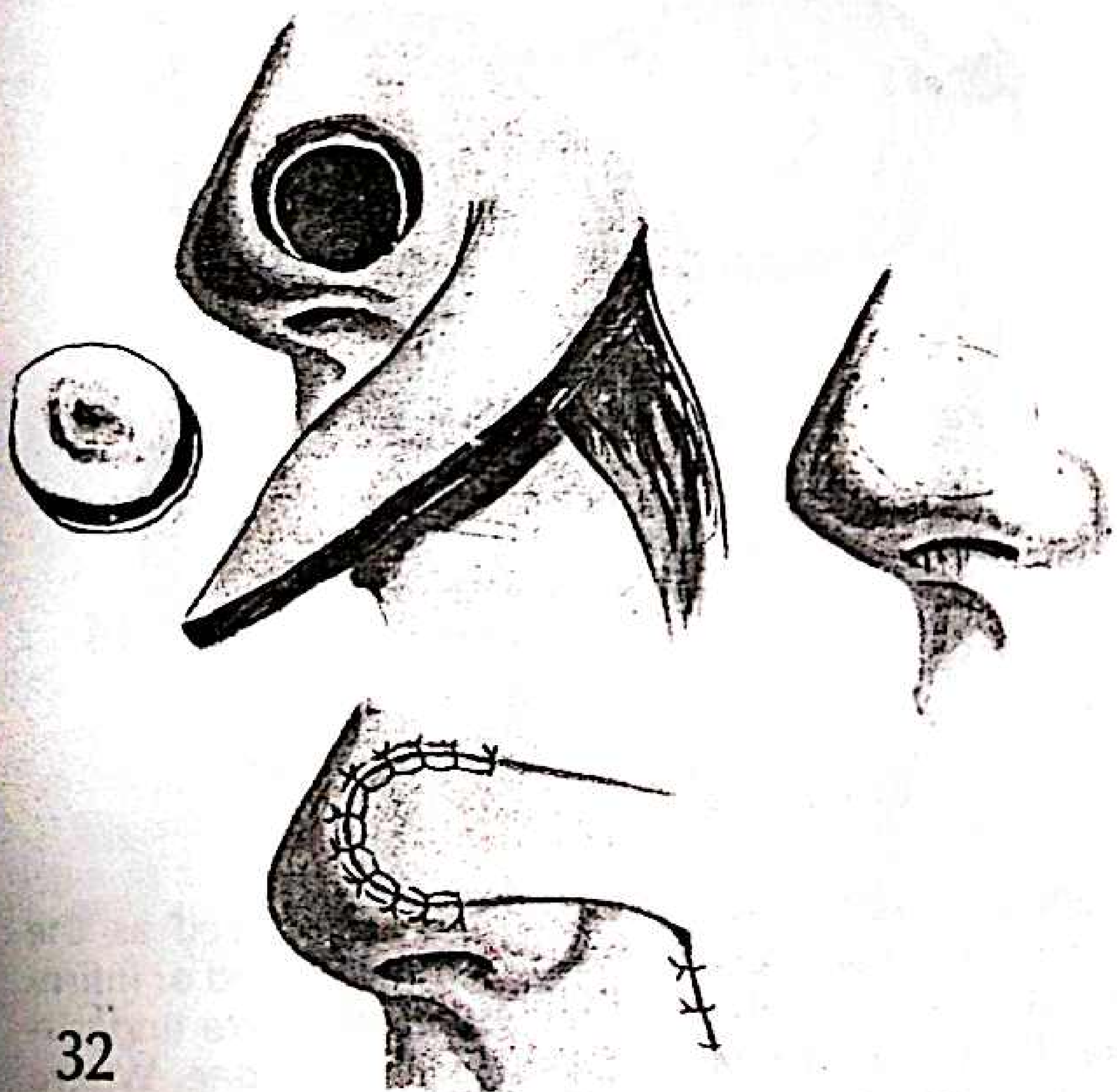

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32

The key to the problem in most instances lies in recognition of failure on the part of the surgeon to make the defect sufficiently deep. The question of making the defect sufficiently deep has pathological implications as well as those of reconstruction. One of the reasons cited for using a free skin graft in preference to a flap, where the alternative exists, concerns the comparative thickness of grafts and flaps and the relative ease or difficulty of recognizing recurrence of tumour under each. The problem is thus one of ensuring deep clearance. As already stressed, clearance of tumour in depth can be effectively assured in many instances by making use of the nasal bones and cartilages as tumour 'barriers', and in the lower half of the nose particularly, there is much to be said for resecting the underlying cartilage, lateral or alar, as a routine, when a flap is being used to resurface the defect.

The technical difficulty of resecting alar cartilage without damaging the nasal lining immediately deep to it is considerably greater than with the lateral cartilage, but it is near the alar margin that the danger is greatest because of the close adherence of the skin to the cartilage in that region. The increase in the depth of the defect which results from the removal of the cartilaginous layer does, however, have the incidental but nonetheless valuable virtue of accepting the flap, with its additional thickness, without creating a localized elevation. This places the surgeon in the happy position of being able to improve his cosmetic result by being more radical in his excision, a relatively rare occurrence in tumour surgery.

Major defects

In reconstructing a major defect of the nose, the provision of adequate nasal lining is of paramount importance as far as the final result is concerned, both in terms of the appearance of the nose and the free passage of air in breathing. Failure in this aspect results in collapse of the reconstructed element, the unlined flap contracting as it heals on its deep surface. Contraction shows itself most obviously towards the nasal tip, where projection from the nasal skeleton is greatest and where the greater part of the air flow in the nasal passages occurs. Virtually total occlusion of the nasal passage as an air conduit is the result. The lesson for the surgeon is that in his excision he should not sacrifice nasal lining unnecessarily.

33

33

It is rarely possible to reconstruct a major full thickness nasal defect as a primary procedure. Skin–mucosal suture is used to close the raw surfaces exposed by the resection and, since lining of the reconstructed nose requires preparation, whether using a lined flap or local inturned flaps as described on pp. 163–164, a period of waiting is unavoidable.

During this time it is frequently desirable to provide the patient with a prosthetic replacement.

The effectiveness of such a prosthesis depends to a considerable extent on the proportion of the nose which is being replaced. When the prosthesis is being used for a small alar defect the appearance is rarely satisfactory, the proximity of the prosthesis to the surrounding nose making the junction between the two and the contrast between them impossible to hide. With such a defect most patients find it preferable to cover the defect with a small dressing. Even a defect of half of the nose is difficult to camouflage for the same reason.

34

34

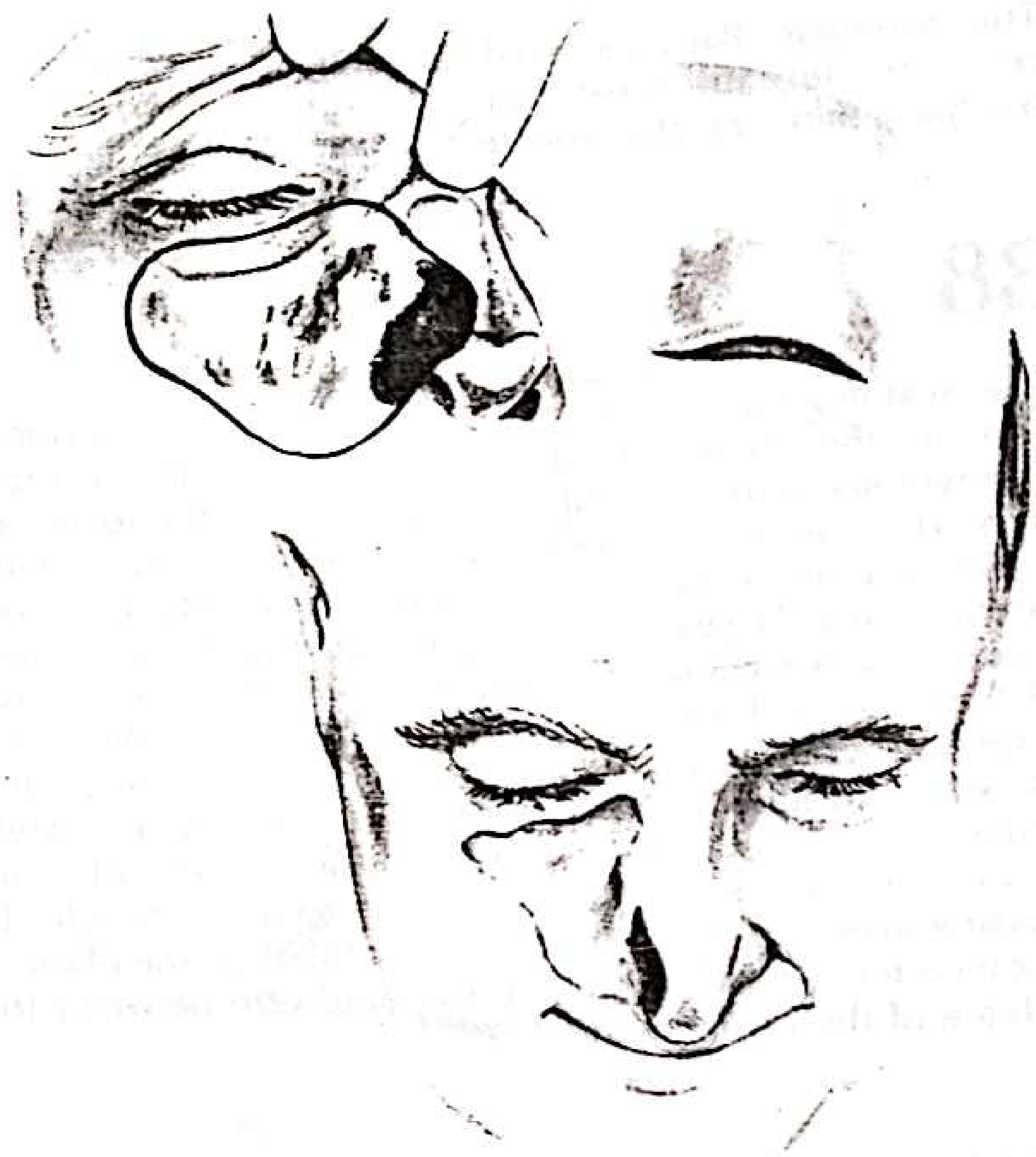
Where the entire nose has been amputated or the defect is such that a prosthesis can be used to cover the entire defect, its effectiveness is much greater. The nose is a cosmetic entity with well defined margins which demarcate it from its surroundings, and to the casual observer a prosthesis which replaces the entire nose is generally not recognized as such. Such a prosthesis can be held in position by skin adhesive or by attachment to spectacles. The latter attachment is both simpler and more effective, the presence of the spectacles adding to the masking effect.

It has to be admitted that, to the onlooker, a prosthesis made by a competent prosthetist has a much more normal appearance than many of the noses which are reconstructed from the patient's own tissues, so much so that in many instances serious consideration should be given to whether or not the prosthesis should be used as the permanent reconstruction. In the case of the old or infirm patient where repeated surgical procedures are undesirable, the decision may be a straightforward one. Where the decision is less clear-cut the patient has obviously a part to play in the decision. In such circumstances the comparison between the appearance of the prosthesis and the probable result of the nose reconstructed from the patient's tissues should be presented in a realistic manner so that he is under no illusions. The emphasis placed on the various aspects of such a discussion will vary with different surgeons, but even in the face of considerable pressure on the part of the surgeon for a permanent prosthesis, most patients, given the choice, opt for a reconstruction. Even so, the excellence of the temporary prosthesis will reduce the pressure on the surgeon to hurry on with the reconstruction.

The hemi-nose

The potential sources of inturned lining flaps are from the nasolabial area and the nasal skin above the defect, as shown in *Illustration 14*. The latter flap is particularly valuable since it avoids extending the skin defect on to the intact half of the nose. The nasolabial inturned flap used in such circumstances is similar in principle to that used in reconstructing the entire nose, as shown in *Illustrations 40* and *41*.

Skin cover is usually provided by a forehead flap, and it can be based either inferiorly or laterally. Since the nasal defect in most instances is a vertical one, the inferiorly based design, using the sickle shape, described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, is the one most often used.



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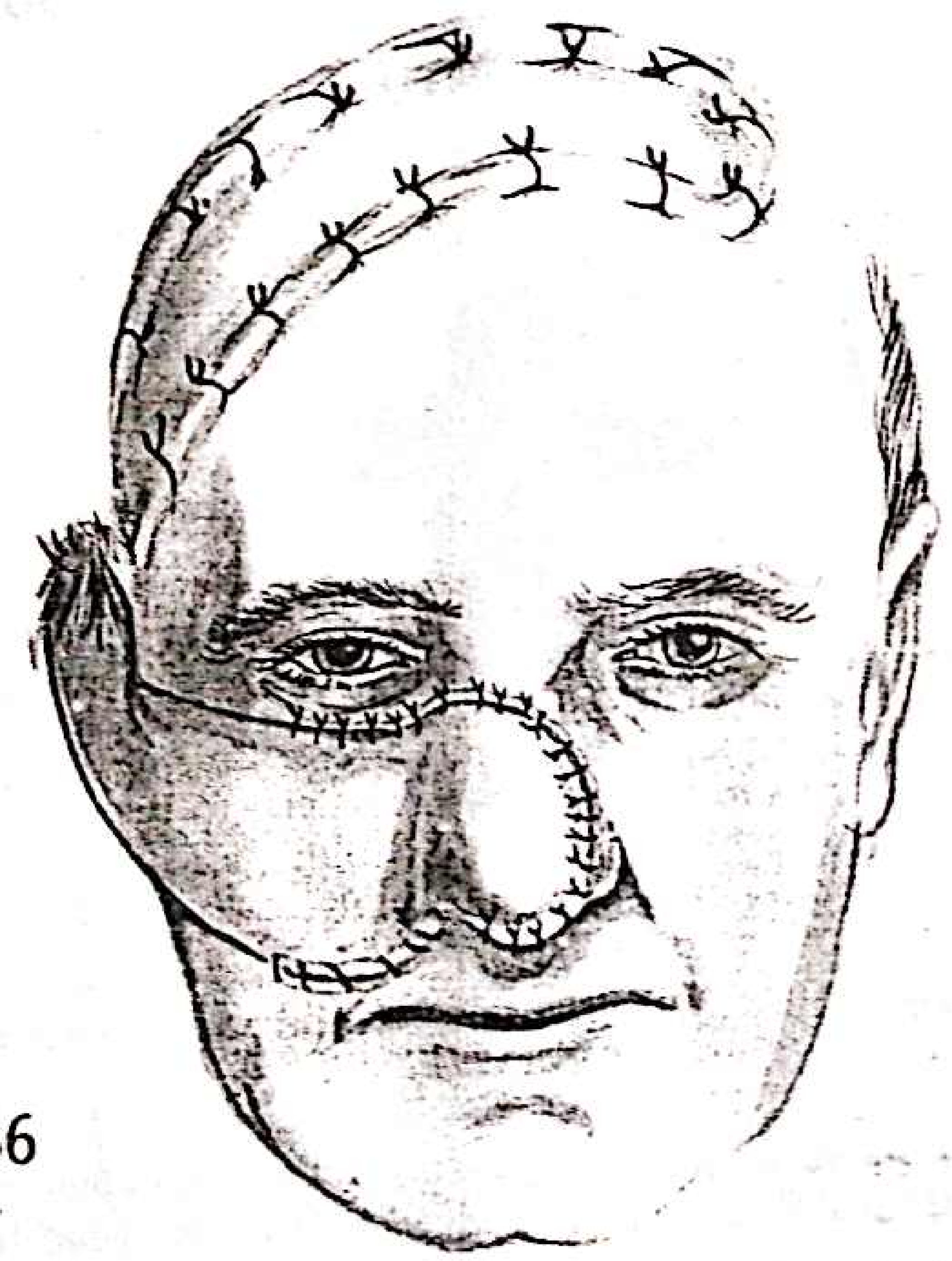
Where the defect extends from the nose laterally to include the cheek, a laterally based flap allows both to be covered simultaneously.



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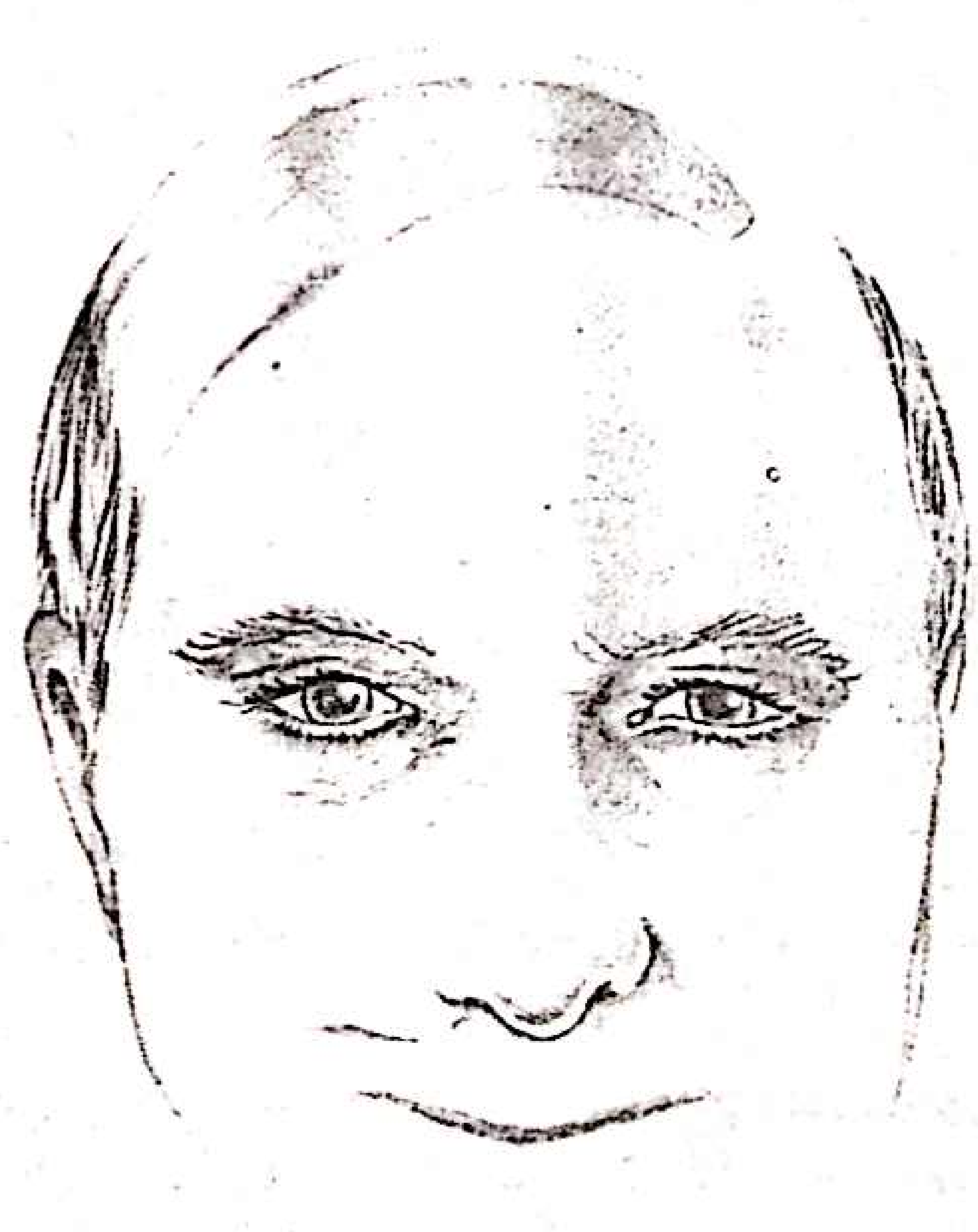
A lined flap, as described on p. 164, is prepared on the donor site. This is usually the forehead, but when the patient is bald a temporal flap, passing vertically upwards and making use of the bald scalp to provide the skin cover, is an alternative source.



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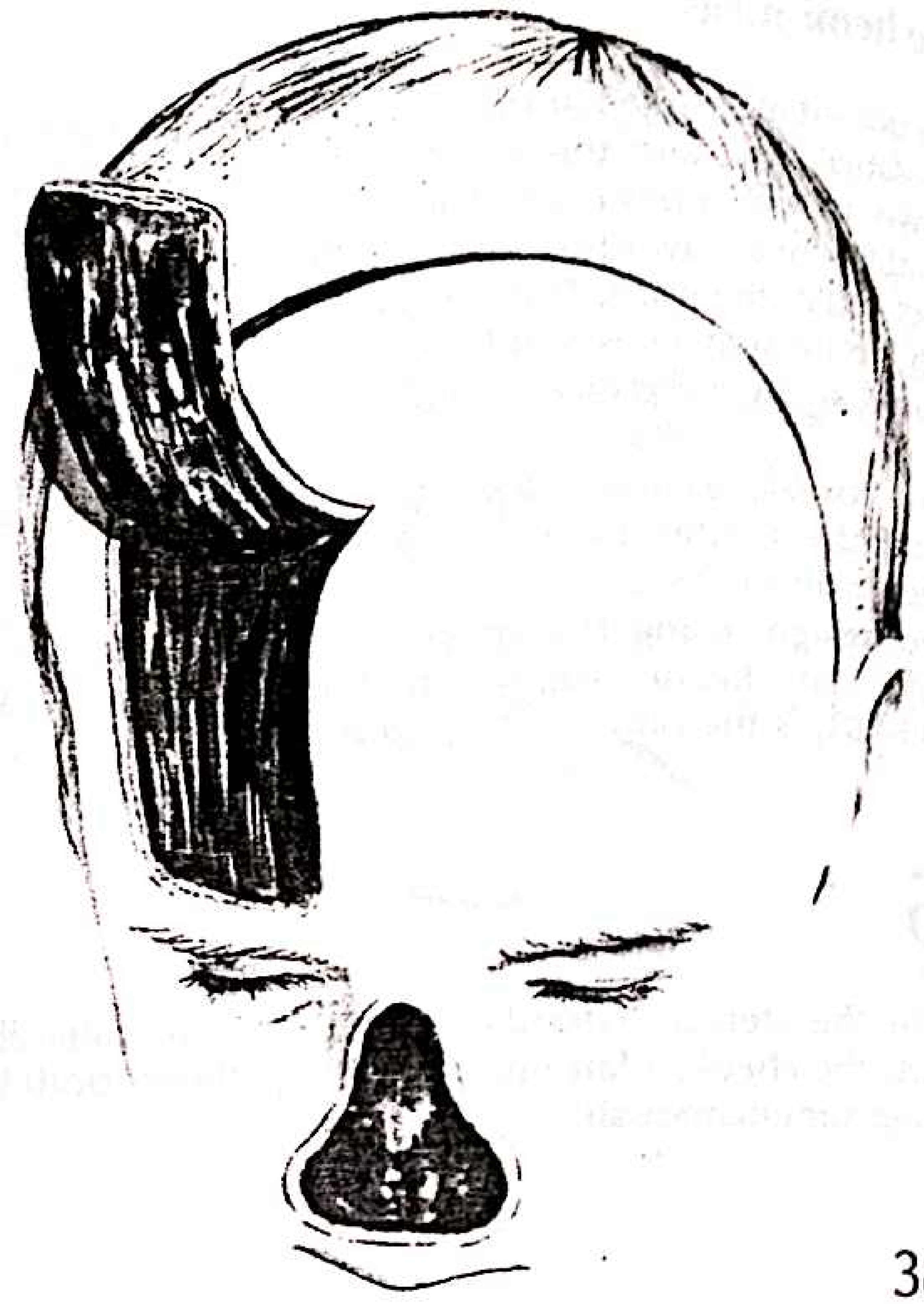
At the completion of the procedure the forehead remains intact.

The whole nose

The forehead flap, as used to provide skin cover in reconstructing the nose, can take two basic forms – the 'scalping flap' and the 'seagull flap'.

38

The 'scalping flap' reconstruction represents the culmination in the evolution of the design of the various eponymous flaps described to make use of the forehead skin. The area of forehead skin which is used to provide the nasal cover is placed immediately above the eyebrow on one side of the midline, and the flap is continued upwards into the hairbearing scalp, curving round to have its base above the eyebrow area on the other side of the forehead, though with the incisions remaining inside the hairline. Ideally, the area of the flap which ultimately provides the nasal cover should be as thin as possible, and it is usual to raise it superficial to the frontalis muscle. In passing upwards on to the pedicle of the flap, the plane is immediately deepened to the standard one between the galea and the pericranium.



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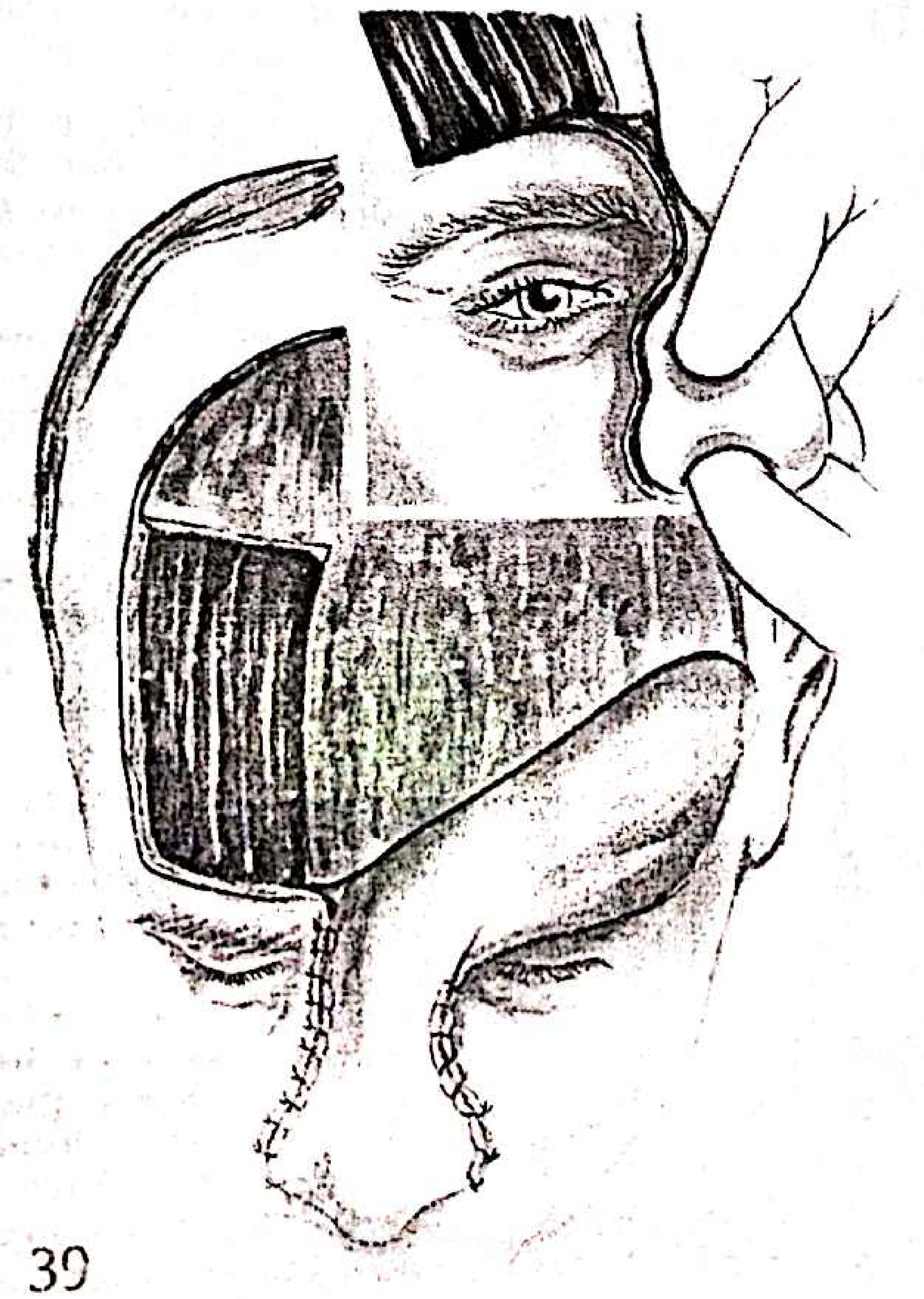

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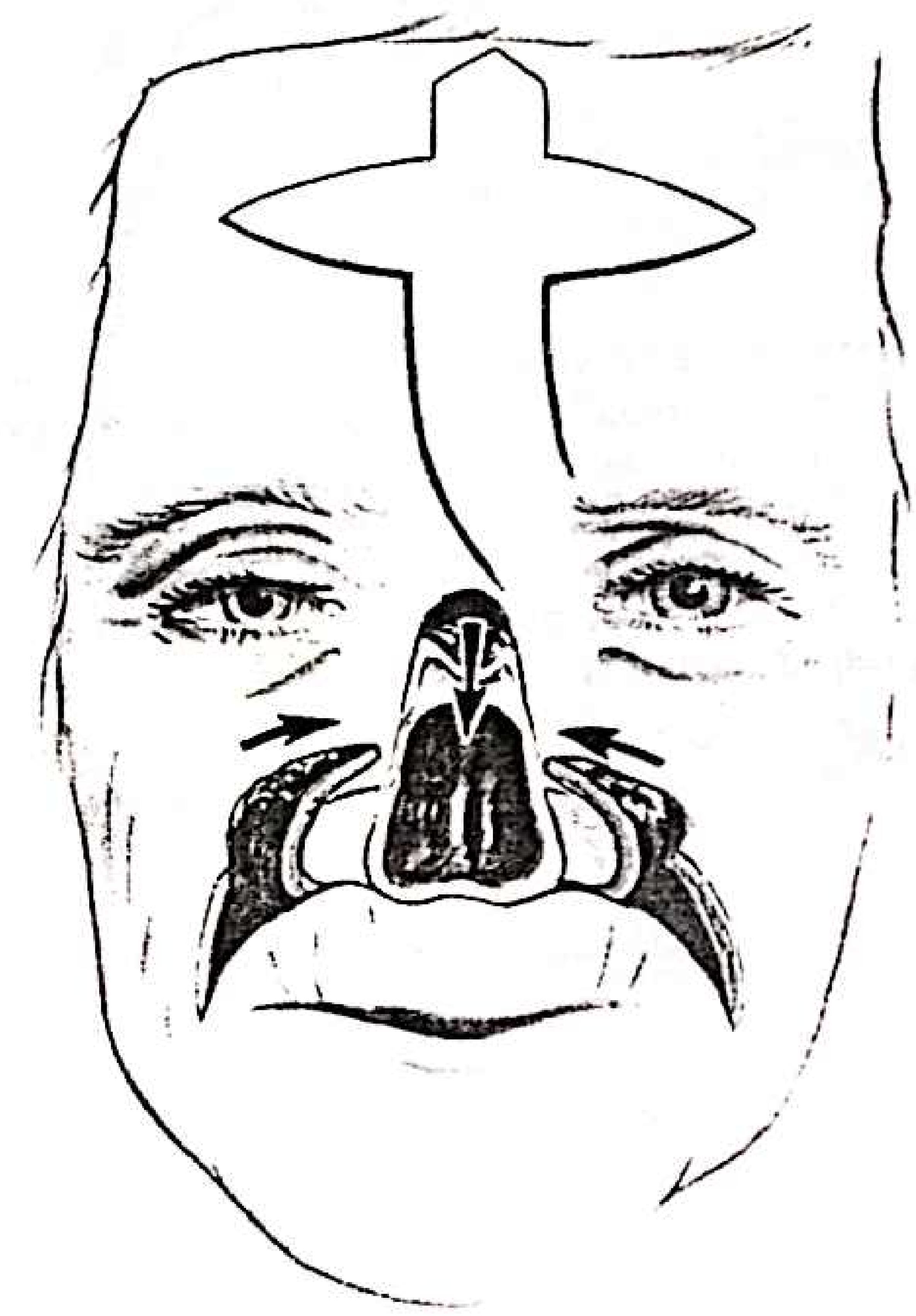
The lower border of the flap is shaped so that it can be folded on itself to provide both the columella and the alae. Even with the flap raised superficial to the frontalis muscle to make it as thin as possible, the double layer which the folding creates tends to give a thick margin to the alae and the columella. The effect, appearance apart, is also to reduce the nostril openings, and even with subsequent thinning the effect is seldom entirely satisfactory.

In the 'seagull flap' reconstruction, lining is provided by inturned local flaps and skin cover by the forehead flap.

40

The lower half of the defect is lined by bilateral inturned nasolabial flaps, the upper half by turning down the nasal skin above the defect and, since their survival is critical, care at every stage, in design and in transfer, is essential. A preliminary delay is standard. The length of each nasolabial flap is dictated by the length of the nostril margin in the reconstruction, together with the proportion of the columellar length required. The lower border of each nasolabial flap, raised and inturned, forms the line of the nostril margin and the flaps should be designed with that consideration in mind. The line must also be continued to the alar base. The two flaps, inturned, are sutured together distally, and to the stump of the columella. This leaves a residual defect above and this is filled by the flap raised on the skin above the defect. This flap, designed with a length to fit the residual defect, and turned down, completes the lining. The defects left by the transfer of the nasolabial flaps are closed directly. The defect left by the turning down of the vertical flap, being above the original nasal defect, is covered by the forehead flap which approaches it from above to provide the overall skin cover of the reconstruction.



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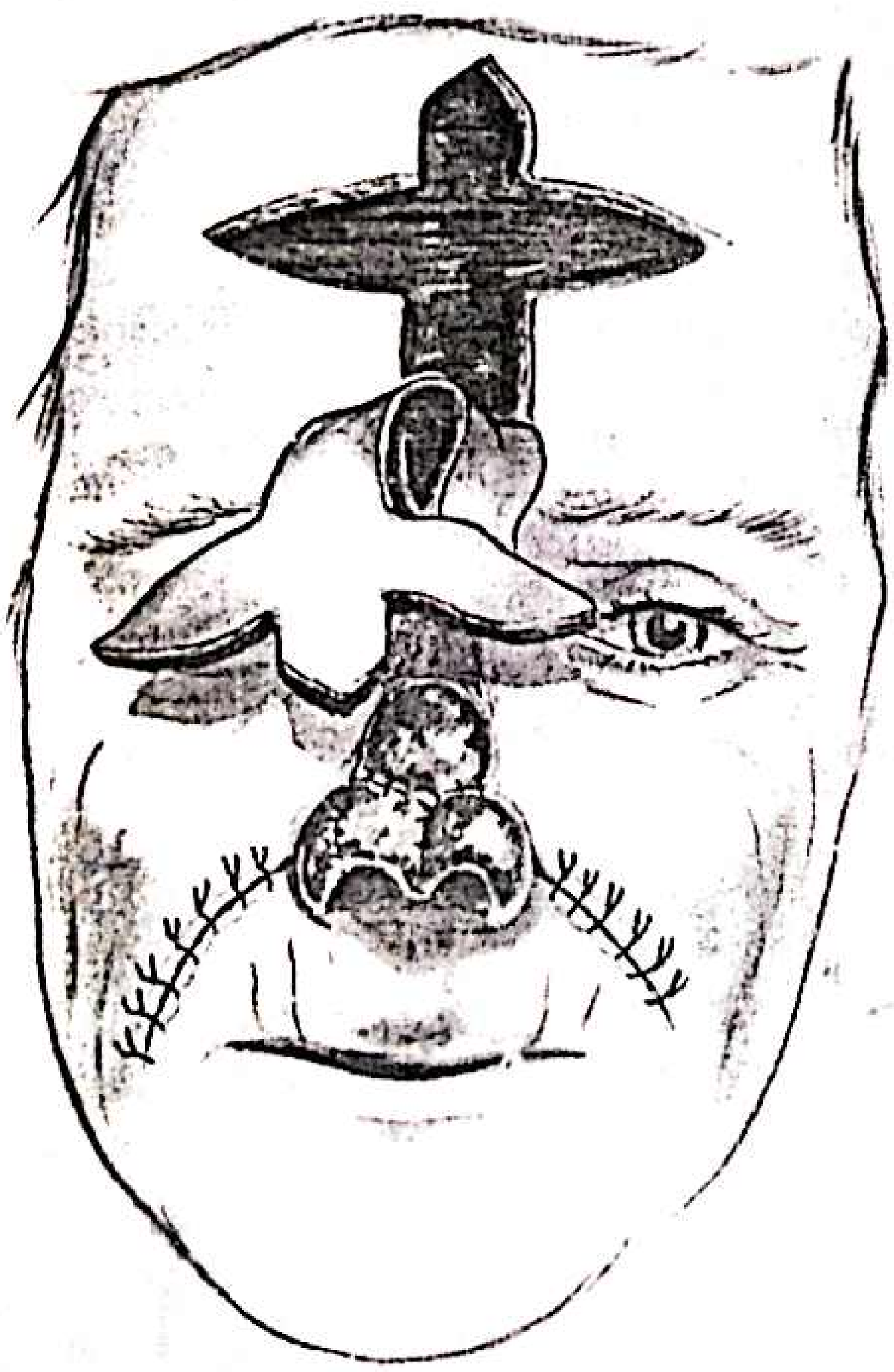

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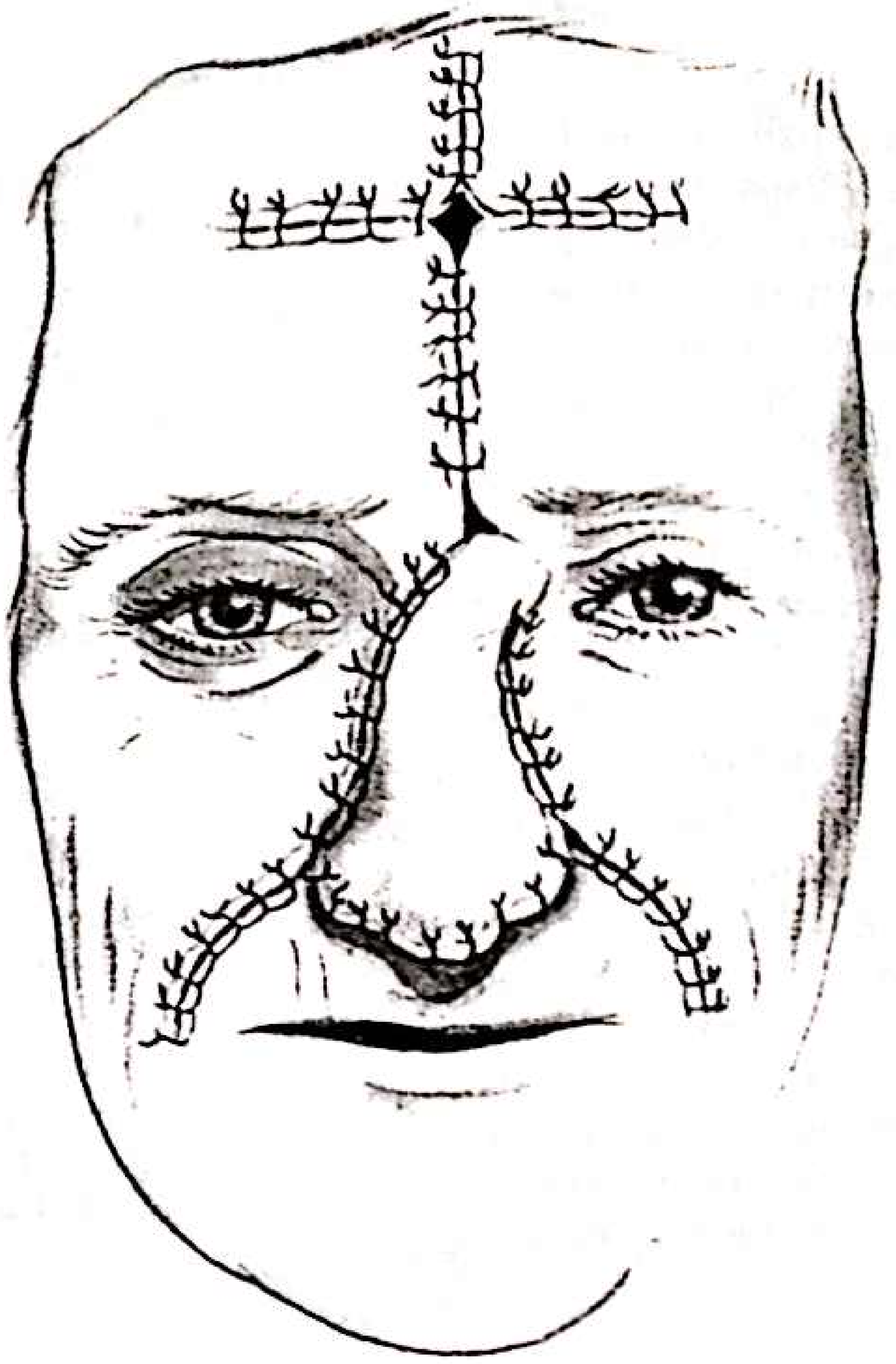
The 'seagull flap' providing the skin cover is designed entirely on the forehead. The 'wings' of the seagull are designed to form the alae, the 'head' the columella, and the 'body' the remainder of the nasal skin. The 'body', approximately 3 cm broad, extends upwards across the forehead from the medial end of one eyebrow, incorporating the supraorbital-supratrochlear vessels. Where the forehead has a height of 7.5 cm, it should be possible to design the flap vertically; with a narrower forehead an oblique design can be used.

With the narrowness of the flap and the 'wings' on each side, a preliminary delay is advisable if the transfer is to be achieved safely, although the absence of vessels entering its deep surface makes elevation as part of the delay unnecessary.

The differences in the design of the two flaps affects the management of the secondary defect created by the transfer. In the case of the 'scalping flap' it is usual to graft the defect of the forehead immediately; the scalp defect may either be grafted or left to granulate over the 3-week period pending division of the flap pedicle, completion of insetting, and return of the pedicle to the scalp.

42

The comparative narrowness of the 'seagull flap' leaves a defect which can usually be closed directly, although a small central area may have to be left to heal spontaneously. With both flaps the advent of the technique of tissue expansion has altered this aspect of the reconstruction, and it should now be possible in many instances to avoid a graft completely.



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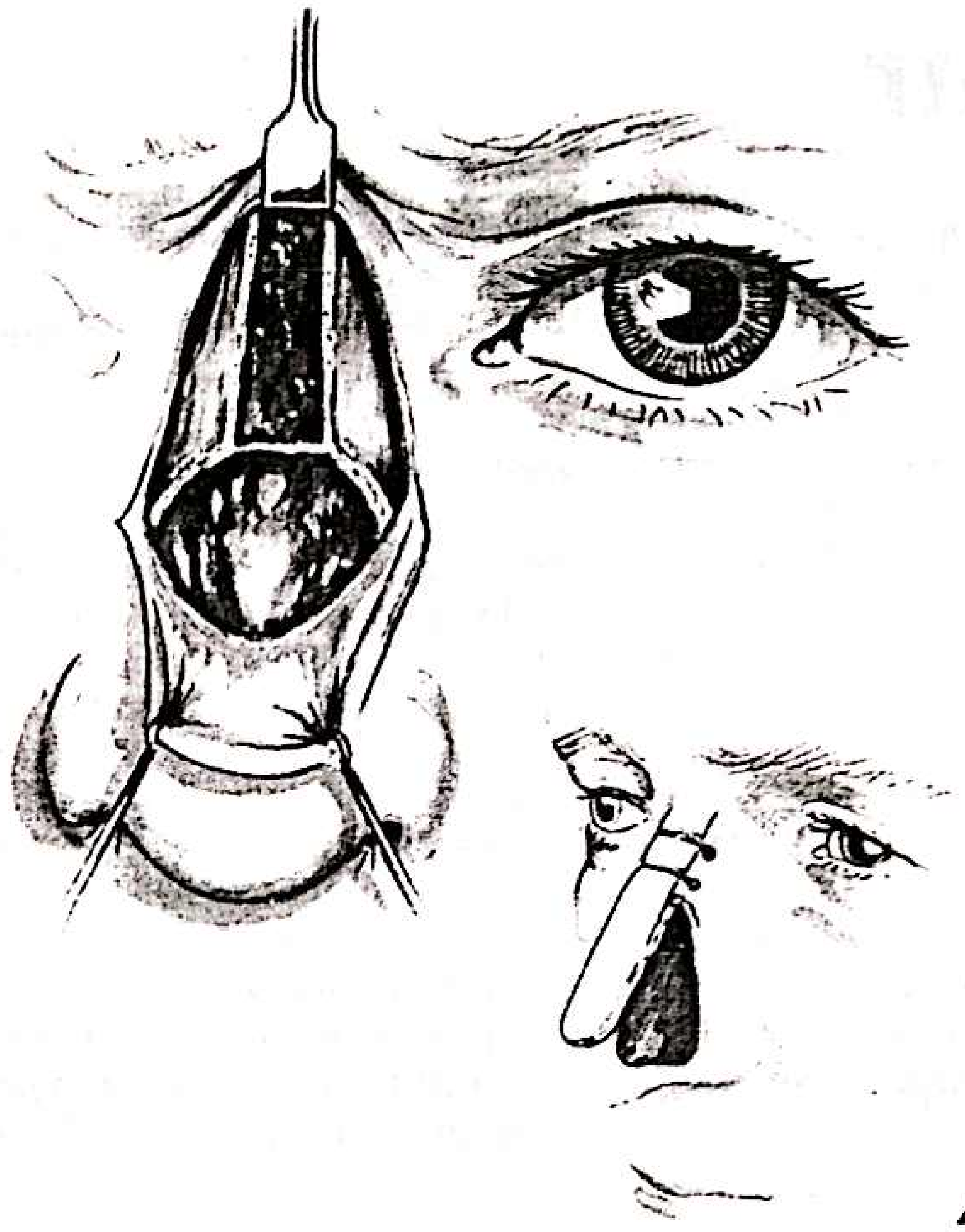
With both flaps it is safe to carry out division 3 weeks after the initial transfer. In the case of the scalping flap the extensive forehead and scalp elements are returned to their original sites, with insetting of the transferred component. With the 'seagull' flap the division and adjustments involve considerably less surgery. It is recommended that if possible its axial vasculature should be left intact, with the aim of reducing the tendency to oedema of the reconstructed nose.

With either design it is seldom possible to achieve a totally acceptable result primarily. Revisions are virtually always required, and surgeons tend to be somewhat coy about revealing the precise number in individual cases. Thinning and contouring are often required and usually have to be carried out in stages.

The effect of losing skeletal support is not obtrusive immediately postoperatively, but it tends to become increasingly so as the induration and operative reaction subside. The nose as a whole becomes less rigid and collapses somewhat, tending to lose what shape it had, and attempts to create a better contour at this late stage are both technically difficult and usually less than totally effective. Because of this it has been recommended that support should be provided as part of the original reconstruction.

43

One of the methods described involves the use of a bone graft, using rib or iliac crest, suitably tailored, and set into a shallow trough prepared in the nasal base where it is wired in position.



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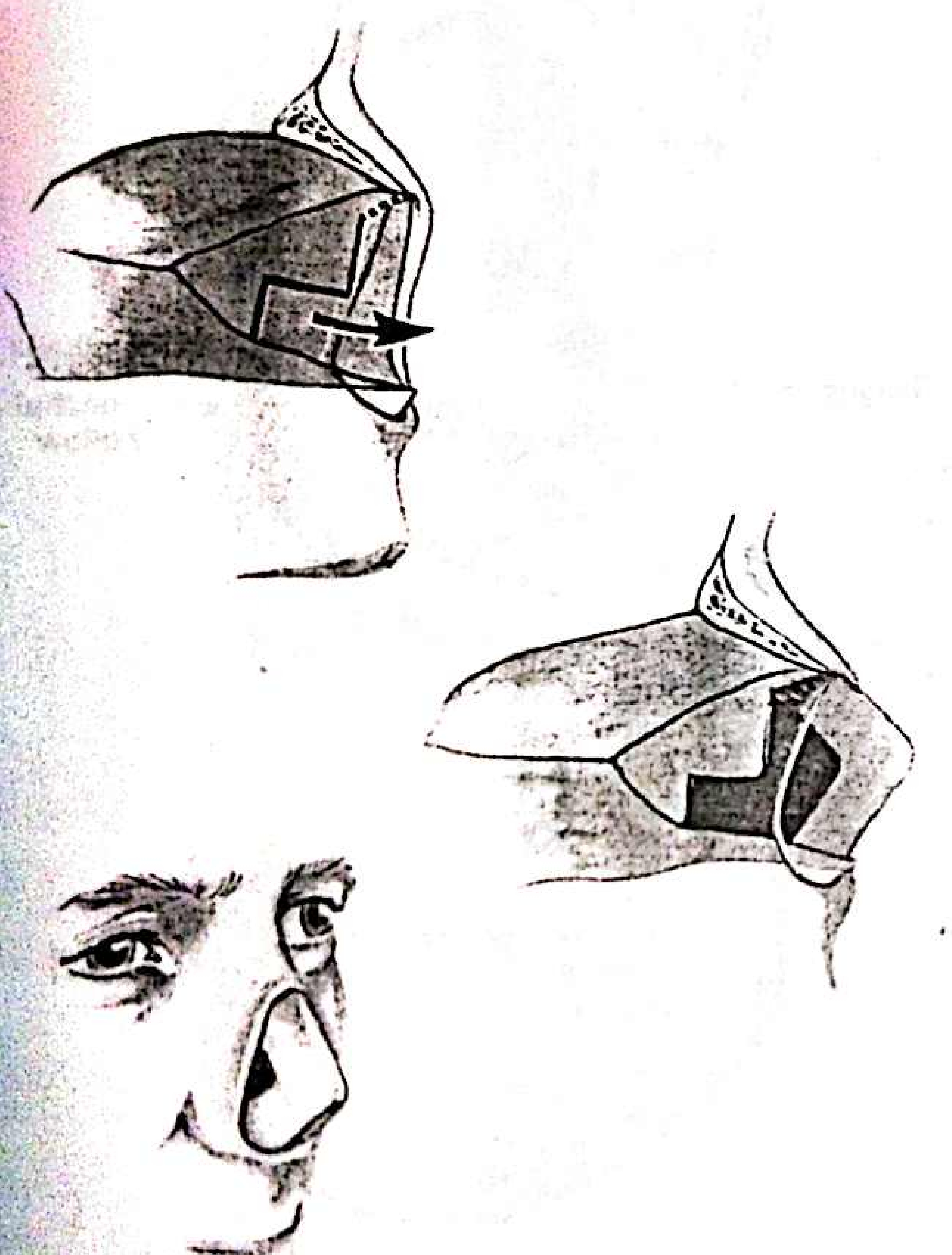

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When residual nasal septum is present, rotation forward of its anterior part as a hinged L-shaped chondromucosal flap, superiorly based, has also been described. The technique is a difficult one to carry out, since it is generally necessary to divide the cartilaginous attachment above to allow the forward rotation to take place. To do this without dividing the overlying mucoperichondrium, cutting off the blood supply to the flap, is not easy.

Both techniques are designed to provide bridge line support over which the skin flap can be draped. The provision of skeletal support increases the complexity of the reconstruction, an aspect which the surgeon must take into account since it possibly also increases the potential for complications. In the hands of the surgeon experienced in the technique the quest for excellence is justifiable, but equally the less experienced surgeon may well legitimately settle for a little less if it reduces the chance of complications.

Today total reconstruction of the nose is rarely required, partly because neoplasms are recognized and treated at an earlier stage, partly because surgeons are more aware of the desirability of conserving lining, thereby making their reconstructive task easier. Whatever the reason, few surgeons have wide experience of the technique. The occasional operator may feel a little disappointed with the result he achieves, but he should feel reassured by the knowledge that his disappointment is shared by other surgeons in similar circumstances.

Illustrations by Ian Ramsden

Ear

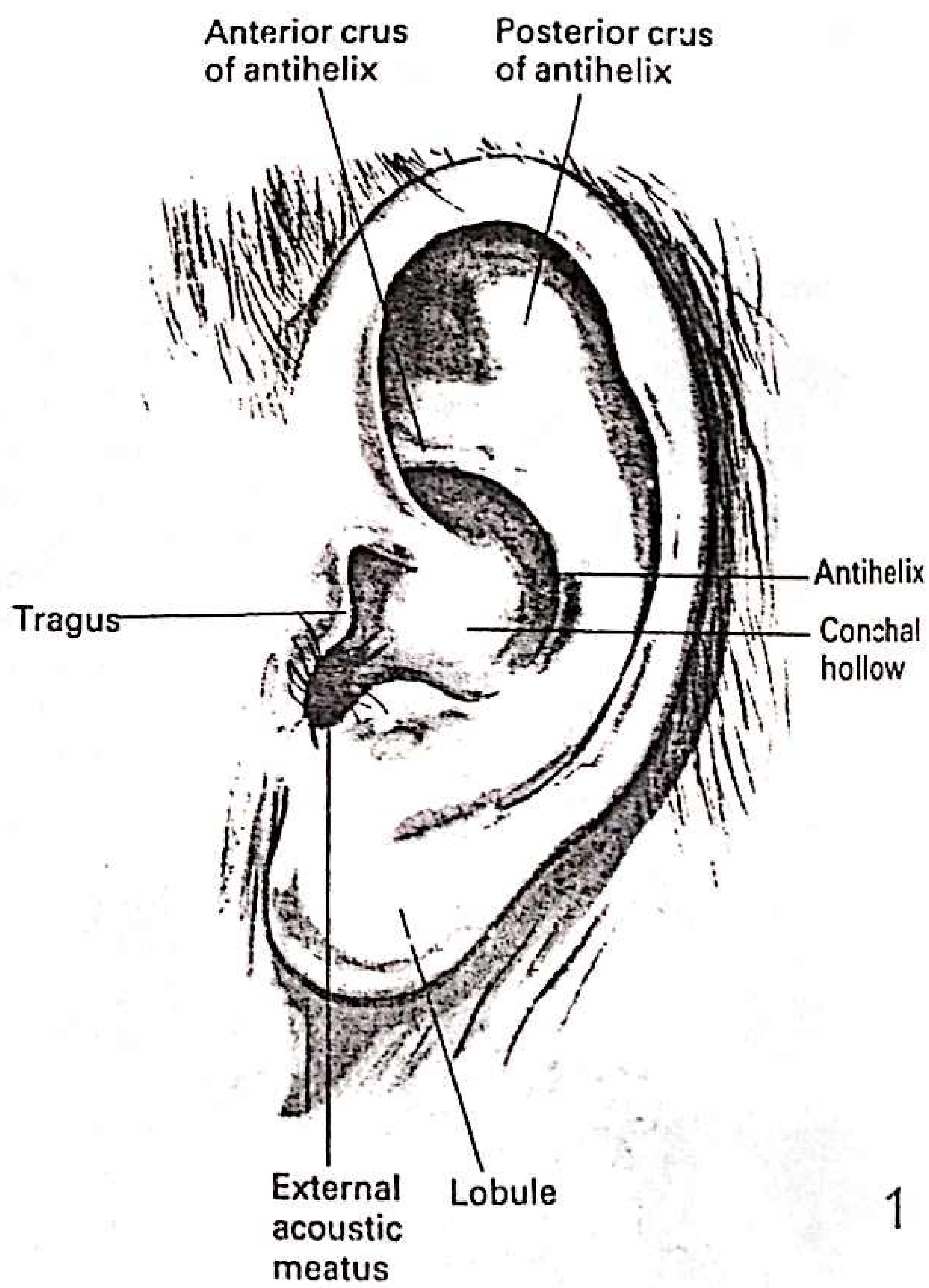
Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Anatomical aspects

1

Where the cartilaginous skeleton of the pinna and the skin are in direct contact the two structures are adherent, one to the other. The degree of adhesion is most marked on the outer surface, and it increases towards the external acoustic meatus. In the meatus the fixation is if anything greater still, both in the cartilaginous and in the bony meatus, to the cartilage in its outer third, to the bone more deeply. On the posterior surface the attachment is significantly less, and the mobility of the skin increases towards the postauricular sulcus.

In the cartilaginous meatus gaps are present in the tube of cartilage. These take the form of fissures on its anterior, superior and posterior surfaces where it is replaced by fibrous tissue.



1

Pathological aspects

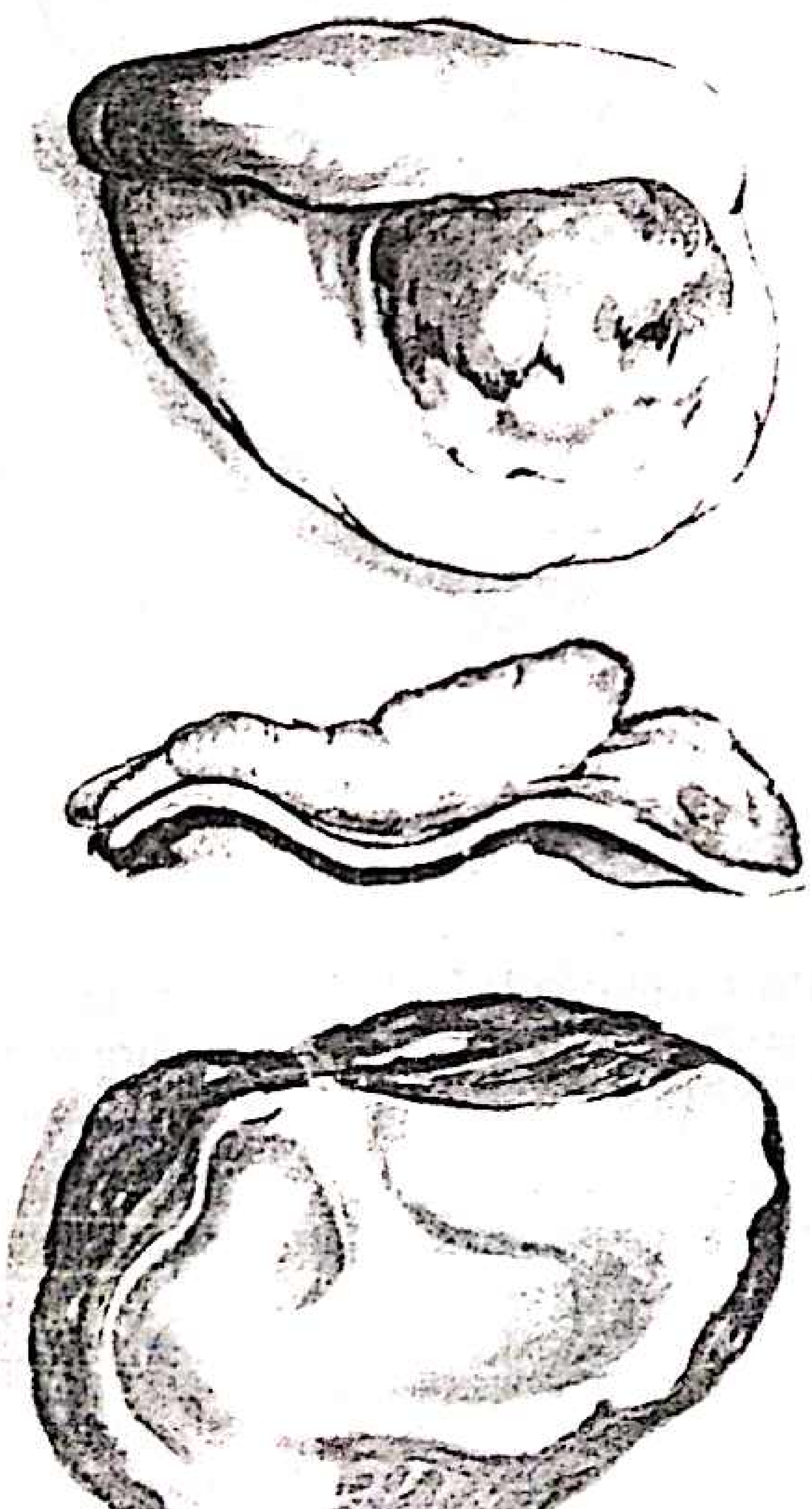
In the pinna the extent of the resection required depends largely on how locally aggressive the tumour is considered to be; the form it takes is largely determined by the local anatomy. Its layered formation, with cartilage sandwiched between a double layer of skin, makes it possible for the surgeon to view excision more specifically in terms of marginal clearance and clearance in depth than in most other tumour sites.

The ease of assessing marginal clearance depends very much on whether the skin is actinically damaged and, if such damage is present, its severity. Actinic damage of the pinna affects males rather than females because the longer hair of the latter shields it from solar radiation. In many adults, particularly males, the diffuse damage which results from longstanding exposure of the ear skin to actinic radiation leads to the clinical picture of a focal area of neoplasia in a background of dysplastic skin.

In the absence of actinic damage where the ear skin is generally normal, the outline of the lesion tends to be clear-cut, making the assessment of marginal clearance relatively straightforward. The clearance required may vary depending on the tumour type but the margin from which clearance has to be assessed is not in dispute.

In the presence of actinic damage the margin of the lesion is often much less clear-cut and clearance is correspondingly difficult to assess clinically. In such circumstances, even when the focal lesion is reported by the pathologist as completely excised, the presence of dysplastic epithelium to the margin of excision may still be noted in the pathology report. Fortunately actinically induced tumours are usually at the less aggressive end of the neoplastic spectrum and the presence of dysplasia at a resection margin does not necessarily call for additional excision.

Depth clearance is largely concerned with whether or not the tumour has extended into or through the cartilage. In this situation it is possible to make use of the cartilage as a 'tumour barrier'. Unless the clinical problem has been complicated by the previous use of radiotherapy, in which case there may be a mixture of radionecrotic cartilage together with residual tumour, cartilage is comparatively resistant to invasion by tumour.



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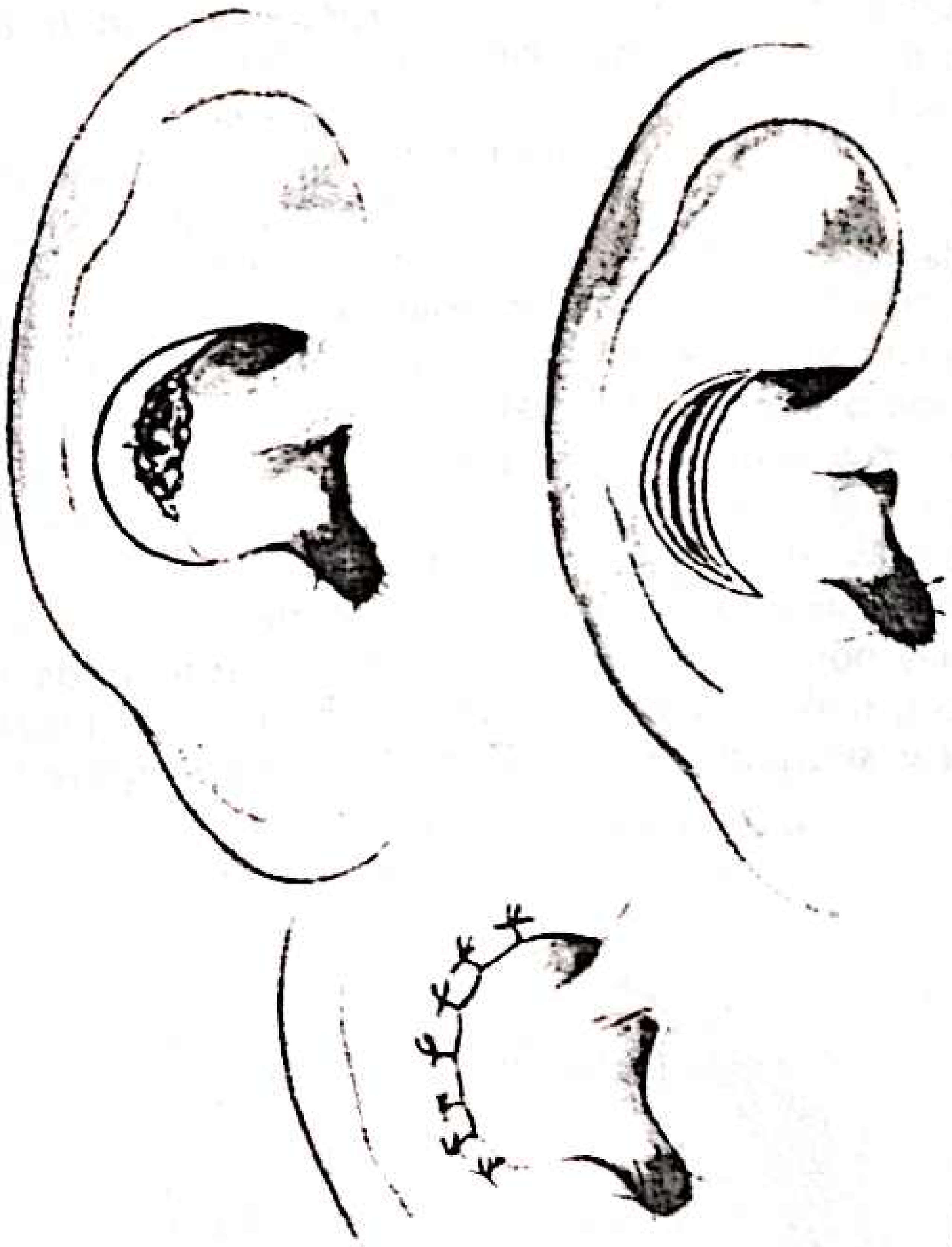
2

If one skin surface only is involved and the cartilage is judged free of tumour, or at most minimally involved, clearance in depth can be assured by resecting the full thickness of cartilage to the margin of the skin excision. The defect which results will take a graft without difficulty. If tumour has clearly spread around the ear margin or through its substance, excision of the entire thickness at the involved site is unavoidable.

The pinna differs from most tumour sites in respect of the reconstructive techniques available, flaps being much less frequently used in reconstruction unless the defect is a massive one extending beyond the pinna itself and infiltrating the temporal bone.

Direct suture

This technique has limitations in practice because of the close adhesion of the skin to the underlying cartilage, greater on the outer than on the posterior surface of the ear and increasing as the external acoustic meatus is approached. On the outer aspect the effect of this is that when a lesion of the conchal hollow is excised, direct suture is virtually impossible.



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When direct suture is being attempted following excision of a lesion overlying the convexity of the ridge of the antihelix, the tightness of the skin can be reduced if a wedge of cartilage is simultaneously excised along the ridge to allow direct suture, but the reduction in tension is not great and only small lesions can be managed in this way.

On the posterior surface the greater mobility of the skin allows larger lesions to be excised and closed directly. The effect is to set the ear back closer to the head but this does not detract significantly from the final appearance.

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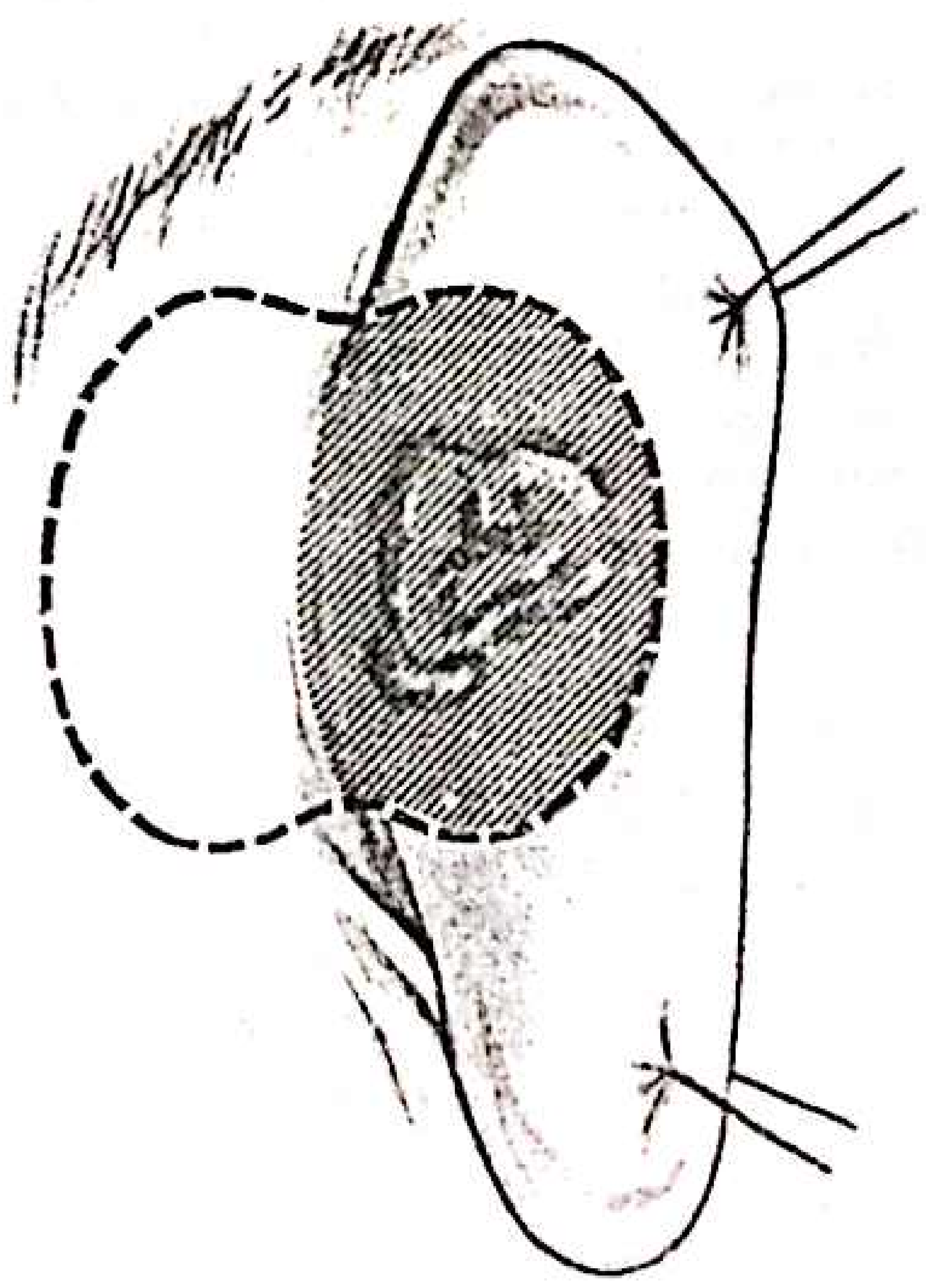

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Towards the postauricular sulcus defects of considerably greater area can be closed directly by enlarging the defect, excising an area of skin from the mastoid area.

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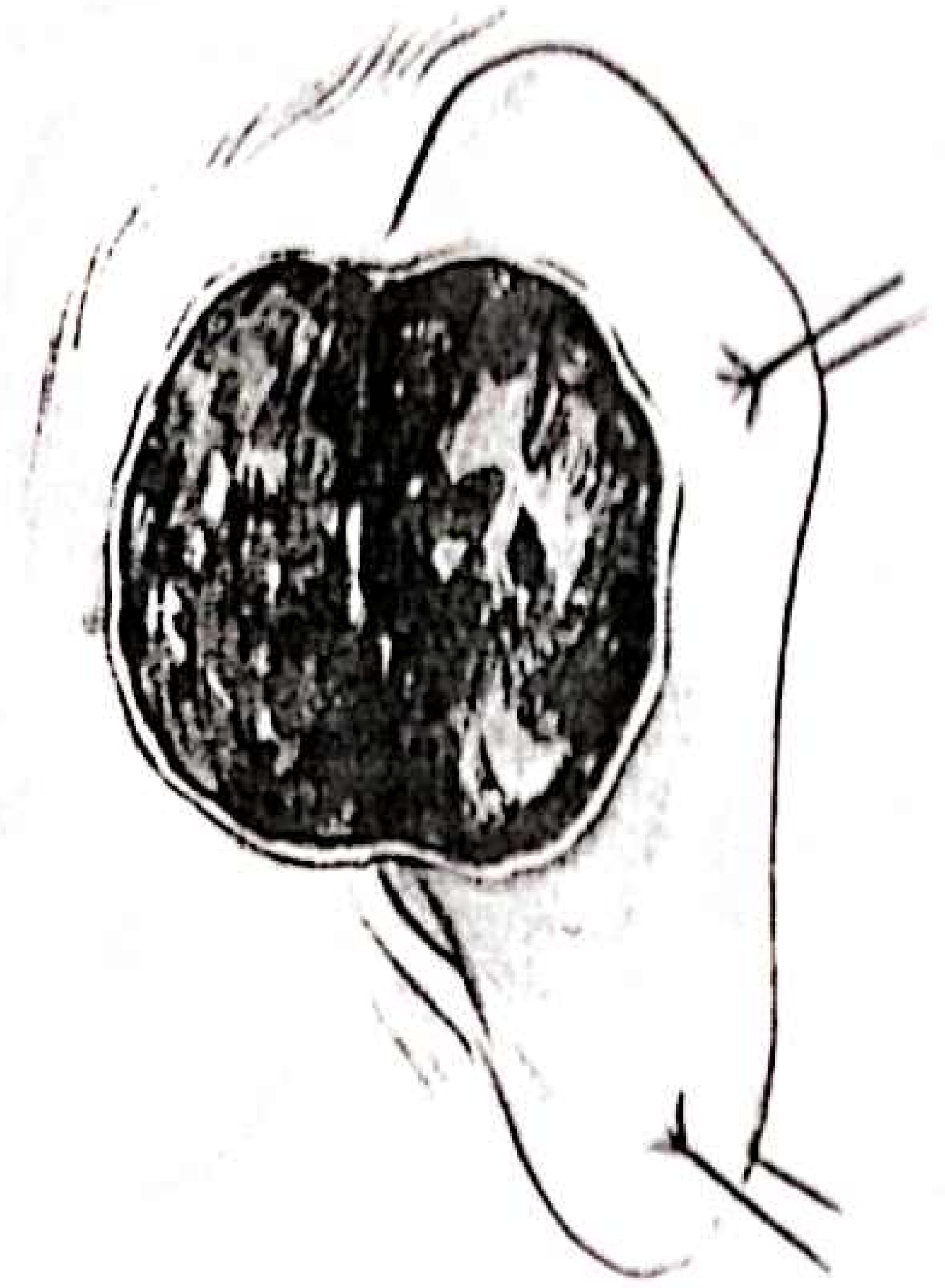
The effect is to make the defect a symmetrical one which involves both the postauricular skin and the adjoining mastoid skin.



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Direct closure can then be carried out, setting the ear back against the scalp, but without loss of the contour of the pinna. This approach to the tumour arising in the postauricular skin can be extended to allow the skin of the entire posterior surface to be stripped.

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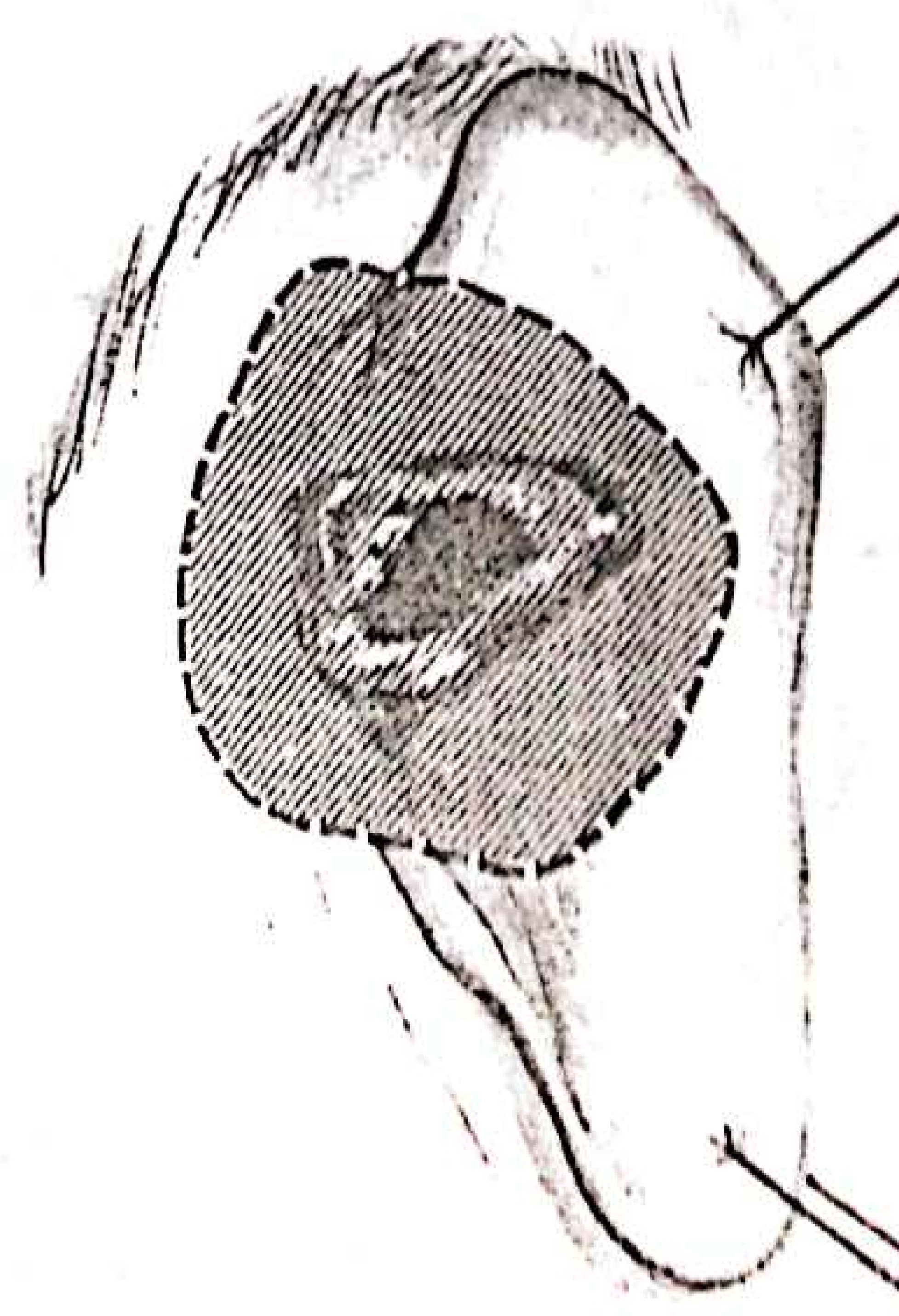
An additional extension of the principle is possible if there is doubt concerning the deep extent of the tumour.



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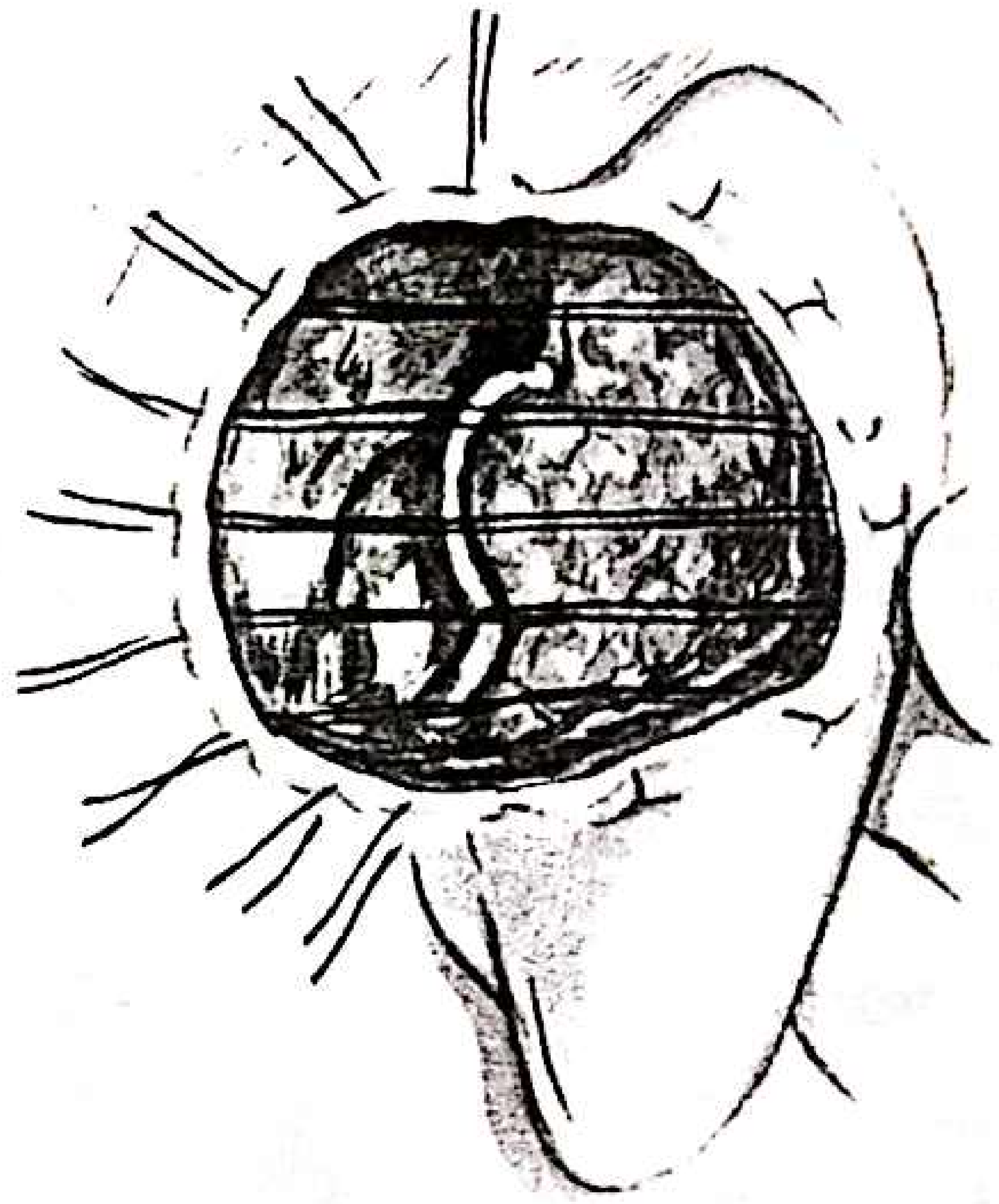
Excision of the ear cartilage over the doubtful area permits direct closure of the defect to be carried out safely. The convolutions of the ear are obliterated as a result but an adequate cosmetic result is still achieved.



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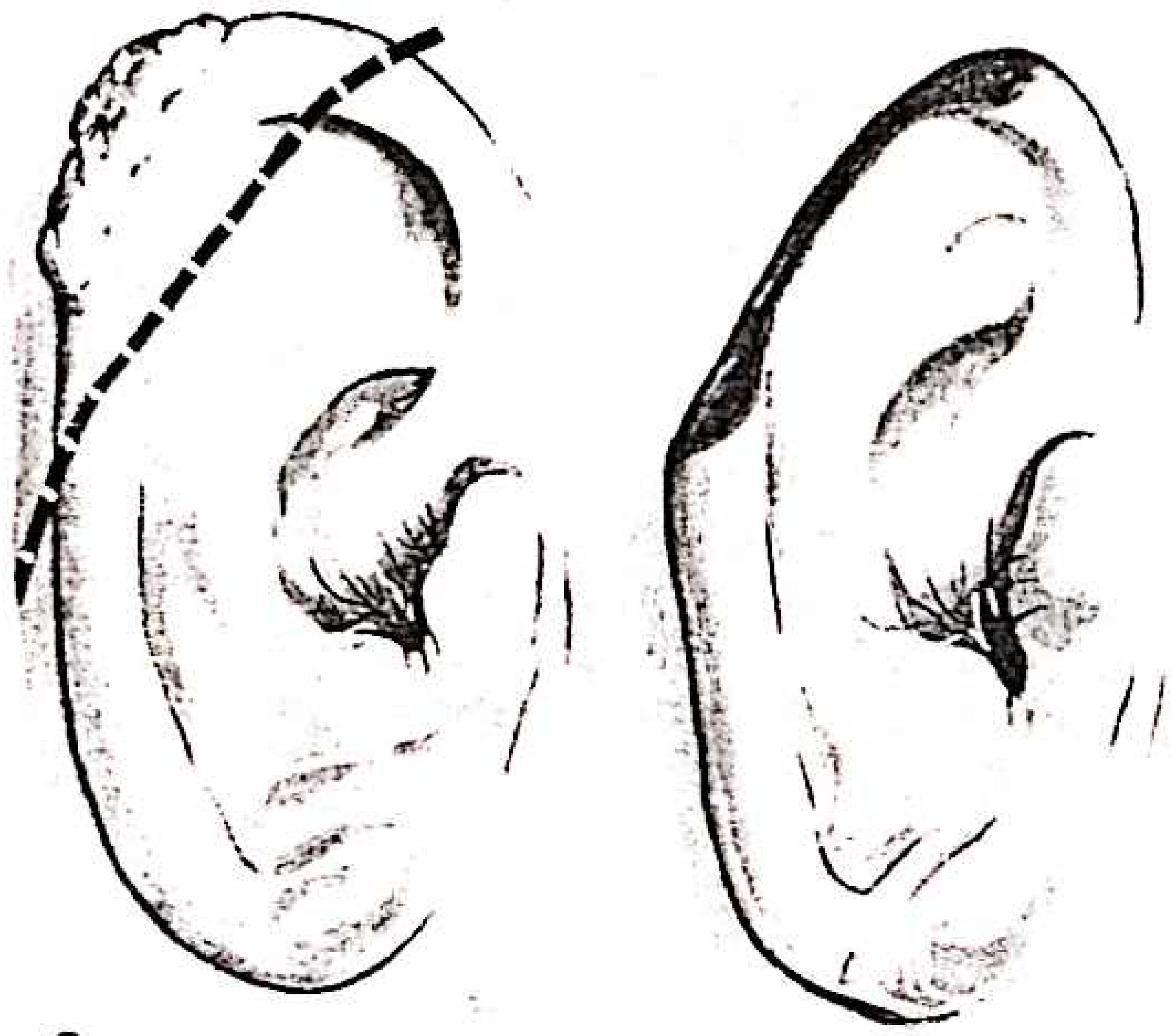

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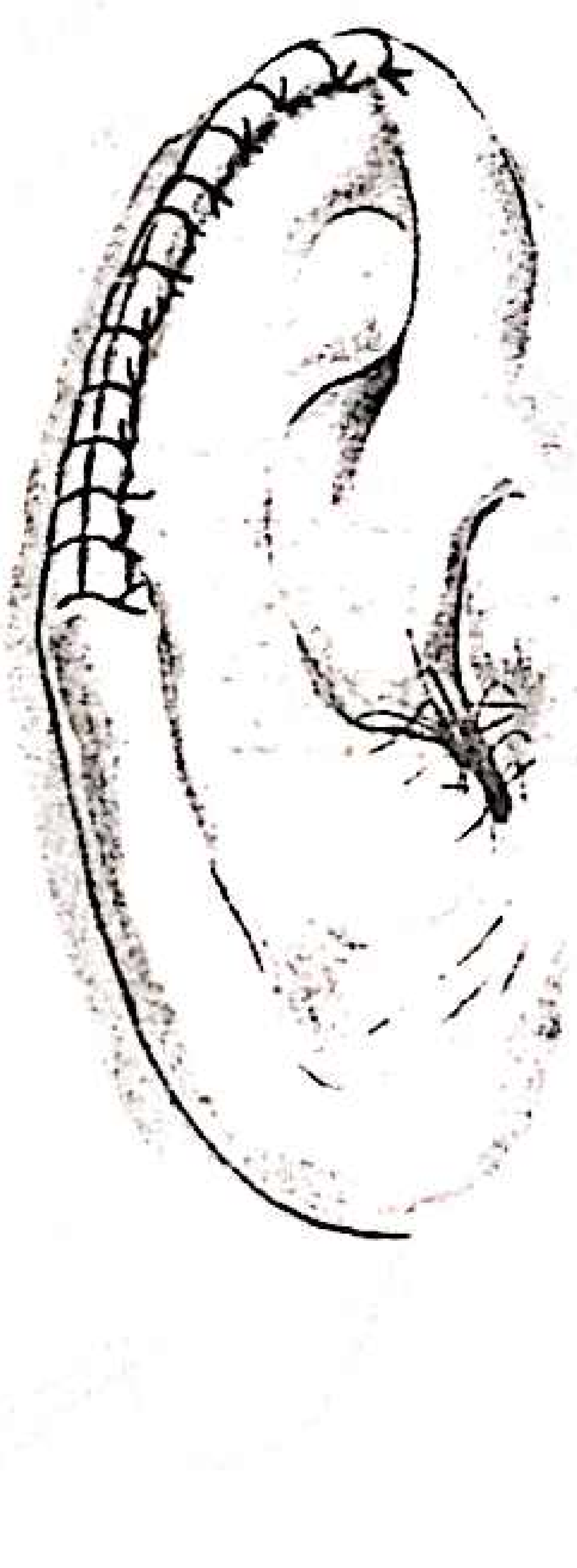
9 & 10

When the lesion is of the margin of the ear, closure of the postexcisional defect is straightforward, sufficient marginal cartilage being excised to allow closure without tension. The effect is to reduce, or even eliminate, the curve of the margin, but in the age group commonly involved this is acceptable to most patients. When cartilage is excised in this way it is wise to extend its excision at each end beyond that required to clear the tumour so that its resection margin passes smoothly on to the normal cartilage. Any sharp prominence left behind at either end is liable to form a nodule which can be painful and is liable to create suspicion of recurrence of tumour.



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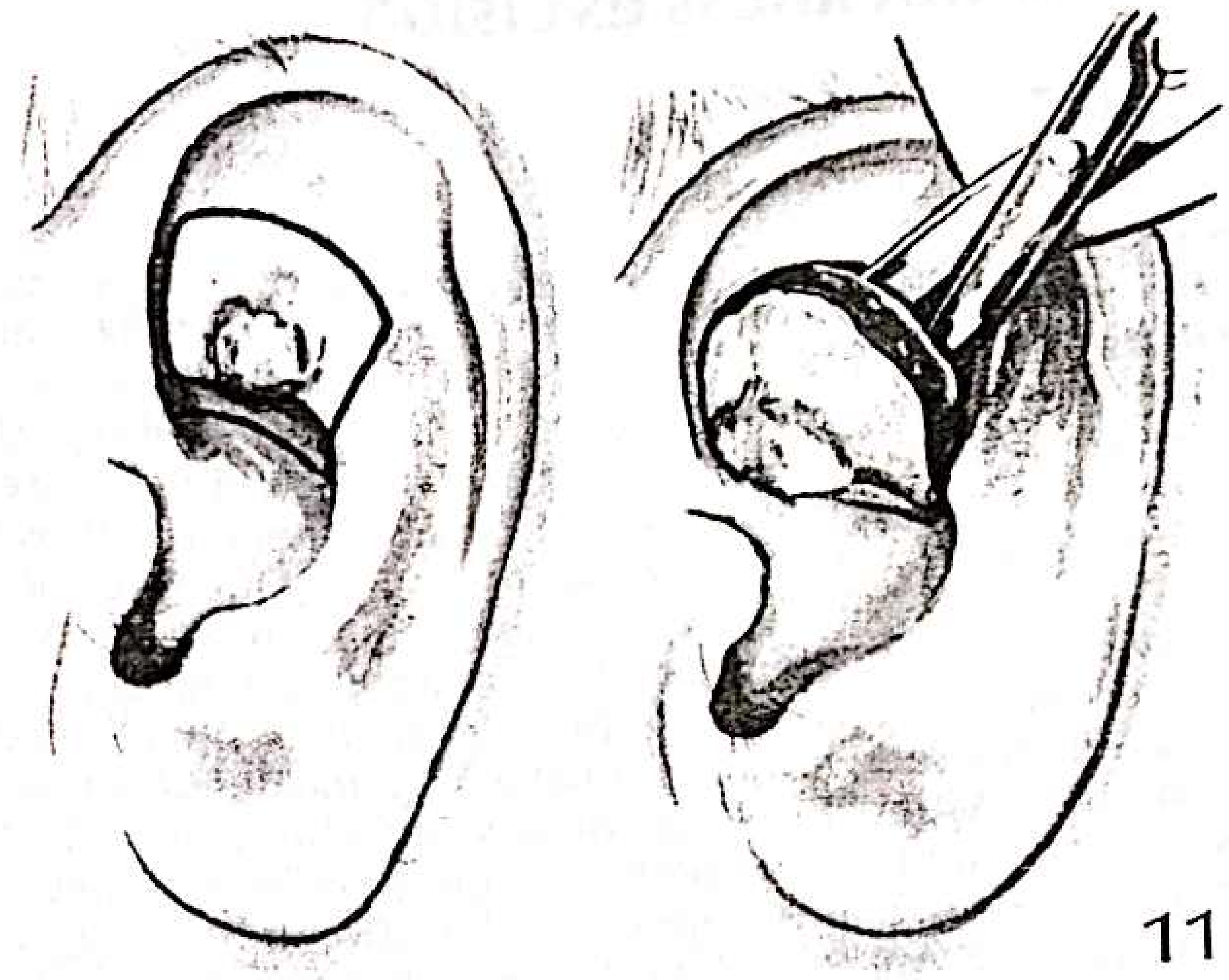
Free skin grafts

11 & 12

The free skin graft used to resurface defects of the pinna is generally of split thickness. In excising a tumour it may on occasion be technically possible to strip the skin alone and leave a defect with a surface of perichondrium which is capable of taking a graft, but on the outer surface of the ear the tumour that can safely be managed with such minimal clearance in depth is a rarity. The close attachment of skin to cartilage makes it difficult to be sure that depth clearance is demonstrably complete and it is generally preferable to excise the tumour-bearing skin with the underlying cartilage as a single specimen. The surface that is left takes a graft well.

The cosmetic excellence of the result achieved depends on the breadth of the cartilage skeleton that remains around the defect and whether it is able to withstand the stress of contraction of the split-skin graft. Used in the conchal hollow the result is excellent; nearer the rim of the pinna, where only a narrow rim of cartilage is left, local crumpling of the ear skeleton results in a break in the curve of its margin.



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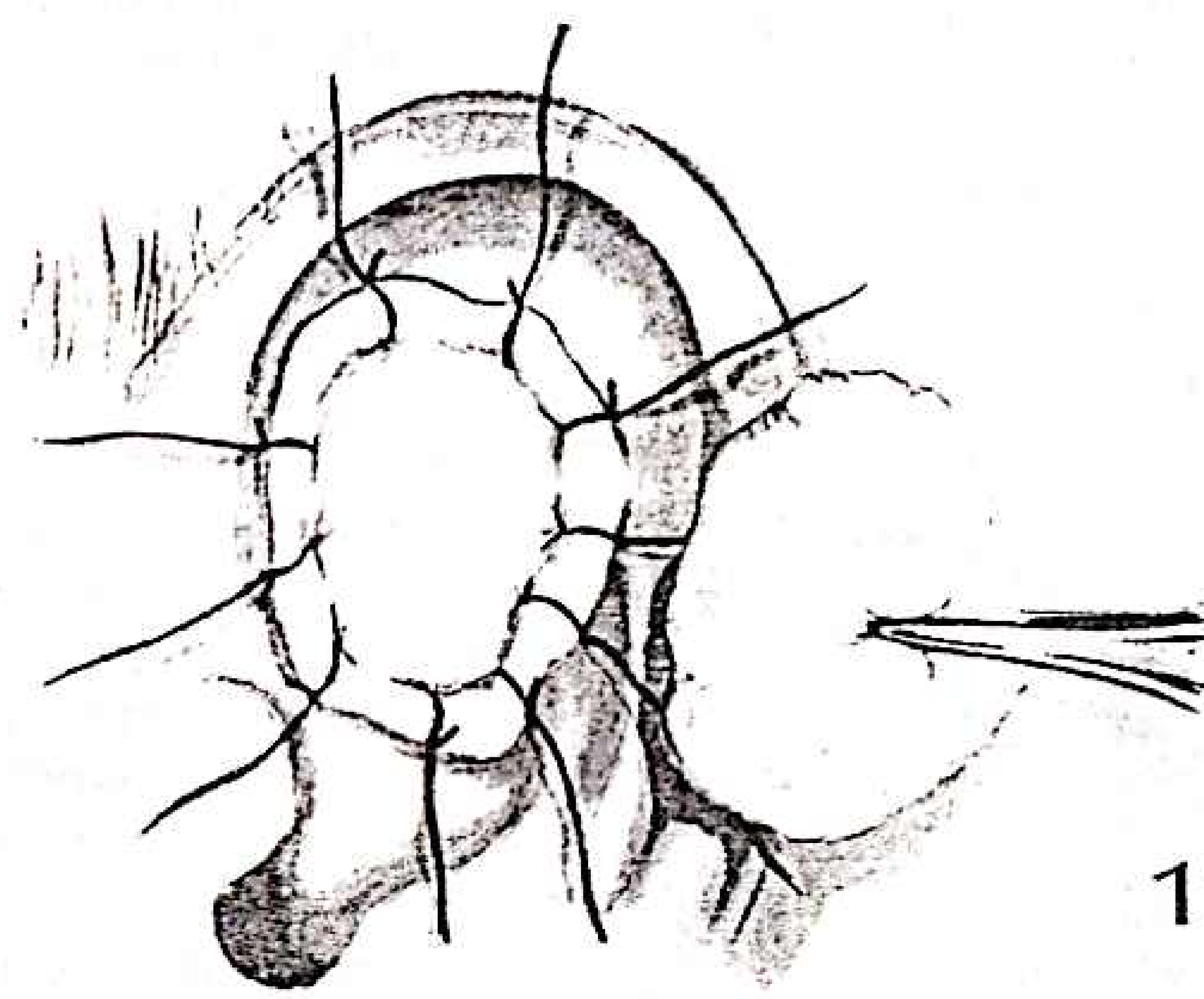

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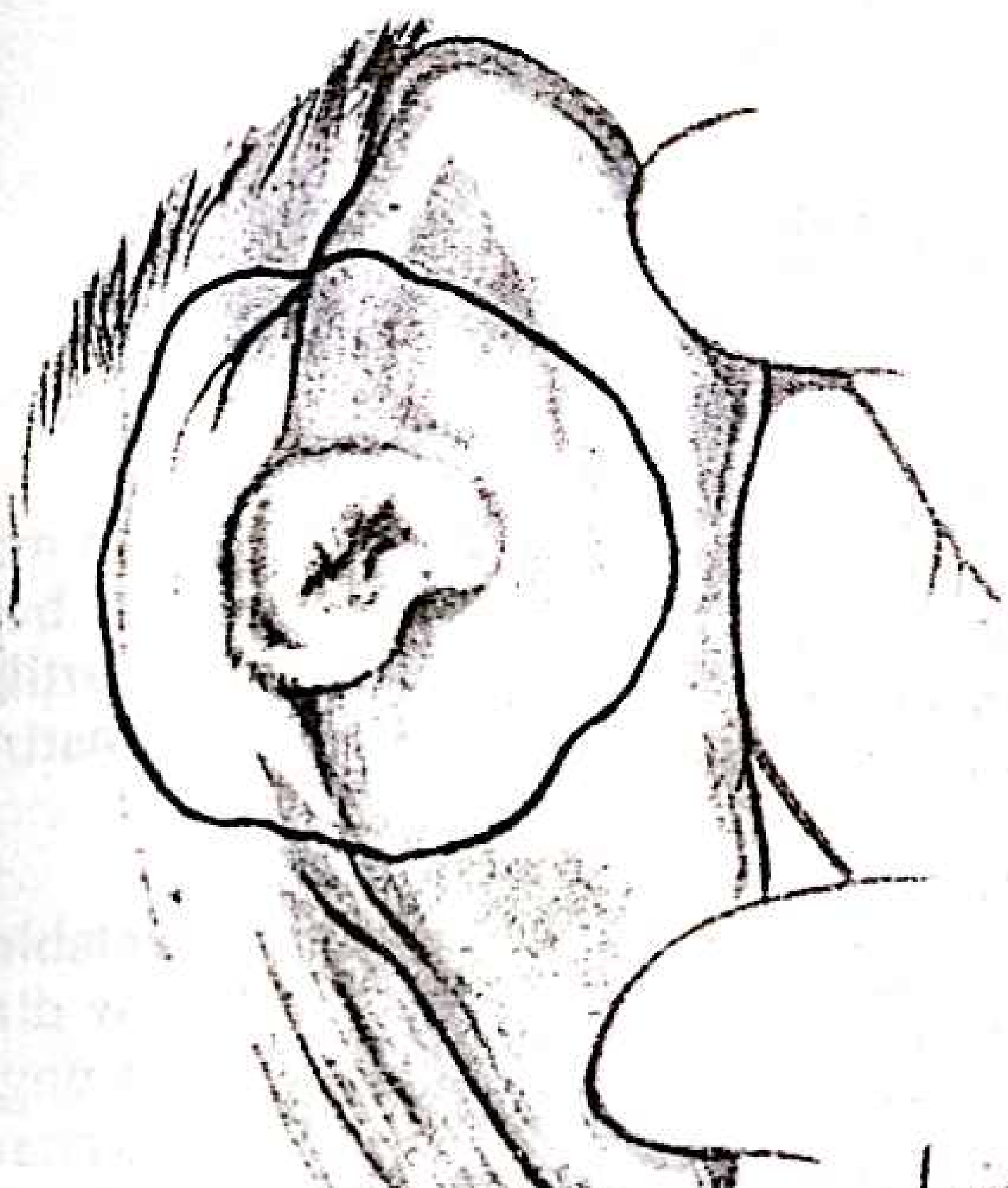

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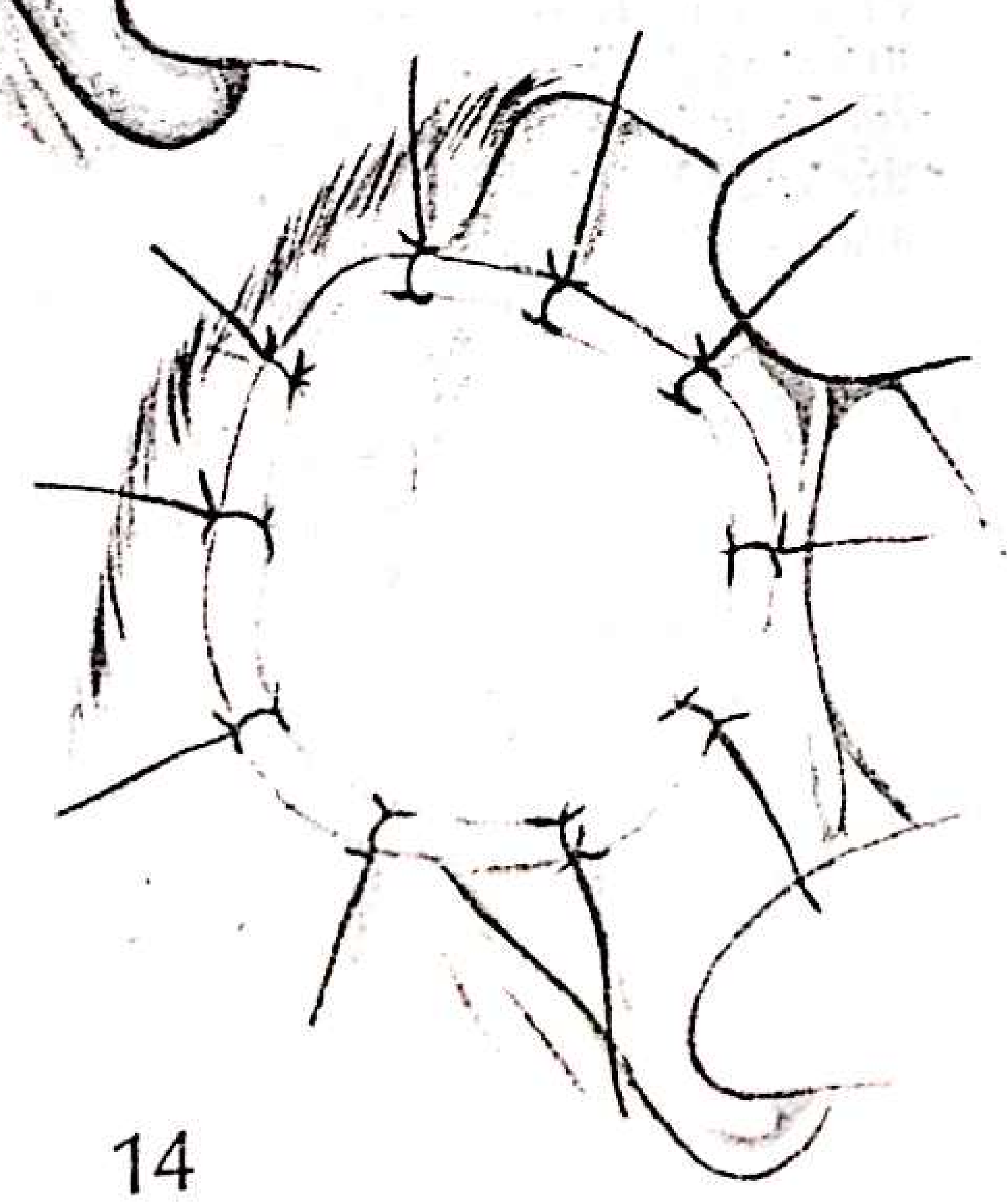

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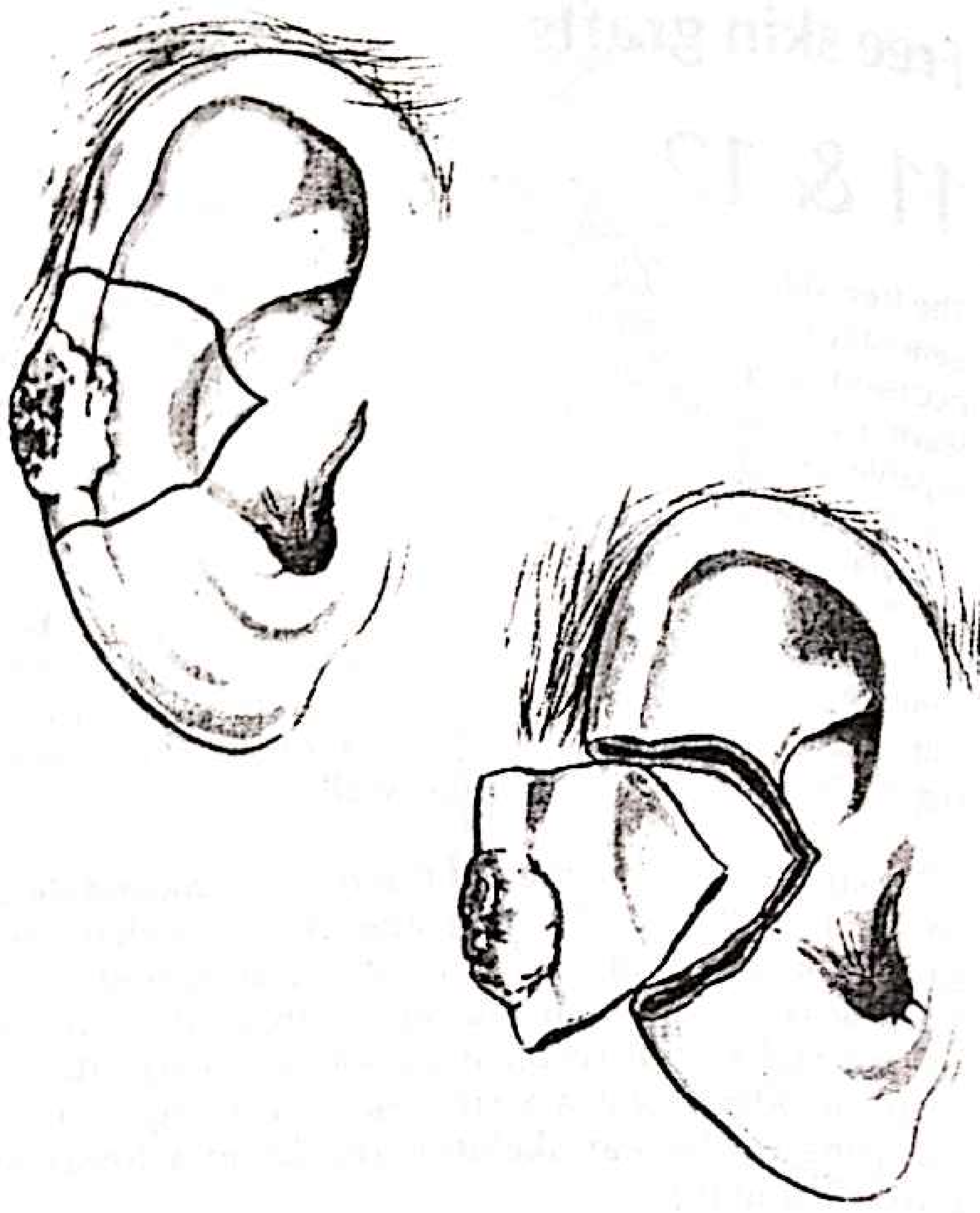
13 & 14

On the posterior surface split-skin grafting can also be used and if required can be extended on to the mastoid skin. Where either direct suture, as described above, or split-skin grafting is technically feasible, the method to be preferred depends on the certainty of deep clearance. If clearance, particularly of the mastoid skin, is in the least doubt, split-skin grafting should be used since it allows the site to be inspected more directly.

Full thickness excision

15

This technique involves excision of a wedge of the pinna and approximation of the two sides of the V, and is used in treating the relatively circumscribed tumour near the margin of the ear. The most important technical aspect of the design is to make sure that the limbs of the V are as equal in length as possible. In contexts other than those of malignancy, various methods of adjusting the limbs of the V to improve the appearance of the final result are described. In the context of a malignant tumour they should be used with the utmost discretion, if at all. Above all, their use must not conflict with pathological considerations. When the limbs of a V are closed directly the straight suture line alone requires to be watched for recurrence. Any manipulations used to improve appearance must not have the effect of extending the line along which tumour could conceivably recur.



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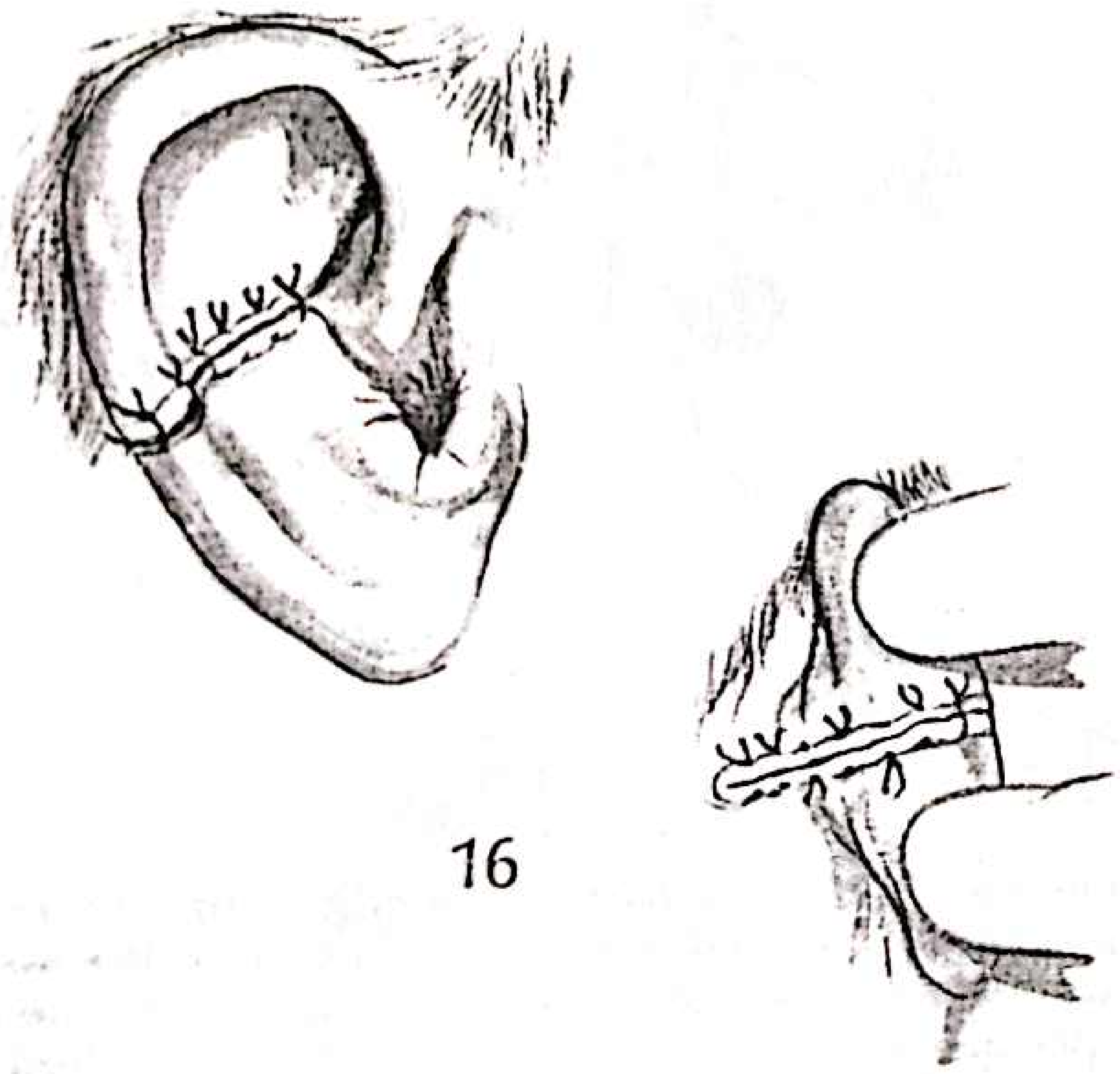

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The firm attachment of the skin to the cartilage can make suturing difficult when the limbs of the V are being approximated. Mobilization of the skin from the cartilage back from the resection line, and the use of mattress sutures, can be helpful in this regard.

The cartilage of the pinna tends to be unpredictable in the changes in the shape of the ear which follow direct closure. Reduction in the size of the pinna, with a degree of cupping, is the most frequent and most obvious change in appearance, although some notching of the rim is also regularly seen. In general the result is poorer the broader the V, and a wedge excised above the level of the meatus also results in more severe cupping than one below.

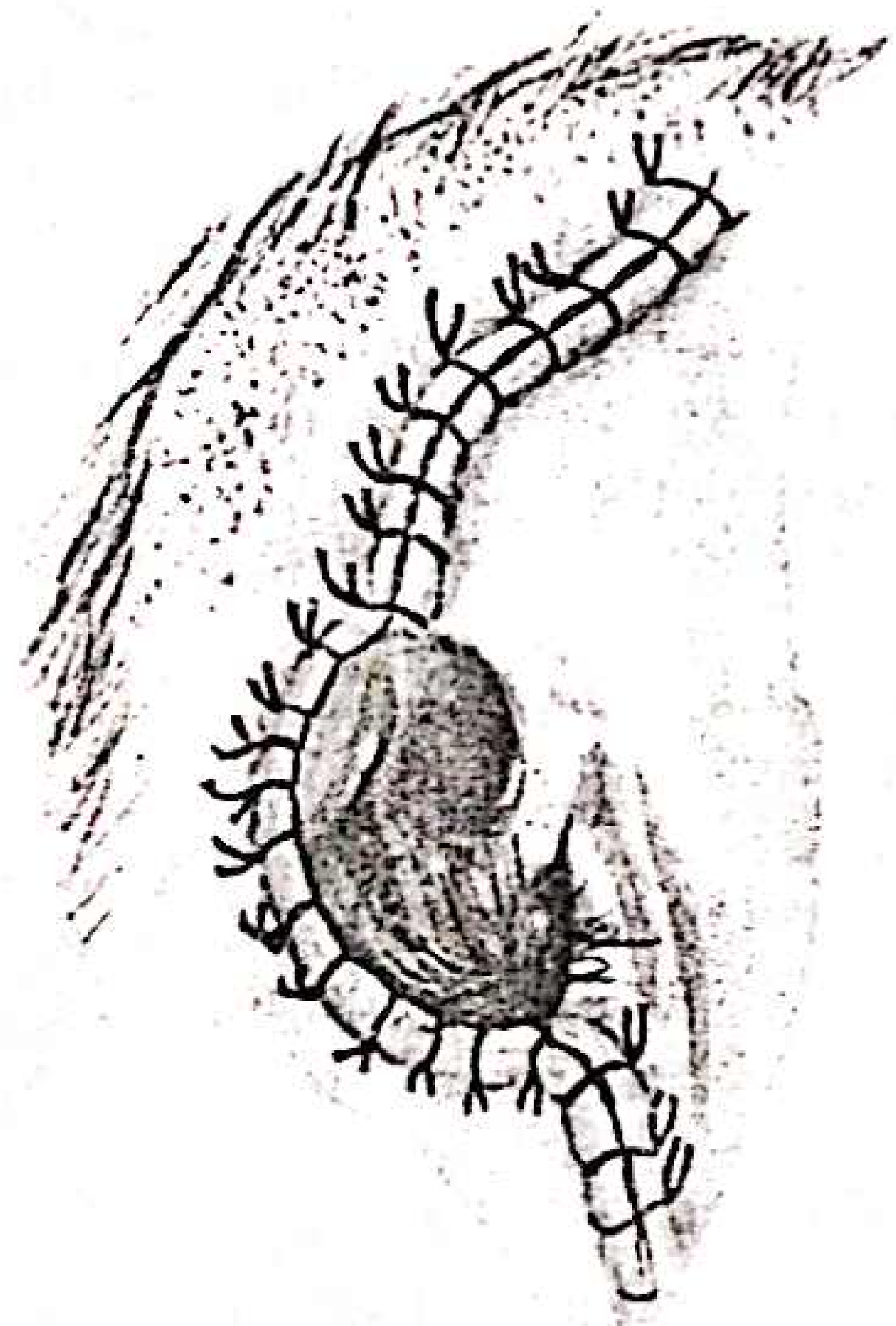
Excision and prosthetic replacement

When the amount of tissue excised from the pinna is such that the tissue left behind cannot be converted into a structure which resembles a normal ear, the decision has to be made concerning whether or not a reconstruction should be attempted, or whether 'reconstruction' should take the form of replacement with a prosthesis. Reconstruction of the pinna may be appropriate in other clinical contexts, but it is seldom applicable in the circumstances attending a major ear excision carried out for malignancy.

17

17

Resection confined to the tissue which is pathologically involved is likely in many instances to leave substantial remnants of the pinna. The question then arises as to whether these remnants should be retained to provide a basis on which a partial prosthesis might be fitted, or whether a better result would be achieved by amputating the entire ear and replacing it with a prosthesis. It is general experience that replacement of the entire pinna is to be preferred. To match a partial prosthesis and the ear remnant in colour and texture is difficult, and to fit one to the other without the junction being obvious is even more so. With the remnants of the pinna and the prosthesis juxtaposed, any minor discrepancy between the two is very obvious and is likely to increase as the colour of the prosthesis fades with time and exposure to sunlight. The total prosthetic ear is less obtrusive since any comparison made is with the other ear. and the two ears are never in full view simultaneously. The fitting of the total ear prosthesis and its retention are also much more straightforward.



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The tragus, however, should be retained if at all possible. Its presence effectively masks what is potentially the most obvious junction line, at the external acoustic meatus.

This approach to the reconstructive problems following near-total resection of the pinna is the one favoured by the prosthetist, but since the potential exists of problems for him which could have been prevented by adequate discussion before the surgery was carried out, such discussion is highly desirable at the outset.

There are several approaches to the problem of retention of the prosthesis and the appropriate one depends both on the prosthetic facilities available and the demands of the patient.

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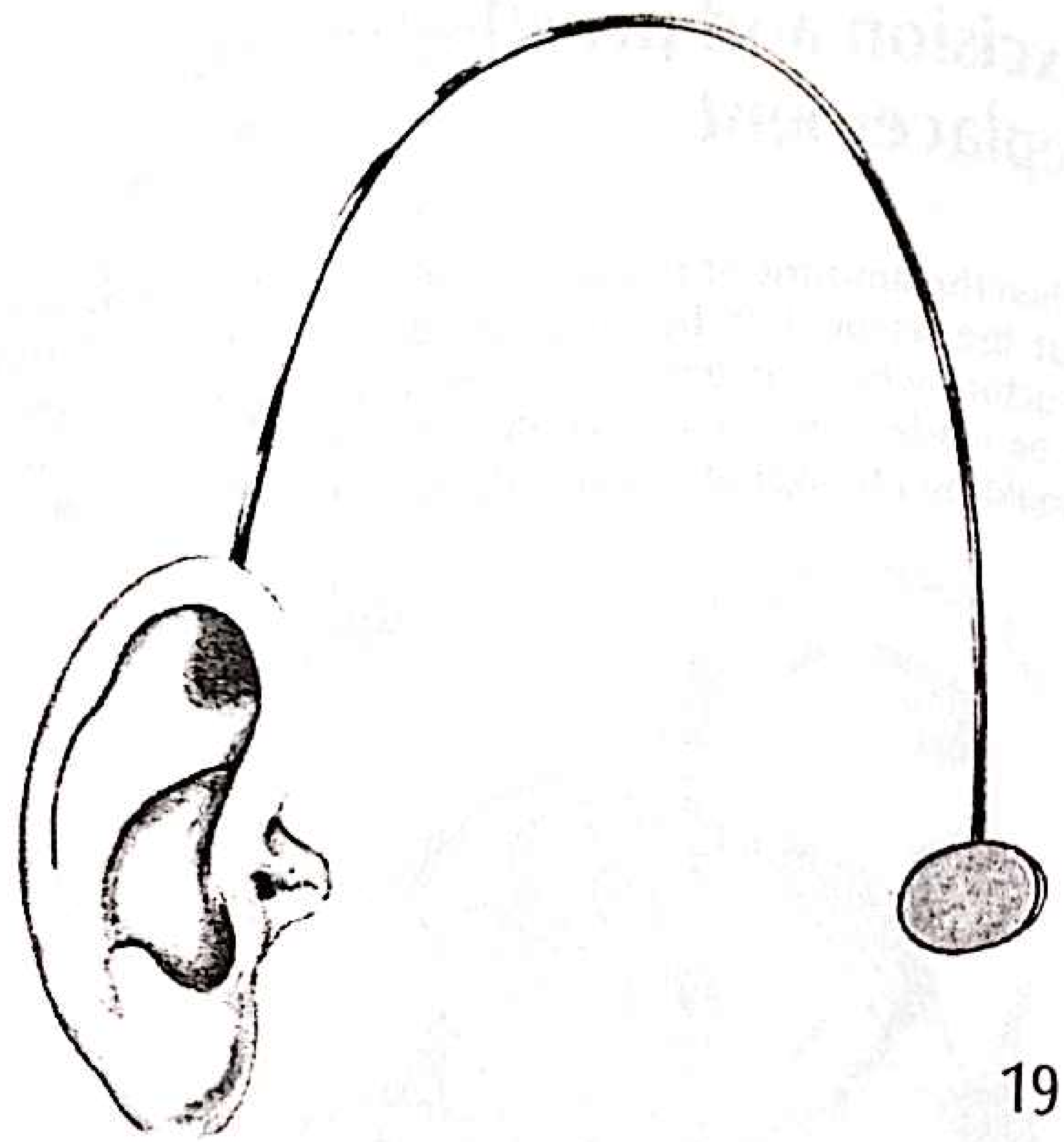
An adhesive can be used to attach the prosthesis to the skin; a length of wire attached to the upper part of the prosthesis, moulded to the shape of the vertex of the scalp and reaching just short of the other ear, to hold the prosthesis in position, is an alternative.



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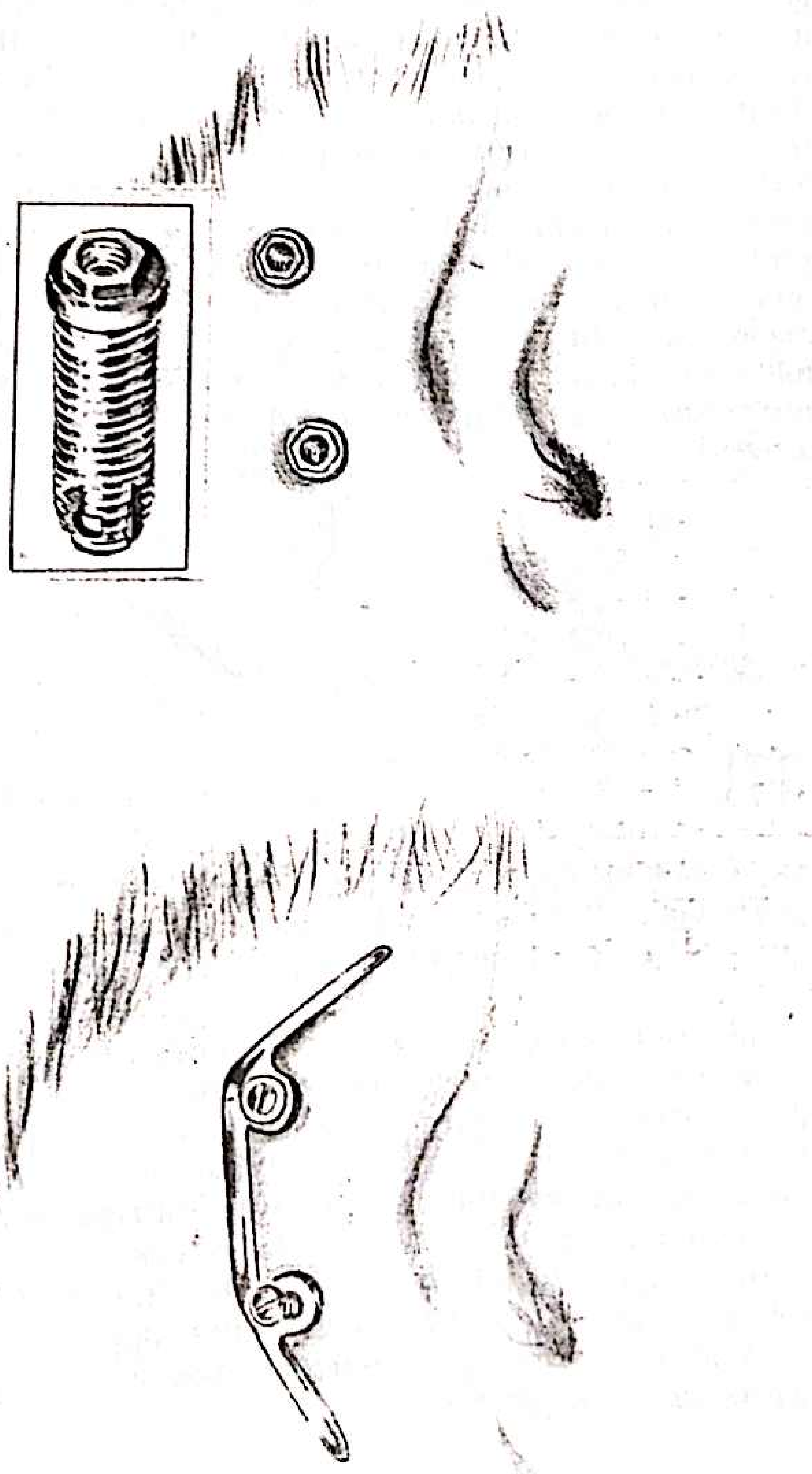
The use of osseo-integrated implants is an additional, recently developed technique in which metallic implants are inserted into the skull, providing 'studs' to which the prosthesis can be fixed.

The insertion of the implants involves a further surgical procedure, and for some of the patients who require resection of an entire ear for malignancy it would be regarded as inappropriate. For such patients one of the alternatives would be suitable. The decision might well hinge on whether or not the patient is bald, since to be cosmetically satisfactory, the wire requires to be hidden in the hair.

When the tumour has been confined to the pinna the defect which is left after amputation can often be closed directly. Extension of tumour outwith the external ear results in corresponding extension of the defect, either along the external acoustic meatus in the direction of the middle ear or on to the skin surrounding the pinna. The defect following each of these extensions will require to be reconstructed using either a free skin graft or a flap. Most minor extensions beyond the pinna are managed by split-skin grafting and this rarely interferes to a significant extent with the fitting of a prosthesis. When a flap is necessary it is usually because the postresection defect includes an area of bare bone, or the temporomandibular joint has been opened in the resection.

The problems of flap selection in those circumstances merge with those created by resections involving the external acoustic meatus and middle ear sites, and will be discussed in that context.



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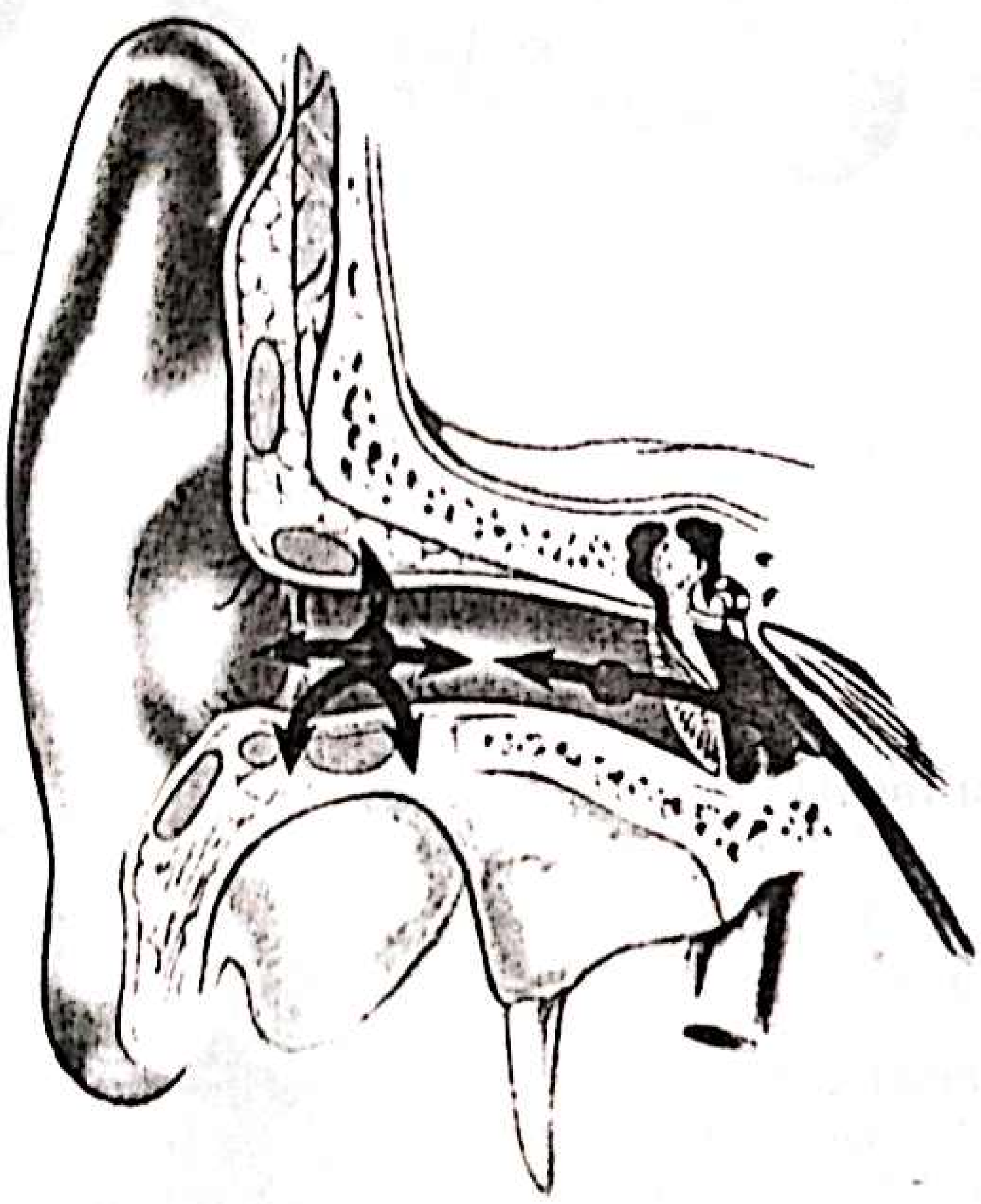
External acoustic meatus

The external acoustic meatus can be involved either by tumour spreading to it from the pinna, most often from the sites adjoining the meatal opening to the surface, or by tumours which arise initially in the meatus or spread to it from the middle ear. From each of these primary sites, meatus and middle ear, tumour may spread to the other site, but the manner in which the tumour presents clinically, and much of the surgical approach to the problems which it creates, depend on which of the two is the primary site. In the case of the tumour which is primarily of the middle ear, the surgical procedure which is appropriate is a formal petrosectomy. This topic is discussed in the chapter on 'Tumours involving the anterior and middle cranial fossae'.

The tumour arising in the meatus is much more accessible at the outset than the tumour arising in the middle ear and its prognosis, treated surgically, though still not good, is very much better than that of the tumour primarily of the middle ear. In the latter site the tumour, concealed in the depths of the petrous temporal bone, is frequently inoperable by the time definitive surgery is undertaken.



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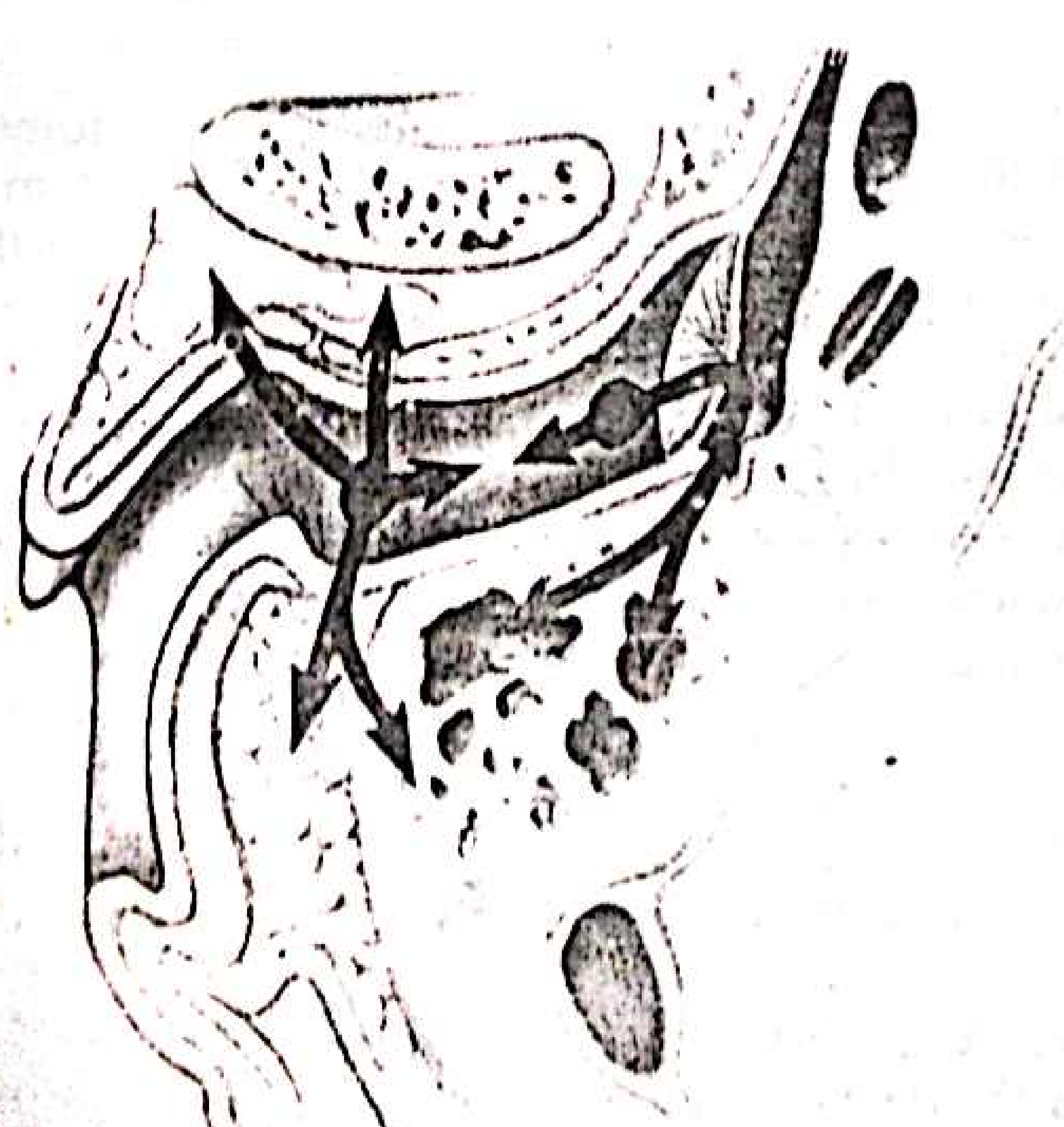
21 & 22

Meatal tumours can be grouped into those which are confined to the lining of the meatus, and those which have extended beyond the lining into the bone and/or cartilage surrounding the meatal cylinder and/or into and beyond the middle ear. The tumour arising initially in the cartilaginous meatus can spread both outwards to involve the pinna and inwards to reach the bony meatus and ultimately the middle ear, and similar spread in two directions, to involve the cartilaginous meatus and the middle ear, occurs with the tumour initially sited in the bony meatus. Once in the middle ear, spread to the mastoid air cells occurs readily, and thence to involve the bone of the mastoid process. The bone of the meatus tends to contain the tumour for significantly longer than the cartilaginous meatus, from which tumour spreads centrifugally to reach the parotid gland and the skin surrounding the pinna, and to involve the mastoid process directly.



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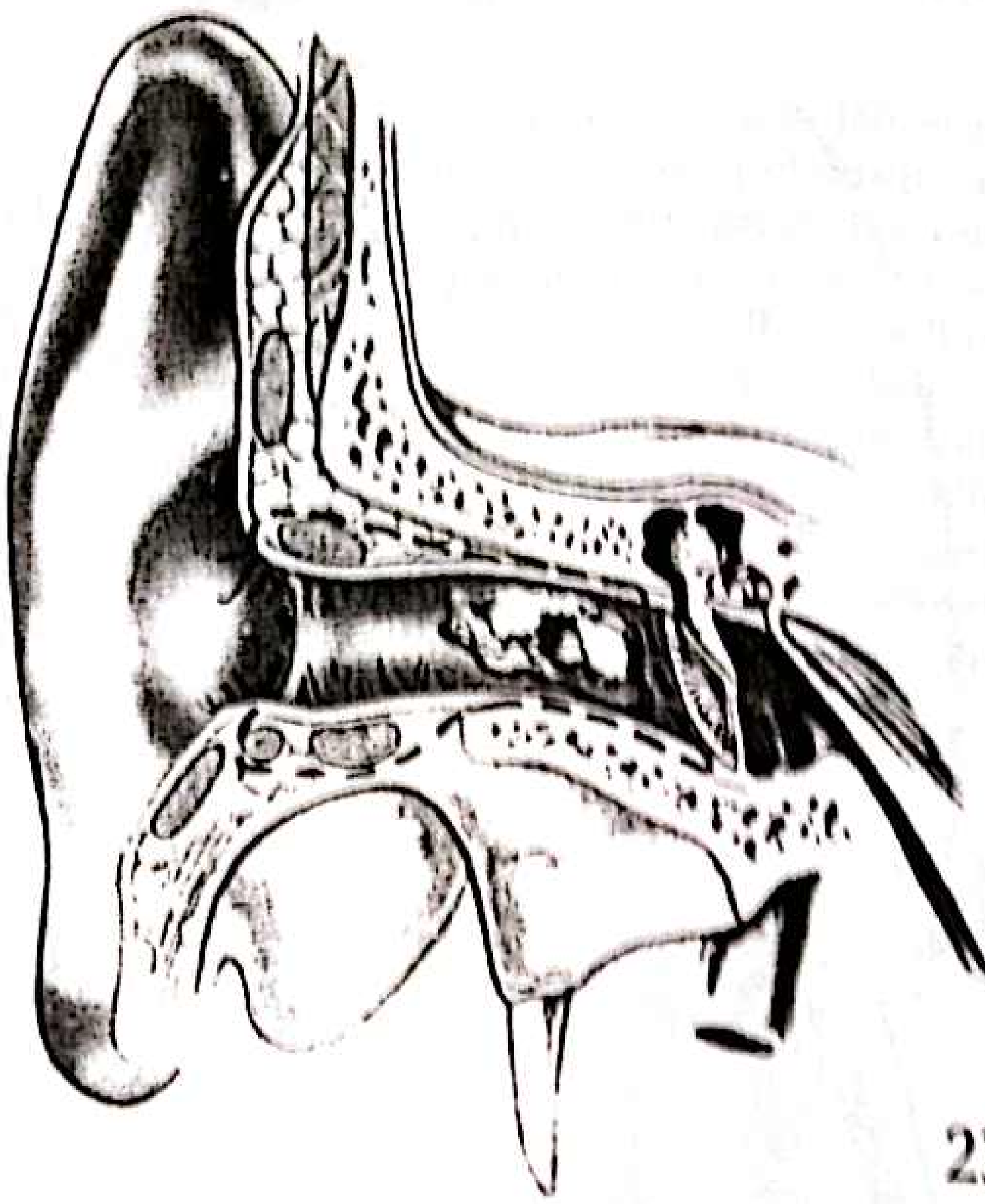
The surgical procedure used to manage the tumour which has spread beyond the meatal lining has been aptly described as a 'core resection'. In this the meatus is removed like an apple core and the tumour is then pursued in the various possible directions of spread. The end result may differ little from a formal petrosectomy, but the operative technique used and the surgical philosophy on which it is based are totally different.



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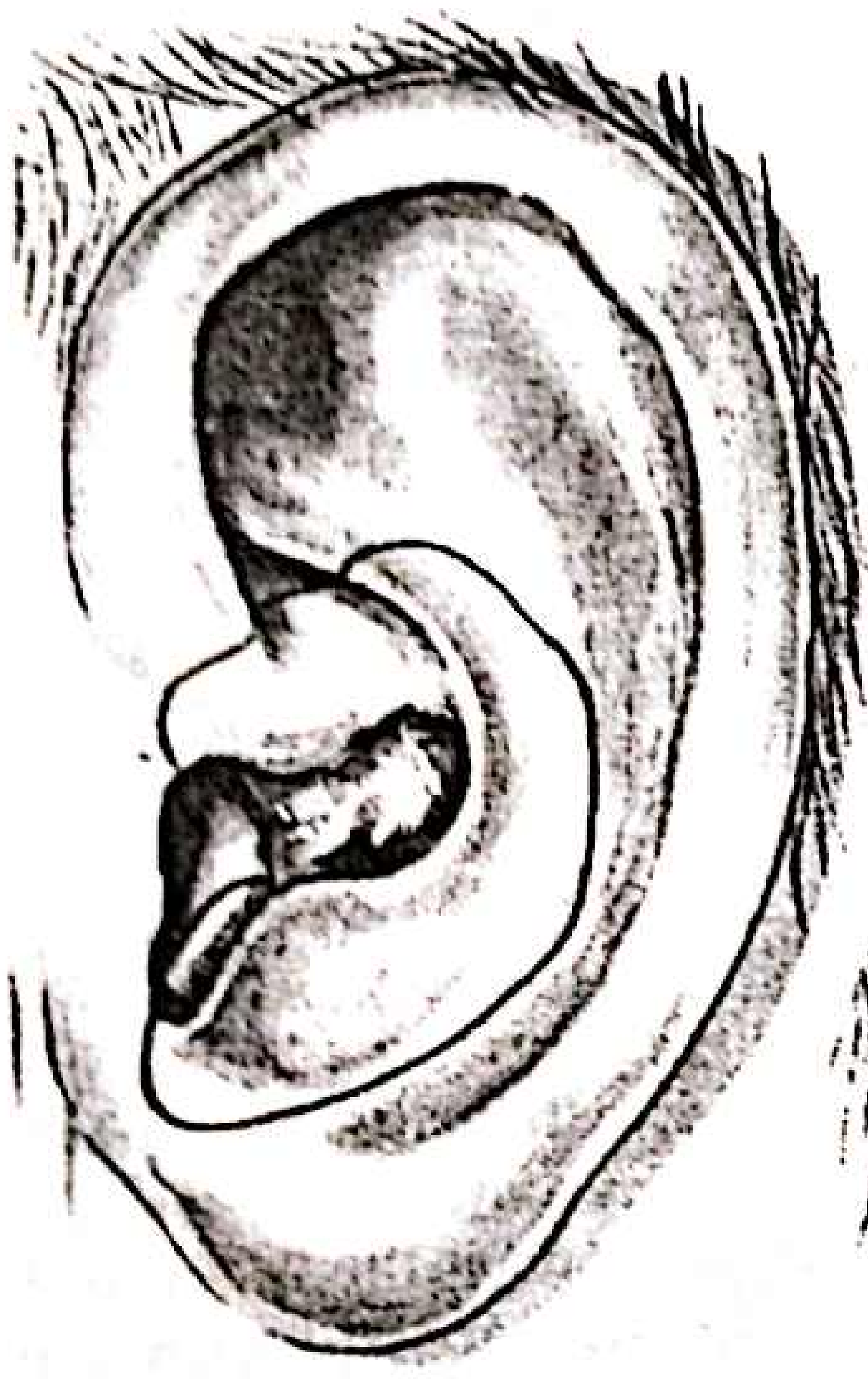

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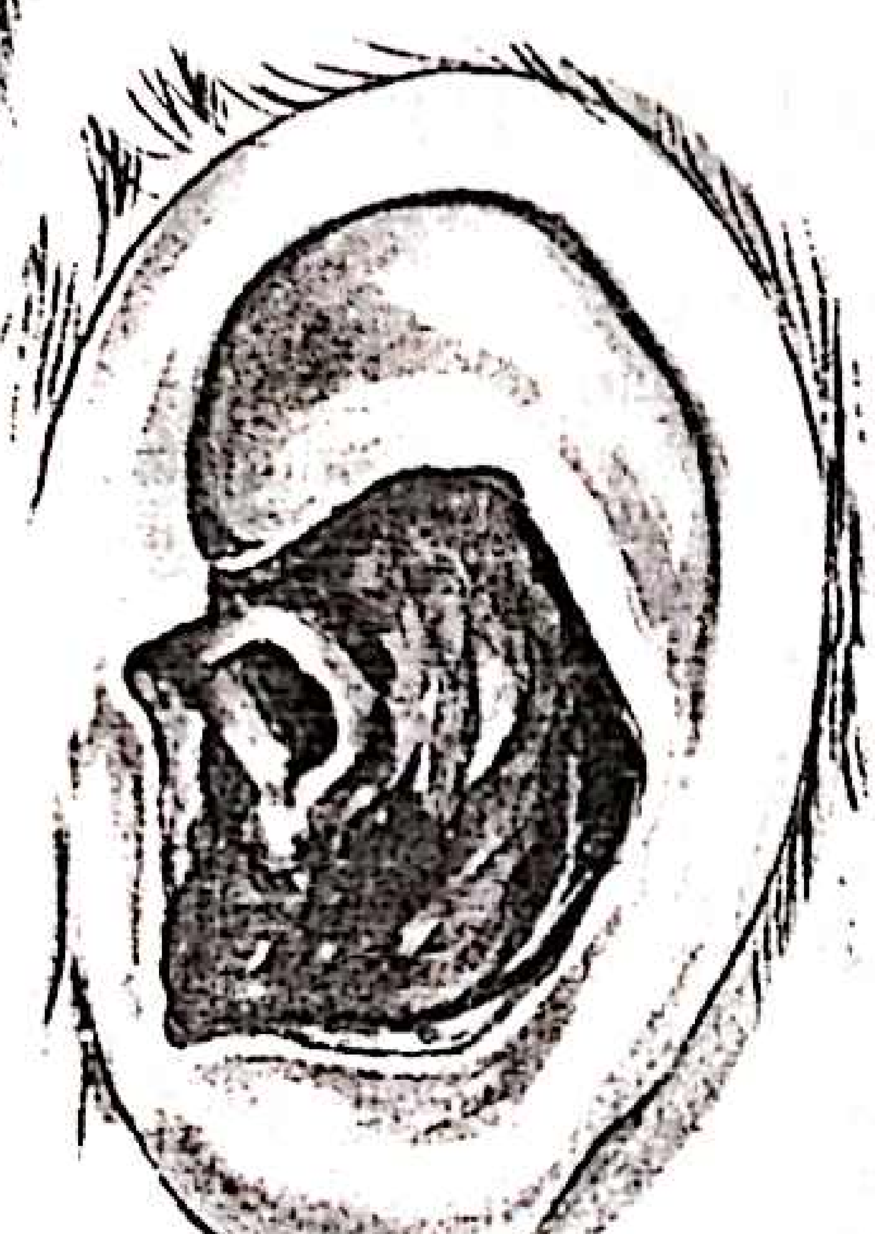

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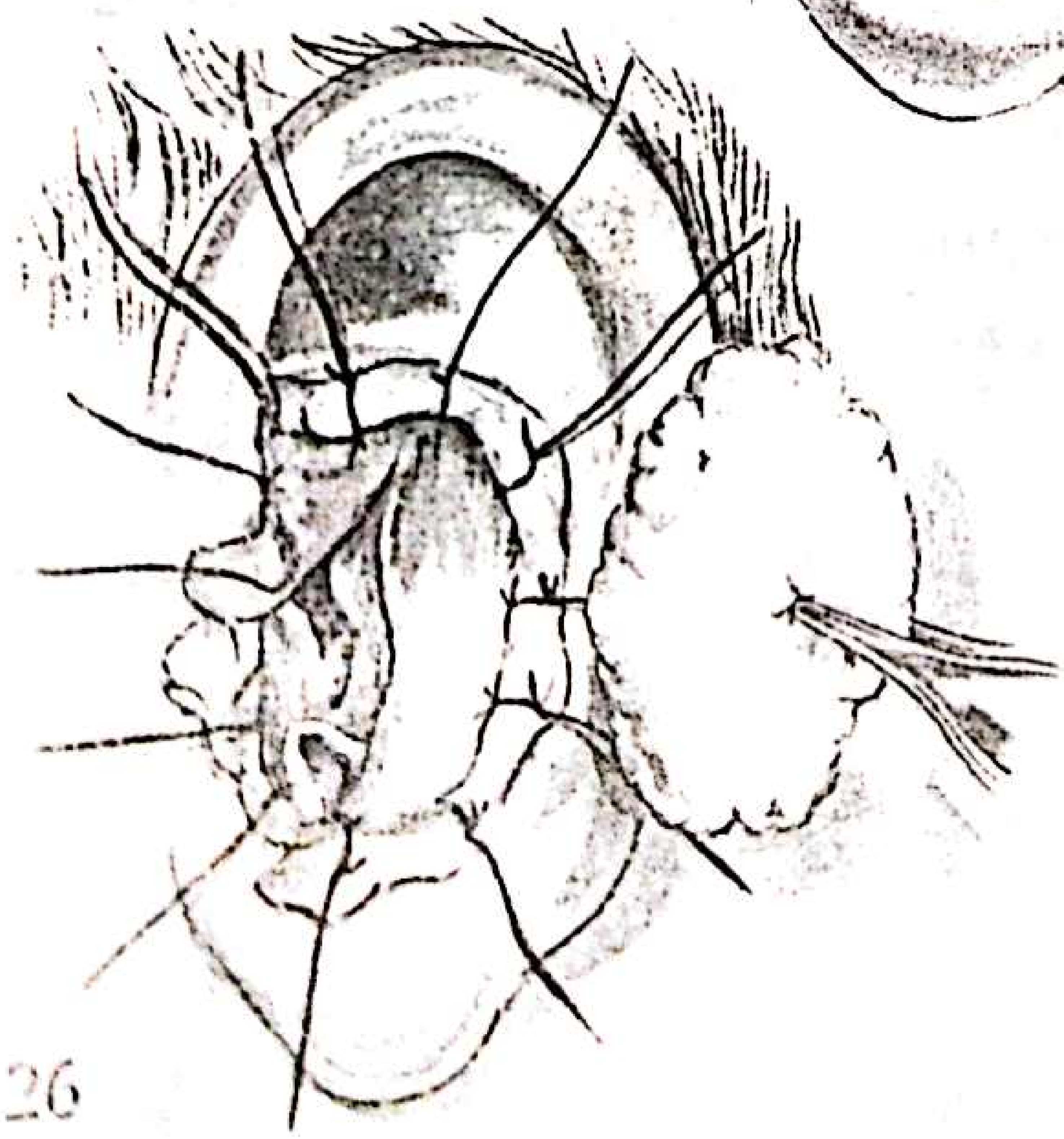

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Minor meatal tumour

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The tumour of the vicinity of the meatal orifice is treated in much the same way as the tumour of the conchal hollow, that is by excising the lesion, preferably with the cartilage which underlies it. In the case of the tumour with a clear-cut margin, excision is straightforward and the defect accepts a split-skin graft with a tie-over bolus dressing.

When the tumour margin is less clear-cut or the tumour extends more deeply into the meatus, the problem of excision is much greater and it is often increased further when the tumour is one of the adnexal group where its margins, even in the benign categories, are liable to be extremely indistinct. A further difficulty in assessing deep clearance results from the fibrous tissue-filled gaps in the cartilage of the meatus, their presence reducing the overall effectiveness of the meatal cartilage as a barrier to tumour spread.

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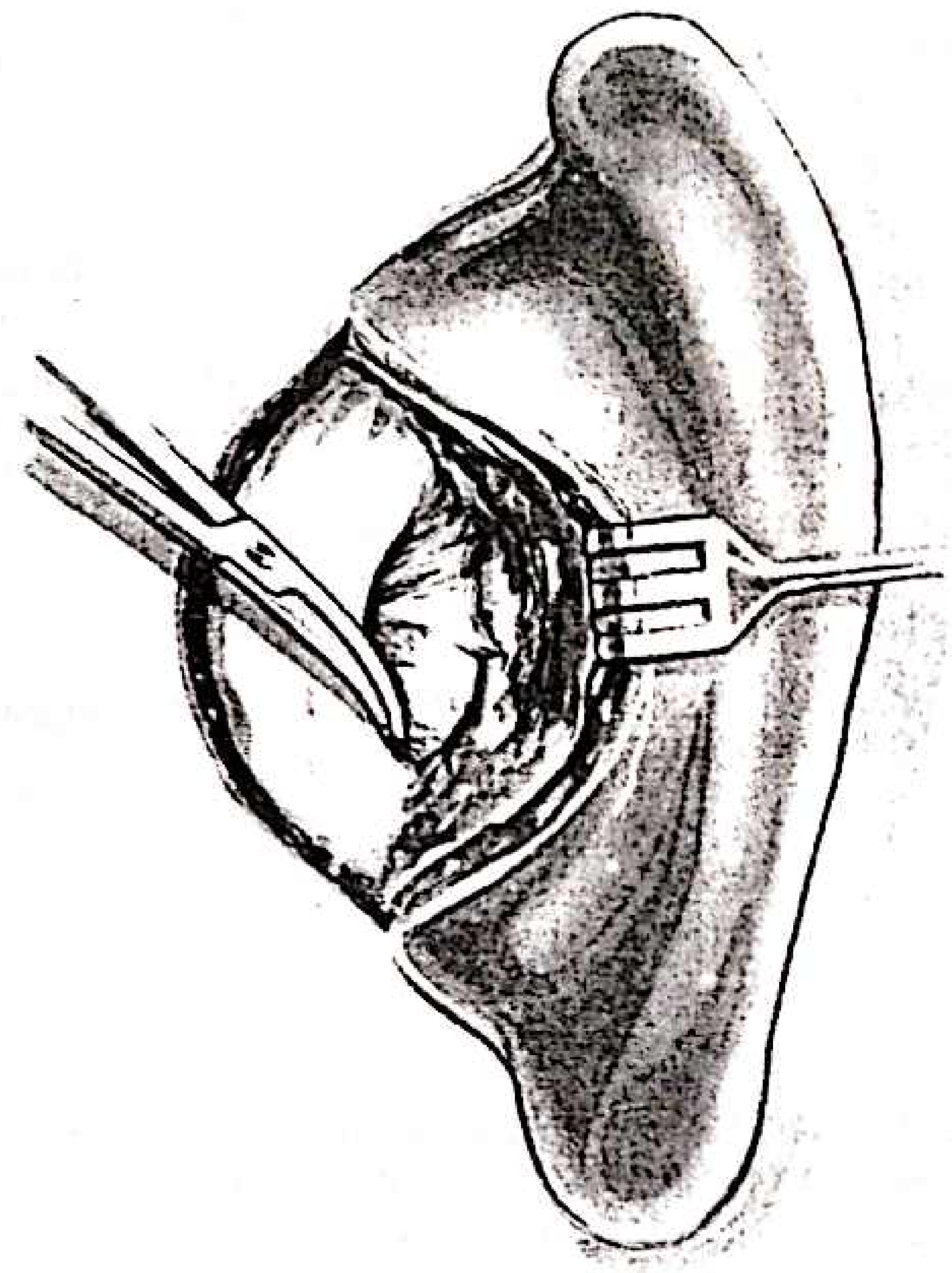
The main technical problem is one of access and this can be at least partly solved by using the postauricular approach to the meatus. Deepening an incision made along the postauricular sulcus to expose the outer surface of the cartilage, the dissection can proceed in this plane, separating the meatus from the surrounding tissues in the direction of the middle ear and controlling its extent by regular inspection of the tumour site within the meatus.



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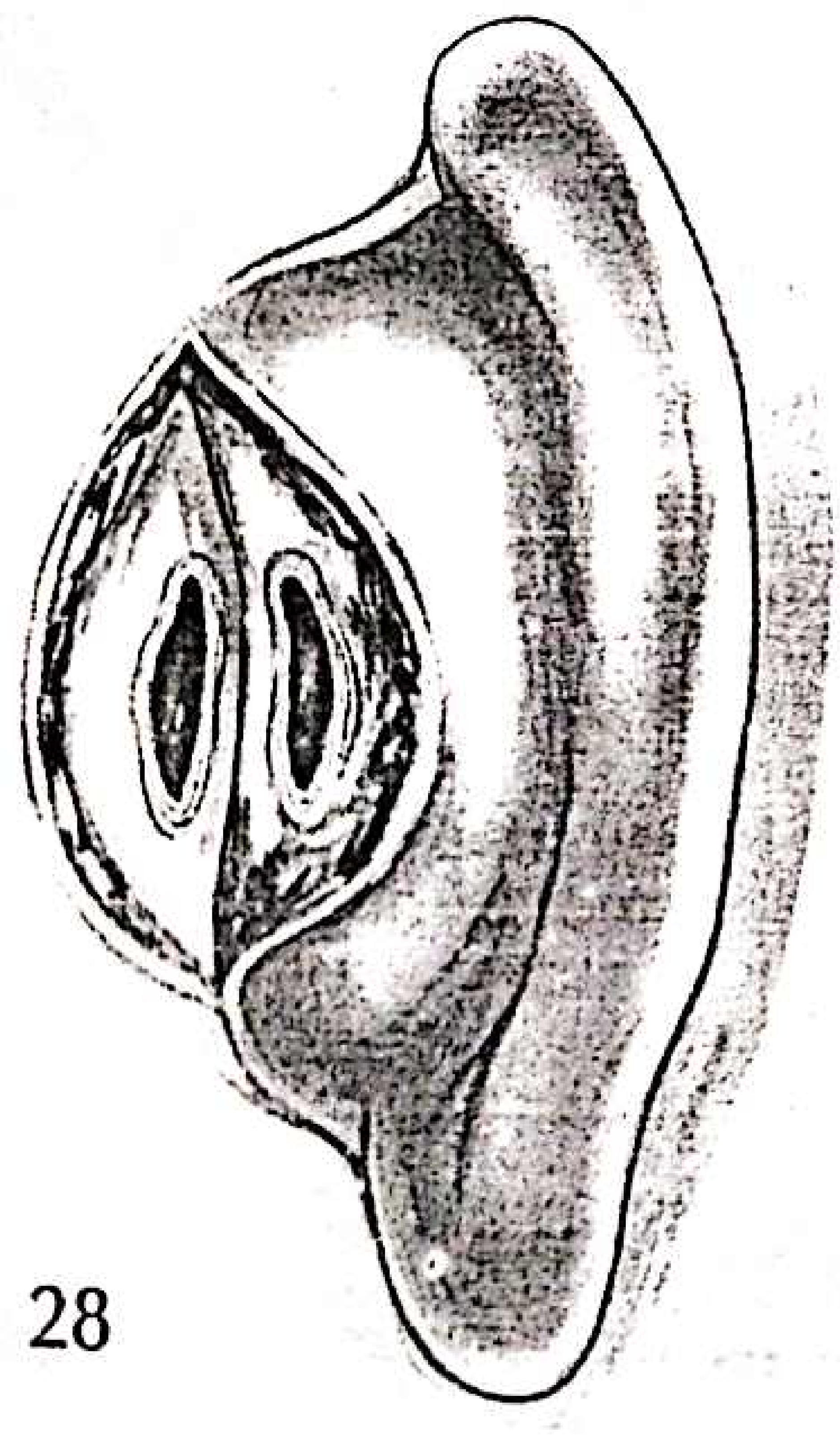

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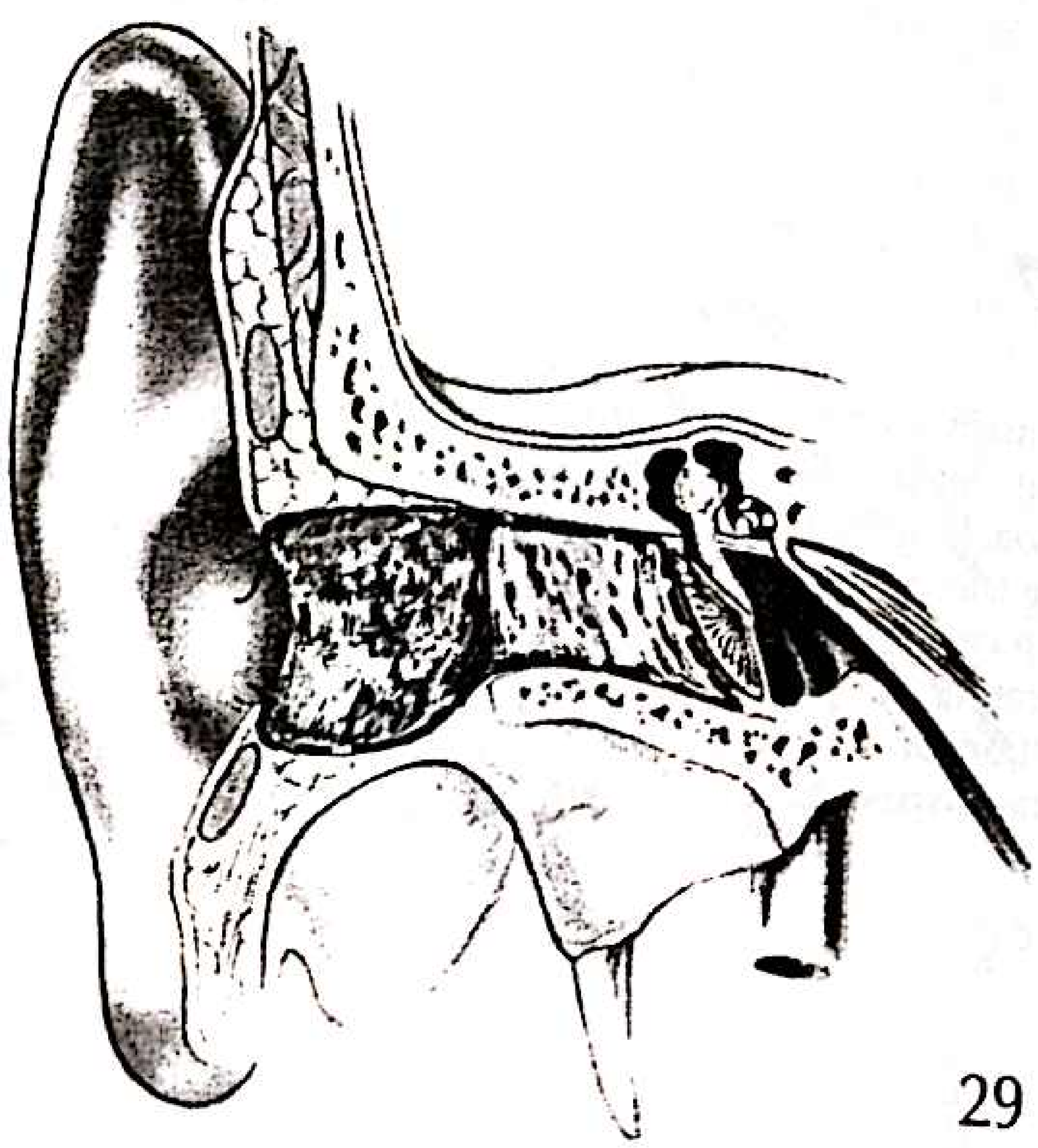
If the visualization which this provides is inadequate, the postauricular incision can be deepened, opening into the meatus between its bony and cartilaginous parts and allowing the pinna to be hinged forward to expose the meatus in both directions. This manoeuvre makes it much easier to see the tumour field, in turn adding to the effectiveness of clearance, particularly if the lesion has a clearcut margin.

Most tumours in this area are either clearly localized to the skin of the meatus or carry a high probability at the outset that they have already extended into and beyond the cartilaginous or bony meatus.

29

In the case of the localized tumour, the defect is generally suitable for split-skin grafting. When the distance of the tumour from the meatal orifice is such that anchorage of the graft with sutures is not technically feasible, the graft is pushed into the meatus using a stent mould or a flavine wool bolus. The effect is to line the meatus with skin over both the defect and the intact meatus. Where the graft overlies the defect it may be expected to take; in the remainder of the meatus it sloughs and is trimmed away in due course.



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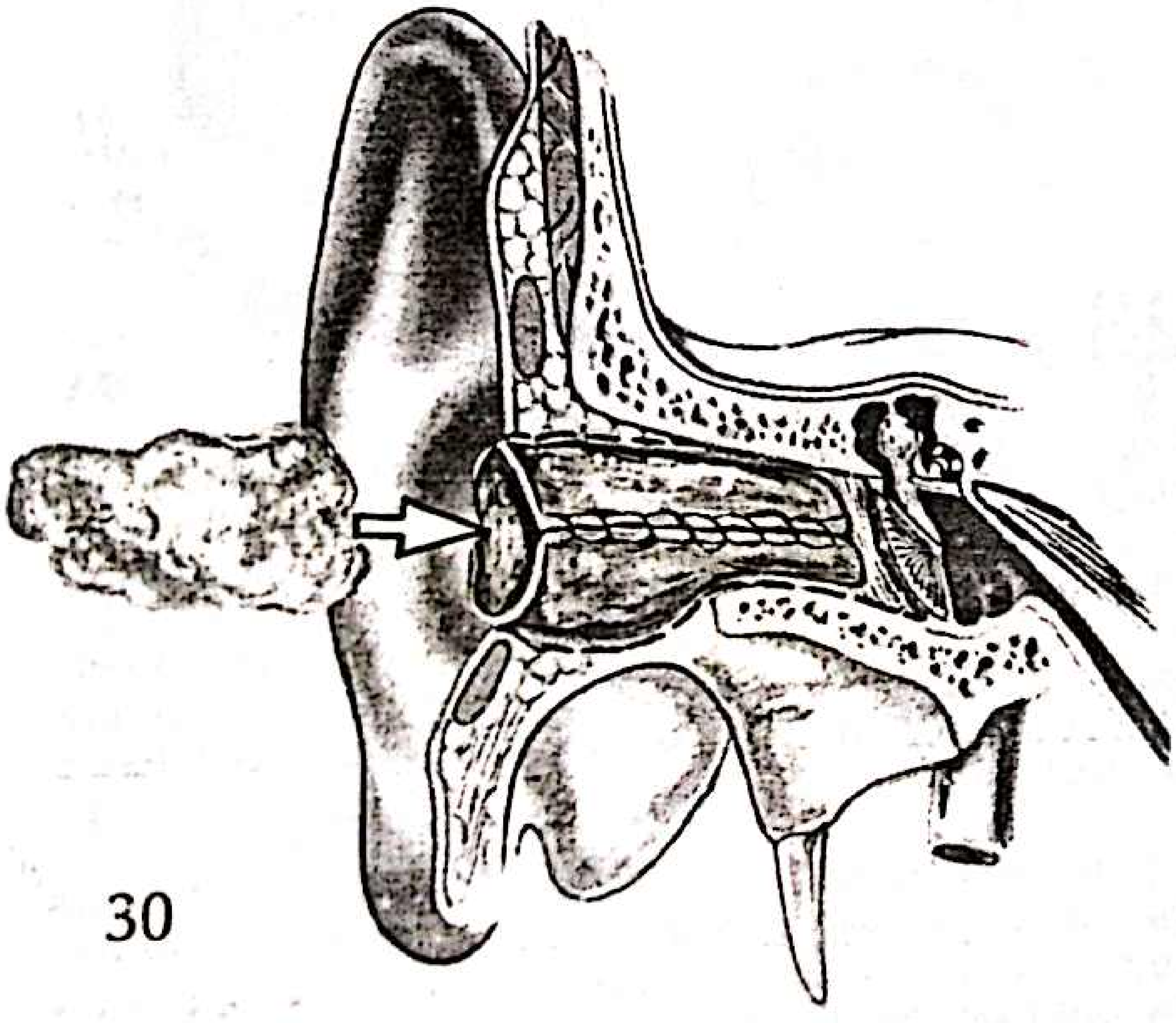

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Which of the two types of bolus is preferable depends on the shape of the defect. The cylindrical defect is managed well using the stent while the defect which is more cone-shaped is better managed with a flavine wool bolus, although pressure has to be applied to its outer aspect to maintain it in position while the graft is taking.

Major meatal tumour

The most frequent form of such a tumour is as a malignant adnexal tumour, a squamous carcinoma or a basal cell carcinoma. In the case of the squamous carcinoma or basal cell carcinoma the tumour, initially of the type suitable for excision and graft as described above, may have been converted into a major problem by the ineffective use of radiotherapy. When this occurs a real difficulty is that of distinguishing between radionecrosis and recurrent tumour.

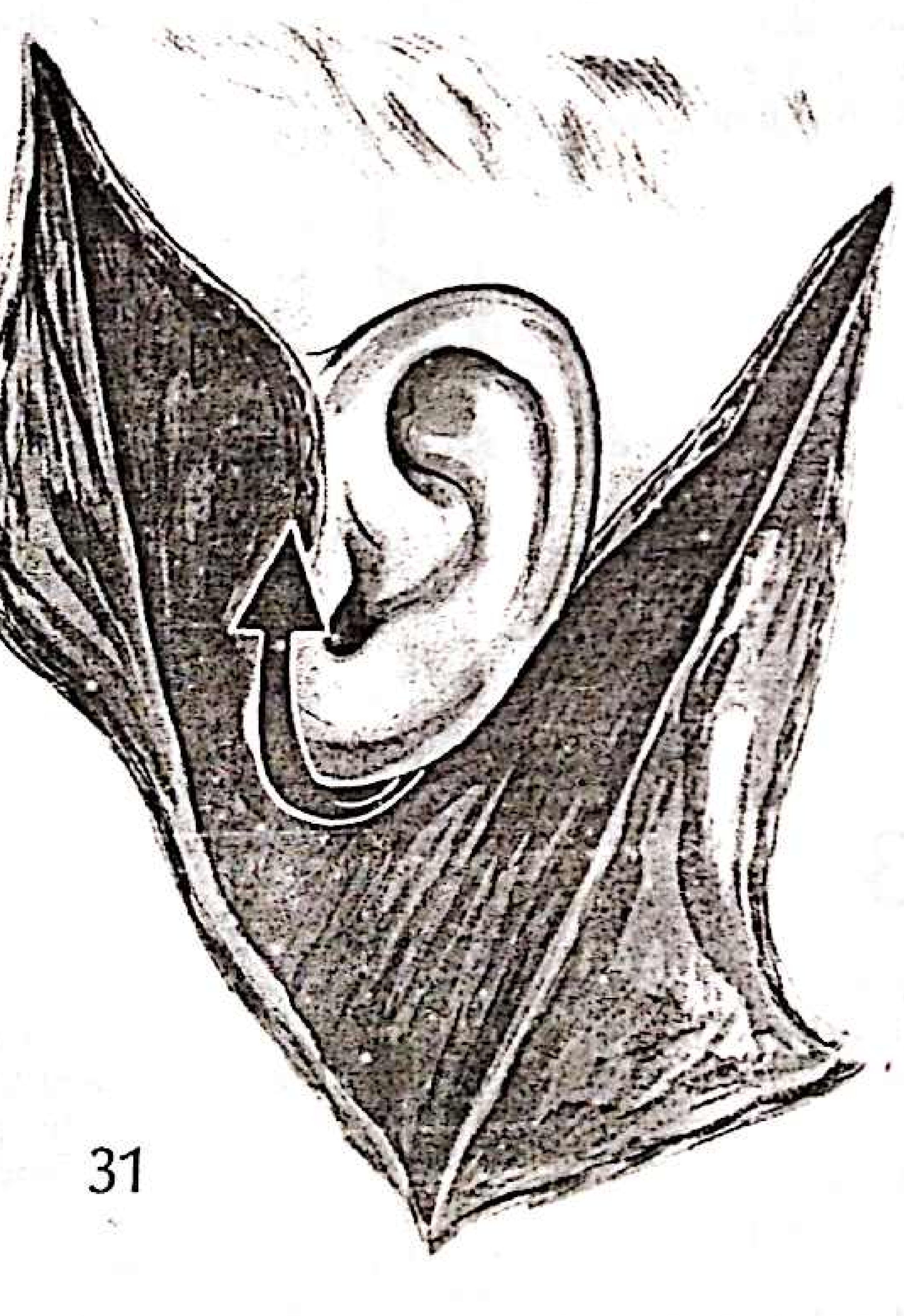
As already stated, such a problem is managed by core resection. Such a resection has no set boundaries and with tumour infiltrating in an indiscriminate manner in skin and soft tissues, cartilage and bone, excision has to be piecemeal. The initial step is to remove the meatal cylinder, before extending the resection in the directions where tumour has been found to have spread.

Extension laterally may involve a resection, partial or total, of the pinna, along with surrounding skin as required. Pursued medially, the resection extends into the middle ear and the mastoid air cells. Depending on the tumour type, evidence of spread and its extent may be relatively easy to recognize, as with squamous carcinoma or basal cell carcinoma. With the adnexal tumours, particularly adenoid cystic carcinoma, it may be extremely difficult or virtually impossible.

By the nature of the problem, approach incisions cannot be standard. The marginal incision is designed to encircle the skin involved by tumour and may vary from one encircling the meatus to one surrounding the entire pinna or even beyond. Not infrequently the pinna itself has to be sacrificed in its entirety.

In core resection the crucial area of extension, and the one which often determines operability, is into the petrous temporal bone surrounding the meatus, and the middle ear with its extensions. In order to expose this area, it is necessary to remove the overlying soft tissues.

When the resection includes the pinna, the entire soft tissue element encircled by the marginal clearing incision is stripped off the skull.



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When the pinna is retained, it is elevated on a broad superiorly based pedicle of parietal skin. With the underlying skeletal structures exposed it then becomes possible to pursue the tumour more effectively in its particular routes of extension.

The tumours which involve this site and which call for a core resection kill as a consequence of local spread rather than by metastases to neck nodes, and a radical neck dissection in continuity is not considered an integral part of the resection. The problem is rather one of local tumour clearance. Even so, exposure of the upper end of the internal jugular vein provides a useful start to the procedure, even if only in order to have both it and the internal carotid artery under control at the outset. It also provides an opportunity to assess whether tumour has spread in that direction, one of the routes of inoperable spread.

In core resection centrifugal extension of the excision beyond the meatus usually involves both the cartilaginous and the bony meatus, and spread of the tumour forward through the cartilaginous meatus will extend into the parotid and may involve the condyle and upper ramus of the mandible, calling for their resection. Even when these structures are not directly involved by tumour, they may require to be resected in order to provide access to the anterior part of the middle ear. Parotid resection, even if partial, may also involve facial nerve resection, and in those circumstances the nerve in its passage through the bone in relation to the mastoid process may also have to be sacrificed.

When the bony meatus is significantly involved, clearance of the middle ear is usually required with deroofing of the mastoid air cells to establish extent of spread and clearance of any involvement.

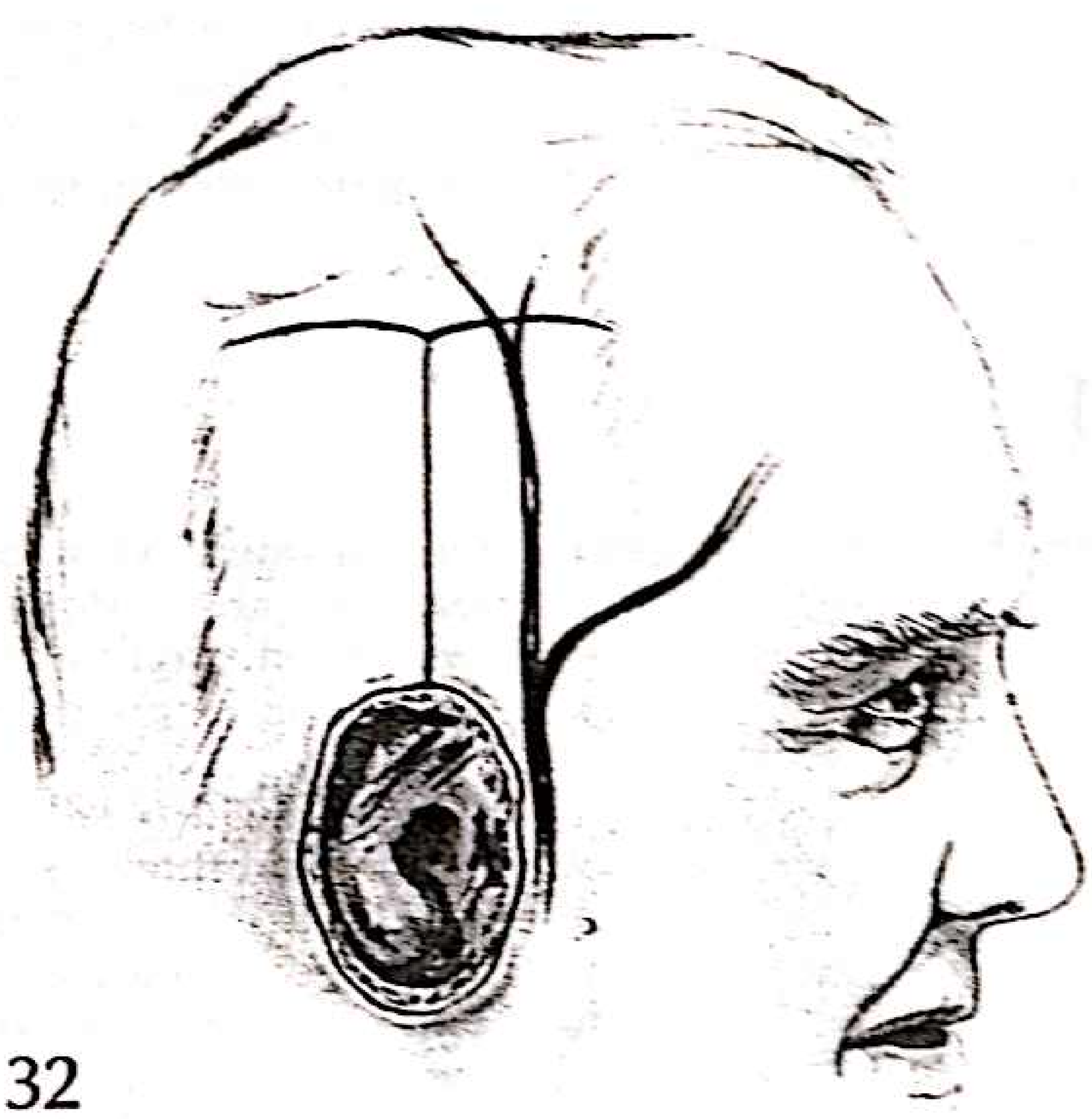
At completion of resection, if the tumour has extended widely, the end result may differ little from a formal petrosectomy, even though the surgical technique, piecemeal rather than formal, has been very different.

Reconstruction of the defect

When the pinna has been retained it is sutured back in position, and to ensure that it sits into the defect and adheres deeply it is essential to provide effective suction.

When the pinna has been resected, the defect is one which is likely to leave exposed bare bone which is not suitable for free skin grafting, and is generally considered to require cover with a flap. At the completion of such a resection the surgeon has frequently reached an end-point beyond which surgery cannot usefully go, and in such circumstances flap reconstruction is clearly appropriate.

If, for any reason, the surgeon considers that a graft would be preferable, the temporoparietal fascial flap may allow such an option. This flap, developed for use in ear reconstruction in a non-malignant context, makes use of the sheet of modified galea overlying the temporal fascia which covers the temporalis muscle. It is perfused by the superficial temporal vessels and can be used only if these vessels are present and functioning postresection.



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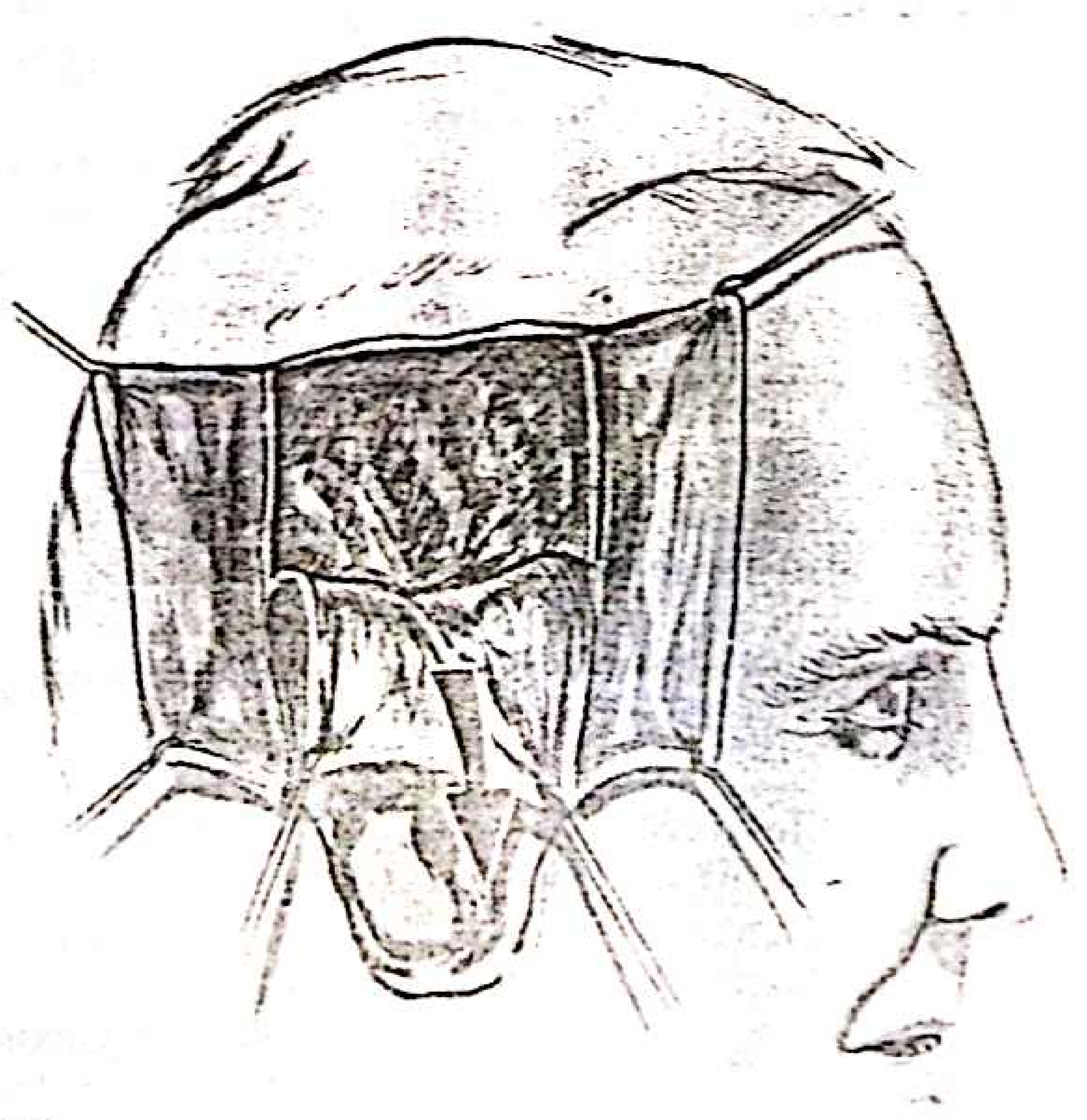
In preparation for raising the flap, its anterior and posterior extent, which approximates to the central part of the temporalis muscle, can be marked on the skin, and the course of the artery determined by palpation or by the use of a Doppler probe. With the periauricular defect already present, the site of the flap is exposed with an a T-shaped incision, the vertical limb centred on the pinna, the horizontal limb at the upper border of temporalis.



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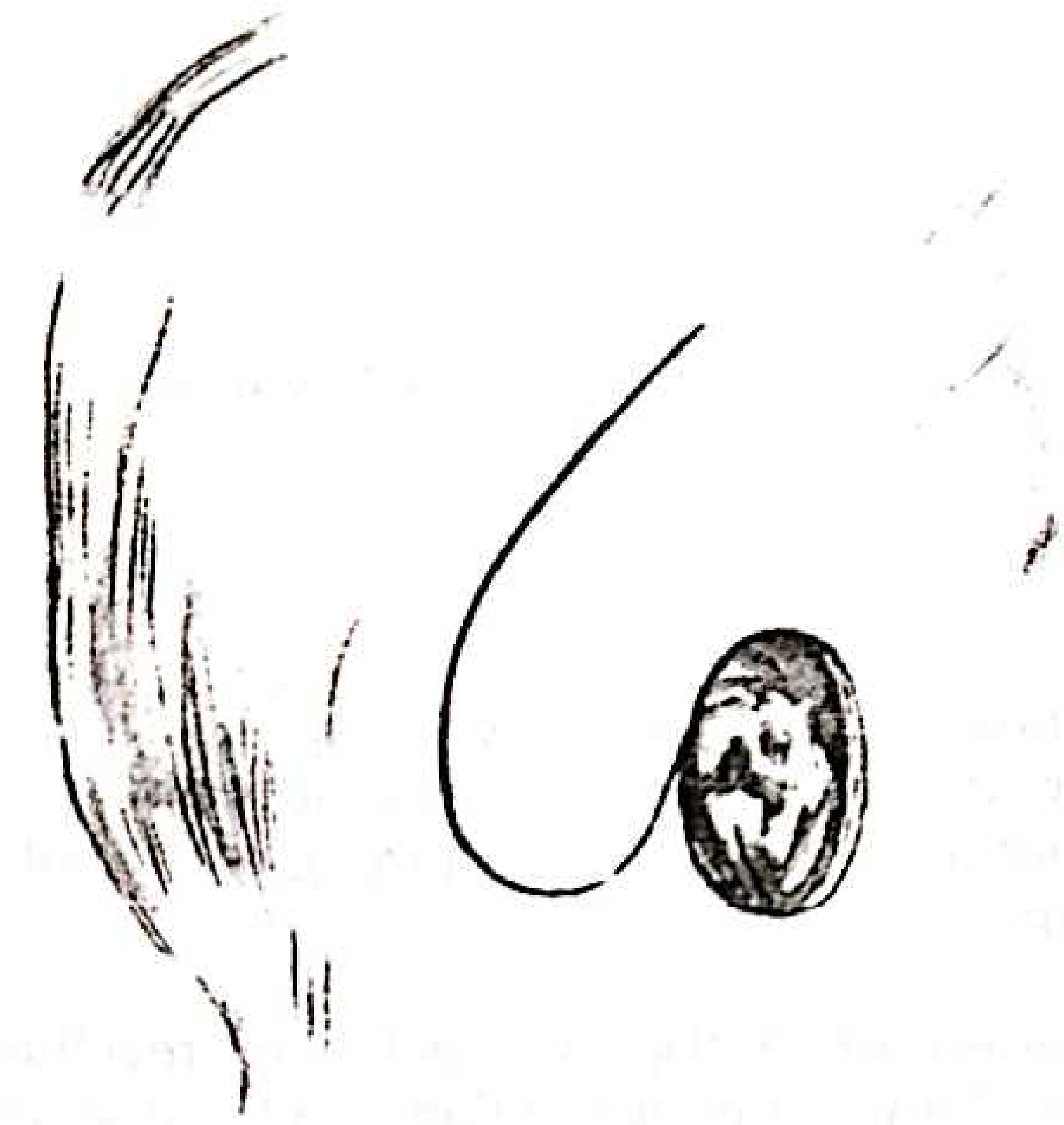
The two skin flaps, anteriorly and posteriorly based, outlined in this way, are raised initially just deep to the hair follicles to avoid damage to the superficial temporal vessels, deepening as the base of each flap is approached. The margins of the fascial flap are defined and incised, and the flap is elevated in the natural and virtually avascular plane between it and the temporal fascia. It is then turned down to cover the defect and provide a surface which can be free skin grafted.

When flap cover is required the problem of selection arises. At the outset this is likely to be based on whether or not the surgeon has the equipment and the skills to use a free flap. If these are not available, there are two alternatives available.

34

One of the alternatives is to design a local flap on the adjoining scalp and transfer it into the defect. Such a reconstruction can either be viewed as providing a temporary solution while the permanent flap cover is being prepared, or used as the permanent reconstruction. In making the decision much will depend on how certain the surgeon is that he has achieved complete clearance of the tumour and how cosmetically acceptable the result has proved to be.

The alternative is to use one of the pedicled flaps – deltopectoral, trapezius, pectoralis major or latissimus dorsi.



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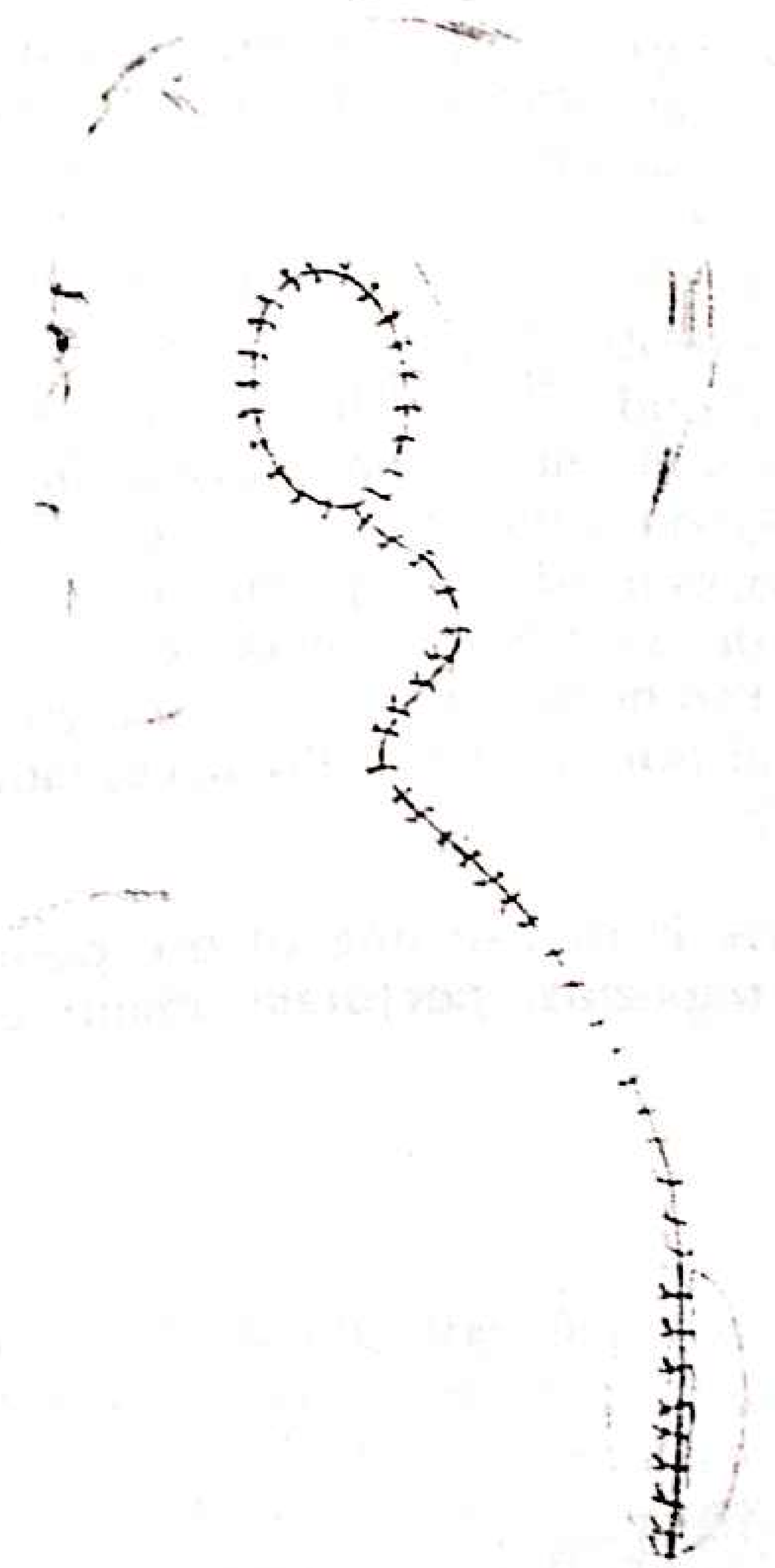
Prior to the advent of myocutaneous and free flaps, the deltopectoral flap would have been the flap of choice. Despite its current eclipse by these alternatives it remains a simple and safe technique, which does not call for particularly sophisticated surgery.



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Of the trapezius flaps, the lower flap has the fewest adverse factors. It has an acceptable reputation for reliability, but it does involve the turning of the patient to raise the flap.

The latissimus dorsi flap is capable of reaching the defect successfully as a pedicled flap, but the dissection is likely to be an extremely arduous one. In practice it is much more likely to be the first choice, used as a free flap, particularly if a neck dissection has not been required.

The pectoralis major myocutaneous flap has serious disadvantages, although for many surgeons it has the virtue of familiarity. Radical neck dissection is not a usual part of the overall resection of a meatal carcinoma, and this rules out the possibility of tunnelling the flap under the neck skin. The alternative, using the flap as a direct transfer with a split-skin graft wrapped round the muscle pedicle, is not recommended, and there is likely to be doubt at the outset concerning whether the flap will reach the defect in any case.

Illustrations by Ian Ramsden

Scalp and forehead

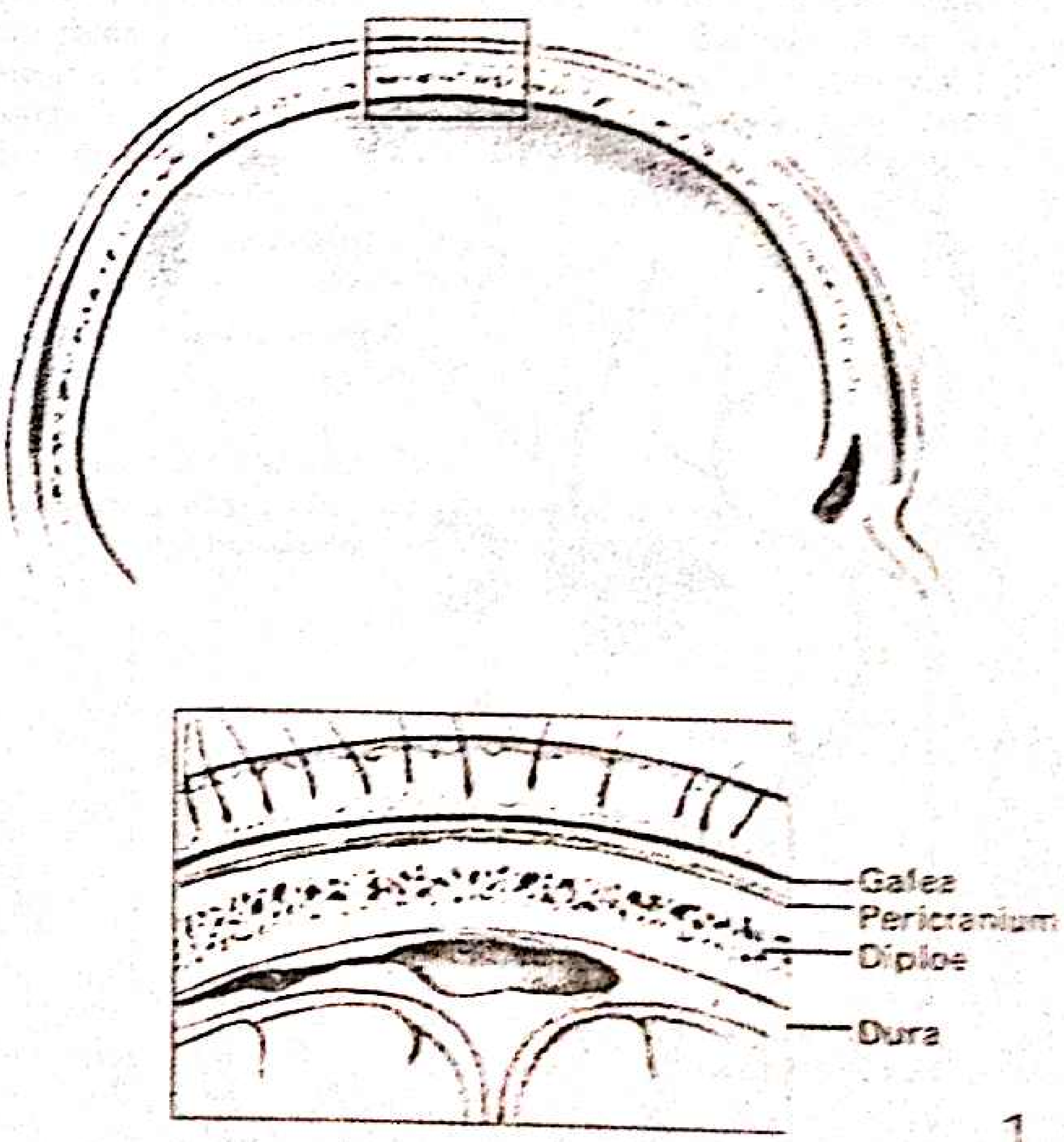
Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Anatomical aspects

The scalp, temporal areas, and forehead have a similar basic structure, although they differ in detail.

1

In the scalp, the skin, superficial fascia and galea aponeurotica are firmly attached to one another and for surgical purposes behave as a single structure. The galea represents the aponeurotic component of occipitofrontalis, linking the occipitalis muscle behind to frontalis in front, and such mobility as exists between the scalp and the underlying skull results from the presence of the relatively loose fibrous tissue layer between it and the pericranium. This layer provides the surgical plane in the scalp. Over the vertex of the skull, where the skull is directly covered by pericranium, the superficial fascia and the galea individually are strong and inextensile; in combination they add to these characteristics a degree of rigidity which is considerably greater than that of soft tissues generally.



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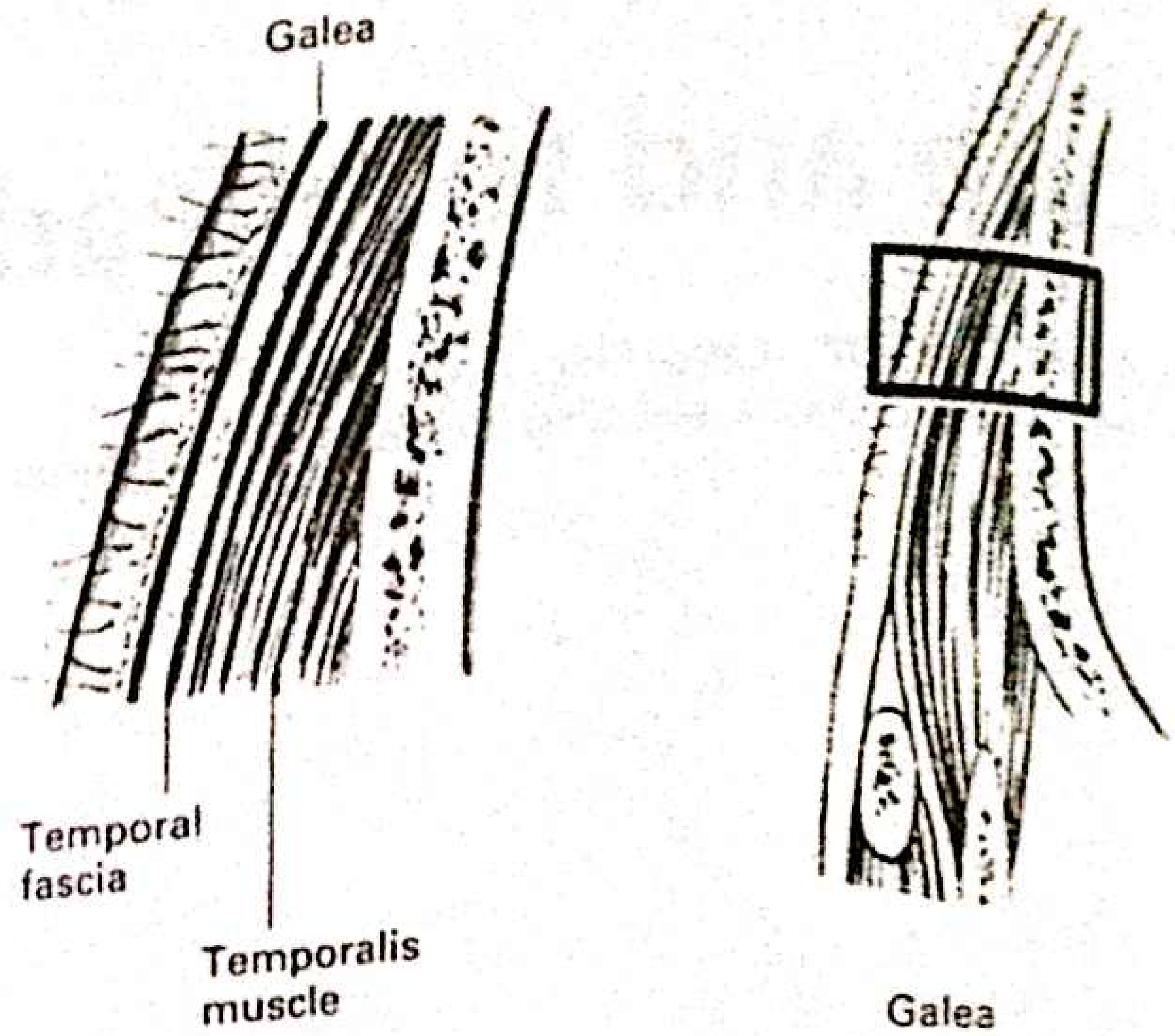
2

In the temporal area, where the bone is covered by the temporalis muscle, the galea becomes thinner and more flexible, and fuses below with the temporal layer of fascia which overlies temporalis, the two having a joint attachment to the zygomatic arch. In this area, the surgical plane changes from being between the galea and the pericranium to lie between the galea and the temporal fascia.



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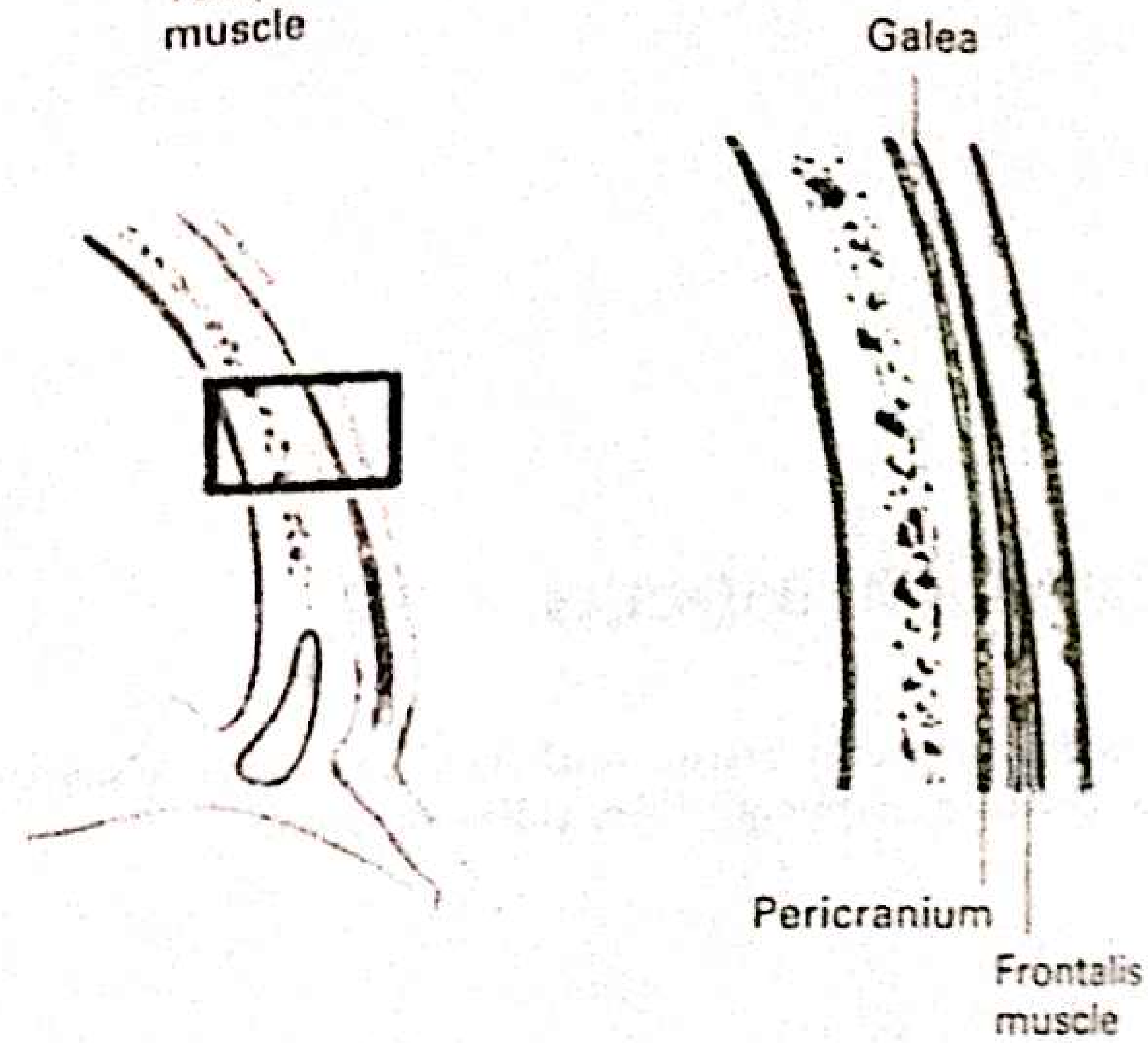
3

In the forehead, the pattern becomes modified with the transition from the galea to the frontalis muscle. The superficial fascia loses much of its fibrous component and becomes thinner, its rigidity reducing and its elasticity increasing. The frontalis muscle has no bony insertion below, but instead fuses with orbicularis oculi and the muscles in the glabellar area.



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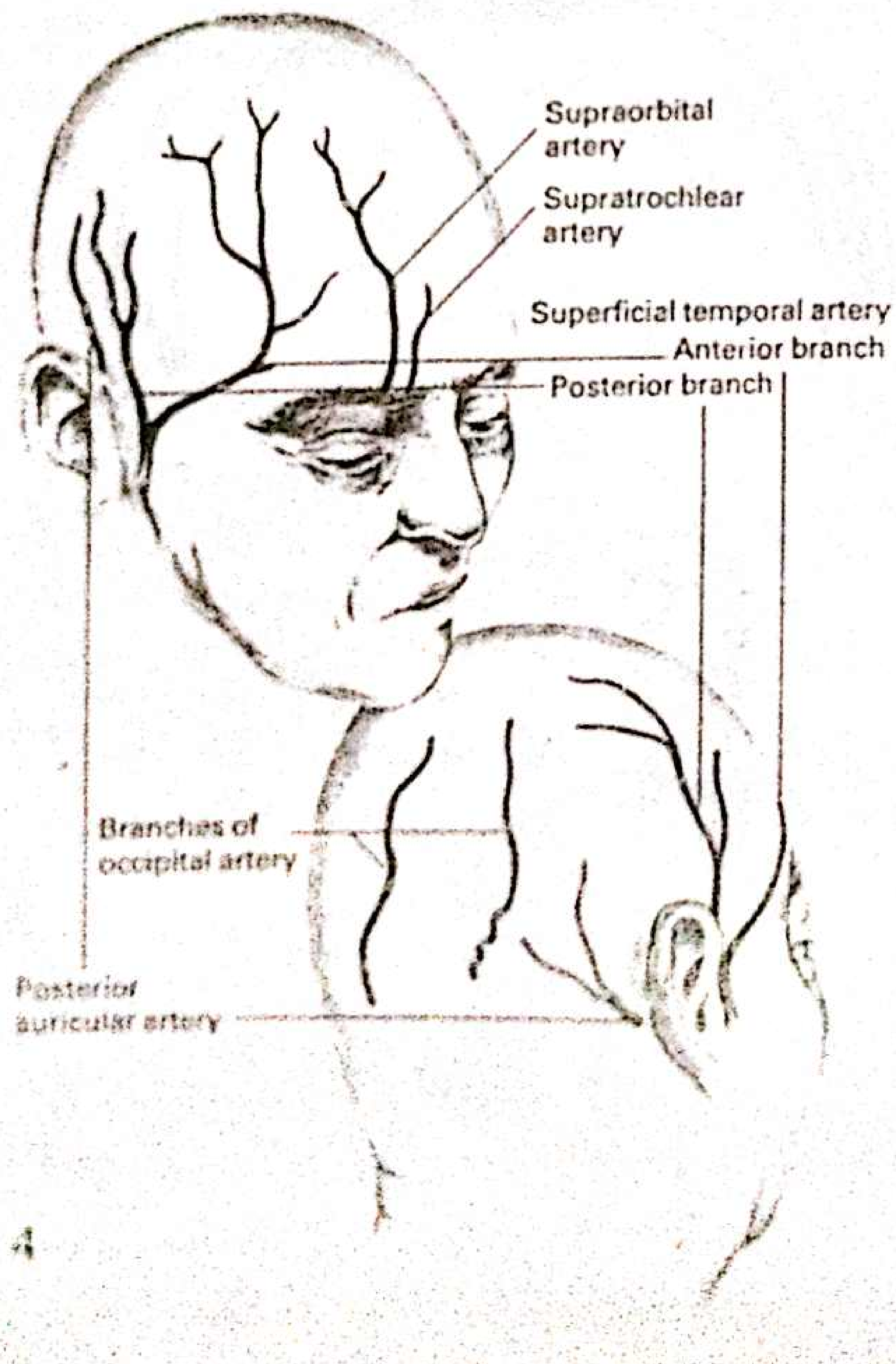

4

4

The entire area is extremely vascular, with a plexus of vessels which runs horizontally in the superficial fascial layer, fed from vessels distributed around its margins, anteriorly the supraorbital and supratrochlear, laterally the superficial temporal, and posteriorly the posterior auricular and occipital vessels. The network is independent of the pattern of supply to the cranial vault, the only vessels which regularly cross the interface between the scalp and the skull being two emissary veins on each side, mastoid and parietal. The vessels of the plexus are numerically, and individually, of a calibre which is sufficient to provide an axial vascular basis for the majority of the flaps which are raised on the forehead and scalp, permitting successful use of length:breadth ratios which are much more liberal than in most body sites.

The inextensibility of the galea also provides a degree of protection to the flaps which are raised on the scalp, preventing much of any tension from being transmitted to their content of blood vessels, and permitting suture under a degree of tension which would be disastrous in other parts of the body. This protection exists also in the forehead, although to a reduced extent.

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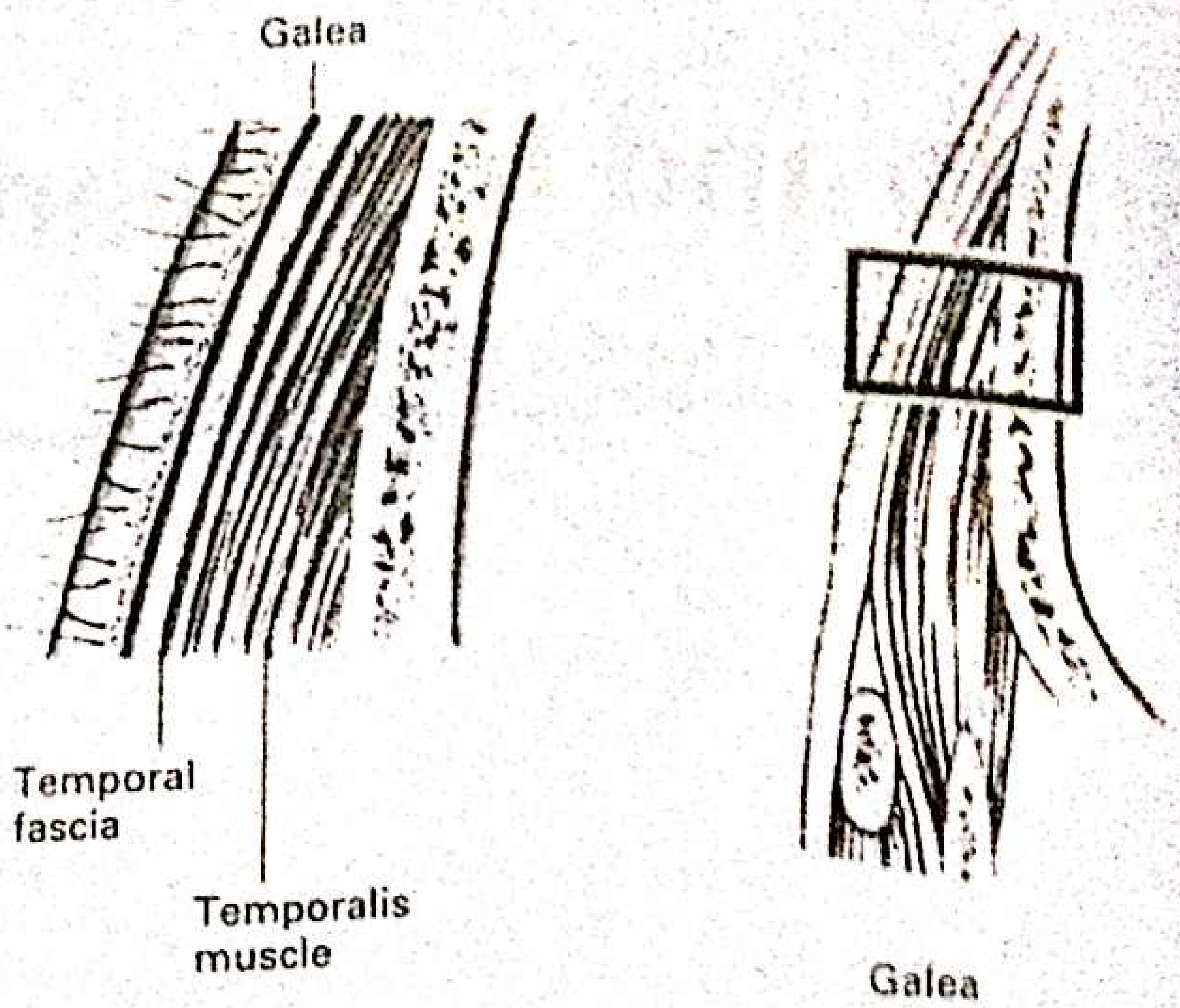

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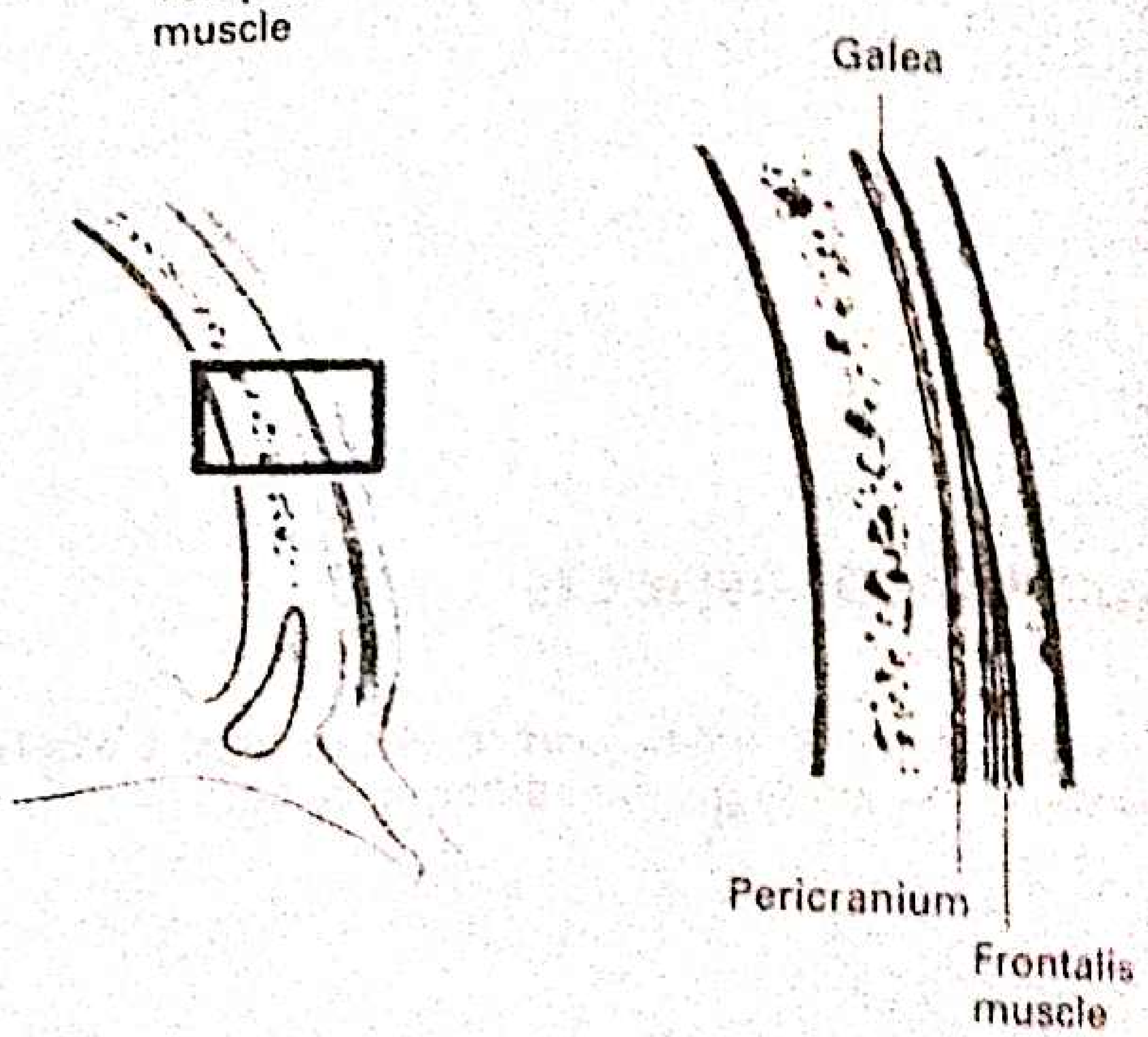

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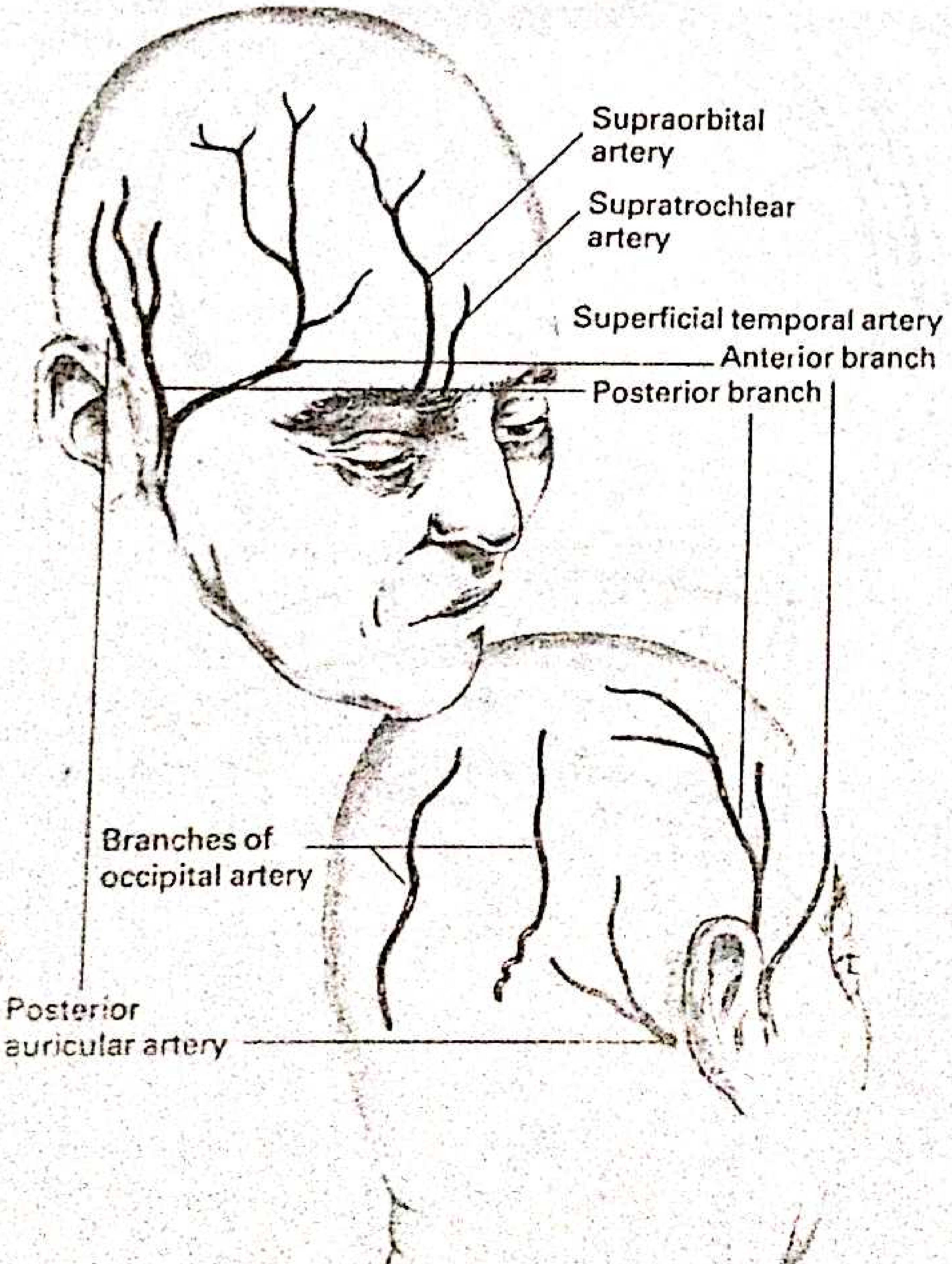

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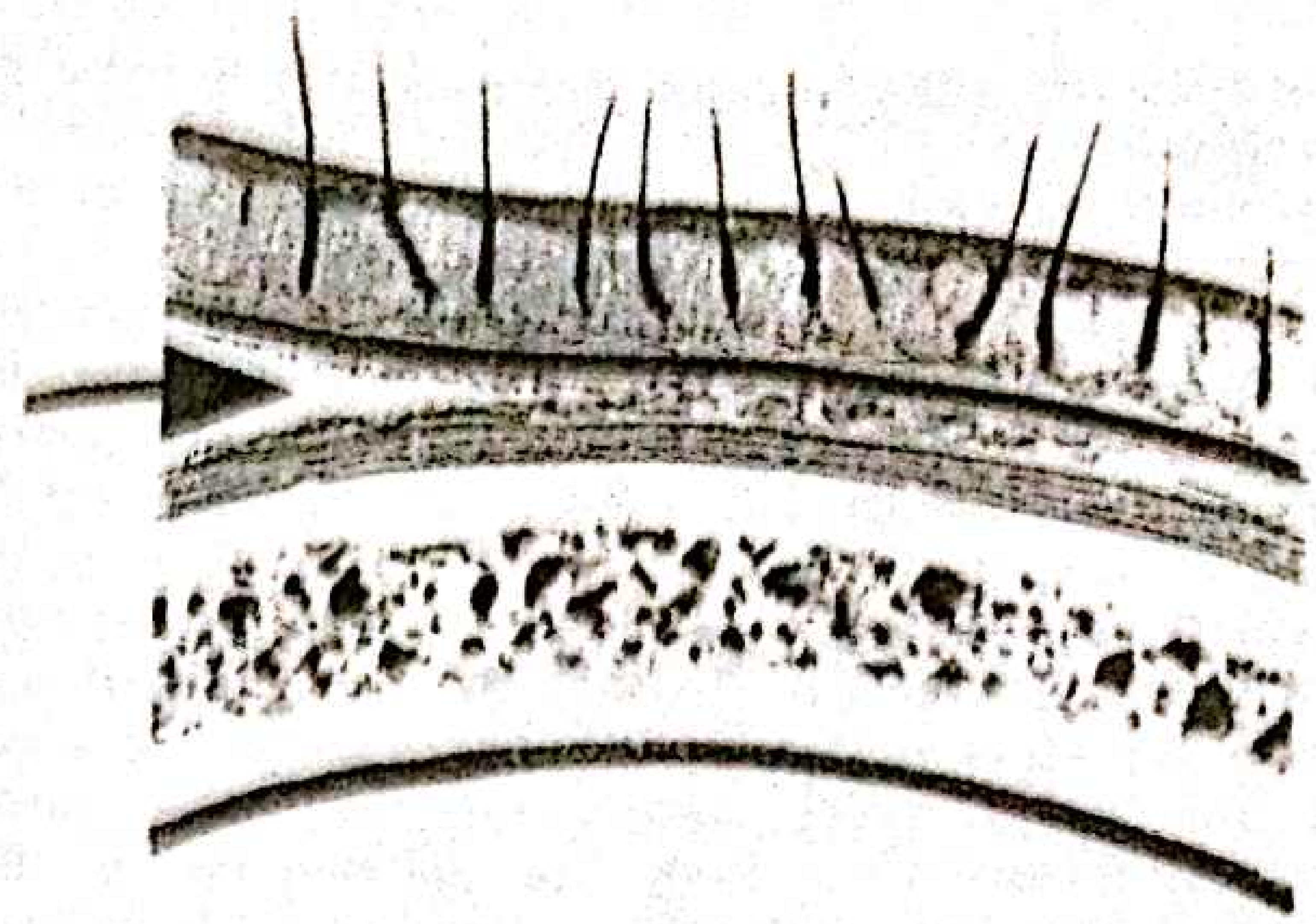
Surgical implications

5

In the scalp, the loose fibrous tissue layer which separates the galea from the pericranium provides the plane in which flaps are raised, the flap with a lining of galea, the skull covered by a layer of pericranium.



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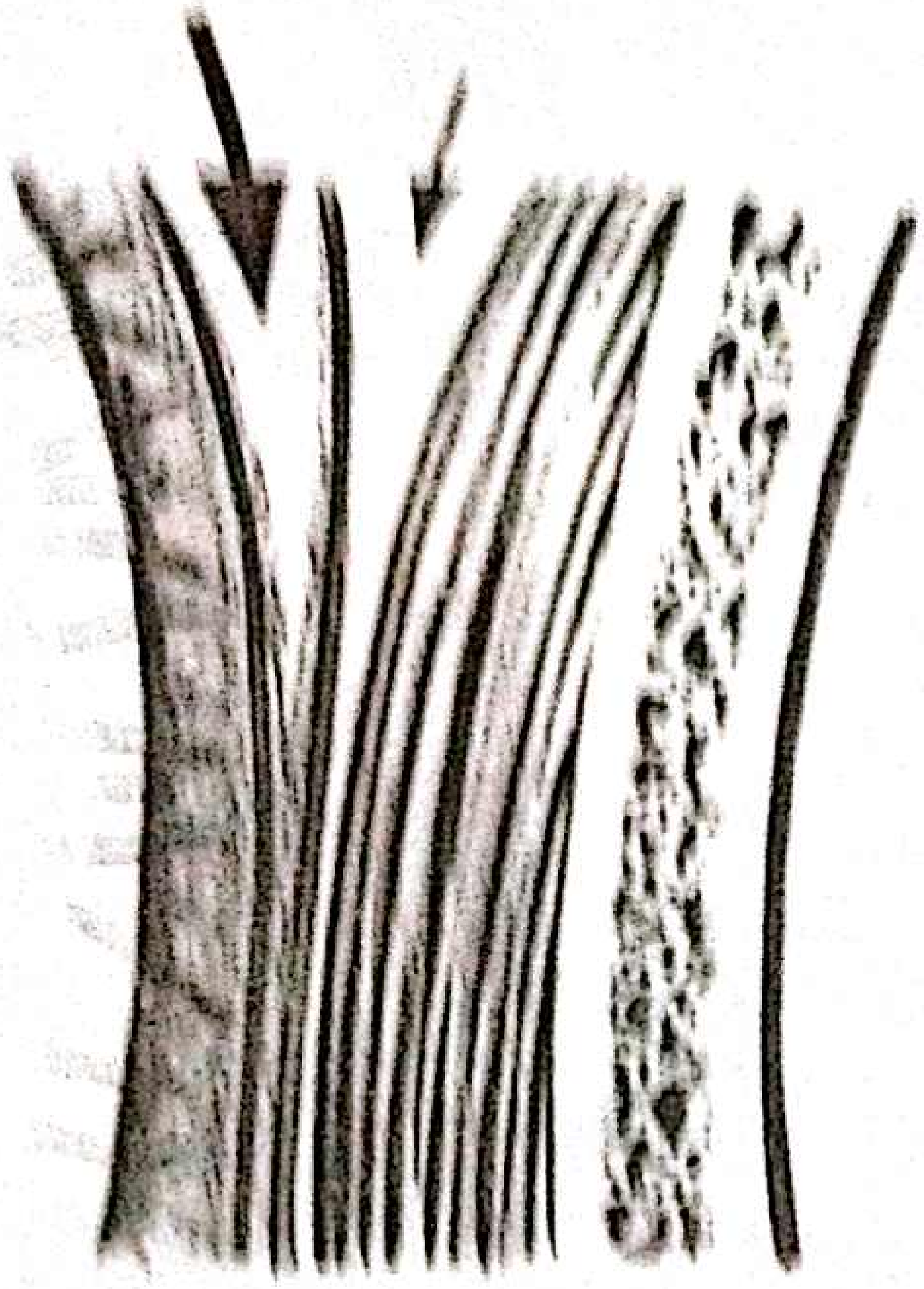

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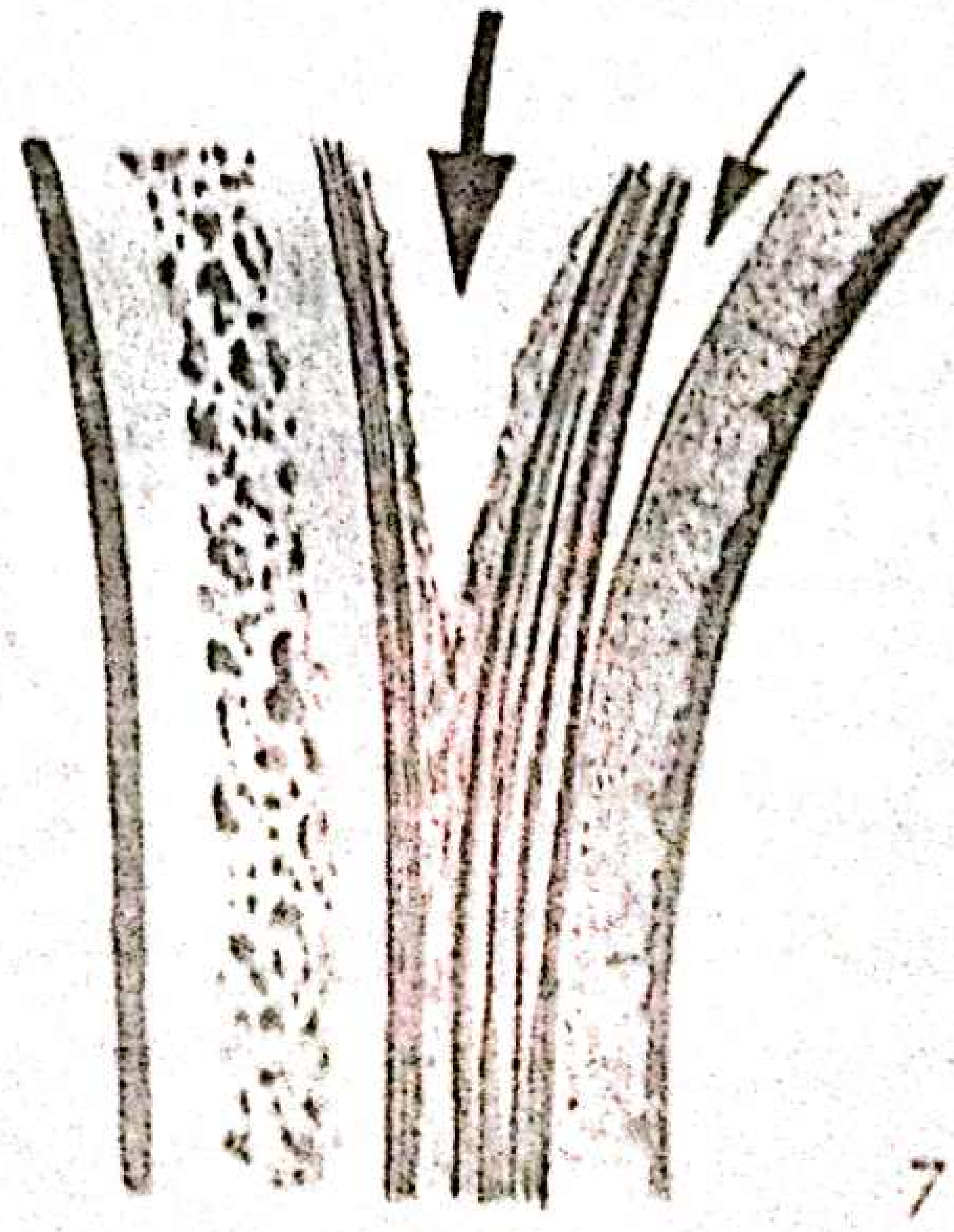
In the temporal area, the plane regularly used is between the galea and the temporal fascia, but a further plane is present between the temporal muscle and the temporal fascia. This is rarely used, except when there is suspicion that the interface between galea and fascia has been crossed by tumour and the fascia requires to be resected.

7

In the forehead, the standard plane of elevation of flaps is deep to frontalis. The replacement of galea by the frontalis muscle layer, however, makes it possible also to raise forehead flaps superficial as well as deep to the muscle, but the plane is not a natural one and has to be created by the surgeon. Such flaps have a reduced safety factor, and only the smaller ones are raised in this plane as a rule. When a larger flap is being raised, the needs of the reconstruction sometimes dictate that its distal segment should be raised superficial to the muscle, but as soon as possible the plane is deepened to include frontalis in the flap.



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RESECTION

The assessment of adequacy of excision in both scalp and forehead resolves itself in a more than usually clear-cut manner into one of marginal clearance and clearance in depth.

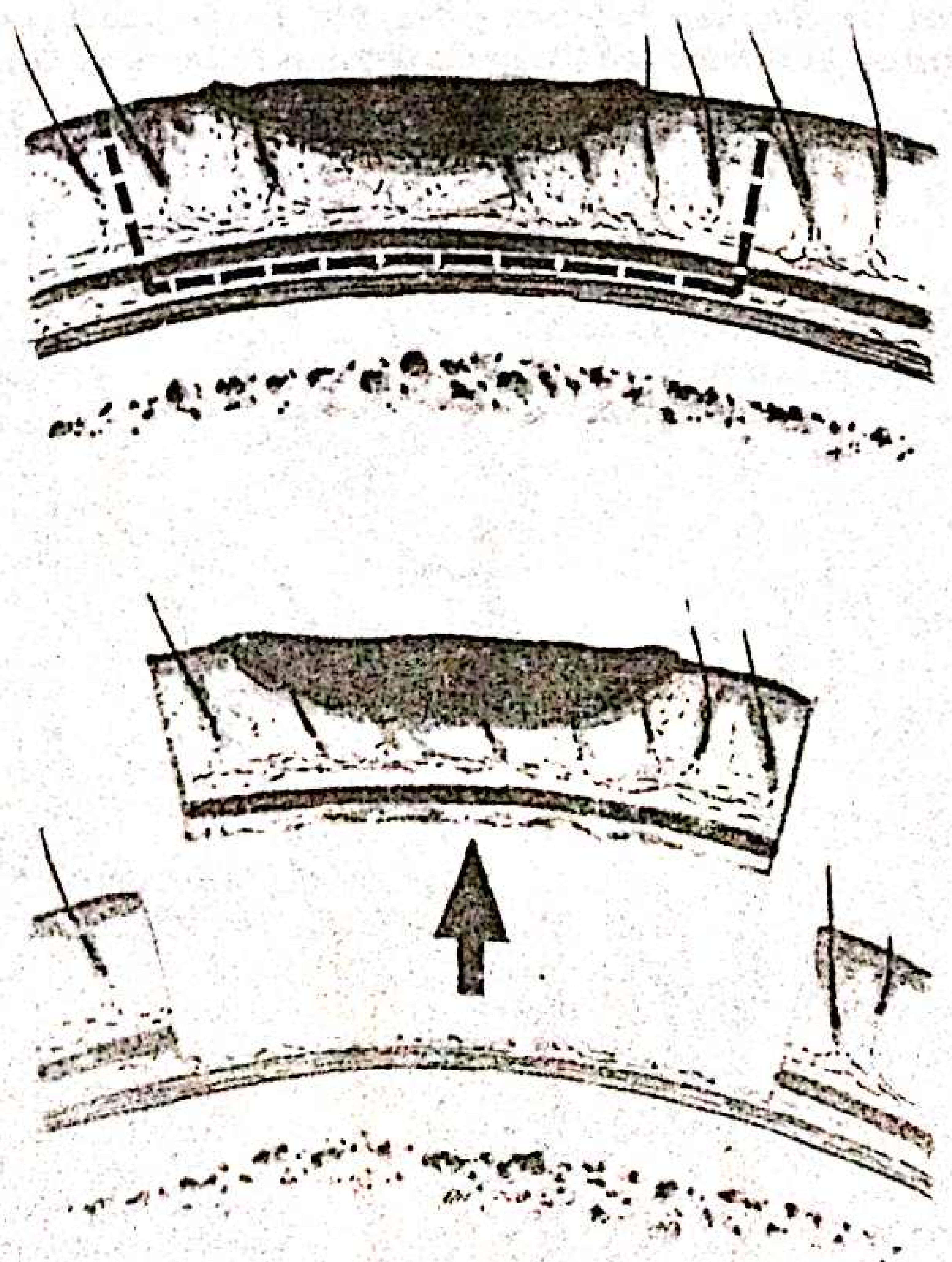
Marginal clearance presents difficulties of assessment which are largely similar to those of facial skin generally. The problems of depth clearance relate to its layered structure, the soft tissues overlying the calvarium, and the dura mater on its deep surface, covering the cortex of the brain. In this stratified formation the layer which provides the 'rubicon', in the sense that the crossing of it by tumour alters the management most profoundly, is the loose fibrous tissue layer which separates the galea/occipitofrontalis layer from the pericranium. In the temporal area, the problem arises less frequently because of the intervening layer provided by the temporalis muscle.

In assessing the deep extent of the tumour preoperatively the most useful guide is a careful clinical examination. It is striking how often the conclusions reached from this are confirmed at operation. The appearance of the lesion alone permits a surprisingly accurate judgment to be made, but it is the presence or absence of mobility which provides the best evidence. The presence of mobility is strong evidence that the pericranium is not involved, but apparent fixity is a less certain criterion, due on occasion to tightness of the scalp rather than to bony involvement. Errors made are more often in the direction of diagnosing fixation where it proves not to be present. Radiographic examination is largely valueless, the clinical evidence of bony involvement usually being unmistakeable by the time radiographic signs are clear-cut.

It is when the clinical signs are equivocal that difficulty arises, and it is then that the preoperative assessment has to be viewed as provisional, confirmed or not at operation. A test which may give an additional clue is the injection of saline under some pressure into the layer between the galea and the pericranium. Ballooning of the area under suspicion is presumptive evidence of non-involvement, but even here the real assessment is made at operation, in watching how the galea strips off the pericranium.

Scalp

In the scalp, resection is generally carried out in a layered manner, each layer being examined as it is exposed for signs of tumour involvement, until clearance in depth has been achieved.



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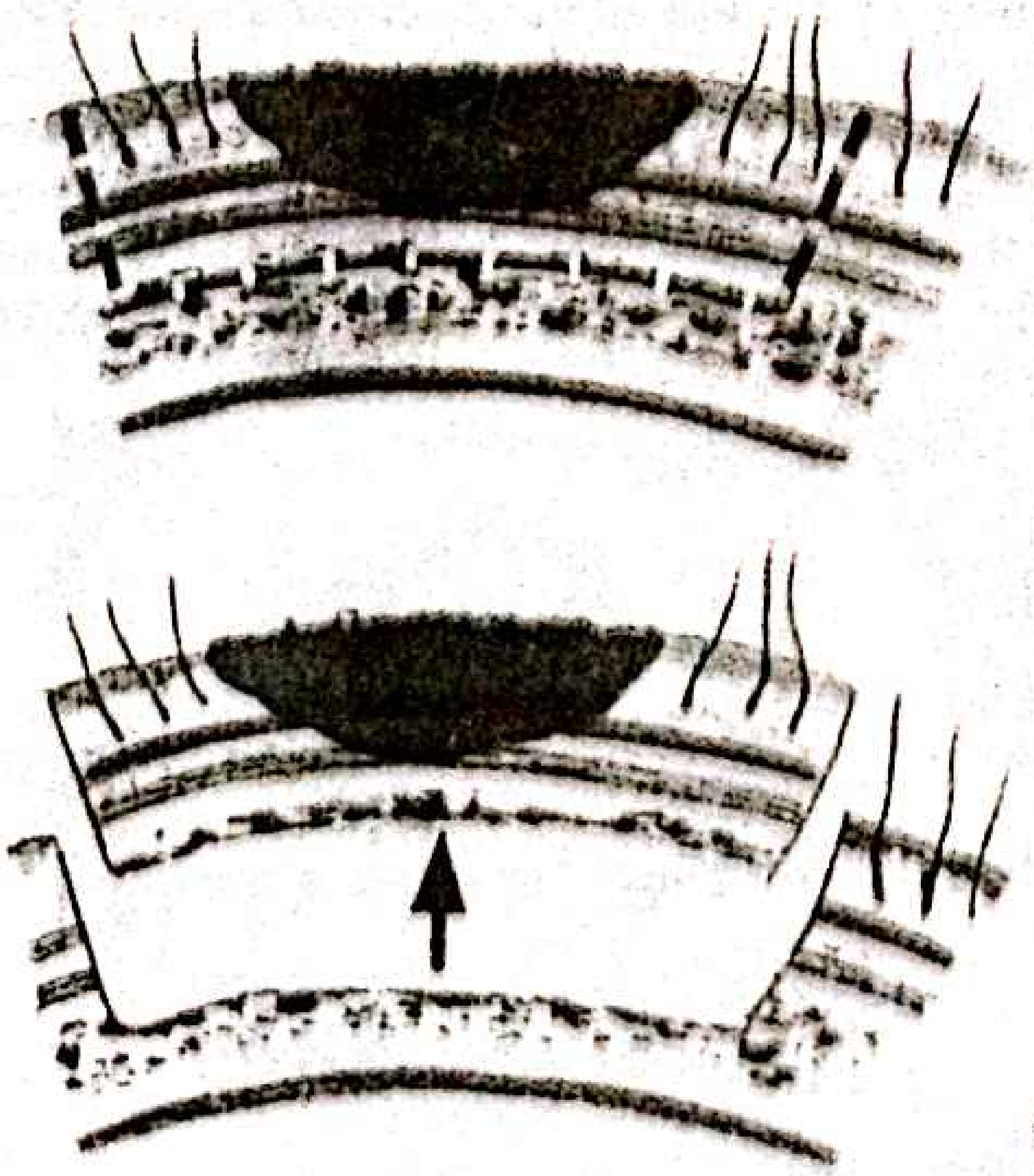
In this sequence the tissues superficial to the interface between the galea and the pericranium are treated as a single structure, so that even if deep infiltration by the tumour is minimal its entire thickness is excised.

The surface which is exposed, and its significance in surgical terms, depends on its site on the scalp, and whether or not it consists of pericranium or the fascia overlying the temporalis muscle. Both surfaces accept a free skin graft readily, but the sites differ in terms of the resection required if the surface is considered to be involved by tumour.

9

In the case of the pericranium, involvement by tumour carries with it the presumption that the outer layer of the calvarium is also involved, even if minimally, and the resection has to be carried out on that basis, deeply at least as far as the diploe.



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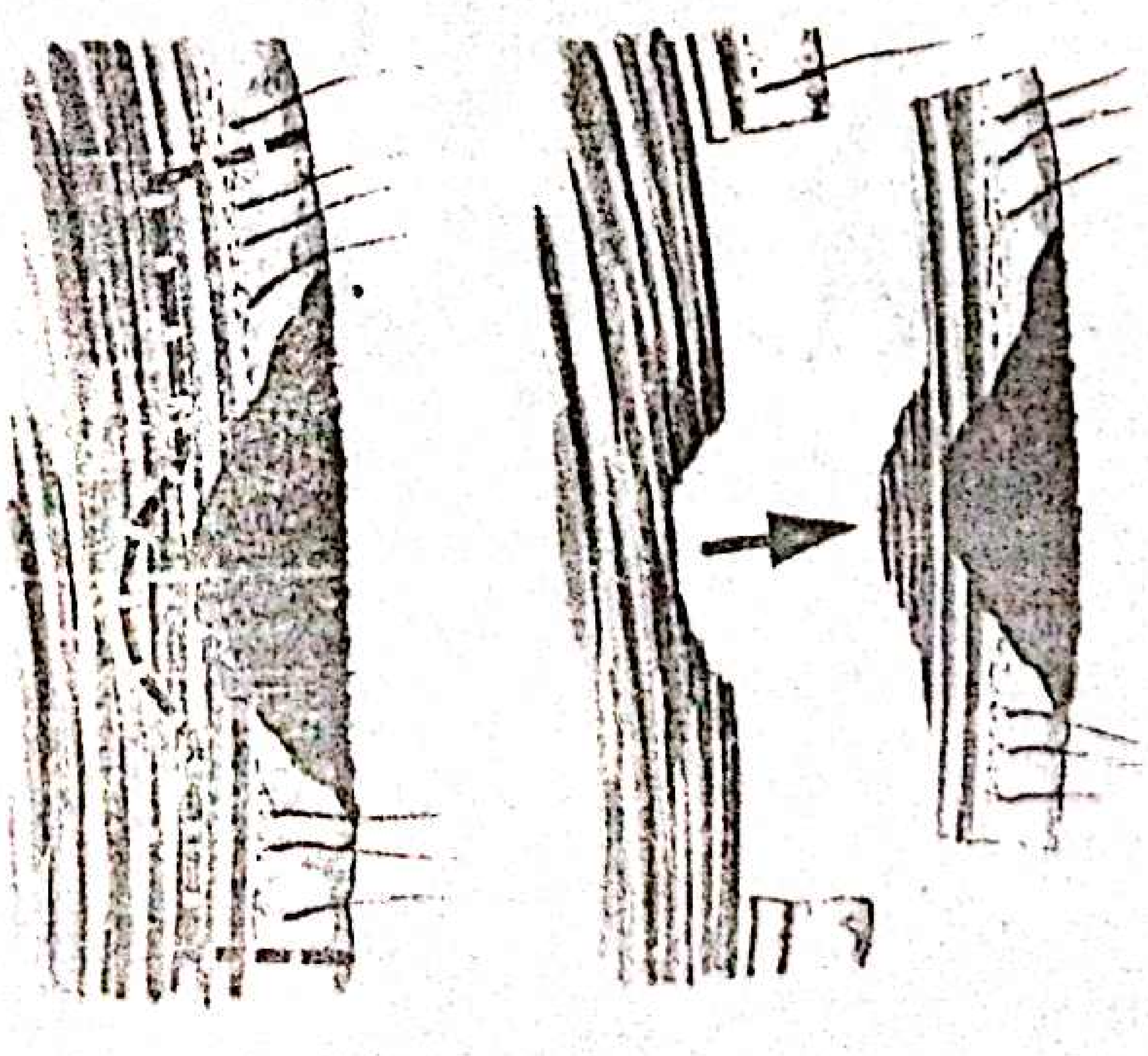
When the temporal fascia is involved, the temporalis muscle is present as a further layer between the fascia and the bone, and the resection can be deepened to include part of its thickness, so that clearance in depth is assured.



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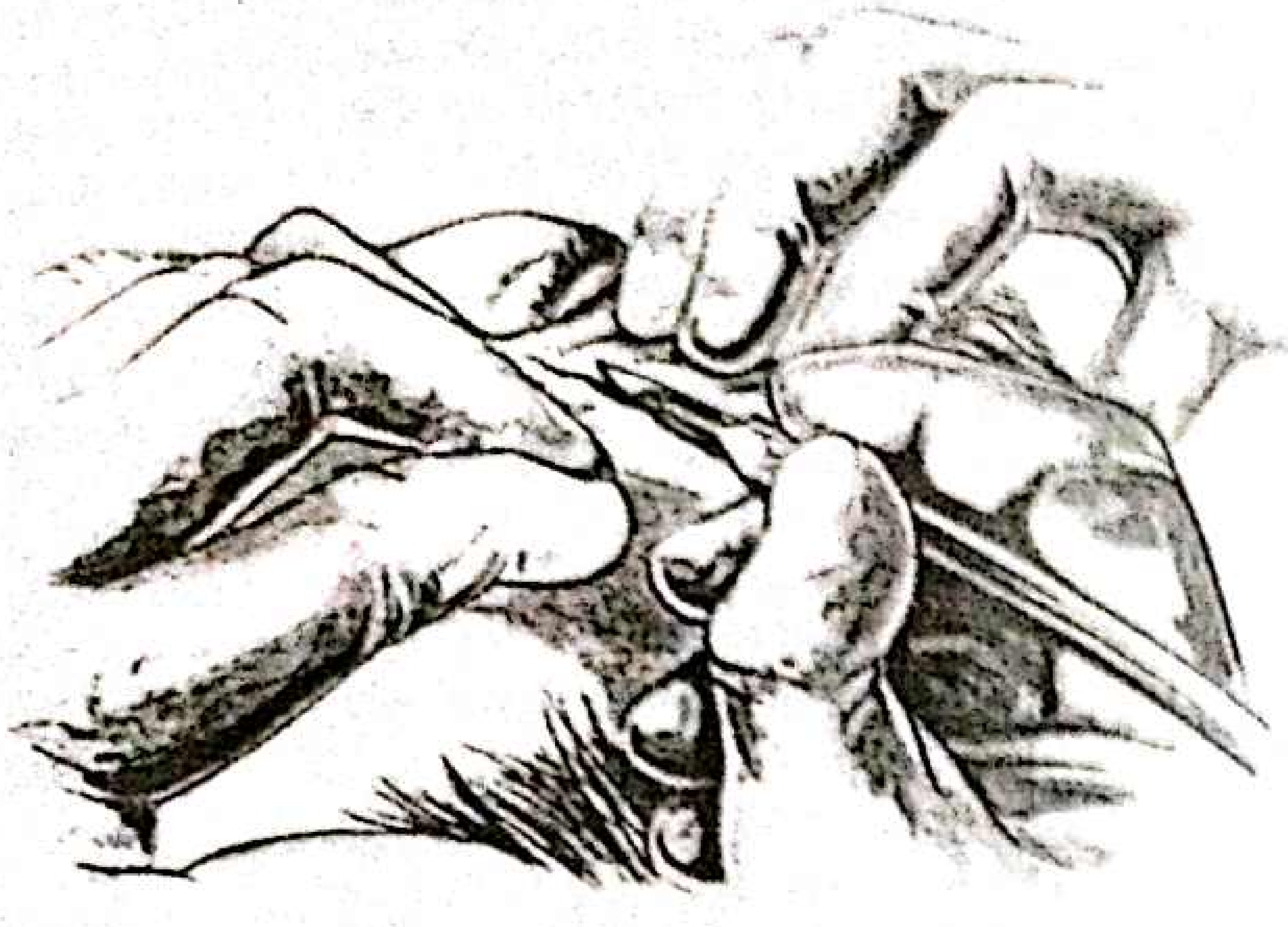
In making the encircling skin incision prior to the resection of a scalp tumour, considerable bleeding can occur. The vascularity of the scalp encourages bleeding generally, but it is also difficult to control the marginal bleeding quickly because the incision is vertical and the scalp is so rigid. The combination makes the use of artery forceps awkward. Two neurosurgical manoeuvres are of value in this situation.

11

The pressure of the assistant's fingers on one side of the incision, and of the surgeon's on the other reduces the bleeding while the incision is being made.



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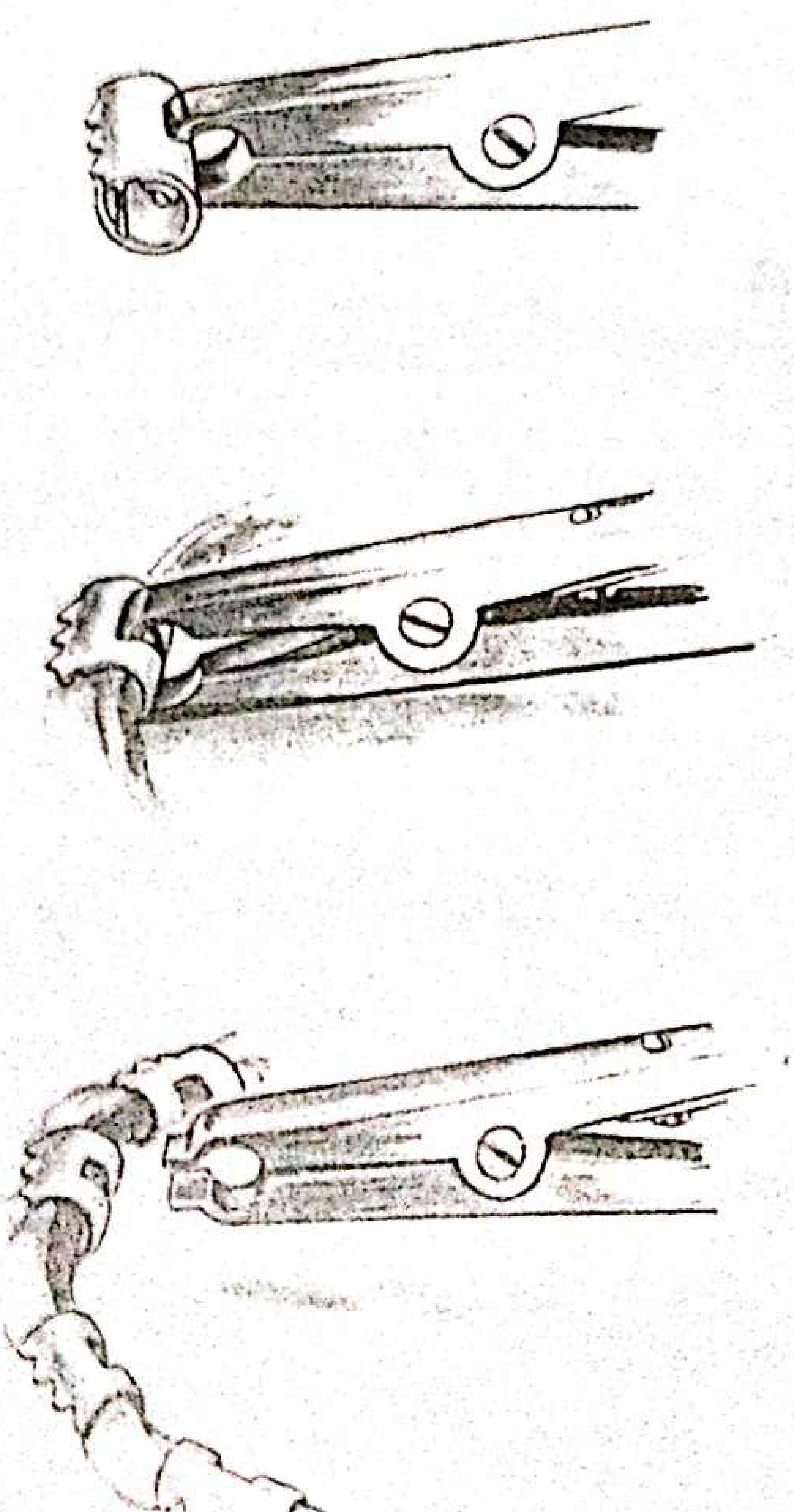

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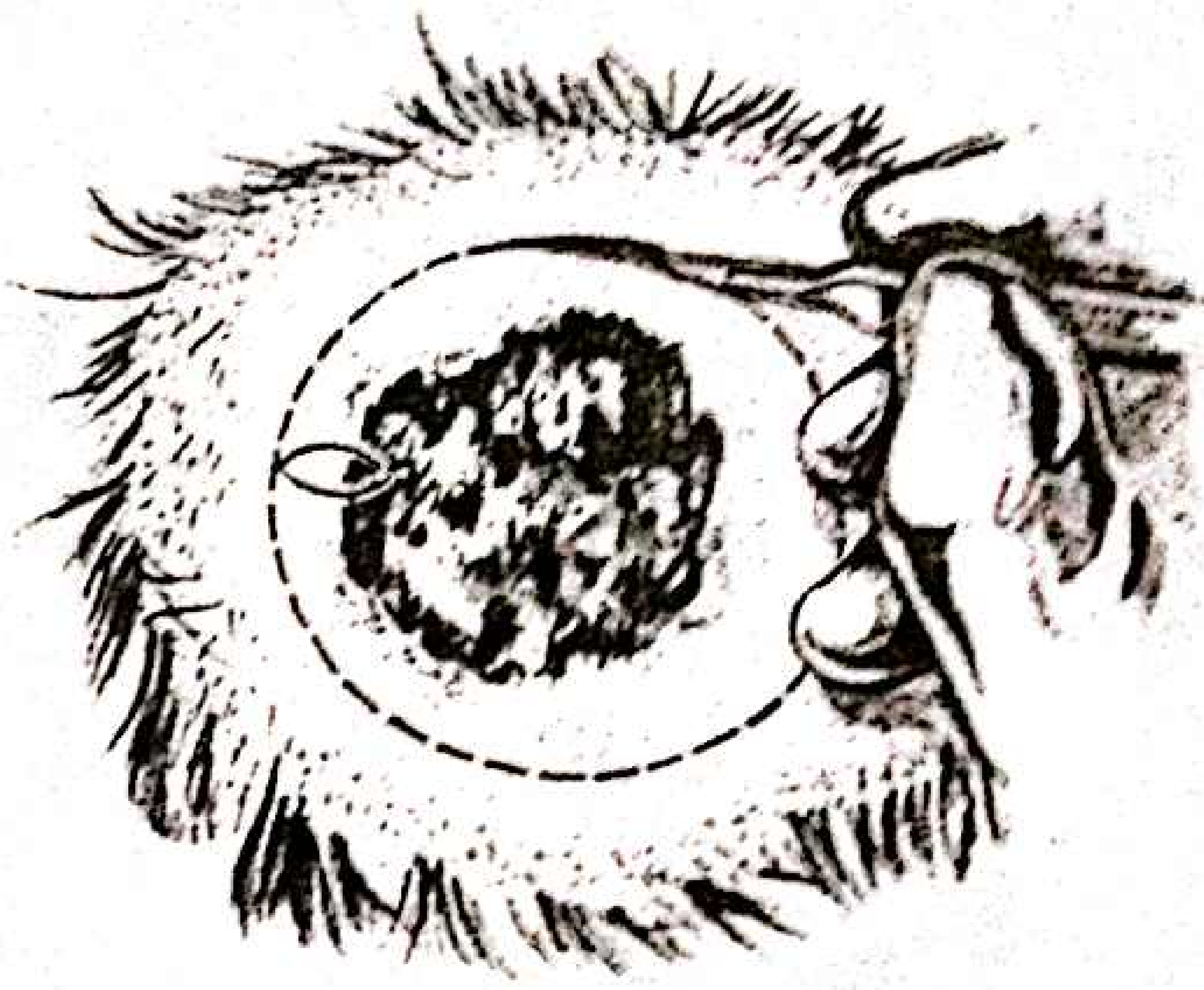
Where the incision is a long one, Raney clips applied along the resection margin effectively stop bleeding from it.

13

Excision is begun at the marginal resection line. Any biopsy site is included in the excision.



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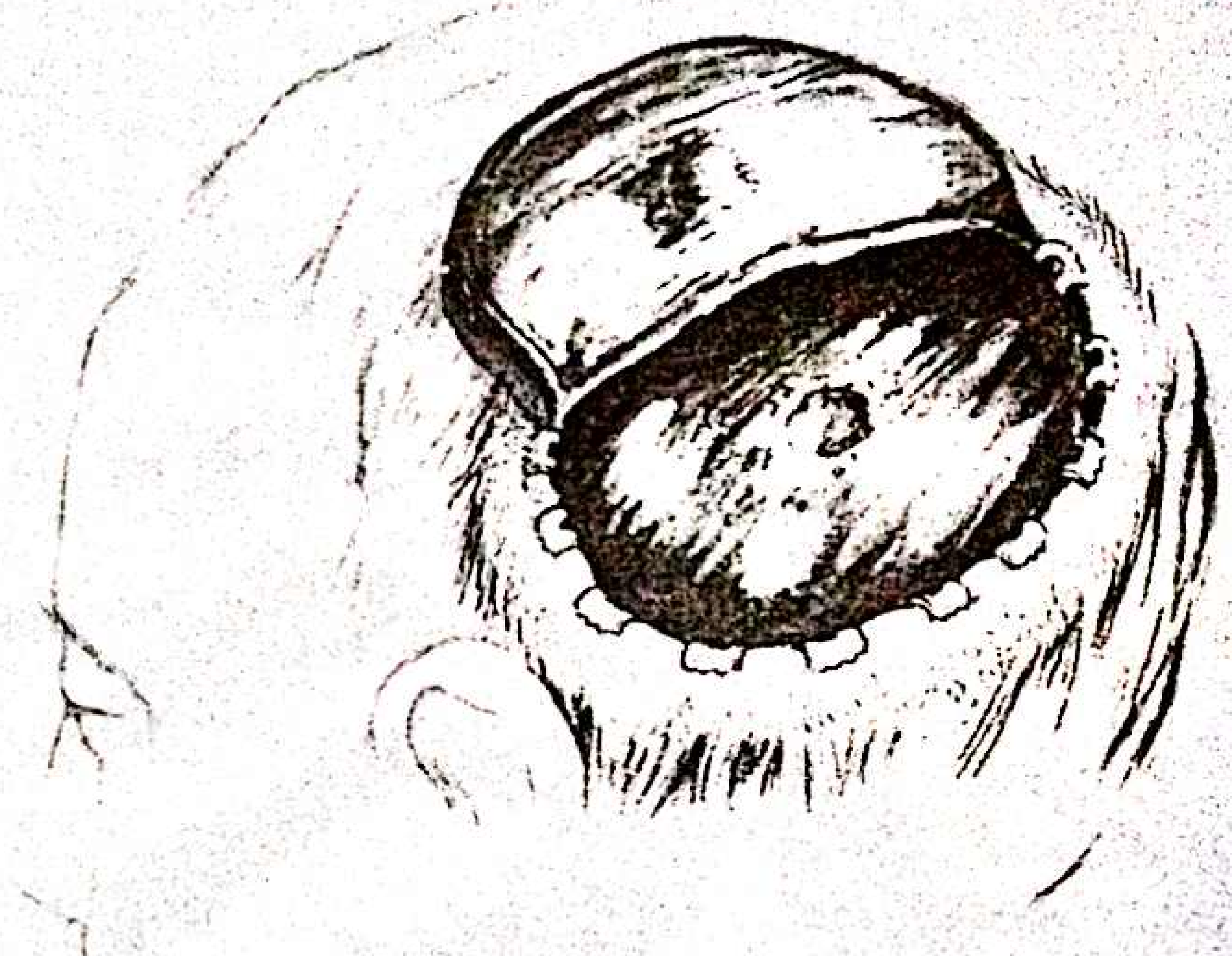
The flap of tissue encircled by the incision, containing the tumour, is elevated in the plane between galea and pericranium. During elevation, a watch is kept for a change in the way it strips from the pericranium, change being suggestive of tumour having spread across the interface. The surface which is exposed, pericranium or temporal fascia, is carefully inspected for a break in the uniformity of its surface, particularly at any point where a change in stripping behaviour was observed. The galea on the deep surface of the resected tissue is similarly examined for any local change in its surface layer.

In the absence of signs on either surface, it can be assumed that the tumour has not reached the galeal layer, although this should be confirmed by the pathologist.

15

When a break in the pattern of one surface is found, a comparable break is usually seen on the other, the two coinciding in position, and such a finding should be regarded as clear evidence that tumour has crossed the interface between them.



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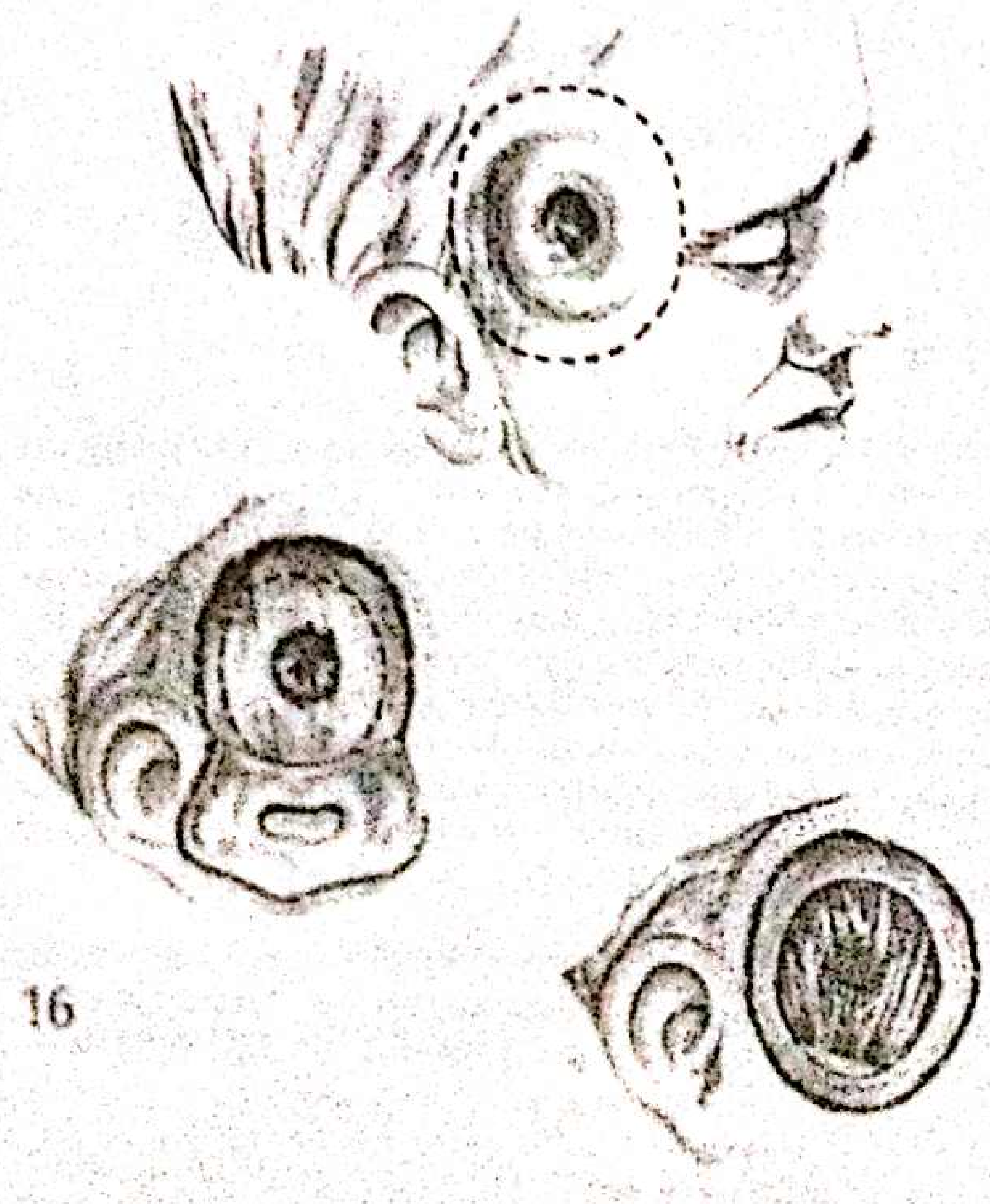

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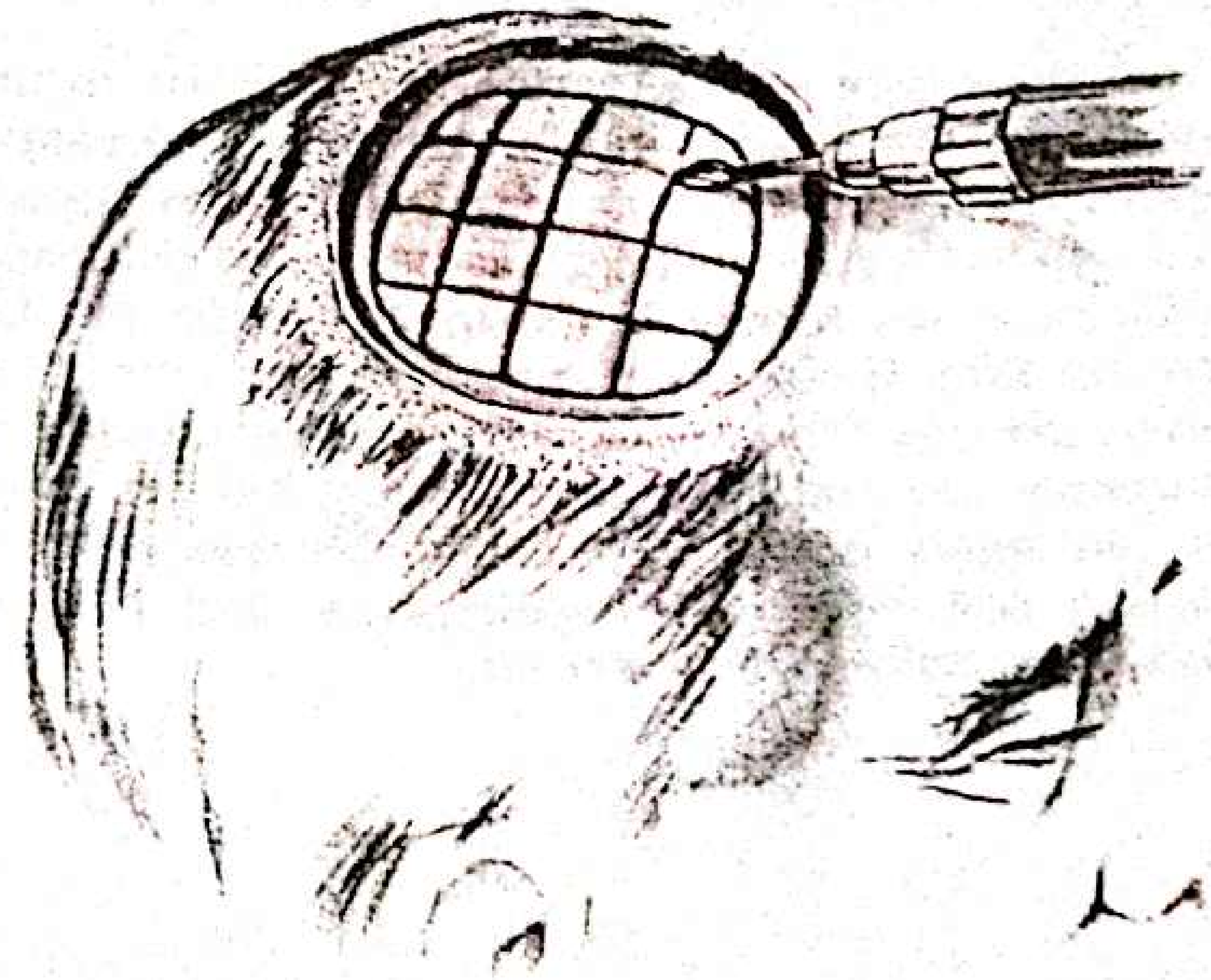
If the site involved is over the temporal fascia, the area of deeper involvement is resected with adequate clearance marginally, watching the surfaces exposed at the interface between fascia and muscle, resection being deepened further if necessary.

When it is considered that there is involvement of the pericranium by tumour, even if the involvement appears minimal, it is not sufficient to scrape it off the bone, even though the bone laid bare looks normal. Stripping the pericranium in such circumstances might be acceptable if it were technically feasible to skin-graft the resulting bare bone, since any residual tumour would show itself before it had progressed significantly. Bare cortical calvarium, however, requires flap cover, and it is the difficulty of detecting tumour deep to a flap at a sufficiently early stage which makes mere stripping of the pericranium in such circumstances unacceptably hazardous. The area requires to be resected. In this respect the calvarium differs from the hard palate because, as described in the chapter on 'Upper alveolus and palate', pp. 283–296, hard palatal bone accepts a skin graft, and as a result stripping of the bone and examination of the exposed surface, with skin grafting of the defect, is an acceptable approach.

The question then arises concerning the form which resection should take and its depth. Where involvement in depth is obvious the solution is clear-cut; the difficulty arises when involvement appears to be minimal.

If involvement appears minimal or the bone looks clinically normal, removal of the outer layer of cortical bone using an osteotome, over an area which ensures marginal clearance, is likely to be adequate, and in practice is probably the procedure most frequently carried out.



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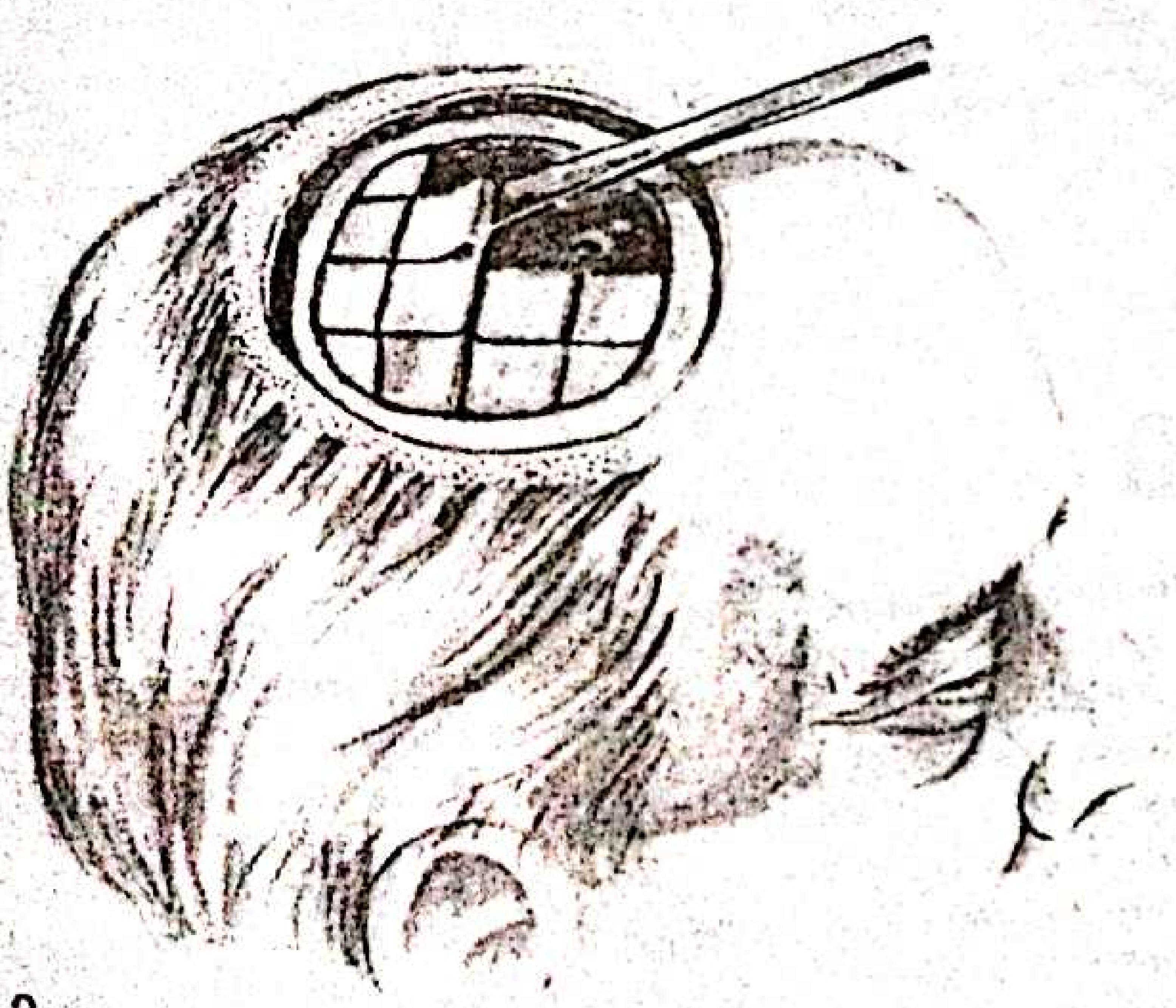
When the decision has been made to restrict bone resection to the outer cortex, the area is divided into squares by making narrow troughs in the cortical bone, down to the diploe, using a contouring dental burr.



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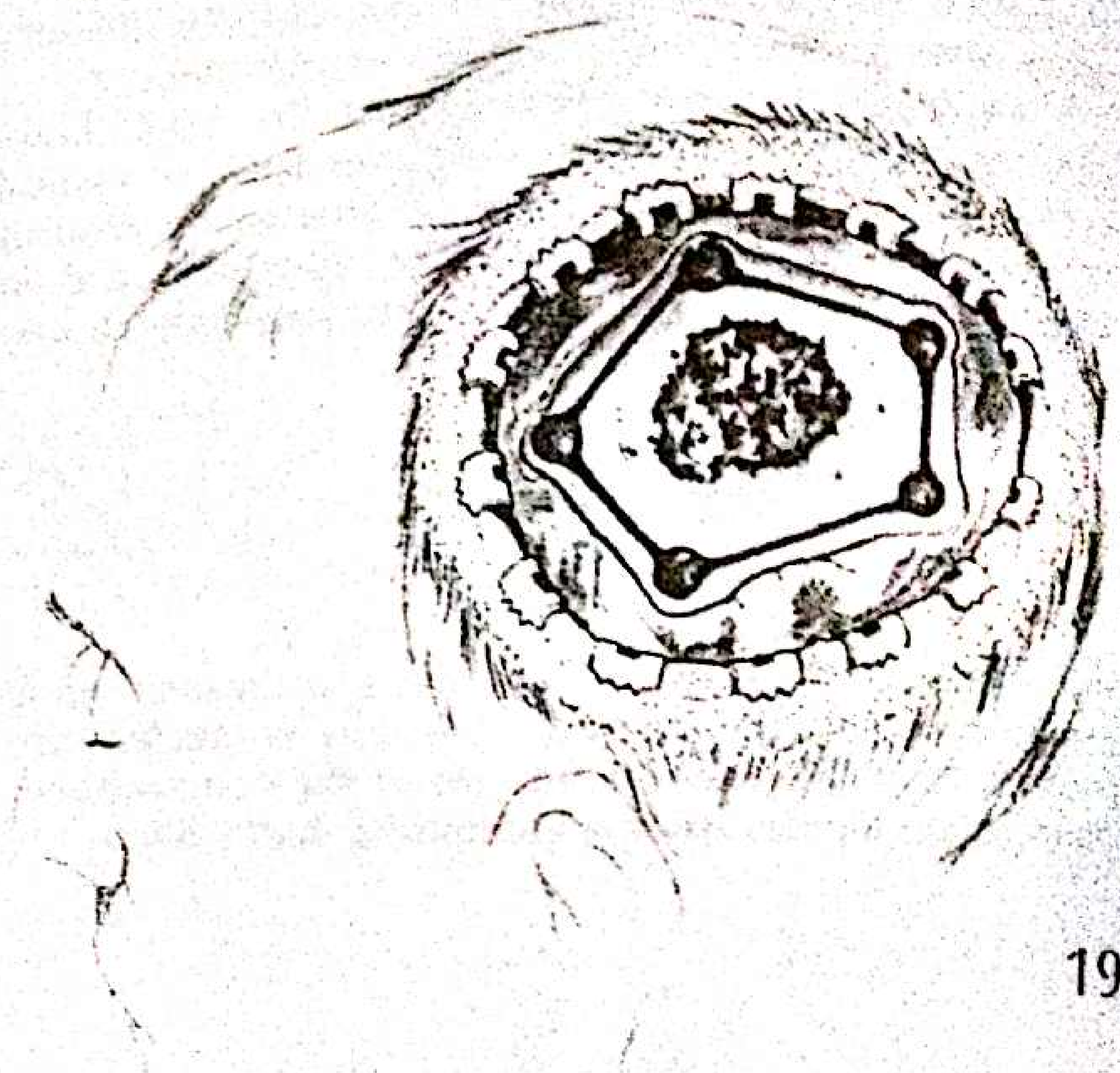
The squares of bone are removed individually using the osteotome. The virtue of this technique is that it generally achieves a greater degree of consistency of level of resection, and leaves a smoother surface.

The unsatisfactory aspect of resecting bone in this way lies in its lack of precision, and the difficulty of monitoring its adequacy by histological examination. Frozen section is not feasible, and even a subsequent report from the pathologist when the bone has been decalcified cannot be regarded as totally reliable.

19

The alternative is to remove the entire thickness of the calvarium over the suspect area, and if bone involvement is regarded as more than minimal it is the appropriate procedure. The bone resection may be carried out using an osteotome and rongeur, nibbling the bone off the underlying dura. The alternative method uses burr holes joined by saw cuts. Provided both methods are carried out scrupulously, the end result is the same, but the latter allows an intact piece of bone to be removed for inspection and histological examination, and in that respect is generally to be preferred.



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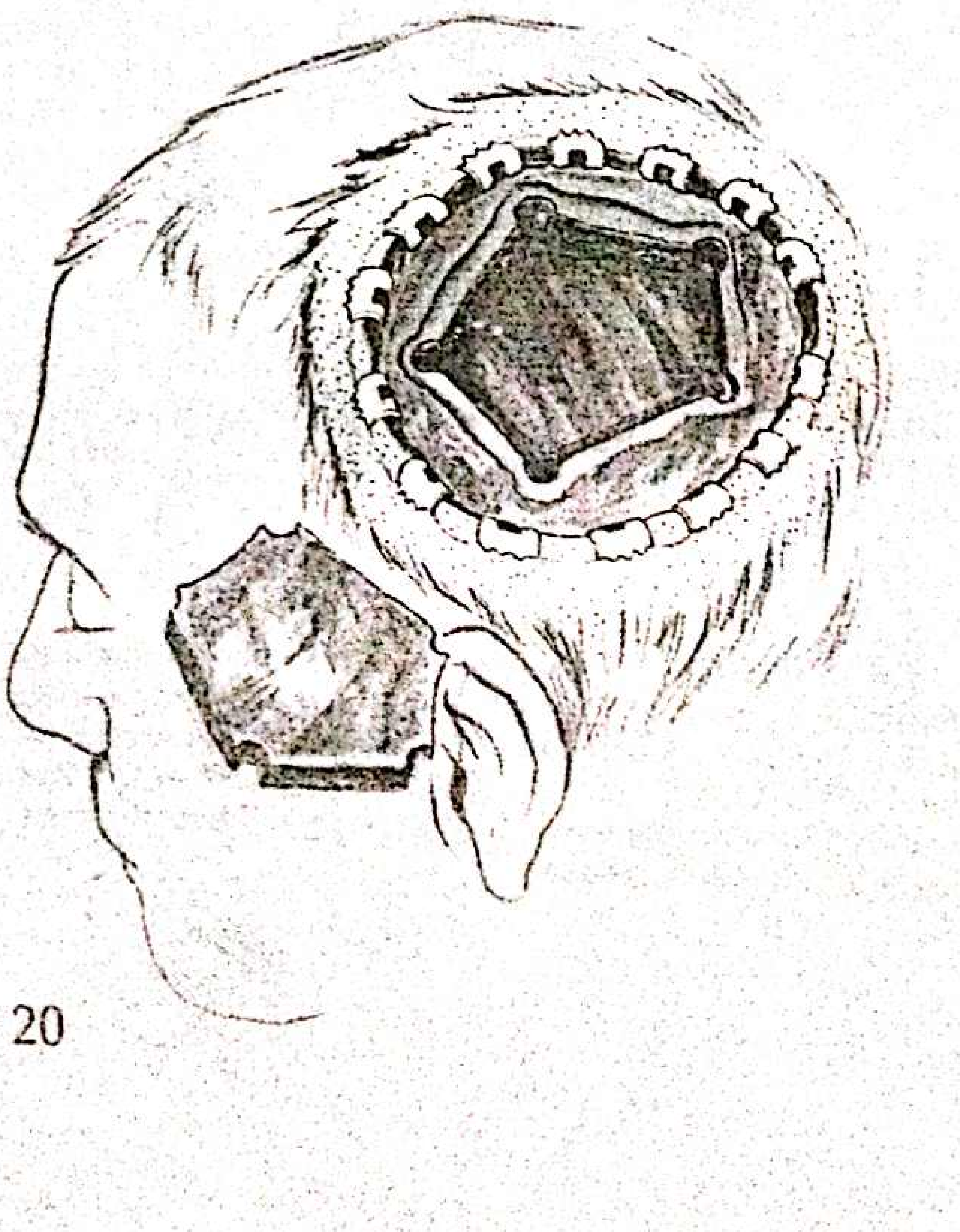

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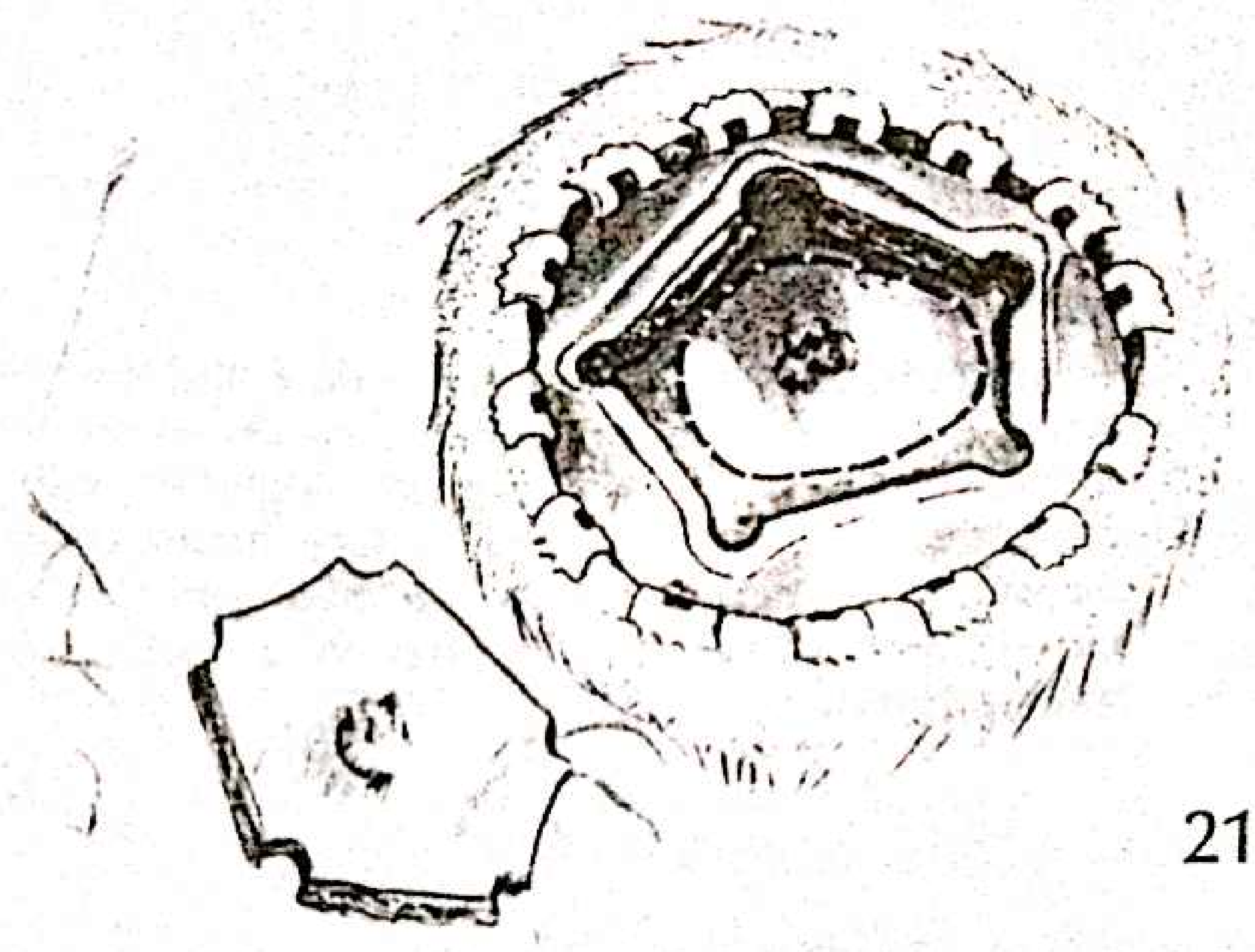
If the tumour has not extended deeply to involve the dura, the bone should strip cleanly off it, and the deep surface of the bone which has been removed will have the uniform appearance of normality, as should the exposed dura.

21

When dura is involved by tumour, both it and the inner layer of cortical bone are likely to show signs of tumour and this calls for resection of the involved area, with suitable marginal clearance.

The ease or difficulty of this depends on the site. Outwith the sites of the venous sinuses, removal of involved dura presents no significant problem, and does not call for neurosurgical expertise. It is in the vault particularly, where the sagittal sinus and its lateral lacunar extensions are liable to be opened if dura is resected, that neurosurgical assistance is essential. Indeed, when a full-thickness bone resection is under consideration, and dural resection in the area of a venous sinus is a possibility, a neurosurgical presence is desirable from the outset.



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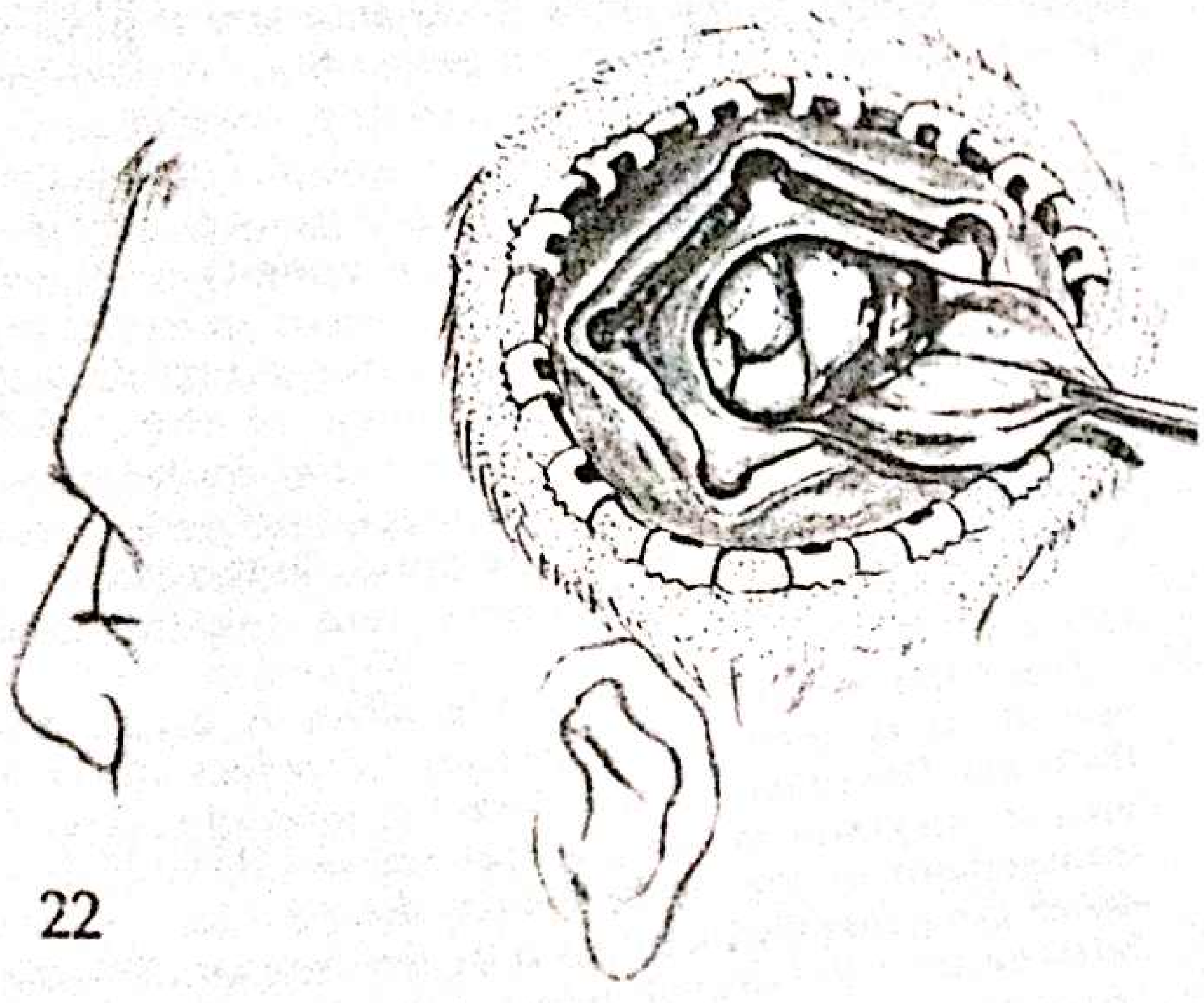

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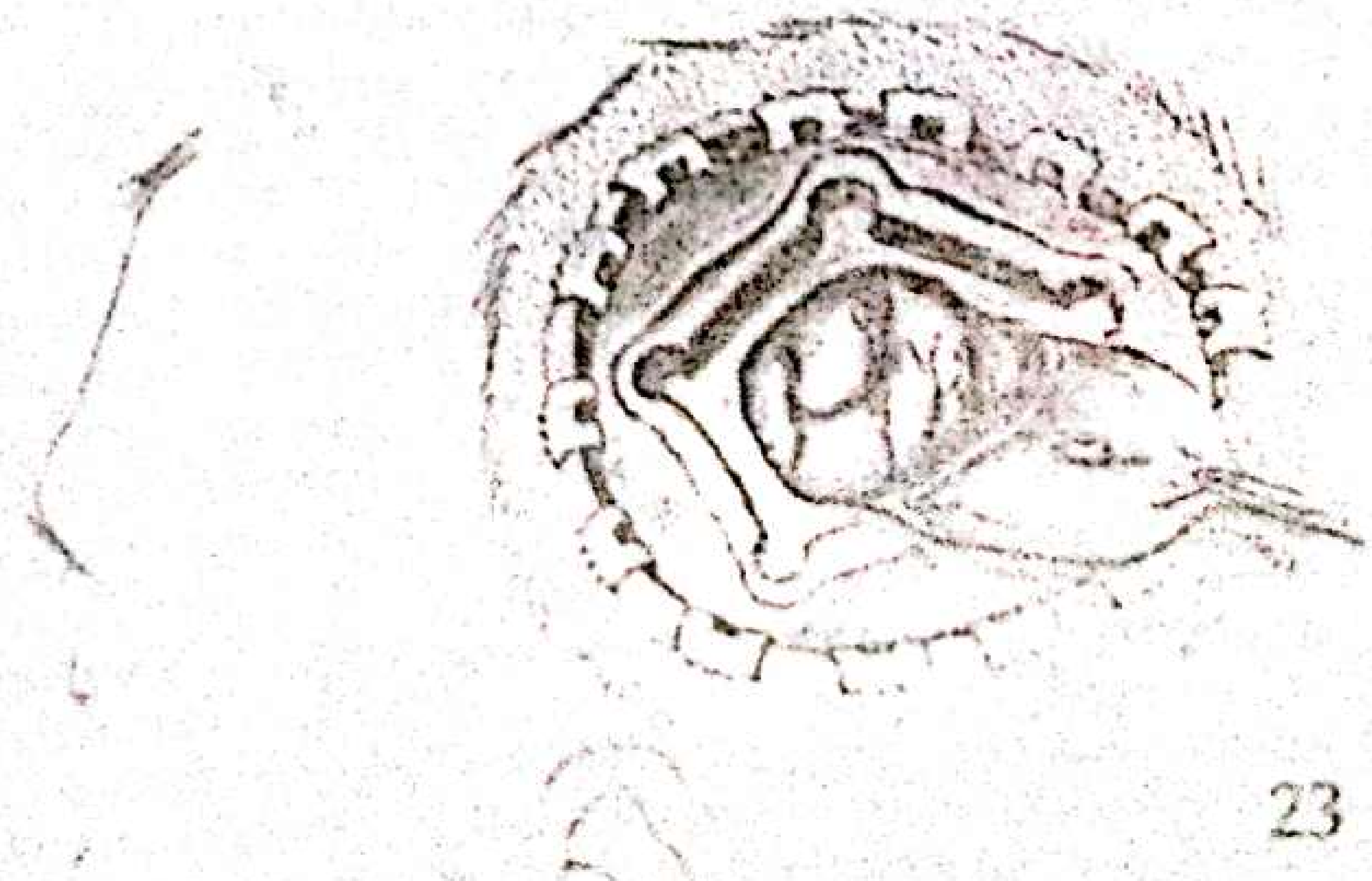
When dura has been resected, the obvious concern of the surgeon is whether tumour has extended to the cortex of the brain. This is not difficult to gauge clinically, since the dura lifts off the brain surface cleanly if the latter is uninvolved. The smoothness of the dural surface and the orderly appearance of the exposed brain also permit of a readily made clinical assessment.

23

The situation may arise where there is a nodule of tumour present on the deep surface of the dura, which is clearly not adherent to the cerebral cortex, witness the fact that the dura has lifted cleanly, leaving an uninvolved cortex. Such a finding implies that the interface between the two has not been crossed.



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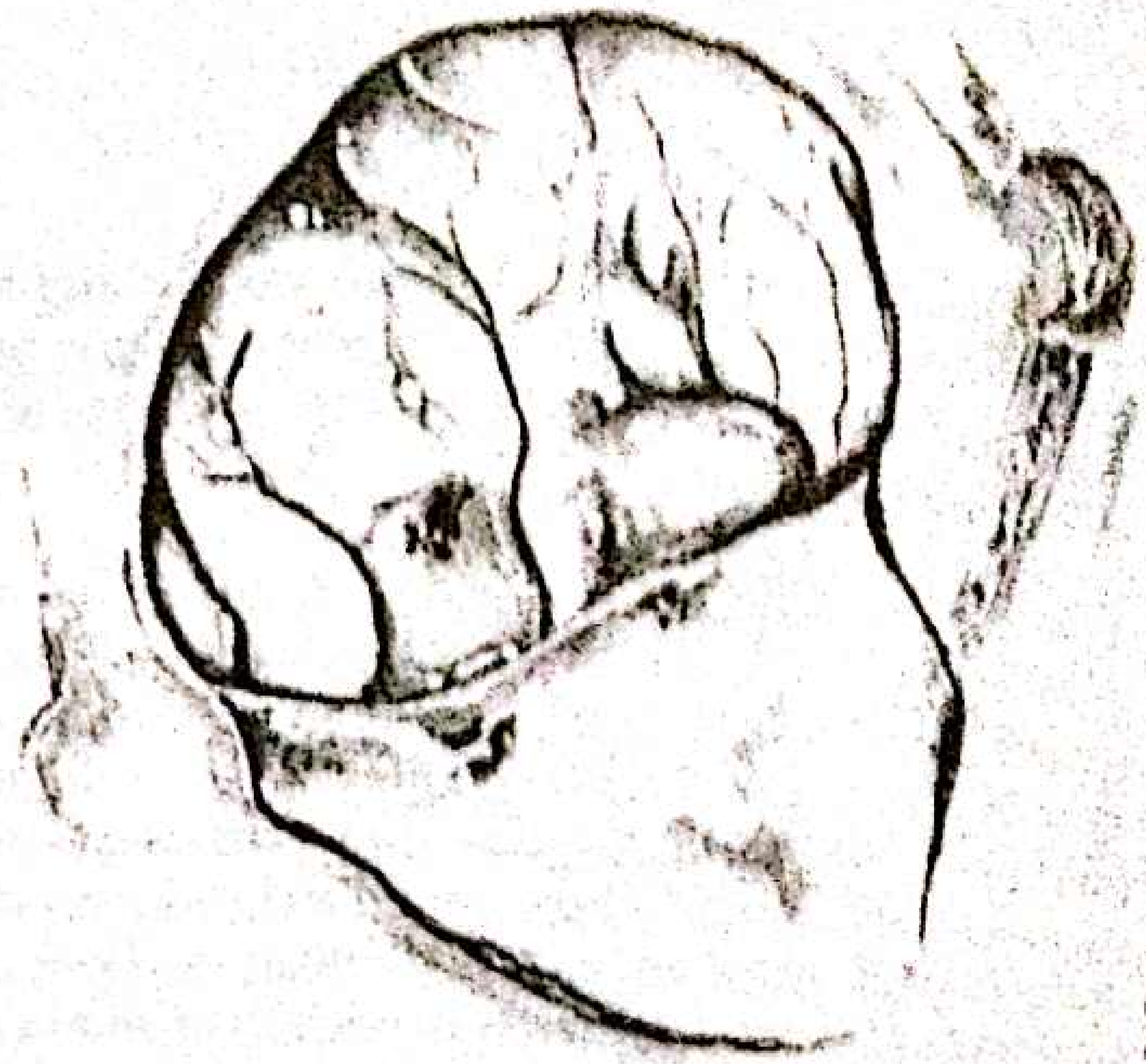
An area of adhesion between the dura and the cerebral cortex with haemorrhage from the cortex where the two surfaces have been pulled apart, together with local interruption of their normal surface appearances, are presumptive evidence of brain involvement. Possible involvement of the brain cortex is a matter for the neurosurgeon.



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Forehead

In the forehead, the problems presented in the resection of tumours, and the manner in which they are managed, are largely similar to those of the scalp, particularly when there is infiltration deeply, and the frontal bone, dura mater and brain are potentially involved, although the presence of the frontal sinus adds a complicating factor. The minor differences involve the more superficial tumours, and they result from the change in the characteristics of the subcutaneous tissues and the replacement of galea by the frontalis muscle.

Instead of the tissues superficial to the pericranium being managed as a single layer, as in the scalp, the mobility of the forehead skin and the presence of frontalis make it possible to handle each layer independently. The planes which separate them are not all natural ones, but with care they can be created surgically, making it possible to carry out excisions at a depth which includes the frontalis muscle or leaves it intact, depending on the deep extent of the tumour. In practice, the plane superficial to frontalis is only used when the tumour is small and clearly superficial.

The presence of the frontal sinus influences the resection of forehead skin tumours overlying it when the question of deep extension arises. The lateral and upwards extent of the sinus is variable and it is for this reason, rather than in order to assess bony involvement, that a radiograph or scan is desirable. Involvement by tumour which is recognizable on scan or radiograph is likely to be already obvious on clinical grounds, and in any case the final assessment is made at operation. Where a preoperative scan has its greatest value is in establishing involvement of the posterior wall of the sinus, since this finding implies potential involvement of the anterior cranial fossa, and is likely to alter the entire surgical approach to the problem, converting it into a craniofacial one, managed along the lines described in the chapter on 'Tumours involving the anterior and middle cranial fossae'.

When the anterior wall of the sinus is involved by tumour, it is generally necessary to resect its entire thickness. The extent of the resection required to clear the tumour marginally is likely to determine the form which management of the bony defect should take. A small defect can generally be bridged by the flap which is used to reconstruct the overall defect, but where the defect is larger it is preferable to remove the entire outer wall of the sinus, saucerizing the cavity and stripping the mucosal lining so that the flap will adhere to the posterior bony wall. The effect is to leave a hollow and this may require subsequent correction.

General considerations

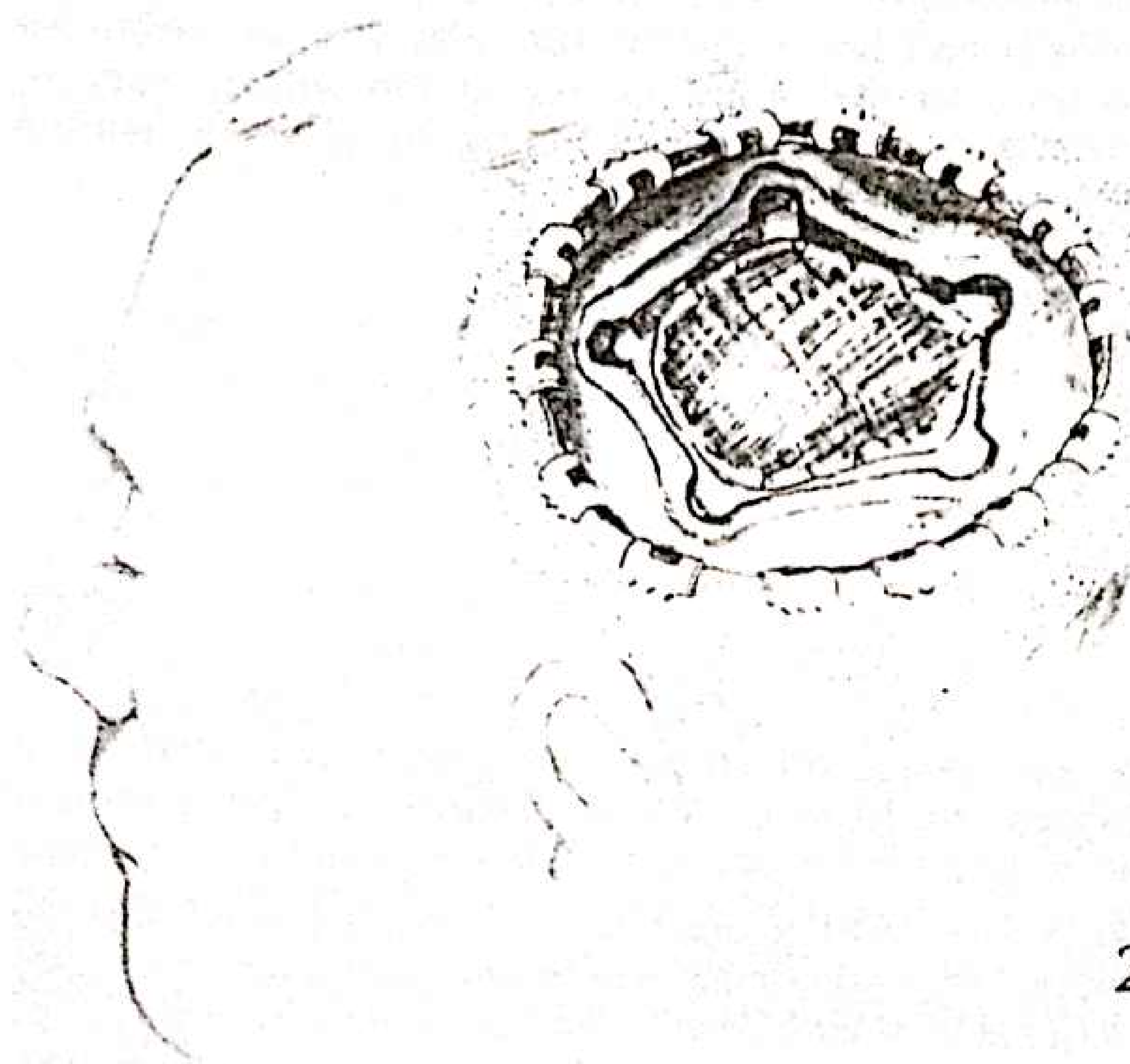
The surfaces which may be exposed in the sequence of resection vary in their reconstructive requirements. Pericranium, temporal fascia and temporalis muscle are all capable of accepting a free skin graft. Occasions may arise where a flap is preferable on cosmetic grounds, but grafting remains available. Bare cortical bone lacks sufficient vascularity to be graftable. Diploe can be successfully grafted but, with the irregularity of the surface usually left when the outer layer of cortical bone has been removed, patchy take of the graft is common, with a tendency to subsequent instability because of the lack of cushioning between the graft and the bone. This can make for difficulty in assessing the presence of recurrent tumour.

A flap is mandatory where the bony resection involves the entire thickness of the calvarium and dura is exposed. In addition to providing more effective protection for the brain, the use of a flap makes it possible to reconstruct the bony defect at a later date.

25

Exposed cerebral cortex covered with pia–arachnoid clearly requires flap cover, but a separate replacement for the dural defect is also required. This usually takes the form of an autograft of fascia lata or temporal fascia, sutured to the margin of the gap in the dura.

Where brain substance has been resected, the decision regarding the form which the immediately overlying cover should take is best left to the neurosurgeon.



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Skin cover

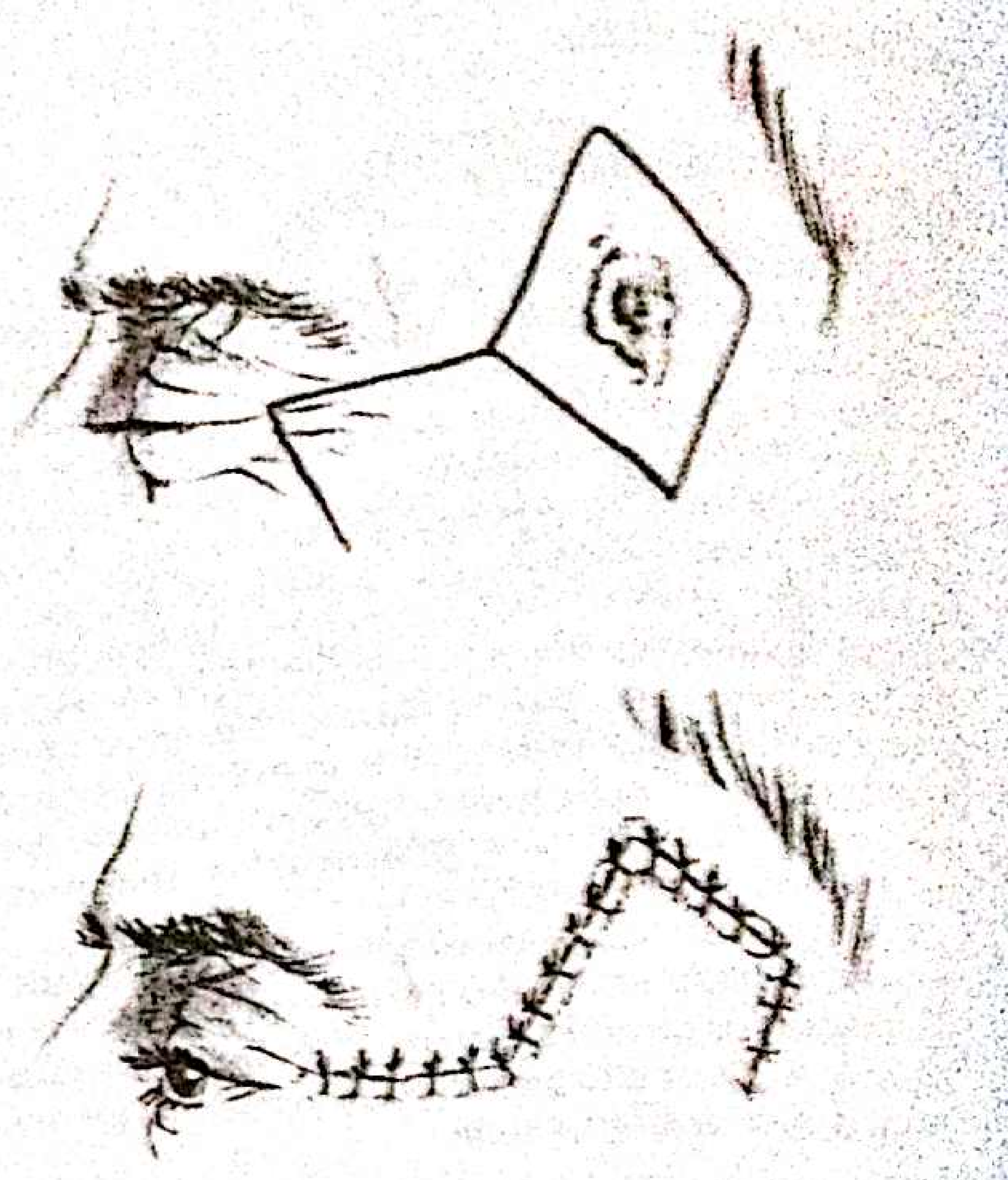
Direct suture

In the scalp, the use of direct suture is limited to small defects because of the rigidity and inextensibility of the galea and superficial fascia. In the bald scalp the added tightness reduces its role still further. No reliance should be placed on achieving any additional relaxation by mobilizing the scalp widely on each side, and this applies also to the making of multiple slits in the galea, despite the regular advocacy of this procedure in the surgical literature. Fortunately the scalp tolerates coarser suture material than the face, and with suture marks not presenting a hazard, closure under a greater degree of tension than would be acceptable elsewhere is permissible.

When excisions are being planned in the forehead, a factor of considerable importance concerns the need to maintain the eyebrow at its correct level, and this has the effect of placing a significant restriction on the amount of tissue which can be excised in a horizontal plane. A further factor which determines the breadth of the horizontal ellipse which can be excised without creating asymmetry of the eyebrows is its level on the forehead. The anchorage of the skin to the frontal bone increases as the anterior hairline is approached, and the higher the horizontal ellipse on the forehead, the less likely it is to raise the level of the eyebrow, unless the surgeon is unwise enough to undermine the skin between the two.

Where the forehead has a well developed wrinkle pattern, the best result is generally achieved using a vertical excision, provided care is taken to match the wrinkle line pattern on each side of the suture line. The forehead also tolerates greater tension across the suture line than one might expect, and sutures can be left in position for longer than generally regarded as ideal without significant adverse effect, any suture marks merging into the wrinkle pattern to become surprisingly unobtrusive in the long term. Mobilization of the frontalis muscle does allow some advancement, but the amount is generally disappointing.

Towards the glabellar area, broader ellipses can be excised because of the recognized local availability of skin, as evidenced by the vertical wrinkle pattern in that area.



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In the temple a regularly recurring difficulty arises because of the need to maintain the relative positions of the anterior hairline and the eyebrow, and it is in solving this problem that the rhomboid flap has perhaps its most valuable role, as discussed in the chapter on 'Reconstructive techniques of the skin', pp. 45–103. There is a skin availability lateral to the outer canthal area, as evidenced by the presence of the 'crow's foot' wrinkle pattern, and the virtue of the flap lies in the way in which it alters the position and line of the defect which results from the excision, so that it makes use of the wrinkle pattern, allowing closure without distorting the eyebrow–hairline relationship.

Free skin grafts

When the defect is small and in a site which is normally visible, the postauricular whole skin graft gives a generally adequate cosmetic result. For larger defects a split-skin graft is usual. The bolus grafting technique is usual for the whole skin graft; the split-skin graft may be applied either using the bolus or the delayed exposed method. The latter method as used in this site is described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, and has a good deal to recommend it. It avoids the problems which may arise in bolus grafting by the over-zealous application of pressure over the unyielding bone. The only serious complication which is liable to arise when delayed exposed grafting is used is that of 'drying out' of the pericranium. This can occur with extreme rapidity under the heat of the operating room lamp, and results in an area of bare cortical bone, with the problems of providing cover which ensue. Prophylaxis involves the protective application of an occlusive dressing, such as multilayer paraffin gauze, as soon as the defect is created.

The cosmetic result achieved by the split-skin graft, whether it is used to reconstruct a postresection defect or to cover the defect left by the transfer of a local flap used for the same reason, is seldom cosmetically satisfactory. Its ultimate colour is unpredictable, paler than the surrounding skin or, more often, hyperpigmented. If the frontalis muscle has been resected, the graft also lacks movement and this is very noticeable. The depth of the defect may not be matched by the thickness of the graft, and an obvious hollow results. In the forehead, all of these are factors which may limit its acceptability. In the scalp, the area of the graft is of course devoid of hair.

Tissue expansion

It is in the alleviation of this unsatisfactory situation that the use of tissue expansion has allowed the cosmetically poor forehead graft to be removed or, in the scalp, to be replaced with hairbearing skin. The technique, which is discussed in detail in the 'Plastic Surgery' volume of *Operative Surgery*, involves the placing of a silicone prosthesis with the form of an 'uninflated balloon' deep to the skin and superficial fascia. At intervals over a period of weeks, the prosthesis is slowly inflated by injecting saline into it under pressure, and as it increases in volume it creates a corresponding bulge in the skin overlying it, expanding it considerably in area. When adequate expansion has been achieved, the prosthesis is removed, and this has the effect of converting the bulge of the skin into an area of redundancy, which is used to reconstruct a defect in the immediately adjoining area.

The technique has proved most effective when the contour involved is convex, and overlies a firm base, ideally bony, conditions met in both the scalp and the forehead. In the scalp, it is used to expand an area of hairbearing skin to replace an adjoining hairless area. In the forehead, its main role is to allow the elimination of the otherwise permanent, and extremely obvious, patch of the split-skin graft which was used either as a primary reconstruction or, more frequently, as cover for the defect left by the transfer of a forehead flap.

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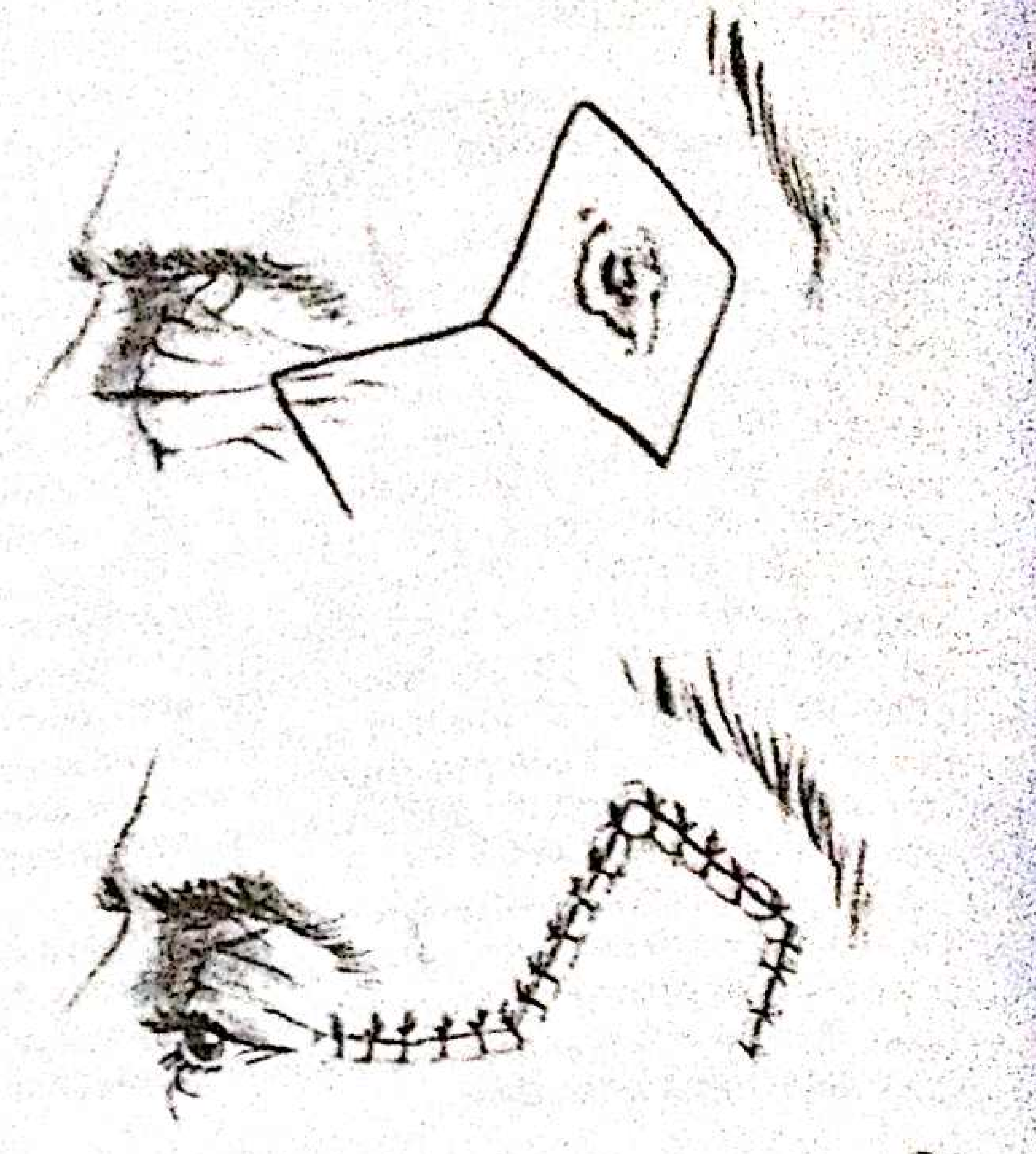

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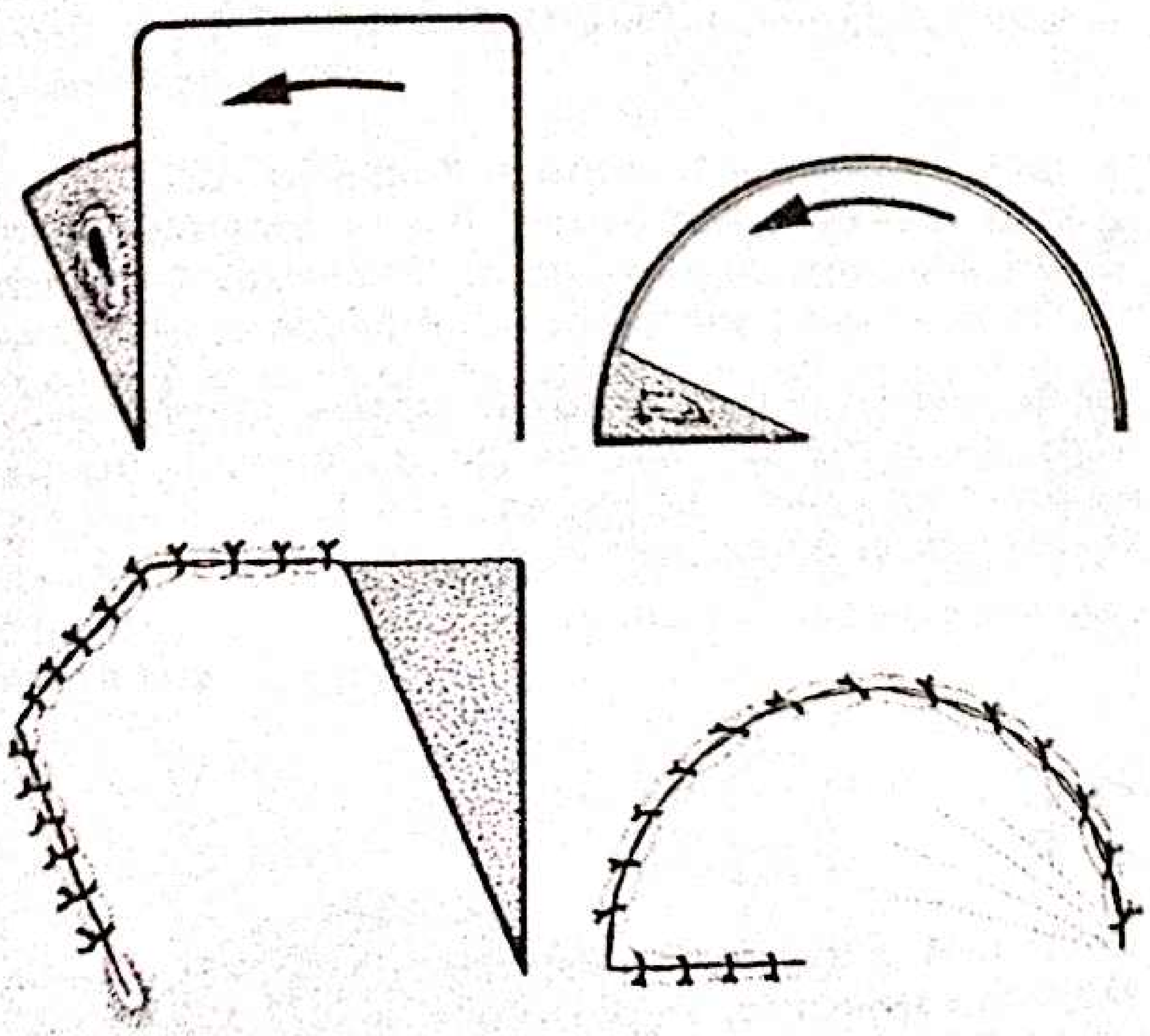
Flaps

The flaps which are used to reconstruct scalp and forehead defects make use of local sources or bring tissue from a distance, the deciding factor in selection generally being the size of the defect. The smaller defects are reconstructed with local flaps, large defects requiring distant flaps.

Local flaps. The extent of the area which is available without the interference of anatomical structures makes it possible to design both transposed and rotation flaps of standard type, while remaining within the confines of the hairbearing area. The excellent blood supply of the site also gives them a safety which is greater than average, but whether the defect is of scalp or forehead, or a mixture of both, there is an overriding design requirement to ensure that the anterior hairline remains as the line of demarcation between the two at the completion of the reconstruction.

Local flaps which would have no credibility among plastic surgeons are regularly illustrated in the surgical literature by line drawings, and it is important to be aware that those which do not conform to the categories of transposed or rotation flaps, and which fail to demonstrably meet the design requirements described below, should be avoided. The principles which underlie both flap types are well established, but their use in the scalp area involves modifications of design, in the case of rotation flaps tightening the planning requirements, in the case of transposed flaps relaxing them.



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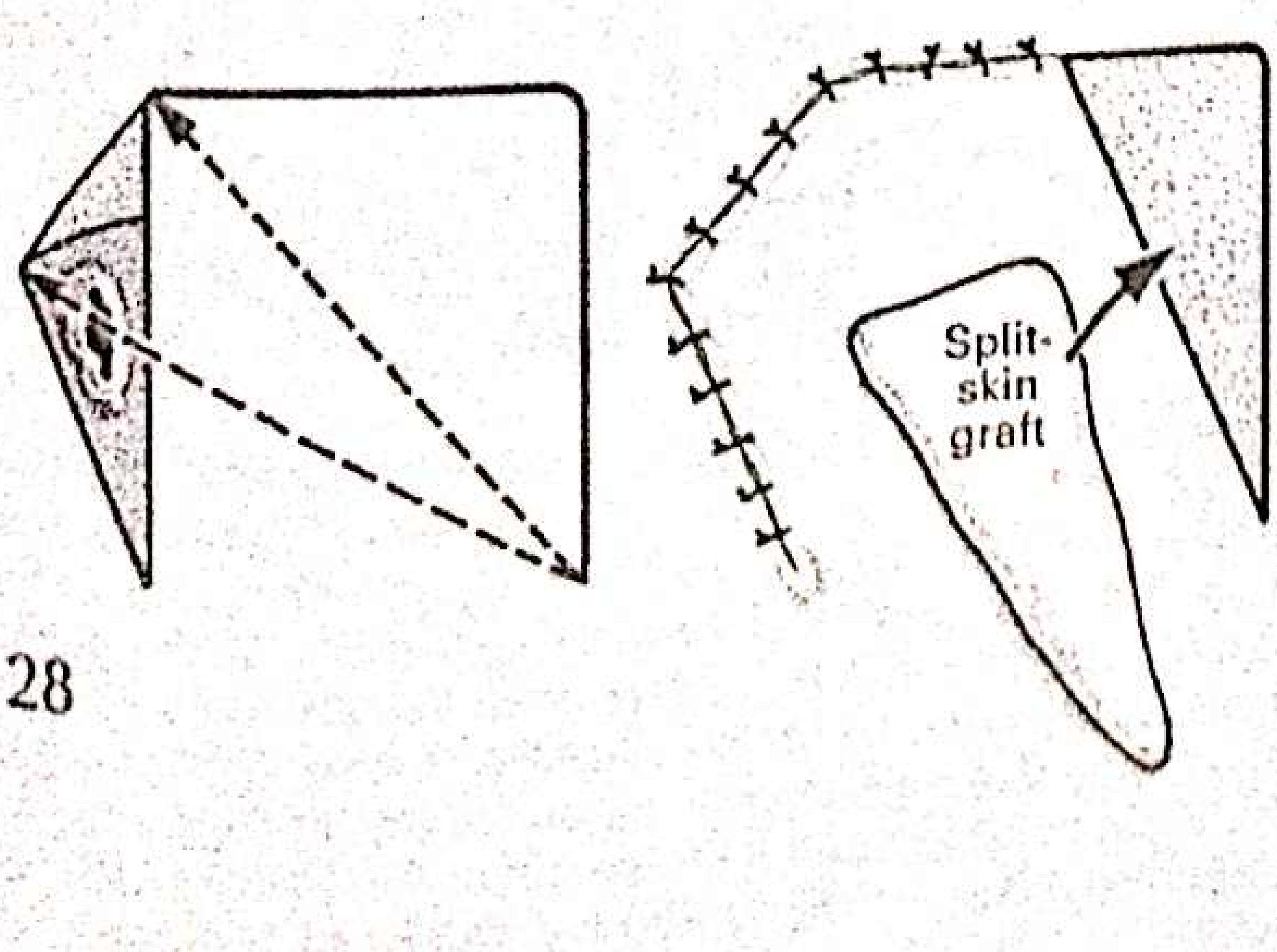
With both flap types, the defect necessary for the reconstruction is designed in the form of an isosceles triangle, extending the defect beyond that which was necessary to resect the tumour – 'triangulation of the defect'. The effect of transferring the flap is to move one of the equal sides of the triangle across the defect, thereby closing it.



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Transposed flaps raised in sites outwith the head and neck area are classically designed as a square because of the need to provide the flap with an adequate blood supply. Movement of the flap laterally closes the defect, but in the process leaves a secondary defect which is usually split-skin grafted. The point around which such a flap pivots in its transfer is not the apex of the triangular defect, as one might imagine, but rather the other side of the base of the flap. It is from this point that measurements are made in designing the flap, to ensure that, when transposed, it will reach and cover the defect.

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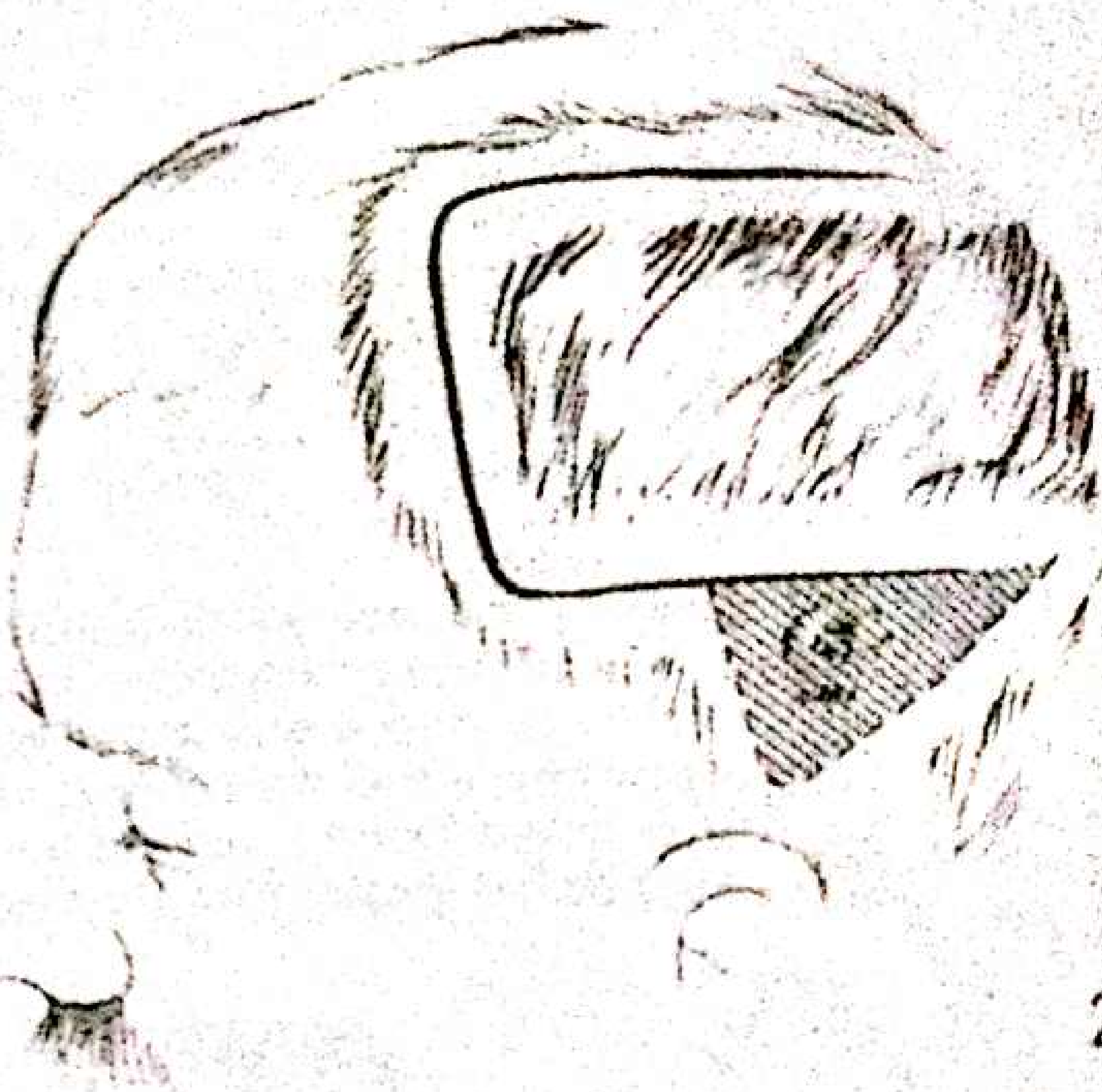
When the flap is designed in the scalp, a certain degree of relaxation of its geometry is permissible because of the excellent blood supply of the scalp in general, which allows flaps which are considerably narrower than their length to be raised and transferred safely.



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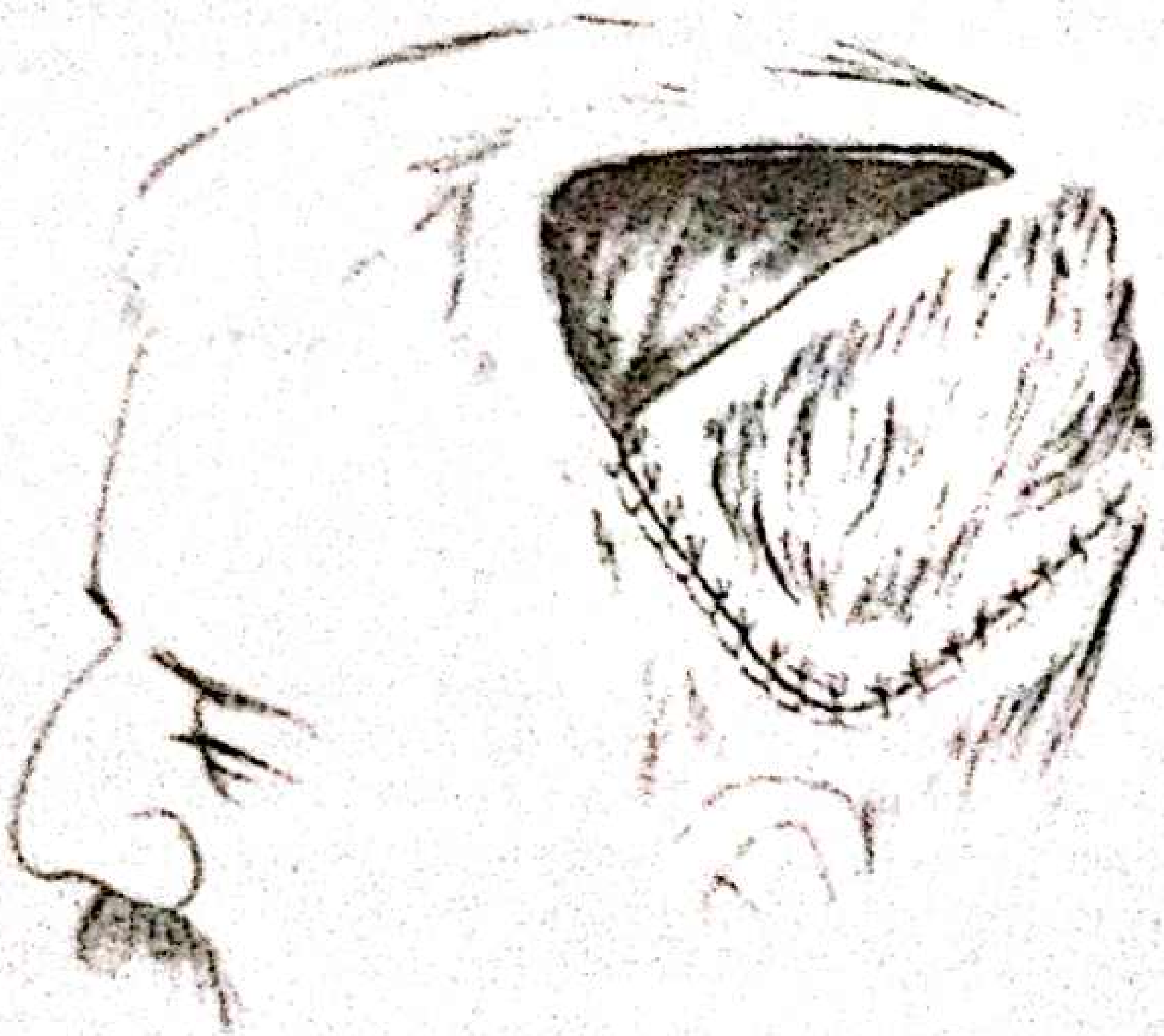

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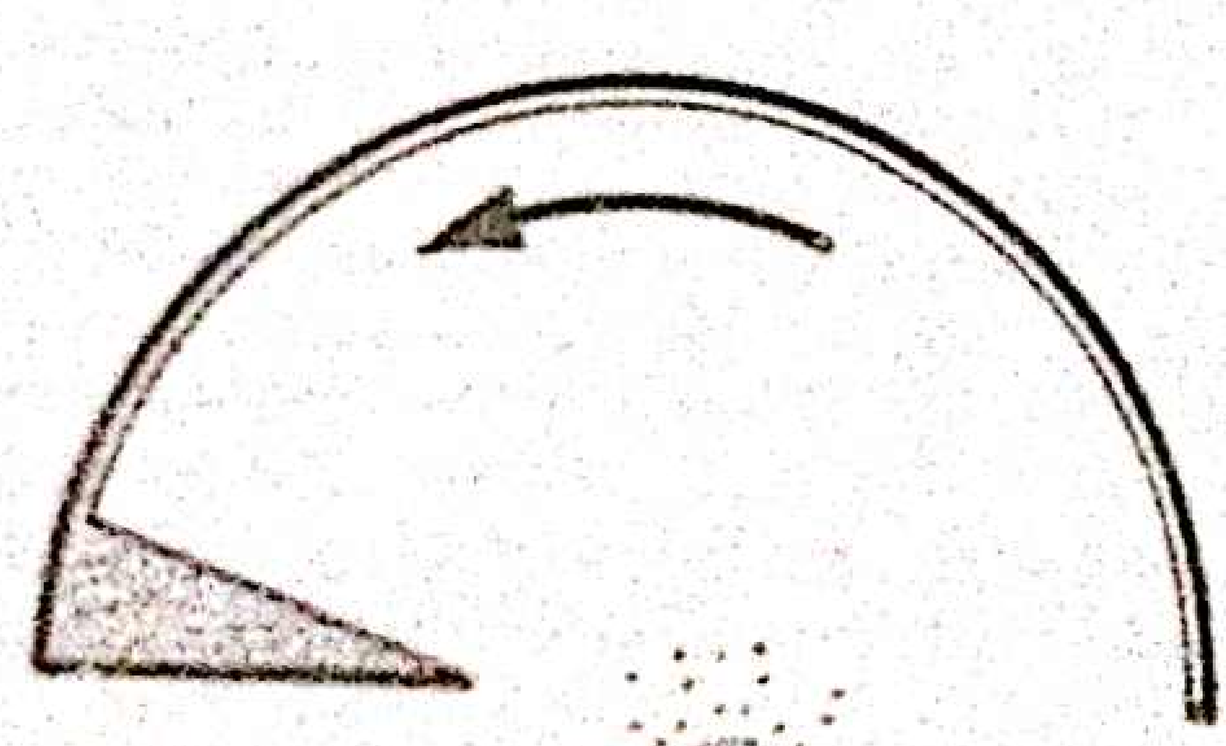
The narrowness of the flap can be increased further with safety when one or more of the anatomically named arteriovenous systems are recognized to be running along its long axis, as for example in *Illustrations 35* and *36*.



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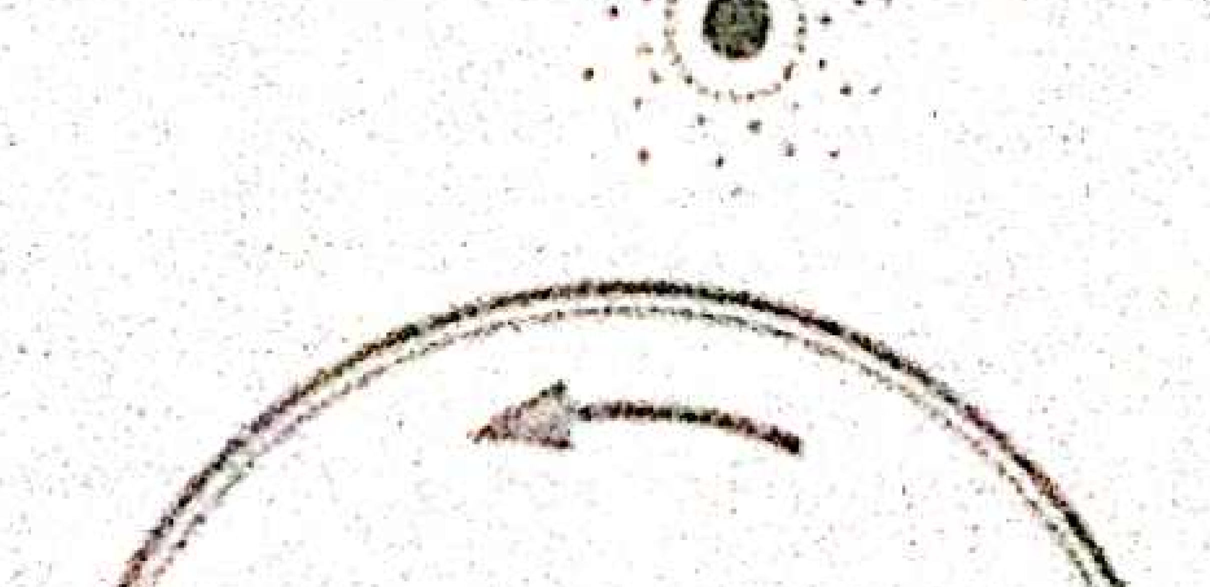
In the case of the rotation flap, the flap approximates in shape to a semicircle, and is rotated into the defect. Used where there is a degree of local tissue flexibility, the precise position of the point around which the flap rotates, although it is near the centre of the semicircle, remains somewhat vague because the tissues around the base of the flap also rotate to some extent along with the flap.



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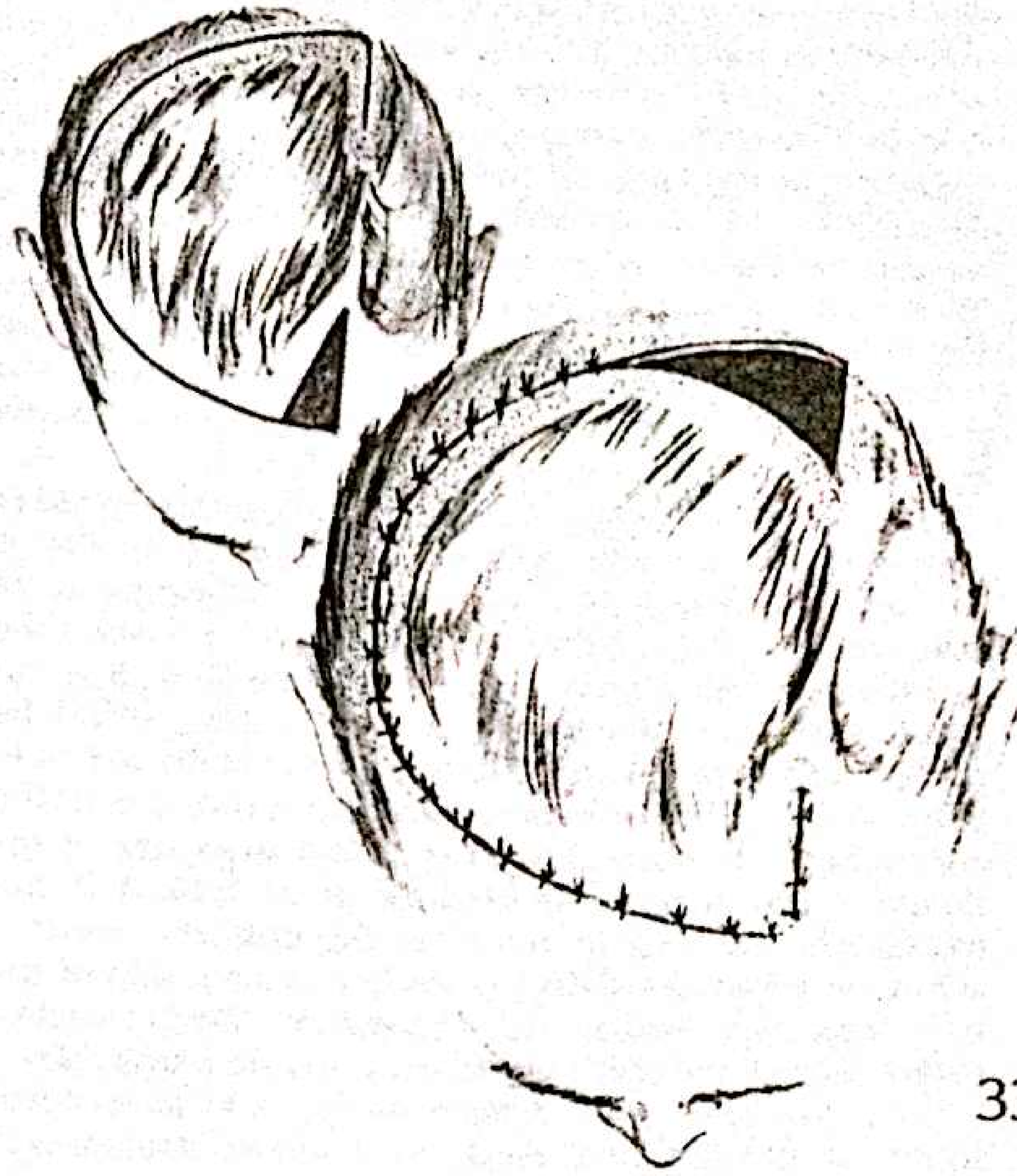
Where it is found that the flap will only rotate into the defect under an unacceptable degree of tension, the tension can often be reduced by making a 'back-cut' in its base. This has the effect of moving the site of the point around which the flap rotates towards the defect, and reduces the tension of the transfer. It also shortens the base of the flap, reducing its blood supply, and because of this it has to be used with discretion in sites other than the scalp. Its usage in the scalp and forehead is discussed below.

33

In the scalp, the rigidity of the tissues and the absence of extensibility set stringent limits on design, and these are added to by the fact that, with bone deep to the flap, 'sympathetic' rotation of the underlying tissues does not occur. The effect is to fix the pivot point firmly at the side of the base of the flap away from the triangular defect, and this adds considerably to the difficulties of design. It is in order to minimize the effect of these factors that, while avoiding unacceptable distortion of the hairline, the flap is made as large as possible in relation to the defect, reducing the amount of rotation per unit size of the flap.

The use of a 'back-cut' also allows the flap to rotate more easily, and moves the pivot point closer to the defect, reducing the tension which is set up by rotation of the flap into the defect. The limitations on its use elsewhere in the body do not apply in the scalp and forehead because of the excellence of the local blood supply, and it is used much more routinely. The secondary defect which is frequently created as a result is split-skin grafted if necessary.

In practice, with both transposed and rotation flaps, a strict adherence to the geometrical principles of flap design is desirable, with formal triangulation of the defect, care taken to establish the site of the pivot point of the flap, and scrupulous measurements taken from it to ensure that the distance from it to the various parts of the flap before the transfer are at least equal to the estimated distance required by the transfer, allowing for the relaxation provided by any back-cut. With transposed flaps, this is a straightforward matter, but with rotation flaps it is less simple.



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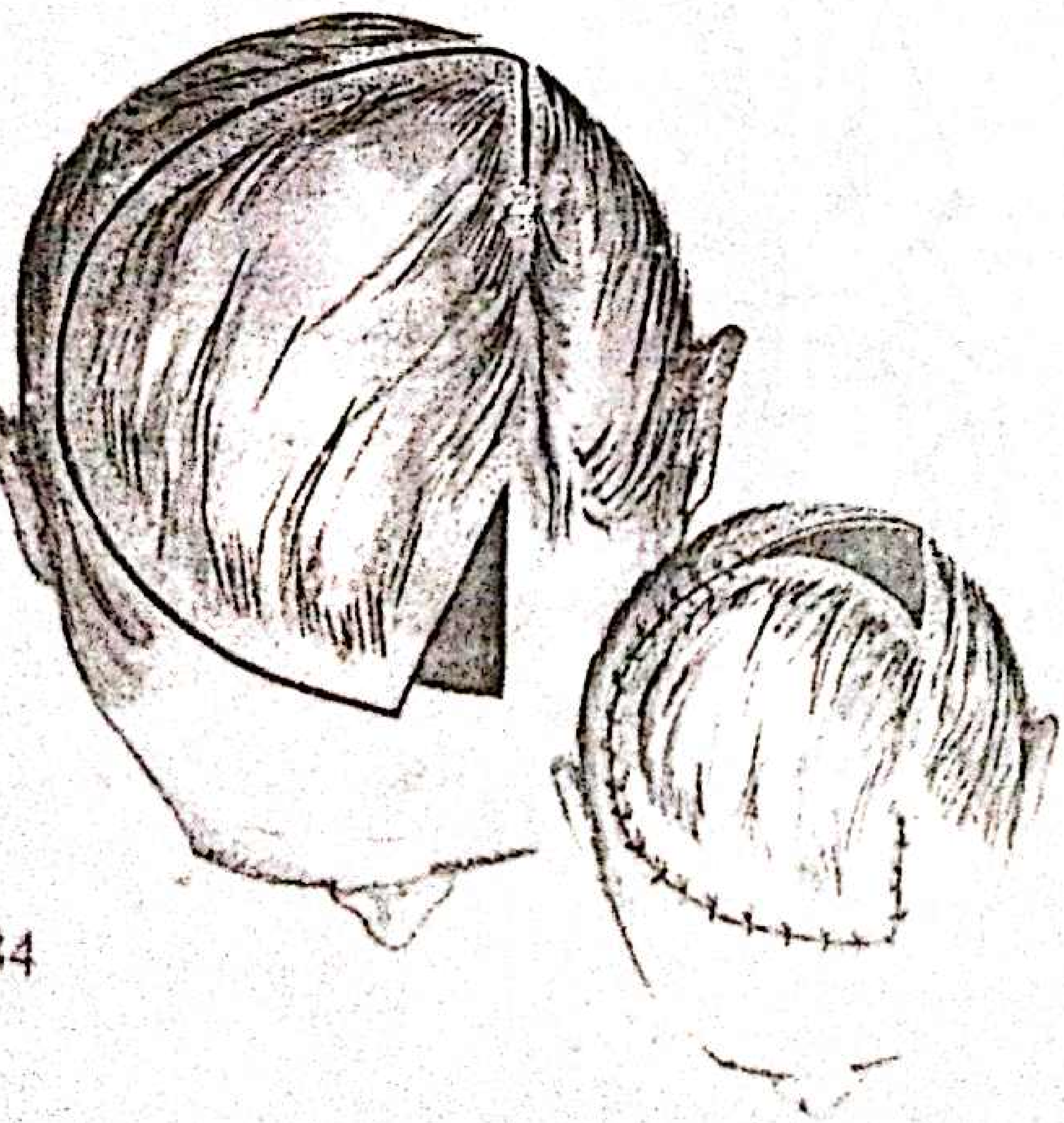

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Because of the difficulty of making these measurements with rotation flaps, a useful additional precaution in planning is to extend the length of the side of the triangle which is forming a margin of the flap.

In using the rotation flap it is particularly important that a flap of adequate size is constructed. The fact that the flap is too small is liable to be less apparent at the design stage, and be recognized only once it has been raised and the transfer attempted. Generous flap design is seldom a misguided exercise.

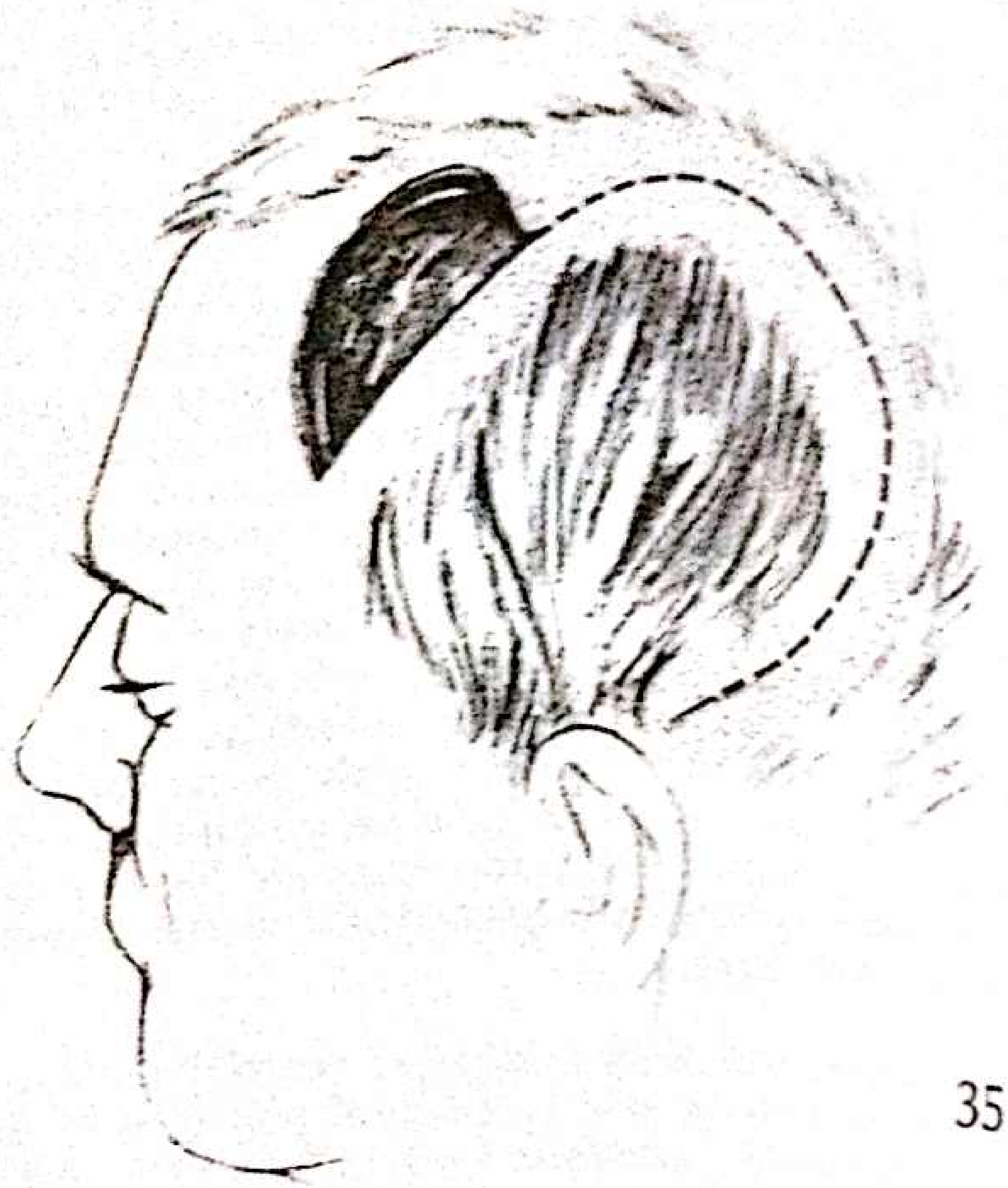
The site of the defect in relation to its size may create problems of flap design. The defect which is sited on one or other side of the sagittal plane leaves a large expanse of scalp available on which the flap can be planned, and the same is true of the defect of the anterior scalp or occiput. It is when the defect is central, both in the sagittal and coronal planes, that difficulties can arise, because the area of scalp on which one might design a flap is distributed around the defect, rather than concentrated on one side of it. The effect is to leave no single area large enough to accommodate an adequately sized flap.

When a local flap cannot be designed, or for any other reason is inappropriate, a flap from a distant source, either pedicled or free, has to be considered.

Distant flaps. Of the possible alternatives, the free flap allows of the greatest freedom of action to the tumour surgeon, in that the defect can be created and its dimensions established before the flap is designed. With the other techniques, this freedom is curtailed to a degree which varies in different circumstances. If the flap selected involves a multistage transfer, the flap has generally to be designed before the resection has been carried out. In the context of malignancy this is a very serious deficiency. When the lesion is of the forehead, a local hairbearing scalp flap might be transferred to cover the defect as a 'holding manoeuvre', while the definitive transfer is being prepared and carried out. Even so, the method is cumbersome and with the free flaps currently available it is unlikely to find favour.

Of the pedicled distant flaps which can be transferred in a single stage, the latissimus dorsi myocutaneous flap is the only one which has been shown to be capable of reaching the vertex of the skull, but in such a transfer the technique is being pushed to its absolute limit. It is not recommended; conversion to a free transfer would be preferable. If the decision has been made at the outset to use a free flap, the latissimus dorsi flap is only one of the alternatives. Its main virtue lies in the large size of the defect it can cover, but because of its bulk it is not necessarily the best in terms of the cosmetic result it achieves. When the defect is smaller in area, one of the free flaps described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, may be preferable.

In the forehead, small defects may be suitable for cover using the standard local flaps, but a serious limitation to the surgeon's freedom of manoeuvre is the presence of the anterior hairline.



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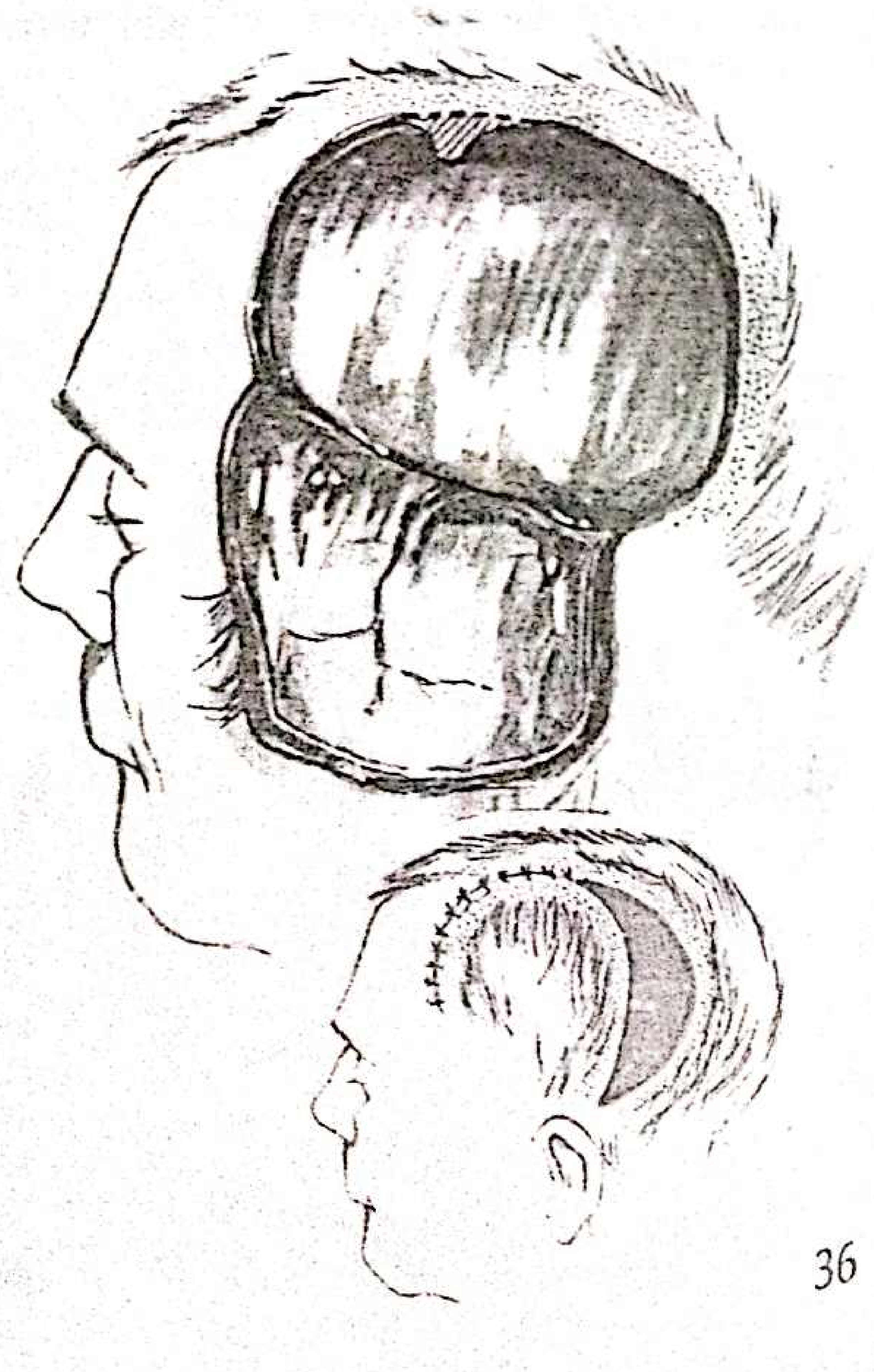
Where the patient has a male pattern receding temporal hairline, a potential solution is to design a flap which has the effect of moving the hairline forward, although not to a degree which gives rise to obvious asymmetry.



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When it proves possible to incorporate a named artery and vein in the flap, its safety is markedly increased.

When the defect can be triangulated vertically, it may be possible to design one or more rotation flaps. Depending on the site of the tumour on the forehead and its size and shape, the triangle enclosing it can have its apex either above or below.

37

In a suitable situation, when the apex is above, a rotation flap can be designed with its outline running laterally above the eyebrow, across the temple and horizontally backwards above the ear towards the occiput, and rotated forward to close the forehead defect. By extending the flap backwards as far as possible a secondary defect can sometimes be avoided, though a back-cut is generally necessary. The resulting defect of the occipital area may require to be split-skin grafted, but if a sufficiently large flap has been planned it is often possible to close it directly.

Where the defect is centrally sited on the forehead, and the triangle has a broad base, the procedure can be carried out bilaterally, each flap covering half of the defect, although backwards extension of each flap has to be limited so that an adequate pedicle is left. Such rotation flaps sensorily denervate the scalp within the convexity of the flap and, with the displacement of the ends of the divided nerves as the flap rotates, recovery of sensation cannot be assured.

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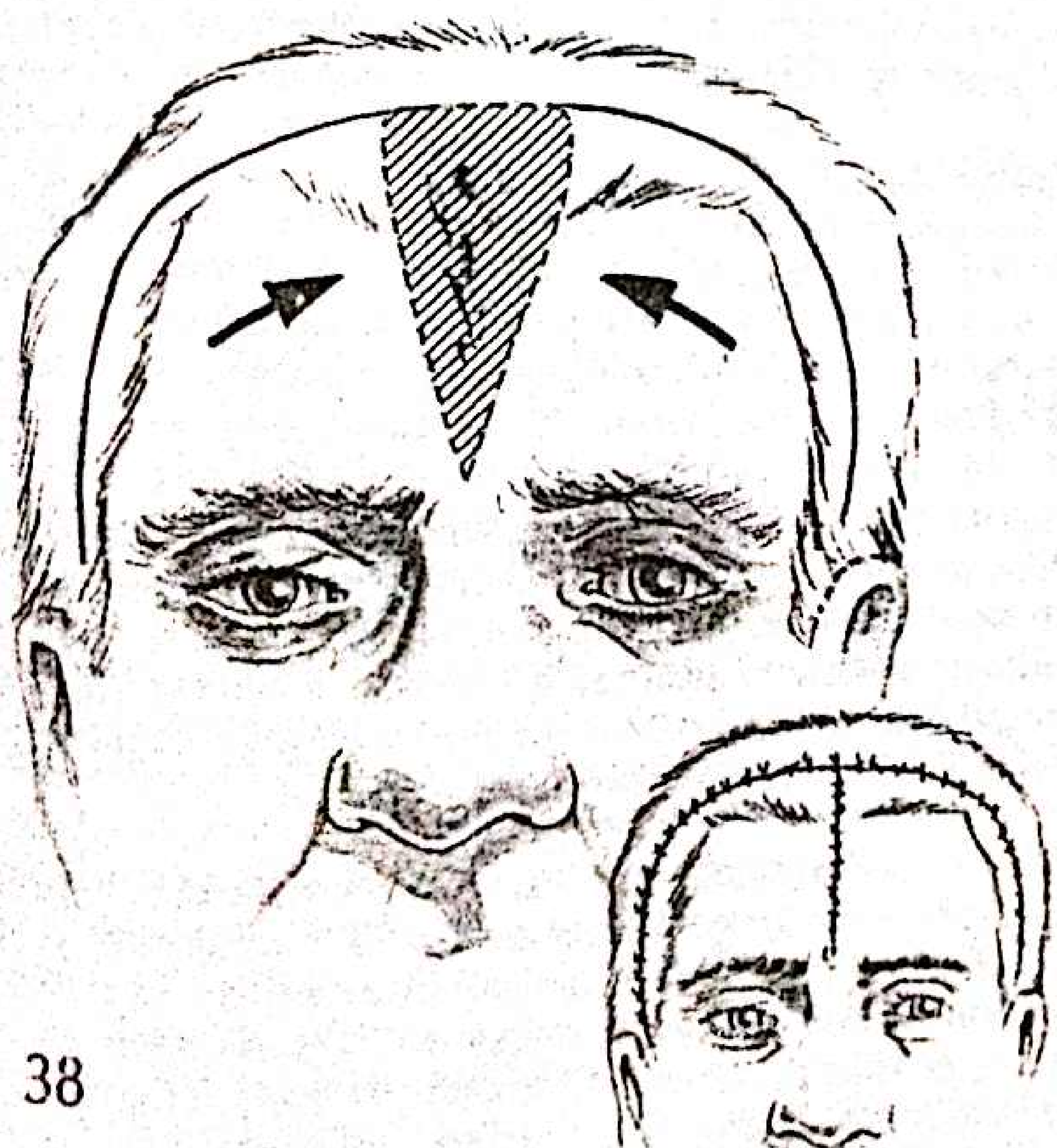

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When the apex of the triangle is below, an inferiorly based rotation flap, based on the pre- and postauricular areas, incorporating the superficial temporal vessels, may provide a potential reconstruction. Bilateral flaps provide a further possibility, each covering half of the defect, to reconstruct the centrally placed lesion where the triangulated defect has a broad base.

Forehead flaps, inferiorly based in this way, have the virtue of maintaining the sensory nerve supply of the forehead.

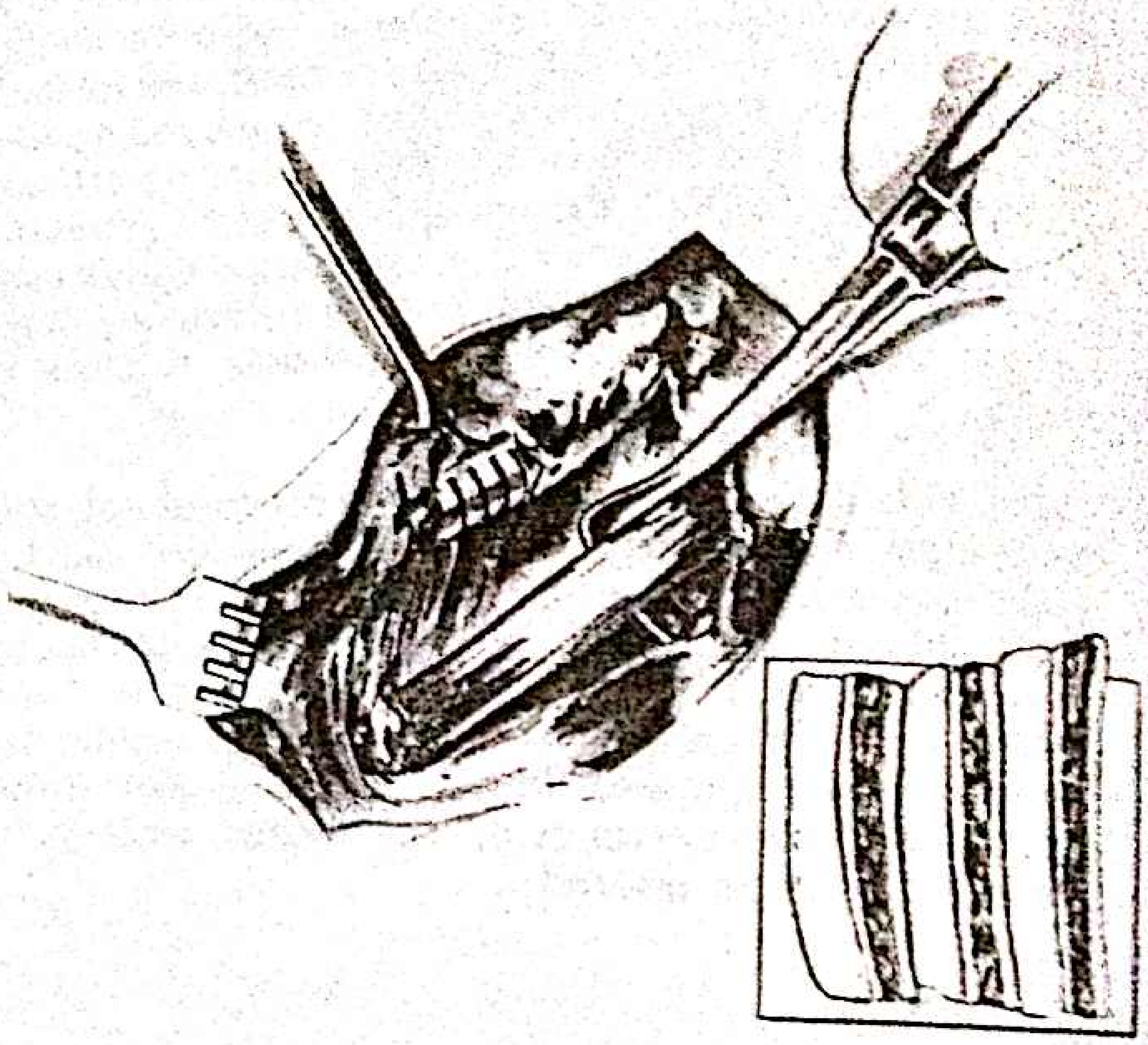
An alternative approach to the forehead defect which is unsuitable for any of these reconstructions is to apply a split-skin graft as a holding manoeuvre, and subsequently replace it using tissue expansion.

Bone reconstruction

How essential it is to reconstruct the bone which has been resected is most often dependent on the size of the defect. A defect which is small in area can generally be left unreconstructed and, in the clinical situation where it has not been felt necessary to involve a neurosurgeon, even the larger defect seldom requires to be reconstructed primarily. The form which a secondary reconstruction should take is likely to vary depending on the size of the defect.

39

In the case of a moderately sized defect, a split-rib graft is an effective method. The rib used is generally the seventh, and is approached by an incision directly overlying it, the rib being stripped of its periosteal cover over the length being resected. Following removal of the length of rib, the margins of the stripped periosteum can be sutured together if desired, but this is not essential. If a length of more than one rib is required, it is generally considered advisable to harvest from alternate ribs. The rib is split into two parts across its greater width, providing two grafts.



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The margins of the bony defect are cleared of soft tissue in preparation for the graft, and the grafts are trimmed to fit the defect and laid in position, side by side. The surface contour which is ultimately achieved retains the slight irregularity of the immediate postoperative situation, but this is seldom a significant problem.

For larger defects, vitallium, tantalum and acrylic have all been used with success. The timing of such a reconstruction, as well as its desirability, has to take account of the initial pathology and the certainty of cure. There is little point in embarking on bony reconstruction unless and until cure of the original condition is reasonably well assured. The time scale involved in reaching such a decision will depend very much on the rapidity of growth of the original lesion, growth of any recurrence being likely to mimic it.

Illustrations by Ian Ramsden

Reconstructive techniques of the oral cavity

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Introduction

The surgical techniques used in closing intraoral defects, namely, direct suture, free skin grafts, and flaps of various types, all have virtues and limitations. These can be demonstrated in relation to the anatomical characteristics of the defect and its extent in terms of the area of mucosa resected, its depth in terms of the structures excised, whether it extends to involve the skin surface, and whether it is capable of accepting a graft.

All of these relate ultimately to the pathological characteristics of the tumour, its extent, its type, and the way in which these influence the defect, but the relationship between pathological factors and the reconstruction is not a direct one, since the defect is ultimately created by the surgeon. A more direct relationship between the pathology and the reconstruction which is appropriate concerns the two ways in which intraoral tumours present – either as a single focus in the midst of an apparently normal mucosa, or multifocally, with several independent foci of tumour arising simultaneously in different sites within the mouth.

Even though the subsequent development of second tumours is increasingly recognized as a hazard in the patient presenting initially with a single tumour focus, the focus itself still tends to be managed in a definitive manner on the tacit assumption that its effective excision will be the end of the matter, and the reconstructions used are also generally based on that assumption.

With the multifocal tumour the approach from the viewpoint of reconstruction is quite different, with a constant awareness that other foci of invasive tumour are either already present or are in the process of developing.

Direct suture

This is a technique which should be used with discretion. In treating the tumour which is relatively small and which does not extend deeply to a significant extent there is an obvious temptation to close the defect directly, but whenever its use is contemplated the effect which it will have on intraoral function must be taken into account. Equally important is to consider whether its use will make subsequent examination of the oral cavity as a whole more difficult.

Its effect on function is most strikingly seen when the closure results in a degree of tethering of the tongue; increase in the difficulty of examining the oral cavity is most likely to result from the production of trismus by the direct closure, or the creation of deep pockets behind the site of closure. It is the posterior mouth, particularly the posterior floor, retromolar trigone and buccal sulci (the areas most difficult to examine even in the normal patient), which are the sites at greatest risk from this effect.

Direct suture used in different areas in the mouth varies in the effect it has on these functional aspects. In the tongue, direct suture of a dorsal defect, particularly if the line of the scar will lie parallel to the midline groove, often has a minimal effect. Closure of a defect of the floor of mouth or side of tongue is likely to have a greater tethering effect, and the effect increases the nearer the defect is to the anterior floor of mouth. In the anterior floor direct suture should be avoided if at all possible. Tethering is almost an invariable consequence and it is concentrated in the part of the tongue which is most susceptible to its adverse effects. Restriction of the movement and reach of the anterior third of the tongue, its free segment, reduces its capacity to dispose of the saliva which gathers in the anterior floor and to manipulate food in preparation for swallowing. Reduction of its reach so that the tip fails to meet the posterior aspect of the upper incisors also adversely affects the enunciation of most consonants in speech.

When trismus is the effect which is being avoided, it is the defect of the buccal mucosa which provides the problem in most instances.

Direct suture restricted to a 'once only' philosophy, and only when the defect is a small one, may be entirely acceptable. It is best avoided in larger defects, particularly in the vulnerable sites and, even more, its repeated use is undesirable.

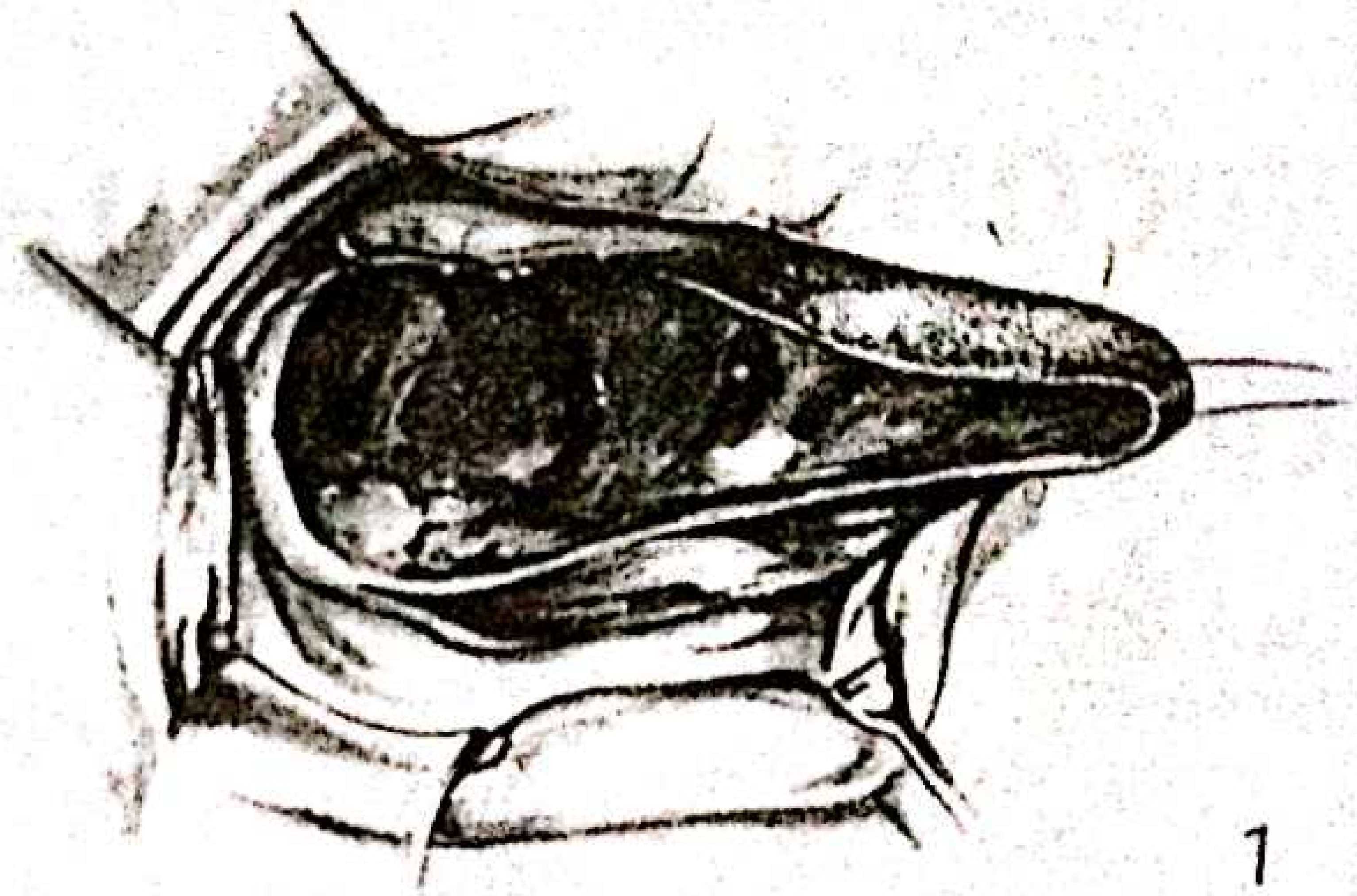
Free skin grafts

Grafting is used in suitable circumstances in the tongue and floor of mouth, the buccal mucosa, and the palate and paranasal sinuses. The technique used differs in each of these sites, the method in each instance being designed to provide the best conditions for take, namely close immobile contact between the graft and the bed. The standard graft is split-skin in thickness.

Tongue and floor of mouth

1

In these sites the most effective technique makes use of quilted grafting. The defect which follows resection of the tumour is one entirely of soft tissue, and capable of accepting a graft.



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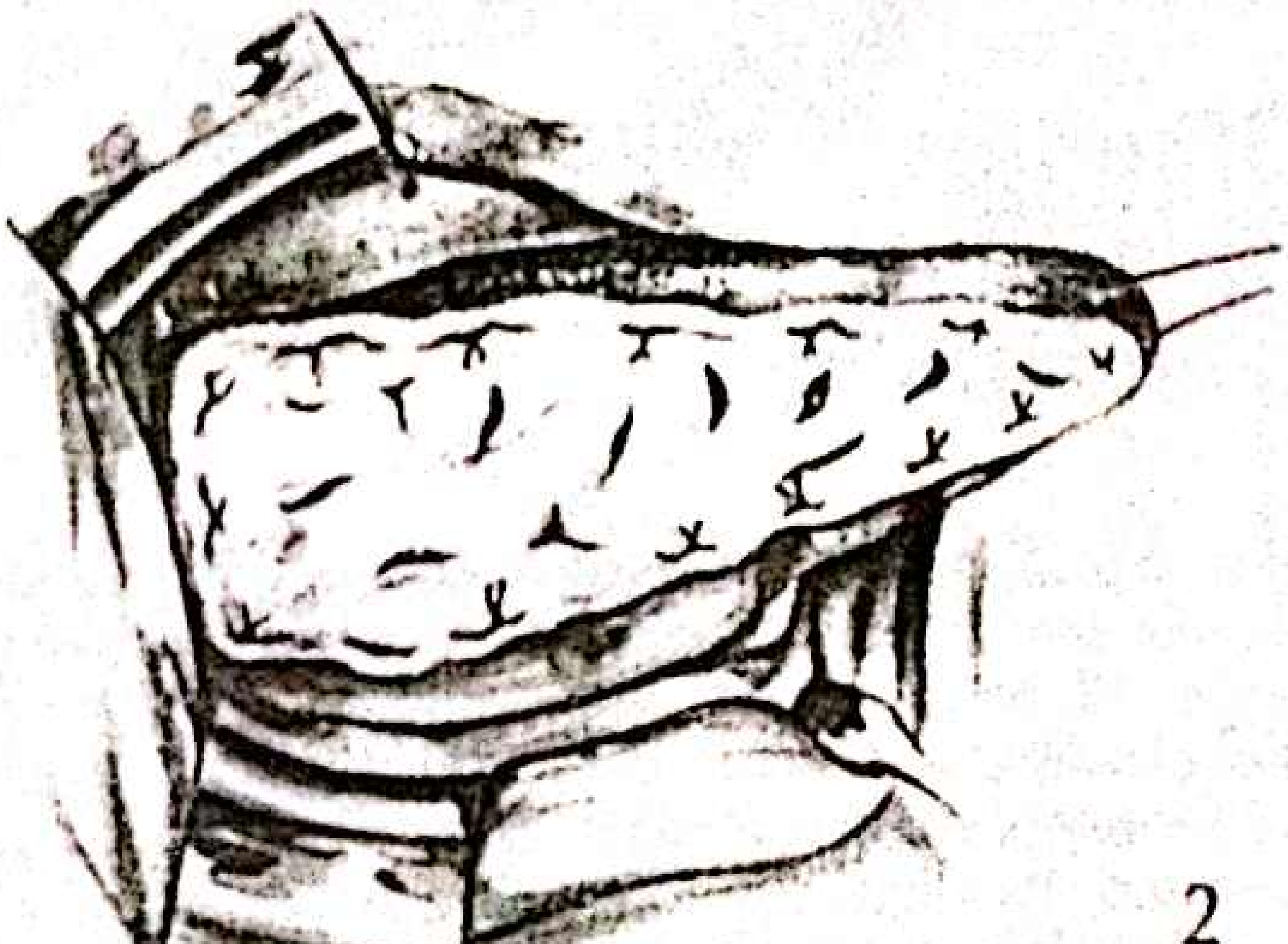
The graft is sutured in position around the margins of the defect and multiple additional sutures are inserted through the graft and the underlying muscle, anchoring the two together and giving the overall appearance of a 'quilt'. Effective haemostasis of the bed is a prerequisite to successful use of the technique, but even with complete control of bleeding prior to application of the graft the inevitably blind insertion of the quilting sutures generally gives rise to bleeding. The adverse effect of this on take of the graft can be markedly reduced by making multiple slits in the graft. The slits allow any clot to escape, squeezed out during the postoperative period.



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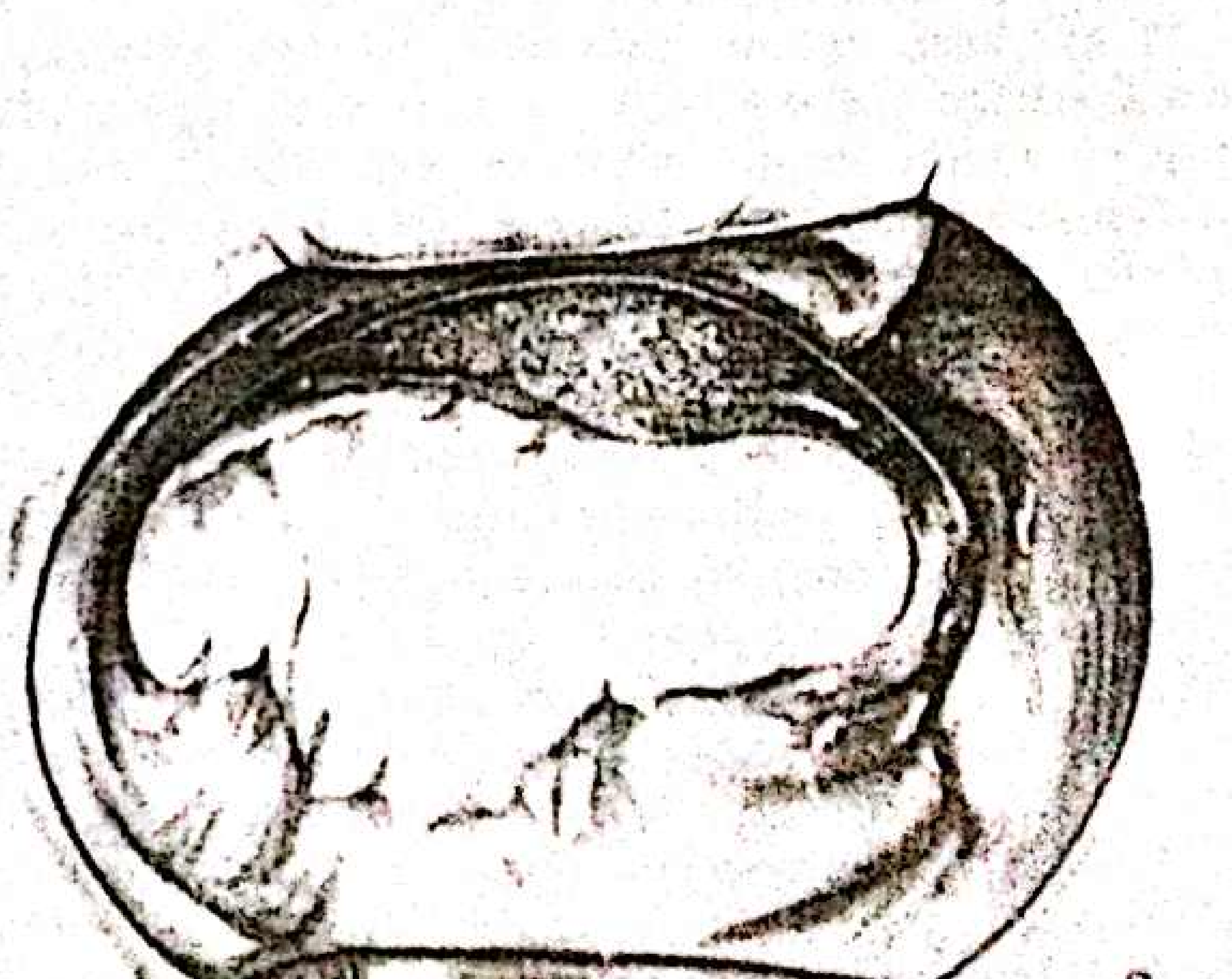
Using this grafting technique the degree of patient discomfort is surprisingly small. A soft diet is necessary for the first week following the application of the graft, with regular mouthwashes. The overlap around the margin is allowed to separate spontaneously. Take of the graft is generally good.



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Where the tumour is in a site and of a size which has required the use of a submandibular approach for exposure, the possibility of a fistula is a distinct hazard should the graft fail. Free skin grafting is probably best restricted to those tumours which can be excised using an intraoral approach. It is a particularly useful technique for the tumour of the side of the tongue which fits into such a category, and it can be used to resurface the defect which is more than merely mucosal, which includes a significant element of muscle substance, even up to one-third of its volume. The mobility of the residual tongue is not impaired, and in that respect the method is preferable to direct closure of the defect.

The method can also be used for small tumours of the lateral floor of mouth, although in practice tumours in that site which are suitable for its use are rare. It may also be technically feasible to use a quilted graft for the small tumour of the anterior floor of mouth or the adjacent ventral aspect of tongue, but it is best avoided in that site. Failure of the graft to take well will result in a tongue anchored to the floor, with the adverse effects on function already described. The use of nasolabial flaps, as described on pp. 226–229, is much to be preferred as being equally effective and much safer.

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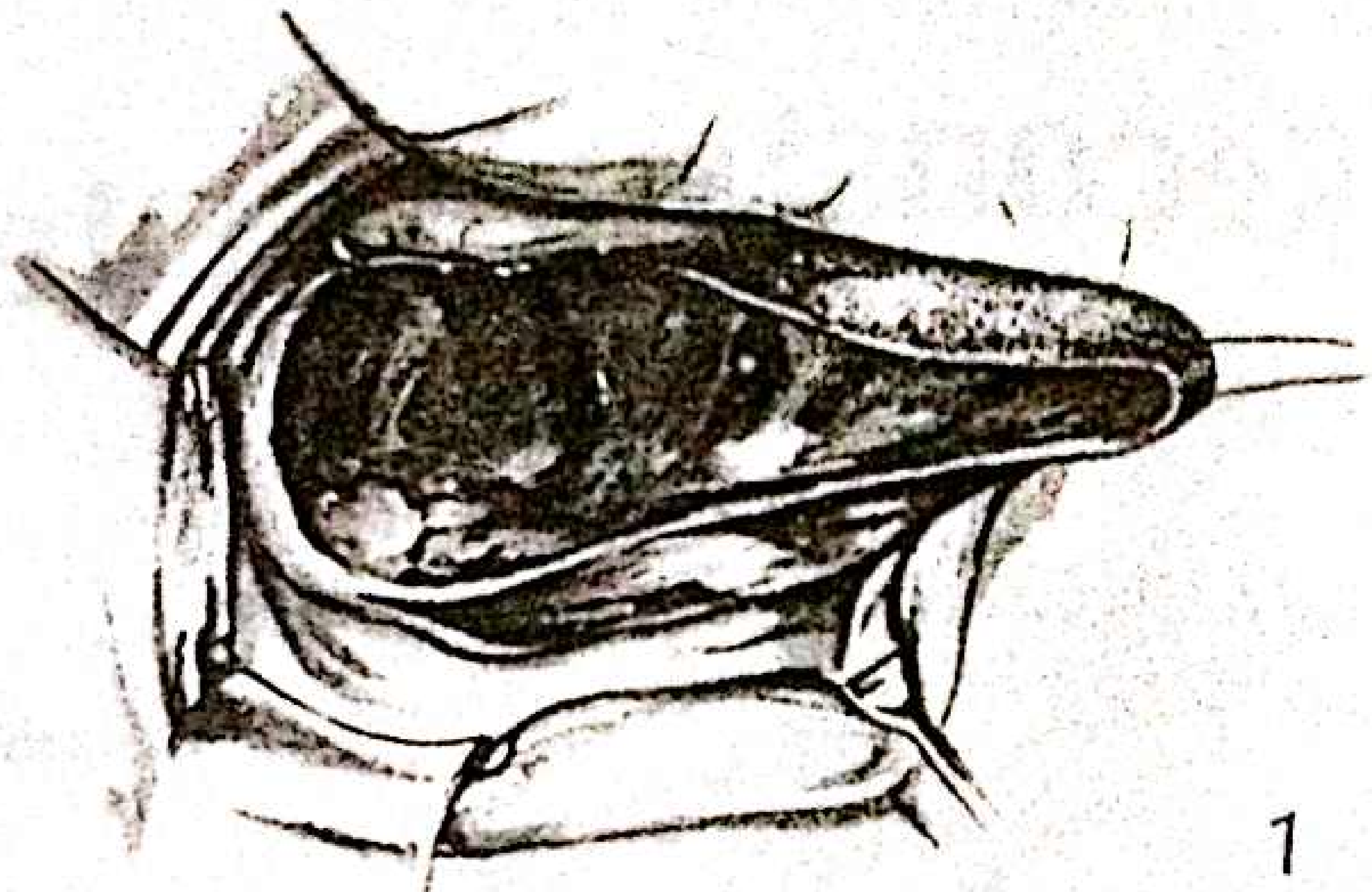

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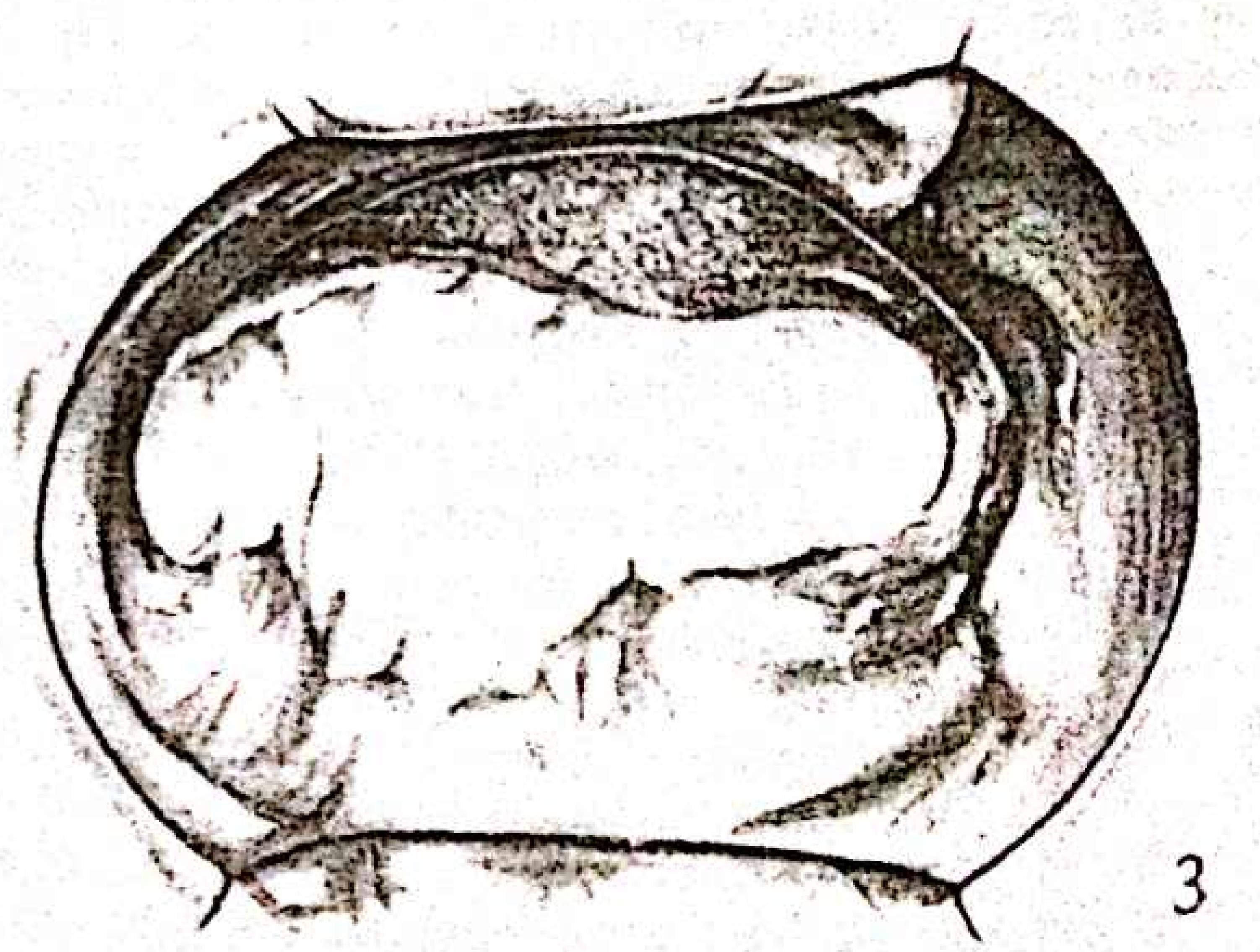

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3

Using this grafting technique the degree of patient discomfort is surprisingly small. A soft diet is necessary for the first week following the application of the graft, with regular mouthwashes. The overlap around the margin is allowed to separate spontaneously. Take of the graft is generally good.

Where the tumour is in a site and of a size which has required the use of a submandibular approach for exposure, the possibility of a fistula is a distinct hazard should the graft fail. Free skin grafting is probably best restricted to those tumours which can be excised using an intraoral approach. It is a particularly useful technique for the tumour of the side of the tongue which fits into such a category, and it can be used to resurface the defect which is more than merely mucosal, which includes a significant element of muscle substance, even up to one-third of its volume. The mobility of the residual tongue is not impaired, and in that respect the method is preferable to direct closure of the defect.

The method can also be used for small tumours of the lateral floor of mouth, although in practice tumours in that site which are suitable for its use are rare. It may also be technically feasible to use a quilted graft for the small tumour of the anterior floor of mouth or the adjacent ventral aspect of tongue, but it is best avoided in that site. Failure of the graft to take well will result in a tongue anchored to the floor, with the adverse effects on function already described. The use of nasolabial flaps, as described on pp. 226–229, is much to be preferred as being equally effective and much safer.

Buccal mucosa

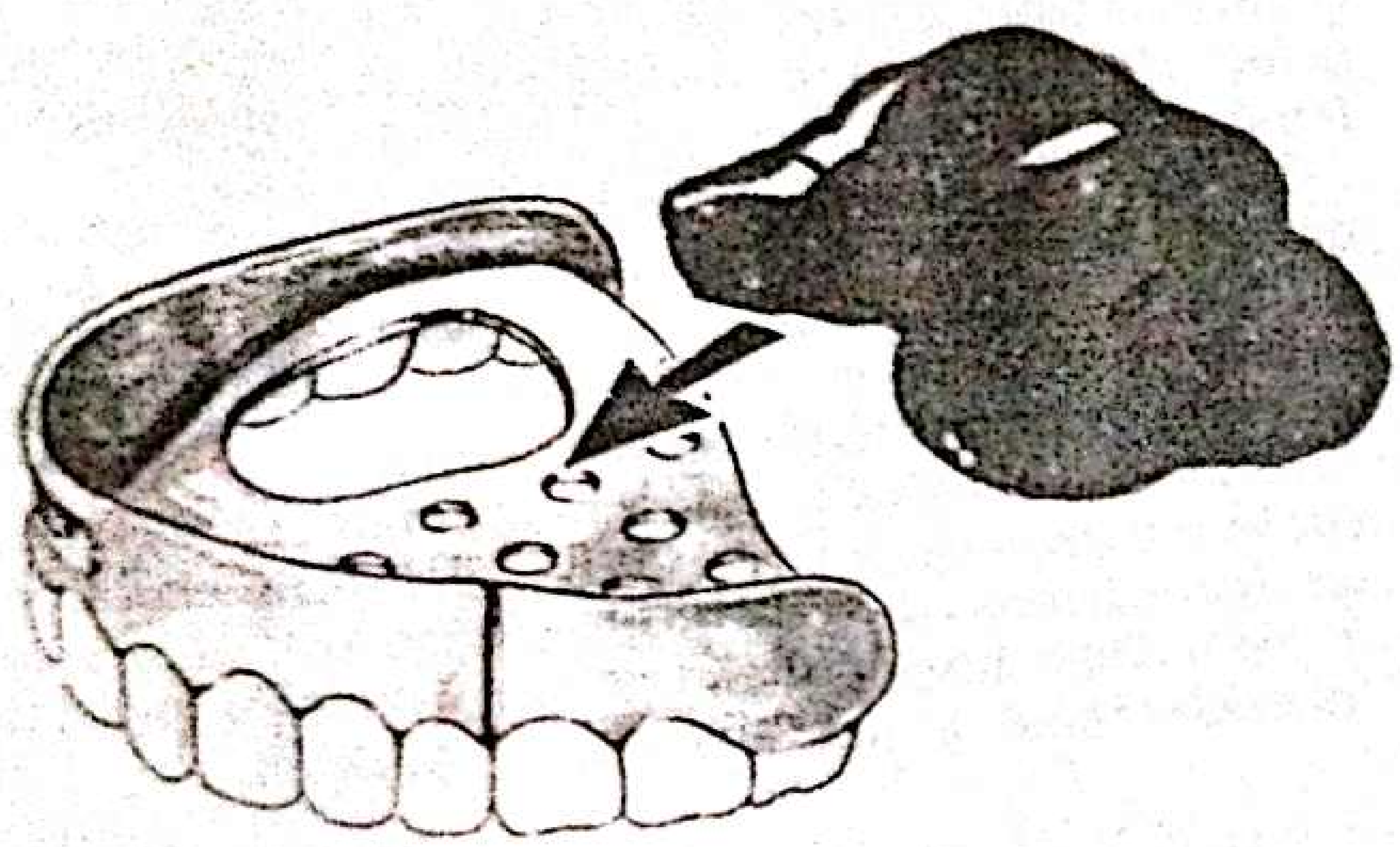
In theory, small defects of this site can be successfully grafted using either the bolus technique with its tie-over dressing, or a quilted graft. Although in practice the quilted graft is likely to result in more consistent graft take, grafting in general is a method to be used with extreme caution. Even with entire take of the graft there is inevitably a degree of graft contraction which the muscles opening the mouth are not strong enough to counter, and such contraction is greatly increased if there is significant failure of the graft.

When the graft is a small one, contraction may be masked by the mobility of the submucosa on the buccinator muscle and trismus may be avoided, making the result an adequate one. Where the defect extends to one or other buccal sulcus, where the mobility of the submucosa is exchanged for the fixity of the mucoperiosteum of the upper or lower alveolus, contracture cannot be masked and trismus results. Grafting in the buccal mucosa is a technique to use rarely if at all, and extension of the defect to involve either upper or lower buccal sulcus is virtually an absolute contraindication.

Upper alveolus, hard palate and sinuses

Grafting of defects in these sites is a standard technique and the method employed makes use of the principle of bolus grafting. In practice the cooperation of an oral surgeon is advisable, since the techniques adopted generally involve the use of specially constructed dental plates.

When the patient is edentulous the denture normally worn provides the basis of the splintage used to hold the graft in position. If a denture is not available a dental impression of the palate and upper alveolus is taken and a 'denture without teeth' is made. The denture, while it matches the contour of the palate and alveolus preoperatively, does not match the contour in its entirety postoperatively. The postoperative contour has two parts, the intact palatal segment and the postexcisional defect. The plate still fits the former but not the latter, and steps are taken to match both contours by making a mould of the postoperative defect, using gutta-percha. This material has the property of becoming soft and malleable in boiling water, hardening as it cools.



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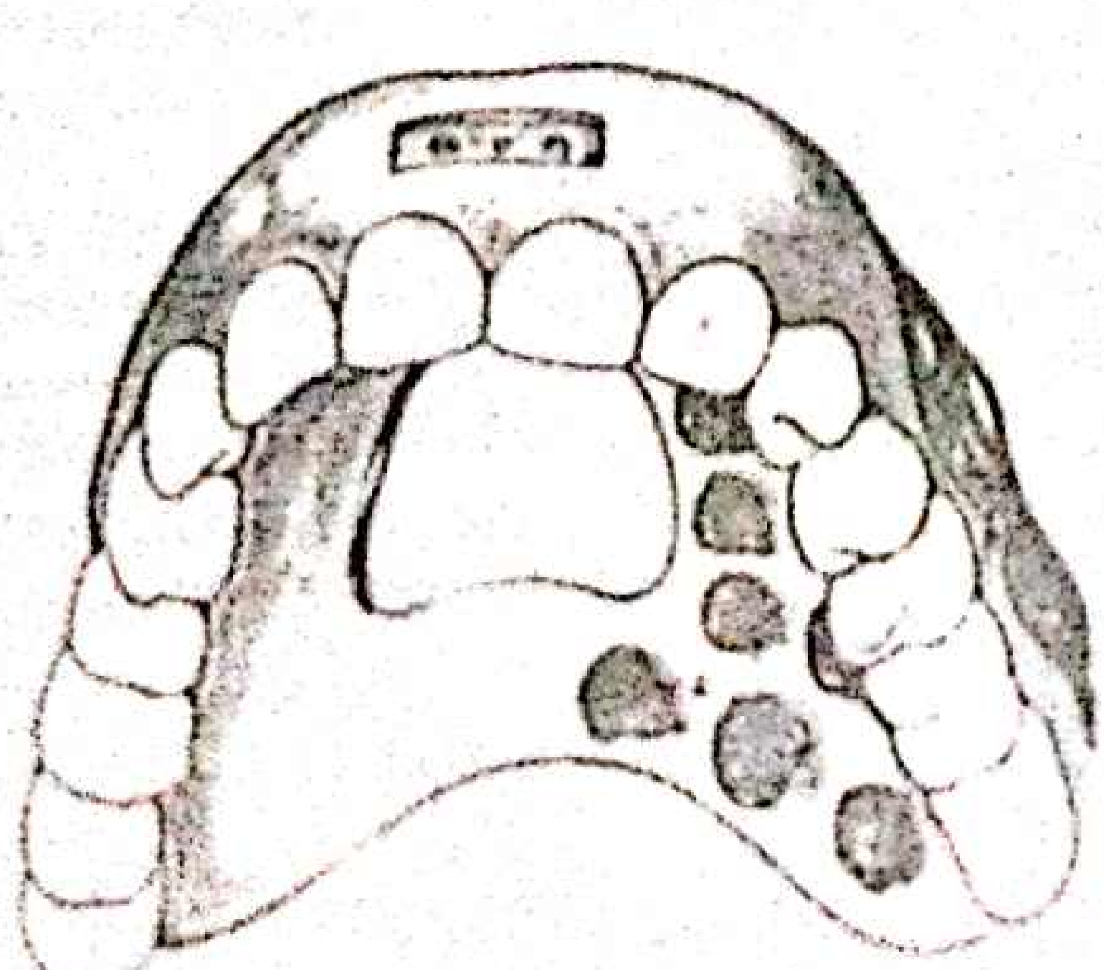
It is desirable to have the mould and the previously constructed plate as a single structure and this is achieved by 'welding' them together. Holes are bored in the segment of the denture to which the mould is to be fixed and a bolus of the softened gutta-percha is pressed against the splint.



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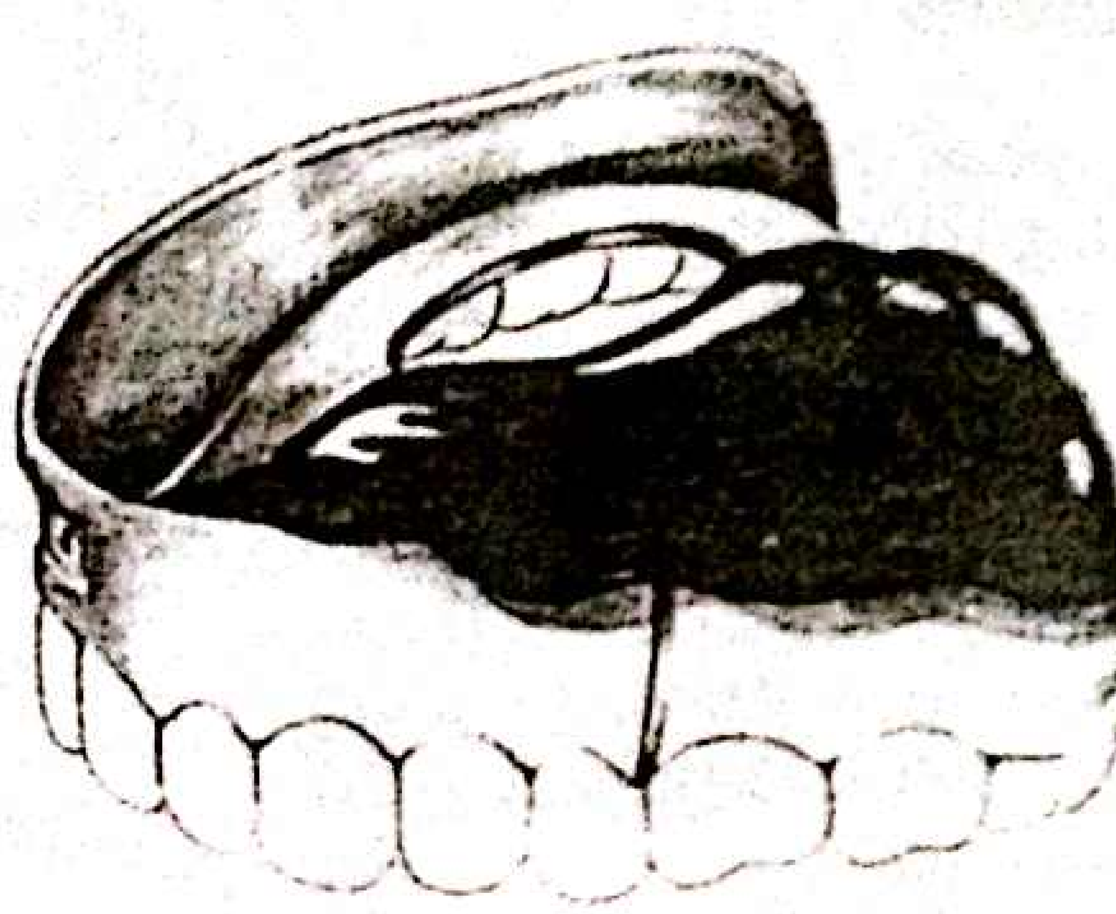
The gutta-percha flows through the holes fixing the denture and bolus together.

6

When resection of the tumour has been completed, a mould is made using the modifed denture to match the combined contours of the intact alveolar segment and the surgically created defect.



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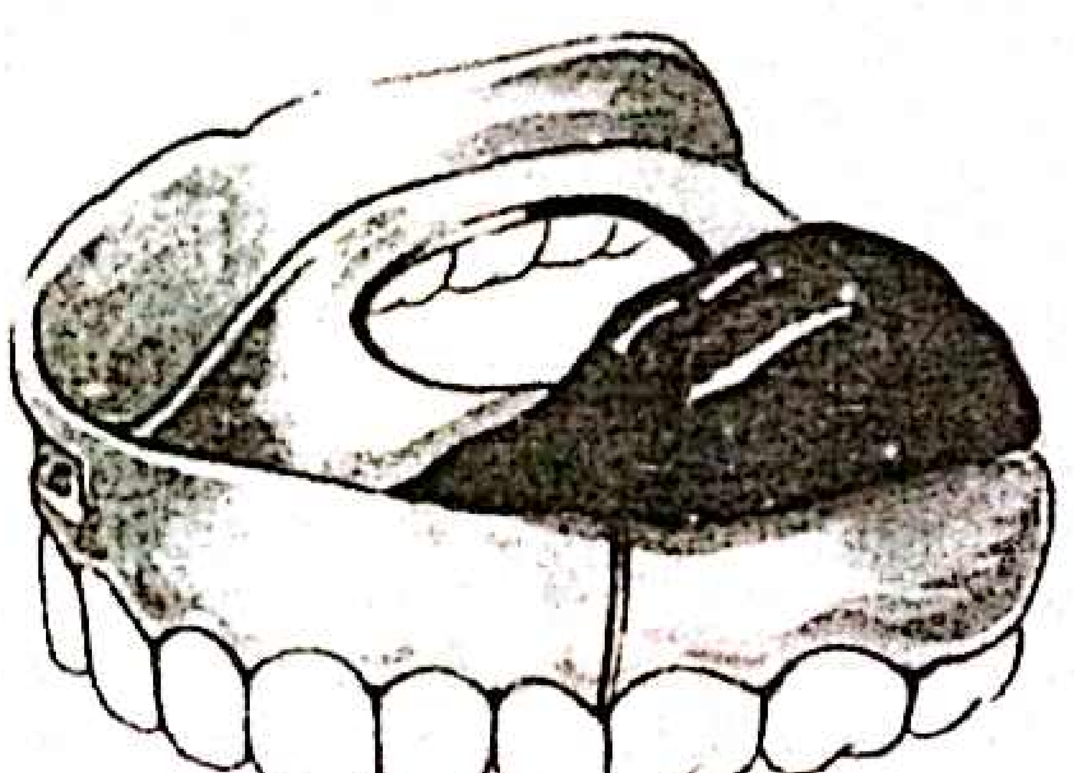
The combined denture-*cum*-bolus is immersed in boiling water, softening the bolus once again and, inserted into the mouth, is pressed against the part of the alveolus which is intact while the soft bolus of gutta-percha moulds to the defect.

The effect is to create a composite consisting of the original denture and the bolus of gutta-percha. The two, in combination, make up a splint which matches the contours of the residual alveolus and the postoperative defect. Held against the alveolus it holds the graft against the defect.

Several methods can be used to hold the splint in position while the graft is taking, but the one to be preferred as being the most comfortable for the patient and most convenient for the surgeon involves direct wiring of the splint to the bony alveolus.

To allow the wiring to be carried out, a central hole is cut in the denture as part of the initial modification and grooves are also cut in the alveolar segment, usually one in the midline anteriorly and one on each side about the 'premolar level', to hold the wires in position.



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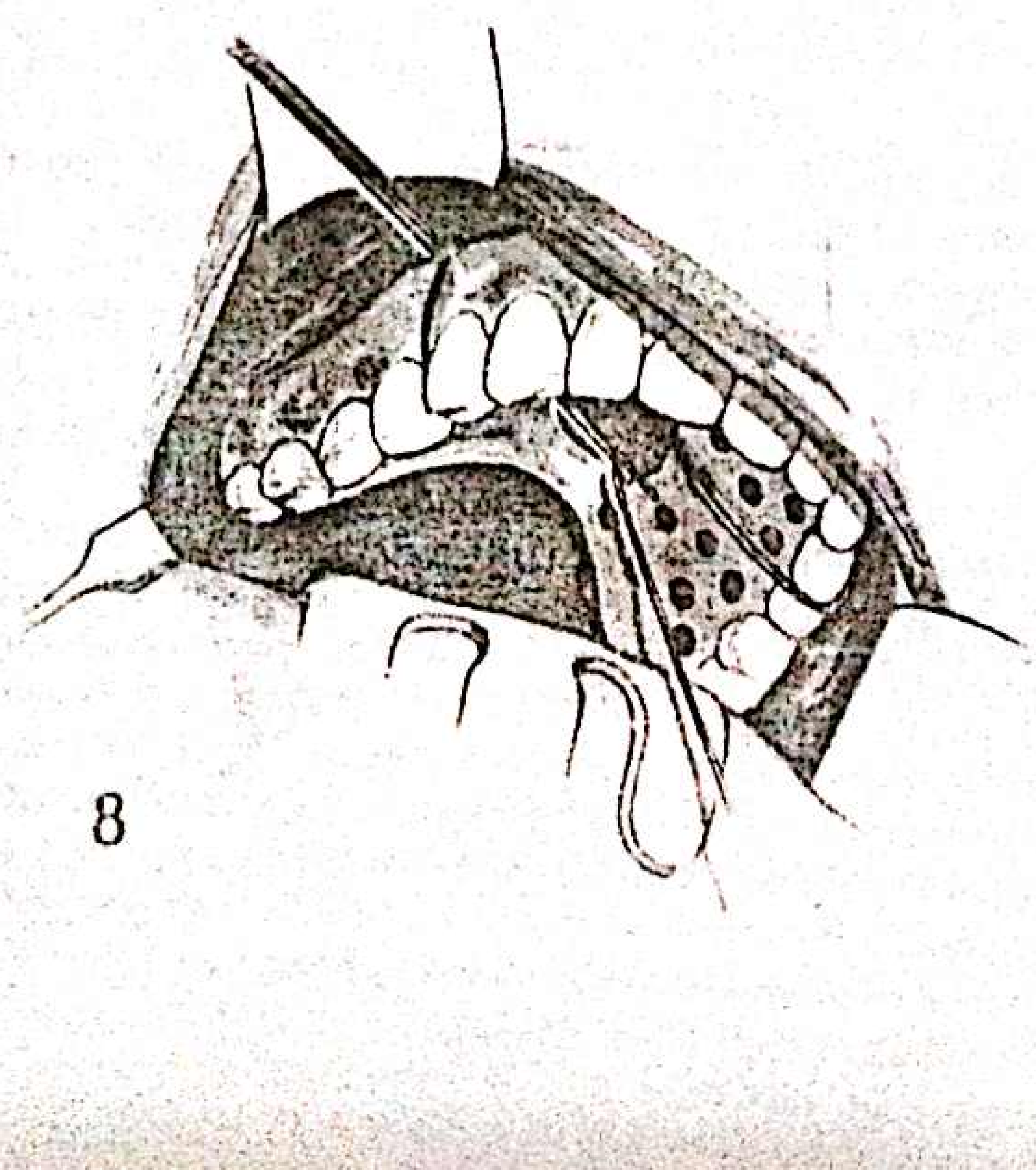
With the splint held in position inside the mouth a curved bone awl is thrust through the upper alveolar bone just above the splint at the site of the groove and brought out through the central hole.



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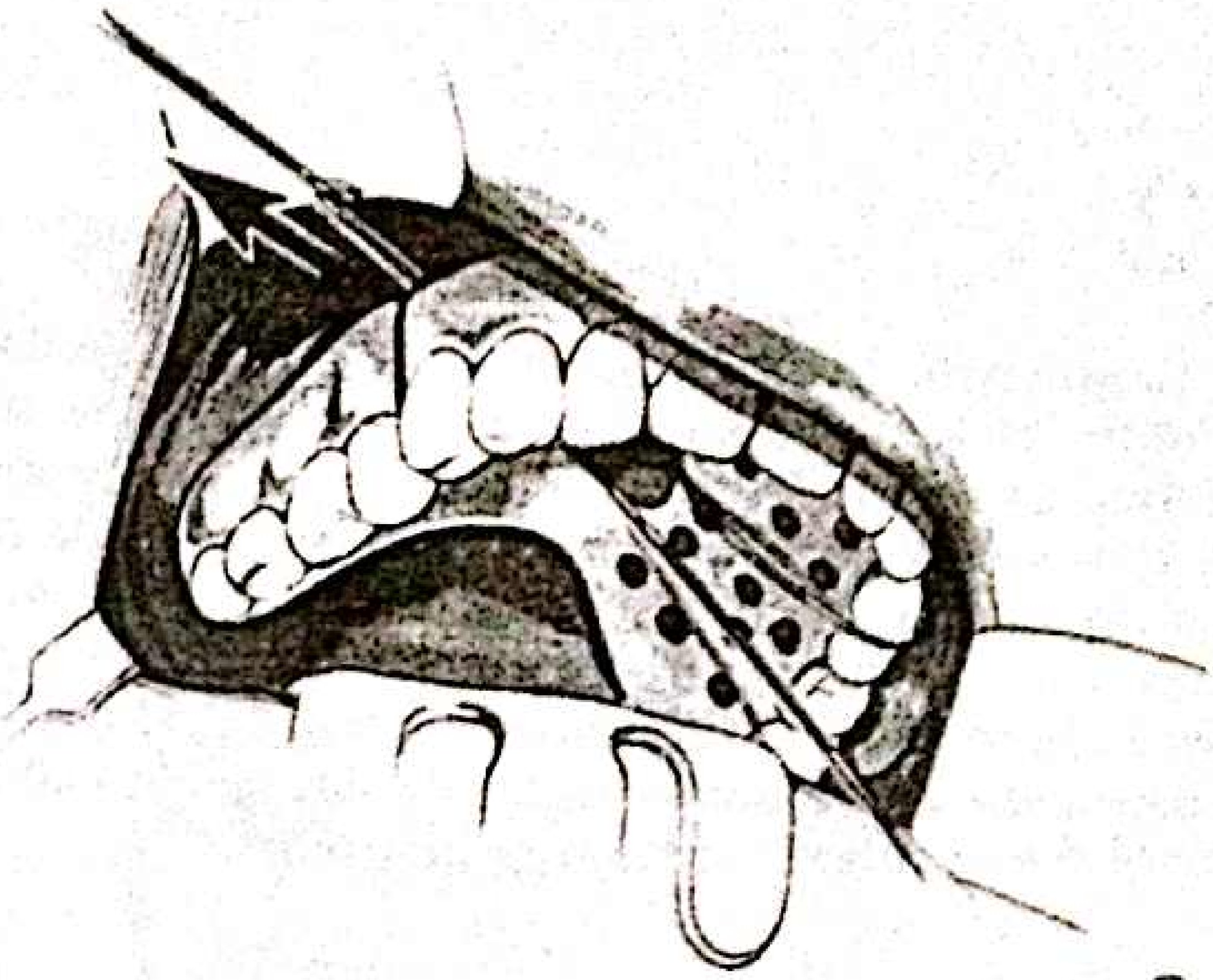
A length of stainless steel wire, diameter 0.4 mm, is threaded through the eye of the awl and the awl is withdrawn, drawing the wire with it.



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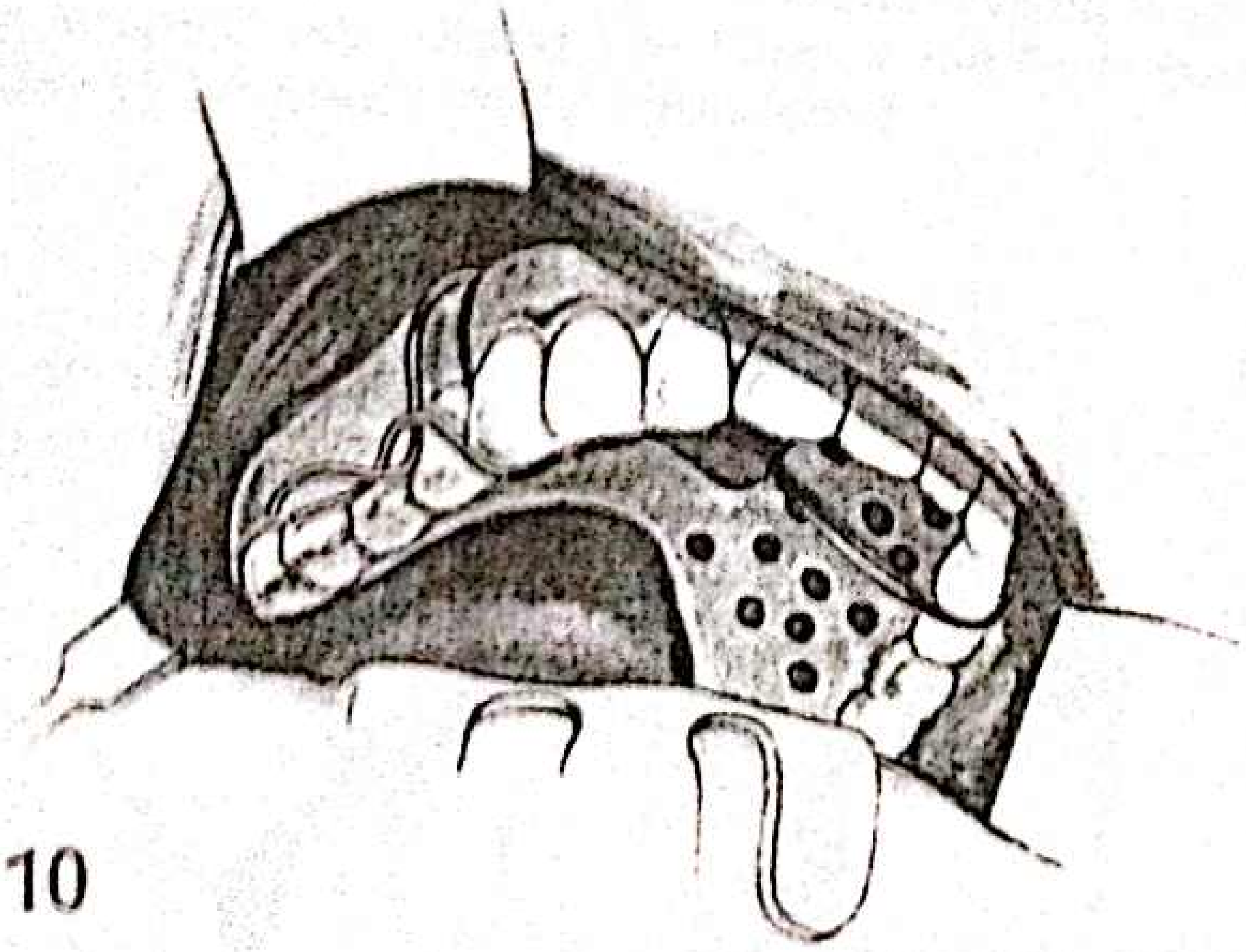

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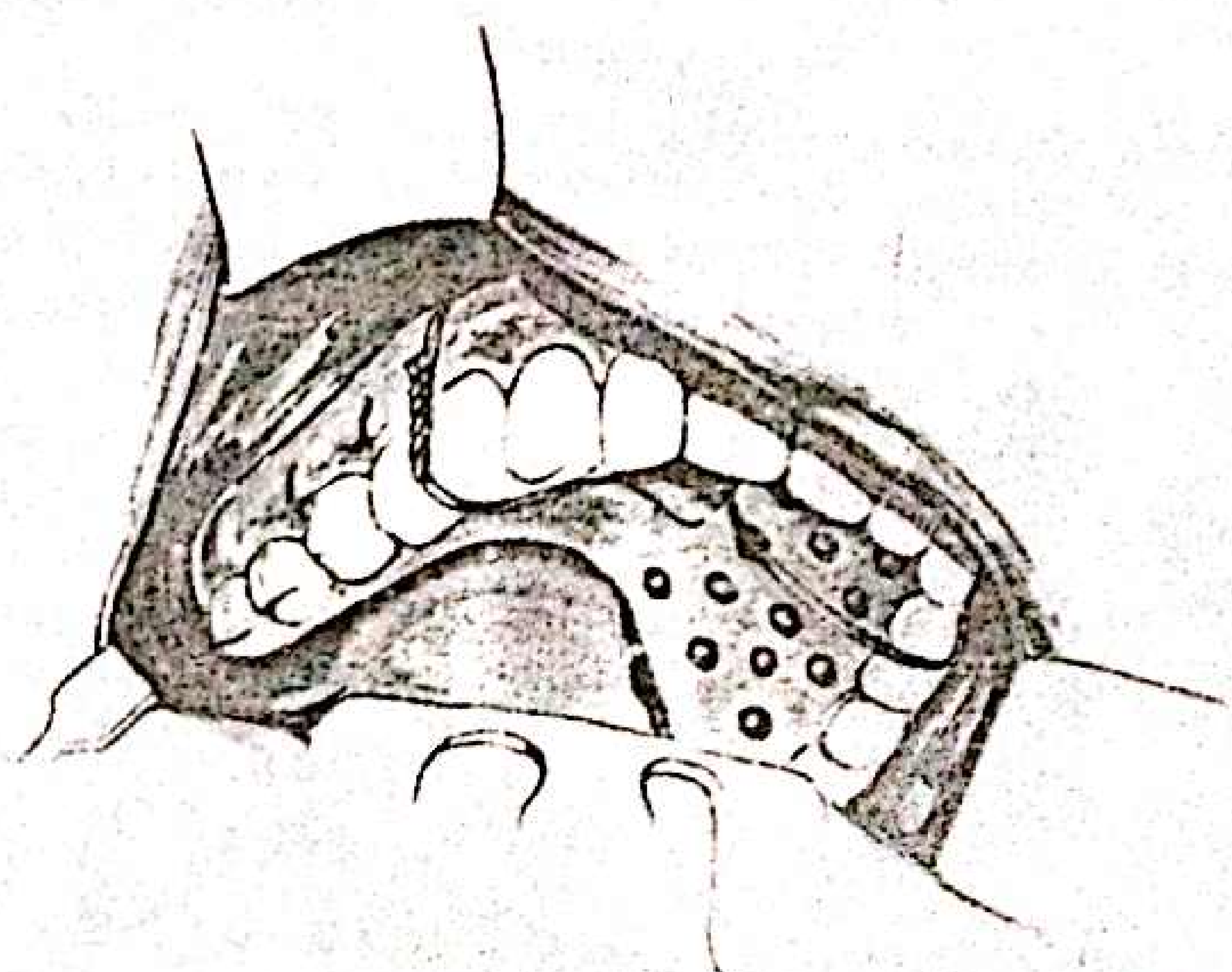
Tight twisting together of the two ends of the wire anchors the splint to the bone, the wires sitting into the groove. The excess wire is cut off and the ends turned in to prevent them from catching on tongue or cheek. A further wire is inserted at one or other of the groove sites depending on the site of the resection.

11

Two such wires fix the splint adequately and in practice only two are usually possible because of the extent of the alveolar resection.

The usual limiting factor to the use of the method is the amount of intact alveolus left after the resection. It is only when the extent and site of the resection precludes the insertion of more than a single wire that an alternative method is required. The possible alternatives are supra-orbital pin fixation and zygomatic suspension.



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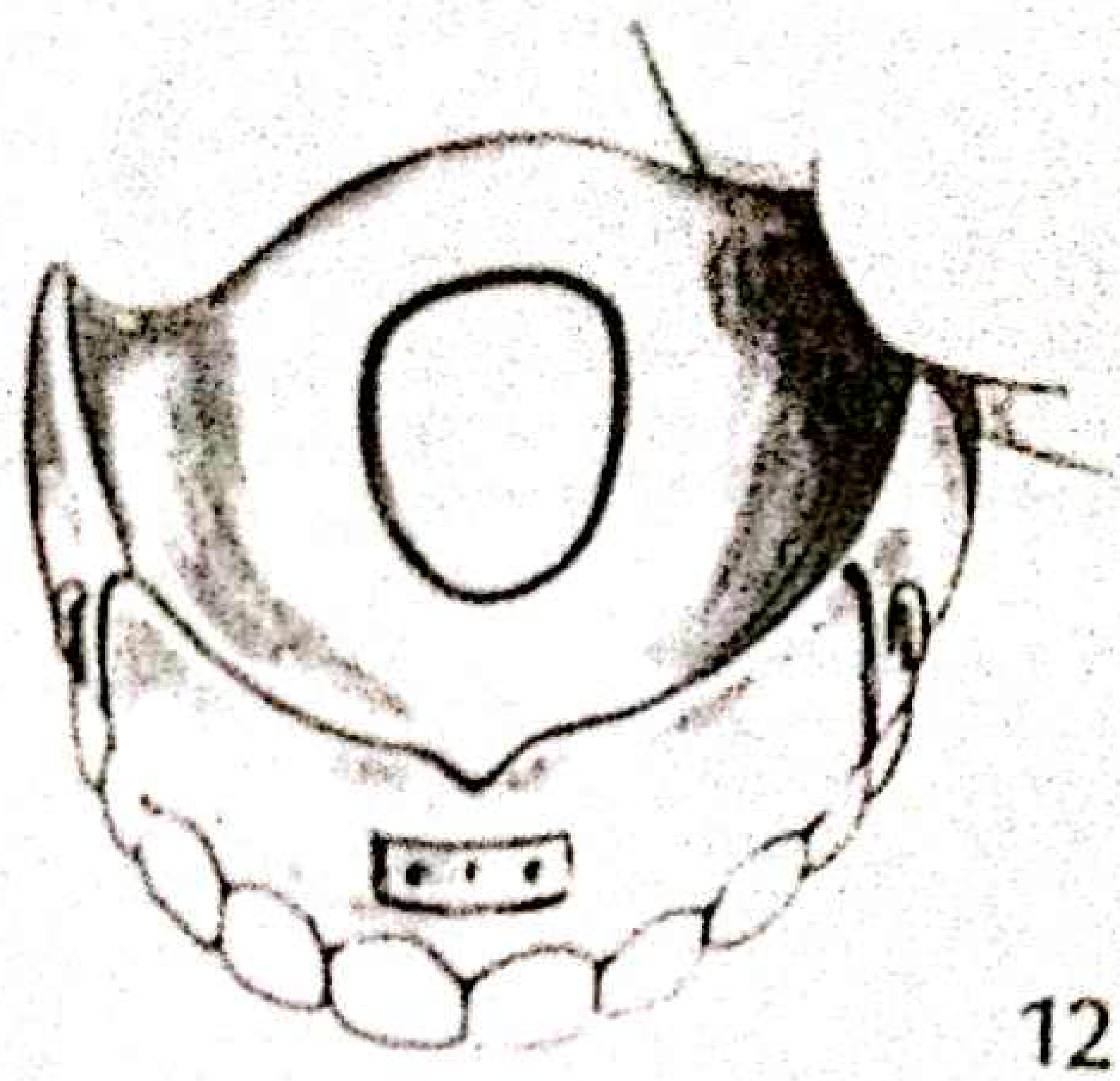
In preparation for the possible use of supraorbital pin fixation, it is necessary to insert a metal plate in the midline anteriorly to which the necessary fixing rods can be attached, a cleat can be inserted on each side of the denture at about the '2nd molar' level for the zygomatic suspension. If there is any likelihood that one or other of these alternatives will be required, the splint should be constructed at the outset with fitments which will allow any of the standard methods to be used.



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Supraorbital pin fixation involves the insertion of a self-tapping rod into the thick bone of the supraorbital ridge above each eye. To these as fixed points the splint is attached using a system of rods and universal joints.

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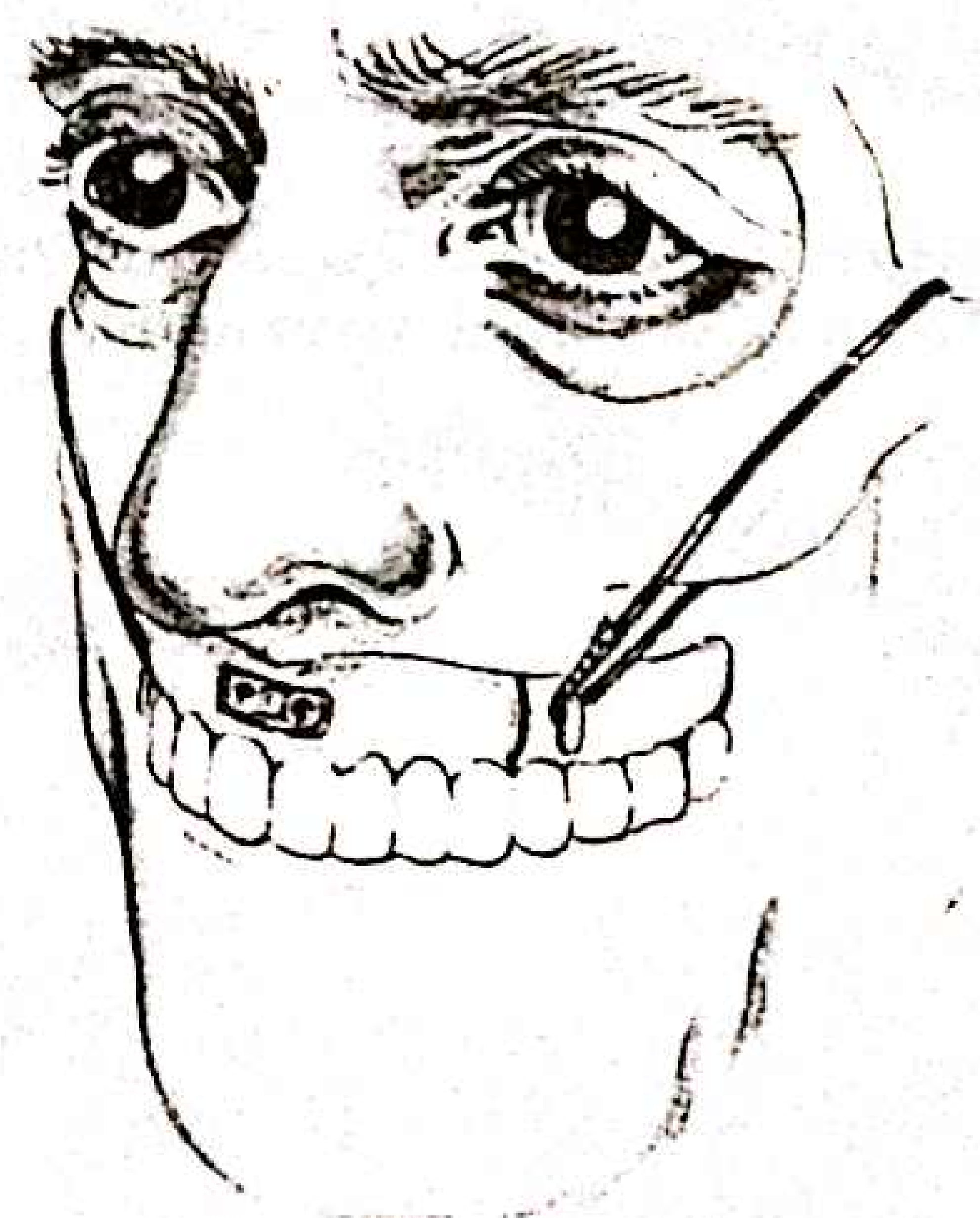
14

Zygomatic suspension involves the insertion of a wire on each side looped over the zygomatic arch with each end brought into the mouth at the site of the cleat. The wires are looped round the cleat and twisted to tighten the splint against the maxilla.

In addition to being much the most comfortable method for the patient, the splint which has been directly wired to the maxilla can be left in position for virtually as long as necessary, even up to 4–6 weeks. Zygomatic suspension is significantly less comfortable for the patient and usually has to be taken down in 10–14 days. Supraorbital fixation is much more cumbersome and is only used when the other methods are contraindicated.

The denture-*cum*-splint which has been described applies to the edentulous patient. Of the possible modifications used for the dentate patient a denture made with holes to accommodate the teeth present is probably the simplest and allows the fixation methods described above to be used largely unmodified.



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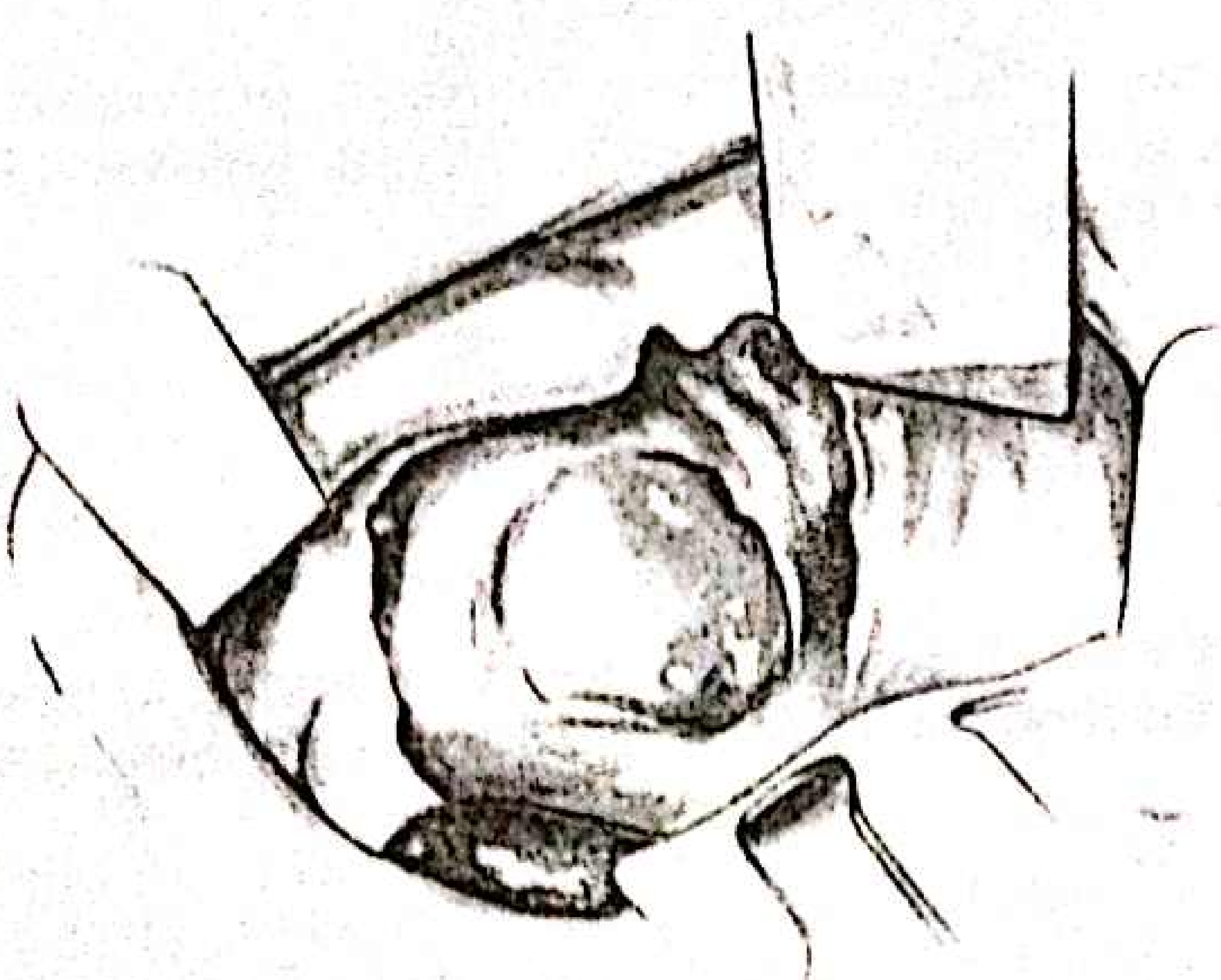

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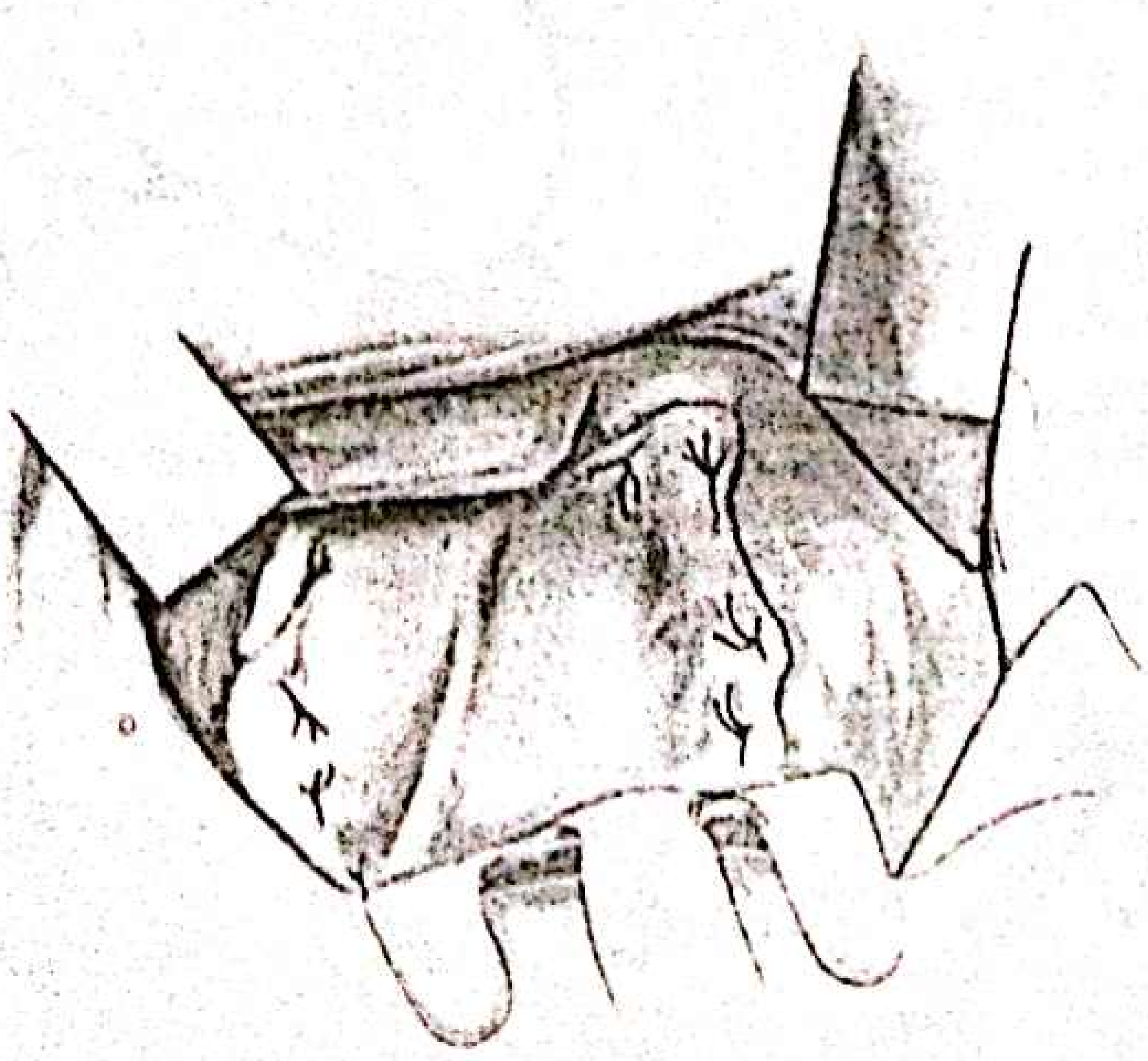
15 & 16

When the defect following resection of the tumour is a shallow one, it is convenient to suture the skin graft to the margins of the defect.

The splint with its bolus of gutta-percha already moulded to the contours of the defect is inserted into the mouth and fixed in position as already described, direct wiring to the maxilla being usually feasible.



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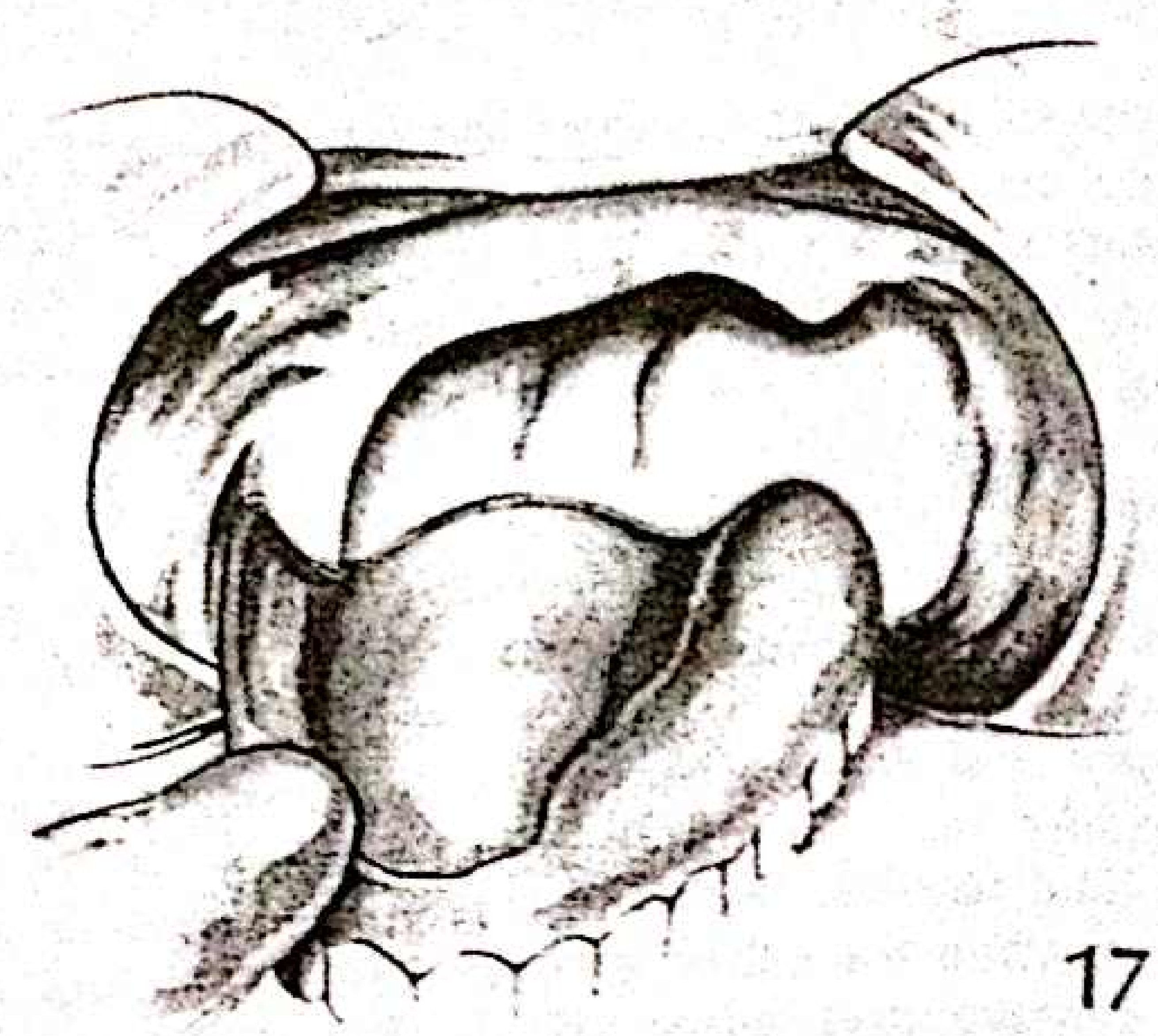
A denture modified to match the new contour inside the mouth is used to complete the reconstruction.



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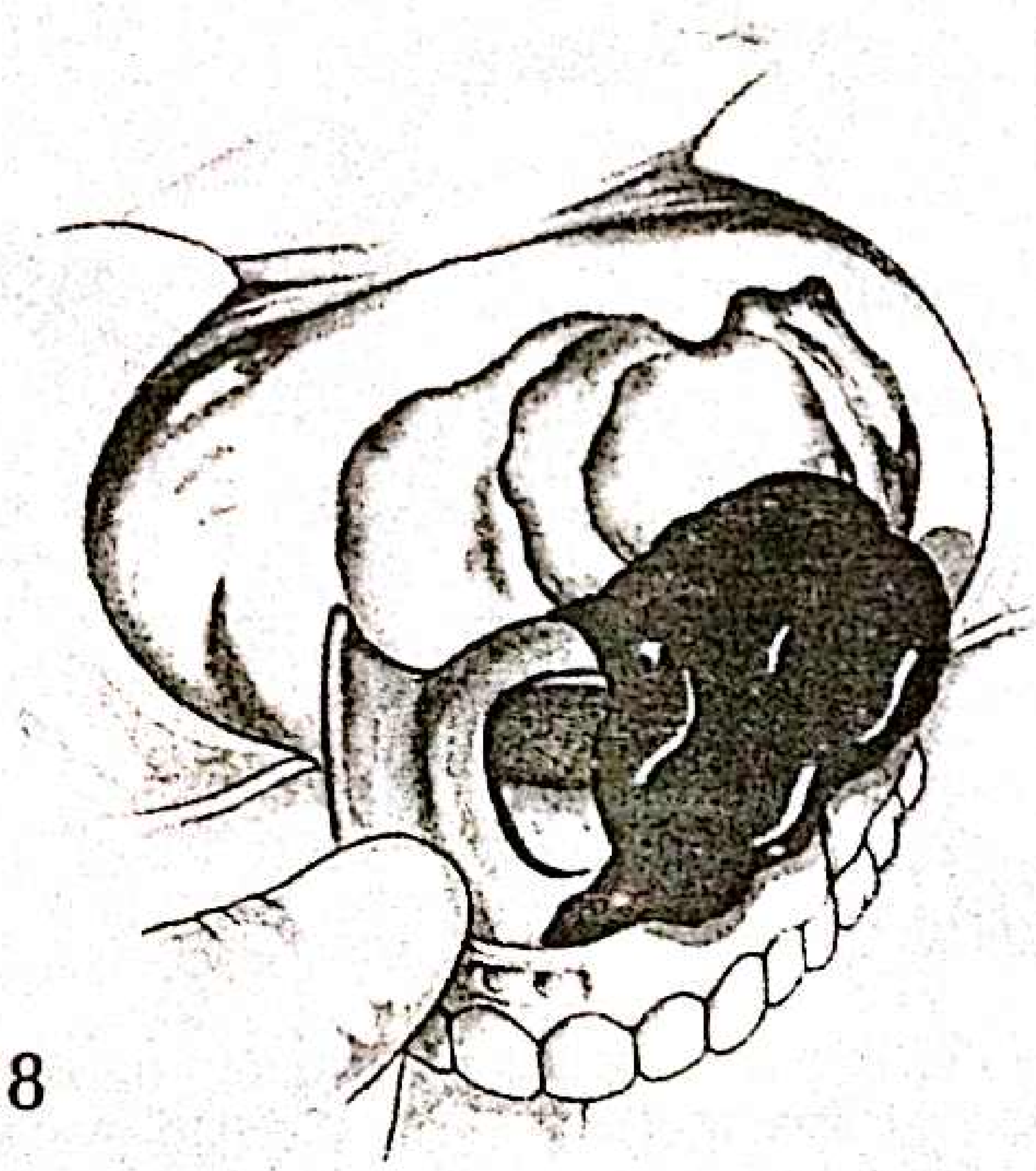
When the defect is deep it is generally preferable to drape the graft over the gutta-percha bolus and insert the graft covered splint into the defect.



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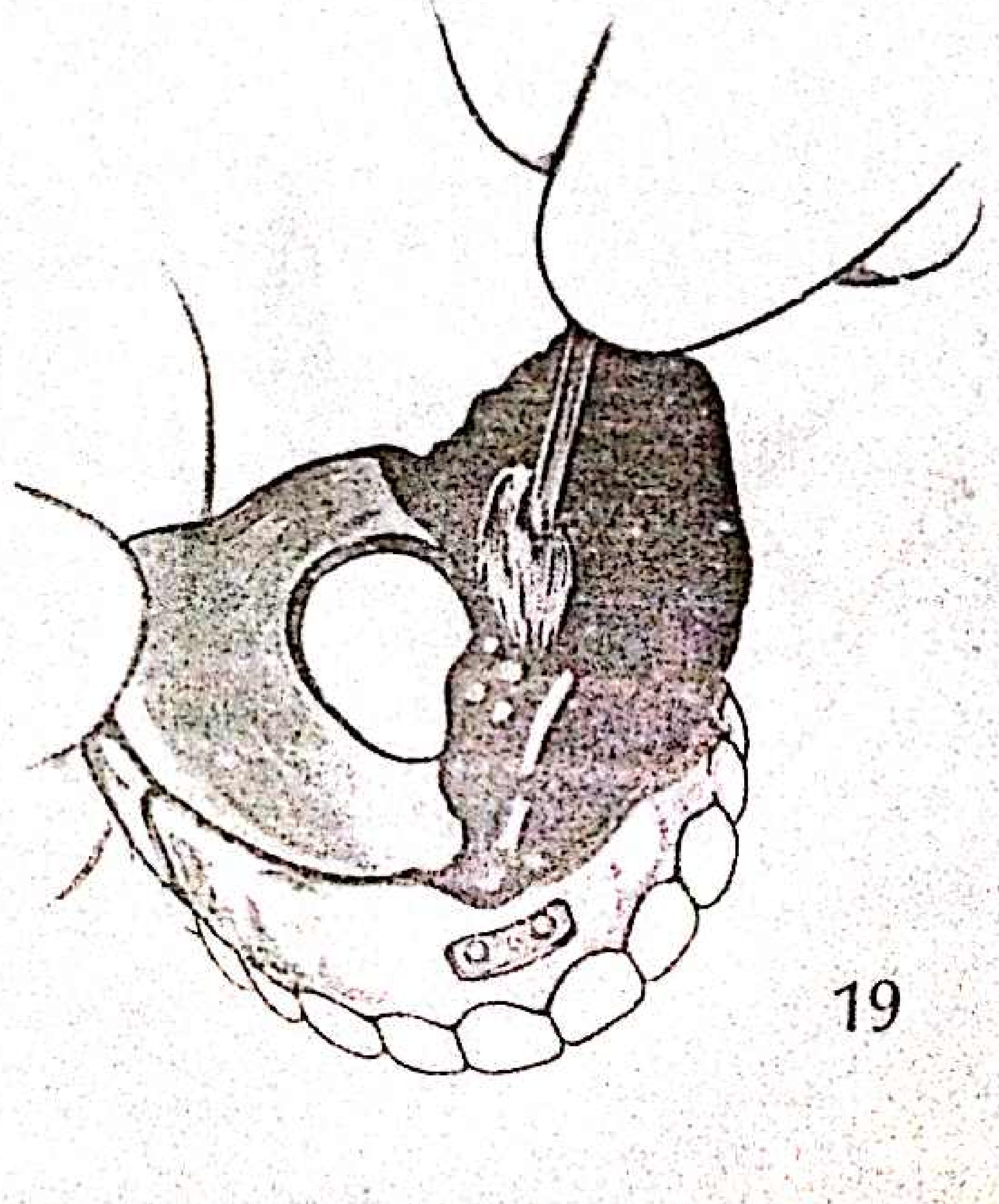
A denture with a bolus of gutta-percha moulded to match the postresection defect is prepared as already described.

19

The surface of gutta-percha is slippery and, when the graft is being draped over it, it is convenient to glue one to the other. With the surface dried carefully, it is painted with Mastisol or Compound Benzoin Tincture (BP), to hold the graft in position.



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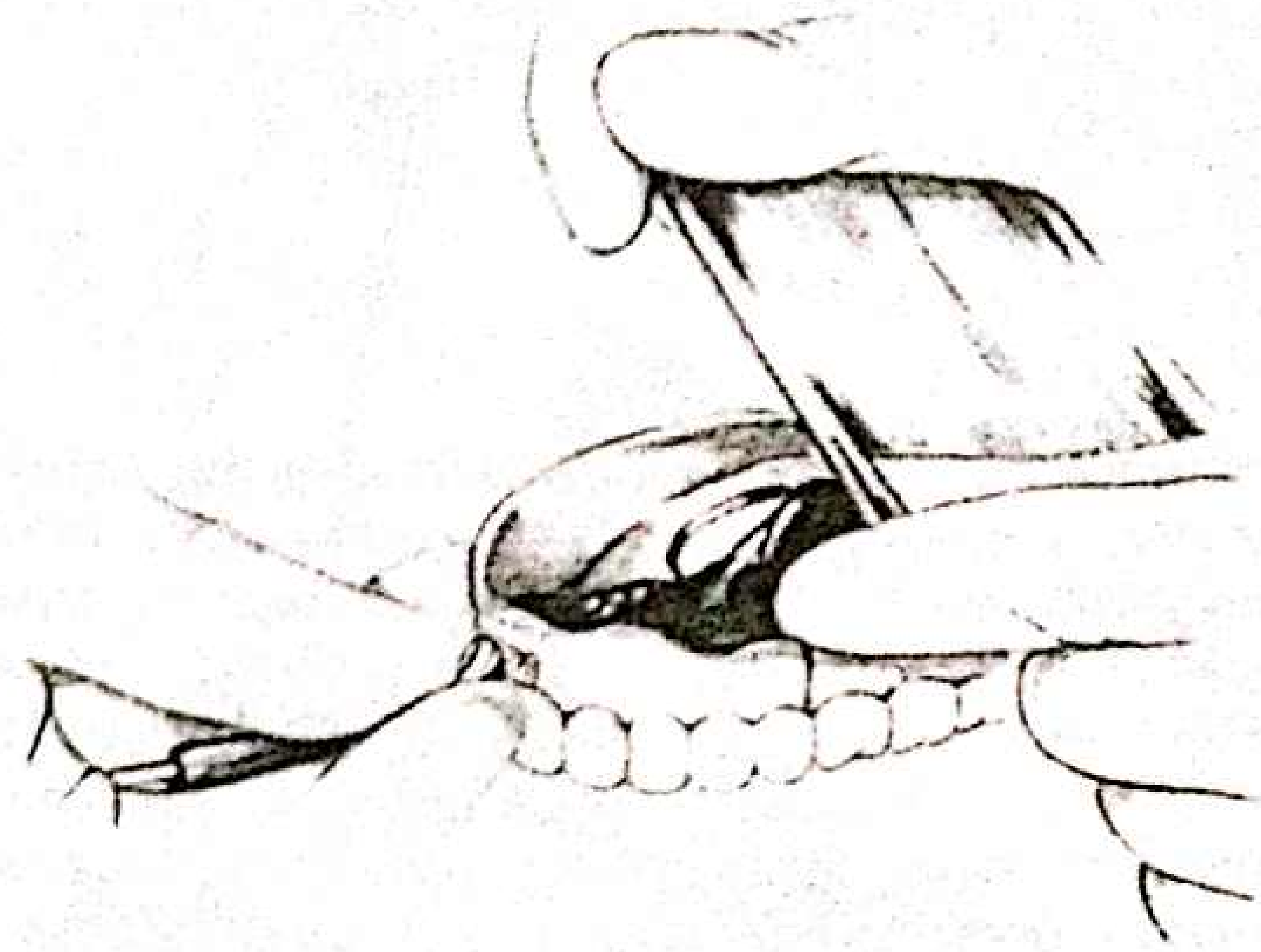
The graft is draped over the bolus, to which it adheres.



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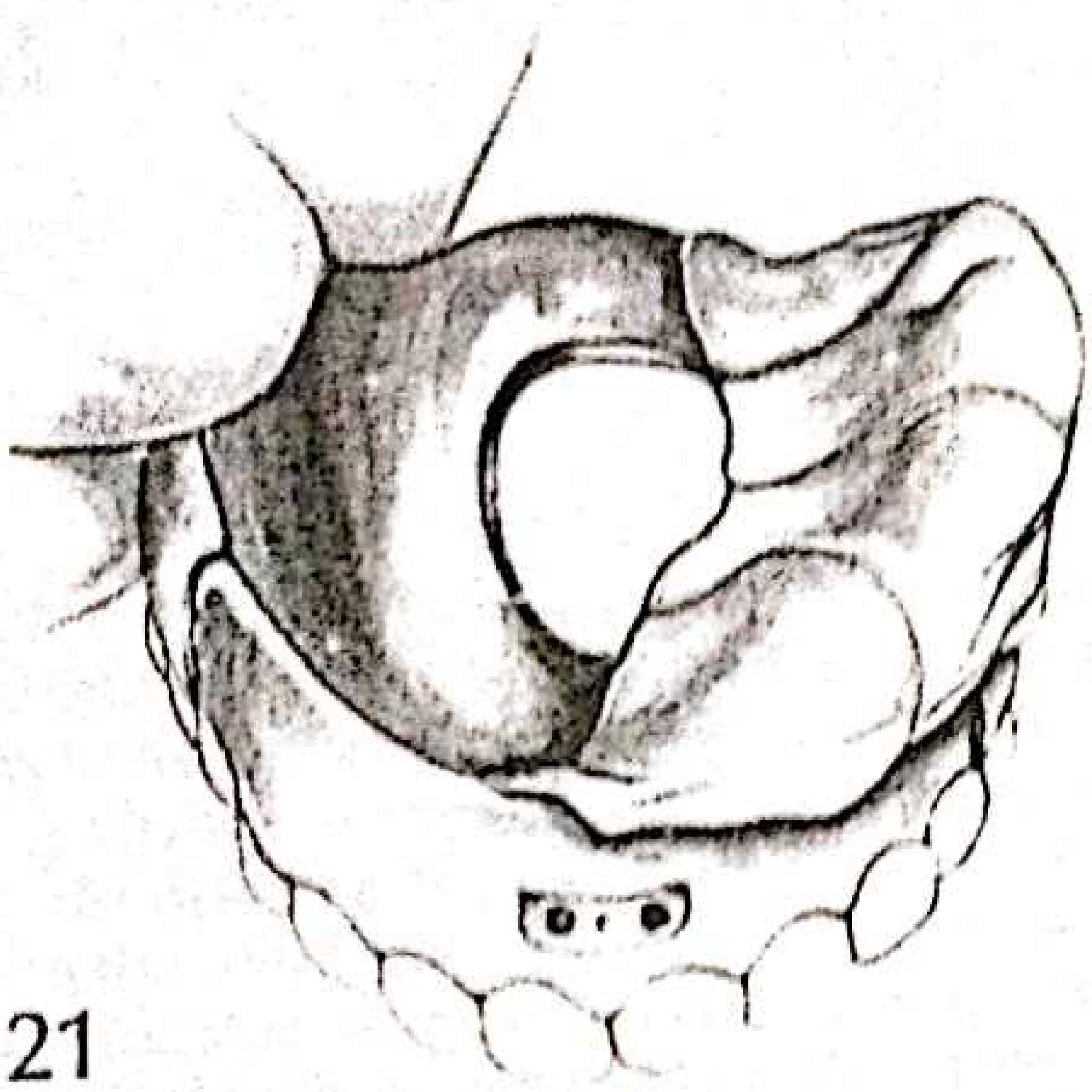

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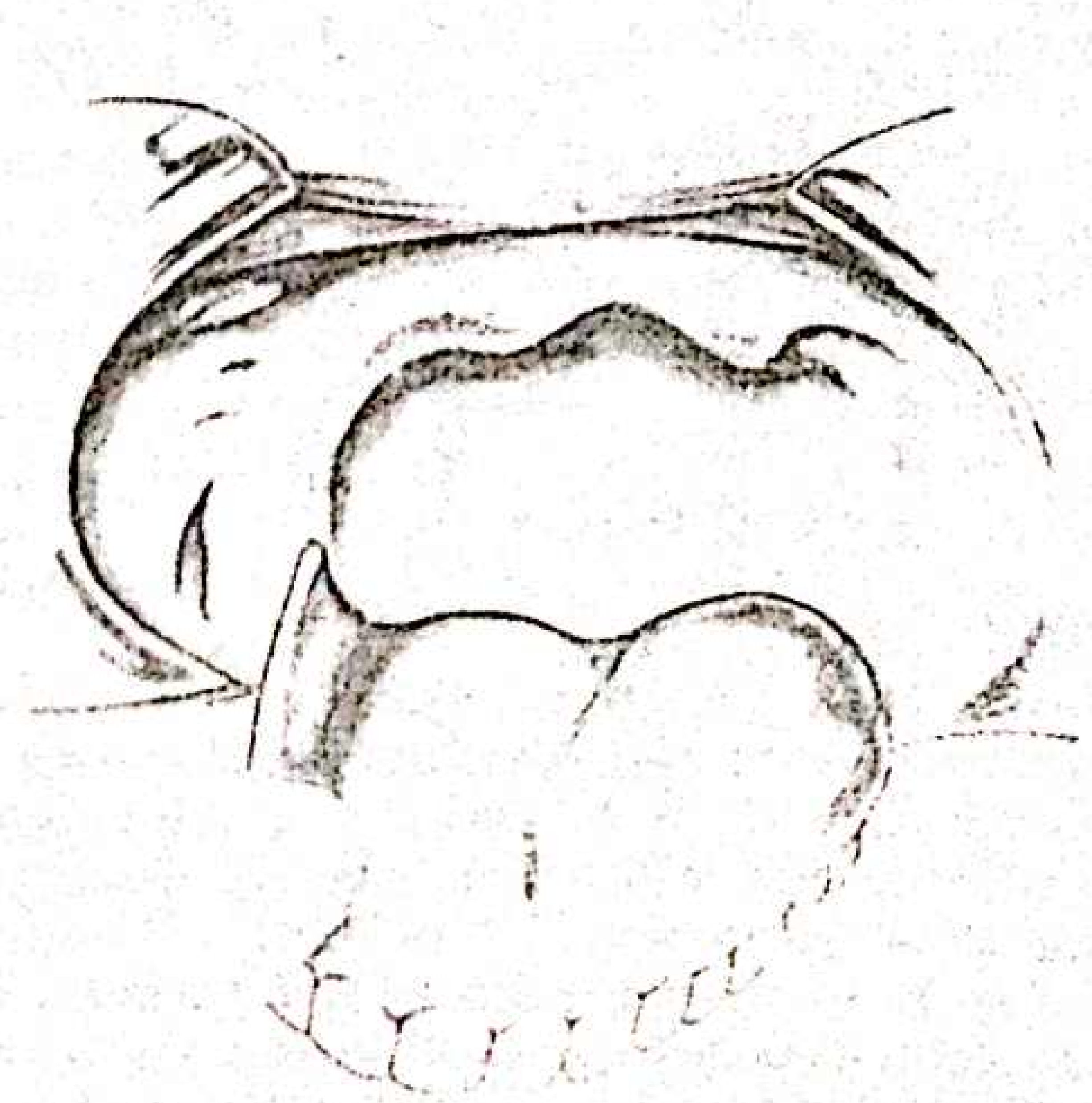
With the irregular surface of the gutta-percha bolus, folds in the graft are unavoidable. These can safely be ignored, the graft taking where it is in contact with a vascularizing surface on the defect. Any folds which were present slough and are trimmed away, leaving a smooth surface when healing is complete.

22

The adhesion between the graft and the gutta-percha bolus wears off, so that by the time for removal of the splint-*cum*-bolus is reached it has gone completely. The fitting of a modified denture completes the reconstruction.



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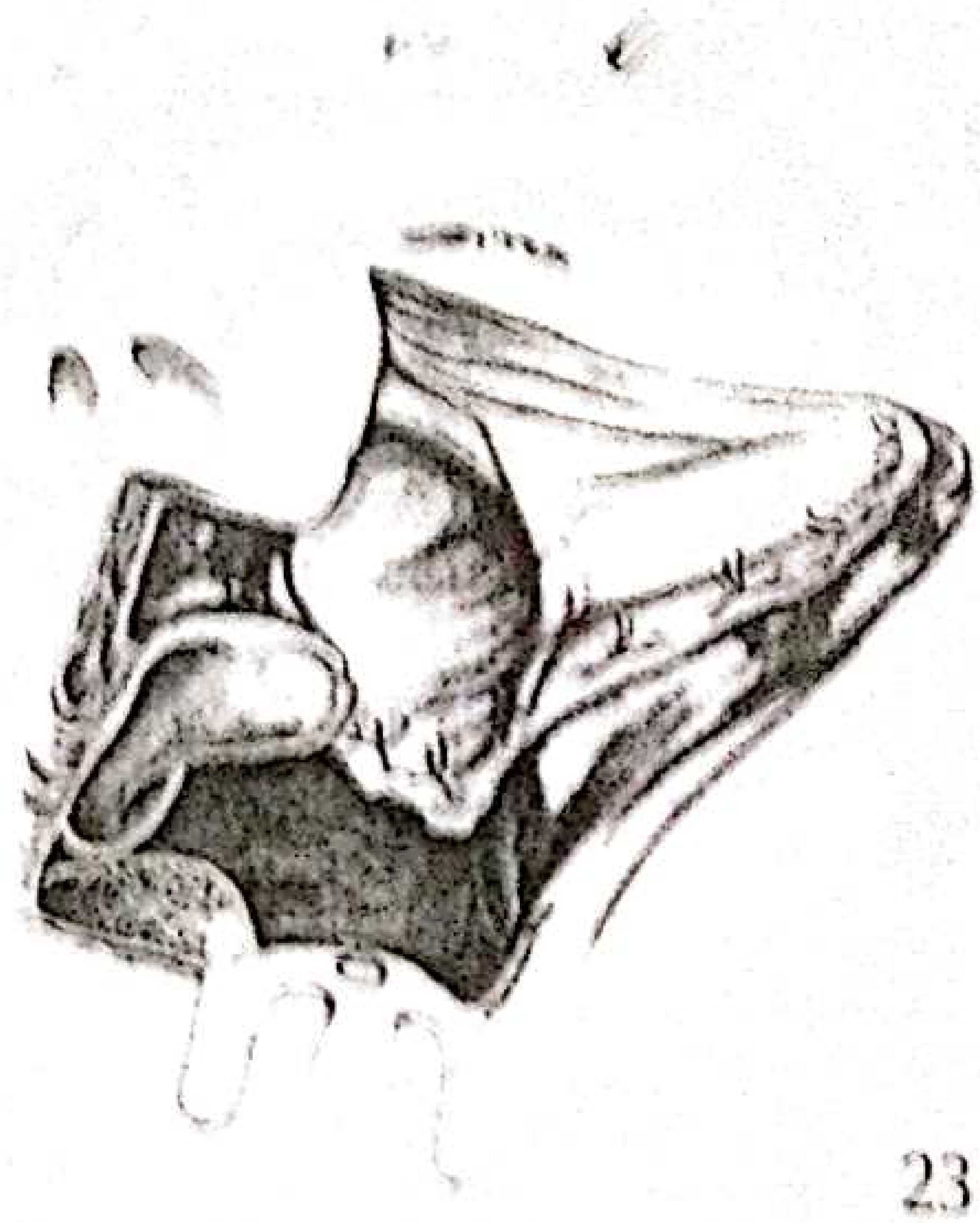
When the defect to be grafted extends into the antrum and ethmoid, a modification of the gutta-percha bolus technique is required. The need for modification arises because, in resecting the maxilla and/or ethmoid, a cheek flap is usually elevated to provide adequate exposure. The insertion of a denture with a large bolus of gutta-percha is straightforward when the exposure used in carrying out the resection permits free access, but when access is restricted postoperatively to the open mouth its removal may be near impossible.



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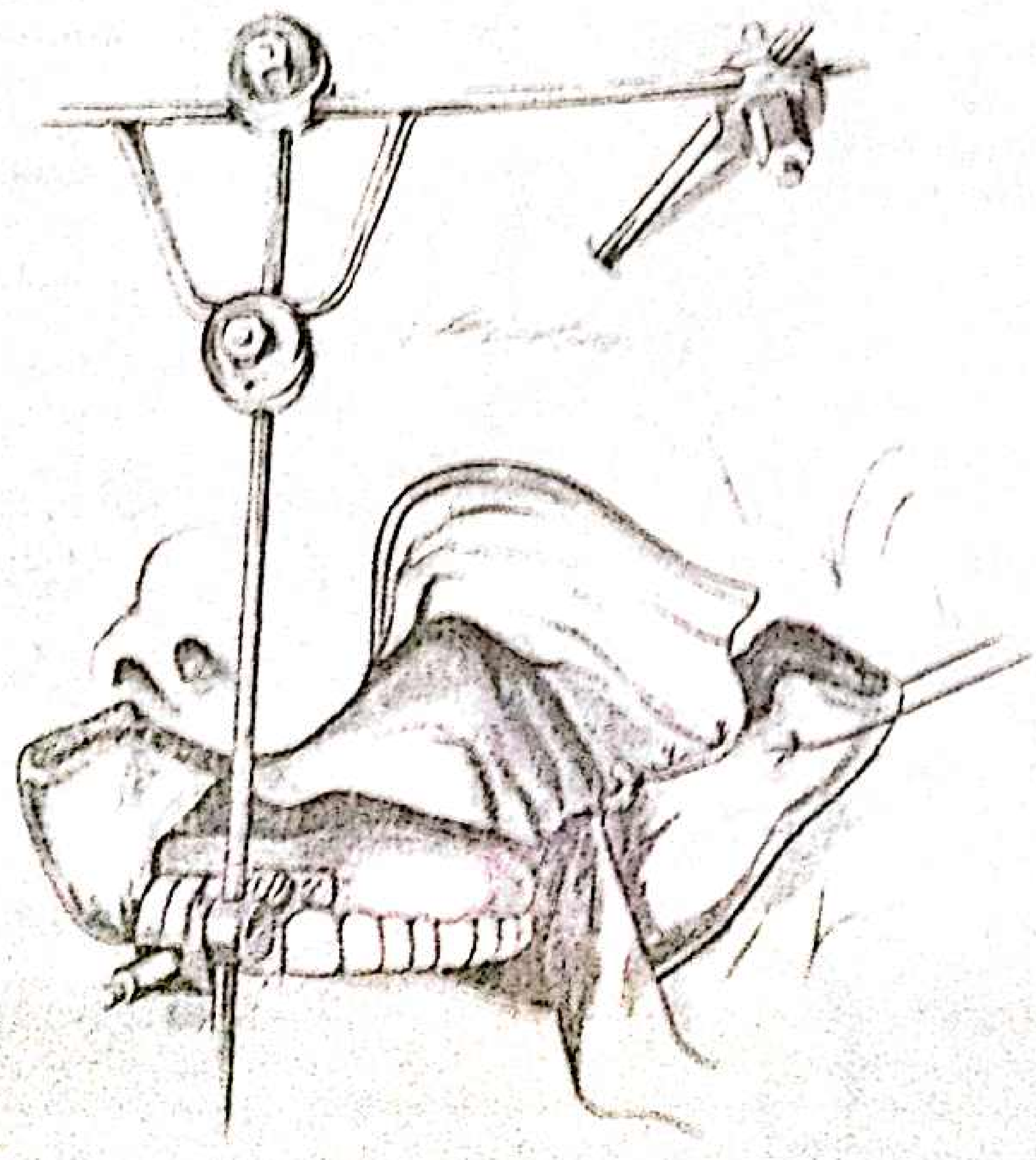

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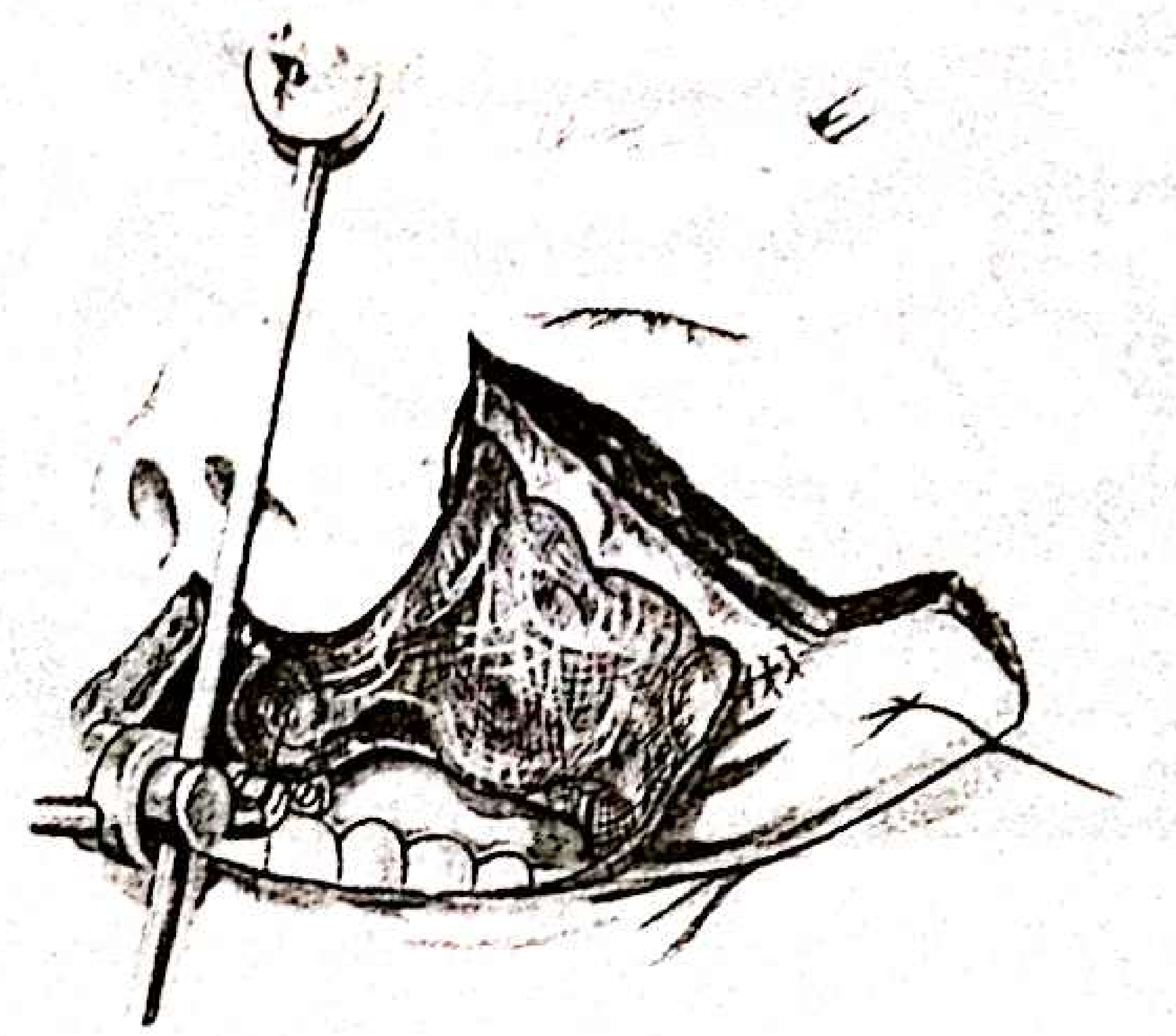
Under those circumstances the dental appliance with its gutta-percha bolus is used only to fill the lower part of the defect and seal the oral cavity off from the sinus/nasal cavity.

25

The remainder of the cavity is packed with a bolus of soft material such as gauze. This combination allows the dental splint to be removed easily at the first dressing through the mouth, with equally easy removal of the gauze pack. The offensive smell which builds up in such a pack can be easily avoided by soaking it prior to insertion in a water repellent fluid such as Compound Benzoin Tincture (BP) or Compound Iodoform Paint (BPC).



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The defect following resections involving the maxillary and nasoethmoidal sites has varied surfaces, some of which, soft tissue and maxillary bone particularly, will accept a graft, while others, such as mucous membrane, will not. No attempt is made at the time of grafting to distinguish the two types of surface. Where the graft abuts on a vascularizable surface, it takes; where the surface is not vascularizable, it sloughs. When slough separation has occurred and healing is complete the lining of the cavity is a mixture of graft and mucous membrane. The reconstruction is completed by the fitting of a suitably modified upper denture. A dental impression of the palatal area and the grafted defect is taken and used as a basis on which the denture is constructed to match the new contours.

The mode of use of grafts, the extent to which they are used, and the problems which arise in their use vary in the different sites in the upper part of the mouth and the sinonasal tract. In the defect of the hard palate it may not be necessary to graft at all. Bare palatal bone is sufficiently vascular to granulate and heal spontaneously; equally its vascularity allows it to accept a graft readily. Grafting tends only to be used when the defect is a large one. When a segment of hard palatal bone has been resected, grafting is more often carried out, not merely because the defect is more extensive but also because the deep surface of nasal and/or antral mucoperiosteum will have been exposed. Grafting is particularly desirable if its continuity has been breached. The graft may bridge the break in continuity and seal it off, preserving the vacuum between the palate and the dental plate which may be fitted subsequently, making for more effective adhesion.

When the antroethmoidal complex has been breached, the management problems which arise subsequently depend very much on the extent to which the various bony walls remain intact, the extent to which graft contracture can occur, and the effect which such contracture has on cosmesis and function. In those areas where the bony wall is intact, contraction of the graft lining it cannot occur. It is when the anterior wall of the antrum has been resected that the problem of subsequent graft contracture arises in its most severe and potentially intractible form. It is standard practice to fill the defect resulting from the resection with a custom-made extension of the upper denture. This acts as an obturator and it is used to keep the graft stretched until its phase of contracture ends, usually in about 6 months. Only then can the denture be converted into a permanency which matches the normal side in the contour it provides. The problem of contracture is greatly magnified if there has been failure of graft take, particularly in the infraorbital area, and good take in this area is particularly desirable.

This aspect, and those involving the making and fitting of the various dental splints, can only be carried out effectively if there is cooperation with the oral surgeon, his back-up of laboratory facilities, and the help of his dental technician.

Graft behaviour

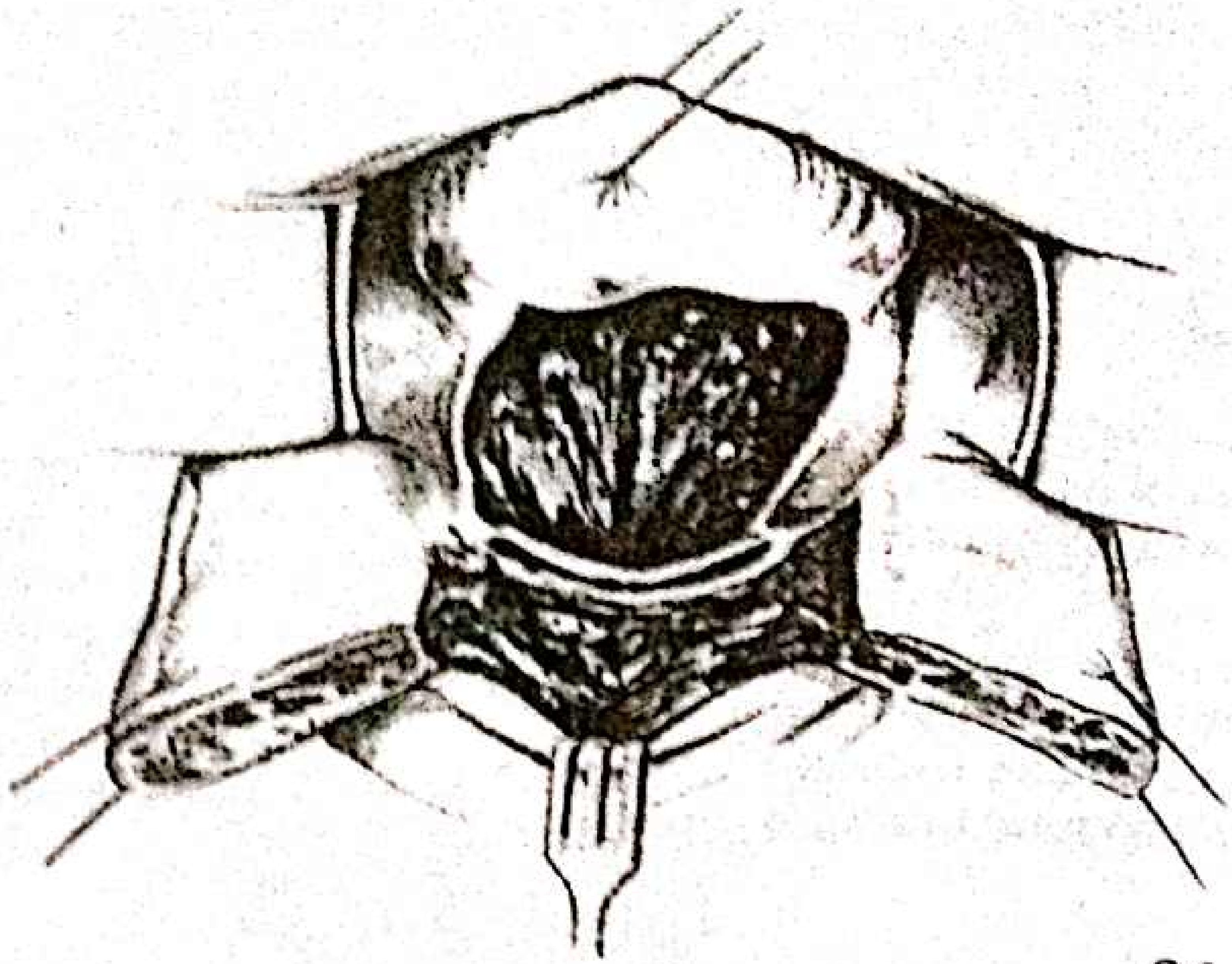
Above the oral cavity, where the lining is a mixed one of skin graft and mucous membrane, the combination gives little trouble if the area is kept clean. In the oral cavity where exposure to food and saliva are complicating factors the graft undergoes a period of acclimatization. Initially it tends to collect food and other debris and requires regular irrigation, but quite quickly it adapts to its change in environment, becoming self-cleansing like the adjoining mucosa.

Flaps

Nasolabial flaps

26

This technique is particularly useful in reconstructing the defect which follows resection of small tumours of the anterior floor of the mouth. It makes use of flaps raised along the line of the nasolabial fold, using that area of skin availability. In its standard design two flaps are raised, one from each cheek, triangular in shape, inferiorly based, with the base lateral to the angle of the mouth.



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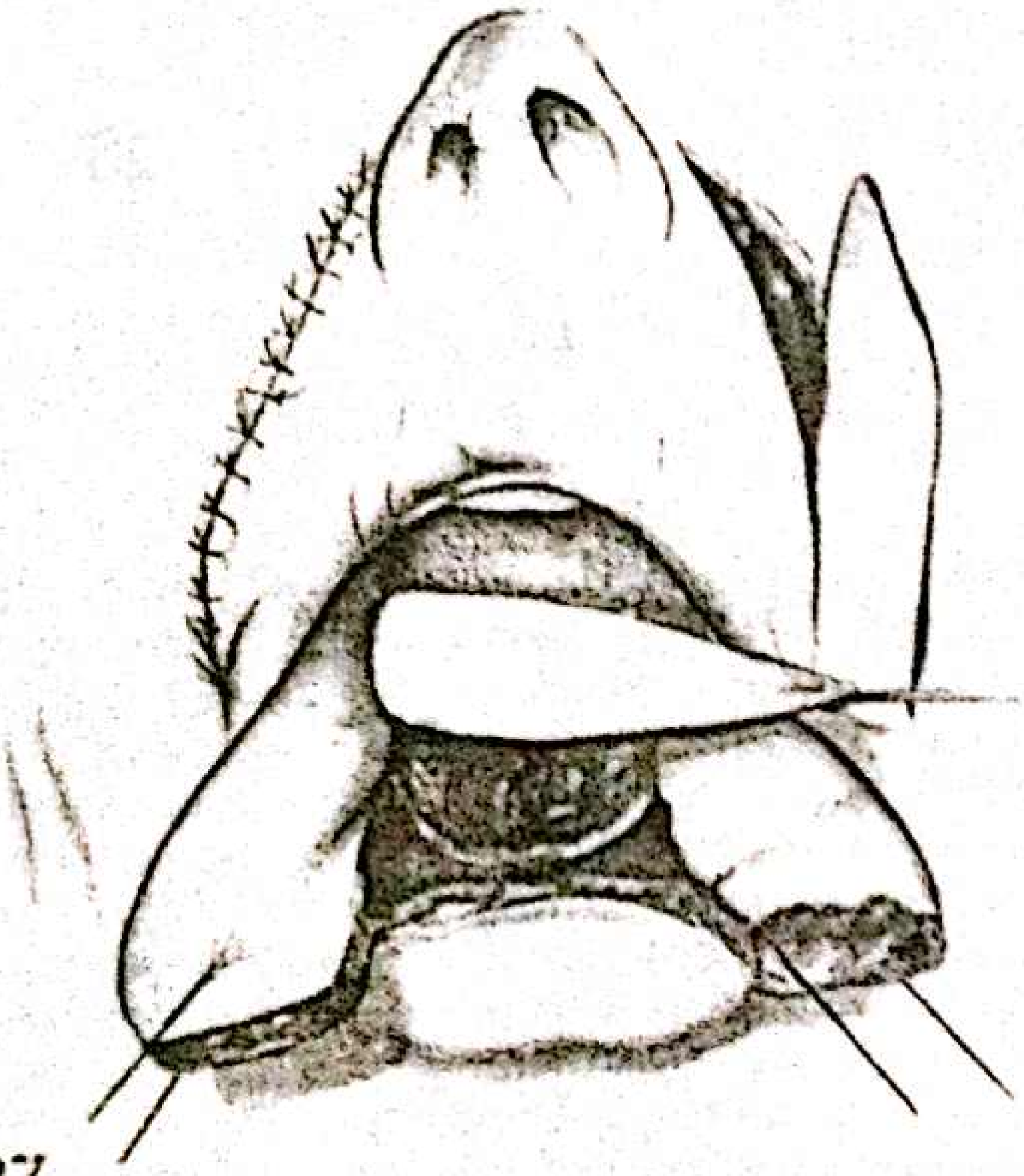

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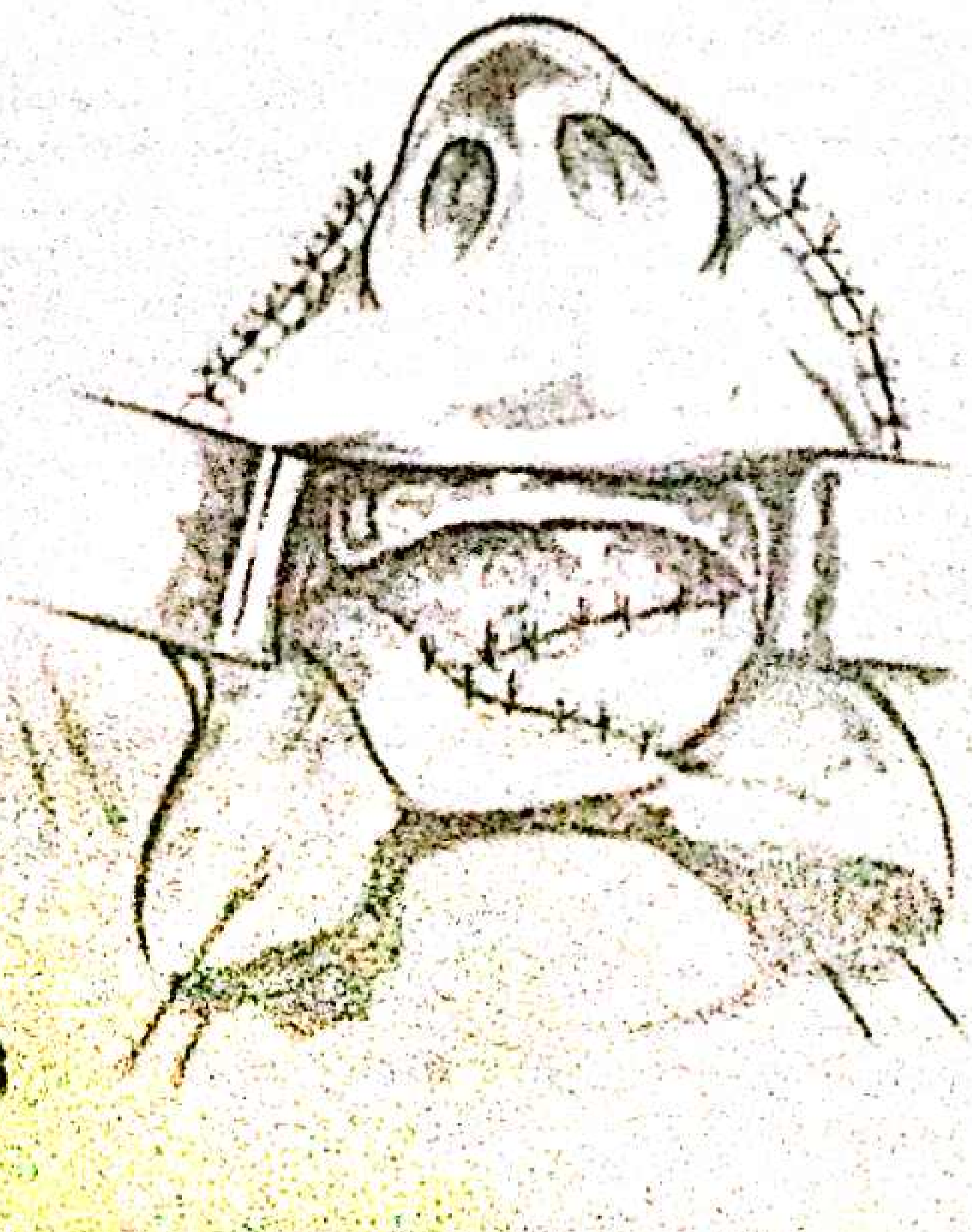
Raised superficial to the facial muscles from that area of hairless skin, each flap is tunnelled through the cheek and brought into the mouth.



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Inside the mouth, the two flaps are interdigitated with one another across the anterior floor, and sutured to the anterior and posterior margins of the defect.

The breadth of each flap is decided by the surgeon's estimation of the local nasolabial skin availability in the individual patient so that the cheek defects can be closed directly. The length of the flap is largely fixed, above by its approach to the inner canthal area and the need to avoid ectropion when the defect is closed. Below, the margin of the beard area is a limiting line in the male, but an independent criterion which determines the level of the base is the level of the floor of the mouth. The two levels usually correspond. The tunnel is constructed through the cheek just above the base and made wide enough to allow passage of the flap without compression. Closure of each cheek is halted at a level which avoids constricting the tunnel with its content of flap.

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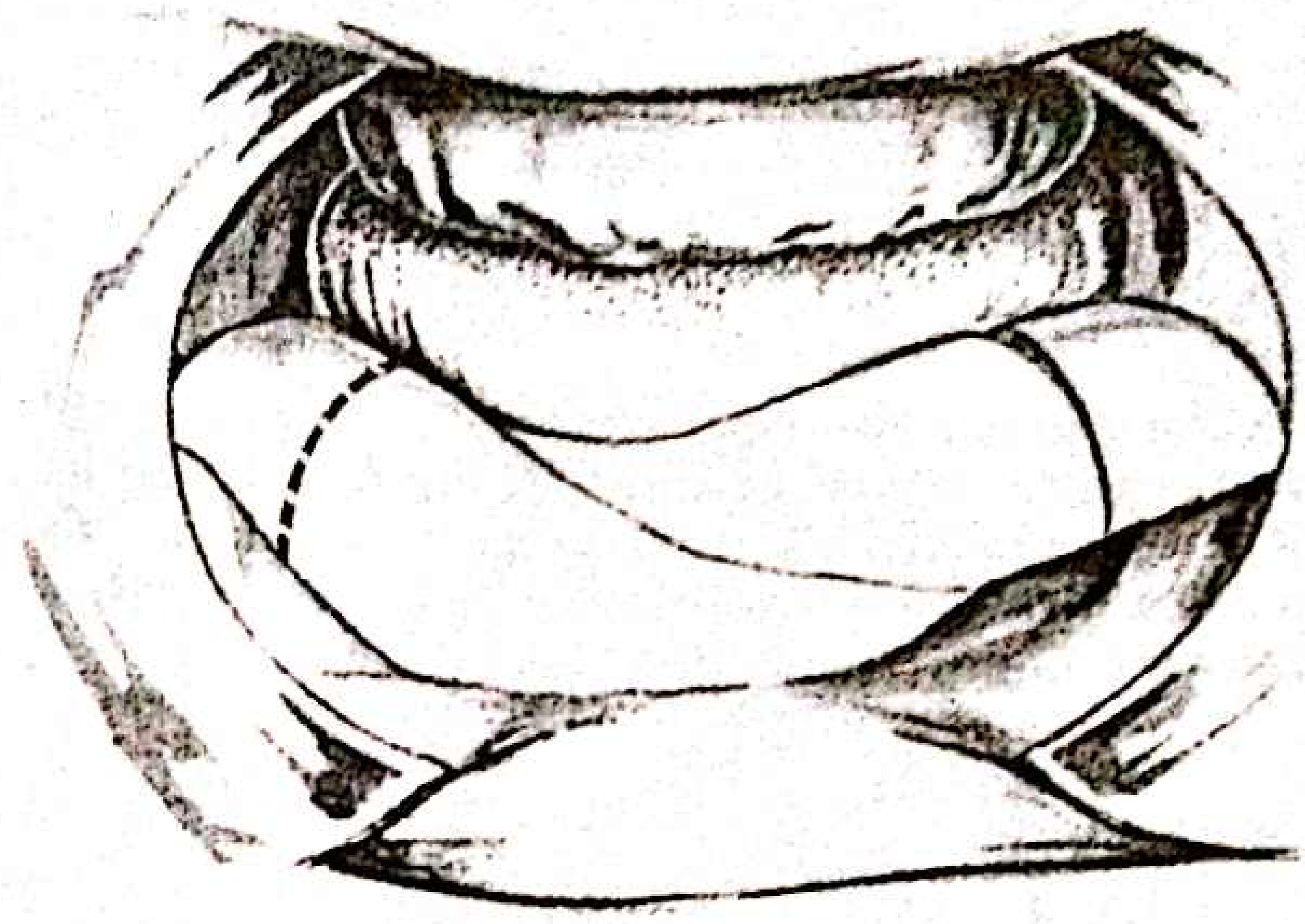
The flaps are left for 3 weeks.



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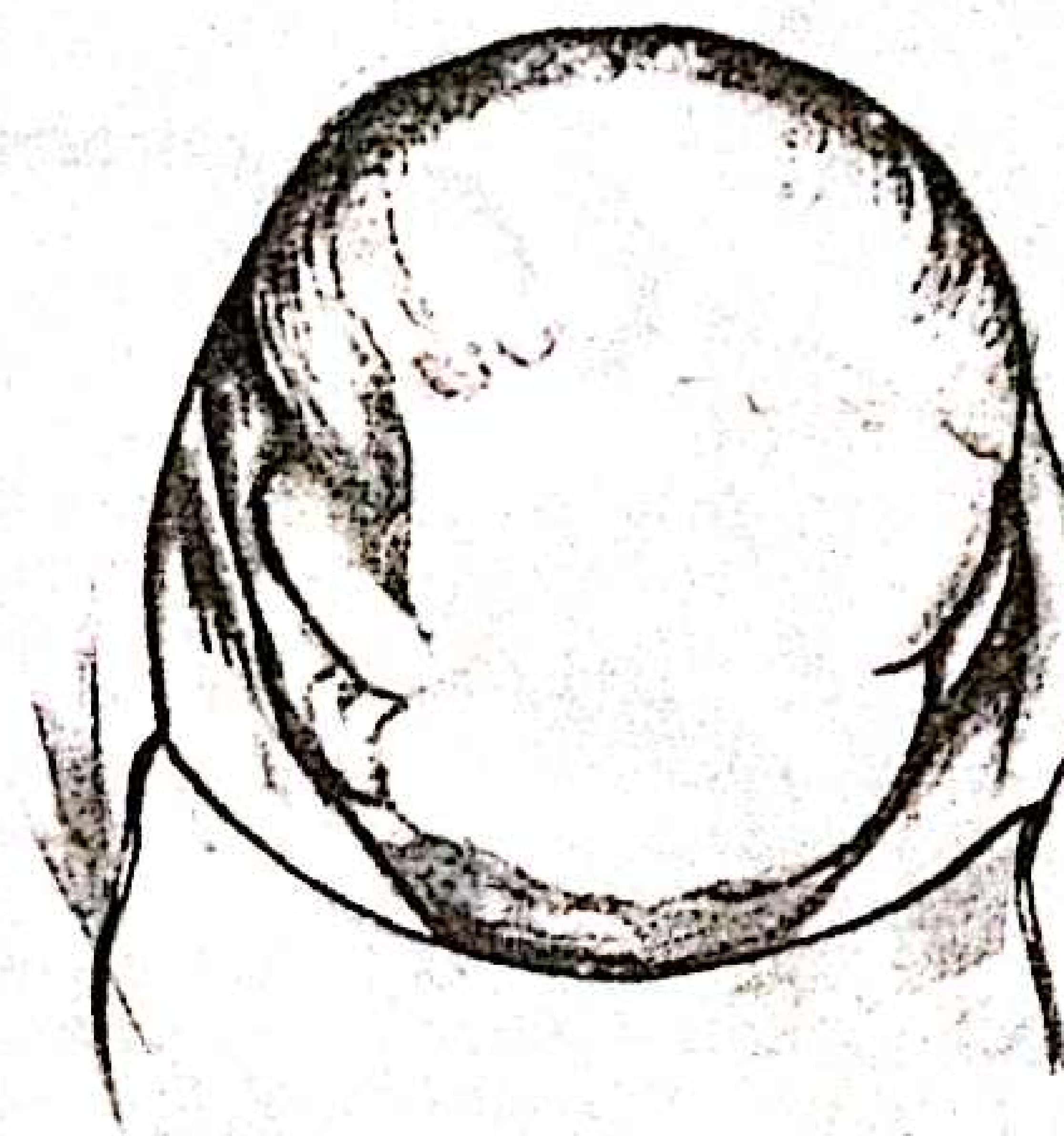
The pedicles are then divided and insetting inside the mouth is completed. The bridge segments are returned to their original site on the cheek or, more often, discarded.



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The two-stage method has advantages, especially in the male, since the 3-week gap in time between the initial transfer and division of the pedicles allows any hair which had been transferred with the flap into the mouth to declare itself, allowing its source to be removed at the time of flap division.

Immediately postoperatively there is usually severe pincushioning of both flaps, but they flatten out quite quickly, presumably as a result of the consistent upward pull in normal activity of the anterior free segment of the tongue.

The reconstruction has considerable merits and equally important limitations. The major limitation concerns the dimensions of the defect for which the flap is suitable. The length of the flap is largely fixed and this determines the horizontal width of the defect. A little over 5 cm is virtually an absolute maximum and less is preferable. The limitations on vertical breadth are a little less stringent, but about 3.5 cm is an average.

The technique is most suitable for the edentulous mouth where resorption of the alveolar bone has reduced the depth of the floor so that the flap passes virtually horizontally to reach the defect. Its use in the dentate mouth poses technical problems because of the depth of the floor. These are discussed in detail in the chapter on 'Anterior floor of mouth', pp. 254–269.

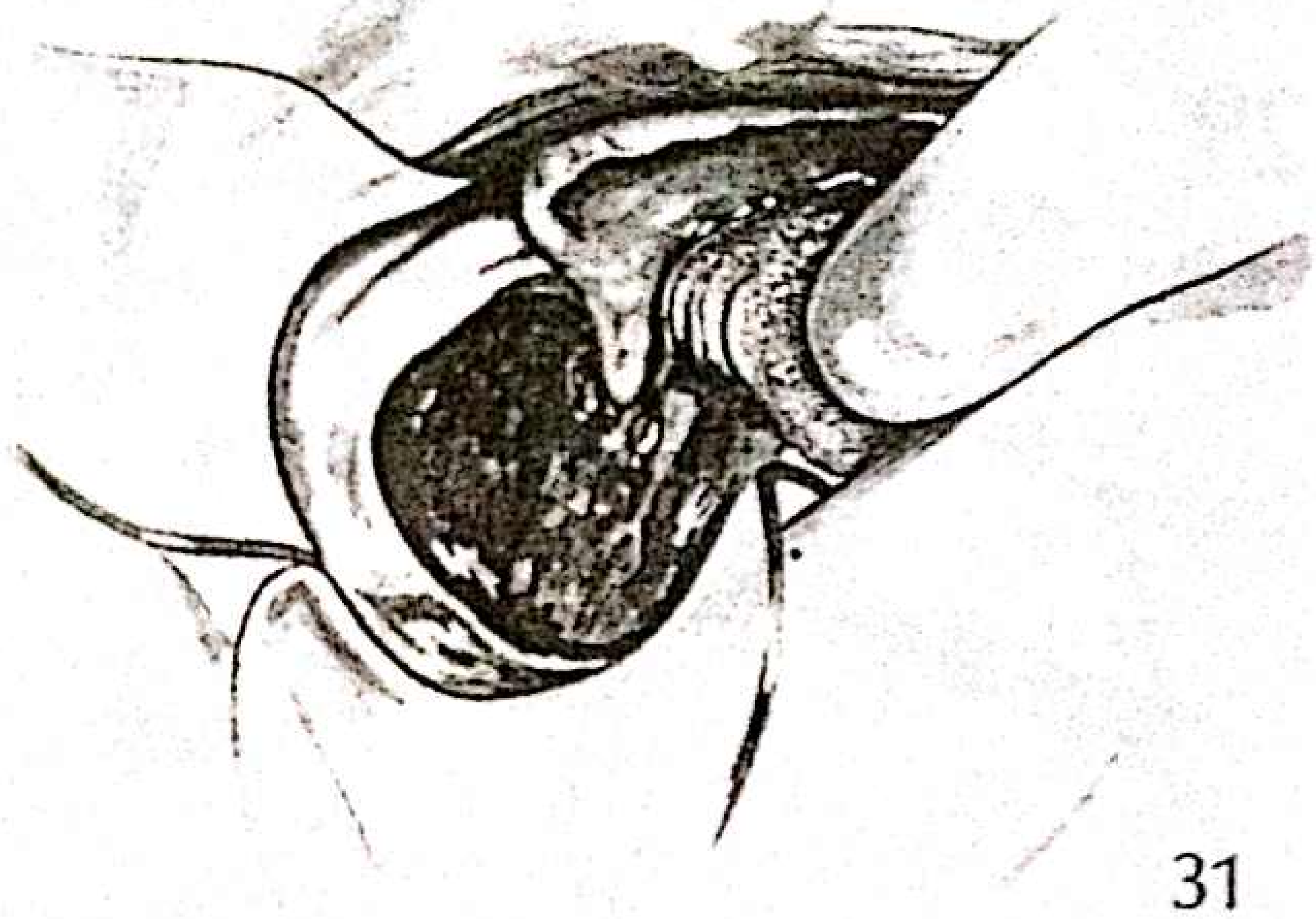
Tumours of the anterior floor of mouth are relatively common and, particularly in the edentulous mouth where the site is easily seen, are increasingly being diagnosed while they are small and suitable for this reconstruction. In such patients the defect often involves the alveolar ridge and anterior floor with extension on to the adjoining ventral aspect of tongue. In practice one of the flaps often covers the floor defect while the other covers the defect of the ventral tongue.

Used in this clinical situation nasolabial flaps have provided a most effective solution to a difficult problem. They have the considerable virtue of holding the tongue in an elevated position during healing, thus preventing the anchorage to the floor which would otherwise occur.

Bilateral nasolabial flaps, though most often used to reconstruct defects of the anterior floor of mouth, are also clearly available to reconstruct mucosal defects of the lips, upper and lower. Where the clinical situation is appropriate, a single flap alone can be used.

31.

The technique has also been used to reconstruct small intraoral defects within the reach of the flap, taking its pivot point as just lateral to the angle of the mouth, at sites such as the adjoining buccal mucosa, the upper and lower alveoli, and the upper and lower buccal sulci.



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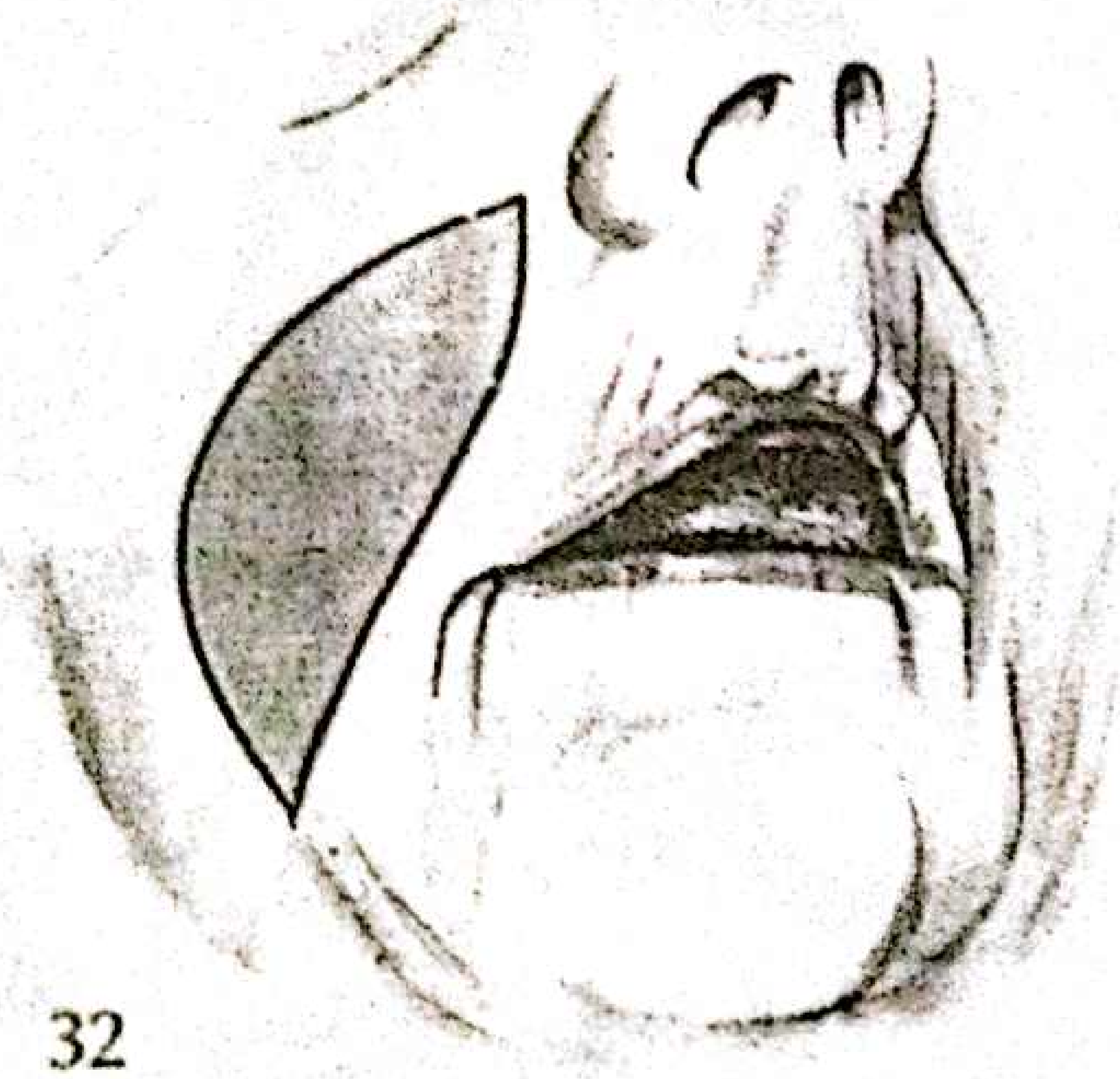

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Used in these sites, where the pivot point around which the flap will rotate in transfer coincides with one end of the defect, the flap can be designed as an island with an entirely subcutaneous pedicle.

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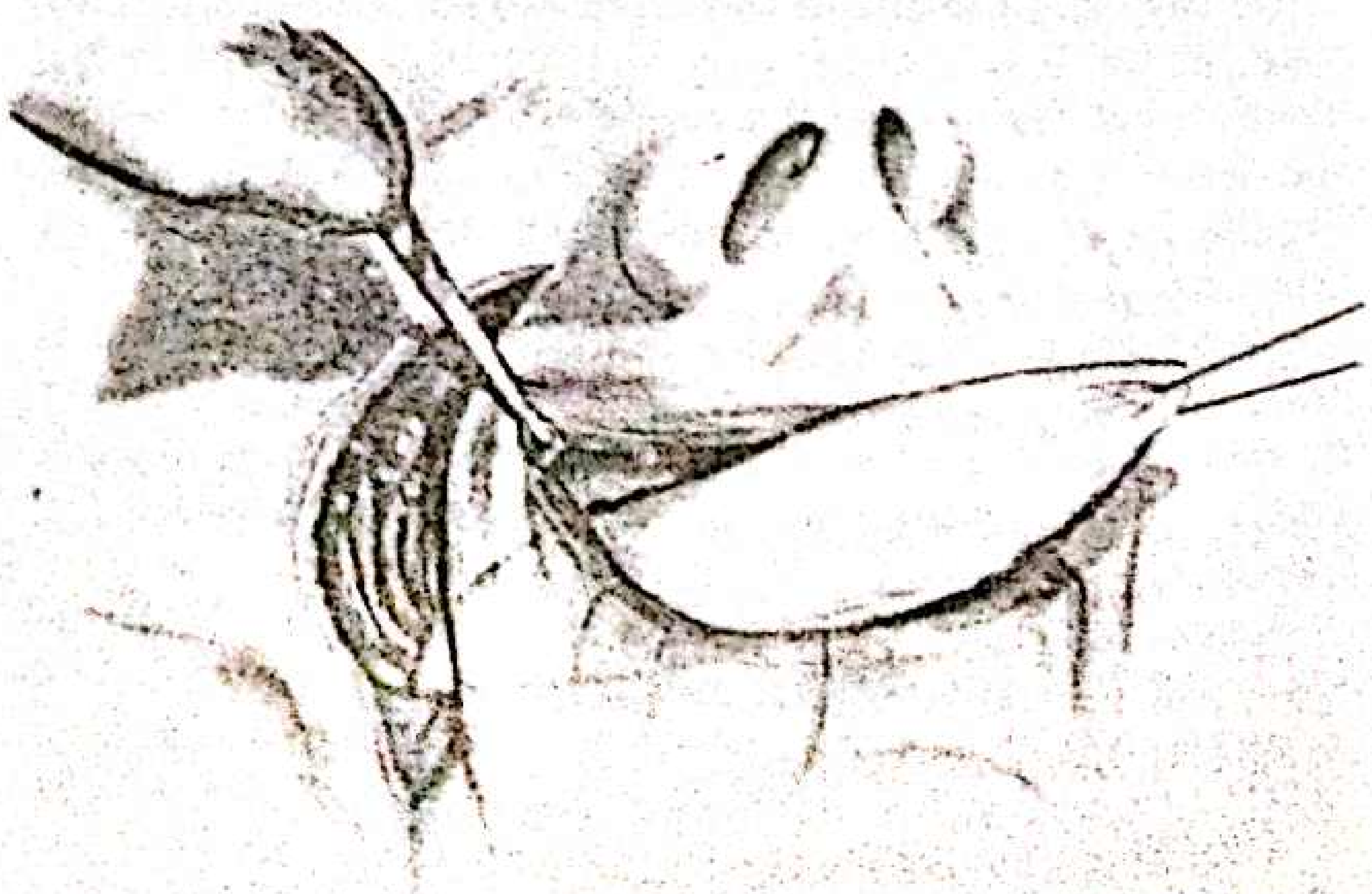
Brought through a tunnel in the cheek on its subcutaneous pedicle, the flap can be rotated on its pedicle to reach its destination.



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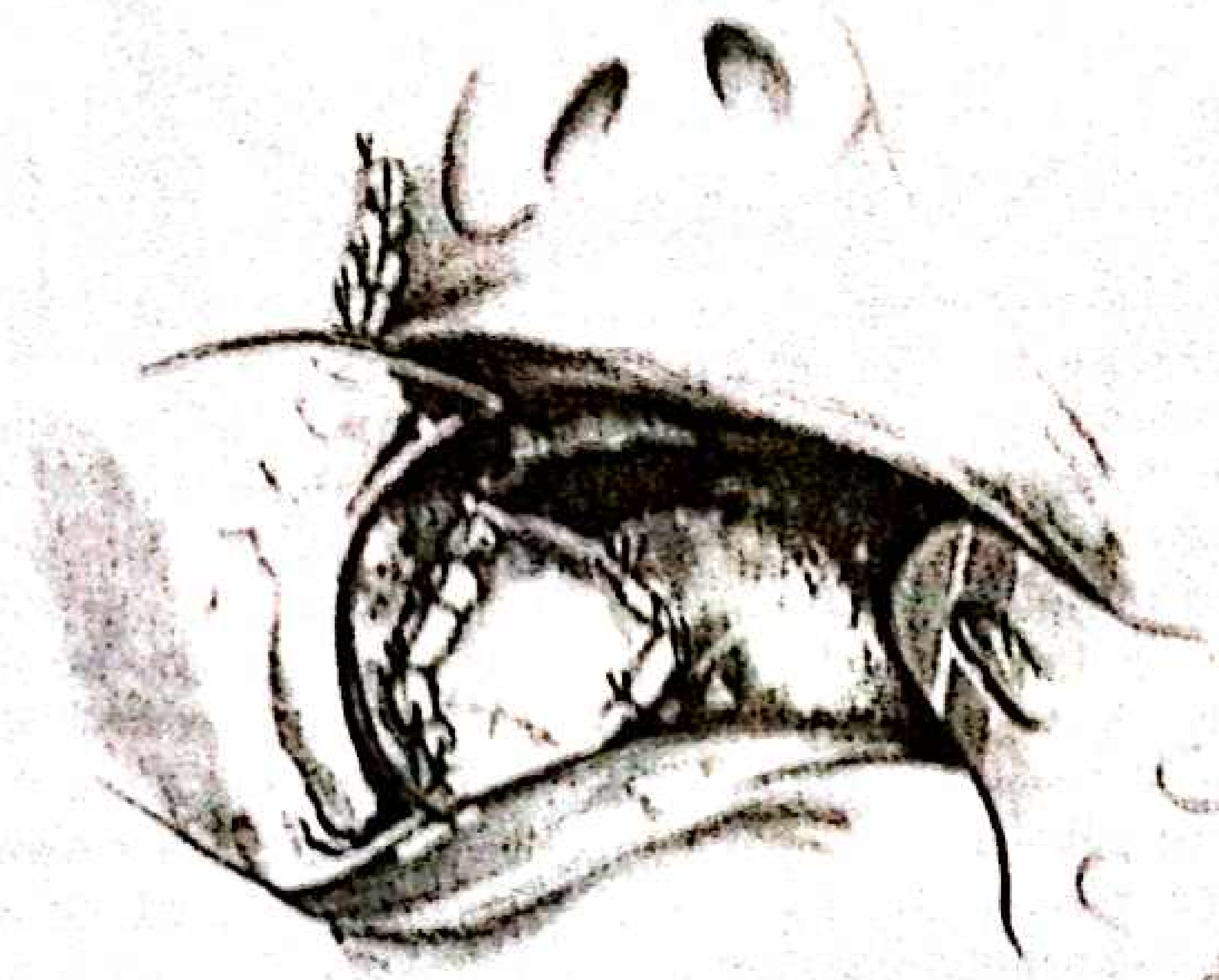
Sutured to the margins of the defect, the reconstruction is completed in a single stage.

Where the defect is at a distance from the donor site, as in the anterior floor of mouth, there is no advantage to an island design, but where the defect is in continuity with the tunnel the island design is a useful modification.



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Forehead flap

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The forehead flap, as used to reconstruct intraoral defects, is laterally based. Its elevation and the management of the secondary defect have been described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103. It is usual to extend it to the contralateral hairline, use of its full length in this way making it possible to elevate it only to the extent which allows it to be transferred to the intraoral site without tension.

It contains the anterior branch of the superficial temporal artery as its axial artery, and is normally raised without preliminary delay. Although it is a safer flap than many, its feeding artery, the external carotid, should be left intact wherever possible. If it is not necessary to raise the flap to its full extent it may be possible also to leave the posterior branch of the superficial temporal artery intact.

Designed and raised in this way the hairbearing skin of the temple is part of the flap, but only the hairless skin is used in the final completed transfer. With division of the bridge segment 3 weeks after the initial transfer, the length of hairbearing skin is returned to the temple.

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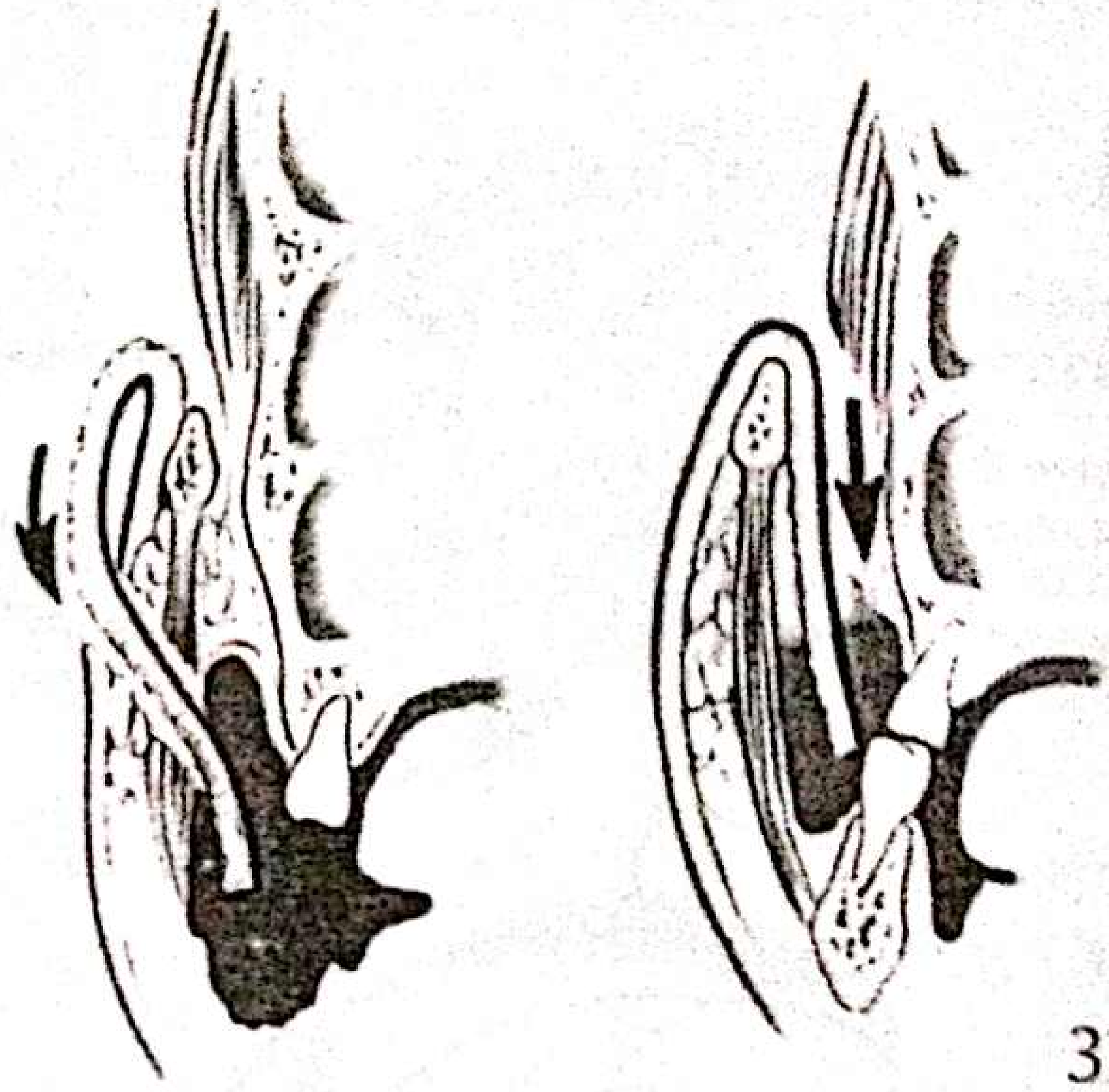
When the opportunity presents of a suitably bald patient, a modified version of the flap can be designed which uses the posterior branch of the superficial temporal artery as its axial artery. Instead of curving across the forehead the flap passes up over the hairless vertex, leaving the final defect in an inconspicuous site. The patient is also left with a normally mobile forehead, in contrast with the standard design.

37

Transfer to the intraoral site is achieved either by making a tunnel directly through the cheek, or by passing the flap deep to the zygomatic arch. When the tunnel through the cheek is used, the flap is turned outwards and passed through the tunnel into the oral cavity. When the flap is passed deep to the zygomatic arch it is turned inwards, following the path of the temporalis muscle into the mouth. The gap between the zygomatic arch and the temporal bone is normally filled by temporalis, and it is consequently only possible to use this route if the lower part of temporalis has been removed as part of an ascending ramus resection.



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The obvious hazard in constructing a tunnel through the cheek is damage to the facial nerve and the method used is designed to avoid this. A horizontal skin incision is made in front of the ear approximately 1.5 cm below the zygomatic arch and two-thirds of the width of the flap in length, and deepened to the parotid gland. With closed blunt tipped scissors, such as McIndoe or Metzenbaum, the tip is thrust through the substance of the cheek in the direction of the intraoral defect, using the index finger in the mouth as a direction finder. With the tip of the scissors in the mouth, the blades are opened and, held open, withdrawn, creating the track.

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Using the gloved index finger the track so made is dilated until the flap can pass through freely. The most frequent cause of flap necrosis is constriction within the tunnel and care should be taken to avoid this by ensuring that its width is adequate.

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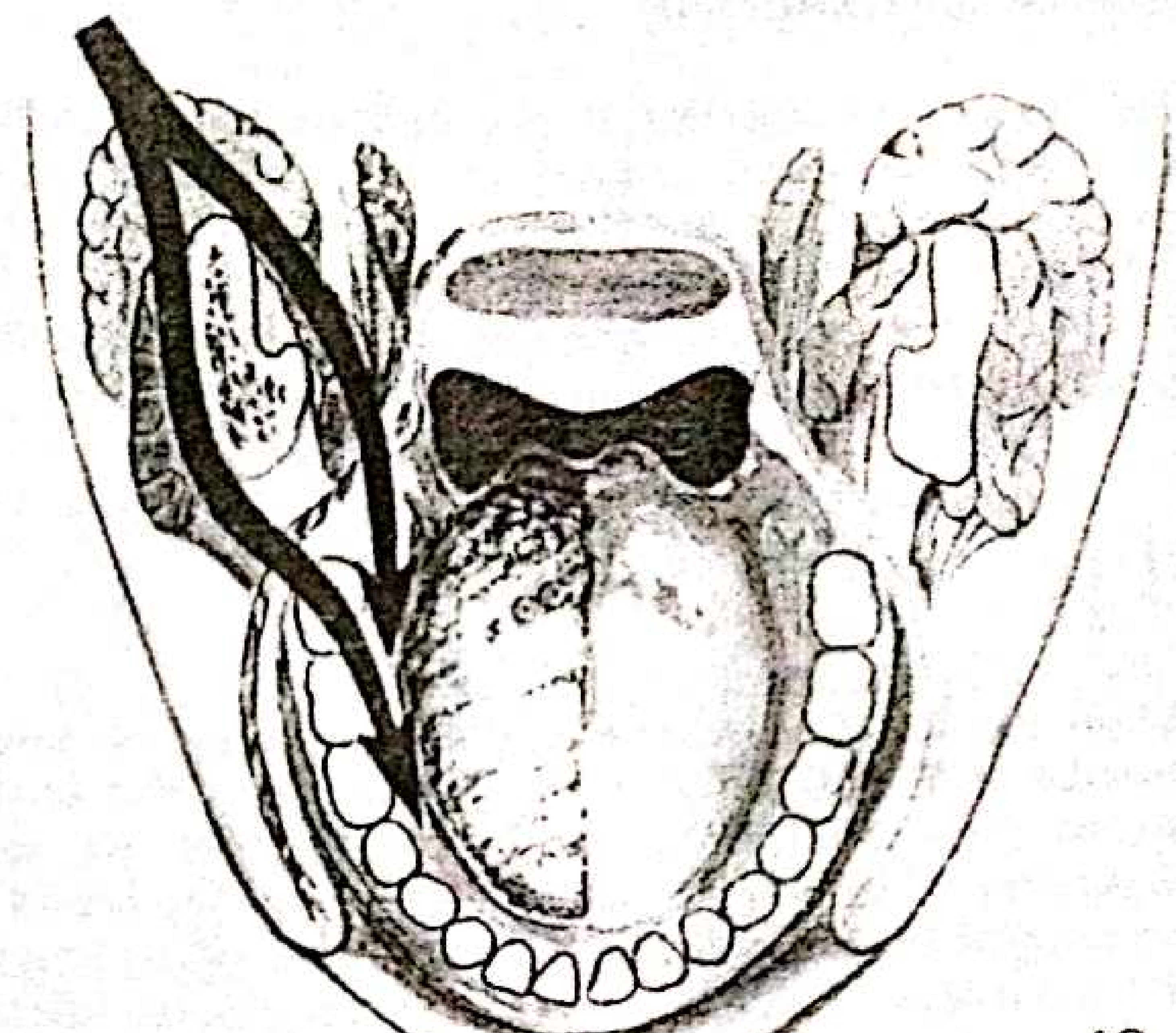
When the ascending ramus of the mandible has been resected the making of the tunnel is straightforward. Such resistance as occurs is usually from the masseter muscle rather than the parotid gland, and some of its fibres have sometimes to be divided. When the ascending ramus is intact, passage into the mouth has to be indirect, in front of the bone. Allowance may have to be made in planning to accommodate the added flap length which can be required when the passage is indirect in this way. In either instance the flap is turned outwards and down so that its skin surface is medial and its deep surface lateral in passing through the tunnel.



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The flap is divided 3 weeks after the initial transfer, and the bridge segment is returned to the forehead. When a tunnel has been constructed, the flap is mobilized freely within the tunnel before being divided. Any tendency to tubing of the bridge segment has to be undone, as described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, before it can be made to fit into its original site in the temple. In closing the tunnel, only the skin end should be sutured. This allows free drainage into the mouth and the tunnel obliterates spontaneously.

When the flap has been passed deep to the zygomatic arch it is much more difficult to mobilize for division of the pedicle – a difficulty which is sufficient to act as a deterrent to the use of that route.

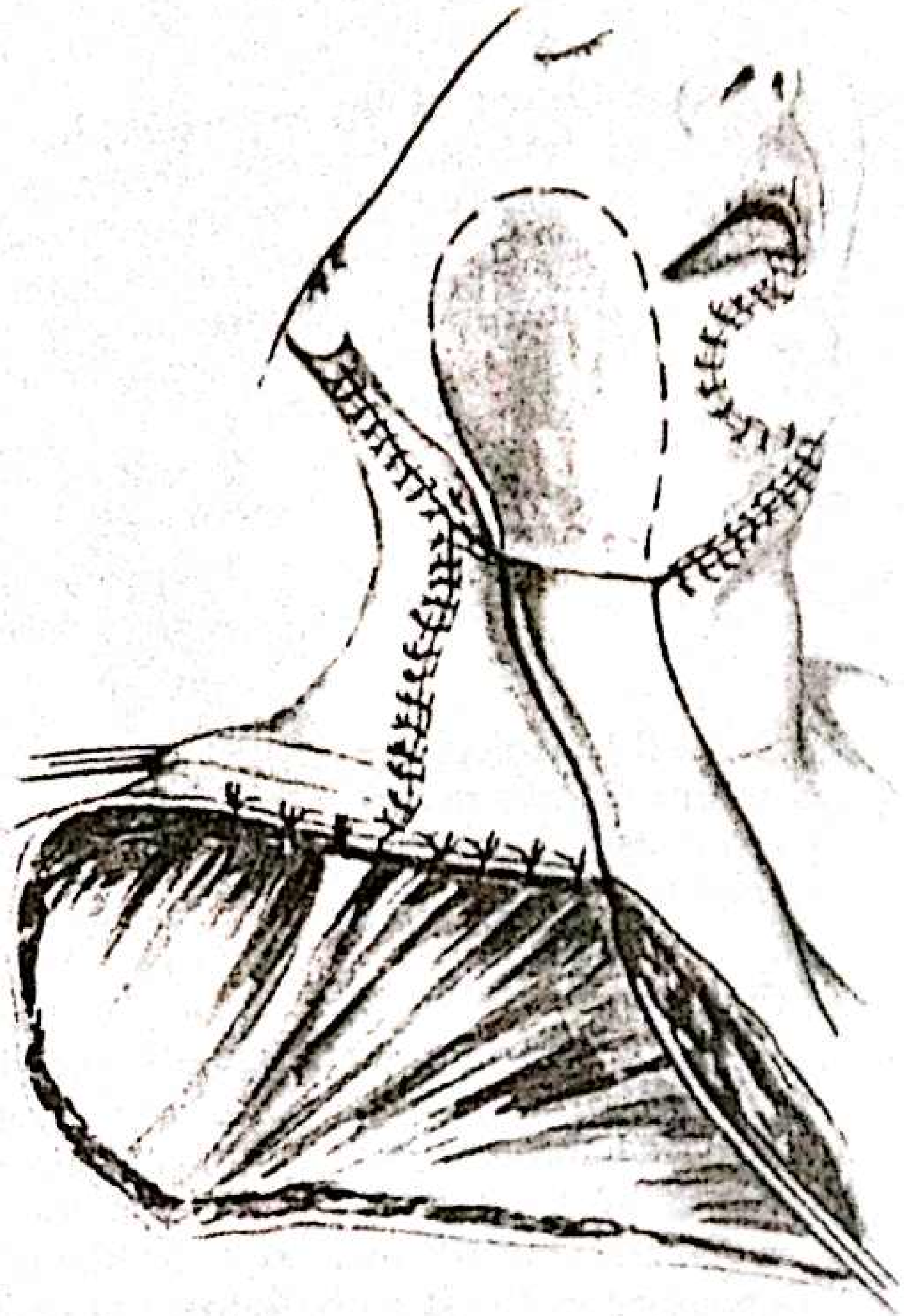
At the time of the original description of the forehead flap, there were no reconstructive techniques which compared with it in safety and effectiveness, and this made it the method of choice. Today the situation is quite different, and for most surgeons it has been relegated to the status of a back-up technique. Apart from the fact that it involves two stages, its major deficiency concerns the secondary forehead defect, the skin graft presenting in most patients a shiny immobile patch which is either relatively non-pigmented or hyperpigmented compared with its surroundings. Female patients generally cope with the problem by changing their hair style, using a fringe to cover the graft, but patients are rarely happy with it. The greatest virtue of the method lies in its safety and comparative simplicity. Other though less obvious virtues concern the fact that it approaches the intraoral defect from above, and this counters any tendency to gravitational sagging of the cheek and submandibular tissues. This virtue is particularly significant when tongue defects are being reconstructed, the flap holding the tongue high in the mouth during the healing phase, and preventing any tendency to tethering to the floor of mouth. At the time of its original description, resection of the hemimandible was a routine part of the overall tumour excision of the tongue and floor of mouth. In those circumstances the thickness and comparative rigidity of the flap, as it lay along the bed of the resected bone, acted to prevent deviation of the remaining bone, and facial symmetry tended to be maintained even in the absence of bone replacement.

DELTOPECTORAL FLAP

The design and elevation of the deltopectoral flap have been described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103. The form of the tunnel used in its transfer to the oral cavity depends on the site of the defect in the mouth, and whether or not a neck dissection is part of the procedure.

41

When the defect is of the buccal mucosa or the lower alveolar area, and when a nodal clearance is part of the overall resection, the submandibular part of the neck dissection incision can be used, the flap passing lateral to the body of the bone. In the case of a defect of the tongue or faucial area, the path used is medial to the mandible.



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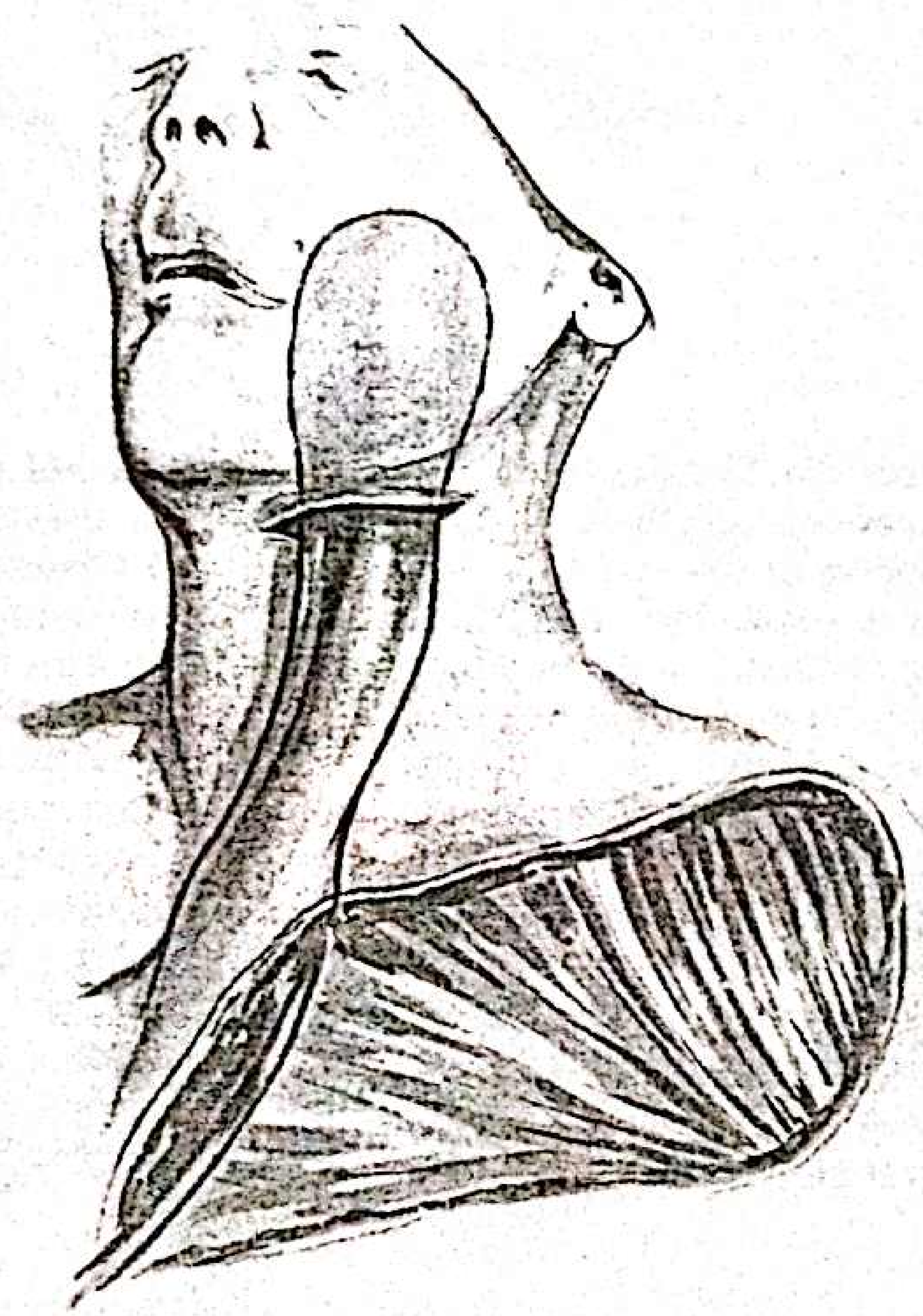

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When the buccal mucosa is being resurfaced in the absence of an associated neck dissection, a tunnel can also be constructed, using a skin incision just below and parallel to the lower border of the mandible, as described in the chapter on 'Buccal mucosa', pp. 270–282.

43

When the route medial to the mandible is being used, an alternative tunnel is deep to the neck dissection skin flaps, and when this route has been selected the MacFee skin incision is usually used for the neck dissection.

In those parts of the flap where the bridge segment is exposed to the surface it is tubed in order to eliminate raw surface; where the bridge segment lies under the neck dissection skin flaps reverse tubing is carried out, so that the flap presents a raw surface to the raw surface created by the neck dissection.

When the bridge segment is exposed to the surface, division and insetting of the flap, with return of the bridge segment to the chest 3 weeks after the initial transfer, is straightforward. When the flap has been introduced into the mouth under the neck dissection skin flaps, the neck flap overlying the bridge segment has to be opened with a vertical incision to allow access for its division.

Division with insetting of the flap inside the mouth leaves a downward draining fistula, and care has to be exercised in closing it to separate the opening into the mouth from that to the surface as far as possible, suturing both openings independently and securely.

43

Used for intraoral reconstruction, the deltopectoral flap has serious deficiencies, and these have reduced its value very considerably, particularly with the current availability of so many more effective alternatives. It has a significant necrosis rate, which appears to be at its highest when the flap has to conform to a convoluted surface. Used to cover a flat surface such as the buccal mucosa, where there is also downward venous drainage, necrosis is not a problem. The fact that the flap reaches the oral cavity from below also creates gravitational problems. The weight of the flap tends to pull mobile structures, particularly the tongue, downwards, anchoring it to the floor of mouth and restricting its free movement. The most effective way that the surgeon has of countering these gravitational effects is to suture the flap, wherever possible, to a fixed immobile structure such as mucoperiosteum. When resection of the hemimandible has been part of the overall resection, the effect of gravity is liable to be more than usually pronounced because of the difficulty of finding an alternative and effective point of mucoperiosteal attachment.

The pectoralis major myocutaneous flap achieves much the same result as the deltopectoral flap in a single stage, and has largely replaced it in intraoral reconstruction. In the buccal mucosal site, however, the advantages the deltopectoral flap has of thinness, safety and relative technical ease still give it a useful role.

43

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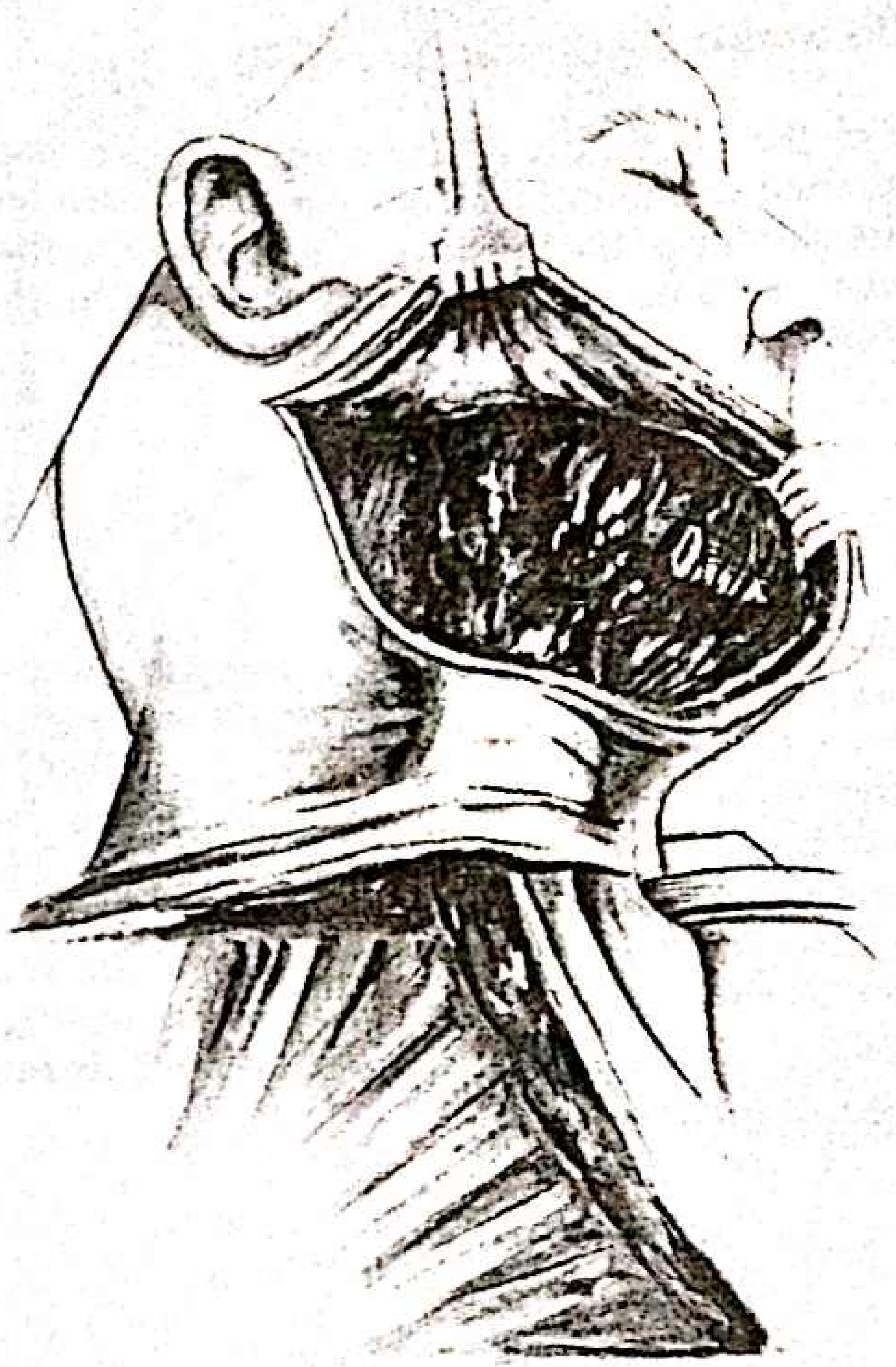

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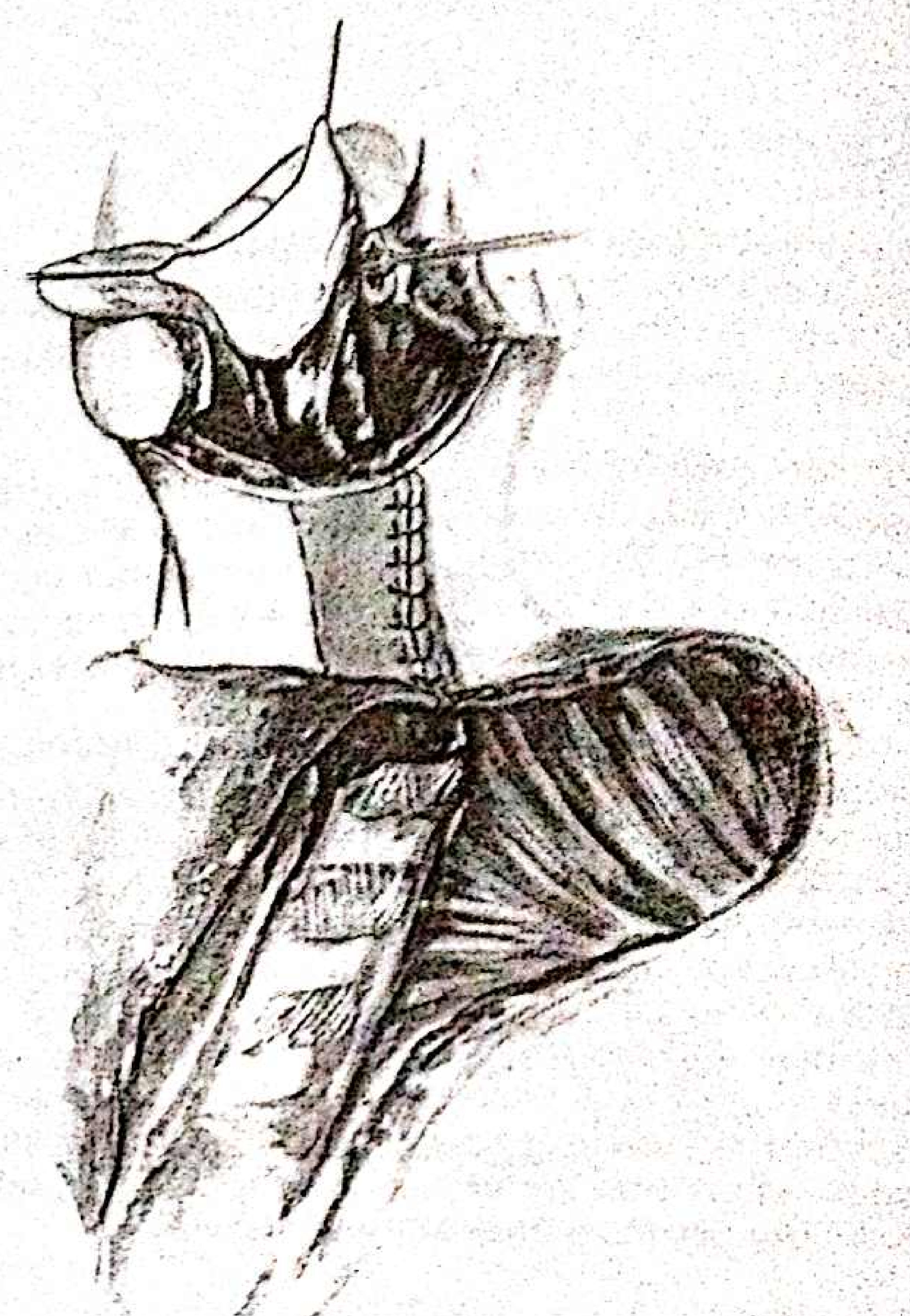
Pectoralis major myocutaneous flap

Elevation of the pectoralis major myocutaneous flap has been described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103. It is in its transfer to the oral cavity that it is liable to differ from its usage in surface reconstruction.



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Once raised, the flap is generally transferred to the intraoral site through the tunnel left by the removal of the tissue resected during a radical neck dissection, most notably the sternocleidomastoid muscle. Since radical neck dissection is an integral part of many of the resections carried out in intraoral malignancy, the tunnel is frequently available, and the bulk which the muscle restores to the neck goes some way to mitigating the asymmetrical appearance which a radical neck dissection creates.

The presence of the muscle pedicle in the neck has the added virtue of providing cover for the carotid arteries. When the neck has not been previously irradiated, the provision of such vascularized cover is not important, since even if there is breakdown of the neck dissection flaps with exposure of the carotid arteries, carotid 'blow-out' is unlikely. As discussed in the chapter on 'General management and complications', pp. 8–21, it is exposure of the carotids in the previously irradiated neck which creates a much more dangerous situation, with 'blow-out' as a major hazard. It is in the irradiated neck that the vascular cover which the muscle pedicle of the pectoralis flap provides has such a valuable prophylactic role, to the extent of largely eliminating the need for alternative methods to cover the segment of the carotids considered to be at risk, such as the transfer of the levator scapulae muscle.

Extension of the transfer of the pectoralis major flap to include a length of the 5th or 6th rib has been described, but it is generally conceded that both ribs, the only ones capable of reaching the oral cavity, receive little or no blood supply from the muscle, and the method is not recommended.

The muscle pedicle in the neck is susceptible to compression, and this is the major cause of necrosis of the skin island. Unless the sternocleidomastoid muscle has been removed as part of the neck dissection, to provide the space needed to accommodate the muscle pedicle of the flap, the probability of compression sufficient to cause skin island necrosis is such that the transfer is contraindicated.

Even in the absence of a compression factor, necrosis of the skin island is probably more common than the published statistics would suggest. The question that follows such a complication is how it should be managed. By the time necrosis is recognized, the muscle component of the flap is generally established in its transferred position. If the resection and the flap transfer have been covered by one of the antimicrobials which control *Bacteroides* infection, the necrotic skin island tends not to liquefy, as it would have prior to the use of these agents. Separation is a much slower process, and because of this, there are advantages in managing the situation conservatively, waiting until separation is almost complete before interfering to remove the slough. The delay in slough removal also gives the muscle element time to stabilize in its transferred position, and its bulk filling the defect largely prevents the healing by contraction which would occur in its absence. With separation of the slough, spontaneous healing takes place over the surface of the muscle, and the final result is generally surprisingly good.

Division of the skin island into two parts in reconstructing a full thickness defect has been described, one to provide lining, one to provide skin cover. The published photographs are evidence that the method can be used successfully, but the surgeon contemplating its use should bear in mind that it does add to the risk of necrosis of one or both of the islands.

Lateral trapezius osteomyocutaneous flap

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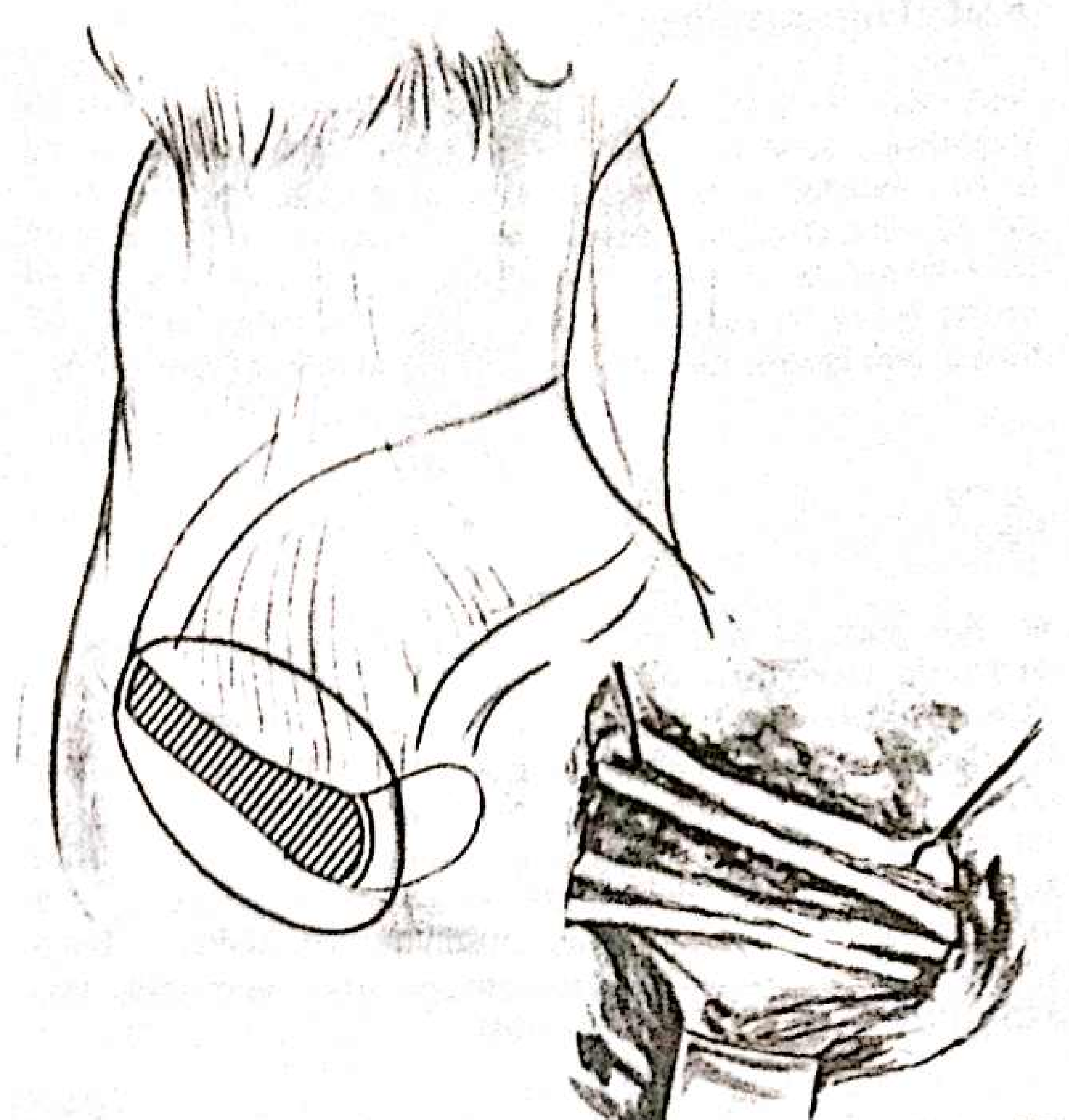
The bony attachment provided by the insertion of the trapezius muscle into the upper lip of the spine of the scapula has made it possible to extend the use of the lateral trapezius myocutaneous flap to include a vascularized length of the spine of the scapula as a composite transfer. The raising of the parent myocutaneous flap was described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, and the same basic technique is used in raising the composite version. The isolation of the skin island provides the access to the muscle pedicle, which is extended as far as its attachment to the spine of the scapula. The origin of the deltoid muscle from the lower lip of the scapular spine is stripped from the bone exposing the lower surface of the spine along which the bone is sectioned.



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The strip of bone, extending medially from the base of the acromion process, is raised in continuity with the muscle pedicle and the skin island to the anterior border of the trapezius muscle, and finally to its vascular pedicle, the transverse cervical vessels.

The bone the flap provides is of good quality, with a significant proportion of cortical bone. Its maximum length is approximately similar to that provided by the radial forearm flap (see pp. 236–240), rather less than that available with the parascapular flap. Receiving its blood supply all along its length, the bone can safely be osteotomized. As with its parent flap, it requires the turning of the patient, and it is subject also to the various limitations which have been discussed in relation to that flap.

46

Latissimus dorsi flap

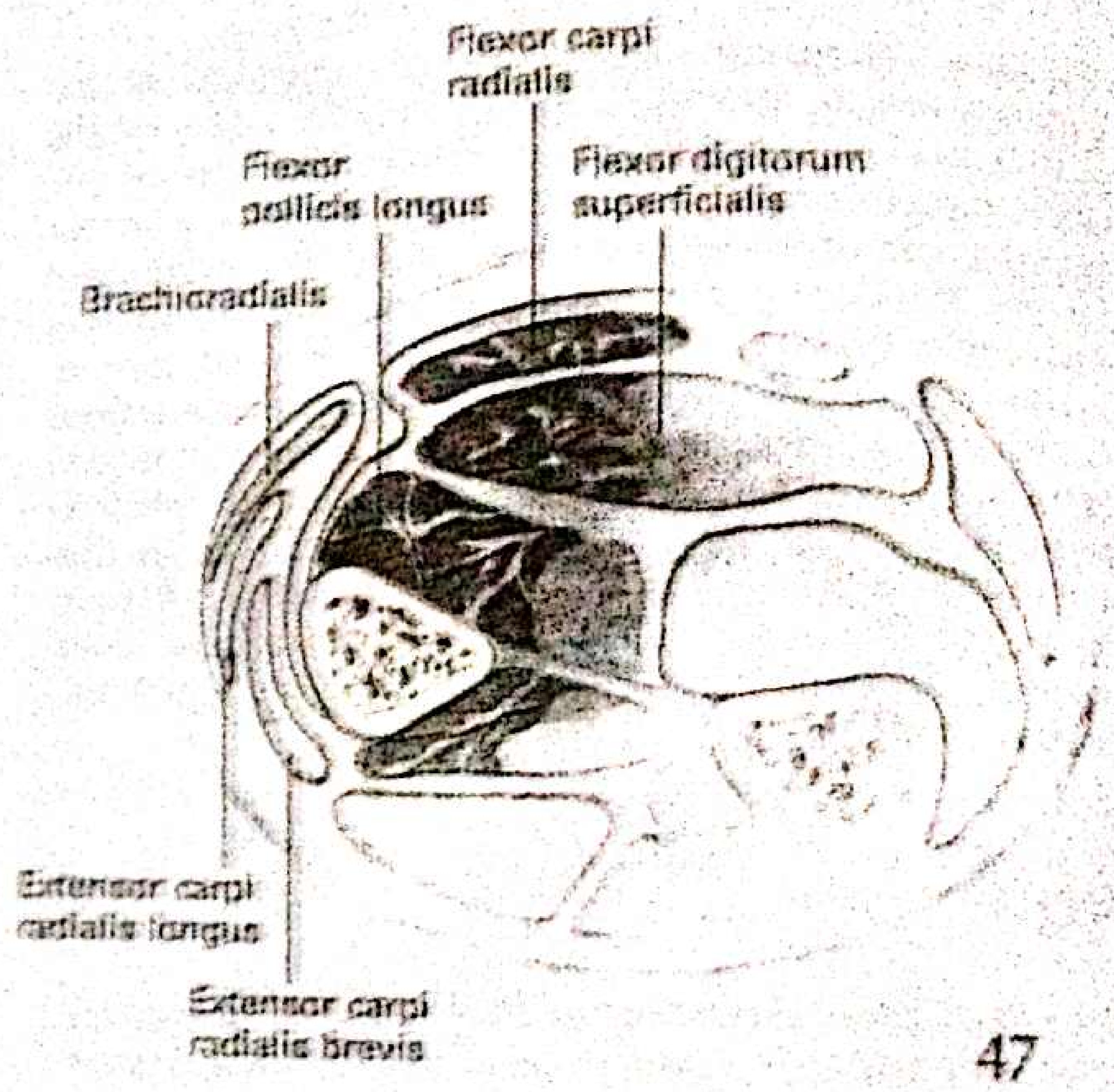
The raising and transfer of this flap, used in an intraoral context, is generally as a free flap, and is similar to that described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103. Its major difference from the other free flaps lies in the volume its muscle element provides. For this reason it has its main use in reconstructing defects which have a disproportionately large volume compared with their surface area. The skin island has an extremely limited capacity to conform to an irregular surface, and in this respect it is similar to myocutaneous flaps generally, but in the large volume defect for which it would be appropriate, this characteristic is not an adverse factor in flap choice. The flap has also been described in an extended version which incorporates a segment of the serratus anterior muscle together with a length of rib, to reconstruct resected mandible. It is generally conceded, however, that rib does not provide a satisfactory replacement for mandible, and the method has not achieved any popularity.

Radial forearm flap

The vascular anatomy of the radial forearm flap and its elevation, used to transfer soft tissue alone, is described in the chapter on 'Reconstructive techniques of the skin', pp. 45–102. Used in intraoral reconstruction, it can also be transferred as a composite with a vascularized length of radial bone to reconstruct a defect involving both soft tissue and bone, the latter usually a length of mandible.

47

In the part of the forearm between the insertion of pronator teres and the insertion of brachioradialis, the intermuscular septum between flexor carpi radialis and brachioradialis, in addition to carrying the branches of the radial vessels to the skin, continues over flexor pollicis longus and reaches the lateral surface of the radius. This surface is devoid of muscle attachments between the insertions of pronator teres and brachioradialis, a 'bare area', covered only by periosteum and, with this, the extension of the septum merges.



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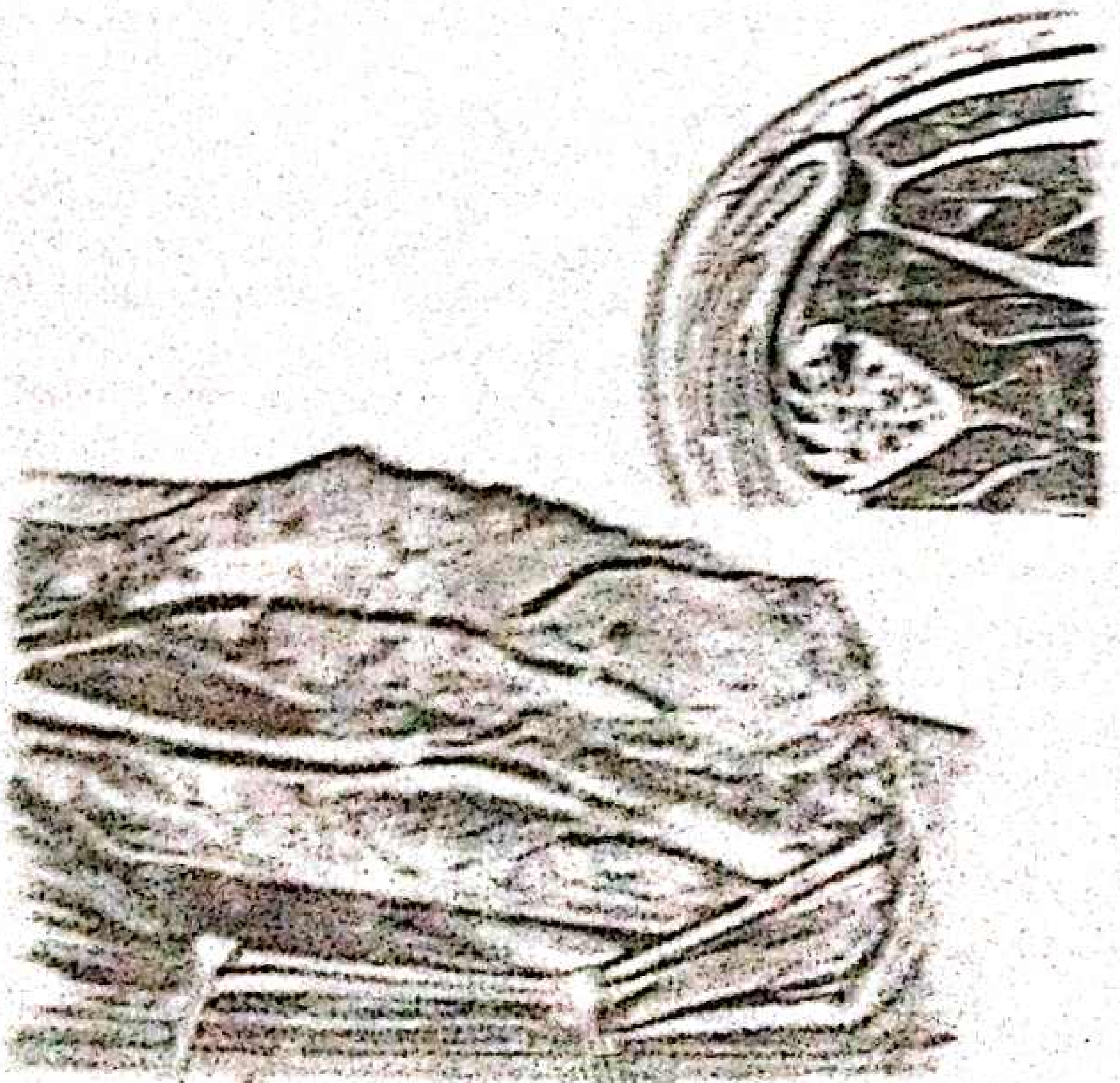
Branches of the radial vessels continue along this extension of the septum, and form a plexus on the periosteum, in this way reaching the bone. The muscles taking origin from the radius on its flexor aspect, immediately adjoining the 'bare area', are flexor pollicis longus and pronator quadratus, and the branches from the radial vessels which enter these muscles help also to perfuse the bone to which they are attached.



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The blood vessels passing superficially in the intermuscular septum to perfuse the skin, and those continuing deeply to perfuse the radius, provide the vascular basis for the transfer of the composite of skin flap with a segment of the radius.

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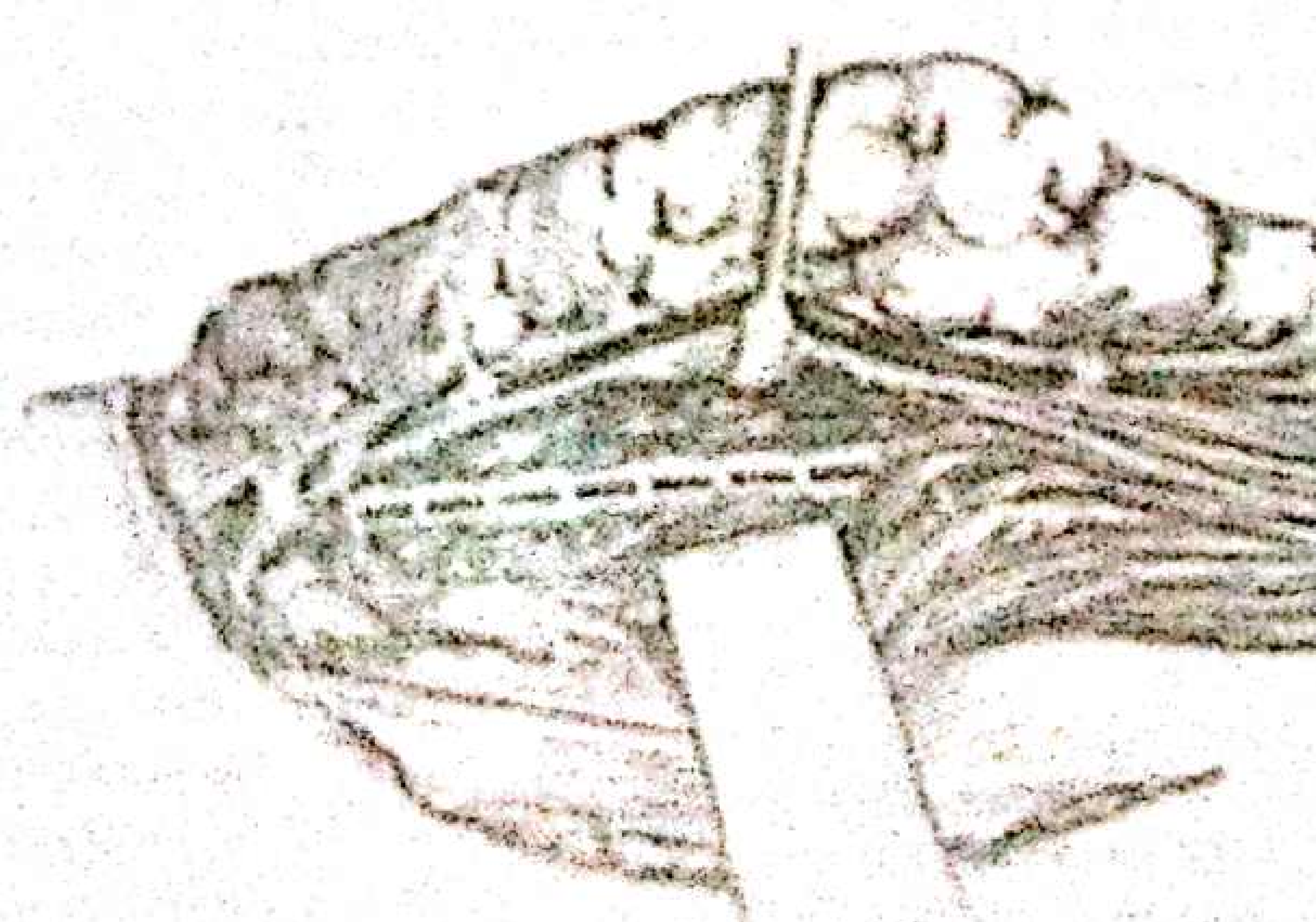
When such a composite of skin and bone is being transferred, the site on the radius from which bone is harvested is the length between the insertions of pronator teres and brachioradialis, approximately 10 cm. On its flexor surface this length of the bone is covered by flexor pollicis longus proximally and pronator quadratus distally; on its lateral surface the bone is covered only by periosteum.

51

In raising the composite flap, the initial dissection proceeds as for the skin island alone (see pp. 99–100), but dissection stops at the stage of mobilizing flexor carpi radialis and brachioradialis from the two sides of the intermuscular septum, exposing the radial vessels and the bellies of flexor pollicis longus and pronator quadratus. The 'bare area' of the radius can also be demonstrated by retracting the tendon of brachioradialis laterally. Careful retraction of the skin flap laterally bares flexor pollicis longus and pronator quadratus. Without disturbing the blood vessels entering the muscles, an arbitrary line is drawn over the muscles in the long axis of the bone, the line along which the muscles and the underlying bone will be sectioned. The bony segment lateral to the cut constitutes the vascularized transfer, the segment medial to the cut maintaining the continuity of the radius. The factors which determine the placing of the line and the direction of the bone cut are discussed below.



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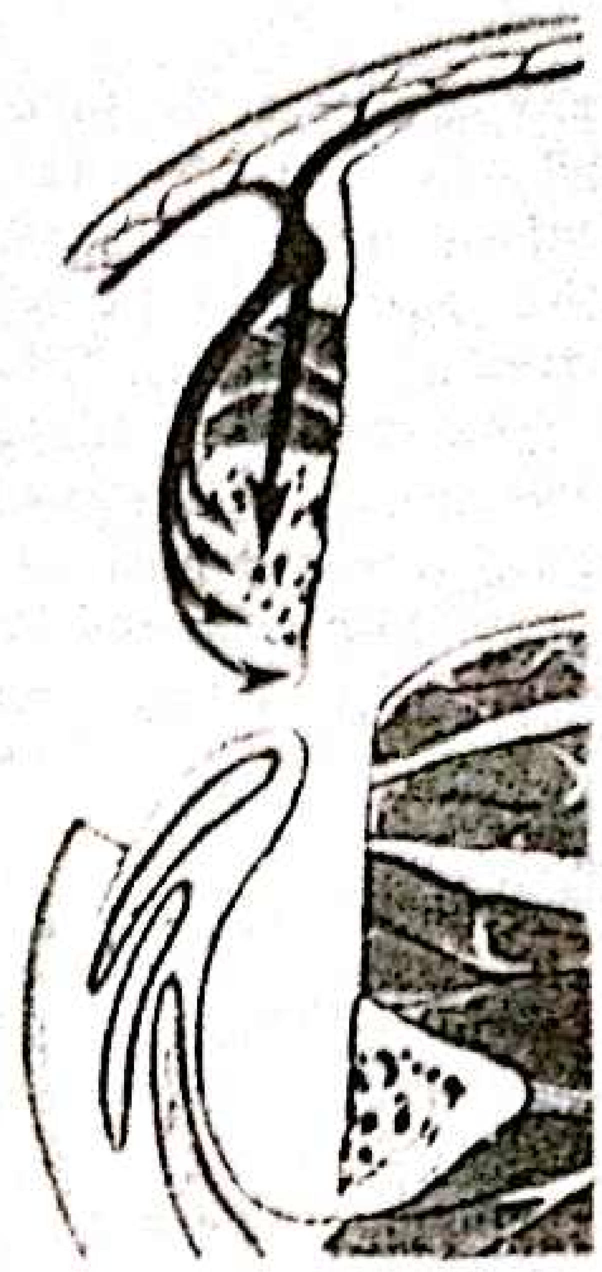

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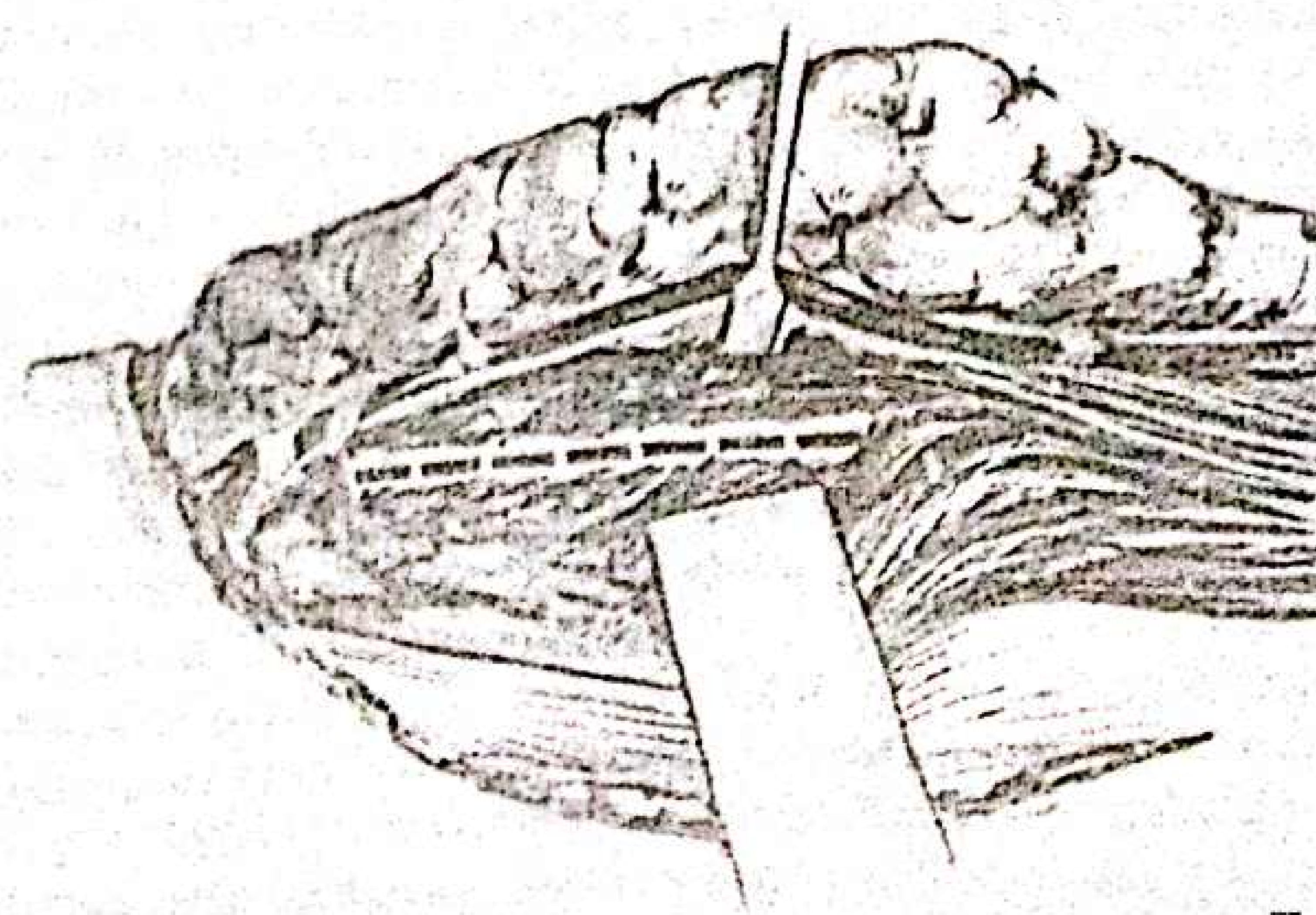

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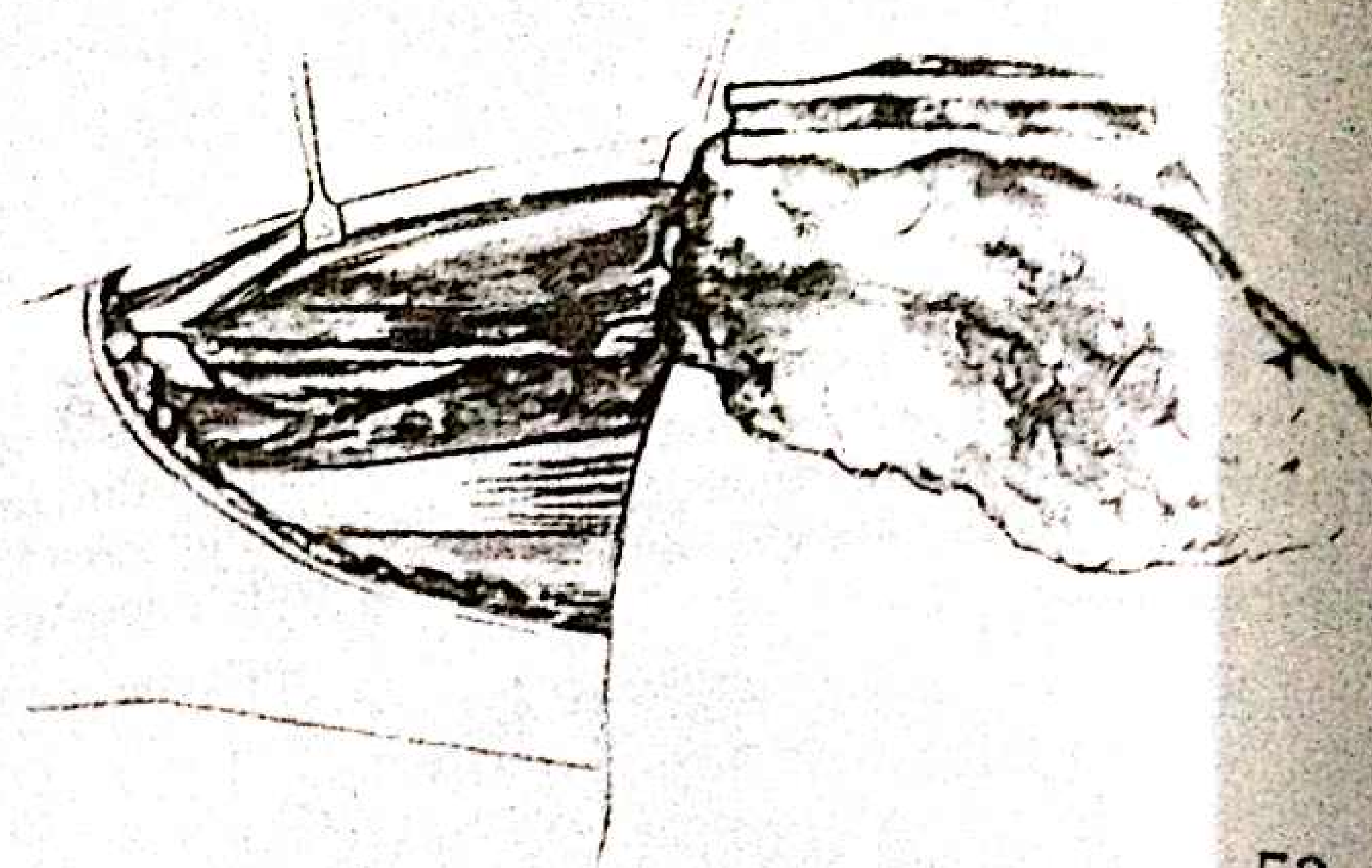
Along the line selected, the muscles, flexor pollicis longus and pronator quadratus, are incised down to the underlying bone, taking care to avoid stripping any muscle fibres from the segment of the bone lateral to the line, the part to be used as the graft. This is an important point of technique, since the small vessels passing from the radial vessels to the muscles, and through them to the bone, provide a significant element of the circulation perfusing the bone. Along the narrow line bared by the cut through the muscles, the bone is sectioned using a fine blade power saw.



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The major hazard of this composite transfer is subsequent fracture of the radius, and various steps are taken to reduce it. Of these, the one probably of greatest importance is awareness that the hazard exists, since the knowledge is likely to induce the desirable element of caution when the bone is being cut, as well as subsequently. Before the hazard was recognized, about half of the thickness of the radius was removed as the graft, but the thickness removed has now generally been reduced to one-third. Orthopaedic surgeons also recognize that removal of a rectangular shaped piece of bone leaves a point of weakness at each end of the site of resection, and this potential source of weakness can be at least partly eliminated by removing an additional triangle of bone so that the sharp end at each extremity of the defect is rounded off. The removal of a wedge of bone has also been suggested, rather than cutting straight through the bone, but the cutting of a wedge is technically more difficult and, given proper aftercare as described below, there is no firm evidence that it reduces the incidence of subsequent fracture.

Much the most important step the surgeon can take is to apply an above-elbow plaster as the final step in the transfer, and maintain it for 4–6 weeks. With this last step, fracture as a hazard has been largely eliminated.

The skin which the flap transfers is thin and extremely pliable, capable of accommodating to the irregularities of intraoral defects without risk to its viability. This last virtue undoubtedly contributes to the rapid return of intraoral function when it is used to reconstruct those areas which are most vulnerable from this point of view, the tongue and faucial area.

The bone which it transfers has the virtues common to all vascularized bone transfers. Its viability is unquestioned, and the fact that its perfusion sources are multiple, spread along its length, means that it can be osteotomized without jeopardizing its viability. It is capable of achieving bony union with the residual mandible without the need for intermaxillary fixation; fixation to the adjoining mandibular bone, using plate and screws, or wire fixation, reinforced with a transfixing K-wire or a stepped interface, appears to be adequate. A soft diet can be permitted as soon as nasal feeding is discontinued, and the bone has proved capable of successfully withstanding 60 Gy of radiation within 6 weeks of its transfer.

It also has certain limitations as a replacement for mandible. Its cross-sectional area is not great, and does not match that of the adjoining mandible, even when the latter is edentulous. The ability of the patient to wear a denture subsequently is uncertain, and later insertion of osseo-integrated implants is not possible.

Parascapular flap

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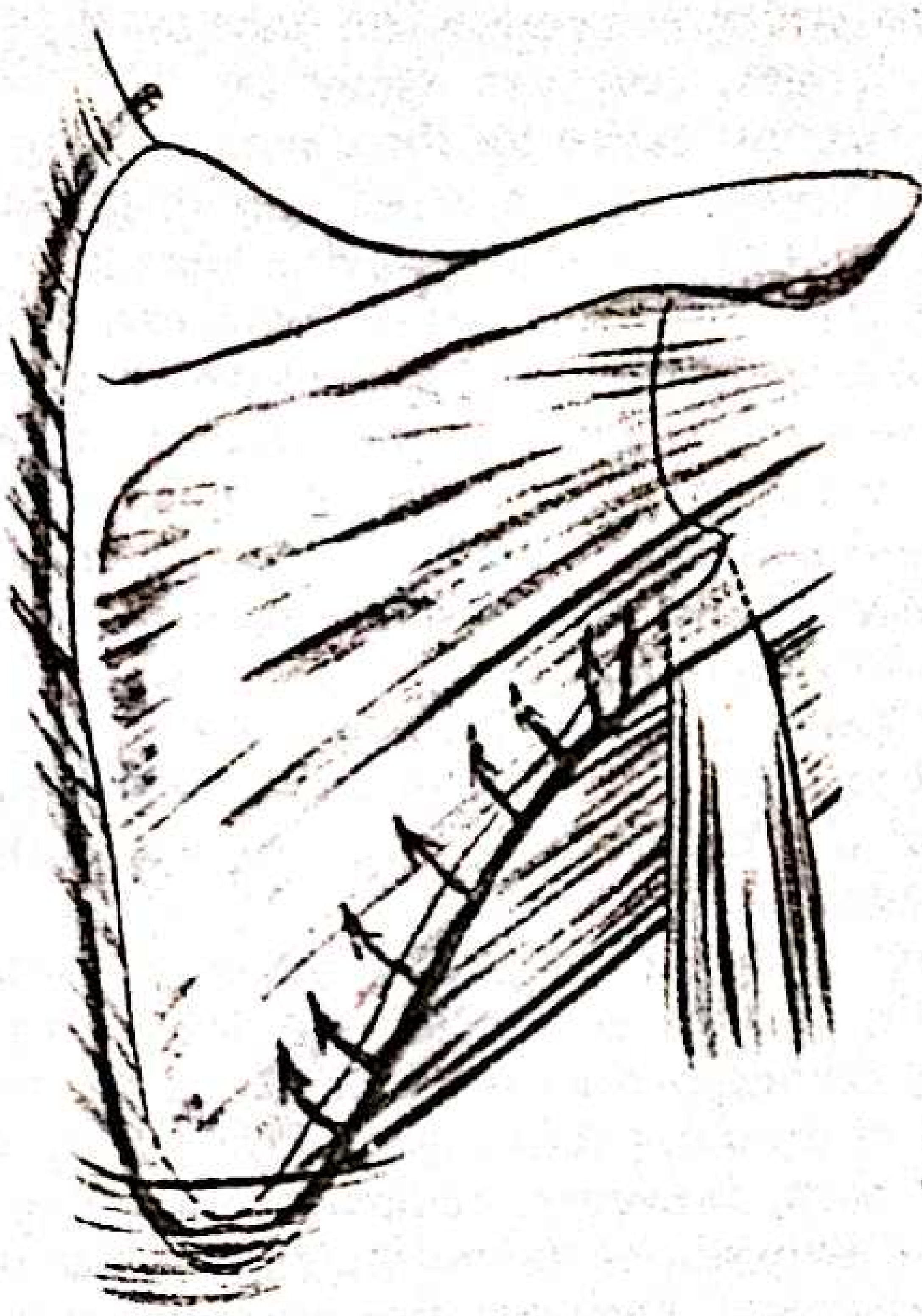
The parascapular flap, described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, has the potential for simultaneous transfer of a strip of the lateral border of the scapula. The circumflex scapular artery, before emerging from the intermuscular space between the teres muscles, divides into musculoskeletal branches and the cutaneous branch, the descending branch of which supplies the parascapular flap. The main musculoskeletal artery supplies the infraspinous muscles, passing into the infraspinous fossa deep to infraspinatus, but before doing so it gives a branch which continues down parallel to the lateral border of the scapula to its inferior angle, where it anastomoses with the deep branch of the transverse cervical artery. In its course it gives off a series of small branches which provide a periosteal supply to the scapula along its lateral border. It is this vessel and its branches which provide the perfusion source of the scapular element of the composite transfer.

The raising of the parascapular flap was described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, and its elevation as part of the composite transfer proceeds as with the parent flap, except towards the entrance to the intermuscular space where, in the case of the parent flap, muscular branches were divided to allow the vascular pedicle to be mobilized. In the case of the composite flap these must be carefully preserved.



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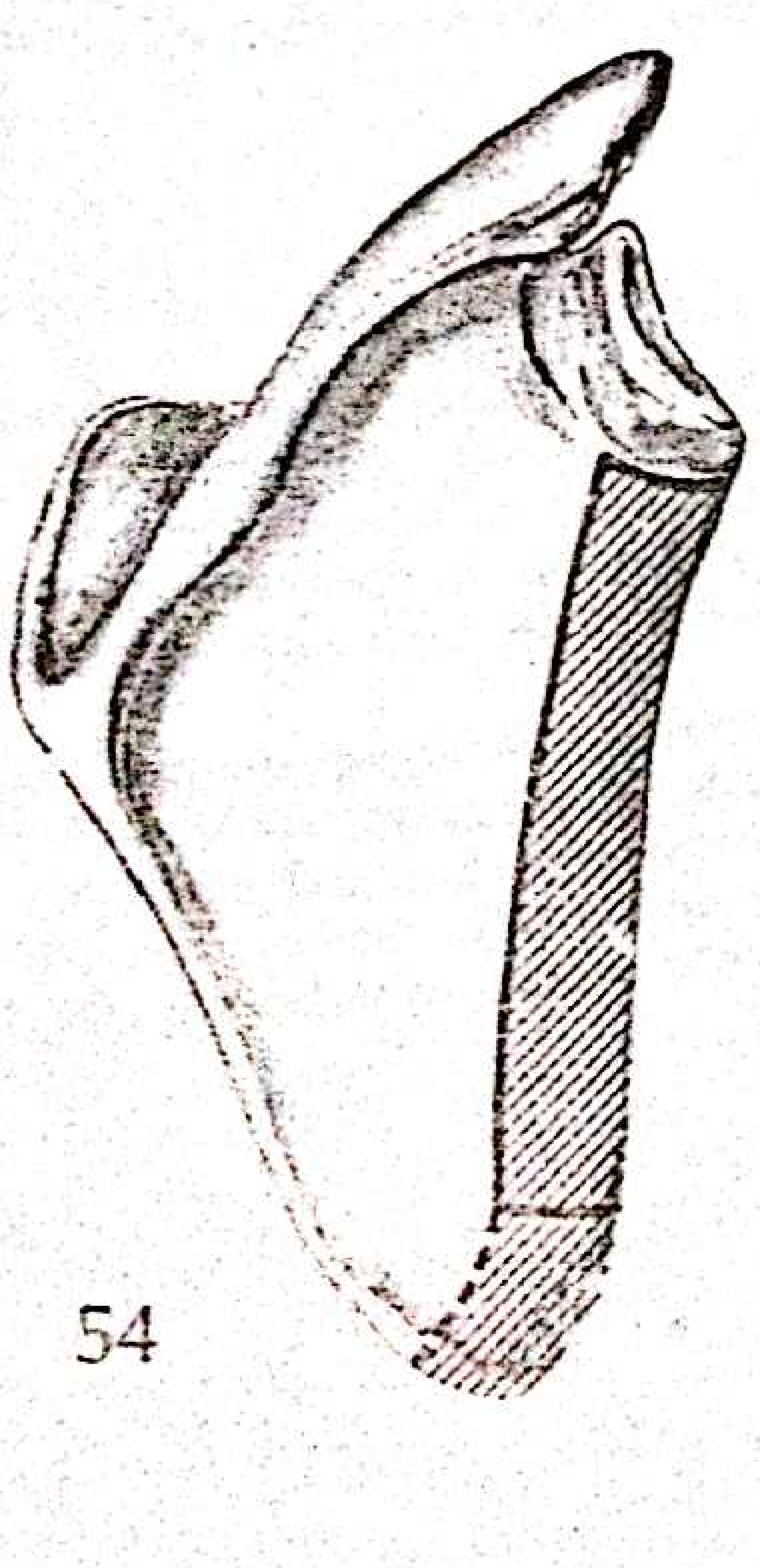

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When the proximal dissection of the vascular pedicle is complete, an incision is made through the muscles attached along the lateral border of the bone, infraspinatus, and the teres muscles, minor and major, down to the scapula. The line of the incision is parallel to that demarcating the thicker bone of its lateral border from the thinner blade, approximately 1.5–2 cm from the lateral border, and the line can be extended for a short distance around the inferior angle on to the vertebral border. Sufficient muscle is stripped from the medial side of the cut to give adequate access to the bone for a neat saw cut through its full thickness. In order to preserve the blood supply which reaches the bone through the muscles, stripping of muscle lateral to the cut must be avoided. Transverse saw cuts through the bone are then made at each extremity of the bony strip which is being harvested, the upper just below the origin of the long head of triceps, the site of the lower depending on the length of bone required. With the strip of bone freed in this way, the muscles passing laterally from it to their insertions on the humerus are divided, parallel to the lateral border of the bone, leaving a sufficient fringe of muscle attached to the bony strip to ensure inclusion of the blood supply which reaches the bone via them. The muscles involved on the superficial surface are teres major and minor, and a small part of infraspinatus; on the deep surface subscapularis.

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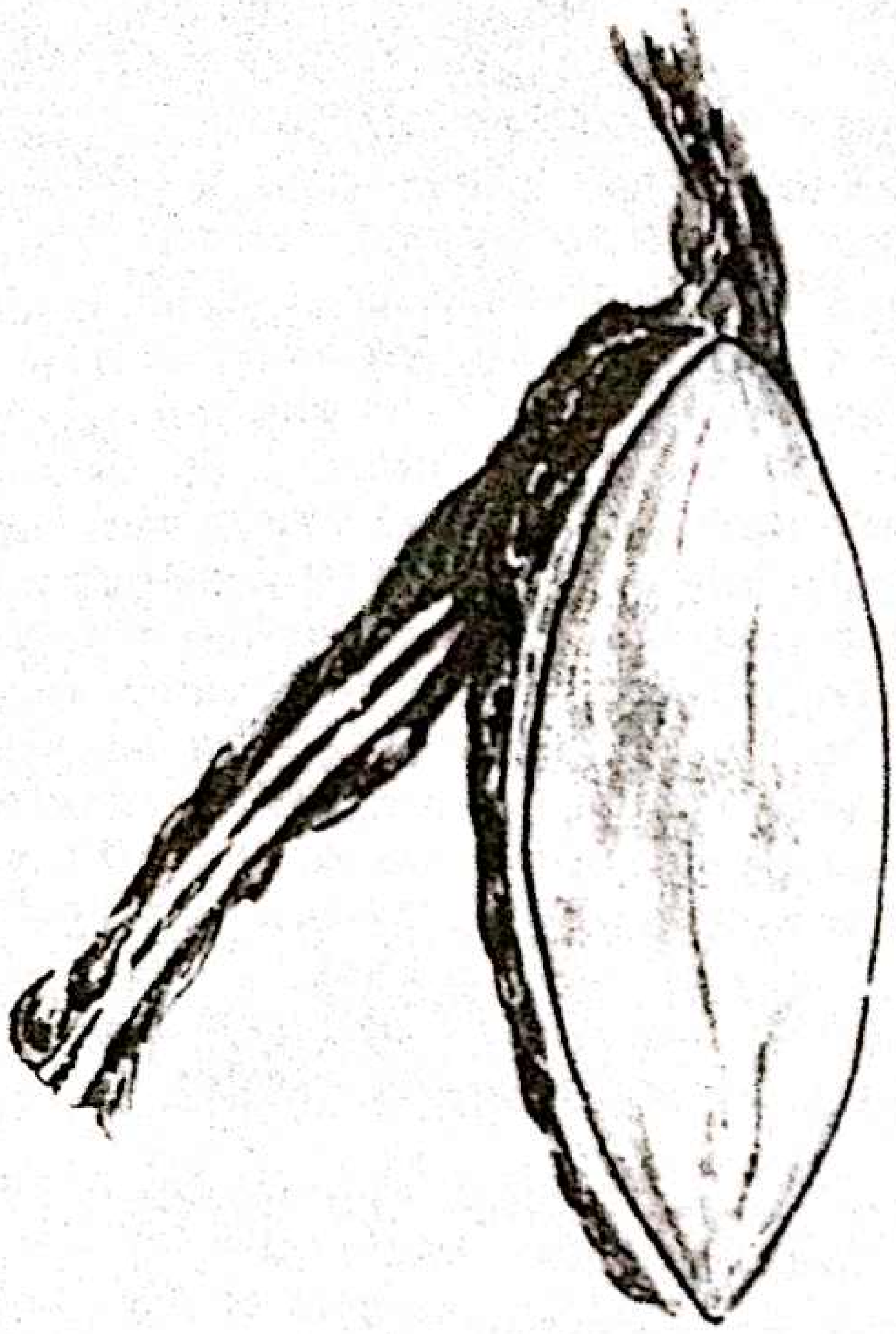
With elevation of the composite flap complete, the two elements, skin and bone, are displayed on their individual vascular pedicles.

The bone which this composite transfers is perfused all along its length, and can safely be osteotomized to provide a contour match for the defect, as long as its soft tissue attachments are preserved, any stripping required in carrying out the osteotomy being kept to an absolute minimum. It is also stated that the bone can subsequently accept osseo-integrated implants, to which a denture can be fixed. In terms of its manner of fixation to the residual mandible and its tolerance to subsequent radiation, it is broadly similar to the radial forearm and lateral trapezius flaps. The maximum length of bone available, when the extension round the inferior angle is used, is approximately 14 cm. The characteristics of the skin island were discussed as part of the description of the parent flap on p. 103, and as with that flap, its raising entails the turning of the patient.

Contrary to what might be expected, attempts to reattach those muscles which were detached or divided during the cutting of the bone increase rather than reduce problems of shoulder stiffness postoperatively. The major question mark, however, remains concerning the considerable disruption of the musculature which it leaves in the scapular area. Postoperative physiotherapy is essential, but in view of the fact that many of the patients involved are in the older age group, the potential for a frozen shoulder must still be a major consideration in flap selection.



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Access to the mouth

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

The limitations in the adequacy of exposure for resecting oral tumours when the approach is restricted to the open mouth have resulted in the development of new methods of providing wider exposure. Virtually all of these involve splitting the lower lip in the midline. The symmetrical arrangement of the muscles which act on the lip and the manner in which the nerves, motor and sensory, and the blood vessels, approach from each side make the midline the logical site, and in practice splitting in that line has a minimal effect on function and symmetry.

1

Intraoral resection is regularly combined with neck dissection as a composite procedure, and the midline vertical lip-splitting incision is then extended over the chin, becoming continuous with the submandibular segment of the standard neck dissection incision.

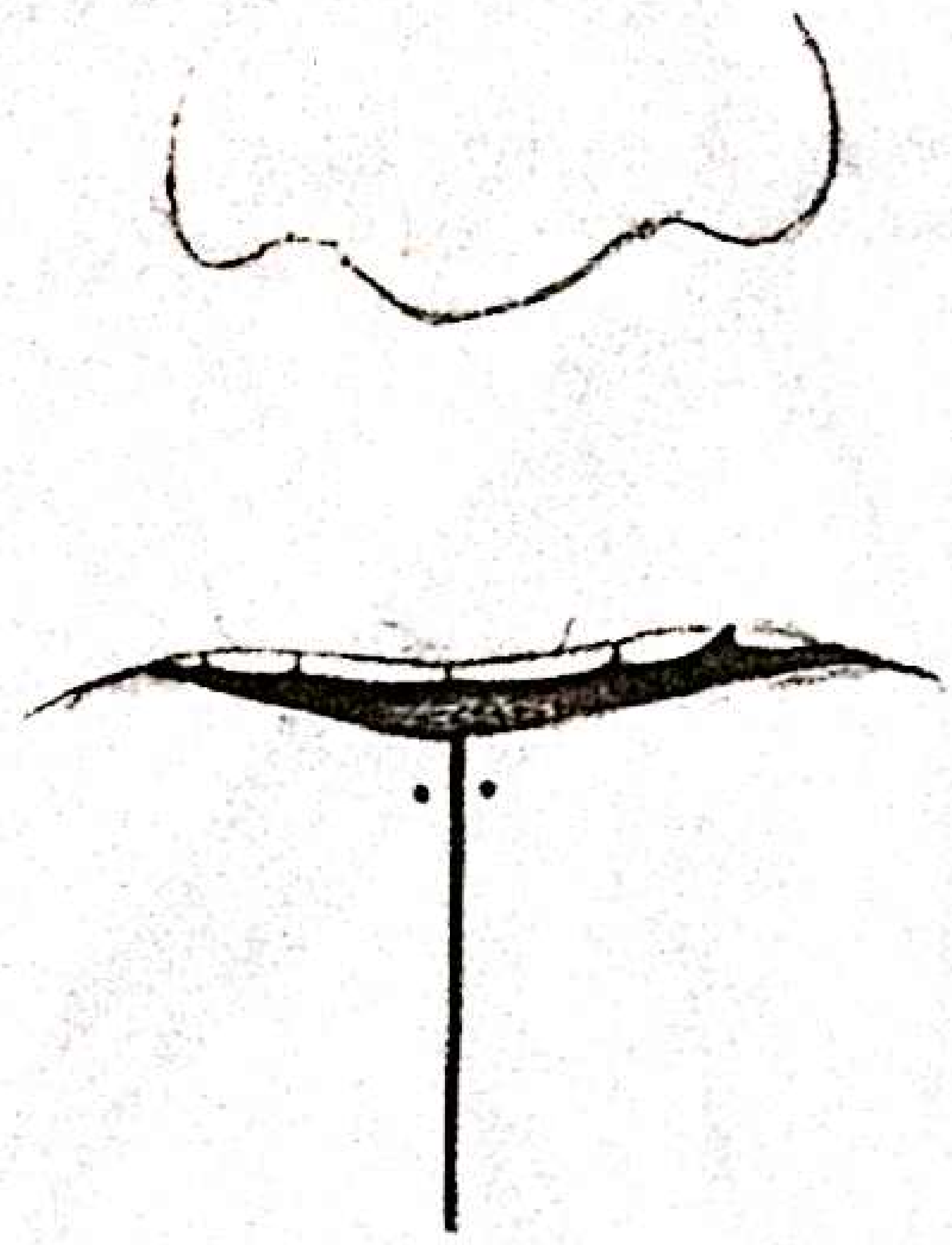
The straight midline lip-splitting incision can be used as the initial step in providing access to all parts of the oral cavity, but there are advantages in using modified versions of the incision, one to be used in the approach to the anterior mouth, the other to expose sites further back in the mouth.

1

Anterior mouth

2

In approaching the anterior part of the mouth, exposure is provided by retracting the lip on each side of the midline incision.



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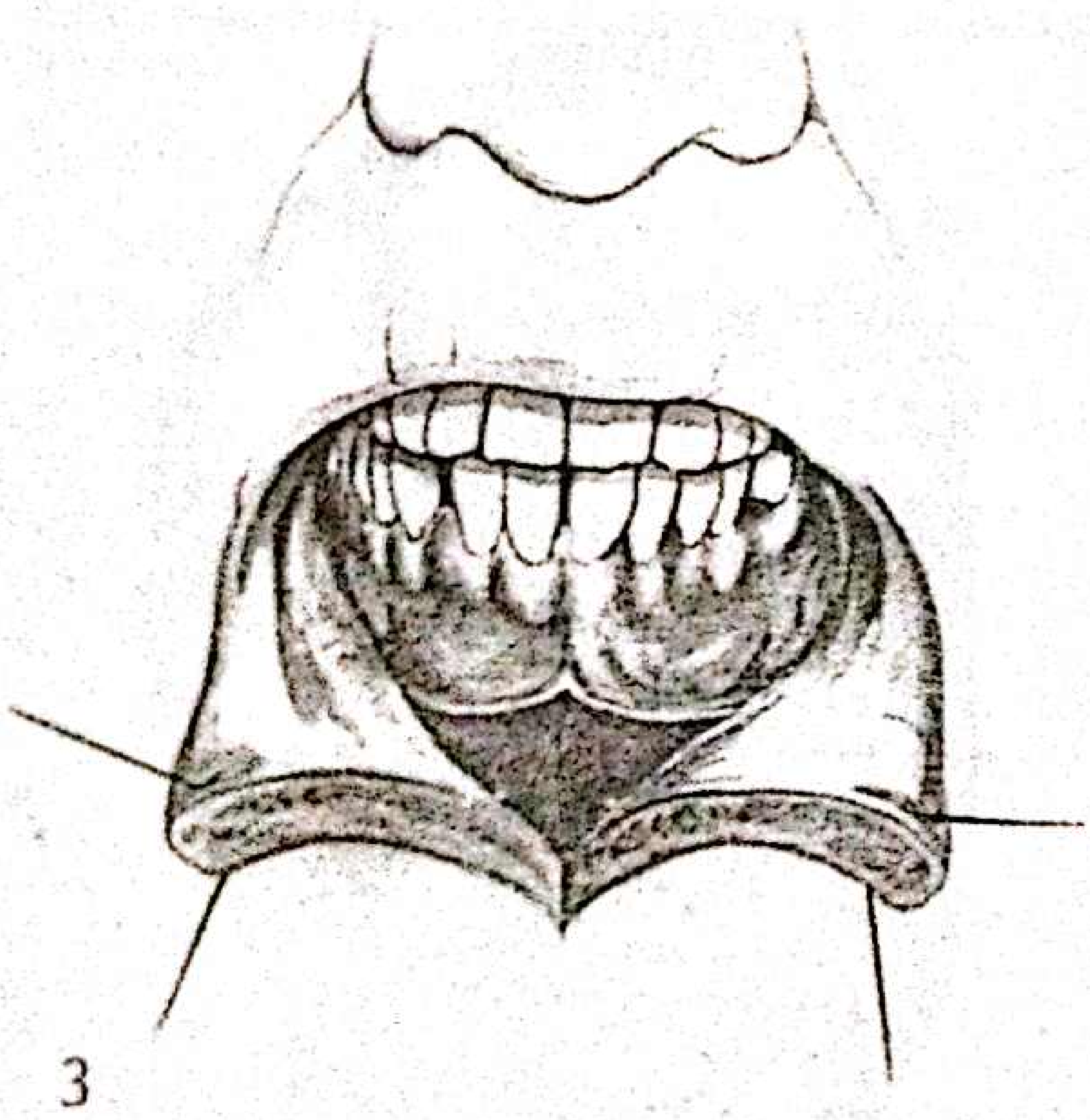

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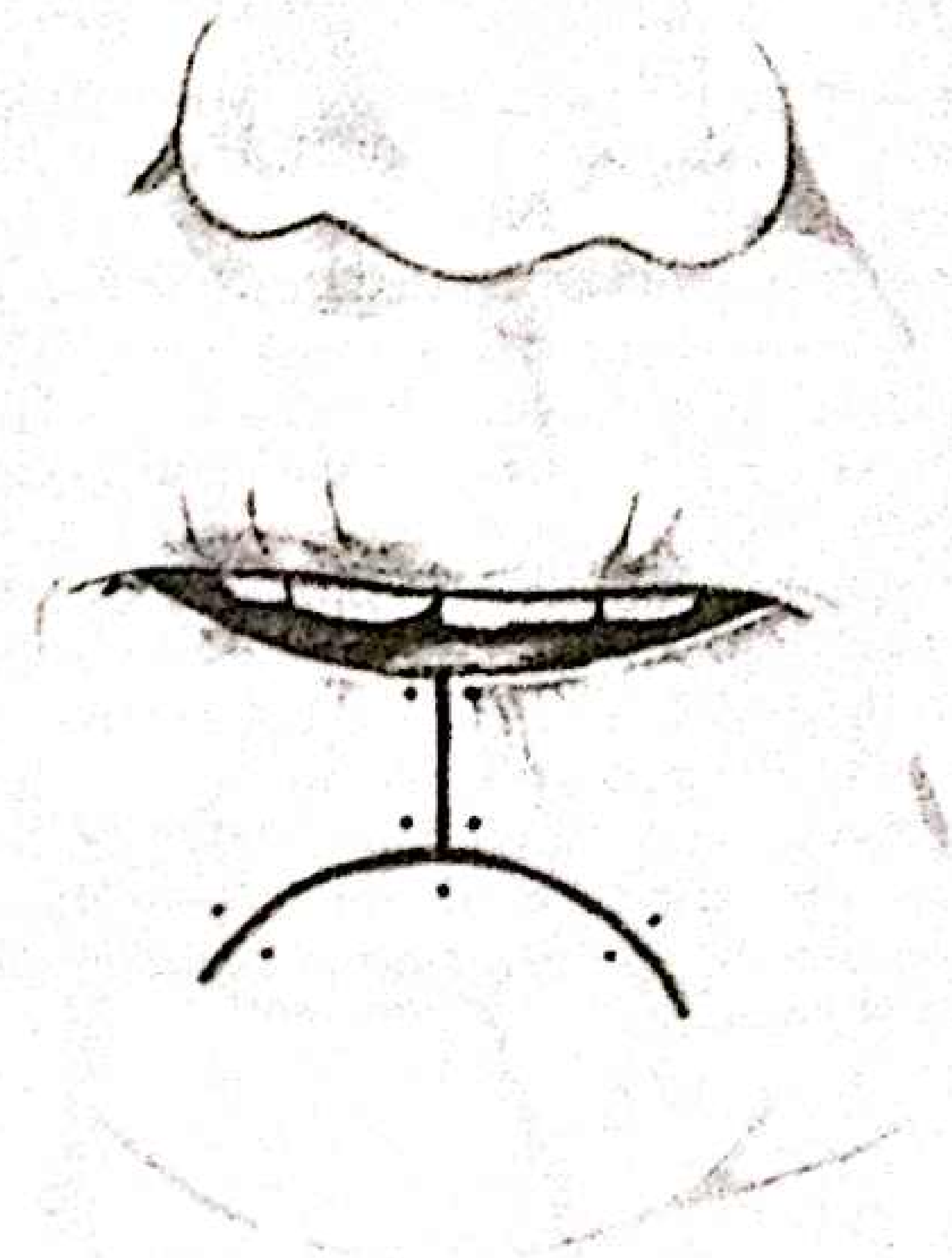
3

When the straight midline lip-splitting incision is used, the lateral retraction of the lip segments, which is required to provide the necessary exposure, involves stripping the soft tissues from the symphyseal mandible.

4

By modifying the incision it is possible to avoid stripping the soft tissues from the bone without reducing the adequacy of the exposure. The central vertical incision is halted at the base of the chin prominence, and from that point its line follows the curve of the base of the chin prominence laterally on each side for approximately 3 cm.



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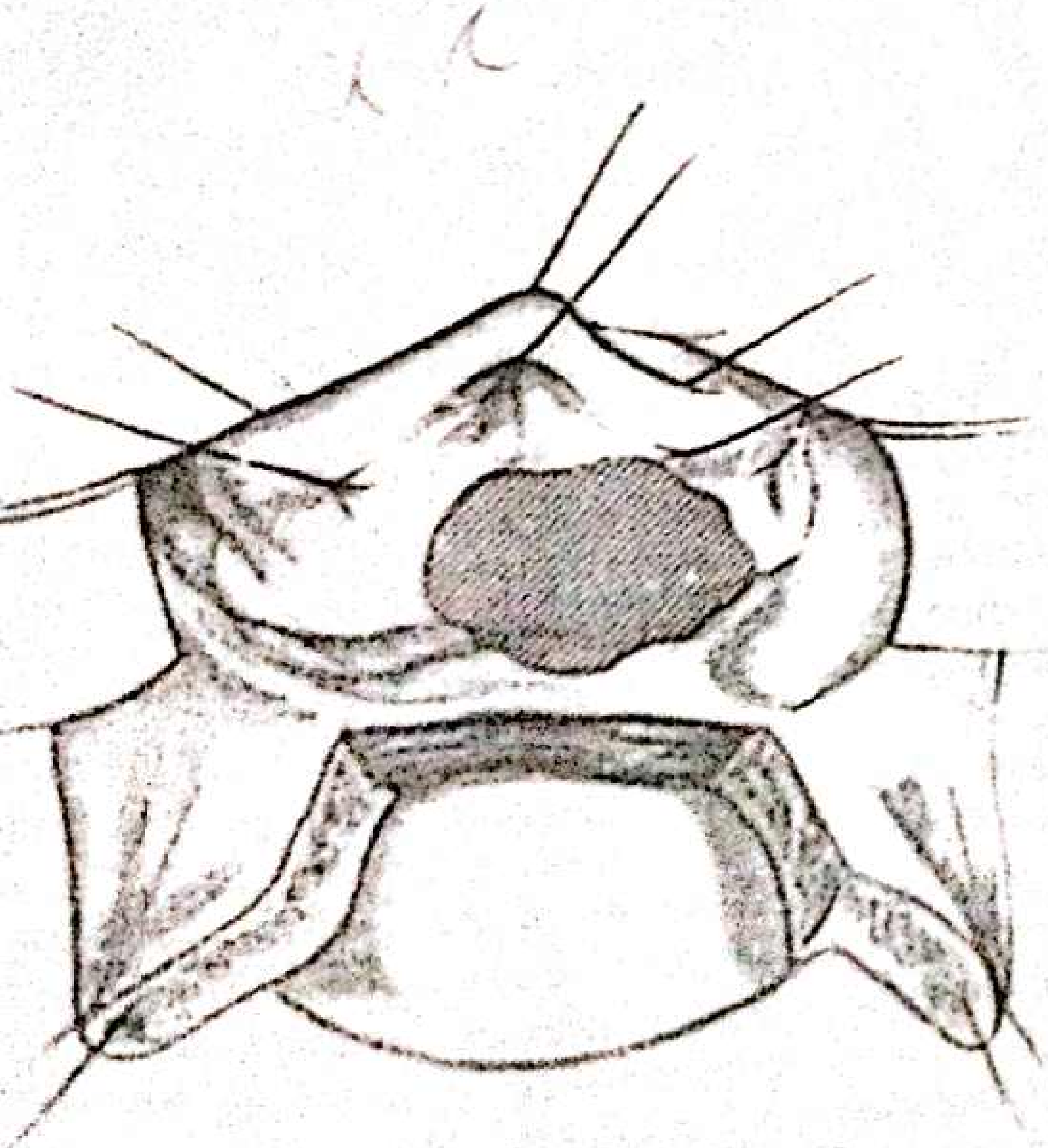

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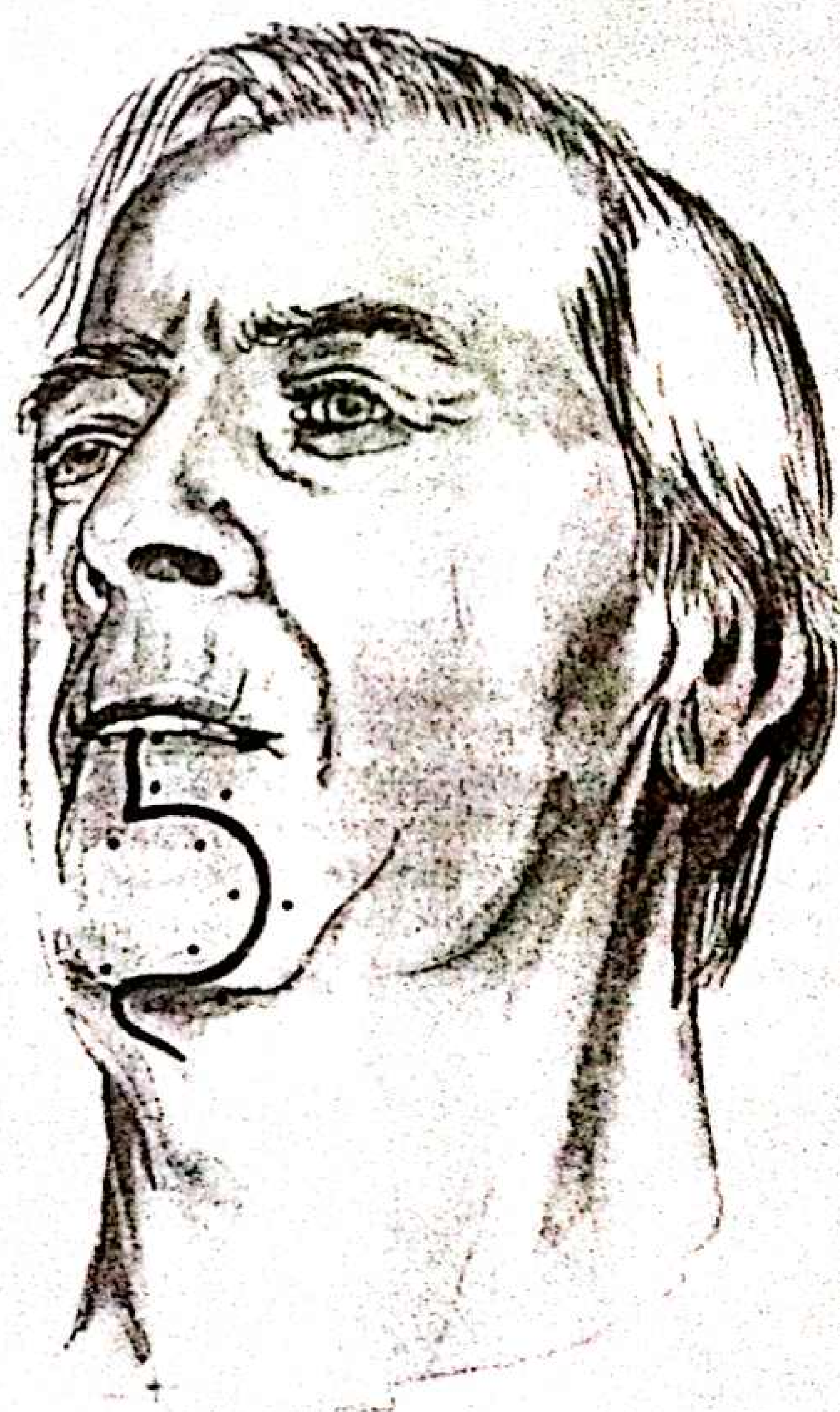
This line matches almost exactly the line of the lower labial sulcus inside the mouth and, by deepening the incision through the full thickness of the lip, a laterally based flap is created on each side of the midline. Retraction of the two flaps provides intraoral exposure exactly similar to that of the classical incision but without any stripping of soft tissues from the mandible.

Exposure of the anterior mouth sometimes has to be combined with resection of lymph nodes in the neck, and the combinations of incisions which are then required vary depending on the clinical problem; in the mouth, in the neck, whether unilateral or bilateral neck dissection, radical or functional. When such a combined procedure is required, various extended versions of the lip-splitting incisions have to be devised, using either the classic or the modified versions. The version used in any particular instance is determined by the demands of the local vascular patterns to ensure adequate perfusion throughout the entire area.

Main oral cavity

6

When the main part of the oral cavity is being approached, the cosmetic result which is achieved when the straight midline lip-splitting incision is used can be improved by altering its line so that it curves round the base of the chin prominence instead of passing down vertically over it. In this modification the vertical incision dividing the lip in the midline stops at the base of the chin prominence. It then turns at right angles and follows the curve of the prominence round to the midline below the chin. Such an incision could theoretically follow the curve on either side of the chin prominence, but it has been found in practice that it is best to follow the curve on the side of the intraoral resection. A rather narrow flap of the half lip results, but the presence of the inferior labial vessels running parallel to its free margin towards the midline ensures its survival.



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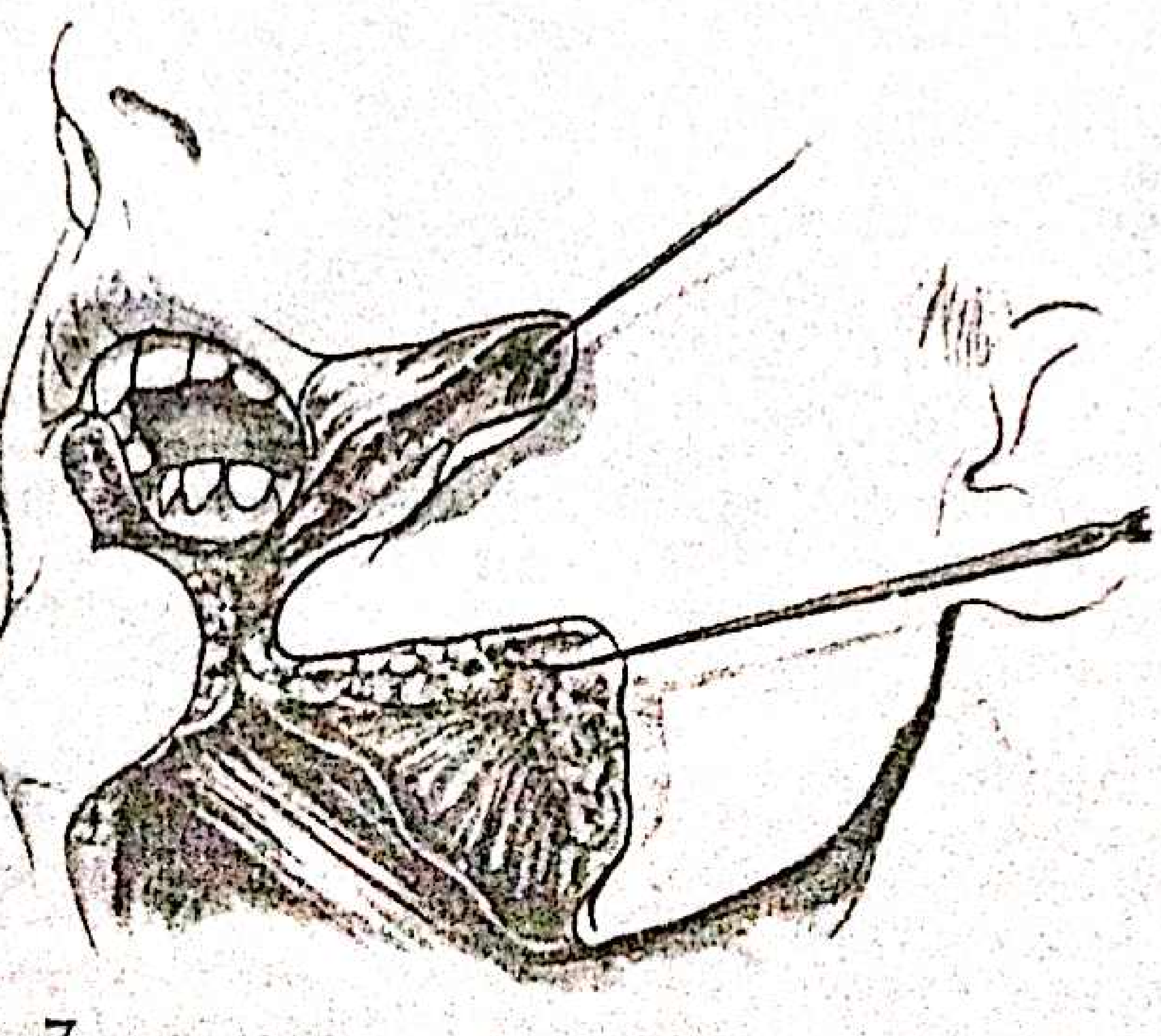

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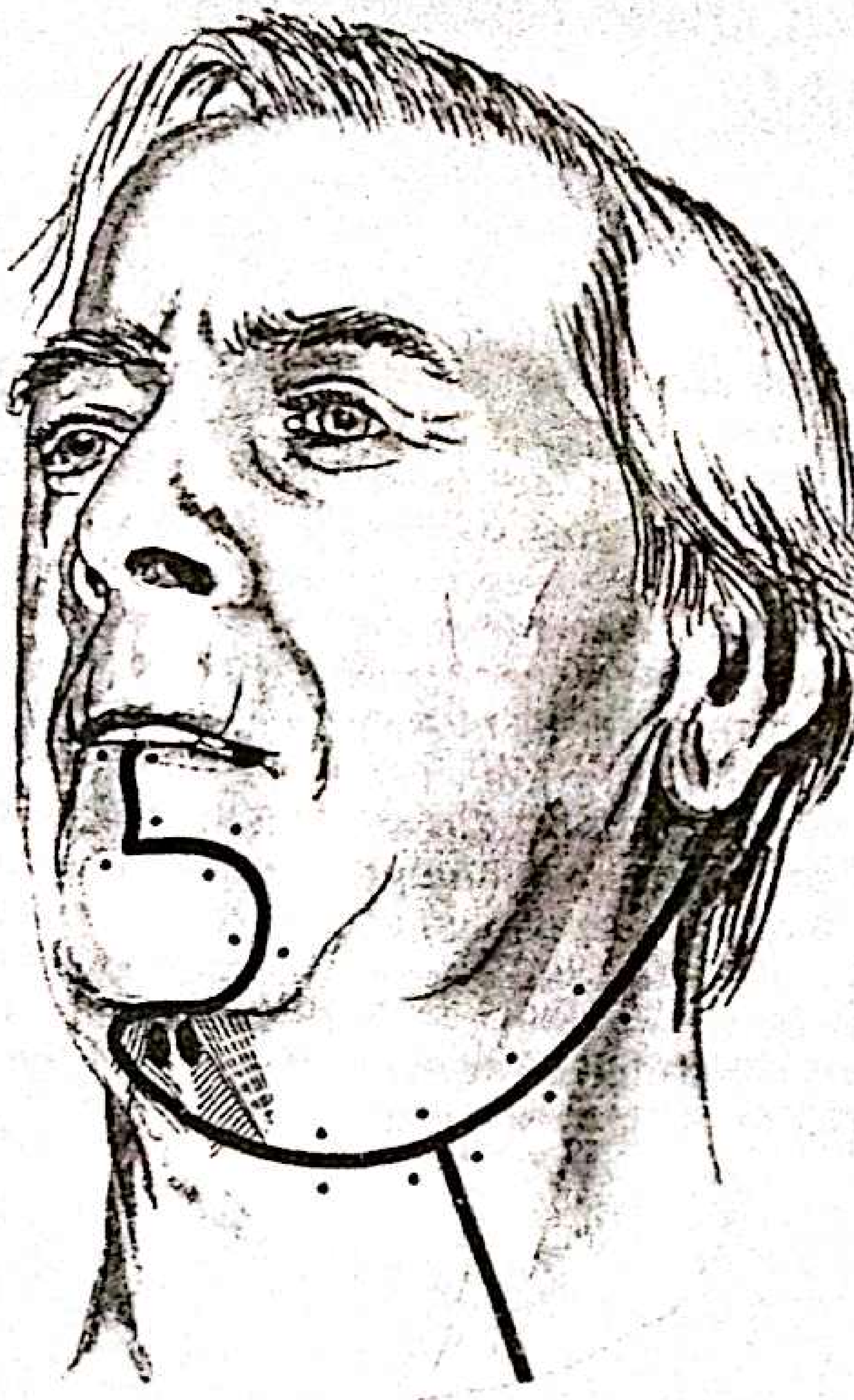
With the exception of the anterior part of the mouth, this lip-splitting incision is used in the approach to all the intraoral sites. The next step involves the raising of a submandibular flap of skin and platysma, making use of the submandibular incision which is part of the standard approach used in carrying out a neck dissection, radical or functional. The lip-splitting incision is carried down on to the submental area, curving round to become continuous with the submandibular incision, and the flap is elevated as far as the lower border of the mandible, taking the usual precautions to preserve the mandibular branches of the facial nerve. When a neck dissection is being carried out in continuity with the intraoral resection, the raising of the submandibular flap contributes to exposure of both the tumour and the submandibular area, but the approach is used even if a neck dissection is not required.

8

When the clinical situation makes it desirable to include the submental lymph nodes as part of the overall neck dissection, the curve of the skin incision can be extended across the midline to provide the necessary access.

The steps which are taken subsequently to expose the tumour depend on whether or not the entire thickness of the body of the mandible is being resected as part of the overall resection. If the bone is considered to be involved by tumour and it is decided that the resection should be of the full thickness of the bone, its extent is determined by two considerations – the presumed extent of tumour within the bone and the possible involvement by tumour of the inferior dental nerve.



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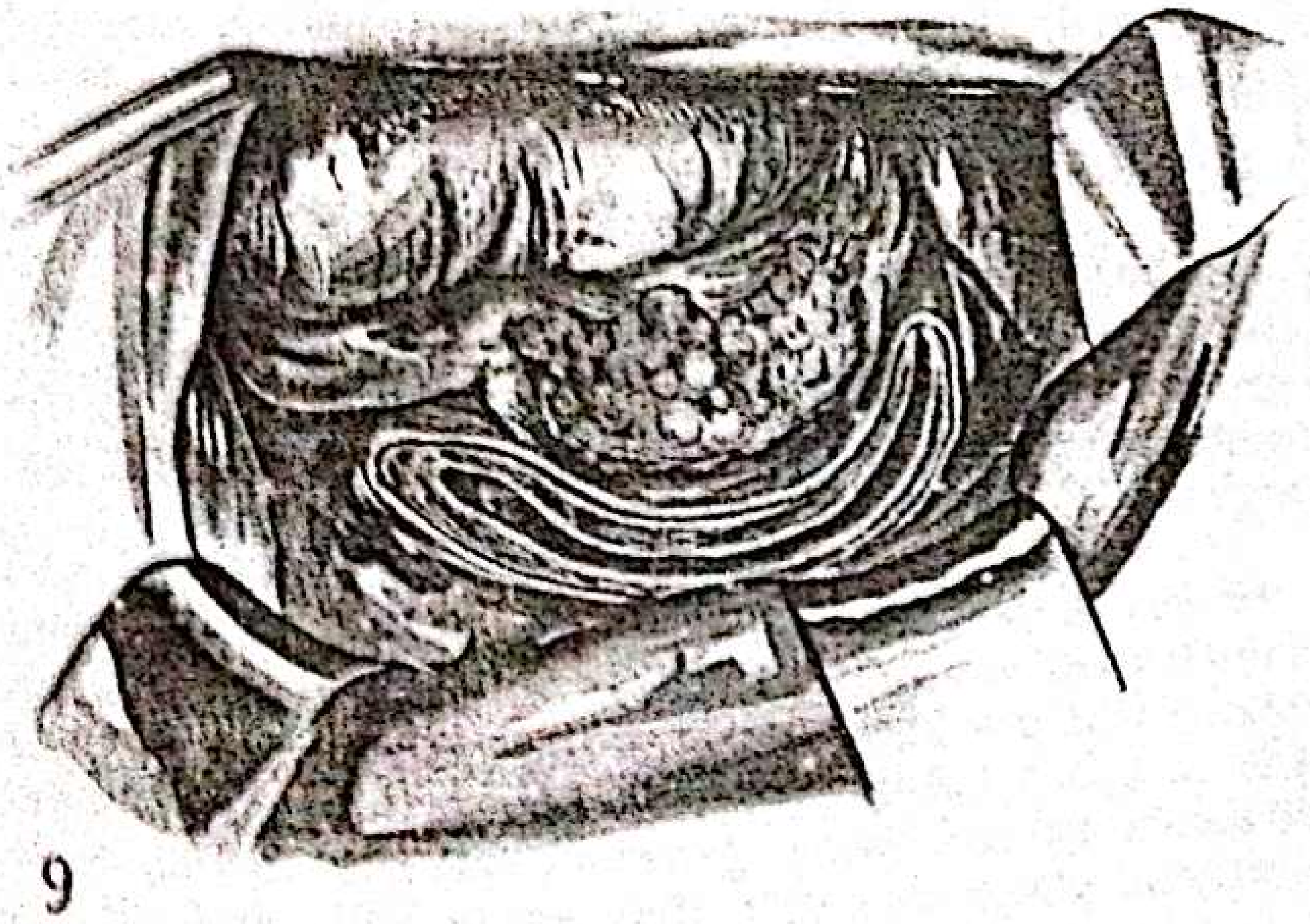

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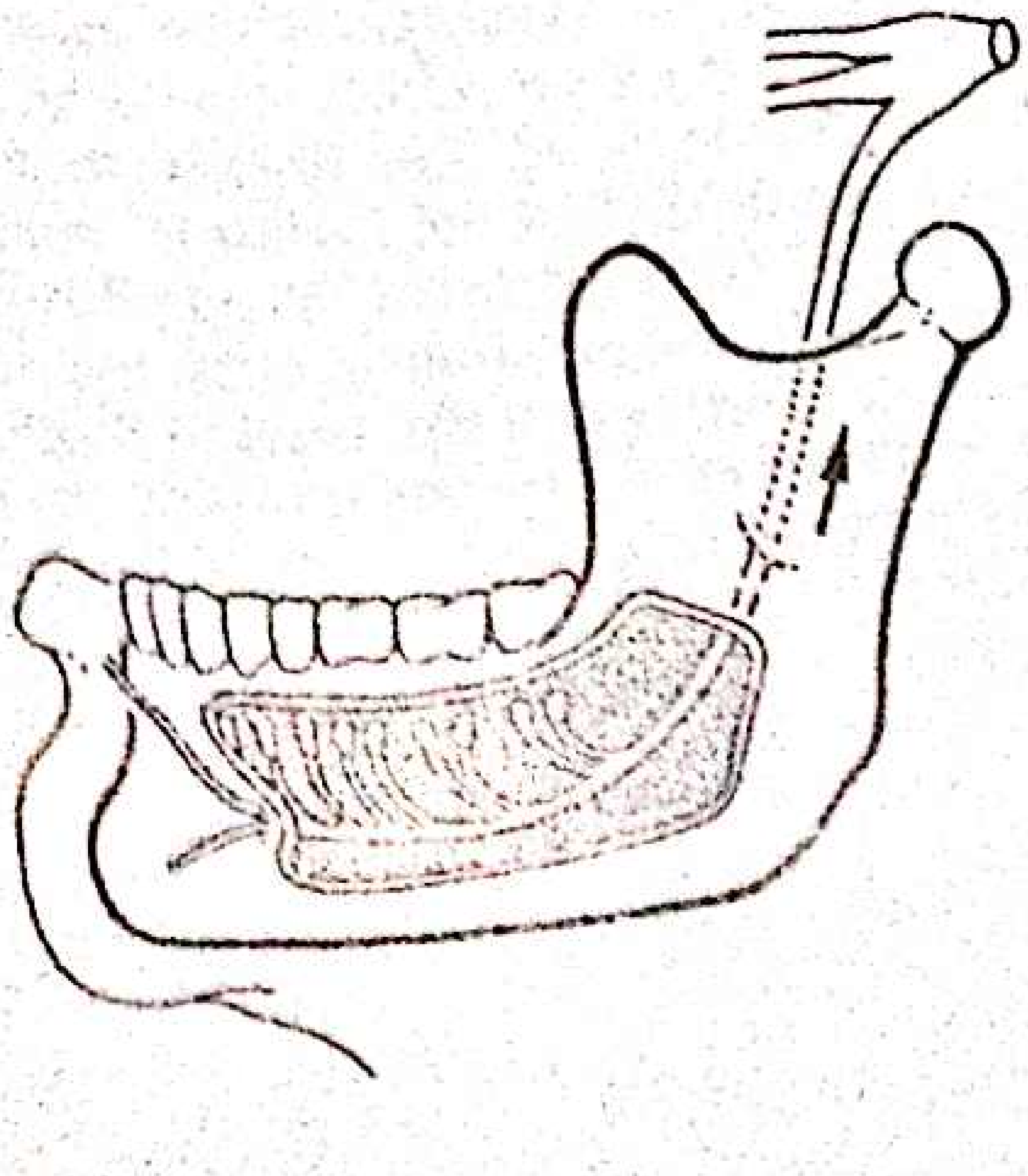
In assessing the extent of tumour within the bone, a useful guide is that the extent of tumour within the bone frequently corresponds with its extent in the soft tissues immediately adjoining it, although in practice the impossibility of using frozen section to determine clearance within the bone is likely to lead to wider clearance of that component of the tumour than of the adjacent soft tissue component.

10

If there is more than minimal involvement of the bone, the possibility of involvement of the inferior dental nerve by tumour in the part of the bone which contains the nerve, the segment between the mental and mandibular foramina, must be viewed as a significant factor in deciding the extent of the bone resection. The recognized capacity of tumour to spread perineurally along the nerve towards the trigeminal ganglion means that, in such a situation, the entire length of the nerve in its extracranial course must be regarded as potentially compromised by tumour. Resection should therefore be from the mental foramen backwards within the bone at least as far as the lingula, and with resection of the nerve extended back to the foramen ovale.



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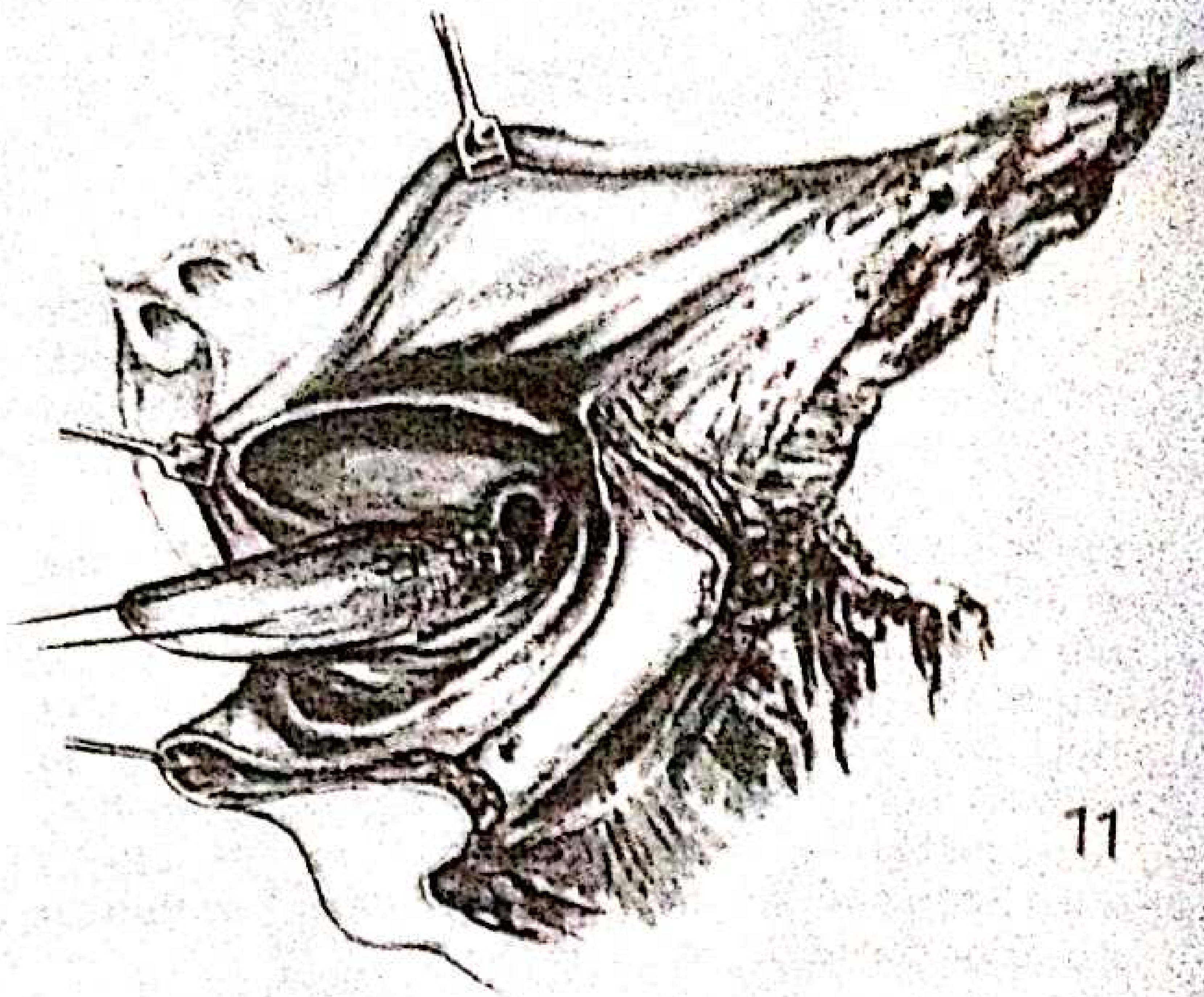
Full thickness resection of mandible

11

When the full thickness of mandible is being resected, an incision is made along the lower buccal sulcus, its line varying a little depending on the site and extent of the tumour, and the soft tissues of the cheek are elevated from the outer surface of the body of the bone. In elevating the soft tissues it is convenient and technically easier to strip them subperiosteally, but in order to clear the tumour locally it may be necessary to leave the bone with a cover of soft tissue. Clearance of the outer surface in this way changes when the anterior border of masseter is reached. Unless the tumour is very advanced this muscle is rarely involved, but in order to pursue the clearance of the ascending ramus it has to be stripped from the bone. This can conveniently be done using a periosteal elevator, and should extend around the lower and posterior margins of the bone.



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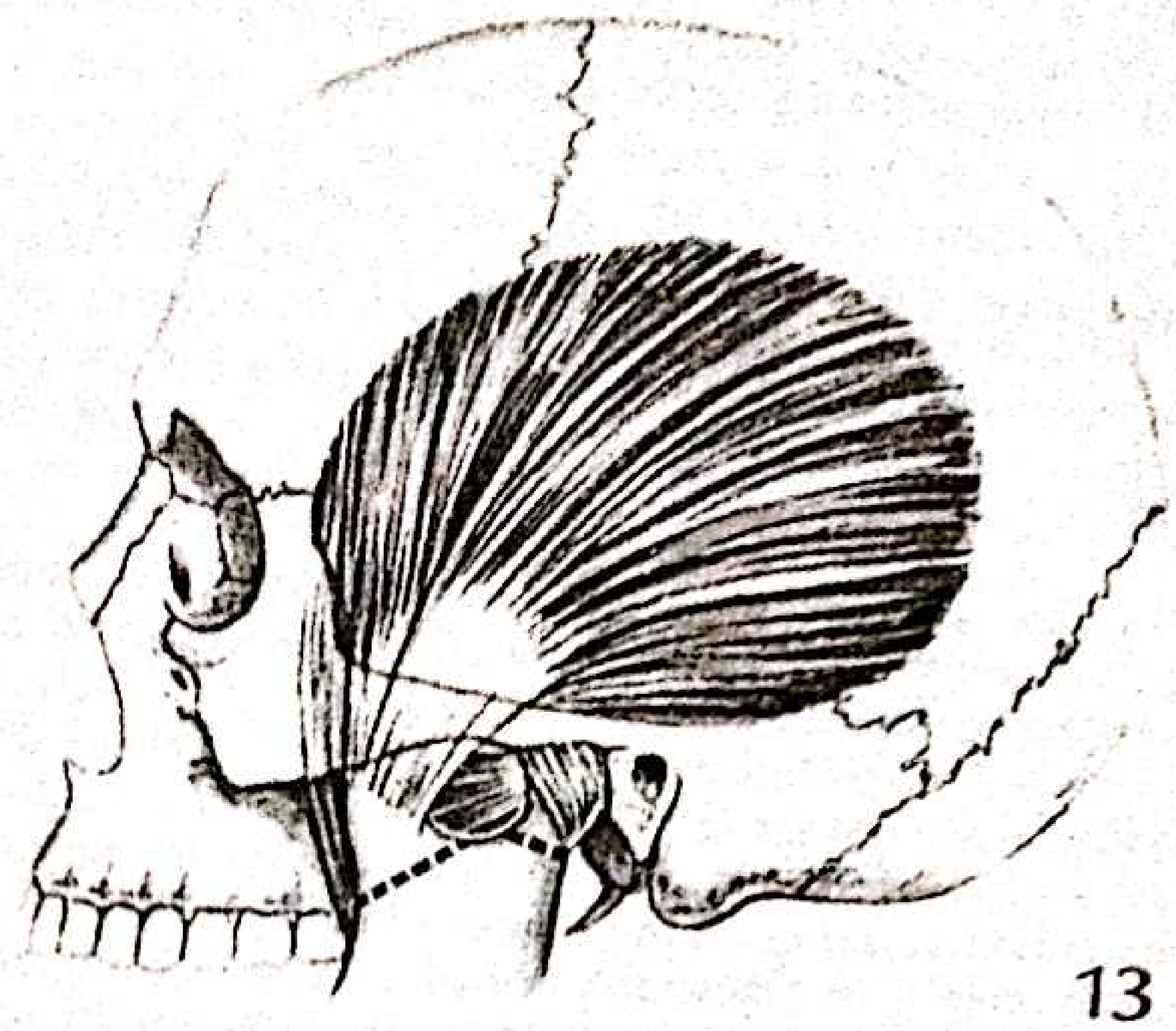
It is convenient at this stage, with its outer surface cleared, to section the mandible anteriorly. This allows the divided segment to be swung laterally, and gives access to the structures medial to it, the lateral floor of mouth and tongue.

When the mandible is being resected because the site of the tumour is medial to it, the soft tissue element of the tumour and the bone are as a rule resected as a single structure, but behind the line of soft tissue clearance, clearance of the bone generally reverts to the subperiosteal plane although, depending how far back the main tumour mass extends, part of the medial pterygoid muscle may require to be resected. Clearance of the medial surface of the ascending ramus should be carried upwards as far as the level of the lingula in the first instance. If perineural spread of tumour within the inferior dental nerve is considered a possibility, it is desirable that the entire extracranial course of the nerve should be resected, dividing it at the level of the foramen ovale, but it is easier to wait until the bone has been fully mobilized before attempting this.

13

The tendon of temporalis is inserted well down along the anterior border of the ramus and, because it does not strip readily, it may be found convenient to section the bone across the base of the coronoid and leave the temporalis tendon largely untouched. It is convenient also to divide the condyle at its base rather than avulse it from the temporomandibular joint, and in this way avoid the bleeding associated with the latter.



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With the bone freely mobile it becomes easier to divide the inferior dental nerve. With the freed mandibular segment pulled gently downwards and forwards, the nerve can be felt as a taut 'string' and divided with scissors at the skull base.

The site of the section of the bone anteriorly is determined by the site of the tumour and the extent to which it is considered to involve the bone. In the past, though to a markedly diminishing extent today, the hemimandible was routinely resected as part of the overall intraoral resection, of tongue for example, although there was no clinical evidence to suggest that the bone was involved by tumour. In such a situation the site selected to section the bone anteriorly is clearly at the discretion of the surgeon, but it should not be brought forward beyond the vicinity of the mental foramen if a reasonable chin prominence is to be maintained.

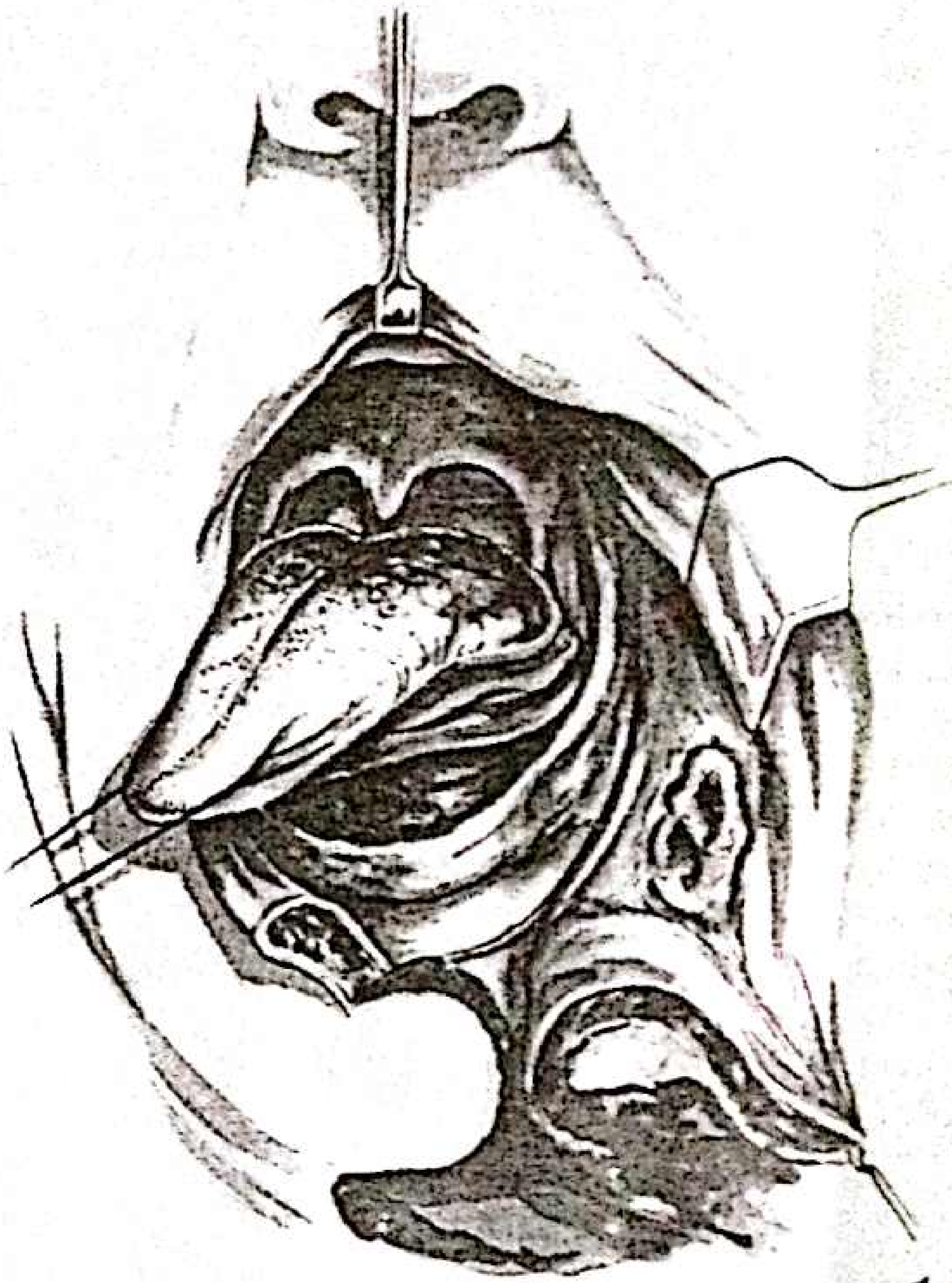
Preservation of mandibular continuity

When mandibular continuity is being preserved, the surgical approach to the tumour depends on whether its site is lateral or medial to the bone.

Tumour lateral to mandible

14

In the case of the tumour lateral to the mandible, a cheek flap is elevated as already described, backwards as far as necessary to clear the tumour posteriorly. Where there is no constraint created by the extent of the tumour, the incision along the lower buccal sulcus should be sited to leave a generous fringe of mucous membrane for ease of subsequent suturing. In the course of raising the flap the mental nerve is inevitably divided but subsequent recovery of sensation is usual if the soft tissues are carefully restored to their preoperative position.



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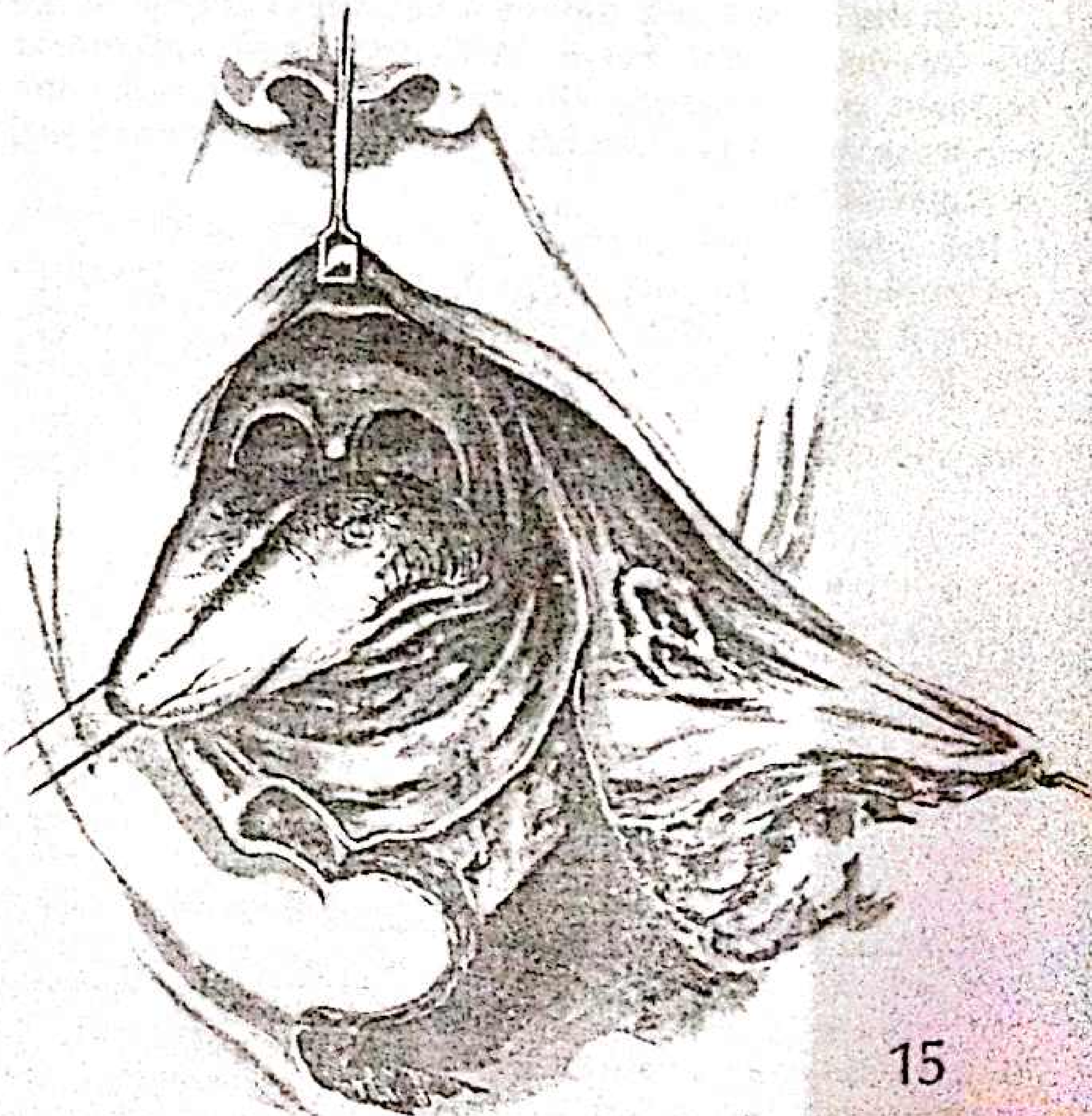
When the pathological situation permits, the cheek flap should be raised from the mandible in a plane which leaves a covering of soft tissue on its outer surface, rather than using the subperiosteal plane, despite the greater technical ease of the latter. Stripping the bone bare has a much greater devascularizing effect on its outer cortex than leaving it with a soft tissue cover.



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Tumour medial to mandible

In the case of the tumour medial to the mandible, two methods have been used in the approach to the tumour and its resection, the 'pull-through' technique, and mandibular osteotomy and lateral 'swing'.

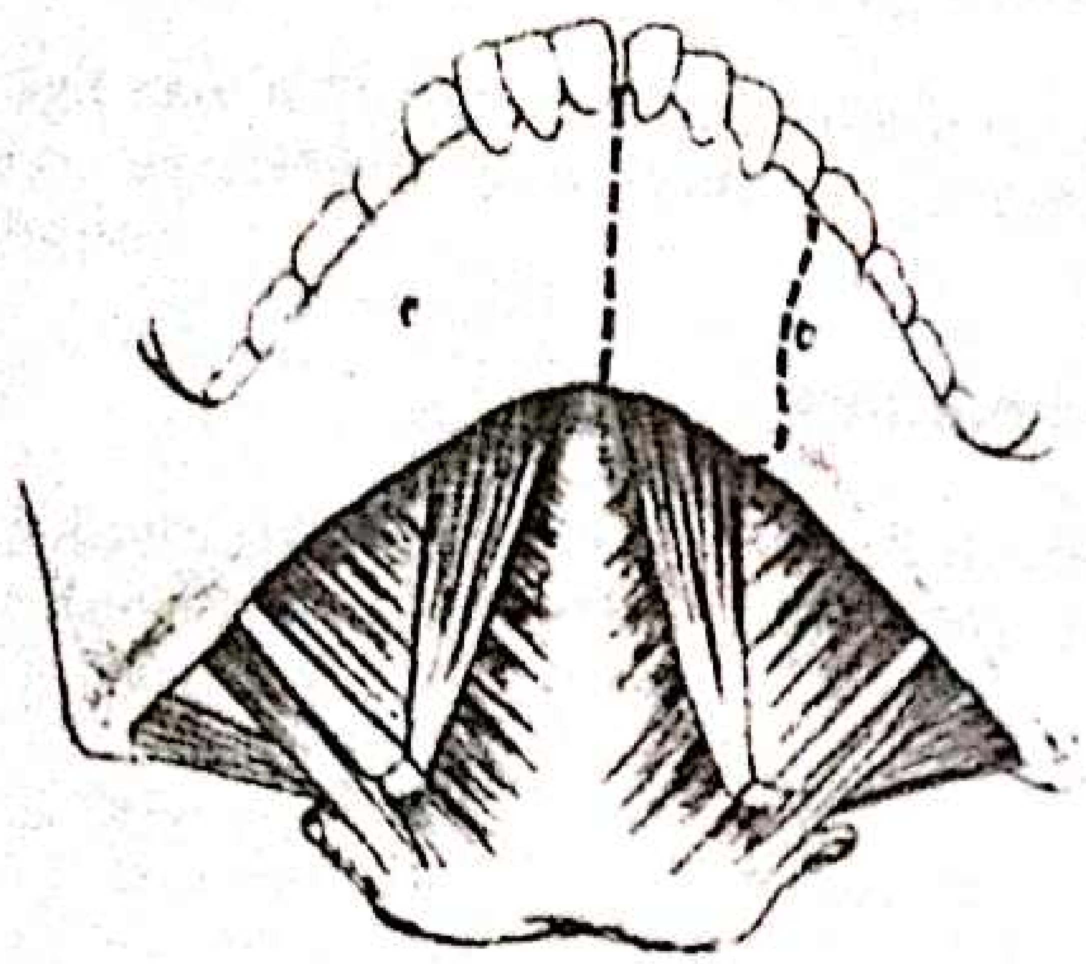
PULL-THROUGH TECHNIQUE

In the pull-through technique, the integrity of the mandible is maintained throughout. Dissection is pursued upwards into the mouth from the submandibular region, and when this approach from below is no longer technically possible, resection is commenced from inside the mouth in a downwards direction, until the two approaches meet. The tumour is then 'pulled through' into the submandibular area and removed. The pull-through method is still used by many surgeons, but the existence today of the much better alternative of the approach using mandibular swing makes it an method which should be abandoned. The exposure which it provides is insufficient to allow an adequate degree of surgical precision.

MANDIBULAR SWING APPROACH

In the mandibular swing approach, an osteotomy of the body of the mandible is carried out and the mucosa and muscles attached to its lingual surface behind the osteotomy site are divided, allowing the hemimandible to be swung laterally, hinging on the temporomandibular joint. The effect is to open up the entire oral cavity. When the tumour has been resected and the reconstruction completed the two ends of the divided bone are approximated to one another and fixed in position.

If this approach is to be used effectively it is important to minimize damage to the blood supply of the mandible so that the bone is left in an optimal state for union of the surgically created fracture. With the loss of the soft tissues normally attached to the medial surface of the body which results from the surgery, the bone has to rely for its blood supply on the soft tissues attached to its buccal surface and this attachment therefore should be disturbed as little as possible. With this in mind the elevation of the submandibular skin flap carried out prior to the osteotomy should stop at the lower border of the mandibular body and any periosteum which is elevated in the process of carrying out the osteotomy and the subsequent bony reconstitution should be reduced to a minimum.



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Choice of osteotomy site

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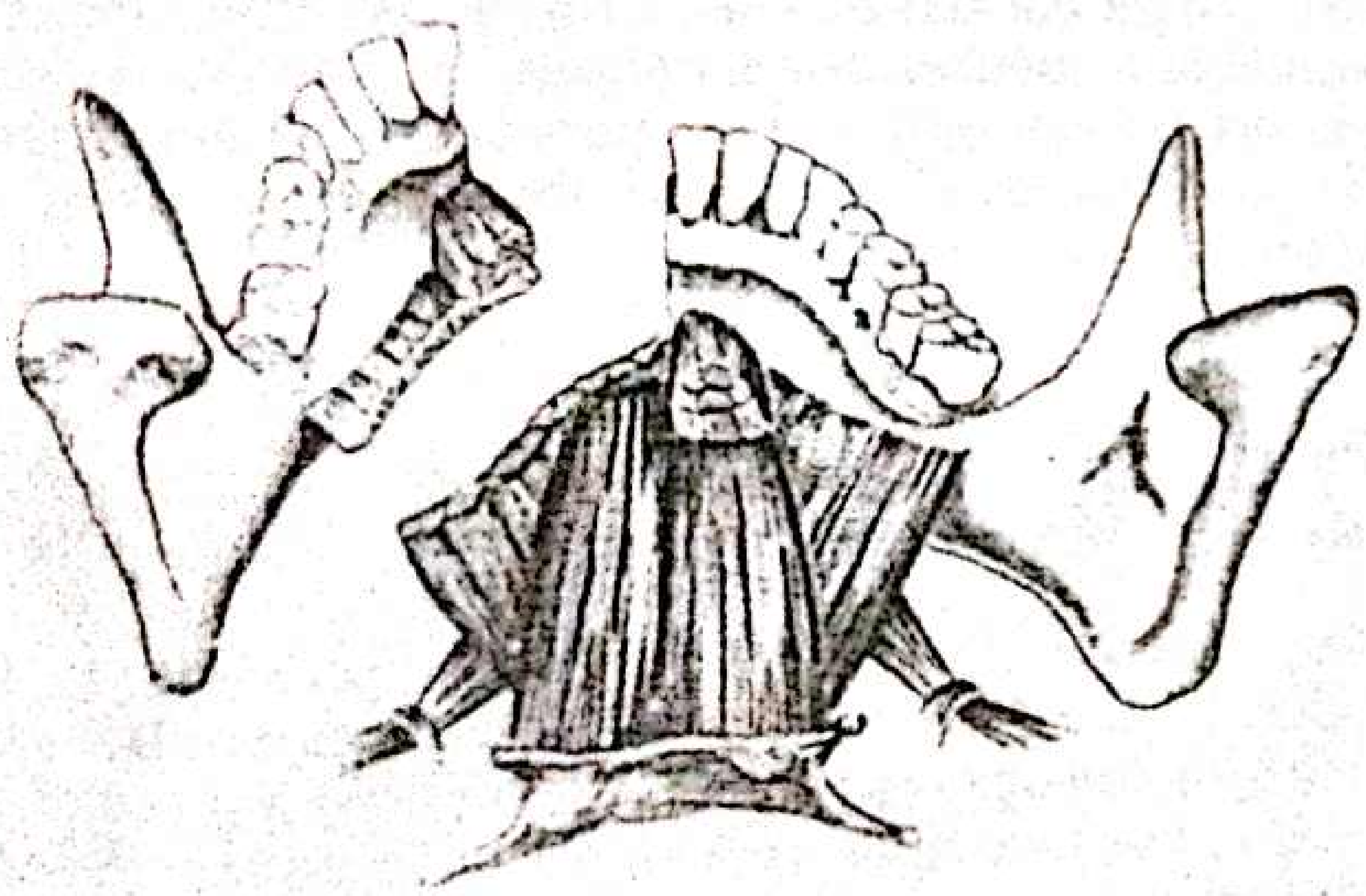
The site at which the osteotomy is carried out can be either at the symphysis or immediately anterior to the mental foramen. The site of the tumour in the mouth may determine which of the two sites is chosen; otherwise other factors are involved in the decision.

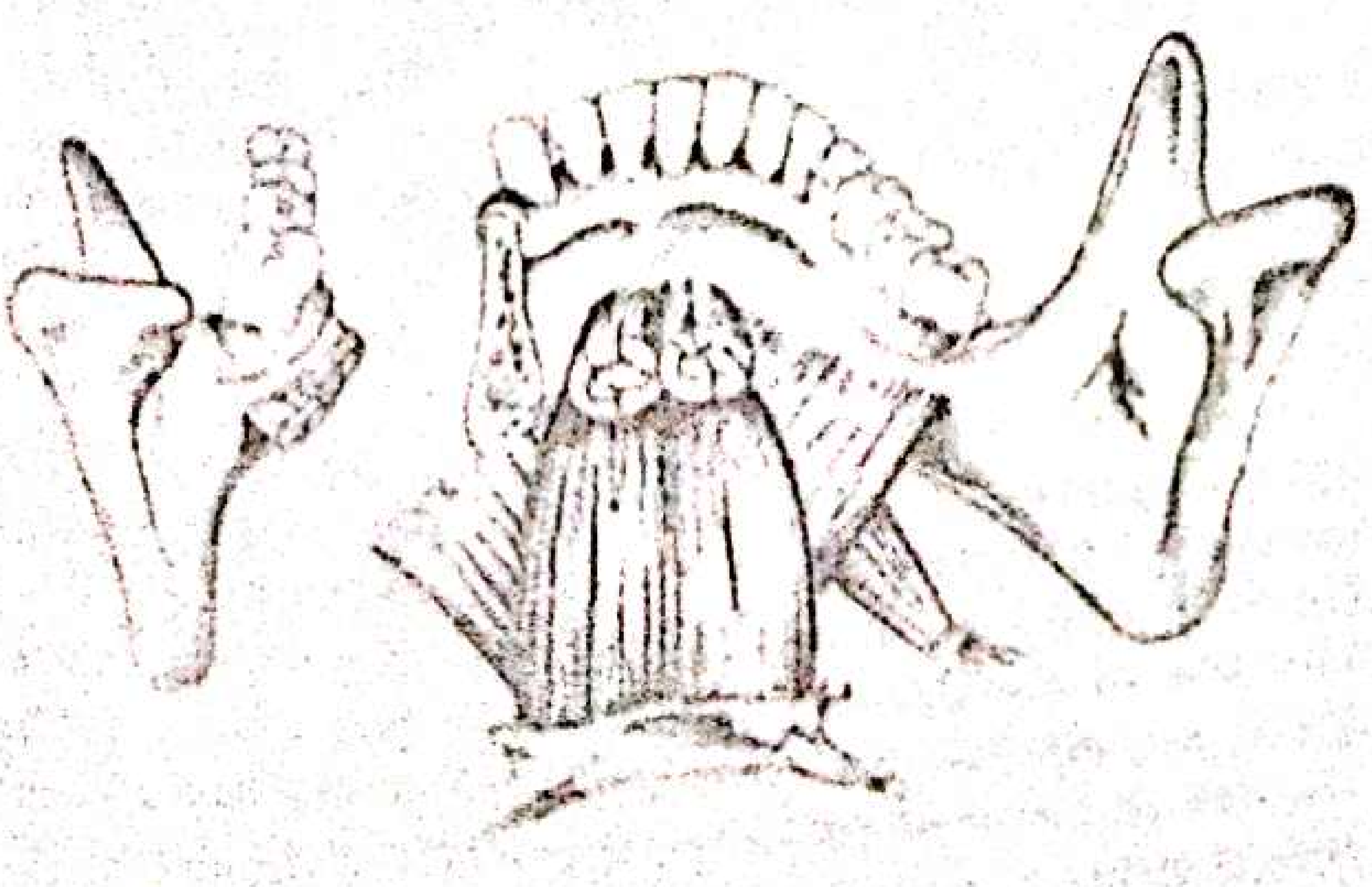


17

Symphyseal site

17

When the symphyseal site is chosen, the midline lip-splitting incision has to be used if soft tissue dissection is to be kept to a minimum. When the osteotomy has been carried out, the structures which have to be divided in order to allow the hemimandible to swing laterally are genioglossus, geniohyoid, the anterior belly of digastric, mylohyoid, and the mucous membrane of the lateral floor of mouth.



18

Lateral site

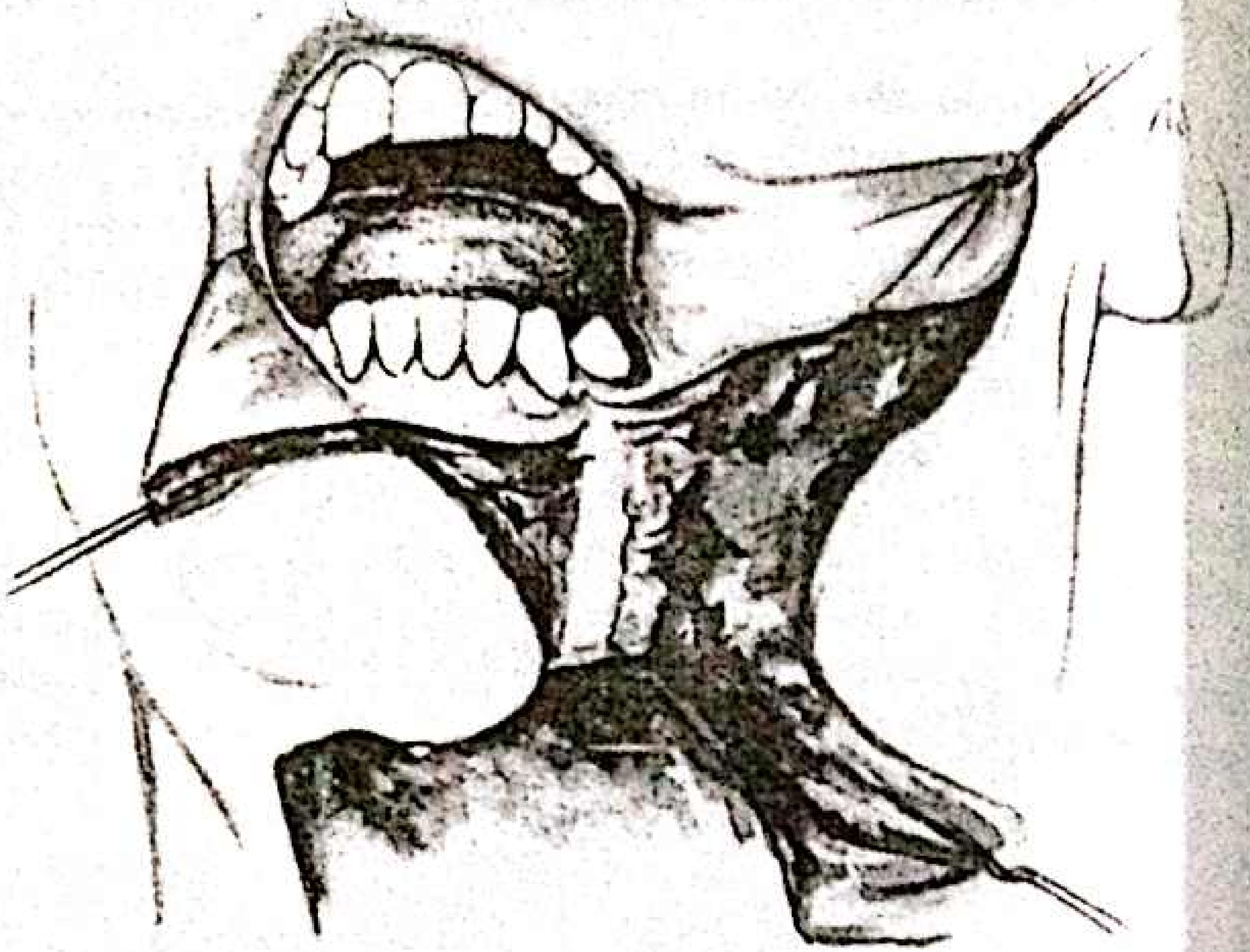
18

When the lateral osteotomy site is used, the structures which require to be divided to allow lateral swing to take place are mylohyoid and the mucous membrane of the lateral floor of mouth. The lateral site, as well as being immediately in front of the mental foramen so that damage to the mental nerve is avoided, also lies immediately behind the insertion of the anterior belly of digastric and lateral to the tongue muscle, genioglossus, as well as geniohyoid.

19

The lateral site also fits well with the modified lip incision, already described. This incision, deepened to the mandible, reaches the bone directly over the site of the osteotomy with a minimum of soft tissue dissection.

In the exposure of the oral cavity which they provide the lateral and the symphyseal sites are comparable. On the rare occasions when sagittal splitting of the tongue is used to expose the posterior third of the dorsum, or the posterior wall of the oropharynx, the symphyseal osteotomy site is the appropriate one to use, but in the absence of clear-cut indications for one or other site the lateral site has the obvious advantage of leaving the tongue musculature undisturbed and restricting the structures which require to be divided to mylohyoid and the overlying mucosa.



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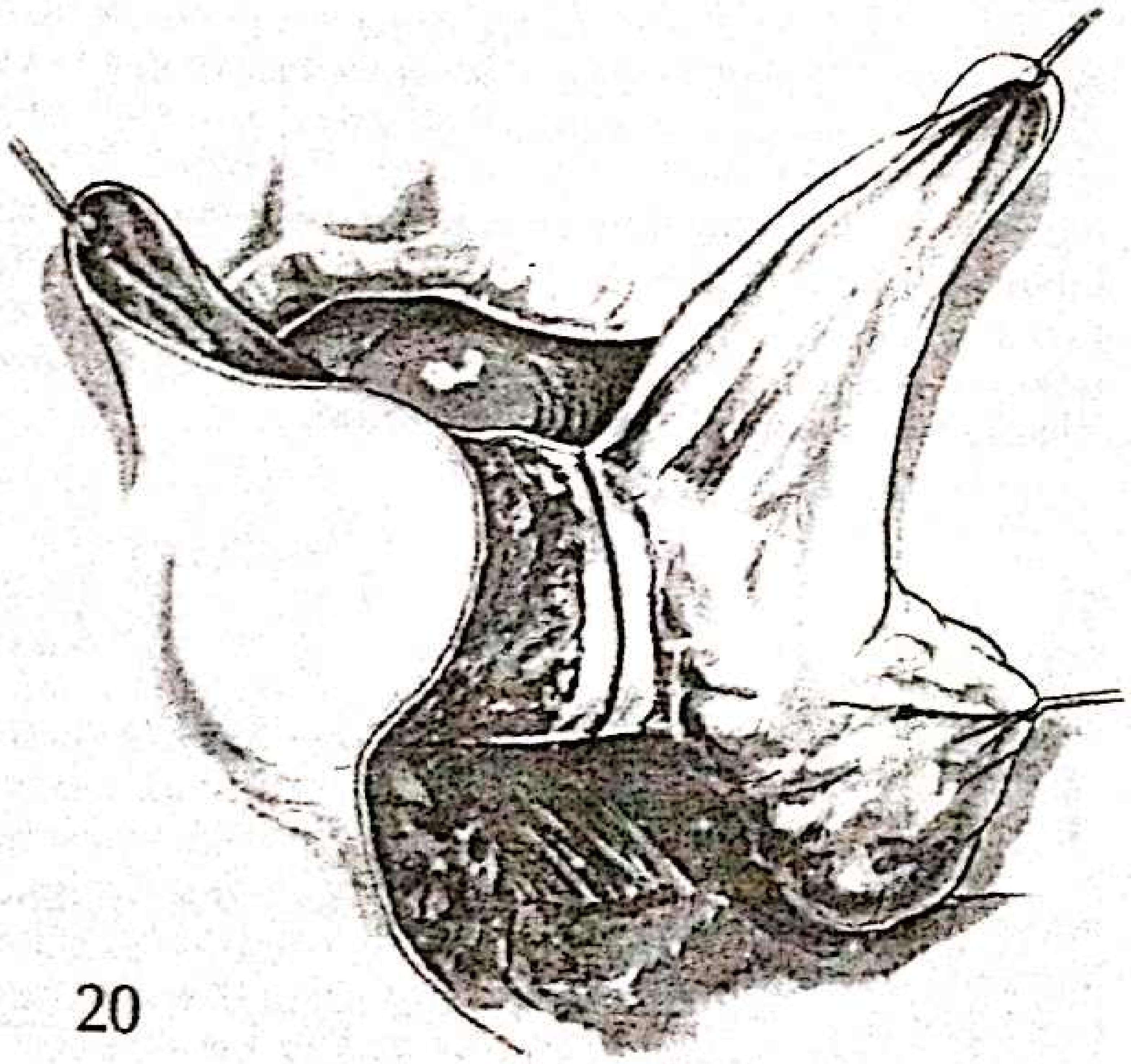

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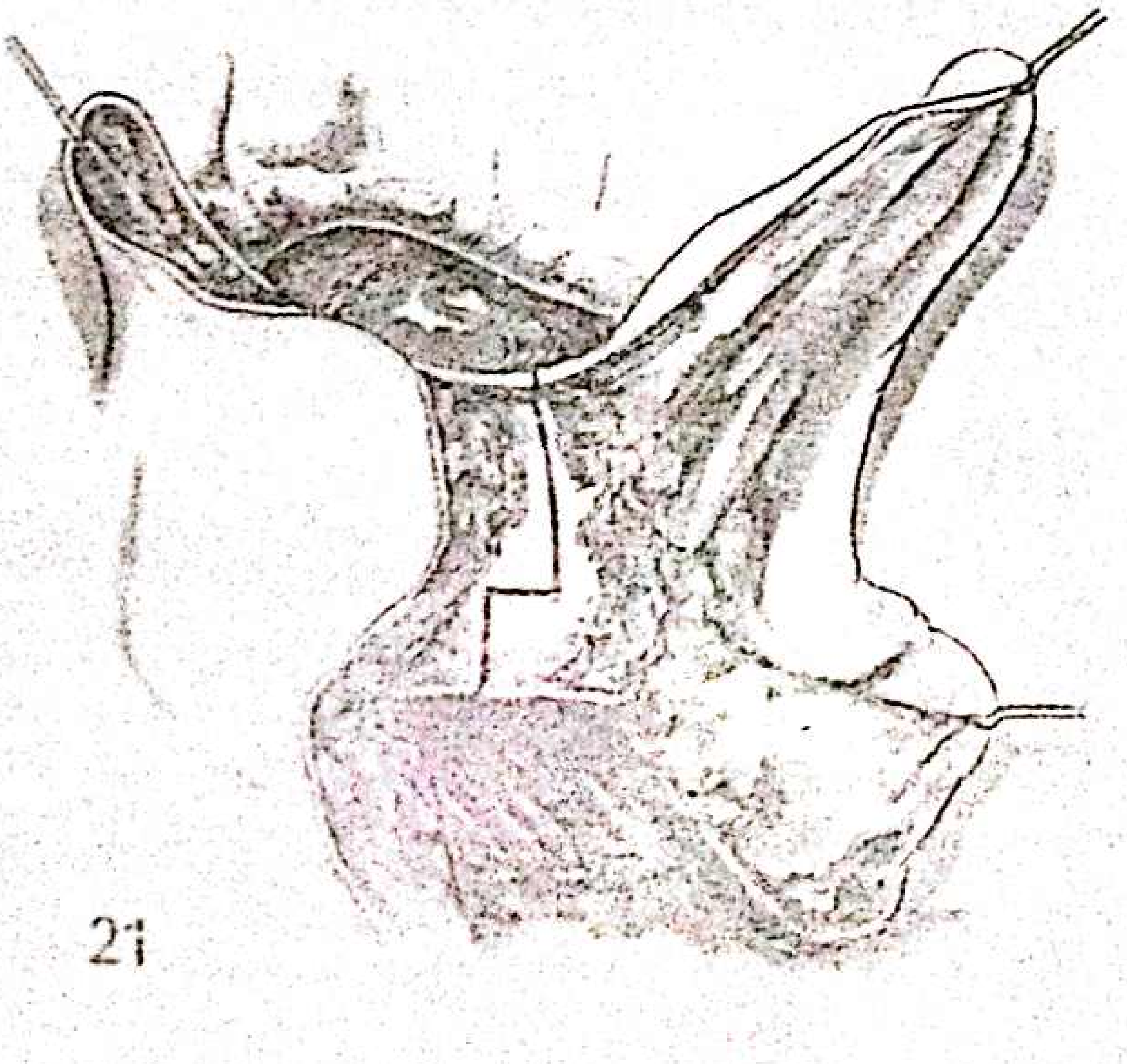


21

Form of osteotomy

The form which the osteotomy can take involves division of the bone using either a straight or a stepped cut.

20

The straight cut can be used irrespective of whether the mandible is dentate or edentulous. Its use also requires the stripping of only enough periosteum to allow access for the saw used to divide the bone, a matter of approximately 4 mm.

21

The stepped cut is more readily applicable in the edentulous mandible, since used in the dentate bone it is liable to damage the roots of the teeth at the site of the cuts unless care is taken. Apart from its greater technical difficulty the stepped cut also involves more extensive stripping of the periosteum than the straight cut. Its virtue lies in the better stability it is considered to provide, particularly in the edentulous mandible.

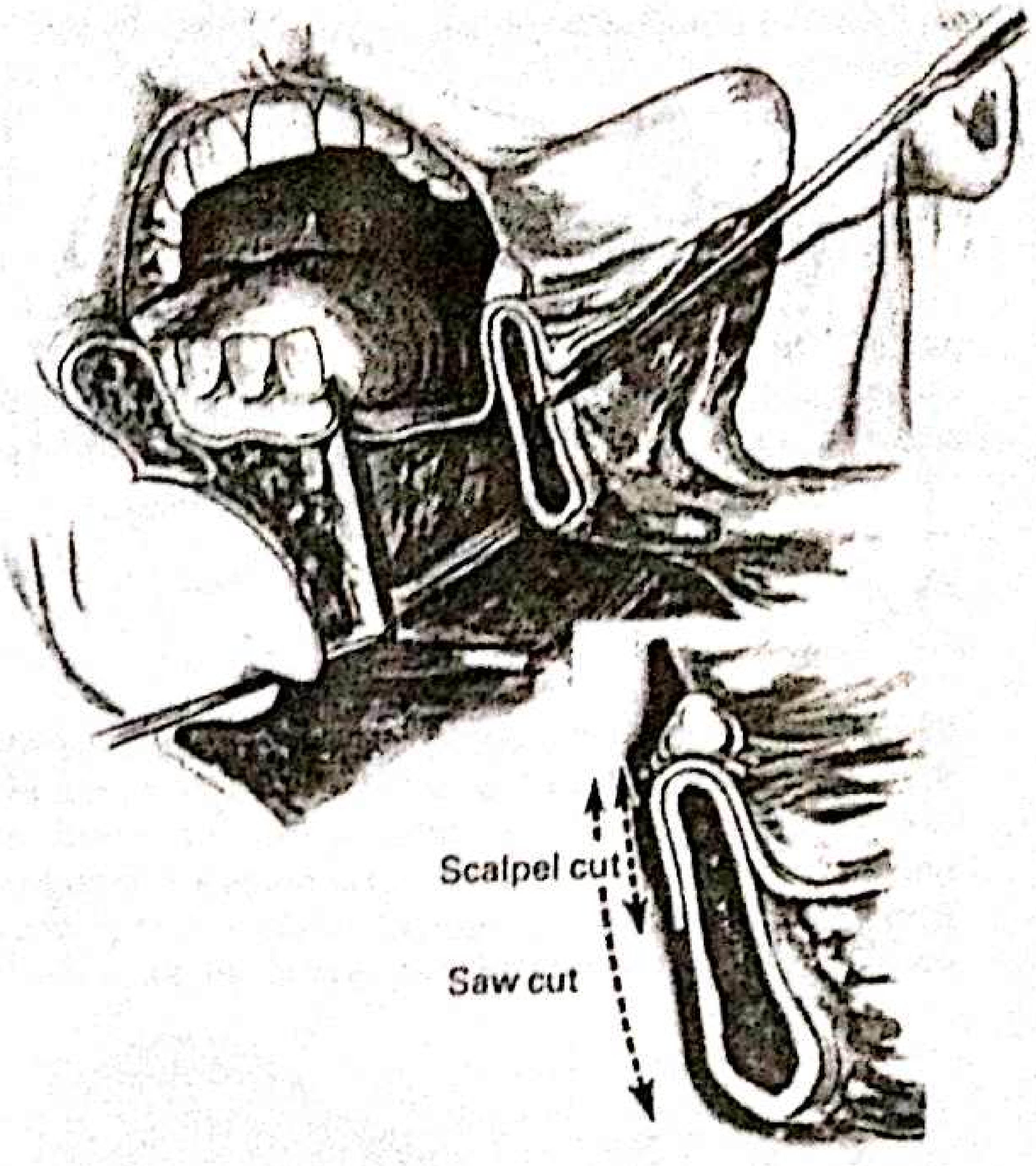
With either cut the mucoperiosteum above the lower buccal sulcus is divided, using a scalpel. Below the level of the buccal sulcus, prior to commencing the cut, straight or stepped, sufficient periosteum is stripped to allow access to the bone.

In the case of the dentate mandible, the extraction of a tooth to leave the space to carry out the osteotomy has generally been regarded as unavoidable, but with the thin blade power saws available today it is rarely necessary. Division of the bone between two teeth is a straightforward manoeuvre. A preoperative occlusal radiograph should be taken to establish a suitable gap for siting the osteotomy.

22

Between the two teeth which have been selected the interdental papilla is divided into equal parts using a scalpel, and the incision through the mucoperiosteum is carried to the bone down as far as the buccolabial sulcus on its outer aspect and equally far also on the lingual aspect. The bone is then divided using the saw. If division of the papilla in this way is not carried out formally and to its full extent using the scalpel, one or other hemipapilla is likely to be torn off the corresponding tooth.

If a Gigli saw is the only instrument available to divide the bone, extraction of a tooth for access is virtually unavoidable.



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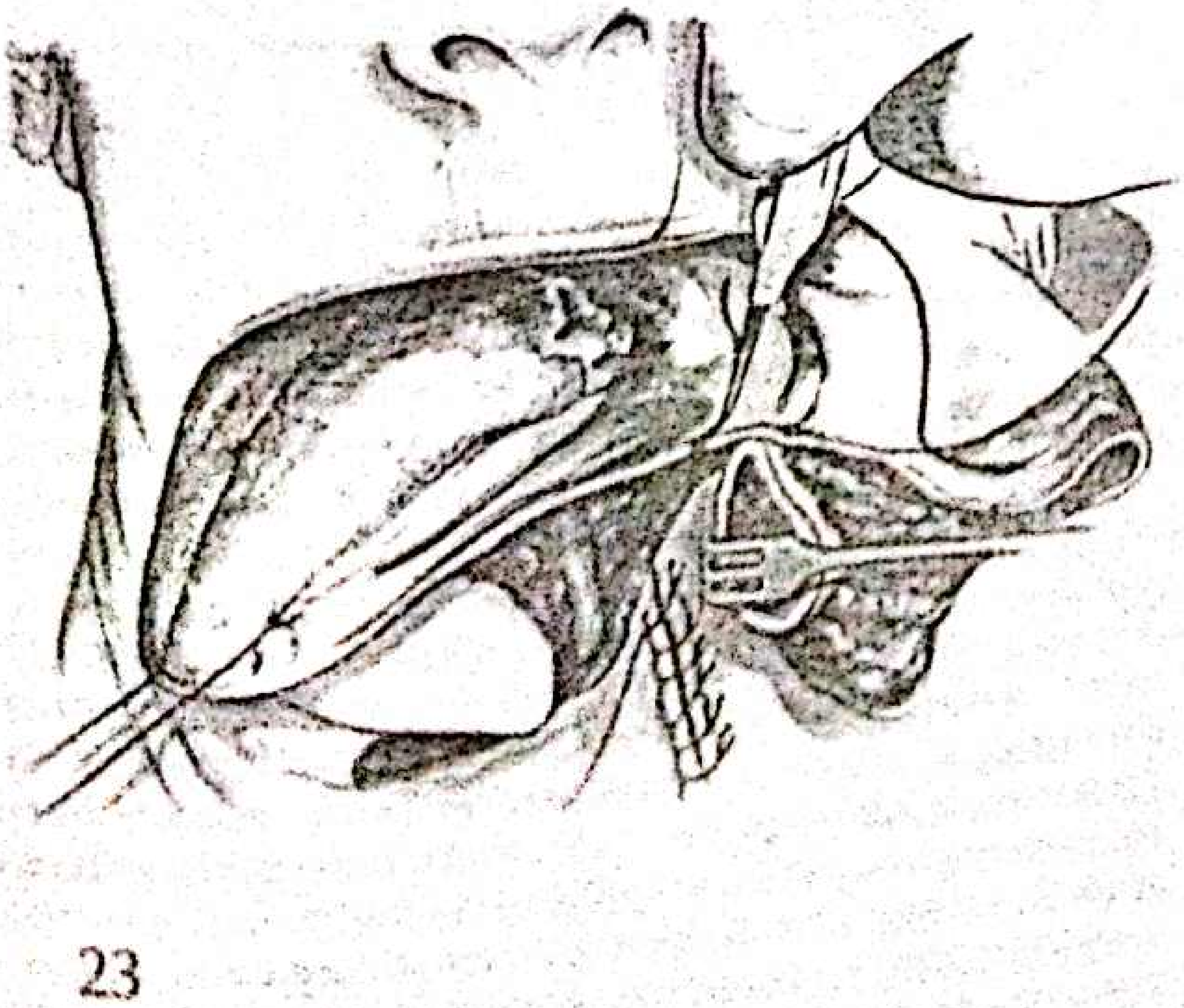
Completion of swing

When the bone has been divided the swing can be completed. With division of the periosteum attached to the lingual plate, the bone ends separate. In the case of the symphyseal site little additional lateral movement takes place until genioglossus, geniohyoid, and digastric have been divided; with the lateral site a degree of lateral swing takes place more obviously from the outset.



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Retraction laterally of the mandibular body puts mylohyoid on the stretch so that it is readily seen and can be divided along with the mucous membrane lining the lateral floor of mouth, leaving the deep lobe of the submandibular gland medial to it. Where the line of division of the mucosa is not obviously clearing tumour, a generous fringe should be left for subsequent suturing. The mucosa can be divided backwards beyond the posterior free border of mylohyoid on to and even beyond the fauces, dividing palatoglossus and palatopharyngeus as required. The exposure which is provided encompasses the entire oral cavity, back to the oropharyngeal and epiglottic areas.

Restoration of mandibular continuity

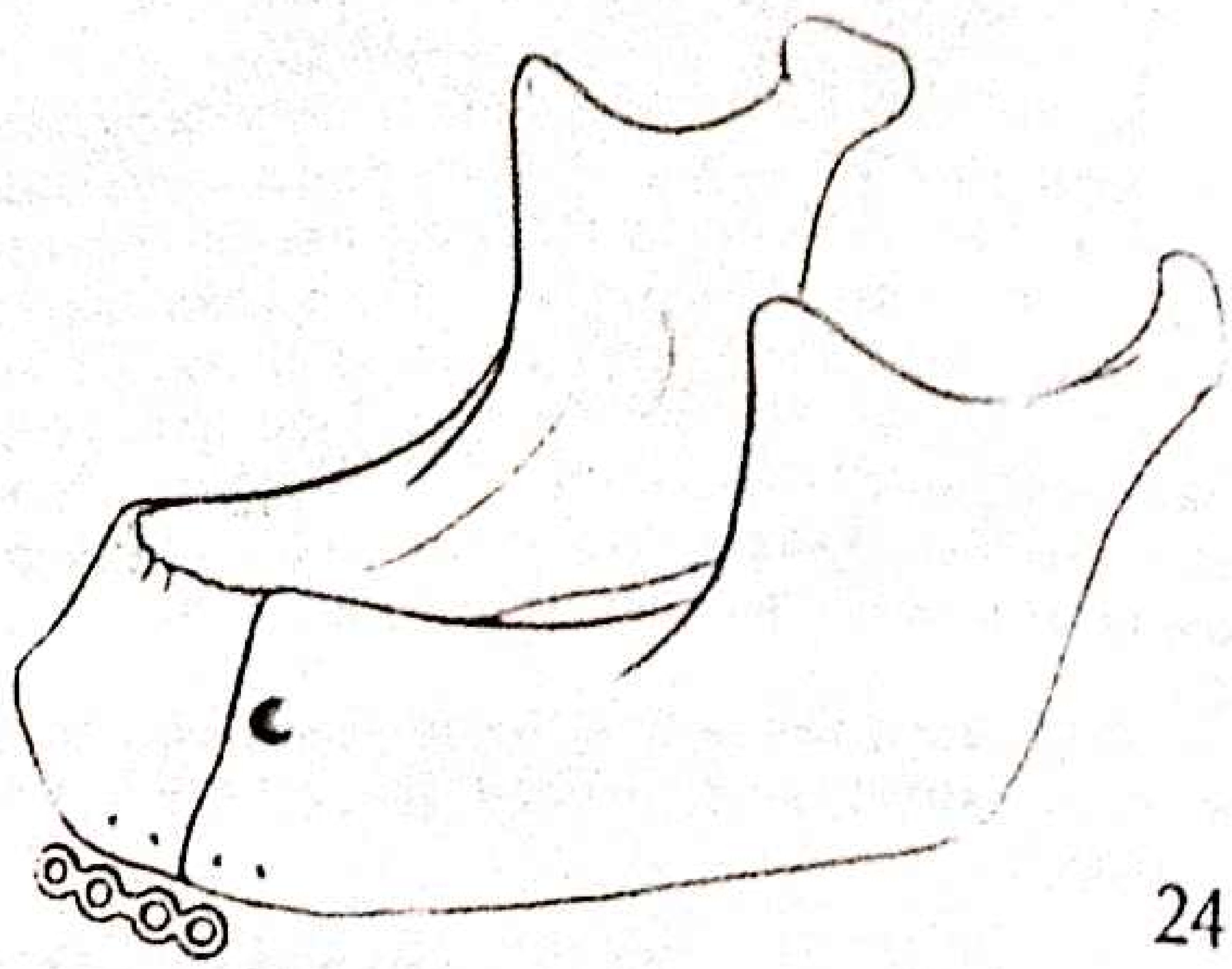
Mandibular continuity can be restored either by plating or by wiring.

Use of plating

When plating is used, it has been standard practice to place the plate deep to the periosteum, but with recognition of the importance of the periosteal blood supply, plating over the periosteum is increasingly used.

24

Before carrying out the osteotomy the bone is exposed in the area over which the plate is to be applied, the plate is placed in position over the site and moulded to the surface contours of the bone. Drill holes are then made in preparation for the subsequent fixation, using screws of sufficient length to engage the lingual cortex of the bone.



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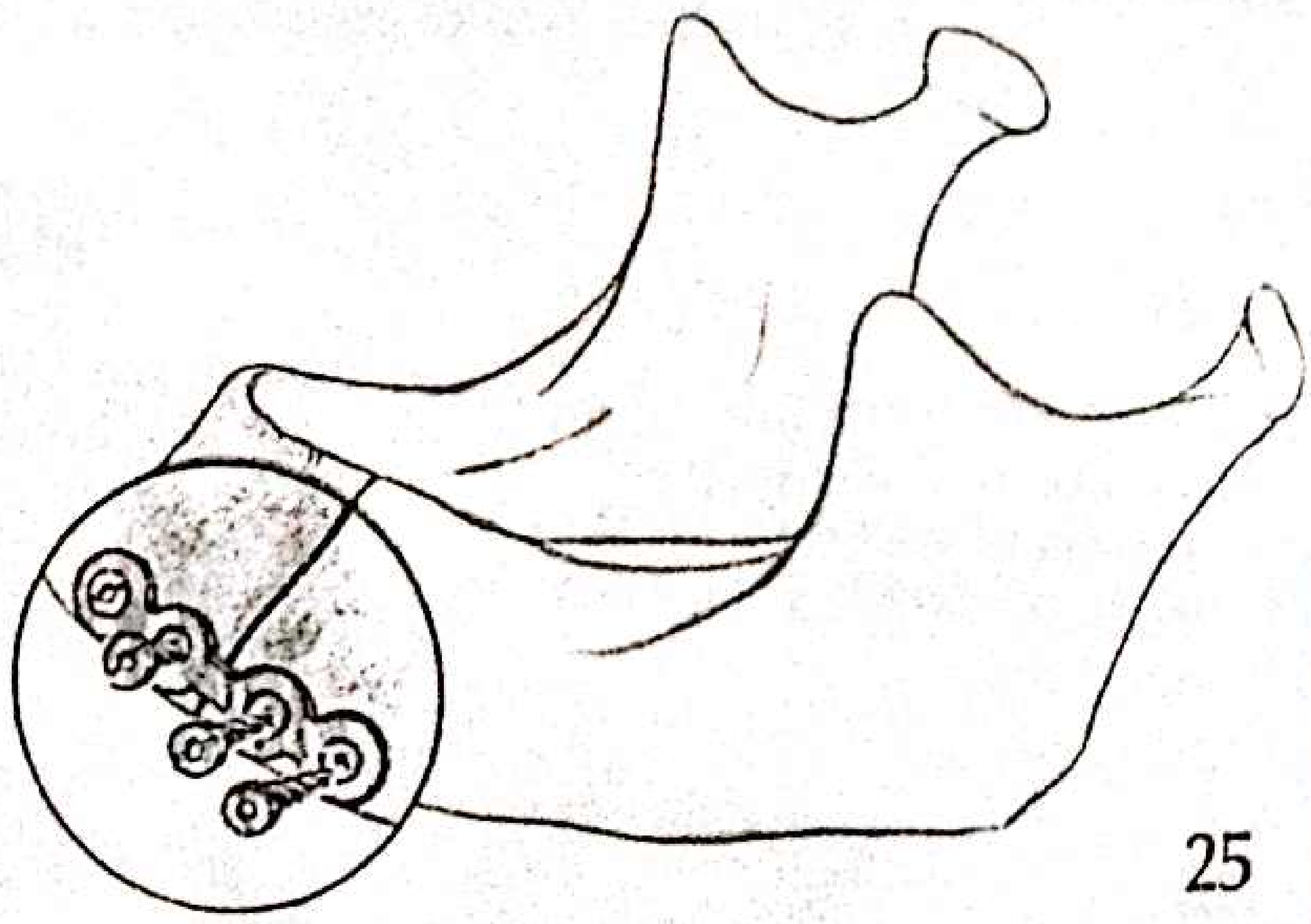
When the excisional and reconstructive surgery is complete, the bone ends are approximated, the plate is placed in position, and the screws are inserted into the holes prepared preoperatively and tightened.

When bony union has occurred at the site the plate can be removed if this is considered desirable. The screws are first extracted using a screwdriver working through a stab incision in the skin directly over the plate. The plate itself is then removed through an incision in the lower buccal sulcus. In the hands of surgeons experienced in its use plating is an effective method, but it is a more demanding technique than the wiring methods.



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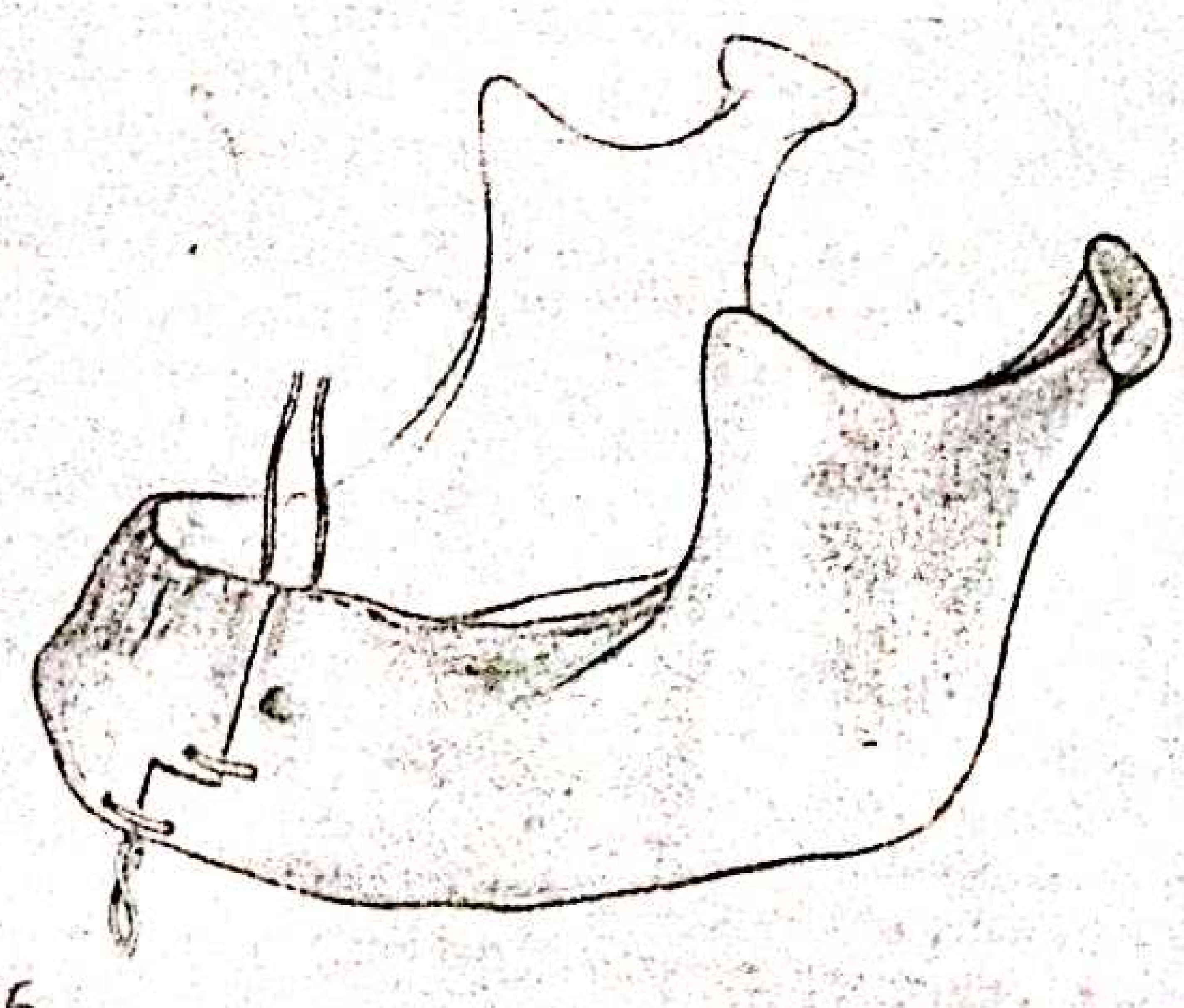

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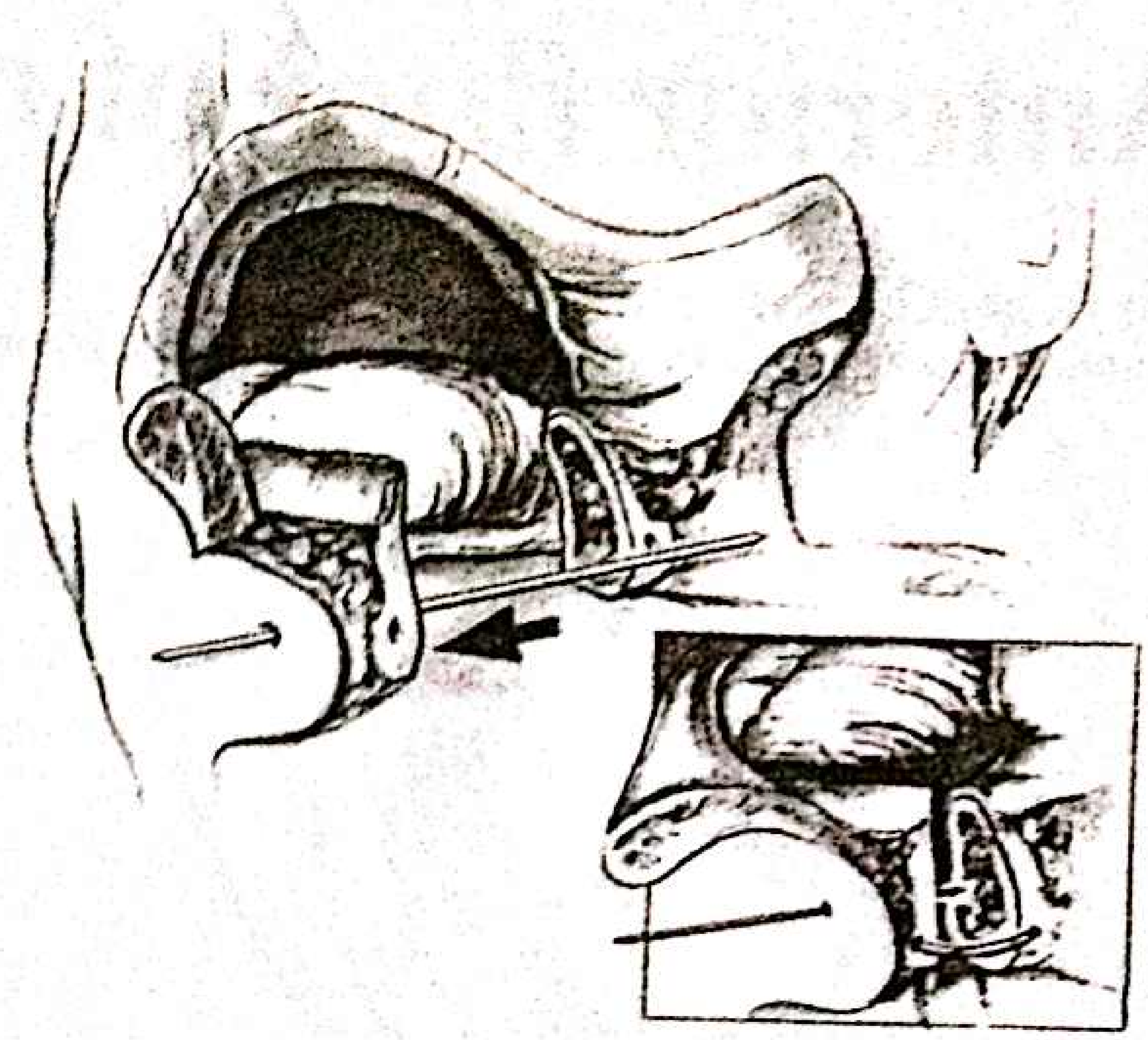
Use of wiring

26

When wiring is used, a simple loop or figure of eight placed at the lower border of the bone may be found adequate to stabilize the osteotomy if a stepped cut has been used, but added stability can be provided if needed with a further wire inserted at the step of the cut. The necessary drill holes are made prior to the osteotomy for subsequent insertion of the wires which will hold the reconstituted mandible in position. The wire, stainless steel, 0.4 mm in diameter, is then twisted until the loop is tight, the excess being cut off and the ends turned in.

27

If a straight bone cut has been used, the single wire loop can be reinforced by a K-wire transfixing the osteotomy site. The short K-wire, primarily designed for hand surgery, 100 mm long, 1 mm in diameter and sharp at both ends, is used for this purpose. When continuity of the bone is ready to be restored, the loop wire is inserted but left untightened. A site is selected in the cut margin of the symphyseal side of the osteotomized mandible where the bone is broad, and the K-wire is driven through the bone until it emerges from its surface and then through the skin of the chin. The drill is then transferred to the other end of the K-wire, pulling it through until its tip is just visible at the osteotomy margin.



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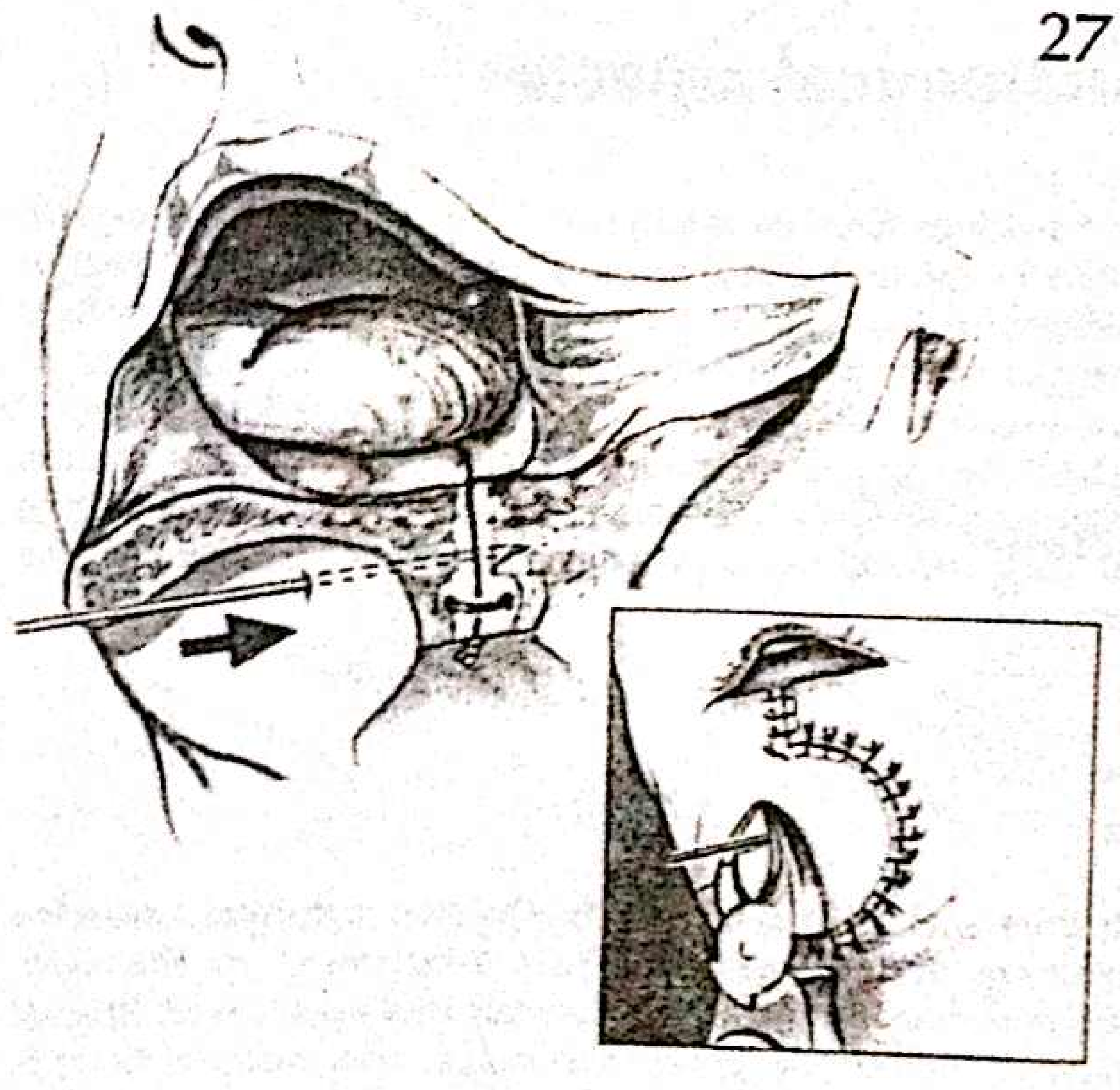
With the bone ends correctly aligned, the loop wire is tightened to hold the bone ends together, the excess is cut off and the ends are turned in. The bone is held steady by the assistant and the K-wire is driven across the osteotomy line until it firmly engages the bone opposite, and provides the added stabilization. The K-wire is then cut off short leaving its tip palpable under the skin of the chin, easily identifiable for subsequent removal under local anaesthesia once bony union has taken place at the osteotomy site.



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It is generally possible to close the mucoperiosteum overlying the bone in the intraoral element of the osteotomy in the edentulous patient, but in the dentate patient suturing becomes increasingly difficult as the interdental papilla is approached, and in the papilla itself it is not possible. Fortunately it is not necessary, the papilla healing and completely reconstituting within a few days, to the extent that the site of the osteotomy cannot be identified on intraoral inspection.

Of these alternative methods plating is probably the most popular, particularly with surgeons who are familiar with its use in other surgical situations. It can create problems nonetheless. The stripping of the periosteum which is generally carried out in preparation for positioning the plate has an adverse effect on the vascularity of the immediately underlying cortical bone, although this effect can be avoided by plating over the periosteum. If postoperative radiotherapy is proposed, the presence of the metal plate creates problems for the radiotherapist, although the degree of concern expressed seems to vary with different radiotherapists. Hitherto the metal used for plate and screws has been stainless steel, but there is a current trend towards the use of titanium instead. It is too early to say whether or not similar problems will attend its use.

Where the mandible has not been previously irradiated bony union at the osteotomy site can be expected, but the effect of previous radiation on the local population of osteoblasts may well preclude bony union of the osteotomy site, fibrous union being more likely. This aspect, as it relates to the use of osteotomy and swing in the previously irradiated mandible, has not been studied and hard fact on the subject is not available. In theoretical terms the use of the symphyseal site in such circumstances might have advantages if fibrous union is all that can be expected, since in relation to the osteotomy site the symmetry of the bone and the muscles attached to it should reduce the stresses to which it is likely to be subjected subsequently.

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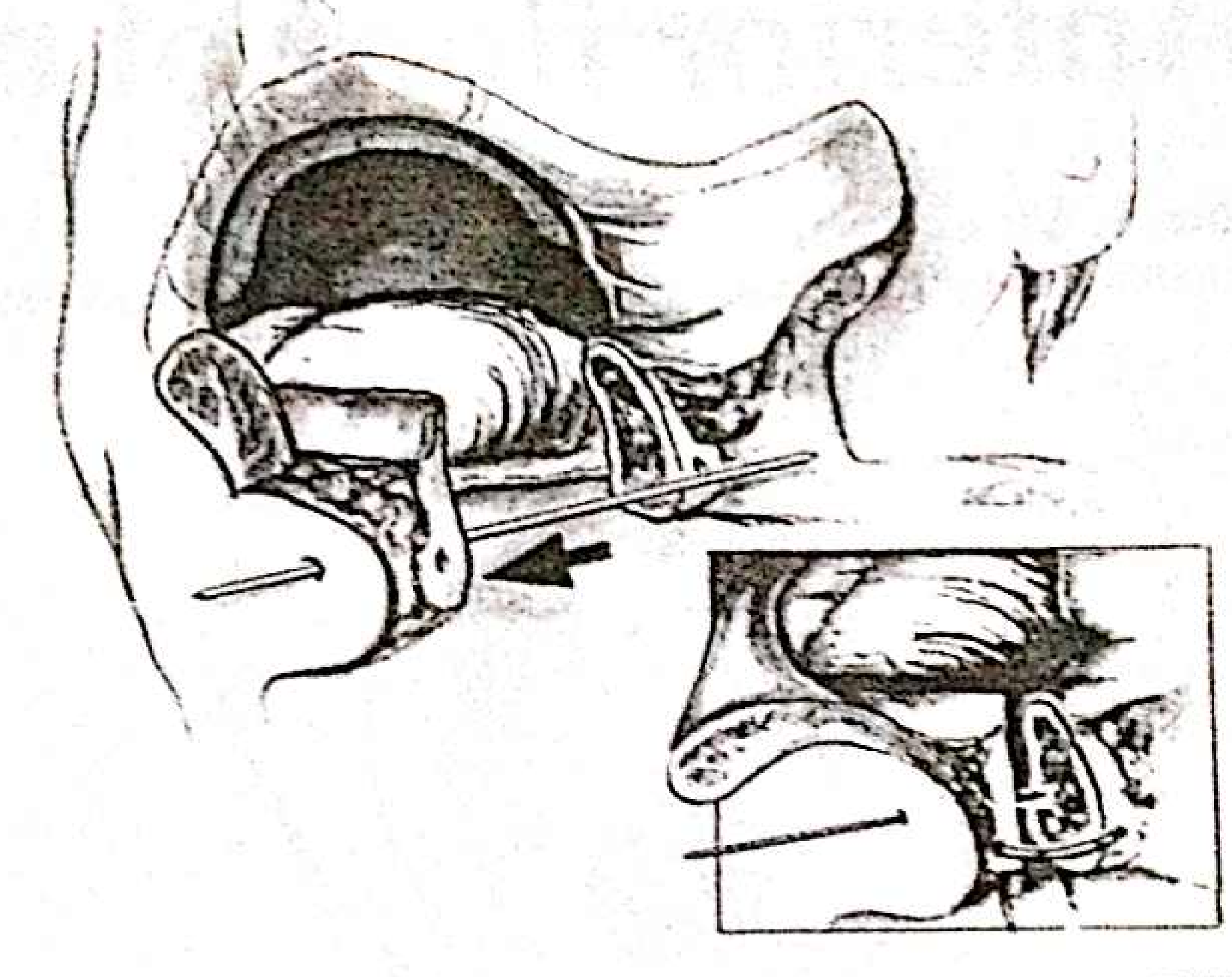

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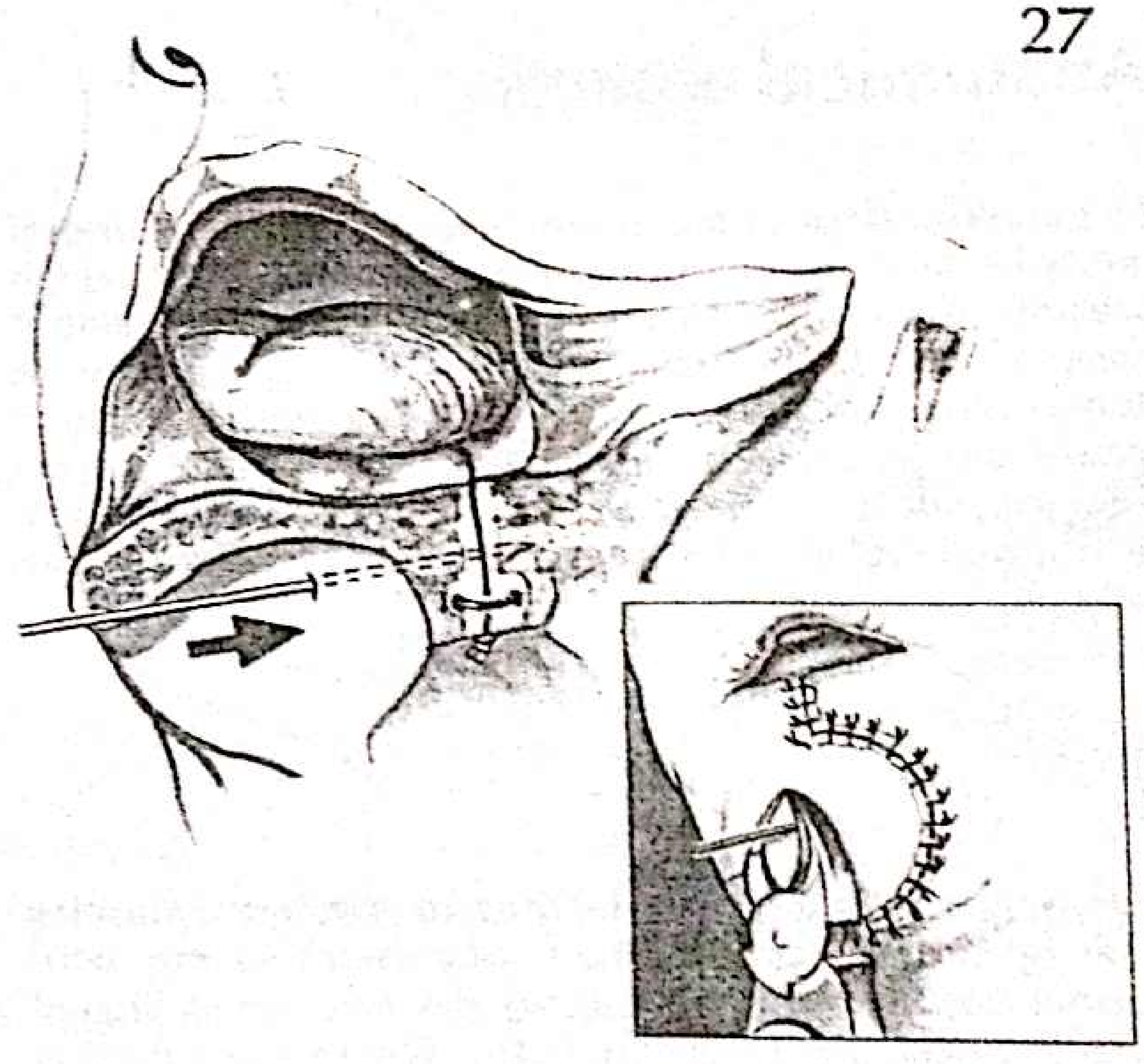

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It is generally possible to close the mucoperiosteum overlying the bone in the intraoral element of the osteotomy in the edentulous patient, but in the dentate patient suturing becomes increasingly difficult as the interdental papilla is approached, and in the papilla itself it is not possible. Fortunately it is not necessary, the papilla healing and completely reconstituting within a few days, to the extent that the site of the osteotomy cannot be identified on intraoral inspection.

Of these alternative methods plating is probably the most popular, particularly with surgeons who are familiar with its use in other surgical situations. It can create problems nonetheless. The stripping of the periosteum which is generally carried out in preparation for positioning the plate has an adverse effect on the vascularity of the immediately underlying cortical bone, although this effect can be avoided by plating over the periosteum. If postoperative radiotherapy is proposed, the presence of the metal plate creates problems for the radiotherapist, although the degree of concern expressed seems to vary with different radiotherapists. Hitherto the metal used for plate and screws has been stainless steel, but there is a current trend towards the use of titanium instead. It is too early to say whether or not similar problems will attend its use.

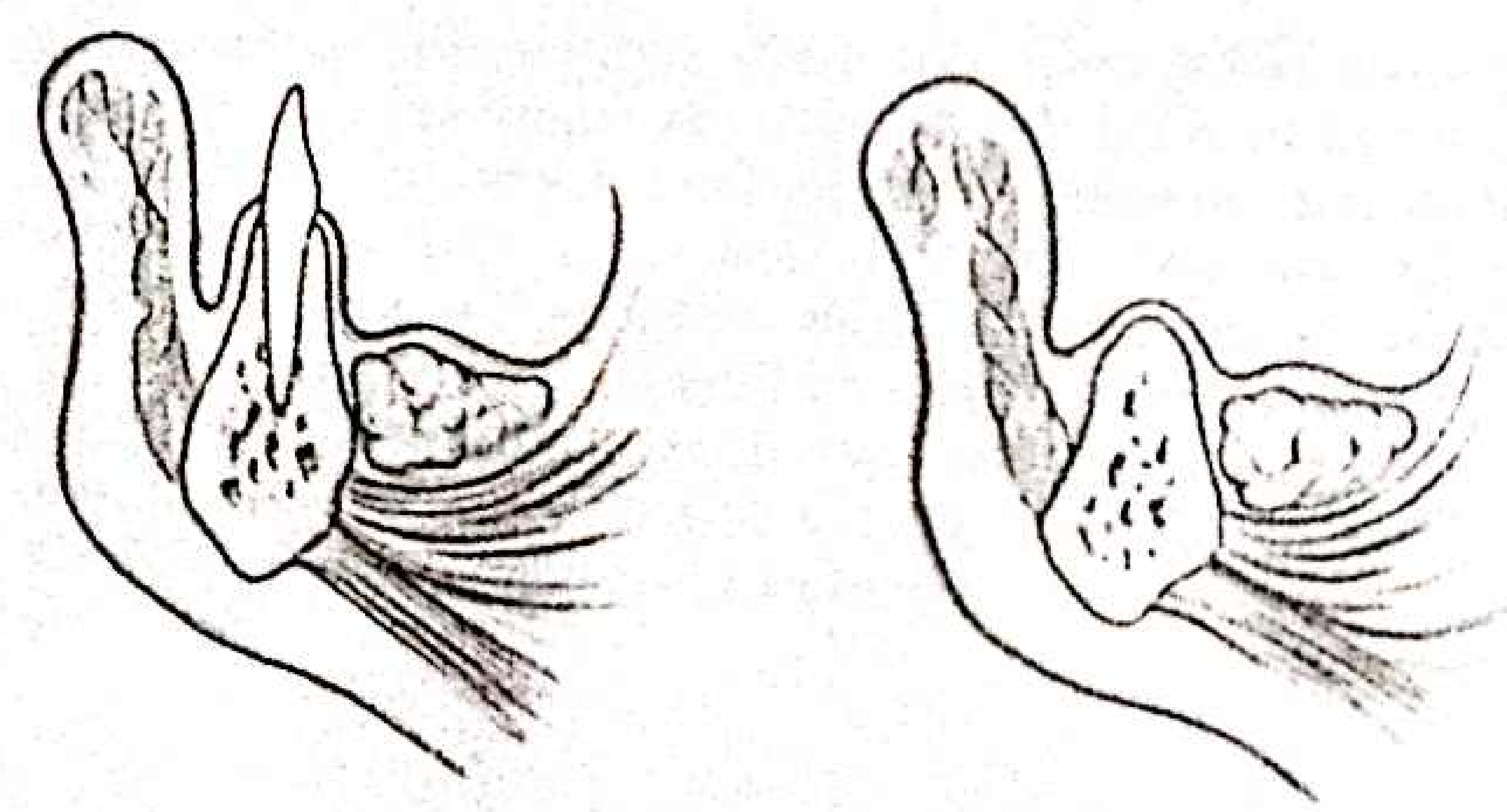
Where the mandible has not been previously irradiated bony union at the osteotomy site can be expected, but the effect of previous radiation on the local population of osteoblasts may well preclude bony union of the osteotomy site, fibrous union being more likely. This aspect, as it relates to the use of osteotomy and swing in the previously irradiated mandible, has not been studied and hard fact on the subject is not available. In theoretical terms the use of the symphyseal site in such circumstances might have advantages if fibrous union is all that can be expected, since in relation to the osteotomy site the symmetry of the bone and the muscles attached to it should reduce the stresses to which it is likely to be subjected subsequently.

Anterior floor of mouth

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Anatomical aspects

The anterior floor of the mouth is recognized as a surgical entity because the problems which tumours in that region present to the surgeon are unique to it. On each side it merges with the lateral floor without any real line of demarcation, although for practical purposes its lateral extent can be regarded as approximating to the mental foramen. Posteriorly it passes without any obvious change in the mucosal surface on to the ventral aspect of the tongue.



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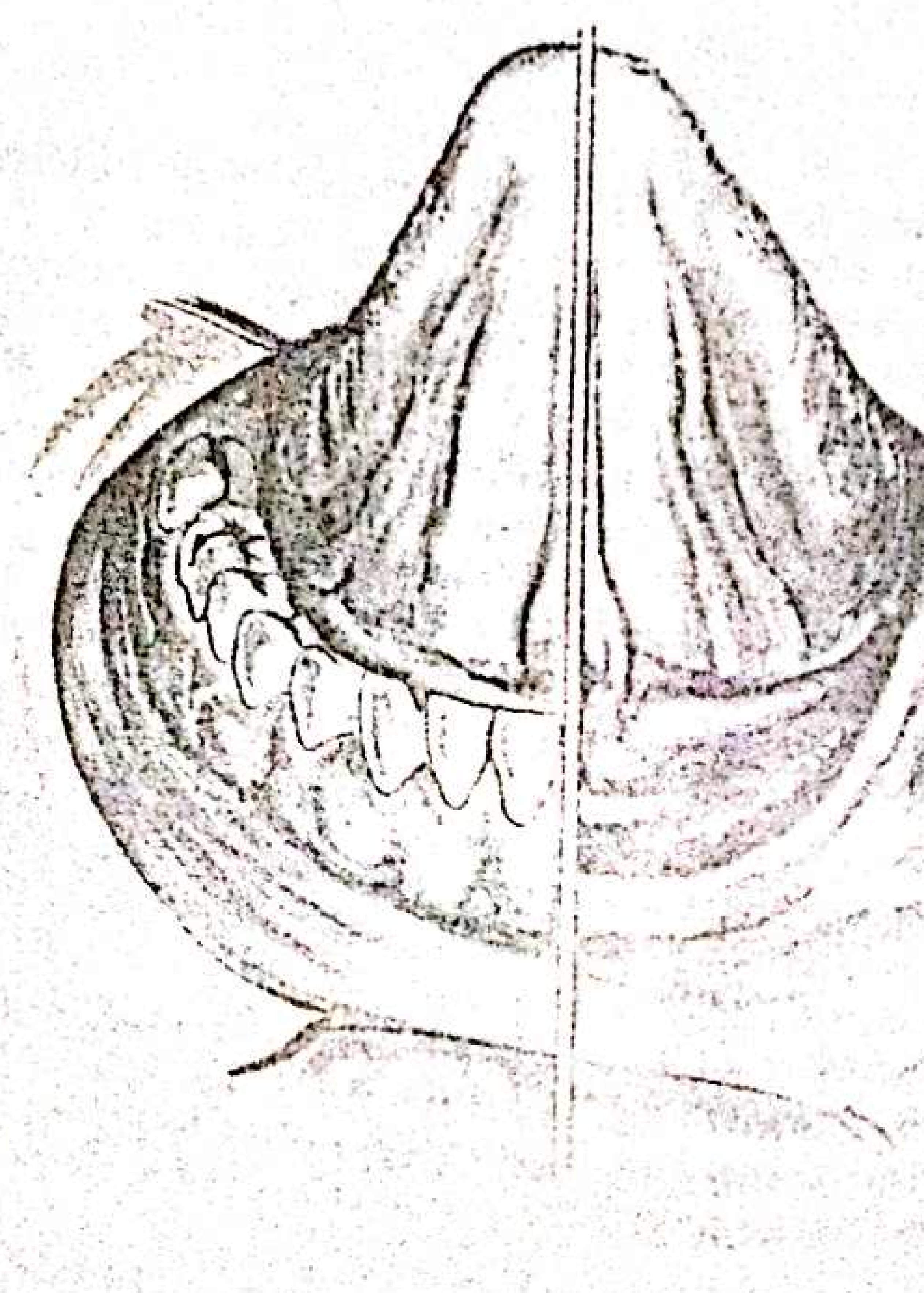
Its muscular floor is formed by the two mylohyoid muscles meeting in the midline. Their attachment to the symphyseal mandible is at a relatively low level on its lingual surface, below the genial tubercles. The mucosal floor is at a higher level in the mouth, the two floors separated by the sublingual glands and the bellies of the genioglossus muscle, one on each side of the midline. While the actual levels of the two floors, mucosal and muscular, remain constant, the apparent depth of the mucosal floor varies greatly, depending on the state of the dentition. When the mandible in the area is dentate, the floor is deep and frequently requires the use of a dental mirror if it is to be examined adequately; the resorption of the alveolar element of the edentulous mandible leaves the floor shallow and easily visualized.

The segment of bone which bounds it anteriorly is the symphyseal area of the mandible, the keystone of the arch formed by the body, the segment without which the arch would collapse. It is also the site of the bony attachment of genioglossus, the main extrinsic muscle of the tongue. In the anterior floor of the mouth it is concentrated into two parallel bands, one on each side of the midline, and each passing backwards from its bony origin to intermingle with the other muscles, intrinsic and extrinsic, in the substance of the tongue.



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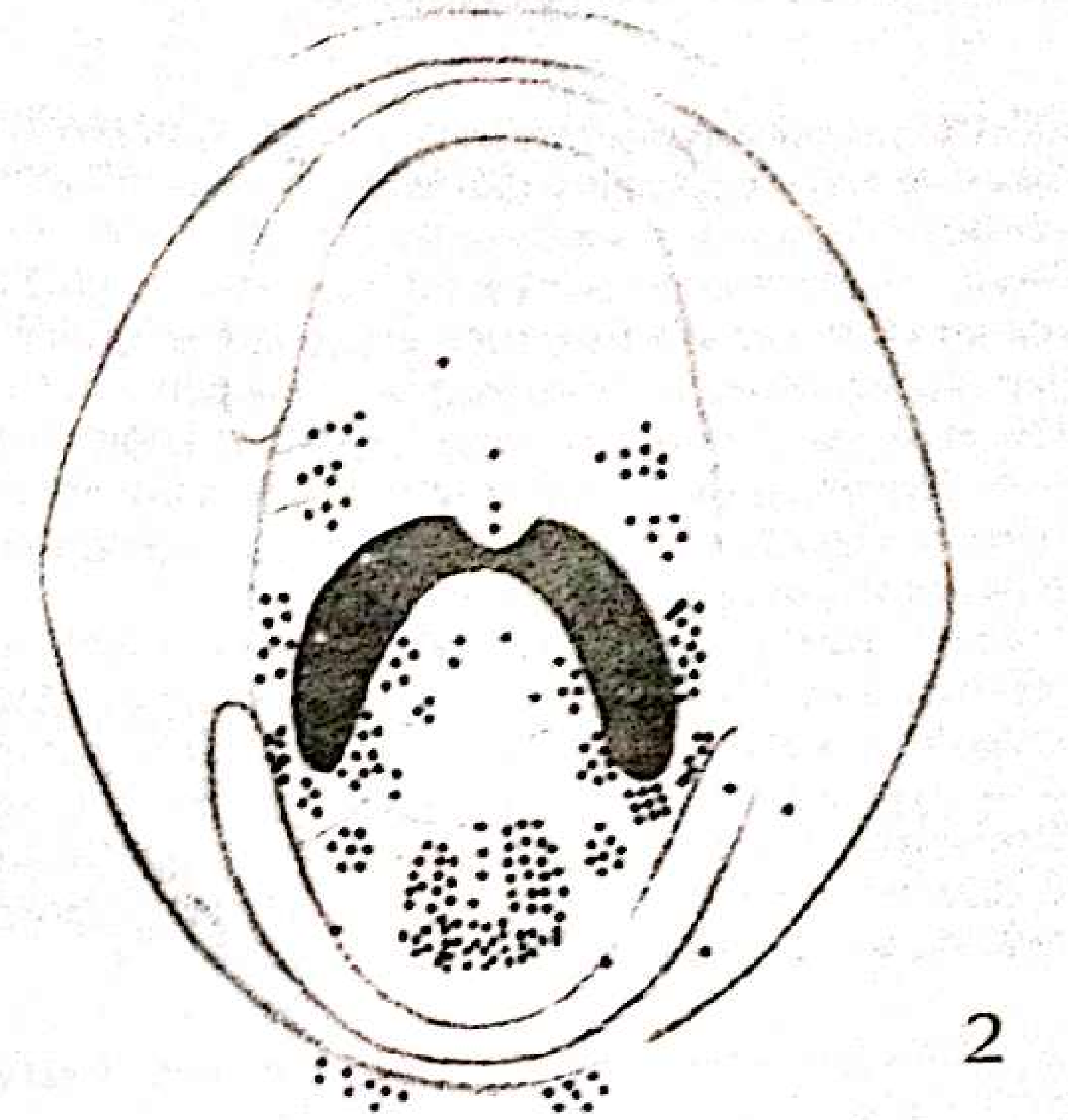
Pathological aspects

2

The anterior floor is one of the commonest sites of squamous carcinoma in the mouth, most often the area surrounding the submandibular duct orifices, as the site incidence scattergram shows. This is one of the more readily visible sites, particularly in the edentulous mouth, and tumours are more often seen at an earlier stage than in sites further back in the mouth.



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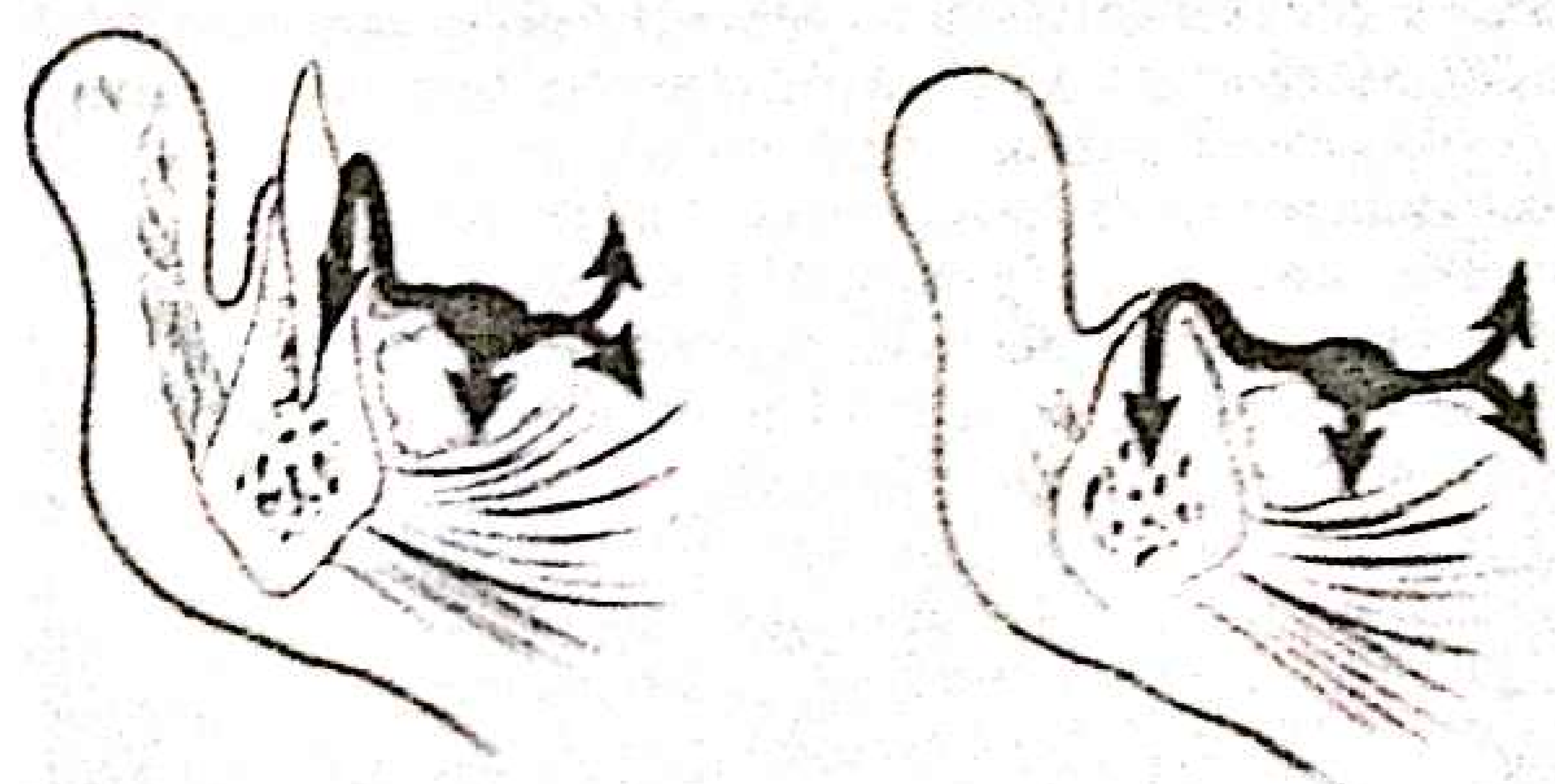
Posterior spread of tumour from the anterior floor is to the ventral aspect of the tongue. Initially such spread can appear to be predominantly marginal, extending over the mucosal surface, but deep infiltration occurring when it reaches the ventral surface of the tongue proper involves genioglossus, the clinical effect being increasingly to limit protrusion of the tongue, anchoring it within the mouth. Behind the sublingual glands the muscle lies immediately submucosally, and as a result it becomes involved by tumour infiltrating deeply at an earlier stage than further forward in the floor where the glands separate the two.

Deep spread of the tumour in the floor infiltrates the sublingual glands. These are more substantial structures than anatomical specimens would indicate, and they are capable of 'absorbing' a considerable volume of tumour before genioglossus, the muscle immediately deep to them, is reached.



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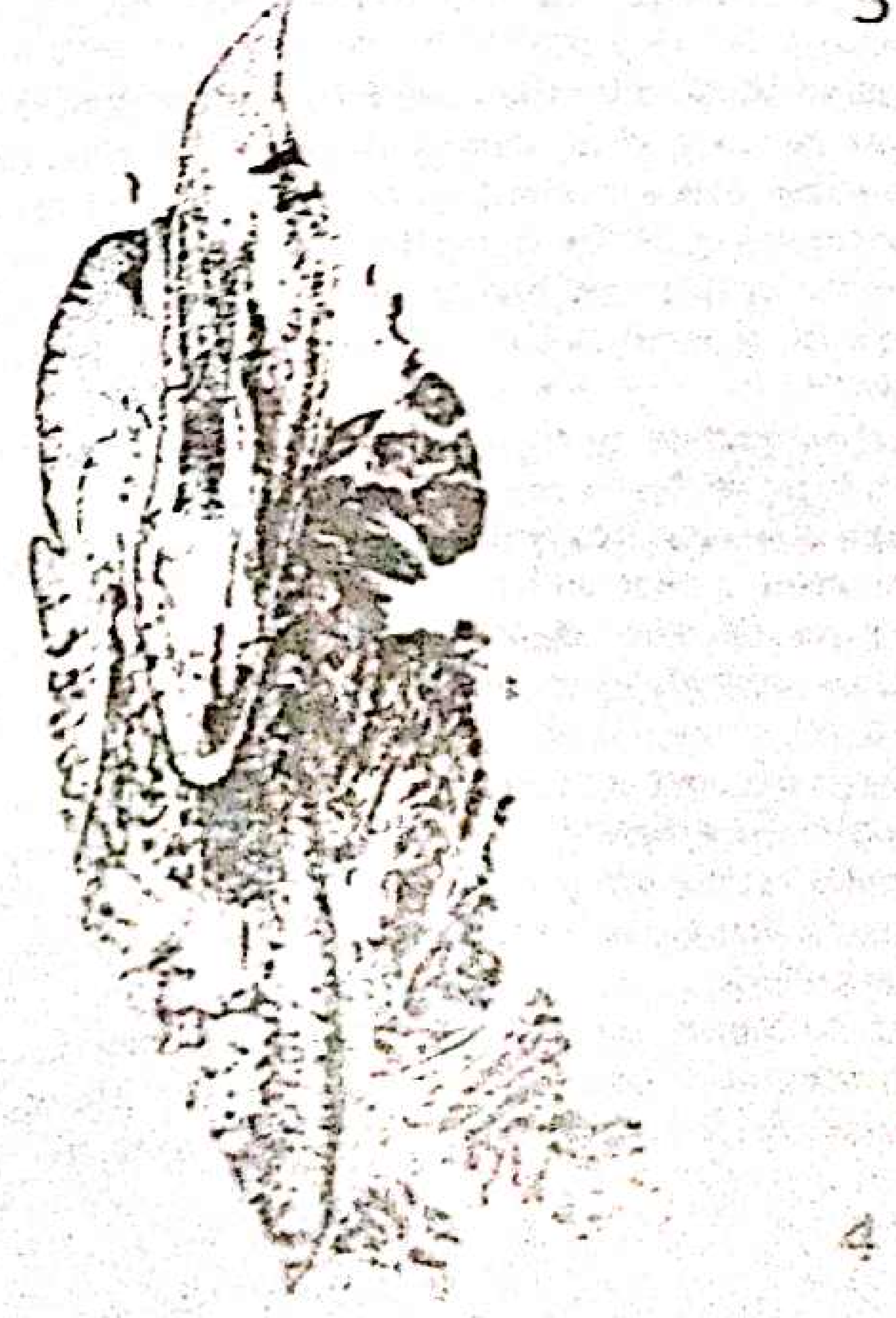
Anterior spread of tumour reaches the mucoperiosteum on the lingual surface of the mandible, but in both the dentate and edentulous bone the standard site of entry of tumour into the bone appears to be the occlusal area, along the periodontal ligament in the dentate bone, through the foramina present along the occlusal ridge in the edentulous bone, as described on pp. 258–261. This pattern is the usual one in the non-irradiated mandible. A similar pattern also occurs in the previously irradiated bone, but in general it is less predictable.

The lateral extent of involvement of the bone by tumour tends to coincide with the extent of soft tissue involvement in the immediate vicinity, at least in its early stages, and in the edentulous mandible the absence of significant nerves within the bone between the mental foramina removes perineural spread as an added hazard.

Despite the presence of the submental nodes in the vicinity of the tumour it is not common to find them the site of metastasis, the submandibular nodes being much more frequently involved.



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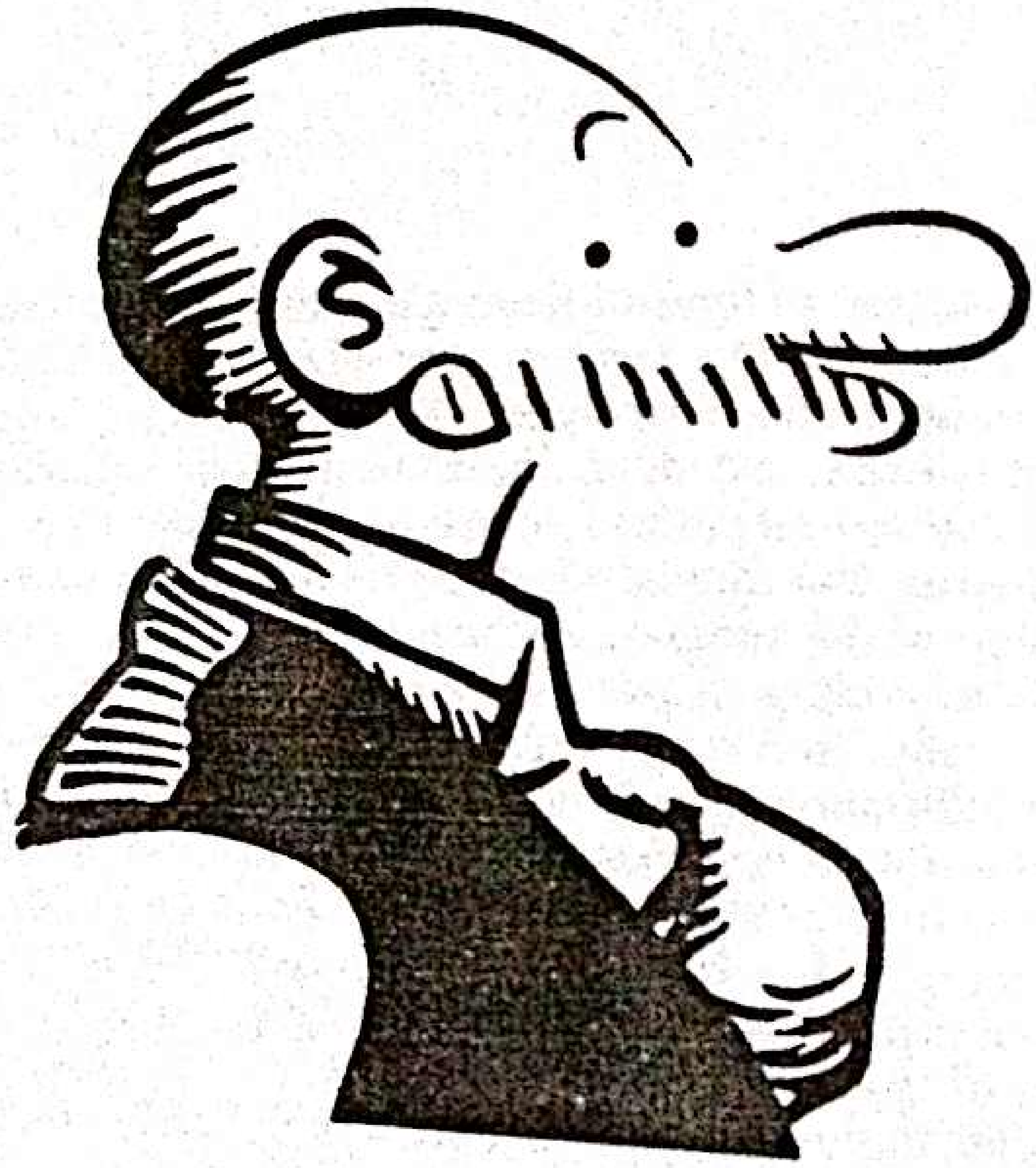
Surgical management

Effective surgical management of tumours of the anterior floor of mouth presents the surgeon with difficulties of greater magnitude than those in the other intraoral sites. These difficulties arise from the fact that the part of the mandible involved when tumour spreads anteriorly is the symphyseal area. As the keystone of the mandibular arch, this is in many ways the most important segment of the bone. Similarly, the segment of the tongue involved when tumour spreads posteriorly, the anterior free segment, is functionally its most important element.

The success of the reconstructions which follow resections in this area depend on the extent to which the surgeon has been able to retain or restore the mandibular arch, and maintain the mobility and reach of the anterior free segment of the tongue, in terms of how effectively it is able to manipulate and dispose of saliva and food in the mouth, and play a full role in speech.

5

Before the techniques of reconstructing postexcisional defects were developed, defects of the anterior floor were merely closed directly, and the effects on function and cosmesis which followed resections in this site, managed in this way, were particularly disastrous. Loss of the symphyseal segment of the mandible resulted in collapse of the arch and loss of the chin prominence, the resulting appearance still graphically referred to, after the cartoon figure of the 1930s, as the 'Andy Gump deformity'. Anchorage of the tongue, particularly its anterior free segment, the result of direct closure of the postexcisional defect, left the patient constantly drooling, unable either to manipulate and dispose of his saliva or speak intelligibly.



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Historically, effective intraoral reconstructive techniques developed in stages, starting with reconstruction of the soft tissue defect, and followed more recently by reconstruction of the bony defect. Separation of the two elements in this way has made it possible to analyse the effects of reconstruction of each independently of the other.

Reconstruction of the soft tissue element of the defect made it possible to leave the tongue freely mobile and functioning effectively. This demonstrated that the functional component of the 'Andy Gump deformity' was predominantly the result of failure to reconstruct the soft tissue adequately, and not due to resection of the bone. It also became apparent that loss of the bony insertion of genioglossus did not have the adverse effect on tongue function which might have been expected. It may be that the main value of the symphyseal insertion of genioglossus is in tongue protrusion, an action little required in normal activity.

The addition of reconstruction of the bony loss demonstrated that the loss of the symphyseal bone predominantly affected the appearance of the patient, although an additional effect of each loss, soft tissue and bony, was to enhance the adverse effect of the other.

The influence of these findings on surgical practice has been to change the attitude of the surgeon to the symphyseal mandible and the anterior free segment of the tongue, towards recognizing the need to conserve tissue which is not involved by tumour, and to reconstruct the key elements of those structures whose resection has been unavoidable.

Resection of the entire thickness of the symphyseal area of the mandible, as opposed to partial resection with maintenance of the continuity of the arch, adds enormously to the complexity of the reconstructive problem and reduces the likelihood of an entirely satisfactory functional result. With this in mind the surgeon should make every effort, whenever the pathological situation permits, to retain even a narrow strip of symphyseal bone in order to maintain mandibular continuity. On the basis of the findings discussed on pp. 259–261, it would appear that partial resection should take the form of a rim resection rather than a sagittal resection with removal of the lingual plate of the bone.

RESECTION

The surgical approach to the tumour which is confined to the anterior floor of mouth has been discussed in the chapter on 'Access to the mouth', pp. 241–253. The resection which is required, and the complexity of the reconstruction, depend very much on the extent to which tumour has spread to involve the base of the tongue and the mandible.

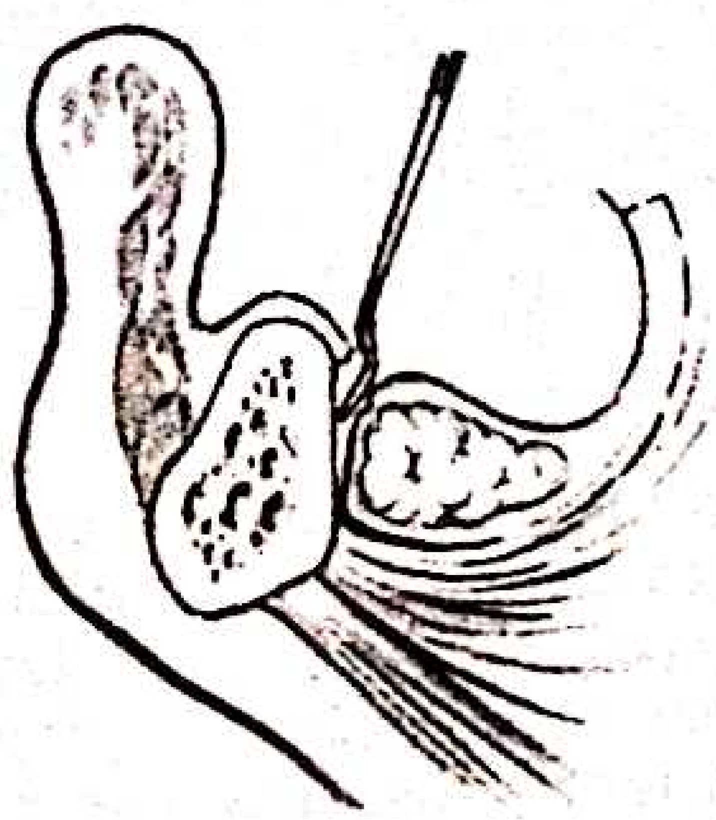
In the case of the small tumour, where such spread is minimal or absent, resection and reconstruction are relatively straightforward and the results are good. In the case of the large tumour, where there is significant infiltration, it is unusual to find the tongue base or the mandible involved alone, involvement of both being much more frequent. The problems of resection and reconstruction are then very much greater, and the results, functionally and cosmetically, are poorer.

The small tumour

Resection of a small tumour invariably involves soft tissue. It may also involve bone, and it is convenient to consider the two tissues separately.

Soft tissue component

The technical difficulty of the soft tissue resection is dependent on whether the patient is dentate, when the relative depth of the floor creates problems of visualization and access, or edentulous, when access is easy.



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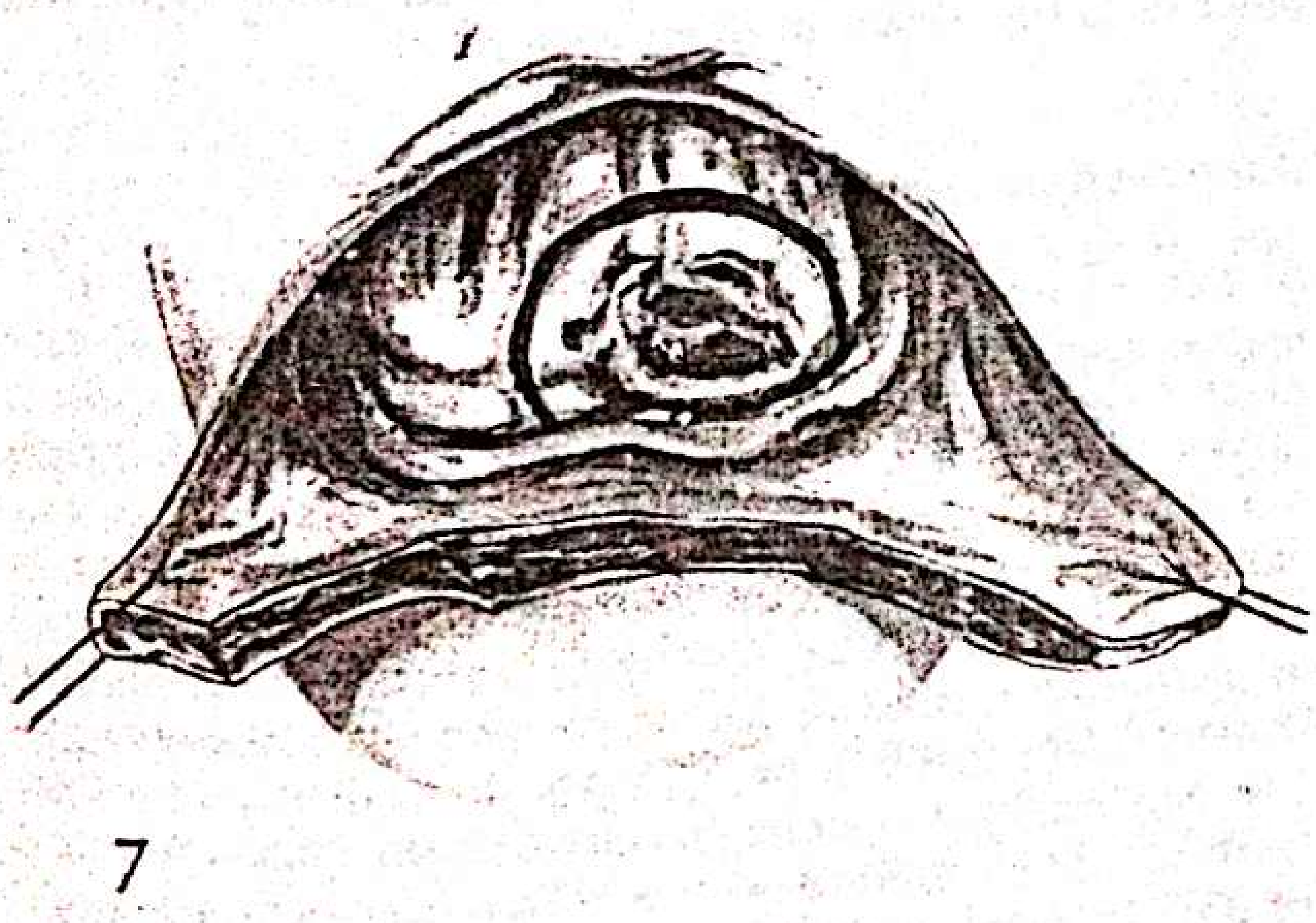
When the tumour is small in area and superficial, the sublingual gland may not be involved, or involved minimally. Despite this there is much to be said for removing the entire thickness of the gland involved, if there is the slightest sign of deep infiltration. An excellent and largely avascular plane of surgical cleavage exists between each gland and the belly of genioglossus deep to it, and resection at this level frequently gives a degree of certainty to deep clearance which is not attainable in any other way.



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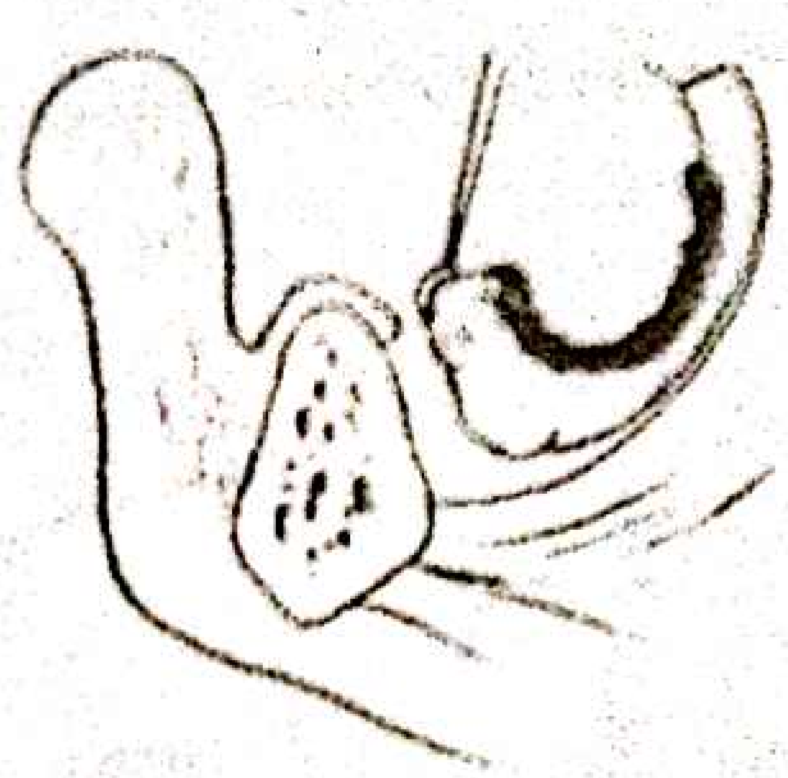
With the line of marginal clearance marked out on the mucosa, the mucosal layer is incised. The incision along the anterior clearance line is then deepened.

8

If the anterior clearance line abuts on the lingual plate of the symphyseal mandible, the soft tissues can be stripped off the bone, retracting them backwards and continuing the stripping until the bellies of the genioglossus muscle, running forward on each side of the midline, become visible. If the clearance line lies behind the mandible, deepening the incision to the muscle layer allows the sublingual glands to be dissected free and mobilized. The effect in either circumstance is to elevate the tumour-containing mucosa together with the sublingual glands.

The lateral mucosal resection line made on each side is deepened as the gland and mucosa are retracted backwards. In the process the submandibular ducts are met and divided and, depending on how far laterally the resection has been carried, the sublingual glands are divided or removed completely. In this part of the resection any vessels found passing forward to the anterior floor should be picked up and ligated. If they are allowed to retract it may be very difficult to find them and they can cause troublesome bleeding. Superficial veins are also present on the ventral aspect of the tongue which drain into the hypoglossal plexus, and these require to be individually ligated or diathermied.



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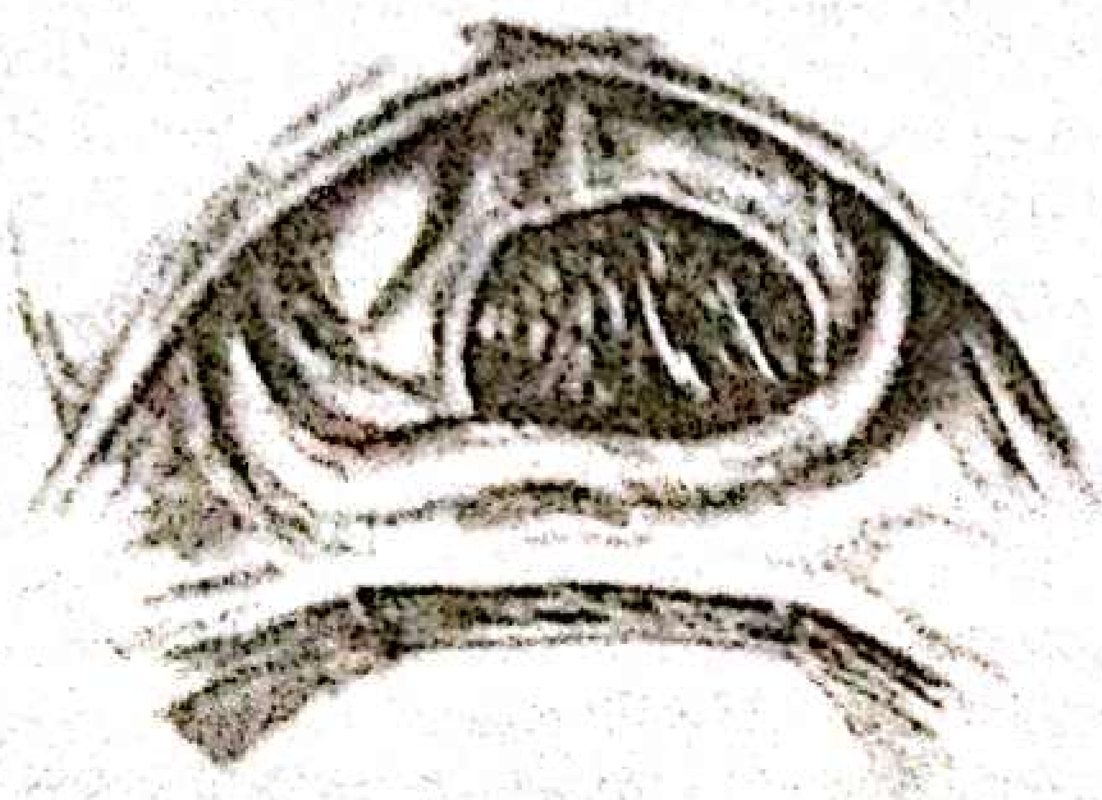

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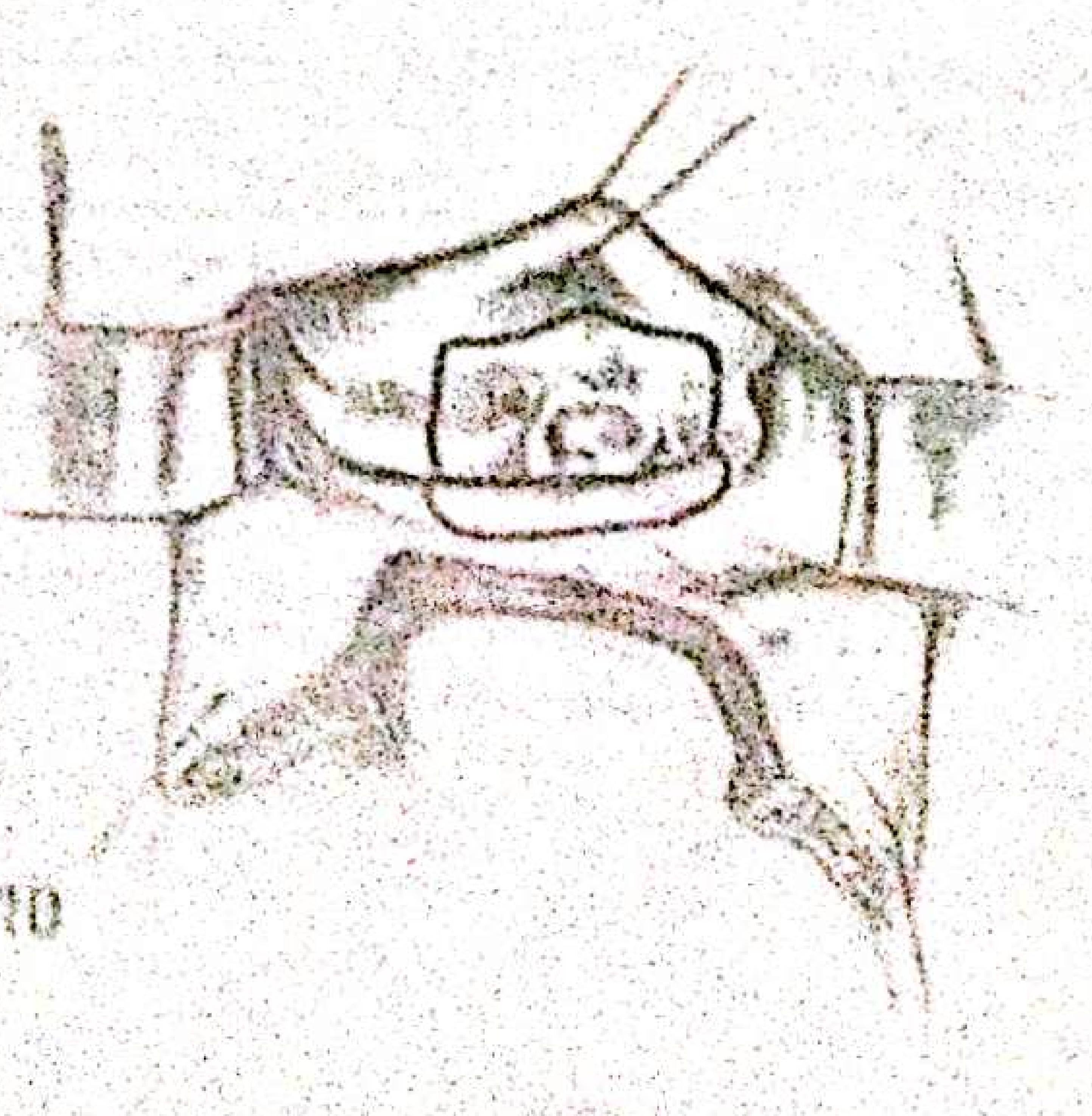
In dissecting upwards towards the upper resection margin one or both lingual nerves may be met, and an assessment should be made concerning whether they can safely be preserved. Regrettably their preservation depends all too often on their being recognized, and this is apt to be a measure of the effectiveness of the haemostasis which is necessary to allow the area to be visualized properly. In this area, the absence of the sublingual glands deep to the mucosa, separating it from the underlying muscle, leaves the mucosa and the tongue musculature in virtually direct contact with one another. An adequate thickness of muscle has generally to be removed along with the mucosa to be certain of deep clearance.

Bony component

In the edentulous mandible the surface extent of any involvement of the bone is readily visible. The resorption of alveolar bone which follows loss of the teeth often leaves the mucosal floor and the occlusal ridge of the mandible on virtually the same level and the tumour is likely to have reached the bone by marginal extension. The extent of soft tissue clearance considered appropriate is usually equally acceptable for the mucoperiosteum overlying the alveolus.



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The soft [illegible] resection [illegible] encircling the tumour merely passes [illegible] the mucosal [illegible] on to and over the alveolar mucoperi[illegible] back on to the floor and complet[illegible] [illegible]al clearance.

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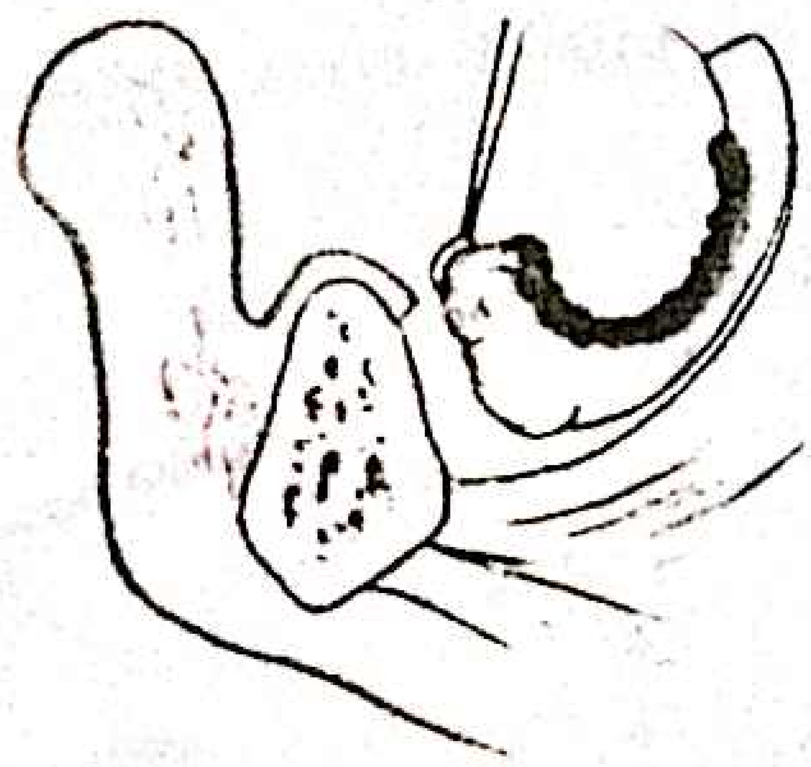

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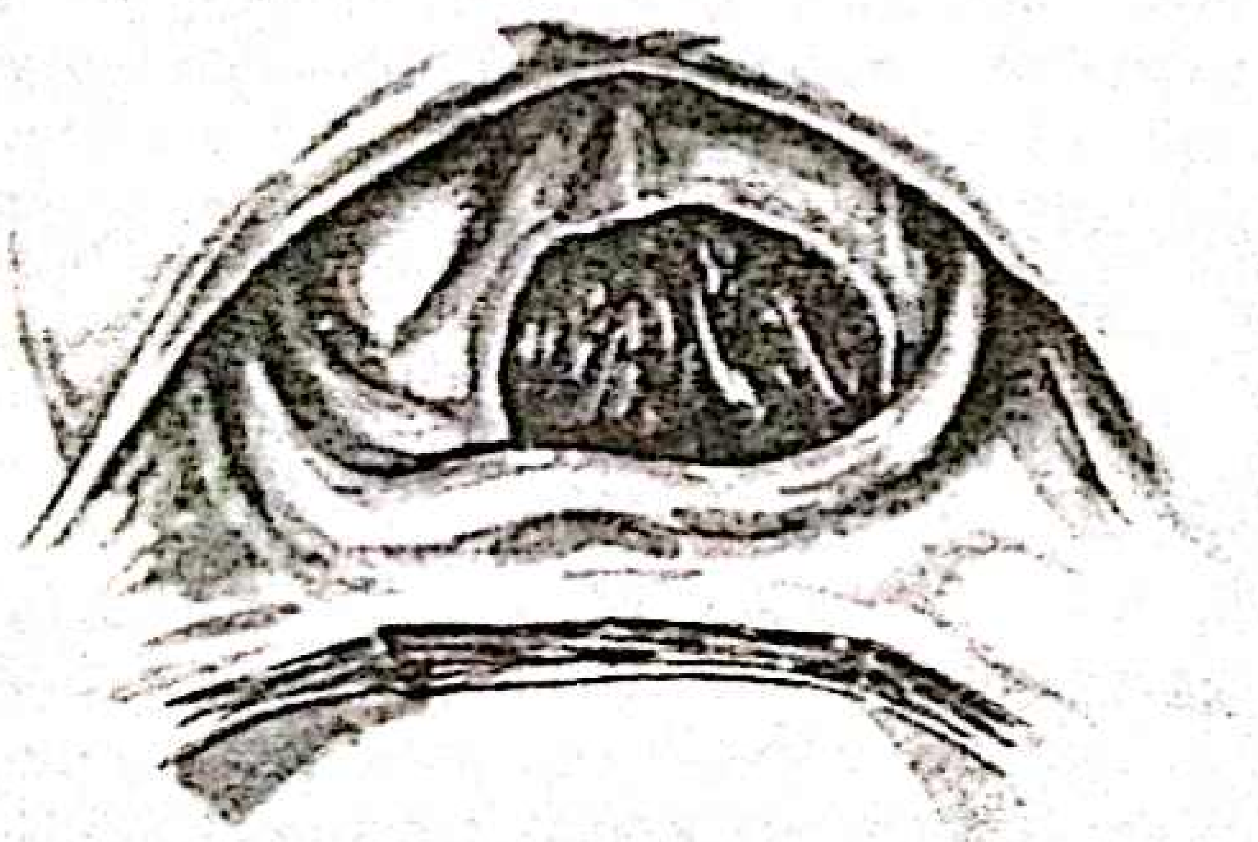

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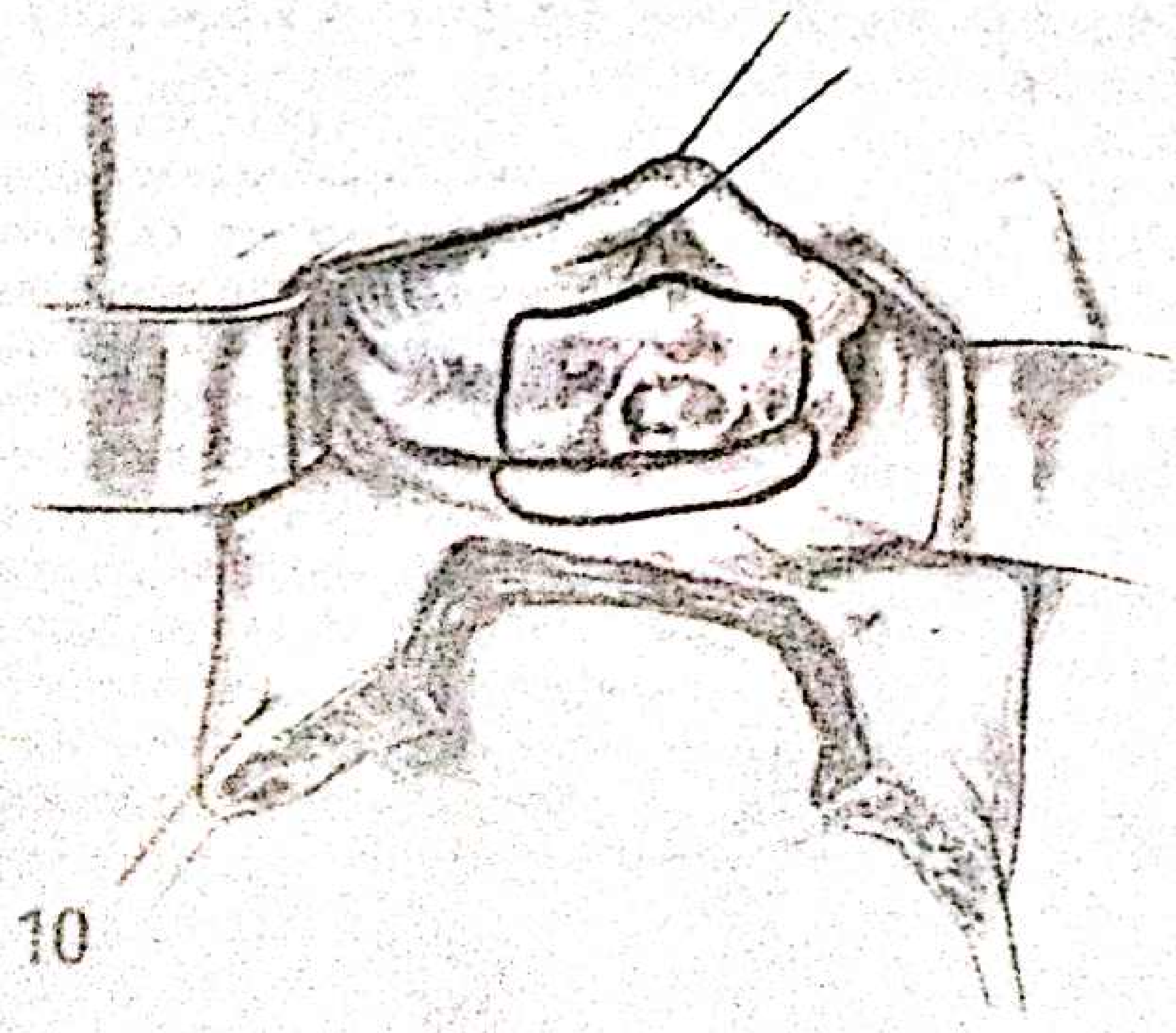

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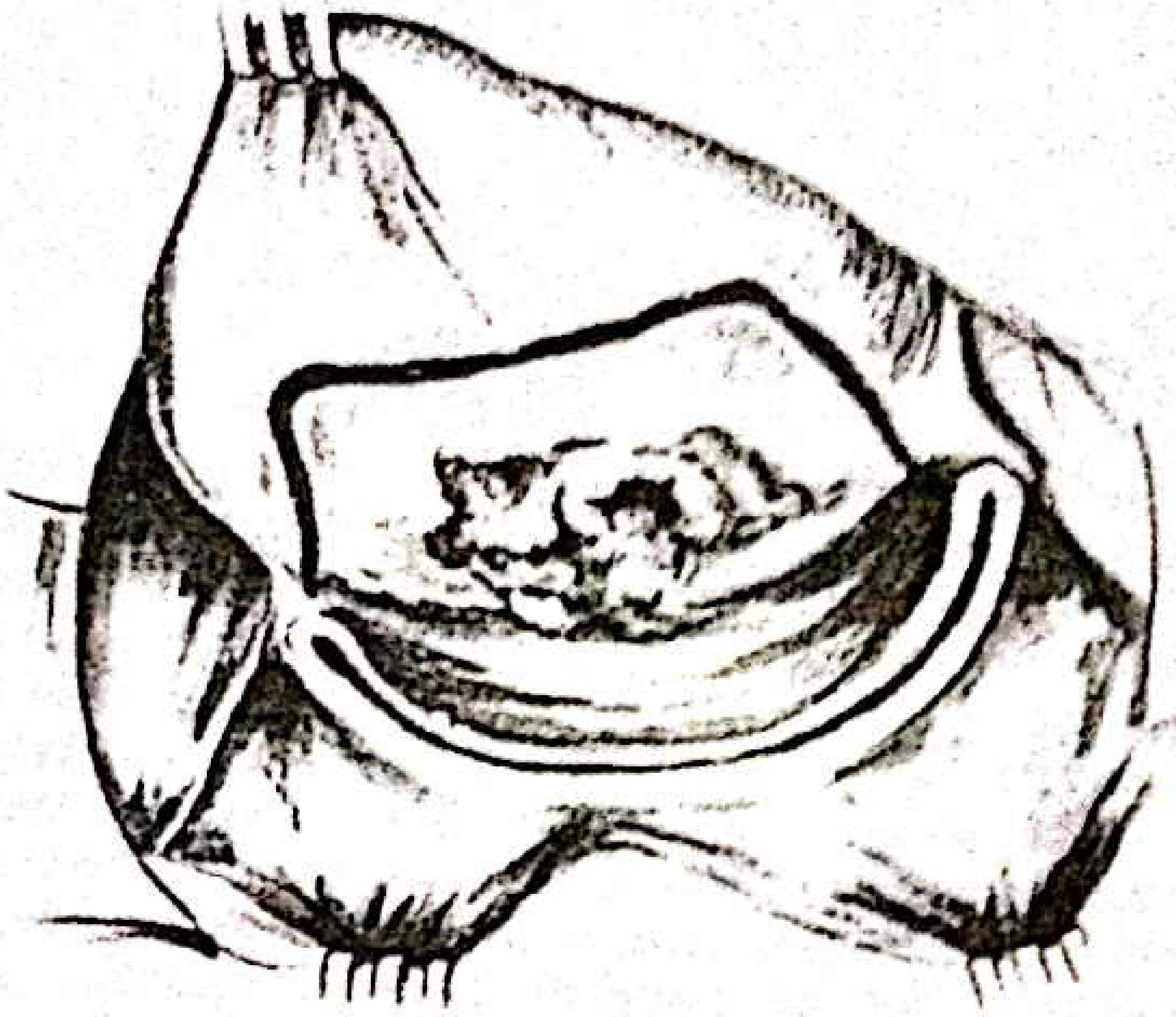
The soft tissue resection line encircling the tumour merely passes from the mucosal floor on to and over the alveolar mucoperiosteum, passing back on to the floor and completing the line of marginal clearance.

11

The mucoperiosteal incision is deepened to bone, and along that line the bone is cut with saw or drill. The direction of the bone cut is important. It is made to ensure that the deep resection line of the bone on the lingual plate matches the deep soft tissue clearance at that point.



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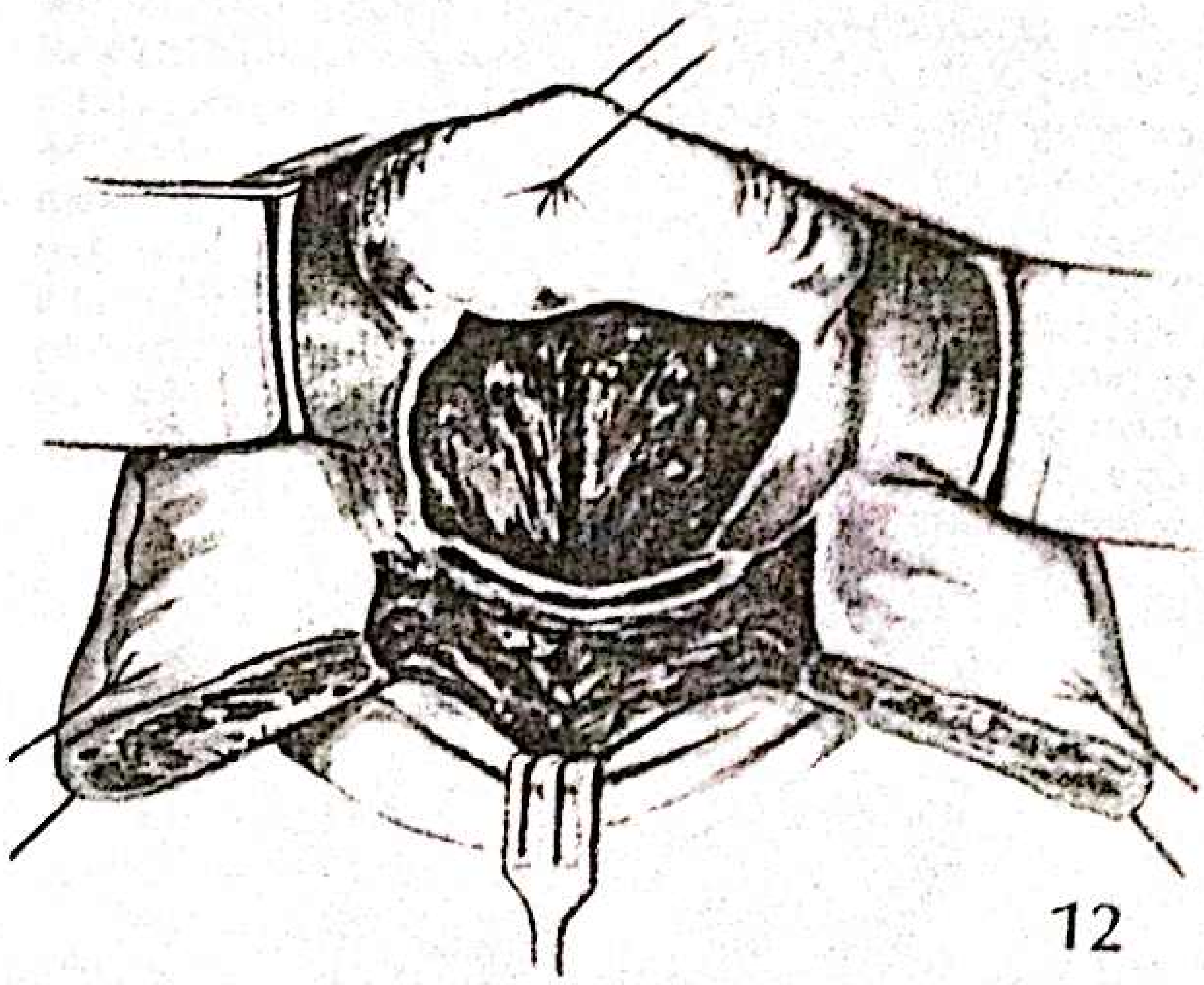
The defect left is a mixed one of soft tissue and the mixed cancellous and cortical resection surface of the bone.



12

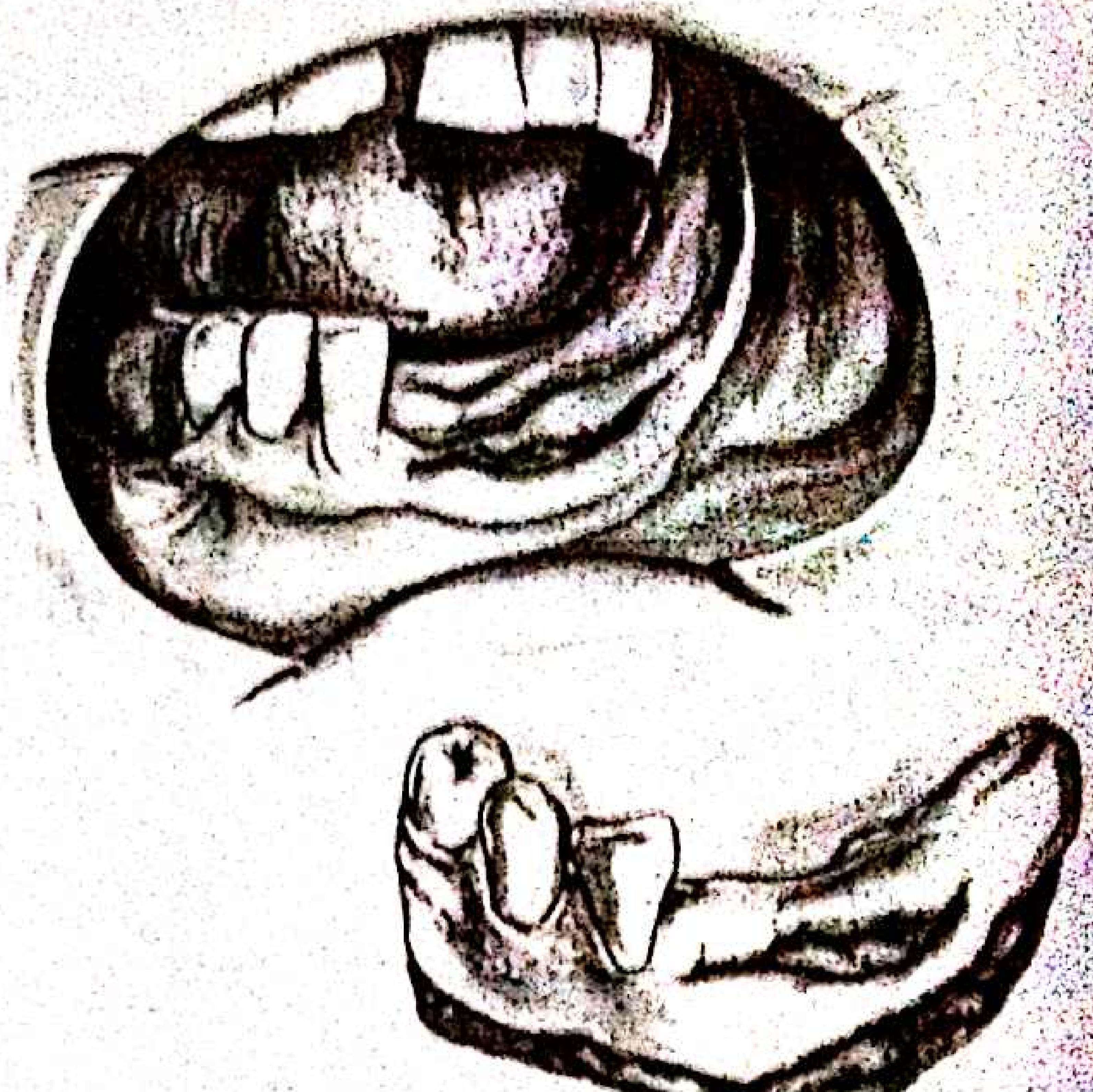
In the bone which is totally or partially dentate the technical difficulty of resection depends on the number of teeth present. The greater the number the greater is the difficulty because of the addition which their presence makes to the depth of the floor. A further difficulty is that of deciding whether or not the bone is involved. Radiographs are not very helpful, a positive result only confirming what is already clinically obvious. A more useful guide is the state of the teeth nearest the tumour. Where the teeth are firmly fixed and there is no obvious involvement of the periodontal tissues in the vicinity the bone is unlikely to be involved by tumour. Unfortunately such patients are seldom careful of their dental state and periodontal disease is the rule rather than the exception. Looseness of the teeth as a result of periodontal disease is commoner in practice than looseness caused by tumour. When tumour is found clinically to have extended to the gingival margin and teeth are loose, it is then that the bone in the vicinity is likely to be involved. In the absence of any foolproof method of assessing the extent of bone involvement other than the assessment of the surgeon at operation it is on this that reliance has to be placed.

If involvement appears to be merely mucoperiosteal it is reasonable to strip the soft tissue from the bone and make a visual assessment, removing a shaving of bone if necessary. If the teeth are firmly fixed it can be assumed that the tumour has not reached the line of the socket and this line can be utilized as a suitable line of clearance in that area. Loose teeth, suspected to be loose as a result of periodontal disease, will have been extracted in any case, allowing the sockets to be inspected. The line of the apices of such teeth, though it is likely to be in the nature of 'overkill' in terms of tumour clearance, is a tempting one to use since in the process it will remove tissue involved by the periodontal disease. The surgeon, in any case, does better to err on the side of resecting too much bone, rather than too little.

13

In the light of the good evidence that the predominant mode of spread of tumour into the dentate mandible is along the periodontal membrane, rather than directly through the periosteum, a rim resection is likely to be the appropriate form of resection in most instances. In the case of the edentulous bone the bone resection is likely to be saucer-shaped; where teeth are present the lateral resection lines are likely to be more vertical. The lower border of the symphysis is broadened to provide an attachment for the anterior belly of digastric, and resection of the alveolar element of the bone in this manner leaves a sufficient thickness of bone for stability. Such resections are unlikely to weaken the bone unduly.

The closer the tumour is to the lingual plate of the dentate mandible, the greater is the technical difficulty of carrying out the resection under adequate vision, and a stage may be reached where, without better exposure, the surgery ceases to be acceptably precise. The problem arises almost exclusively in the dentate mandible, but when it does arise there is no alternative to carrying out a preliminary mandibular osteotomy at a site selected to clear the tumour laterally. Clearly it is a decision which one would reach reluctantly, but in such a situation adequate exposure takes priority.



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The large tumour

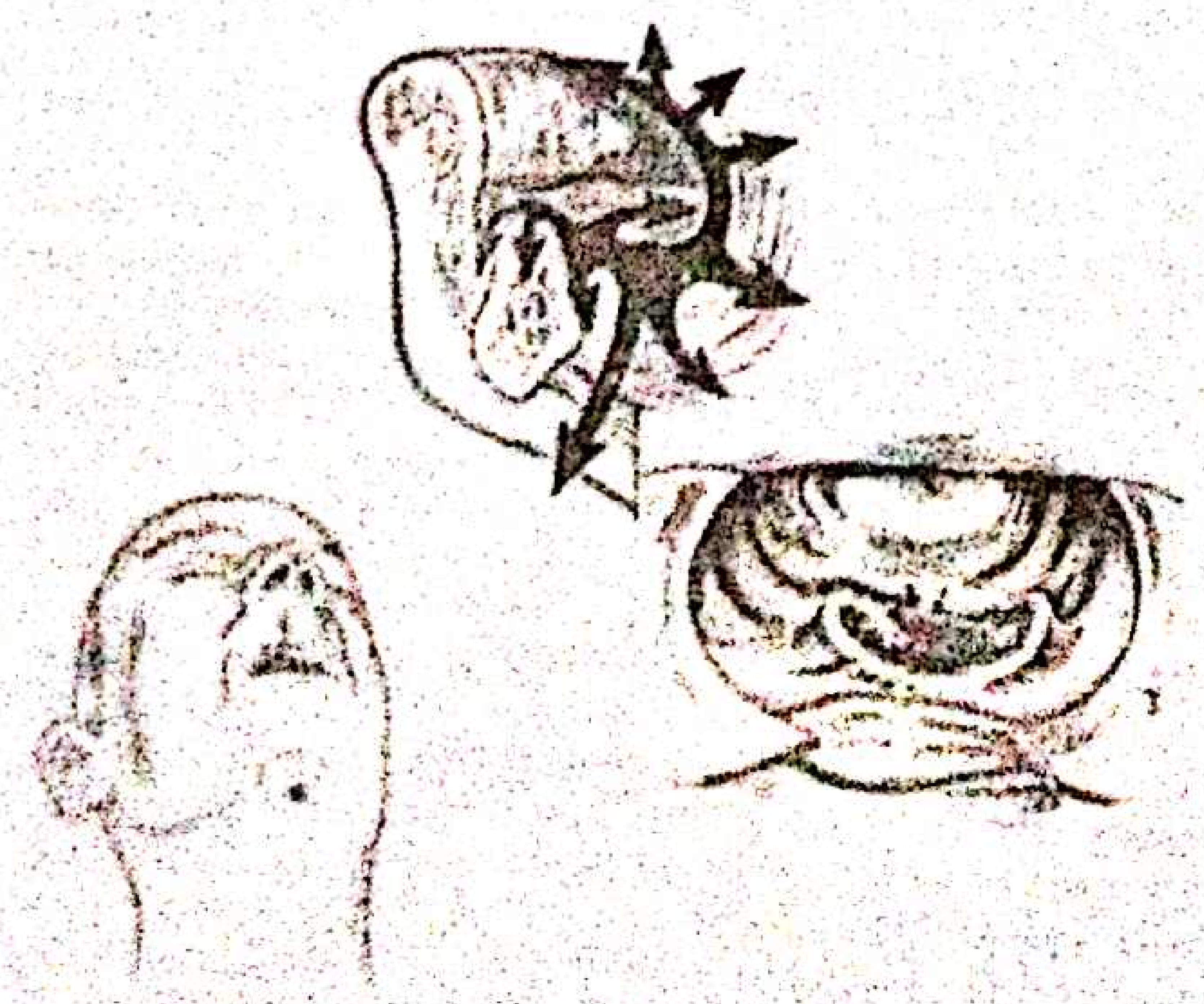
In resecting a large tumour, the resection still involves soft tissue and bone. The differences lie more in the volume of tissue of both types which requires to be resected.

Soft tissue component

14

Resection of the tumour extends increasingly downwards, involving the muscles in the floor of the mouth, genioglossus, geniohyoid and ultimately mylohyoid, and backwards into the tongue substance, predominantly in its base, although ultimately extending up towards its dorsum. The resulting defect tends to leave little soft tissue in the floor, and in addition there is extensive loss of the ventral aspect of the free part of the tongue, although often leaving a rim of the dorsum of varying thickness.

Further extension of tumour occurs in the soft tissues in contact with the symphyseal mandible, ultimately surrounding it and fungating externally, usually behind the chin prominence. Resection has then to be correspondingly extended, although this latter form of spread often puts the tumour beyond the limits of operability.



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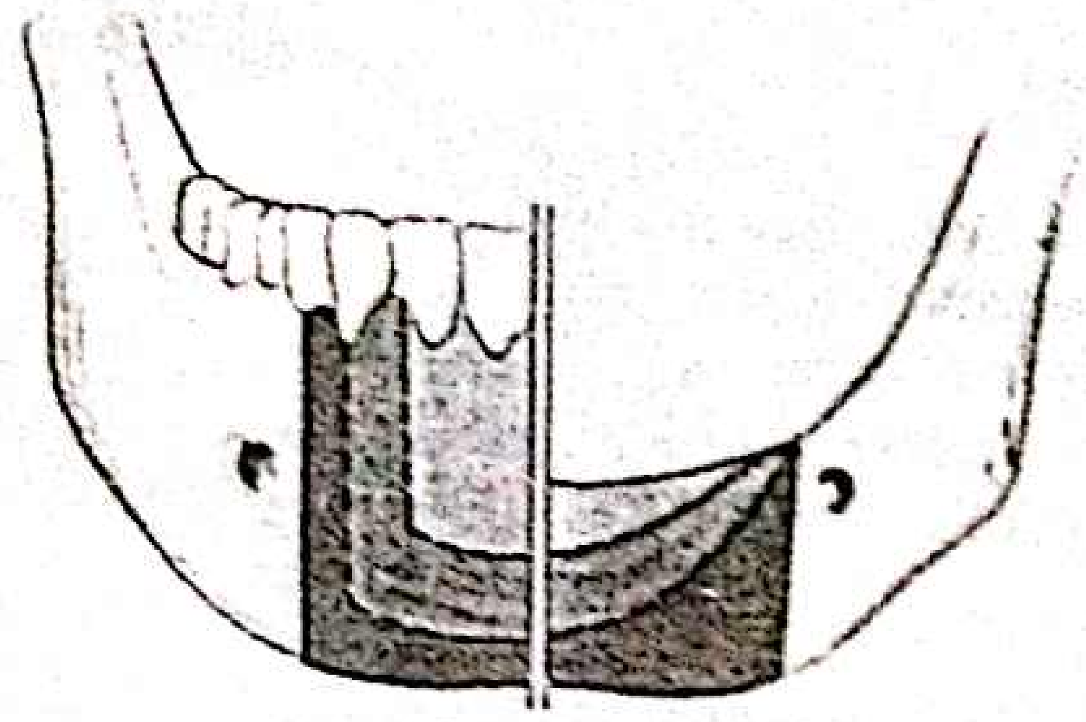
The resection required is increasingly likely to involve the entire thickness of the symphyseal mandible. The resection, as it extends to match extension within the bone, will begin from the occlusal surface and extend towards the lower border of the bone, usually extending laterally at the same time, until the full thickness has been resected.

The easy option for the surgeon is to resect the entire thickness of the mandible at the outset, but the increase in morbidity and the greatly increased magnitude of the reconstructive problems which are created, and an immediate worsening of the result, functional and cosmetic, can be expected. This should encourage the surgeon to make every effort, the pathological situation permitting, to retain continuity of the mandibular arch.

Maintenance of the arch in such circumstances may make the resection more difficult technically, but the prospect of the easier reconstruction, limited to one involving soft tissue only, more than compensates.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When it is clearly not possible to save any of the symphyseal bone, it is often because it is encircled by tumour in the overlying soft tissues, rather than because it is extensively infiltrated directly from the soft tissue component of the tumour. The part of the bone which is generally last to become involved by tumour is its lower outer rim and it is to this part that attention should generally be directed.


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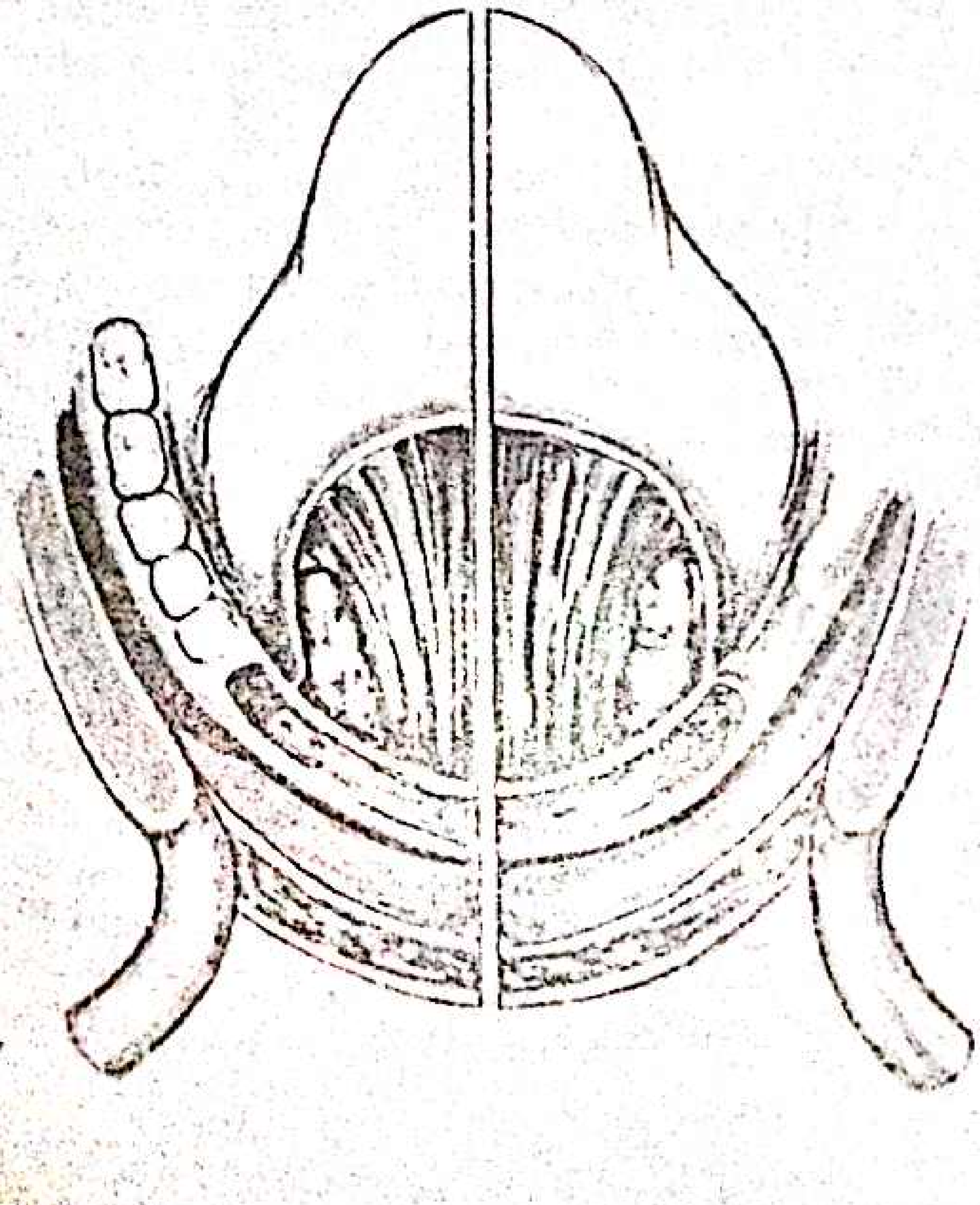
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The viability of such a narrow strut is likely to be a matter of concern and this is best maintained by retaining as far as possible the soft tissue attachments to its labial surface, along the lines discussed in the chapter on 'Tongue, lateral floor and lower alveolus, faucial area and retromolar trigone', pp. 297–325.

RECONSTRUCTION OF SOFT TISSUES

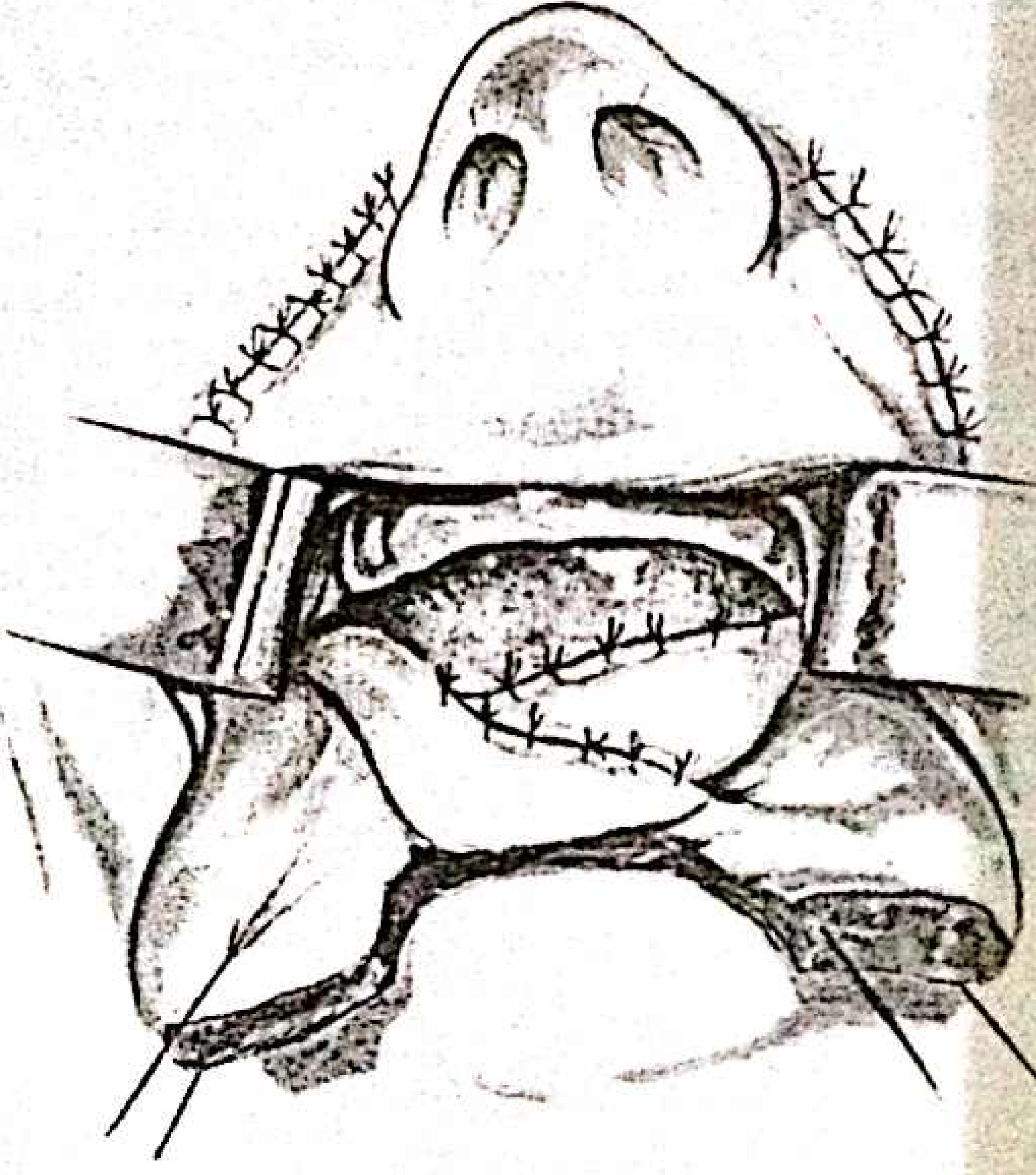
Small defect

The temptation to close the small defect by direct suture should be resisted totally. The adverse effect on tongue function which is likely to result from the tethering of its anterior free mobile element is such that direct suture is not an acceptable method.

18

The most effective reconstruction makes use of bilateral nasolabial flaps, and the details of the technique have been described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240. As long as its use is restricted to the area between the premolar teeth, and preferably in the edentulous mouth, as discussed below, the method is applicable to the defect which includes bare bone, as well as the purely soft tissue defect.

One of the less obvious virtues of this reconstruction results from the fact that the flaps approach the ventral aspect of the tongue, when this forms part of the defect, from above on each side. The effect is to 'sling' the free portion of the tongue in an elevated position within the mouth during the healing phase, acting in a positive manner to prevent it from becoming anchored to the floor of the mouth.



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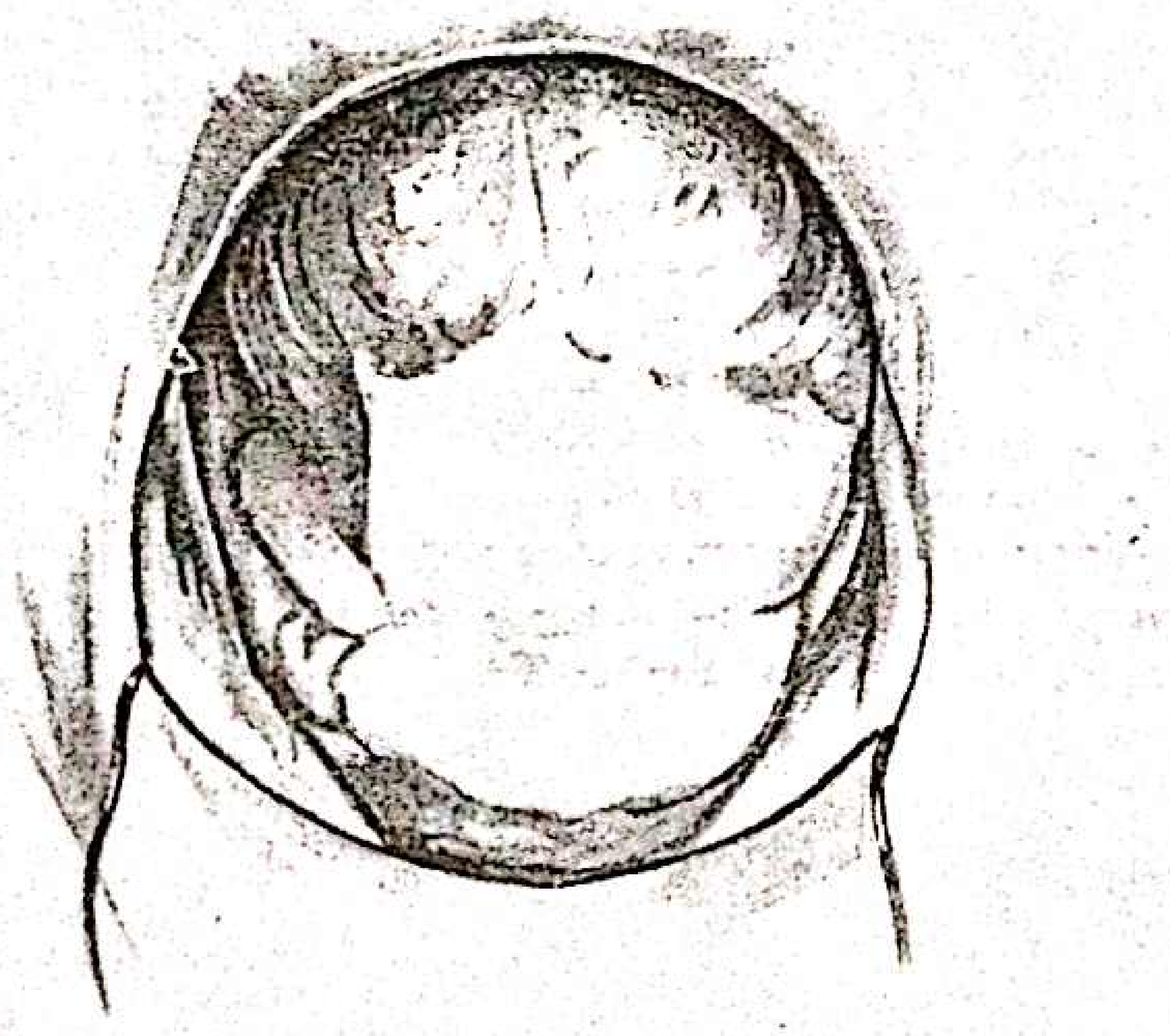

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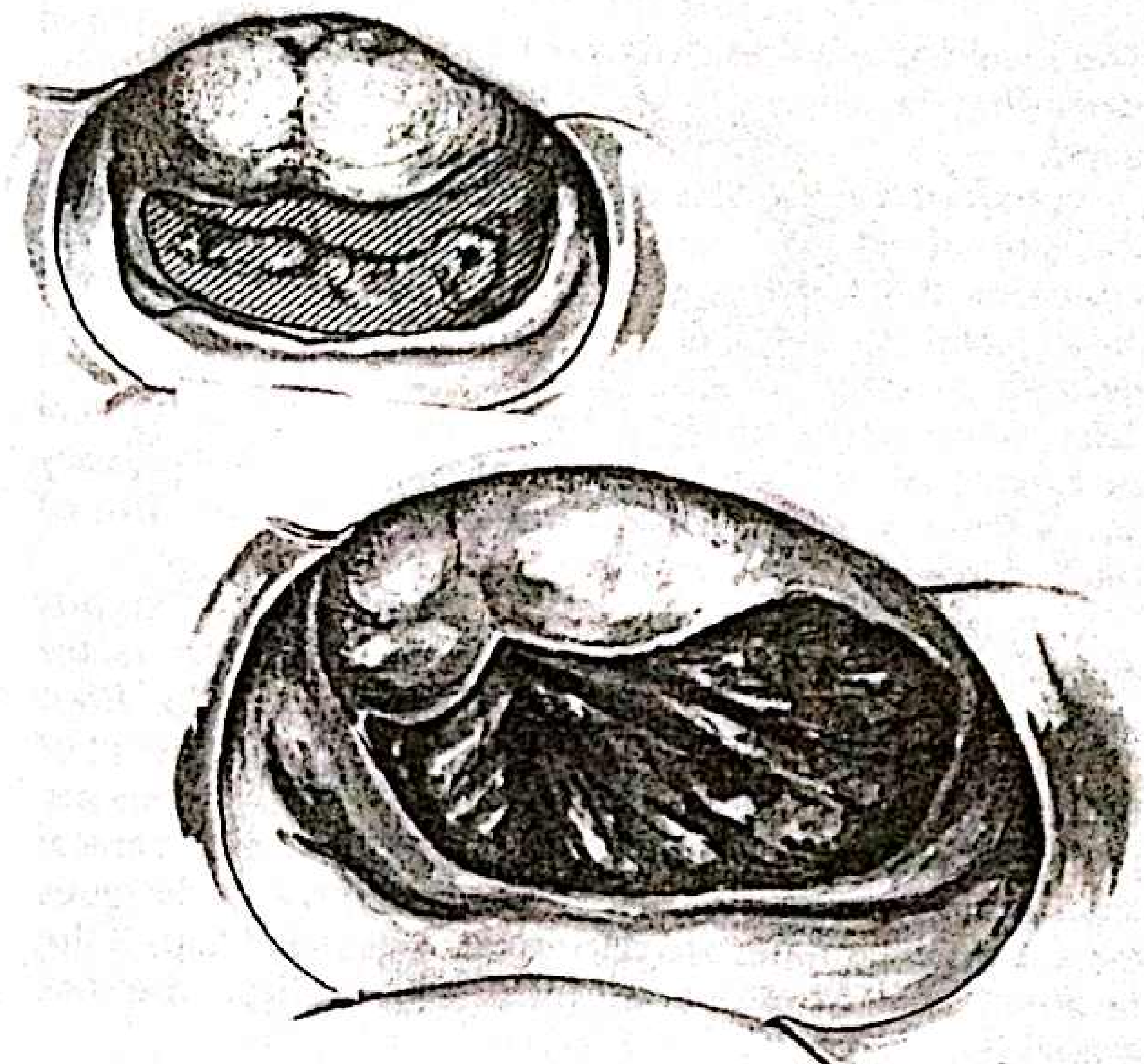
The flaps, immediately following their transfer, tend to show pincushioning of varying severity, but with time and possibly also under the influence of the traction exerted by the movement of the tongue they flatten out. It is often found that one of the flaps resurfaces the floor while the ventral surface of the tongue is resurfaced by the other.

In the edentulous mouth with its shallow floor, the technique is a relatively easy one, but the presence of teeth in the symphyseal region and the increase in the depth of the floor converts it into one of greater technical difficulty. Not merely is the resection more difficult because of the inaccessibility of the tumour in the depth of the floor, especially if it involves the alveolar mucoperiosteum, but the difficulty extends also to the transfer of the flap. The distance to be travelled before the flap reaches the defect is significantly increased, and the inset is correspondingly smaller as well as being difficult to achieve effectively. Detachment of the inset becomes a hazard, not merely because of the smallness of the inset and the technical difficulty of achieving it satisfactorily, but also because during recovery from the anaesthetic the patient is liable to bite through the pedicle of the flap unless a temporary bite-block is provided to keep the jaws open.



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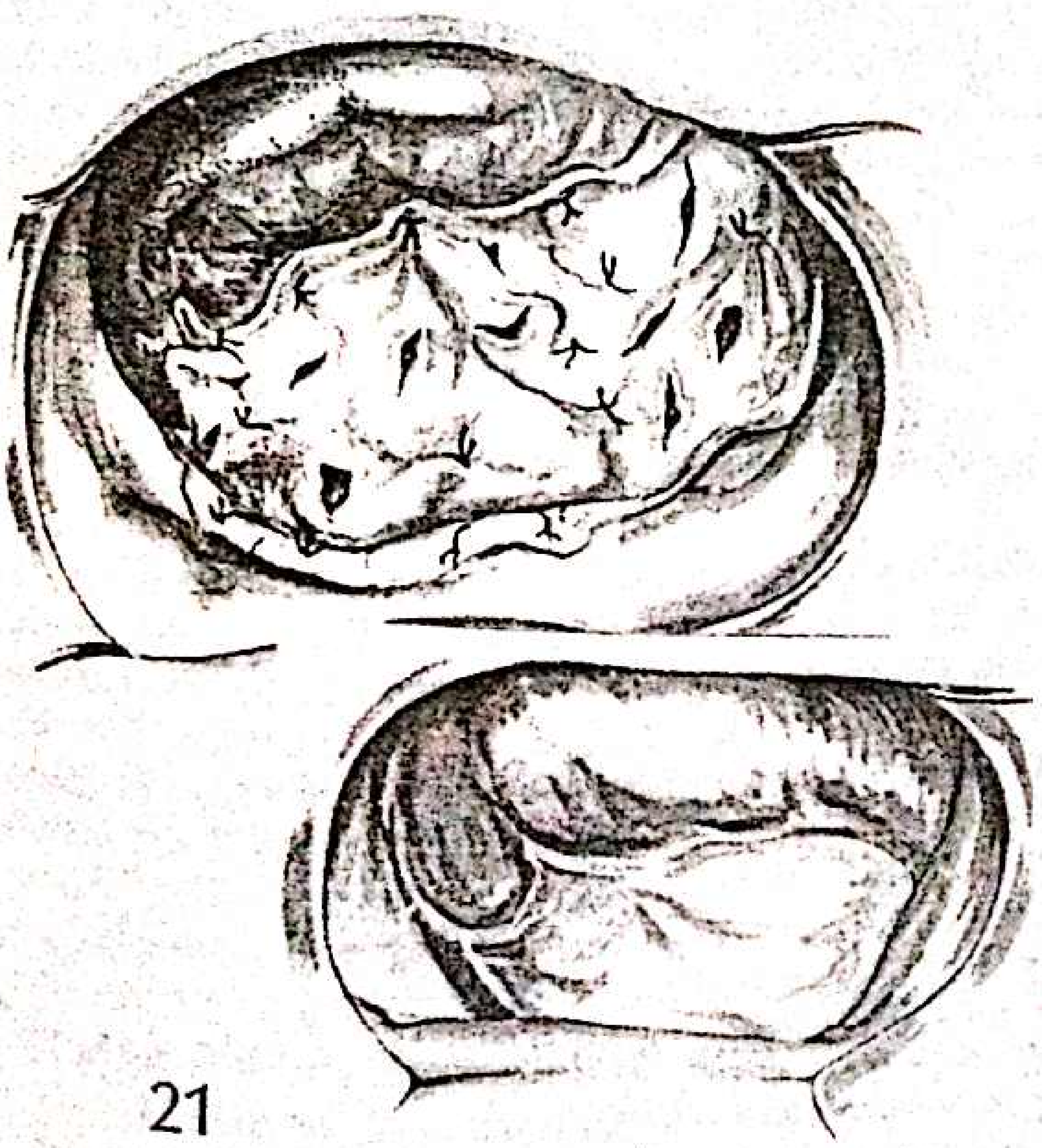
When the defect is entirely one of soft tissue an alternative to the nasolabial flaps is the quilted split-skin graft, as described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.



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21

The effectiveness of the technique is dependent on good take of the graft, and in this site the technique is a particularly demanding one. The result which follows graft loss, partial or total, is healing by second intention with wound contraction, its severity determined by the degree of graft loss. Failing 100 per cent take of the graft, the end result is liable to be little better than that obtained when direct suture is used, with tethering of the anterior tongue. Grafting is capable of giving an excellent result if the graft takes well, but the probability is not sufficient to give it priority over bilateral nasolabial flaps, where the result is so much more predictable.

Large defect

The local flap sources discussed above are not capable of providing the necessary tissue and distant flaps have to be used.

As part of the process of selecting a flap to reconstruct the large defect, an aspect which requires consideration concerns the sequence of spread of the tumour, both locally and to the regional lymph nodes. The general policy regarding the use of neck dissection is discussed later, but it can be stated that if a neck dissection, radical or functional, is being carried out as part of the primary surgery, or is a real possibility in the future, the use of neck skin as a flap source should not be considered.

It is difficult to overstress that when the various alternative flap sources are being compared the factor which has much greater relevance in the anterior floor than in most other intraoral sites is the potential effect of the flap on tongue function. The potential flap types are pedicled flaps and free flaps, and as in other clinical situations where alternative reconstructive techniques exist, the possibilities are narrowed to pedicled flaps if the facilities and expertise to transfer free flaps are not available.

The pedicled flaps which are derived from sources situated below the defect, and which approach the floor of mouth from below, have the grave disadvantage of being subject to the effects of gravity, and pull the tongue downwards to the floor of the mouth. Most large defects of the anterior floor involve the ventral aspect of the tongue and its base, and there is an inherent tendency in any case for the tongue remnant to become anchored to the floor, a tendency which the surgeon has to take active steps to counter. Even when continuity of the mandibular symphysis has been maintained, and the bone is able to provide a fixed anterior margin to which the reconstructing flap can be sutured, and act as a counter to the effect of gravity at that point, there is no comparable anchorage able to counter the downward pull of the flap along the posterior margin of the defect, where the flap is filling the defect of the ventral tongue.

The added effect which resection of the symphysis is likely to have on flap selection must also be considered. The loss of the symphyseal bone should totally rule out the use of those flaps subject to gravitational problems which are capable of transferring only soft tissue, since, in the absence of the symphysis, the pull of gravity is transmitted directly on to the lower lip, and draws the entire complex, lip and tongue, downwards.

The pedicled flaps which might be used for the purely soft tissue defect are the deltopectoral, the pectoralis major, the lateral trapezius, and the forehead flaps.

The pectoralis major and deltopectoral flaps suffer most severely from the adverse factor of gravity, when used to reconstruct the anterior floor. Their deficiencies, particularly compared with the alternative flaps available today, are such that they do not merit serious consideration. The lateral trapezius myocutaneous flap has a pedicle which extends only down to the clavicular area and it is less susceptible to the adverse effects of gravity. It can also be transferred as a composite together with a segment of the spine of the scapula, as described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240. Its major adverse factors are the need to turn the patient in order to raise the flap, and the unreliability of its vascular basis, particularly the venous element. The overall effect has been to seriously restrict its usage. It would not be a first choice.

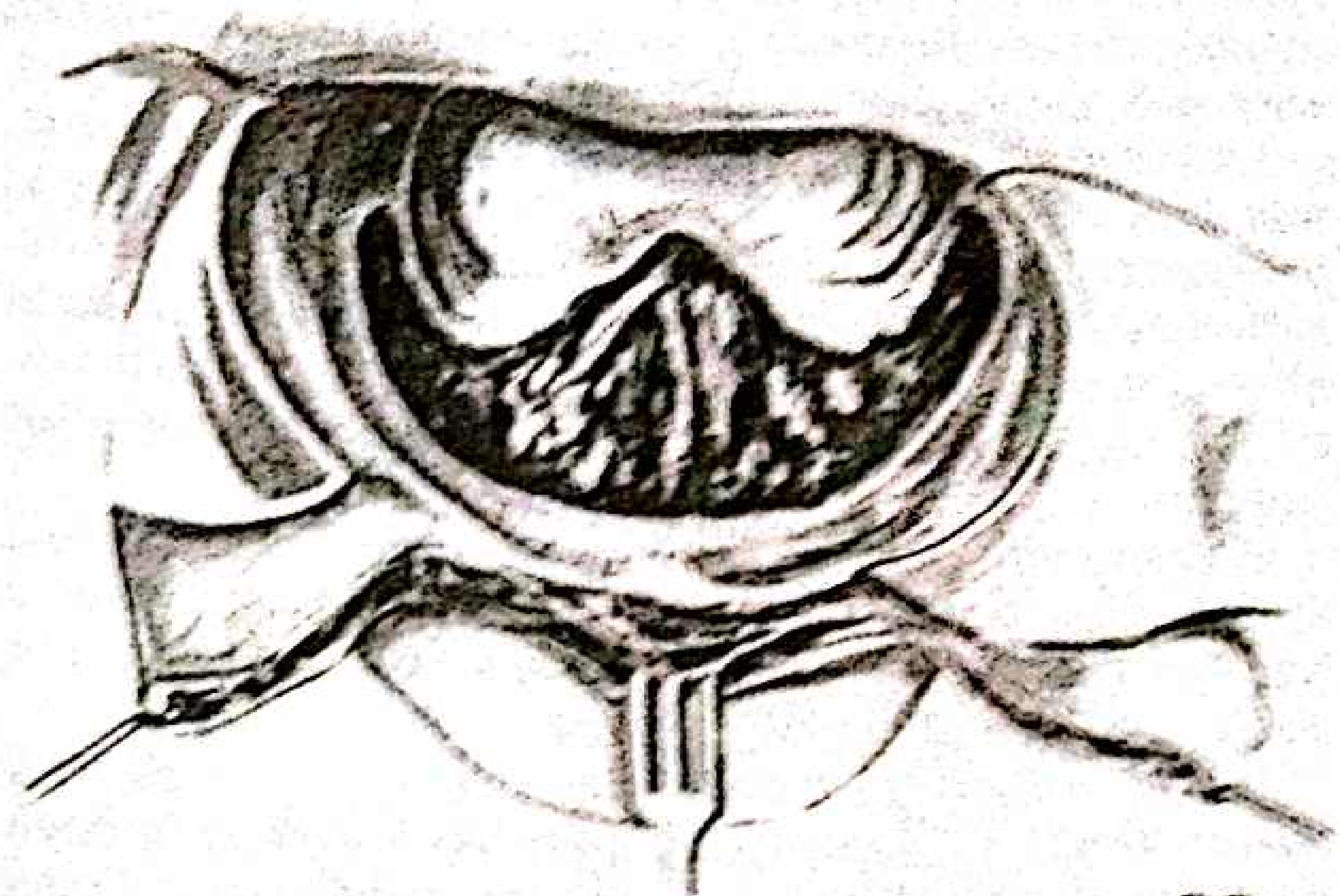
The pedicled flaps which approach the mouth from below require a portal of entry. The simultaneous neck dissection in continuity which is almost always carried out in the case of a large primary tumour allows the flap to be brought up into the mouth under the skin flaps raised as part of the neck dissection.

The forehead flap reaches the intraoral defect from above and in this respect its upward pull is advantageous, tending to hold the tongue in an elevated position. Its undesirable qualities, the appearance of the secondarily grafted forehead and the need for two operative stages, have already been stressed. It does not transfer bone and this would be a limiting factor if a combined soft tissue-bone reconstruction was required. For the surgeon whose expertise is limited to the use of a pedicled flap, however, it will give a better functional result than any of the flaps which reach the defect from below, by preventing anchorage of the tongue in the floor of the mouth.

The latissimus dorsi myocutaneous flap is likely to be used only as a free flap, and an important factor in considering its potential suitability relates to its muscle bulk compared with the area of its skin paddle. For the defect in which the area of mucosa resected is large relative to the total volume of tissue resected it would be inappropriate; for the large volume defect it is likely to be more effective, although its immobile bulk is likely to act adversely by limiting the mobility of that part of the free segment of the tongue which remains following the resection.

22

The free flaps, radial forearm and scapular, are free of the adverse factors which relate to the effect of gravity and they have the added virtues of flexibility and a relative absence of bulk. These characteristics allow the flap to conform more readily to the convoluted surface which is likely to be presented following tumour excision in this area.



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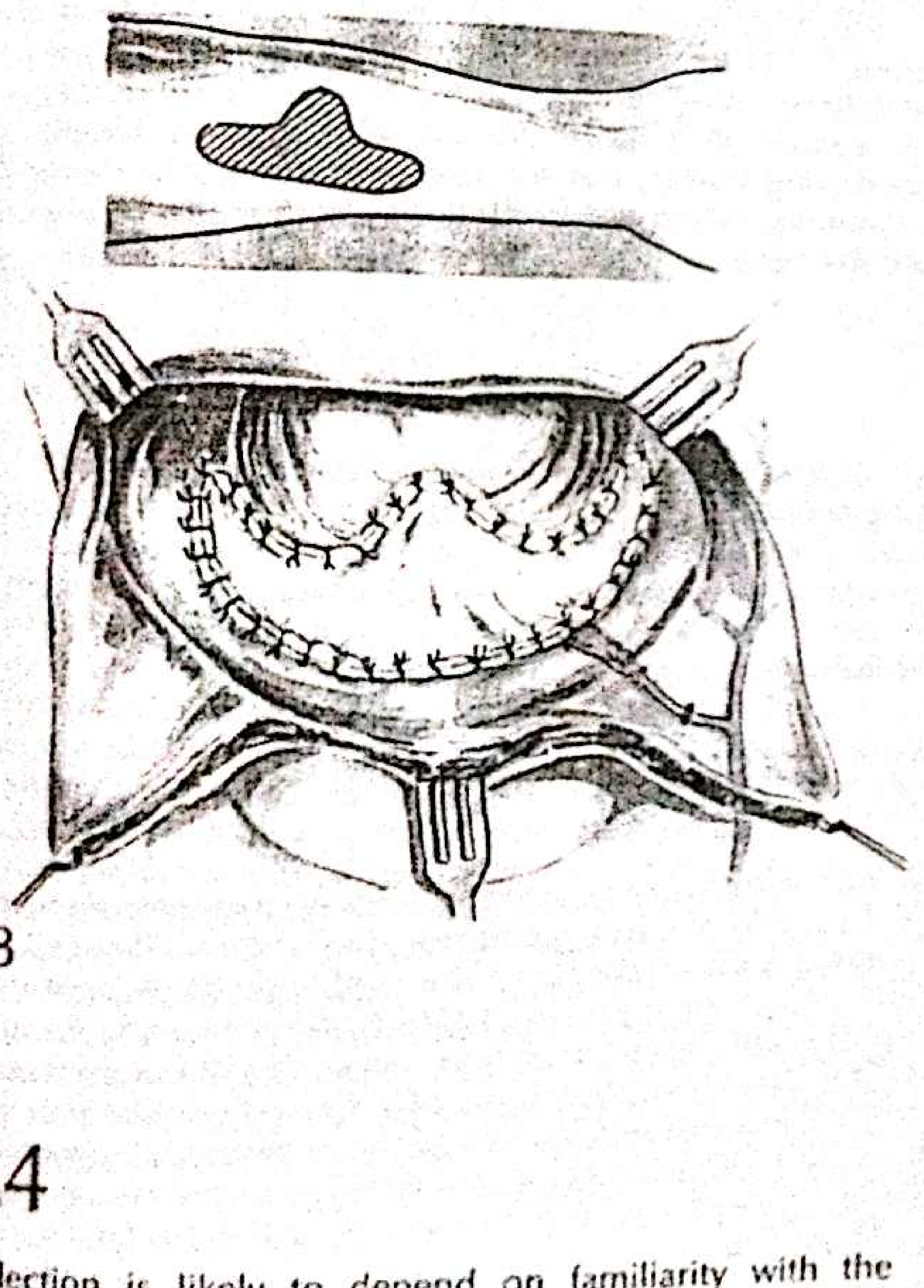

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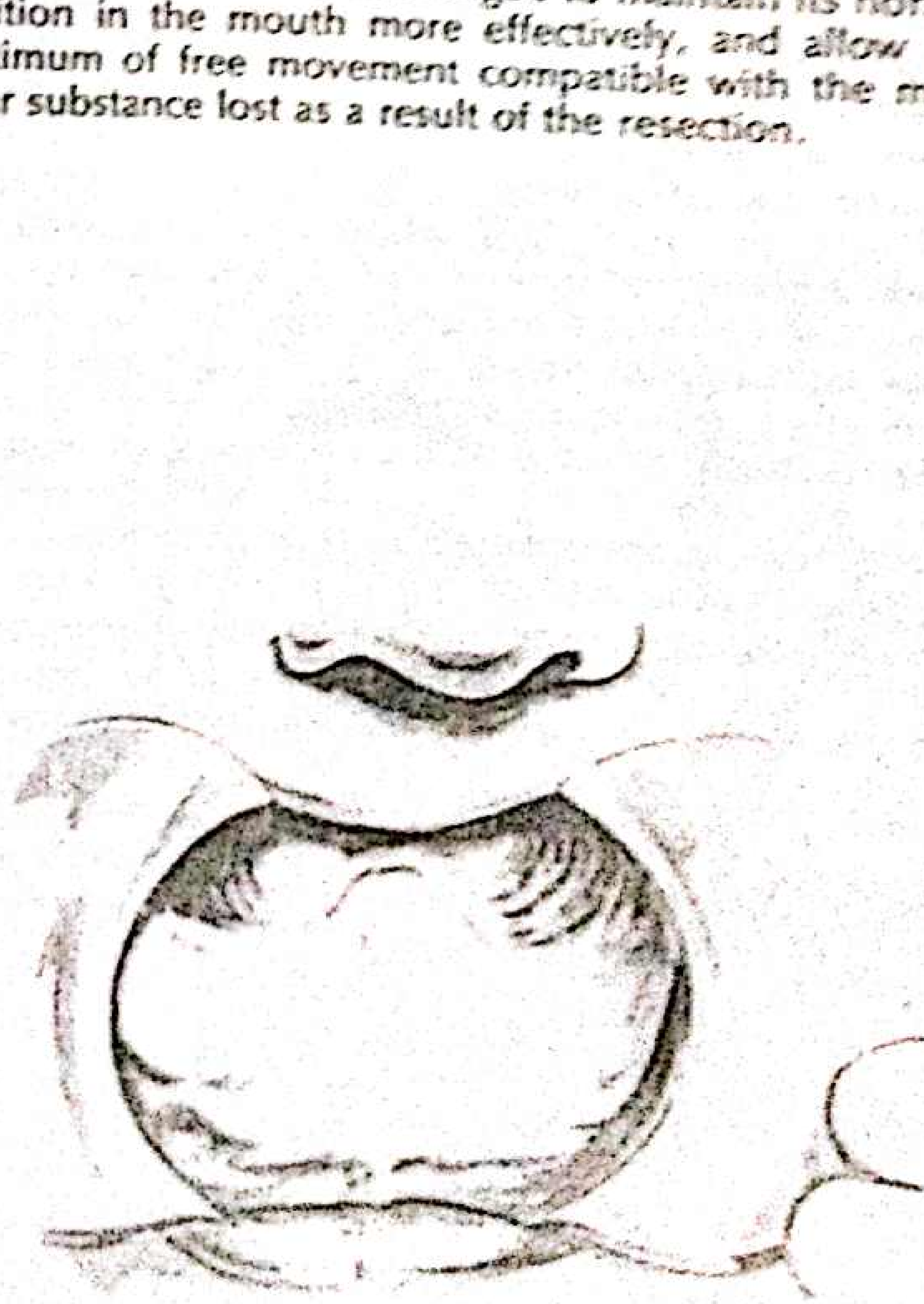
The effect is to enable the tongue to maintain its normal position in the mouth more effectively, and allow the maximum of free movement compatible with the muscular substance lost as a result of the resection.

24

Selection is likely to depend on familiarity with the method chosen. Both flaps can be used either as a purely soft tissue transfer, or as a composite together with bone.

Their characteristics, good and bad, have been discussed, as have the techniques of raising and transferring both flaps as purely soft tissue, in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, and as composites together with bone in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.



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BONE RECONSTRUCTION

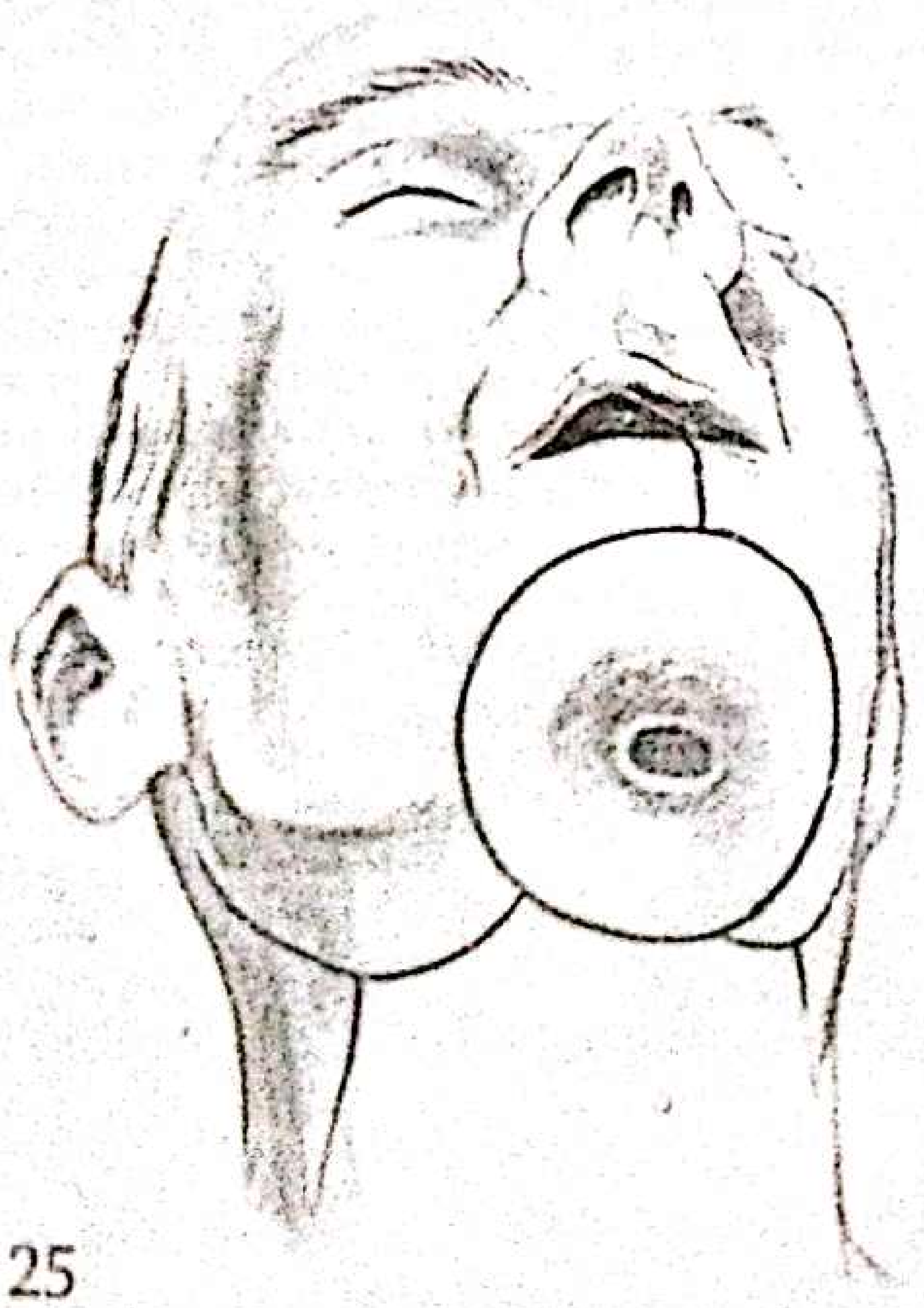
Prior to the development of the reconstructions which transfer vascularized bone, either alone or as a composite with soft tissue, the surgical approach to the symphysis, resected as part of the excision of an intraoral carcinoma, was one of secondary bony reconstruction, attempts at primary bone grafting having proved uniformly disastrous, with loss of the graft. Initial management was confined to efforts to stabilize the mandibular segments on each side of the defect, as far as possible in their preoperative position.

With the soft tissue defect reconstructed there were two approaches to the bony defect. It was either left as a permanency or, with healing complete and the reaction settled, a bone graft was inserted.

Today, with the demonstrated safety of vascularized bone transferred primarily, this approach has largely been abandoned, the soft tissue and the bony defects being reconstructed simultaneously using the radial forearm flap with a length of radial bone or the parascapular flap with a length of the lateral border of the scapula. With both techniques, the skin element resurfaces the soft tissue defect and the length of bone, in the case of the radius about 10 cm, in the scapula 12–14 cm, is used to restore bony continuity across the symphysis. The bone cut from both radius and scapula is straight, but in each instance the vessels which perfuse it enter the segment of bone all along its length, so that osteotomy can safely be carried out to allow it to match the curve of the symphysis. When such an osteotomy is being carried out, any disturbance of the soft tissues attached to the bone should be kept to an absolute minimum. The problem arises more with the scapular flap, where there is soft tissue attached to both sides of the bone, and some periosteal stripping is difficult to avoid.

An alternative which has been described is osteotomy of the bone into multiple segments, each of which is fixed with a screw to a metal plate moulded to the defect. While the effect is to provide a shape which matches the curve of the mandibular symphysis and provide good stability, it does so at the expense of potential problems if, as is likely, postoperative radiotherapy is contemplated.

The transferred segment of bone is fixed to the resection margins of the mandible and the osteotomy is stabilized using plates or wires. Wiring is effective, particularly if it is reinforced with a short length of transfixing K-wire, but the use of plates is increasing in popularity. When used effectively, both methods eliminate the need for postoperative intermaxillary fixation.



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Skin involvement by tumour

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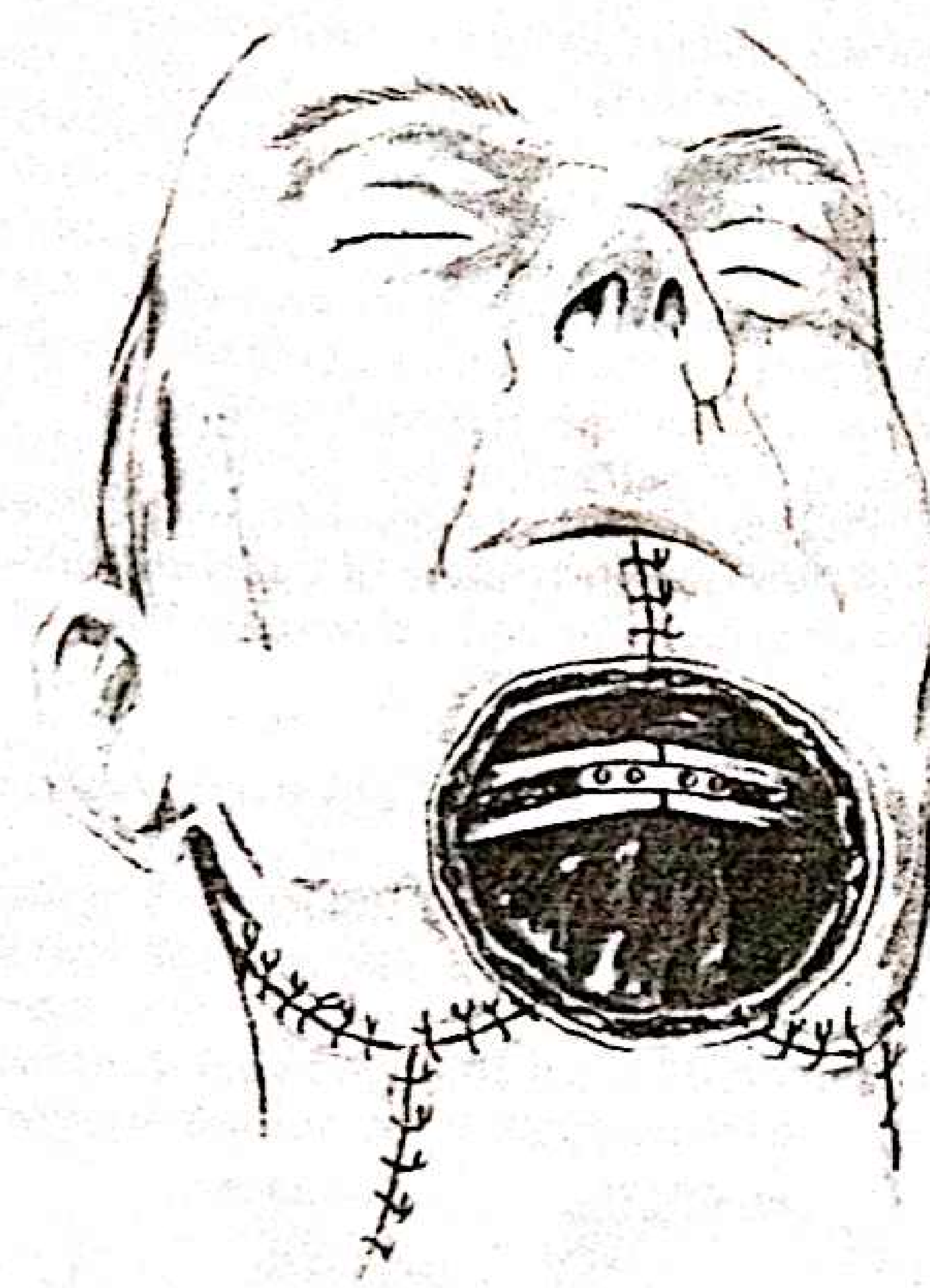
When the tumour has extended locally to involve the skin of the chin or the submental area, the additional resection required adds markedly to the problems of reconstruction, necessitating provision of both skin cover and lining, together with vascularized bone. In such a situation, there is little alternative to the use of a free composite flap of skin and bone to provide two of the necessary elements – bone plus either lining or skin cover. The remaining soft tissue element can consist of a further free flap or a pedicled flap.

26

When the chin area is being resected, as much as possible of the upper part of the lip should be retained, within the requirements of tumour clearance. Quite apart from the desirability of retaining a red margin from the point of view of cosmesis, the muscle content of the lip segment retained in this way is likely to make a very significant contribution to function both in terms of preventing drooling of saliva, and in countering the effect of gravity on the reconstructing flaps passing upward from the chest to the defect.



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Various factors may be expected to be concerned in the details of decision-making. The patient who allows such an extensive tumour to develop without seeking treatment may be viewed as unlikely to be fit to withstand the necessarily long procedure involved in an extensive resection and probable neck dissection, possibly bilateral, followed by a double free flap transfer, one of which is a composite with bone. With the current excellence of the anaesthesia generally available, the length of the procedure is a less important factor than previously. In any case the argument can be countered by the consideration that the patient may be better served by a single, though admittedly long, procedure, than the two-stage procedure, inevitable with a pedicled skin flap. A further consideration concerns whether a realistic assessment will not reach the conclusion that the tumour is inoperable.

If the decision is taken to carry out a resection-reconstruction, the question immediately arises as to which of the flaps should carry the bone, the lining flap or the skin cover flap. This might depend on the estimated extent of the tongue resection. When a tumour is sufficiently advanced to require the resection of involved skin, it has usually infiltrated equally extensively into the base of the tongue, and it may be considered that replacement of the resulting volume loss requires the bulk which a latissimus dorsi flap, used as lining, can provide. The flap providing the skin replacement would then have to provide the bone in addition.

In the absence of such a compelling reason, the soft tissue element of the composite is probably best used as the lining flap, since this allows easier access for the manipulation of the bone, probably involving an osteotomy as well as the fixation to the resection margins of the mandible.

If a pedicled flap is being used to reconstruct the skin element of the defect, the obvious alternatives are the pectoralis major and the deltopectoral flaps. Both are capable of providing good skin cover, although of different thicknesses; selection would depend on matching the thickness of the flap to that of the defect. A significant factor against the use of either flap concerns the effect of gravity, an aspect which has already been discussed, here acting to pull down the reconstructed lip.

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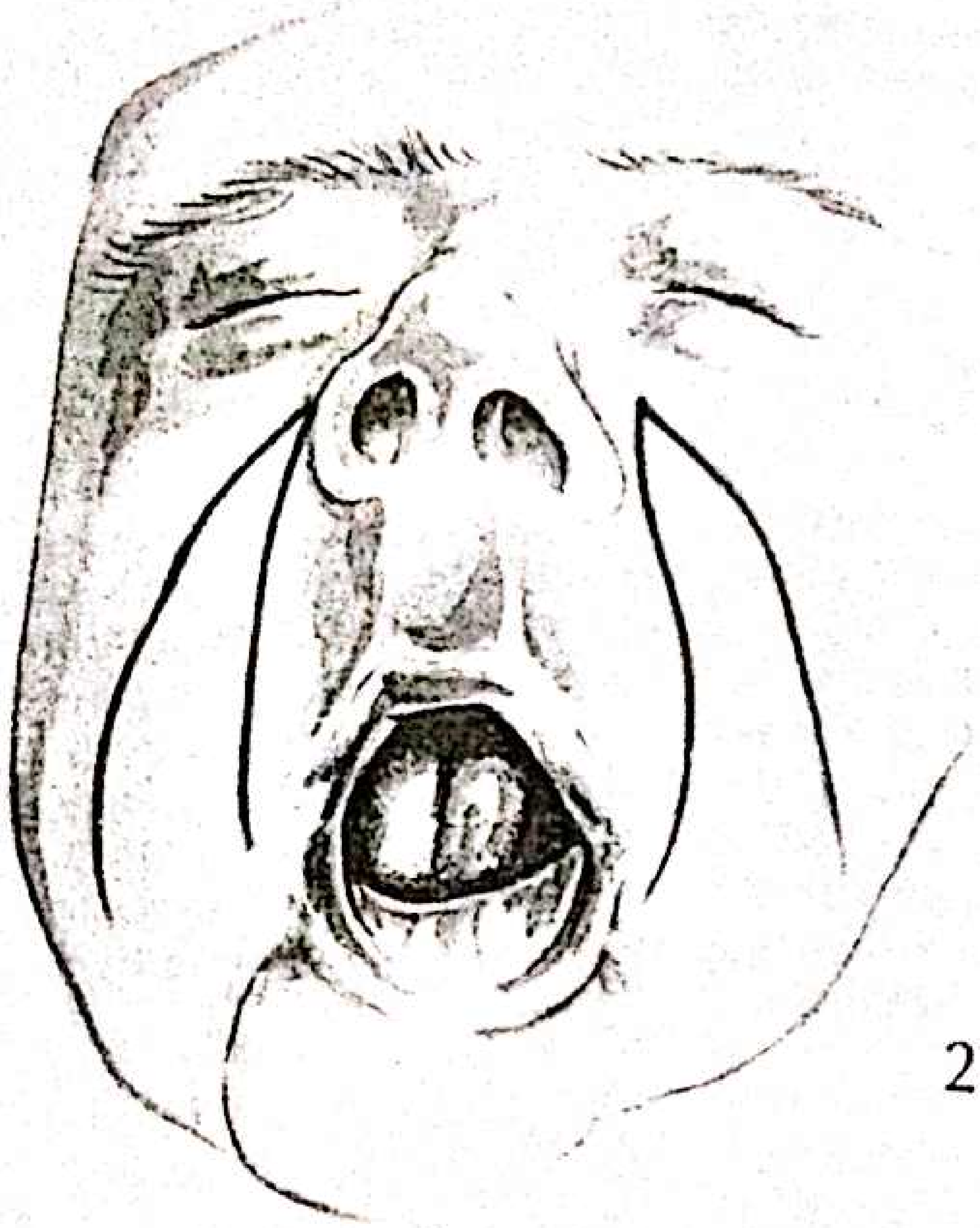
At the completion of the reconstruction, a problem of oral competence may remain because of drooping of the lower lip.



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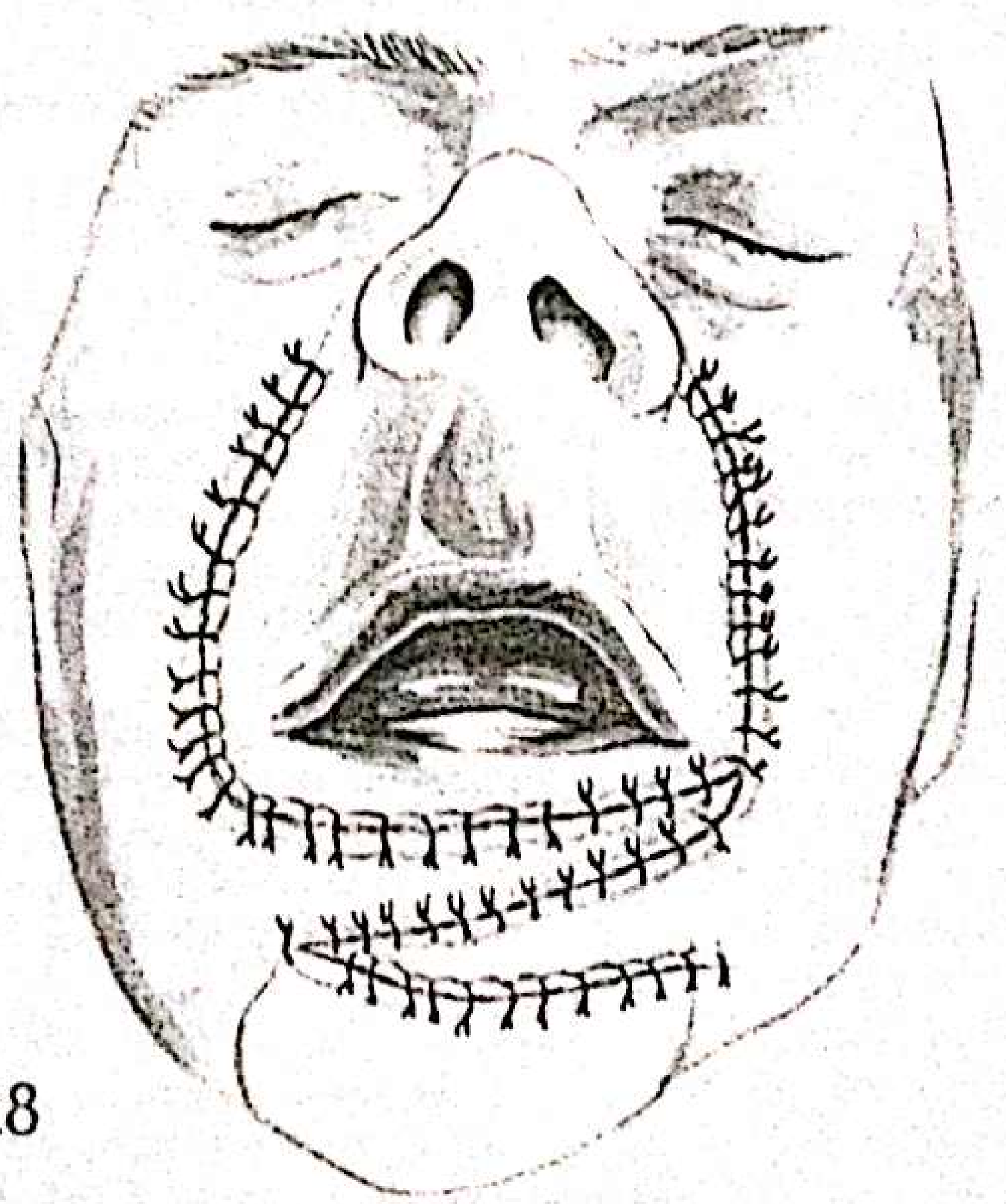

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In such a situation, the transfer of two inferiorly based nasolabial flaps can produce considerable improvement.

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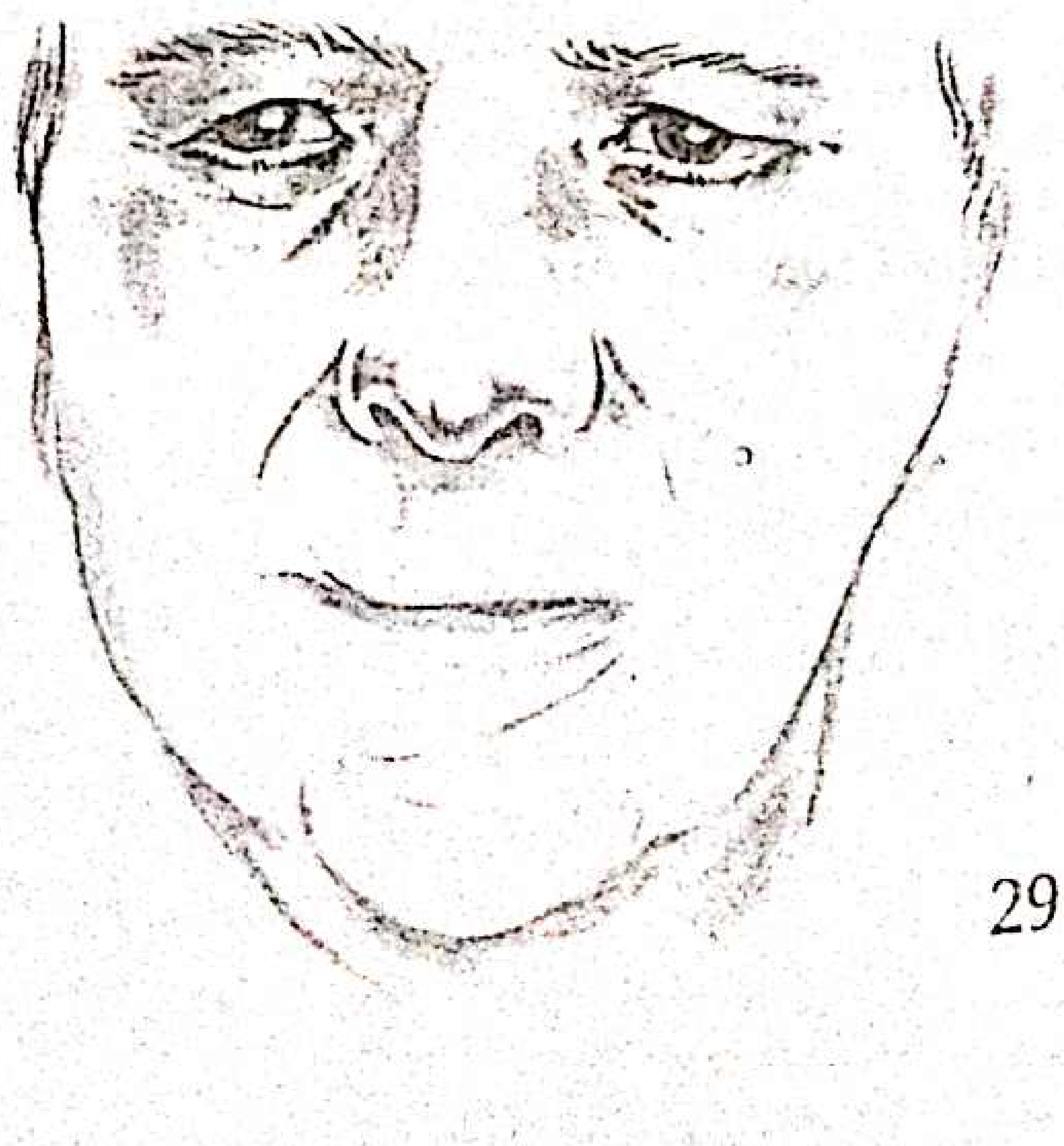
The flaps, interdigitated and set into the reconstructed lip, insert additional tissue and have the effect also of 'hitching it up'.



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Submandibular salivary glands

A problem which can arise in the early postoperative period following resection of the anterior floor of the mouth is swelling of one or both submandibular glands, the result of obstructive sialadenitis, but creating suspicion of metastatic disease. The submandibular salivary gland is extremely sensitive to interference with its normal drainage pattern. Construction of a new opening for the duct at the time of tumour resection has been described, but personal experience has found it to be either impracticable or ineffective. The development of the swelling early in the postoperative period should in theory act as a factor in distinguishing it from metastatic disease, but the distinction can be a difficult one to make if an association with food is not clear-cut. A short period of observation, coupled with aspiration needle biopsy, may resolve the dilemma, but if these are inconclusive, excision of the gland with immediate frozen section may be needed.

Neck dissection practice

If the surgery has been carried out without need to open the submandibular or sublingual areas, a prophylactic neck dissection is not obligatory, regular examination of both sides of the neck being adequate. If the submandibular triangle has been breached as part of the primary tumour resection, a neck dissection should be carried out in continuity, functional if the neck is clinically negative, radical if nodes are palpable. If it proves necessary to carry out a bilateral radical neck dissection, every effort should be made to preserve one internal jugular vein. In practice, the two sets of neck nodes are rarely equally involved, and a functional dissection on one side is practicable.

Acknowledgements

Illustration 2 is taken from Mashberg A, Meyers H. Anatomical site and size of 222 early asymptomatic oral squamous cell carcinomas, *Cancer* 1976, p. 2149 with permission of the editor and the authors. *Illustration 5* is used with permission of Dr Ralph Millard.

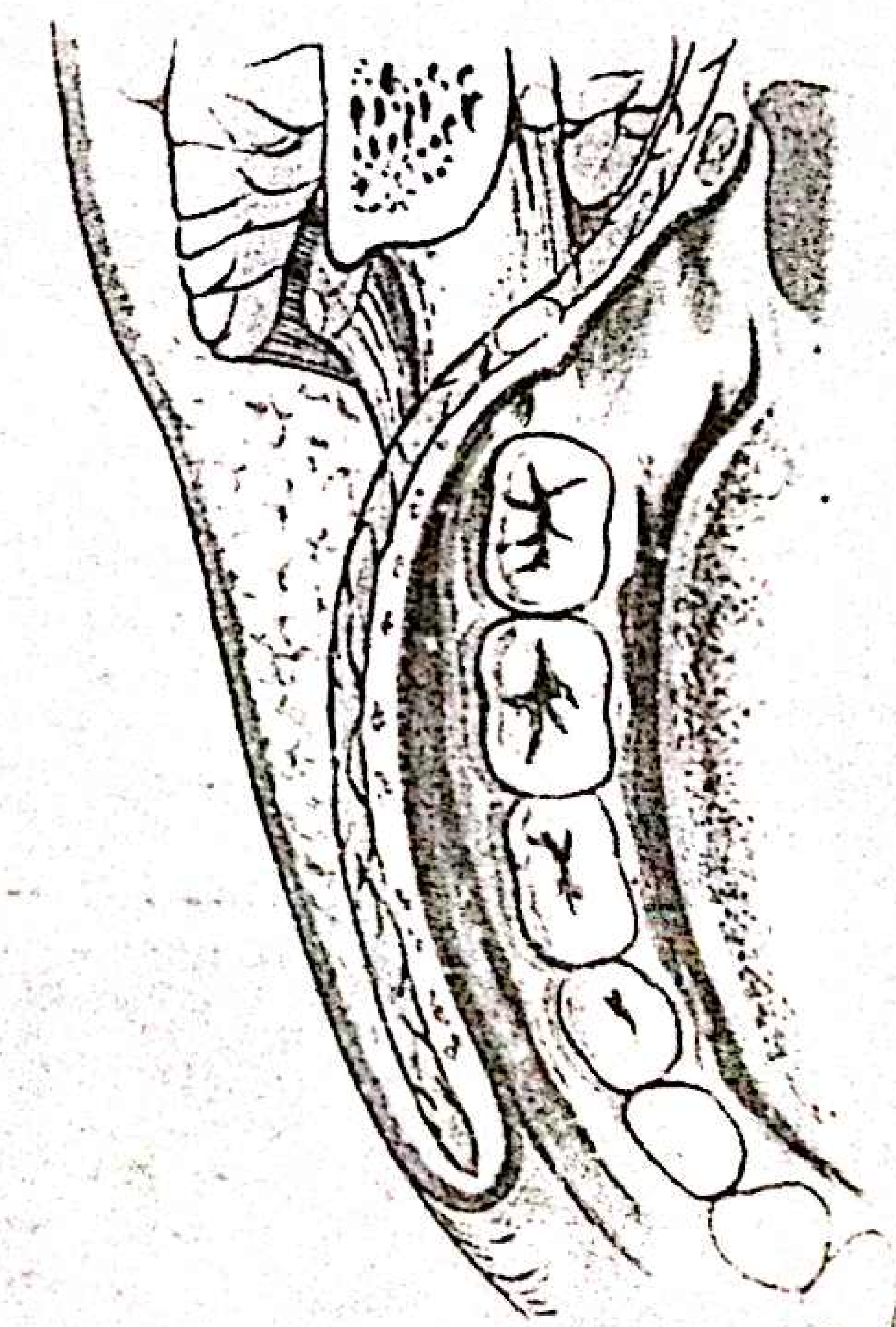
Buccal mucosa

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Anatomical factors

1

The buccal mucosa, in forming the lining of the cheek, extends from the upper to the lower buccal sulcus and from the angle of the mouth to the line of the pterygomandibular raphe. The mucosal surface is largely devoid of features, apart from the parotid duct opening opposite the crown of the second upper premolar tooth, and it passes anteriorly to line the lips and posteriorly on to the soft palate and faucial area without any obvious transition. The cheek in this area has a layered structure – mucosa, submucosa, buccinator muscle and skin, and the submucosa contains a large number of mucus-secreting minor salivary glands. The mucosa and the buccinator muscle are relatively mobile one on the other, the submucosa which separates the two having a loose texture, creating a well defined plane between the mucosa and buccinator, capable of being exploited surgically. Despite the differences in their muscle content, the lips and the cheeks have a similar basic structure. Along the lines of the upper and lower buccal sulci the relative mobility of the mucosa changes to one of virtual total fixity deeply, characteristic of alveolar mucoperiosteum.



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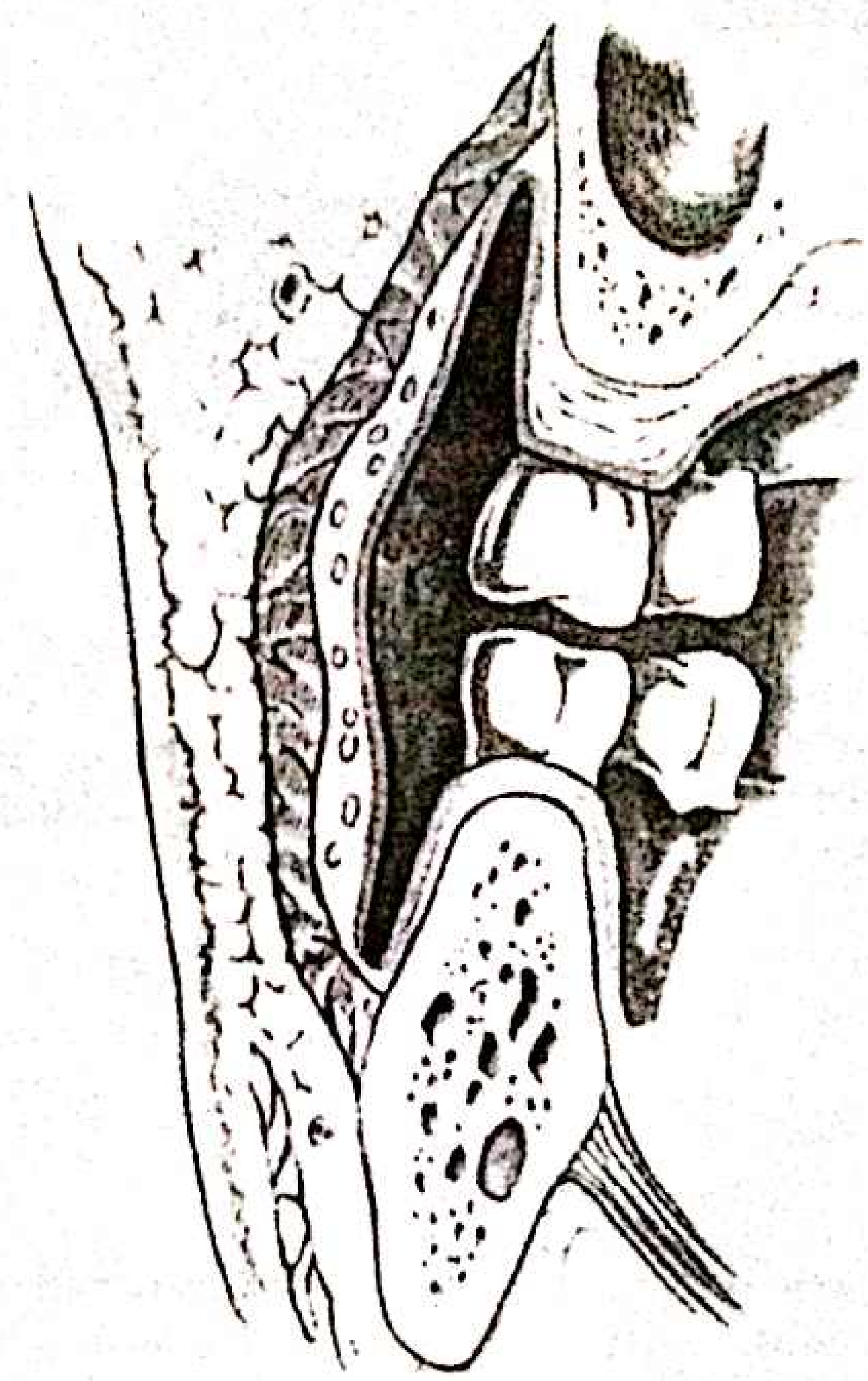
Between the angle of the mouth and the opening of the parotid duct the skin and the muscle are intimately attached to one another, with no defined surgical plane between the two. Behind the ductal opening they become separated, the separation increasing as buccinator swings medially in its approach to the pterygomandibular raphe.



2

Pathological aspects

The great majority of buccal carcinomas are squamous, although tumours of the minor salivary glands occur occasionally. Squamous carcinoma can arise as a single tumour but multifocal neoplasia is also regularly seen, in the form of multiple foci of tumour appearing both simultaneously and as fresh neoplasms developing after a lapse of months or years following apparently successful treatment of what at the time appeared to be a single tumour. Where the chewing of tobacco is endemic, either alone or as part of the betel nut-*cum*-lime quid, squamous carcinoma with a distinctive verrucous appearance and an equally distinctive pattern of behaviour is recognized, arising in the site within the mouth where the quid is held, usually the lower buccal sulcus.

The flat surface of the buccal mucosa and its layered structure make it possible to discuss tumour spread in terms of deep spread and marginal spread, and a similarly logical approach can be applied to surgical eradication.

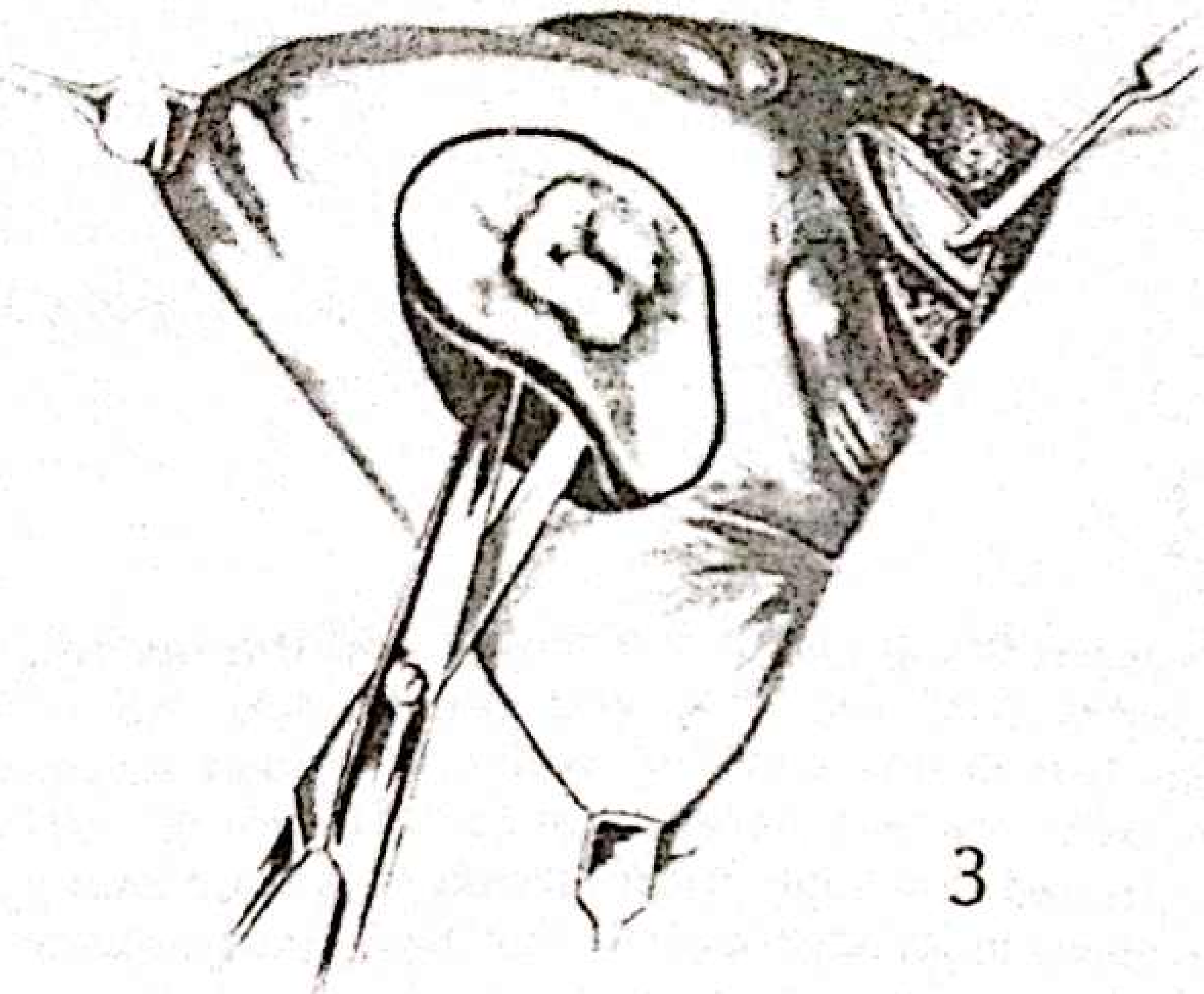
Tumour spreading deeply increasingly involves the various layers of the cheek, finally reaching the skin surface, but it is infiltration across the submucosal layer to involve the buccinator muscle which results in the greatest change in the clinical characteristics of the tumour, relative mobility of the tumour changing to fixity. The direction of marginal spread, which dominates the clinical picture and determines the pattern of much of the surgery, depends very much on the site on the mucosa where tumour first appeared. Spread anteriorly involves the angle of the mouth and the lips. Backwards spread is to the pterygomandibular raphe, the retromolar trigone and the soft palate. Upwards and downwards spread reaches the alveolar mucoperiosteum, upper and lower, and by the time the tumour has reached one or both of these structures deep infiltration has usually also reached buccinator, a combination which adds trismus to the clinical picture.

When a second tumour develops months or even years after the original resection in the mucosa, which was left unresected because at the time it looked clinically normal, problems arise both of recognition and management, particularly if a flap has been used to reconstruct the original postexcisional defect. The presence of the second tumour is liable to be obscured if it arises behind the previous flap and delay its early recognition. With this as a potential hazard the surgeon should consider, in managing a tumour which requires a flap to reconstruct the defect, whether he should remove the remaining mucosa back to the pterygomandibular raphe prophylactically, and resurface the entire area.

Resection

3

An approach to the tumour through the open mouth may be possible when it is small and situated anteriorly. Such a limited approach is only effective when the incision encircling the tumour can be made under good vision and, for the tumour which is mobile deeply, a plane can often be established in the submucosal layer with blunt-tipped scissor dissection. The factor which limits such a restricted approach is whether the exposure is capable of sustaining an adequate precision of surgery. When there is the least doubt about this, added exposure is required.



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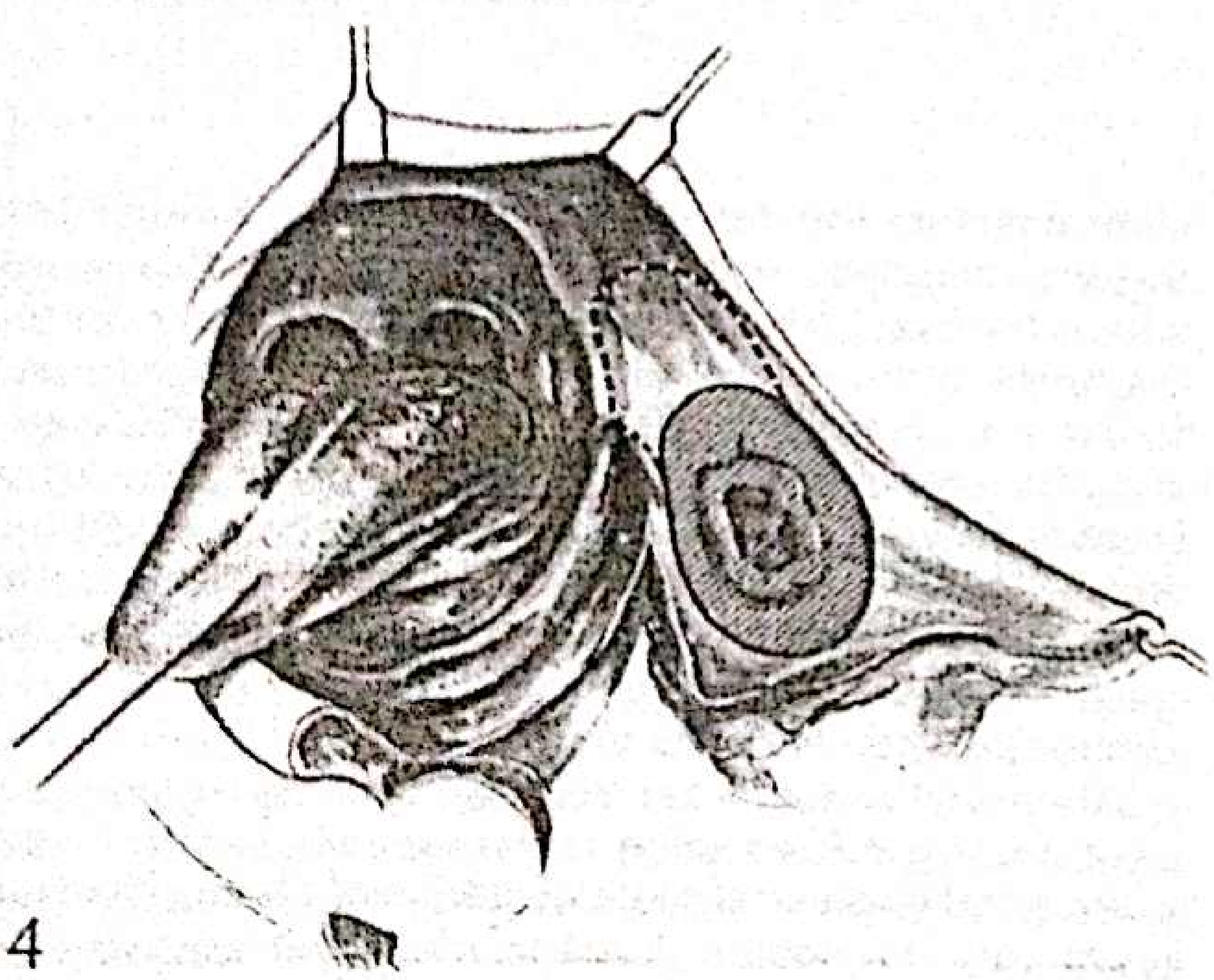

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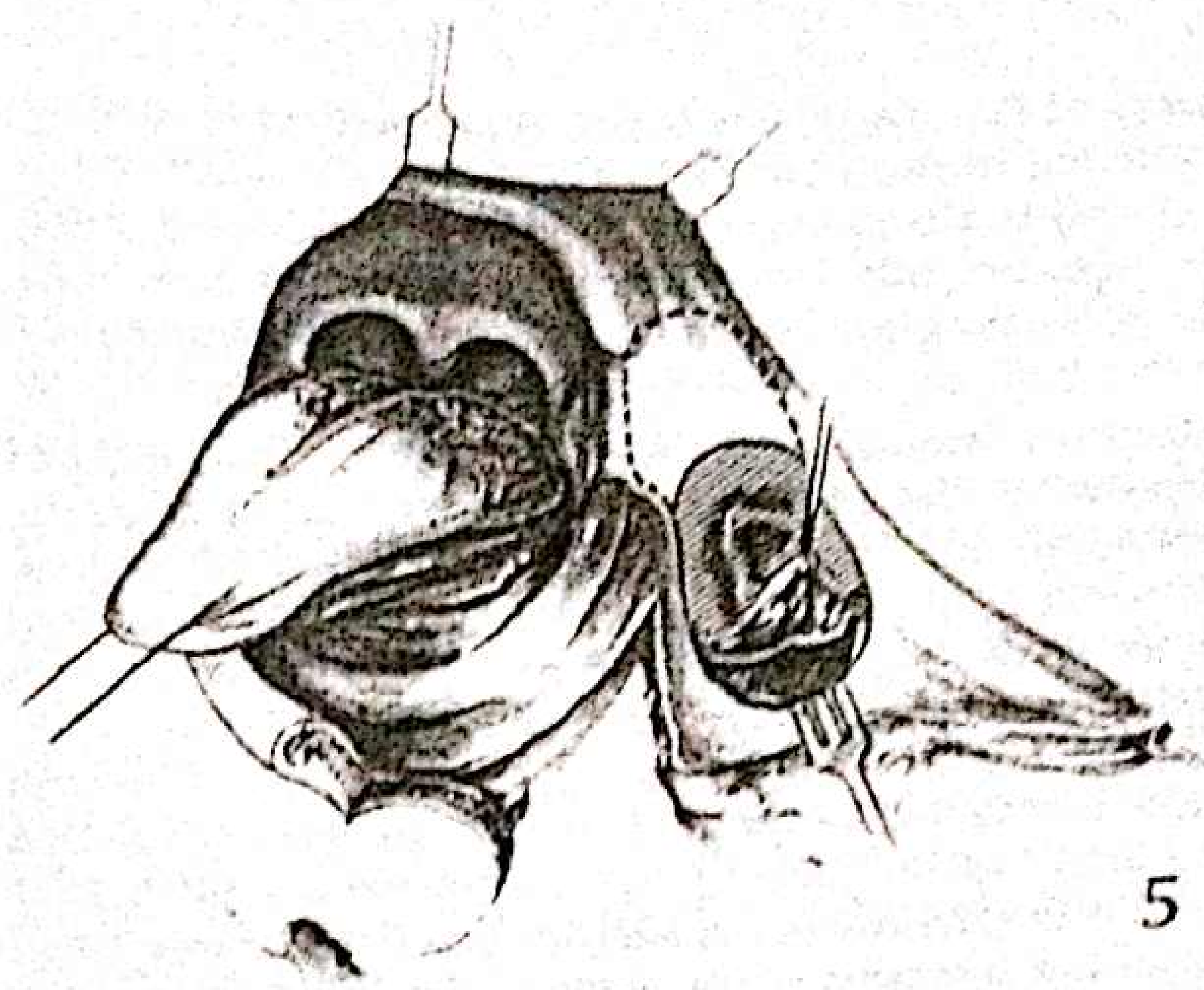
The approach which provides such additional exposure makes use of the submandibular component of the neck dissection incision continued forward with splitting of the lower lip. As described in the chapter on 'Access to the mouth', pp. 241–253, the cheek is then turned back, allowing the tumour to be properly seen and its extent assessed. In elevating the cheek flap from the mandible it is generally preferable, if the pathological situation permits, to use a dissection plane which leaves some soft tissue on its outer surface. The alternative of stripping the soft tissue at a subperiosteal level, leaving the bone bare, is much more damaging to the blood supply of the bone. There is no value in elevating the cheek beyond the anterior border of masseter since behind this line the buccal mucosa passes medial to the muscle.

5

With the cheek turned backwards and upwards and the tumour fully exposed, the line of marginal clearance can be marked on the mucosa. When the anterior clearance line is being delineated it may help to avoid subsequent trismus if the line is curved anteriorly, or even converted into a horizontal V, instead of being made vertical. Contraction of the scar is then less likely to give rise to trismus.

With the clearance margins outlined, the tumour is dissected off the cheek flap, as far back as the anterior border of masseter. The plane of deep clearance then leaves the cheek, passing deep to the muscle in the direction of the pterygomandibular raphe. The parotid duct is met in the process and divided. In theory the duct should be ligated but in practice it seems to matter little whether or not this is done.



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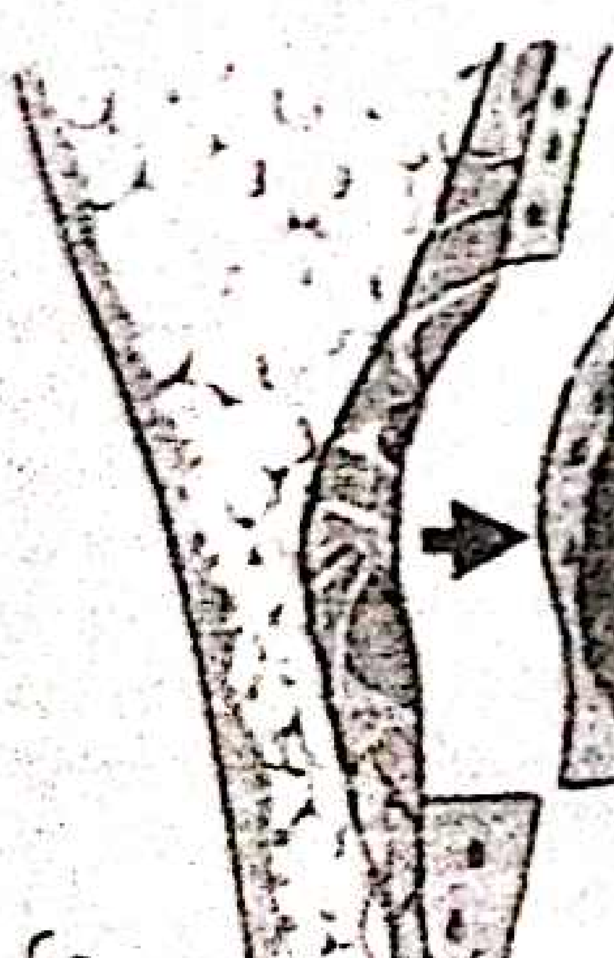
In assessing marginal clearance, the problem of a fresh tumour developing subsequently in the mucosa adjoining the original tumour site has already been alluded to. The possibility may well influence the surgeon and make him add to the area of mucosa removed at the time of the initial resection, even to the extent of stripping the entire buccal mucosa on a prophylactic basis.

Quite apart from any virtues which such a policy might have on pathological grounds, it has also certain advantages from the point of view of reconstruction. For the reasons discussed on p. 275, the reconstruction of choice for virtually all defects of the buccal mucosa involves the use of a flap transferred from outwith the oral cavity. Small defects which require a flap of this kind are technically more difficult to reconstruct than larger ones. Translated into the context of the reconstruction of a buccal mucosal defect, it is technically easier to reconstruct one which extends from the angle of the mouth to the pterygomandibular raphe, and from the lower to the upper buccal sulcus, than a defect of smaller size in the same area. Because of its greater technical ease, such a reconstruction stands a better chance of being successful and with a functional result in no way inferior.



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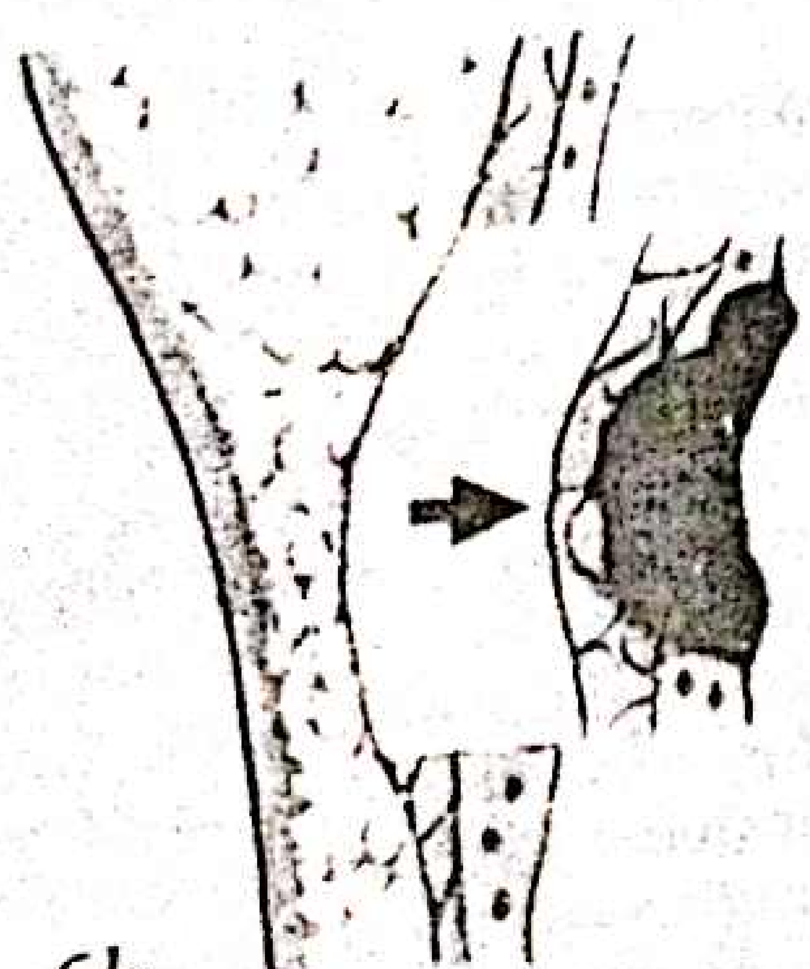

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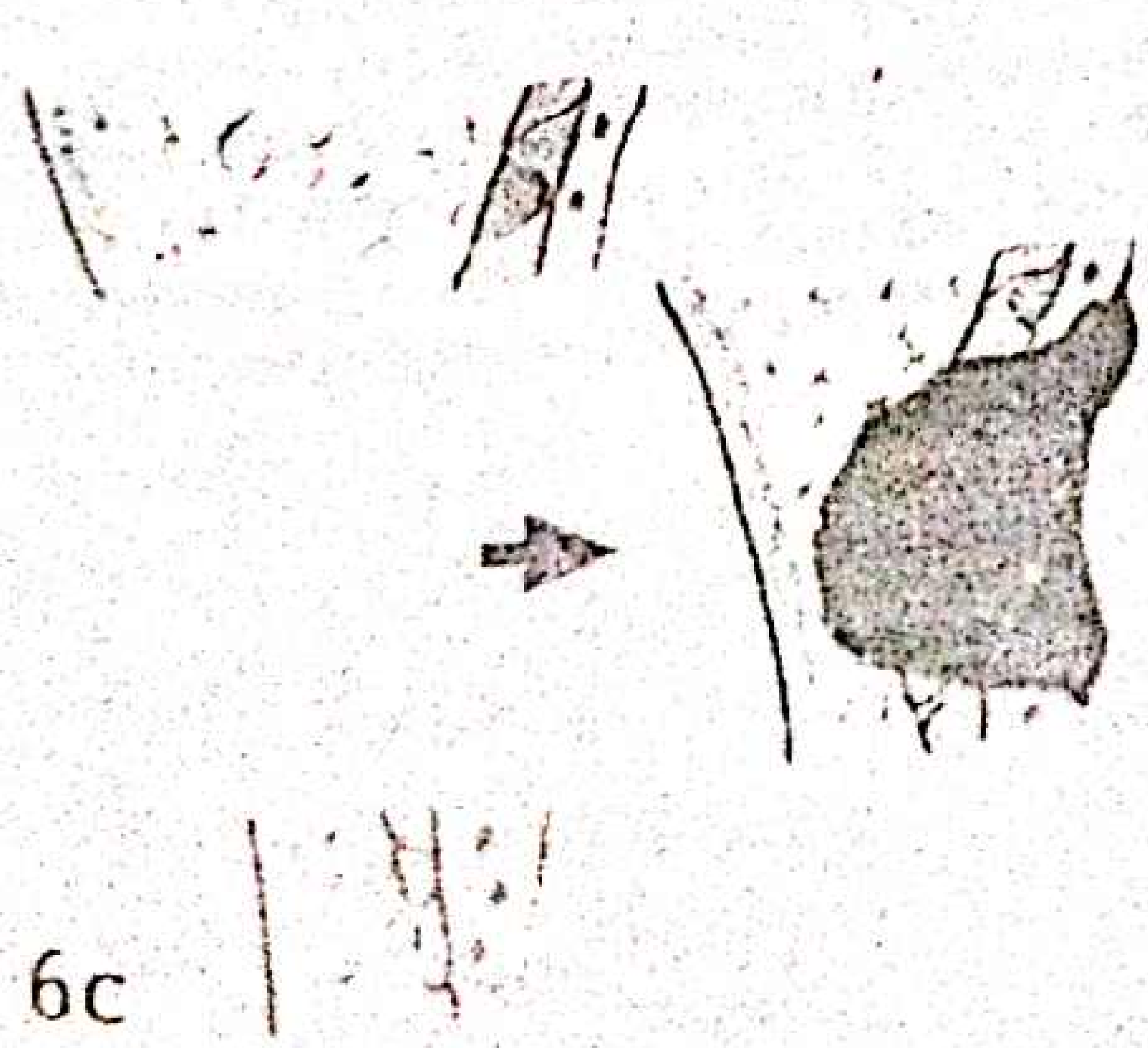


6c

6a, b & c

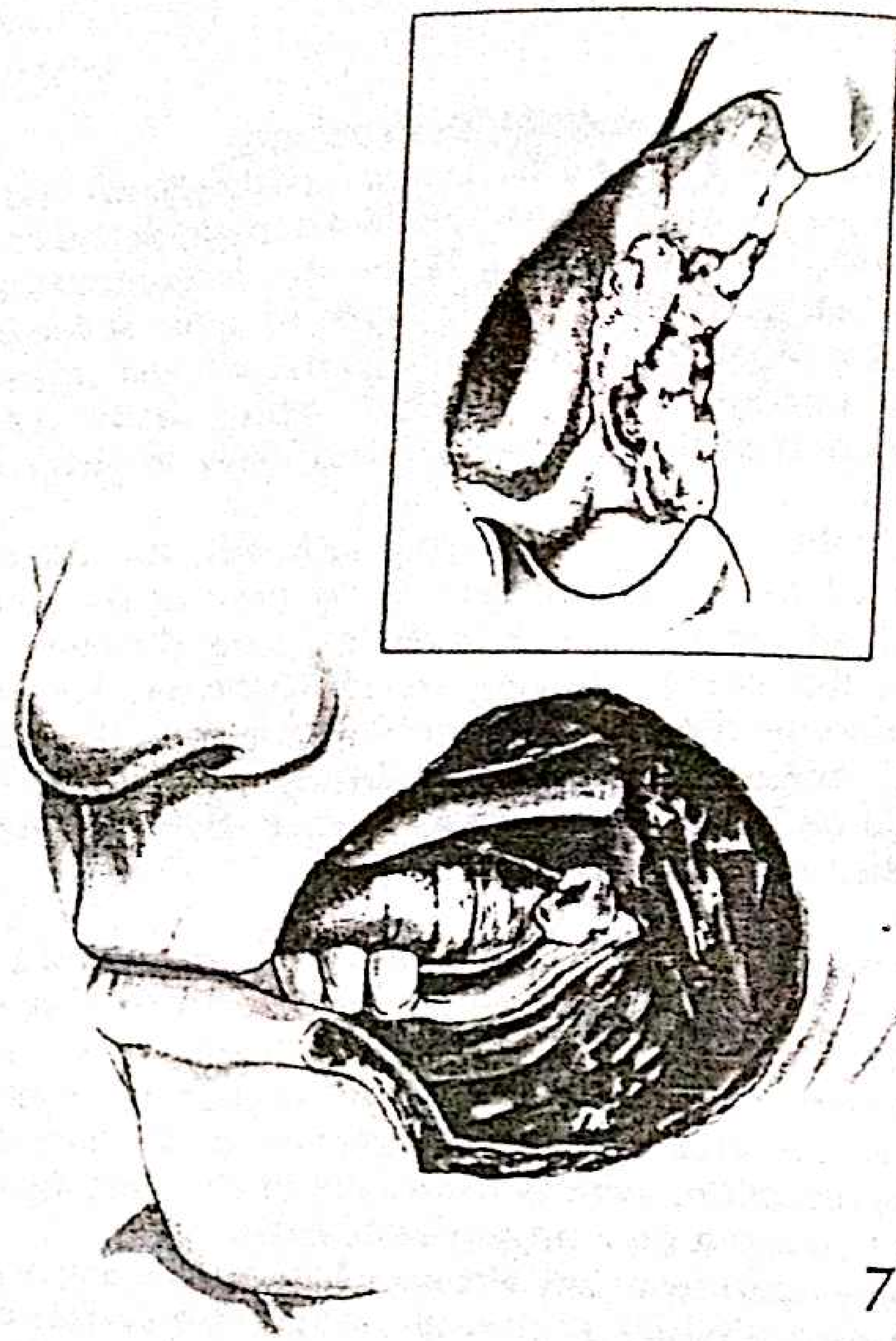
In clearing the tumour deeply the submucosal plane is the significant one. Even when infiltration has not reached it, clearance at that level is convenient, the plane being a relatively avascular one. Excision at a more superficial level has no real advantage. It is when a deep ulcer is present with fixation to the muscle that clearance in depth becomes more difficult, resection of a proportion of the thickness of the muscle being required, up to and ultimately including the skin if it is considered to be involved.

When the tumour extends up to and beyond the upper buccal sulcus the resection has to be extended correspondingly. Tumour may extend to this site from the hard palate/upper alveolar site as well as from the buccal mucosa, and its management is discussed in the chapter on 'Upper alveolus and palate', pp. 283–296.

Extension to the mandible is managed according to the findings at operation, with mandibular resection extending from rim resection increasing up to resection of a segment of the entire thickness of the body and ascending ramus.

7

Extension anteriorly to the angle of the mouth, and beyond to the upper and lower lips, is managed by extending the resection in that direction to include elements of both lips. Deep infiltration has to be matched by an increasing depth of resection, ultimately involving and requiring resection of the full thickness of the cheek. The thickness of the tissue which separates the mucosa from the skin diminishes with passage forward towards the angle of the mouth, and full thickness defects tend most often to involve the anterior part of the cheek, often requiring resection of the angle of the mouth where skin and mucosa meet. When a full thickness resection is required, the use of a submandibular incision for exposure becomes unnecessary, exposure ceasing to be a problem, and local clearance becomes largely marginal.



7

The place of neck dissection

Tumours of the buccal mucosa are sufficiently distant from the neck nodes that the carrying out of a 'prophylactic' neck dissection along with resection of the primary tumour is not generally regarded as mandatory in the absence of palpable neck nodes.

The elevation of the submandibular skin flap which is used to expose the tumour site is carried out in the plane immediately deep to platysma and does not interfere with the submandibular nodal area, so that the pattern of lymph node spread, which in the first instance is predominantly to that group from the buccal mucosa, is not interfered with. Lymph node metastasis developing subsequently is managed by the standard radical neck dissection.

The buccal carcinoma which presents with associated palpable neck nodes at the outset is managed by resection as described above, with reconstruction of the defect as outlined below, coupled with a radical neck dissection. The primary tumour and the neck nodes are sufficiently separated from one another that in continuity dissection is not really feasible, unless a full thickness segment of the body of the mandible is being excised as part of the overall resection of the primary tumour.

Reconstruction

Resection of a buccal carcinoma results in a defect which can involve either the partial thickness of the cheek or one involving its full thickness, mucosa through to skin. The methods used to reconstruct each are quite different, the partial thickness defect requiring the provision of lining alone, the full thickness defect requiring replacement of both lining and skin. The planning of reconstruction is affected also by whether or not the defect involves the angle of the mouth and the adjoining upper and/or lower lip, and whether the resection has been extended to include alveolar mucoperiosteum, possibly along with underlying bone, of the lower and/or upper alveolus.

Management of the defect of angle and lips is discussed as a specific reconstructive problem (pp. 281–282). The main influence which resection of one or other alveolus process. The site of the mucosal resection line is also altered, but the reconstructing flap, regardless of its type, is usually still sutured to the mucosal resection line in its new site.

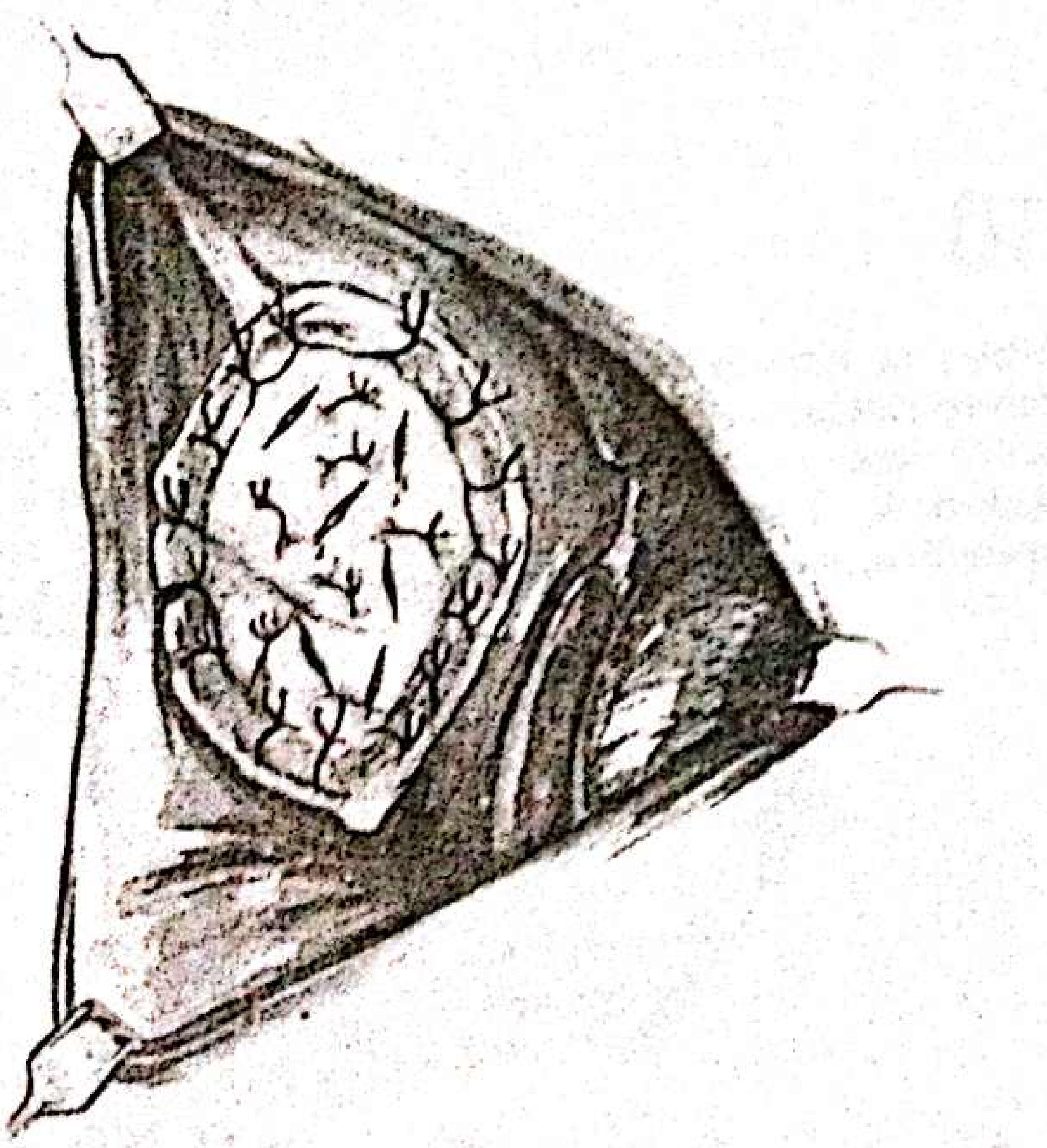
Partial thickness defect

In theory such a defect can be reconstructed by direct suture, by a free skin graft, or by a flap. A consideration which over-rides all others in making the choice is whether the reconstruction will result in the creation of trismus, either immediately or subsequently. Apart from the functional disability which trismus causes, it prevents the adequate examination of the entire oral cavity which is essential if such patients are to be followed up properly, in the search for both local recurrence and fresh tumours.

Direct suture has the effect of reducing the total area of buccal mucosa and with the need to avoid trismus its role must be a minimal one. The small defect might be viewed as suitable because the reduction in area is minor, but the principle is a bad one.

Free skin grafting suffers from the same unsatisfactory features, although to a lesser degree. The graft will be split-skin in type and split-skin grafts are recognized to contract secondarily. It is this characteristic which creates the problem. If the defect is small and does not extend to either buccal sulcus, the loose texture of the submucosal layer and the resulting mobility of the mucosa may compensate a little for contraction of the graft, with little or no trismus resulting. Nonetheless, as with direct suture, the principle is not a good one.

A further hazard which tends not to be mentioned when the possibility of grafting is being discussed in this context is the penalty of graft failure. The site is technically a difficult one to graft with consistent complete take, partial failure and even total loss of the graft being a regular occurrence. In other intraoral sites the final result after partial take is often acceptable; in the buccal area it is not. The result is inevitable and intractable trismus, which requires to be corrected surgically with replacement of the graft by a flap.



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8

When the defect is considered suitable for grafting, the quilting technique, described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240, is the one most likely to result in consistent maximal graft take.

When the defect reaches one or other buccal sulcus, the mobility of the mucosa is exchanged for the deep fixity of alveolar mucoperiosteum, ruling out the possibility of compensation, and in the process completely ruling out the free skin graft as a possible method of reconstruction because of the inevitable trismus which will follow its use.

Flaps, pedicled or in the form of a free flap, do not contract secondarily and they provide the method of choice for most buccal defects. In selecting a suitable flap an important consideration is the need to match the thickness of the flap to that of the tissue excised from the cheek. The thickness of the cheek is not great and a thin flap is generally to be preferred. When the cheek defect involves its full thickness, flap thickness as a factor of importance is redoubled, the thickness not merely of the flap providing lining but also of that providing skin having to enter into the surgeon's calculations. The effect for practical purposes is to rule out the use of myocutaneous flaps. The bulk of muscle added to that of their skin component makes them unacceptable.

Considered purely on grounds of thickness, the flaps which use the skin of the neck would be suitable, but in considering their suitability, pathological considerations also arise. The neck is the site to which buccal carcinoma metastasizes, and the trend in most centres has been to avoid using the neck skin for reconstructive purposes in the context of head and neck malignancy.

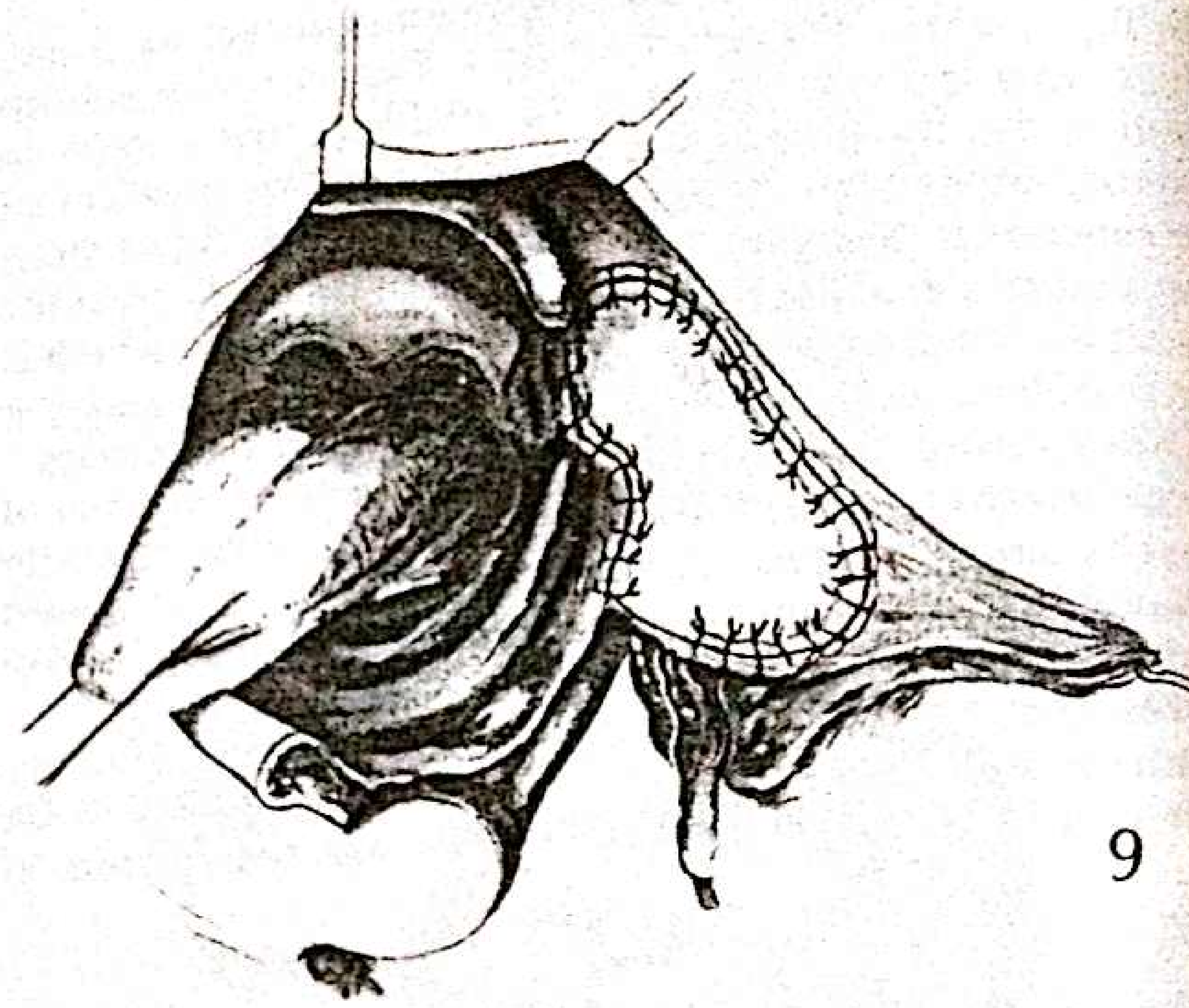
As with many reconstructive problems involving the oral cavity, decisions today depend very much on whether or not the surgeon has the facilities and the microsurgical expertise to carry out free flap transfers.

9

The free flap suitable for use in the defect of the buccal mucosa is one of the fasciocutaneous group, these being the ones whose thickness most nearly matches that of the defect. The differences between the alternatives are marginal and the one selected is likely to be that with which the surgeon has the greatest familiarity. The radial forearm flap is probably the most frequently used. It carries the convenience of not requiring the turning of the patient and has vessels of a large calibre.

The alternatives to free flap transfers are pedicled flaps, and those with a suitable thickness and sufficiently close to the defect are the deltopectoral flap and the forehead flap, the former introduced into the mouth through a submandibular portal, the latter tunnelled through the cheek.

The deltopectoral flap, although it no longer holds the position which it once had in intraoral reconstruction, remains an effective reconstruction for the defect of the buccal mucosa. Its route of entry into the mouth depends on whether the tumour has been excised intraorally or a submandibular flap has been used for access.



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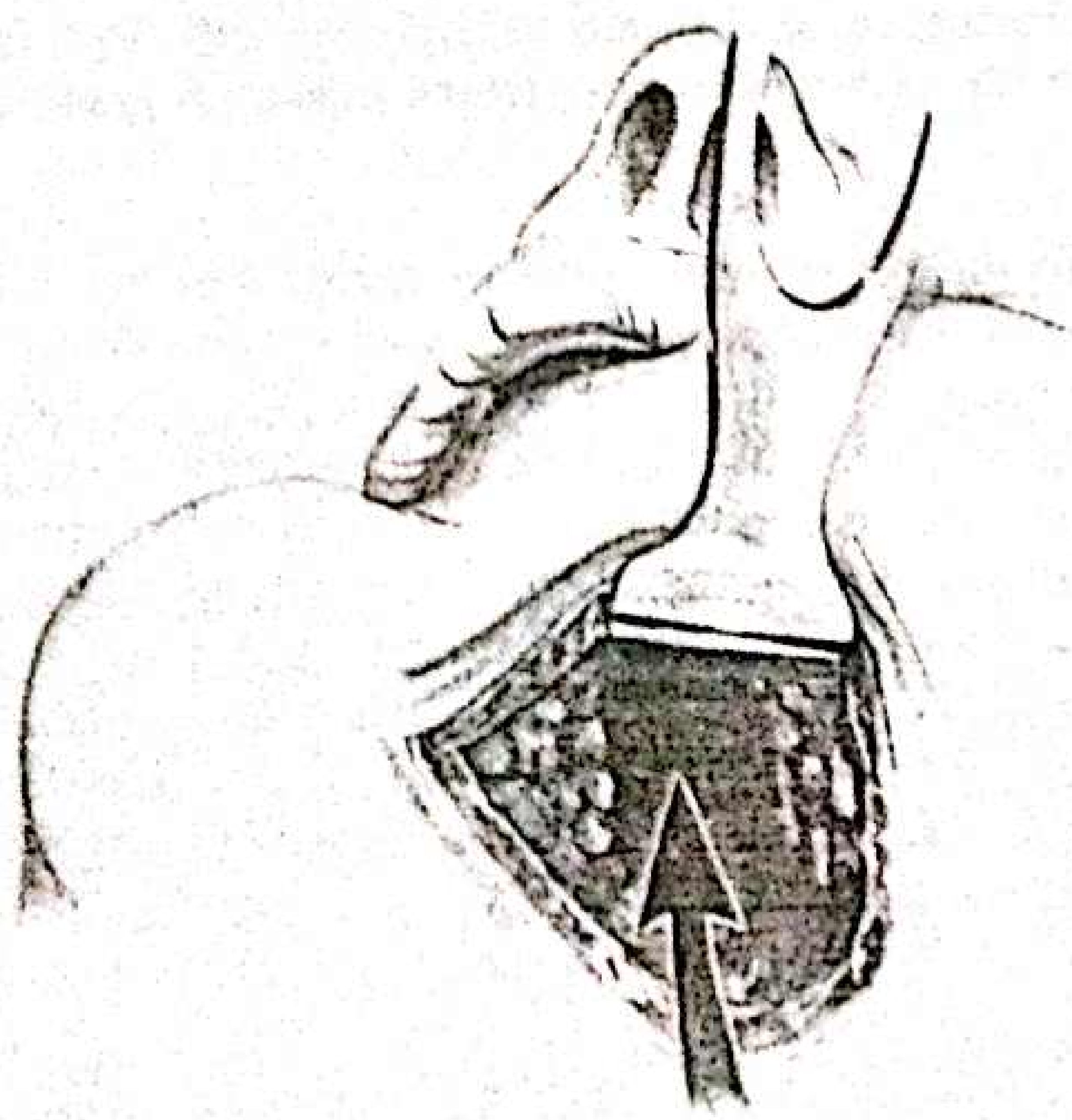

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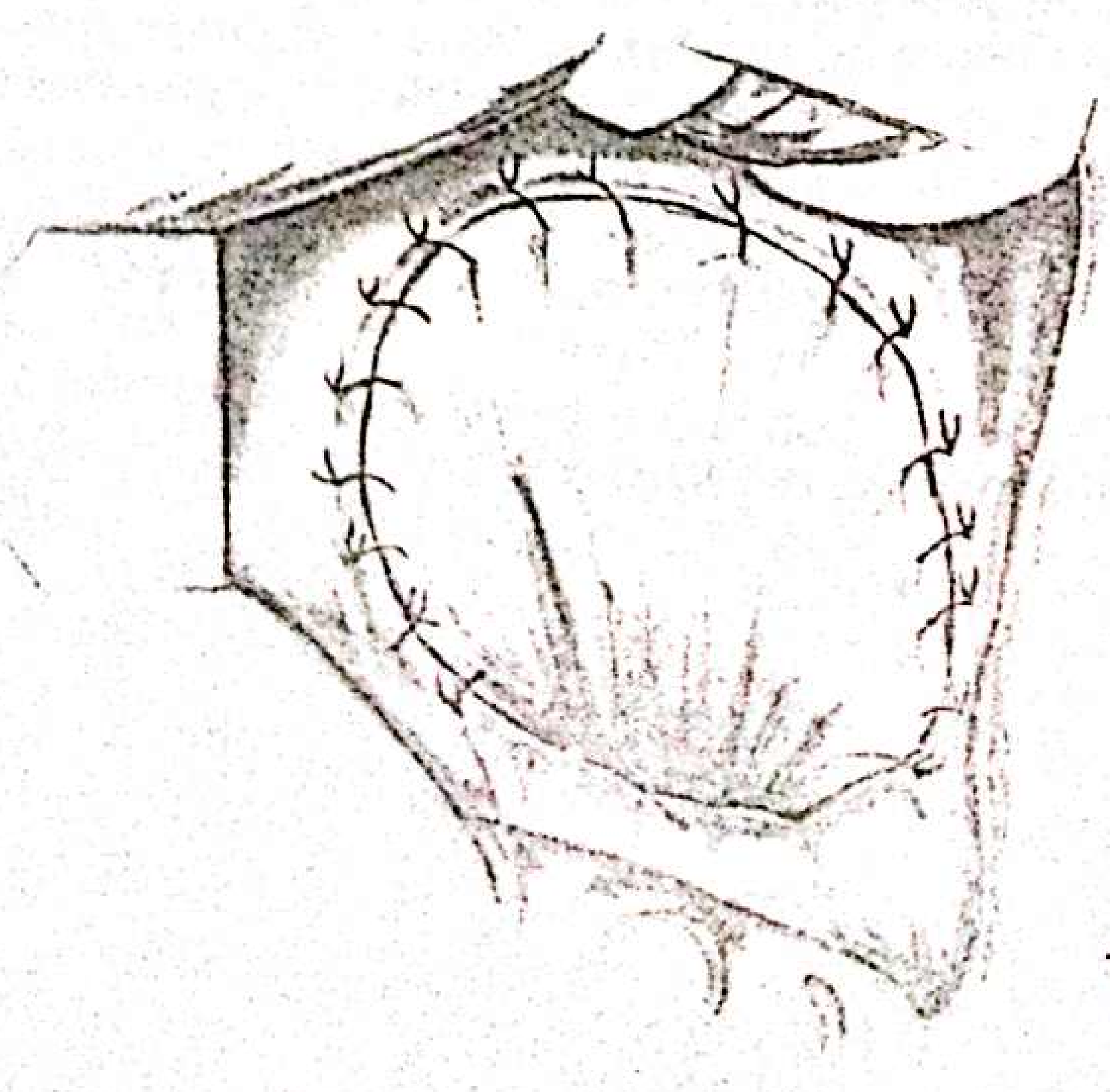
When the tumour has been excised entirely intraorally, a tunnel can be constructed using a skin incision parallel to and a little below the lower border of the mandible. The tunnel is then dissected upwards superficial to the mandible, reaching the lower margin of the defect.

11

The deltopectoral flap is fed through the tunnel and sutured to the margins of the defect.

The flap is divided 3 weeks later, its bridge segment is returned to the chest, and the skin incision used in making the tunnel is closed. It is not necessary to suture the divided flap inside the mouth as a separate layer.

In practice the tumour whose excision leaves a defect large enough to require reconstruction with a flap can rarely be resected with an adequate degree of precision using an entirely intraoral approach, and the tunnel method is seldom appropriate.



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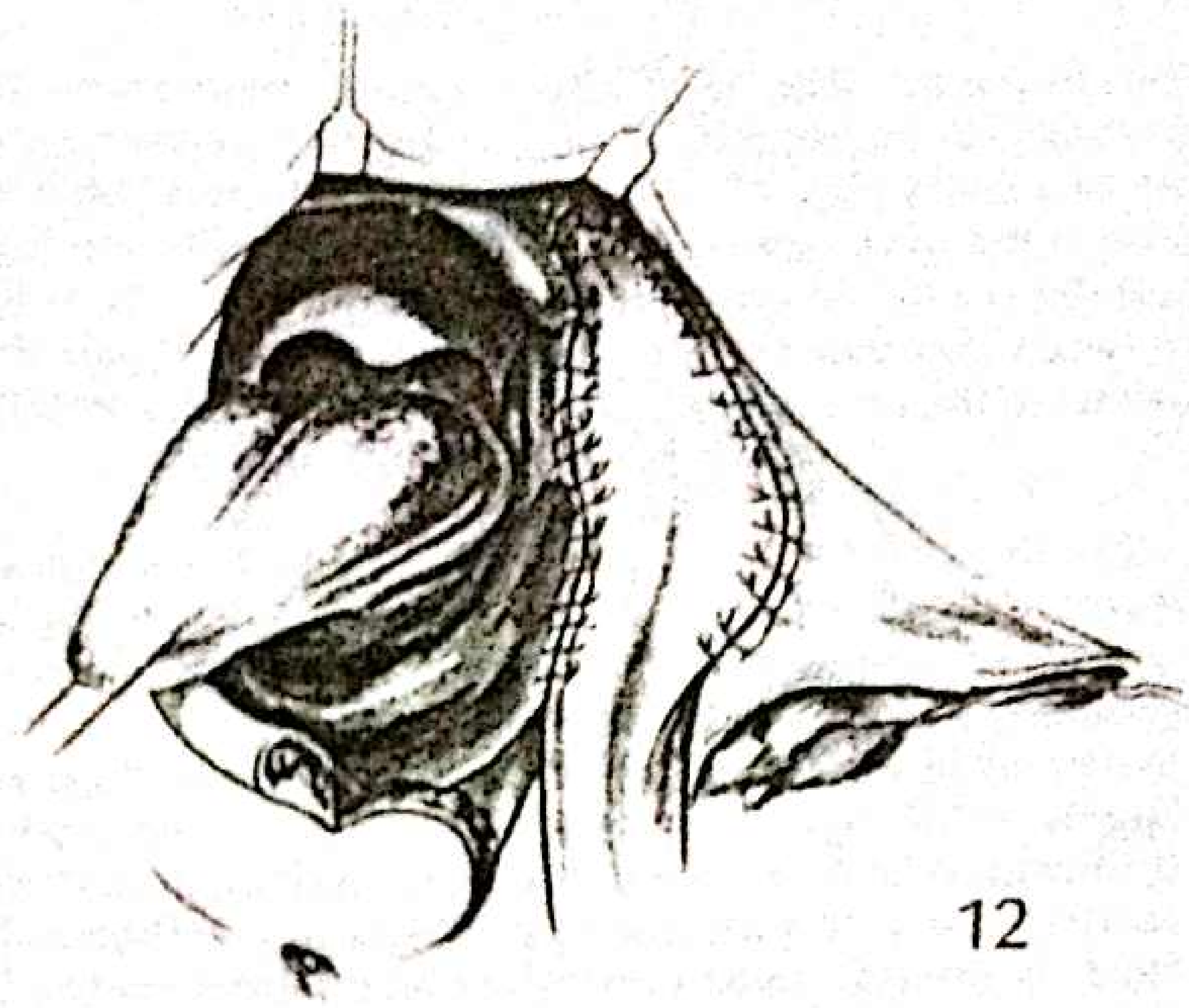
When a submandibular flap has been raised, it is used as the portal to the defect in the mouth. In order to withstand the effects of gravity on the flap, it is desirable to suture its distal end to a fixed structure inside the mouth, such as the alveolar mucoperiosteum, even if this entails excising mucosa up to the upper buccal sulcus, beyond the resection required to clear the tumour marginally.



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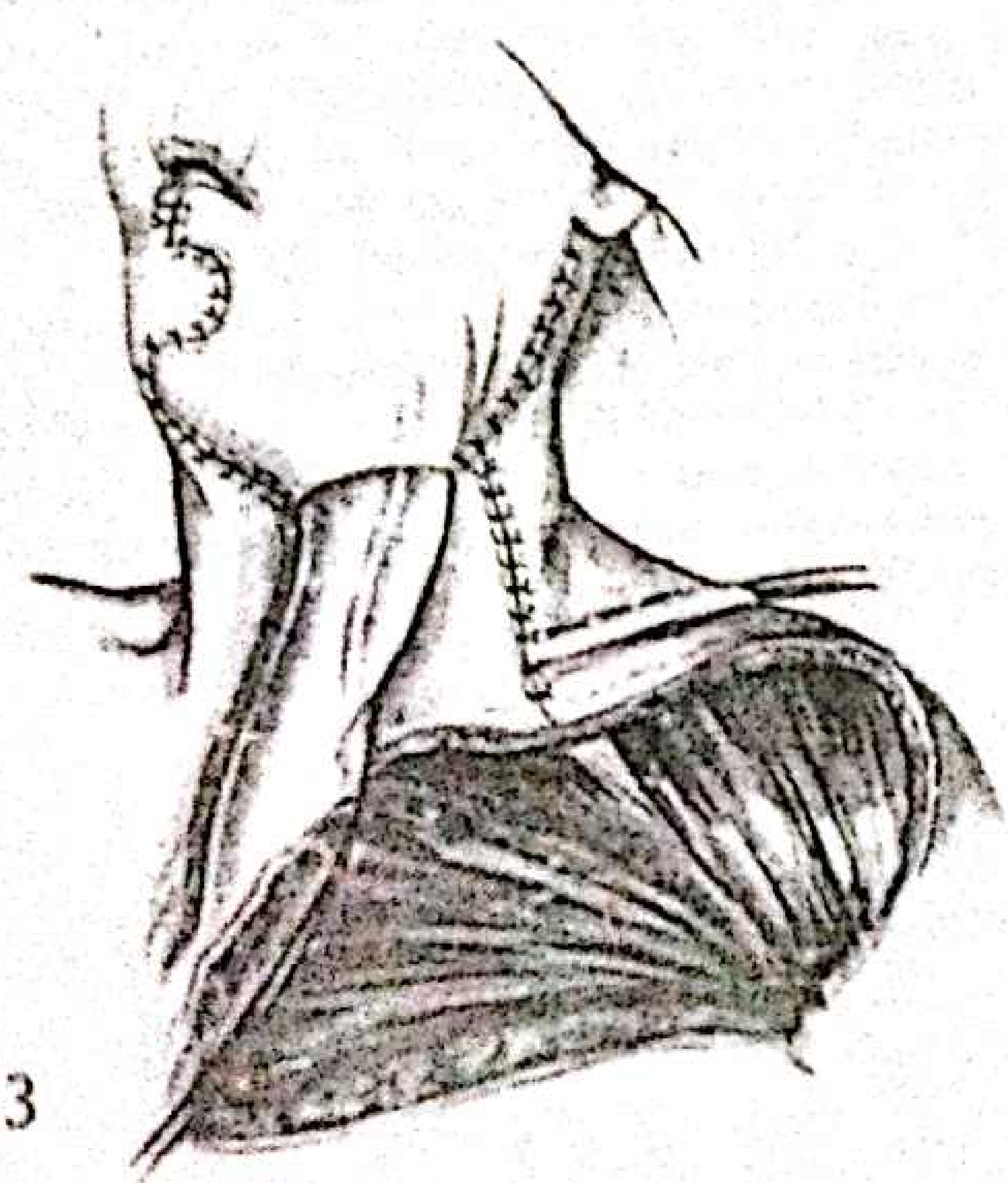

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The presence of the flap prevents the submandibular defect from being closed completely and, even when its pedicle has been divided with return of the bridge segment to the chest and completion of insetting inside the mouth, a permanent fullness of the submandibular area generally remains. With its downward drainage, the deltopectoral flap is less prone to the problem of haematoma collecting deep to it, but even so it is probably advisable to insert a suction drain to ensure that it adheres deeply.

The flap is divided 3 weeks after the initial transfer and its bridge segment is returned to the chest.

14

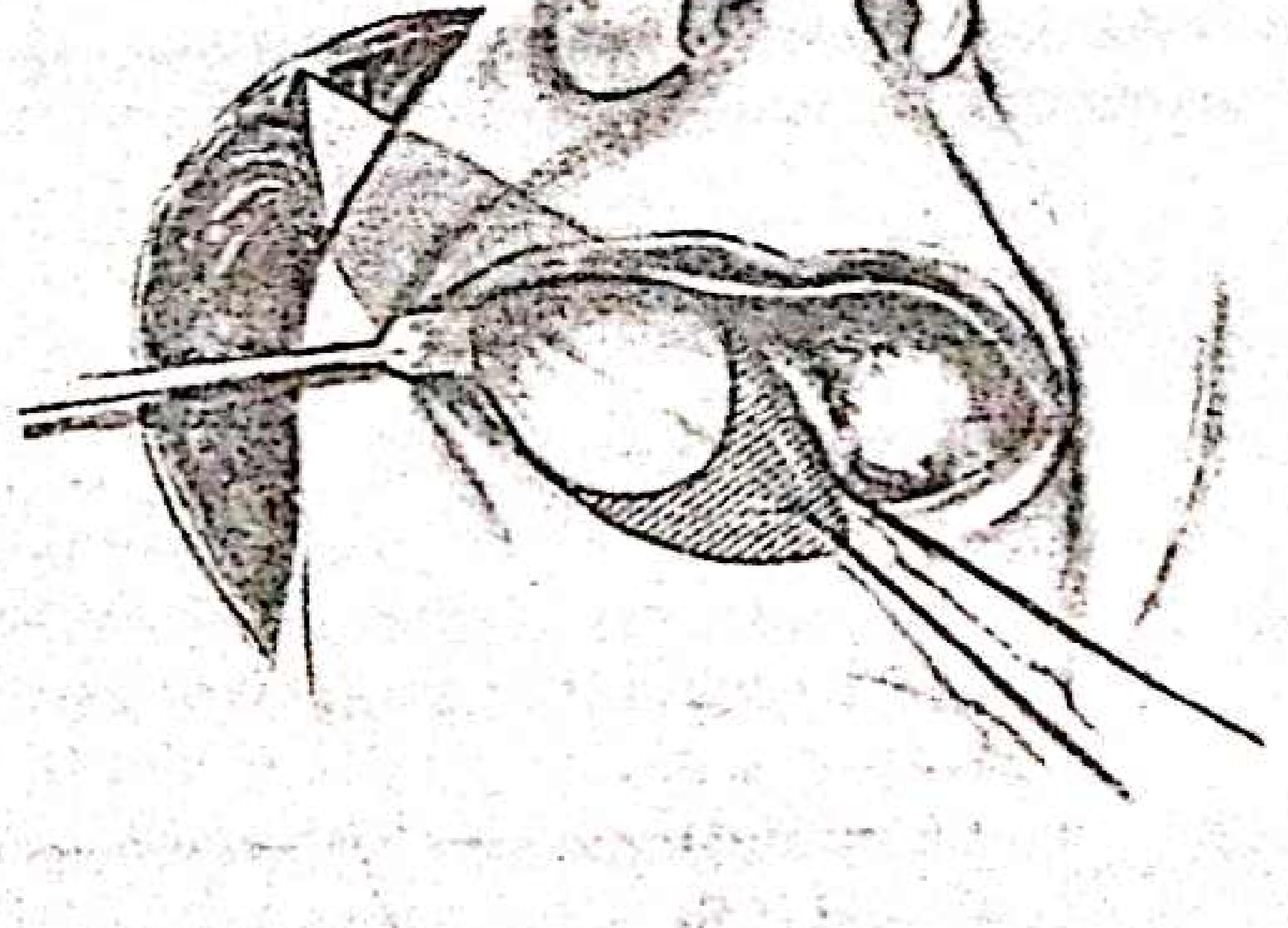
The forehead flap is laterally based, transferred as described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240. A problem which is liable to arise is the occurrence of a haematoma between the flap and the cheek. To prevent this a suction drain with its tip between the two surfaces can be inserted through the tunnel in the cheek used to bring the flap into the mouth.

14

The fact that both of these reconstructions involve two stages may be considered by some surgeons to be an unsatisfactory aspect, although the final result achieved generally matches that obtained using a free flap. From the point of view of their effectiveness the two flaps are largely comparable, but the appearance of the grafted forehead, unavoidable with the forehead flap, is unacceptable to many. It is increasingly viewed as a method to be held in reserve, used only when alternatives cannot be used, or have been used and failed. For those communities where the forehead is still regarded as an acceptable flap source, however, the method is a satisfactory one giving excellent results.

A marginal extension of the tumour which may complicate reconstruction is to involve the upper and/or lower alveoli. To what extent the primary reconstruction should attempt to restore the *status quo ante* as regards any bony defect is questionable, particularly as regards an upper alveolar defect. The flap used to reconstruct the lining of the cheek should merely be sutured to the margin of the upper alveolar defect. No attempt is made to restore the buccal sulcus at this stage in the reconstruction, and in practice it often remains unrestored permanently.

The question of attempting reconstruction of any mandibular defect is a more complex one and is dependent on the local facilities and the reconstructive expertise of the surgeon. The management of the mandible, its conservation, the use of rim resection, the retention of the segment of the ascending ramus posterior to the lingula, and the replacement of the resected segment of the body by vascularized bone when the tumour is medial to the mandible, as discussed in the chapter on 'Tongue, lateral floor and lower alveolus, faucial area and retromolar trigone', pp. 297–325, apply equally to the mandible involved by tumour approaching from the buccal mucosa, except that the approach is from lateral rather than medial. The possibility of a simultaneous reconstruction of soft tissue and mandible has also become a reality, using vascularized bone transferred as a composite with a free skin flap.



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Partial thickness angle defect

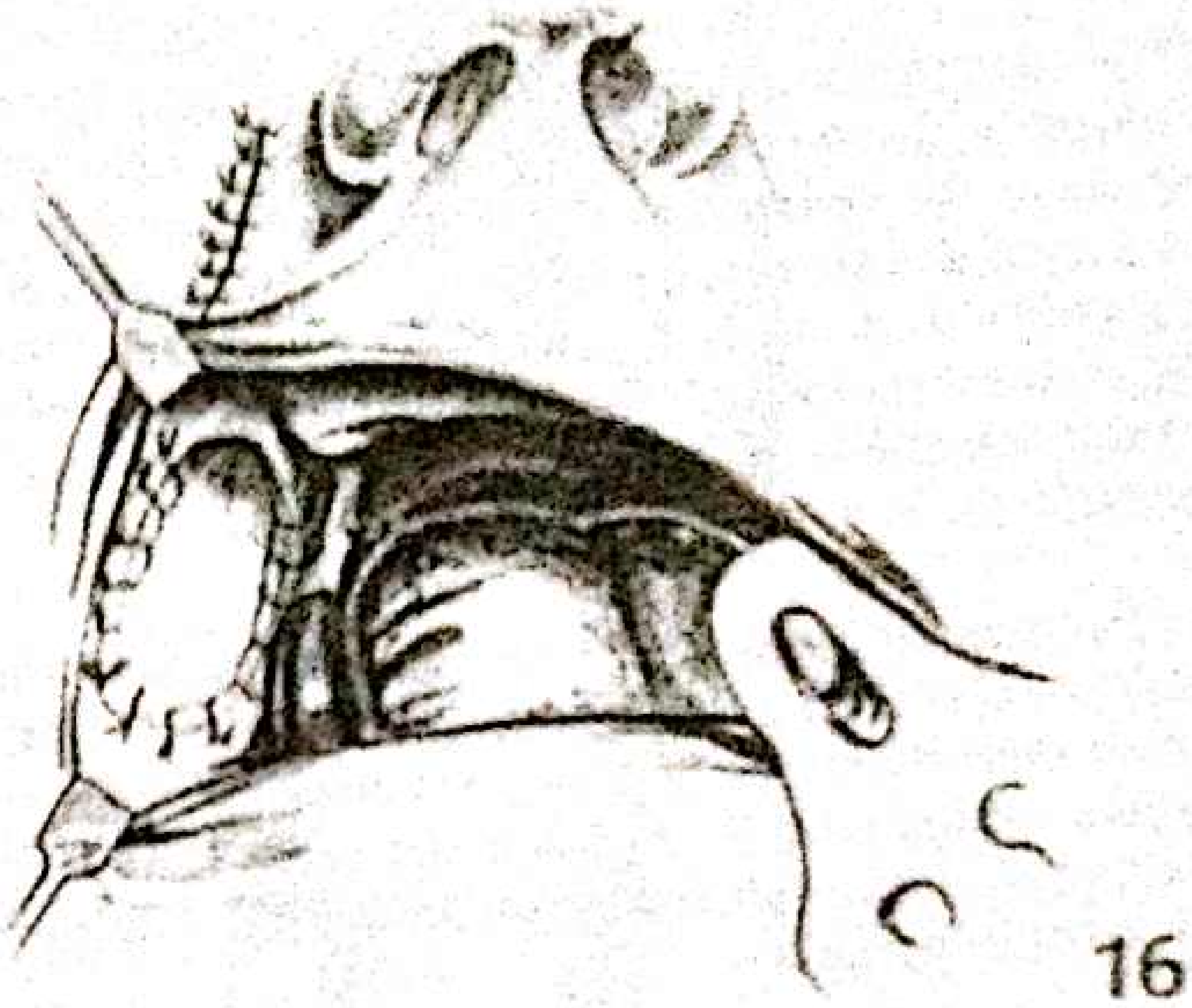
15

This defect can conveniently be reconstructed using an island nasolabial flap tunnelled through into the oral cavity as described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

16

The use of the flap as an island is possible because the defect is in continuity with the tunnel through the cheek, and it makes the reconstruction a single-stage one.

The same flap can also be used to reconstruct small mucosal defects within its reach, whether of the buccal mucosa or the upper and lower lips.



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Full thickness cheek defect

Reconstruction of the full thickness defect of the cheek requires the provision of both lining and skin cover, and the reconstruction may be complicated by extension of the tumour to involve the angle of the mouth and the adjacent lips, and/or extension of the tumour to involve the body of the mandible to the extent that its resection is required. The management of the problems posed by both extensions is discussed as a separate issue.

When the alternative methods of reconstructing the full thickness defect are being compared it is desirable, as already stressed, that the reconstructed cheek should match the thickness of the normal cheek. This largely confines the selection to fasciocutaneous flaps, free or pedicled.

In the case of a pedicled flap the temptation to use a single flap doubled on itself to reconstruct both surfaces should be resisted. There is no doubt that this is possible and there are published papers to prove the point, but the results achieved in terms of cosmesis have been consistently inferior to those obtained when two flaps are used, one for each surface, with an independent source for each. This is particularly so when, as is often the case, the defect includes the angle of the mouth.

As with so many reconstructive problems today, the methods likely to be used depend on whether the surgeon has the facilities and expertise to use a free flap.

17

17

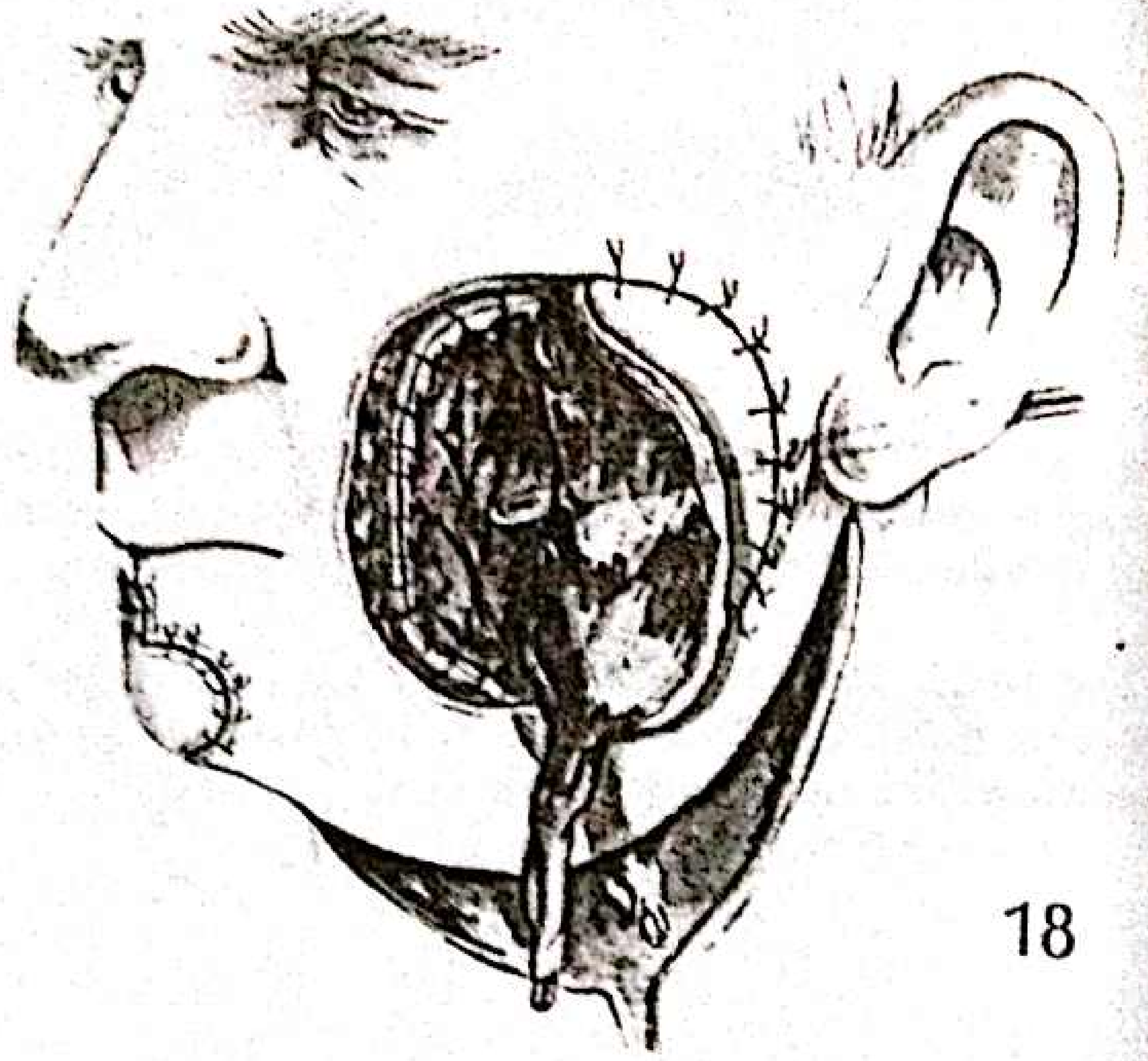
For the surgeon whose repertoire includes microsurgery, any of the available fasciocutaneous free flaps are capable of being used. This increases the potential permutations considerably, with the alternatives of using free flaps for both lining and cover, a free flap for one surface, mucosal or skin, and a pedicled flap, probably deltopectoral, for the other. As already remarked, the free flap used is likely to be selected on the basis of familiarity rather than any specific virtues which it is alleged to possess. The currently popular free flaps, radial forearm and scapular, are both capable of being transferred as a composite along with a segment of vascularized bone from the radius and scapula, so that each is capable of providing simultaneous replacement of a mandibular segment resected as part of the overall tumour excision.

In the case of a free flap it is possible to design it in the form of two islands, sharing a common perfusion source, and such a design can provide lining and skin cover simultaneously. The single perfusion source, however, means that any vascular mishap will involve the entire reconstruction, lining and skin cover. The use of two sources spreads the risk, and is more likely to leave a situation which can be salvaged should one flap necrose.

18

The vascular anastomosis apart, the use of free flaps simplifies the local reconstruction from a technical point of view, the lining flap sutured to the mucosal resection line, and the skin cover flap to the skin resection line. It is desirable to have early and effective adhesion of the two flaps to one another, and to this end the use of a suction drain, carefully placed to avoid injuring the vascular pedicle(s), is essential.

The use in combination of a free flap as lining, with a deltopectoral flap to provide skin cover, might well commend itself as reducing the number of microvascular anastomoses required with a corresponding reduction in operating time, but the decision is very much one for the individual surgeon.



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In the absence of the capacity for free flap reconstruction, the most generally applicable reconstruction makes use of a forehead flap for lining and a deltopectoral flap for cover. The disadvantage of the skin graft on the secondary defect of the forehead has to be accepted but, allowing for that, the final result can be an excellent one, the thickness of the reconstructed cheek matching the normal very well.

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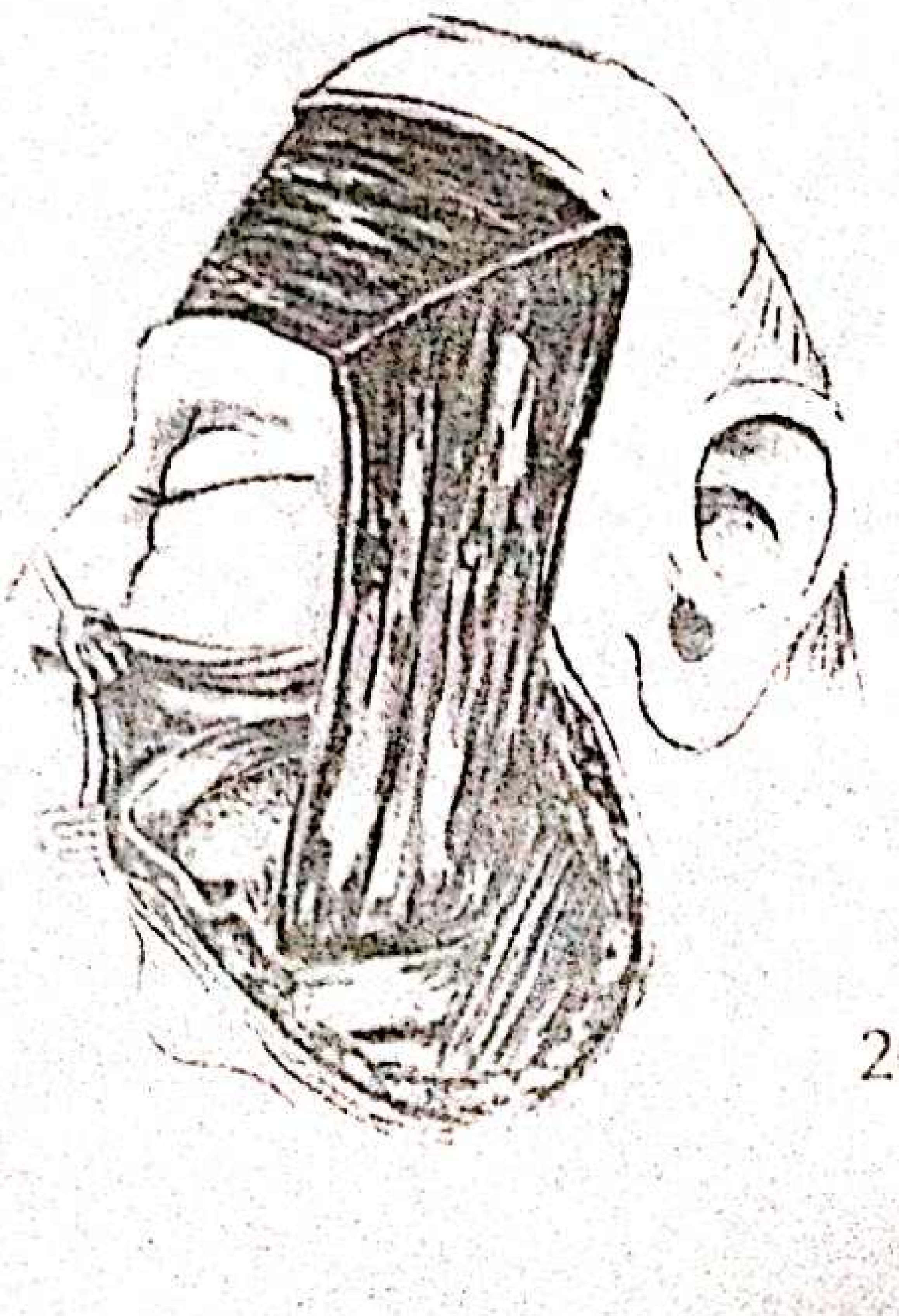
The standard design of forehead flap, hinged along the line of the zygomatic arch and turned down, lies conveniently along the defect, rarely requiring a tunnel. With the flap sutured to the mucosal margins of the defect any fistula is posterior and there is no leakage.



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The deltopectoral flap is sutured to the margins of the skin defect except where the forehead flap is approaching the mouth. If the flaps heal well marginally and adhere to one another quickly it is generally safe to divide both pedicles at 3 weeks, returning each bridge segment to its donor site and completing insetting.

21

Angle of the mouth

When the angle of the mouth has been resected with a segment of the adjoining upper and lower lips as an extension of a full thickness cheek resection the temptation to reconstruct the angle immediately, as described in the chapter on 'Lips', pp. 105–123, using an Abbe–Estlander flap, should be resisted, even though it restores the continuity of the oral sphincter and on that score has certain attractions. With a large cheek defect immediately lateral to it, the angle reconstructed in this way lacks the dilator component which is present when an Abbe–Estlander flap is used in the standard manner and which holds it laterally. As a result the reconstructed angle drifts medially, creating a distortion which is difficult to correct subsequently.

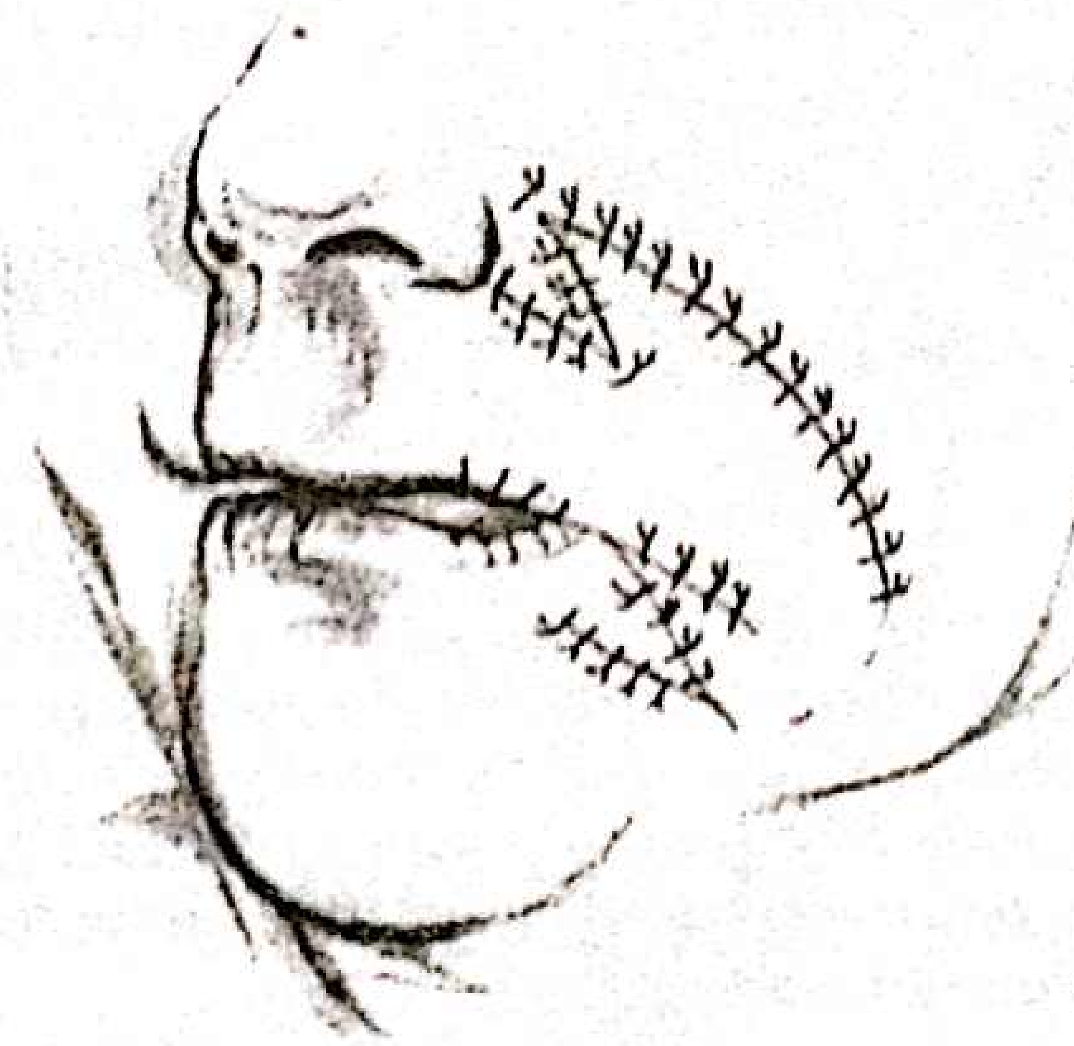
22

22

More effective in the long term is to suture together the cut red margins of the two lips, creating a new angle to the mouth in an abnormally medial position, and accept the asymmetry of the mouth as a temporary measure. This allows the cheek defect to be reconstructed using one of the methods already described.

23

When the postoperative reaction has settled and the tissues have softened, the asymmetry of the mouth can be accurately gauged with the patient awake and it is possible to see how much extension laterally of the angle will be required to restore resting symmetry of the mouth. The relevant markings can be made on the skin before the patient is anaesthetized and the lining and cover flaps divided as far laterally as necessary. The free margins of the divided flaps will of course lack a vermilion, but this can be restored with a horizontally positioned V-shaped tongue flap from the adjoining lateral margin of the tongue using the technique described in the chapter on 'Lips', pp. 105–123. Even when a tongue flap has been used to provide cover for the raw surface in this way, a degree of contraction occurs bringing the reconstructed angle a little medially. The initial incision used in moving the angle laterally should be extended a little beyond the estimated final position to allow for this. Coincidentally with the repositioning of the angle, the opportunity can be taken to carry out any scar revisions considered necessary around the margin of the flap reconstructing the skin defect, incorporating Z-plasties if appropriate.



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When the resection of the entire thickness of the cheek has been extended to include a segment of the body of the mandible, the reconstruction appropriate to the defect depends on whether reconstruction of the resected mandible is part of the plan.

If it is intended to reconstruct the bony defect, the management of the soft tissue element does not differ significantly from that already outlined for the full thickness cheek defect, except that one of the flaps, probably the lining flap, has to be a composite one, incorporating both bone and skin, in order to restore bony continuity and provide mucosal replacement.

When it is not intended to reconstruct the bony defect, the thickness of the defect becomes markedly increased, and the form the reconstruction should take has to be altered to take account of the added bulk of the defect. The flaps capable of providing the necessary bulk are the myocutaneous flaps, latissimus dorsi, used either as a free or pedicled flap, and pectoralis major. These flaps, used to line the defect, are likely to give the best ultimate symmetry to the face, using one of the fasciocutaneous flaps to provide skin cover. Both myocutaneous flaps have been used to reconstruct both lining and skin cover as a single flap, and there is no doubt that this is technically possible. Whether it is capable of providing the best final result is less certain.

Upper alveolus and palate

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

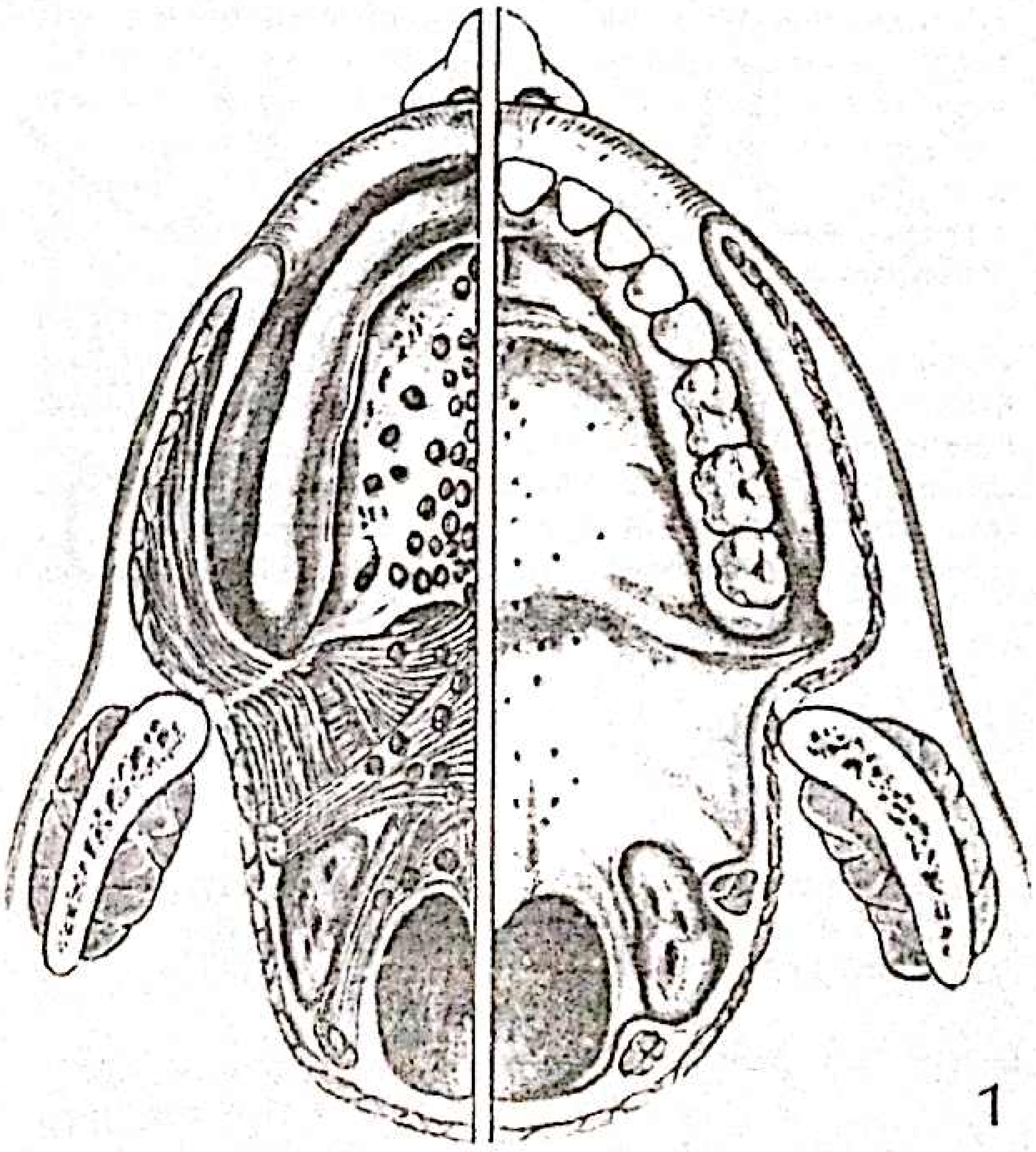
Anatomical considerations

1

The hard palate has a three-layered structure, with a layer of bone sandwiched between oral and antronasal mucoperiosteal layers. On its oral surface the bony layer is rough; its antronasal surface is smooth, the difference reflected in the comparative ease with which the mucoperiosteum can be stripped off the two surfaces. The two components of the mucoperiosteum, mucosal and periosteal, behave surgically as a single structure.

The soft palate maintains the three-layered structure of the bony palate, a musculo-aponeurotic layer replacing the bone. On both surfaces, nasal and oral, the mucosa passes from the hard to the soft palate with little change in surface appearance. Minor salivary glands are widely distributed in the submucosa of both the hard and the soft palates, their orifices visible on the surface of the mucosa, particularly around the junction of the two.

In the dentate maxilla, the second premolar and the first two molars extend through the full thickness of the alveolus, their apices lying under the mucosa of the antrum. In the edentulous alveolus, there is resorption of the bone of the occlusal ridge, with multiple defects along its line, comparable to those seen in the occlusal ridge of the edentulous mandible, described in the chapter on 'Tongue, lateral floor and lower alveolus, faucial area and retromolar trigone', pp. 297–325. The mucoperiosteal occlusal ridge in the edentulous patient has a rounded cross-section and a smooth surface; stripped of its mucoperiosteum the ridge is narrow with a sharp, irregular edge.



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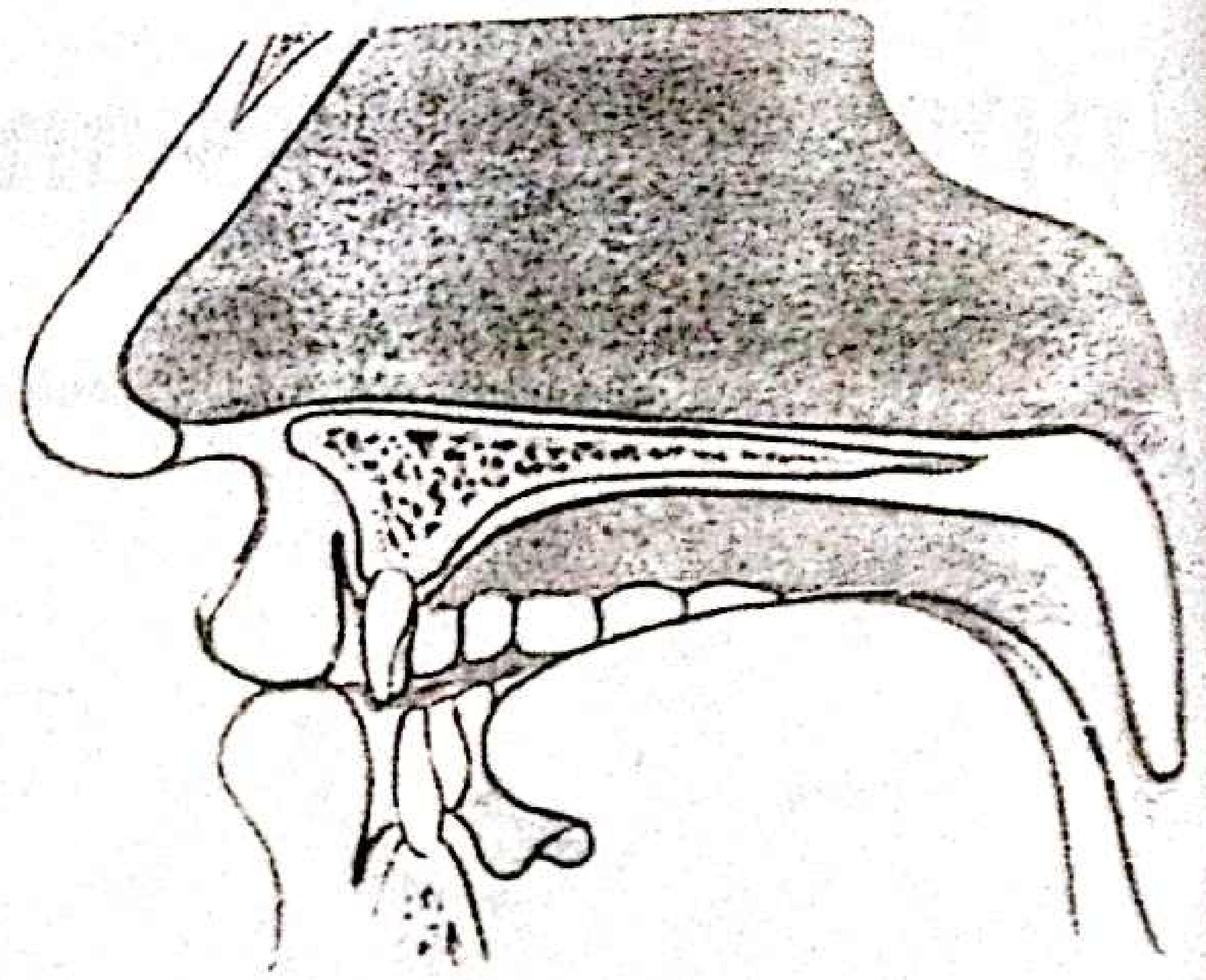
The thickness of the bony palate decreases as it passes backwards towards its posterior free border.



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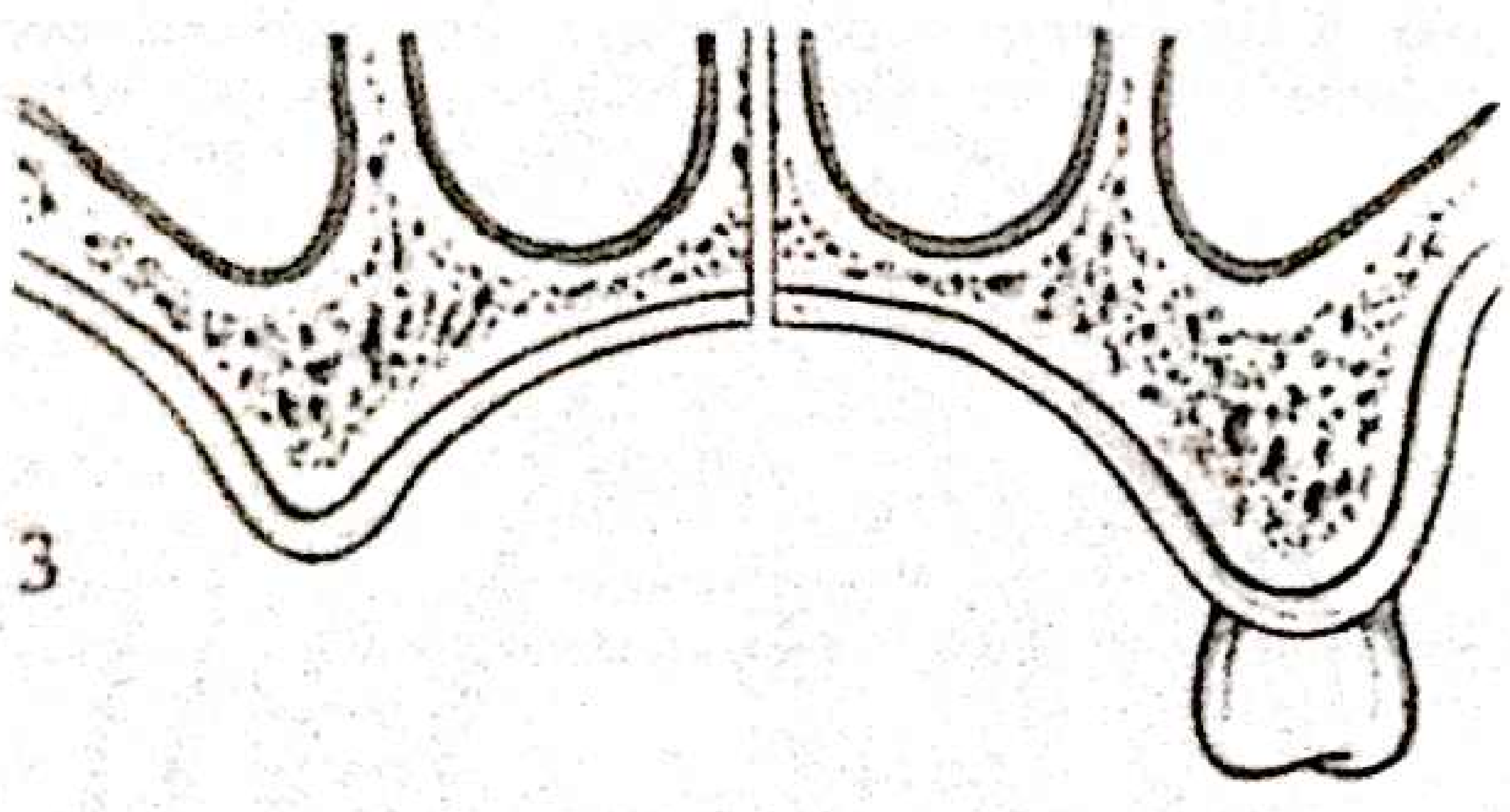

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In the coronal plane, the thickness of the bone also decreases from the alveolar ridge towards the midline, but superimposed on this are linear thickenings formed on its upper surface by the attachments of the nasal septum and the bony partitions, which separate the nasal cavity from the antral cavities on each side.

The bone of the palate is unusually vascular, to the extent that, stripped of its mucoperiosteal covering and left bare, it does not form a surface sequestrum, but granulates and heals from the margins of the mucosal defect. Its vascularity also makes possible successful split-skin grafting of defects in which the palatal bone is left exposed following the resection, a capability which is made use of in reconstructive surgery of the area.

Pathological considerations

The palatal area is not a common site for tumours, but those which occur most often are squamous carcinomas. The hard palate is also a recognized site for tumours of the minor salivary glands present in its submucosal layer, pleomorphic adenoma and adenoid cystic carcinoma being the types most often seen.

In their marginal spread, palatal tumours extend over the alveolar ridge onto the buccal sulcus and buccal mucosa, and backwards onto the soft palate and the area between the two, behind the maxillary tuberosity.

In spreading deeply, tumour involves the layer of cortical bone on the oral surface of the palate. The relative thinness of the palatal bone means that it has only to extend further for a short distance to reach the layer of cortical bone on its antronasal surface. Clinical experience, however, is that spread of squamous carcinoma through the full thickness of the bony palate occurs less quickly than one might expect considering the shortness of the distance involved, suggesting that the bone shows a degree of resistance to tumour spread. Involvement of the bone with squamous carcinoma, and its extent, are generally clinically obvious. The same cannot be said when the tumour is adenoid cystic carcinoma, spread of this tumour into and through bone being notoriously silent.

The anatomical characteristics of the bony palate, with its relatively small proportion of medullary bone in relation to its upper and lower layers of cortical bone, also appears not to be conducive to the rapid spread of carcinoma laterally, beyond the marginal extent of the tumour in the overlying soft tissues. Its extent in the bone is generally found to be less than that of the soft tissue component of the tumour immediately overlying it.

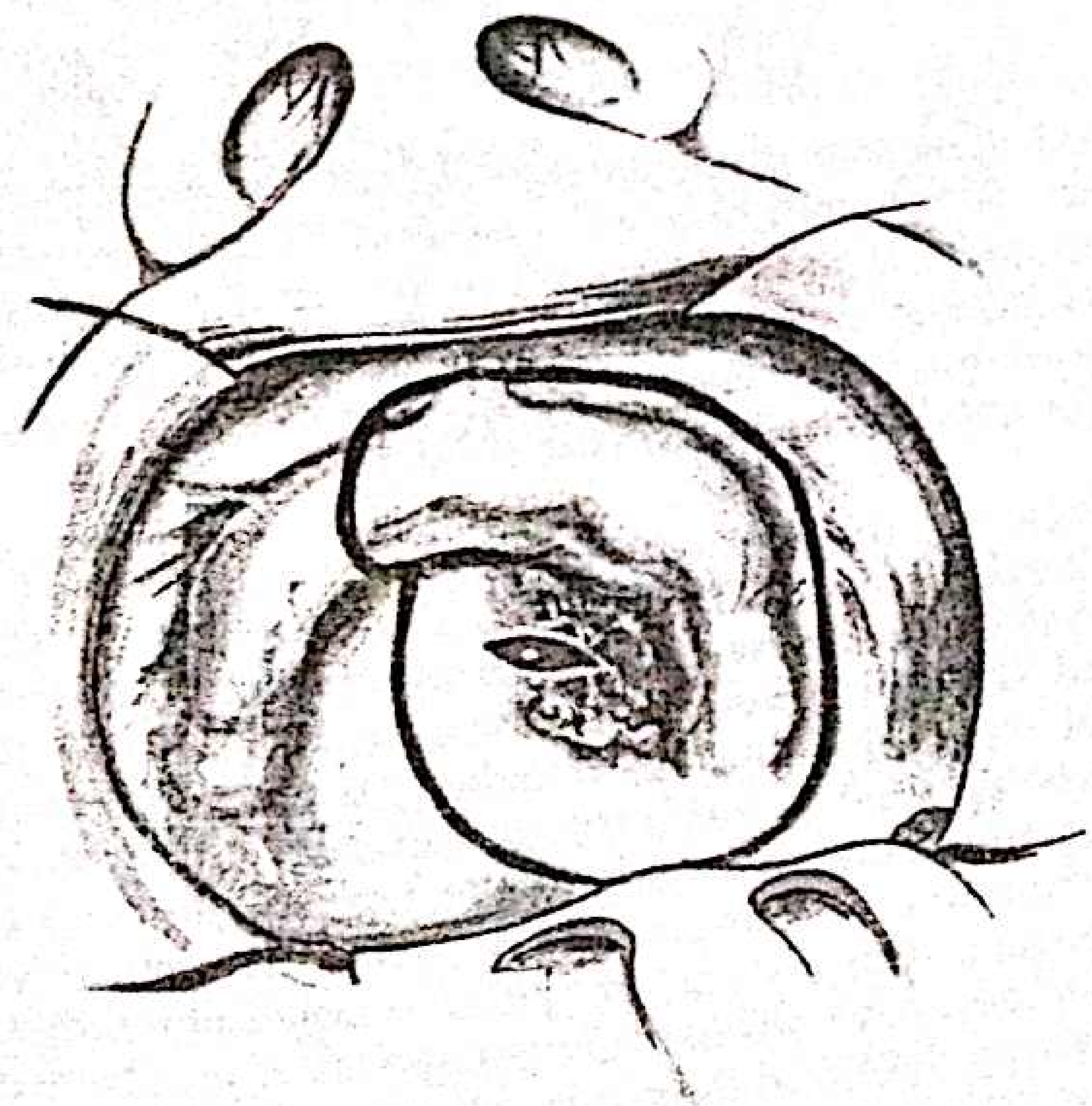
When involvement of the antronasal area is sufficiently extensive to constitute the major part of the tumour, it is managed along the lines described for maxillectomy in the chapter on 'Radical maxillectomy'.

Hard palate and alveolus

RESECTION

The method most frequently used to reconstruct the defect following resections involving the palate and upper alveolus is by split-skin grafting the defect. The technique of skin grafting, described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240, makes use of a modified denture, and a dental impression of the alveolus and palate, from which the denture is prepared, is taken preoperatively.

The standard surgical approach to the palatal tumour is through the mouth, gagged widely open. If the access which this provides is inadequate, the extensile approach used in the resection of the maxilla, splitting the upper lip, and continuing the incision as required round the alar base and upwards along the line demarcating nose from cheek, is likely to be the most useful.



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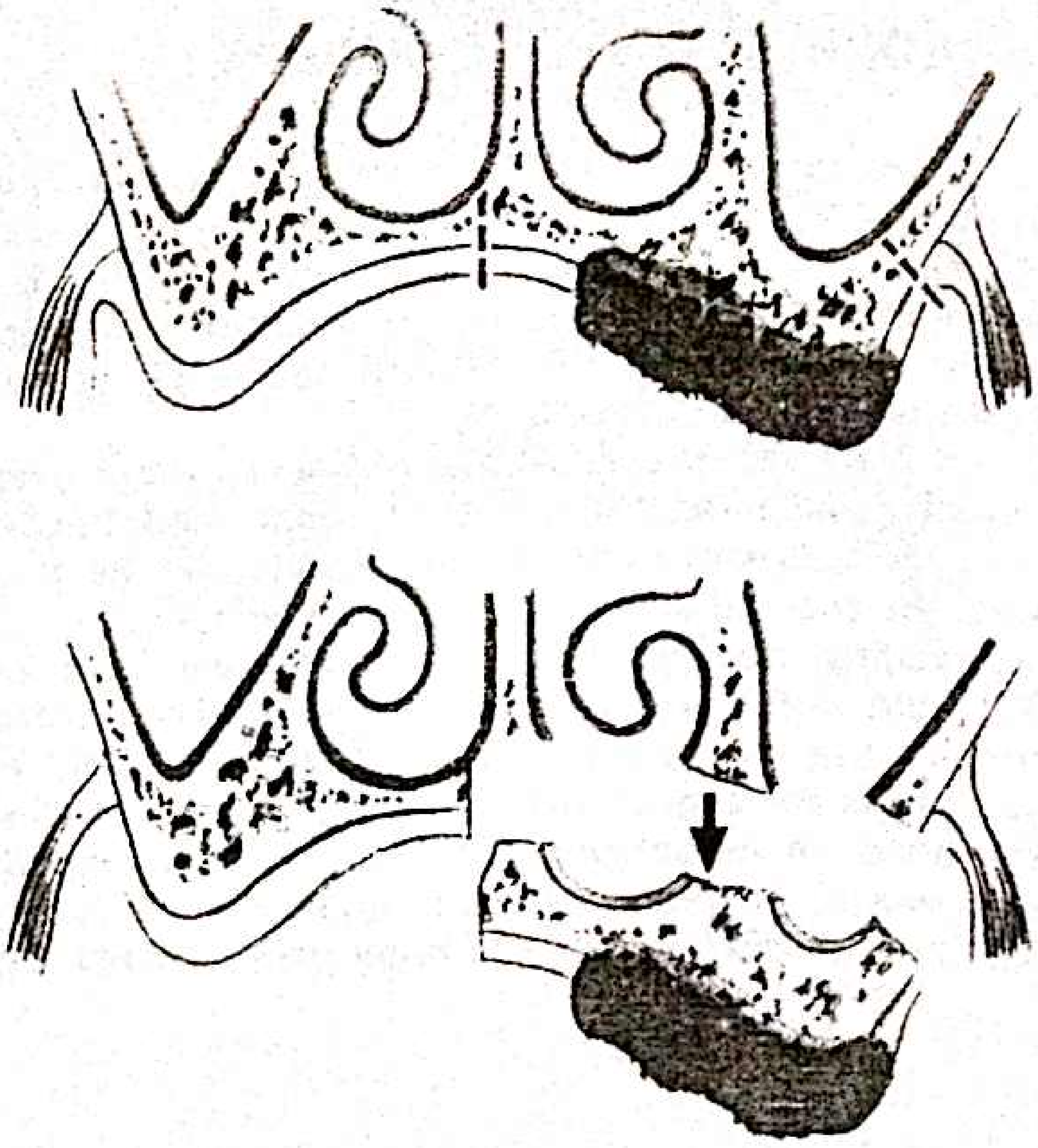
The line of marginal clearance of the tumour is marked on the mucosal surface of the palate, and along this line the mucoperiosteum is incised down to the underlying bone.

The ensuing resection can be carried out either monobloc or as a layered resection.

5

In monobloc resection the involved segment of the bony palate is resected together with its overlying mucoperiosteum, levered off as a single block. The block may strip from its attached antronasal mucoperiosteum or remove that layer also. If the mucoperiosteum remains in position, it is inspected for involvement by tumour and, depending on the clinical assessment, resected or left alone.



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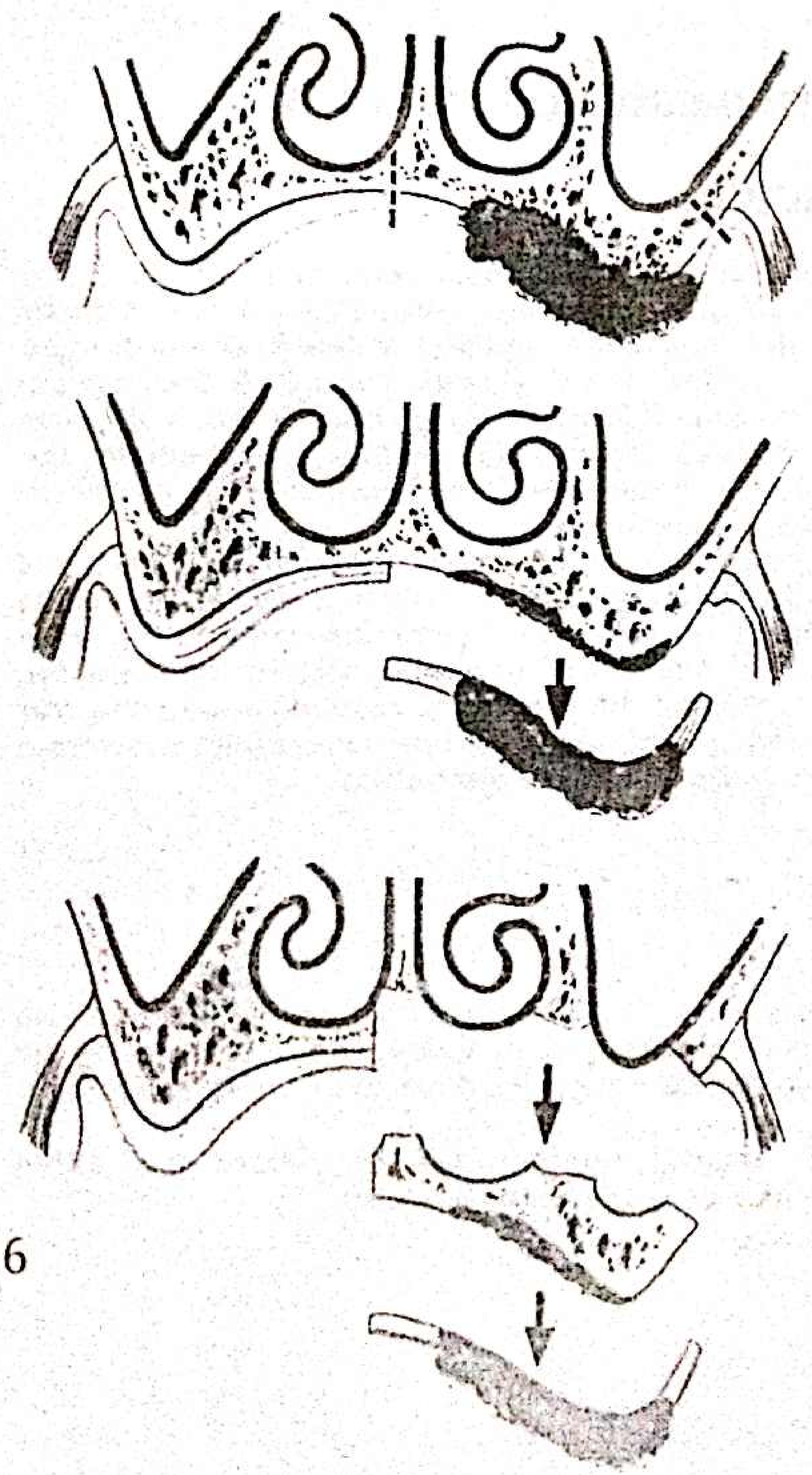

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Layered resection involves removal of the various layers *seriatim* as the pathological situation dictates – the oral mucoperiosteal layer, followed by the underlying layer of palatal bone, and finally the layer of antronasal mucoperiosteum, each layer being assessed clinically for tumour involvement as it is laid bare.

Which of the two methods is appropriate in the individual instance depends on the surgeon's preoperative assessment of the extent to which the carcinoma has spread deeply. When the tumour is considered at the outset to involve the bony palate, with the possibility/probability that it has already reached the antronasal mucoperiosteum, the resection is best carried out using the monobloc method. It is when there is doubt concerning the extent of deep involvement that the layered approach should be considered. If involvement of the bony palate is in doubt, involvement of the antronasal mucoperiosteum is likely to be in even greater doubt, and its preservation is worthy of consideration if the result is a likely to provide a useful dividend in subsequent management.

Monobloc resection

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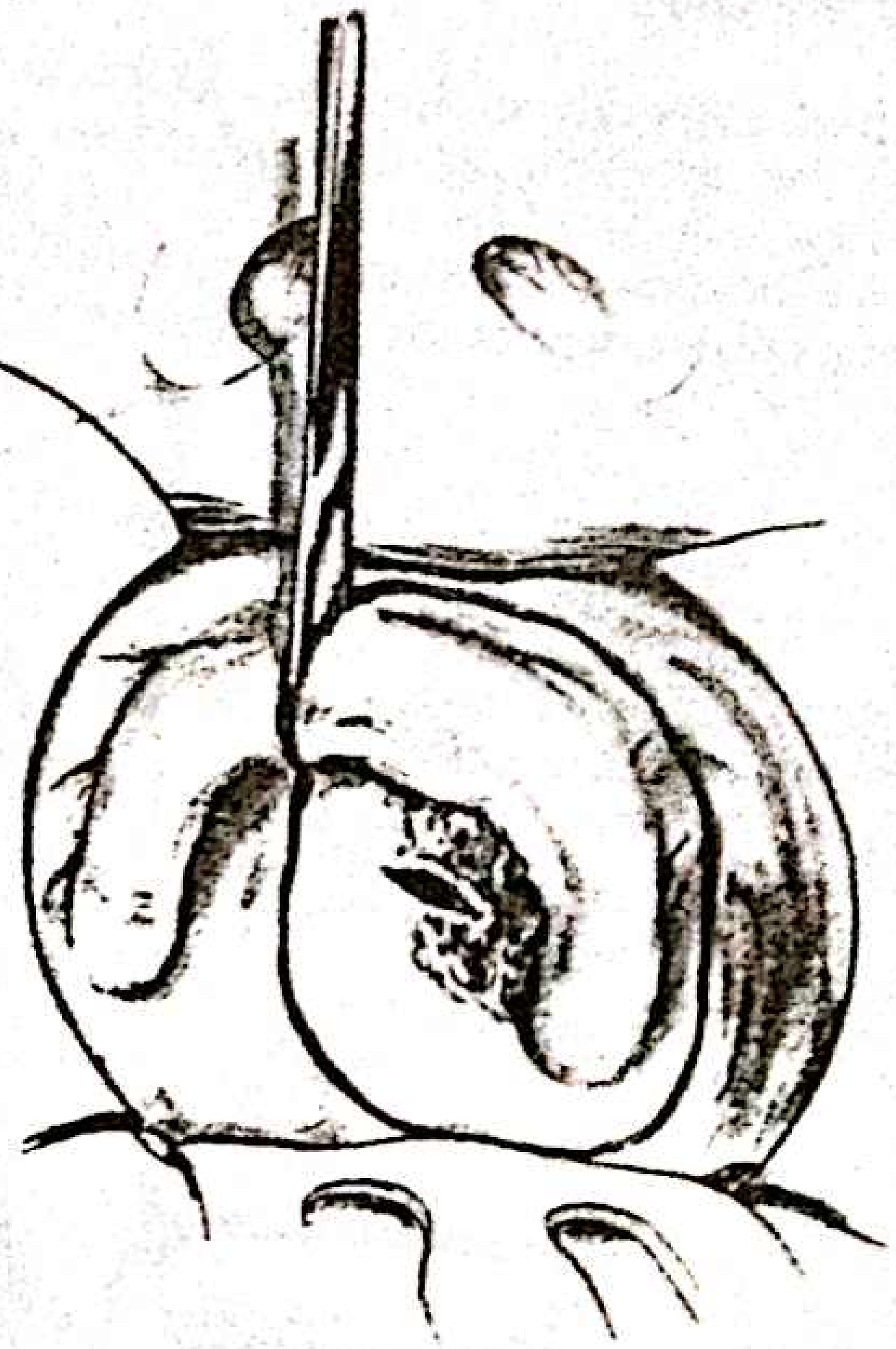
Using a thin-bladed nasal osteotome, the bone is divided along the line of the marginal mucoperiosteal incision.



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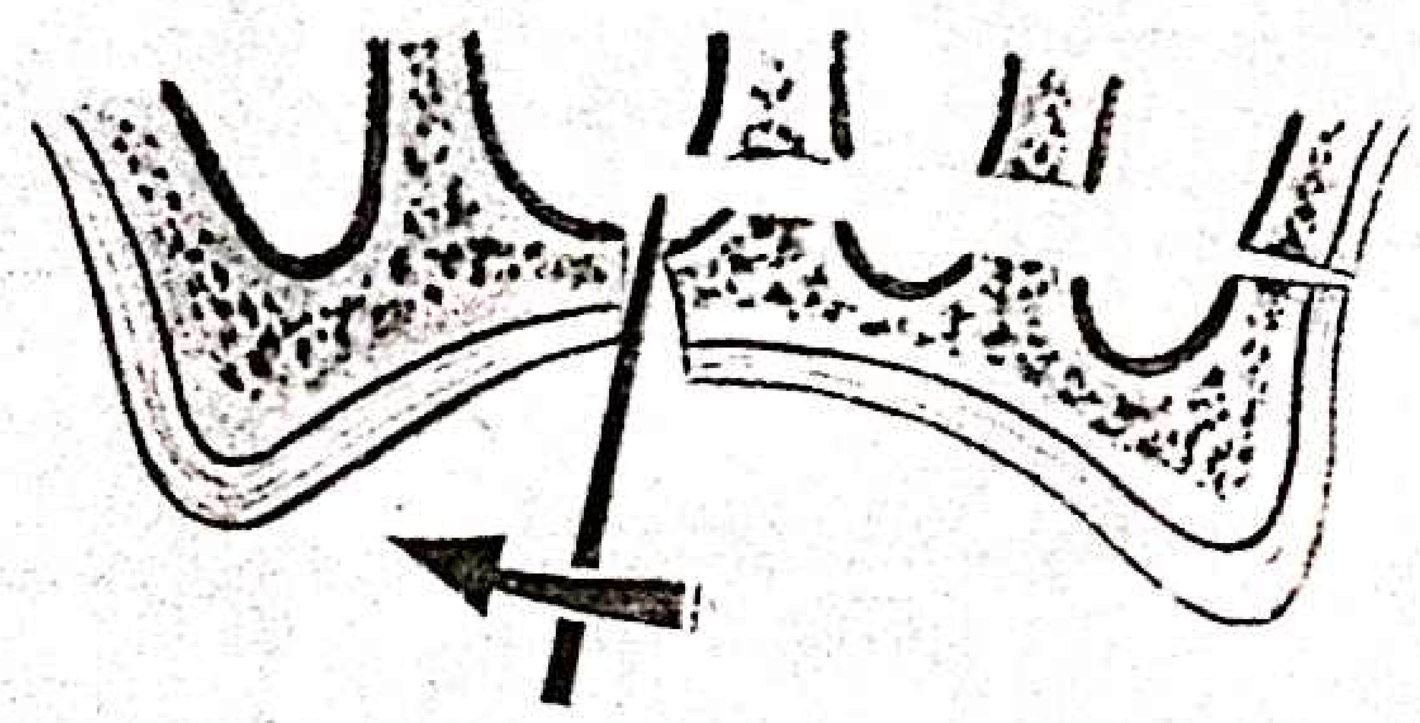

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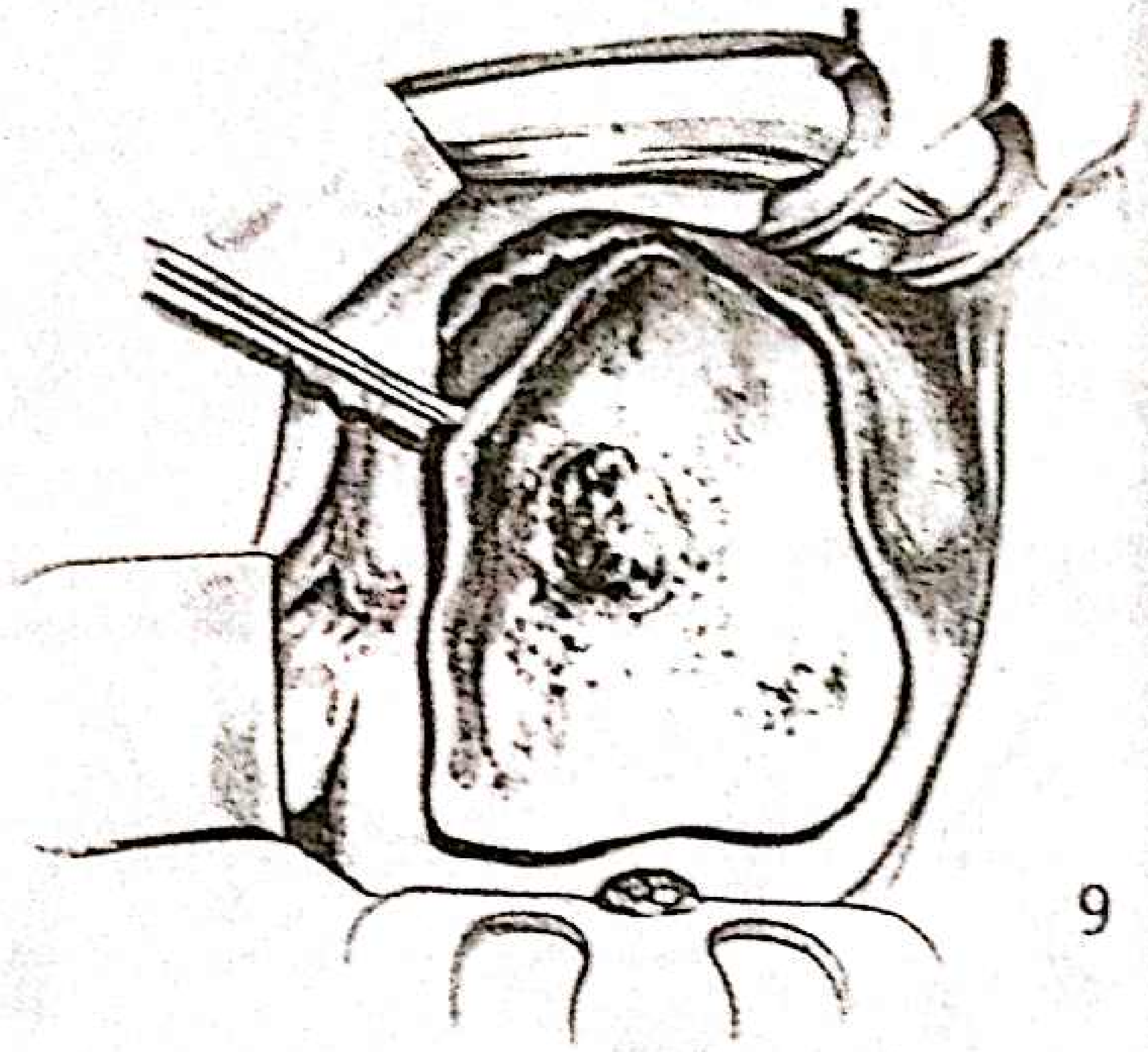
When the bone along the marginal resection line has been divided through its complete thickness, the osteotome is introduced through the line of section at a site where the bone is thickest and leverage can be most effectively applied. The bony block is then levered off the mucoperiosteum attached to its antronasal surface, forcibly fracturing any of the bony septa attached to the area resected.

The bone may strip cleanly, and when this occurs it is a strong indication that the antronasal mucoperiosteum is free of tumour, mucoperiosteum involved by tumour being found to adhere to the bone, tearing, and coming away with it. With the site cleared, it can be inspected and additional tissue, bony and mucoperiosteal, is removed if necessary, to ensure local clearance of the tumour.

Even when the mucoperiosteum lining the nasal floor and/or antrum is not involved by tumour, the blind leverage of the bone carried out in this manner frequently tears it, leaving a defect of variable extent. The effect is to make the subsequent fitting of a satisfactory denture much more difficult, for the reasons discussed below.

Layered resection

The layered approach to resection does not entirely eliminate the possibility of damage to the antronasal mucosa, but it reduces its likelihood. It is particularly suitable for the clinical situation where there is real doubt concerning involvement of the palatal bone.



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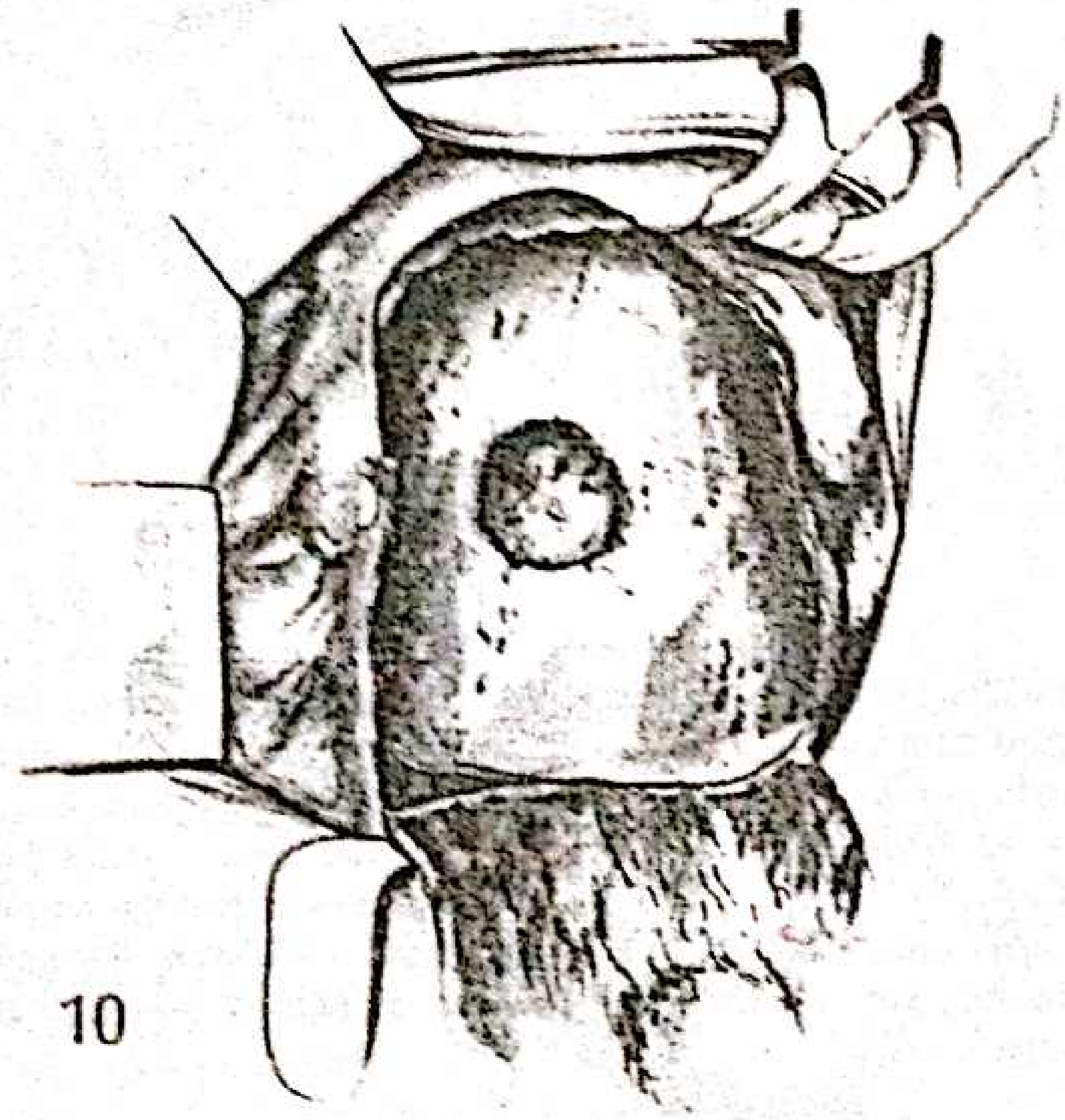
When such a layered technique is used the palatal mucoperiosteum within the line of marginal clearance of the tumour is stripped off the bony palate.



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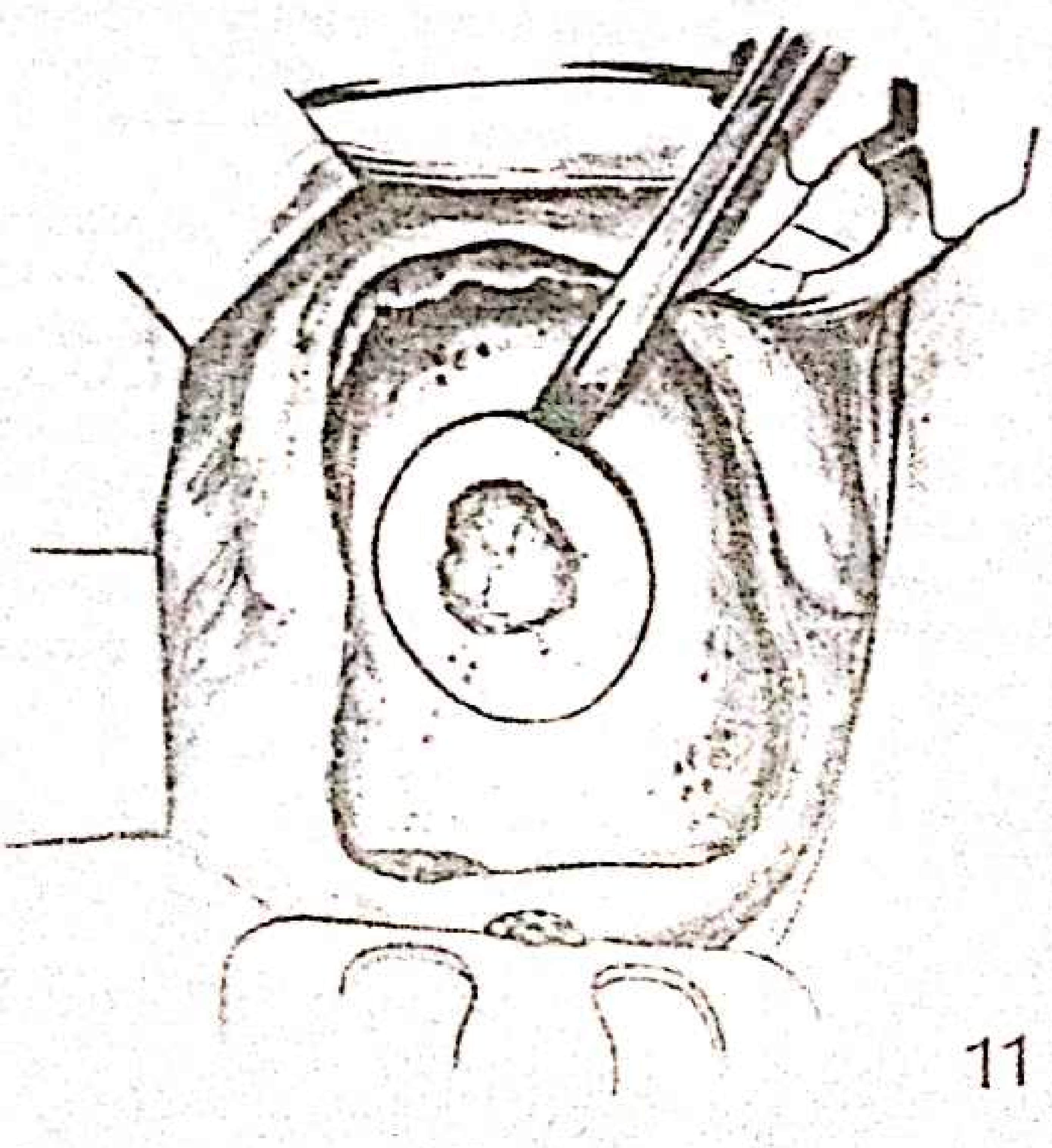
The deep surface of the mucoperiosteum, and the palatal bone which has been laid bare, are both carefully inspected for evidence of involvement by tumour. Evidence of periosteal involvement is a break in the uniformity of its surface; in the exposed bone, a localized area of roughening and apparent erosion of the surface is highly suggestive. The assessment is not a difficult one to make.

11

If there is any suspicion that the bone is involved, the area is outlined with an adequate margin, and the full thickness of the bone is carefully sectioned round its entire circumference, using a thin bladed nasal osteotome, until its slight mobility indicates that it is being held in position only by its attachment to the antronasal mucoperiosteum. In making the marginal bony cut, there is some advantage in making the cut oblique rather than vertical, even if the effect is to add a little to the extent of the bony defect. The oblique cut makes easier the insertion of the cleft palate rasp used to strip the antronasal mucoperiosteum from the upper surface of the palatal bone.



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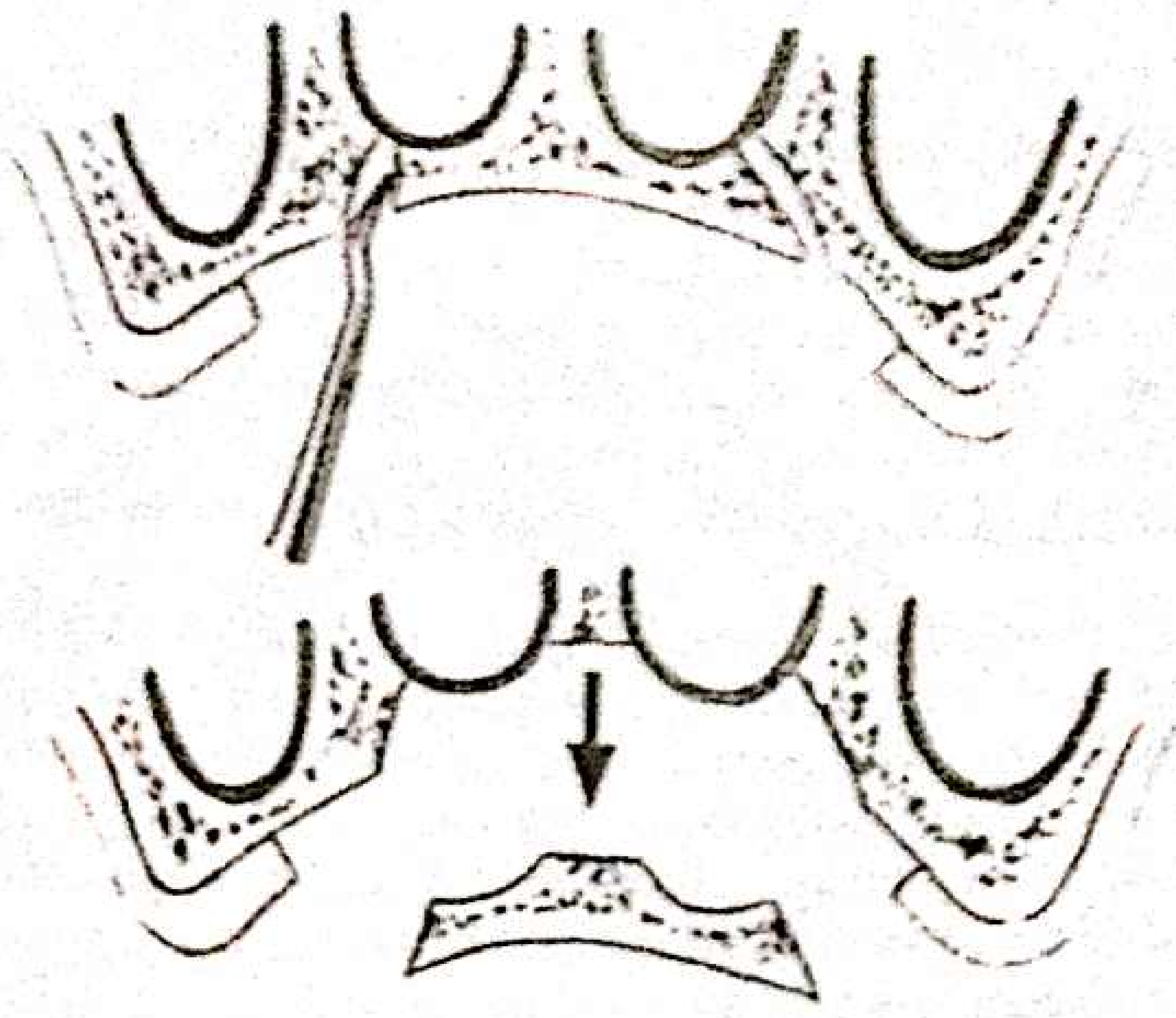
Beginning at one of the thinner areas of the palate, the cleft palate rasp is inserted along the marginal bony cut, and used to free the antronasal mucoperiosteum from the bone. As the nasal septum and the lateral nasal wall are reached, they are either sectioned along their line of junction with the hard palatal bone, using the nasal osteotome, or fractured by levering the palatal bone free.



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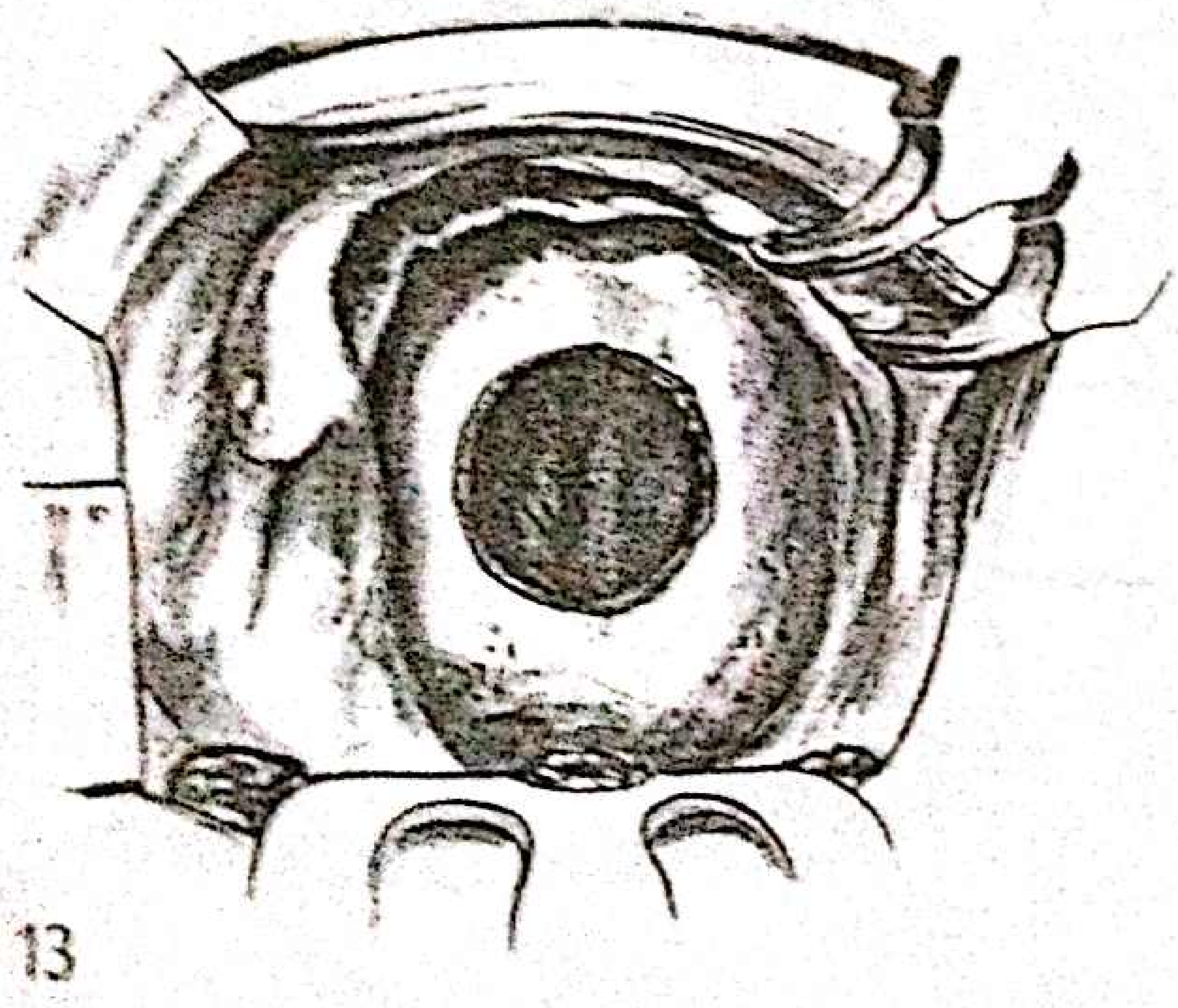

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Following removal of the segment of palatal bone, its upper surface, and that of the antronasal periosteum from which it was separated, are carefully inspected for tumour, and any excision of the mucoperiosteal layer which may be required to complete the tumour resection is carried out.

Layered resection is more likely to result in an intact periosteal surface than the blind leverage of the monobloc approach. Even if a tear does occur, it tends to be small, mucoperiosteum is less likely to be lost, and successful bridging of the tear by the graft can be expected. If an area of mucoperiosteum fails to strip from the bone, it generally indicates that it is involved by tumour.

In the clinical situation for which the layered approach might be regarded as appropriate, the two methods, monobloc and layered, are equally radical in pathological terms. The layered approach is made possible because of the unique anatomical situation, where the mucoperiosteal layers involved are so closely adherent to the layer of bone sandwiched between them that the three layers can share a single marginal resection line. The justification of the method in functional terms lies in the considerable increase in the probability of retaining unbroken the antronasal mucoperiosteum, this making, as discussed below, the subsequent fitting of a satisfactory denture much easier.

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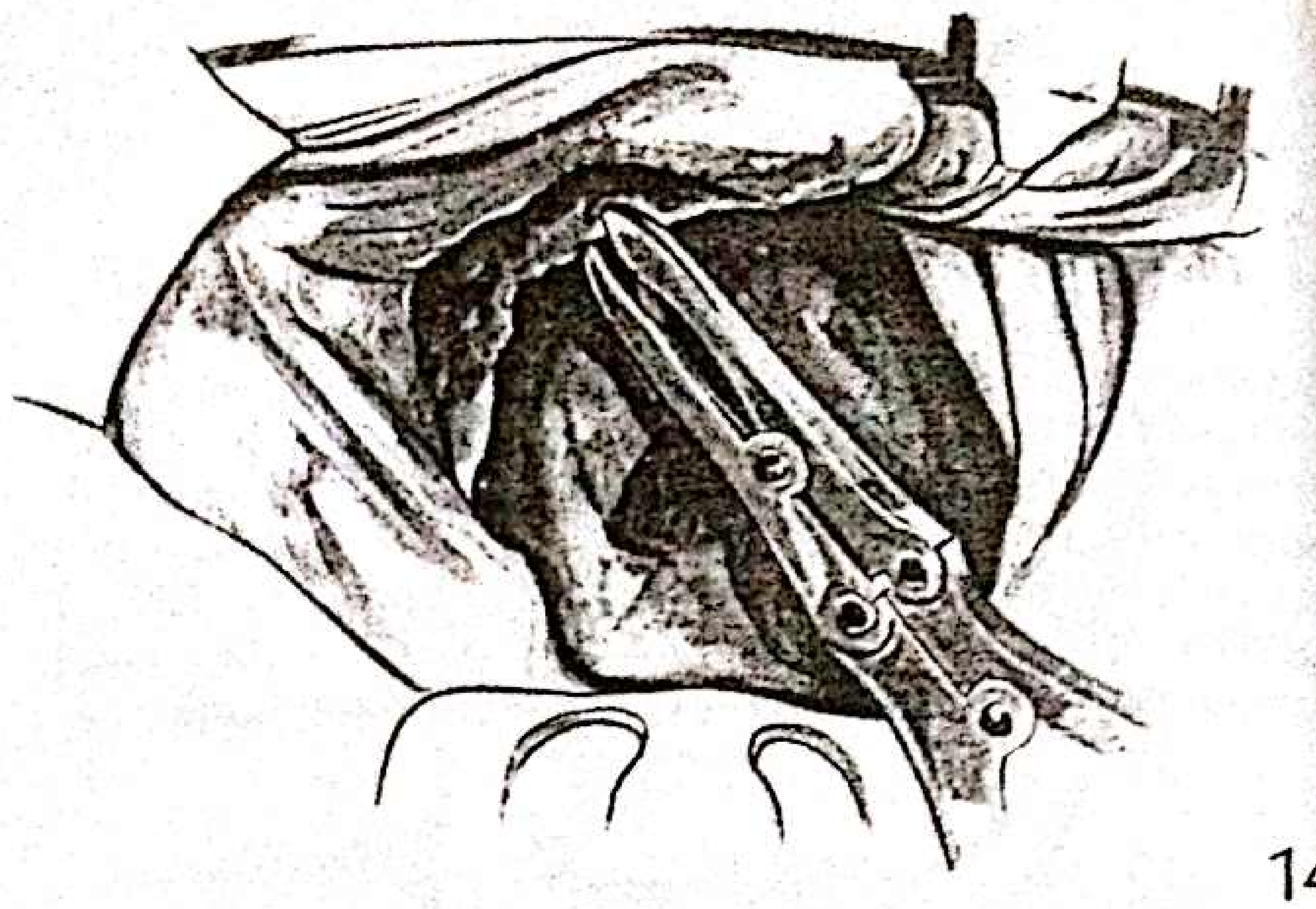

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The edentulous upper alveolus, when it is stripped of its mucoperiosteal cover, has the form of a narrow ridge with an irregular margin, and when it is left exposed in the course of the resection, monobloc or layered, it is generally advisable to trim the ridge and remove any roughness which may be present, in readiness for the application of the split-skin graft, as discussed below.

Note: It must be stressed that the layered approach should not be used in resecting an adenoid cystic carcinoma, or squamous carcinoma where the tumour has been previously irradiated. Adenoid cystic carcinoma is capable of penetrating through the entire thickness of palatal bone without any visible evidence of its presence, and it should always be excised monobloc, up to and including the next mucoperiosteal layer. A similarly monobloc approach is also advisable in the previously irradiated squamous carcinoma, because of the near impossibility of determining by clinical appearance whether the individual layers are free or not of tumour.

RECONSTRUCTION

Because of the vascularity of the bony palate, small postexcisional defects can safely be allowed to heal spontaneously. Defects which are larger in area, or have involved resection of the bone, are generally split-skin grafted, using the method of application of the graft and its retention described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

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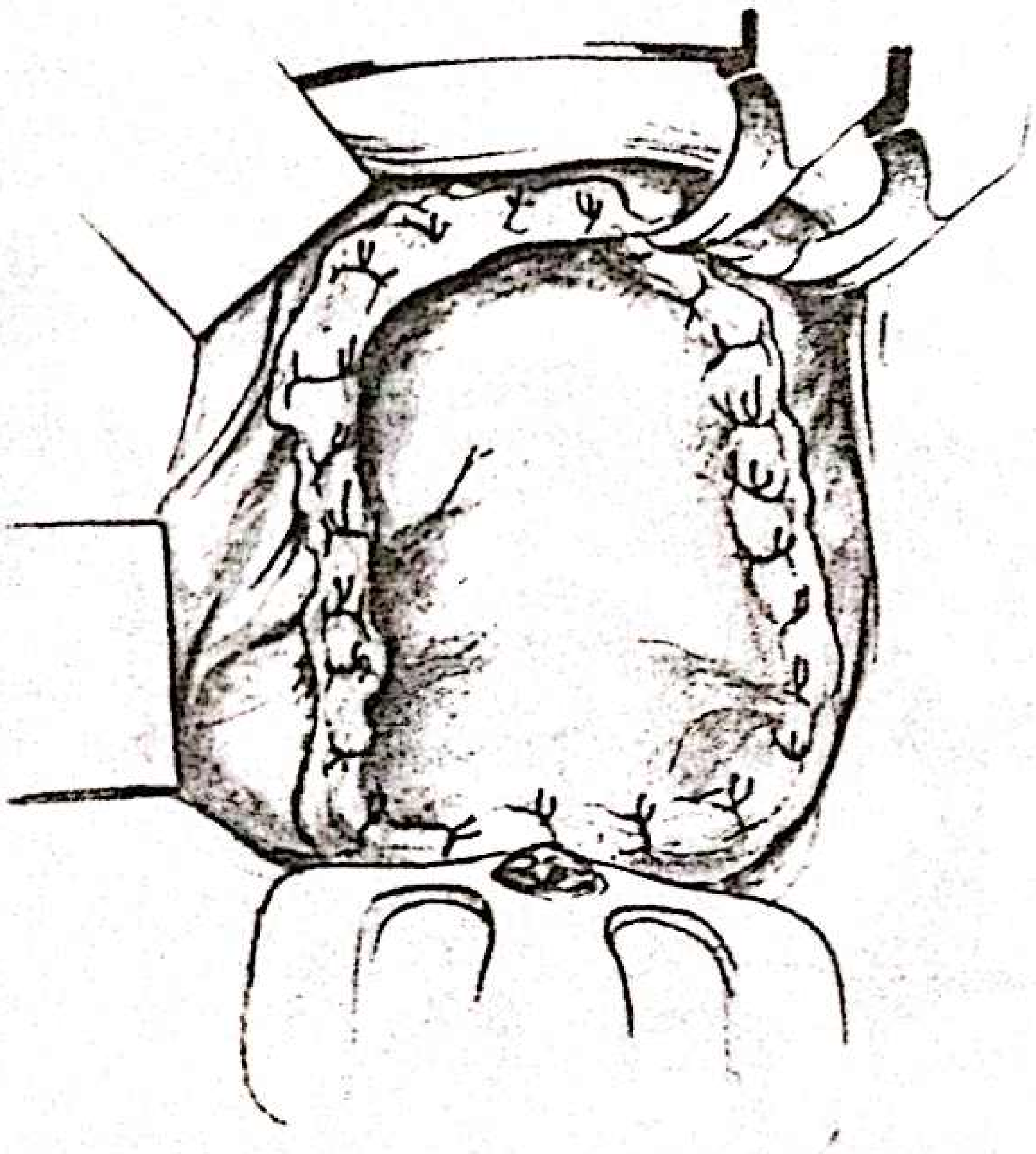

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The defect following resection of a palatal tumour is generally a shallow one, and it is convenient to suture the graft to its margins.

Regardless of whether or not the antronasal mucoperiosteum has been resected, is torn, or remains intact, the entire exposed surface is covered with the graft. The surface may have several different tissues – bare bone, exposed periosteum and intact mucosa, but the graft is applied to the whole area regardless of the type of surface, on the principle that where it meets a vascularizing surface it will take, while elsewhere it will slough.

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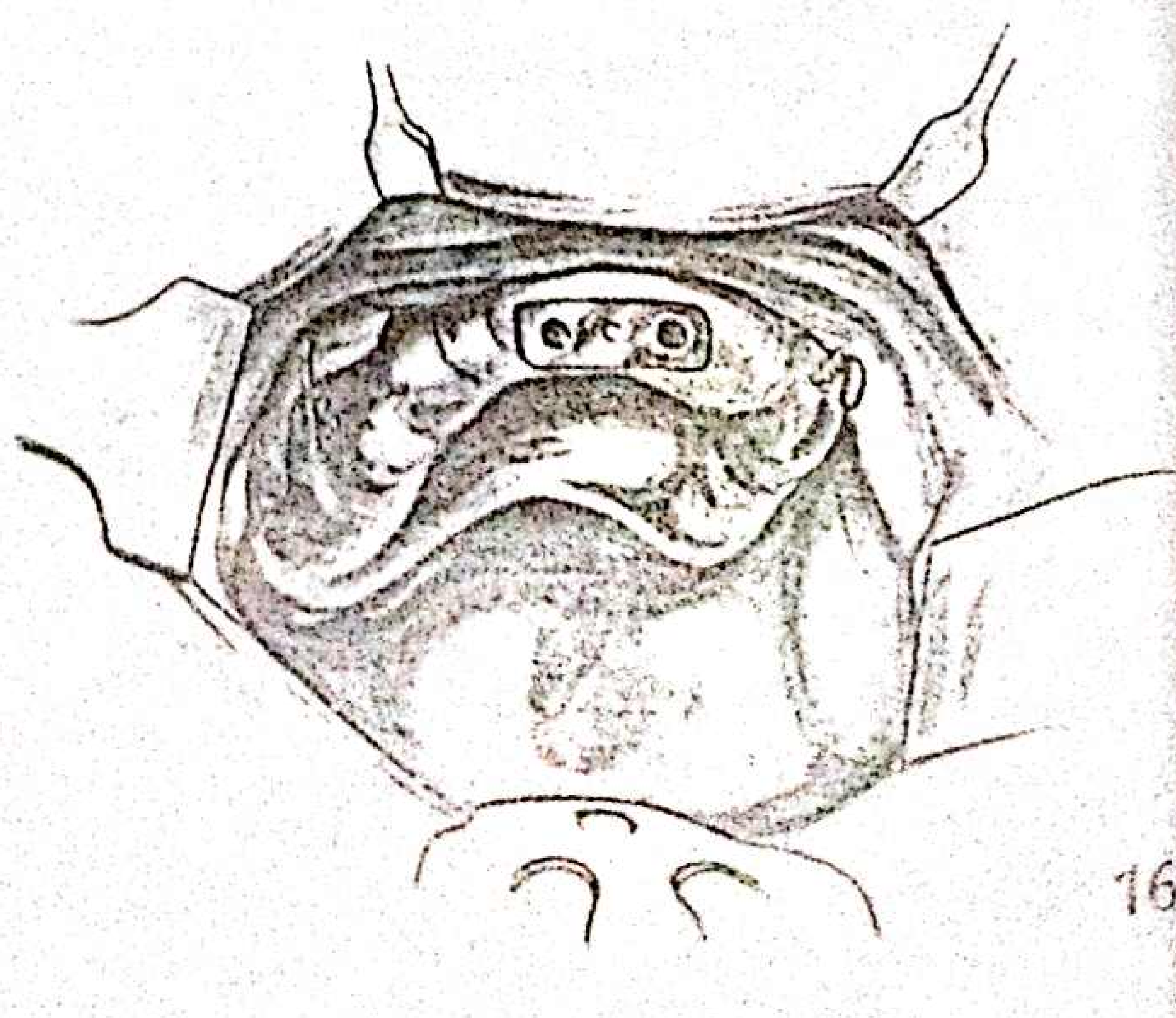

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The denture-splint is inserted and fixed in position.

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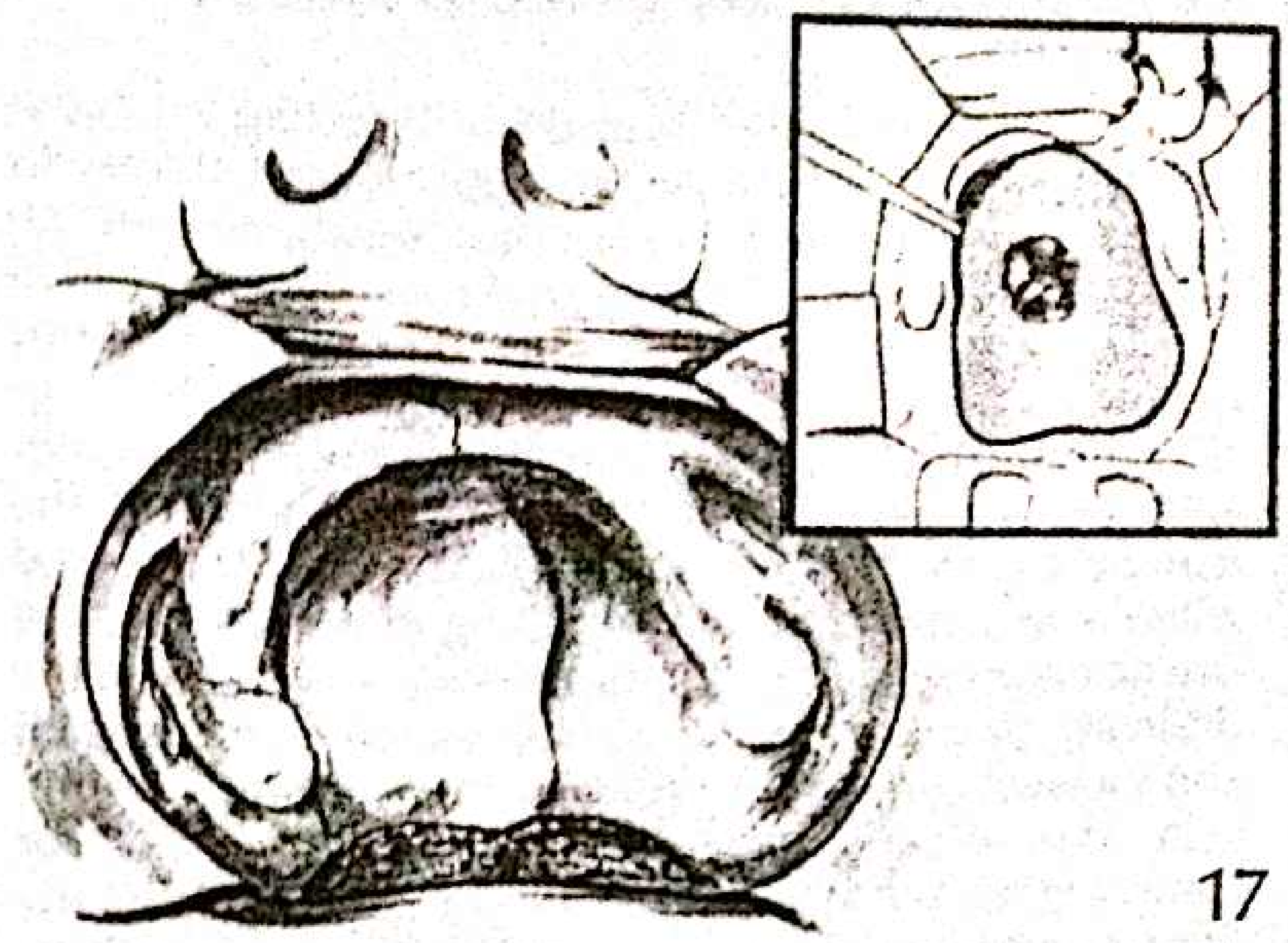
When the area has finally healed, a mixed surface of graft and mucosa is left, and this seems to function satisfactorily.



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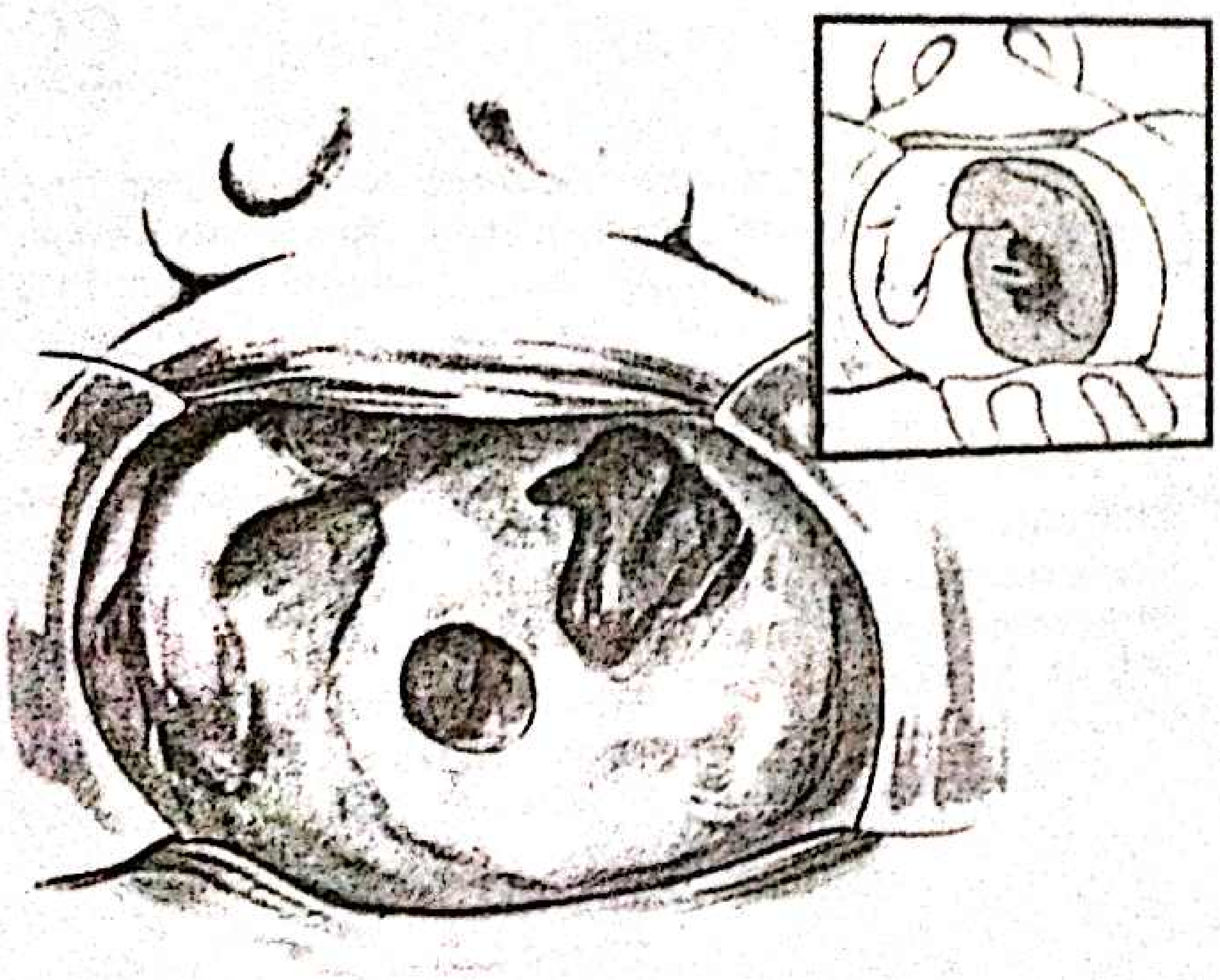

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18

Depending on the level of the resection, the open nasal cavity and/or antrum may be part of the exposed surface.

The final step in reconstruction, with healing of the site complete, is the making and fitting of a denture modified to match the new contours of the palate.

It is at the stage of fitting the denture that the benefit of an unbroken surface becomes evident. The adhesion of a denture is very dependent on the vacuum seal between the upper surface of the denture and the palate. This depends on an intact palatal surface, and with a modified denture the vacuum seal is even more important. The presence of a fistulous connection between the oral and antronasal surfaces of the palate breaks the seal and reduces its effectiveness, making the adhesion necessary for effective use of the denture much more difficult to achieve. It is for this reason that, in carrying out the resection, the surgeon should make every effort, the pathological situation permitting, to avoid creating such a connection, and this justifies use of the layered approach.

In theory, it might be feasible on occasion to close the palatal fistula if one is present, but are there good grounds for not doing so, at least in the short term. To leave the defect exposed allows effective inspection of the site for recurrence of tumour, and on that score it is preferable, at least for sufficiently long to be certain of cure. If denture fitting is still giving rise to problems, an attempt may reasonably be made then to close the fistula.

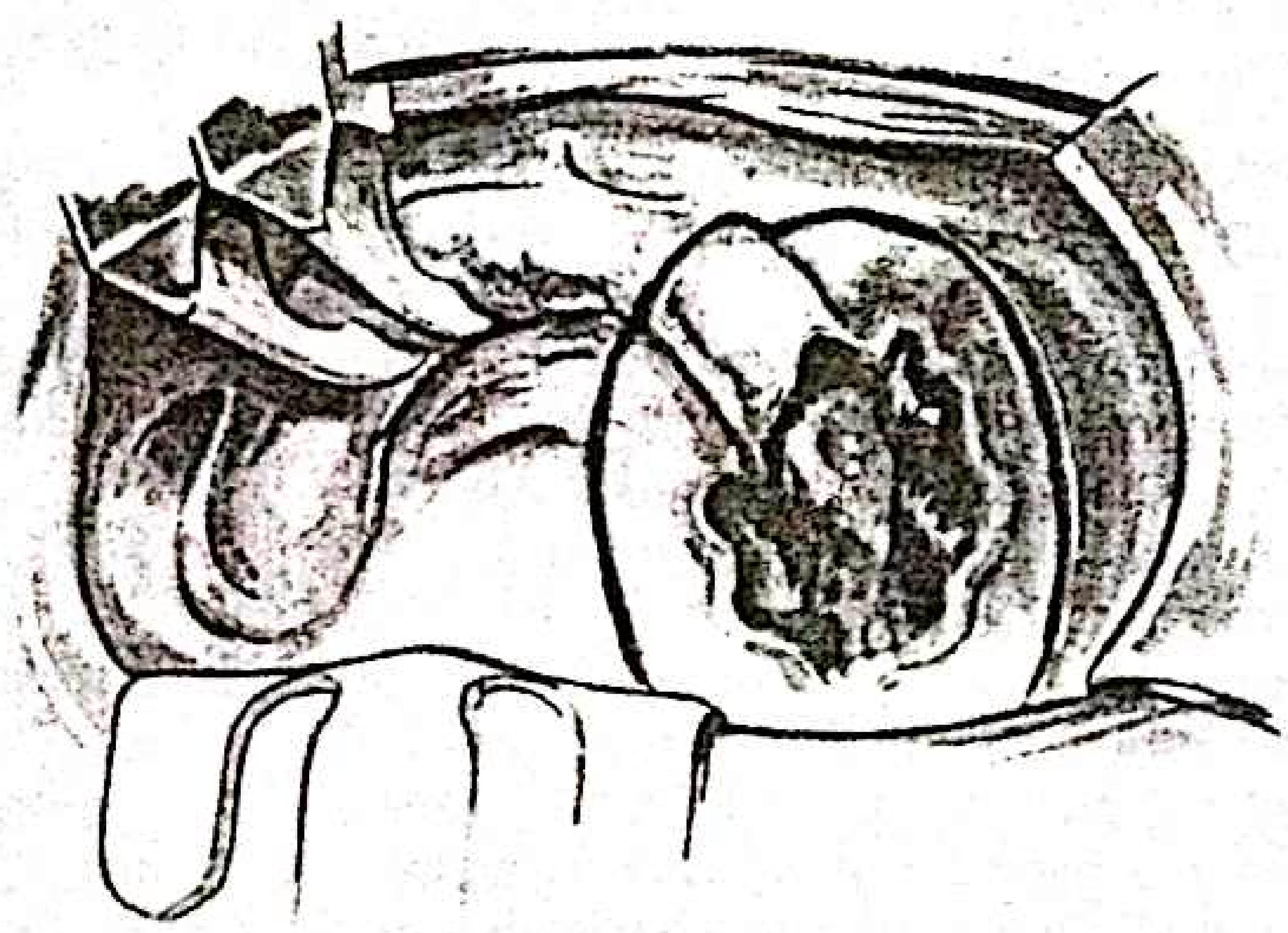
The question of using a free flap to reconstruct such a defect sometimes arises, particularly when the defect is a large one. To use a free flap in such a situation exchanges the unyielding surface of mucoperiosteum or graft-covered bone, against which the denture is pressing, for the soft yielding surface of the flap. The stability which the bony base provides shows to its greatest advantage when the denture is under stress, as in mastication. It is for this reason that the use of a skin graft is generally to be preferred.

Extension to the buccal sulcus

The technical difficulty involved in resecting a tumour which has arisen close to the upper buccal sulcus, or spread to it from the upper alveolus, usually depends on its site in relation to the premolar area. When it is sited anterior to the premolar area, resection is straightforward; behind it, resection is much more difficult. In the latter site, the difficulty results from the presence of masseter and the anterior part of the ascending ramus of the mandible in the lateral wall of the sulcus. Their combined effect is to narrow the sulcus, making access difficult. The use of a gag to hold the mouth open for access adds to the difficulty by putting the masseter muscle under tension and narrowing the sulcus further.

In this situation there is much to be said for commencing the resection from the palatal side of the tumour, where access is easier, before it moves laterally to the more technically difficult area of the sulcus itself.

The question also arises whether to use the layered form of resection, as opposed to the monobloc approach. The main advantage of the layered approach lies in the increase which it presents of avoiding a fistula, and so facilitating the effective subsequent fitting of a denture. However, a fistula in the alveolar area, as opposed to one over the hard palate, has a significantly less deleterious effect on subsequent denture fitting, and this reduces considerably any advantage the layered approach might otherwise have. Considering possible difficulties of exposure, particularly when the molar area is the one involved, monobloc resection has a good deal to commend it. It permits clearance in the alveolar area, both medially and in depth, to be assured at the outset, and the plane of the resection established, before it moves laterally to the more technically demanding sulcus area, where clearance of tumour extending into the upper buccal sulcus and adjoining buccal mucosa has to be tackled. The layered approach is feasible; whether it is preferable is doubtful.



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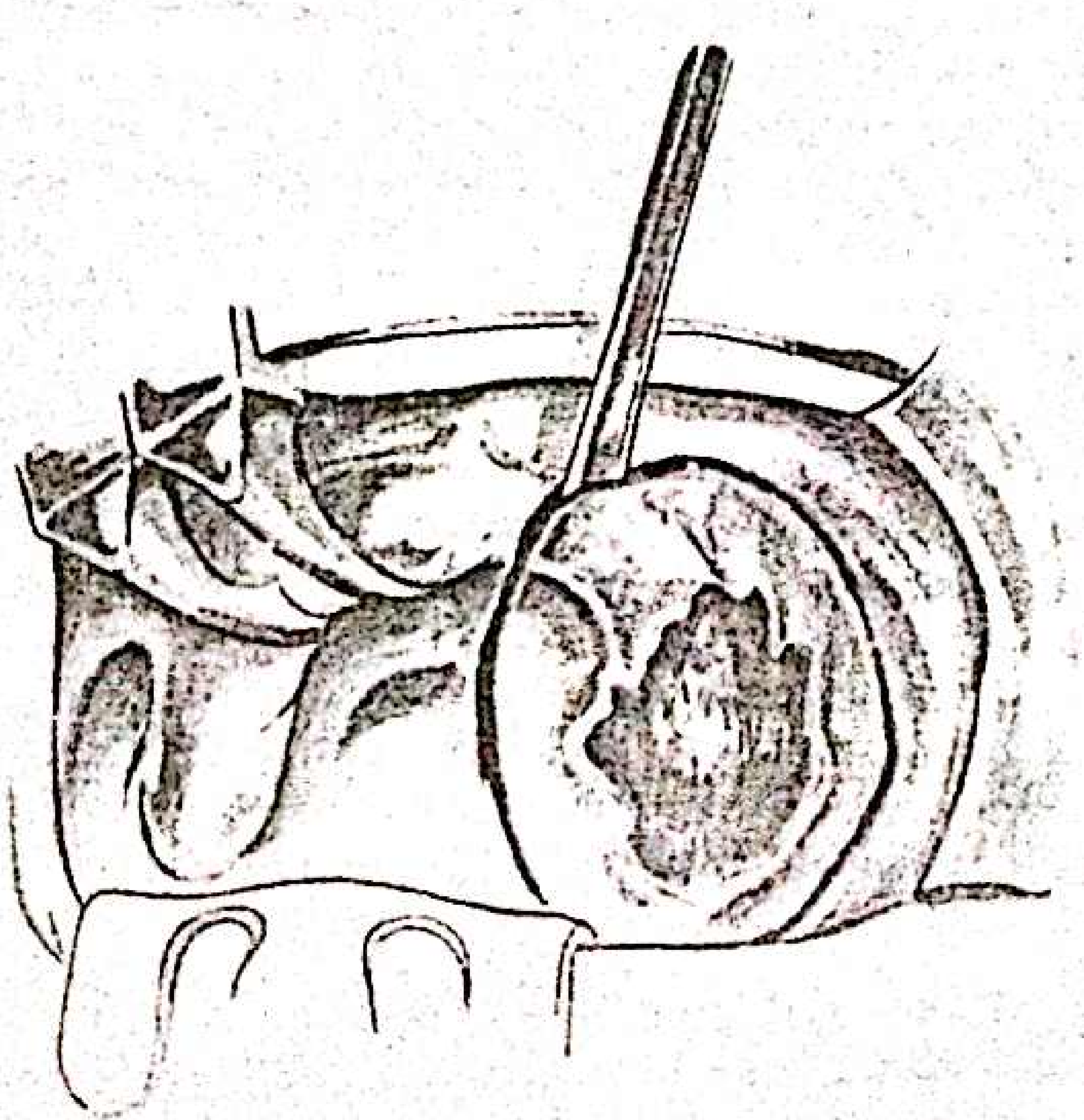
In carrying out the resection, an incision clearing the tumour marginally is made, and deepened to the bone where it overlies the palate and the lateral wall of the antrum.



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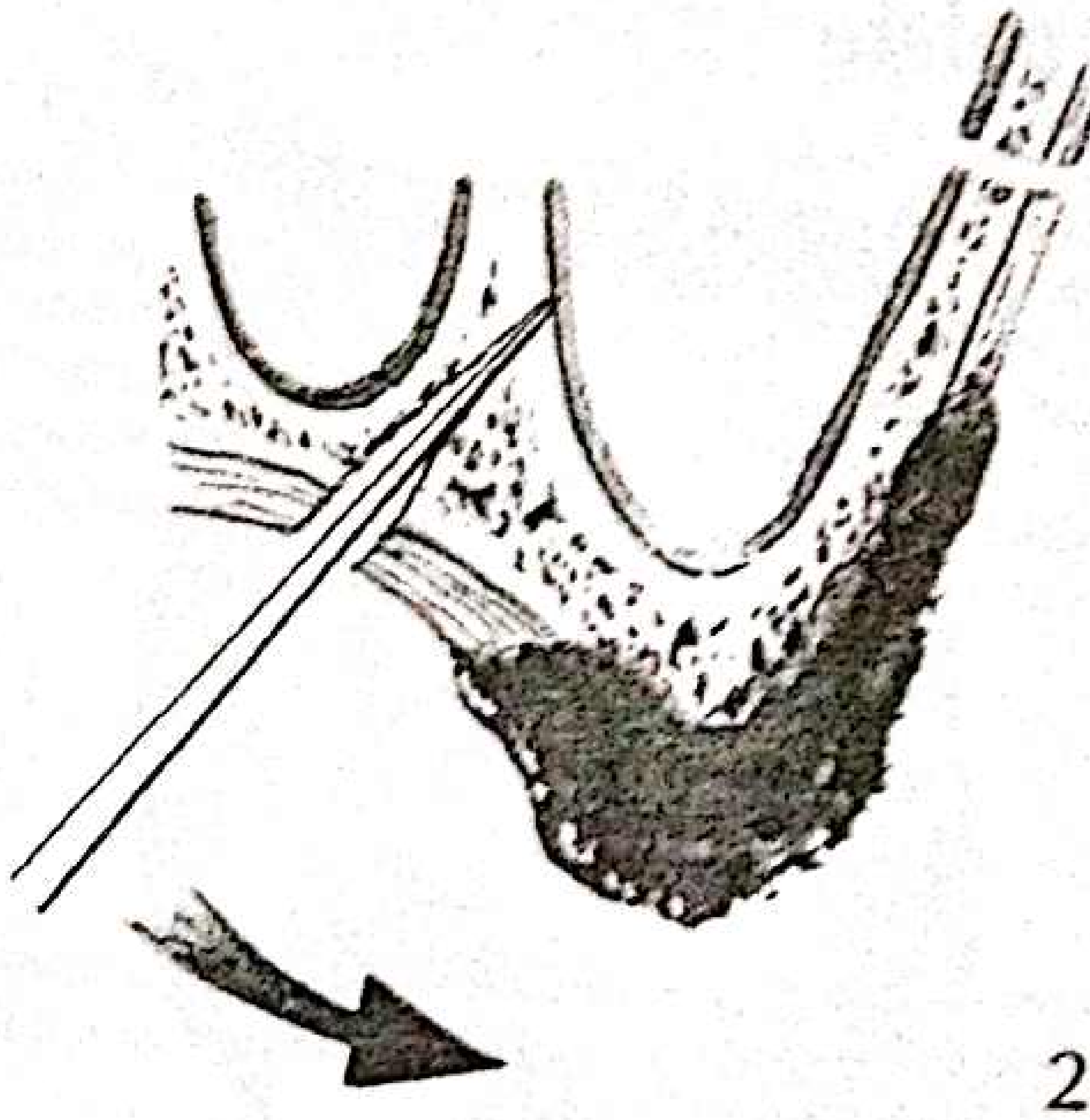
Along this line the bone is sectioned through its full thickness using a thin-bladed nasal osteotome. Division of the bone is continued up into the buccal sulcus, along the anterior and posterior lines of resection, until it is clearly beyond the area of tumour involvement.

21

The division of the lateral bony wall of the antrum is then completed, and the resected antral segment levered outwards. The plane in which the segment strips varies. If the tumour has not extended through the bone to the antral mucoperiosteum, the bone may strip cleanly, leaving the antral mucoperiosteum either intact or minimally torn. If the tumour has extended deeply to involve the lining of the antral cavity, bone and lining will lift off the cavity as a single structure, tearing away from the uninvolved surrounding antral lining, leaving the antral cavity open.

The soft tissue containing the tumour is then stripped further off the antral wall, upwards into the sulcus, until it is beyond any extension of tumour in that direction. The direction of the resection is then carried laterally, to clear the upward extension of the tumour in the soft tissues and allow it to be mobilized downwards.



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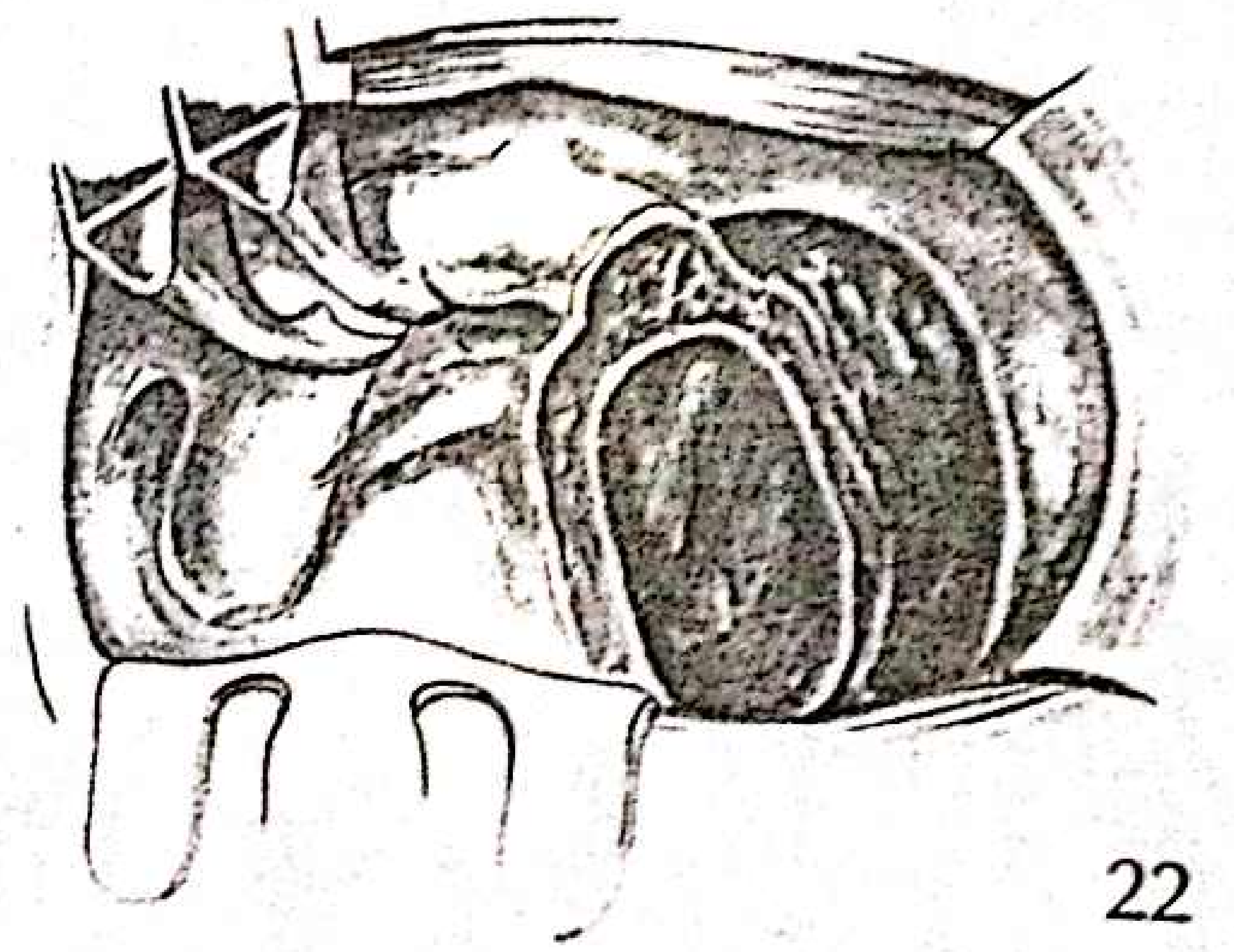
Any extension of tumour onto the buccal mucosa is cleared marginally and in depth, completing the greater part of the resection, and allowing the antral area to be inspected for adequacy of clearance. If the bone has stripped cleanly from the antral lining, the probability is that the area is free of involvement, but the antral surface of the resected bone and the periosteal surface of the mucoperiosteum are still inspected and any additional resection carried out. When the lining has torn away with the bone, there is a strong likelihood that it is involved by tumour and, if inspection indicates this to be so, further resection of bone and/or antral mucoperiosteum must be carried out to clear the area of antral involvement.



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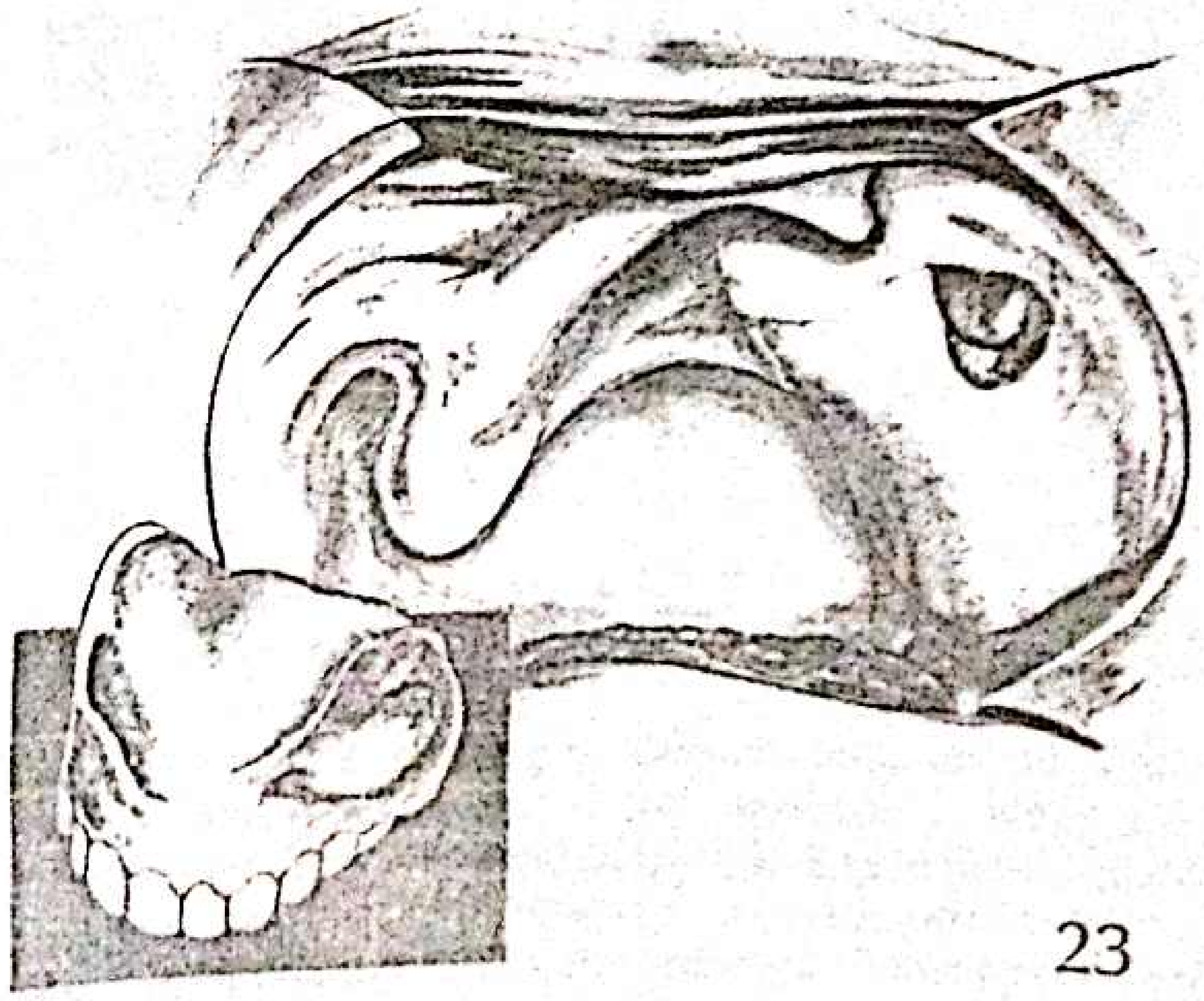
The defect is split-skin grafted, using the technique already described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240, with the subsequent fitting of a denture modified with an extension to fill the defect and complete the reconstruction. As already stressed, the lateral fistula which results involves only a small area of the hard palate, and is of considerably less significance from the viewpoint of denture adhesion than one nearer the centre of the palate, which involves the nasal cavity. Indeed, the extension of the denture, sitting into such a laterally placed cavity, often acts as a stabilizing factor in its retention.

When tumour extends beyond the palate onto and behind the maxillary tuberosity, it is managed by adding to both the extent of the resection and the dental splint which retains in position the split-skin graft used to cover the defect. Here the problem of a fistula does not arise, because the site lies behind the antrum. Tumour



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extension of minor degree, backwards onto the soft palate, is also managed by extending the resection, along with the subsequent graft and the dental splint. Any significant extension of tumour beyond the upper buccal sulcus onto the buccal mucosa is managed as described in the chapter on 'Buccal mucosa', pp. 270–282.

Soft palate

The surgical approach to resection of the tumour which arises on the soft palate is with the mouth gagged widely open. With its musculotendinous layer sandwiched between nasal and oral mucosal surfaces, resection is largely a matter of clearing the tumour marginally to a level which also clears it in depth, up to resection of its full thickness.

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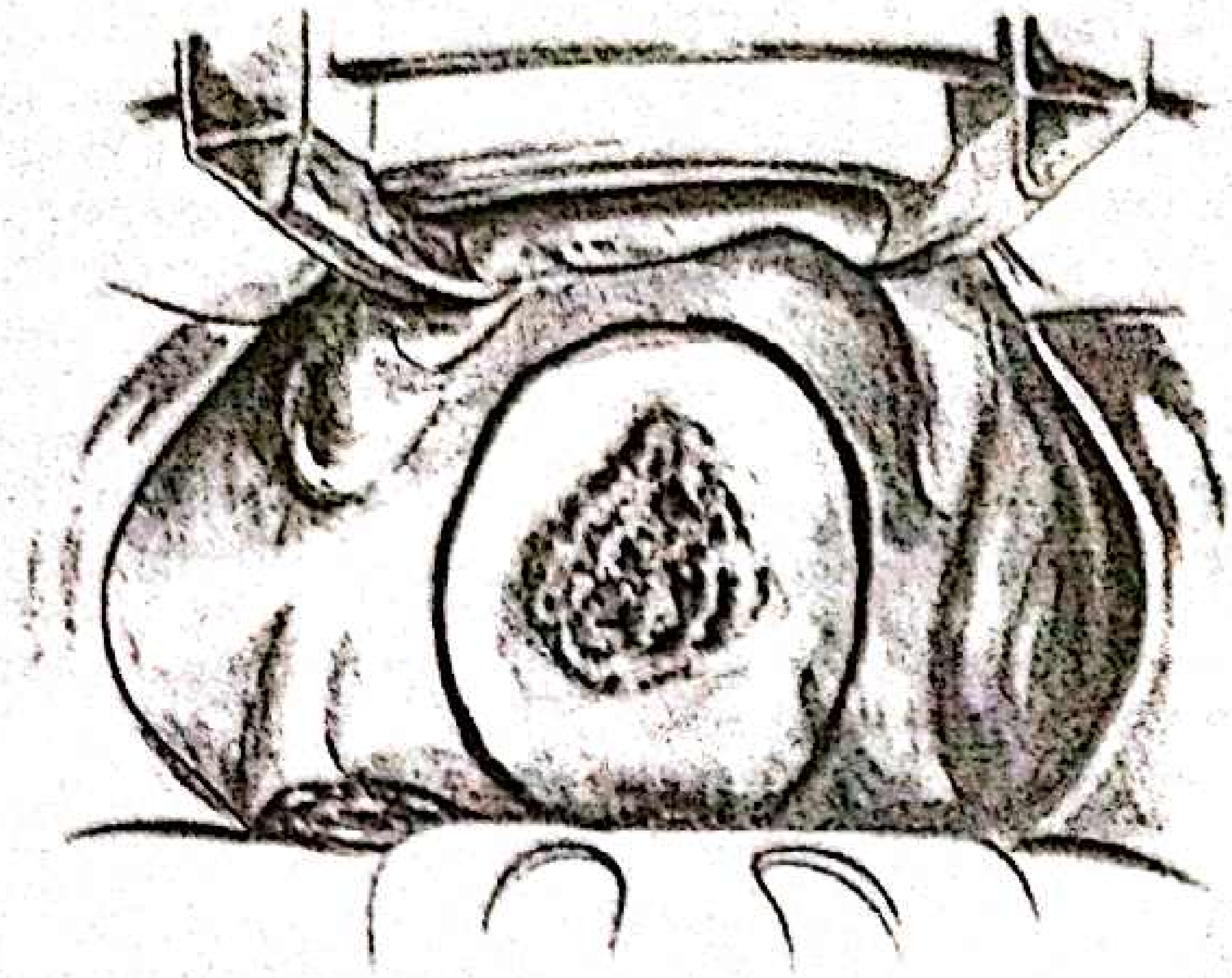
The tumour which does not involve the full thickness of the palate can be managed with a resection which leaves an intact nasal mucosal surface.



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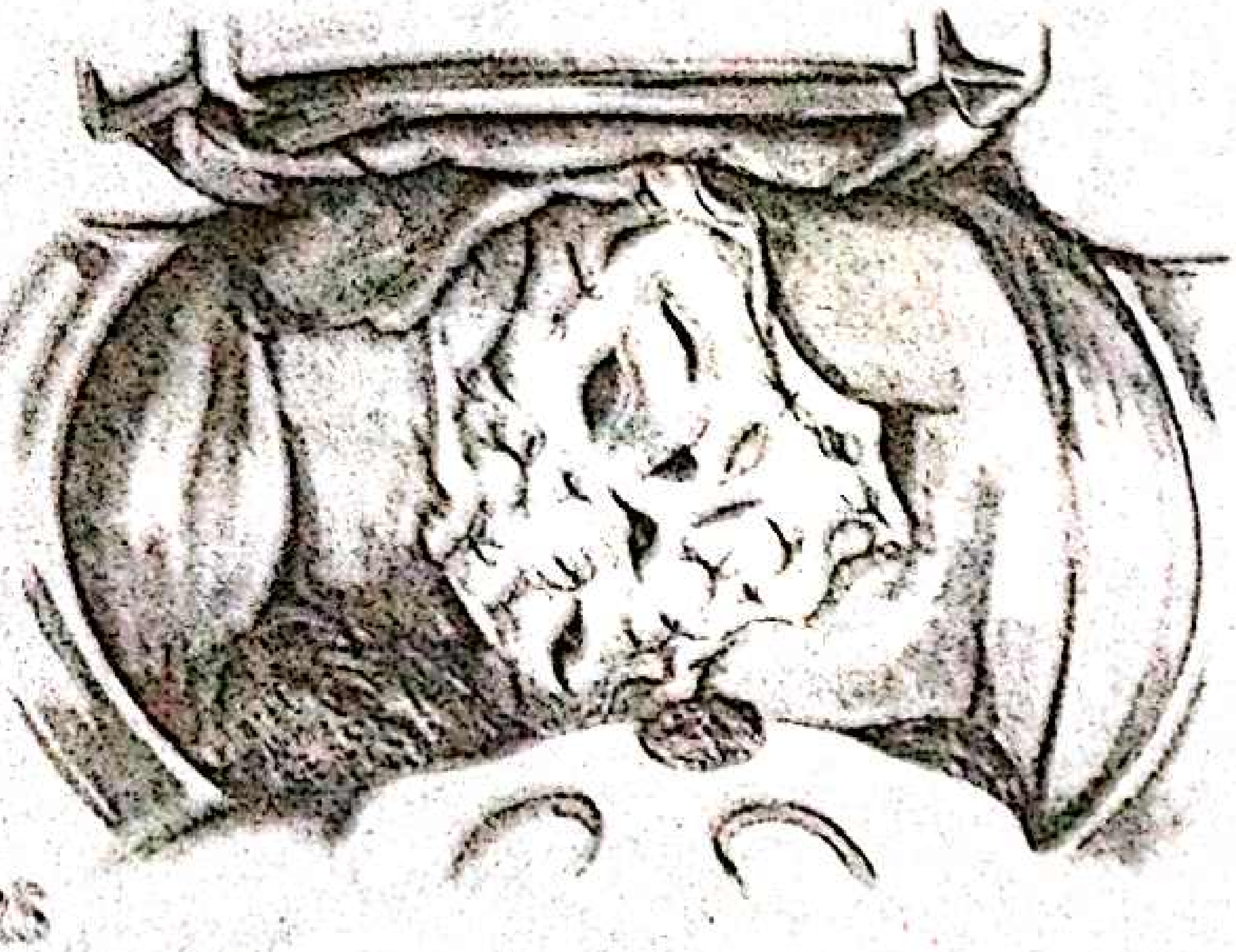

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25

Split-skin grafting of the defect should be carried out, using the quilted grafting technique described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.

26

In this clinical situation quilted grafting is the technique most likely to succeed, but it has to be accepted that success is likely to be partial at best, given the mobility of the palate. The absence of palatal rigidity is also likely to allow a degree of secondary contraction of the graft. Even so, the degree of contraction is likely to be less than would occur with direct closure of the defect or healing by secondary intention.

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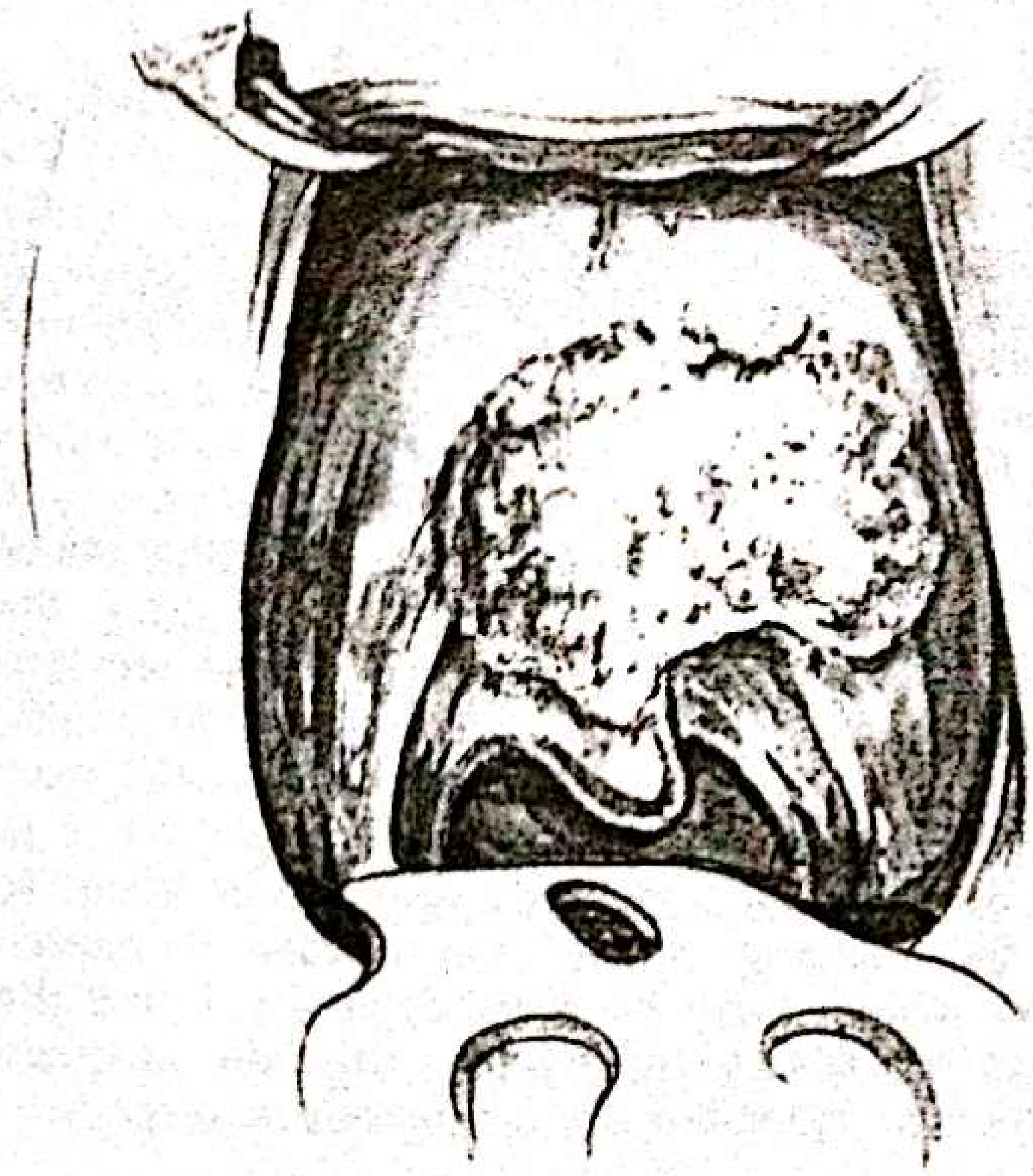
The more extensive tumour requires a full thickness palatal resection.



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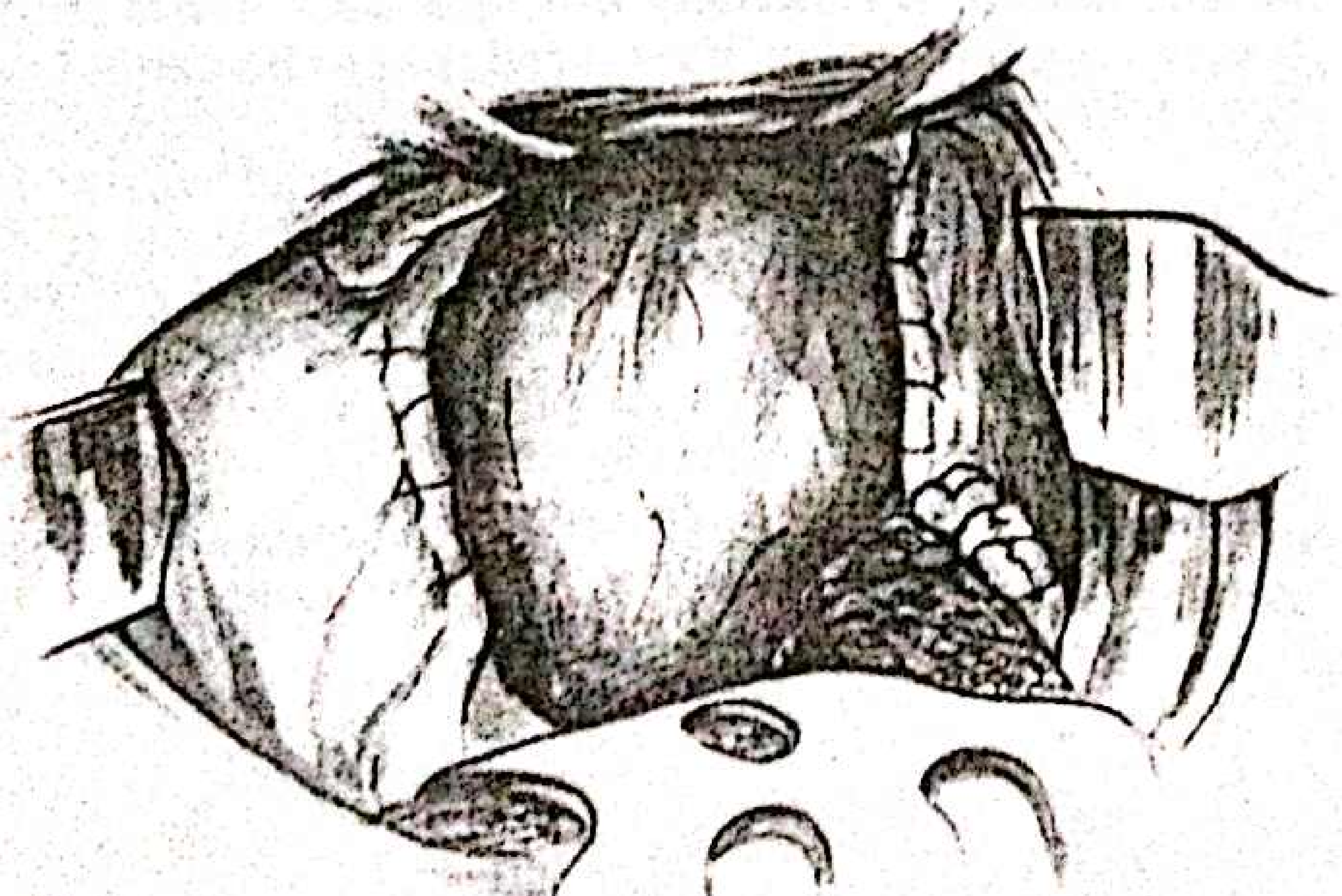
When the tumour extends over much of the palate there is little that can be done to reconstruct the defect in a functional sense, and suture together of the nasal and oral mucosal surfaces is usual, allowing the margins to heal with the defect fully displayed.



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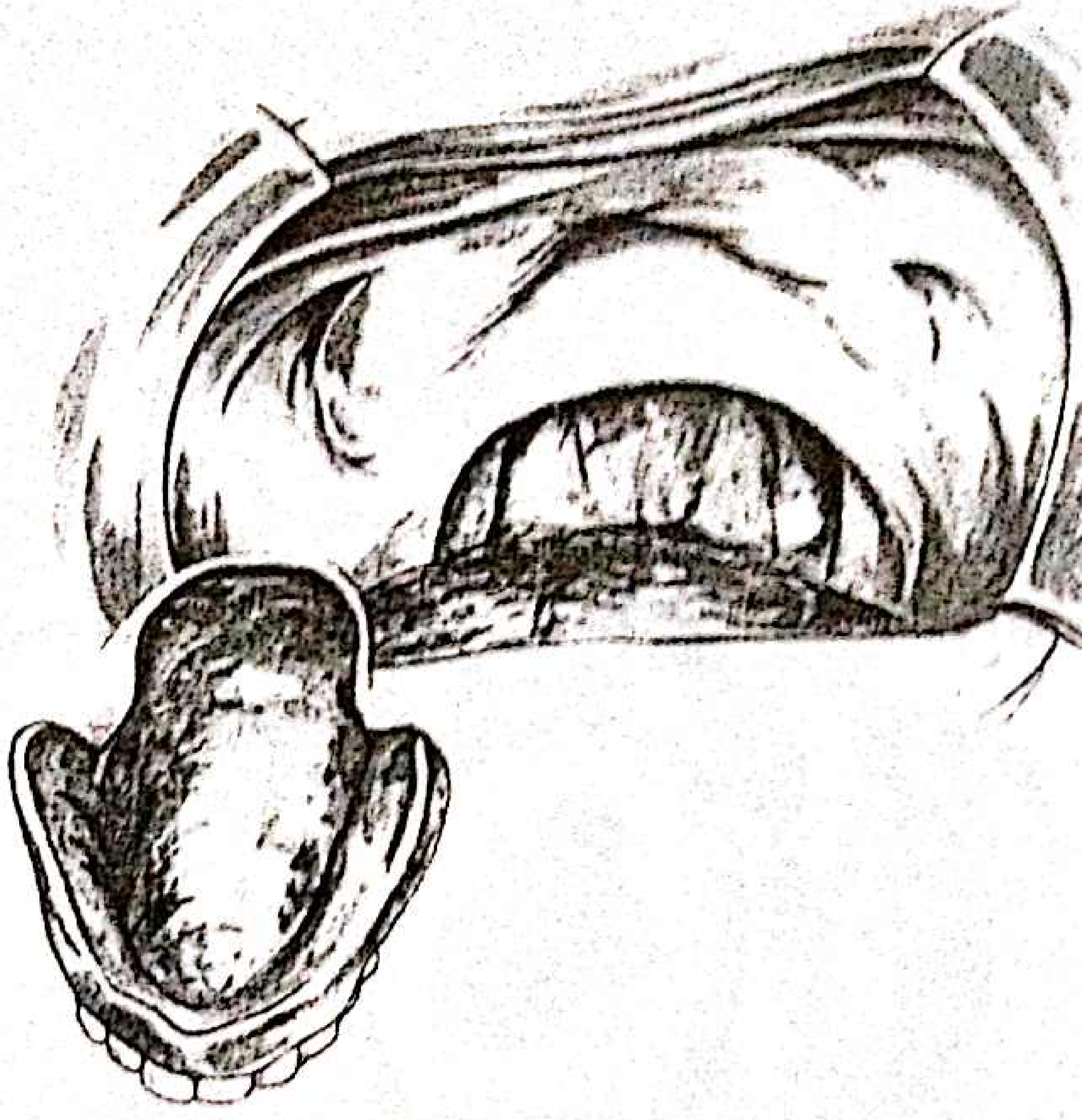
The surgical approach to reconstruction of such an extensive defect of the soft palate is conditioned by the fact that the primary function of the soft palate is in speech production. The determining factor in this role lies in its musculotendinous content, but its effectiveness is dependent also on the thinness and mobility of the soft palate as a whole. The major resection, which leaves only palatal remnants along the margins of the original structure, cannot be reconstructed in such a way that mobility will be restored. The best that can be achieved, using the patient's own tissues, is a replacement of the previous thin, mobile palatal 'apron' with a thick, immobile, non-functioning flap. Given such an unsatisfactory prospect, a simpler and more effective approach is to extend a dental plate backwards with a thin 'shelf' to simulate the hanging palate. The quality of speech production achieved can be surprisingly good, and the method has the added virtue of permitting more adequate inspection of the resection site for tumour recurrence.



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In practice, involvement of the soft palate by tumour is most often the result of spread onto it from those neighbouring areas which are more frequent sites of primary cancers, spread upwards from the faucial area, or medially from the retromolar trigone. In such circumstances the soft palatal element is managed as an extension of the primary site, in terms of both resection and reconstruction.

From the viewpoint of reconstruction of the palatal defect, the problem is quite different from that posed by the tumour primarily of the palate, where its musculotendinous structure is destroyed. The tumour reaching the palate from an adjoining site reaches it from one or other side, and the resection is of a lateral segment only. The residual palate retains its basic structure, and reconstruction of the defect with a satisfactory result may be feasible, making use of one of the thin flexible flaps currently available, such as the radial forearm free flap.

Neck dissection practice

The anatomical separation between the hard and soft palate from the neck nodes means that a resection of the primary tumour in continuity with the neck nodes is not feasible. Nodal resection, if required, has to be carried out as an anatomically independent procedure. Metastasis to the neck nodes from these primary sites, particularly the hard palate (much the more frequently involved site of the two), is not common and, in the absence of palpable nodes, standard practice is to follow up the patient carefully, carrying out a neck dissection only if nodes become palpable subsequently. Where the involvement of either site is by extension from an adjoining area, nodal management is dictated by that which is standard for the particular primary site.

Illustrations by Ian Ramsden

Tongue, lateral floor and lower alveolus, faucial area and retromolar trigone

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

Introduction

The tumours which arise in these sites have in common the method employed to expose them when access through the open mouth is inadequate, namely the mandibular swing approach, as described in the chapter on 'Access to the mouth', pp. 241–253.

The surgical resections which are carried out are determined by the demands of the pathological situation. Reconstruction of the defects is aimed at alleviating their functional and cosmetic effects. This has particular relevance when the tongue and, to a lesser extent, the mandible are involved, as they contribute so much to oral function and facial cosmesis.

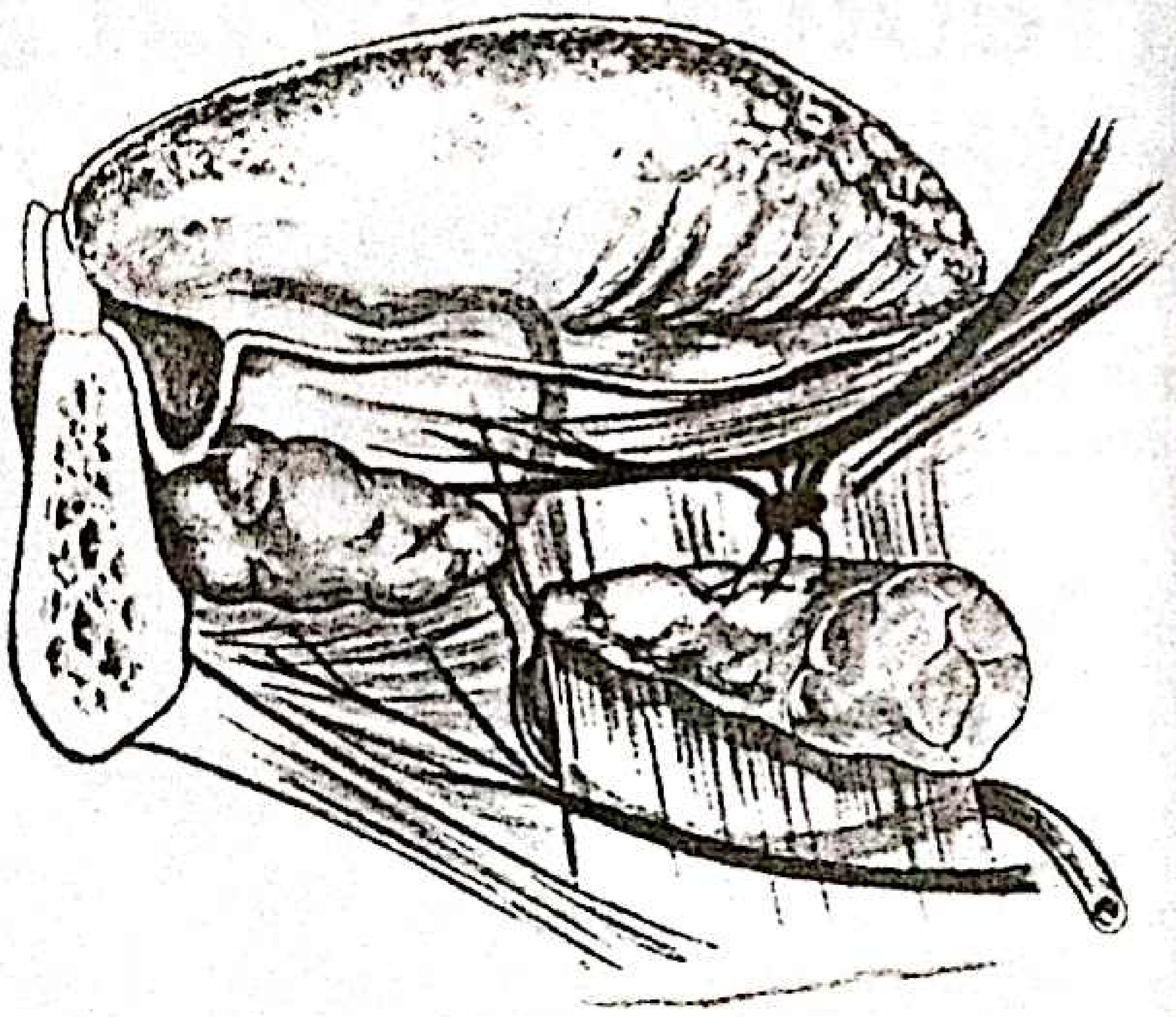
TONGUE

Anatomical considerations

1

The bilateral blood supply of the tongue ensures that the segment which is left following resection survives in most instances. However, the minimal anastomosis across the midline vertical septum separating the two halves is responsible for the occasional necrosis of the tip which can occur when a length of the parent trunk of the lingual artery has been excised during resection of a tumour in the posterior half.

The dual nerve supply, motor and sensory, which reaches the tongue from each side, largely explains the excellent function which often remains even after extensive resections, given an effective reconstruction. The effect on function appears to be vested more in the motor than in the sensory supply, although it may be that the influence of loss of sensation on function has been ignored as being more difficult to assess.



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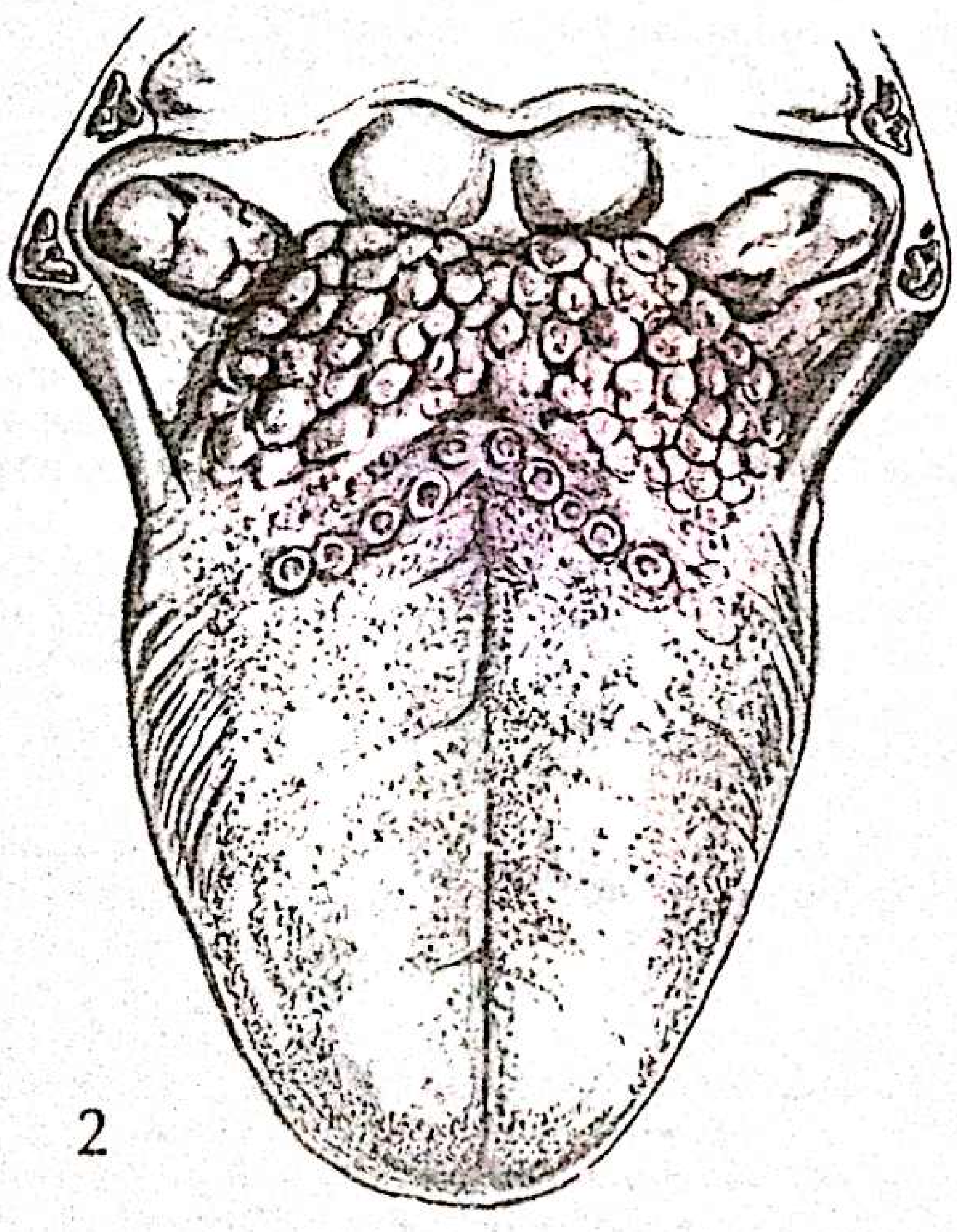

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In the posterior third of the tongue, the papillated surface is replaced by a mucosal surface which, although smooth, has an irregular contour created by the presence of lymphoid follicles in the submucosal layer. These create a surface induration which has, on occasion, to be distinguished from the induration which results from tumour spread.

Pathological considerations

The most common site of squamous carcinoma of the tongue is along its lateral border, particularly in the middle third. The incidence diminishes towards the posterior third, and even more so towards the tip. When the ventral aspect of the anterior free segment is involved, it is virtually always as a result of marginal spread from the anterior floor of the mouth. The dorsum is a rare site.

The tongue has the reputation of being a tumour site from which nodal metastasis occurs early and frequently, but in practice the presence of positive nodes usually implies a well established tumour.

3

The site of the tumour in the tongue largely determines the pattern of nodal involvement. The more anterior the site the greater the probability of initial spread to the submandibular group, with subsequent spread to the deep jugular chain; the further back the tumour is in the tongue, the greater the likelihood of spread direct to the deep jugular chain, usually high in the neck, very occasionally lower.


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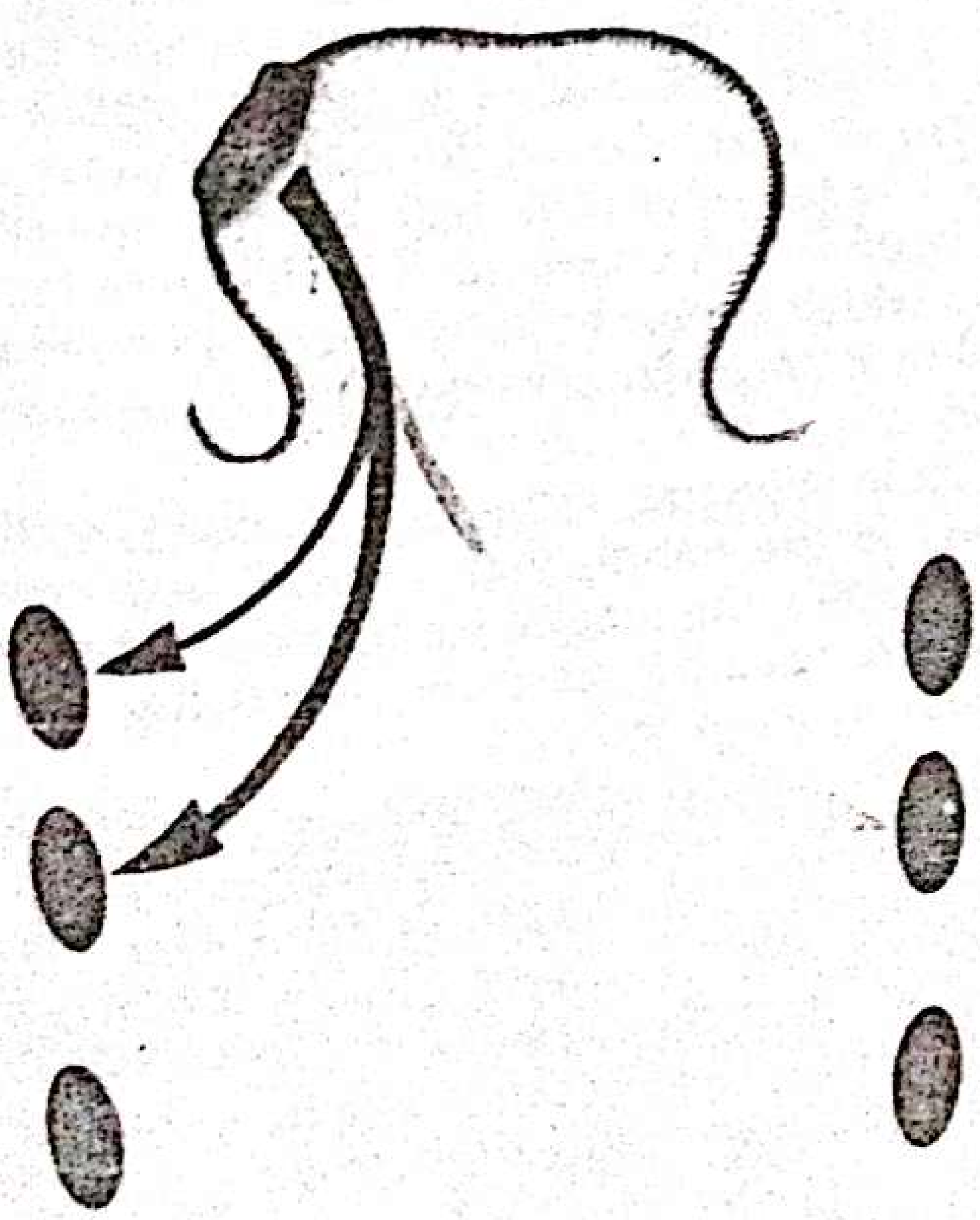
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In contrast to blood supply, lymph vessels pass from the tongue to both sides of the neck. From the lateral aspect, tumour emboli can be carried in the lymph to the nodes on either side of the neck, but in clinical practice ipsilateral spread is much the most frequent pattern. Contralateral spread generally develops only once the ipsilateral vessels are blocked by tumour, ablated by surgery, or fibrosed by radiotherapy.

The statement that 'in 50 per cent of individuals, lymphatics from the tongue pass through the mandibular periosteum *en route* to the submandibular nodes', has been used to provide support for the concept of hemimandibulectomy as an obligatory element in the surgical management of tongue carcinoma. This concept is now totally discredited. Surgical excision where the mandible was not resected has proved therapeutically effective in practice, and it has been amply shown that when the mandibular periosteum is involved by tumour, it is by direct extension from the primary site, and not by lymphatic spread.

Functional considerations

The segment of the tongue which is resected is determined by the site and size of the tumour, and to that extent it is beyond the surgeon's control. The aspects of function which he can influence relate to the effectiveness of his reconstruction, and they concern the part the tongue plays in swallowing and in speech, and in the manipulation and disposal of saliva and food.

The anterior free segment makes the greatest contribution to tongue function in the normal mouth. It acts as the 'sweeper' of the mouth, collecting the saliva which pools in the anterior floor, manipulating the food bolus in mastication, and positioning both food and saliva within the mouth in preparation for swallowing. In speech it plays a key role in the sounding of consonants, their proper enunciation requiring the placing of its tip against the gingival mucosa related to the posterior surface of the upper incisor–canine area.

The central third of the tongue, and to a lesser extent the posterior third, are also concerned with the swallowing sequence, the dorsum being pressed against the hard palate, and the bolus of food and/or saliva pushed backwards towards the oropharynx.

Direct suture, split-skin grafting, and flaps have all been used following resections of the various parts of the tongue, and the functional results which each has achieved has made it possible to analyse the effects of the various forms of surgical insult to the different parts of the tongue. They have also provided added insight into certain aspects of normal tongue function.

Surgery can affect the function of the tongue through denervation, motor and/or sensory, through loss of substance, and as a result of tethering.

Denervation

The effect of denervation on function does not appear to be great, probably because it is usually unilateral, although it may also be that its effects are overshadowed by other effects of the resection, so that the patient is not aware of its specific effect on function.

Substance loss

The use of skin grafting of the postexcisional defect, where the loss of the tissue resected is not restored, has allowed a comparison to be made of the effect of pure loss of substance with that of the same defect when the volume and shape of the tongue have been restored with a flap, and also with the tethering effect of direct closure of the defect.

In the anterior free segment of the tongue, loss of substance is generally the result of the resection of a tumour which has spread backwards onto the ventral surface of the tongue from the anterior floor of mouth. The surgery required to resect such tumour extension increasingly involves removal of the muscle substance in the anterior tongue, and also the genioglossus muscle as it approaches its attachment to the symphyseal mandible. The effect on tongue function is clearly considerable, but if a reconstruction is used which is designed to maintain the tip of the tongue free and mobile, the adverse effect is less than might be expected, even if the bony attachment of genioglossus, its major extrinsic muscle, is lost. The soft tissues in the area appear to provide an adequate alternative point of fixation.

In the side of the tongue, pure loss of substance has little adverse effect on function, as long as the defect is less than a quarter of the tongue's total volume. Some lateral escape of air occurs in speech, but manipulation of food and saliva is largely unimpaired, and swallowing is not affected. When the loss of substance is made good by inserting a flap to restore the original shape and volume of the tongue, function is maintained to a remarkable degree, even when the loss is considerably greater than a quarter of the original volume. It is surprising how effective the residuum of functioning muscle is in moving the immobile reconstructing flap.

Tethering

The functional deficit which results from tethering of the tongue depends on the site of the tethering.

In the anterior free segment, the effect of tethering is to reduce the reach of the tip of the tongue and limit its movement. Inability to reach the upper incisor teeth leaves the patient unable to speak clearly, because of his inability to enunciate almost half of the consonants properly. The tip is also unable to clear the anterior floor of the saliva which normally pools there, to manipulate food and saliva in preparation for swallowing, or to initiate the act itself.

In the middle segment, tethering generally holds the tongue lower in the mouth than normal, and exerts its effect by preventing the tongue from pressing against the hard palate, an essential function in passing the food bolus back for swallowing.

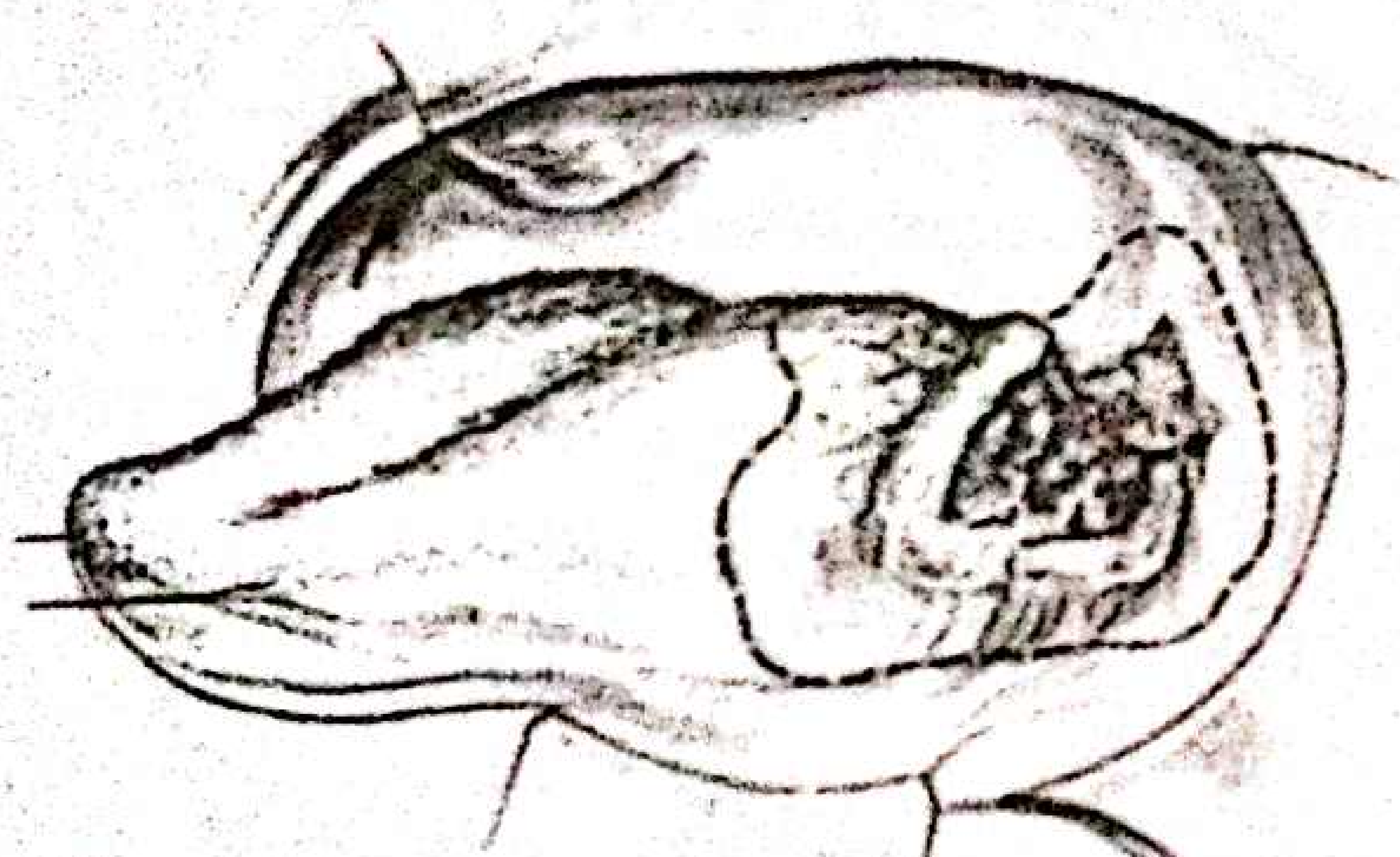
The effects of denervation, loss of substance and tethering of the tongue cannot be totally divorced from one another in the clinical situation, but by far the major factor in creating the adverse effects seen in practice is tethering. The improvement in function which has resulted from the use of reconstructive techniques has largely reflected the extent to which they have eliminated tethering.

Surgical approach

Whether the open mouth provides adequate exposure of the tumour of the tongue is determined partly by its site in the tongue, but much more by whether or not the patient is dentate. For the resection to have a proper degree of precision, the approach confined to the open mouth is usually restricted to the edentulous patient. When the teeth are present, the depth of the mucosal floor prevents adequate visualization of the tumour site. In the edentulous mouth, the reduction in the height of the mandible which results from the absence of the teeth, coupled with the resorption of the alveolar mandibular bone which follows their loss, as described on p. 309, makes the entire side of the tongue easily visible. The tongue itself can also be pulled forward more readily at operation, to the extent that small tumours along its lateral border, extending back almost to the anterior faucial pillar, can be excised with a proper degree of precision.

When additional access is required, the mandibular swing approach should be used. This approach, as described in the chapter on 'Access to the mouth', pp. 241–253, provides excellent exposure of all parts of the tongue.

The extent of the tumour, and the clearance required, are assessed as much by palpation as by vision, induration being the characteristic by which the presence of tumour is recognized. In general this is a reliable criterion, but there are instances where the reaction to the tumour, which is responsible for the induration, appears to be less than average, given its lateral extent. The surgeon should be on the lookout for this occurrence and extend depth clearance accordingly. Induration as a criterion of extent also loses a considerable amount of its reliability when the tumour has been previously irradiated. The induration which is the result of the radiotherapy, and that due to residual or recurrent tumour, cannot be distinguished from each other with certainty.



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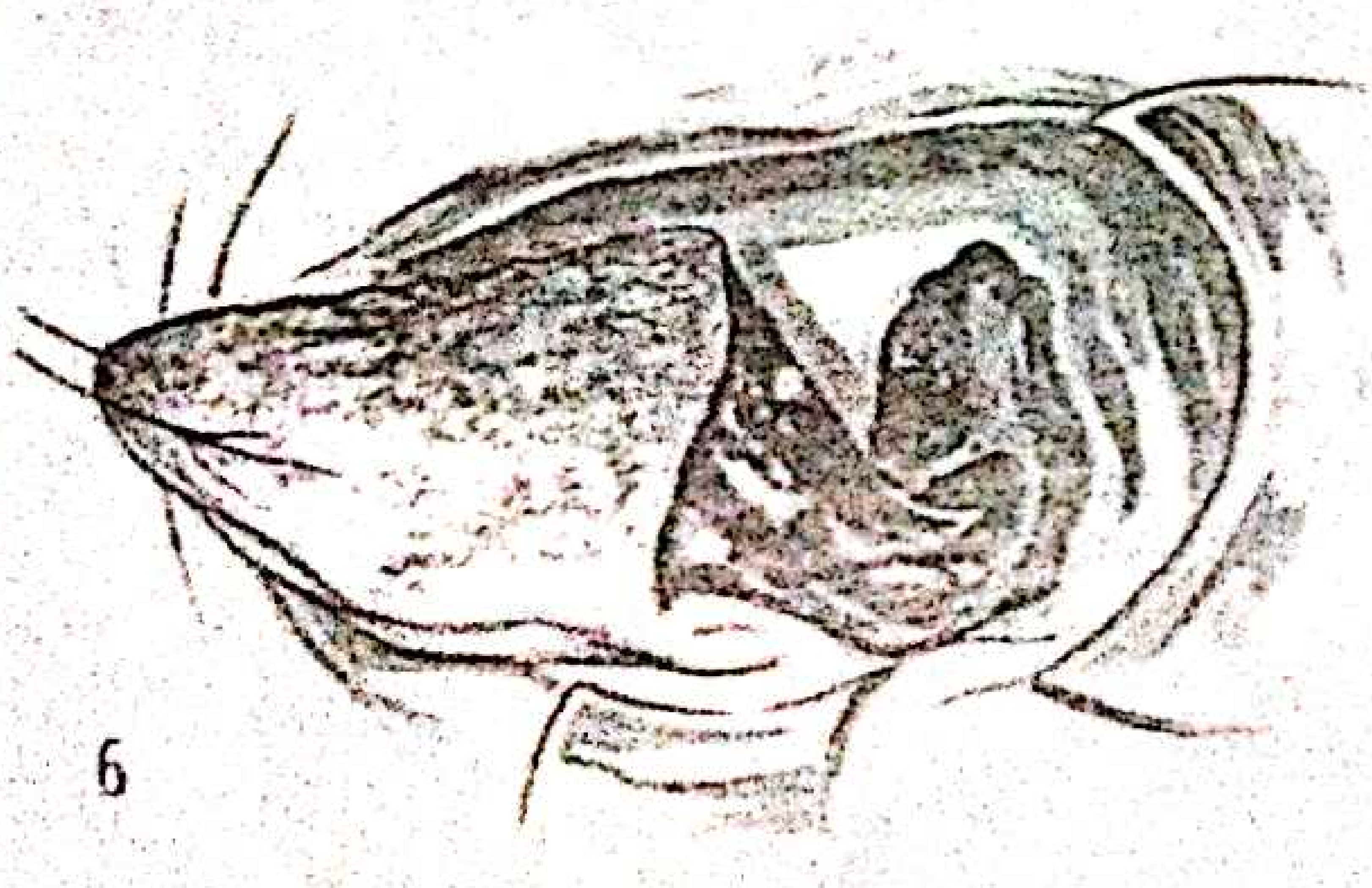
Small tumour

RESECTION

5

A small tumour is conveniently defined as one which can be excised through the open mouth. The first step in the resection is to place a traction suture through the tongue substance near the tip. This allows the tongue to be drawn forward, and helps to stabilize it. The margin of the excision is then outlined on the mucosal surface with Bonney's blue. This dye is sufficiently water-resistant to remain visible for as long as necessary.



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The mucosa is incised along the marked line, down to the underlying muscle. Excision is best begun along the dorsal margin, deepening the marginal incision and working towards the floor. Resection can be facilitated by inserting a catspaw retractor, held by the assistant, along the dorsal resection margin, to provide a stable base against which the surgeon can work in cutting into the muscle to clear the tumour deeply. Large vessels, met as the resection through the muscle proceeds, are picked up for ligature or diathermy. With the defect fully displayed, haemostasis is completed.

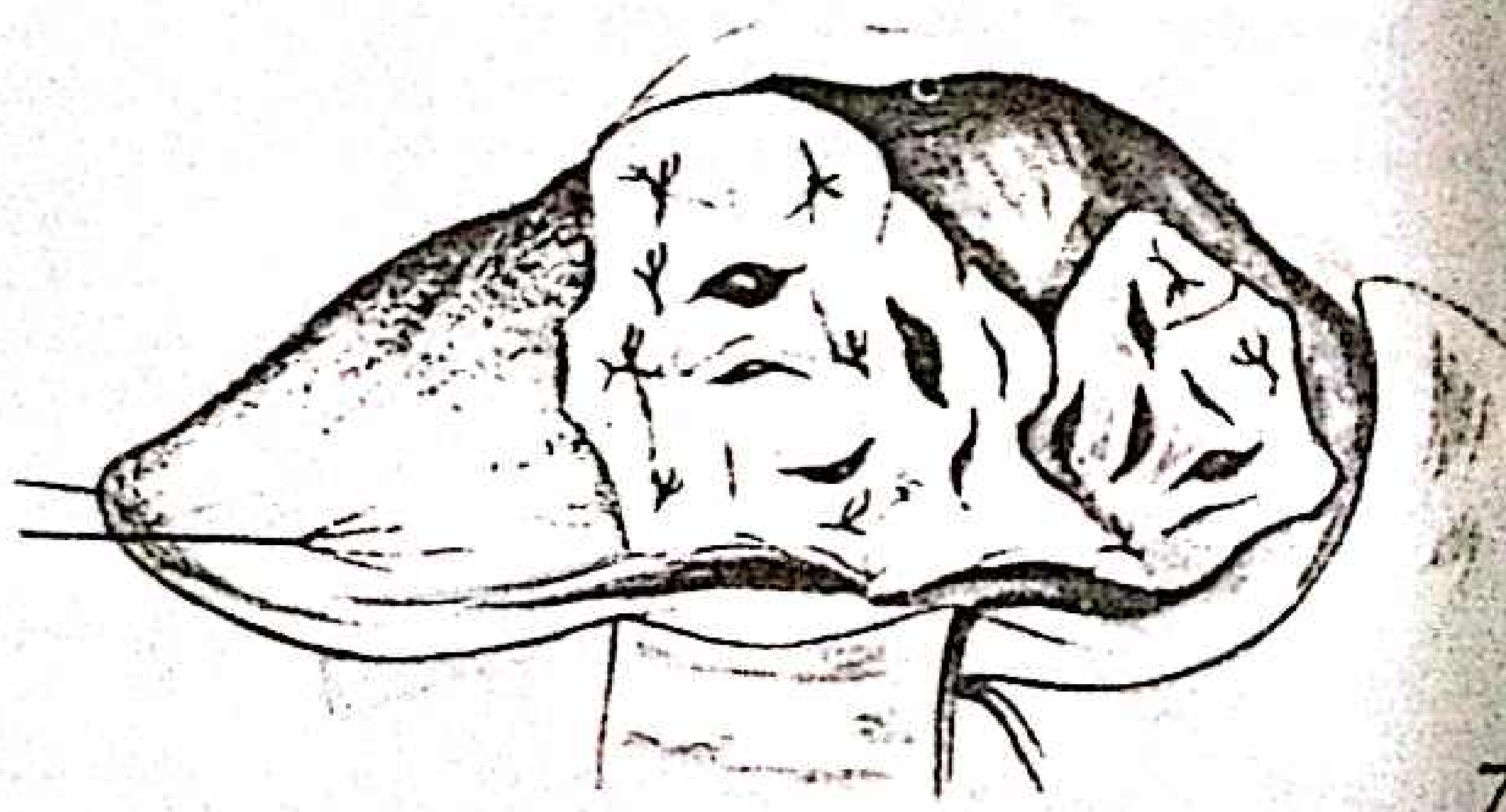
RECONSTRUCTION

The alternatives available are direct suture and split-skin grafting of the defect.

As already discussed, the adverse functional effects which follow resection of the tongue are in large measure the result of tethering, and because of this direct suture has an extremely limited role. When the resection is of the dorsum, direct suture may be acceptable if the defect is a small one, since the overall effect is to narrow the tongue, rather than to prevent it from reaching the palate to play its part in the swallowing sequence. However, defects of the dorsum following tumour resection are seldom small, and the technique is rarely indicated. When direct closure is being considered for a defect of the side of the tongue, its unacceptability parallels the degree of tethering which it is likely to produce. When the defect is of the anterior free part of the tongue, direct suture is virtually always contraindicated.

7

The alternative method, and the one to be preferred, is to apply a split-skin graft to the defect, using the quilted grafting technique, as described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240.



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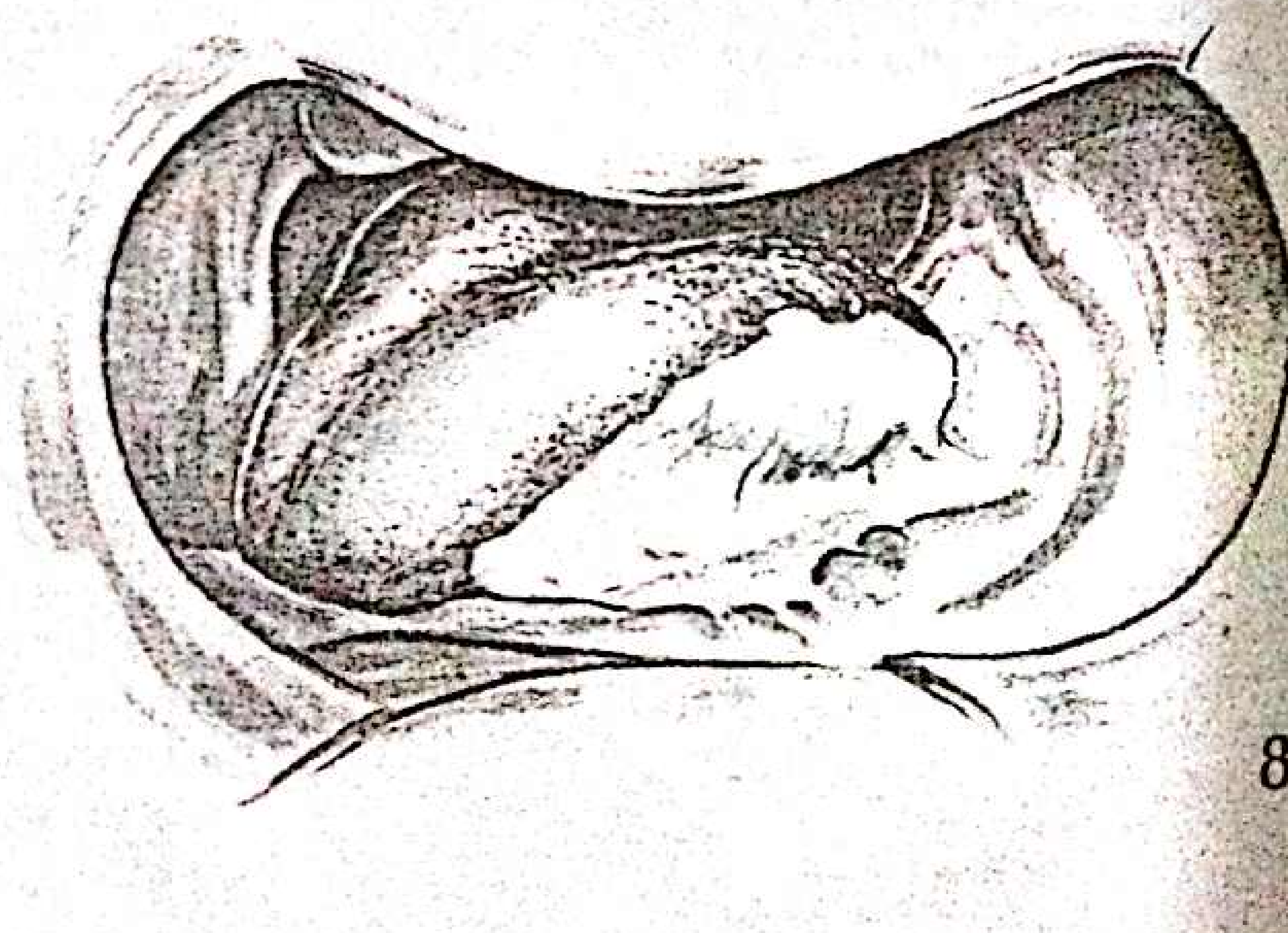
The final result, with healing complete, shows an absence of distortion or tethering of the tongue.



8

Large tumour

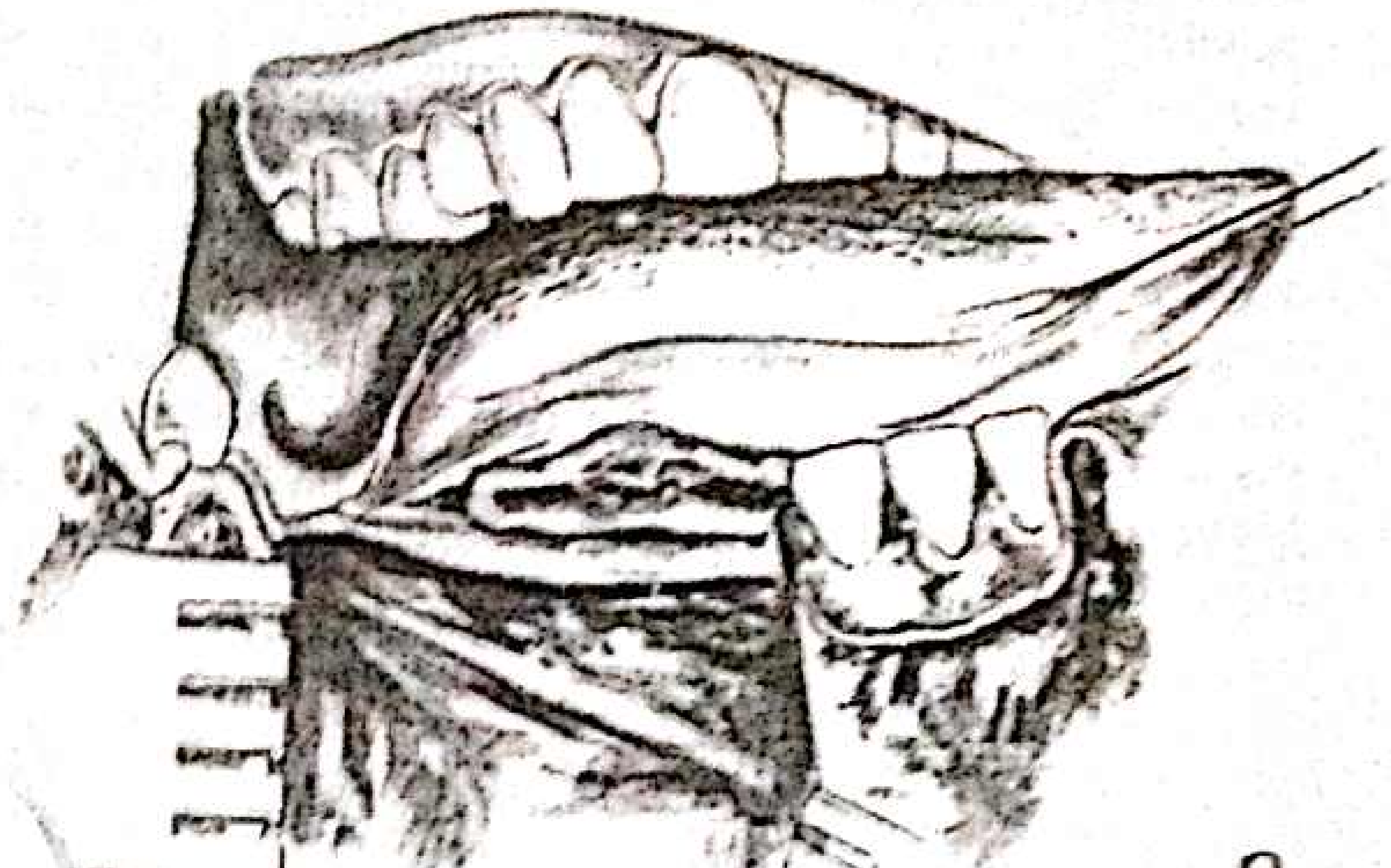
RESECTION

For the present purposes, a large tumour can be defined as one which is unsuitable for resection using an entirely intraoral approach.

Where the tumour is laterally sited, a neck dissection, radical or functional, has generally been carried out as a preliminary to the intraoral resection, to the stage where the submandibular salivary gland has been mobilized from the lingual plate of the mandible.

9

The mandibular swing approach to the tumour, using the lateral osteotomy site to divide the bone, is then used. The initial effect of the outward swing of the mandibular segment is to place the mucous membrane of the floor, and the underlying mylohyoid muscle, on the stretch.



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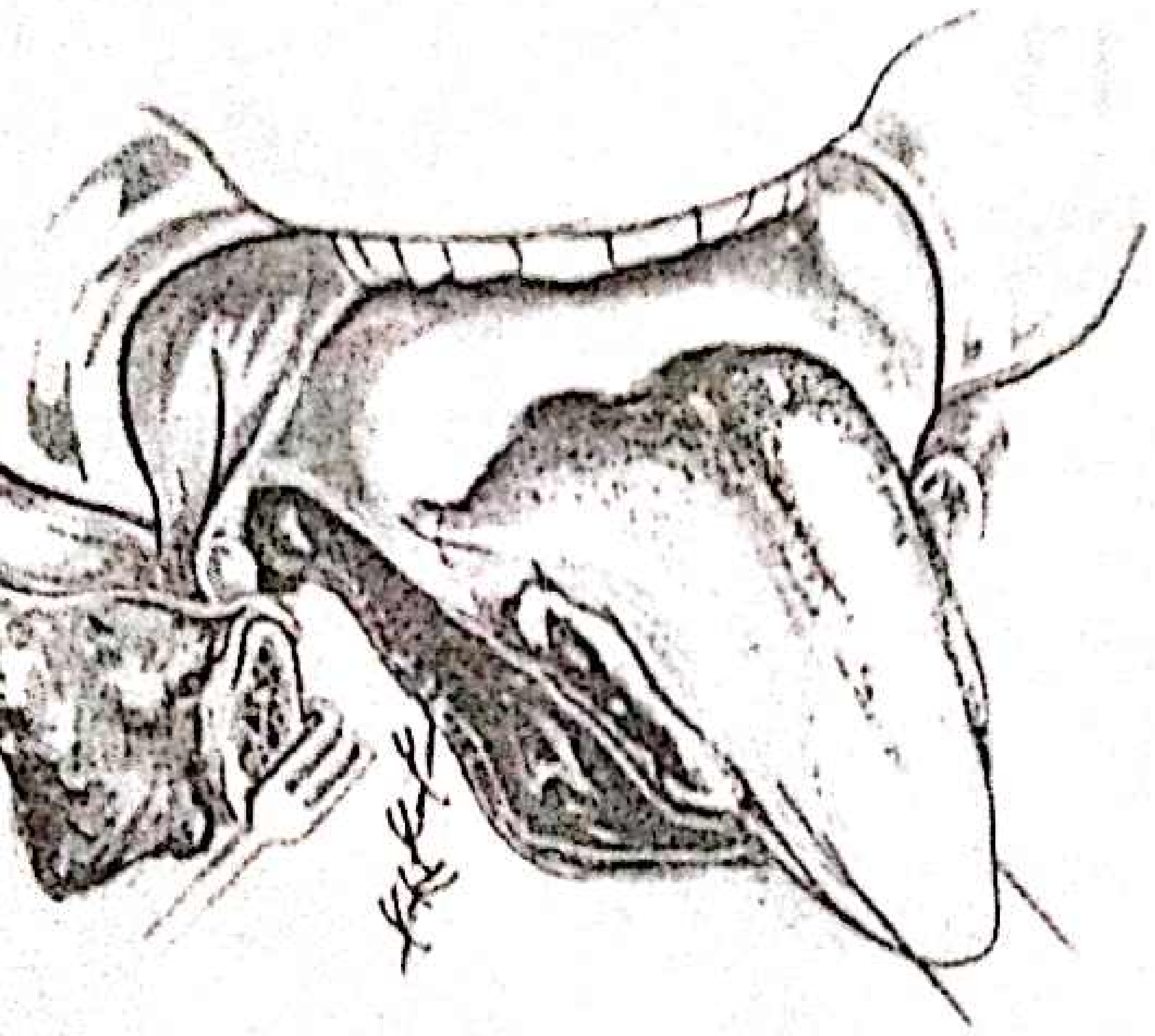

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Mylohyoid and the mucous membrane are divided, parallel to the line of the alveolus, leaving a fringe of mucosa for subsequent suturing. How far the incision is continued back along the floor depends on the site of the tumour on the tongue, and to what extent it has spread on to the floor, but it is generally continued until the tumour is fully exposed. With the superficial lobe of the submandibular salivary gland mobilized, the effect of the incision along the floor is to leave both lobes of the gland attached to the soft tissues on its medial side, to be removed as part of the resection specimen.

Clearance of the tumour has to take precedence, and in carrying out the resection the muscular anatomy of the tongue has to be ignored totally. In the process, branches of the hypoglossal and/or lingual nerves are liable to be divided or removed. It is when the tumour is of the middle third, extending forward, that branches of both nerves are at greatest risk; where the tumour is further back in the tongue the risk is less.

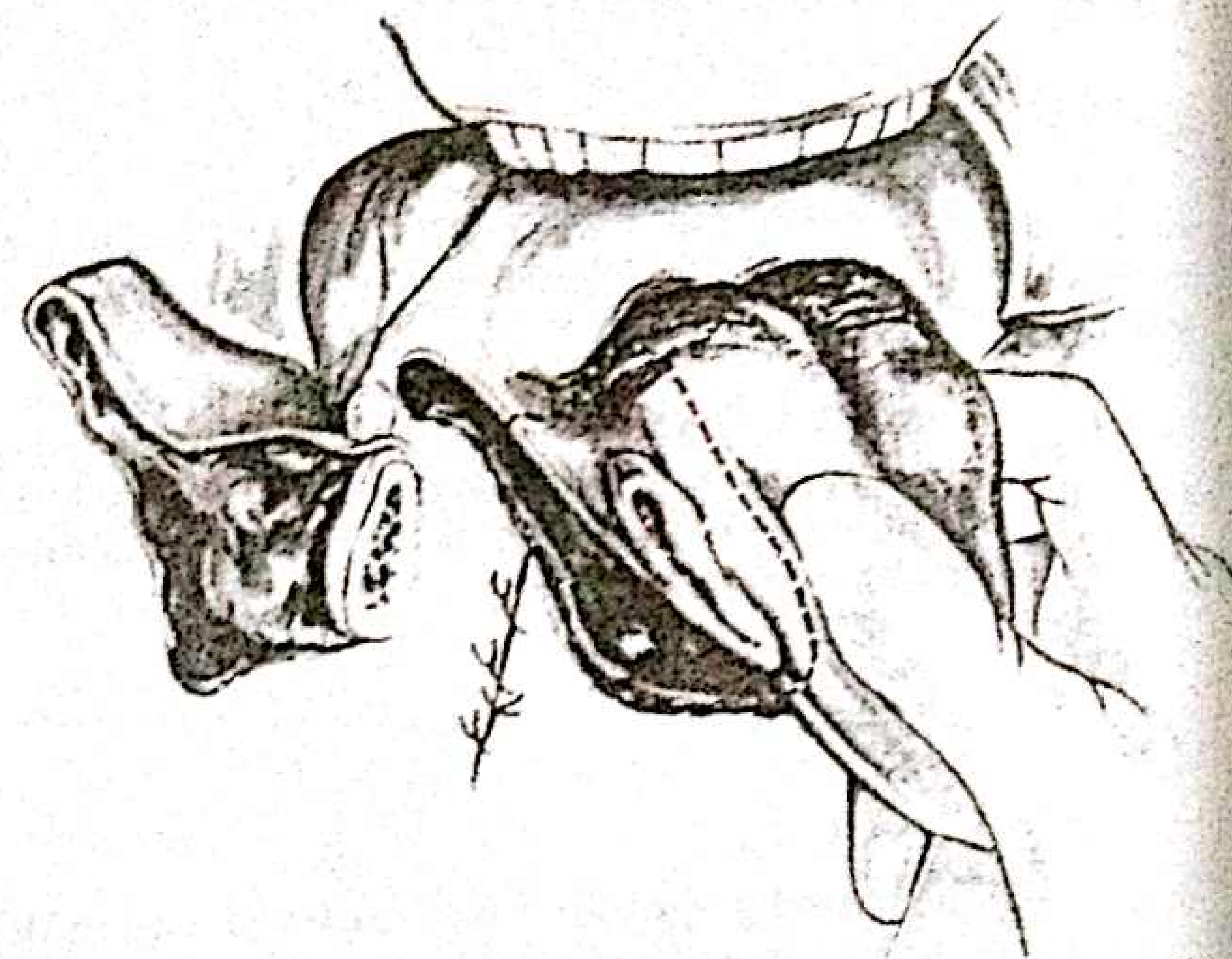
11

11

When the tumour is of the middle third of the tongue, the incision along the floor which allows mandibular swing to take place meets the line of marginal clearance of the tumour at an early stage. Where the two incisions meet, the lateral marginal clearance becomes the incision used to allow completion of the swing.

12

In carrying out the excision of the malignant ulcer, particularly of the middle third where the tongue is minimally supported by the surrounding tissues, a difficulty for the surgeon is that of stabilizing the tongue against the cutting edge of the scalpel, while at the same time trying to control the bleeding from the cut muscle surface, particularly when large branches of the lingual vessels have been divided. An effective method of coping with both problems is for the surgeon to steady the other side of the tongue between his finger and thumb. It can also help, depending on the site of the tumour in the tongue, to have the assistant pull on a traction suture through the tip. The combination usually allows the resection to proceed with minimal interference from bleeding.



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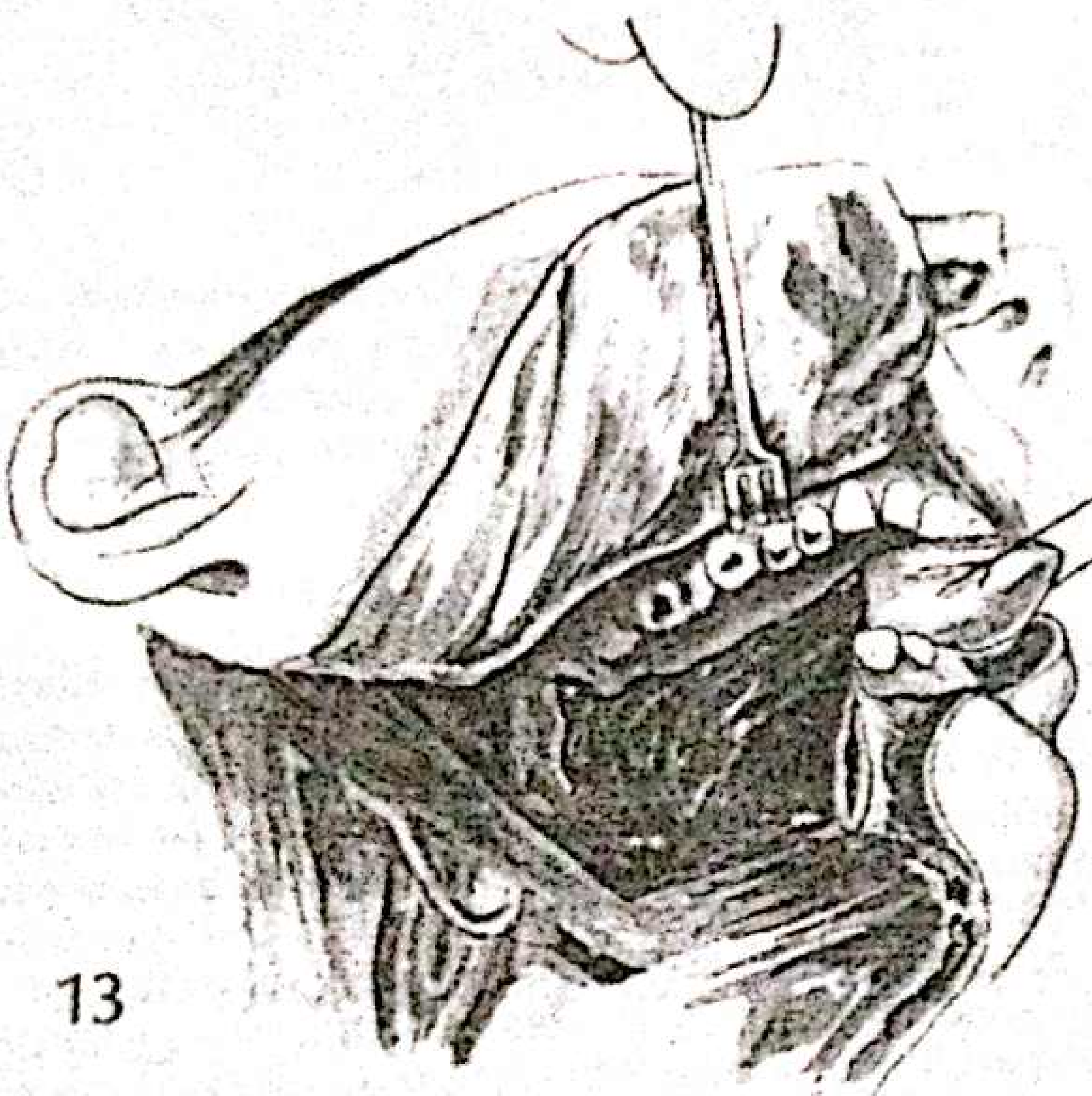

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Individual bleeding sources are dealt with once the resection has been completed.

14

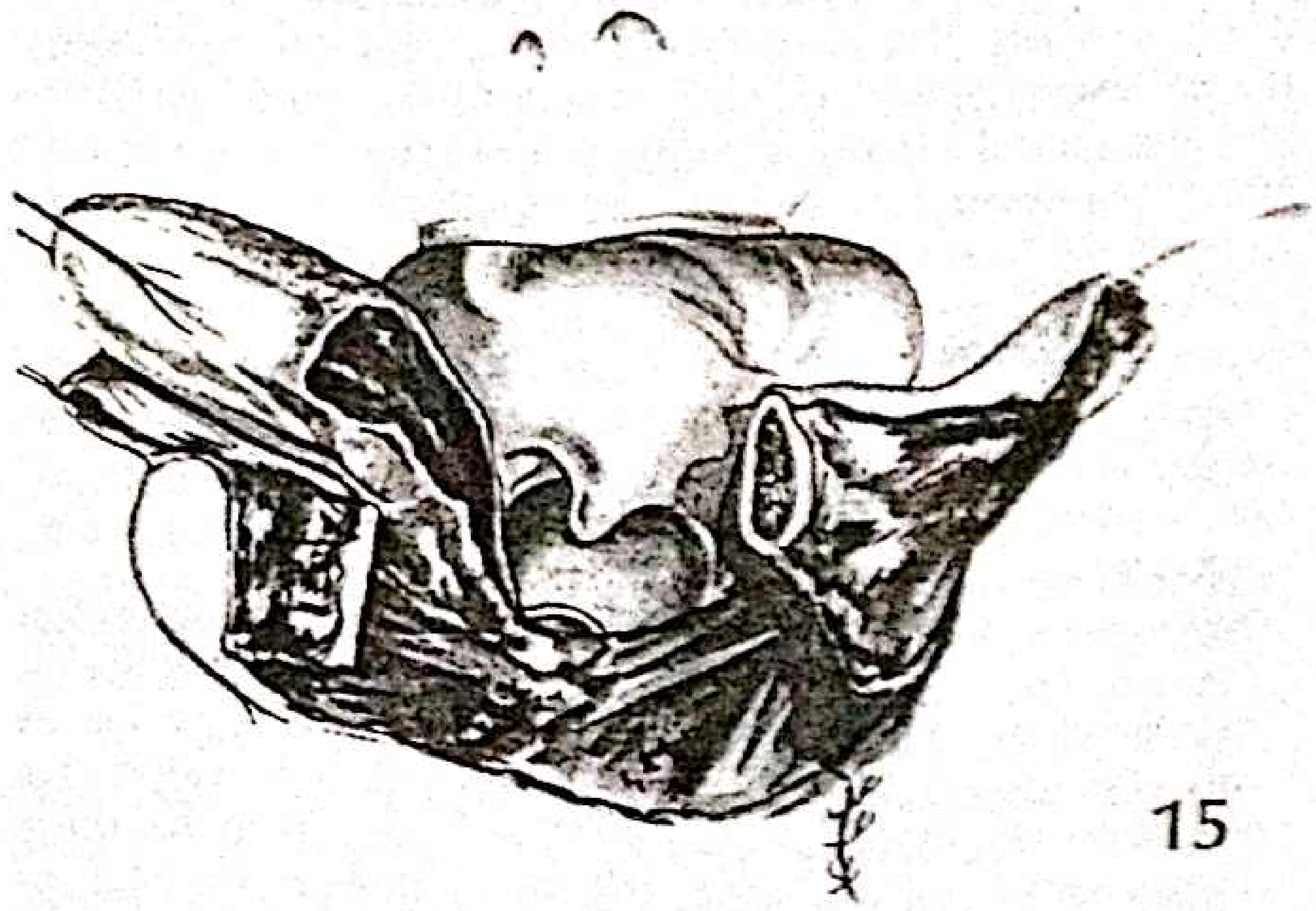
When the tumour is of the posterior third of the tongue, the incision along the floor has generally to be continued backwards beyond the posterior free border of the mylohyoid muscle before it reaches the line of marginal resection. At this point it helps to establish the tissue which has to be divided in passing towards the floor, between the faucial pillars and the posterior third of the tongue, if the surgeon's finger is passed backwards along the lingual surface of the mandible, mobilizing the mucosa with the superior constrictor of the pharynx and the faucial muscles, from the medial surface of the medial pterygoid. The effect is to define the structures which have to be divided in order to complete the swing and expose the tongue back to the epiglottis.

14

15

The tumour is then resected as already described for the middle third of the tongue, and with the resection complete, the bleeding from the resected tongue surface is controlled. Diathermy is adequate for the small vessels, but ligature of the main vessels is probably safer.

In terms of subsequent swallowing function, the epiglottis is a watershed. If it has been possible to leave it intact, and the principles of reconstruction to be described are maintained, swallowing is unlikely to be compromised and inhalation problems should be minimal.



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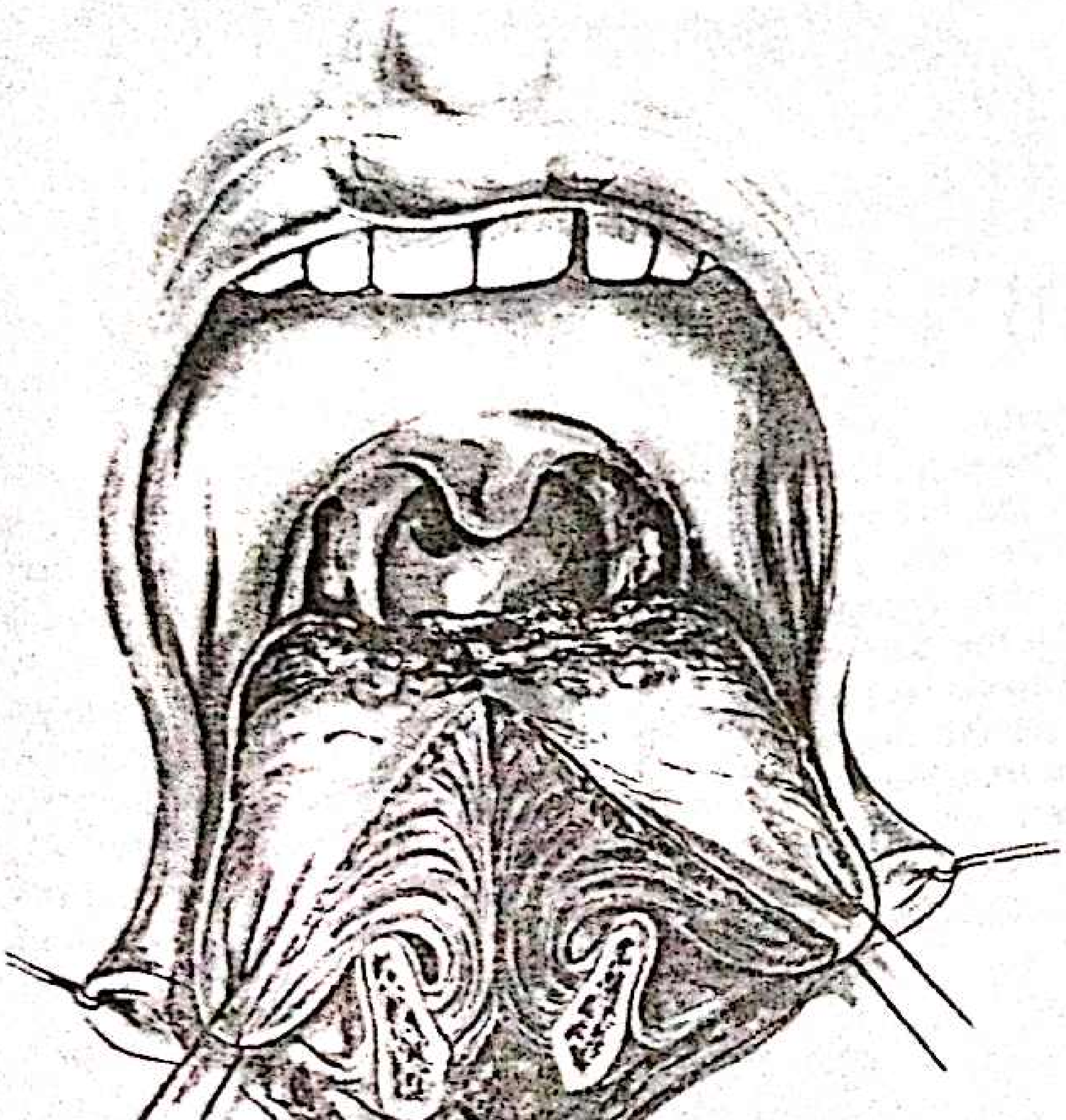

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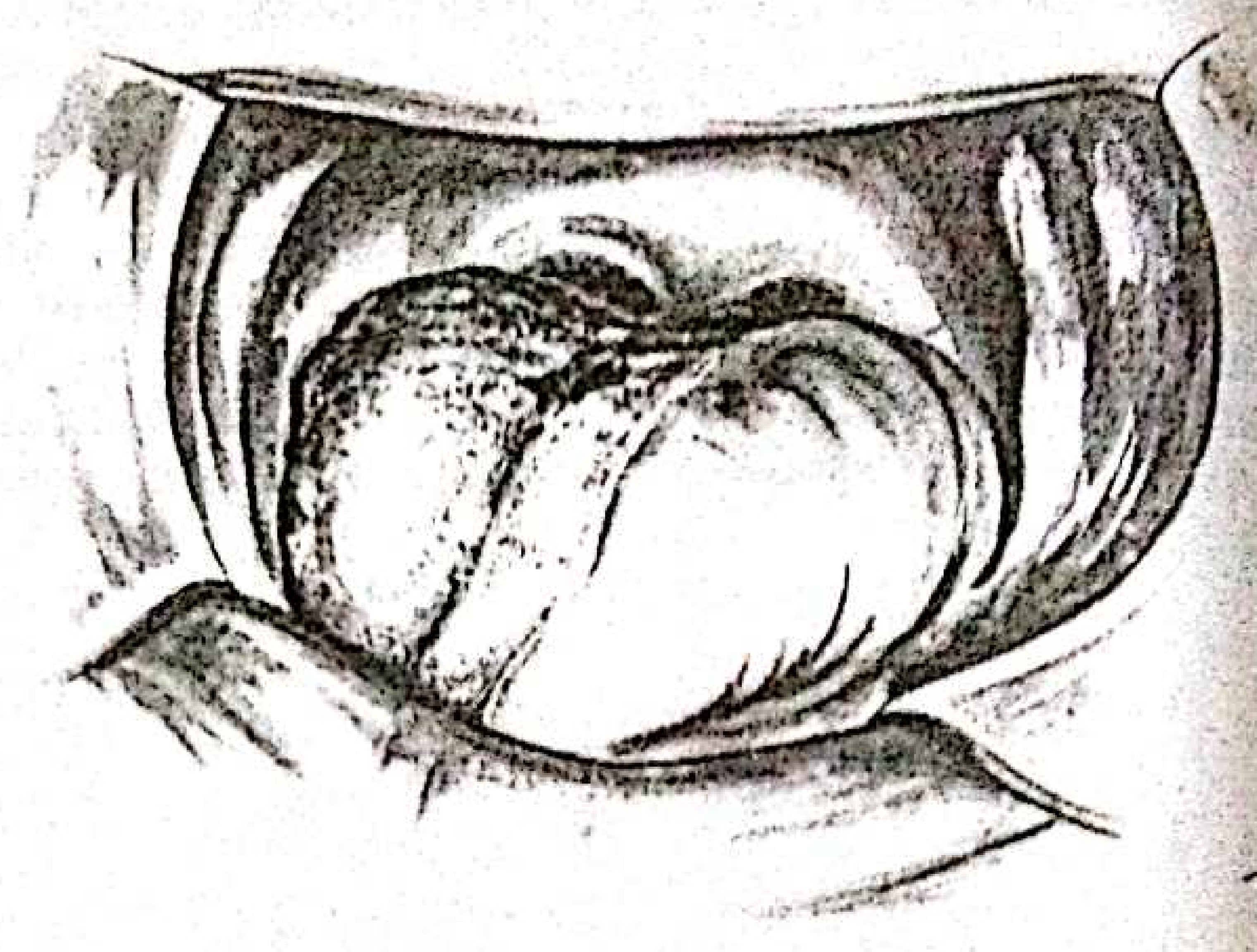
While carcinomas of the tongue commonly arise on one or other side, the tumour on occasion is midline, and this creates problems of access, particularly if the posterior third is the site. If the tumour has already metastasized to one or other side, the surgeon may reasonably approach the site from the side to which metastasis has occurred. In the absence of palpable nodes, there are advantages in the Trotter approach, carrying out a symphyseal osteotomy, followed by division of the tongue backwards along its central septum until the tumour is reached. Resection can then be carried out as already described.

RECONSTRUCTION

17

If optimal tongue function is to be achieved, it is essential to replace the resected tissue with a flap which matches it in volume and shape, leaving the composite as far as possible in the position within the mouth which the tongue occupied prior to the surgery, and with the same volume and shape. This is, of course, a counsel of perfection, but the closer the surgeon is to achieving it, the better the functional result he is likely to achieve.



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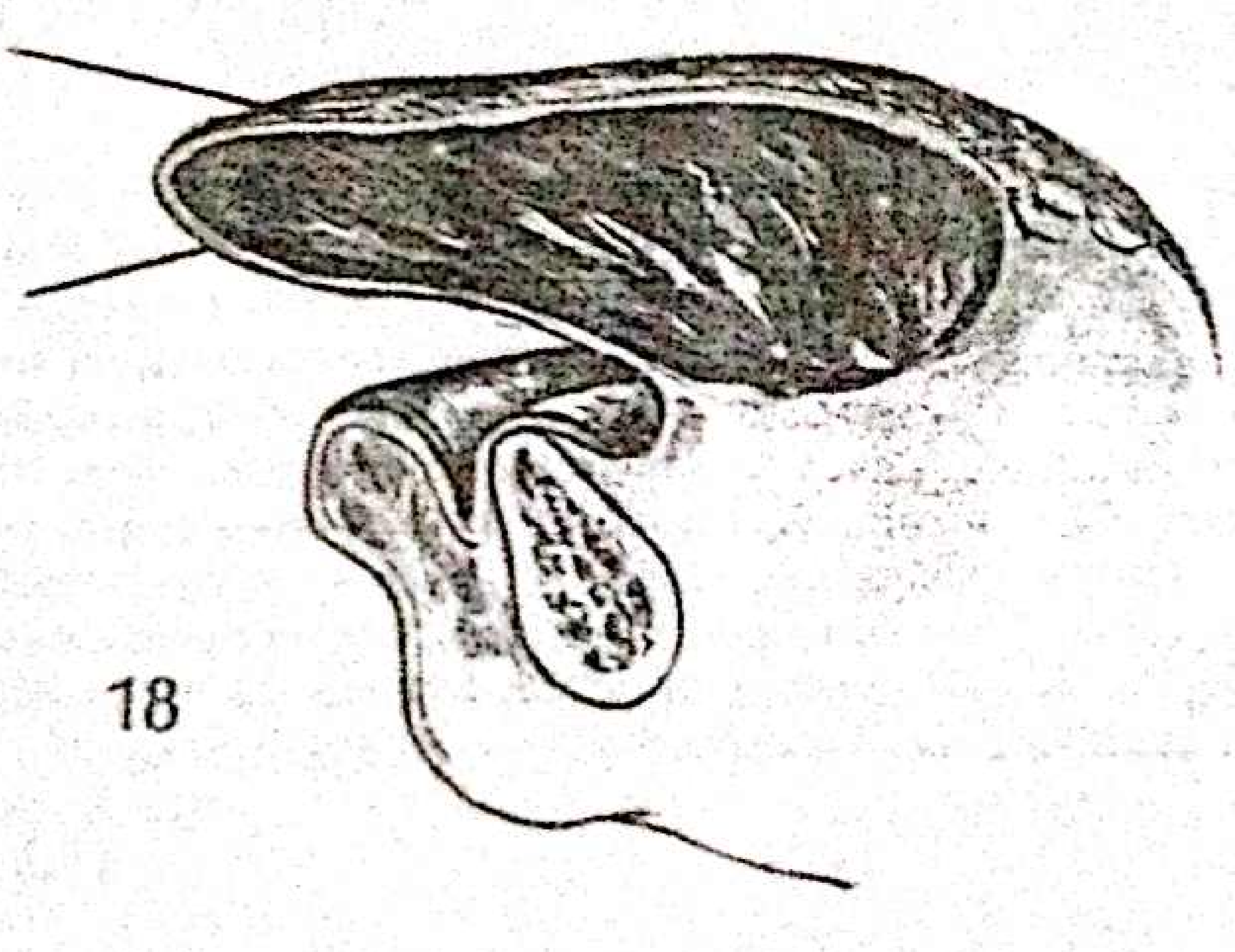

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A further aspect of importance concerns the management of the defect when it includes the anterior segment of the tongue. When the resection is complete, and with traction on the suture pulling the tip forward, the anterior part is liable to appear extremely insubstantial and of little value.

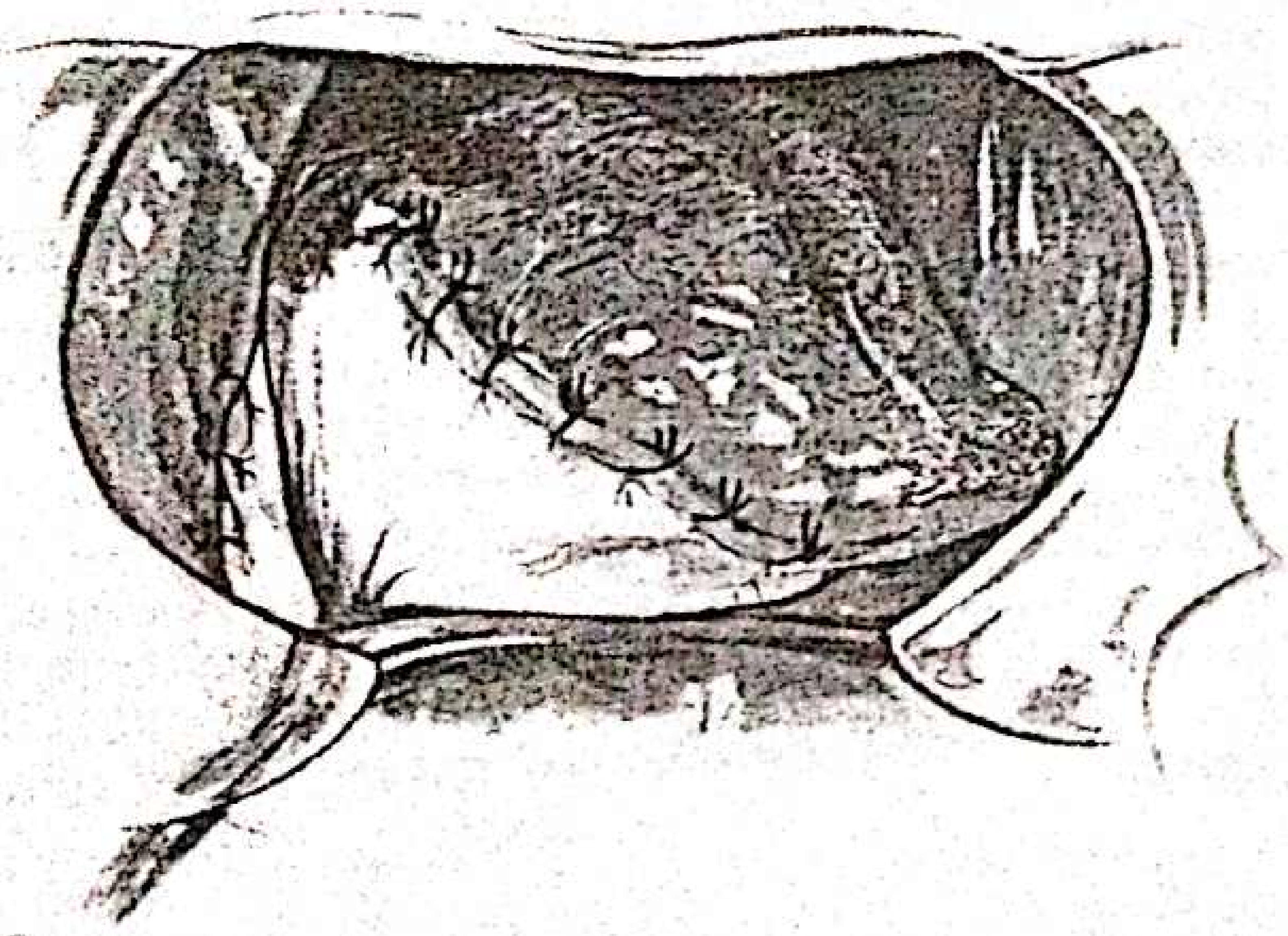
In the past it was liable to be closed directly, or even more disastrously, turned back as a flap and used to partly close the main defect, direct suture being used to close the remainder. Both manoeuvres, in particular the turning back of the tip, are extremely crippling to tongue function, and run totally counter to the reconstructive principles which have been stated.

Reconstruction of the resected segment of the anterior tongue is essential if the best possible function is to be restored, and the restoration should leave the unresected element as undisturbed as possible. What appeared as insubstantial with the patient anaesthetized and the tongue atonic, will be found to be surprisingly substantial and functionally effective, with the patient awake, and his tongue in use.

The potential reconstructive techniques make use of either pedicled flaps or free flaps. The pedicled flaps which might be considered approach the defect from either above or below. The flaps which approach from below are subject to the effect of gravity on the flap, and this factor is a very serious consideration in flap selection. The tongue has no bony attachment able to counter the effect of gravity, and any flap which is subject to a significant gravitational effect is likely to pull the tongue remnant down to the floor of the mouth and tether it in that position, to the detriment of its function.

The flaps which approach from below are the myocutaneous flaps, pectoralis major and lateral trapezius, and the deltopectoral flap. The deltopectoral flap has little if any place in reconstructing a tongue defect, because of its extreme susceptibility to the effect of gravity, and a similar criticism applies to the myocutaneous flaps. The limiting factors of the lateral trapezius flap were discussed in the chapter on 'Reconstructive techniques of the skin', pp. 45–103, and although it is less subject to gravitational problems because of its relatively short pedicle, it is unlikely to be a first choice. The pectoralis major flap is much more subject to the effect of gravity because of its long pedicle. Initially it can provide an apparently good result, but as the operative reaction settles and the tissues soften in the neck it tends to pull the tongue down to the floor, tethering it in that position. Its bulk varies with the thickness of the subcutaneous fat on the chest wall, but to replace tongue alone it is still likely to be more bulky than the ideal. Even so, the surgeon who is restricted in his options, and unable to use a free flap, may feel that he has no alternative, but he must accept that the result is likely to be less than optimal.

The forehead flap approaches the defect from above and holds the tongue high in the mouth during the healing phase. Its bulk provides a satisfactory match and it also models well to the tongue defect. In the long term it will give a much better functional result than any of the alternatives which have been described, but at the expense of a two-stage procedure and a grafted forehead defect, both adverse factors which are generally conceded to preclude its use as a first choice.



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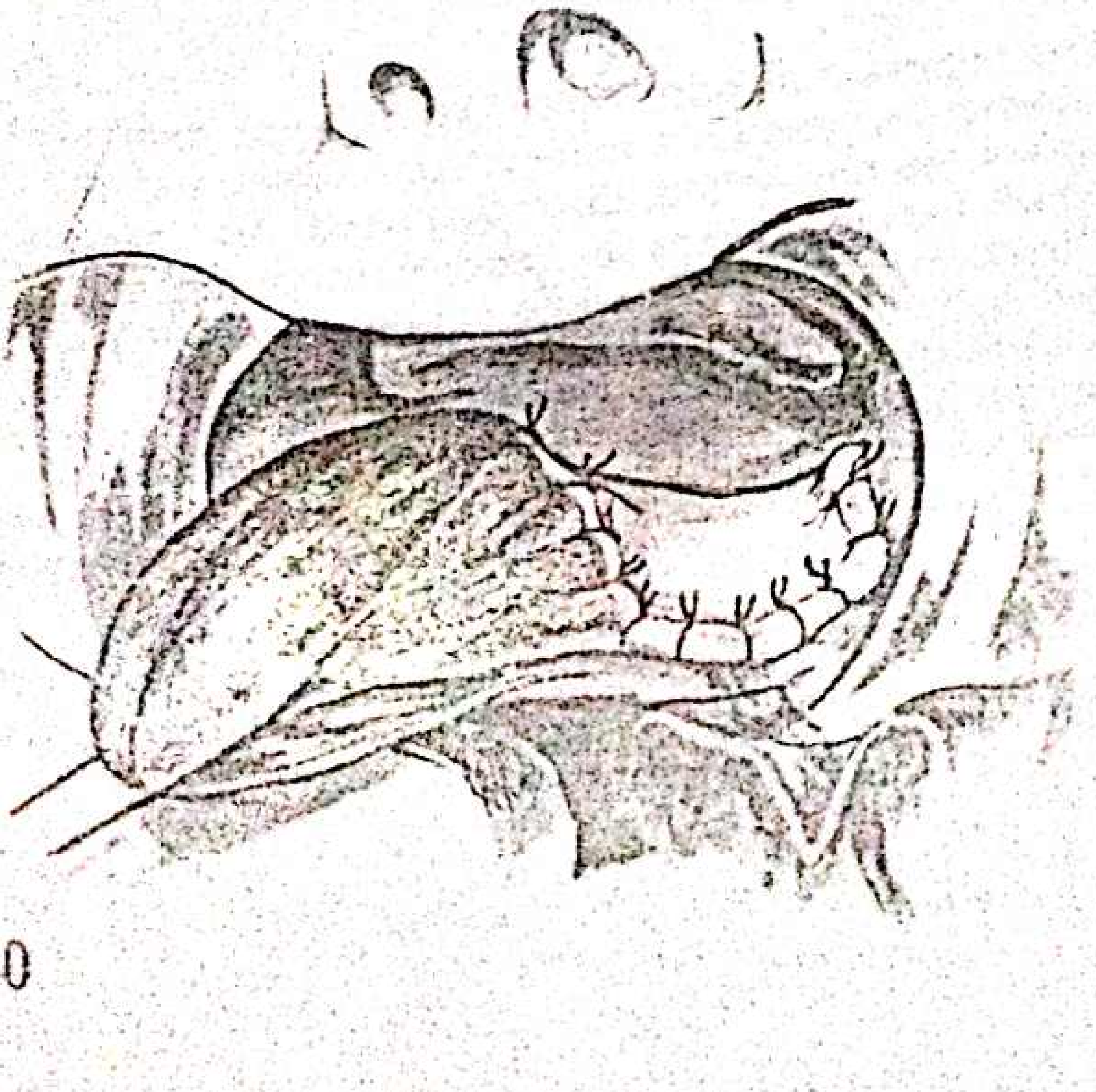

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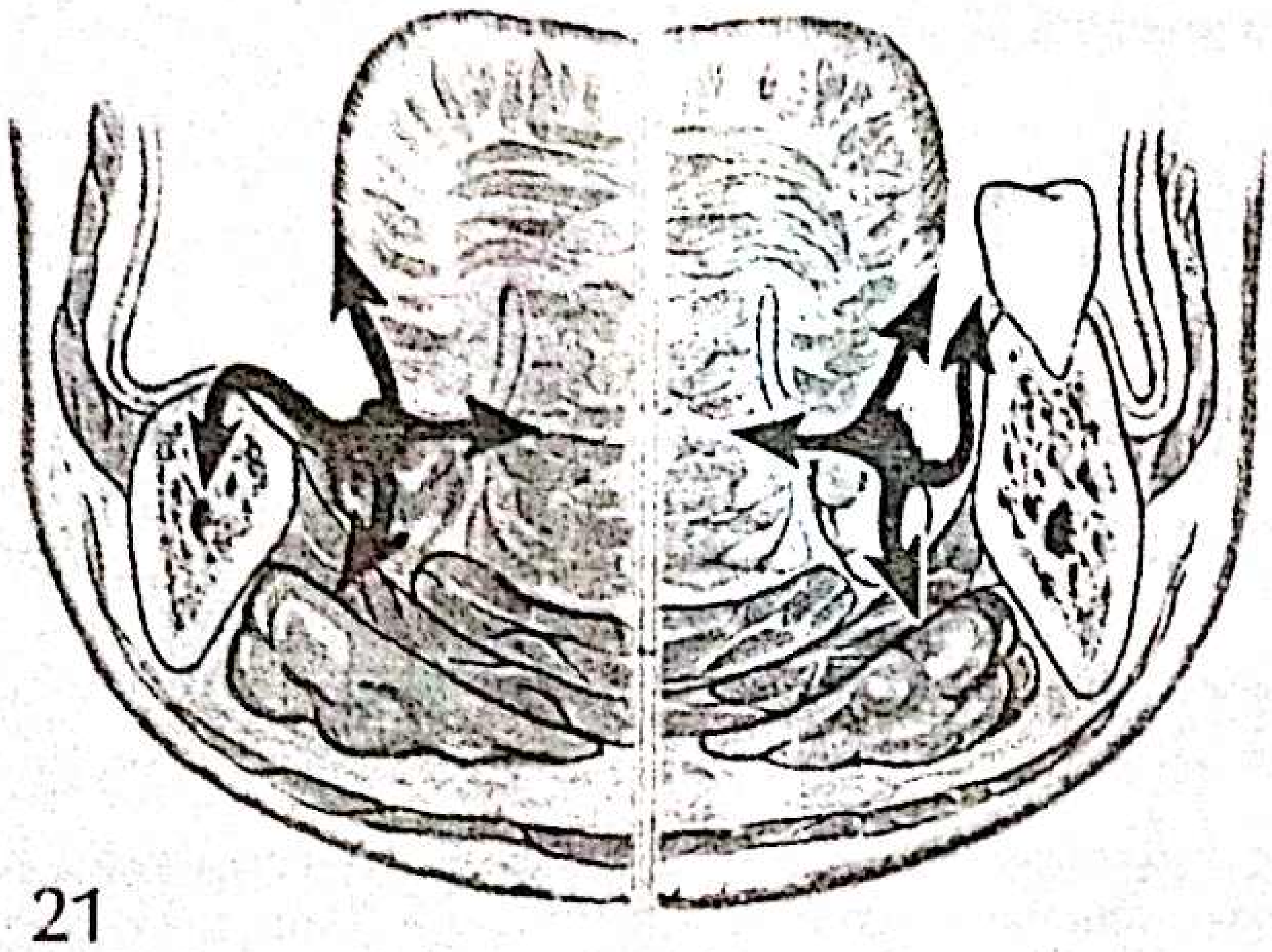
For the surgeon who has the choice, a free flap will give much the best result for the average defect, with an absence of gravity problems and freedom to mould the flap to the defect. The flap with which the surgeon has the greatest familiarity is likely to be chosen in practice, but of the alternatives, the radial forearm flap has the advantage of convenience compared with one of the scapular flaps in not requiring the turning of the patient. Its bulk, in relation to its surface area, is usually about right, in reconstructing defects of both the middle third and the posterior third. In this it contrasts with the latissimus dorsi free flap, whose volume of muscle is likely to have too much bulk for the defect, unless the tongue resection has been near total.

LATERAL FLOOR AND LOWER ALVEOLUS

Judged by the site incidence provided by the survey of early asymptomatic cancers of the oral cavity, shown in the chapter on 'Anterior floor of mouth' p. 255, squamous cancer of the floor of the mouth has a higher incidence than the literature generally would suggest. The probable explanation is that, particularly in the dentate mouth with its deep and relatively inaccessible floor, the tumour, when first noticed, has already spread either medially to the side of the tongue, or laterally onto the alveolus, and is mistakenly attributed to that site. Carcinoma involving the lower alveolus which has spread from the lateral floor of mouth is much commoner than the primary neoplasm arising in the mucoperiosteum overlying the alveolus. The mandibular surgery which is carried out is also similar, regardless of whether the floor of mouth or alveolus is the primary site. It is convenient, therefore, to consider their surgical management together.



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Tumour spread

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The tumour which spreads medially from the floor to involve the side of the tongue differs slightly in its behaviour from that of the tumour arising in the tongue itself, involving it at a lower level and, in spreading deeply, infiltrating the muscles of the tongue at its base and ultimately fixing it in the mouth.

In infiltrating deeply, the tumour of the lateral floor reaches the deep lobe of the submandibular salivary gland and the mylohyoid muscle which lies below it. Together, the two provide an unexpectedly significant 'barrier' to tumour spreading through to reach the submandibular triangle. Involvement of the superficial lobe of the submandibular gland by direct spread through the muscle is uncommon, and indicates advanced disease. With the tumour held above mylohyoid in this way, it reaches the lower alveolus by lateral spread rather than by spread deeply.

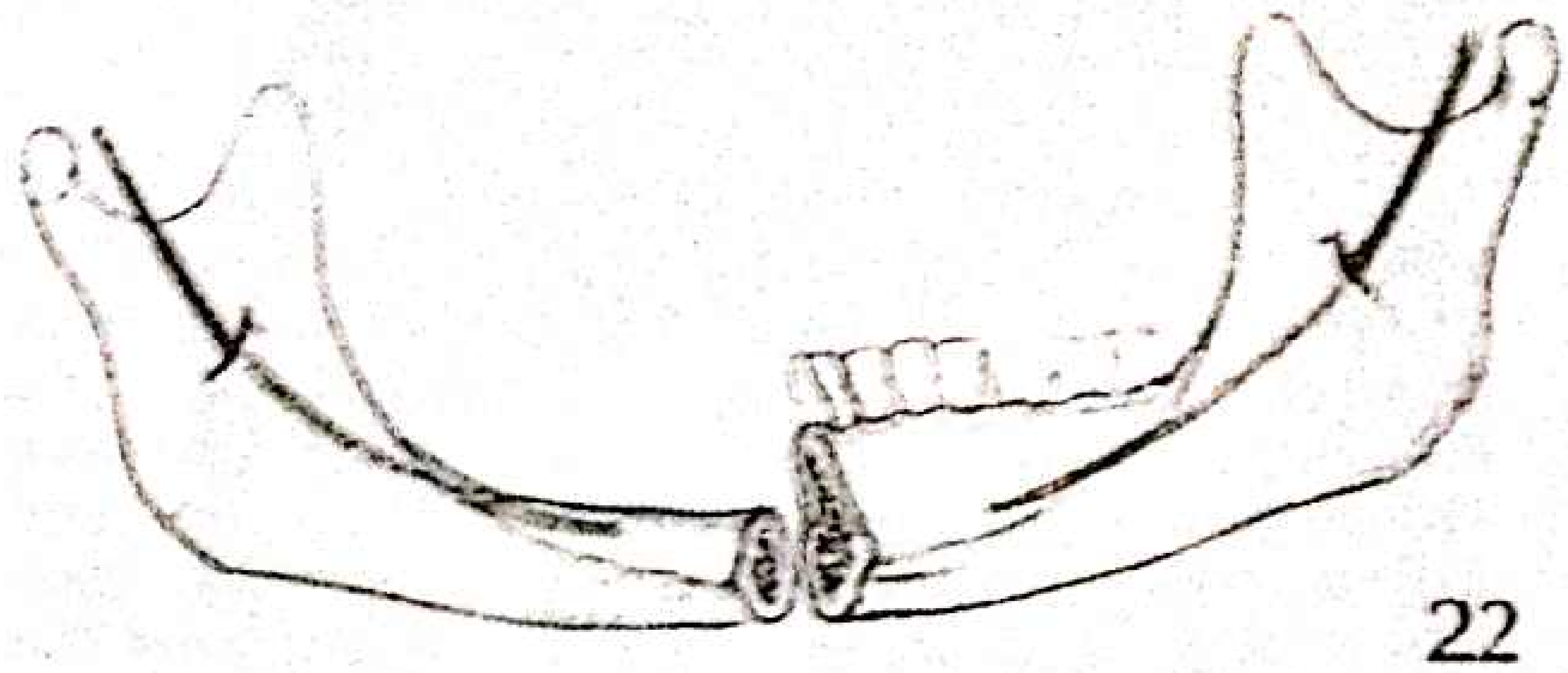
Mandibular involvement

The sequence of mandibular involvement depends on whether the patient is dentate or edentulous, and whether or not the tumour has been irradiated. The manner in which tumour spreads into and through the mandible thereafter determines the type of bone resection which is required, and the form it should take is strongly influenced by anatomical factors relating to the blood supply of the mandible.

Loss of the teeth

22

Extraction of the teeth is followed by resorption of the alveolar element of the body of the mandible, reducing the overall vertical height of the bone. The loss is virtually confined to the bone above the mandibular canal, the distance between it and the lower border of the bone remaining unchanged. As a result, the canal itself comes to lie much closer to the occlusal ridge, its precise level depending on the degree of resorption. In the extreme instance, there may be areas where there is no bone directly over the inferior neurovascular bundle, cover consisting merely of the mucoperiosteum overlying the occlusal ridge.



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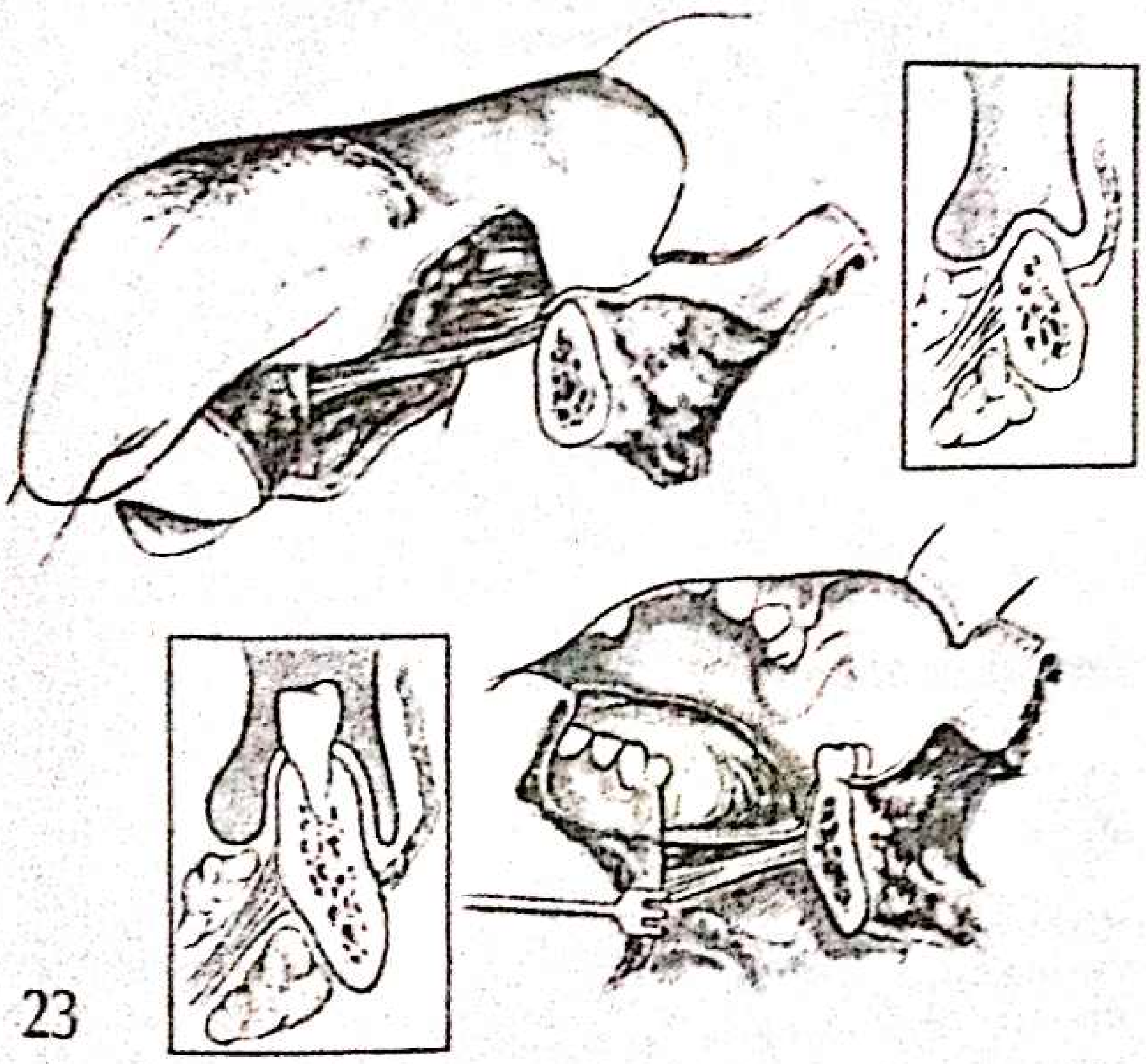

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As a result of the alveolar resorption, there is also a change in the relative position of the attachment of mylohyoid to the mandible. In the dentate bone, there is a significant width of bone above the muscle attachment; in the edentulous bone, the muscle is attached just below the occlusal ridge.

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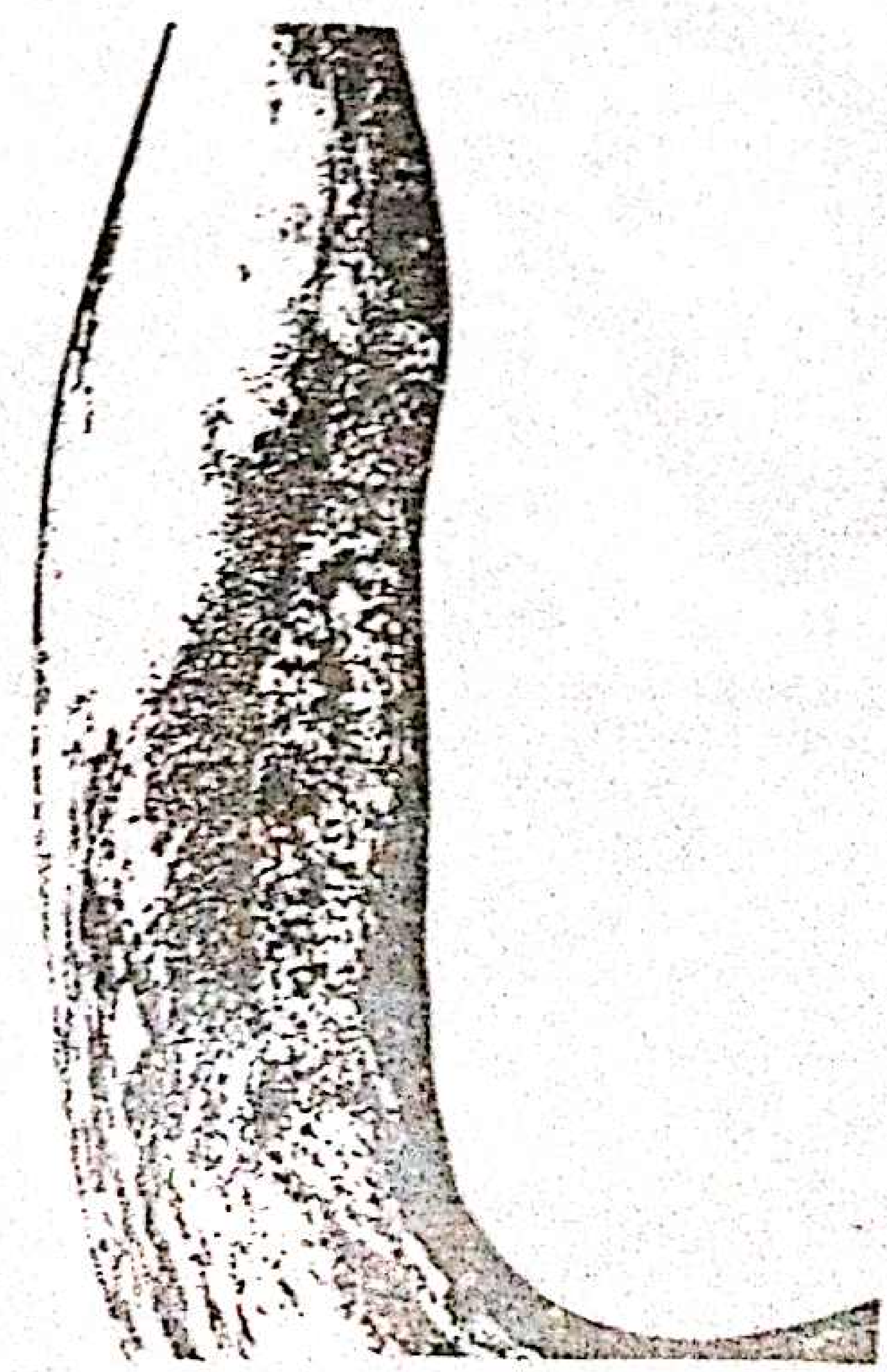
Replacement of the site of the pre-existing tooth socket by cortical bone, which occurs as part of the remodelling of the alveolar segment, remains incomplete to a varying extent, the remodelled ridge being marked by multiple foramina.



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At each foramen the protective barrier of cortical bone, which separates the mucoperiosteum from the medullary cavity of the bone, is absent. The absence of a cortical bone lining to the mandibular canal also leaves the inferior dental neurovascular bundle in direct soft tissue communication with the mucoperiosteum overlying the occlusal ridge. Tumour, once it reaches the occlusal ridge, is thus free to infiltrate unimpeded into and through the medullary cavity of the bone to the inferior dental nerve, with the potential thereafter to spread perineurally to the trigeminal ganglion.

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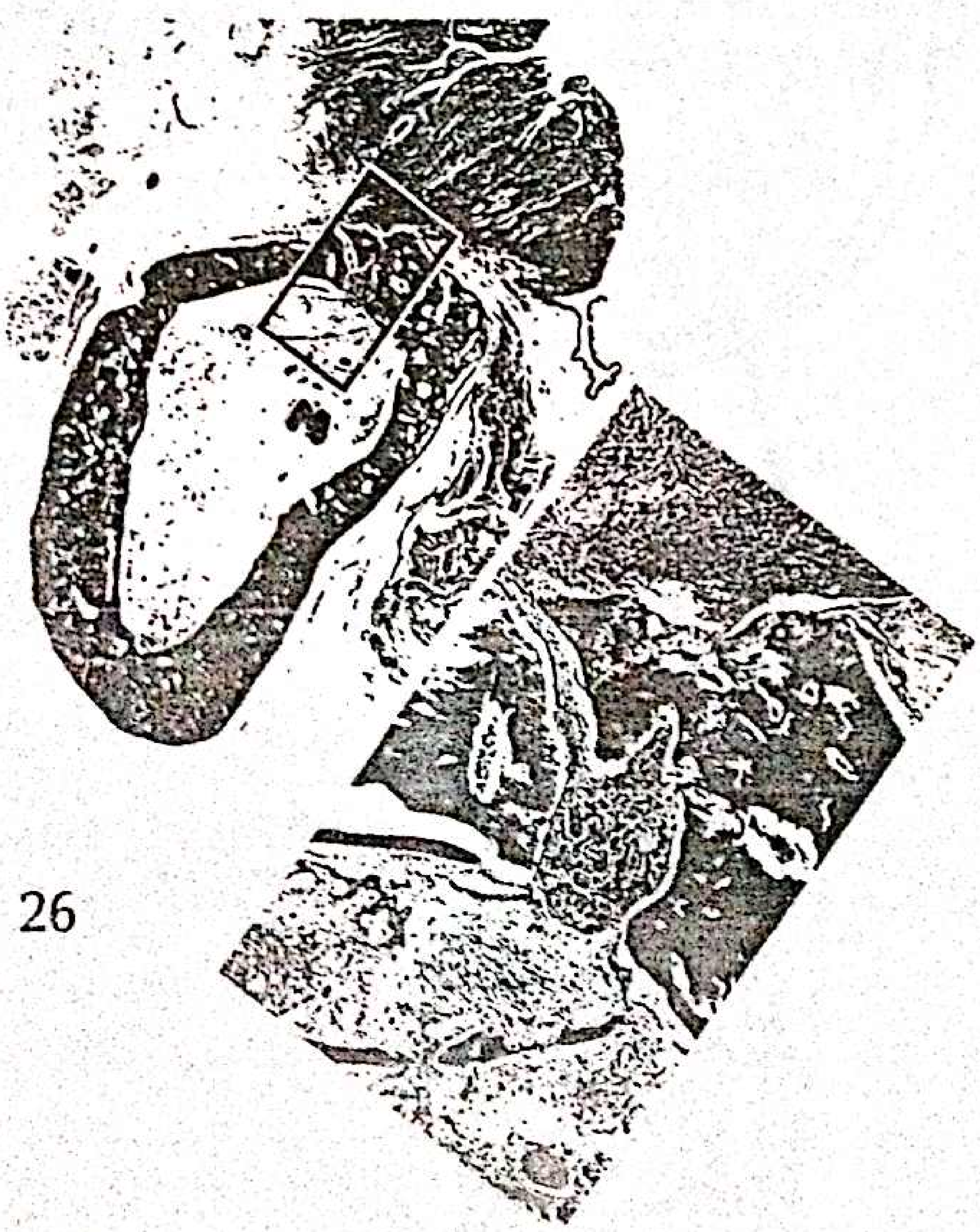

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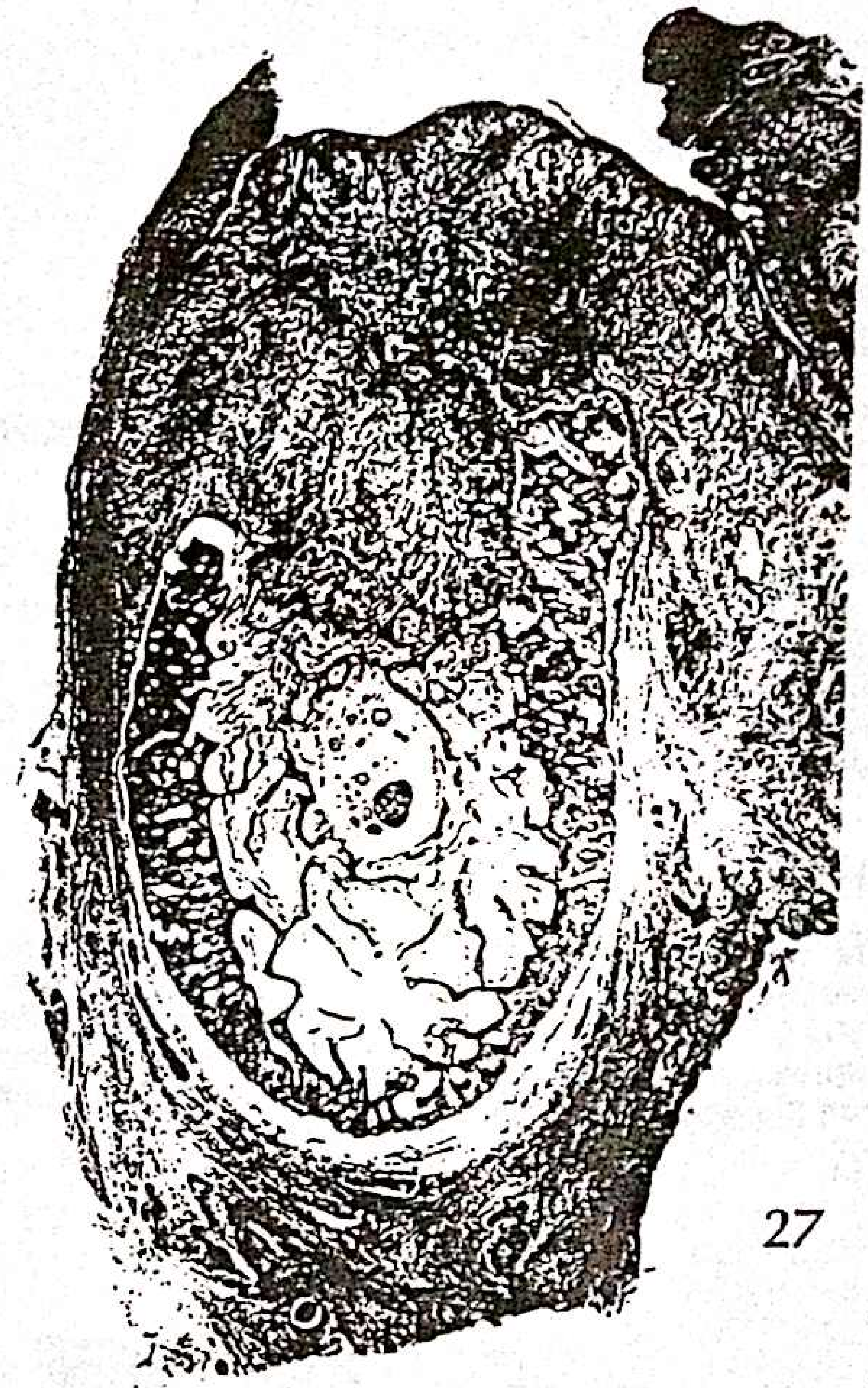
Sequence of invasion

26

In the edentulous bone which has not been irradiated, the mechanism of invasion is documented as occurring through the foramina along the occlusal ridge. The proximity of the mylohyoid insertion to the occlusal ridge is clearly a contributing factor to the sequence, lateral spread of tumour from the floor bringing it quickly to the ridge and the foramina scattered along its line. In the dentate mandible the comparable sequence is less well documented, but the information available would suggest that the occlusal area still provides the usual route of tumour invasion, along the periodontal membrane. Within the bone, spread takes two forms.

27

One form of tumour spread is down through the medullary bone on a 'broad front', the lower border being the last part to be destroyed.



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In the other form of spread, tumour spreads to the perineural spaces around the inferior dental nerve.

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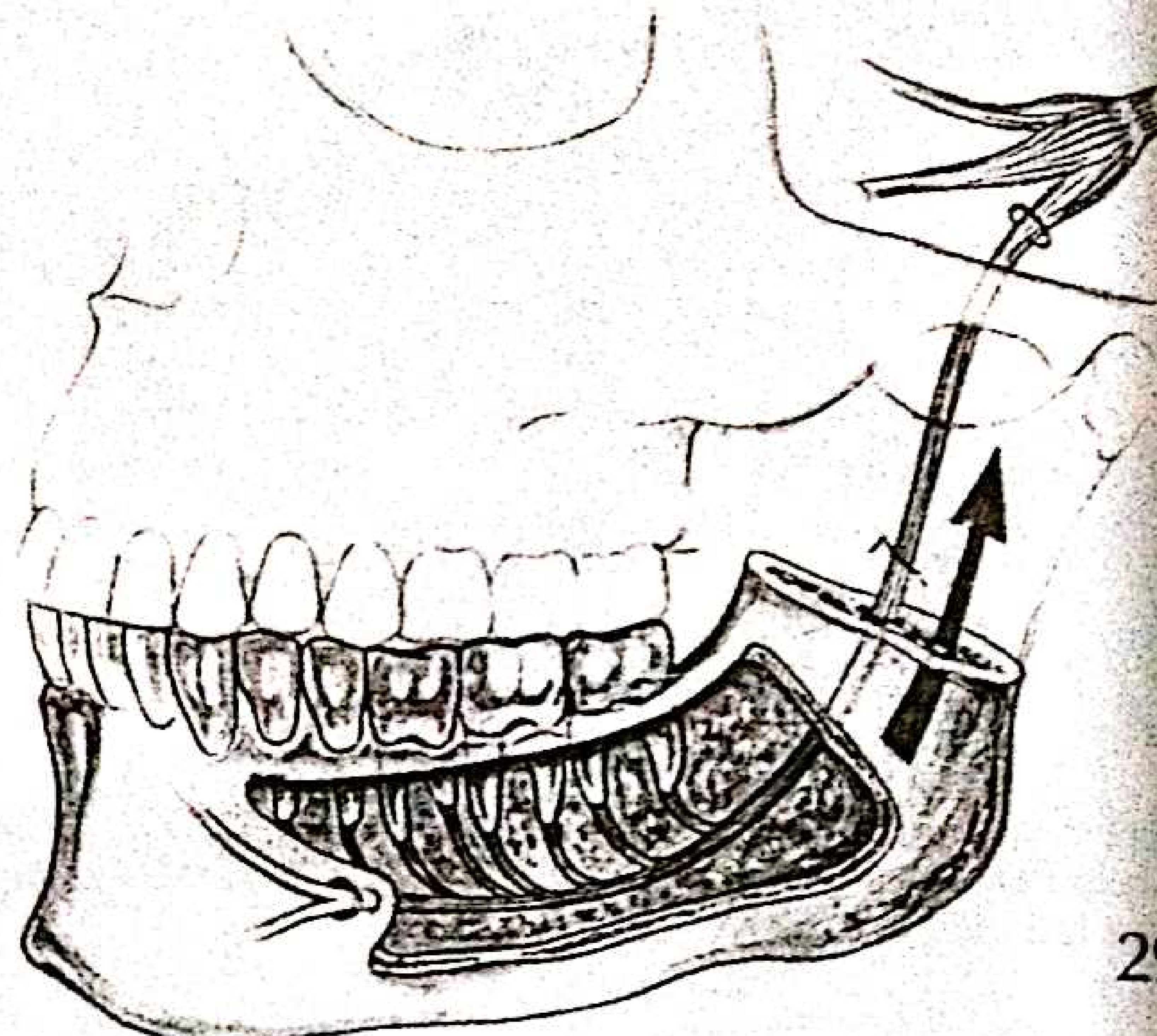
From there, tumour passes perineurally, predominantly proximally, to reach the trigeminal ganglion.



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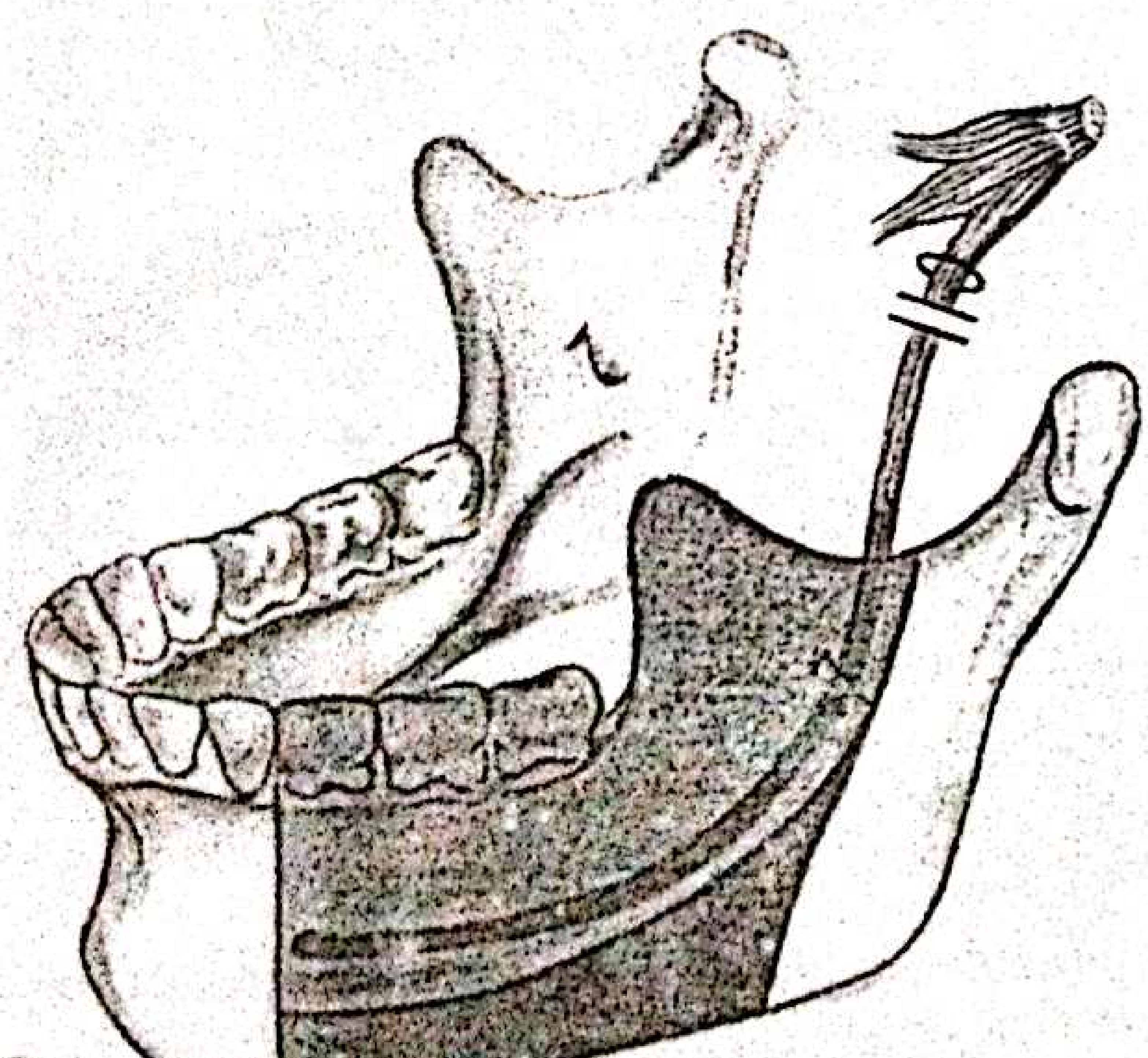
The irradiated mandible

In the mandible which has been irradiated, invasion through the occlusal area still occurs, but not invariably. There is a loss of predictability of the entire pattern of spread, with multiple foci of invasion through other sites on the bone seen more frequently.



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Implications for resection

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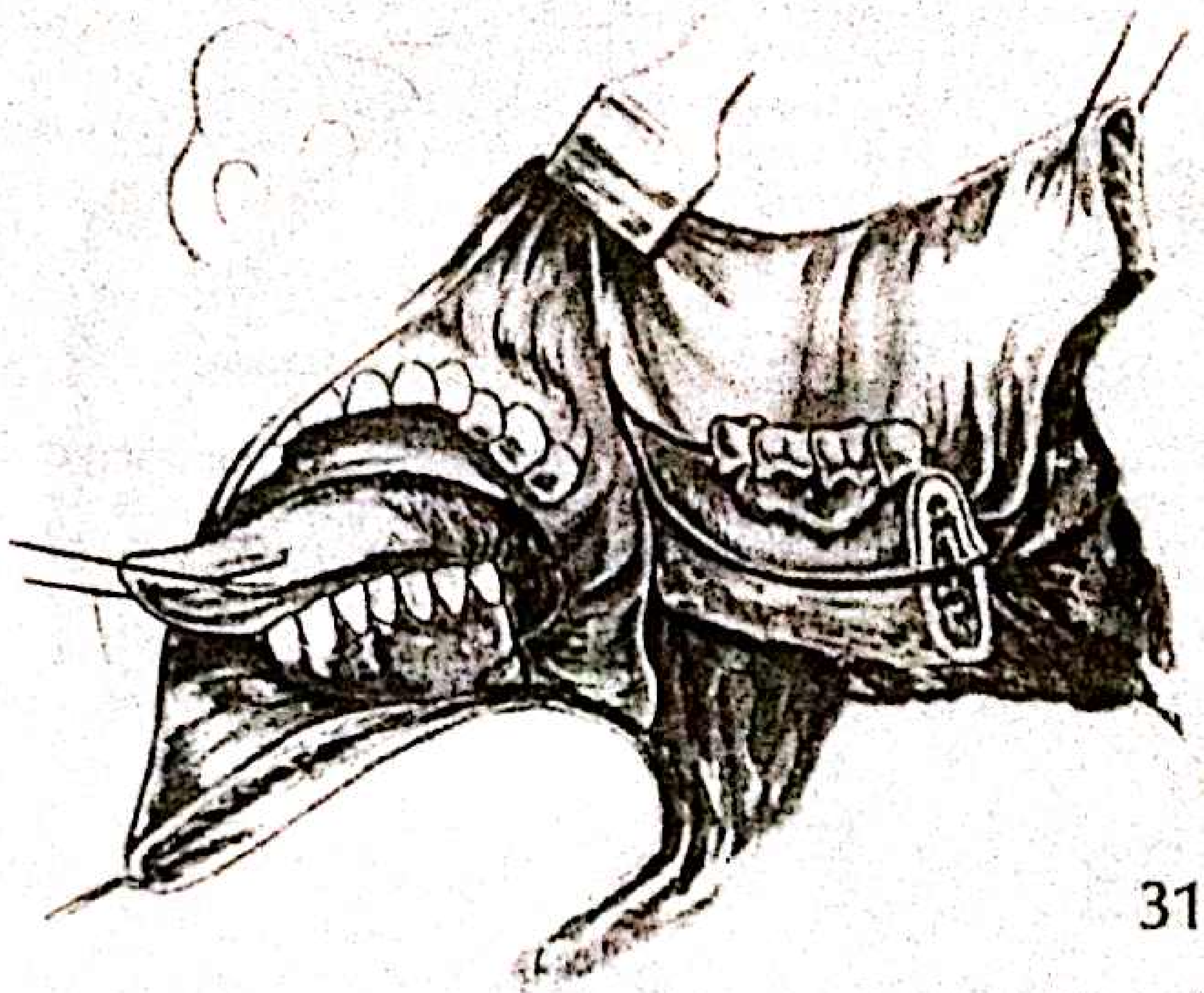
In the light of these findings, the form of conservative resection most likely to clear the tumour effectively in the bone is a rim resection, extending towards the lower border of the mandible as the bone becomes increasing involved by tumour, up to a full thickness resection.

The influence of perineural spread will be that if the bony involvement is more than minimal, the segment of bone should be resected at least down to and including the mandibular canal with its contained nerve, from the mental foramen back to the mandibular foramen, and the nerve itself should be pursued further proximally, and resected at the level of the foramen ovale in the skull base.



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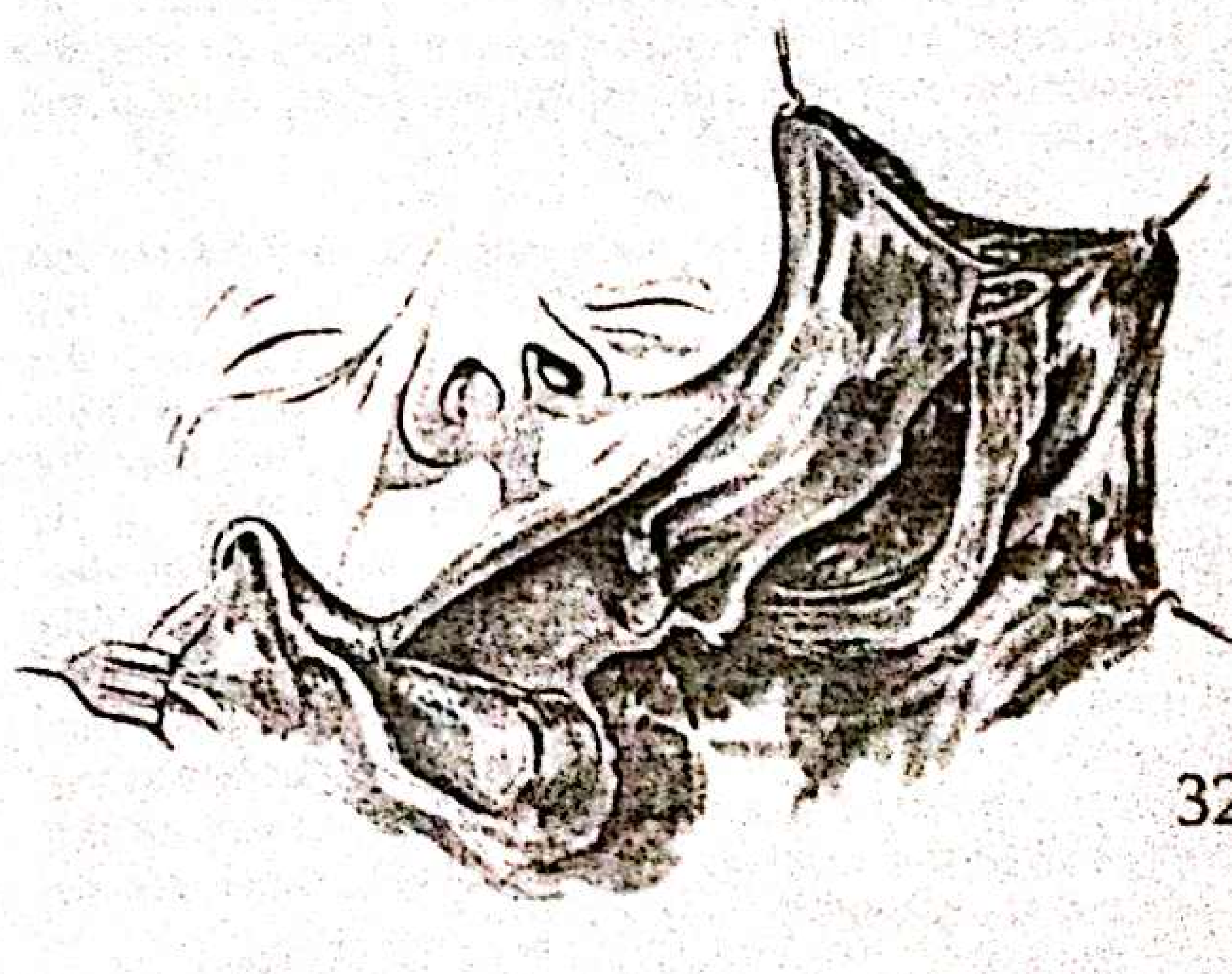
Mandibular blood supply

31 & 32

If a conservative mandibular resection taking the form described above (that is, a rim resection of the mandible which includes the mandibular canal with the inferior dental vessels and nerve) is used in conjunction with mandibular swing, the viability of the mandibular segment which remains after the resection will depend on which of its vascular sources are likely to remain after the resection. The only vascular sources which can be expected to be consistently functioning will be those which reach the bone through the soft tissue attachments along its buccolabial surface, between its lower border and the lower buccal sulcus.

If the viability of the residual mandibular segment is to be maintained, and successful bony union obtained at the osteotomy site, care must be taken to preserve these attachments.



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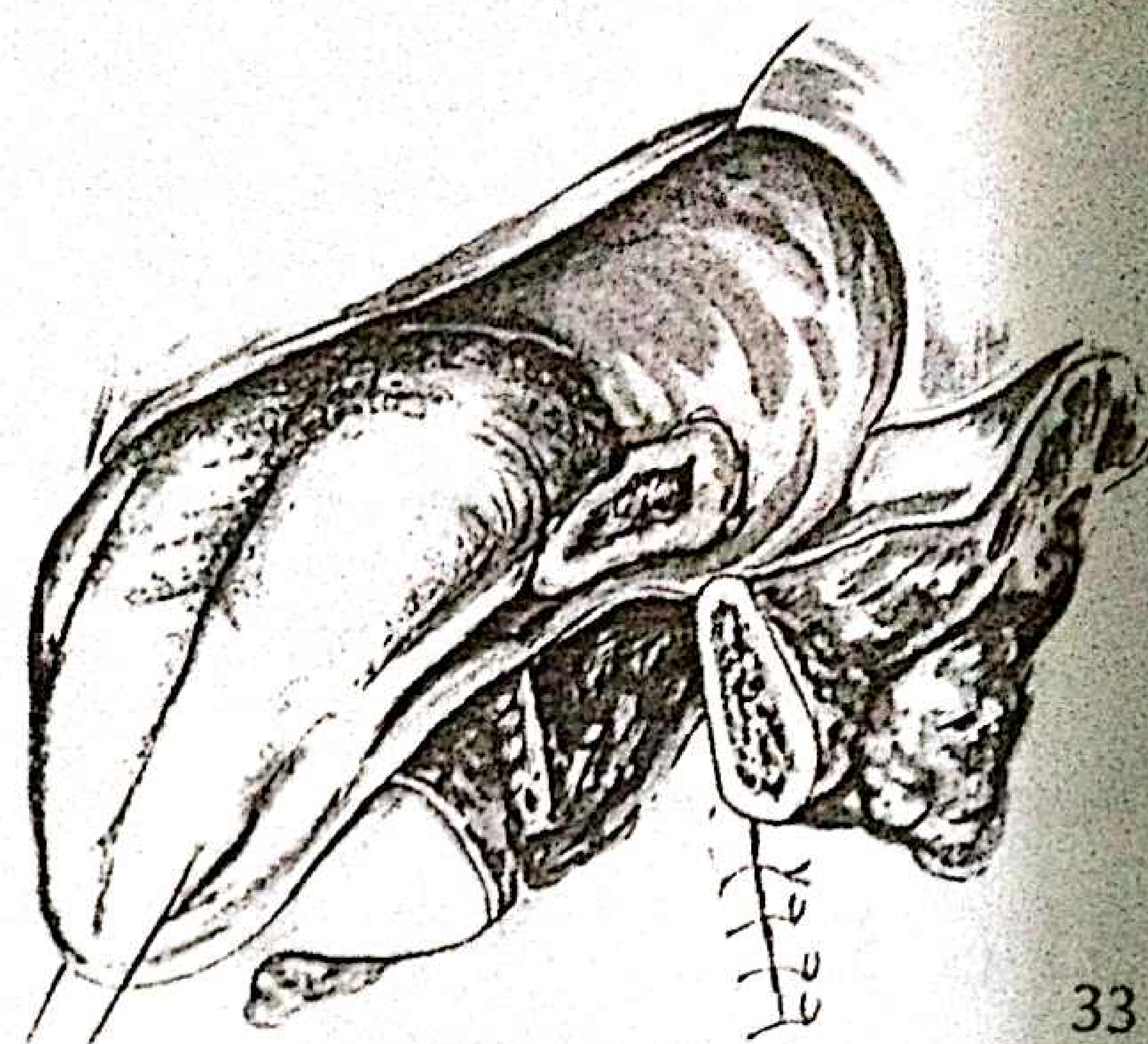
RESECTION

The form of the resection carried out depends on the surgeon's estimate of the degree of involvement of the mandible. This determines whether a bone resection that preserves mandibular continuity is possible, or whether resection of the full thickness of the bone is necessary. If there is clearcut radiographic involvement of the mandible, a full thickness resection is generally unavoidable; in the absence of radiographic evidence the assessment has to be a clinical one.

Resection preserving mandibular continuity

This form of resection is appropriate when it is considered that there is only limited involvement of the mandible by tumour, and that it is safe to preserve the lower border of the bone. The technique is an 'extensile' one, in that the resection can be extended in response to the findings at operation, up to a full thickness resection of the bone.



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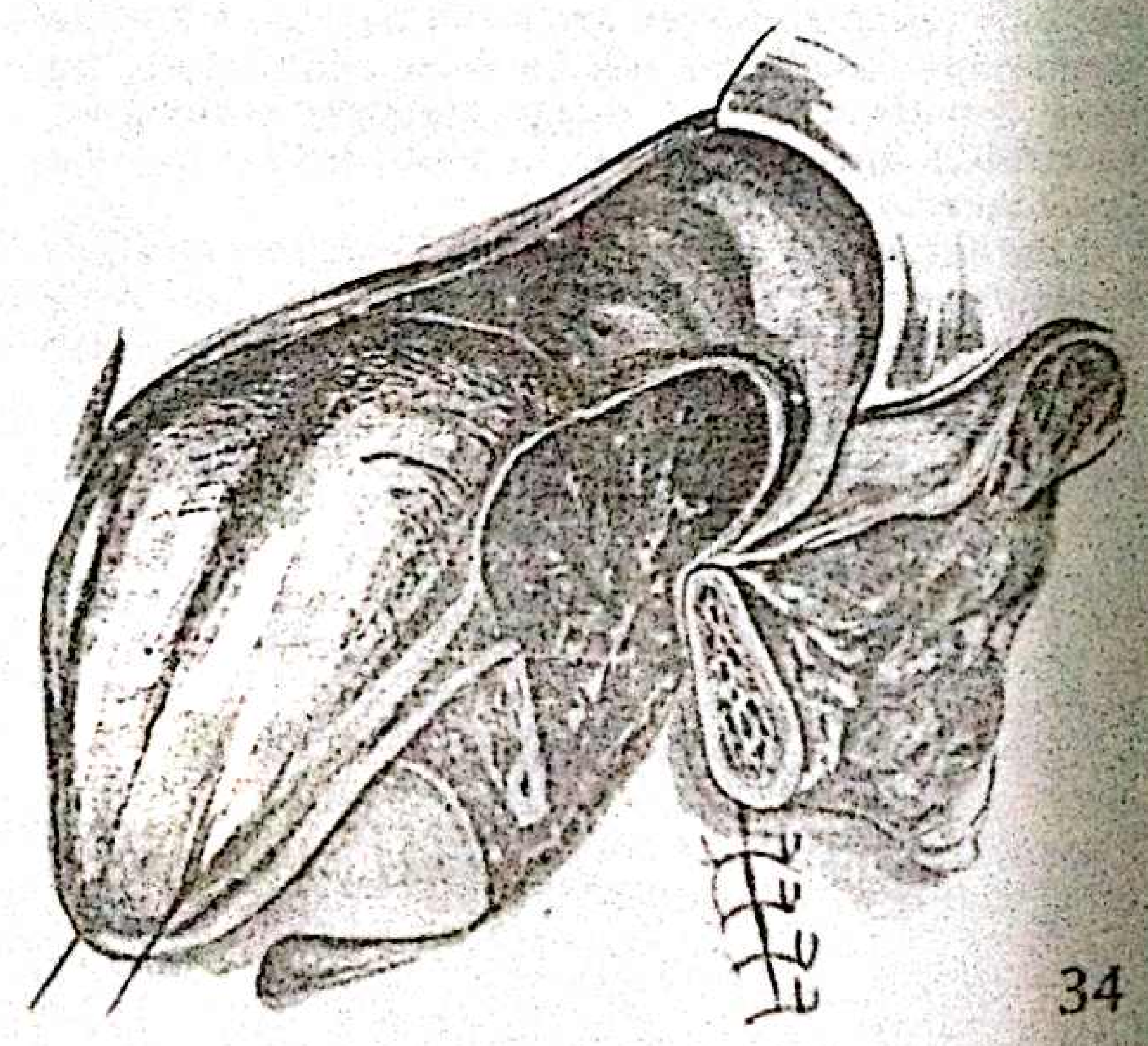
The neck dissection is completed as far as the mobilization of the superficial lobe of the submandibular salivary gland from the medial surface of the mandible, and the oral cavity is opened using the mandibular swing approach. The lateral osteotomy site is used if there is adequate anterior clearance between the tumour and the site, failing which the symphyseal site is used. With the periosteum on the lingual surface of the bone divided, the mandibular segment behind the osteotomy is retracted laterally, opening up the floor.

The tumour is then resected along its medial resection line, leaving it attached laterally to the mandible by the mucous membrane and mylohyoid. At this point the decision has to be made as to whether or not mandible requires to be resected. The assessment of whether the bone is involved by tumour, and the extent of its involvement, has in most instances to be a clinical one. Given that the tumour generally invades the mandible through its occlusal area, the finding that the submandibular salivary gland strips easily from the mandible, that X-ray of the bone was negative, and that the surface of the bone is smooth, the probability of involvement of the bone below the level of the mandibular canal can be regarded as remote.



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In the edentulous mandible, the height of bone above the attachment of the mylohyoid muscle is small and, if the margin of the tumour has not reached the mucoperiosteum above the attachment of mylohyoid to the bone, it can be assumed that the mandible is free of tumour. The resection can be carried out on that basis, leaving the mandible intact.

35

When the margin of the tumour is closer to the occlusal ridge, and even more when it overlies the ridge, there is a strong presumption that the bone is likely to be involved. If the involvement is considered to be minimal, a local deep shaving of the occlusal area should provide sufficient clearance.

36

With greater involvement, a formal rim resection would be appropriate, at a level to include the mandibular canal. The mental foramen, which can be palpated, provides a guide to the level of the canal in the bone.

Working the saw through the bone from its medial side, a horizontal cut should be made, curving up towards the condyloid notch, and including the lingula in the specimen to ensure complete removal of the inferior dental nerve within the bone. If the degree of bone involvement has been considered sufficient to merit removal of the nerve within the bone, its removal should be extended proximally as far as the foramen ovale at the skull base.

In the dentate mandible, the state of the teeth provides a reliable guide to involvement of the bone. If marginal spread of the tumour has not reached the gingiva, and the teeth are firmly fixed in their sockets, it can safely be assumed that the mandible is free of tumour. Loose teeth should raise suspicion of bony involvement, particularly if the tumour has extended marginally to reach the gingival margin. Extraction of the loose teeth will allow the sockets to be inspected, but if there is doubt, the alveolar bone should be removed, including the mandibular canal with the inferior dental nerve, as described for the edentulous mandible.

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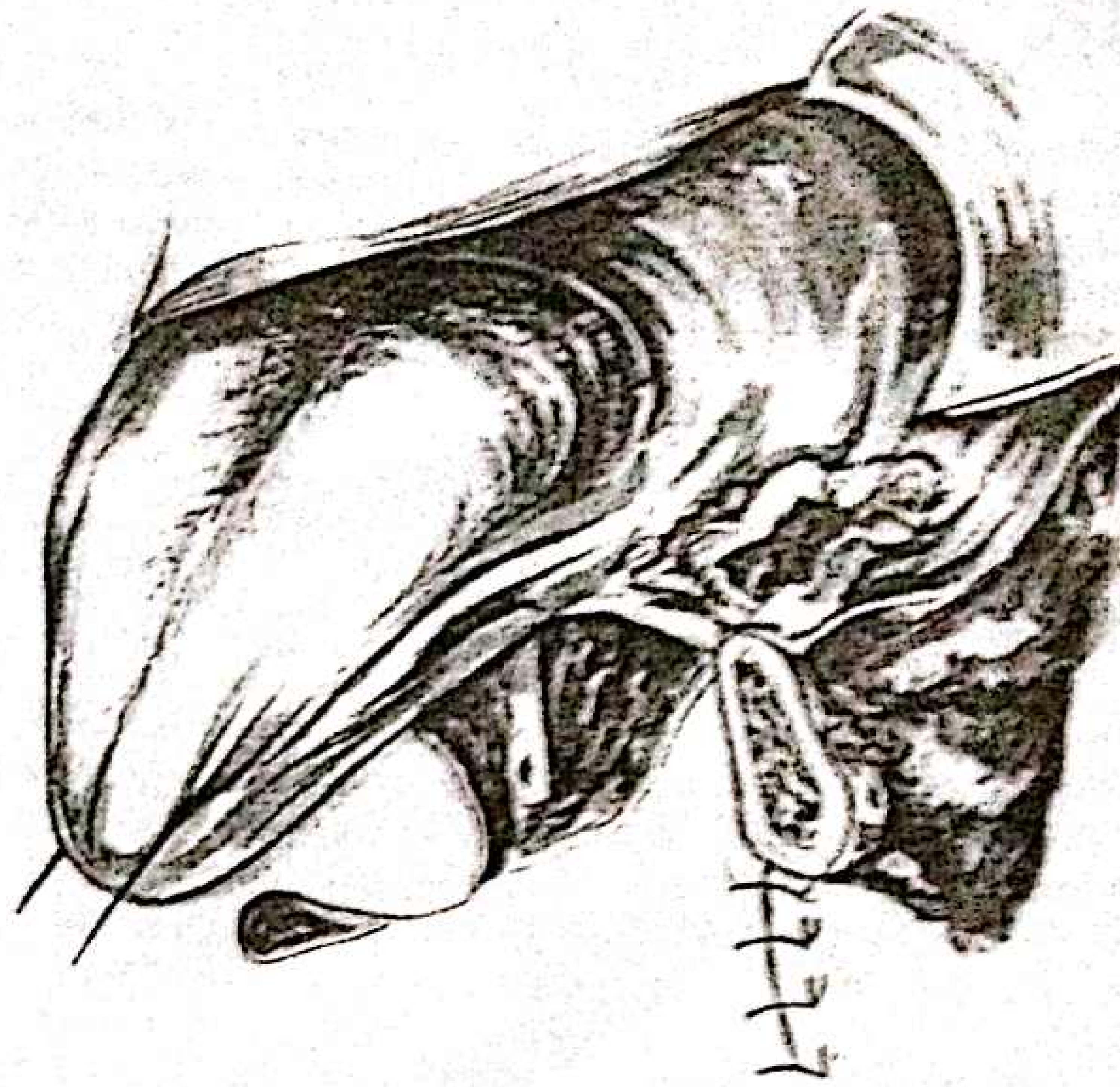
The bone cut is made from the lingual plate as with the edentulous mandible, so that the bony element left in both instances, dentate and edentulous, retains its lateral soft tissue attachment with the blood supply to the bone which it carries.



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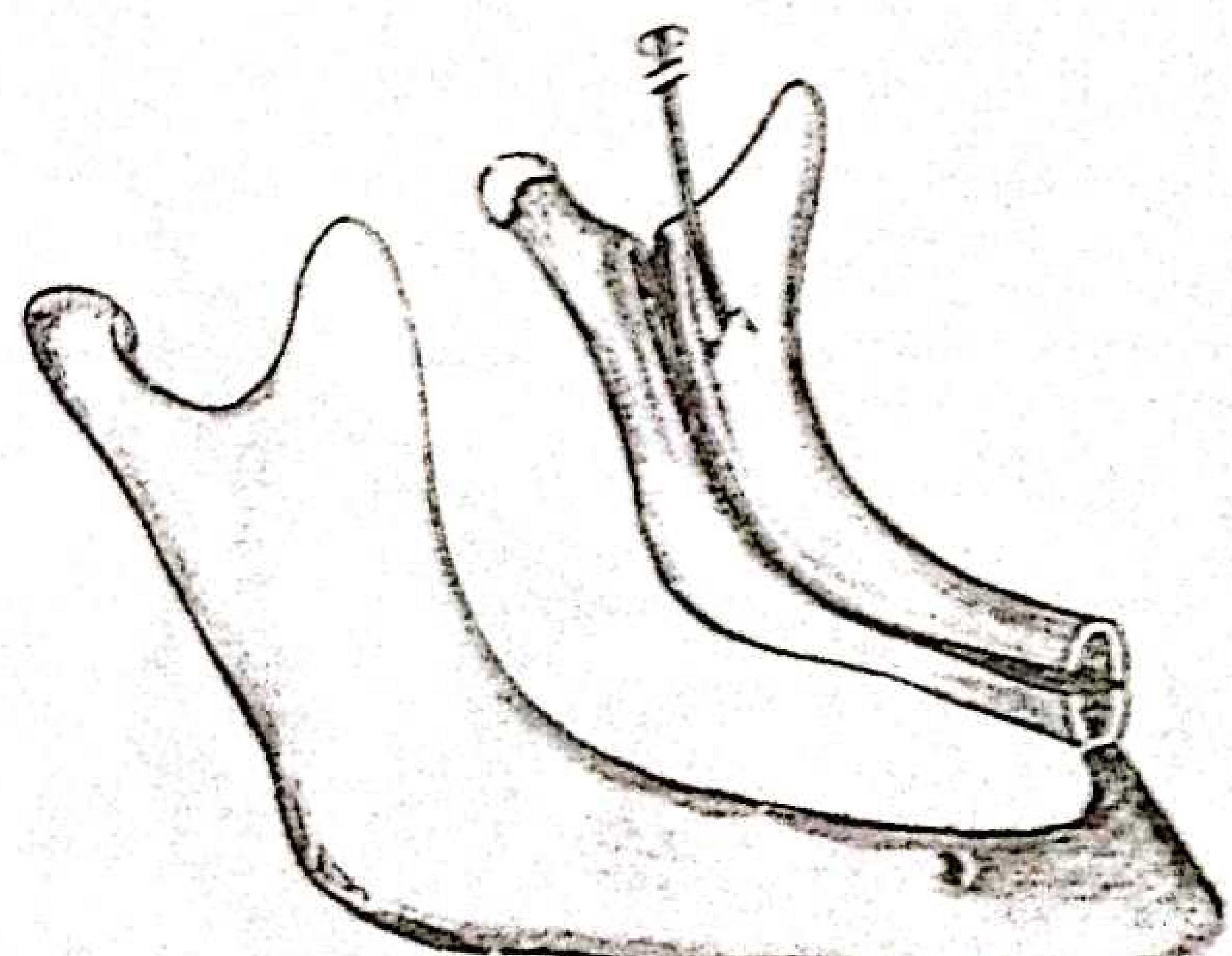

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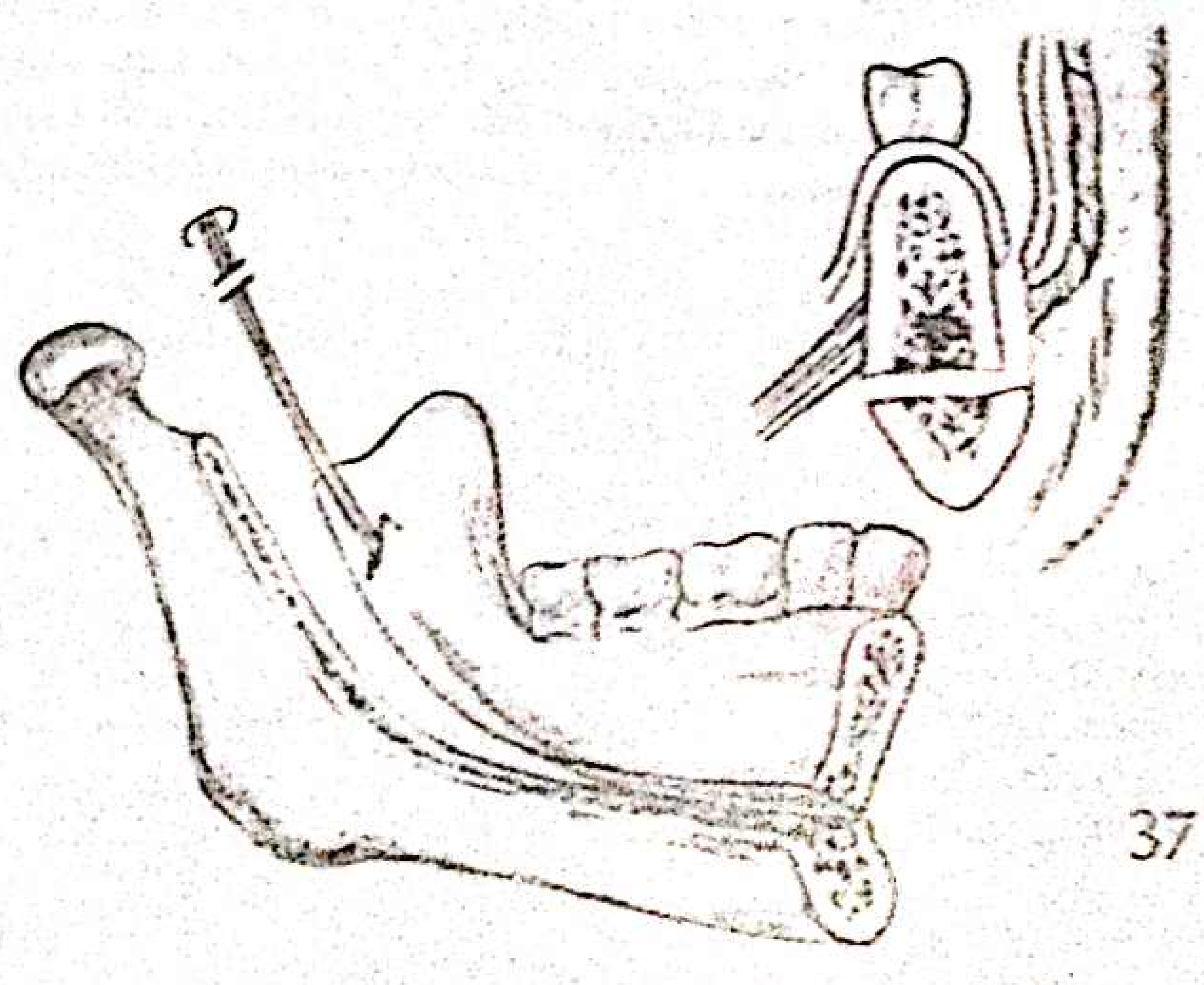

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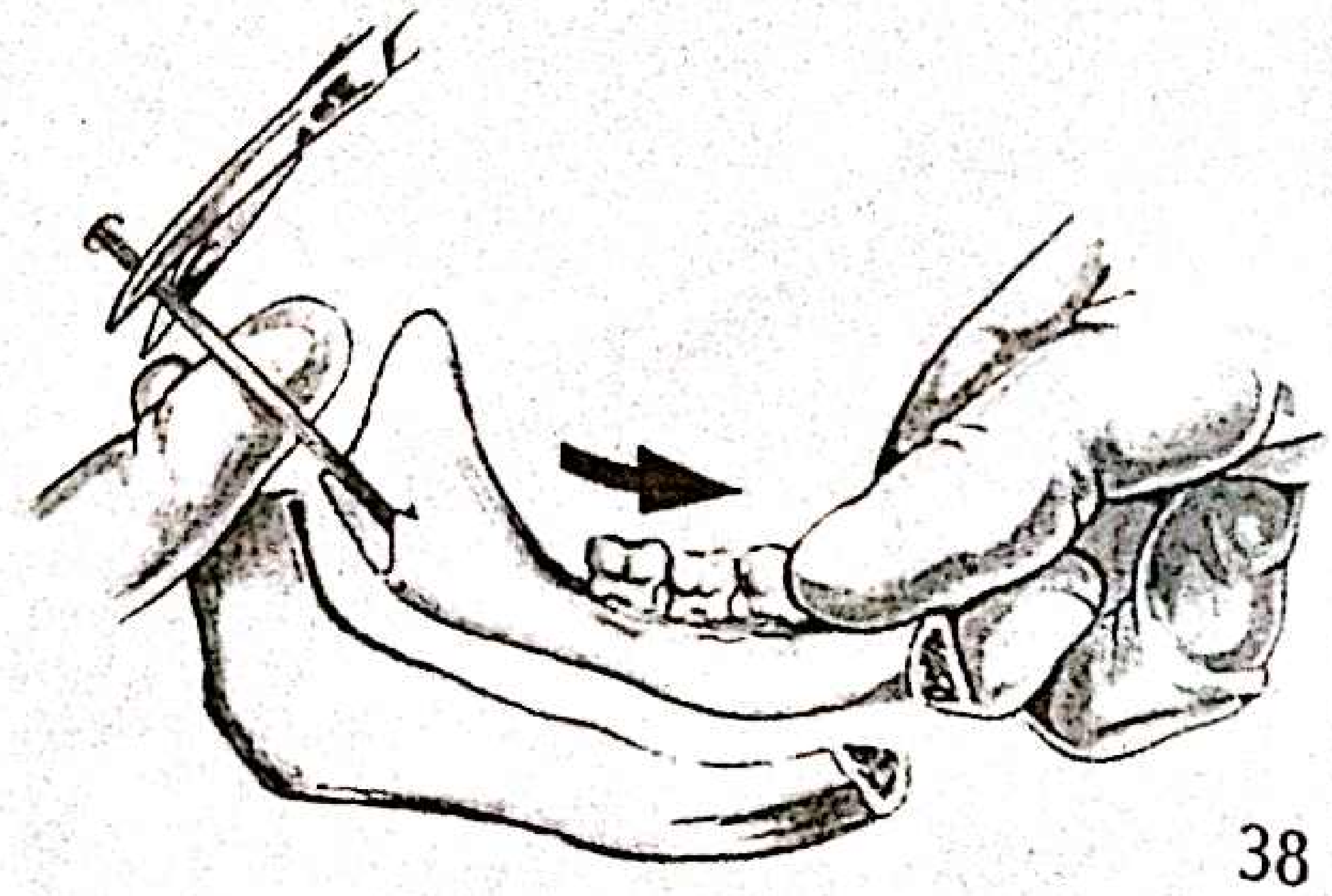
The inferior dental nerve can be conveniently divided at the skull base by pulling the loosened segment of mandible, whether dentate or edentulous, downwards and forwards. The nerve is then felt by the finger as a piece of taut 'string', and can be divided with scissors at the skull base.



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Mandibular resection

When the decision at the outset is to resect the full thickness of the mandible, the local resection is likely to be preceded by a radical neck dissection, completed to the stage of dissecting the submandibular salivary gland with its content of nodes clear of the mylohyoid muscle.

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A lip-splitting incision is then carried out, and the mucous membrane lateral to the mandible is incised backwards along the lower buccal sulcus. The soft tissues attached to the outer aspect of the body of the mandible, together with the submandibular skin flap, are elevated from the bone as far back as the anterior border of masseter, subperiostially if the tumour is clearly confined within the bone, marginally clearing any tumour which has spread laterally beyond the occlusal ridge.

Positioning of the anterior line of resection of the bone is based on the general finding that the extent of tumour spreading anteriorly and posteriorly within the medullary cavity of the mandible matches the extent in the soft tissues immediately adjacent to the bone. To ensure that the inferior dental nerve, with its potential content of tumour spreading perineurally, is completely removed, however, the line should be sited at least as far anteriorly as the mental foramen.

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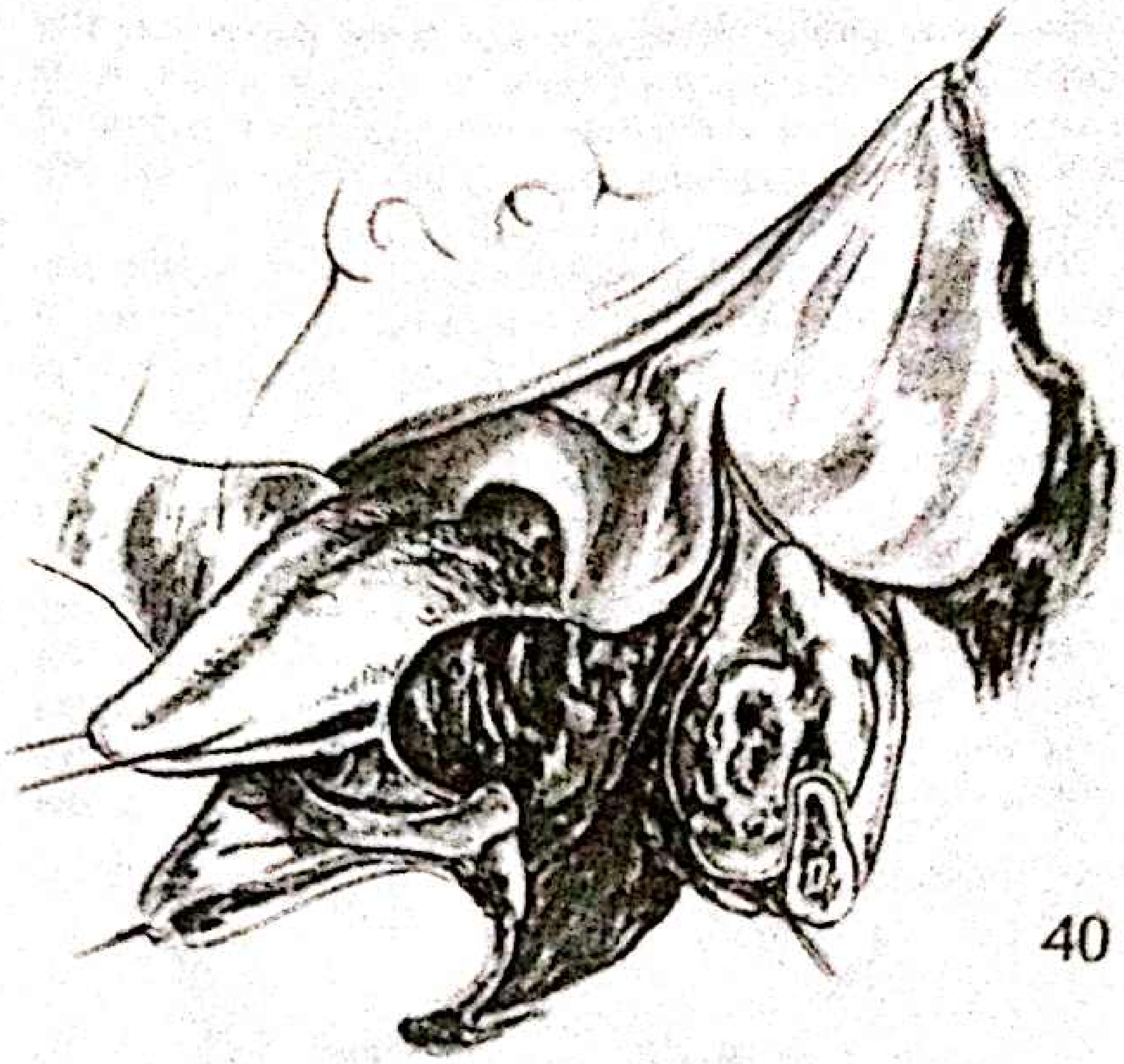
With the bone divided at the anterior resection line, the posterior segment of the body can be retracted laterally, exposing the full surface extent of the tumour and allowing the medial soft tissue line of resection to be established. The tumour, together with any medial extension which involves the tongue, is then cleared marginally and in depth as far as its posterior clearance margin. The specimen at this stage consists of a single block of tissue comprising the tumour with the submandibular salivary gland complex, attached to the body of the mandible. Behind the posterior line of resection, the mucosal resection lines on the lower buccal sulcus and medial to the bone converge into a single line over the alveolar ridge in the region of the retromolar trigone.

How far this single mucosal incision is continued upwards over the anterior border of the ascending ramus depends on the extent of the exposure required. In most instances the bone of the ramus can be bared subperiostially, but the form which resection takes thereafter depends on whether or not the intention is to reconstruct the resected mandibular segment.



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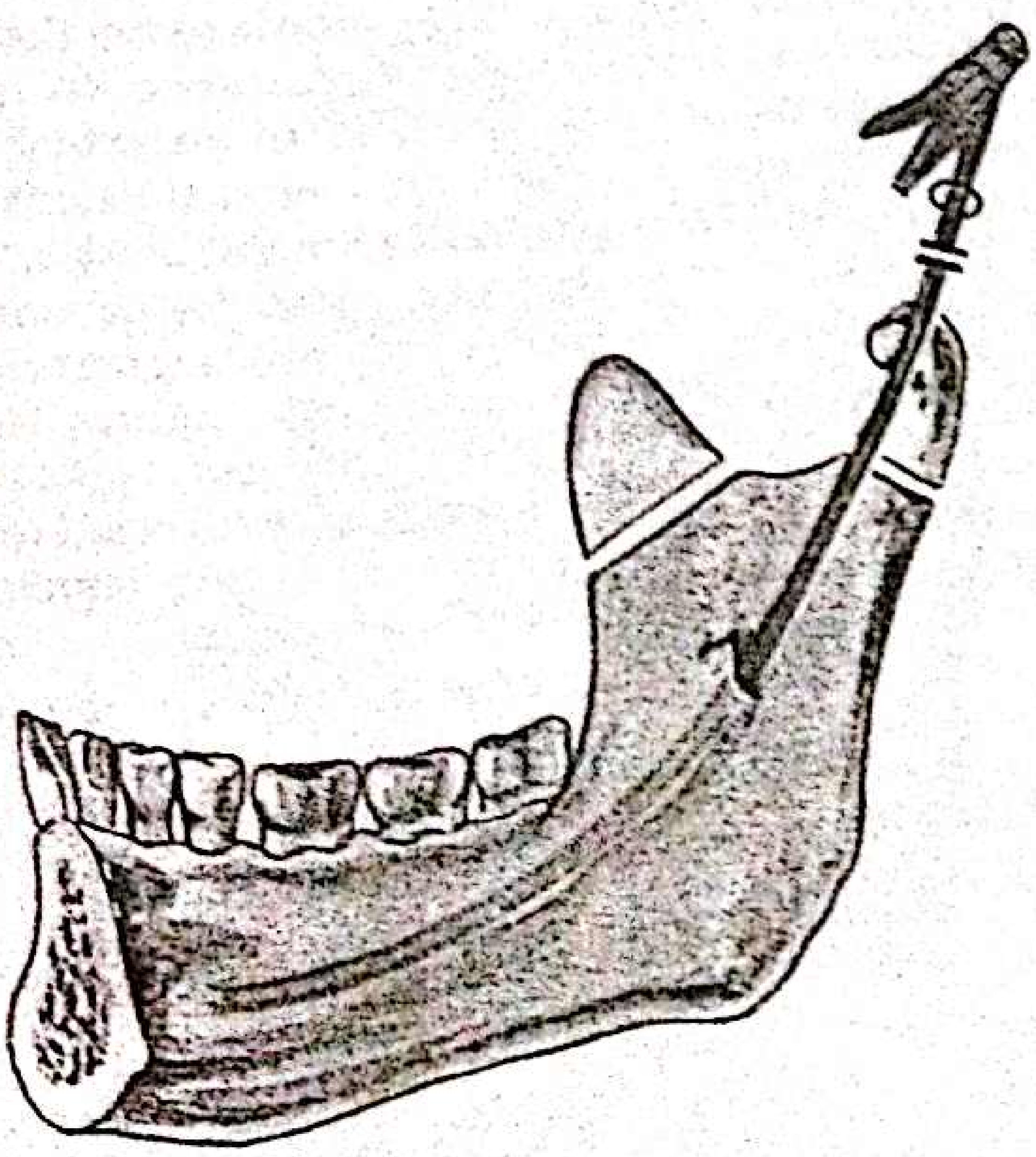

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When the intention is not to reconstruct the resected mandibular segment, subperiosteal stripping of the ascending ramus is continued up to the neck of the condyle and the base of the coronoid process, both being divided with bone cutting forceps at that level. Using the manoeuvre described in *Illustration 38*, the inferior dental nerve can be divided at the foramen ovale and its entire extracranial course removed.

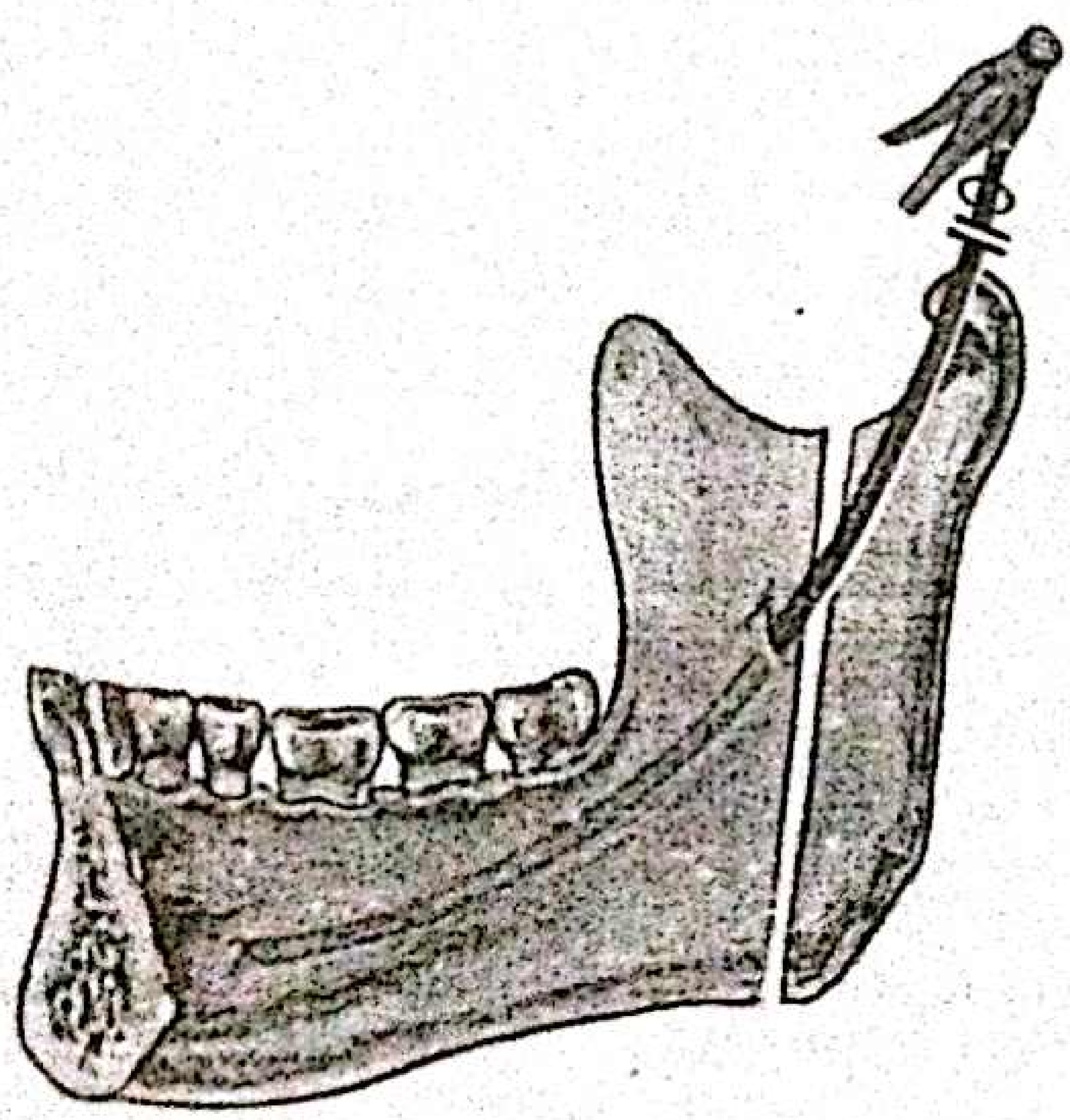
RECONSTRUCTION

When mandibular continuity has been preserved, the defect, from the point of view of reconstruction, is in many ways similar to the defect left following resection of the tongue, already described on pp. 303–305, and the reconstructive options are similar.

When a full thickness segment of the mandible has been resected, the decision has to be made whether or not the bony defect should be reconstructed. As part of the decision-making process, an assessment has to be made of the likely effect of loss of the bone on function. This in turn depends on the site of the resection and its extent.

Resection of the ascending ramus has surprisingly little effect on function, other than reducing the strength of the bite. There is a virtual absence of such sequelae as cross bite and trismus. As the line of resection passes forward along the body of the bone towards the symphysis, the strength of the bite is increasingly lost, and chewing becomes less effective, but it is once the symphysis is passed that the major change occurs. The strength of the bite and chewing power are then weakened to the extent that a soft diet may be unavoidable. There is also a striking change in appearance, the chin prominence being increasingly lost. Loss of the chin prominence also follows when the symphyseal segment of the mandible is lost, creating the Andy Gump appearance discussed on p. 256. Whether the change in appearance is matched by a comparable deficit in tongue function depends on the adequacy of the soft tissue reconstruction.

When the intention is to restore the continuity of the mandible, the surgeon can make the reconstruction easier for himself at the stage of resection by preserving the segment of the ascending ramus behind the lingula, which carries the condyle above.



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The ascending ramus is virtually never involved by tumour, unless by direct spread from the soft tissues attached to it, and in the case of a carcinoma of the floor of the mouth this is an extremely rare occurrence. Its rarity makes it frequently possible, instead of resecting the entire ascending ramus, to carry out a vertical osteotomy behind the lingula. The lingula marks the site at which the inferior dental nerve enters the bone, and the osteotomy just behind it divides the ramus into two segments, an anterior, which contains the nerve and requires to be removed as part of the overall resection, and a posterior, which can be preserved. The nerve can be resected to the skull base, without dissecting in the pterygoid region, by using the method described in *Illustration 38*.

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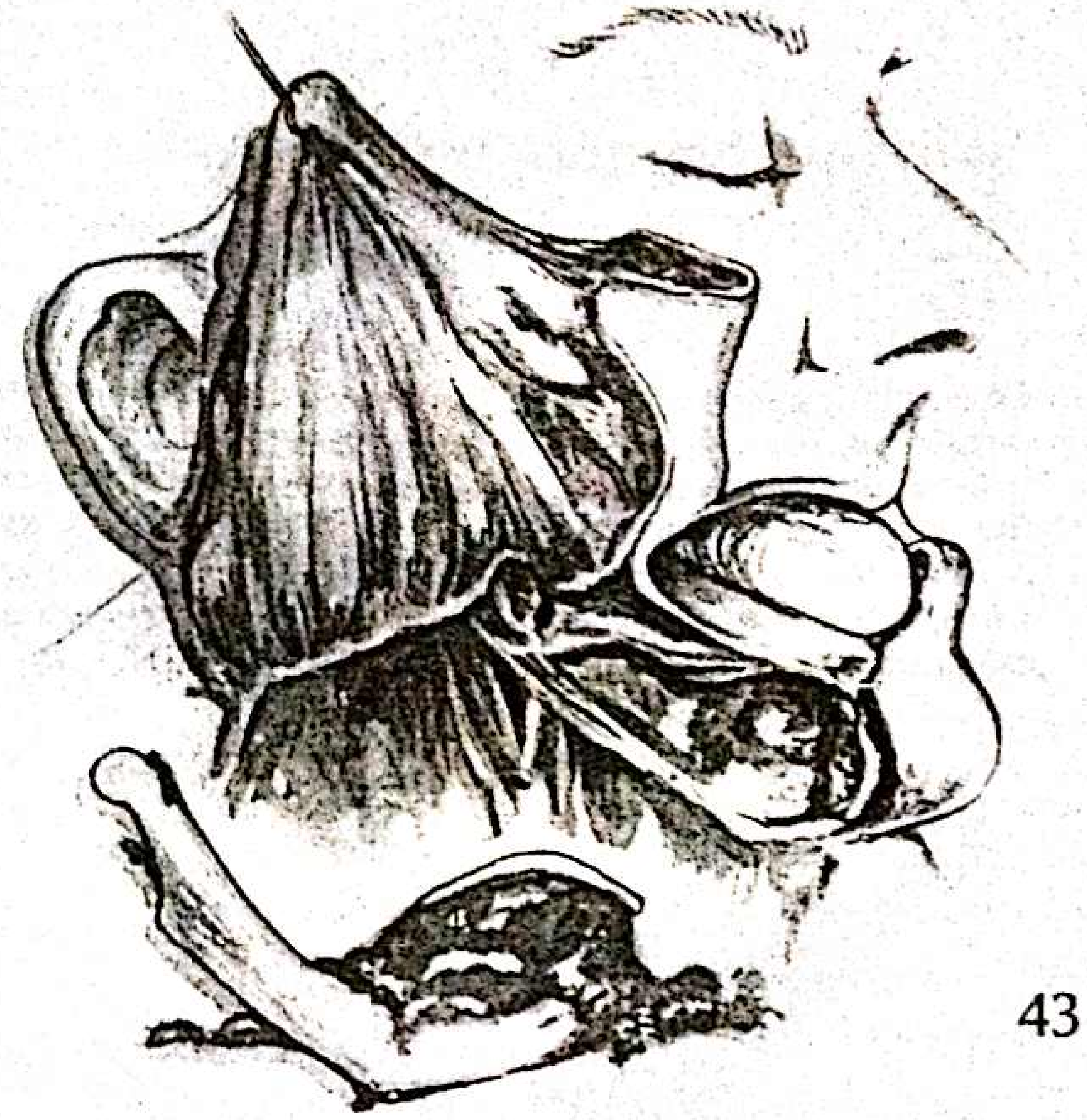
The effect is to leave a linear defect of the body of the mandible, and this is much easier to reconstruct than the L-shaped defect which results from resection of a segment of the body of the mandible together with the entire ascending ramus.



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When the bony defect is being reconstructed, a composite radial forearm flap with a length of radius, to match that of the linear bony defect of the mandibular body, or a parascapular flap with a length of scapular margin, both as described in the chapter on 'Reconstructive techniques of the oral cavity', pp. 215–240, can be used to reconstruct the soft tissue and bony defect simultaneously. The bone is fixed in position with plates and screws, or by wiring.

When reconstruction of the bone is not being carried out, the overall volume of the defect to be filled with soft tissue is considerably greater. The bulk of tissue which the pectoralis major myocutaneous flap provides is able to fill the defect and maintain facial symmetry. An alternative to the pectoralis flap might be the latissimus dorsi free flap. It has much the same characteristics as the pectoralis flap in terms of the bulk which it provides, but has no particular advantage to give it preference. It is also a much more technically demanding transfer. With both reconstructions, the skin island passes from the buccal mucous membrane directly across to the resection margin along the lateral border of the tongue.

Skin involvement by tumour

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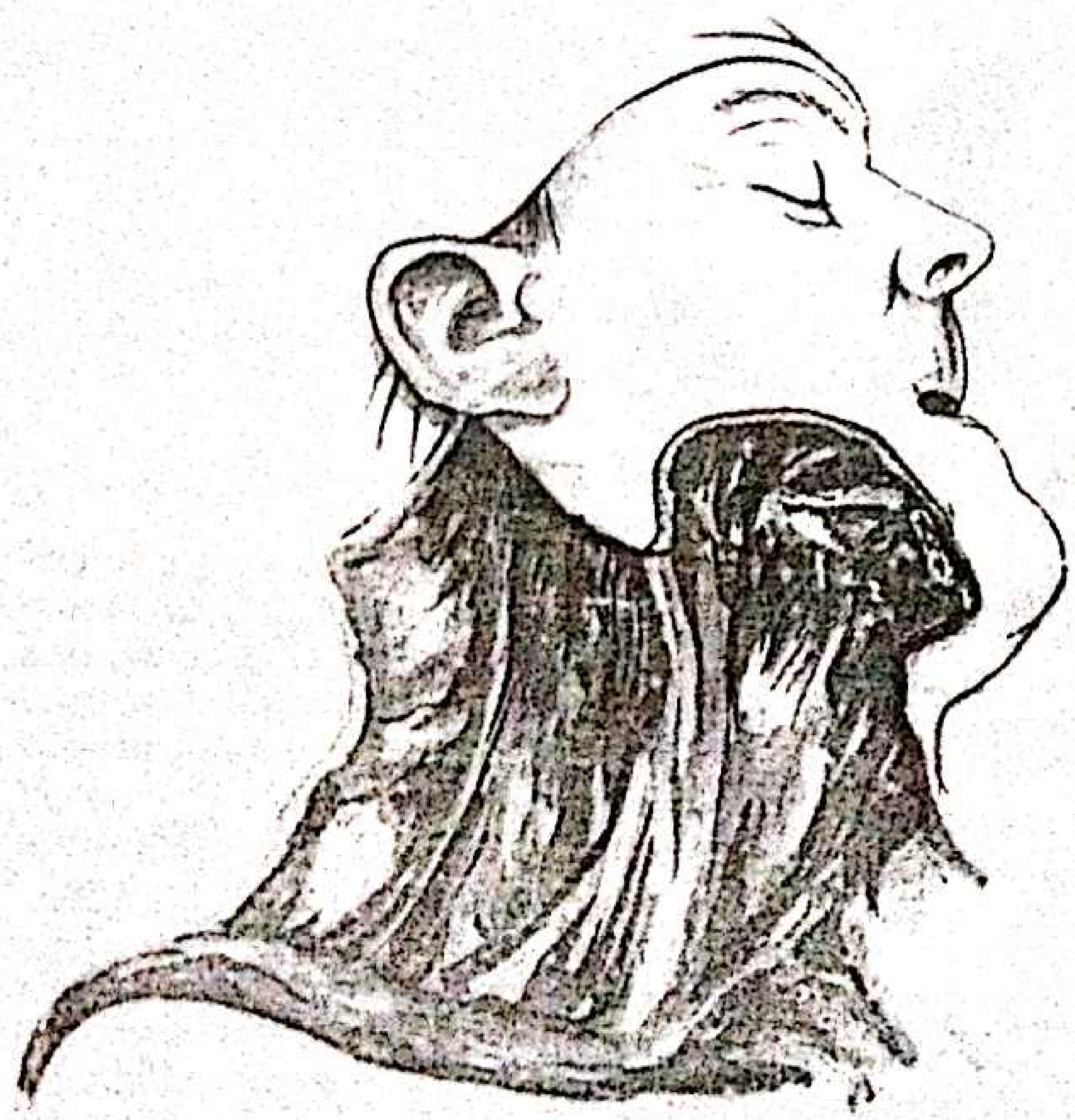
External fungation of tumour from the lateral floor of the mouth implies very advanced local disease, with tumour extending into the medullary cavity of the mandible from the site of entry in the occlusal area and eroding its cortical shell from within, as well as encircling the bone and eroding it from without, and ultimately fungating externally along its lower border.



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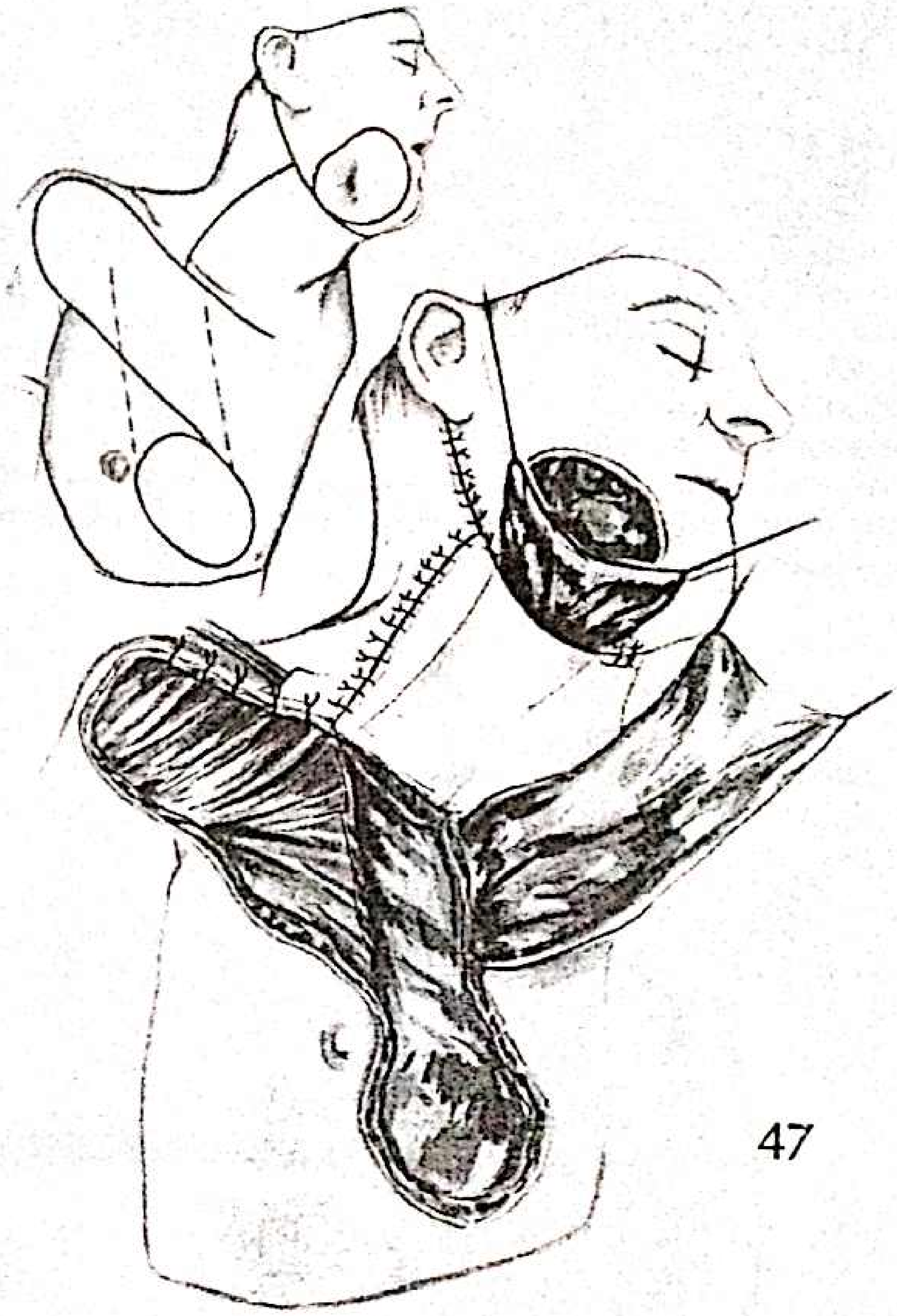
The resection required for such a tumour is inevitably a full thickness one, with skin, mucosal, and bony elements. The mandibular resection will be of the full thickness of the bone, its extent depending on the assessment of the anterior and posterior extent of the tumour within the bone, and the estimated extent of the presumed perineural spread of tumour along the inferior dental nerve. With such advanced disease, the entire extracranial course of the nerve has to be considered at risk and requiring to be resected. With the site of the fungation in the submandibular triangle, the line of the anterior resection is likely to extend forward at least as far as the mental foramen, in order to clear the tumour within the bone. In the process this will also clear the inferior dental nerve anteriorly. The factors which should determine the posterior bony resection line when the inferior dental nerve is considered to be the site of perineural spread have already been discussed, and shown to be dependent on whether the intention of the surgeon is to reconstruct the resected segment of bone.

In deciding the details of reconstruction, and in particular whether to reconstruct the bony defect, it might reasonably be felt that the extremely doubtful prognosis of such a patient should encourage simplicity, and that to contemplate reconstructing the resected mandible is undesirable. If, however, it is decided to reconstruct the mandible, a composite free flap would be required, reconstructing bone and lining simultaneously. Skin cover could be provided by a second free flap, or a deltopectoral flap, the latter being faster and simpler, although involving a second stage.

47

If the decision is not to reconstruct mandible, the lining component of the reconstruction requires to have a significant amount of bulk if reasonable postoperative symmetry of the face is to be maintained, and the pectoralis major myocutaneous flap can provide this well. The skin incision regularly used to expose its muscle pedicle follows the outline of a deltopectoral flap, and partly raises it. To raise the flap completely extends the dissection minimally, and makes it available to provide skin cover for the defect.



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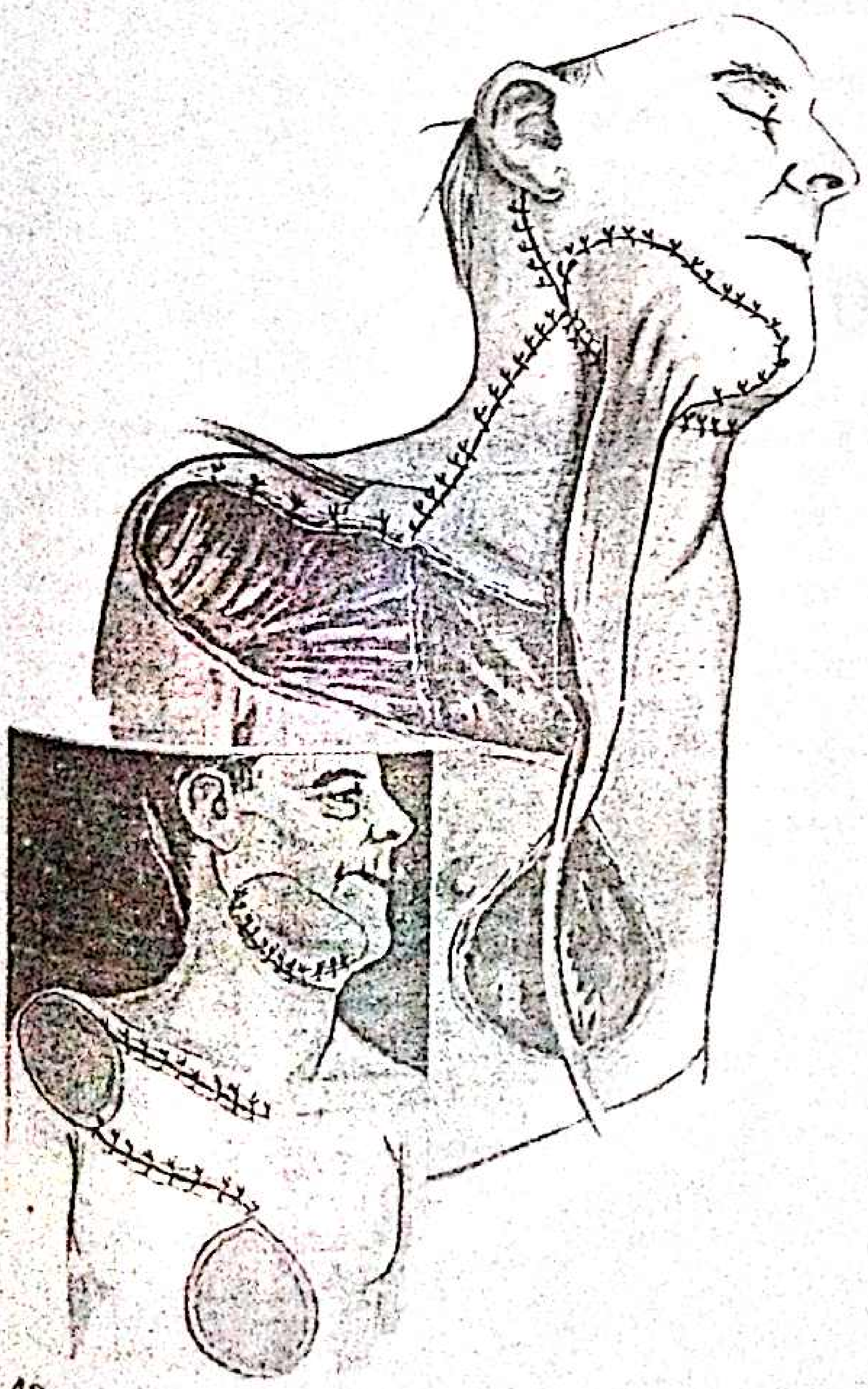

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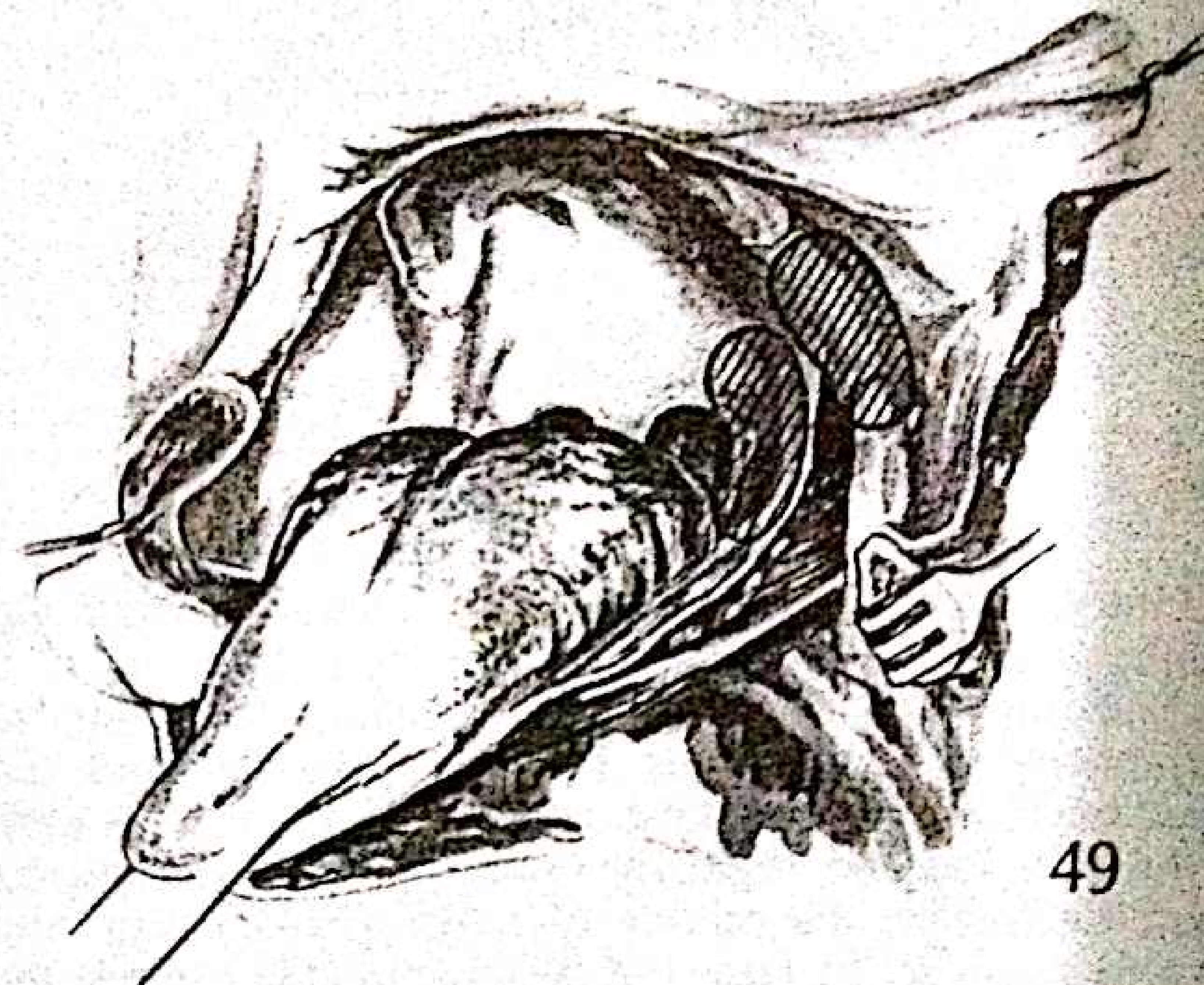
Admittedly, the reconstruction then becomes a two-stage one, but the relative simplicity of the combination and the concentration of donor sites on adjoining areas on the chest more than compensates.

FAUCIAL AREA AND RETROMOLAR TRIGONE

49

These sites are both exposed in the same way, using the mandibular swing approach. Neck dissection, radical or functional, depending on the clinical nodal status of the neck, is carried out as a preliminary. With the submandibular triangle cleared, the lower lip divided and the mandibular osteotomy carried out using the lateral site, the mucosa and mylohyoid are divided backwards along the floor, leaving a mucosal fringe on the mandibular side for subsequent suturing.



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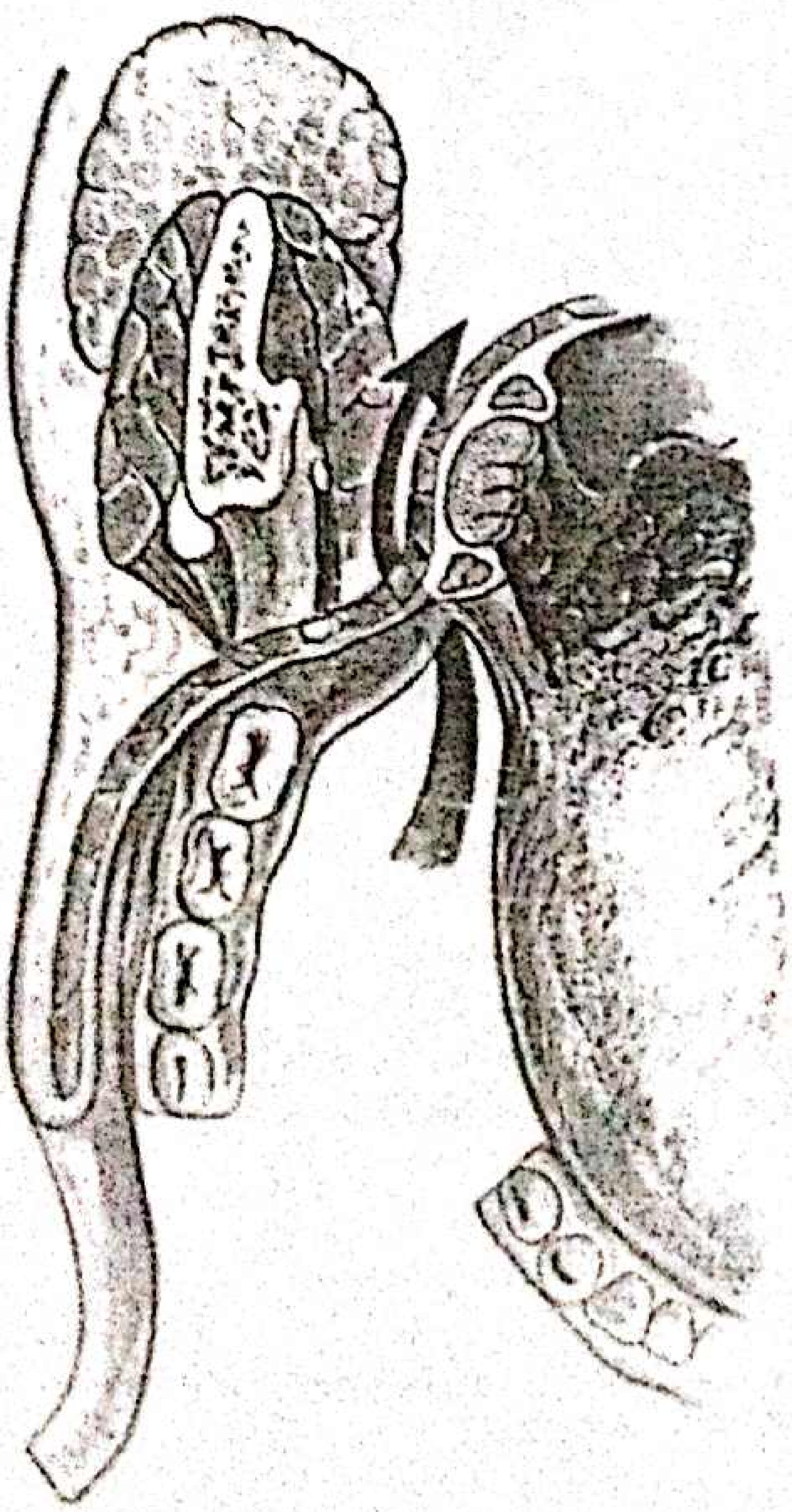

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RESECTION OF THE FAUCIAL AREA

In the case of the faucial tumour, the division of the mucosa and mylohyoid is continued backwards beyond the posterior border of the muscle.

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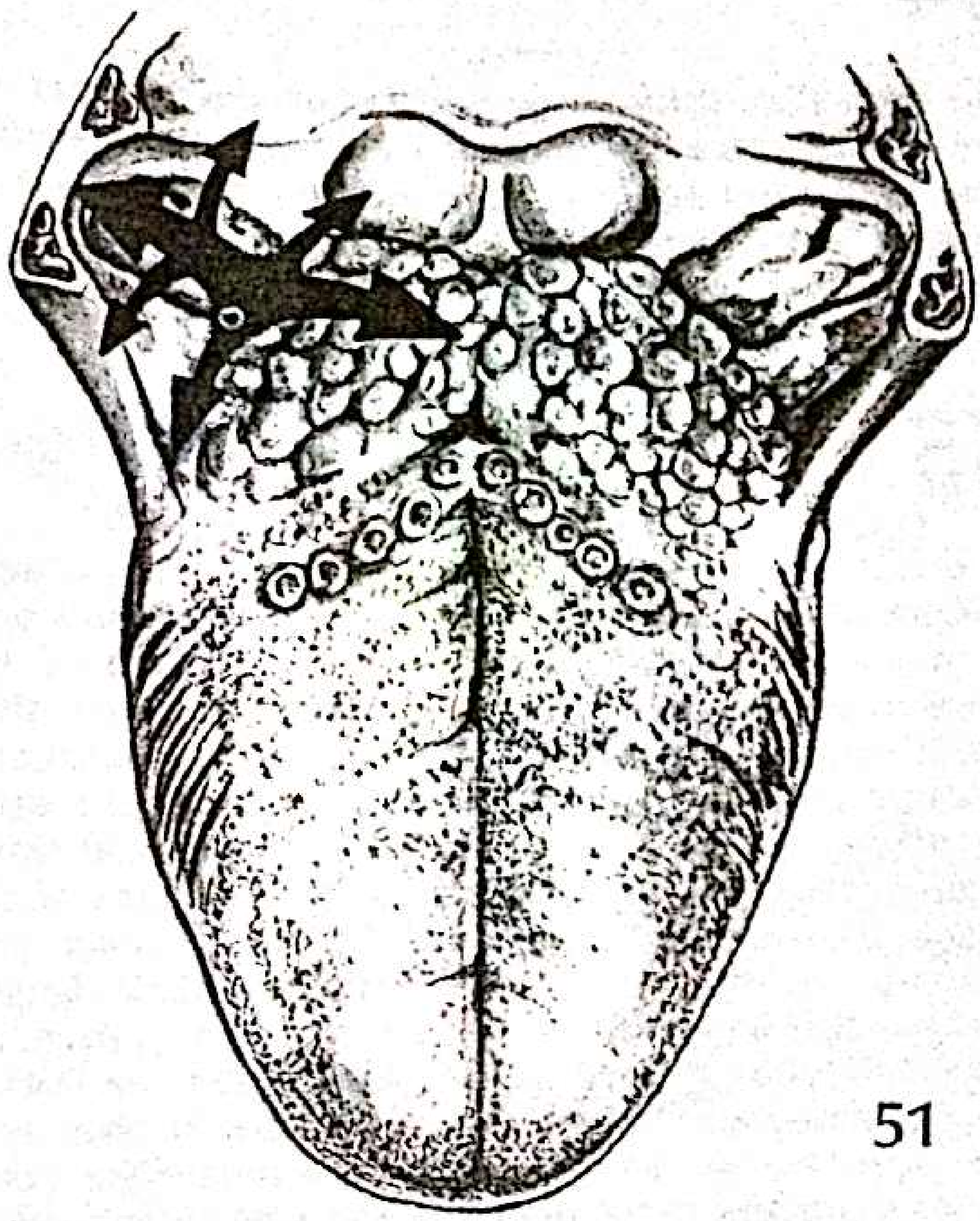
The finger of the surgeon should then be passed back along the medial surface of the mandible, where it is covered by the medial pterygoid muscle, mobilizing the superior constrictor muscle with, inside it, the faucial pillars and the tonsil from the medial pterygoid muscle. The ease with which the two muscle groups separate indicates that the tumour has not extended deeply to involve the medial pterygoid muscle. Infiltration of tumour deeply from the faucial site to involve the pterygoid muscle seems to be a relatively late phenomenon, possibly because the patterns of activity of the two muscle groupings are totally distinct from one another.

51

Tumours in this area, apart from spreading to the soft palate and lateral pharyngeal wall, also extend across the posterior part of the floor of the mouth onto the posterior third of the tongue. In resecting the tumour, the line of marginal clearance, when worked out on the mucosal surface, is usually an extremely irregular outline, involving to a greater or less extent the faucial pillars and tonsillar fossa, soft palate, posterior floor of mouth, and tongue. The resulting defect is a correspondingly irregular one.



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RESECTION OF THE RETROMOLAR TRIGONE

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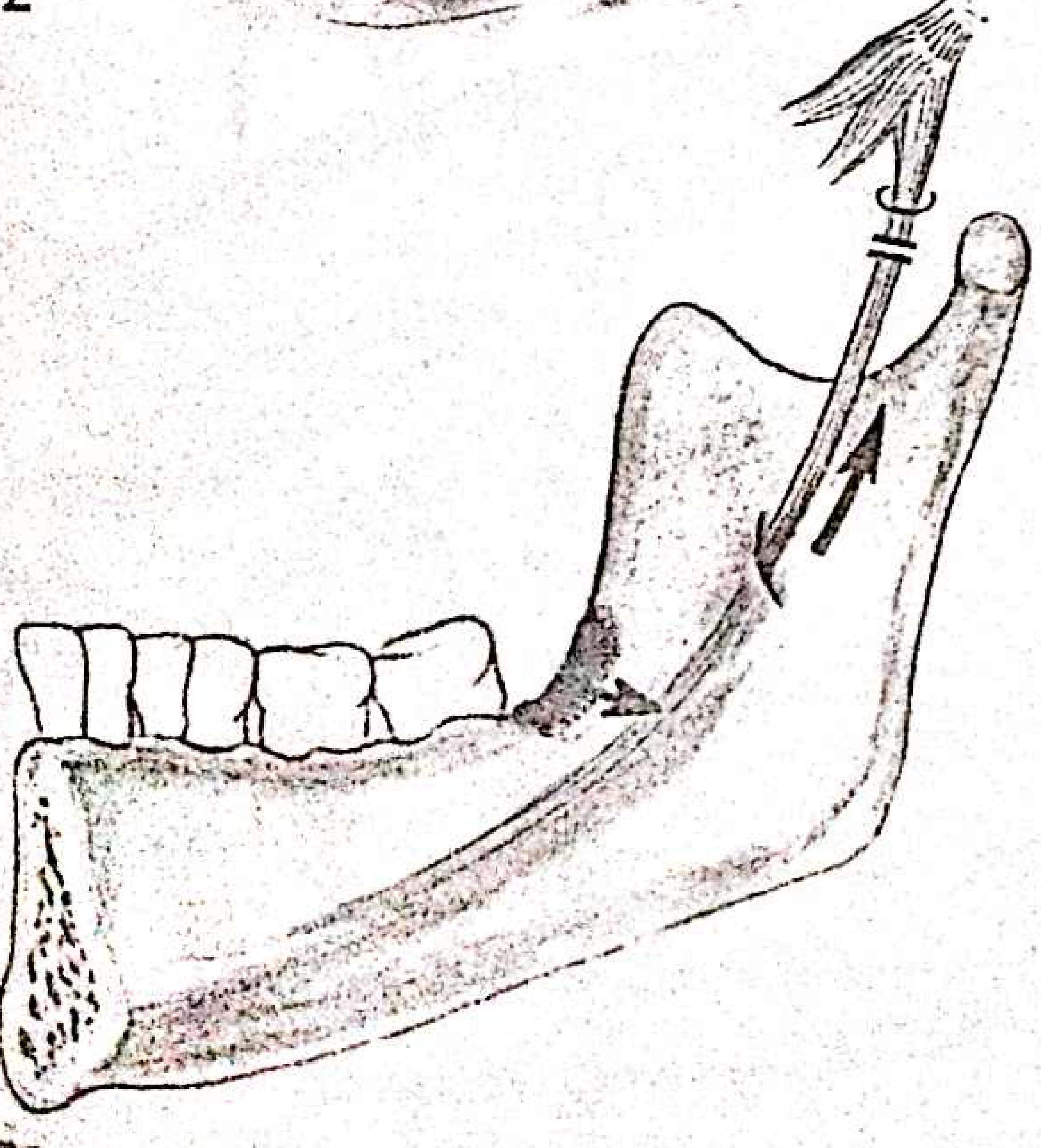
Marginal spread of the tumour of the retromolar trigone medially involves the adjoining soft palate and the posterior floor of mouth; backwards the mucosa overlying the pterygomandibular raphe is involved; and forwards the alveolar ridge, extending over its lingual and buccal surfaces.



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In infiltrating deeply, the tumour involves the mandibular bone lying immediately deep to the mucosa of the trigone and, when it reaches the inferior dental nerve, spreads perineurally to the trigeminal ganglion.

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On each side of the ascending ramus, deep spread is to the medial pterygoid, masseter and temporalis muscles. The infiltration of these muscles is responsible for the trismus which develops in the advanced case.

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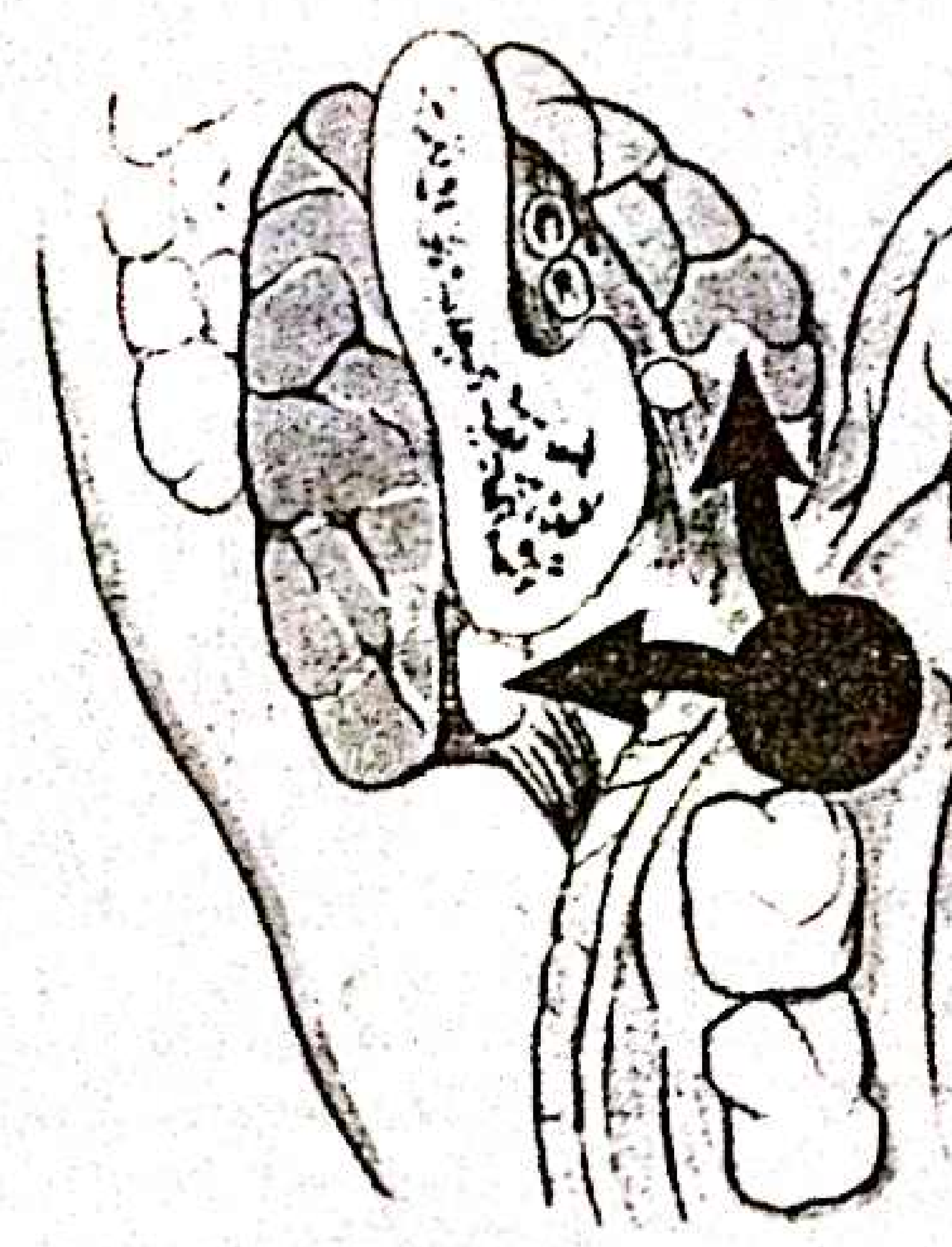
In resection, following the mandibular swing manoeuvre, division of the mucosa and mylohyoid is carried back until it meets the anterior marginal resection line of the tumour. The complete line of marginal resection is then marked out on the mucosa, and the tumour cleared as it extends in the soft tissue directions which have been described. The effect is to leave the resected soft tissue element attached to the mandible in the region of the trigone. Using the experience that the anterior and posterior extent of tumour in the mandible largely matches that of the soft tissue adherent to its surface, an estimate of the extent of involvement can be made. Even if the estimate indicates minimal or no bony involvement, the closeness of the mucosa to the underlying bone makes it prudent to remove a deep shaving of the cortical bone for histological examination, although it may not be necessary to remove the inferior dental nerve.

56

Evidence of deeper involvement requires removal of the bone down to and including the mandibular canal, back as far as the lingula, and probably continuing the bone cut up to the condyloid notch, dividing the temporalis tendon and removing the wedge of bone along with the length of nerve proximally to the skull base, using the technique described on p. 316. Pursuit of the nerve distally seems to be less necessary, experience indicating that perineural spread in this area is virtually exclusively proximal.

When the tumour has spread extensively posteriorly, as indicated by the presence of trismus so severe that tumour extent cannot be adequately assessed preoperatively, it may be necessary at operation to alter the approach strategy, elevating the soft tissues from the buccal aspect of the mandibular body, as described in the chapter on 'Buccal mucosa', pp. 270–282. When the anterior marginal clearance line is reached, the bone is divided with a vertical cut, so that the trismus can be released and the tumour more adequately visualized. In such a clinical situation, masseter, medial pterygoid and temporalis are likely to be extensively involved, and the ascending ramus with its muscle cover requires to resected *en masse*. The likelihood of involvement of the inferior dental nerve is high, with the probability that tumour has already reached the trigeminal ganglion. Clearance of the entire pterygoid fossa is usually required, but in those circumstances the tumour is likely to be inoperable.



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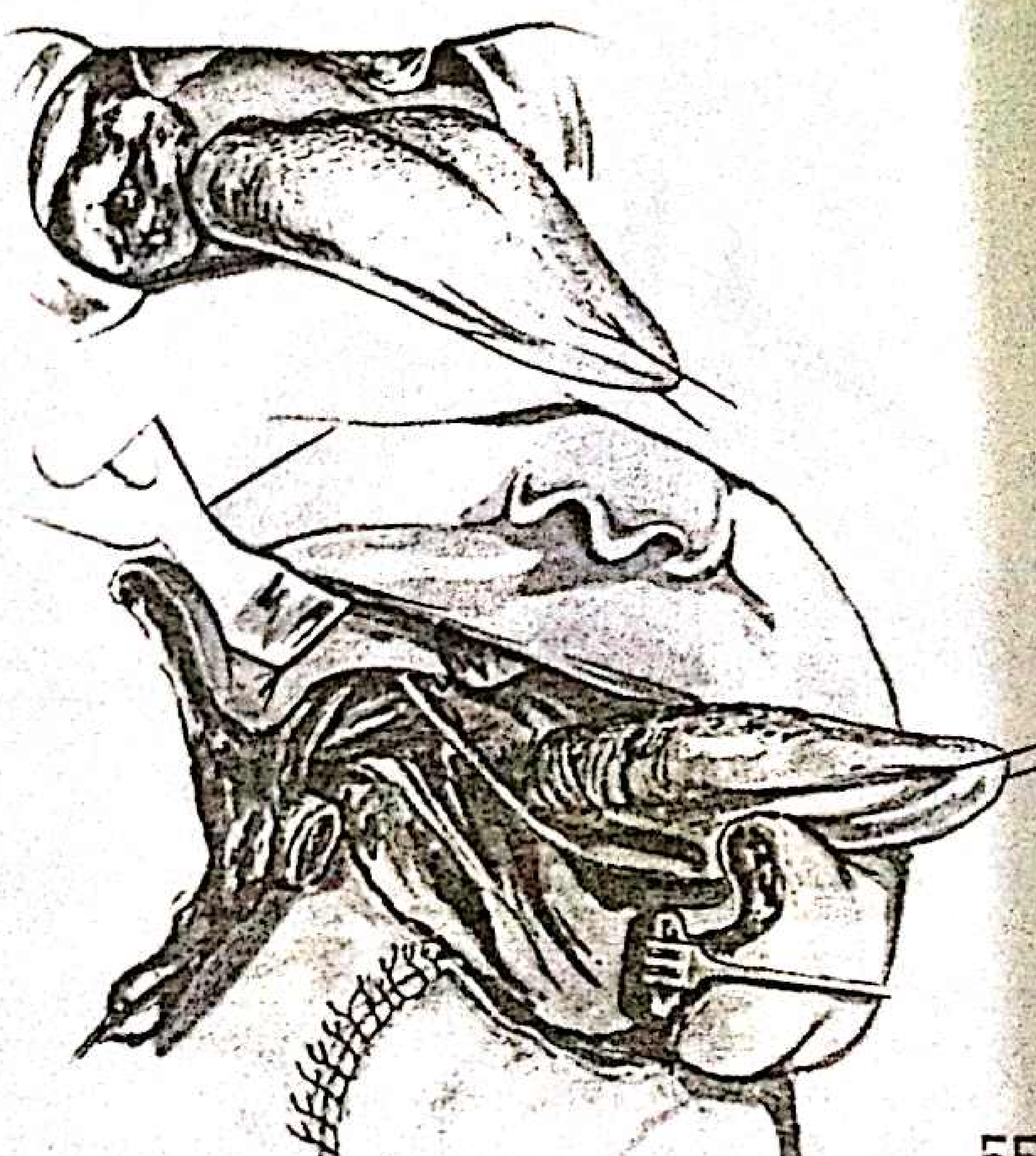

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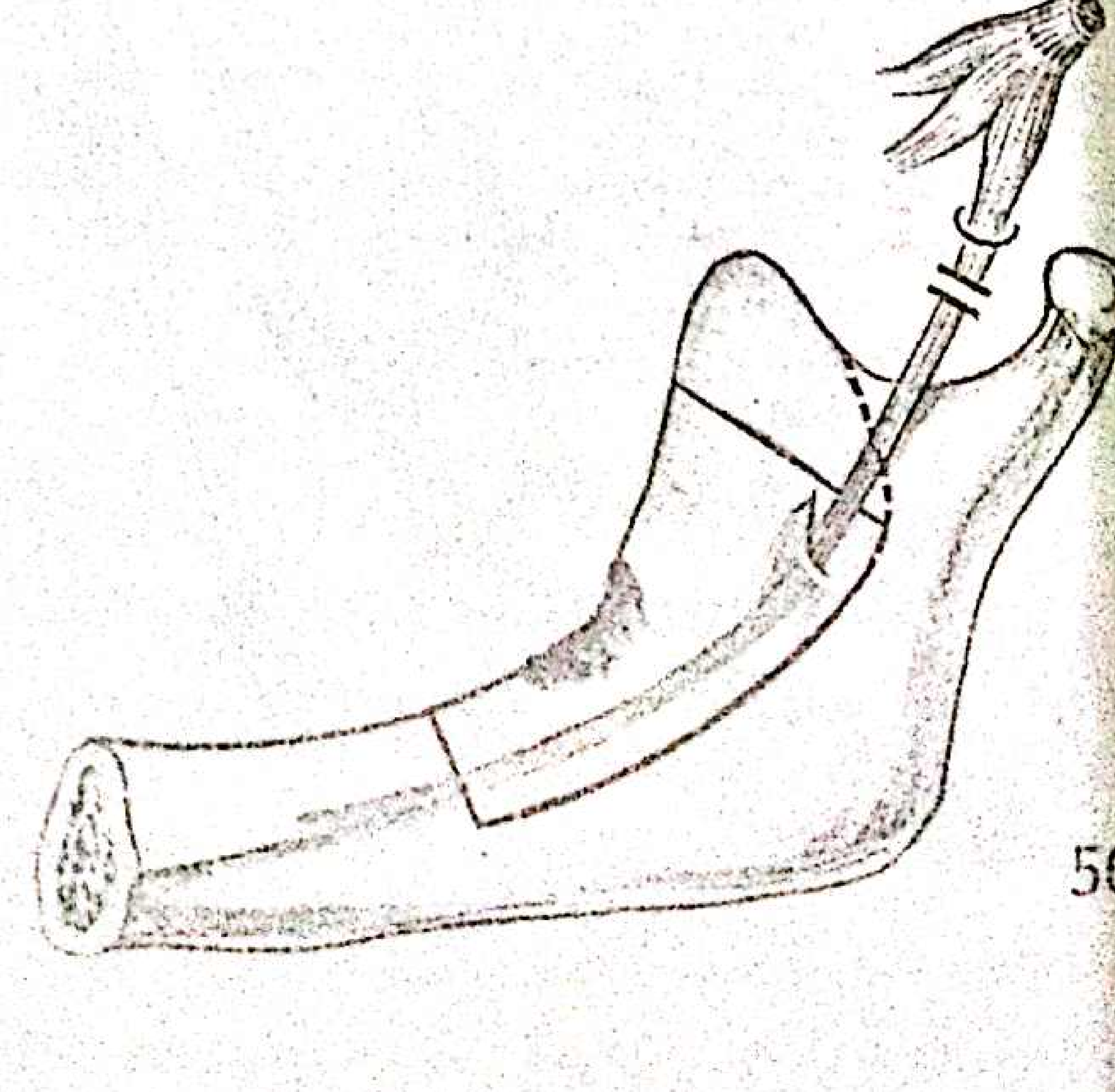

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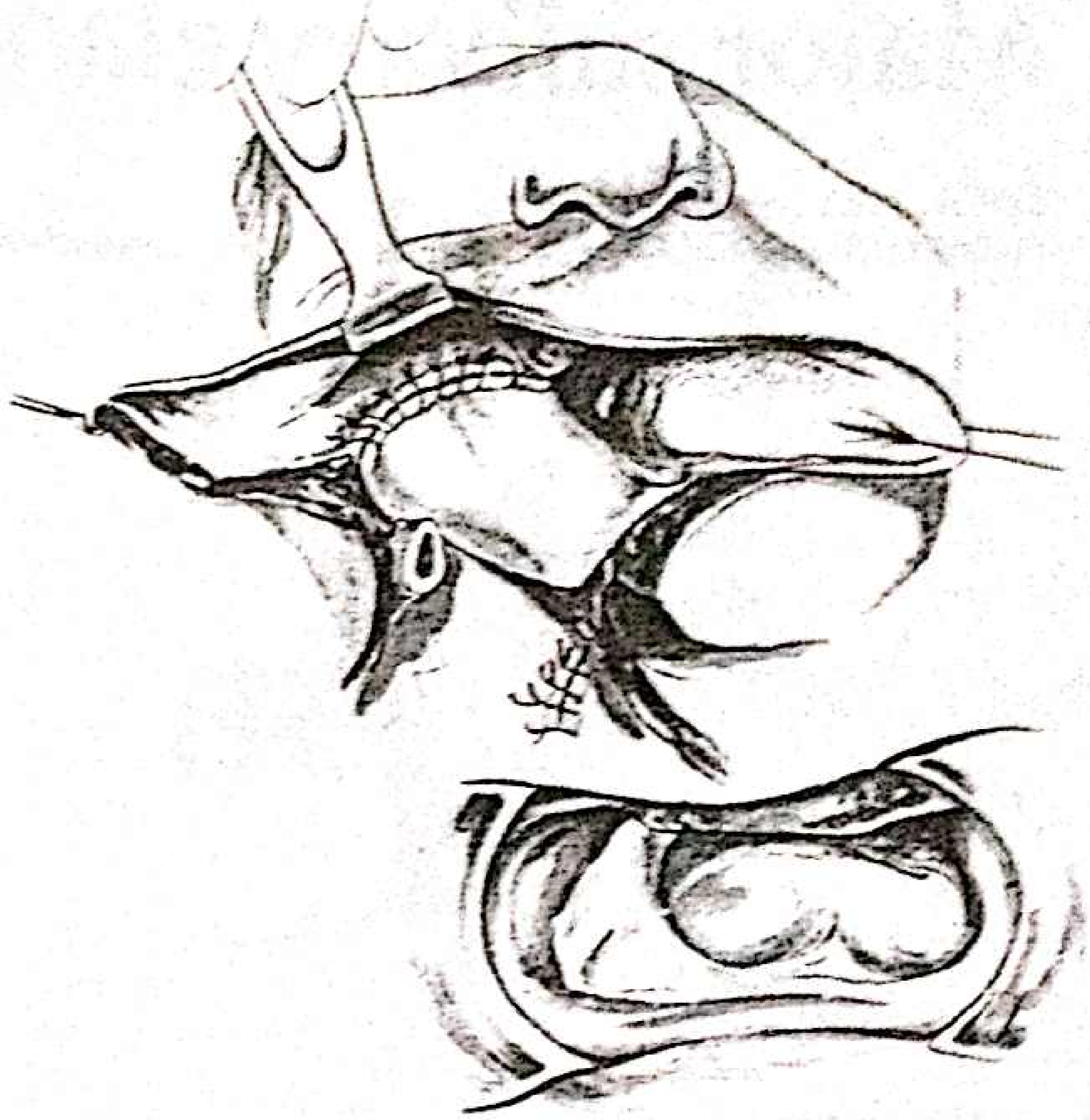
RECONSTRUCTION



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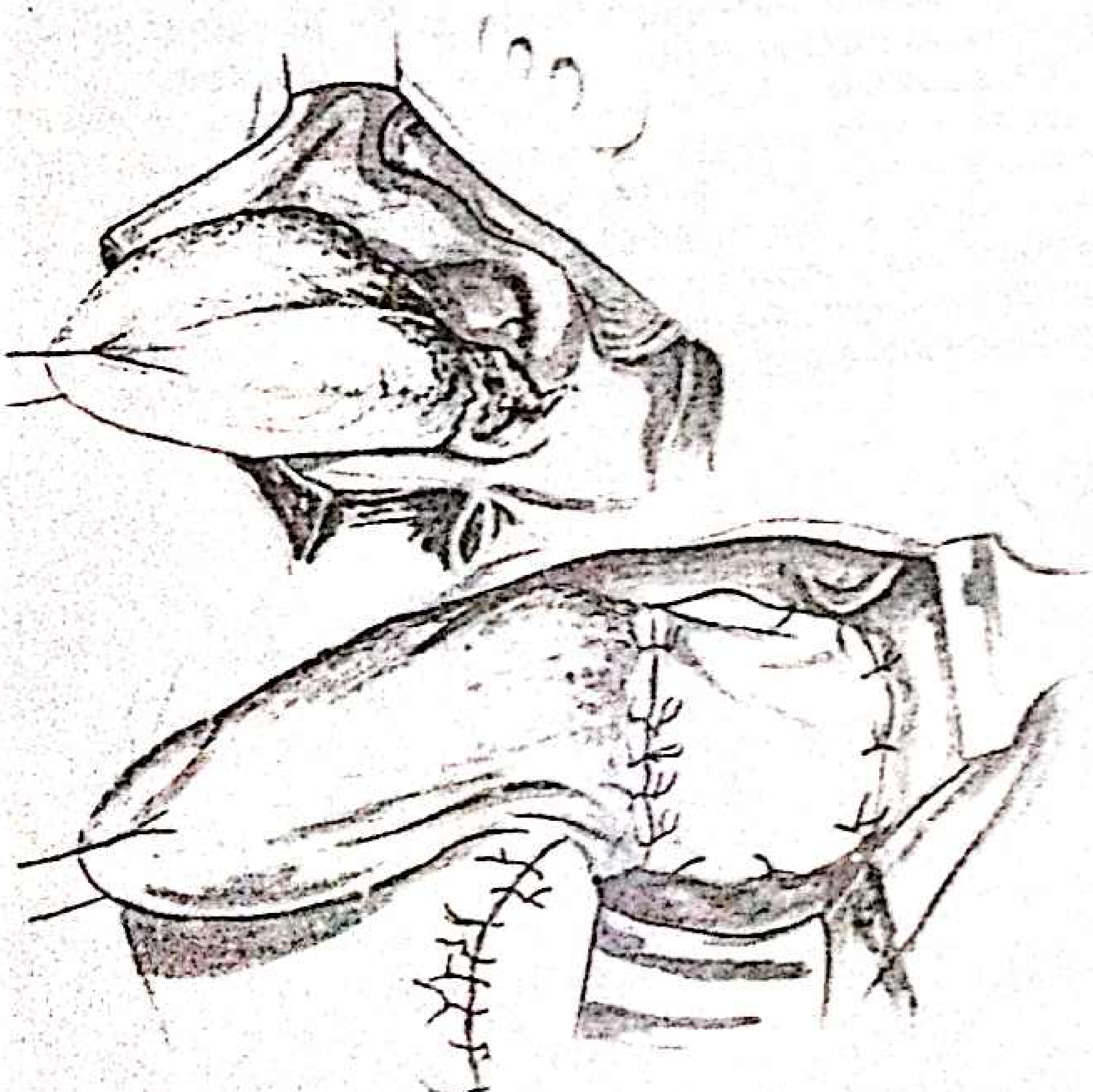
It is in the reconstruction of the postresection defects of both of these sites that free fasciocutaneous flaps have proved their worth. Flexibility of the flap is an essential quality because of the marked irregularity of the defect it has to match. From this point of view, the thinness and flexibility of the radial forearm flap make it probably the best one to use, although one of the scapular flaps provides an alternative.



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As a rule, the size of the required flap can only be an estimate, because of the irregular contour of the defect, but the calculation is best made on the basis of the length of the margin of the defect. If this has been estimated reasonably accurately, suture of the flap edge-to-edge with the margin of the defect will close it, and the flap itself contours to the defect remarkably effectively once mandibular continuity has been restored. Even when the margin includes the side of the soft palate where it is passing down to the faucial pillars, end-to-end suture round the palatal margin is possible because of the thinness and flexibility of the flap, and the ultimate functional result is generally excellent.

Myocutaneous flaps are much less functionally effective in this clinical context, unable to mould to the contours of the defect.

Major salivary glands

Ian A. McGregor ChM, DSc, FRCS
Formerly Director, Plastic and Oral Surgery Unit, Canniesburn Hospital, Glasgow, UK

PAROTID GLAND

If the surgery of the tumours which involve the parotid gland is to be both safe and effective, knowledge of its relationships to the structures which surround it and those which pass through it is essential. These relationships are of greater than average complexity, involving structures of importance, confined within a small space with fixed boundary walls. To know them in the normal subject is necessary, but equally important is to be aware how they can be distorted by the presence of tumours, both simple and malignant. Appreciation of the variation in the technical difficulties likely to be encountered in patients with different physiques is also desirable.

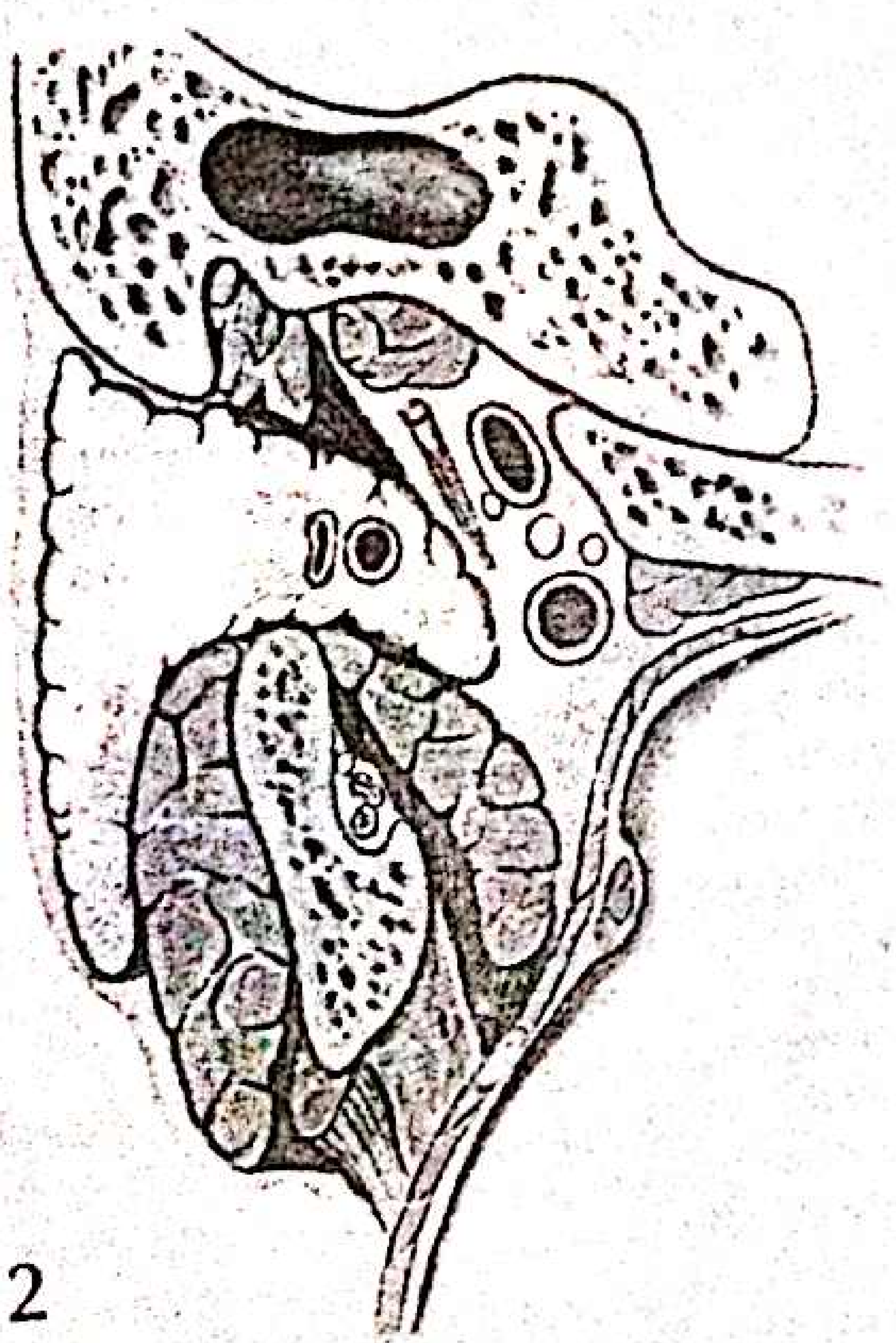
Intraglandular relationships might appear to be more relevant in the surgery of simple tumours, while the anatomy of the gland as it relates to its surroundings has more obvious significance in the surgery of malignant tumours, but a knowledge of both intra- and extraglandular relationships still forms the basis of the proper surgical management of both simple and malignant tumours.

Anatomical aspects

1

The body of the gland fills the space between the ascending ramus of the mandible and the surface presented by the external acoustic meatus and the mastoid process, its contours moulded to the irregularities of the bed in which it lies. The anterior border of the bed is formed by the projection backwards of the ascending ramus with masseter covering its superficial surface and medial pterygoid covering it deeply. The outer surface of the external acoustic meatus, bony and cartilaginous, forms the posterior border of the bed above, continuing below into the mastoid process and for a short distance along the anterior border of sternocleidomastoid. The floor is formed by the styloid process with its attached muscles and the posterior belly of digastric. These structures separate the gland from the internal jugular vein, the internal carotid artery and cranial nerves IX, X, XI and XII.

1



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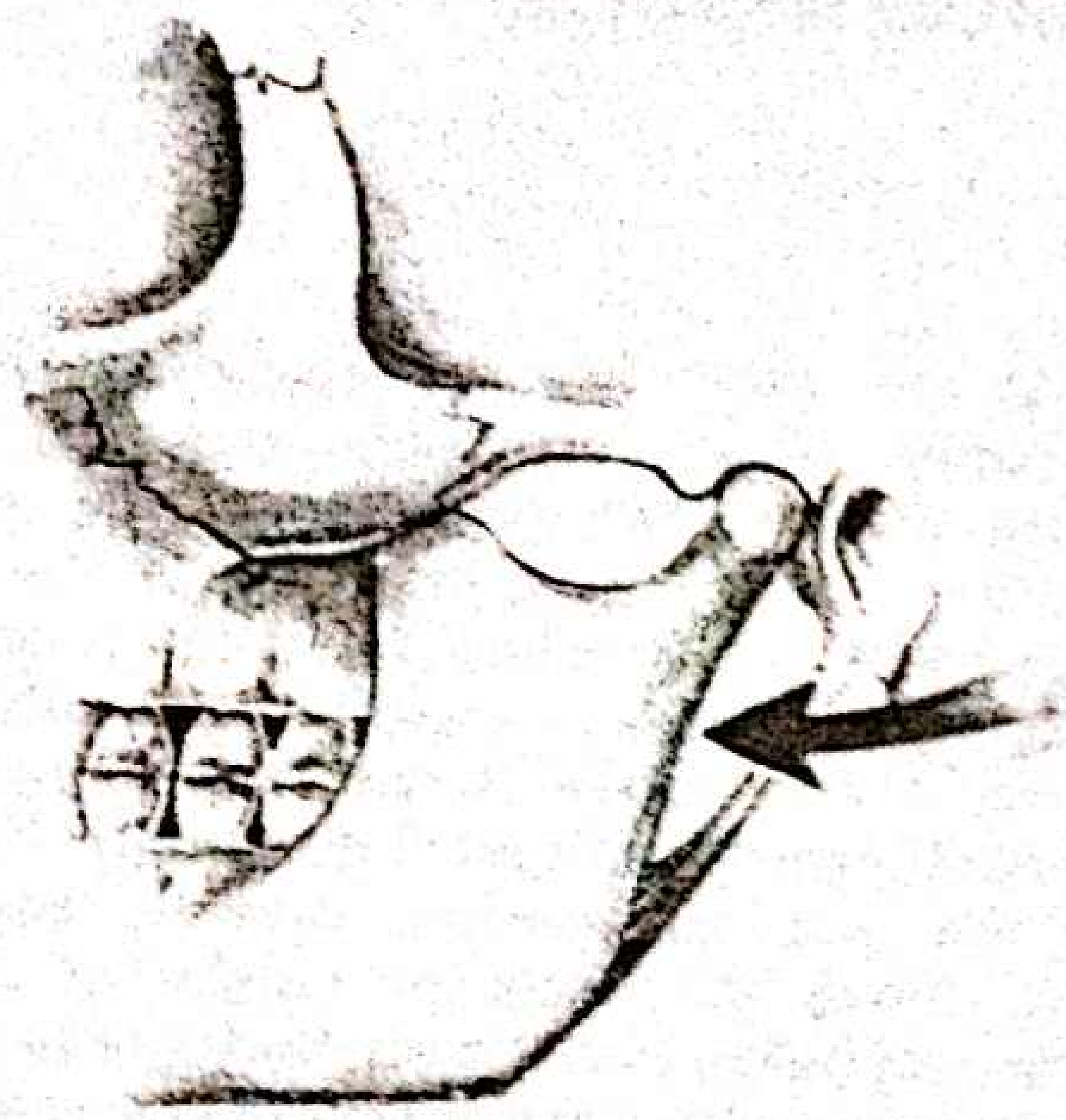
The gland has several extensions beyond its main borders. It extends forwards both superficial and deep to the mandibular ramus, overlying part of masseter and medial pterygoid. Just below the condylar neck, above the attachment of medial pterygoid to the bone, where the bone and muscle separate, the gland extends into the gap between the two. In the region of the condyle the gland fills the narrow recess between the capsule of the temporomandibular joint and the external acoustic meatus. Below the meatus it extends on to the outer surface of the mastoid process and over the anterior border of the sternocleidomastoid muscle.

There is no natural plane of cleavage between the gland and the skin capable of being exploited surgically. The gland is also firmly fixed to the structures which border it both anteriorly and posteriorly, with particularly firm fibrous attachments to the external acoustic meatus, the mastoid process and the fibrous sheath of sternocleidomastoid. In contrast, its attachments to the structures lying deep to it are generally much looser.

3

One of the fascial attachments is named the stylomandibular ligament. This structure is a thickening of the fascia deep to the gland, and it passes from the styloid process to the posterior border of the ascending ramus of the mandible just above the angle, separating the parotid from the submandibular gland. Together with the mandibular ramus it forms the boundaries of a narrow tunnel, the stylomandibular tunnel, through which a process of the gland projects towards the pharynx. This process of the gland is occasionally the site of tumour, resulting in the so-called 'deep lobe' tumour, which presents as a swelling in the faucial and lateral pharyngeal area rather than externally.

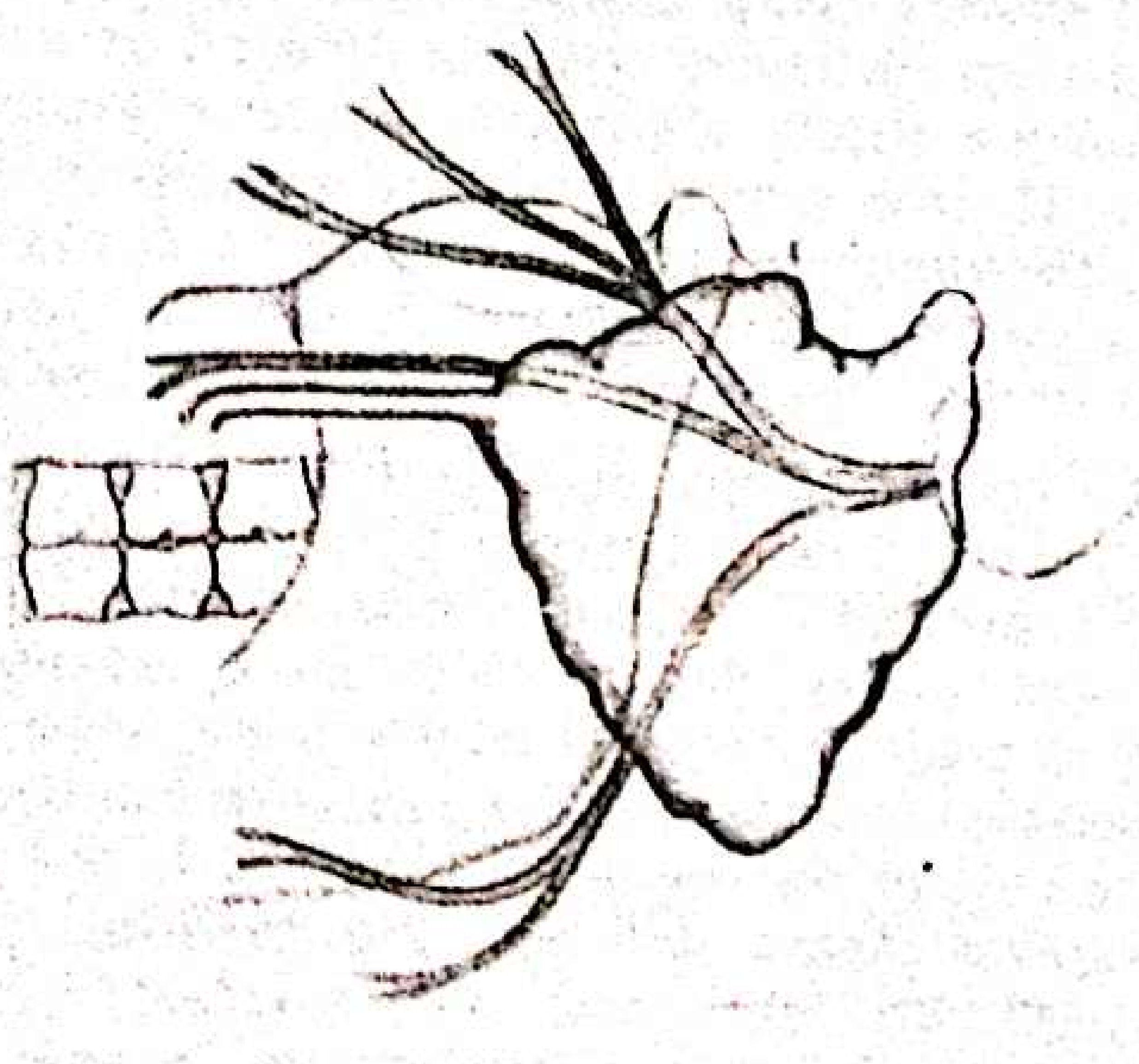


3

From the extension of the gland over masseter the parotid duct passes forward, curving medially round the anterior border of the muscle to pass through the fibres of buccinator and open into the mouth opposite the crown of the second upper molar tooth.

The structures of surgical significance which pass through the gland are the facial nerve, the external carotid artery and the retromandibular vein with their branches.

4



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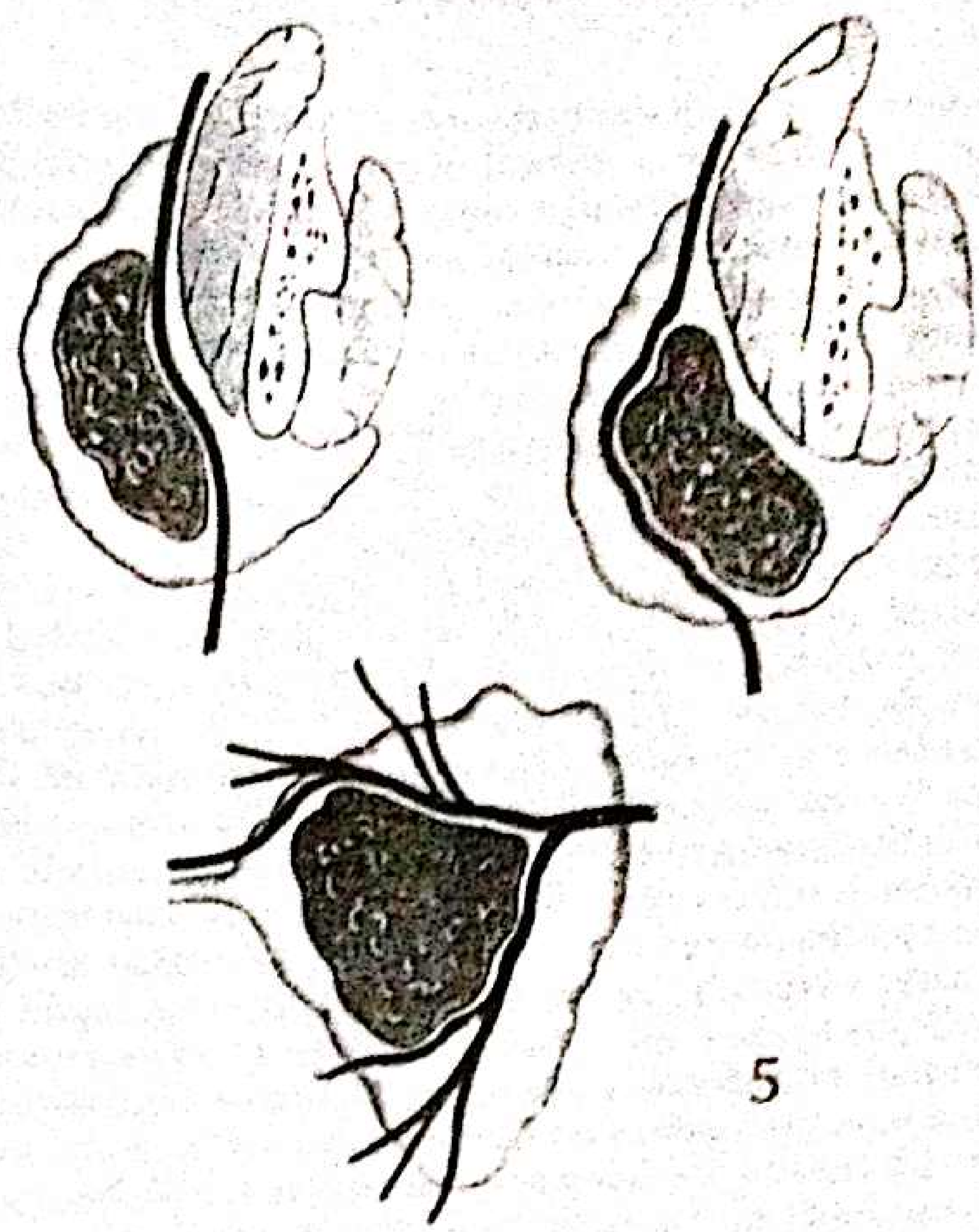
The facial nerve emerges from the stylomastoid foramen in the angle between the posterior belly of digastric and the skull base, and passes into the gland almost immediately. During its short free course it gives off small branches to the posterior belly of digastric and stylohyoid. Within a short distance of its entry into the gland it divides into an upper and a lower branch, the upper branch turning sharply upwards, the lower largely maintaining the line of the main trunk. Further division takes place, creating five main branches. The temporal and zygomatic branches share the motor supply of orbicularis oculi, the temporal branch alone supplying the forehead musculature. The lowest branch, the cervical, supplies platysma, and the remaining branches, buccal and mandibular, share the supply of the remaining facial muscles. Variations in the pattern of branching are common, but these do not present a serious hazard to the surgeon, since at operation the branches are traced through the gland under visual control in those clinical situations where maintenance of the continuity of the nerve is of prime importance. The pattern is also frequently altered when a tumour is present in the gland.

The main trunk of the nerve and its branches have certain constant relationships and these the surgeon uses for identification purposes. The main trunk emerges close to the origin of the posterior belly of digastric before it enters the gland, and it is at this site that the nerve is most frequently sought. The mandibular branch lies alongside the retromandibular vein as both emerge from the lower margin of the gland, and buccal branches of the nerve are found running alongside the parotid duct. These two relationships are also used to identify the nerve.

5

In the normal gland the facial nerve passes through the substance of the gland and does not separate it into superficial and deep lobes. An apparent separation into lobes is produced by the pattern of growth of those tumours which are not malignant. Such tumours occasionally develop in the plane of the nerve separating the main branches widely, but more often they develop either superficial or deep to it. The effect this creates is of branches of the nerve running in a plane between the tumour and a 'deep lobe', or between the tumour and a 'superficial lobe'. In such circumstances the nerve is frequently stretched over the capsule of the tumour and in direct contact with it, requiring to be dissected free at operation, and leaving a sizeable area of the tumour capsule exposed, without any covering of normal parotid.



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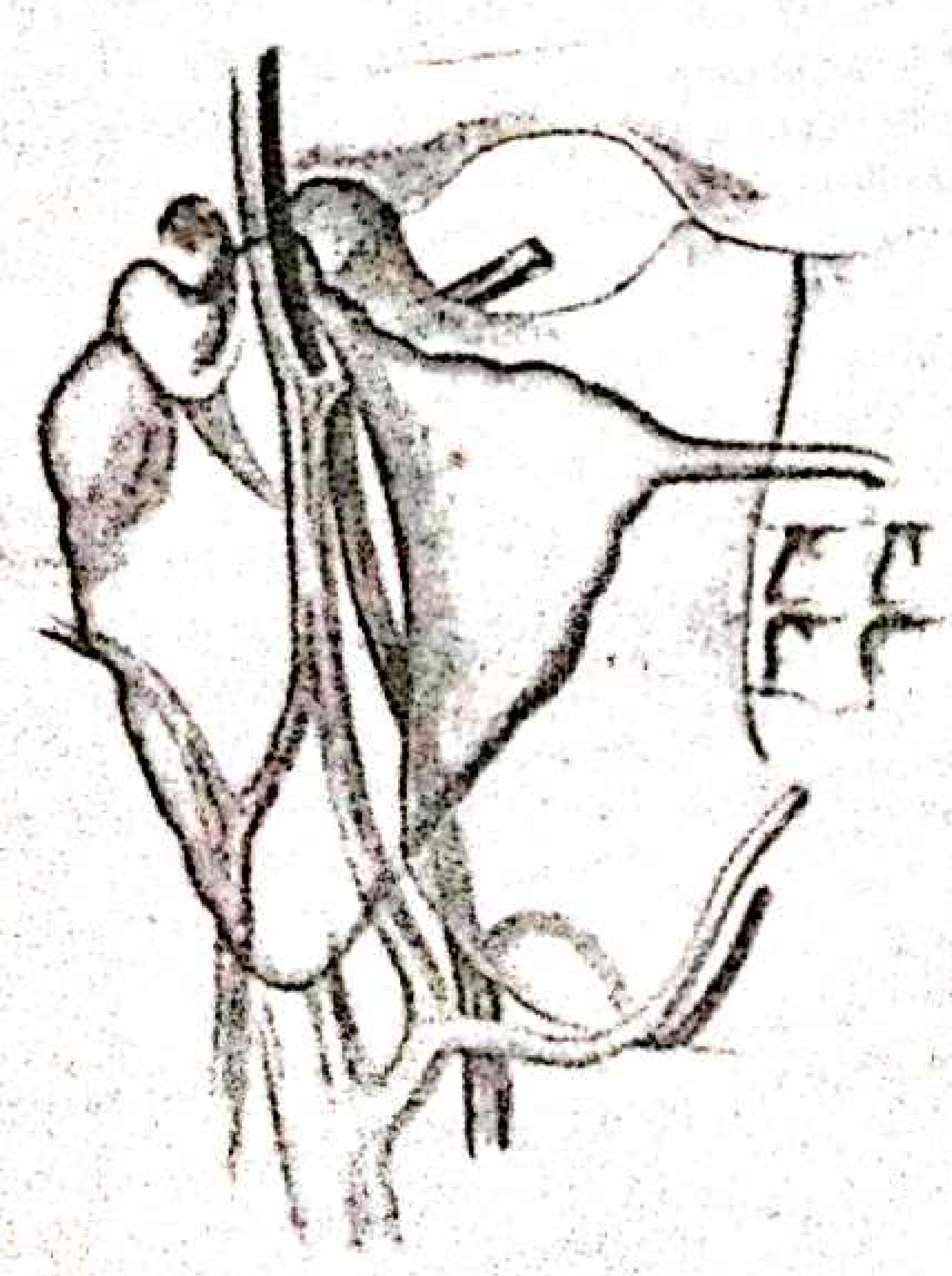
Immediate replacement by a graft of the segment of nerve which may have been resected as part of the overall resection procedure is an increasing practice, and this has been associated with a substantial improvement in the results achieved. Important elements in this improvement have been greater accuracy in joining the nerve ends, made possible by the use of the operating microscope, and greater care taken to ensure that the axons regenerating through the graft reach their proper motor end point. When the gap in the nerve is distal, where branching has already taken place, matching is straightforward. Greater difficulty arises where the proximal resection has been near the stylomastoid foramen, through the main trunk. Fortunately at this level separation into the axonal groups in preparation for branching has already occurred, the craniomedial side of the trunk being destined for the orbicularis and frontozygomatic muscles, with passage down towards the cervical branch parallelling passage towards the caudal side of the nerve.

6

The retromandibular vein enters the gland at its lower border, and the external carotid artery, more deeply placed in the neck, enters at a higher level on its deep surface. They pursue a parallel course upwards through the gland deep to the facial nerve, the vein superficial to the artery. Their main significance in parotid surgery lies in the fact that, at about the level of the junction of the middle and upper third of the gland, they both branch into maxillary and superficial temporal vessels. The maxillary vessels pass round behind the neck of the mandibular condyle in the segment of the gland which lies deep to it, emerging from the gland to pass into the infratemporal region, while the superficial temporal vessels continue upwards to emerge from the upper border of the gland and perfuse much of the scalp.



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Pathological aspects

Tumours of the parotid are more often than not excised on the basis of a clinical rather than a pathological diagnosis. Several factors contribute to this unsatisfactory situation. Much the commonest tumour of the parotid is the pleomorphic adenoma, providing approximately 75 per cent of the total incidence in that site. This tumour has a well recognized capacity for seeding if its capsule is breached, with 'spillage' of cells, and the tumour growth which follows seeding in this way can be extremely difficult to eradicate, attempts being liable to place the facial nerve at considerable risk. It is because of this that formal biopsy of the tumour nodule is contraindicated.

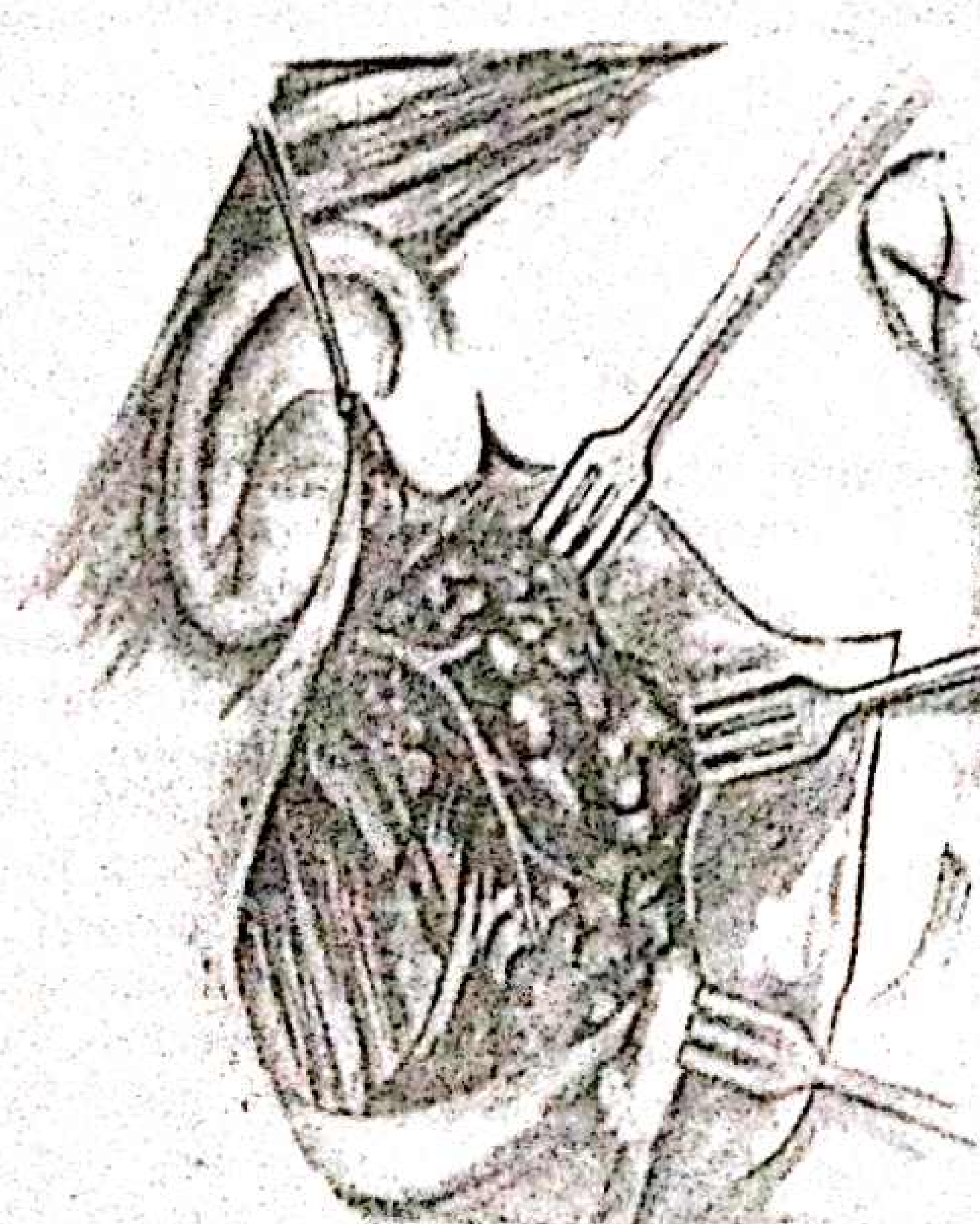
A potential alternative which has been described is needle biopsy, but this procedure has a recognized incidence of tumour recurring along the track of the needle, and because of this it has also been condemned. With the instrument which was used, namely a cannula, to provide a solid core of tissue for histological examination the condemnation was entirely valid. Aspiration needle biopsy, using a 22 gauge needle, has not been found to have this hazard, but it has still proved of limited value. The lack of uniformity implicit in the name pleomorphic adenoma, the tumour encountered most frequently, and the difficulty of obtaining a representative sample because of the small volume of tissue which the needle provides, accounts for the failure of even the most experienced cytologist to make a diagnosis in a proportion of instances. A positive diagnosis is of value, but a negative one is not necessarily significant.

This unsatisfactory situation would not be acceptable were it not for the fact that approximately 90 per cent of nodules arising in the parotid are either due to a pleomorphic adenoma or a tumour, such as an adenolymphoma, which will be managed in the same way. As a result any diagnostic test, to be of real value, has to better this random situation. The consequence of these facts is that the surgeon frequently has to operate with a degree of uncertainty.

With earlier referral to the surgeon of patients with parotid swellings, an increasing proportion of carcinomas present at the stage of a discrete nodule in the substance of the gland without overt signs of malignancy. In such circumstances the most that the surgeon can do is to have an increased index of suspicion on the basis of such factors as faster than average growth, a harder than expected nodule, less than expected mobility of the nodule within the gland. Even these may be misleading both in terms of their presence or, more often, their absence. Adenoid cystic carcinoma grows no faster than pleomorphic adenoma, induration may be masked by overlying normal parotid, and mobility is difficult to assess when the tumour is deep to the facial nerve. It is in this situation that aspiration needle biopsy may be of help, since the greater cellular uniformity of the frank carcinoma is liable to provide better diagnostic material, both in terms of the adequacy of the specimen and ease of diagnosis. Even so, the surgeon at operation must always be on the look-out for signs of malignancy in what he diagnosed clinically as a simple tumour.

Surgical approach

In managing a pleomorphic adenoma or comparable tumour the surgeon is pursuing two objectives simultaneously – removal of the tumour intact and preservation of the integrity of the facial nerve. The technique employed in practice is to pursue the nerve into the gland and trace its course through the gland, in the knowledge that it does not enter the tumour.



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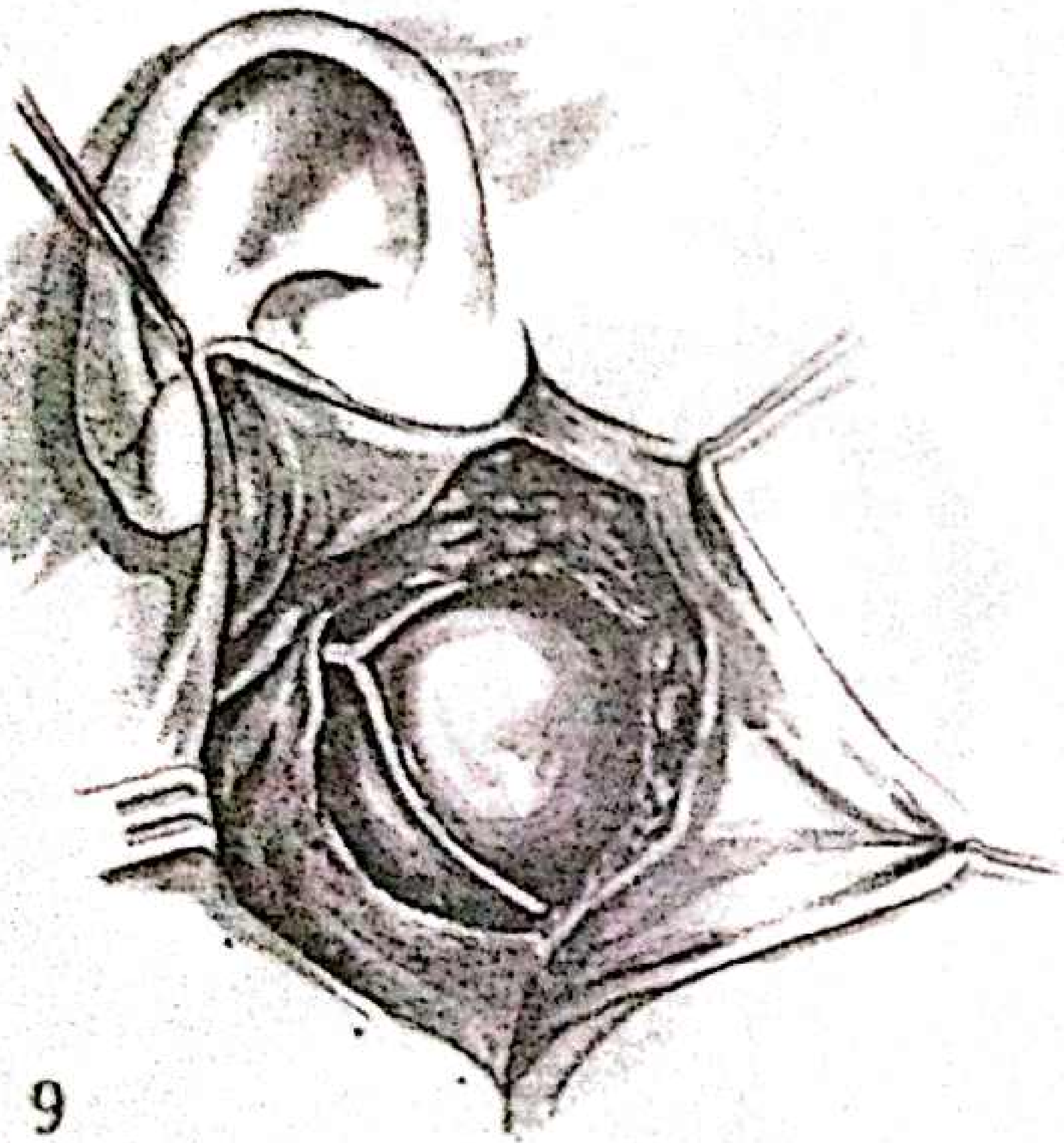
7

When the tumour is superficial to the nerve, extending exposure of the nerve has the effect of mobilizing the superficial 'lobe' with its content of tumour, allowing the latter to be removed.

8

When the tumour is deep to the nerve, exposure of the nerve mobilizes the gland superficial to it and lays bare the tumour-containing gland deep to it, allowing it to be removed once the nerve branches overlying it have been mobilized and drawn aside.

8



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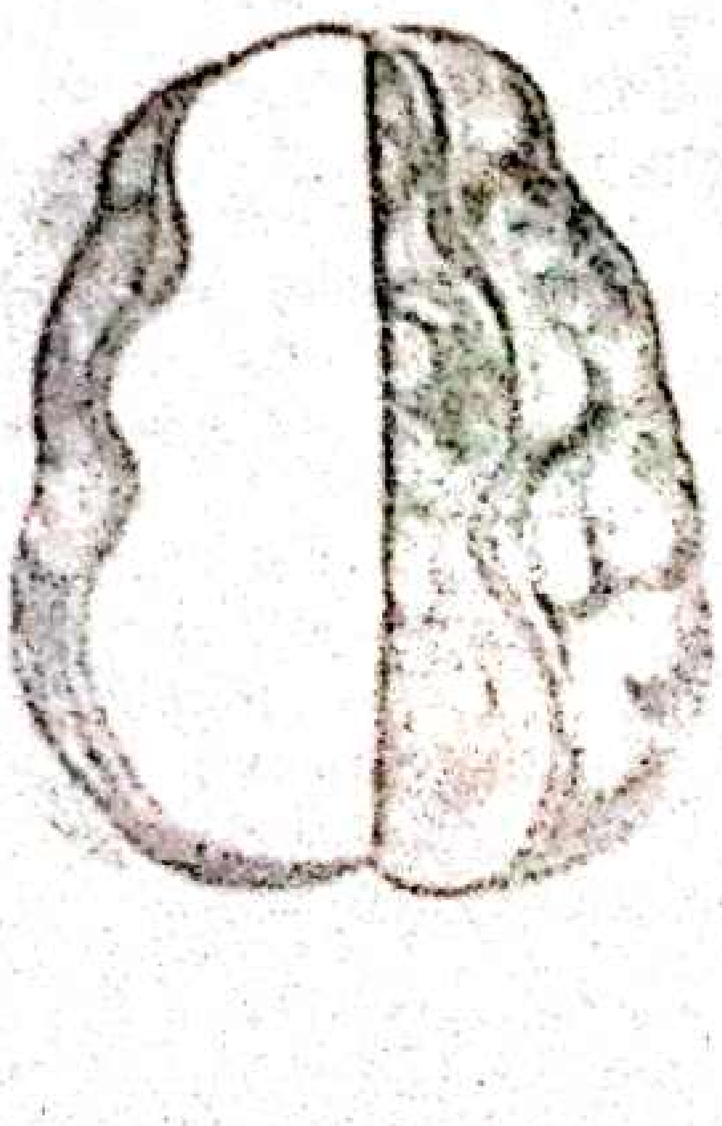
In either event the exposure and tracing of the nerve within the gland is the key to excision of the tumour. Frequently in the process of tracing the nerve, the tumour capsule is exposed with one or more branches of the nerve running directly over it, requiring to be carefully dissected free.

The statement is regularly made that 'the tumour must be removed with an intact covering of normal parotid', but with nerve branches frequently found stretched over and in direct contact with a significant area of the tumour capsule this is clearly not possible in many instances.

10

An awareness of the characteristic shape of a pleomorphic adenoma is of considerable help to the surgeon when he is dissecting close to the tumour. In its early stages of growth the tumour is rounded, but as it enlarges it becomes markedly knobbly, the covering capsule of fibrous tissue which forms a cleavage plane between it and the surrounding gland, thinnest over the convexities, thickest in the hollows.



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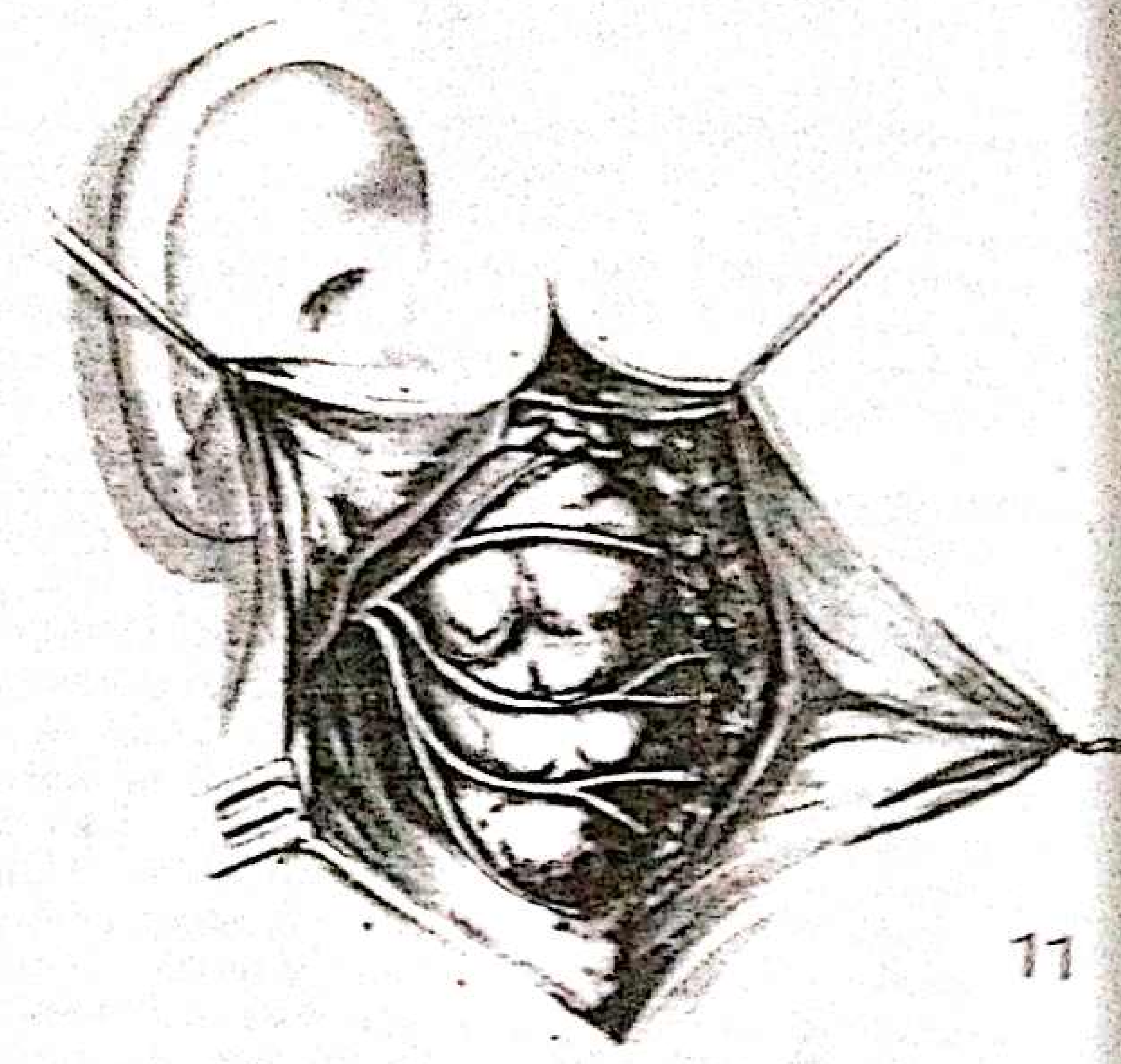
It is during the exposure of the facial nerve in this way that the presence of a malignant tumour can first be suspected and then confirmed. The appearance of the surface of a simple tumour, such as a pleomorphic adenoma or adenolymphoma, is quite characteristic, with a well defined capsule, and when the presence of such a capsule becomes apparent the clinical diagnosis is largely confirmed.



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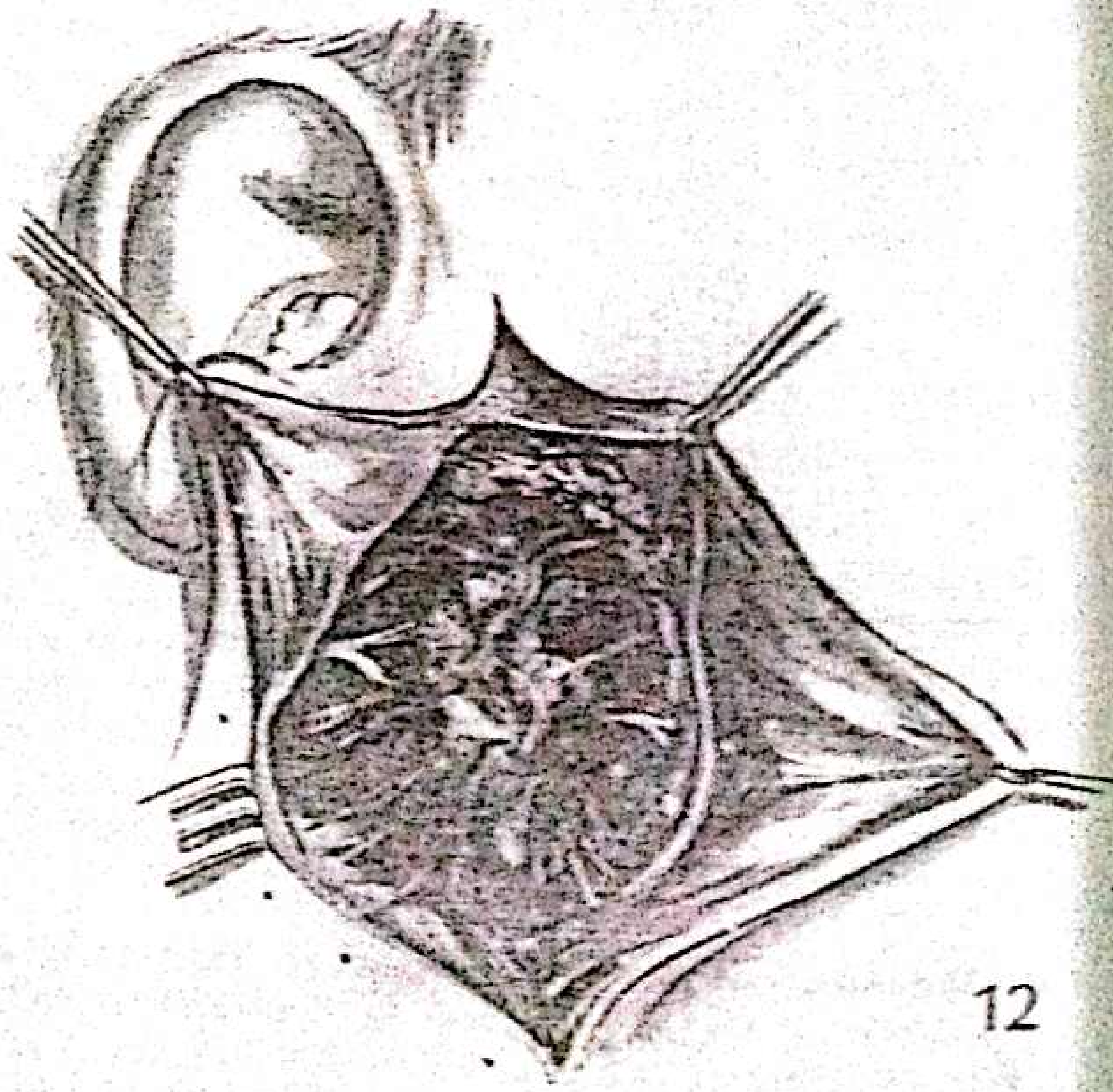
When the nerve is being dissected and such a capsule does not appear, malignancy should be suspected. Confirmation is virtually absolute when one or more branches of the nerve vanish into the tumour. The surgeon's entire strategy must then change, with the integrity of the nerve taking second place to clearance of the tumour nodule with an adequate cover of surrounding parotid, resecting facial nerve branches as necessary to achieve this objective.

The last 50 years has seen a change in the surgical approach to tumours of the parotid, particularly in the management of pleomorphic adenoma, a change from enucleation of the nodule to formal removal of the tumour-containing 'lobe' of the gland. Several factors contributed to this change. Most important was recognition of the unacceptable recurrence rate which followed enucleation in the form which it took at that time, namely the making of a short incision over the nodule, deepened to enter the plane of the tumour, followed by enucleation using either blunt or digital dissection. Coincidentally, the technique involving formal identification of the facial nerve as a preliminary to parotidectomy was described. Contributing also was the separation of those tumours which presented initially in a similar manner into different pathological categories, each with a markedly different prognosis, and each requiring its individual surgical approach.

For the clinically benign tumour, an area of controversy still exists, concerning the place, if any, of enucleation of the tumour as the method of excision. It must be acknowledged at the outset that the form which such enucleation takes today is far removed from that of 50 years ago, but the stigma of the name still attaches to the technique despite its change in form. Today the surgeon using the technique is aware of the lobular appearance characteristic of a pleomorphic adenoma, and the method employed is one of careful stripping of the gland off the tumour using minimal traction, recognizing its lobular contour as it is exposed, and eventually lifting the tumour from the bed, recognizably intact.



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Carried out in this way, in the hands of those experienced in its use and using it selectively, enucleation is doubtless effective, but it does carry certain pitfalls. Among them is the tumour which is found to be deep to the facial nerve and whose enucleation would pose significant technical problems; also the unexpected finding that the clinical diagnosis was mistaken and the tumour is malignant, of the type which presents initially as a nodule in the gland, such as adenoid cystic carcinoma or high grade mucoepidermoid tumour. It is not a recommended technique, even in its modern guise.

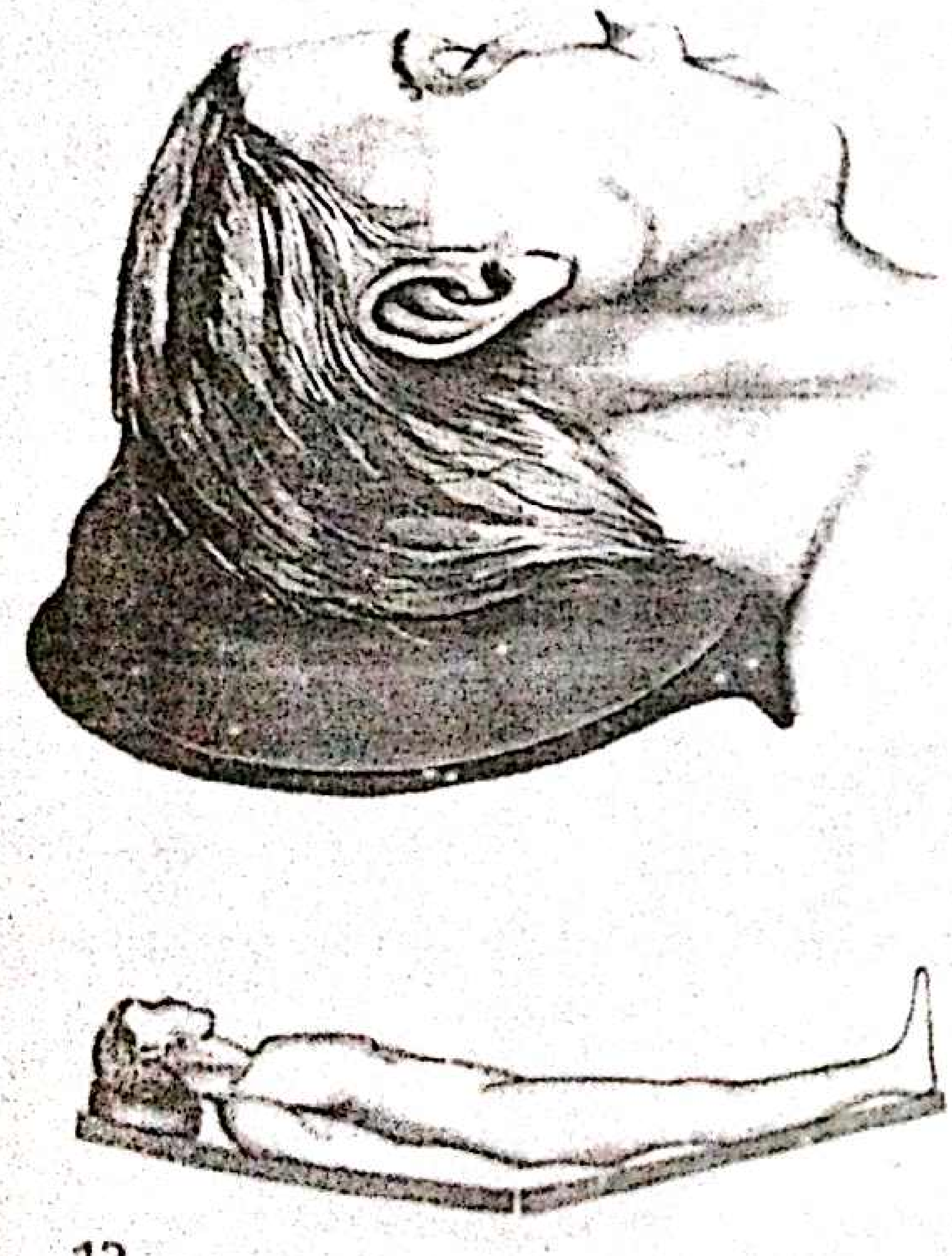
PAROTIDECTOMY

Depending on the site of the tumour and its presumed pathological status, parotidectomy can be separated into several distinct elements:

1. Preparation and placing of the patient.
2. Skin incision and exposure of the gland.
3. Identification of the facial nerve, proximally as the main trunk and distally as one of the branches.
4. Tumour resection, which can take several forms:
   (a) Superficial lobectomy.
   (b) Total parotidectomy, with preservation of the facial nerve.
   (c) Radical parotidectomy, with or without neck dissection in continuity.
5. Reconstruction, required if skin or nerve have been resected.

Preparation and placing of the patient

The potential risk to the facial nerve must be discussed fully with the patient, since damage is a hazard even when the tumour is simple, and the possibility exists that a branch of the nerve or even the entire nerve may have to be resected if the tumour is unexpectedly found to be malignant. Since a reasonably accurate estimate of the degree of risk can be made preoperatively, an appropriate degree of optimism can be expressed. Temporary postoperative weakness of the facial muscles is not infrequent and the patient should be made aware of the possibility, particularly of its temporary nature, provided the nerve at operation is seen to be macroscopically intact. The fact that it might prove necessary to resect the nerve should be explained, but also whether or not this is likely, and also that nerve grafting will be carried out if it is practicable, together with an estimate of the probable result in terms of its adequacy and the time taken to achieve it.



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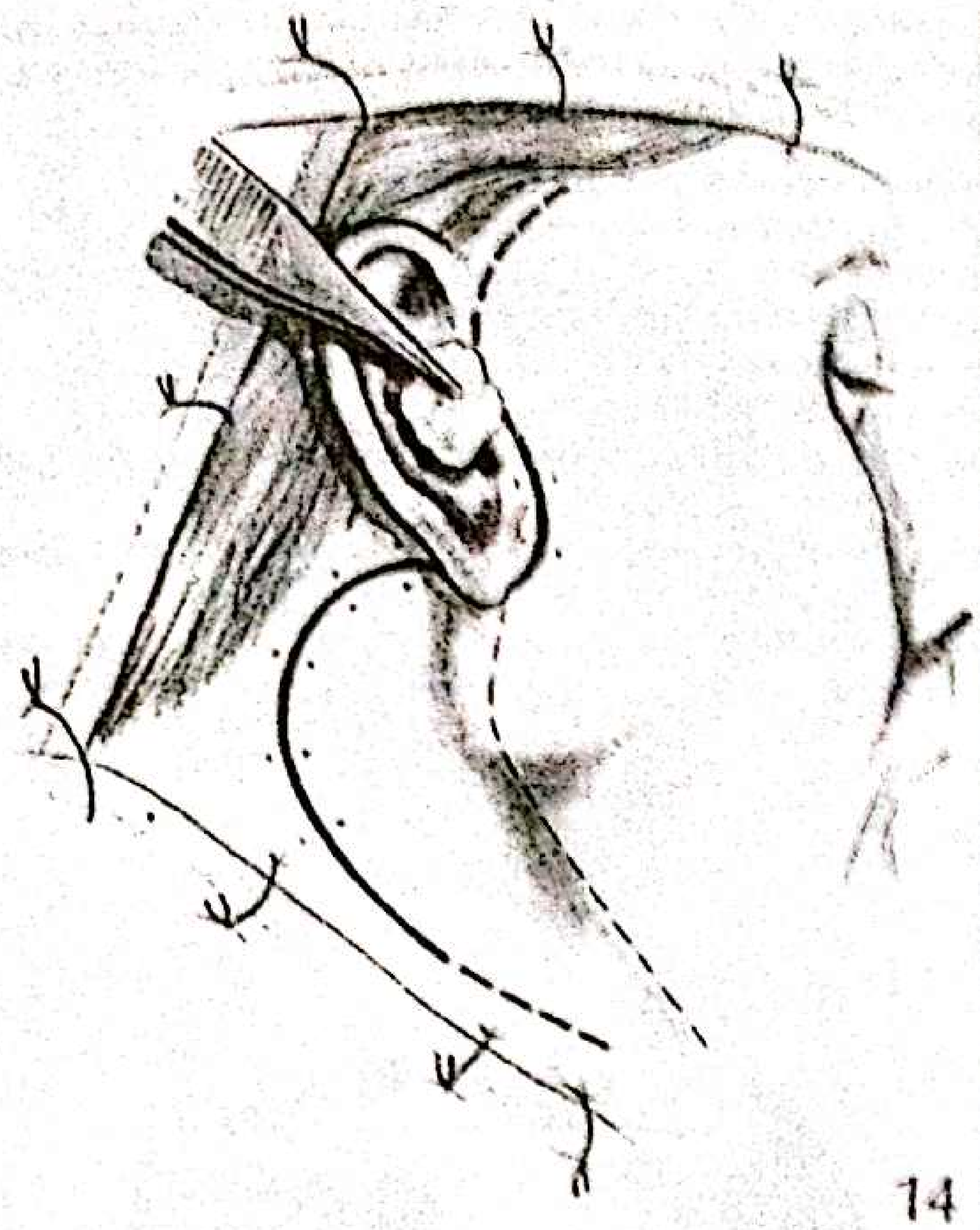
With the detergents and skin sterilizing agents currently available, it is not necessary to shave any hair other than the beard area. The patient is positioned supine on the operating table with a slight head-up tilt and the head stabilized in a head ring, turned to the opposite side and extended. Endotracheal anaesthesia is usual, and the use of a hypotensive technique makes for a technically easier procedure. If the anaesthetist avoids using a muscle relaxant, any stimulation of the facial nerve during the operation is more readily detected and for the same reason the entire side of the face is left exposed in applying the towels. These are liable to be dislodged during the surgery and are probably best held in position by suturing them to the skin. A pledget of cotton wool should also be inserted into the external acoustic meatus to keep it free of blood.

14

With the aim of combining good exposure with the best cosmetic result, the incision makes use of the junction line between the pinna and the cheek and is carried back under the lobule of the ear, turning forward in a gentle curve to lie in the skin crease which runs across the neck at this level. The flap extending backwards below the ear lobule which this incision creates is somewhat at risk from a vascular point of view and care should be taken to minimize this by making it neither too narrow or too long. A vertical wrinkle line is frequently present immediately in front of the pinna and in this the incision is placed, failing which it should be placed as close as possible to the pinna.

Depending on the site of the tumour in the gland the incision may require to be extended to allow a skin flap to be raised which will expose the site of the tumour adequately. The preauricular incision can be extended upwards into the hair in a gentle forward curve and the neck incision can be extended forward as required.

Prior to the making of the incision its line should be drawn out on the skin with Bonney's blue and the problem of matching the two sides of the incision during closure of the wound can readily be solved at the same time by tattooing matching points at intervals along its line.



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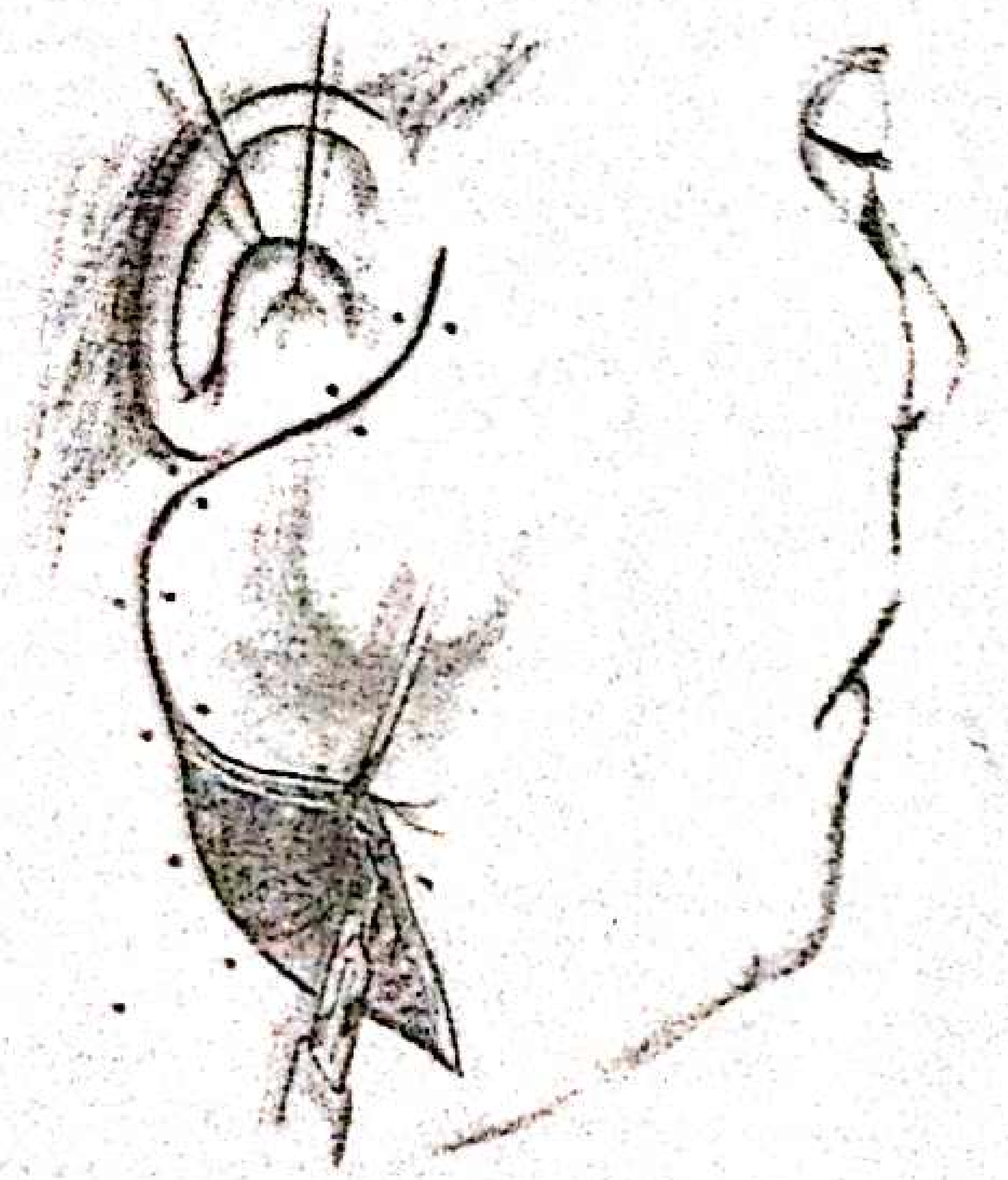

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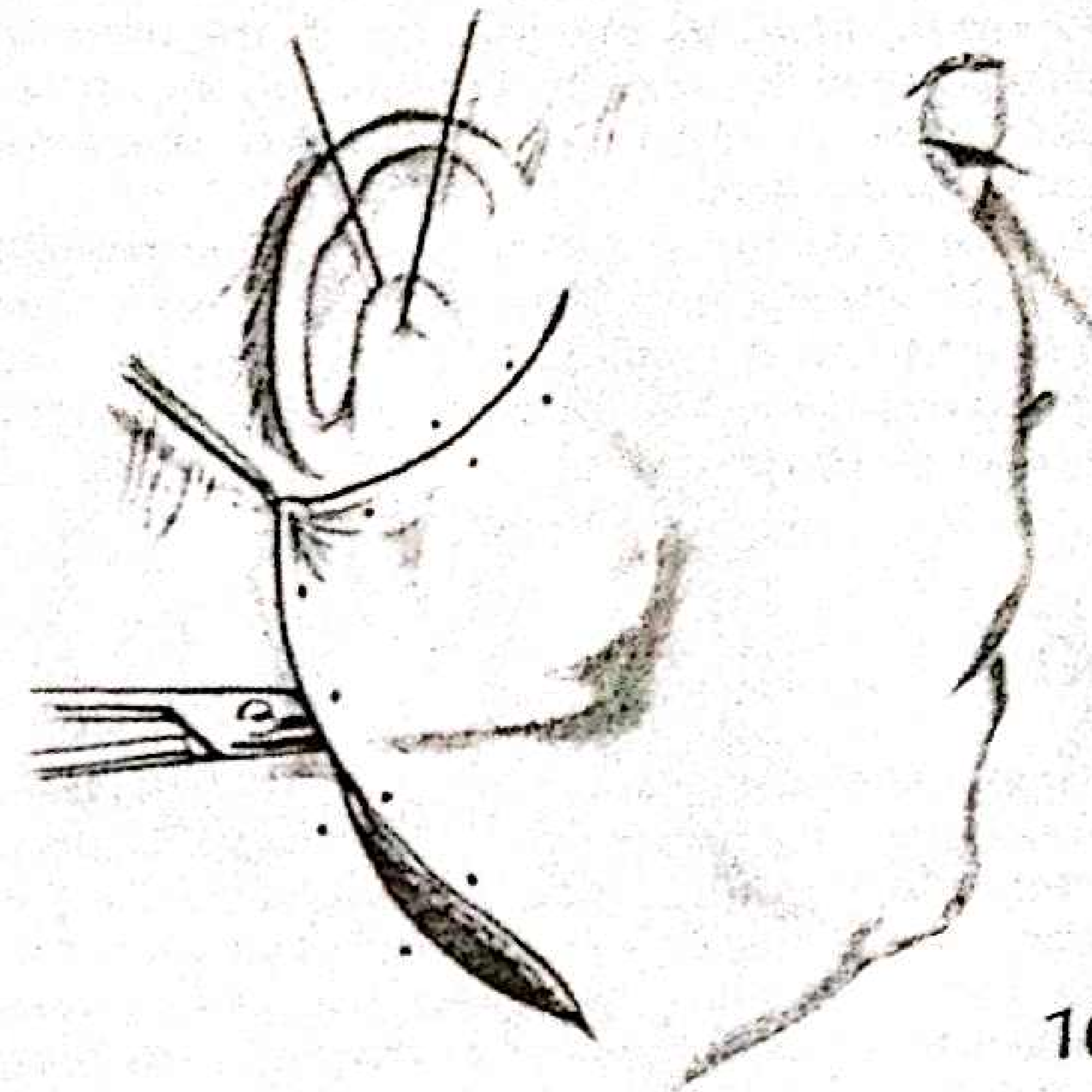
The skin flap overlying the gland is raised at a level which includes a proportion of the subcutaneous fat, the 'face lift' level. This is not a natural tissue plane. It has to be created surgically, and the first centimetre or so of the flap is best raised using a scalpel.

16

Thereafter it will be found that by using McIndoe scissors the flap can be raised quickly, with minimal blood loss, at a remarkably uniform level, and one which ensures a good blood supply to the skin of the flap. McIndoe scissors have a rounded tip, are gently curved on the flat, and can safely be thrust through the fat with the prominence caused by the scissor tip just visible on the skin surface. The closed blades are inserted into the fat and opened against the resistance of the flap which is held taut using skin hooks inserted into its margins. As the flap is raised and can be retracted, residual fibrous attachments come into view and are divided.

The area over which the flap is raised depends on the site of the tumour within the gland and its presumed extent, but it should be generous. If identification of buccal branches of the facial nerve is being used, the gland must be exposed at least as far as its anterior border.



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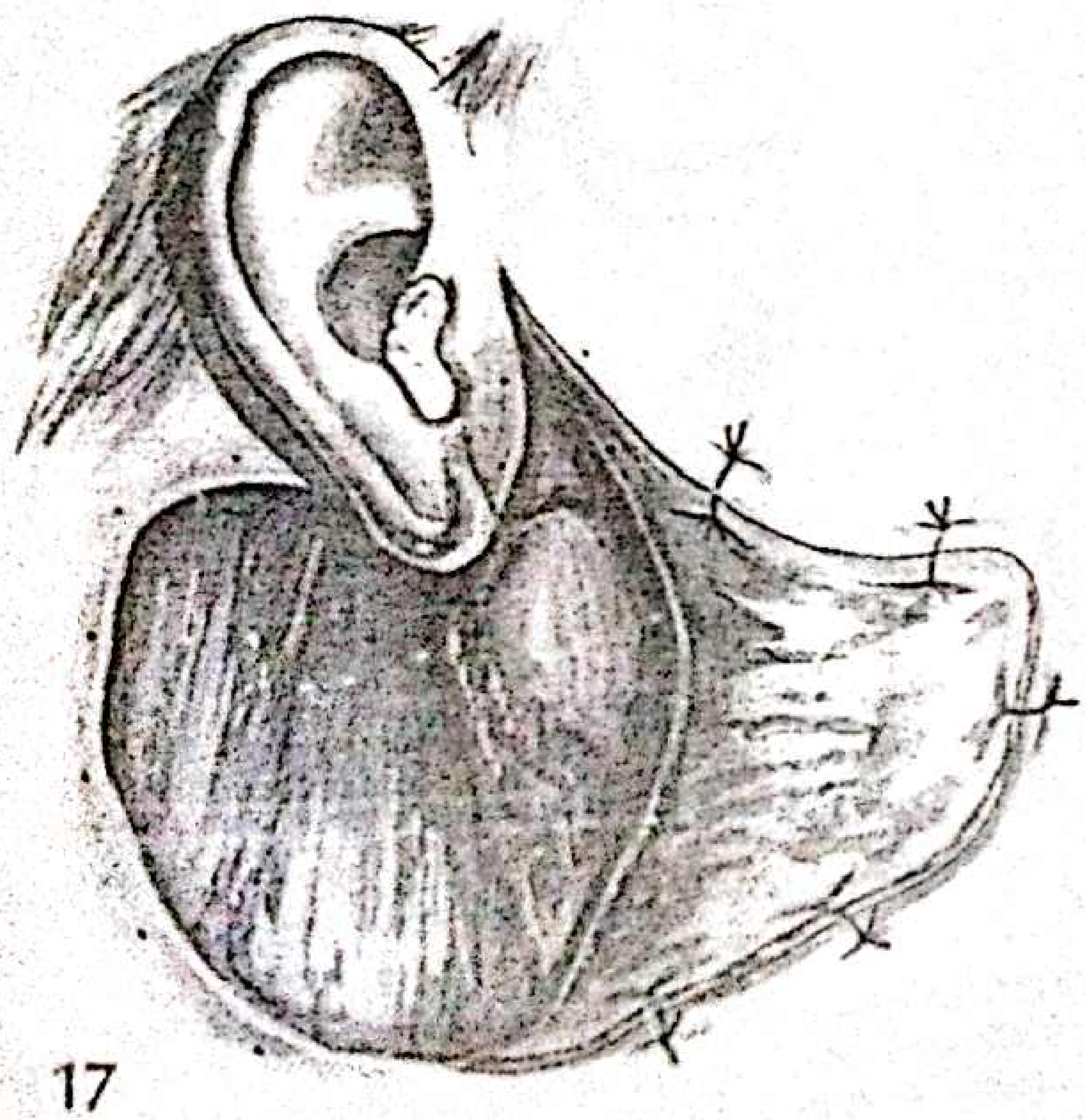

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With the flap elevated it is often convenient to turn it forward and fix its margin to the skin anteriorly with sutures. This removes the need for retraction, but its exposed surface should be kept moistened with saline gauze.

Identification of the facial nerve

There are three recognized methods of identifying the facial nerve; proximal identification of the main trunk, identification of the mandibular branch of the nerve, and identification of distal branches, most often buccal branches of the nerve.

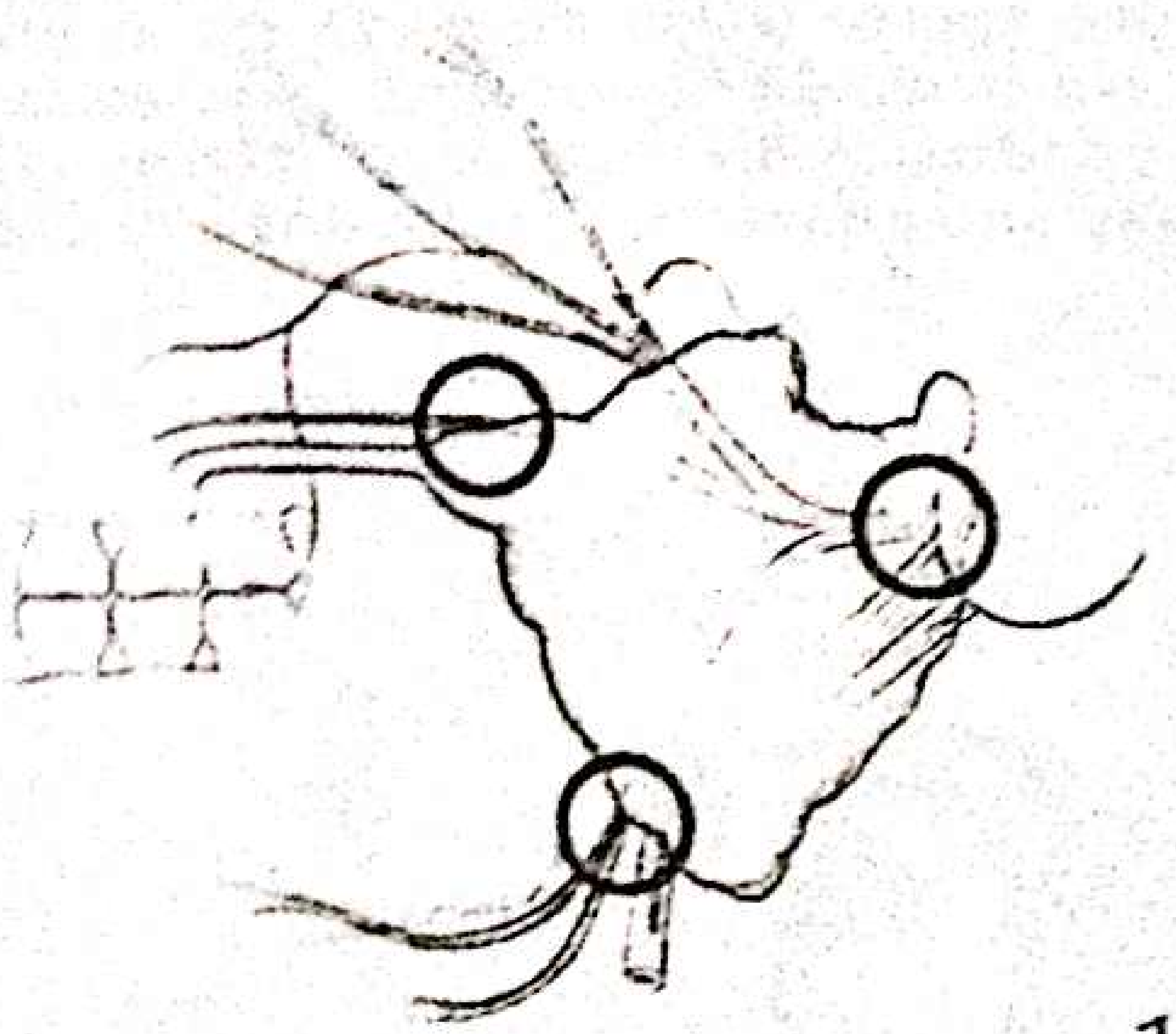
The use of the nerve stimulator is often recommended as an aid in identification. While it is occasionally of value, it is striking how it is generally discarded as the surgeon gains experience and develops confidence in recognizing the nerve by its appearance.

18

Proximal identification involves finding the nerve between its emergence from the stylomastoid foramen and its point of entry into the gland. While the nerve within the gland is related to soft tissue rather than skeletal structures, its path before entering the gland has certain constant relations to the skull base and its attached muscles and in searching for it at this site these structures must be identified as a first step. Structures such as the parotid gland with its fascial coverings, and the ear lobe, are not relevant to the dissection, for the time being at least, and are retracted out of the way.

Mandibular branch identification depends on the constant relationship between the mandibular branch of the nerve and the retromandibular vein as both emerge from the lower border of the gland. The nerve, which runs parallel to and just in front of the vein, is readily identified once the more easily recognized vein has been found. Identified in this way, it can be traced back into the gland leading to the main trunk and the other branches.

The buccal branches run alongside the parotid duct and with this structure aiding identification they can be traced back into the gland. In order to find them the skin flap has first to be raised beyond the anterior border of the gland. If the flap has been raised at the correct level, a layer of fat covers both the gland and the structures in front of it, including the nerves emerging from its anterior border. Dissection of this layer off the gland, and continued beyond its anterior border, exposes them. The small blood vessels which run alongside the nerves provide an additional means of identification, not merely for the buccal branches but for other branches also.



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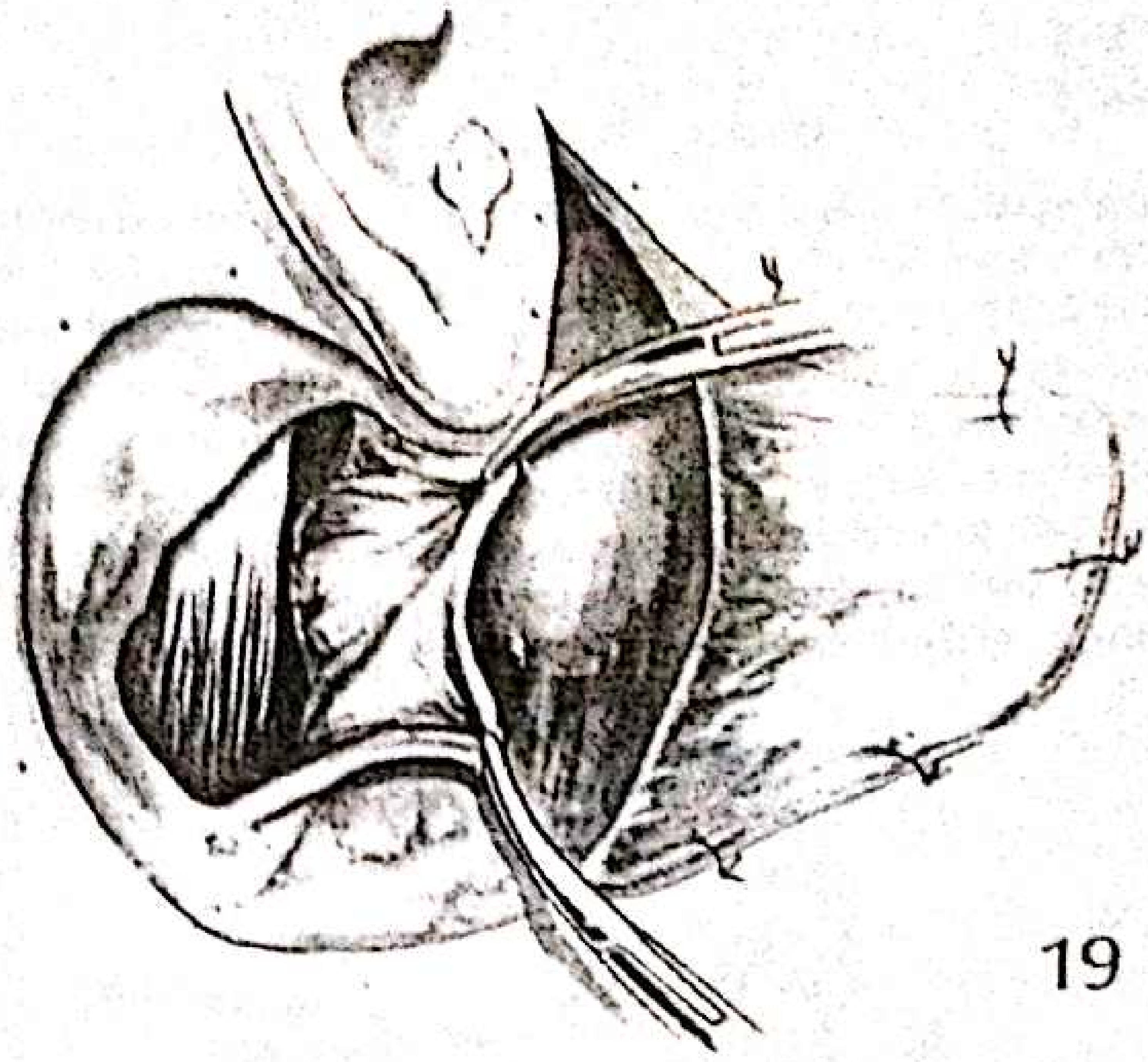
With these methods of identifying the facial nerve available, the question of matching the method to the clinical situation arises. Identification of the main trunk is the most frequently described method, and is probably the one most often used in practice, but it is not always appropriate. The factors to be considered in selecting the method to use concern the size of the tumour and its site within the gland, its pathological type, and the body configuration of the patient. If the gland is free of tumour near the entry point of the nerve into the gland, proximal identification becomes easier because the gland can be dissected free from the acoustic meatus and mastoid without the constraints which result from the presence of the tumour in the immediate vicinity. Even so, the dissection is considerably more difficult, and is carried out at a deeper level in a more confined space than the advocates of the method imply. If the patient is fat or the tumour lies between the mastoid process and the mandibular ramus, proximal identification can become a nightmare, and the surgeon will welcome an alternative. In such a situation, identifying a branch at a distance from the pathologically involved area has much to commend it. When the tumour is clearly malignant at the outset, all the methods of identification may be required so that the trunk proximally and the branches distally can be tagged prior to division with a view to the insertion of nerve grafts.

19

The fascial covering of the gland is firmly attached to the external acoustic meatus, bony and cartilaginous, as well as the anterior and lateral surfaces of the mastoid process and the fascial sheath of sternocleidomastoid, and the initial step is dissection of the gland from these structures.

In dissecting the gland free from sternocleidomastoid, the anterior border of the muscle is identified and traced up towards its attachment to the mastoid process, retracting the gland forward and the muscle backwards. During this dissection the great auricular nerve is generally recognized running upwards from the posterior border of the muscle towards the pinna. At this stage the nerve can be left intact, but if it is subsequently found to be impeding dissection it should be divided without hesitation. The anaesthesia of part of the pinna which results is rarely of great moment. Its initial extent varies and the anaesthetic area usually diminishes with time as the surrounding sensory territories extend. If there is the possibility that a nerve graft may be required, a length of the nerve can be stored against the eventuality.



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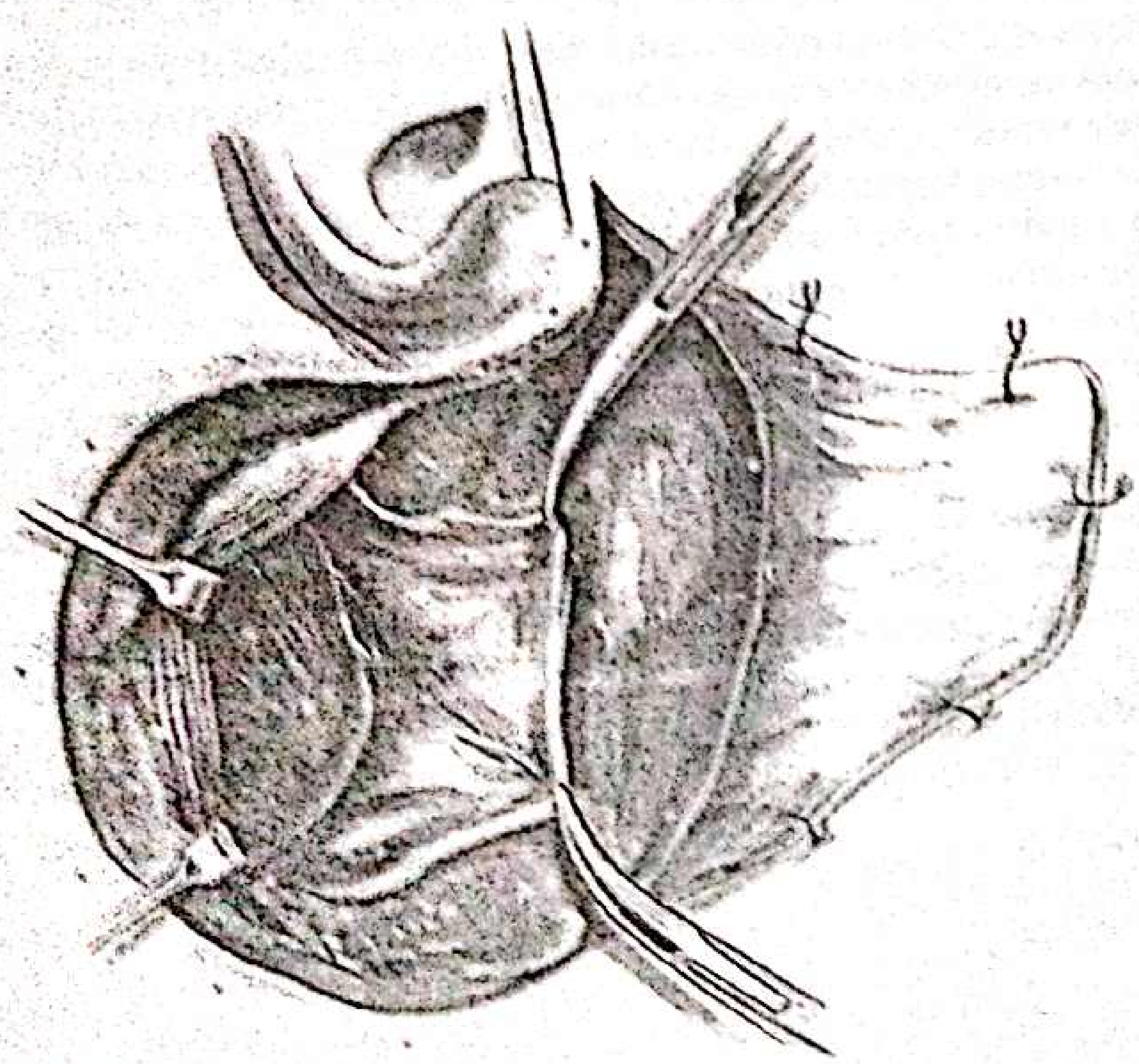

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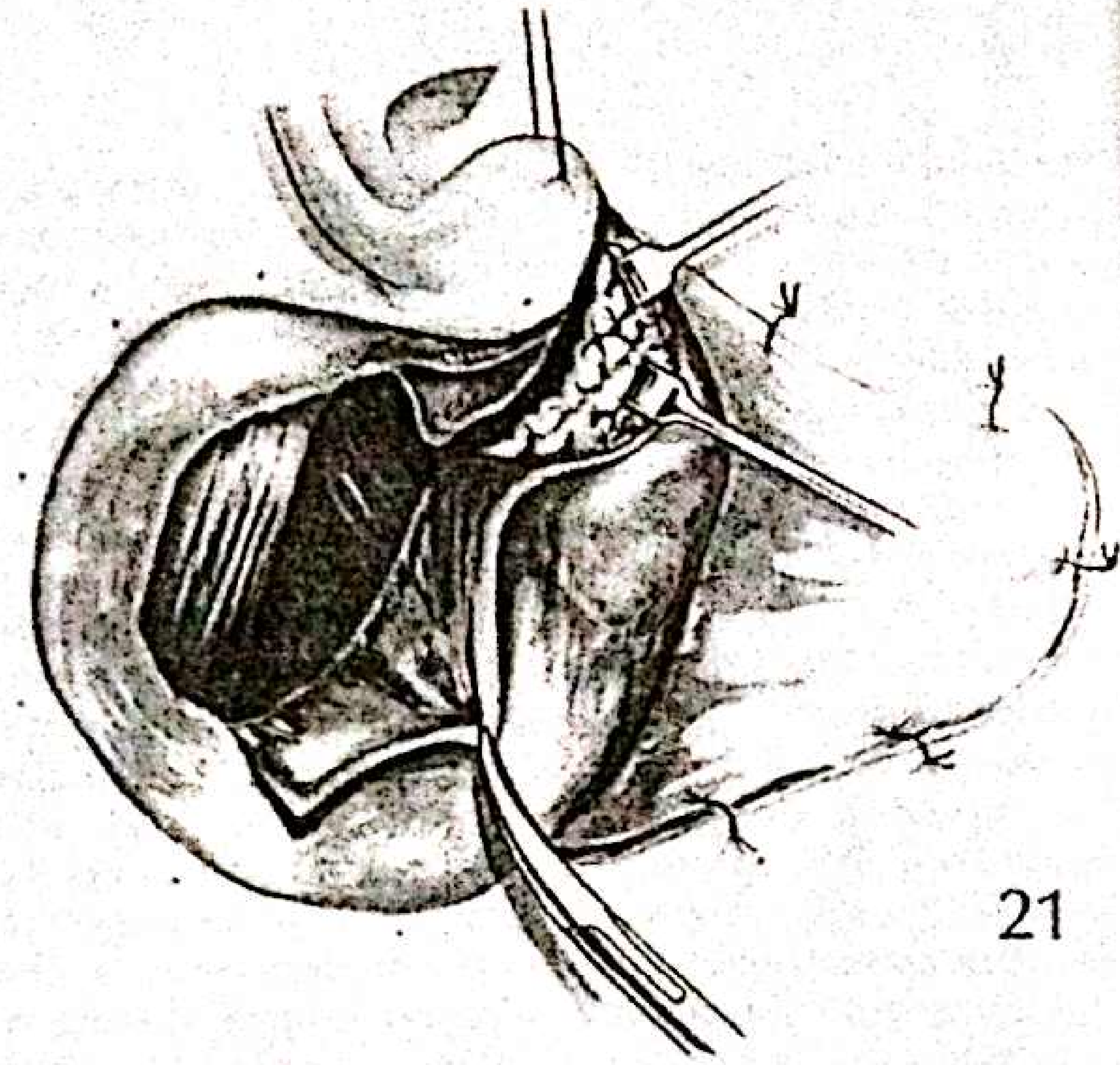
Separation of the gland and the muscle carried towards the skull base exposes the posterior belly of digastric, recognized by the different direction of its fibres from those of sternocleidomastoid. The muscle should be cleared, taking care in relation to its deep surface which overlies the internal jugular vein and the internal carotid artery. The occipital artery is also a related structure, running parallel to it on its deep surface. The upper border of the muscle is traced back towards its origin deep to the mastoid attachment of sternocleidomastoid. It is in this area that the nerve will be found passing from the stylomastoid foramen to the gland.

21

It is seldom possible to complete this dissection without at the same time separating the gland from the external acoustic meatus. The plane between the gland and the meatus is a little difficult to establish initially, but once established it is straightforward to maintain it, keeping strictly to the cartilage of the meatus. The plane is virtually bloodless and dissection can be deepened without hazard until the bony meatus is reached, a junction felt with the finger rather than seen.



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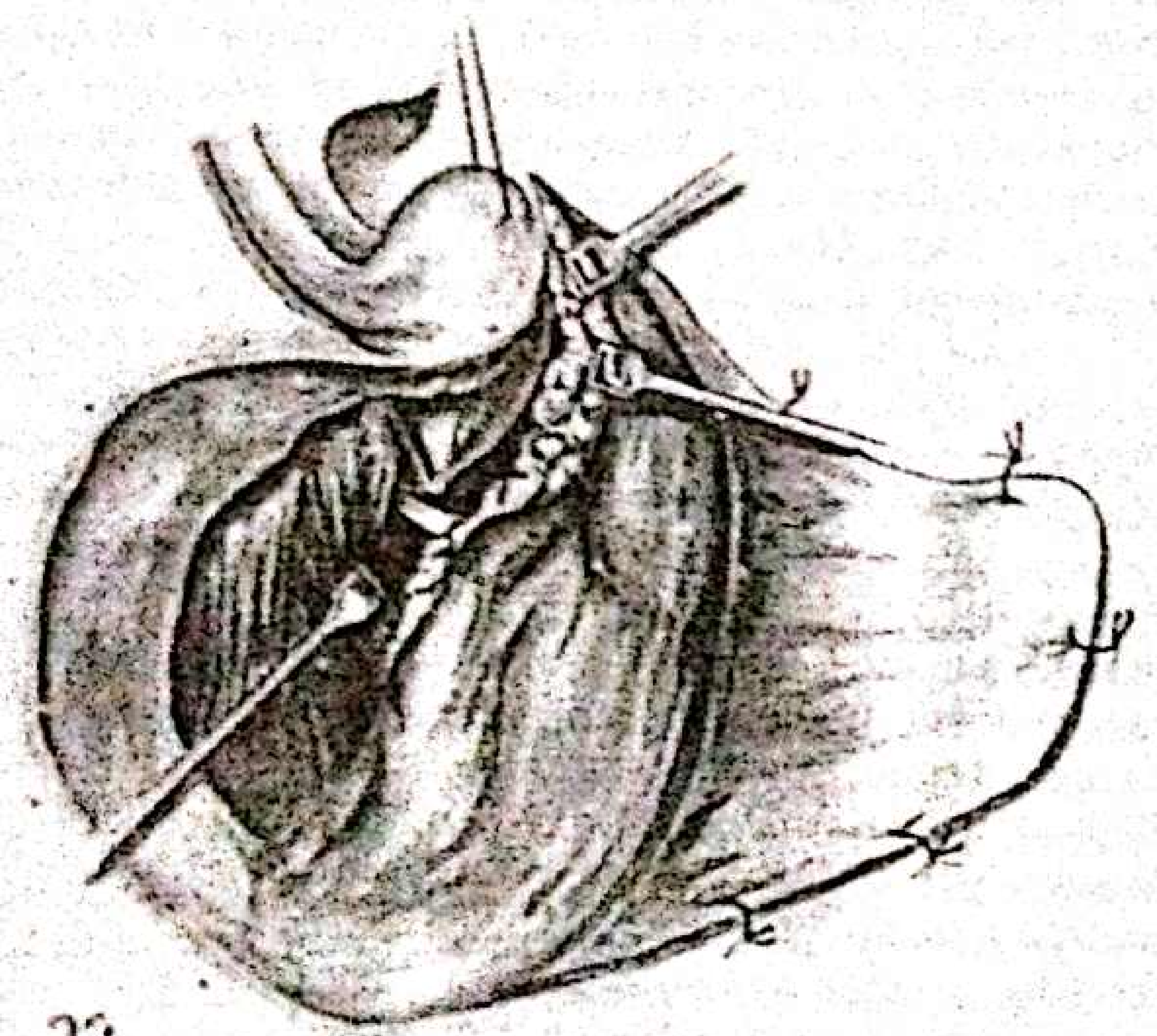

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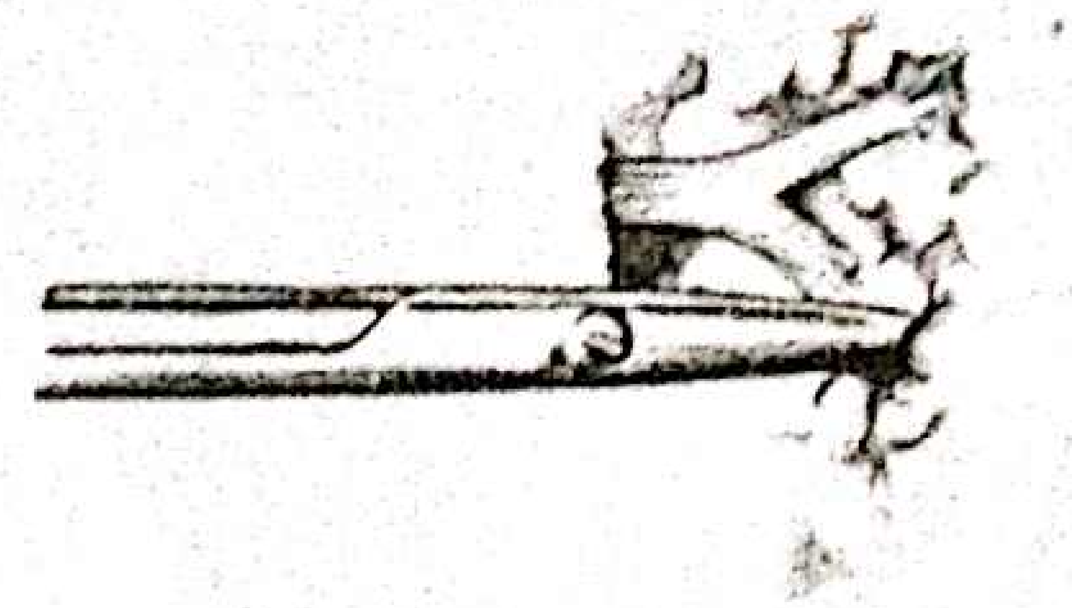
Thereafter, dissection continues in the same plane, but with considerably greater care because of the proximity of the facial nerve. Below, the dissection becomes continuous with the mastoid dissection, and the parotid, grasped via its fascia, is retracted forwards. In deepening the dissection in this area tough fibrous strands are found connecting the gland to the meatus. These require to be divided cautiously for they can be difficult to distinguish from the facial nerve. A helpful pointer is the presence of a small projecting triangular process, consistently present in the lower border of the cartilaginous meatus, most readily identified by the palpating finger, which points medially towards the nerve, its apex lying close to it. Recognition of the nerve, once it has been exposed, is not difficult.

Tumour resection

The dissection technique of most surgeons in parotid surgery makes use of a mixture of blunt and sharp dissection, the blunt dissection involving the opening of closed scissor blades, the sharp dissection dividing the tissue 'plane' which has been opened up. The consistency of salivary tissue, with its glandular lobules bound together by fine fibrous tissue strands which open up readily, is particularly suitable for this style of dissection. The use of mosquito forceps for this purpose has been described, but blunt-pointed scissors of the McIndoe type, curved on the flat, preferably smaller in size to limit the power which can be exerted by the opening blades, are rather more refined in action.



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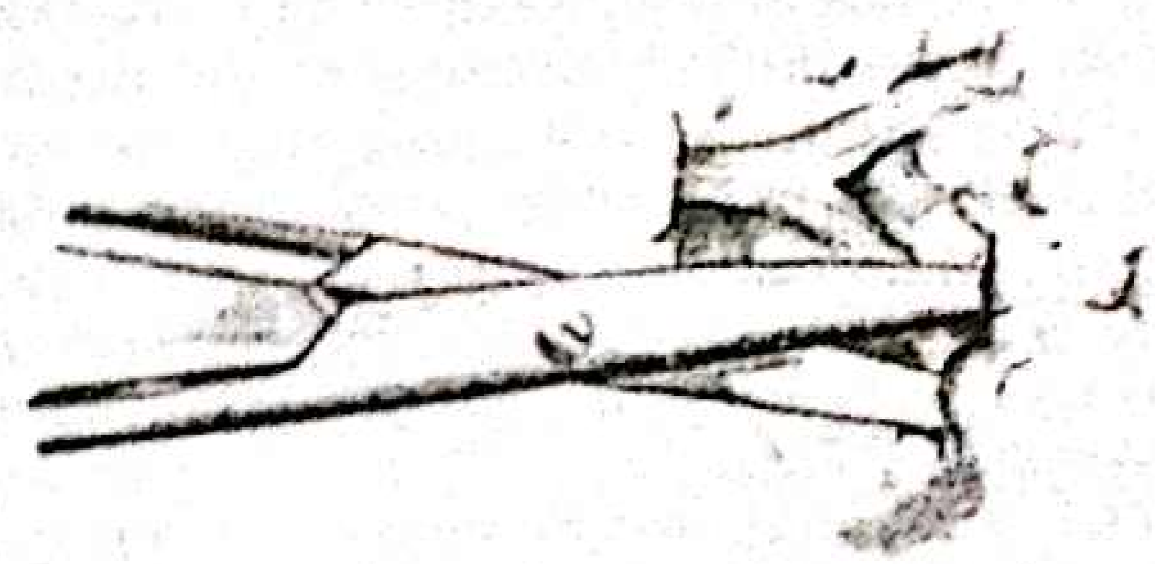
The scissor blades are thrust gently forwards into the substance of the gland along the line of the nerve and opened slightly to create a 'plane', on each side of which the glandular tissue is divided, allowing a little additional retraction and extended exposure of the nerve branch which is being traced forward. The manoeuvre is then repeated, so that with each cut, which is a small one, the dissection is slowly but surely advanced. Depending on the local situation, a single branch may be pursued for a considerable distance; alternatively, advancement on a broad front, involving dissection along more than one branch, may be more advantageous.



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If difficulty is met with at one point, it is often useful to employ the 'siege' principle, transferring dissection to another site where progress is easier, and with progress, reversion to the original site becomes possible. Always the 'siege' is moved to attack the easiest and safest point.

Traction is applied to the segment of the gland which is being elevated in the resection sequence, but the vigour with which it is applied must be carefully controlled. It should never be applied directly to the tumour; rather it should be mediated through the surrounding gland, overlying fat or fibrous sheath. In certain circumstances retraction using catspaw retractors is more effective, but the same limitations apply as with the use of traction, the aim with both being to achieve the desired effect without rupturing the capsule of the tumour.

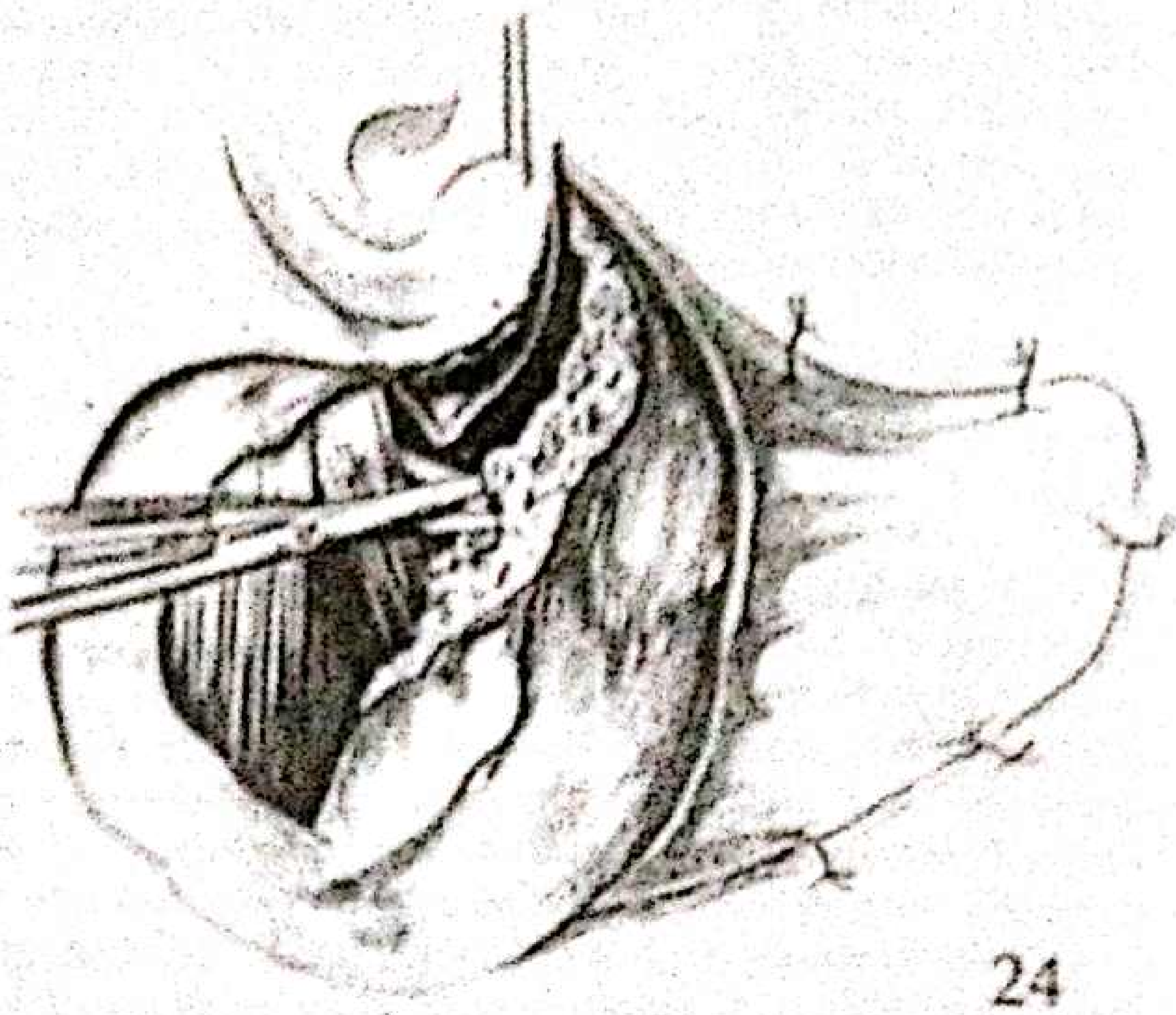
Tumour spillage, as a result of rupture of the capsule, is an ever-present hazard and if it should occur the aim becomes to limit the area of contamination as much as possible. Careful application of the suction nozzle to the site of the leakage will at least reduce the tension within the tumour and minimize further escape of tumour tissue. Thereafter, any traction applied to the tumour-containing gland, which has the effect of raising the pressure inside the tumour, has to be used with extreme circumspection. At completion of the resection, steps are taken to 'decontaminate' the operative field. The procedure likely to be most effective is irrigation with a tumour sterilizing fluid. The fluid which should be used has not been clearly established, but cetrimide has at least been shown to be effective in this role at an experimental level, presumably acting through its effect on surface tension and preventing the adhesion of any tumour cells. It has the merit also of immediate availability in most operating theatres and minimal toxicity.

Superficial lobectomy

This procedure, frequently referred to as superficial parotidectomy, involves resection of salivary tissue superficial to the facial nerve and is the appropriate procedure in managing the simple tumour superficial to the nerve. The basis of the technique used is to dissect along the line of those branches of the nerve which are in relation to the tumour. As dissection proceeds the effect is to free the portion of the gland superficial to the nerve, together with its content of tumour.

24

If the nerve has been identified proximally, the first technical problem relates to the restricted access initially available. The direction of the intraglandular dissection is forwards, in the line of the parent trunk of the nerve, but to establish this is difficult because of the depth of the nerve and the narrowness of the area of access. As a result the initial dissection is apt to be a little untidy until 1–2 cm of nerve has been exposed within the gland. Branching occurs quite quickly and from this point on branches are traced in turn, adding to the retraction of the 'lobe' as dissection extends forwards.



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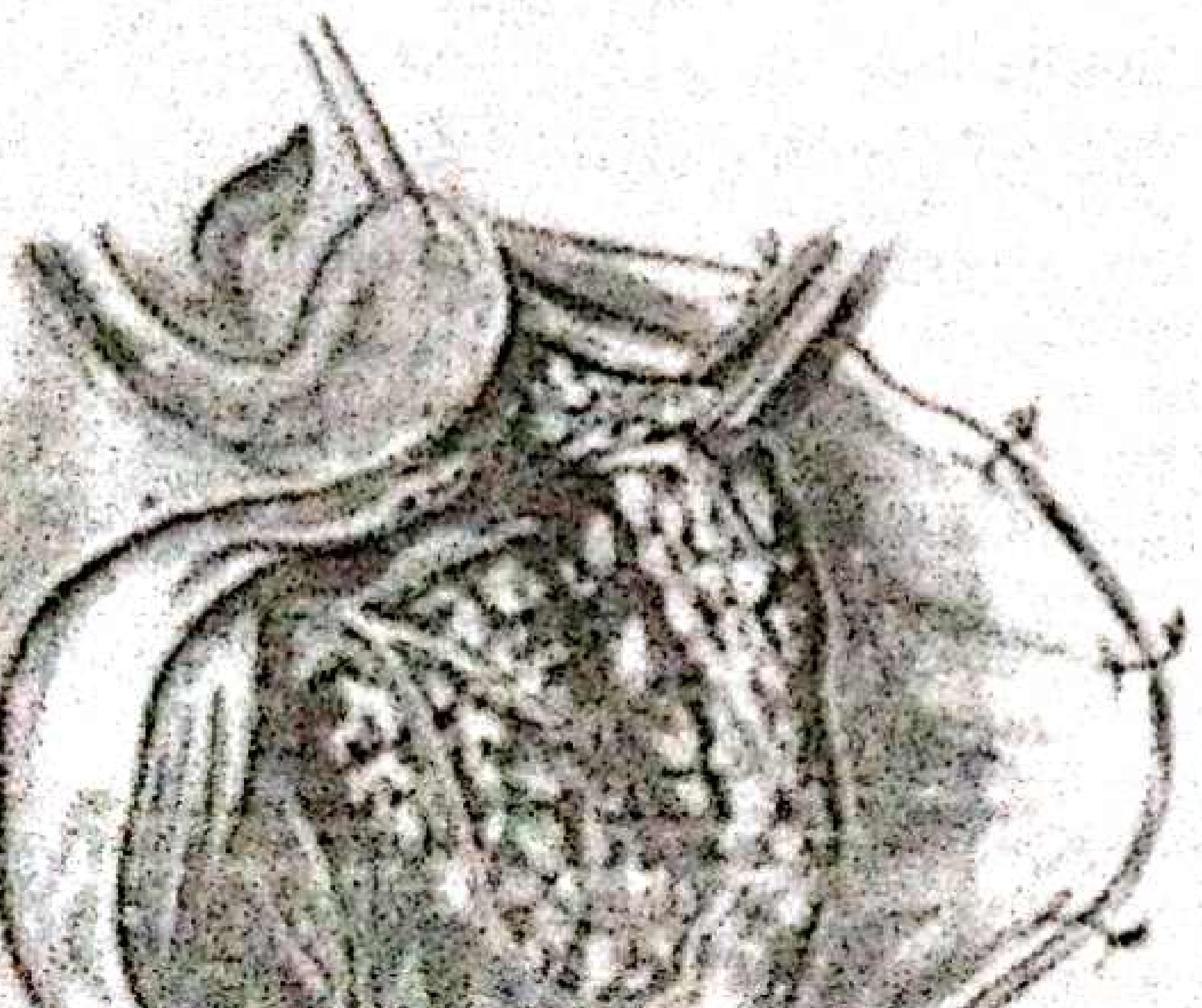

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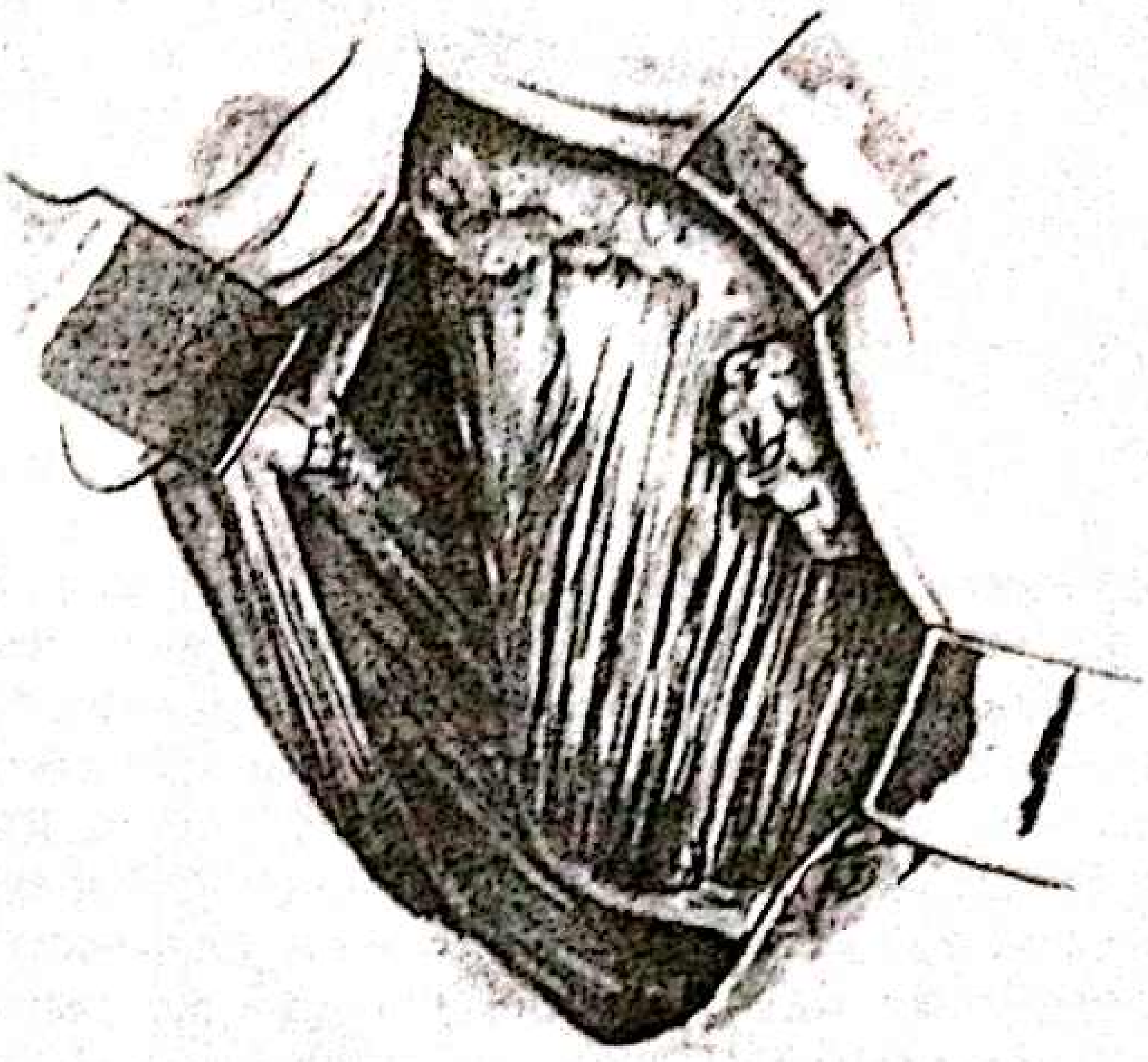
In the process of dissecting the nerve the capsule of the tumour is frequently exposed, more often than not with the branches of the nerve in direct contact with it and requiring to be carefully dissected free. Along the other surfaces a cuff of normal parotid surrounding the tumour is preserved.

When dissection forwards has clearly extended beyond the tumour, it is usual to move in a generally superficial direction, leaving the nerve, while remaining at a discreet distance from the tumour. This change of direction has to be done with care, remembering that lateral retraction of the tumour-containing segment of the gland has the effect of changing the line of the branches. Unless care is taken to allow for this fact, branches may be inadvertently divided.

26

The preoperative diagnosis of simple tumour may prove to be incorrect, and the possibility should always be in the mind of the surgeon. If approach to the tumour as the nerve is dissected fails to produce anything resembling a capsule, suspicion should be aroused; if a nerve vanishes into the substance of the tumour mass the diagnosis of malignancy is certain. The steps which must then be taken are to identify the nerve distal to the tumour, together with any other branches sufficiently close to the tumour to be considered in danger. Adding to the marginal clearance by increasing the thickness of the cuff of normal parotid surrounding the tumour would also be an appropriate precaution, and with the involved nerves tagged both proximally and distally the tumour and its incorporated nerves can be resected. Management of the resulting nerve deficit is discussed on pp. 344–345.



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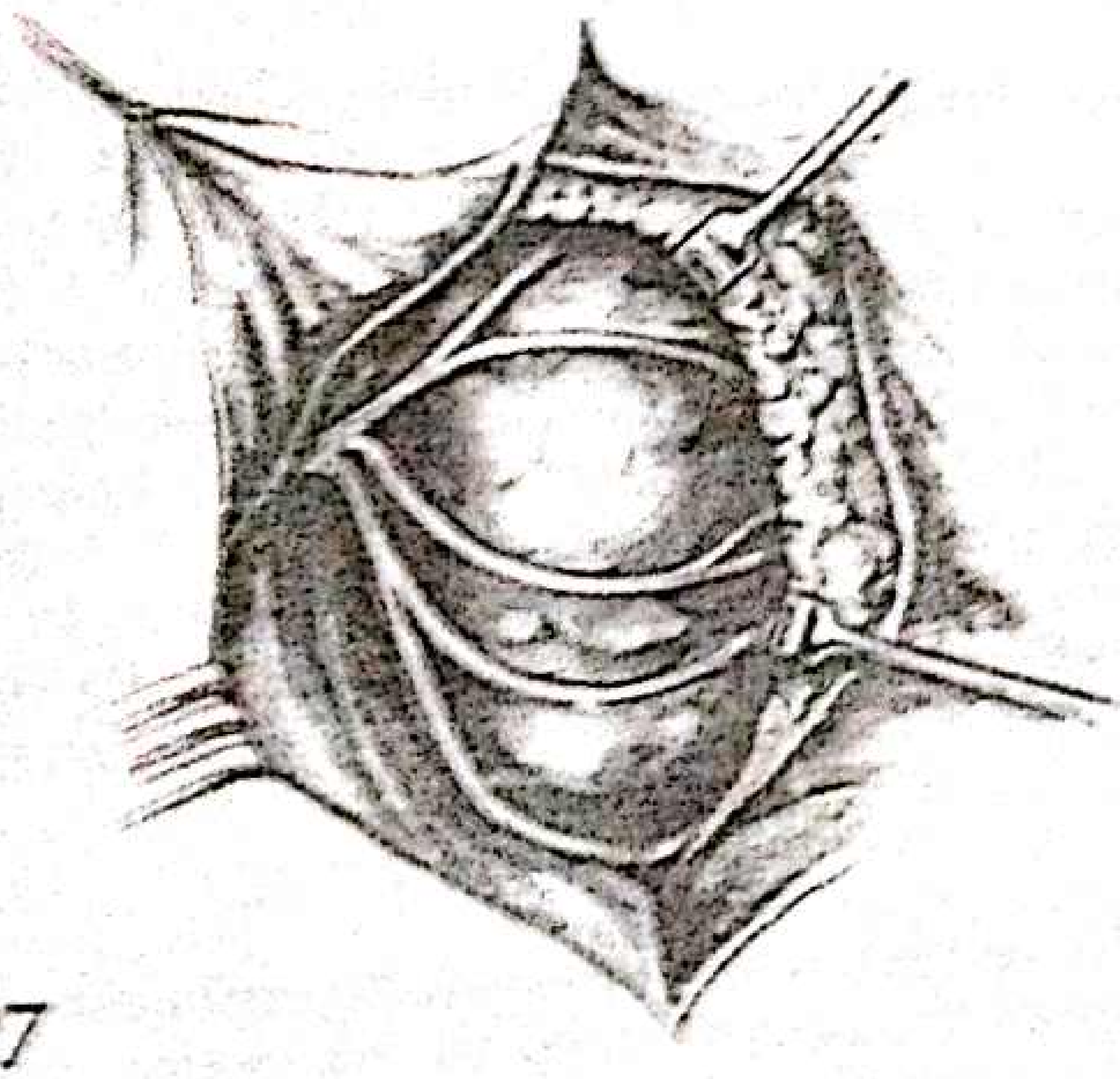
Total parotidectomy preserving the facial nerve

It is not always possible to be certain preoperatively that the tumour has arisen in the superficial lobe, and the surgeon is regularly faced with finding the nerve superficial to the tumour. He may then have to carry out what is in effect a near total parotidectomy with preservation of the facial nerve. A comparable situation may arise when the tumour is found to have extended through the stylomandibular tunnel into the parapharyngeal space, and its management is described in the chapter on 'Swellings of the parapharyngeal space', pp. 349–357.



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In removing a tumour deep to the facial nerve the branches of the nerve proximal to the tumour are traced through the gland, mobilizing or partly excising the 'superficial lobe', depending on the local situation, and exposing the tumour-containing 'deep lobe'.

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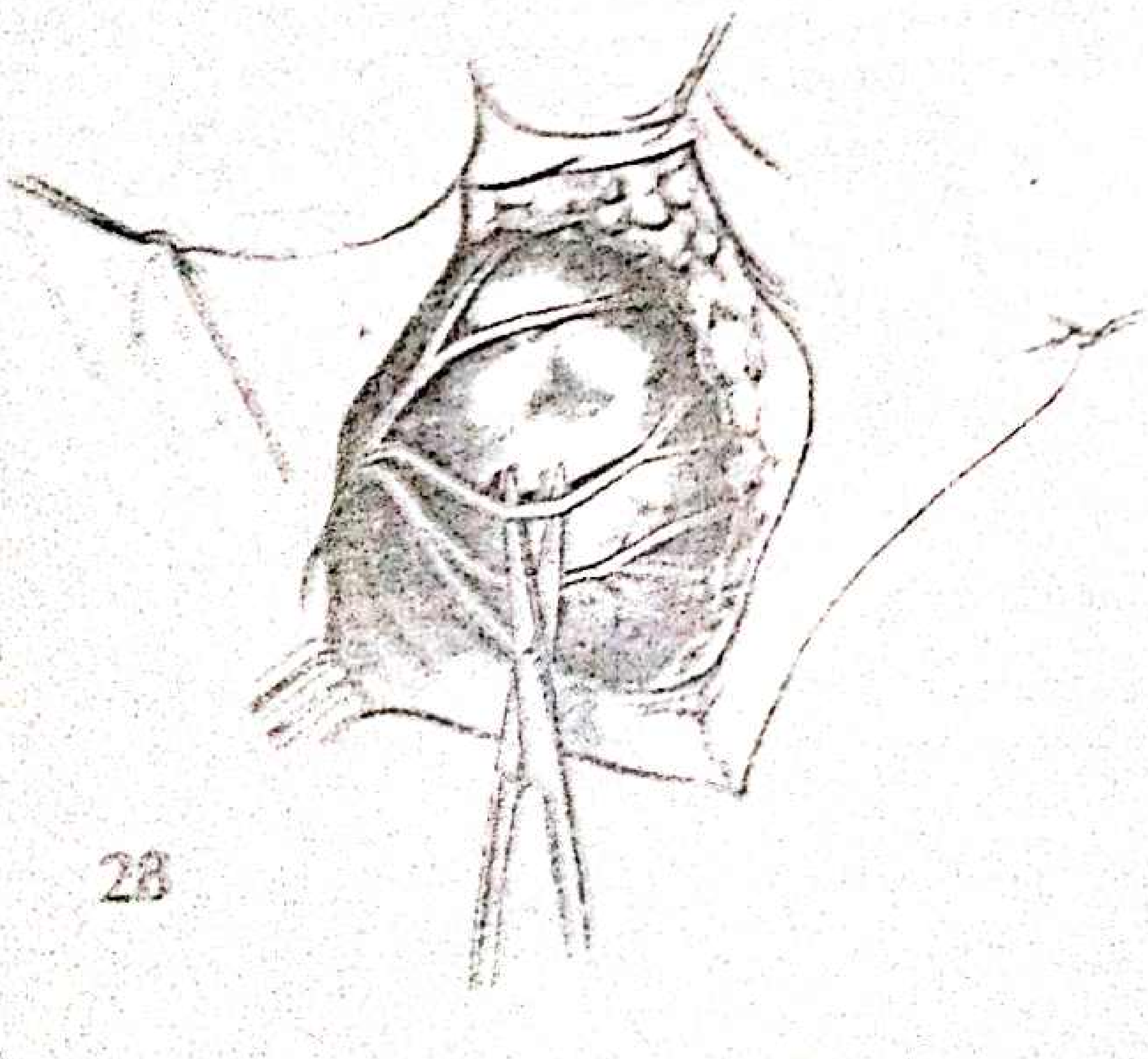
As in the case of the superficial lobectomy, exposure of the nerves frequently shows them to be stretched over the capsule of the tumour, and requiring to be dissected free.



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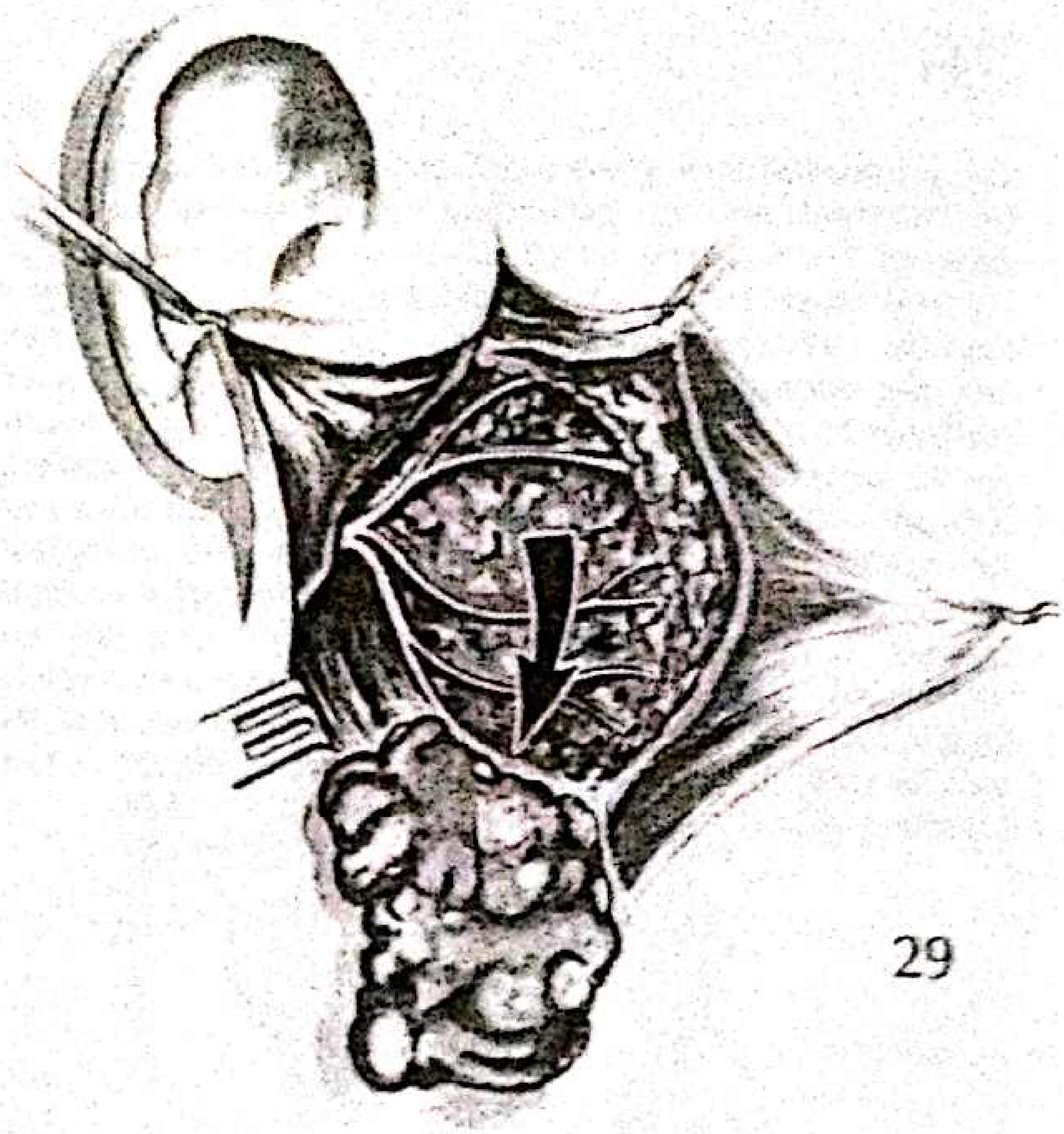

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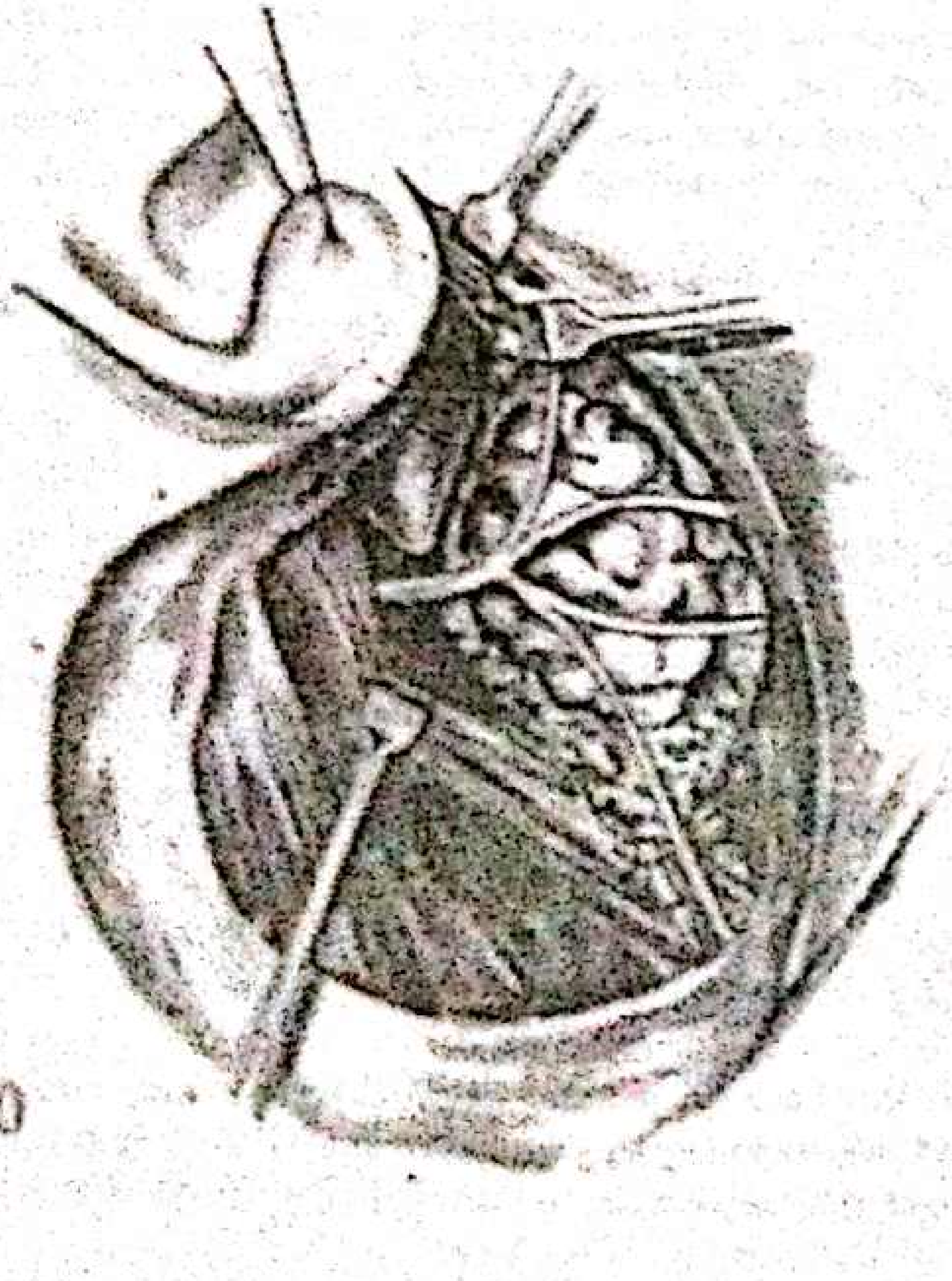
When the branches have been freed from the tumour, it may be found that a considerable proportion of the capsule has been exposed, and it may then be possible to retract the branches of the nerves and continue dissecting the tumour free from the surrounding parotid in the extracapsular plane which has already been established. This is most likely to be the situation when the tumour, despite being in the 'deep lobe', has grown predominantly laterally and is presenting as a prominent swelling in the cheek with the nerve stretched over its outer surface.



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When the tumour is more obviously embedded in the substance of the parotid deep to the nerve, it may be necessary to resect much of the gland with its content of tumour. The external carotid artery and retromandibular vein are then ligated as they enter the lower pole of the gland, and as the tumour-containing 'lobe' is freed and retracted upwards the maxillary vessels are divided, and finally the superficial temporal vessels.

Radical parotidectomy

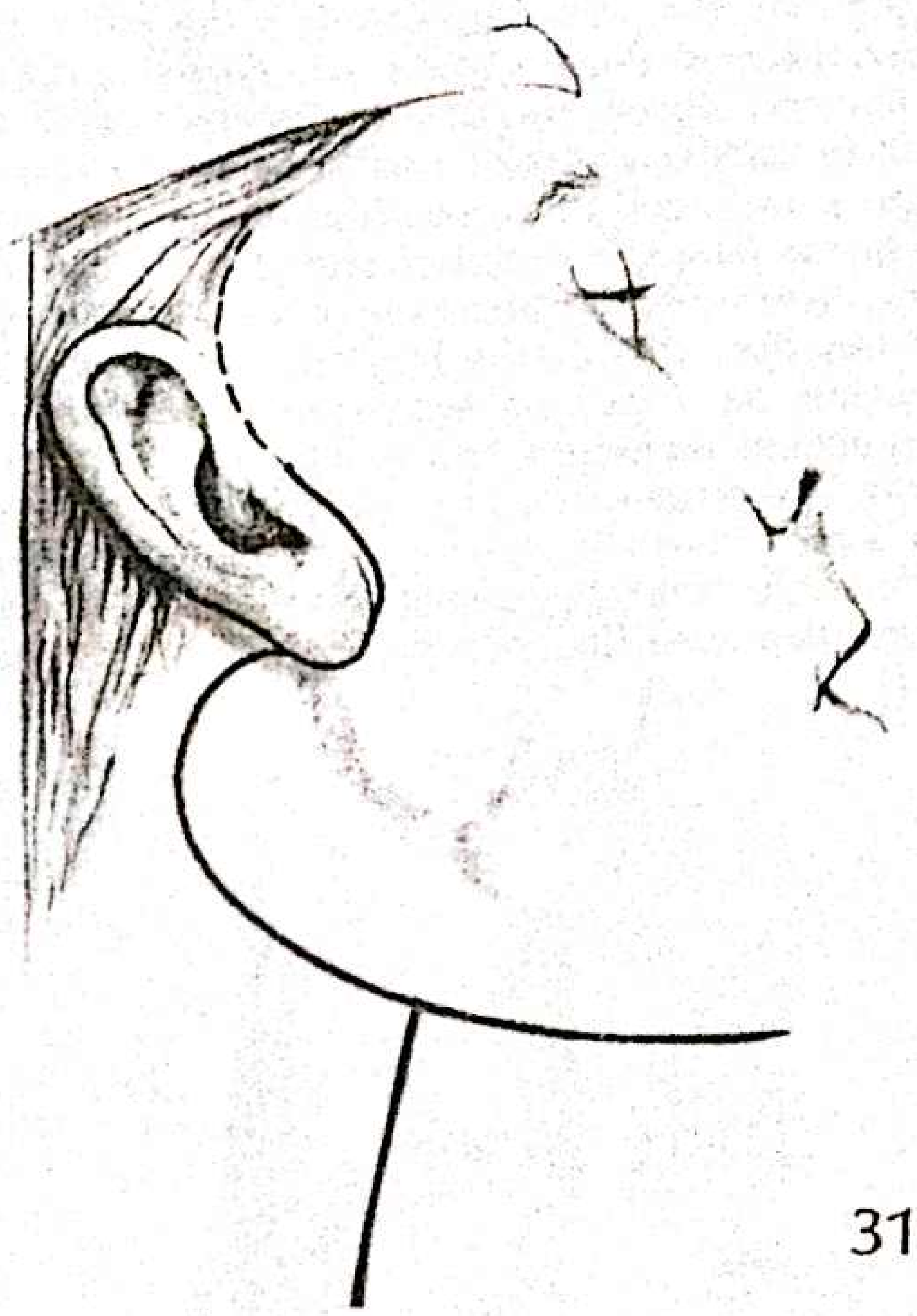
This procedure is required when the gland is extensively involved by tumour which has the clinical characteristics of carcinoma or has been diagnosed as carcinoma by aspiration needle biopsy. Depending on the tumour type and the clinical state of the neck nodes, the resection may be confined to the parotid or be carried out in continuity with a radical neck dissection.

31

The skin incision does not differ from that used in managing a simple tumour unless a neck dissection in continuity is being carried out, in which case the submandibular element of the incision is continued on to the submental area and is met by a vertical neck incision.

Segments of the branches of the facial nerve are likely to be sacrificed in the process of tumour resection, the number depending on the findings at operation. Whenever possible the main branches beyond the tumour should be tagged with a view to subsequent nerve grafting.

Tumour extending into the surrounding structures may come to involve the pterygomasseteric sling and the ascending ramus of the mandible anteriorly; the cartilaginous and bony external acoustic meatus and even the pinna posteriorly; the skin overlying the gland superficially; and the styloid process and its related muscles, together with the posterior belly of digastric, deeply. The initial site of the tumour within the gland generally determines the pattern of local extension, but any of the structures cited may require to be excised as part of the overall resection.



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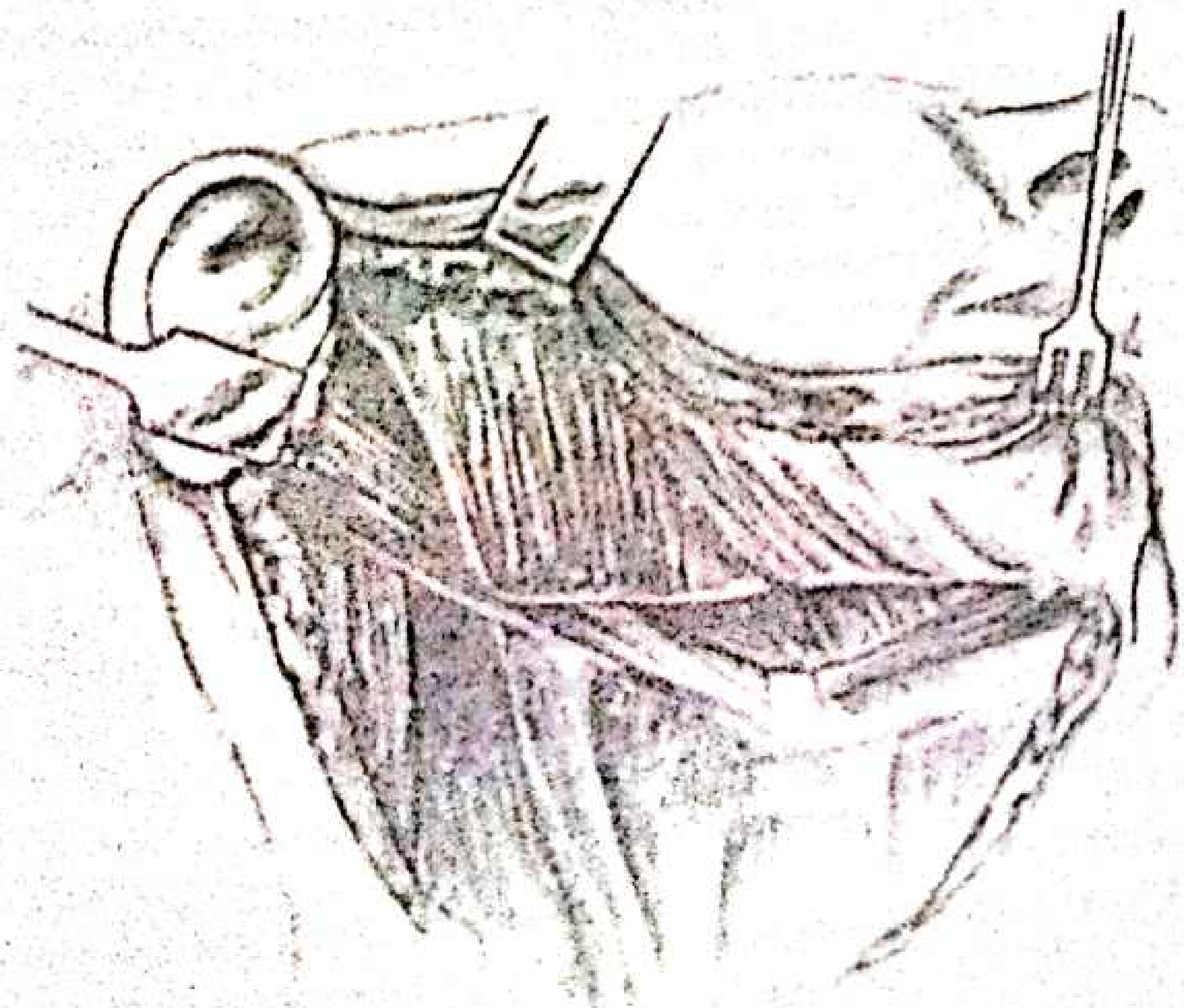

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Particularly when the tumour has extended deeply, there is value in carrying out at least the upper part of a radical neck dissection as a routine, even if the deep cervical nodes are not clinically involved. This allows the approach to the skull base to reach the appropriate depth before the tumour is reached. It is usually necessary in such a situation to resect the muscles arising from the styloid process as well as the posterior belly of digastric. Division of the styloid process at its base as a first step makes it easier to remove the muscles as a block.

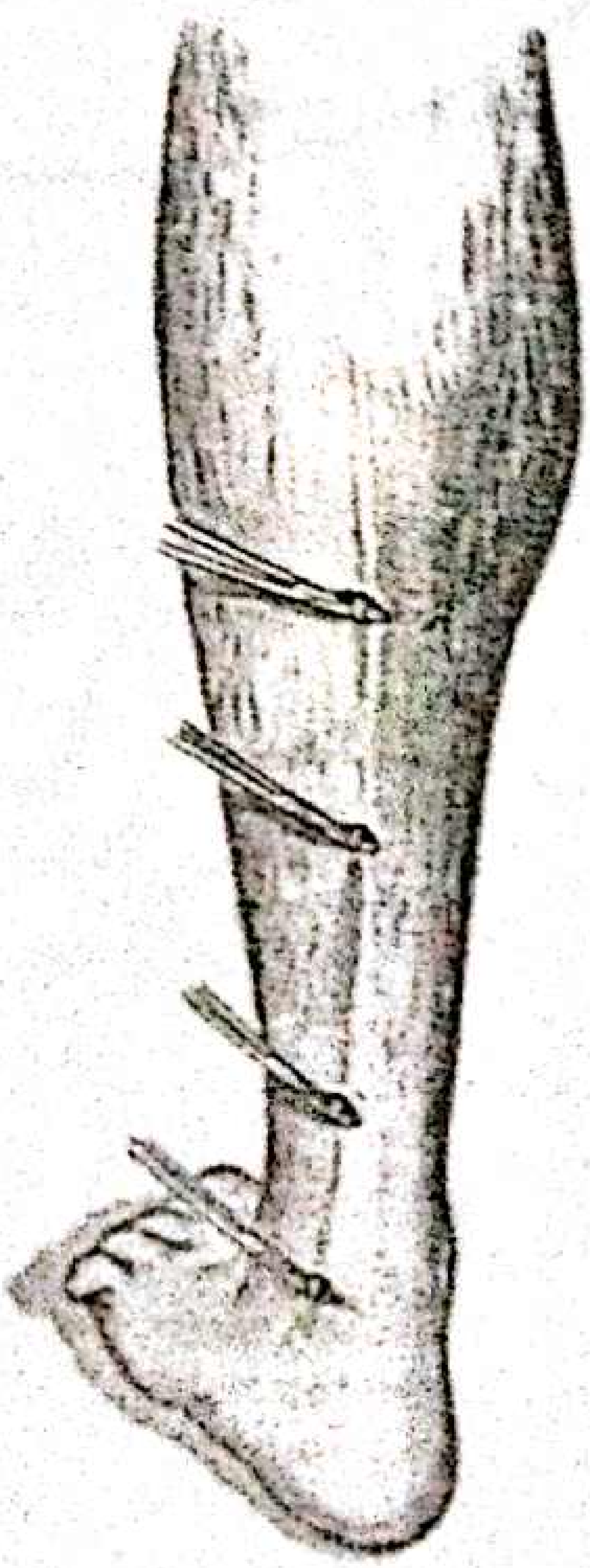
Reconstruction

When the skin overlying the parotid has been resected as part of the parotidectomy, the reconstruction which is appropriate is largely dependent on whether the defect is one of skin alone, with minimal loss of glandular substance, or one in which the loss of substance is significant, the latter more likely if the entire gland has been resected along with the skin overlying it.

For the surgeon who lacks the facilities or the technical skill to carry out a free tissue transfer, the deltopectoral flap is an excellent reconstruction for the purely skin defect as long as it does not extend above the line of the zygomatic arch, this being the extreme limit of the reach of this flap. Any of the free fasciocutaneous flaps will provide an excellent alternative, the choice usually dependent on which flap the surgeon is most familiar with. The greater volume of a myocutaneous flap is likely to match the mixed defect of skin and gland more effectively, most conveniently in the form of a latissimus dorsi flap, pedicled or free, depending on the microsurgical expertise of the operator. These techniques are described in the chapter on 'Reconstructive techniques of the skin', pp. 45–103.

Local flaps, using the scalp or neck skin, are less suitable, technically feasible only if it has been necessary to excise the pinna as part of the resection.

Resection of part or all of the facial nerve is an inevitable consequence of many lobectomies or total parotidectomies properly carried out in treating malignant tumours. Nerve grafting, carried out immediately after the resection, provides the best possibility of reducing the disabilities of such a palsy, and in preparation for this, as already stressed, the ends of any divided nerve should be tagged with black silk for easy identification subsequently. Grafting used to restore continuity of individual branches holds out the prospect of virtually full recovery of function. Grafting used after resection of the entire nerve poses much greater problems technically, and the results are both less predictable and likely to be less than perfect.



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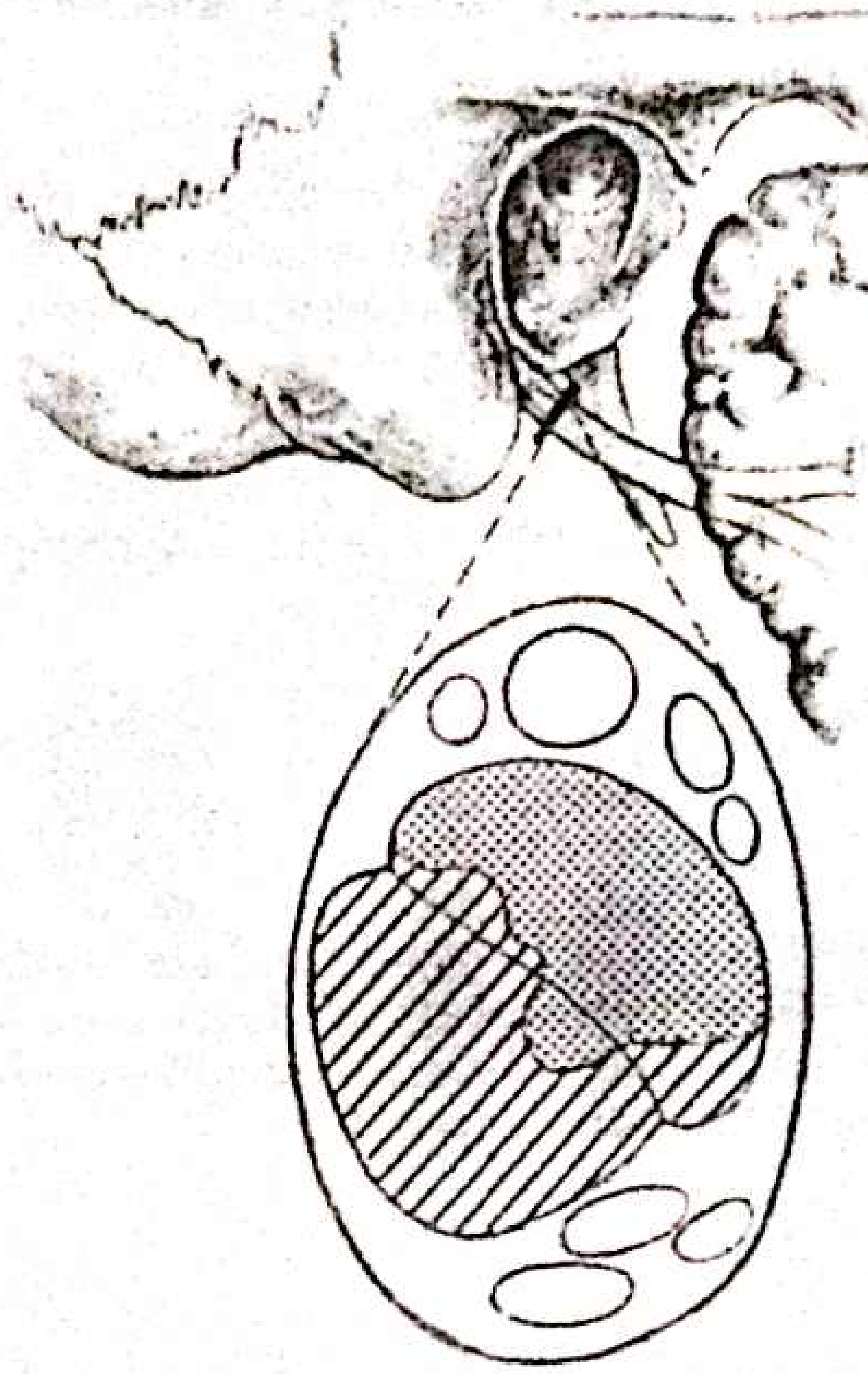
The source of the graft depends on the length required. The great auricular nerve may be available locally but, if a distant source has to be used, the sural nerve is the one recommended as suitable in diameter and not producing a disabling sensory deficit.

A nerve graft has no directional orientation and, if branches are present, its distal end should be sutured to the proximal stump of the divided facial nerve, so that axons regenerating along the graft are not side-tracked into a branch instead of reaching the distal stump of the divided branch. Using epineural suture with 7/0 monofilament nylon, two grafts can usually be sutured to the proximal stump of the nerve, and these are best concentrated on the branches to the eyelids and mouth. It may be possible on occasion to split each graft into two elements and provide four ends for distal suture. The greater accuracy of approximation of the nerve ends possible when the operating microscope is used is likely to result in better functional recovery.

34

In the past, a major problem of grafting has been absence of a way of ensuring that axons regenerating through the graft reached their proper end-point. Some way towards solving this problem has been the discovery that, at the level of the stylomastoid foramen, the craniomedial side of the parent trunk is distributed to orbicularis oculi and the forehead muscles, with passage down to the cervical branch parallelling passage to the caudal side of the nerve. Recovery of function is usually limited to voluntary movement, recovery of the involuntary quality indicative of normal facial expression being a rarity.

When nerve grafting is not possible or is unsuccessful, various steps can be taken to mitigate the effects of the facial palsy. These are described in the 'Plastic Surgery' volume of *Operative Surgery*.



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Postoperative management

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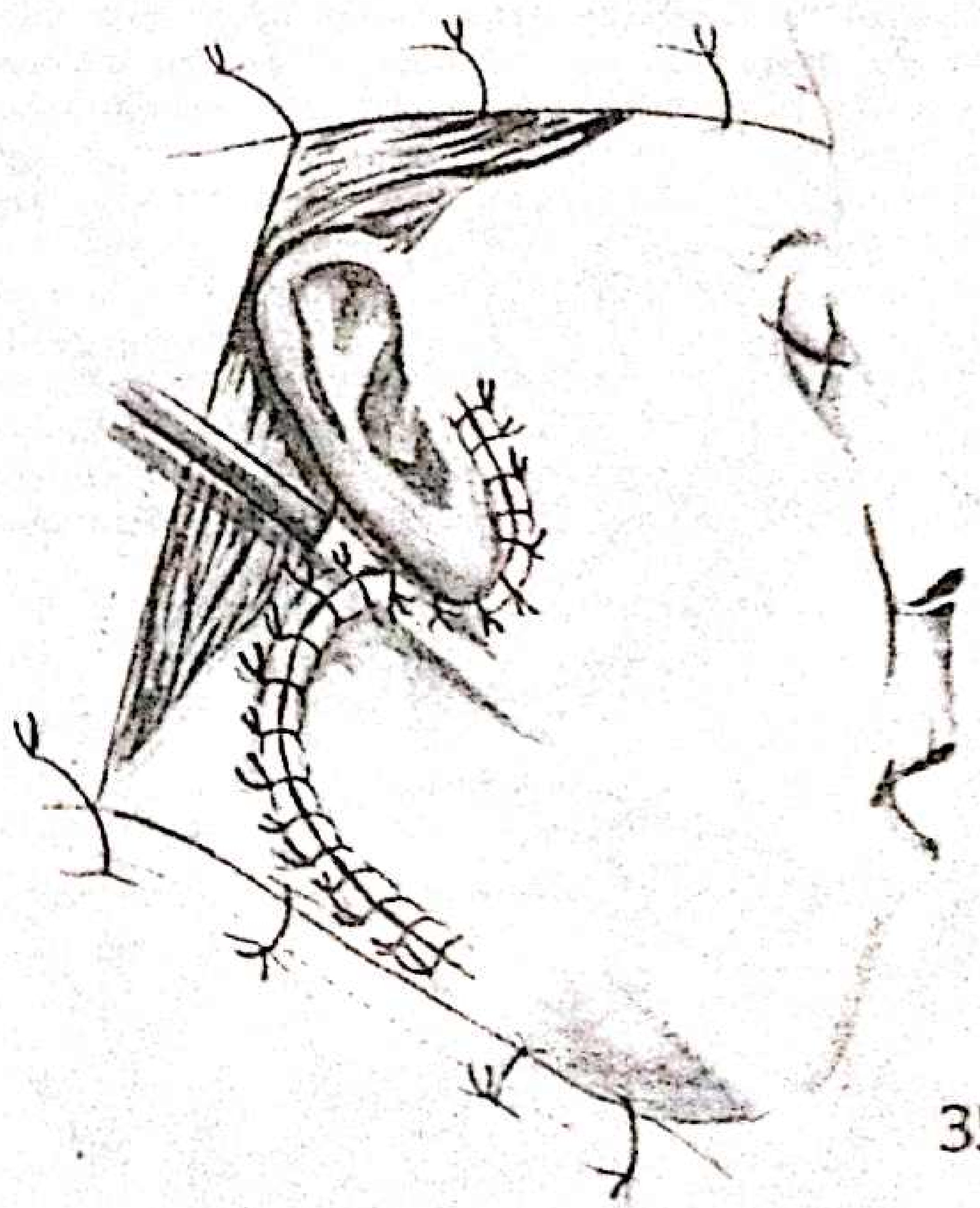
Parotidectomy, in whatever form it takes, partial or total, involves a considerable amount of soft tissue dissection as well as removal of part of the substance of the gland, creating both an area of raw surface and one of dead space. The combination makes postoperative haematoma a significant hazard. To counter this, suction drainage is usual. Pressure dressings covering the operative field are unnecessary; indeed they prevent monitoring of the cheek for loss of its usual postoperative concavity, a loss which indicates a developing haematoma. Suction should be continued until drainage has stopped completely.

The early complications likely to follow a parotid resection are salivary fistula and facial palsy; a later complication is auriculotemporal syndrome.

Even if suction has been effectively applied and drainage has stopped completely, swelling of the cheek may develop after the drain has been removed. This on aspiration usually proves to be due to a collection of saliva. The complication should be managed by repeated aspiration until it settles. It invariably does settle, even if slowly, although reassurance of the patient is usually required during this rather trying period.

Temporary postoperative weakness of the facial muscles is not uncommon even when there has been no obvious damage to the facial nerve at operation. It is generally attributed to stretching of the nerve, but it can occur when such stretching has been demonstrably absent. As part of the resection it is often necessary to mobilize branches over a considerable length, and it may be that this results in a degree of devascularization of the nerve which is responsible. Regardless of cause, if nerve continuity has been demonstrably present at the end of the operative procedure, the patient can safely be reassured regarding recovery.



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Auriculotemporal syndrome, the sweating which occurs within the territory of the auriculotemporal nerve when salivary secretion is stimulated, may develop months after the parotid surgery. It is fortunate that most patients regard it as a nuisance rather than a disaster, since its occurrence is one which can be neither foreseen nor prevented. Reassurance of the patient that the condition has no serious implications is usually sufficient therapy.

SUBMANDIBULAR GLAND

The restrictions imposed by the presence of the facial nerve on the surgery of parotid tumours do not apply to those which arise in the submandibular gland and it is usual in all instances to carry out, as a minimum, removal of the entire gland.

The surgical approach to the submandibular tumour is different from that which obtains when a problem which is not neoplastic is being managed.

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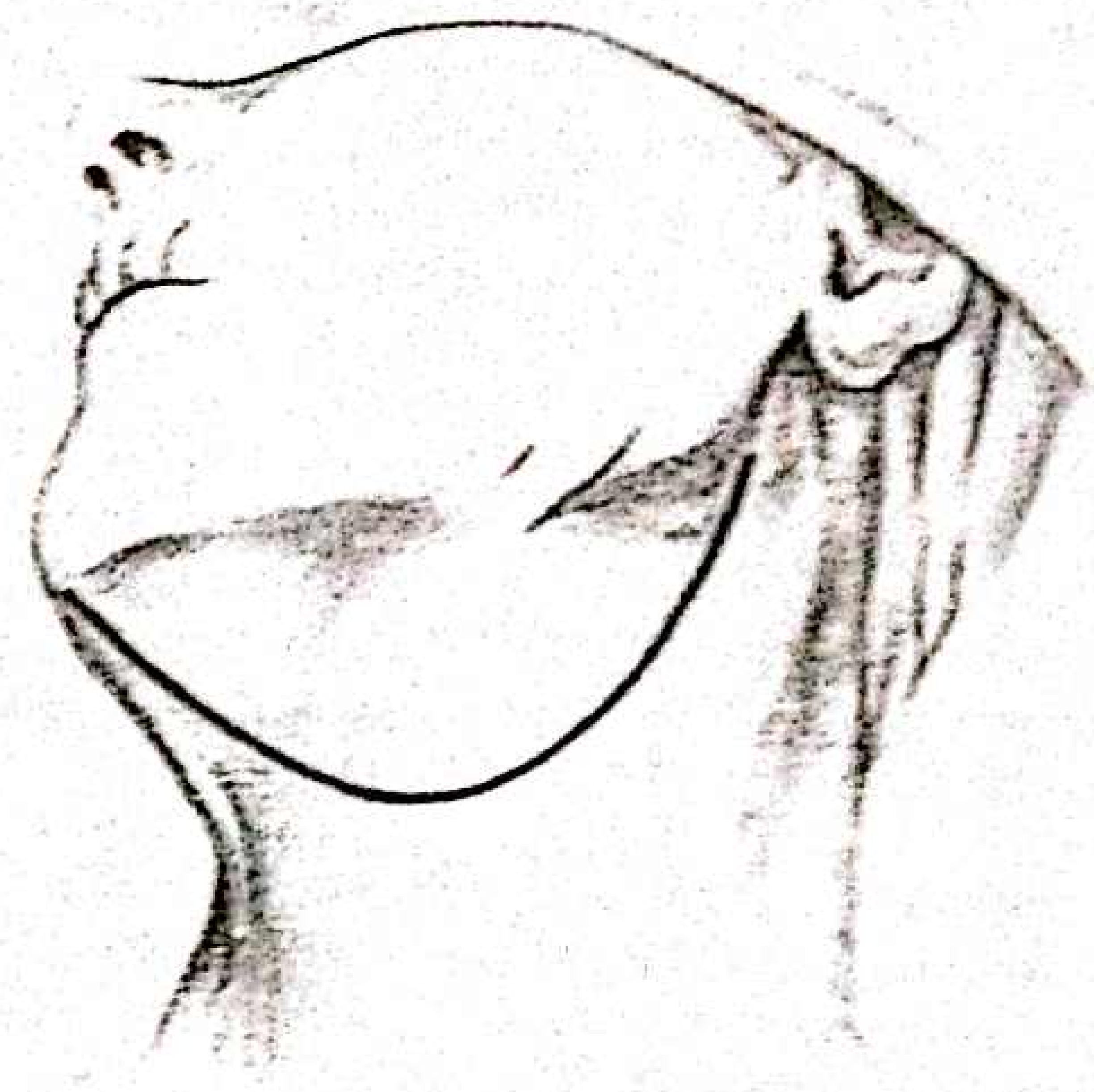
The area requires to be widely exposed and to achieve this the skin incision has to be an adequate one. It should correspond to a segment of the submandibular element of a neck dissection incision.



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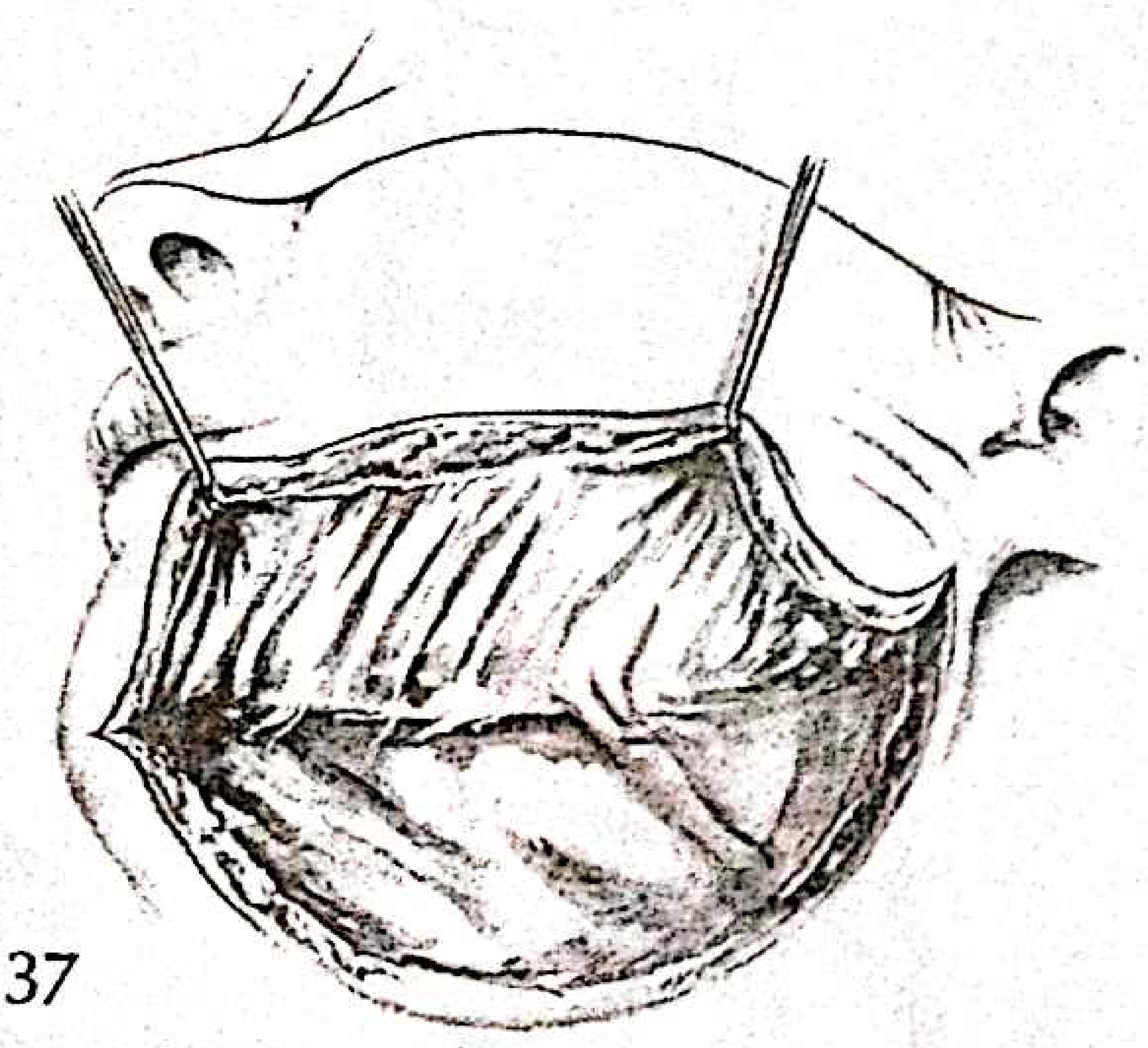

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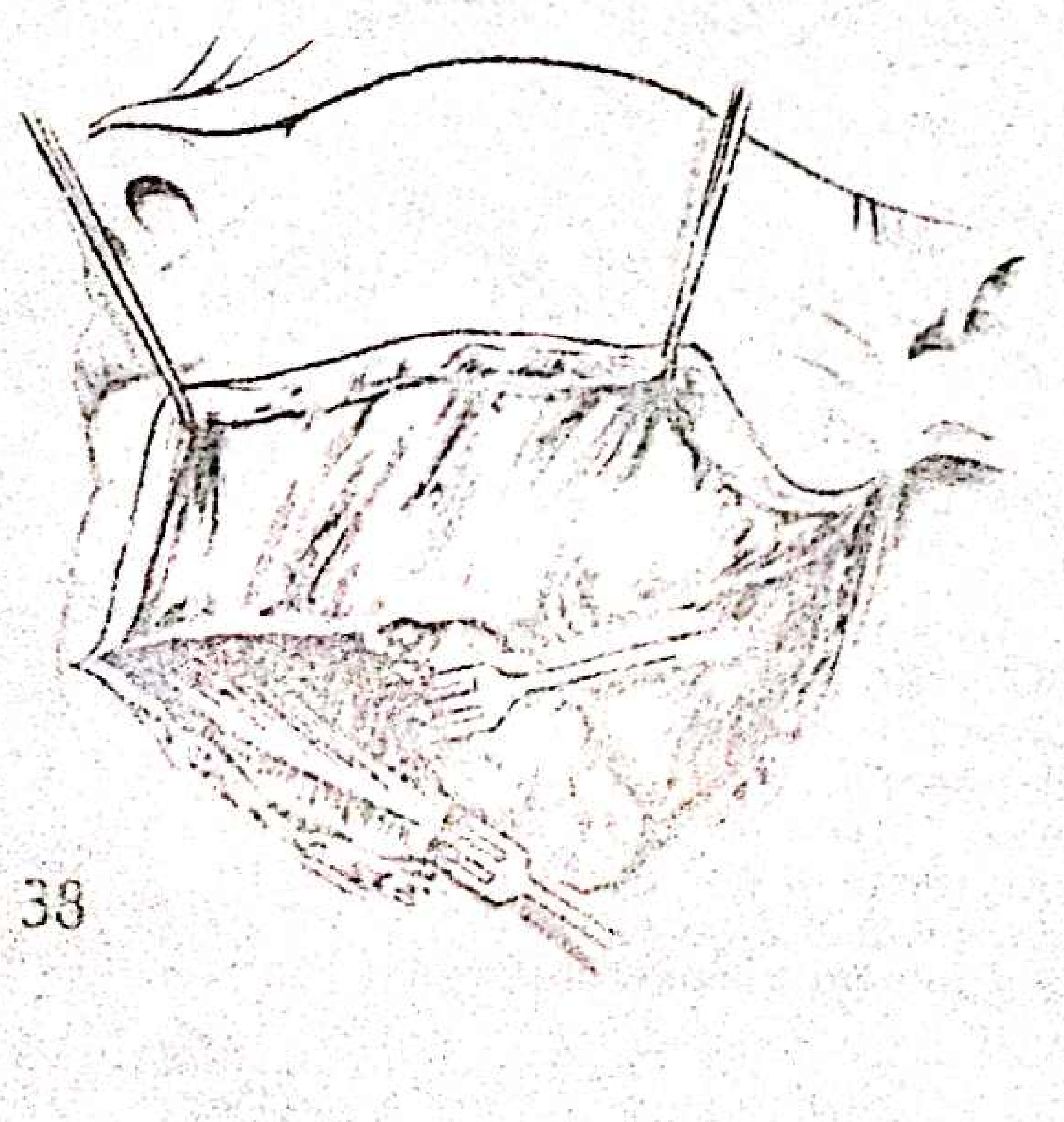
In elevating the skin flap outlined by the incision to the lower border of the mandible, it is desirable to preserve undamaged the branches of the mandibular division of the facial nerve. In the submandibular area these branches run in a thin, but distinct, loose layer of areolar tissue, immediately deep to platysma. When the skin flap is raised together with platysma, this tissue layer should be raised as part of it, with a careful watch kept for the branches. The superficial lobe of the gland lies largely in the triangle formed by the two bellies of digastric and the lower border of the mandible, its floor formed by mylohyoid muscle. It has no anterior attachment of significance and excision can therefore begin anteriorly with identification and clearing of mylohyoid and the anterior belly of digastric.



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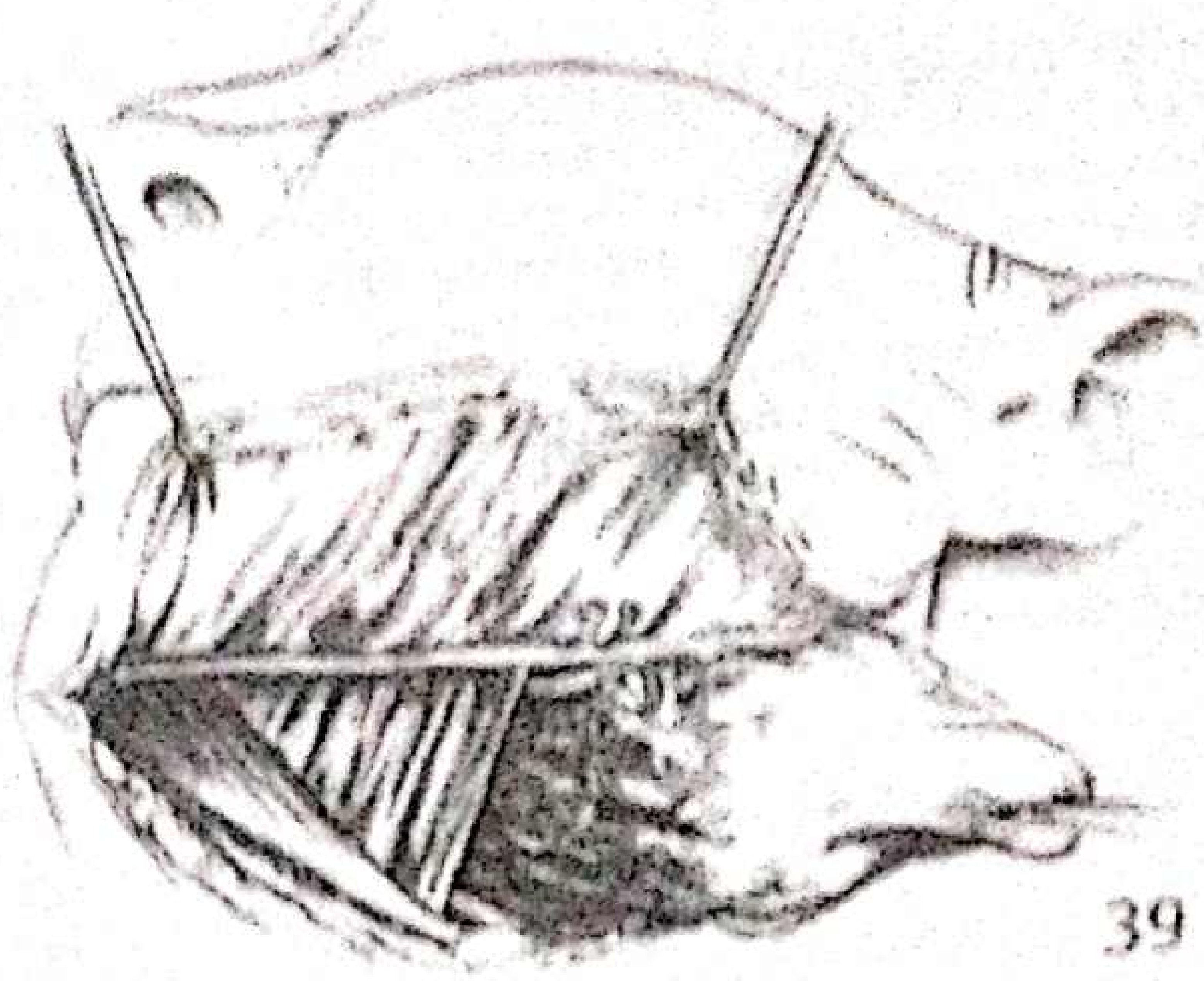
Mobilizing the superficial lobe of the gland and its fascial covering and retracting them backwards, the anterior belly of digastric is exposed with, deep to it, the superficial surface of mylohyoid. In the process, fascial attachments to the lower border of the mandible are divided.



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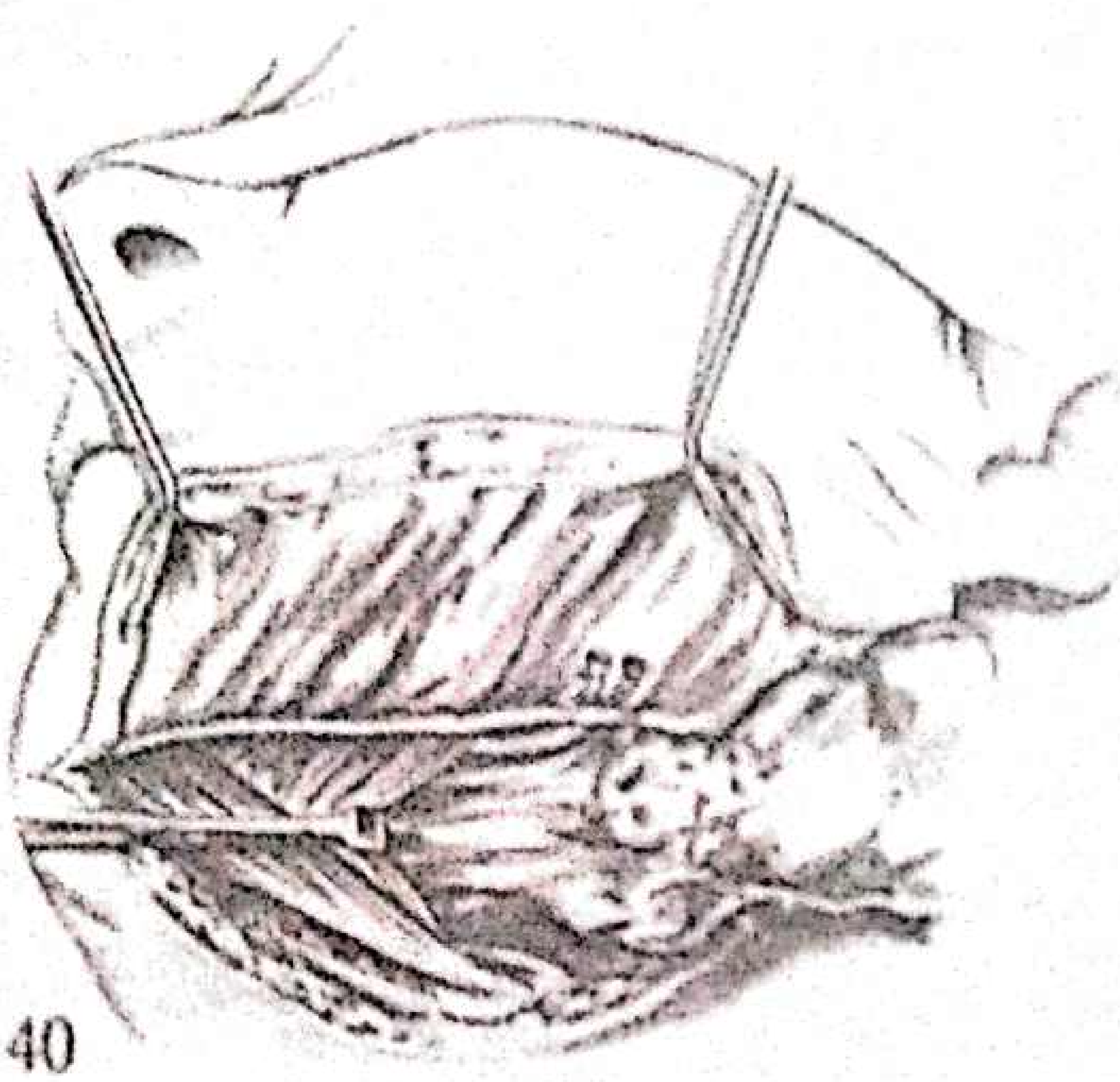
Mobilization of the superficial lobe is continued backwards as far as the posterior free border of mylohyoid. In the process the gland is separated from its loose attachment to the deep surface of the mandible below the mylohyoid insertion, and as mobilization proceeds backwards, the facial artery and vein crossing the lower border of the mandible are met and divided.



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With the mylohyoid muscle exposed, a retractor is inserted around its posterior free border. Its retraction forwards exposes the deep lobe of the gland with the duct passing forward from its anterior extremity. Above and approximately parallel to it runs the lingual nerve; below and similarly parallel is the hypoglossal nerve. Surrounding the latter is a plexus of veins, the hypoglossal plexus. Care is required with this plexus, making sure that its branches are carefully ligated when they are divided. The submandibular duct is divided and the gland dissected free from the hyoglossus muscle deep to it, taking care to preserve intact the two nerves running alongside the duct.

41

Mobilization of the deep lobe in this way leaves the gland
still attached by the facial artery. It is found emerging from
the tissues deep to the gland, and is divided between
ligatures. The wound is then closed with a suction drain.

This form of submandibular gland excision is appropriate for the management of simple tumours. In the case of a malignant tumour the margins of resection have to be increased as appropriate. This might include excision of platysma and the overlying skin, mylohyoid, hyoglossus, together with local resection of intrinsic tongue muscle.

41

SUBLINGUAL GLAND

From the viewpoint of its neoplasms and the manner in which they are managed surgically, the sublingual gland behaves in many respects like a minor salivary gland. Both are rare sites for tumour and the incidence of the various tumours which do occur are largely similar, with the malignant types, particularly adenoid cystic carcinoma, much commoner than in the parotid. With its closeness to the mucosal surface of the anterior floor of the mouth, there is no contraindication to the use of biopsy. As a consequence the surgeon operates with a proper histological diagnosis. The surgical management is largely similar to that of squamous carcinoma of the same mucosal site, described in the chapter on 'Anterior floor of mouth' pp. 254–270, with the proviso that salivary tumours are radioresistant. The surgeon who bases the extent of his resection on the assumption that postoperative radiotherapy is not available as an adjunct of real value is the one most likely to treat the patient effectively. The recognized capacity for 'silent' perineural spread or adenoid cystic carcinoma may also lead the surgeon to extend his clearance margins considerably, faced with this particular tumour.

Illustrations by Patricia Archer, Robert Lane and Gillian Lee

Swellings of the parapharyngeal space

O. H. Shaheen MS, FRCS, FRCS(Ed)
Consultant ENT Surgeon, Guy's Hospital, London, UK

Anatomy

The upper part of the pharynx is separated from its surroundings by three spaces, namely the retropharyngeal, the lateral or parapharyngeal, and the infratemporal fossa. All three are important from a surgical standpoint, particularly in the context of neoplastic disease, but whereas the infratemporal fossa is limited to the confines of the ascending ramus of the mandible, the other two continue inferiorly in the direction of the thoracic inlet.

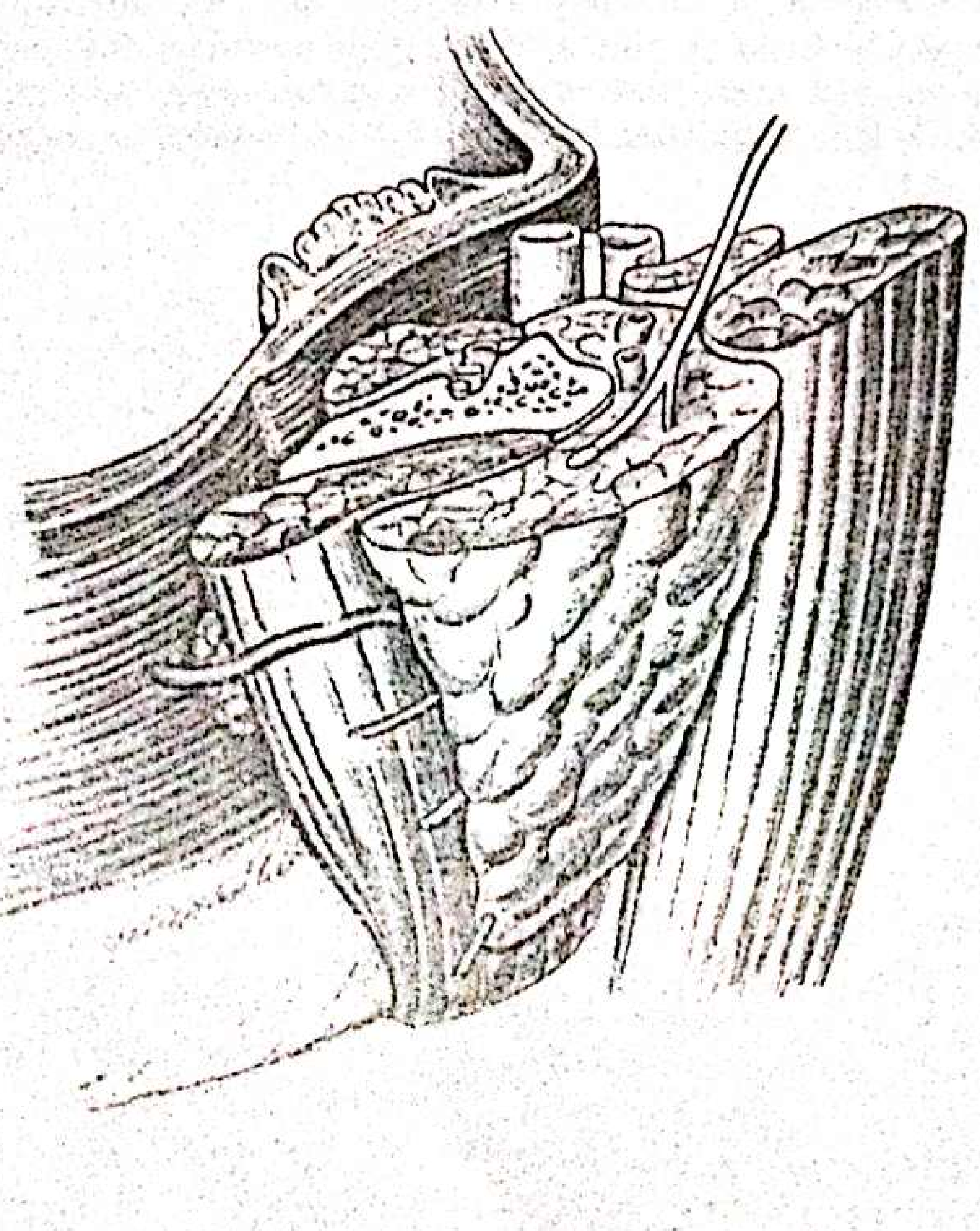
The retropharyngeal space intervenes between the posterior aspect of the pharynx and the prevertebral muscles. The infratemporal fossa occupies a position between the posterior segment of the lateral aspect of the pharynx and the outer upper aspect of the medial pterygoid on the one hand, and the ascending ramus of the mandible on the other. It is continuous with the temporal fossa superiorly, and with the parapharyngeal space posteroinferiorly.

Textbooks of anatomy invariably describe the infratemporal fossa in detail, but rarely mention the parapharyngeal space with which it is continuous, and from which it is separated inferiorly by the medial pterygoid muscle.

1

1

The roof of the parapharyngeal space is the sharp angle formed by the insertion of the medial pterygoid into the inner aspect of the lateral pterygoid plate, and the superior constrictor muscle. The medial boundary is the anterior part of the lateral wall of the pharynx, while the lateral limit superiorly is formed by the medial or undersurface of the medial pterygoid muscle and the deep part of the parotid gland. Below the level of the mandible the mylohyoid muscle and contents of the submandibular triangle represent the lateral extent of the space, and lower still is the deep cervical fascia covering the carotid triangle.



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Anteriorly the upper part of the parapharyngeal space narrows into the cul-de-sac formed by the pterygomandibular raphe and posterior part of the buccinator muscle, and below that by the submandibular gland, while posteriorly the space is bounded by the prevertebral muscles. Some, however, might argue that the internal carotid artery, vagus and internal jugular vein, which occupy the length of the parapharyngeal space, represent a more natural posterior limit.

The space is crossed from lateral to medial by the stylopharyngeus and styloglossus muscles, and by the pharyngeal branch of the vagus and the superior laryngeal nerve. It is separated by a thin fascial partition from the retropharyngeal space, and is continuous with the infratemporal fossa superiorly, above and behind the medial pterygoid muscle.

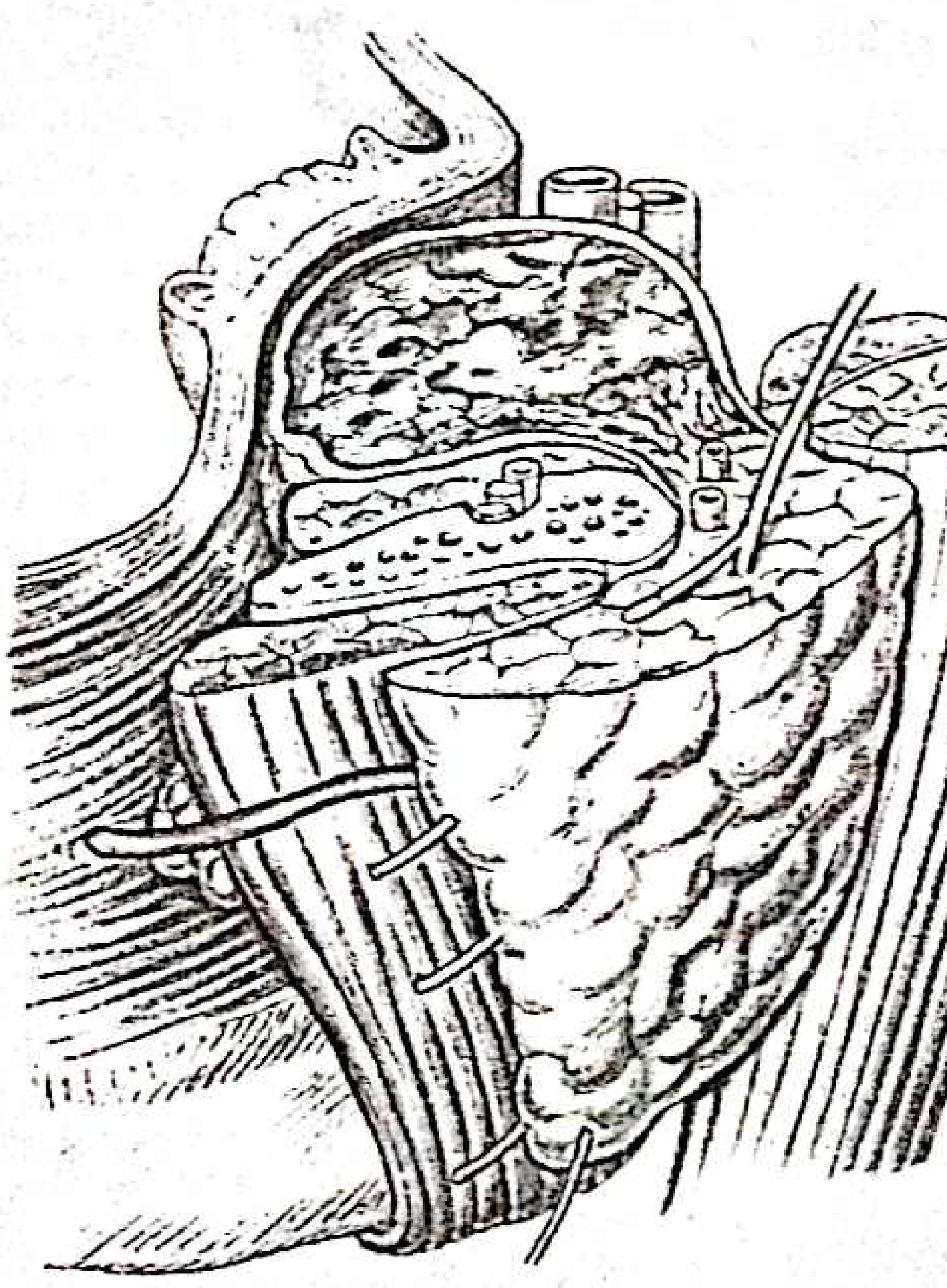
Pathology

There are three main pathologies which affect the parapharyngeal space. The most common of these are tumours of salivary origin, both benign and, less frequently, malignant, pleomorphic adenoma being by far the most common.

Chemodectomas in the form of carotid body tumours or glomus vagale originate in the carotid triangle and grow upwards to fill the parapharyngeal space. Least common are tumours of nerve origin, namely neurilemoma, neurofibroma and ganglioneuroma.

Pleomorphic adenoma

Pleomorphic adenomas may arise from within the parotid gland, deep to the facial nerve, and grow primarily in a medial direction towards the pharynx, occupying the parapharyngeal space in the process. If their site of origin within the parotid gland is substantial, they may lie in intimate contact with the undersurface of the facial nerve, and may cause the superficial lobe of the gland to bulge outwards as a moderately conspicuous swelling.



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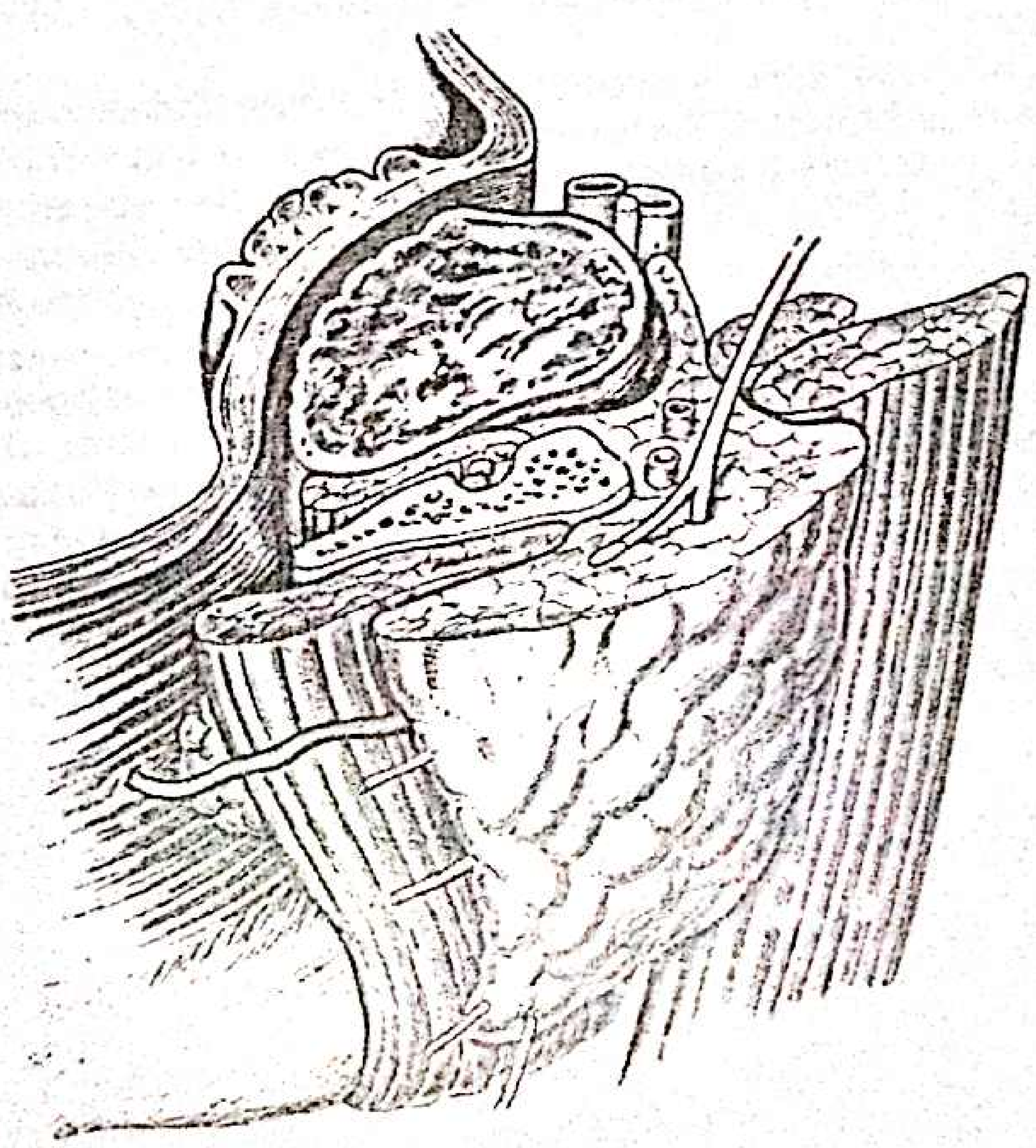
3

In order to negotiate a passage into the parapharyngeal space, they have to pass through the hiatus bounded on the one hand by the posterior edge of the ascending ramus of the mandible, and on the other by the thick tough fascia called the stylomandibular ligament, which takes its origin from the styloid process and inserts into the angle of the mandible.

Growth is unrestricted across the parapharyngeal space, but as the tumour grows it displaces the medial pterygoid muscle, upwards and outwards. At the pharyngeal end, the soft palate, tonsil and anterior faucial pillar are pushed forwards and inwards.



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Tumours arising from the ectopic salivary tissue in the parapharyngeal space simply fill up the space without significant displacement of the parotid gland in an outward direction, but invariably displace the palate and faucial structures inwards.

The test for ballottement is most obviously positive when an adenoma takes origin from within the parotid gland, since the tumour is integrally part of the parotid. The distinction between the two sites of origin can now be confidently made with computed tomographic scanning, and better still with nuclear magnetic resonance imaging.

The operations available to deal with both these entities are chosen on the basis of site of origin, possible proximity to the facial nerve, size of swelling, and relationship to the skull base.

The approaches available are transparotid, submandibular with or without mandibular osteotomy, and midline mandibular osteotomy with eversion of the mandible. The purely transpharyngeal approach without mandibular division will not be discussed since it is considered inappropriate.

Operations

Premedication

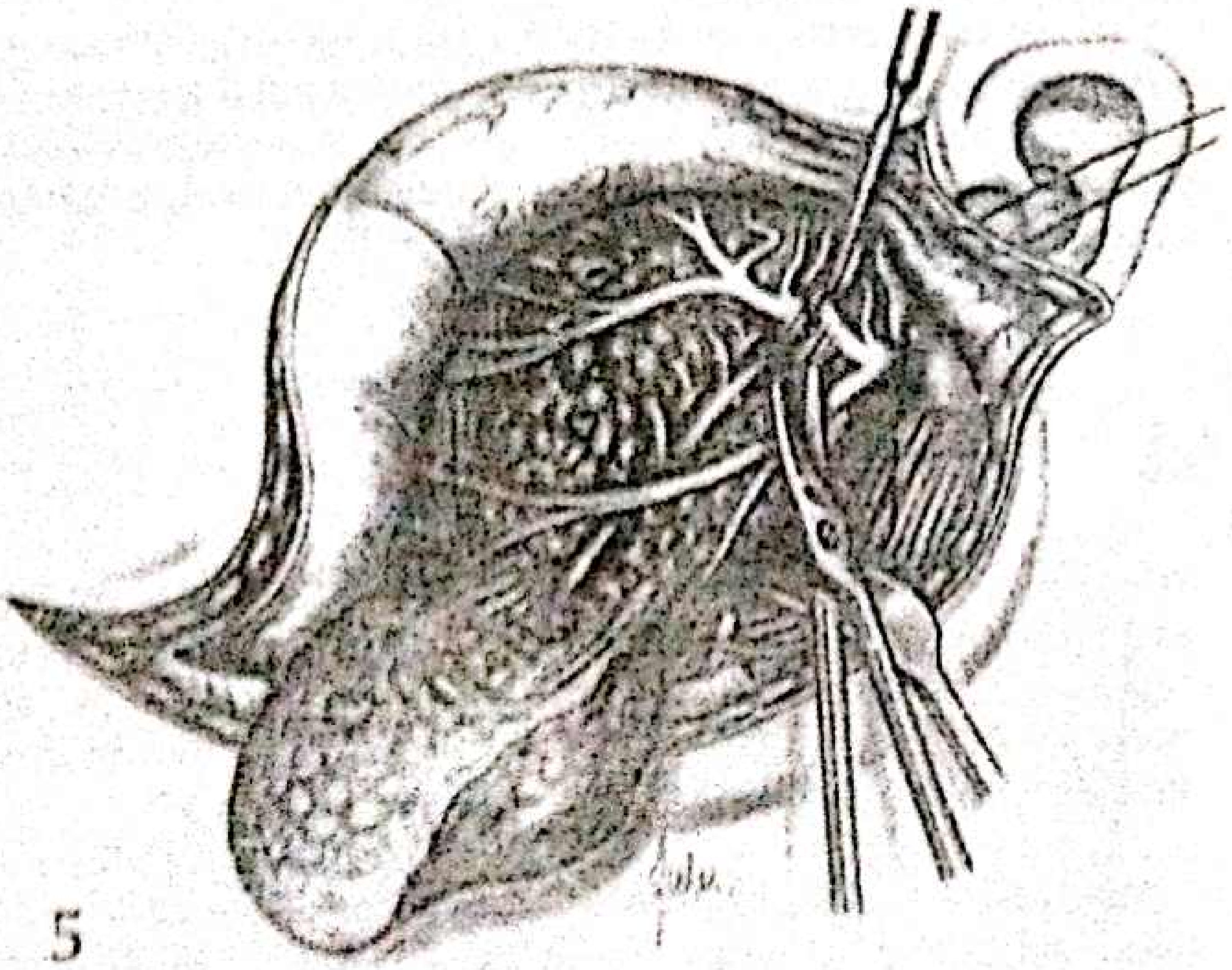
This is usually given 1 h before operation and the choice of drugs is a matter of personal preference. A popular combination is papaveretum (Omnopon) 10–20 mg and hyoscine 0.2–0.4 mg given intramuscularly.

Anaesthesia

General anaesthesia with spontaneous respiration is maintained. The use of relaxing agents and intermittent positive pressure respiration is unnecessary and probably undesirable since a relaxant might conceivably interfere with the results of direct stimulation of the facial nerve.

Position of the patient

The patient is placed in the supine position with the neck slightly extended by a sandbag placed between the shoulders. The head is turned away from the surgeon. The table is inclined in a head up position to reduce venous congestion and lower arterial pressure. The towels are so arranged that the corner of the homolateral eye and the corner of the mouth are just visible.



5

TRANSPAROTID APPROACH

5

A superficial parotidectomy is performed, at the end of which the superficial lobe is left pedicled inferiorly instead of anteriorly. The pedicle ideally should lie between the cervical and mandibular branches of the facial nerve. Alternatively the superficial lobe can be excised completely and the deep lobe removed as a separate specimen. The branches and the main trunk of the facial nerve are dissected off the underlying deep lobe, using small scissors to divide the fascial attachments of the nerve to the underlying gland. This manoeuvre is helped by lifting and supporting the nerve and its branches with a nerve hook.

The deep lobe is separated with scissors from the posterior border of the ascending ramus of the mandible and from the temporomandibular joint, the digastric muscle and the bony external auditory meatus. Its deep aspect is gently separated from the styloid process to which it may have some fibrous attachments.

The retromandibular vein is divided at the point where it emerges from the deep lobe of the gland, and the superficial temporal vein is secured superiorly just below the zygomatic arch. Similarly the external carotid artery is divided at its point of entry into the deep lobe of the gland, just above the stylohyoid muscle, and the superficial temporal artery is interrupted at its point of emergence from the gland.

6

The internal maxillary and transverse facial branches of the external carotid artery are divided in the interval between the deep lobe of the gland and the ascending ramus of the mandible.

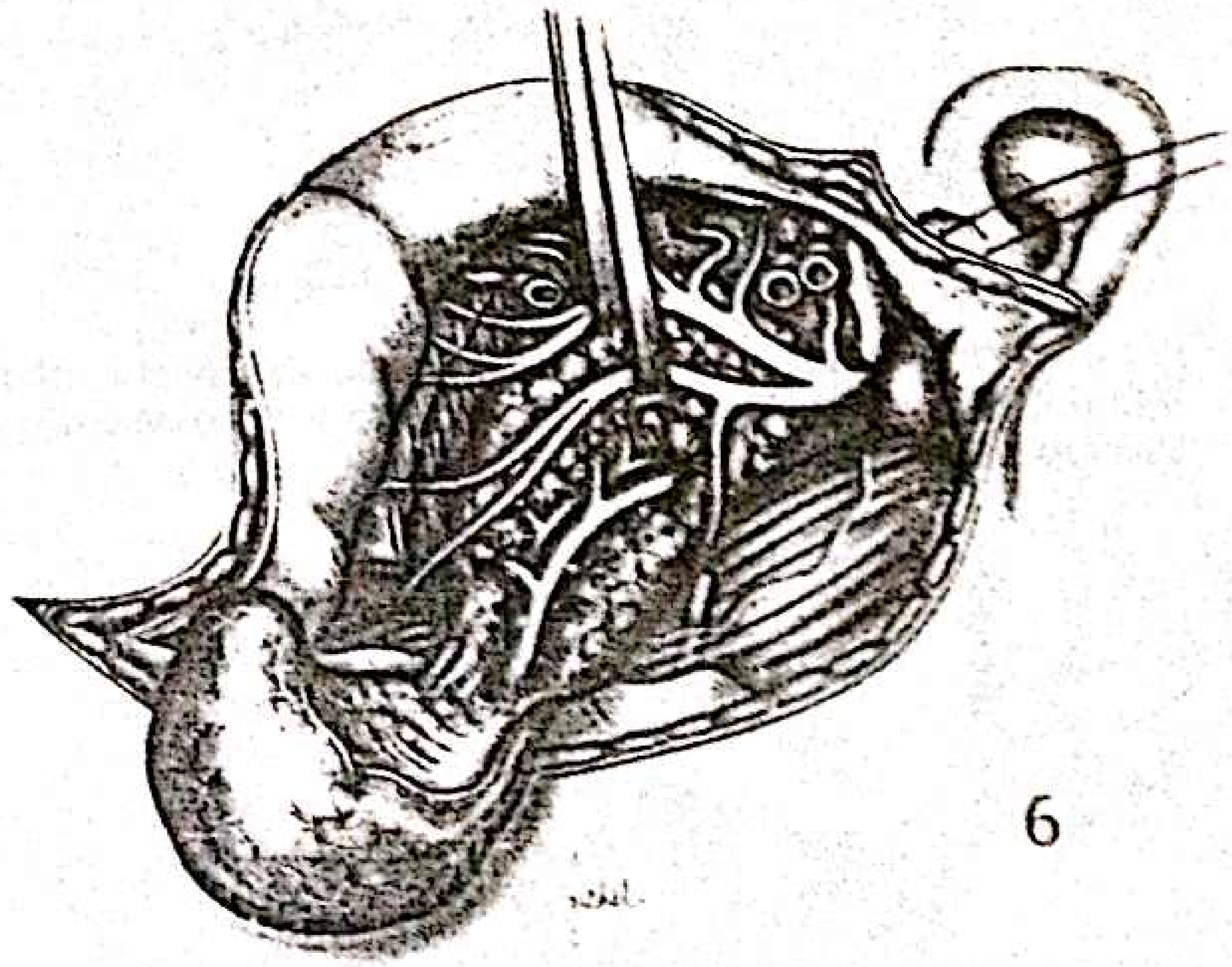
Mobilization of the tumour, which lies medial to the deep lobe of the gland, is commenced using blunt dissection, but leaving its lateral extremity attached to the gland. Care is taken not to breach its substance, for although most deep pleomorphic adenomas are firm and reasonably well encapsulated, a softer variant which is prone to rupture is not uncommonly encountered.

To assist access to the deep part of the tumour the stylomandibular ligament needs to be divided and it may be helpful to fracture and remove the styloid process.

Once the tumour is reasonably free from its surroundings it is extricated in a lateral and downward direction from beneath the facial nerve, together with the deep lobe of the parotid gland, which has been already freed from its attachments during an earlier stage of the operation. Any remaining bleeding points are secured, taking care not to damage the flail facial nerve and its branches, which may overlie points of bleeding in the depths of the wound.

A wide-bore suction drain is inserted deep to the digastric muscle so that the nerve is not sucked into the drain.

The wound is closed in layers and a pressure bandage applied to the area to reduce haematoma formation.



6

Complications

Temporary weakness of the muscles of the face is common following this operation as the result of a stretch effect. If the tumour is spilt during the course of the surgery, the patient may subsequently get a multinodular recurrence.

SUBMANDIBULAR APPROACH

Incision

7

A horizontal incision is made just above the level of the hyoid bone, extending from the midline to a point which overlaps the sternomastoid muscle.

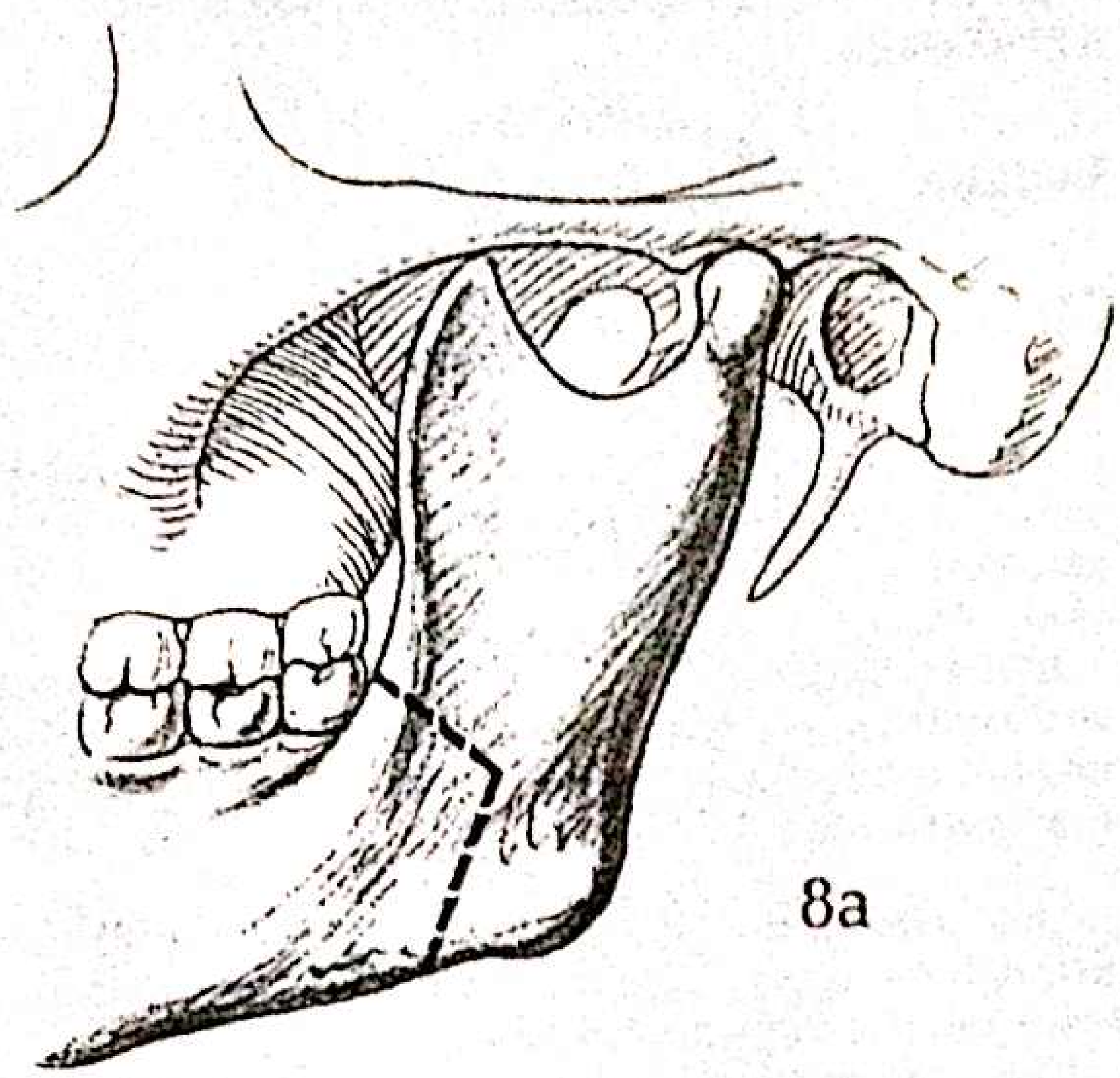
7

The submandibular gland is excised. With the submandibular gland out of the way, the approach to the tumour which lies in the parapharyngeal space is commenced. It has to be stressed that much of the procedure is carried out blind because, apart from the lower part, much of the neoplasm cannot be clearly seen.

The plane of separation is established by blunt dissection between the tumour on the one hand and the inner aspect of the medial pterygoid muscle and the deep lobe of the parotid on the other. It must be remembered that the neoplasm may actually take origin from within the deep lobe and the plane of dissection between it and the salivary gland may not be altogether clear or easy to define. If the tumour is poorly encapsulated and soft in consistency, rupture may occur at this site. Release of the intraparotid portion of the tumour may be facilitated by dividing the stylomandibular ligament at its point of insertion into the periosteum at the angle of the mandible.

Dissection then continues around the rest of the neoplasm in all directions. Medially and anteromedially, where it abuts against the superior constrictor muscle, separation is easy to achieve unless a prior biopsy through the oropharynx has been unwisely performed, in which case the neoplasm is generally firmly stuck to the pharyngeal wall.

Separation superiorly may also be difficult if the tumour is large and reaches the base of the skull. Dissection at this level is restricted and not helped by the fact that it has to be performed entirely by blind blunt dissection.

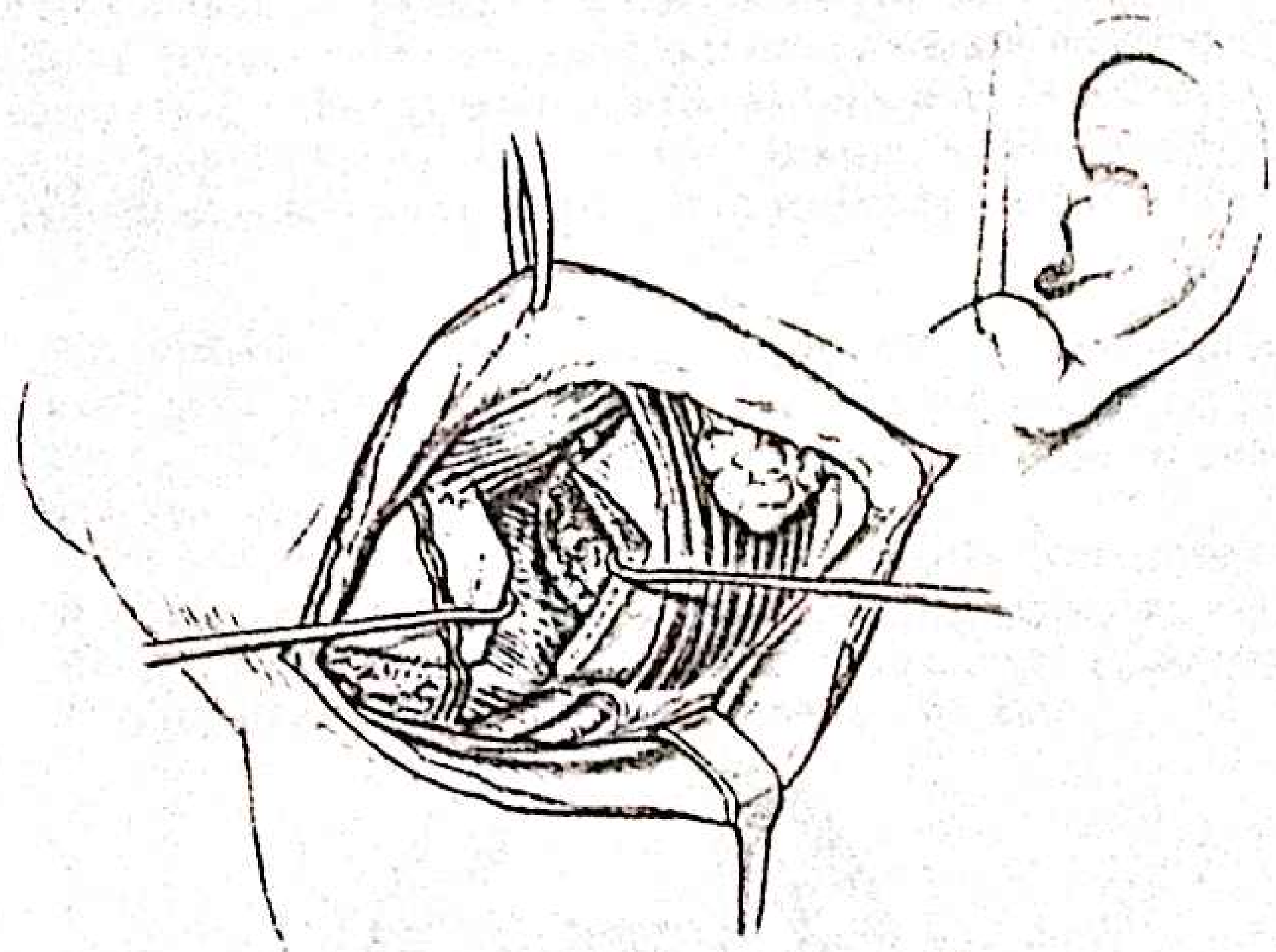


8a

8a, b & c

Access to the upper part of the neoplasm may be helped by dividing the horizontal ramus of the mandible at the point immediately anterior to the ascending ramus. This entails freeing enough of the masseter muscle and mandibular periosteum off the bone, proceeding from below upwards, in order to provide sufficient room for the division of the horizontal ramus of the mandible at its junction of the ascending ramus. The osteotomy may be accomplished either with an oscillating or a Gigli saw in the form of a V with the apex posterior to provide the maximum of stability when the bone ends are subsequently wired together.

Once the mandible is divided the ascending ramus may be everted upwards and laterally, to facilitate access to the upper part of the tumour. Following removal of the tumour, the mandibular fragments are realigned and wired together with stainless steel wire, or alternatively plated. The wound is drained with a suction drain and closed in layers.



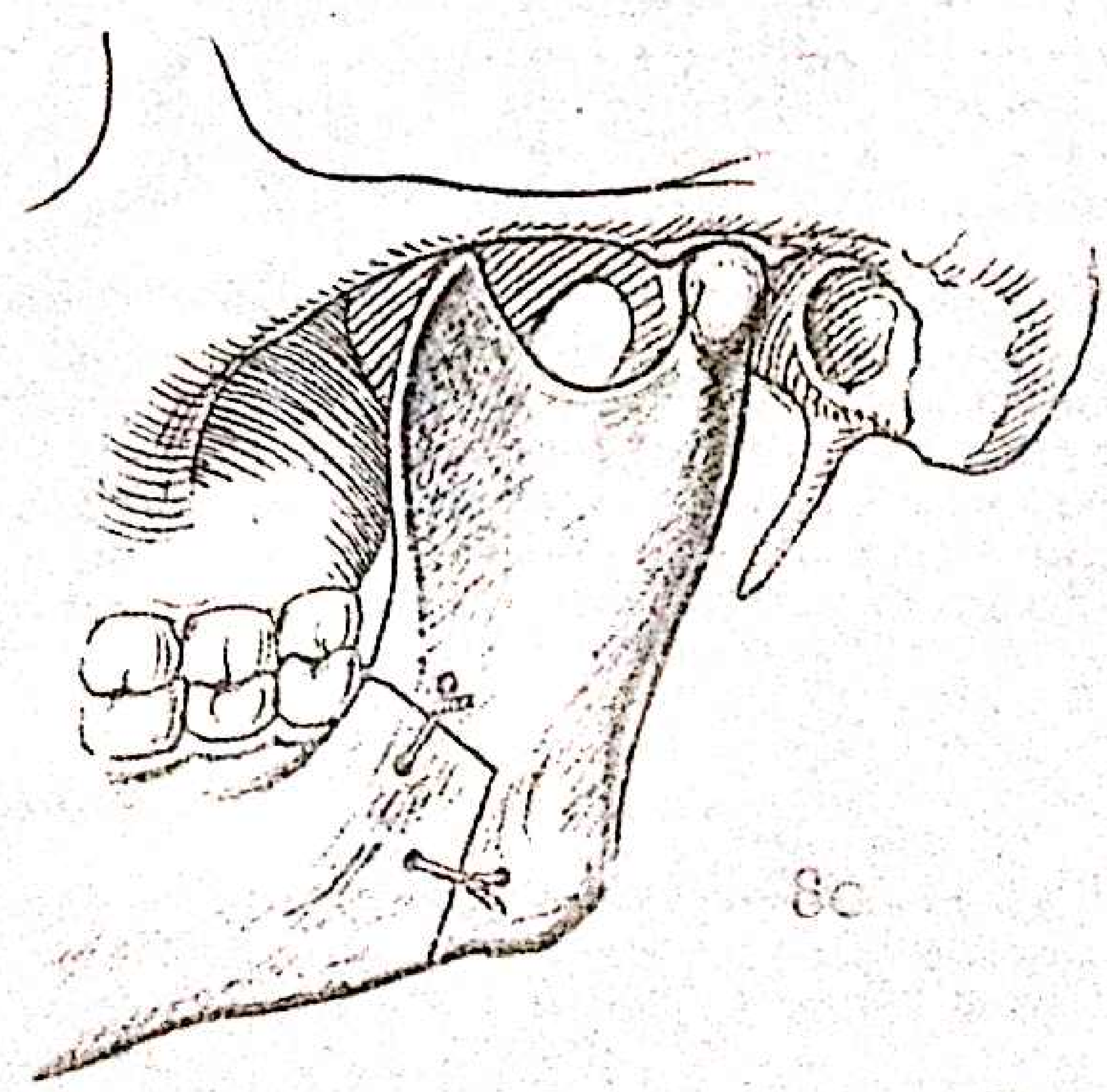
8b

Complications

Damage to the mandibular branch of the seventh nerve may occur, either during removal of the submandibular gland or subsequently if traction on the upper flap is excessive.

The division of the alveolar nerve results in anaesthesia of the lower lip, but recovery is usual if the bone ends are properly aligned and adequately fixed.

Spillage of tumour during the operation is likely to result in multinodular recurrence of tumour.



8c

MIDLINE TRANSMANDIBULAR/PHARYNGEAL APPROACH

Incision

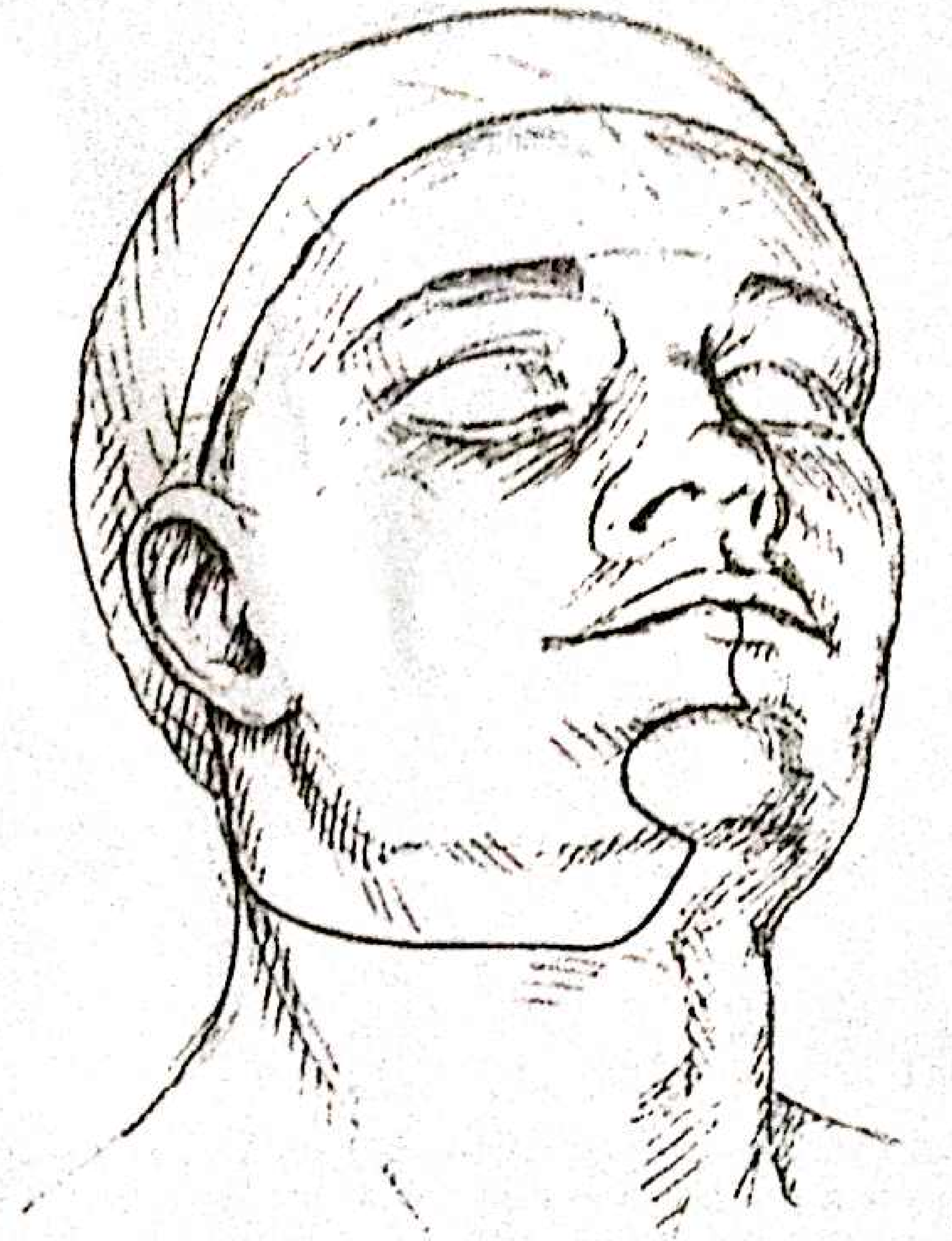
9

A staggered incision through the lower lip is carried out with a vertical line drawn to the prominence of the chin and a curve thereafter which follows the contour of the chin.

At the point of the chin the incision inclines downwards and laterally, preferably in a skin crease, just above the level of the hyoid bone. It ends at the anterior border of the sternomastoid or just beyond.

The submandibular part of the incision is deepened through the platysma and deep cervical fascia, again at a level just above the hyoid bone.

The submandibular gland is removed. The removal of the gland has the advantage of releasing the lingual nerve from its attachment to the deep part of the salivary gland, so that when the intraoral part of the operation takes place there may be some chance of preserving the lingual nerve as it crosses the floor of the mouth from lateral to medial.



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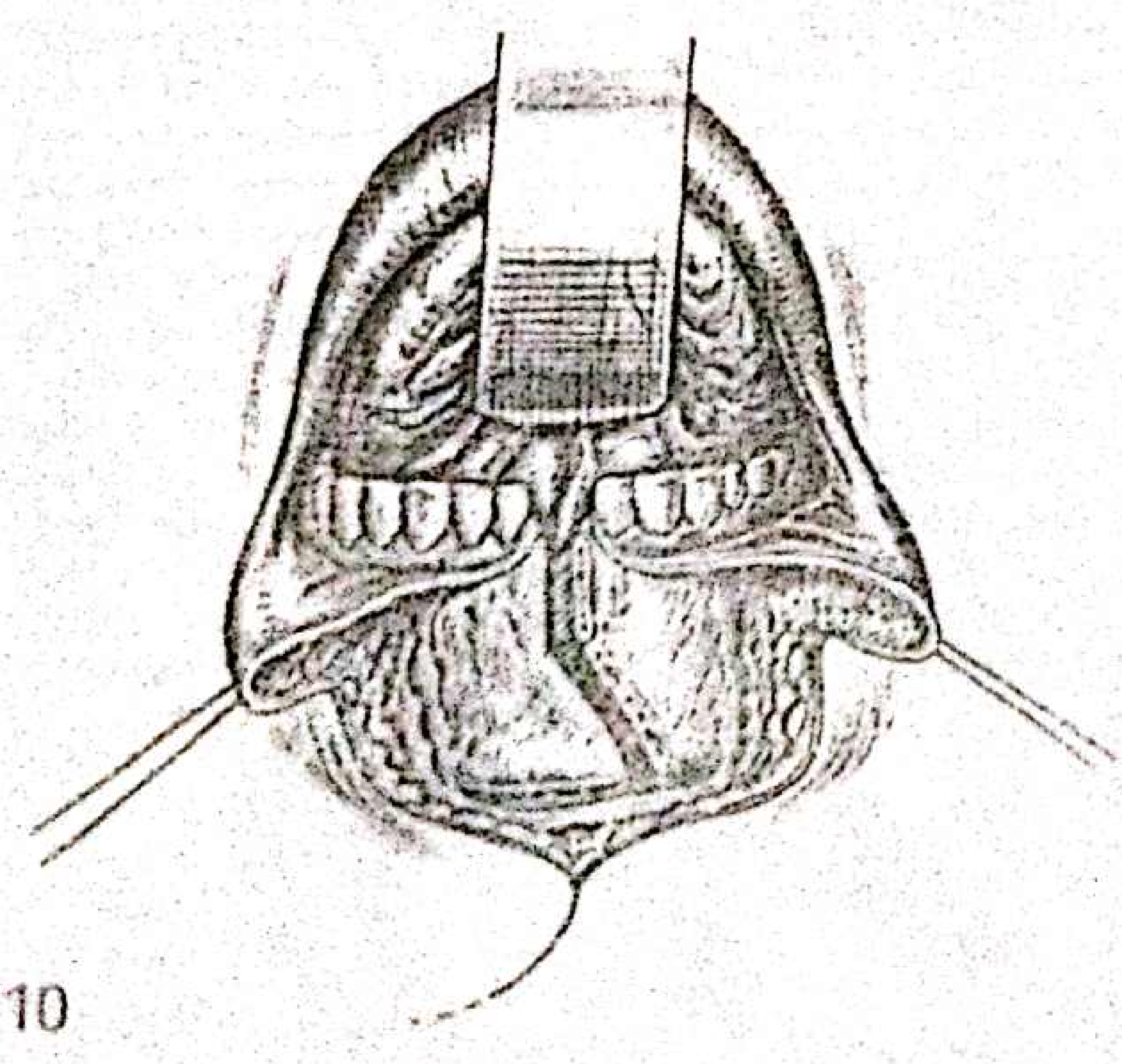

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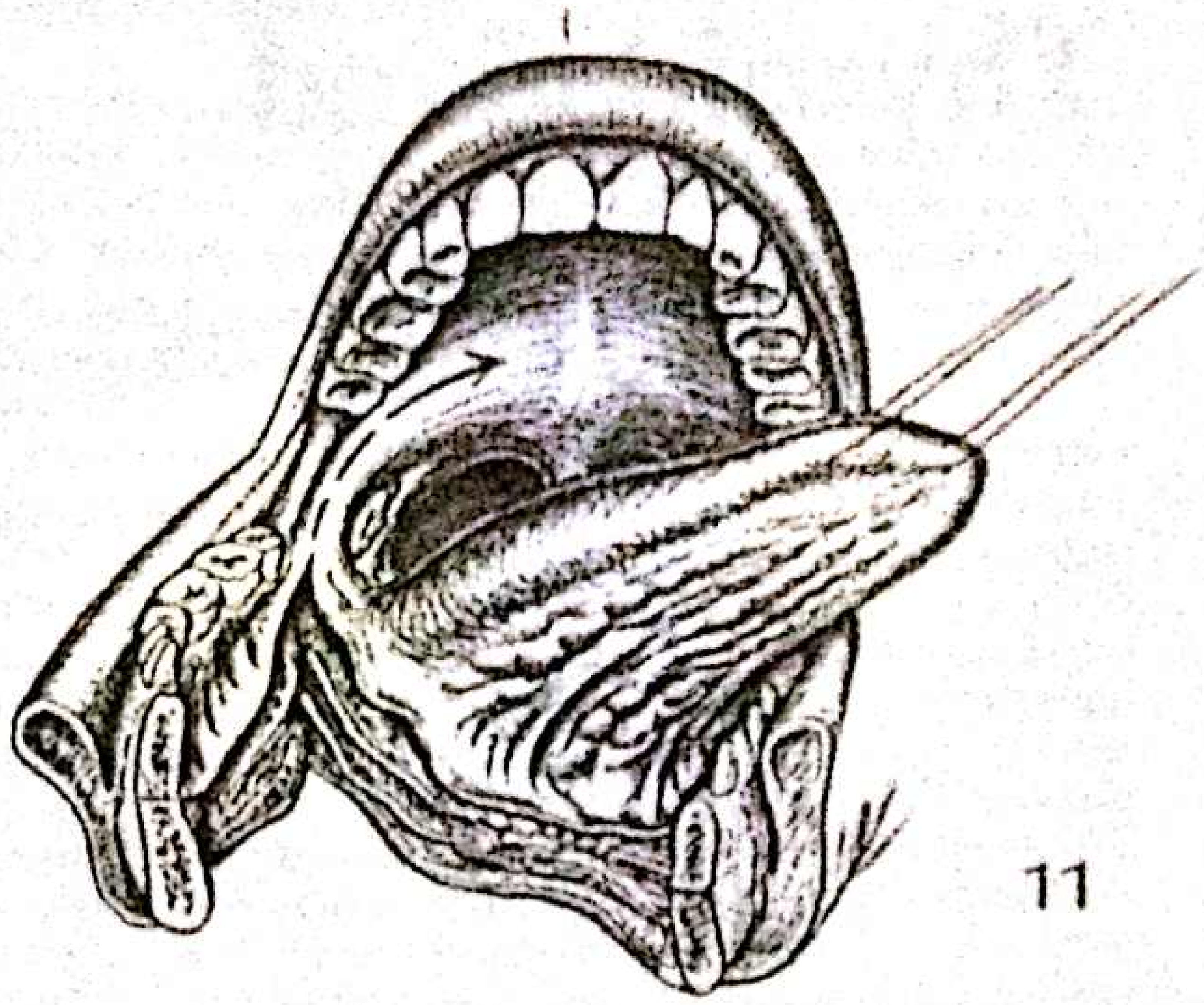
10

At the site where the mandible is to be divided a metal plate is laid on the chin and drill holes made through this for subsequent plating. The mandible is then split in the midline in the staggered manner to enhance subsequent stability and the mucous membrane of the mouth incised.

11

The mucosal incision at the midline is then carried backwards and laterally, just inside the horizontal ramus of the mandible, and this incision is deepened to include division of the mylohyoid muscle close to its insertion into the inner aspect of the horizontal ramus of the mandible. This permits eversion of the horizontal ramus of the mandible and helps to identify the passage of the lingual nerve from lateral to medial.



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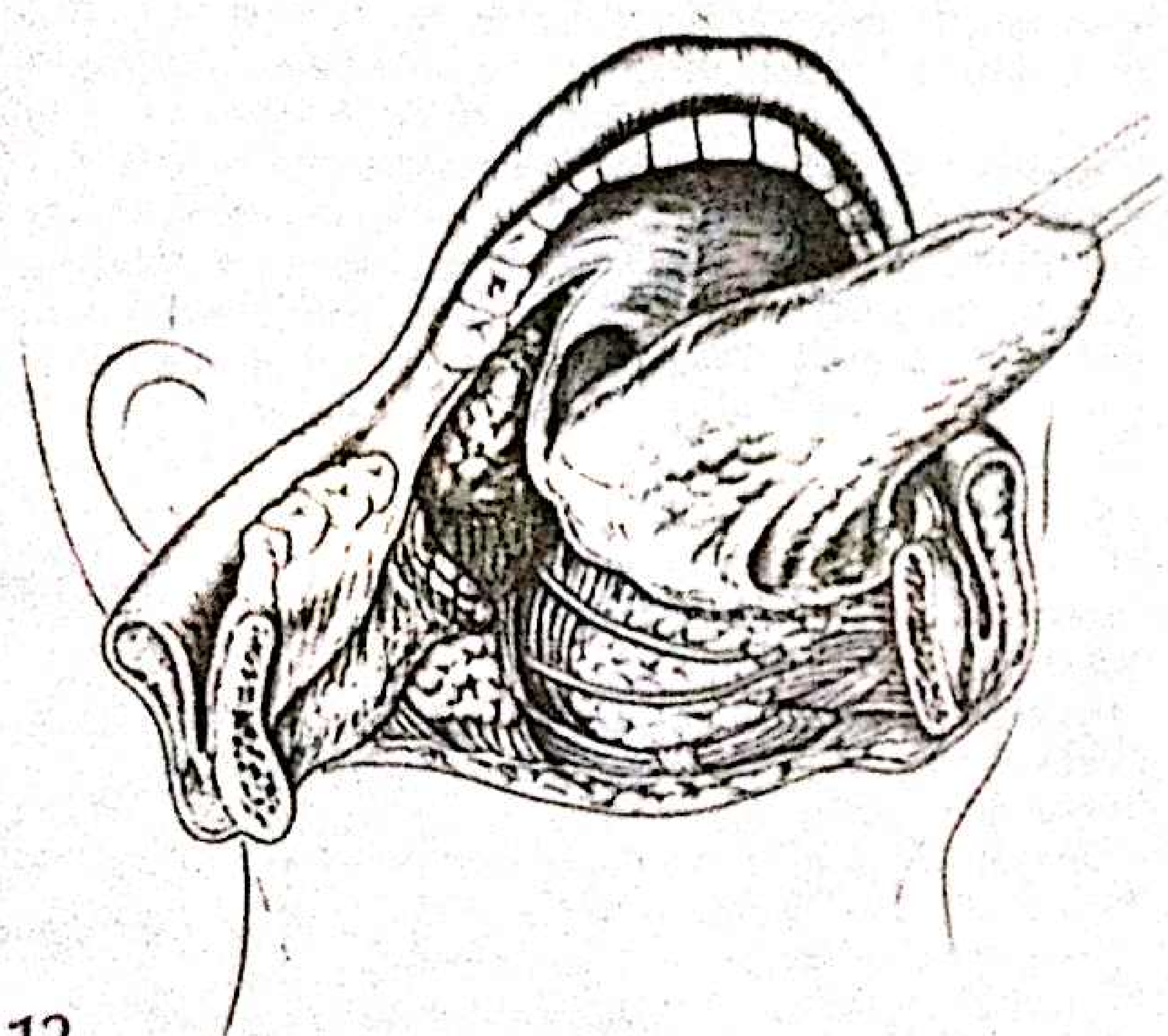

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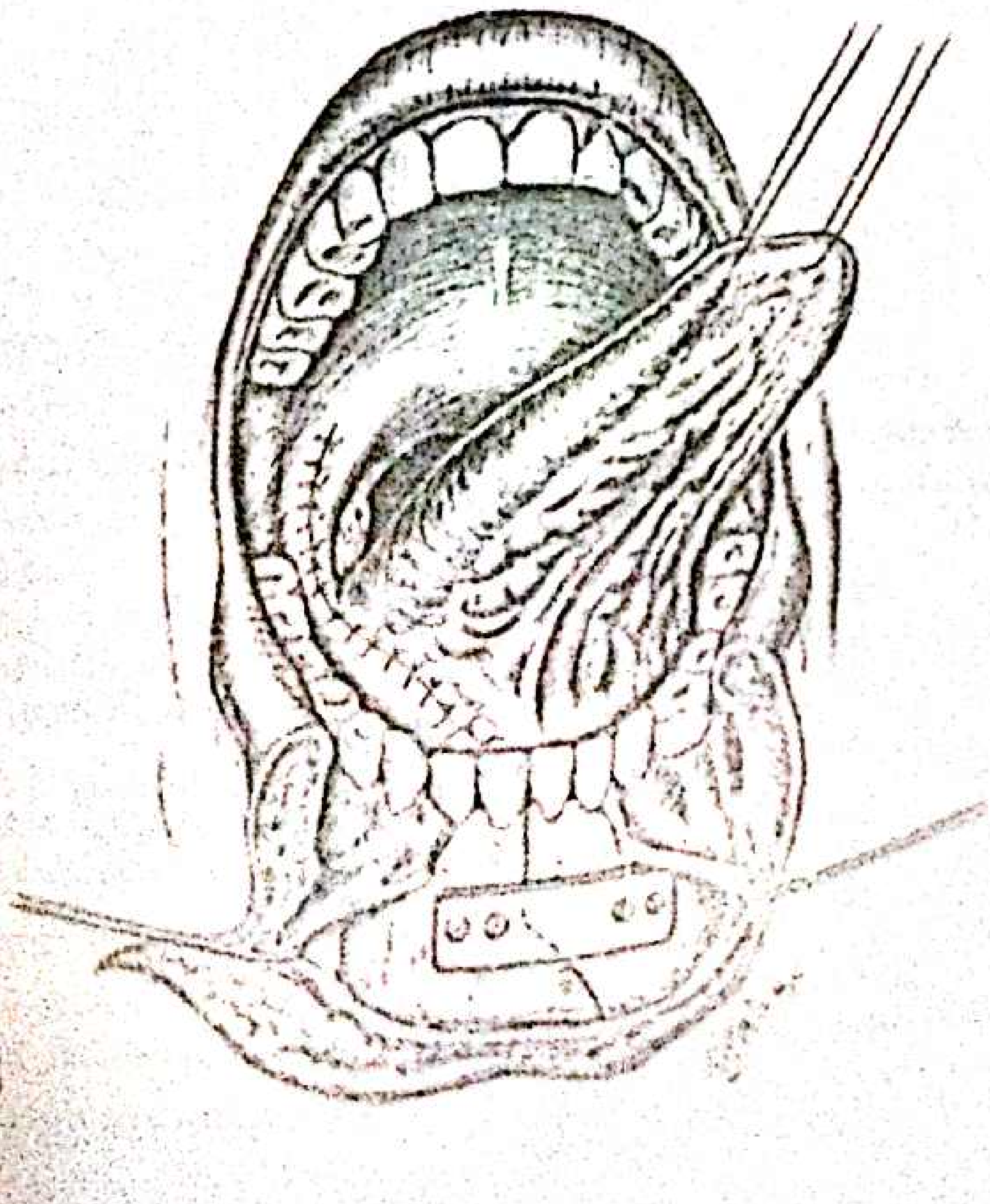
12

The incision in the mucous membrane is continued backwards, up on to the anterior faucial pillar and ends in the soft palate. It is deepened to include division of the superior constrictor muscle.

The hemimandible is retracted laterally as far as possible to allow the surgeon full access to the parapharyngeal space. The tumour is separated from the adjacent structures by blunt dissection and then excised.



13

13

The divided muscles are repaired with chromic catgut and the mucous membrane of the floor of the mouth is closed with silk or a synthetic suture material. The mandibular split is plated and the soft tissues forming the chin and the rest of the incision are closed in layers. The parapharyngeal space is drained with a large-bore suction drain, which emerges through a separate and lower stab wound.

Complications

Lingual anaesthesia may commonly be caused by damage to the lingual nerve. The patient may also experience temporary trismus for a period of weeks after the operation.

Illustrations by Gillian Lee

Thyroid gland

Carl E. Silver MD, FACS
Professor of Surgery and Professor of Otolaryngology, Albert Einstein College of Medicine and Director of Head and Neck Surgery, Montefiore Medical Center, New York, USA

Robert J. Cusumano MD
Assistant Professor of Otolaryngology, Albert Einstein College of Medicine, Montefiore Medical Center, New York, USA

Introduction

The ancient Chinese employed ground sheep's thyroid for treatment of goitre and cretinism. Roger of Palermo in AD 1170 recommended ashes of seaweed and sea sponge for this purpose, and in his *Cyrurgia Rogeri* described a method of thyroidectomy by 'incising the skin and pulling out the goitre with a hook'[1]. Theodore Kocher, who devoted much of his life's work to the problems of goitre – for which he recieved the Nobel Prize in 1909 – applied the principles of meticulous haemostasis and detailed operating technique to thyroid surgery. The main concepts of modern thyroidectomy were developed by Lahey[2] during the 1930s.

Thyroid surgery, in the nineteenth and early twentieth centuries, was performed mostly for the removal of enormous benign goitres and for the treatment of hyperthyroidism. In current surgical practice these indications have become rare; almost all thyroid surgery is now performed for treatment of malignancy or for removal of potentially malignant thyroid nodules. The latter situation accounts for the majority of operations performed on the thyroid gland at the present time.

It is not possible to formulate a rational surgical plan for management of thyroid carcinoma without an understanding of the unique behaviour of various thyroid tumours, and of the controversies regarding management of these lesions.

Pathology

Prognosis in thyroid carcinoma is related almost entirely to the histological type of tumour. The relative frequency of various types of thyroid carcinoma is summarized in *Table 1*. Papillary carcinoma is the most common, comprising 50–60 per cent of all lesions. With a 3:1 female predominance, it occurs at a younger age than other thyroid tumours, with peak incidence in the third decade of life[3]. Tumours in patients over 40 years of age tend to follow a more aggressive course[4–6]. Although lymph node metastases occur frequently (30 per cent palpable and 70 per cent occult), prognosis is usually excellent. Five-year survival of papillary carcinoma is approximately 90 per cent[7,8]. Significant mortality occurs mostly with intra-thyroid lesions greater than 4 cm in diameter or locally invasive tumours[9]. Lesions with mixed papillary and follicular histological patterns behave similarly to pure papillary carcinoma, as does follicular carcinoma in patients under 40 years of age.

Follicular carcinoma is more prevalent and follows a more aggressive course in patients over 40 years. In these patients, metastases occur mainly haematogenously, and are seen in 50–65 per cent of patients. Tumours showing moderate or marked angioinvasion behave more aggressively than those with minimal angioinvasion[4]. Size is not an important prognostic factor in follicular carcinoma[10]. Five-year survival is approximately 70 per cent for lesions seen initially without distant metastases and 20 per cent when distant metastases are present[11].

Medullary carcinoma is rare, sometimes occurring familially or in association with multiple endocrine neoplasms. Lymph node metastases occur in approximately 50 per cent of cases and, unlike papillary carcinoma, are associated with lower survival rates. Five-year survival ranges between 55 and 80 per cent in various series of patients[12,13].

Anaplastic carcinomas comprise 5–15 per cent of all cases of thyroid carcinoma, occurring most often in the seventh and eighth decades of life. Prognosis is extremely poor with 5-year survival below 10 per cent[14].

Table 1 Classification and incidence of thyroid cancers

Type of tumour	*Incidence (%)*
Papillary	62
Occult (< 1.5 cm)	35
Intrathyroid	50
Extrathyroid	15
Follicular	18
Minimal angioinvasion	50
Moderate or marked angioinvasion	50
Anaplastic	14
Medullary	6

Adapted from Woolner *et al.*[4]

Surgical management

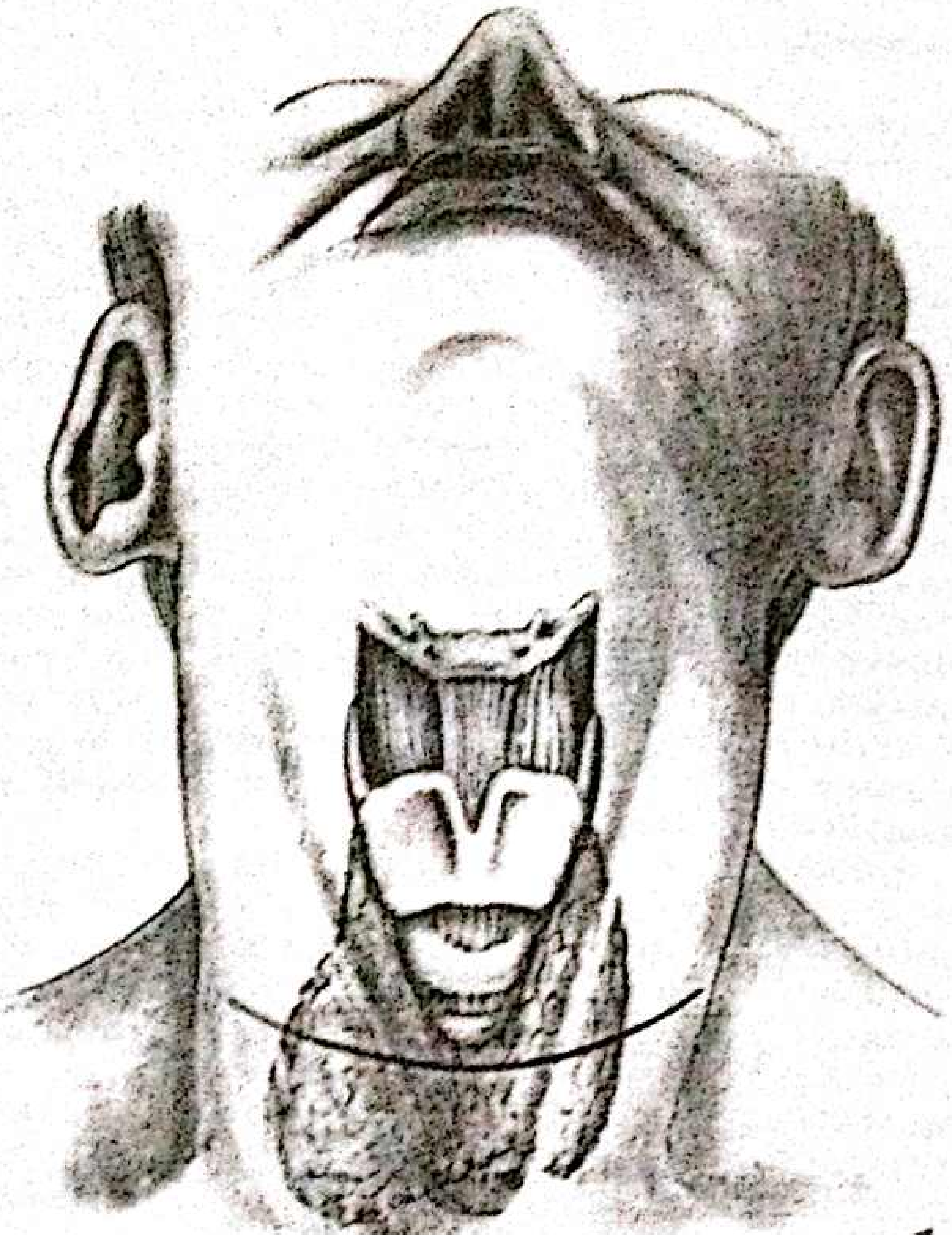
The standard surgical approach for a potentially malignant thyroid nodule is to perform total lobectomy on the involved side and obtain intraoperative frozen section. The decision whether to remove the contralateral lobe depends on frozen section diagnosis and often other factors, such as local invasion, tumour size or lymphatic spread.

While most authors agree that the treatment of choice for occult papillary carcinoma (less than 1.5 cm in diameter) is hemithyroidectomy and isthmusectomy followed by thyroid stimulating hormone (TSH) suppression[15], the question of unilateral or bilateral thyroidectomy for larger tumours is more controversial. Although the incidence of occult multicentric lesions in the opposite lobe in papillary carcinoma is high[16,17], there is an extremely low incidence of clinical carcinoma in the opposite lobe after properly performed hemithyroidectomy in patients maintained on long-term TSH suppression[18,19]. For tumours larger than 1.5 cm, and for lesions with extrathyroid invasion, total or subtotal thyroidectomy produces a lower incidence of local recurrence, but no significant difference in long-term survival[5,8]. This must be weighed against the increased incidence of postoperative complications, particularly hypoparathyroidism, incurred by total thyroidectomy. The latter can be reduced, but not eliminated, by subtotal rather than total resection of the contralateral lobe.

A majority of surgeons tend to resect the contralateral lobe for tumours larger than 1.5 cm, if frozen section at initial surgery is positive for malignancy. Factors such as extensive multifocal involvement of the ipsilateral side, narrow margins, extrathyroid spread and metastatic disease may influence this decision. A more difficult problem is encountered when frozen section has failed to confirm the diagnosis of malignancy, which is subsequently reported after permanent sections have been interpreted one or more days postoperatively. The indications for 'completion' thyroidectomy in such cases differ among surgeons, based on the previously stated arguments. The factors listed above, which may influence the decision for contralateral resection at initial operation, are often helpful in reaching a decision regarding a second operation.

Most surgeons treat follicular carcinoma in the same manner as papillary carcinoma, although invasiveness of the lesion, difficulty in obtaining a frozen section diagnosis, and the presence of distant metastases may influence the decision to perform total thyroidectomy[4,6]. For medullary carcinoma, total thyroidectomy is necessary because of the aggressiveness of the lesion and the high incidence of bilateral and multicentric involvement[12,13].

Elective surgical treatment of potential lymph node metastases in well differentiated thyroid carcinoma usually consists of paratracheal and upper mediastinal node dissection. Modified complete neck dissection preserving the sternomastoid muscle, the accessory nerve, and possibly the internal jugular vein is reserved for clinically palpable nodes in the lateral neck. Elective lateral neck dissection does not improve prognosis in well differentiated thyroid carcinoma[20], but it is advocated by many authors for treatment of medullary carcinoma because of the high incidence of lymph node involvement with associated poor prognosis[12,13].



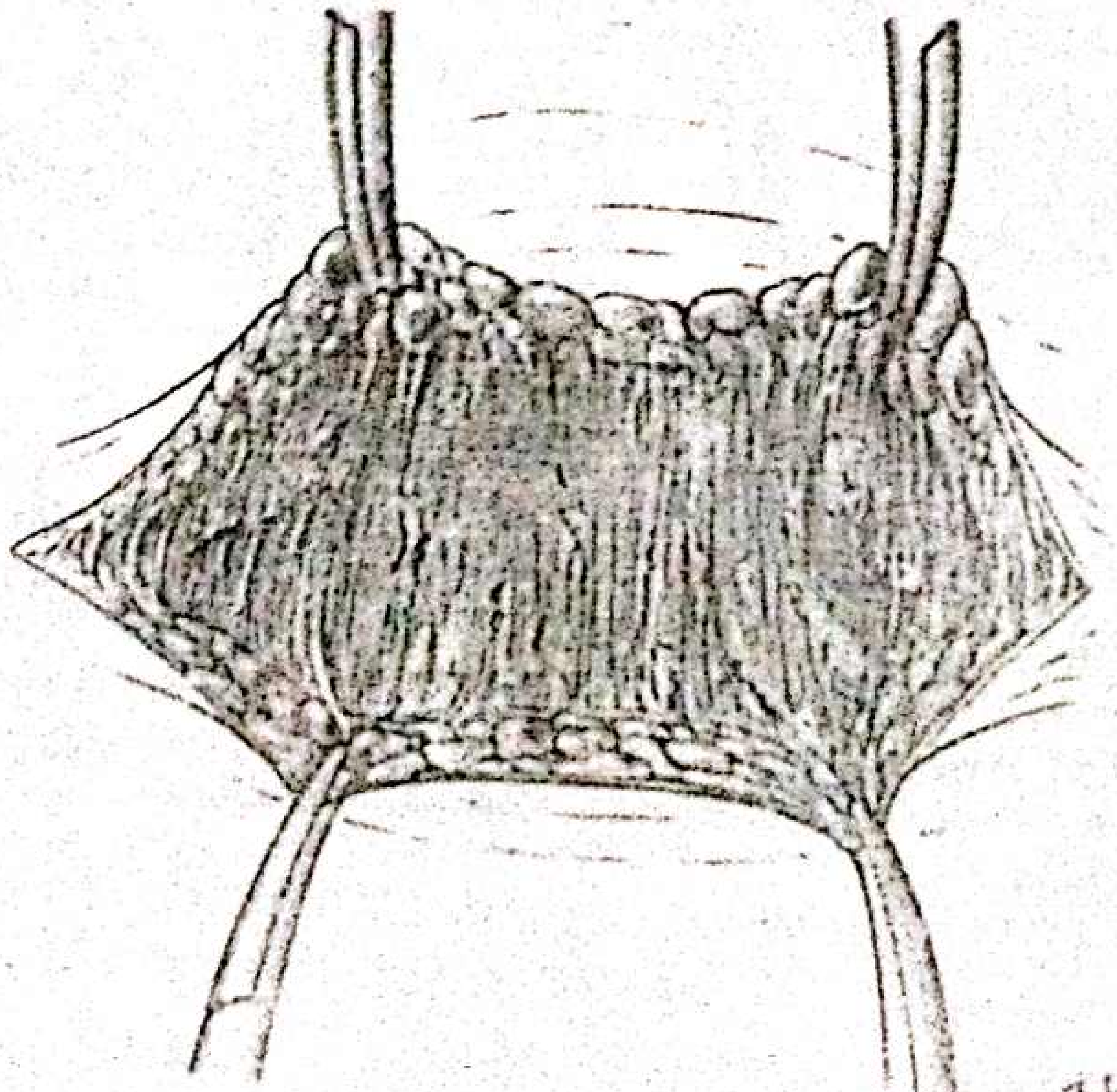
1a

Operations

TOTAL THYROID LOBECTOMY (HEMITHYROIDECTOMY)

1a & b

The standard incision for thyroidectomy is a transverse incision placed low in the neck at the level of the thyroid isthmus, preferably in a natural skin crease. The skin incision is continued down to the subcutaneous layer deep to platysma.



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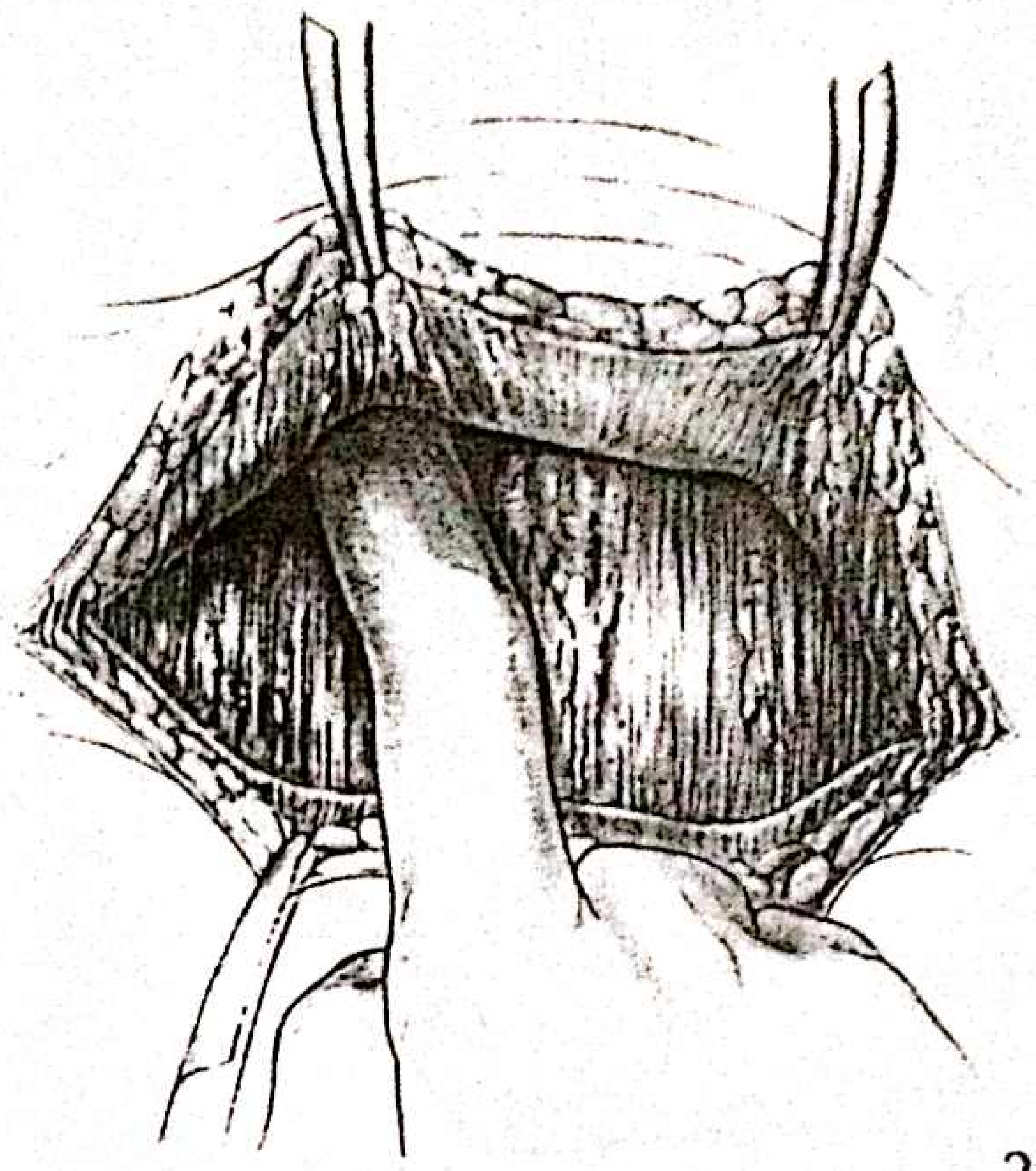
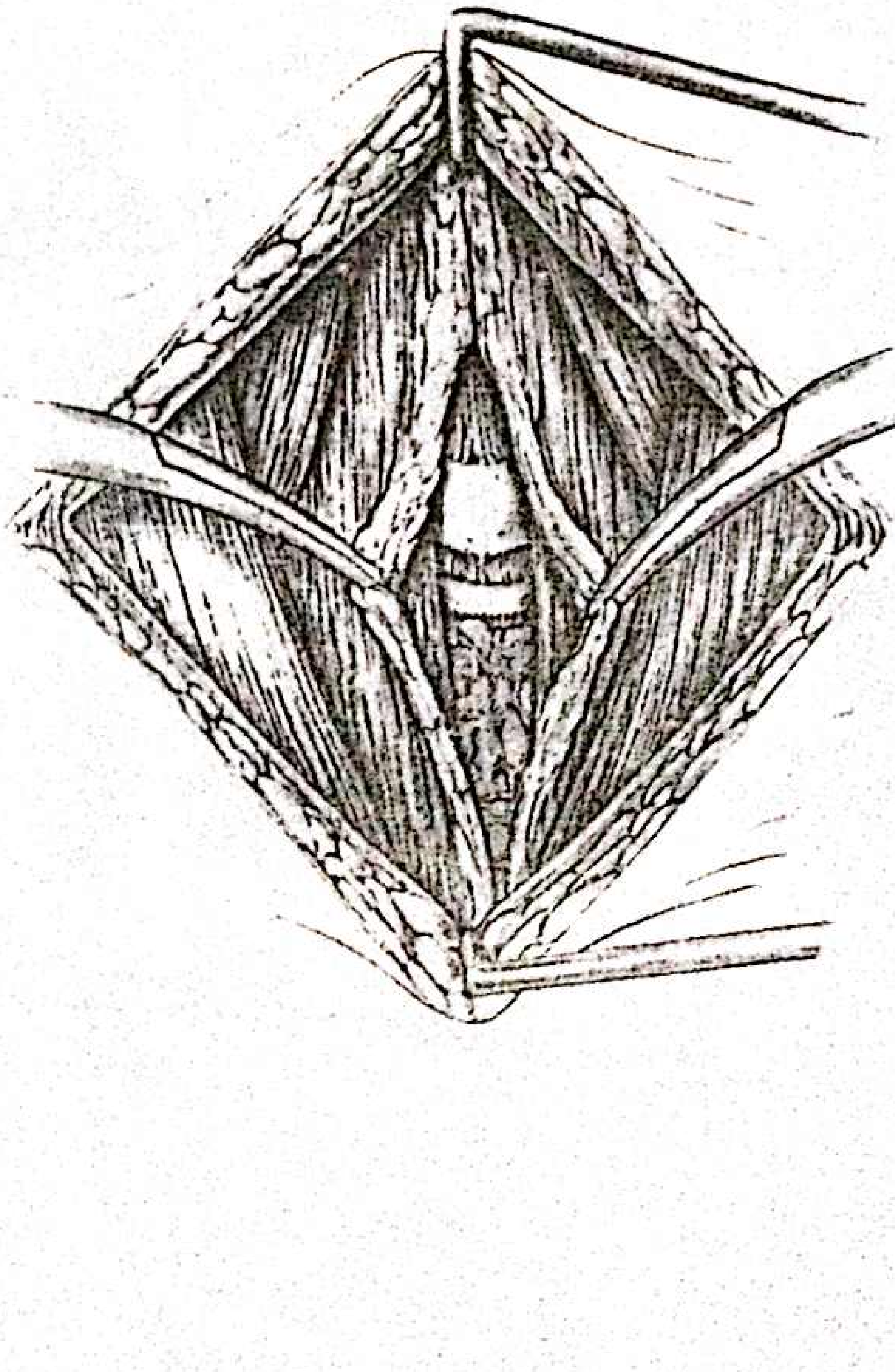


2a

2a & b

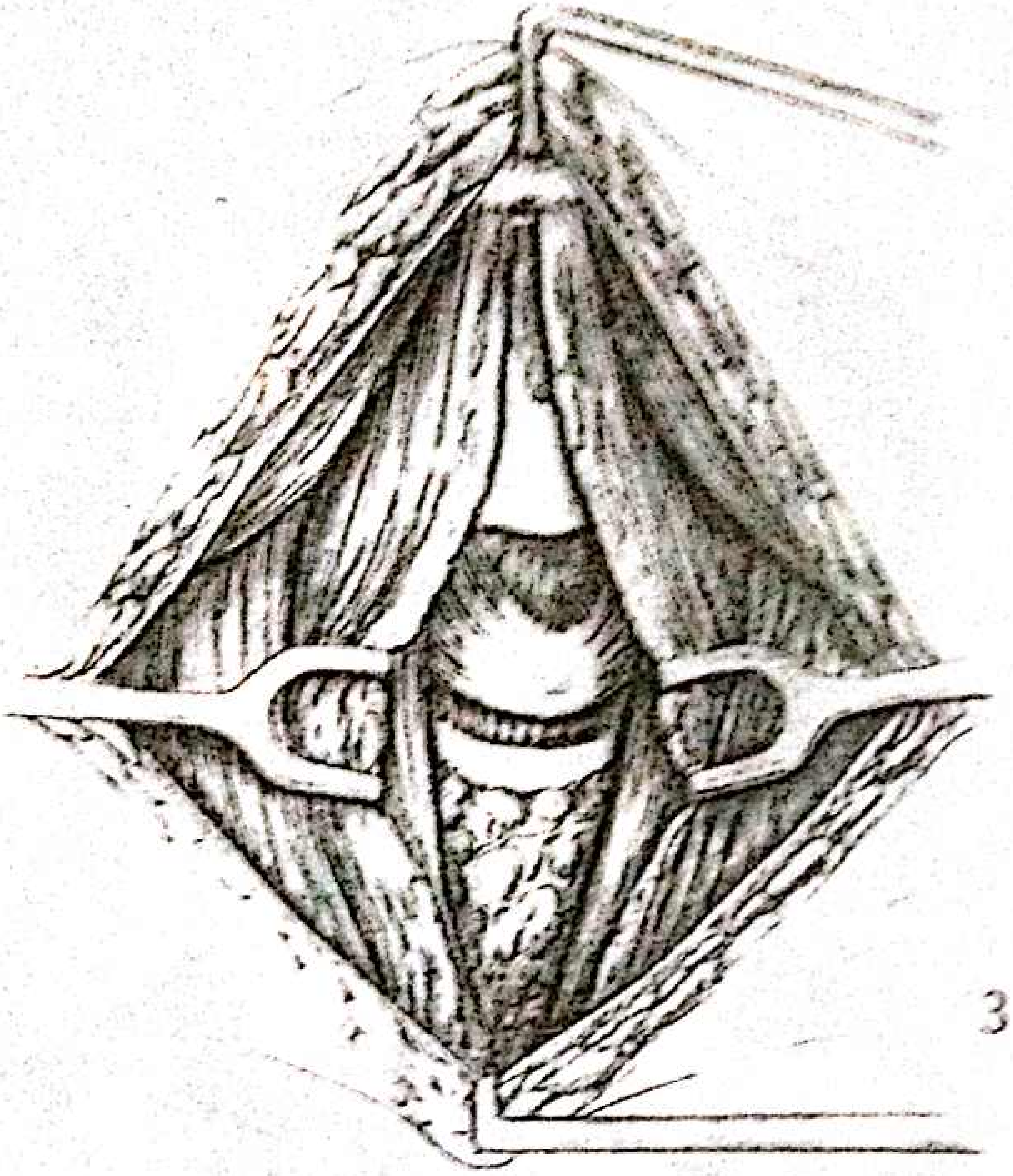
With a combination of sharp and blunt dissection, the superior flap is raised to the level of the thyroid prominence and the inferior flap down to the suprasternal notch. The edges of the wound are held with a self-retaining retractor. The infrahyoid ('strap') muscles are separated in the midline through a long vertical incision from the hyoid bone to the sternal notch.



2b

3

These muscles are retracted laterally.



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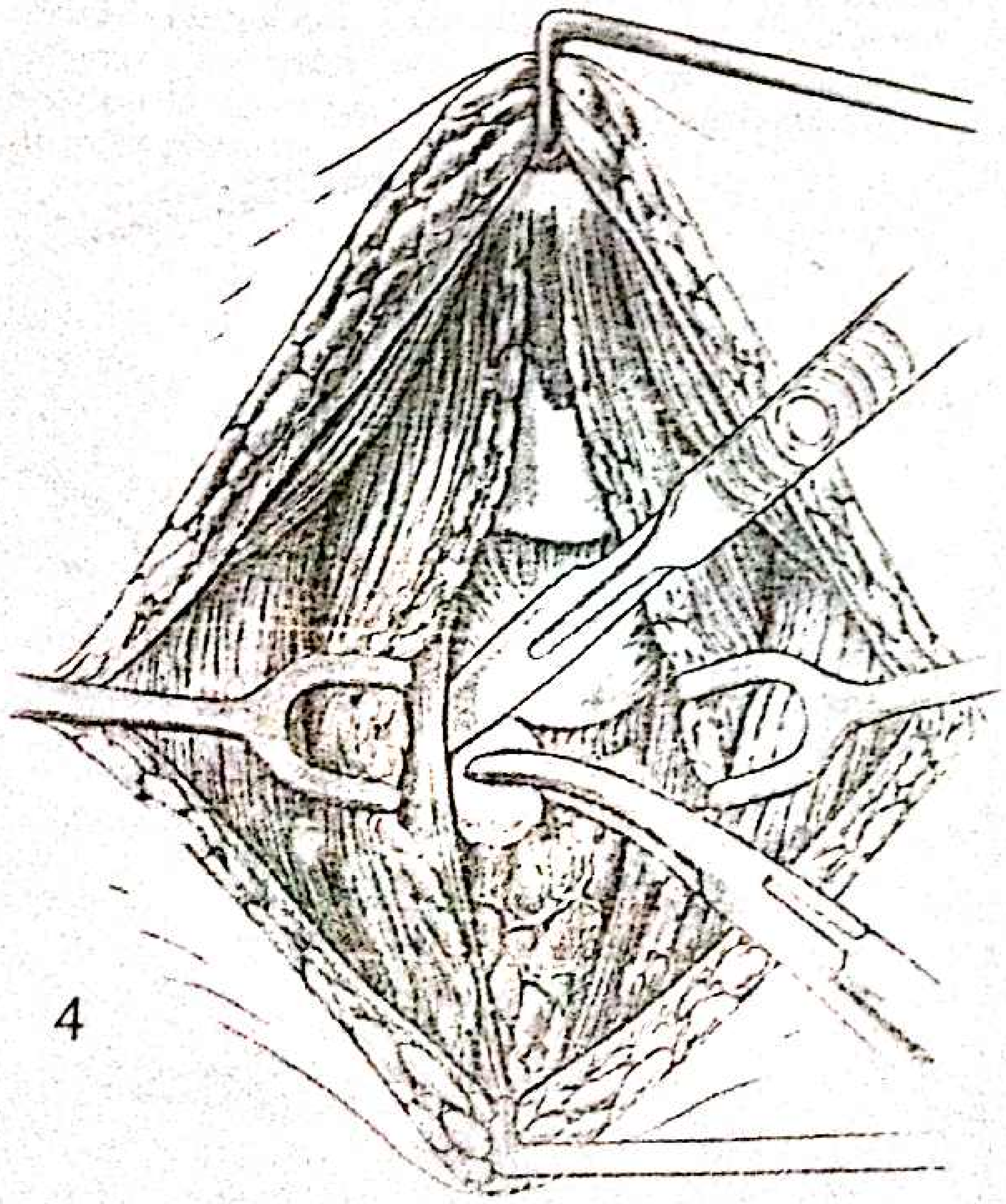


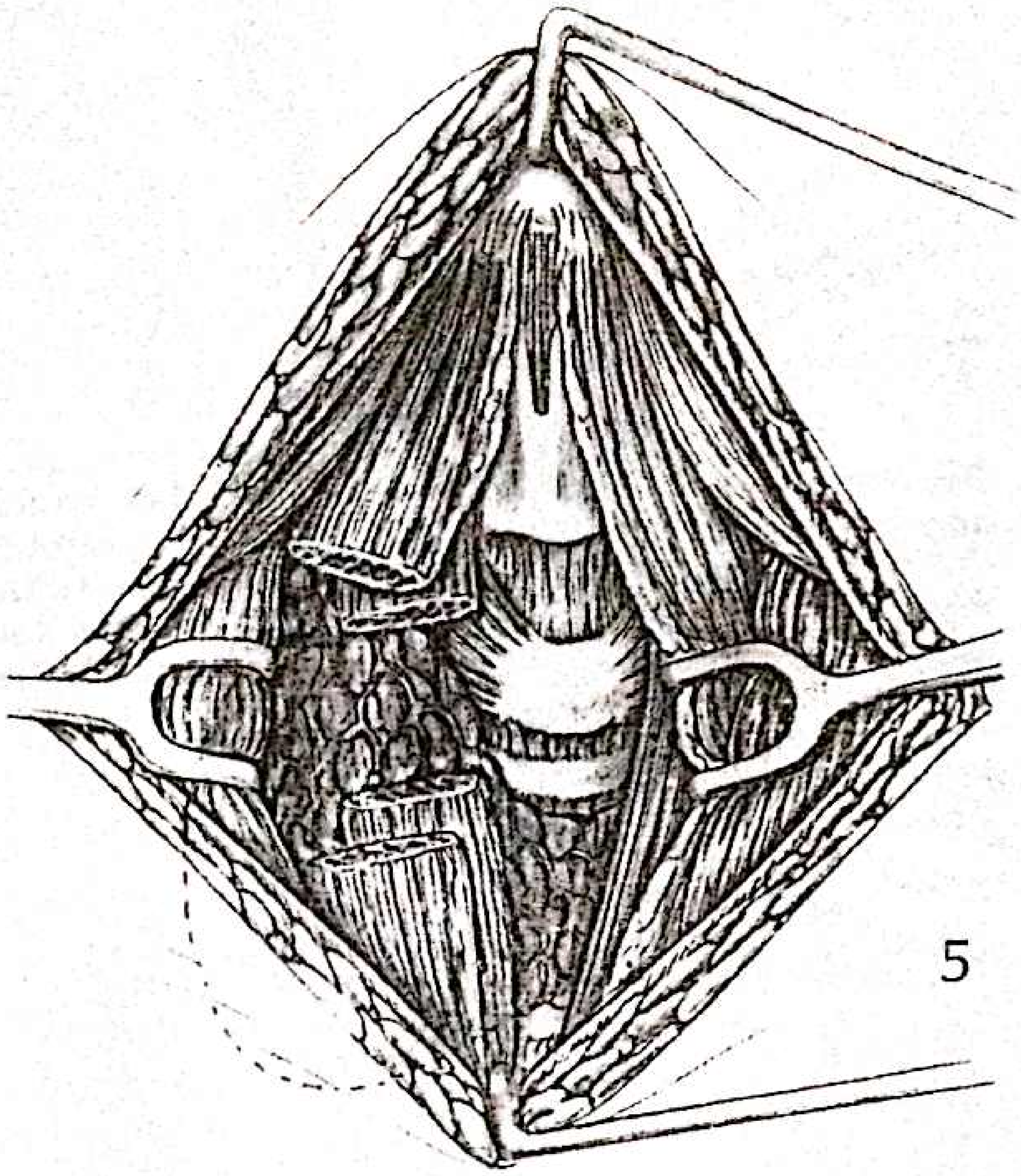
4

4

The deeper sternothyroid muscle is normally slightly adherent to the thyroid capsule and is separated by gentle sharp and blunt dissection.

5

For bulky tumours, the sternohyoid and sternothyroid muscles may be transected. This is performed by first separating the sternomastoid muscle from the strap muscles.



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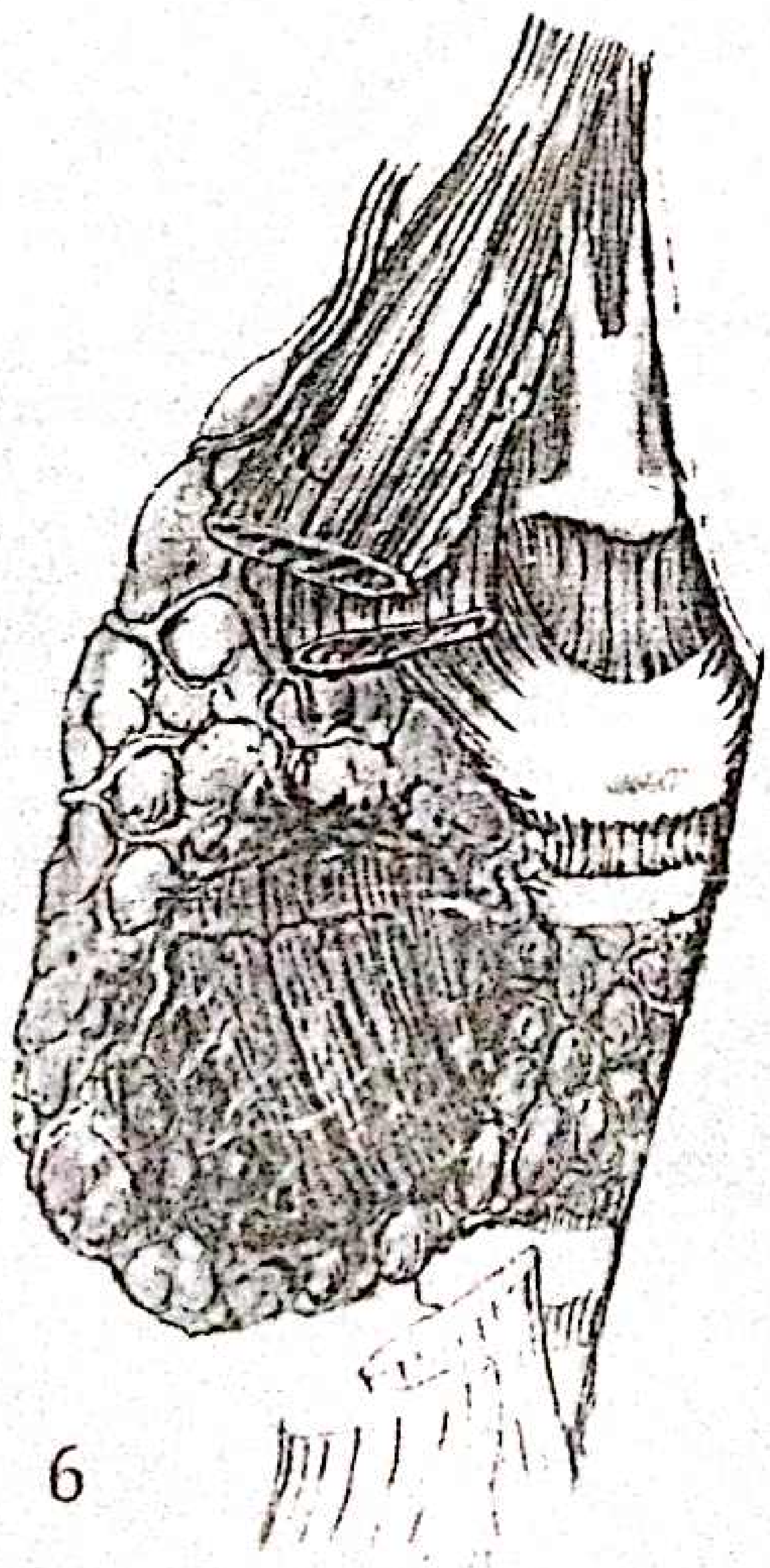


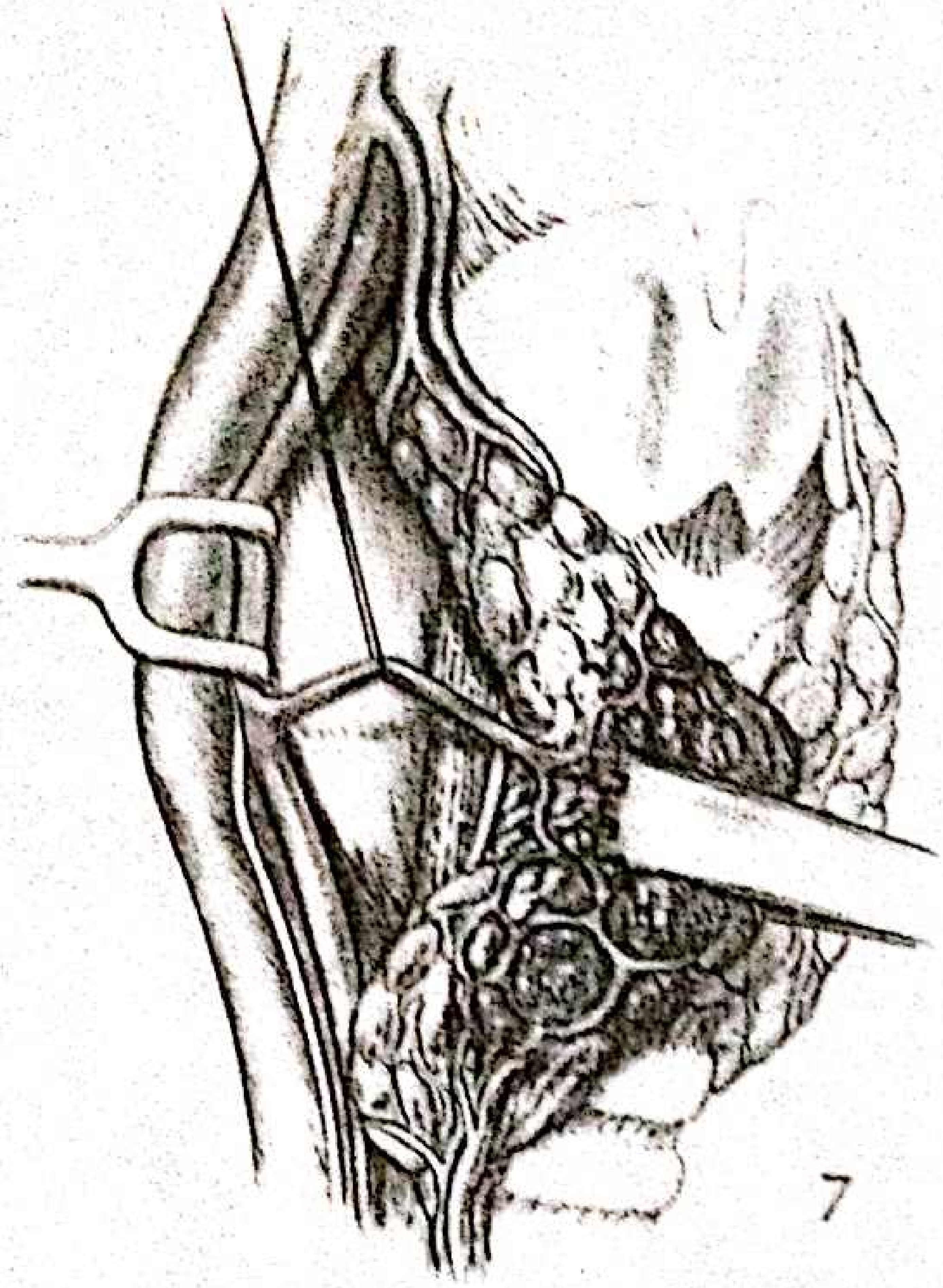
6

6

If the tumour is adherent to the infrahyoid muscles, they are resected in continuity to the specimen.

7

The middle thyroid veins are then divided. The thyroid lobe is retracted medially and separated from the carotid sheath structures. A ligature is passed around the inferior thyroid artery but not tied. This ligature is useful for retraction of the vessel, which aids in identification of the recurrent laryngeal nerve.



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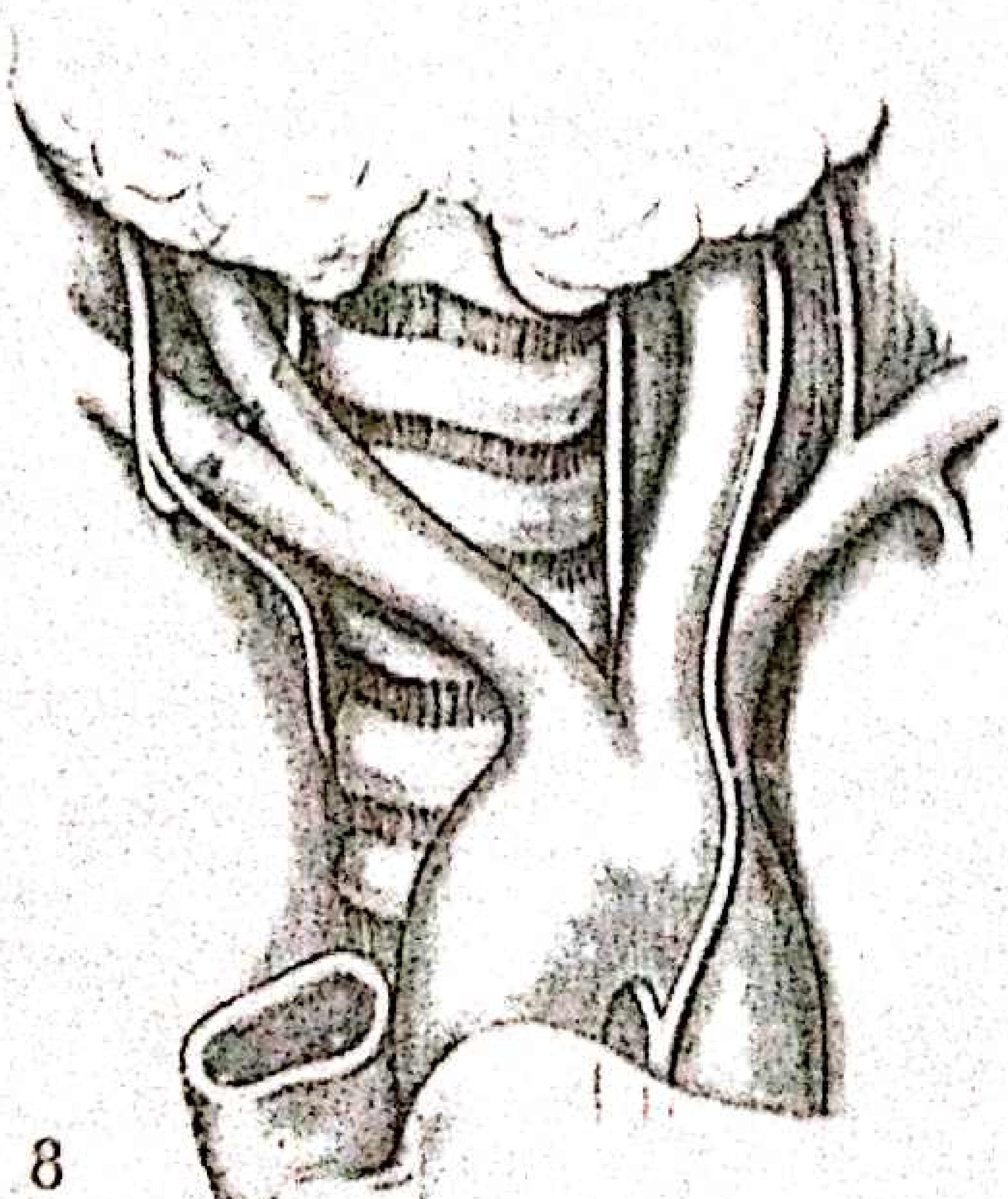


8

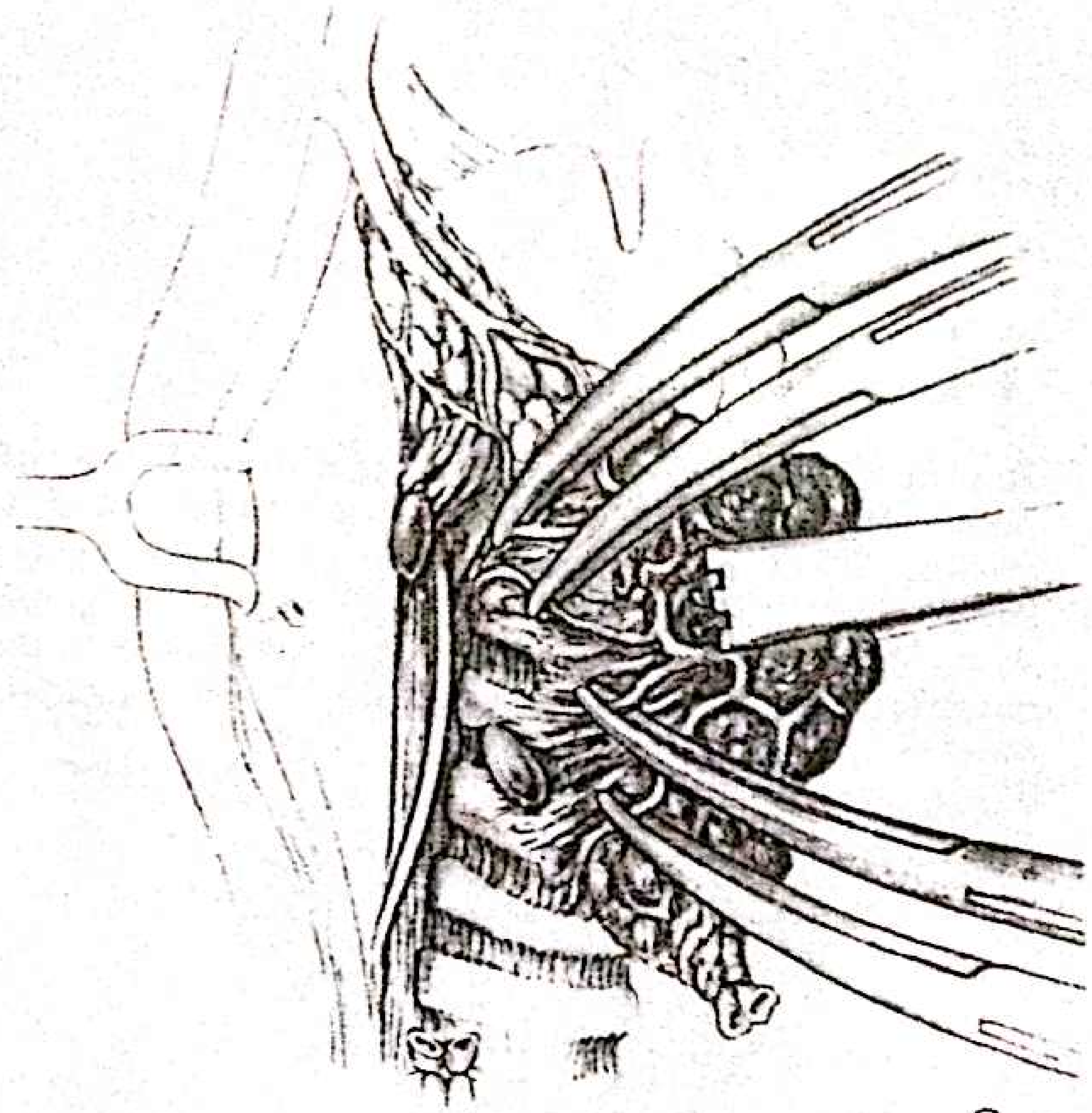
8

The recurrent laryngeal nerve is identified, passing either deep or superficial to the inferior thyroid artery. The left recurrent nerve 'recurs' beneath the aortic arch and ascends in a straight up and down course at the lateral border of the trachea. The right nerve 'recurs' beneath the subclavian artery and approaches the larynx at a slight angle.

After positive identification of the nerve, the ligature around the inferior thyroid artery is tied. On the contralateral side, if bilateral thyroidectomy is performed, the vessel is retracted with an elastic loop, which is not tied, in order to enhance preservation of blood supply to the parathyroid glands.

9

After identification and complete exposure of the recurrent nerve, the superior and inferior parathyroid glands are identified. These glands are separated from the thyroid lobe and retracted laterally whenever possible.



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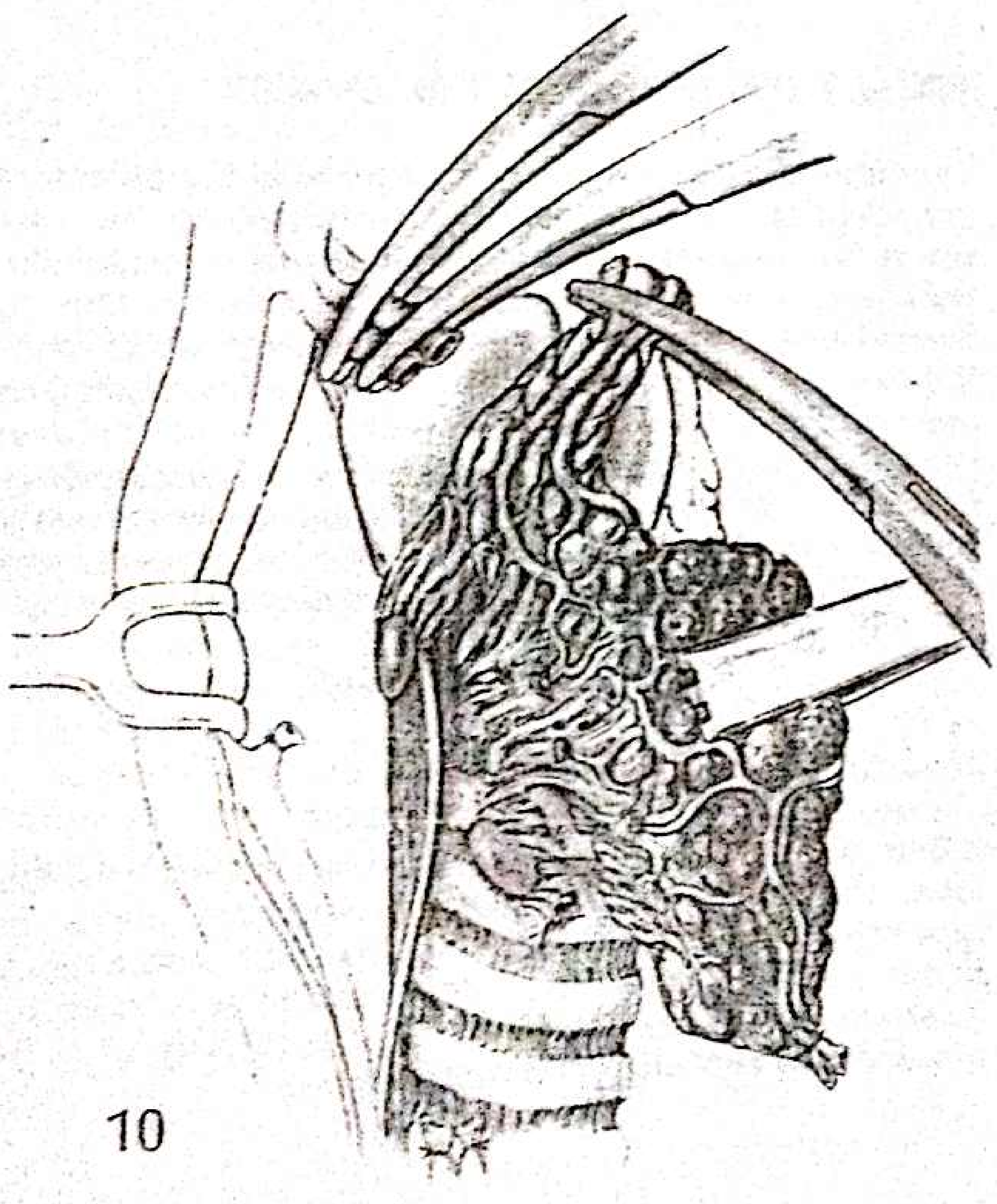

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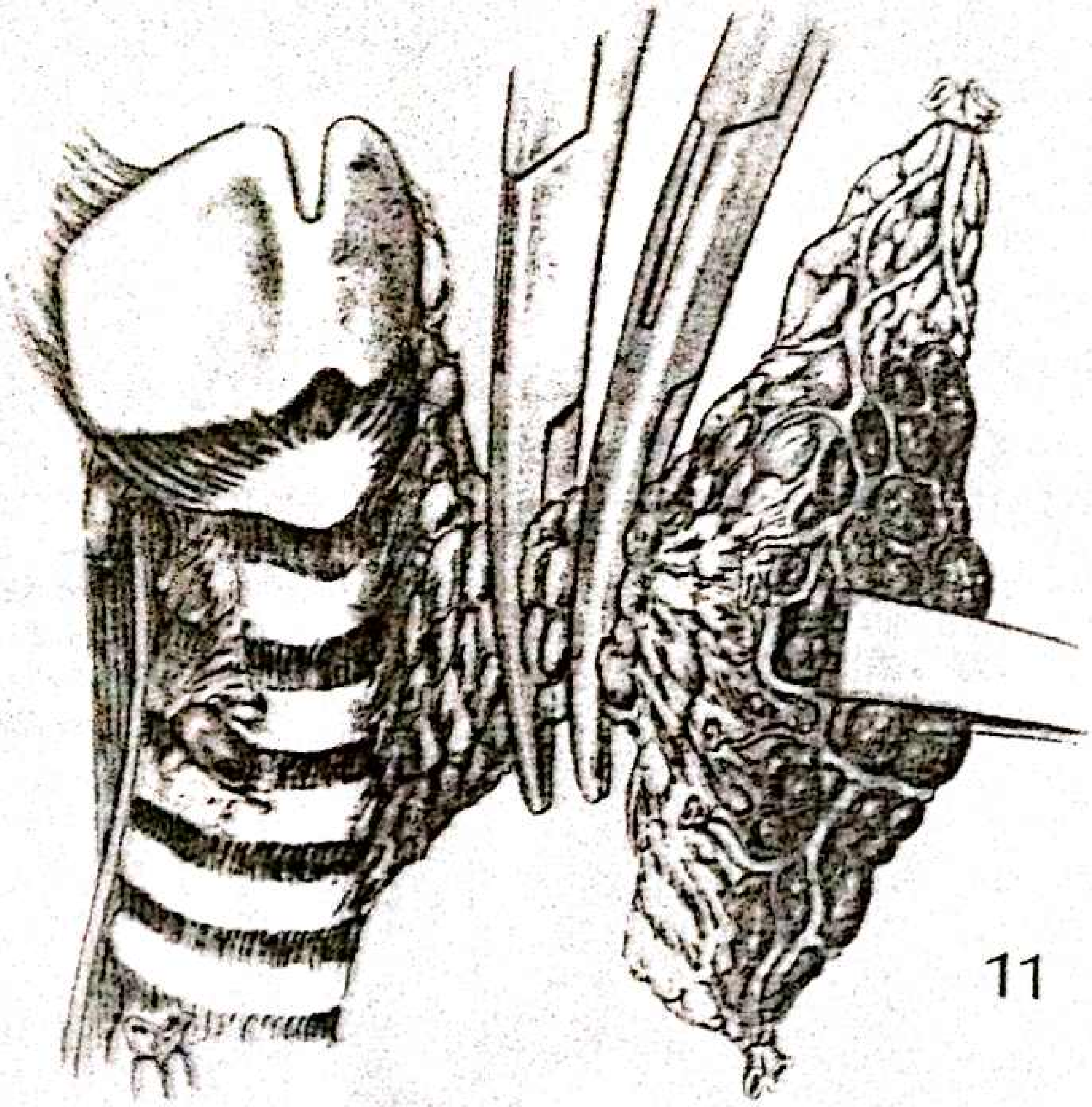
10

When the recurrent nerve and inferior and lateral attachments of the lobe are freed, the superior pole is mobilized and triply clamped, divided and suture ligated.



11

11

The lateral suspensory (Berry's) ligament is now the only remaining substantial attachment of thyroid gland to trachea. This is divided and the thyroid lobe separated from remaining loose attachments to the trachea by gentle sharp dissection. The isthmus is transected close to the contralateral lobe, thus completing the hemithyroidectomy.

TOTAL THYROIDECTOMY FOR CANCER

The cervical incision and exposure for total thyroidectomy are identical to that for hemithyroidectomy. In cases where the diagnosis of cancer has not been established preoperatively and the nodule is confined within the thyroid lobe, a standard hemithyroidectomy is performed. If frozen section reveals a diagnosis of carcinoma, the operation may be extended to include the contralateral lobe and paratracheal and superior mediastinal lymph nodes. Controversies regarding the necessity for resection of the contralateral thyroid lobe in cases of well differentiated carcinoma have been discussed above.

12a

12a & b

When resecting a grossly normal contralateral thyroid lobe, the parathyroid glands are preserved either by separating them from the thyroid lobe with intact blood supply, or by performing 'intracapsular' or 'subtotal' resection of the lobe. Parathyroid tissue may also be preserved by replantation if necessary.

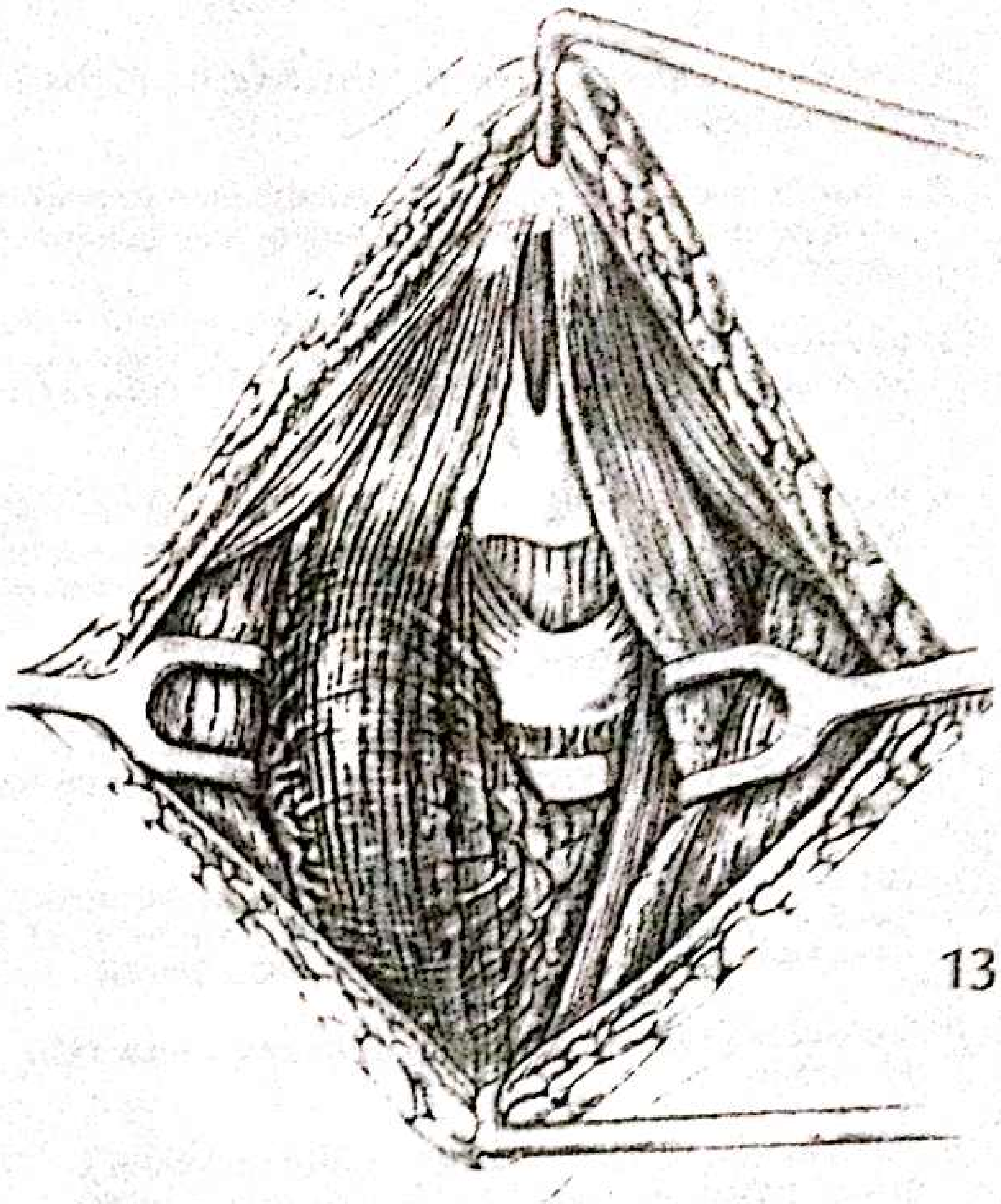
13

For previously diagnosed or strongly suspected thyroid malignancy, a lateral rather than a midline approach may be preferred. This permits assessment of tumour extension into the carotid sheath and facilitates separation of the thyroid lobe from the carotid sheath structures. The sternomastoid muscle is mobilized and retracted laterally and the omohyoid muscle is divided.

The sternohyoid and sternothyroid muscles are transected and overlying portions are left attached to the tumour mass.

A segment of the internal jugular vein may be resected if infiltrated with tumour, but carotid artery involvement is considered a criterion of unresectability. As much ipsilateral paratracheal and superior mediastinal lymphoareolar tissue is resected as possible. The parathyroid glands are preserved when possible, but one or both glands may be sacrificed if they are in close proximity to the tumour. Frozen section biopsy is helpful in distinguishing parathyroid tissue from metastatic lymph node.

The recurrent laryngeal nerve is sacrificed if involved with tumour. If the vocal cord was functioning preoperatively, malignancy is confirmed by frozen section before sacrificing the nerve.



13

SUBTOTAL THYROIDECTOMY FOR HYPERTHYROIDISM

Radioisotope treatment has largely supplanted surgery for diffuse toxic goitre in adults. However, in young individuals and in women of childbearing years, where radioisotope therapy may be undesirable, surgical resection is effective. Surgery is also useful in cases of hyperthyroidism where a potentially malignant nodule is present.

Sufficient thyroid tissue must be removed to ensure cure of the hyperthyroidism. While postoperative hypothyroidism can be managed easily with thyroid hormone replacement, persistent hyperthyroidism requires either reoperation or radioisotope treatment. Bilateral 'total' thyroidectomy carries too great a risk of hypoparathyroidism. Bilateral 'subtotal' thyroidectomy has traditionally been the standard operation for hyperthyroidism. However, it may be preferable to resect one lobe in its entirety, with subtotal resection of the other lobe. In this way, only unilateral reoperation would be necessary in the event of recurrent hyperthyroidism.

In subtotal thyroidectomy a small amount of posterior capsule and thyroid tissue is preserved, along with the inferior thyroid artery and parathyroid glands (see *Illustration 12b*).

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Parathyroid glands

Carl E. Silver MD, FACS
Professor of Surgery and Professor of Otolaryngology, Albert Einstein College of Medicine and Director of Head and Neck Surgery, Montefiore Medical Center, New York, USA

Robert J. Cusumano MD
Assistant Professor of Otolaryngology, Albert Einstein College of Medicine, Montefiore Medical Center, New York, USA

Introduction

Hyperparathyroidism, in recent years, has been encountered with increasing frequency by the medical profession. Primary hyperparathyroidism is often detected at an early stage by automated serum calcium determination. Secondary hyperparathyroidism is seen in a large group of anephric patients maintained by renal dialysis. Accurate and readily available parathyroid hormone assay enables accurate diagnostic confirmation of a disease that in the past could only be suspected on the basis of indirect evidence. Procedures of varying sophistication and accuracy may be employed for localization of lesions that are almost never detectable on physical examination or routine radiographic studies.

Indications

Surgical treatment should be considered for all patients with well documented primary hyperparathyroidism who present acceptable risk for operation. Some clinicians have advocated observation without surgery for 'asymptomatic' patients with minimal hypercalcaemia. This approach may be desirable for patients who cannot undergo surgery with acceptable risk, or for truly asymptomatic patients with calcium levels consistently under 11.0 mg/dl. Most patients with hyperparathyroidism, however, when carefully questioned will admit to some degree of subtle symptomatology, and may have developed early secondary physical manifestations such as skeletal demineralization, detectable only by special diagnostic procedures. These factors, together with the high success rate and low morbidity of the procedure, justify operation in most 'asymptomatic' patients who are in good general health.

Adequate documentation of hyperparathyroidism includes persistent serum calcium levels of 10.6 mg/dl or higher combined with inappropriately high parathyroid hormone levels. Common symptoms of hyperparathyroidism include lethargy, weakness and bone pain.

The indications for surgery in secondary hyperparathyroidism are controversial and beyond the scope of this discussion. Most patients with secondary hyperparathyroidism for whom surgery is recommended have severe renal osteodystrophy.

Localization studies

Many localization studies have been employed for preoperative identification of parathyroid disease. While non-invasive imaging modalities, such as computed tomographic (CT) scanning and ultrasonography, are limited by low sensitivity, thallium technetium subtraction scanning is accurate for detection of lesions that weigh more than 300 mg and is finding increasing acceptance as a preoperative test. 'Invasive' procedures, such as arteriography and selective vein catheterization with determinations of parathyroid hormone levels from various sites, can accurately localize parathyroid lesions in approximately 80 per cent of cases. These procedures, however, are not indicated before initial exploration because of significant morbidity and the high surgical success rate without them. Angiography and vein catheterization are extremely useful for parathyroid localization in recurrent or persistent hyperparathyroidism following previous surgery.

Pathology

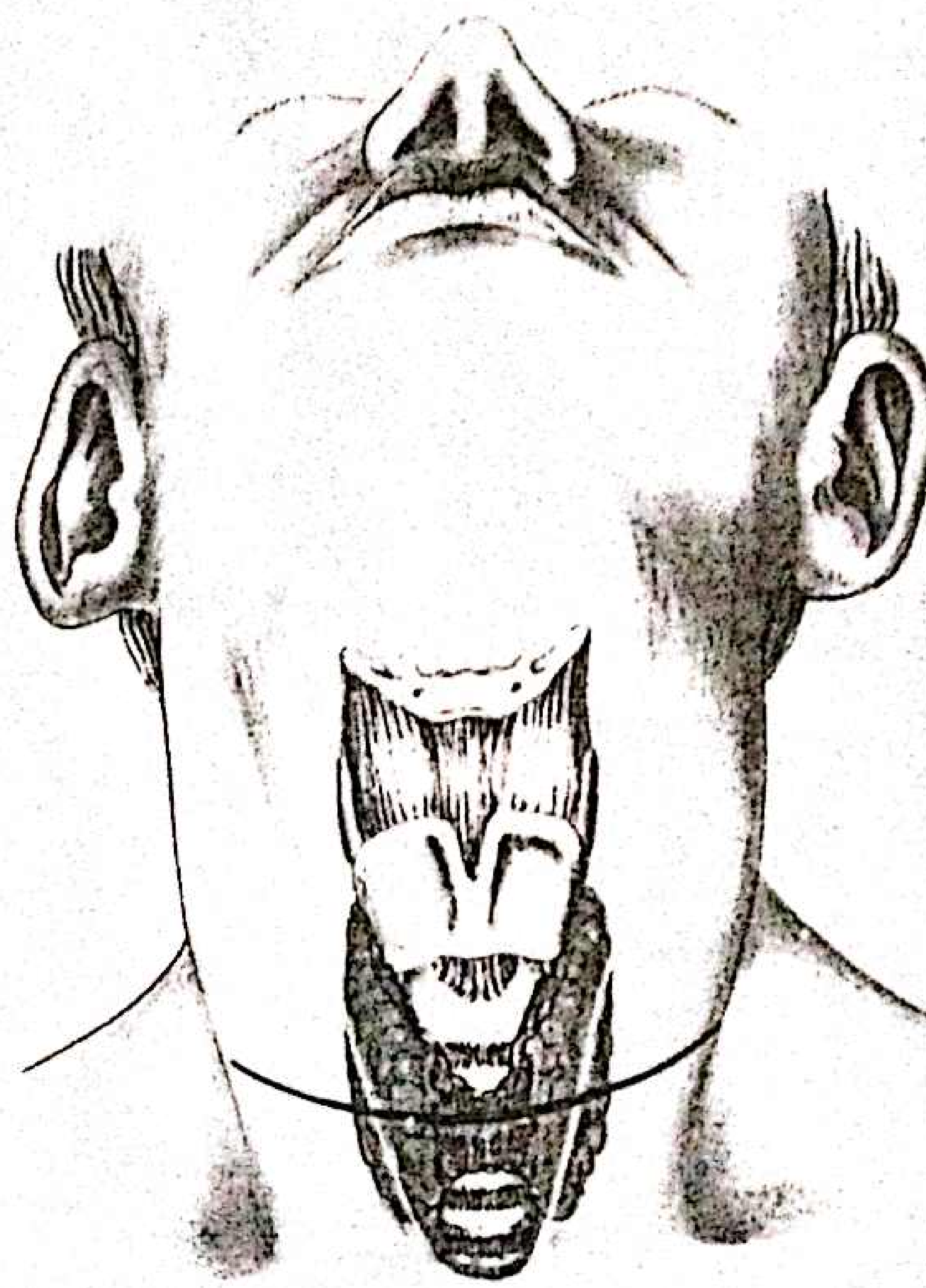
The distinction between 'adenoma' and 'hyperplasia' is not as clear as was previously believed. Although the majority of patients with primary hyperparathyroidism have a single enlarged (over 100 mg) abnormal gland, approximately 25 per cent of hyperparathyroid patients have two, three or four grossly and/or microscopically abnormal glands. Significant microscopic abnormalities include absent intracellular fat, hypercellularity and microscopic nodularity. Subtle microscopic abnormalities, such as diminished extracellular fat and an apparent preponderance of oxyphil cells, are of questionable physiological significance. Patients with gross and microscopic abnormalities of all four glands have generalized parathyroid hyperplasia. This is usually seen in secondary hyperparathyroidism as well as multiple endocrine neoplasia and other varieties of familial hyperparathyroidism.

Parathyroid carcinomas are extremely uncommon. They are distinguished from benign lesions by their local invasiveness, since the cytological differences between benign and malignant parathyroid tumours may be difficult to discern on frozen section.

Extent of tissue resection

Most surgeons agree that the incidence of multiple parathyroid lesions is sufficiently high to warrant bilateral exploration of parathyroid tissue in all patients. We recommend biopsy of all glands for unequivocal identification, to detect microscopically abnormal glands, and for histological documentation in the event that re-exploration becomes necessary.

In cases of primary hyperparathyroidism, all enlarged abnormal glands are resected, whereas glands which are grossly and histologically normal are left *in situ*. Normal size glands with significant microscopic abnormalities should be excised, while grossly normal glands with minimal histological aberrations, as discussed above, are left *in situ*. Subtotal parathyroidectomy is the usual treatment for diffuse hyperplasia. Total parathyroidectomy with autotransplantation of a small quantity of parathyroid tissue into the forearm may be preferred for patients at high risk for recurrence. This includes younger patients with four large glands, patients with familial hyperparathyroidism and the multiple endocrine neoplasia syndromes, and patients with secondary hyperparathyroidism. Placement of the graft in the forearm will eliminate the need for cervical re-exploration in cases of graft-dependent recurrence.



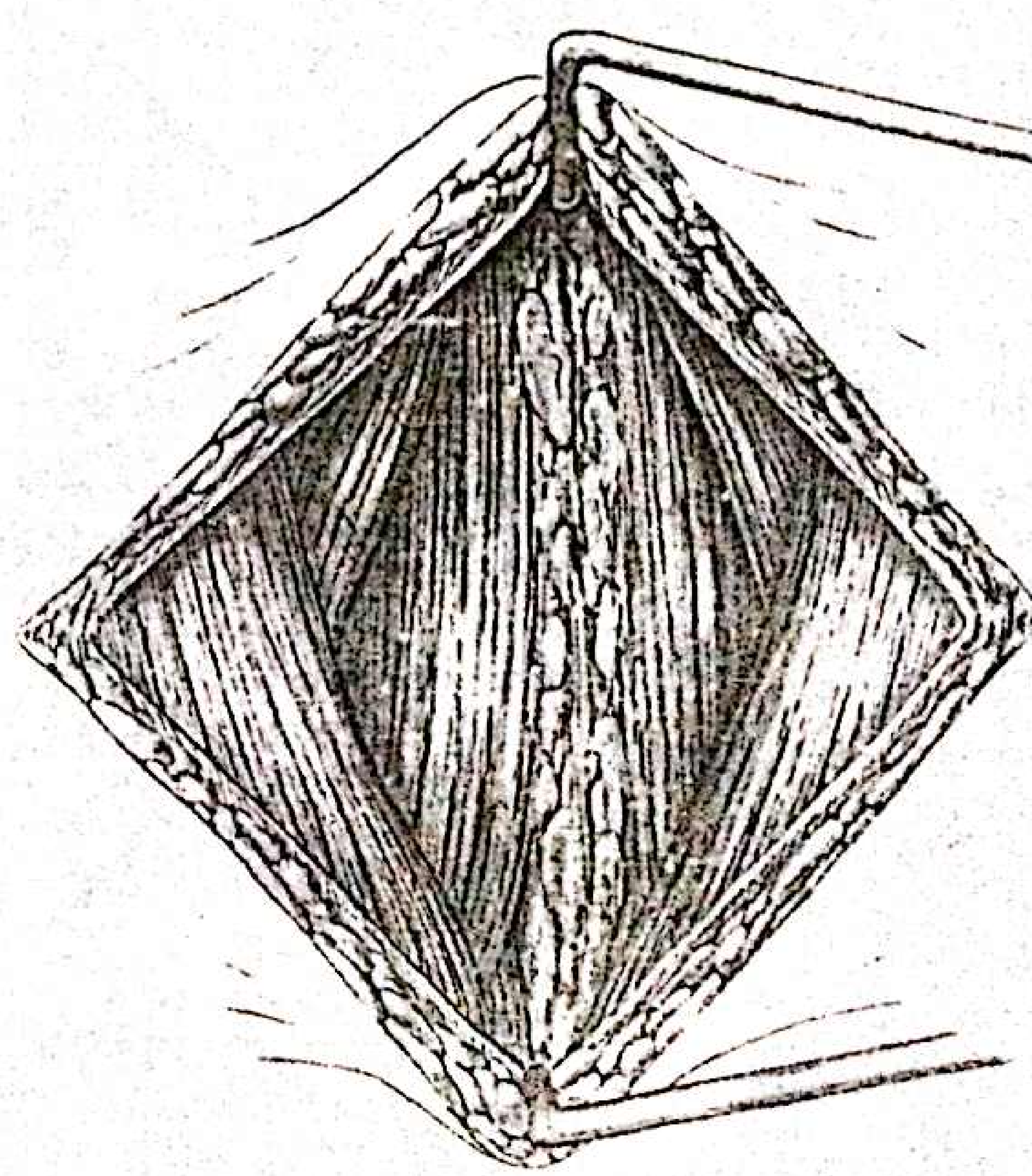
1a

Operation

Parathyroid exploration

1a & b

The incision for cervical parathyroid exploration is placed transversely, preferably in a natural skin crease at the level of the thyroid isthmus. Inferior and superior skin flaps are elevated in the subplatysmal plane.



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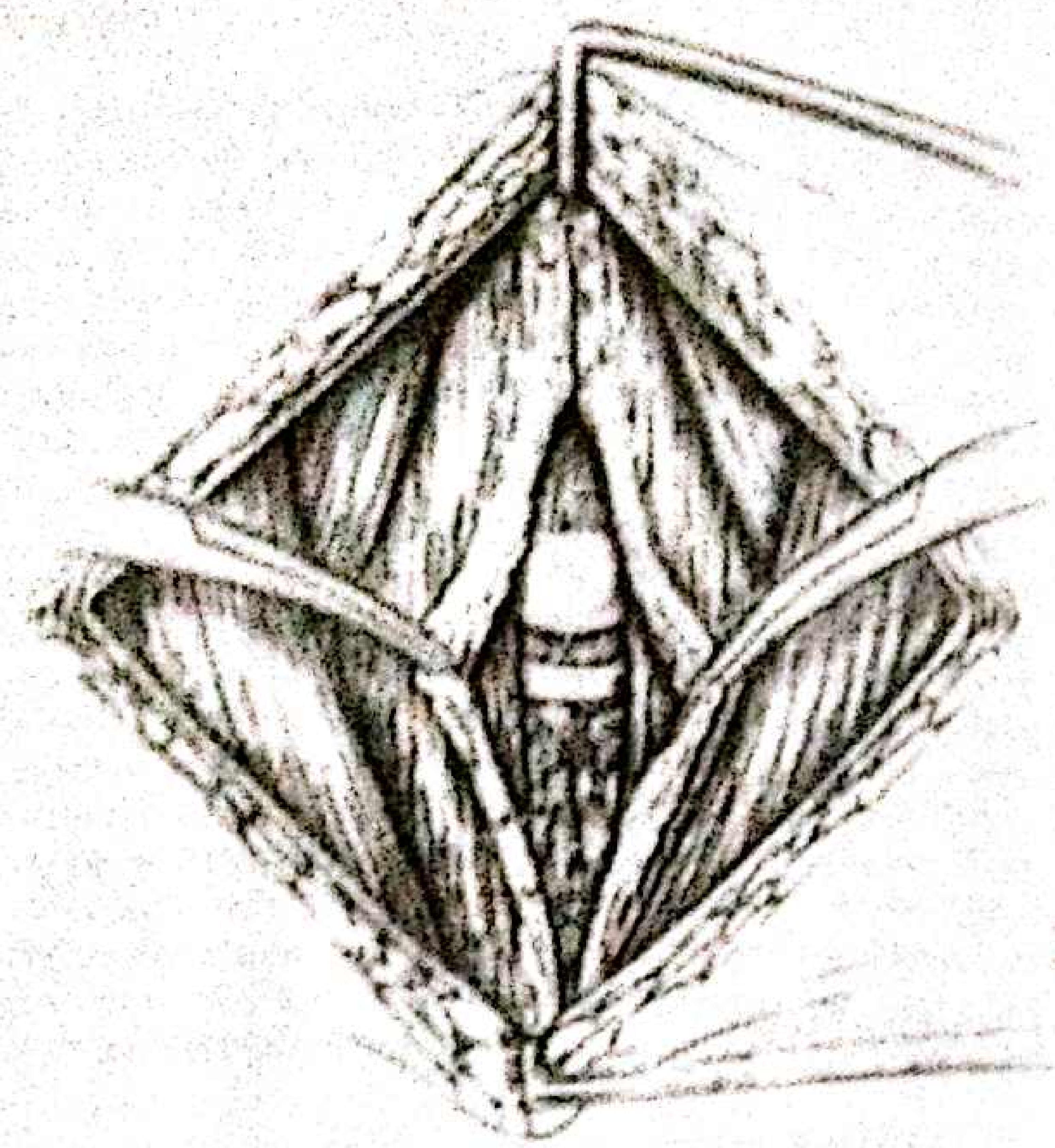
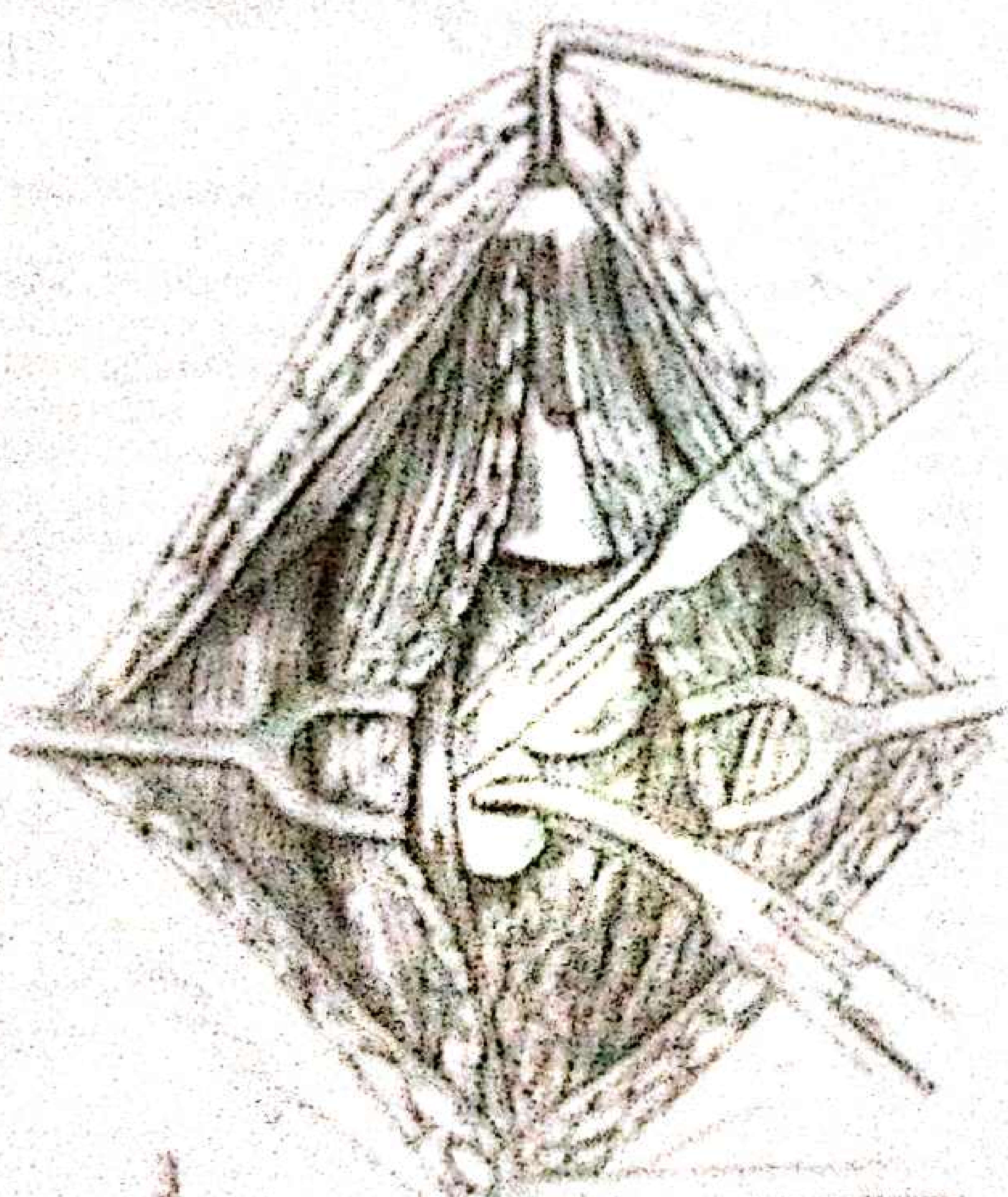


2

2

The infrahyoid muscles are separated by midline vertical incision.



3

3

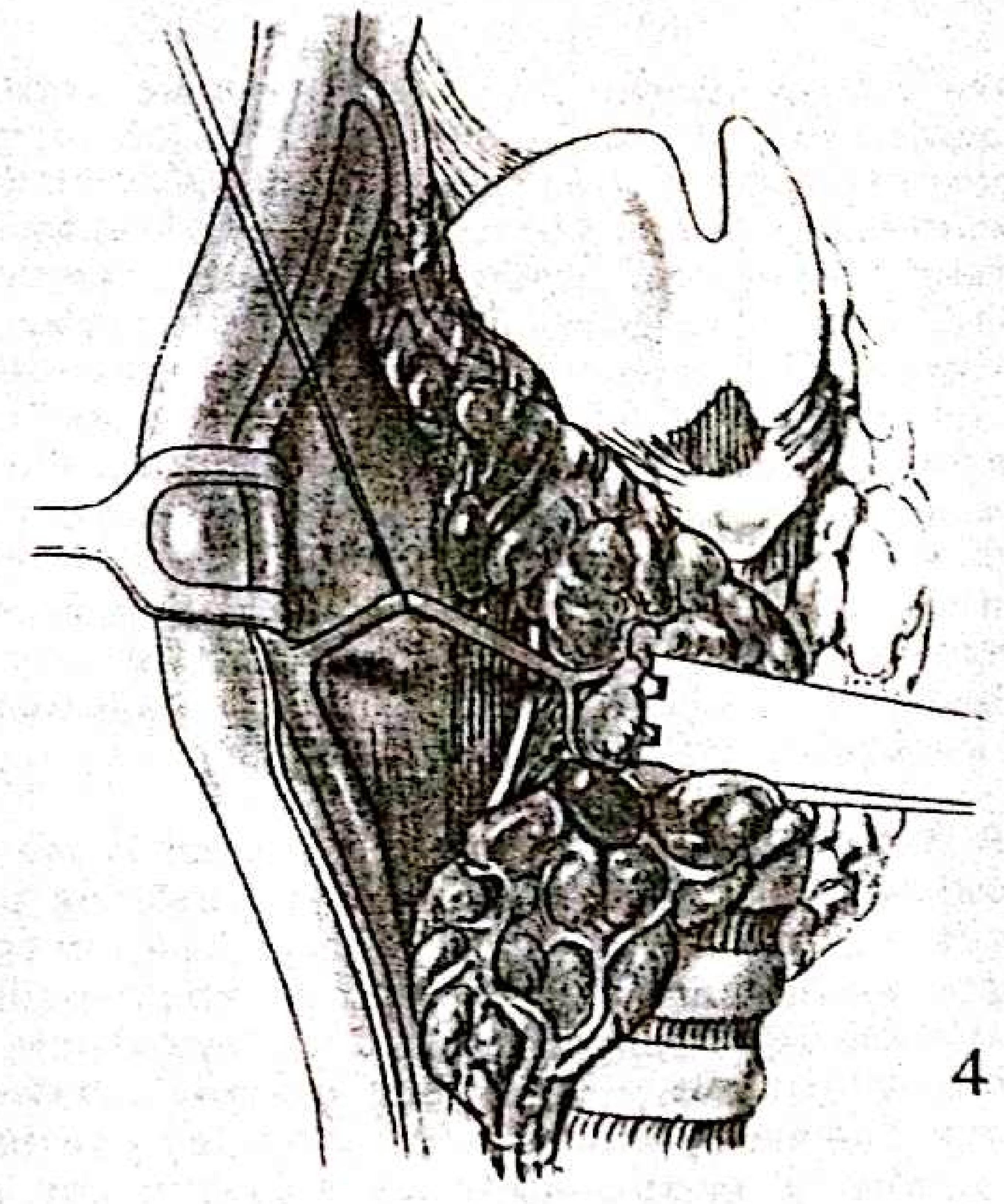
The muscles are retracted laterally, while the thyroid lobe on the side to be explored is separated from its overlying sternothyroid muscles.

4

The thyroid lobe is retracted medially and the infrahyoid muscles are retracted laterally or divided. Areolar tissue between the larynx and carotid sheath is bluntly dissected. The inferior thyroid artery (ITA) is identified and mobilized and the recurrent laryngeal nerve (RLN) is exposed throughout its course.

The parathyroid glands are normally located on the posterolateral surface of the thyroid gland. The superior parathyroid gland is usually situated lateral to the RLN and superior to the ITA. The inferior parathyroid gland is usually located medial to the RLN and inferior to the ITA.

Normal glands are beige in colour and oblong in shape, while abnormal glands are often a darker shade of brown, larger and more spherical.



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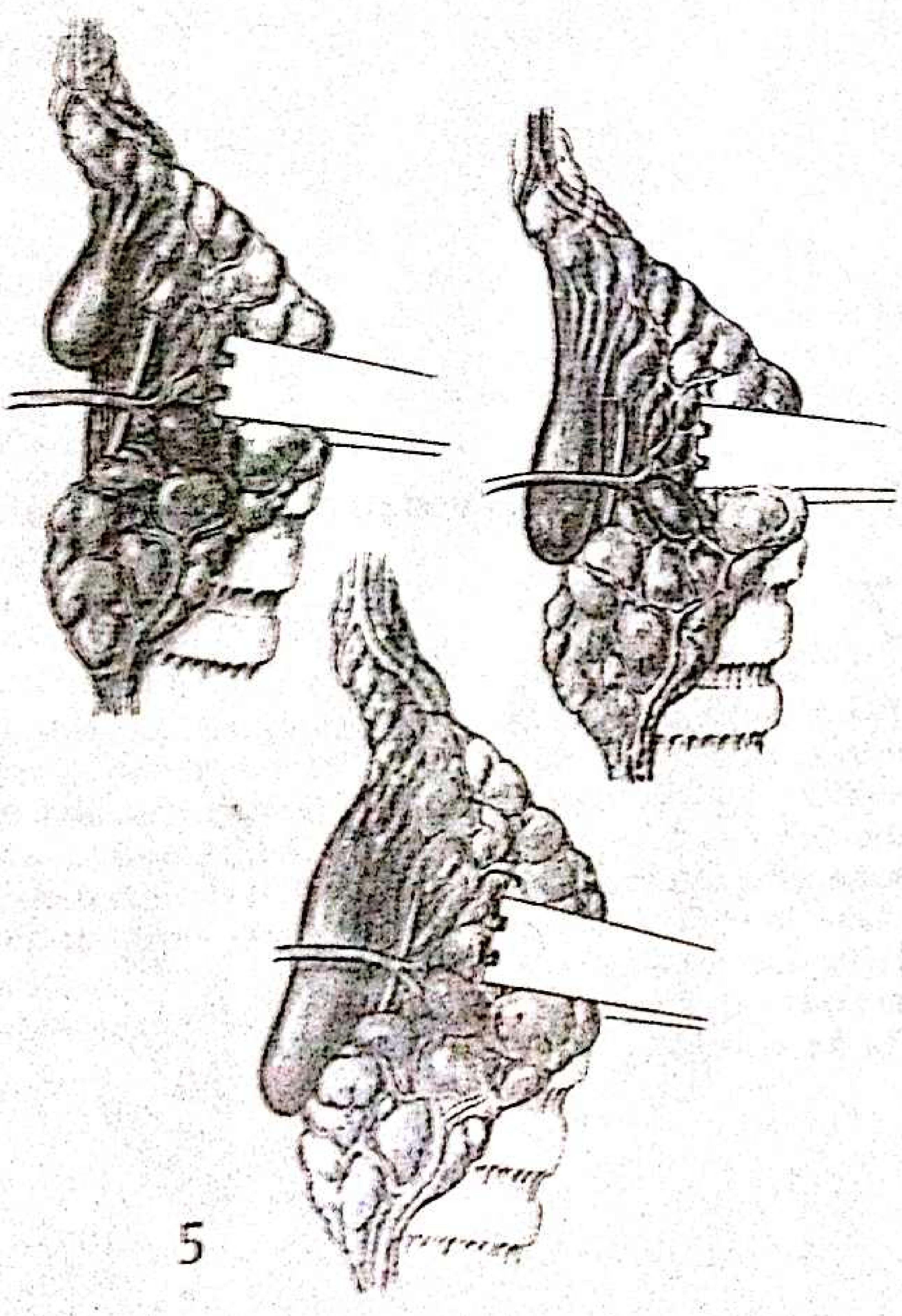


5

5

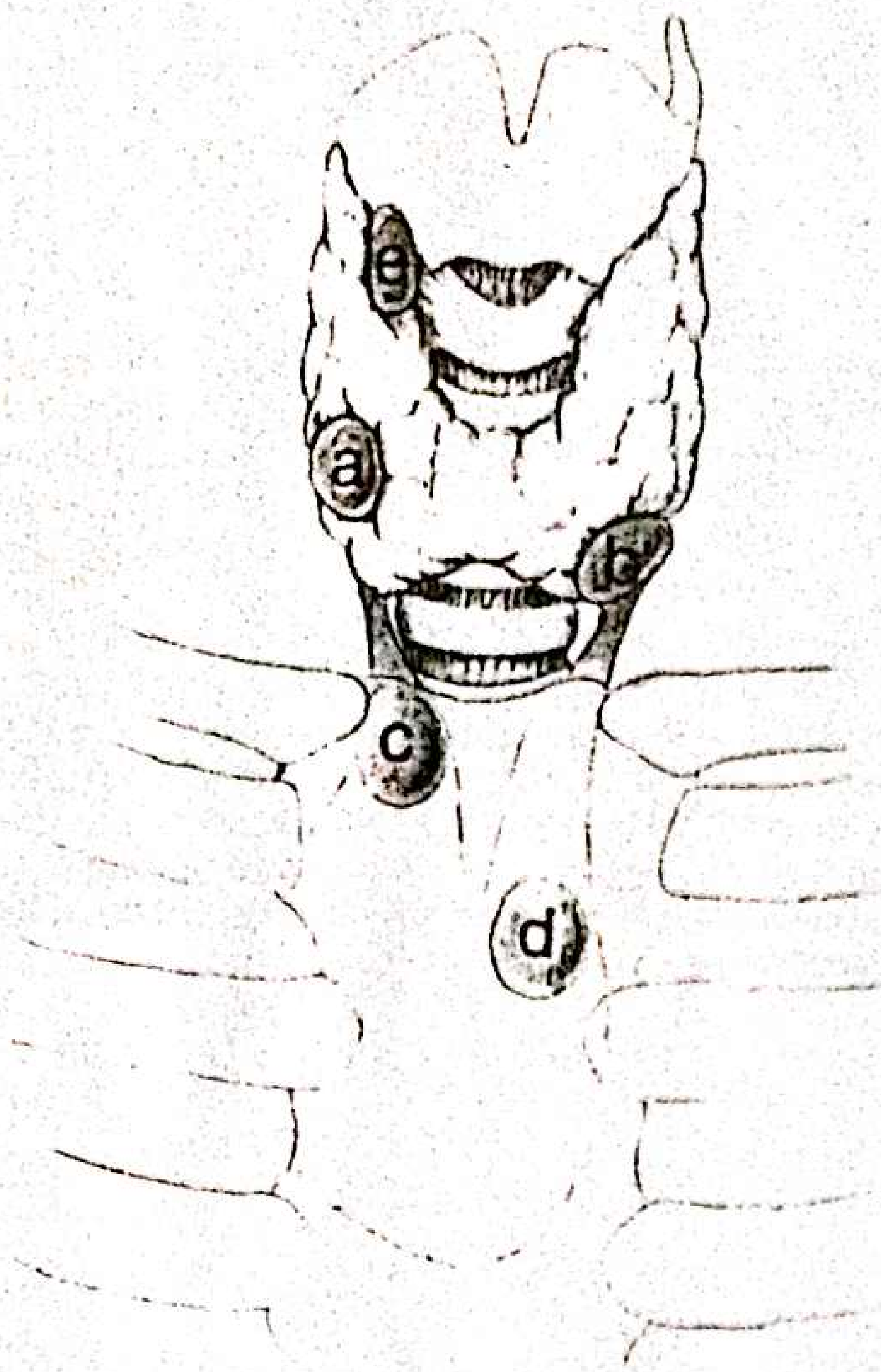
The superior parathyroid glands are usually more constant in location and easier to identify than the inferior glands. Superior parathyroid lesions of various sizes are shown here. As the superior parathyroid gland enlarges, it follows the path of least resistance and may descend in a prevertebral plane deep to the ITA. It may be seen bulging through the fascia after the thyroid gland has been mobilized. It may also be in a retro-oesophageal location, or descend into the posterior mediastinum.

6

The inferior parathyroid glands are more variable in location than the superior glands. The inferior glands originate from the same embryonic anlage as the thymus (third pharyngeal pouch) and may be situated anywhere along the embryonic course of descent of the thymus. Additionally, mechanical factors come into play as an enlarged gland expands along the path of least resistance.

Inferior parathyroid lesions are usually located medial to the RLN and inferior to the ITA (a). They are also often located in the thyrothymic ligament at the inferior thyroid pole (b), within the thymic capsule inferior to the thyroid gland (c), or substernally in the superior mediastinum (d). Occasionally, an inferior parathyroid gland may have failed to descend and may be situated at the superior pole of the thyroid (e).

If the parathyroid glands are not found in the usual locations, the search is extended by exploring and, if necessary, resecting thymic tissue from the lower cervical region and superior mediastinum. The retro-oesophageal area is also explored, as is the superior thyroid pole. Both thyroid lobes are inspected for an intracapsular lesion. We do not, however, perform hemithyroidectomy on the side of a 'missing' parathyroid gland. Manubriotomy is not performed at initial exploration unless a parathyroid lesion is known to be present beneath the sternum and cannot be safely resected through a cervical approach. If a cervical parathyroid tumour is not found, exploration is terminated. The patient is then evaluated for persistent hyperparathyroidism and, if necessary, will undergo further localization studies and re-exploration.



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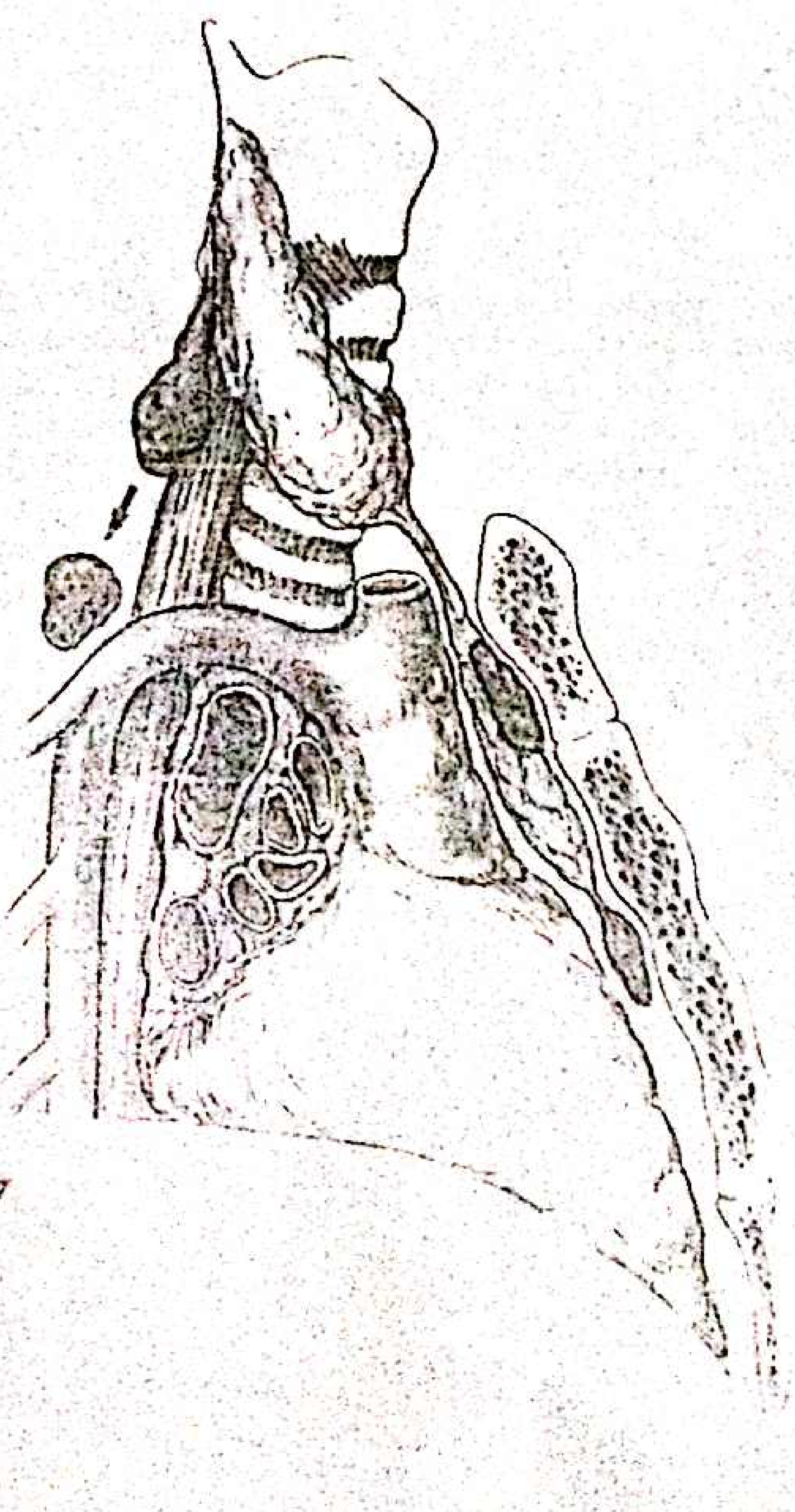


7

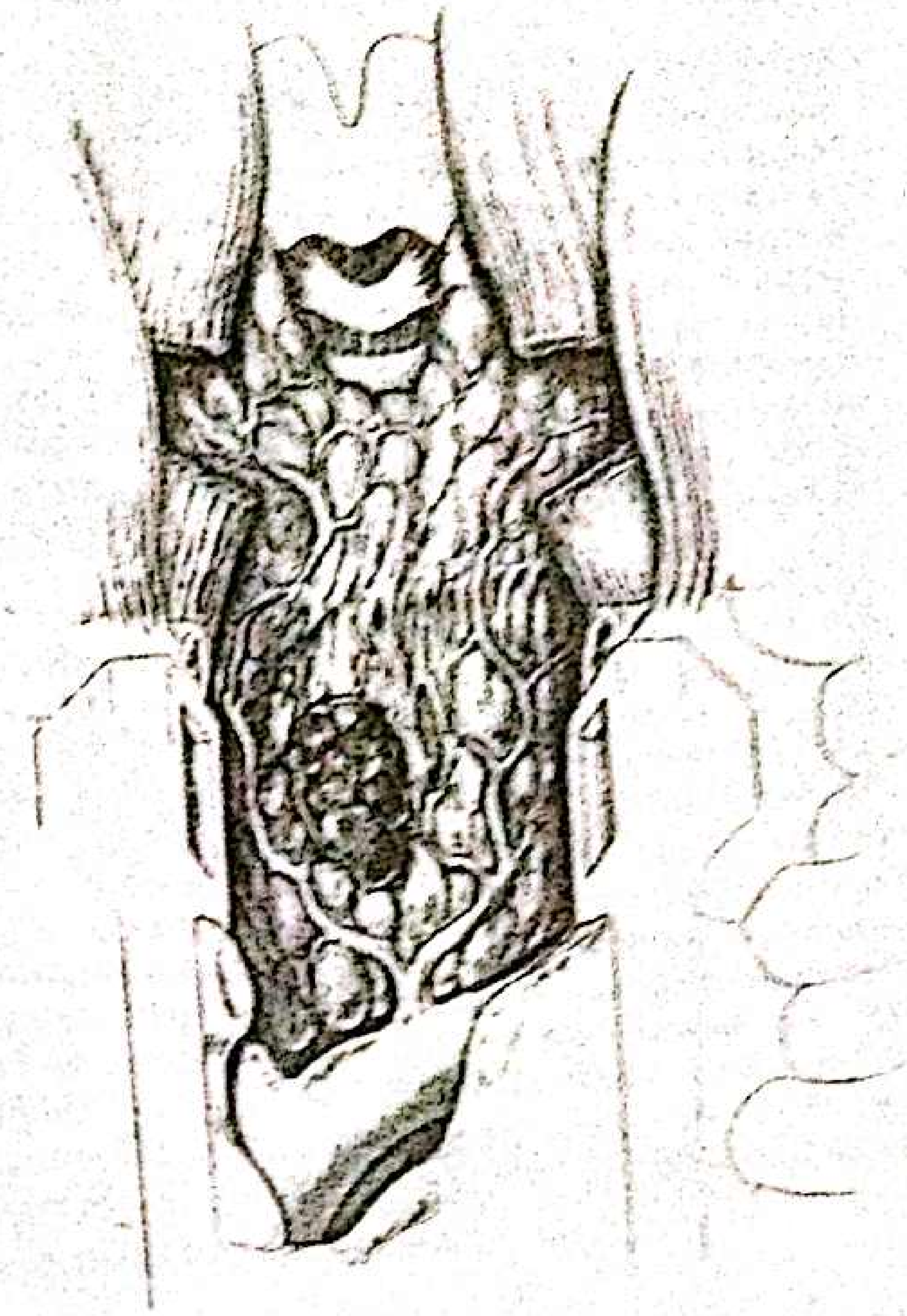
Management of mediastinal parathyroid lesions

7

The different paths of descent taken by the superior and inferior parathyroid glands determine their location in the mediastinum. Inferior parathyroid lesions descend into the substernal region or superior mediastinum, while superior parathyroid lesions descend in the prevertebral plane into the posterior mediastinum. Most of these lesions can be excised through a purely cervical approach. Lesions requiring manubriotomy or thoracotomy account for fewer than 5 per cent of all cases.

8

Intrathymic lesions of the inferior parathyroid gland can usually be removed through a cervical approach. Occasionally a trans-sternal approach, as shown here, is required for a lesion deep in the superior mediastinum. On extremely rare occasions, a superior parathyroid lesion may descend deeply into the posterior mediastinum and require posterolateral thoracotomy for access.



8

Management of parathyroid hyperplasia

Diffuse parathyroid hyperplasia is treated by either subtotal parathyroidectomy (STP) or total parathyroidectomy with autotransplantation (TPA). The objective is to correct the symptoms of hypercalcaemia by removing parathyroid tissue, but to prevent permanent hypoparathyroidism.

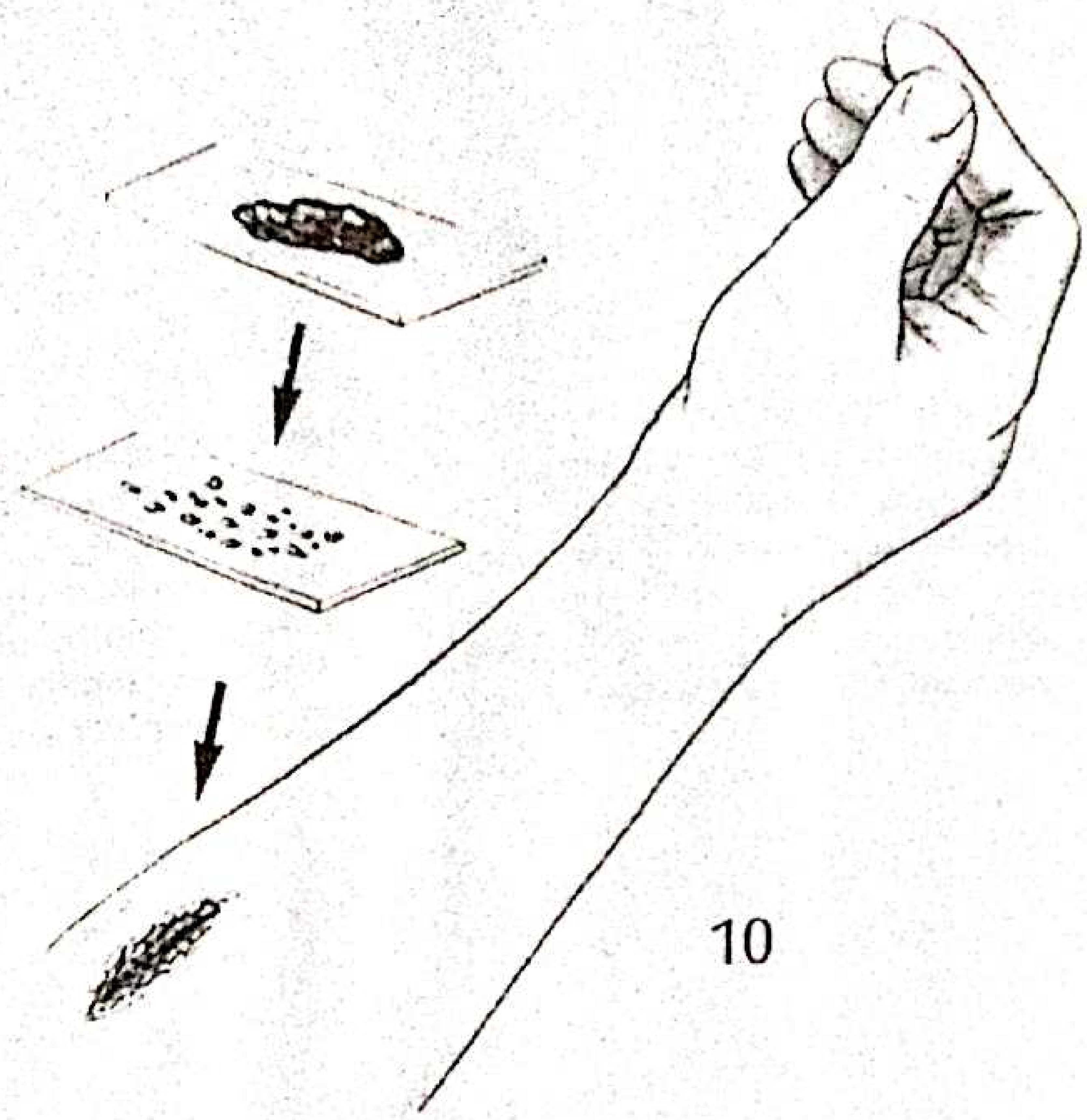
9

In STP, three parathyroid glands are completely excised and the fourth gland is partly excised. A portion of tissue, approximately the size of a normal gland (50–60 mg), is left in place and is tagged with a coloured non-absorbable suture to aid in future identification.

10

In TPA, all four parathyroid glands are removed. Diced parathyroid tissue (50–80 mg) is transplanted into a forearm muscle, most frequently the brachioradialis. The parathyroid tissue is taken from more than one parathyroid gland, and its identity is confirmed by frozen section. Multiple pockets are bluntly dissected in the muscle and slivers (approximately 1 × 3 mm) of parathyroid tissue are placed in the pockets. It is important to secure haemostasis, because haematoma will prevent take of the grafts. The fascia is closed with coloured non-absorbable suture material to aid in future identification.

STP is a simpler surgical procedure than TPA, with a shorter period of postoperative hypercalcaemia and less risk of permanent hypoparathyroidism. In case of recurrence, however, secondary exploration of the neck may be technically difficult. In patients who have undergone TPA, treatment of recurrent disease by partial excision of implanted tissue from the forearm is far simpler. TPA is a more complex surgical procedure and produces a longer period of postoperative hypocalcaemia (10–14 days). There is, however, an extremely high graft success rate and no appreciable incidence of late graft failure. Unfortunately, not all cases of recurrent hyperparathyroidism are graft-dependent. Factors influencing the choice between STP and TPA have been discussed above.



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Re-exploration

Parathyroid re-exploration is technically difficult due to postoperative scarring. Parathyroid lesions may have been overlooked at initial exploration, or they may be mediastinal, intrathyroidal or ectopic in location. Localization studies are very important in deciding which side of the neck should be explored first, and whether the lesion is in the neck or mediastinum. Thallium technetium subtraction scans, angiography, and selective vein catheterization are frequently helpful. The prognosis for successful re-exploratory surgery is poor in cases where preoperative studies have failed to localize a lesion.

Before undertaking re-exploration, the operative and pathology reports from the initial exploration are reviewed. Knowledge of which parathyroid glands were and were not positively identified at prior exploration is of paramount importance in determining the possible location of a recurrent or persistent parathyroid lesion, as has been discussed above. Only histologically confirmed parathyroid glands are regarded as indeed having been identified. Exploration is begun on the side indicated by localization studies in order to minimize unnecessary dissection. The parathyroid region is explored through a lateral approach to avoid dissecting adherent strap muscles from the thyroid gland. If a mediastinal lesion was localized by preoperative studies, manubriotomy is usually required for exposure. Microscopically abnormal glands left *in situ* at initial operation may have enlarged and become the source of recurrent hyperparathyroidism. Autotransplantation may be necessary if the only remaining parathyroid tissue will be removed at reoperation.

Further reading

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