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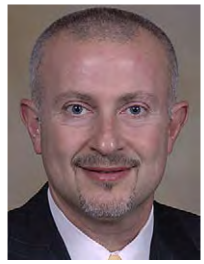
Atlas of the Oral and Maxillofacial Surgery Clinics

Preface



G.E. Ghali, DDS, MD, FACS
Guest Editor

Cleft lip and palate are congenital deformities, which, because of their frequency and localization to the orofacial region, are of great significance to the oral and maxillofacial surgeon. Although confined to a fairly small anatomic region, the typical cleft deformity requires significant specialized care by many disciplines. Nearly 15 years ago, the American Cleft Palate – Craniofacial Association (ACPCA) proposed parameters of care designed to help standardize the management of cleft patients. The goals of these cleft teams are to carry out periodic assessments and make suggestions regarding timing and sequencing of care. Although mainly a North American phenomenon, the ACPCA guidelines have been taken on a global front and interpreted differently by many countries. The result has been a vast array of management protocols without universal standardization.

Because it is neither practical nor desirable to expect all surgeons worldwide to conform to a single surgical technique, I have elected to divide the lip and palate into the 2 most popular techniques for repair. For the primary unilateral cleft lip-nose repair utilizing modified Millard technique, Drs. Costello and Ruiz provide a very detailed and thorough breakdown of this popular technique. Dr. David Precious provides an interesting and eloquent description of the primary unilateral cleft lip-nose repair as well as the bilateral primary cleft lip-nose repair, both utilizing the Delaire technique. The primary bilateral cleft lip-nose repair utilizing the modified Millard technique is also described by the editor. Relative to primary palatal repair, this is divided into the modified Von Langenback technique described by Dr. Kevin Smith and the primary palatoplasty utilizing a Furlow technique described by Dr. Bruce Horswell. The alveolar cleft repair is described in detail by Dr. Bruce Epker. I am indebted to these experienced surgeons for providing their time and efforts to this Atlas. I am hopeful that an overview of these techniques, as provided in this Atlas, will be of value to those practicing oral and maxillofacial surgeons and residents interested in the field of cleft surgery.

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Atlas of the Oral and Maxillofacial Surgery Clinics

Unilateral Cleft Lip and Nasal Repair: The Rotation–Advancement Flap Technique

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The comprehensive treatment of cleft lip and palate deformities requires thoughtful consideration of the anatomic complexities of the deformity and the delicate balance between intervention and growth. The primary cleft lip and nose repair occurs first, and sets the stage for the remainder of the procedures. Specific goals of surgical care for children born with cleft lip and palate include:

- Normalized aesthetic appearance of the lip and nose
- Intact primary and secondary palate
- Normal speech, language, and hearing
- Nasal airway patency
- Class I occlusion with normal masticatory function
- Good dental and periodontal health
- Normal psychosocial development

The surgical reconstruction of clefts requires that the surgeon maintain a cognitive understanding of the complex malformation itself, the varied operative techniques employed, facial growth considerations, and the psychosocial health of the patient and family. This article aims to present the overall reconstructive approach for repair of the unilateral cleft lip and nose deformity using the rotation-advancement repair technique modified from the original description by Millard. Several other techniques exist and are used in various forms by most surgeons. In fact, many surgeons use a combination of techniques described in this publication to tailor their approach for each cleft. The heterogeneity of clefting requires a customized approach, and the surgeon can benefit from understanding several different operative approaches (Figs. 1 and 2). The technique described here and used by the authors is primarily based on what is still the most common version of unilateral cleft lip and nose repair in the world. The reader is encouraged to fully evaluate this version as well as the multitude of descriptions available for the other techniques described in this issue. To date, no technique has definitively been proven to produce the best results. Thus, as with many surgical techniques, the surgeon is left to make the best decisions possible based on personal experience, mentoring, the available literature, and continual evaluation of personal outcomes.

Treatment planning and timing

The timing of cleft lip and palate repair is controversial. Despite several meaningful advancements in the care of patients with cleft lip and palate, a lack of consensus exists

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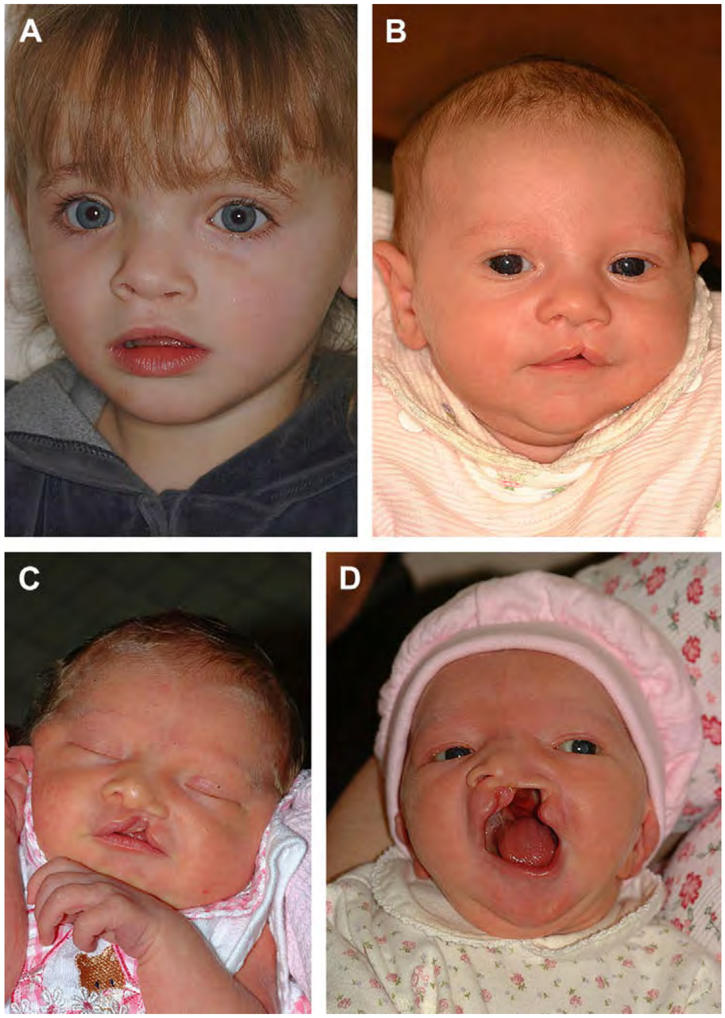

Fig. 1. Cleft lips come in a variety of configurations, such that each repair must be customized to establish the most normal morphology. (*A*) Microform left unilateral cleft lip only, not requiring primary repair. (*B*) Minor left incomplete unilateral cleft lip only. (*C*) Left incomplete unilateral cleft lip and palate with a Simonart's band. (*D*) Wide left complete unilateral cleft lip and palate.

regarding the timing and specific techniques used during each stage of cleft reconstruction. Surgeons must continue to carefully balance the functional needs, aesthetic concerns, and the issue of ongoing growth when deciding how and when to intervene. In no other type of surgical problem is the issue of early surgery's effect on growth more apparent than in the treatment of cleft lip and palate deformities. The decision to surgically manipulate the tissues of the growing child should not be made lightly, and should take into account the possible growth restriction that can occur with early surgery. Nevertheless, many patients with congenital deformities will benefit from surgical intervention based on functional or psychosocial reasons. Understanding the growth and development of the craniofacial skeleton is critical to the treatment planning process. In many cases, waiting for a greater degree of growth to occur is advantageous unless compelling functional or aesthetic issues are present that cannot or should not wait.

Due to many different treatment philosophies, the timing of treatment interventions is considerably variable amongst cleft centers. Therefore, it is difficult to produce a timing regimen that everyone agrees upon. Each stage of surgical reconstruction and the suggested timing based on the patient's age are presented in Table 1. Special considerations may alter the sequencing or timing of the various procedures based on individual functional or aesthetic needs. It should be noted that significant differences exist worldwide regarding the timing of different repairs. This timing varies greatly and, as of yet, cannot be guided by truly definitive outcome research.

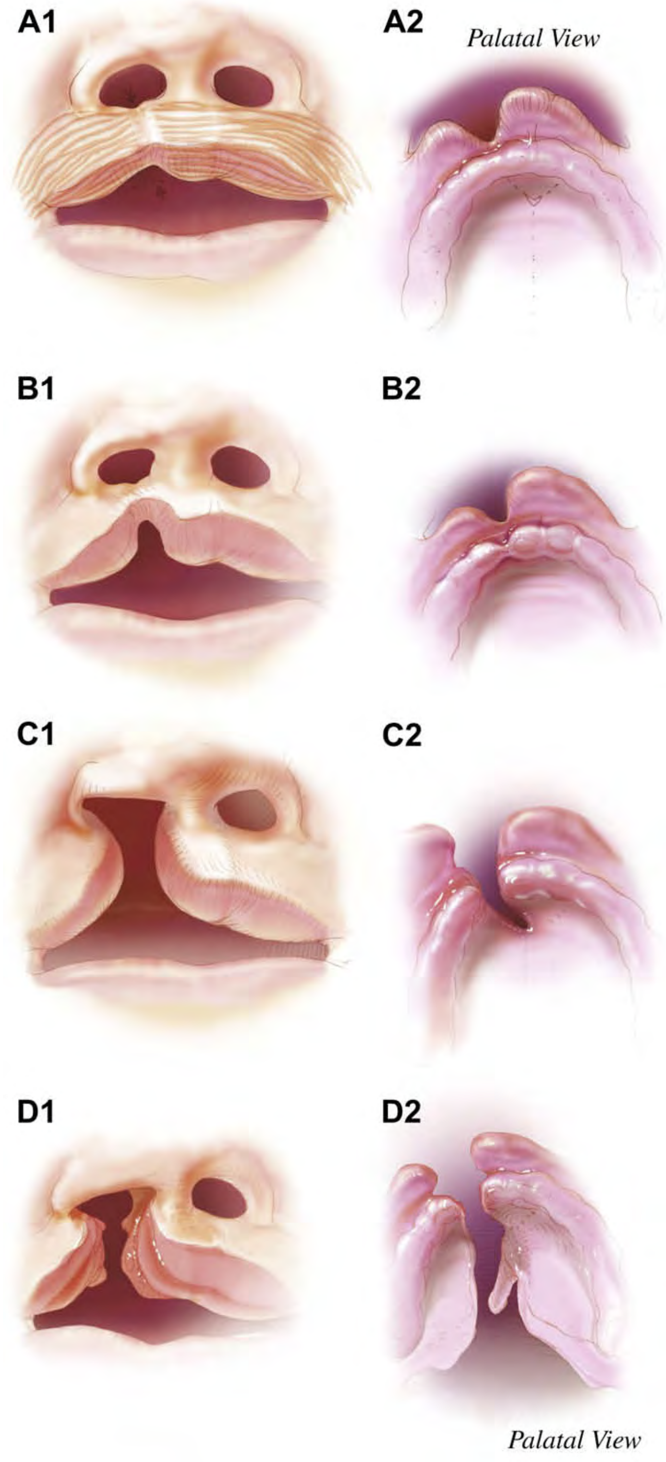

Fig. 2. There is significant variation in the configuration and severity of the unilateral cleft lip and nasal deformity. The surgical repair is tailored to the specific dysmorphology of each patient. Approximately 75% of all unilateral cleft lip defects, including microform and incomplete cases, will also have a defect of the underlying skeletal structures of the maxilla and alveolus. (*A1*, *A2*) Microform cleft lip. (*B1*, *B2*) When repair is indicated, these defects require excision of the hypoplastic tissue within the cleft (incomplete fusion), dissection of the appropriate layers for reapproximation, and mirror-image reconstruction with the contralateral side. Incomplete cleft lip deformities may have a short noncleft vertical height and the nasal deformity may be relatively mild. (*C1*, *C2*) Complete unilateral clefts of the lip without a cleft palate will exhibit the significantly rotated and flattened lower lateral cartilage, hypoplastic vermilion and white roll tissue, as well as even shorter vertical height along the noncleft margin medially. The anterior palate cleft can exhibit more separation and shows involvement up to the incisive foramen, which is the embryologic division point between the primary and secondary palate. (*D1*, *D2*) The complete unilateral cleft lip and palate typically presents as a wider defect with larger separation at the alveolus. The nasal deformity may be more severe, and the vertical mismatch between the lateral and medial segments may be more significant. The septum may or may not be attached to the contralateral palatal shelf (unilateral or bilateral cleft palate).

Table 1
Staged reconstruction of cleft lip and palate deformities

Cleft lip repair	After 10 weeks
Cleft palate repair	9–18 months
Pharyngeal flap or pharyngoplasty	3–5 years or later based on speech development
Maxillary/alveolar reconstruction with bone grafting	6–9 years based on dental development
Cleft orthognathic surgery	14–16 years in girls, 16–18 years in boys
Cleft rhinoplasty	After age 5 years, but preferably at skeletal maturity; after orthognathic surgery when possible
Cleft lip revision	Anytime once initial remodeling and scar maturation is complete, but best performed after age 5 years

Cleft lip repair is generally undertaken at some point after 10 weeks of age. One advantage of waiting until the child is 10 to 12 weeks old is that it allows a complete medical evaluation of the patient so that any associated congenital defects affecting other organ systems (eg, cardiac or renal anomalies) may be uncovered. The surgical procedure itself may be easier when the child is slightly larger, and the anatomic landmarks more prominent and well defined. The anesthetic risk-related data historically suggested that the safest time period for surgery in this population of infants could be outlined simply by using the ‘‘rule of 10s.’’ This rule referred to the idea of delaying lip repair until the child was at least 10 weeks old, 10 pounds in weight, and with a minimum hemoglobin value of 10 dL/mg. Today more sophisticated pediatric anesthetic techniques, advances in intraoperative monitoring, and improved anesthetic agents have all resulted in the ability to provide safe general anesthesia much earlier in life. Despite the ability to provide safe anesthesia earlier, there is no measurable benefit to performing lip repair before 3 months of age. Some surgeons have advocated that lip repair be performed in the first days of infancy, based on the idea of capitalizing on early ‘‘fetal-like’’ healing. Unfortunately, these hoped-for benefits have not been observed, and problems with excessive scarring and less favorable outcomes have been encountered instead. Children may have more scarring at this early age, and their tissues are smaller and more difficult to manipulate. The esthetic outcomes consequently may be worse if surgery is performed at an earlier age, and because there are no clear benefits to earlier repair, the recommendations for repair remain at approximately 3 months old.

As with the timing of other interventions, lip and nasal revision is best reserved for when most growth is complete. Most of the lip and nasal growth is complete after age 5 years. Lip revision may be considered just before school age at about 5 years old or later. However, this may be performed earlier if the deformity is severe. Nasal revision is performed after age 5 years, as most of the nasal growth is also complete by this time. If orthognathic reconstruction is likely, then rhinoplasty is usually best performed after orthognathic surgery, as maxillary advancement improves many characteristics of nasal support. However, when nasal deformity is particularly severe, rhinoplasty can be considered earlier even if orthognathic surgery is expected. Multiple early revisions of the lip or nose should be avoided so that excess scarring does not potentially impair ongoing growth.

Cleft lip and nose repair

Presurgical Taping and Presurgical Orthopedics

Facial taping with elastic devices may be used for application of selective external pressure, and may allow for improvement of lip and nasal position before the lip repair procedure. In the authors’ opinion these techniques often have greater impact in cases of wide bilateral cleft lip and palate, in which manipulation of the premaxillary segment may make primary repair technically easier. Although one of the basic surgical tenets of wound repair is to close wounds under minimal tension, attempts at improving the arrangement of the segments using taping methods have not shown a measurable improvement.

Some surgeons prefer presurgical orthopedic (PSO) appliances rather than lip taping to achieve similar goals. PSO appliances are composed of a custom-made acrylic baseplate that provides improved anchorage in the molding of lip, nasal, and alveolar structures during the presurgical phase of treatment. Although the use of appliances probably makes for an easier surgical repair, there has been a lack of clinical evidence to demonstrate that there is any measurable improvement in aesthetics of the nose or lip, dental arch relationship, tooth survival, or occlusion of the patient. Studies have looked at the dental arch relationships and other outcomes in patients who have infant PSO devices, and no improvement has been seen. In addition, no long-term improvement in speech outcome has been demonstrated in patients who had PSOs. Furthermore, concerns regarding potential negative consequences of these types of appliances have been raised. PSOs also add significant cost and time to treatment early in the child's life. Some appliances require a general anesthetic for the initial impression used to fabricate the device. Frequent appointments are necessary for monitoring of the anatomic changes and periodic appliance adjustment.

The Latham appliance was popular for expanding and aligning the maxillary segments of the patient with a cleft palate. The appliance is a pin-retained device that is inserted into the palate with acrylic extensions onto the alveolar ridges. A screw mechanism is then used to manipulate the segments as desired. The Latham appliance in conjunction with gingivoperiosteoplasty has been shown to be associated with significant growth restriction of the midface when used in infancy to approximate the segments for repair. Children who have had Latham appliances have been shown to have significant midfacial growth restriction in adolescence 100% of the time, whereas children who had not had the Latham appliance have midface hypoplasia much less frequently.

The Grayson nasoalveolar molding appliance has become popular with some centers in attempts to manipulate the segments without pin retention before lip and nose repair. The nasoalveolar molding (NAM) appliance is adjustable by removing or adding acrylic and manipulating protrusive elements that attempt to mold the nasal cartilages. This device attempts to align and optimize the position of the alveolar segments, lip structures, and nasal cartilage to improve repair. Unfortunately, the hoped-for advantages of this appliance have not been realized. In addition, no long-term data are available regarding growth in the craniofacial skeleton after using this protocol. The limited short-term data that are available cannot be extrapolated to determine the ultimate outcome on growth, function, or aesthetics. Many surgeons use gingivoperiosteoplasty in conjunction with the PSO, using limited flaps to close the alveolus cleft during the primary repair of the lip or palate. Many surgeons who use this appliance in conjunction with their primary lip repairs perform a gingivoperiosteoplasty in an attempt to have bone form at the alveolus. This procedure is more easily performed with the segments aligned in close proximity, as the flaps are small. Experiences with similar techniques in the 1960s involving primary bone grafting were poor with respect to growth. Subsequent studies have confirmed the high incidence of growth restriction in this population. In addition, there have been no convincing long-term objective data showing improvement in either lip or nose aesthetics.

In their current state of technical refinement, there is no compelling evidence that any of the PSOs offer an improved outcome with respect to aesthetics, function, or growth in patients with cleft lip and palate. Coupled with the fact that appliances are time-consuming, and have a high cost of fabrication and use, it is difficult to advocate their uniform use. As with other interventions considered for patients with clefts, costly and unproven interventions should be avoided, although they may prove to be helpful in select cases. There may be a subset of more severe clefts that do benefit from the devices. It is hoped that long-term data will be forthcoming to help determine which specific patients may benefit from PSO appliance treatment.

Lip adhesion

Some surgeons attempt to surgically approximate the segments of the cleft lip before definitive lip repair in an attempt to achieve a better relationship of both the lip structures and the dental arches. This position is achieved by advancing small flaps of tissue across the cleft site. Whereas some surgeons advocate the use of this technique in wide bilateral clefts, it is rarely performed in unilateral cases. The lip adhesion is usually completed at 3 months of age. In most cases this will convert a wide complete cleft into a wide incomplete cleft, as the scar will eventually be excised from the cleft site, recreating a similar wide deformity. The definitive lip repair is then completed 3 to 9 months later by excising the scar and reapproximating the remaining lip structures. Furthermore, at the second procedure there is usually less supple tissue to work with when performing the definitive repair. As with most endeavors in cleft surgery, repeated early interventions tend to complicate later refinements due to excessive scarring. In general, adequate mobilization of the flaps in one stage will make tension-free skin closure possible in almost every case without the need for taping, PSO appliances, or lip adhesion.

Primary unilateral cleft lip repair

Clefts of the lip and nose that are unilateral present with a high degree of variability, and thus each repair design is unique (see Fig. 1). The repair technique preferred by the authors for cleft lip and nasal deformities is demonstrated in Figs. 1–12. Important components of the surgical technique include the creation of a 3-layered closure (skin, orbicularis muscle, and mucosa), the excision of hypoplastic tissue from the cleft margins, and the approximation of anatomic landmarks. Critical in the process is the reconstruction of the orbicularis oris musculature into a continuous sphincter. The rotation and advancement flap technique has the advantage of allowing for each of the incision lines to fall within the natural contours of the lip and nose. This procedure is advantageous because it is difficult to achieve ''mirror-image'' symmetry in the unilateral cleft lip and nose with the normal side immediately adjacent to the surgical site. Procedures involving the use of a Z-plasty technique to achieve downward rotation of the central lip vermilion produce a scar that crosses the vertical lip, in sharp contrast to the linear configuration of the noncleft linear philtral column (see Fig. 11).

Surgical technique

After induction of general anesthesia, an oral Ring-Adair-Elwyn tube is placed and taped in the midline of the lower lip, with care taken to avoid any pull/distortion of the upper lip. Alternatively, a flexible-reinforced oral endotracheal tube may be used. Care is taken to prep

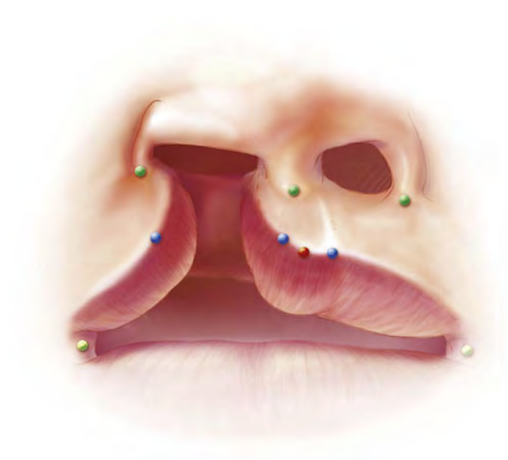

Fig. 3. Right-sided complete cleft of the lip and nasal deformity is shown with key anatomic landmark points marked during surgical planning. The blue points indicate the location of the white roll along both philtral columns. In determining the placement of the marks adjacent to the cleft defect, points are placed within well-defined white roll where the vertical dimension of the vermilion has not decreased. The red point is the central portion of what will be the new Cupid's bow. The green points represent the width markers for the nasal base, allowing the surgeon to judge the relative size discrepancy between the nostrils after reconstruction. It is important to recognize and outline the hypoplastic tissue present within the cleft margins, and the appropriate tissue to keep within the reconstruction lateral to the blue markings along the vermilion edge.

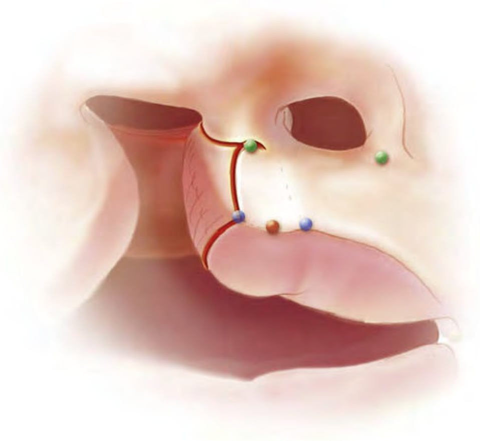

Fig. 4. Vertical and horizontal incisions on the noncleft side. Care is taken to excise all of the hypoplastic tissue along the cleft defect. This hypoplastic tissue region of the cleft defect lacks a defined white roll, sufficient vermilion width, and a well-formed orbicularis muscle layer, thus allowing ‘‘good’’ tissue, containing adequately defined mucosa, muscle, and skin, to be reapproximated in the repair. The horizontal incision allows for release and downward ‘‘rotation’’ to create lip length. The incision is not extended beyond the contralateral philtral column. The vertical and horizontal components of the incision are connected in a gentle curve. A portion of nasal floor is also retained medially for mobilization as the medial nasal sill.

and drape the patient in such a way that the entire face is left within the operative field for maximal visualization. The eyes are lubricated and covered for corneal protection with sterile tape or corneal shields. Symmetric positioning is helpful when marking the patient and judging surgical symmetry. The injection of local anesthetic containing vasoconstrictor to aid in hemostasis is delayed until after skin markings are created using surgical marker to avoid any distortion of the soft tissues.

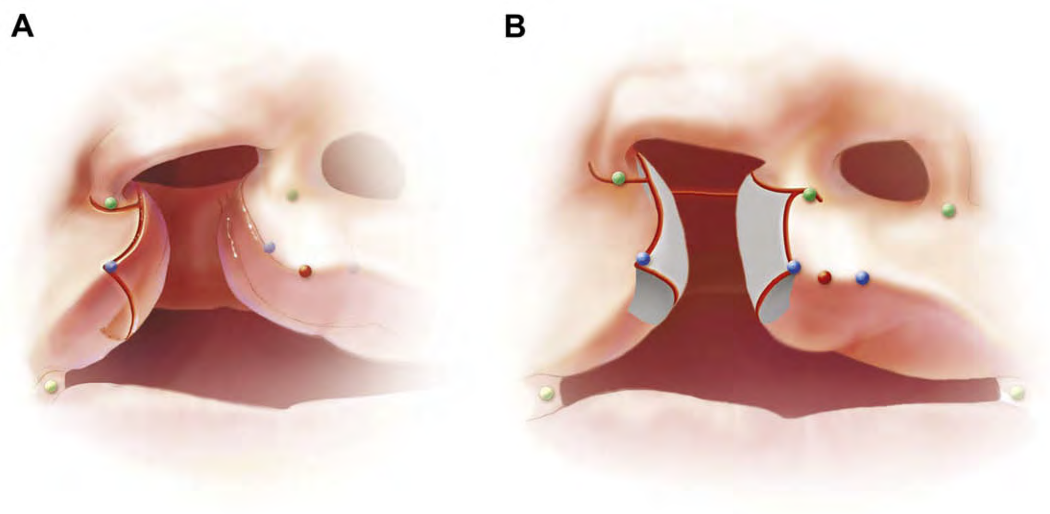

Fig. 5. (*A*) Cleft-side incisions are shown. Again, the dissection begins with the excision of all of the hypoplastic tissue along the cleft defect. Note the ghosted/shaded area of excised tissue which is full-thickness and extends onto the mucosal side of the cleft. The lateral nasal sill tissue is also preserved to meet the medial tissue flap from Fig. 3. The lateral portion of the incision is made within the alar crease to allow for access to the nasal cartilage during the primary nasal reconstruction. On the cleft side, the horizontal and vertical incision lines are connected at a sharply defined, right angle. (*B*) The composite diagram of the excised hypoplastic tissue shows the amount of tissue removed and the development of the flaps for reapproximation. Note the height that is created by the curve of the vertical incision on the non-cleft (medial) edge to match the vertical height of the cleft (lateral) side. This medial incision can be cut back additionally to create more length, but this should not violate the columella.

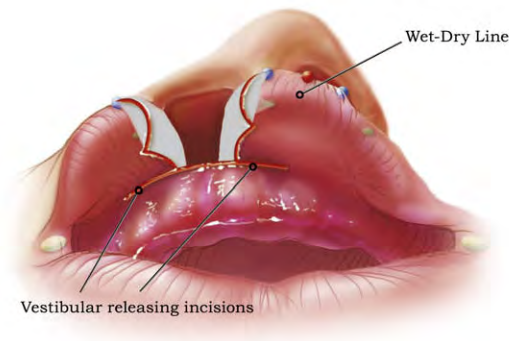

Fig. 6. An inferior view demonstrates the vestibular incisions and excised hypoplastic tissue in 3 dimensions—this extends to the tissue at the wet-dry line. The frenum is preserved when possible.

An ultrafine surgical pen is used to mark anatomic landmarks, and the vertical and horizontal incisions of the rotation and advancement flaps (see Fig. 3). These marks include the white roll points at the center of Cupid's bow, and the philtral column regions within the central lip segment and at the leading edge of the lateral advancement flap. The vermilion tissue thins along the margins of the cleft defect as the white roll and wet-dry line tend to converge. Points identifying the junction of both soft tissue flaps are marked within the white roll before the vermilion thins on either side. The vermilion border white roll points described earlier are temporarily tattooed with methylene blue solution using a tuberculin syringe and 30-gauge needle. Some surgeons prefer to mark the vermilion border and the height of contour of the white roll just above the vermilion, allowing for approximation of 4 points instead of 2. The remainder of the hypoplastic tissue is planned for excision (see Figs. 4 and 5). The authors believe that incorporating this tissue via rotational flaps or ''banking'' flaps simply leads to a future excision of this poor-quality tissue. The natural creases and contours of the surrounding tissues are used to complete the incision marking and hide the future incisions.

Injection of 0.5% lidocaine with 1:200,000 epinephrine via local infiltration is then performed for hemostasis. A full 7 minutes is allowed to elapse before making the first incision to ensure time for the solution to take effect optimally.

A fine ophthalmic blade, 15c blade, or 11 blade is used to create the vertical and horizontal incisions. The authors begin with the incisions and dissection of the lateral (advancement) flap. Hypoplastic tissue from the margin of the cleft defect is excised and the skin is undermined above the orbicularis oris muscle. Care is taken to maintain a consistent plane of dissection over

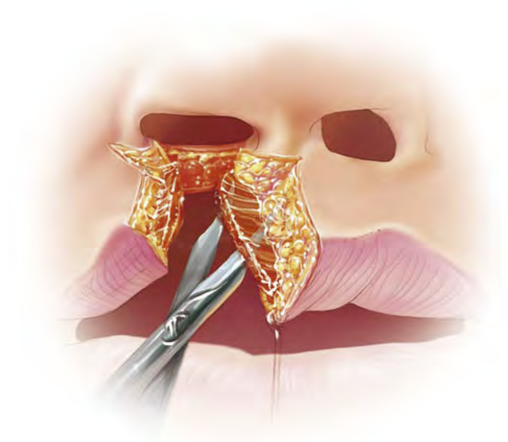

Fig. 7. The muscle is separated from the overlying skin, abnormal attachments under the ala and nasal spine, and mucosa as a separate layer. This procedure can be performed with a sharp knife or with the assistance of tenotomy scissors. The flaps must be mobilized enough to close the cleft without tension.

Fig. 8. Reapproximation of the muscle later occurs by advancing the cleft (lateral) side toward the noncleft (medial) muscle to reform the circular orbicularis oris. Multiple mattress and interrupted sutures are used to evert the musculature and interdigitate the fibers. The authors prefer to reapproximate the perinasal musculature as well, but this is not described in this manner in the classic advancement-rotation repair technique. The skin flaps are also advanced in a passive fashion as a separate layer.

the muscle because there is no fascial layer in this area. Hypoplastic tissue is discarded, and the 3 layers are carefully dissected sharply into well-defined mucosa, muscle, and overlying skin. Single skin hooks are placed within the body of the orbicularis oris, and Guthrie hooks can be used to elevate the flaps. The surgeon may prefer to use a 15c blade for this skin flap and muscular dissection once experience is gained. However, the novice surgeon may consider using Stevens tenotomy scissors for blunt and sharp dissection during this step. Hemostasis is gained using an electrocautery Bovie instrument with a fine needle-point tip. A vestibular incision is created within the oral cavity and dissection is continued toward the piriform rim region (see Fig. 6). Thorough dissection then allows for mobilization of the musculature and dissection of the perinasal musculature in preparation for advancement of the cleft-side segment. Next, the vertical and horizontal incisions are made on the central (rotation) lip segment and a similar dissection is performed (see Figs. 7 and 8). On the central (rotation) lip, the junction of the horizontal and vertical incisions is rounded instead of the right angle that is formed on the lateral (advancement) flap side. A generous curve can be made to rotate the segment further inferiorly to create vertical length. In addition, a small back cut can be made, being careful not to violate the columella with any portion of the incision. Dissection of the skin overlying the orbicularis muscle is limited on the central lip segment side to avoid distortion of the philtral dimple.

The nasal floor dissection requires that incisions are extended along the junction of the alveolar mucosa and vestibular nasal skin. The nasal sill skin is elevated and used to form a nasal floor as a separate maneuver. The authors do not favor dissection or closure of the maxillary/alveolar cleft (gingivoperiosteoplasty), but the soft tissue closure up to this point is helpful in limiting the unrepaired cleft side that may contribute to nasal air escape during speech or leakage of foodstuffs during eating and drinking. It is helpful to close the mucosa of the floor of the nose before reconstructing the base of the nare.

Certain details and concepts of the primary nasal deformity and repair warrant additional attention within this summary (see Fig. 9). Primary nasal reconstruction may be considered at the time of lip repair to reposition the displaced lower lateral cartilage and alar tissues to varying degrees. Several techniques are advocated, and considerable variation exists regarding the extent of nasal reconstruction performed by each surgeon. The primary nasal repair may be achieved by releasing the alar base, augmenting the area with allogeneic dermal grafts, or even a formal open rhinoplasty with active sculpting and suturing of the lower lateral cartilage. Because lip repair is done at such an early point in growth and development, the authors prefer minimal surgical dissection due to the effects of scarring on the subsequent growth of these tissues. McComb described a technique that has remained popular for several years because it achieves major goals of primary reconstruction, but without a particularly aggressive approach. This

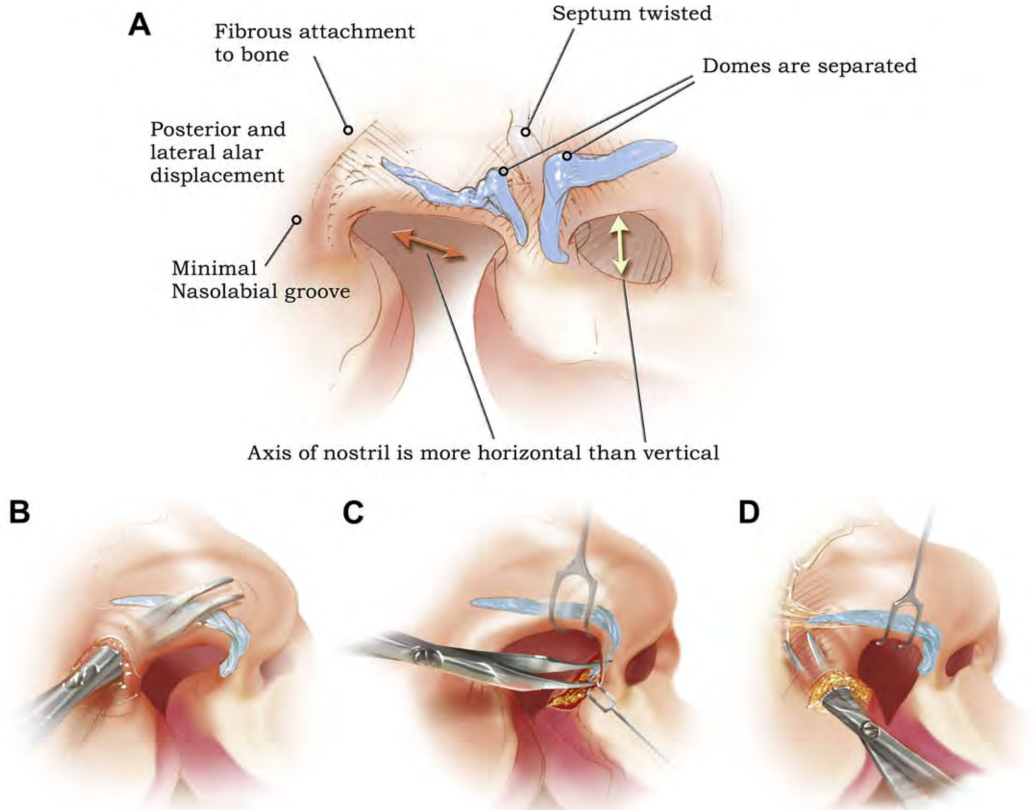

Fig. 9. (*A*) The nasal deformity is addressed with the incisions open, but is addressed separately here by first identifying the degree of deformity. This diagram shows the typical deformity of the lower lateral cartilage on both sides, with splaying of the affected side and rotation caudally/laterally. The noncleft side is also affected with tip asymmetry and nostril deformation. Unilateral clefts create a bilateral deformity of both the lip and nose, but this is most evident across the nasal tip area. (*B*) The tenotomy scissors are used to dissect over the lower lateral cartilage and free up this tissue from its abnormal insertions, in anticipation of bolstering the nasal complex with nasal stenting. The dissection is carried across the nasal tip and variably up the nasal dorsum as needed. (*C*) Some surgeons also dissect up the medial portion of the lower lateral cartilage in an attempt to free up the abnormal positioning of the medial aspect of the nose as well. Tenotomy scissors are used to dissect superficial to the cartilage meeting the nasal tip dissection performed from the lateral. (*D*) The lower lateral cartilage and alar tissues on the affected side are released to allow the surgeon to bring the tissues to the medial for nasal floor reconstruction, and to reposition the nasal complex to improve symmetry. Stevens tenotomy scissors allow for precise dissection, with a blunt tip for dissection around the cartilage components.

technique consists of dissecting the lower lateral cartilage free from the alar base and the surrounding attachments through an alar crease incision. This incision allows the nose to be bolstered or stented from within the nostril to improve symmetry.

The authors prefer a primary nasal reconstruction that can be performed in a similar fashion to the technique described by McComb. This reconstruction allows for release and repositioning of the lower lateral cartilage and alar base on both sides without aggressive degloving of the entire nasal complex. Other open rhinoplasty techniques have been suggested, using direct incision on the nasal tip or through prolabial unwinding techniques. As with most early maneuvers, aggressive rhinoplasty at this time may incur early scarring that affects the growth potential of the surrounding tissues, making revision more difficult and long-term aesthetics less than ideal. Excellent results can be achieved with several different techniques.

By way of the philtrum incisions and the lateral alar crease incision, Stevens tenotomy scissors are used to carefully dissect the lower lateral cartilages from the overlying skin (see Fig. 9B–D). The alar tissues are released from abnormal insertions on the lesser segment of the maxilla, and elevated free from their periosteal attachments along the hypoplastic and retropositioned piriform rim. A medial dissection may also be performed to further dissect and consequently elevate the cleft-side lower lateral cartilage. This procedure allows for favorable

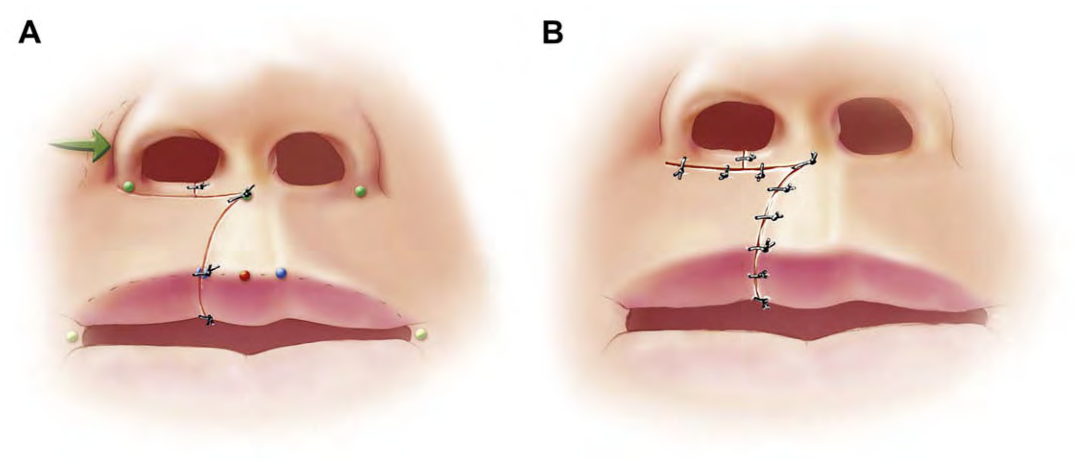

Fig. 10. (*A*) Closure of the skin occurs at several key areas with stout suture such as 6-0 Monocryl. This suture medializes the cleft-side ala after it is released from the piriform rim and perinasal attachments (discussed elsewhere). The length of the vertical closure line should approximate the philtral column length on the contralateral side, and there should be no notching present in the red portion of the lip or vermilion from any view. (*B*) The remainder of the skin is closed with minimal suturing, but excellent approximation and eversion of the skin. Symmetry should be achieved, and suture lines designed to fall within the natural creases of the nasal base and philtral columns.

reconstruction of the nasal floor, and elevation of the lower lateral cartilage and ala with the aid of a bolster dressing. When the repair is finished, a silicone nasal former may be used, but care should be taken not to put excessive pressure on the nare or columella with the device. A careful size choice and suturing that does not put undue pressure on the nasal tissue will avoid this potential problem.

Once fully mobilized to allow for repositioning without tension, the orbicularis oris muscle is reconstructed with 4-0 vicryl suture on a RB-1 tapered needle (see Fig. 8). The initial repositioning suture is placed in the mid-body of the musculature, allowing for detailing of the positioning of the inferior alignment of the musculature. Accurate repositioning of the musculature allows for approximation of the vermilion tissues in a manner that aligns the tissues in near ideal position, even without further suturing. Several other sutures are placed within the body of the musculature, and if the surgeon favors repositioning of perinasal musculature, this can be incorporated as a modification of the original description by Millard.

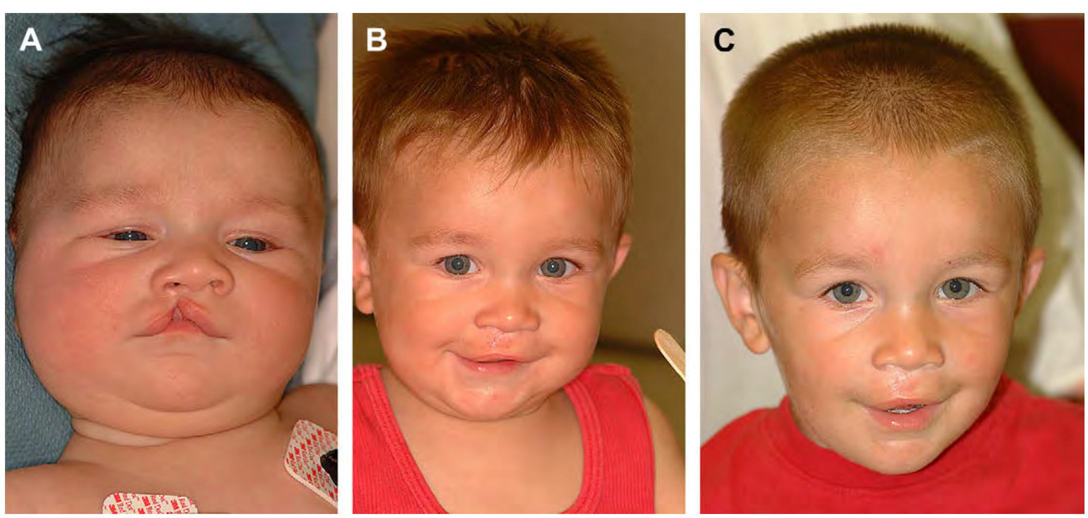

Fig. 11. (*A*) Three-month-old child with a right-sided incomplete unilateral cleft lip. Note the short philtrum near the midline that must be rotated downward to avoid notching and to improve symmetry. (*B*) Nine-month-old boy after the rotation-advancement repair of his cleft lip and nasal deformities. (*C*) The same child 2.5 years after his cleft lip and nasal repairs.

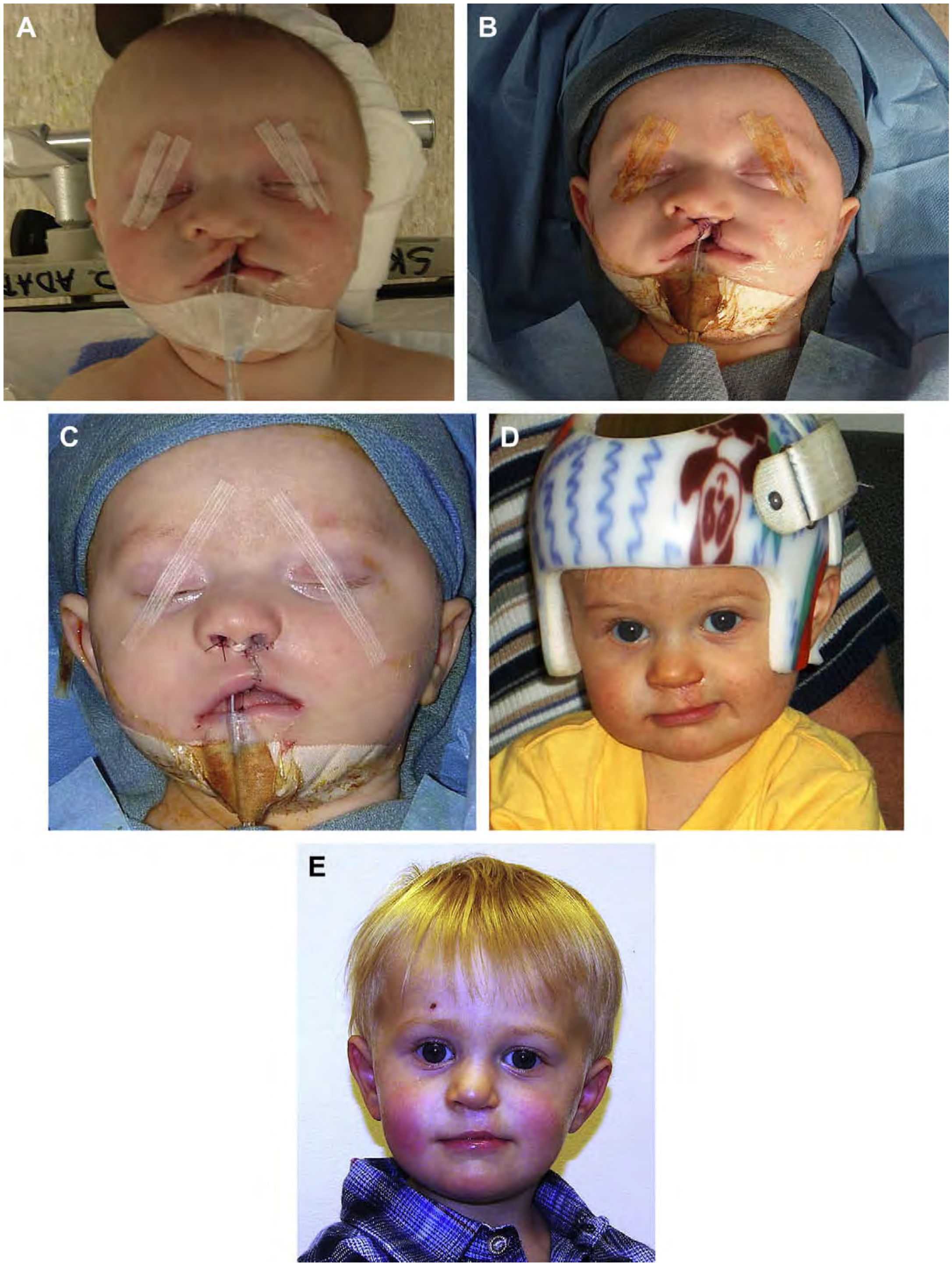

Fig. 12. (*A*) Three-month-old child with a left-sided incomplete, but wide, unilateral cleft lip, who has a rather severe nasal deformity with significant caudal and lateral splaying of the lower lateral cartilages, and deviation of the nasal tip. (*B*) Intraoperative markings are made with a marking pen, indicating the modified rotation-advancement repair technique. (*C*) Closure is completed, and a silicone nasal former is placed in a fashion that limits pressure on the columella. (*D*) Postoperative appearance at 6 months after the repair. (*E*) Postoperative appearance at almost 2 years after the repair.

The systematic closure of the skin is then performed using a combination of 6-0 Monocryl, 6-0 blue-dyed chromic, and 6-0 fast-absorbing synthetic gut sutures (see Fig. 10). It should be noted that the advancement flap does not always need to be maximally advanced into the defect to achieve the best symmetry and approximation of the anatomic components. However, the incision line of the nare reconstruction should not form a confluence with the tip of the advancement flap, as this point may form a cicatrix.

The appropriate amount of curvature is provided within the rotation segment to allow for equal length of the philtral columns after healing. At times, this vertical height may be quite short, requiring a small back cut or extension of the curvature. Again, some surgeons prefer to use a curved wire or other measuring device to precisely measure the length; the authors prefer to customize the length for each patient based on the response of the tissue and relative tension present within that vertical segment. Once this segment is of adequate length, the approximation of the vermilion and insetting of the advancement flap occurs with ease and no tension. Freeing these tissues from the musculature and subcutaneous tissues within the fascia overlying the musculature is important in achieving appropriate mobility.

Some investigators use tissue adhesive to augment the repair or primarily reposition the skin. The authors prefer the benefits of everting the skin precisely with suturing, using a Serrat needle holder or other fine-tipped needle holder with carbon tips. The surgeon needs to be willing to reposition sutures to achieve optimal repositioning of the segments. Care is taken to evert skin tissue during closure. The area is carefully cleansed using a blotting technique rather than wiping, as this will break or loosen more delicate sutures. A dressing is then placed using a small amount of Mastisol and 0.25-inch Steri-strips placed without tension. Temporary arm restraints or "no-nos" are placed for 2 weeks with intermittent removal to allow for adequate movement of the upper extremities. Postoperative evaluations are performed weekly for several weeks. Complete remodeling of the repair can take 18 months to 2 years (see Fig. 11).

Summary

The comprehensive care of patients with clefts requires an interdisciplinary approach that demands precise surgical execution of the various procedures necessary to effectively treat cleft deformities. Cleft lip and primary nasal reconstruction has benefited from several technical refinements and modifications since the initial description of straight-line repairs and early z-plasty techniques. Today, the use of a rotation and advancement flap technique remains the most popular technique employed for the unilateral deformity. Still, clear evidenced-based literature that delineates the differences between repair techniques is lacking. Surgeons are left to use their own experience and training when deciding which repair technique is best for a particular patient. Excellent results can be achieved using any number of variations of the rotation-advancement technique for unilateral cleft lip and nasal repair.

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Atlas of the Oral and Maxillofacial Surgery Clinics

Primary Bilateral Cleft Lip/Nose Repair Using a Modified Millard Technique

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The complexity of a bilateral cleft lip repair must be well understood by any surgeon performing this procedure. Multiple factors play a role in the difficulty that one must overcome to correct the obvious facial deformity. These include a widely displaced lateral lip segment, lack of developed lip tissue in the anterior segment, and a displaced premaxillary segment. All three need to be taken into consideration to obtain an optimal result.

Historically, techniques used for repair of a bilateral cleft lip were based on the repair of a unilateral cleft lip. The procedure was done as a staged process, first repairing the more severe side and correcting the contralateral side at a later date. Following this idea, most procedures were based on the proposal that the prolabium had limited growth potential. This led to multiple designs and geometric shapes to correct for this growth potential. The triangle and rectangle flaps were examples of this idea, creating an abnormally long lip with irregular scars. Soon after, the straight line closure and variants were developed to decrease the unnatural length of the lip; unfortunately, these techniques created problems with aberrant scaring. Not much thought went into the relevance of the orbicularis oris until the latter part of the twentieth century. Others reported on the reconstruction of the muscle, creating continuity between the two lateral lip elements. That procedure was referred to as the functional cleft lip repair. It did have its opponents, however, who thought it would lead to growth restriction of the premaxilla.

Additions stemming from the work of Millard, Mulliken, McComb, Trott, Mohan, and Cutting discuss the correction of the cleft nasal deformity in addition to the repair of the lip. Although extensively described and used by surgeons, the authors believe that the results of the cleft nasal deformity are easier to predict and more stable if the correction is undertaken once most of the child's growth has taken place.

Although not all clefts are similar, the application of basic principles with slight dimensional modifications to the technique generally produces an aesthetically pleasing result (Figs. 1 and 2). The authors' preferred timing for repair is between the ages of 3 and 6 months.

Surgical technique

The patient is placed in a supine position on the operating table with a small shoulder roll for support. A broad-spectrum antibiotic, typically a cephalosporin, is given before surgery as prophylaxis. Before the procedure, for reduction of the postoperative inflammatory phase, a combination of short- and long-acting steroids is administered unless contraindicated. After induction, an oral endotracheal tube is secured to the patient's chin in the midline. After surgical preparation, the anatomic structures are palpated and marked with a sterile surgical pen.

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Fig. 1. Preoperative frontal view of a child with a typical bilateral cleft lip deformity.

Design

Anterior Lip

The design of the planned surgical incisions is marked, starting with the prolabium (Fig. 3A). At the level of the lip-columellar crease in the midline, two points are placed approximately 2 to 2.5 mm apart. The length of the philtral column is then established by marking a point 6 mm inferior to the lip-columellar crease. The widest point on the philtral column, established 1.5 mm superior to the inferior point, is 3 to 3.5 mm in width and forms the peaks of Cupid's bow. These points are connected to produce the final design of the philtral column (see Fig. 3B, C). The width of Cupid's bow and the length of the philtral column are directly related to the age of the patient. Repairs in older patients have less of a tendency to widen over time. The measurements used to design the philtral column should be slightly enlarged in older patients to compensate for this decreased amount of growth potential.

Fig. 2. Postoperative frontal view of the same child 5 years after repair using a modified Millard technique.

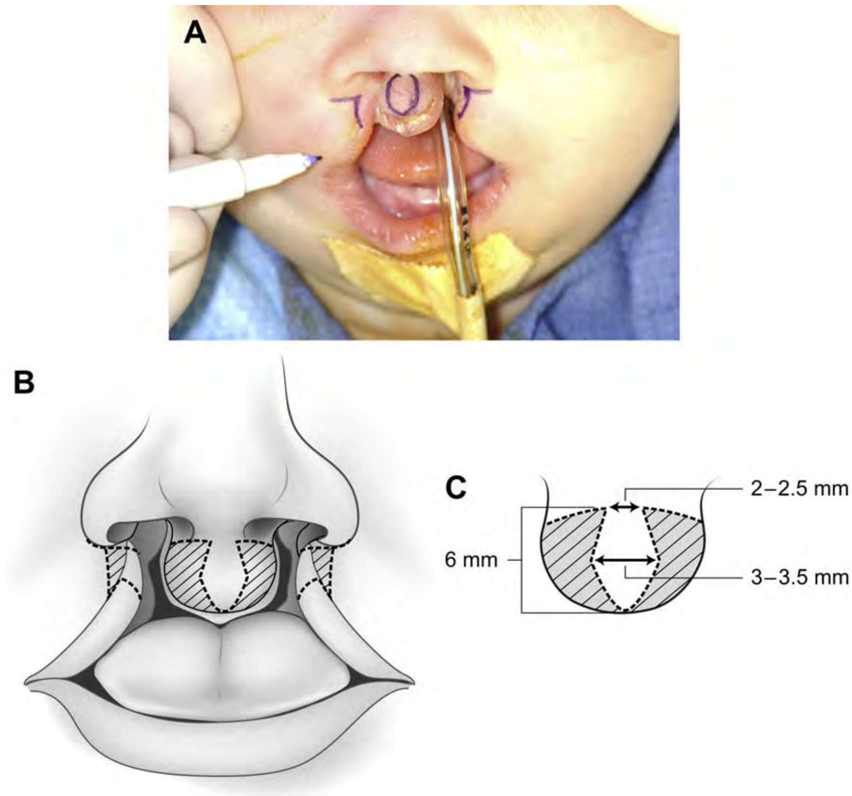

Fig. 3. (*A*) Intraoperative clinical markings for typical incision design for bilateral lip repair. (*B*) Schematic illustration of prolabial, premaxillary, and lateral lip incision design. (*C*) Schematic close-up delineates the authors' generally preferred measurements.

Lateral Lip

The nasal base incisions are first marked bilaterally, creating a curvilinear line along the alar crease. This forms the releasing incisions that aid in the advancement of the lateral lip elements. The peaks of Cupid's bow are then marked and positioned at the vermilion-cutaneous border, where the vermilion border of the lip and the white roll begin to converge. The marks may then be adjusted to create an equal distance bilaterally from the commissure of the mouth to the marked points (Fig. 4). A line perpendicular to the tangential line at the vermilion-cutaneous border is then marked through the vermilion. After markings, bilateral infraorbital nerve blocks are performed and the anterior and lateral lips and alar bases are injected with 1% lidocaine and a 1:100,000 epinephrine mixture.

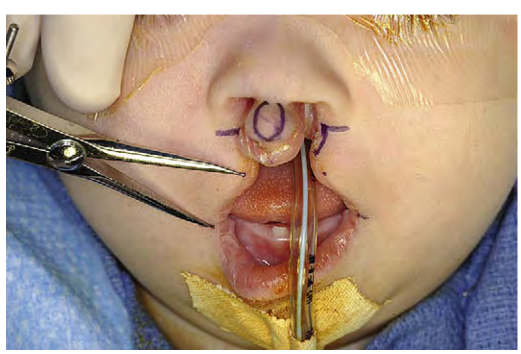

Fig. 4. Intraoperative markings assess the distance measured, using calipers, to optimize equality from the commissures to the proposed peaks of Cupid's bow.

Fig. 5. Intraoperative view demonstrates residual vermilion, which, after trimming, is used to aid in the premaxillary mucosal closure.

Incision

After placement of the moistened throat pack, the first incision is initiated on the prolabium. This incision includes skin and subcutaneous tissue. The flap should be raised from the philtral notch, elevating superiorly and gradually enlarging the thickness of the flap so as to preserve the columellar blood supply. The remaining vermillion and skin are reflected and turned intraorally as a flap based on the premaxilla (Fig. 5). This tissue aids in the intraoral closure of the mucosal surface.

The alar bases are then freed from the lateral lip elements along the curvilinear line (Fig. 6). The vermilion border is incised in a partial-thickness fashion to the point marking the peak of Cupid's bow. Preservation of the lateral vermilion mucosal flaps inferior to the peak of Cupid's bow is essential for reconstruction of the central lip region. The dissection to release the lateral lip elements from the maxilla is done with sharp scissors in a submucosal plane. The lateral lip elements must be completely separated from the intraoral mucosa. This dissection is usually performed at the malar prominences for adequate mobilization. The orbicularis oris is separated from the lateral lip flaps in the subdermal plane (Fig. 7). The muscle bundles are separated from the anterior maxilla at the alar base to reorient the fibers in a horizontal direction (Fig. 8). The nasovestibular web is released from its attachment at the piriform rim (Fig. 9). This release allows advancement in an anteromedial direction, correcting alar base width.

Closure

The nasal floor is reconstructed from flaps created from the premaxilla and the released nasovestibular web. The edges of the vermillion border are approximated and temporarily sutured into position to aid in initial positioning. Once the vermilion border is in the correct position, mucosal closure is begun. A slowly resorbing suture, such as 4-0 polyglactin 910, is recommended in these areas. The lateral lip mucosa is advanced and sutured to the premaxillary

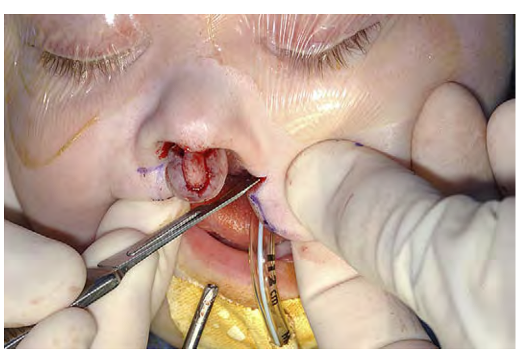

Fig. 6. Scalpel is used to create a full-thickness incision and free each respective lateral lip element.

Fig. 7. Sharp scissors are used to initiate the submucosal dissection deep to the orbicularis muscle and the subdermal dissection superficial to the orbicularis muscle.

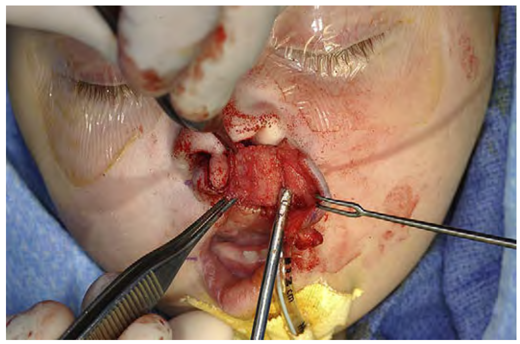

Fig. 8. Demonstration of the dissected orbicularis oris muscle bundle and reorientation in the corrected horizontal plane.

Fig. 9. Incision of the nasovestibular webbing by means of electrocautery as the final component of the lateral lip release.

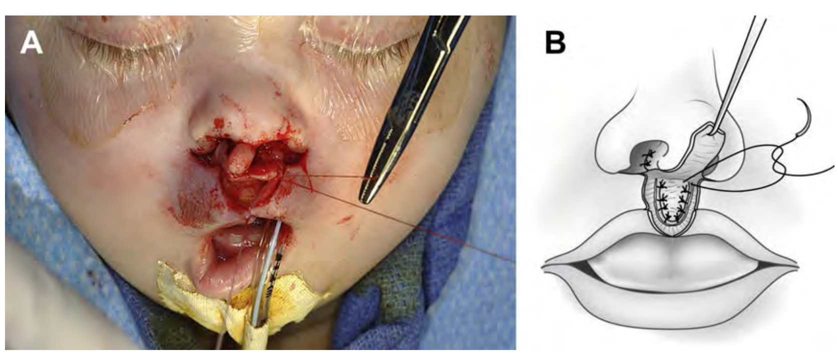

Fig. 10. (*A*) Suturing of lateral lip mucosa to the premaxillary mucosa on each respective side. (*B*) Schematic illustrates the mucosal closure.

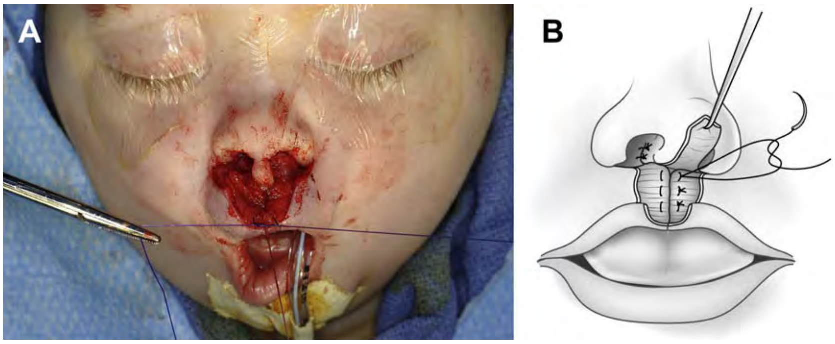

Fig. 11. (*A*) Several slowly resorbing sutures are used to achieve reconstruction of the orbicularis muscle. (*B*) Schematic illustration demonstrates muscular approximation across the midline and columellar base.

Fig. 12. Inset of the newly constructed philtrum.

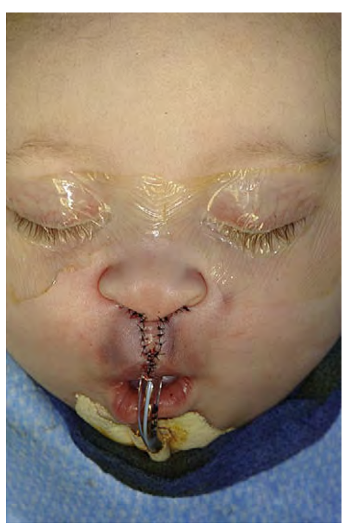

Fig. 13. Completed skin approximation of bilateral philtral columns and nasal sills.

Fig. 14. Sterile strips and adhesive are placed and maintained for as long as possible, or until the time of suture removal in 5 to 7 days.

mucosa (Fig. 10). It may be necessary to trim the edge of the lateral lip or premaxillary mucosa before suturing.

After the intraoral closures, attention is turned toward construction of a continuous orbicularis oris muscle. The reoriented ends of the muscle are advanced horizontally and sutured into position using horizontal mattress sutures starting at the inferior edge and working superiorly. A slower resorbing 3-0 polyglactin 910 or polydioxanone suture on a tapered needle is recommended in this area (Fig. 11). Once at the superior edge, the orbicularis muscle is sutured deep to the columellar base at the anterior nasal spine to maintain positioning.

The leading skin edges of the lateral lip are advanced after the newly created philtral column is inset (Fig. 12). Closure is accomplished with a fine nonresorbable suture in a staggered fashion to prevent damage to the philtral flap. The remaining skin sutures at the alar bases complete the closure (Fig. 13).

Postoperative Care

Sterile strips are applied after an adhesive application to reduce the tension placed on the closure (Fig. 14). The patient is admitted for overnight monitoring and is routinely discharged home on postoperative day 1 or 2. The wound is kept dry for at least 48 hours, and the sterile strips are removed at the time of suture removal in 5 to 7 days. During the postoperative period, the patient is fed through a syringe fitted with a wide-gauge catheter for 1 week; during that time, the bottle is restricted.

Summary

Many techniques historically have been described for repair of the bilateral cleft lip. Bilateral cleft lip repair is a challenging procedure regardless of who does the repair or what technique is used for the repair. Success depends on adherence to the following surgical goals: (1) orbicularis muscle union, (2) maintenance of symmetry, (3) appropriate prolabial management, (4) appropriate lateral lip management, (5) development of median tubercle, and (6) appropriate alar base reconstruction. Keeping these goals in mind, along with adequate mobilization of the soft tissue flaps, has generally yielded aesthetically and functionally pleasing results in the authors' experience.

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Primary Unilateral Cleft Lip/Nose Repair Using the "Delaire" Technique

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With the exception of those special cases of clefts associated with holoprosencephaly, wherein there exists true tissue hypoplasia, the anomalies observed in labiomaxillary clefts result essentially from displacement, deformation, and functional hypotrophy of the dentoskeletal elements and the covering soft tissues. This is particularly true with the maxillary bony segments, the dentoalveolar elements that they support, and the nasal cartilages. It is also true for the nasolabial muscles, which are all present on the cleft side but whose absence of normal insertions and the resultant dysfunctions are directly responsible for supra- and subjacent anomalies. Displacement, deformation, and functional hypotrophy also affect the mucocutaneous structures that border the labial clefts. This fact is less well known, but it has, nevertheless, great importance in the selection of incision design in the primary closure of cleft lip. The goal of primary closure is not only to re-establish normal insertions of all the nasolabial muscles but to restore the normal position of all the other soft tissues, including the mucocutaneous elements.

Surgical correction of cleft lip remains an elusive problem, principally because the fundamental surgical problem is not clearly conceptualized. This failure to define the problem accurately is attributable to the fact that the relevant anatomy is complex, poorly understood, and frequently erroneously described. Meaningful correction of cleft lip can be achieved only when the surgeon is fully appreciative of normal and pathologic spatial relations and functions of the anatomic elements, particularly the muscular elements, which cause the deformity. The treatment goal therefore is to obtain anatomic-functional balance between the soft tissues and the skeleton.

Congenital labiomaxillary clefts result from the absence of fusion or incomplete fusion of the maxillary and medial nasal processes. The superficial muscles of the face, which arise from the second branchial arch, migrate laterally and medially between the epidermis and subjacent ectomesenchyme and normally reach the midline in the week that follows fusion of the facial processes. In a complete labiomaxillary cleft, the muscles of the nasal floor and the upper lip cannot bridge the gap of the cleft and they cannot unite with their muscular counterparts on the noncleft side. The muscular integrity of the region is considerably disrupted, which has a profound effect on the underlying skeleton.

The transverse nasal muscle is the most important physiologic element in the nasolabial ring. It passes from the anterior border of the nasal bone to the incisive crest and then to the nasal septal perichondrium. Not only is this muscle responsible for nostril constriction, but, together with the external fibers of the orbicularis oris muscle, it provides support for its corresponding half of the upper lip and, indirectly, the labial commissure. The internal fibers of the oblique portion of the orbicularis oris normally extend into the columella and are connected to the anterior border of the nasal septum, its perichondrium, and the skin covering the columella. The nasal septum remains in the midline because symmetric muscles are inserted on both sides of it. The superior median interincisive suture is situated along the length of the septum and is united to it by the septopremaxillary ligament and the midline septum of the upper lip.

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When there is a total unilateral labiomaxillary cleft, the muscles on the cleft side remain lateral to the defect; even if they are correctly formed, they cannot function normally (Fig. 1). Deprived of the nasal septum and the anterior nasal spine as a point of anchorage, the system collapses much as a circus tent would do if it lost its central pole. Growth of the minor segment of the maxillofacial complex seems to be reduced as a probable consequence of absence of stimulation from the nasolabial muscles. On the noncleft side, the nasolabial muscles that are inserted on the nasal septum pull it into the noncleft nostril. Furthermore, on the noncleft side, which is frequently but erroneously referred to as the normal side, the premaxilla is also underdeveloped by an amount equal to the degree to which the median interincisive suture is bent to this side.

The lower lateral cartilage on the cleft side is flattened by divergent muscular traction corresponding to the degree of its missing normal support. The cartilaginous deformations can be considerable; however, except in rare cases, such as holoprosencephaly, there is little or no hypoplasia of the cartilage. Indeed, there is frequently no cutaneous hypoplasia, and if the skin appears insufficient, it is because it has not been distended by function (Fig. 2). The sagging nasal capsule induces a retrusion of the nasal bone on the cleft side, giving rise to an internal rotation of the anterior maxillary pillar, which results in lateral displacement of the medial canthus. The resultant telecanthus is often mistaken for true unilateral hypertelorism. Early complete reconstruction of the soft palate, combined with functional reconstitution of the nasolabial musculature of the lip and the septum, provides important prerequisites for future balanced facial growth. These clinical observations suggest that the nasal septum directly influences growth of the premaxilla and indirectly influences growth of the maxilla; in so doing, it plays an active role in facial growth.

Cleft lip, with or without cleft palate, occurs more frequently than cleft palate alone and is the most common significant orofacial anomaly. Clefts of the lip and anterior maxilla have been thought to result from a deficiency of mesenchyme in the facial region attributable to failure of neural crest cell migration or proliferation of facial mesenchyme. The author believes that orbicularis oris muscle deficiency may be related more to perinatal functional dysmorphogenesis than to congenital mesenchymal deficiency.

The quality of surgical treatment of congenital clefts of the lip depends to a much lesser degree on the technical skill of the surgeon than on the appropriateness of the operative technique that is used. Surgery should reconstruct form and function of the divided face, such that balanced growth of the facial skeleton can take place. The surgeon ought to have sound knowledge of the initial faults and their postoperative sequelae, on which can be based adaptation of technique according to the needs of each case.

Schematically, the superficial muscles of the face are arranged in three interdependent rings that function normally in a manner of mutual maintenance. In the case of total labiomaxillary clefts, the vascular, nervous, and muscular elements provided by the lateral cervical blastemas remain on the lateral side of the cleft. The transverse nasal muscle, levator labii superioris

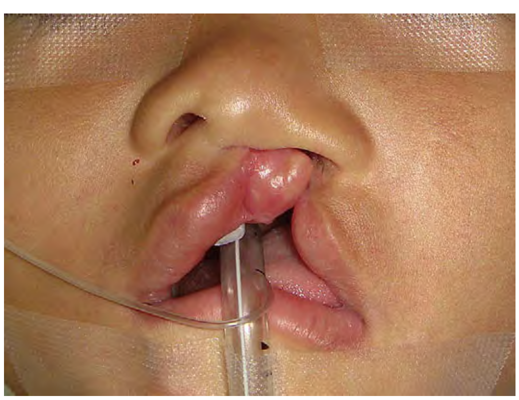

Fig. 1. When there is a total unilateral labiomaxillary cleft, the muscles on the cleft side remain lateral to the defect, and even if they are correctly formed, they cannot function normally. Deprived of the nasal septum and the anterior nasal spine as a point of anchorage, the system collapses much as a circus tent would do if it lost its central pole.

Fig. 2. The skin appears insufficient because it has not been distended by function.

alaeque nasi, levator labii superioris, depressor septi (myrtiformis), and horizontal and oblique heads of the orbicularis oris muscle thus do not insert on their corresponding elements on the medial side of the cleft. Consequently, they are prolapsed laterally against the minor maxillary segment from which they cannot solicit stimulation and normal growth. Neither can they participate, as they normally do, in growth at the interincisive suture, and the developing incisor teeth are relatively anteriorly malpositioned as a result. The nasal septum is pulled by the muscles on the noncleft side, displacing it and the anterior nasal spine in this direction. These muscular anomalies have a global, facial, ripple effect that influences mandibular equilibrium. On the cleft side, the labial commissure is deviated lateroinferiorly, influencing the depressor anguli muscle, which, in turn, favors lateral deviation of the chin to the cleft side. This accentuates the nasal asymmetry, and all the anterior part of the face is thus distorted and malformed.

If untreated, this condition persists without remarkable aggravation throughout growth, which explains why patients who are not operated on until adulthood have facial growth but with deformities of the same type as those observed at birth. In effect, at birth, the malformation is already the result of disequilibrium and muscular dysfunction that does not change a great deal unless the patient is operated on. After primary cheiloplasty, the anatomic and functional equilibria are radically transformed. Unfortunately, the anatomic reconstruction is rarely excellent, particularly with classic techniques that attribute great importance to the plastic (esthetic) aspect but less importance to the functional aspect. When this reconstruction is imperfect, it results in dysfunctions that disadvantageously affect subsequent skeletal growth of the face. If, however, the primary nasolabial reconstruction is good, anatomy, function, skeletal growth, and total facial aesthetics can be excellent (Fig. 3). The fundamental goal of the surgeon is thus to achieve anatomic muscular reconstruction, particularly with respect to anchorage of the complex nasolabial muscles of the cleft side to the nasal septum and muscles on the noncleft

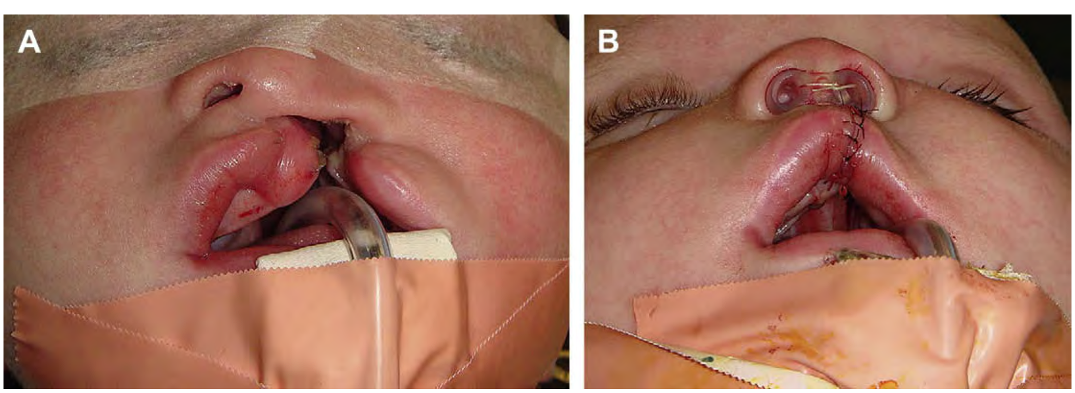

Fig. 3. (*A*, *B*) Surgery to achieve anatomic muscular reconstruction of the nasolabial muscles on the cleft side so that they are anchored to those and the nasal septum of the noncleft side establishes a new anatomic and functional equilibrium that provides optimum conditions for subsequent facial growth.

side. The technique that allows this objective to be met, termed the *primary functional cheilorhinoplasty*, has been well described, particularly with respect to muscle reconstruction.

Displacement, deformation, and functional hypotrophy also affect the mucocutaneous structures that border the labial clefts. This fact is less well known, but it has, nevertheless, great importance in the selection of incision design in the primary closure of cleft lip. The goal of primary closure is not only to re-establish normal insertions of all the nasolabial muscles but to restore normal position of all the other soft tissues, including the mucocutaneous elements. Thus, one can only realize Veau's ''embryological surgery'' by re-establishing at surgery all the anatomic and functional conditions that normally ought to have been present at the end of the embryonic stage.

The characteristics of mucocutaneous abnormalities on both sides of the cleft include malposition of nostril skin onto the upper part of the lip, retraction of the labial skin, alteration of the white roll of the lip, and presence of a special mucosa neighboring the mucocutaneous junction on the sides of the cleft. There is malposition of nostril skin onto the upper part of the lip. As a consequence of the absence of normal muscular support of the floor and the sill of the nose, the skin of the lateral alar part and the medial columellar part of the nasal vestibule is lowered and intrudes onto the upper part of the lip. The limit between skin of nasal origin and that of the lip is usually well defined because the nostril skin is finely stippled, whereas that of the lip has more hair and is finely striated.

On the lateral side of the cleft, the skin of the lip is raised by the mass of the nasolabial head of the orbicularis muscle. In practice, the limit between nostril skin and the lip skin corresponds to a line drawn perpendicular to the mucocutaneous junction from the most external point of the border of the alar base. On the medial side of the cleft, the limit between the nostril skin and the lip skin is similarly well visualized by a line drawn oblique to the mucocutaneous junction from a point situated on the columellar border at a distance from the superointernal angle of the nostril equal to that of the noncleft side.

There is retraction of labial skin. On both sides of the cleft, the skin of the lip is less drawn out than normal by the underlying muscles. This results in a reduction in cutaneous length, which is classically thought to be attributable to primary hypoplasia. The skin, however, is actually a bit thicker as a result of the retraction.

There are alterations in the white roll. The limits of the white roll of the lip, relative to the simple ''mucocutaneous junction'' that it follows, are gradual. From the lateral side, the roll progressively diminishes to approximately 2 to 3 mm before it disappears. On the medial side below the inferior part of the philtrum, the limits are less clear.

There are abnormalities in the characteristics of the mucosa neighboring the mucocutaneous junction. Normally, the labial lining consists of three well-defined areas: an external cutaneous area; an internal area of wet mucosa; and an intermediate area called ''the zone of Klein,'' which is formed by a dry mucosa directly attached to the small compressor muscle of the lips. In labial clefts, particularly on the lateral side, the area that separates the skin from the wet mucosa is different from normal vermillion. Actually, the mucosa of this excessive area is finer than normal and is without an underlying glandular bed and the compressor muscle of the lips.

Thus, these clinical observations support the notion that disorganization of the system responsible for premaxillary growth is an important cause of dentoskeletal defects in patients who have a cleft deformity. Further, irrespective of the existence or not of a distinct human premaxilla, it retains sufficient independence to demand that the restoration of its anatomy and physiology, in addition to that of the entire medial septal system and nasolabial musculature, must be the cornerstone of successful primary and secondary cleft surgery. The author believes that this can best be achieved at approximately 6 months of age, when there has been sufficient development of muscle to permit careful identification and suturing of the relevant nasal and labial muscles to the nasal septum. Concomitant with primary lip surgery at 6 months of age, primary soft palate muscular construction must be performed to establish deep symmetric function and to aid in reduction of the width of the hard palate cleft, which provides the most favorable conditions with respect to the palatal mucoperiosteum during closure of the hard palate at approximately 12 months of age.

To re-establish the normal situation and dimensions of the mucocutaneous elements in primary closure of total, unilateral, labiomaxillary clefts, it is necessary to achieve good position

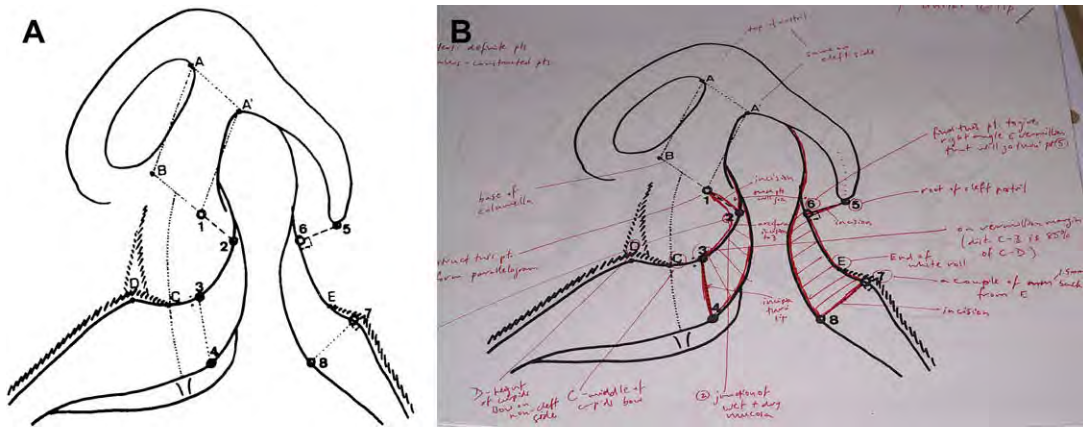

Fig. 4. (*A*) Incision design (Delaire) for complete cleft lip. A, Superior nostril angle of the noncleft side. A′, Superior nostril angle of the cleft side. B, Base of the columella on the noncleft side. C, Midpoint of the philtrum at the mucocutaneous junction. D, Summit of Cupid's bow at the mucocutaneous junction on the noncleft side. (1) Point of extension from B on a line parallel to A–A′ at a distance from A′ equal to A–B. (2) Point of extension of B–1 at the mucocutaneous junction. (3) Point on the mucocutaneous junction on the cleft side, such that C–D = C–3. (4) Point situated at the junction of the vermillion and the wet line of the lip at a distance from the midline of the lip equal to C–3. (5) Point of junction of the nasal ala and the lip on the cleft side. (6) Point at the mucocutaneous junction on the line 5–6, which is perpendicular to that mucocutaneous border. (E) Point of extremity of the white line of the lip on the cleft side. (7) Point on the white line of the lip approximately 2 to 3 mm lateral to E. (8) Point situated at the junction of the vermillion and the wet line of the lip on the line 7-8, which is perpendicular to the vermillion junction and the wet line of the lip. (*B*) Planning sketch used for teaching purposes.

of the skin of the floor and sill of the nostril, obtain good height of the skin of the cleft side, recreate good form and continuity of the white roll of the lip, establish equal vermilion height on both sides of the cleft and on both sides of the middle of the lip, and excise abnormal mucosa from both sides of the cleft (Fig. 4).

To achieve good positioning of the skin of the floor and the sill of the nostril, it is absolutely imperative to respect the cutaneous areas and their individual characteristics relative to the skin of the lip. By definition, this rules out all those incisions that intrude on these areas, notably those that enter the nostril curving inside or outside of the ala and extending to the columellar base. This also rules out all cutaneous excision in the upper part of the lip. The best incisions in the upper part of the lip are thus those that pass exactly between the skin of the nose and that of

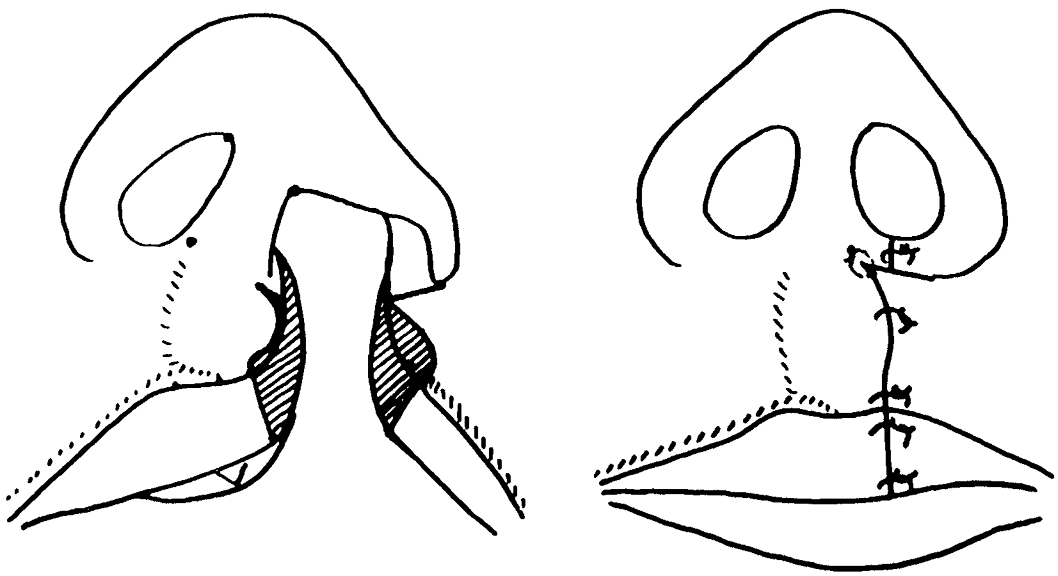

Fig. 5. Incision design (Delaire) when there is little retraction of the cleft margins and the white line of the lip is not too accentuated.

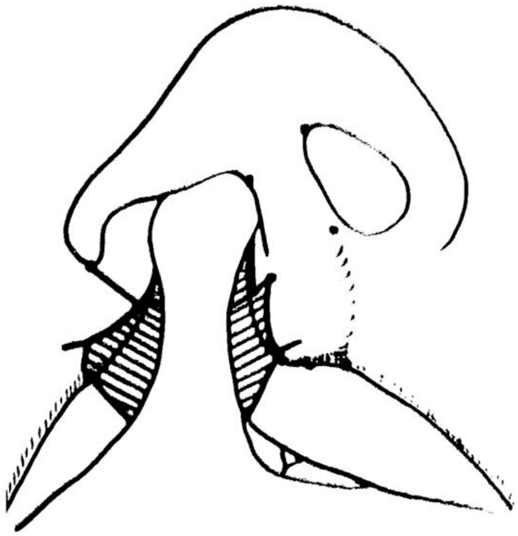

Fig. 6. Incision design (Delaire) for a right-sided complete unilateral cleft lip when there is large retraction of the cleft margins and the white line of the lip is not too accentuated.

the lip and stop laterally at the external border of the alar base and medially below the border of the columella (Fig. 5).

To obtain good height of both sides of the cleft relative to the noncleft side, it has been thought necessary, classically, to elongate the labial skin on the cleft side using various plastic procedures, such as the quadrangular flap (Le Mesurier), the triangular flap (Tennisson, Randall, Skoog, Trauner, or Malek), arciform flaps (Millard), or undulating flaps (Pfeiffer). Actually, because the skin of the lip is retracted as a consequence of the absence of abnormal muscular actions, it suffices to reconstruct carefully the equilibrium of the nasolabial muscles, which, usually within a few weeks after primary surgery, causes the overlying skin to distend progressively to the correct height. In cases in which the preoperative retraction is quite severe, however, one can use a small equilateral triangular flap (marked just above the white roll) that inserts into an equivalent triangle obtained by making a short incision on the internal side of the cleft. This incision never exceeds 2 to 3 mm, and it never extends past the midline (Fig. 6). Care should be taken when using this triangular flap because the postoperative distention of the skin is accompanied by a slightly excessive lowering of the mucocutaneous roll, which ultimately requires a minor revision.

To establish good continuity and normal form of the white roll of the lip, it is advisable to make reference marks to give equal length to both halves of the middle concave part of Cupid's

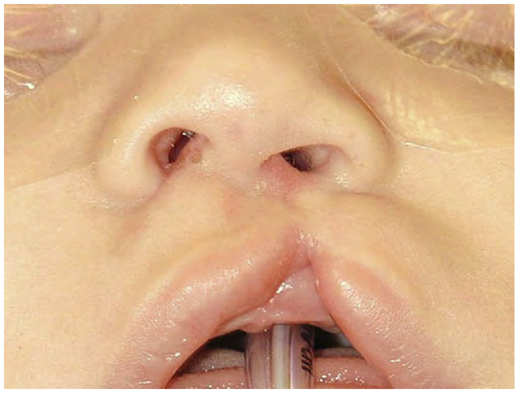

Fig. 7. When incomplete clefts of the lip are compared with total unilateral clefts, there is little difference in the skin of the lip, the mucocutaneous roll, and the mucosal borders of the cleft. At the upper part of the lip, however, the skin that is derived from the nostril not only intrudes onto the lip but is variably distended by labial traction.

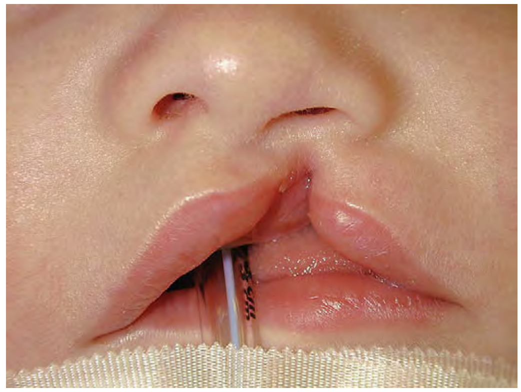

Fig. 8. In incomplete unilateral cleft lip, there seems to be an excess of nasal skin here, but one must avoid excision of it.

bow and to align the extremities of this mucocutaneous white roll precisely at the end of the operation. Marking the reference points on the white roll is generally easy on the lateral side of the cleft up to a point a few millimeters from its internal limit, where it gradually fades away. This precise point where it begins to fade away ought to be well marked at the beginning of the operation. To do this, the author uses a double-Veau needle with methylene blue on both sides of the mucocutaneous junction. On the medial side of the cleft, however, the roll is less pronounced, and it is normally absent from the middle of the lip. Its extremity is thus determined by measurement using the distance from the middle of the lip to the internal slope of the philtral crest of the noncleft side as a reference. To align the two margins of the

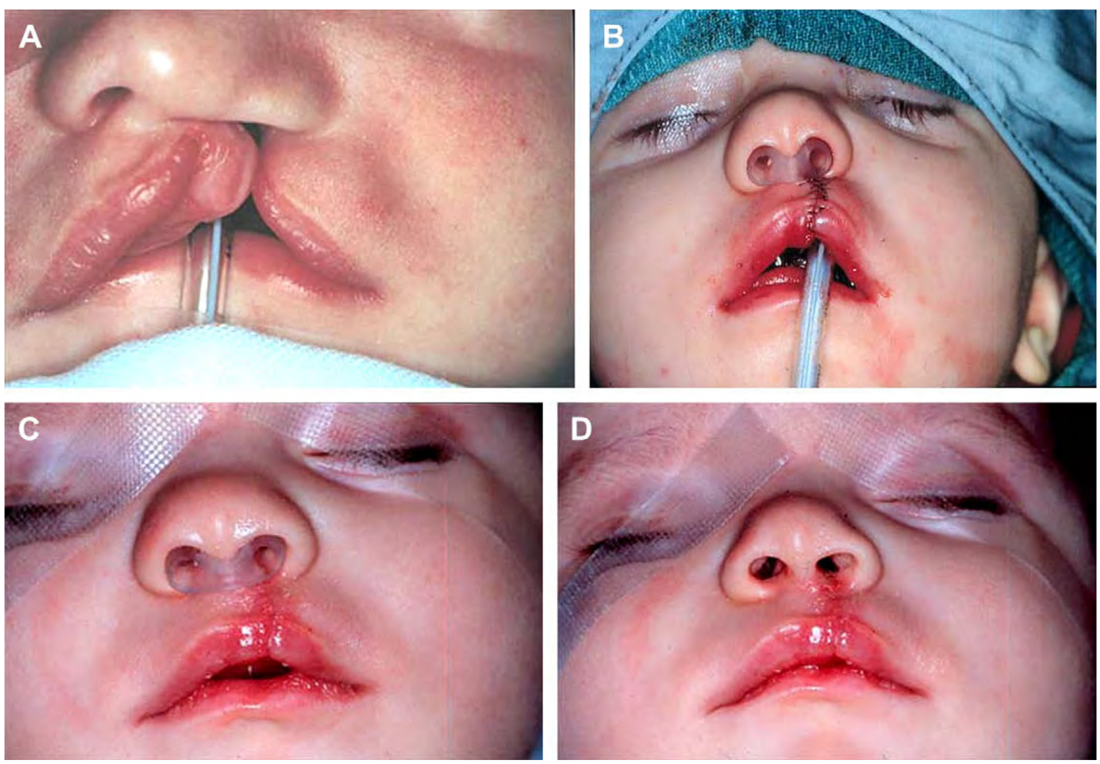

Fig. 9. (*A*) Before surgery. (*B*) Once the fundamental relations have been surgically created, their maintenance can be ensured with the use of a silastic intranasal retainer, which is stabilized by stay sutures for the first week after surgery. (*C*, *D*) After this time, the retainer can be removed, cleaned, and replaced in the nose on a regular schedule for 10 to 12 months. The nasal retainer has proved to be useful in maintaining surgically realized anatomic corrections through functional cheilorhinoplasty. Nasal airway patency and nostril symmetry are improved as a result of use of the nasal retainer. No restrictions on feeding or sucking are placed on the child after surgery.

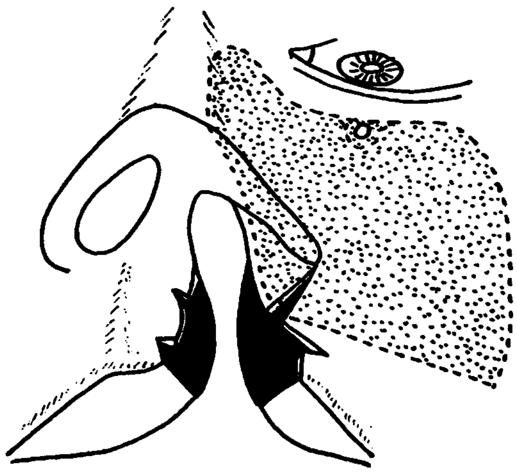

Fig. 10. Wide subperiosteal undermining of the facial surface of the maxilla up to and including the infraorbital nerve.

mucocutaneous roll at the end of the operation, the previously tattooed points are helpful. The small external triangular flap and the corresponding internal incision (both situated equidistant from the mucocutaneous roll) also aid in accurate reconstruction. When this plastic procedure is not indicated, one can replace it with an arciform design of the two labial incisions. It can even be replaced by a little flap, a "V"-shaped extension of the external mucocutaneous roll, which fits into an incision of the same length exactly at the mucocutaneous junction of the internal side of the cleft. This flap is useful when the mucocutaneous roll of the external side of the cleft is marked, whereas that of the internal side is scarcely visible. In fact, in the absence of this little flap, there can be an unaesthetic difference in the thickness of the roll on either side of the suture line.

To achieve vermilion height, which is equal on both sides of the cleft and identical to that of the noncleft side, it is advisable to place the tattoo reference clearly on both sides of the mucocutaneous roll and, moreover, to tattoo the limit between vermilion and the wet mucosa. One must define the orbicularis muscle and the glandular bed, clearly marking their respective limits at the level of the inferior part of the vermillion. During the final suturing, it is necessary to reconstruct the transverse fibers of the orbicularis oris muscle symmetrically before closing the mucocutaneous roll and the junction of the vermilion and the wet mucosa. Excision of the excess mucosa on both sides of the cleft is necessary for good muscular suturing. Although the

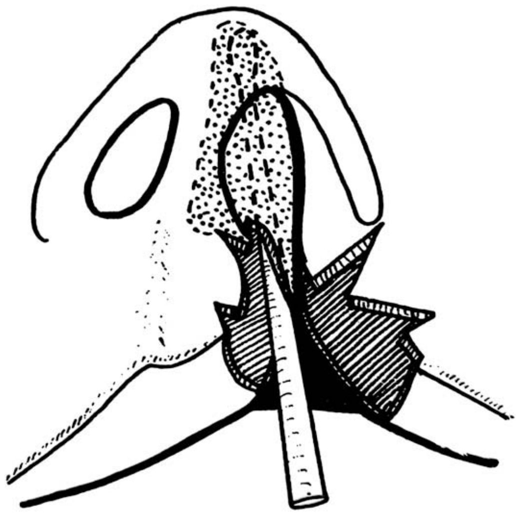

Fig. 11. Wide subperichondrial dissection of the cleft side of the nasal septum to allow proper midline placement of the septum.

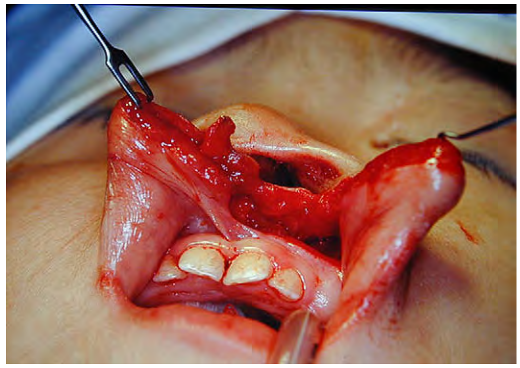

Fig. 12. Watertight closure of the nasal floor and preservation of the maxillary labial frenum are important prerequisites of good nostril function and subsequent facial growth.

medial triangle is systematically excised, the excessive mucosa on the lateral side can be conserved to form a superior pedicle flap for the inferior part of the nasal layer.

Regarding incomplete deformities, relative to total unilateral clefts, there is little difference in the skin of the lip, the mucocutaneous roll, and the mucosal borders of the cleft. At the upper part of the lip, however, the skin that is derived from the nostril not only intrudes onto the lip but is variably distended by labial traction (Fig. 7). Therefore, there seems to be an excess of nasal skin here, but one must avoid excision of it (Fig. 8). In fact, once this skin is placed in a good position, it gradually assumes proper dimensions. On occasion, a minor secondary revision can perfect its alignment. The flap designs should thus follow the same principles as those that govern total labiomaxillary clefts: delineation of areas of nasal and labial skin and restoration of these respective areas to a good position, most often without the use of a lateral

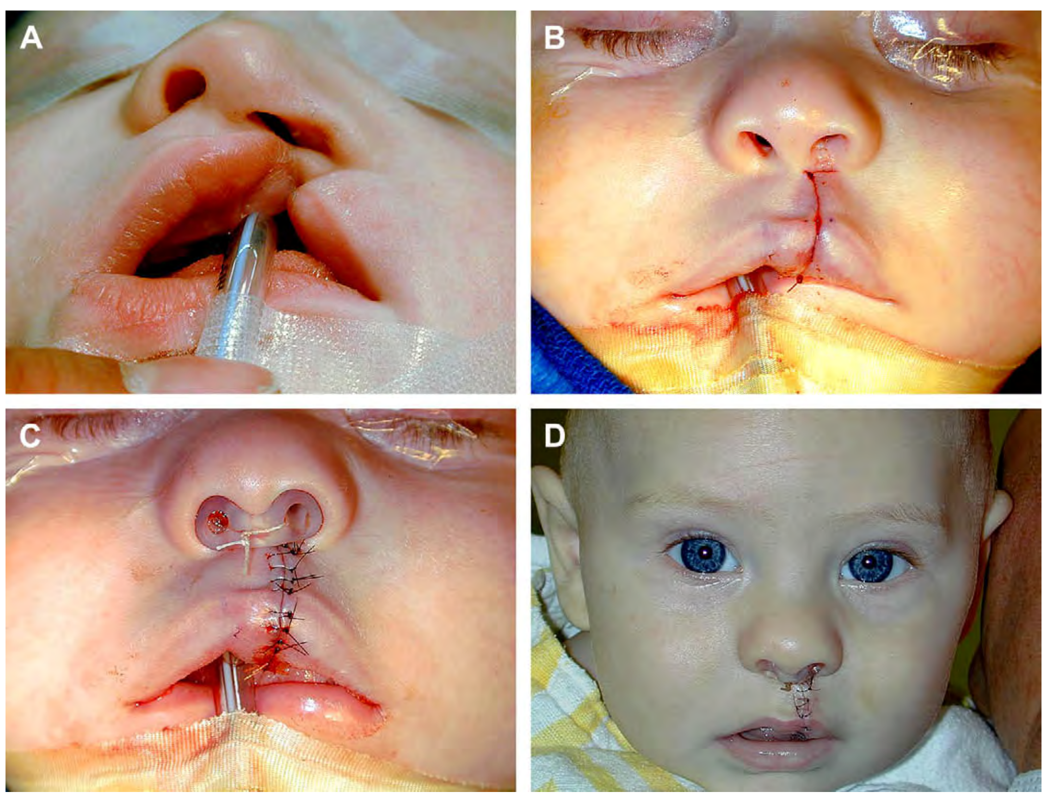

Fig. 13. (*A*) Immediate preoperative condition of the baby. (*B*) Muscle reconstruction, such that all the anatomic elements of the surface structures rest together passively. (*C*) Placement of skin sutures and nasal retainer. (*D*) Baby 5 days after surgery.

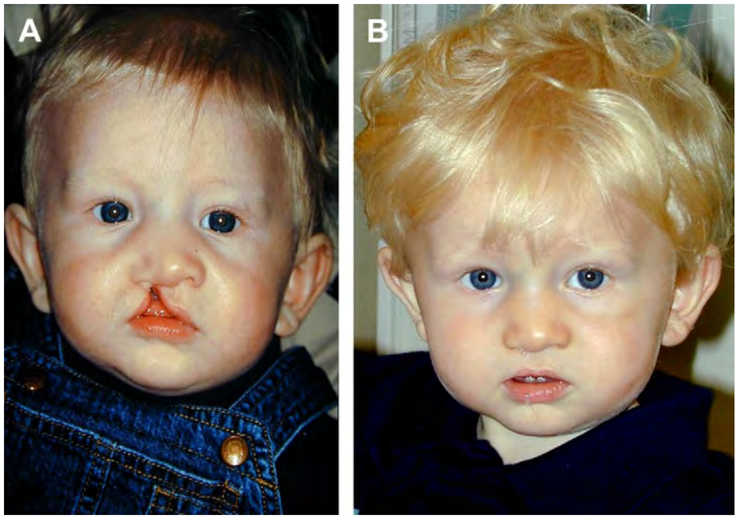

Fig. 14. Preoperative and postoperative photographs of a child treated at 6 months of age according to the principles of Delaire.

triangular flap. In the author's experience, nasal airway patency and nostril symmetry are improved as a result of the use of a nasal retainer (Fig. 9). To advance the lateral soft tissues of the cleft adequately, it is necessary to carry out wide subperiosteal dissection of the facial aspect of the maxilla (Fig. 10). To achieve the proper midline position and attitude of the nasal septum, the surgeon must perform a wide subperichondrial dissection of the cleft side of the septum (Fig. 11). Both of these surgical acts permit the creation of a watertight nasal floor while preserving the integrity of the maxillary labial frenum, which is an important constituent of the nasal septal midline traction system (Fig. 12). It is necessary to reconstruct the nasolabial muscles of the cleft such that the skin margins are passive and touching each other at the moment of skin closure (Figs 13 and 14).

Summary

At the end of the primary lip operation, the surgeon must have achieved the following:

1. Straight nasal septum positioned in the facial midline
2. Symmetric reconstruction of the nasolabial muscles
3. Absence of vestibular oral nasal communication
4. Functional patent nostril on the cleft side

Knowledge of these characteristics provokes new primary incision designs that better respect the origins of cutaneous areas, thus avoiding unnecessary mutilation and scarring, particularly at the base of the columella, nasal ala, and mucocutaneous roll. These incision designs can provide optimum results only when they are combined with excellent muscular surgery, which is the foundation of congenital cleft repair.

Today, there are two opposing views regarding surgery to correct cleft lip and palate deformities. There is a static concept that simply brings together apparently inert elements to give a corrected appearance. There is also a dynamic concept that, through redeployment of muscles, establishes vital function of structures heretofore buried and inhibited by their malposition.

It is necessary to apply this latter creative concept to the correction of the labiomaxillopalatine cleft itself and the sequelae of its correction by using functional surgery, the essential objectives of which are re-establishment of "normal" oral-facial muscular balance, lip competency, and good nasal breathing. If these functional bases are achieved, the best possible aesthetic result can always be obtained.

Failure of muscular union in the midline at approximately the seventh week in utero deforms and disturbs the entire region by retruding the structures of the cleft side, completely vertically distending the nasolabial soft tissues. Thus, the constituent muscles are present in the lateral aspect of the cleft, and it is necessary for the surgeon not only to identify and reinsert them with particular accuracy but to minimize, as much as possible, the creation of unnecessary scar tissue. This demand ought not to have any exceptions, and it is only after having put in place the muscular and cartilaginous structures that one can complete, if it is necessary, purely plastic operations, such as cartilaginous grafts, compound grafts, and plasties of varying complexity, which rarely are indicated in this type of surgery, when all the deformities have already been corrected according to this functional aim.

Acknowledgments

The author sincerely thanks Professor Jean Delaire whose work constitutes a major world contribution to the treatment of patients who have cleft lip/palate.

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Primary Bilateral Cleft Lip/Nose Repair Using the "Delaire" Technique

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Once differentiation of the cells forming the future face has been initiated by one or more epithelial-mesenchymal interactions, other factors regulate subsequent development and growth of the maxillofacial complex. Individual elements or regions do not develop and grow at the same rate; there is a well-known phenomenon of relative growth. Such regional differences imply that development and growth are not regulated globally.

Control of development and growth is therefore not global but local. Two sets of local controlling factors that can be at play are (1) intrinsic differences in different regions of the skeleton, muscles, nerves and (2) differences in the local environment in which individual elements develop. Evidence for intrinsic differences comes from documentation of differences in osteogenic and hematopoietic capability between bones that develop endochondrally and those that develop intramembranously or differences in inherent versus evoked growth potential (eg, capability of primary cartilages, such as Meckel's cartilage, to proliferate and grow independently of external influences versus the requirement of secondary cartilages, such as that of the condylar process of the dentary, for extrinsic [muscular] stimulation of growth).

Evidence for differences in local environments within the embryo comes from the concept of functional matrices developed by Moss [1]. During late embryonic life, the development and growth of the cranium are influenced by the expanding and growing brain, those of the mandible and palate by the growing tongue, and those of the maxillofacial region by the expanding eye and growing nasal septum. The same elements of the head and face are therefore subject to regulation by different factors at different times during pre- and postnatal development.

Regulation of the development and growth of individual elements is not a case of all intrinsic or all extrinsic control. These responses are possible because the progenitor cells modulate their proliferative potential in response to stimuli (presumably mechanical) associated with muscle pull. A low intrinsic growth potential can be massively augmented and regulated in response to functional demand, a requirement that can be taken advantage of by surgical manipulation.

Adjacent skeletal units, even though controlled by different functional matrices, influence one another because they are adjacent, begin their development at different times, develop and grow at different rates, and respond to different controls. Thus, the cranium grows fast and early to keep pace with the early and rapidly growing brain, whereas the mandible and maxilla grow slowly and late, with their rates being more in tune with general somatic growth than with brain growth.The influence of cranial growth on facial growth is because of timing, structure, and function. Because the cranium grows to keep pace with the rapid and early growth of the brain, it especially influences growth of the upper third of the face, which, accordingly, displays the fastest rate of facial growth and complete growth first at around 12 years of age. The remainder of the maxillofacial region is less affected by brain growth and, accordingly, grows more slowly

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and for a longer time, with growth not being completed until the late teens or early 20s when the wisdom teeth erupt.

The anterior attachment of the facial skeleton to the base of the skull provides the structural component linking cranial and facial growth. The functional component is provided by the three major sense organs (eye, ear, and nose), with their tissues and cavities acting as functional matrices for maxillofacial growth. Skeletal units have been used to identify the elements of the maxilla that respond by growth to particular functional matrices: growth of the eye influencing the orbital unit, growth of the nasal septal cartilage influencing the nasal unit, growth of the teeth in the alveolar unit, and growth of the maxillary sinus in the pneumatic unit. Progressively, the relevant muscles exert their influence on growth and maintenance of adult form. Thus, the major functions of neural integration—sight, sound, smell, digestion, and respiration—all influence maxillofacial growth to varying degree and at various times during pre- and postnatal development. This explains, in part, the bewildering diversity that is seen clinically, particularly with respect to bilateral cleft lip/palate (Fig. 1).

It is evident from the preceding sections that craniofacial development is hierarchic and integrated, with important temporal and spatial components adding to the complexity of control mechanisms. Consequently, there is no single basis for craniofacial malformations. Also to be considered is the remarkable capacity of the embryo to compensate for loss, deficiencies, or deviations from normal development, a phenomenon known as developmental regulation. For example, a halving of the rate of cell division (by slowing the cell cycle) in a population of migrating neural crest cells would be expected to produce a mesenchymal condensation that was only 50% of the normal size (as happens in some mutants). Because osteogenesis may not commence in condensations that are lower than a threshold size, such a reduced rate of cell division would be expected to lead to skeletal deficiencies or abnormalities. An increase in the proportion of cells that are mitotically active (normally, not all the cells in a population are dividing) could compensate for the extended cell cycle, however, resulting in production of a condensation of normal size in which normal skeletogenesis is initiated. Indeed, whole mammalian embryos can compensate for massive reductions in cell number and return to normal size within as little as 3 days. It can therefore be difficult and perhaps misleading to pinpoint alterations in a single development event as the basis for a malformation without a careful analysis of many developmental processes.

Congenital labiomaxillary clefts result from the absence of fusion or incomplete fusion of the maxillary and medial nasal processes. The superficial muscles of the face, which arise from the second branchial arch, migrate laterally and medially between the epidermis and subjacent ectomesenchyme and normally reach the midline in the week that follows fusion of the facial processes. In a complete labiomaxillary cleft, the muscles of the nasal floor and upper lip cannot bridge the gap of the cleft nor can they unite with their muscular counterparts on the noncleft side. The muscular integrity of the region is considerably disrupted, which has a profound effect on the underlying skeleton (Fig. 2).

In bilateral clefts, on each lateral side of the labial cleft, the mucocutaneous lining essentially has similar characteristics to those in the total unilateral cleft. On the median process, however, it is different. The skin is actually much retracted and supported by underlying connective tissue that is not retracted. Moreover, the ensemble of skin and connective tissue is compressed by the dental buds, themselves anteriorly displaced by the posteroanterior pressure that is exerted by the lower lip and absence of the external upper labial sling. The columella is also retracted, and its lower part intrudes onto the median process, where it more or less blends in with the skin of the lip (Fig. 3). Other than in exceptional cases of holoprosencephaly, there is little or no true hypoplasia. Simple postoperative distention of the labial skin and columella is therefore, by itself, capable of giving the reconstructed lip good height without having to resort to procedures of elongation that needlessly mutilate the lip. There is no trace of mucocutaneous roll on the median process because its constituent elements, such as the labial muscles, remain on each side of the labial cleft.

On the lateral surface of the cleft, the cutaneous incision designs at the junction of the nasal skin and labial skin are performed in the same fashion as those for total unilateral cases. At the lower part of this incision, however, one must respect and conserve all the mucocutaneous roll, which tapers out for 3 to 4 mm along the mucocutaneous junction, and particularly all the excess mucosa bordering the cleft.

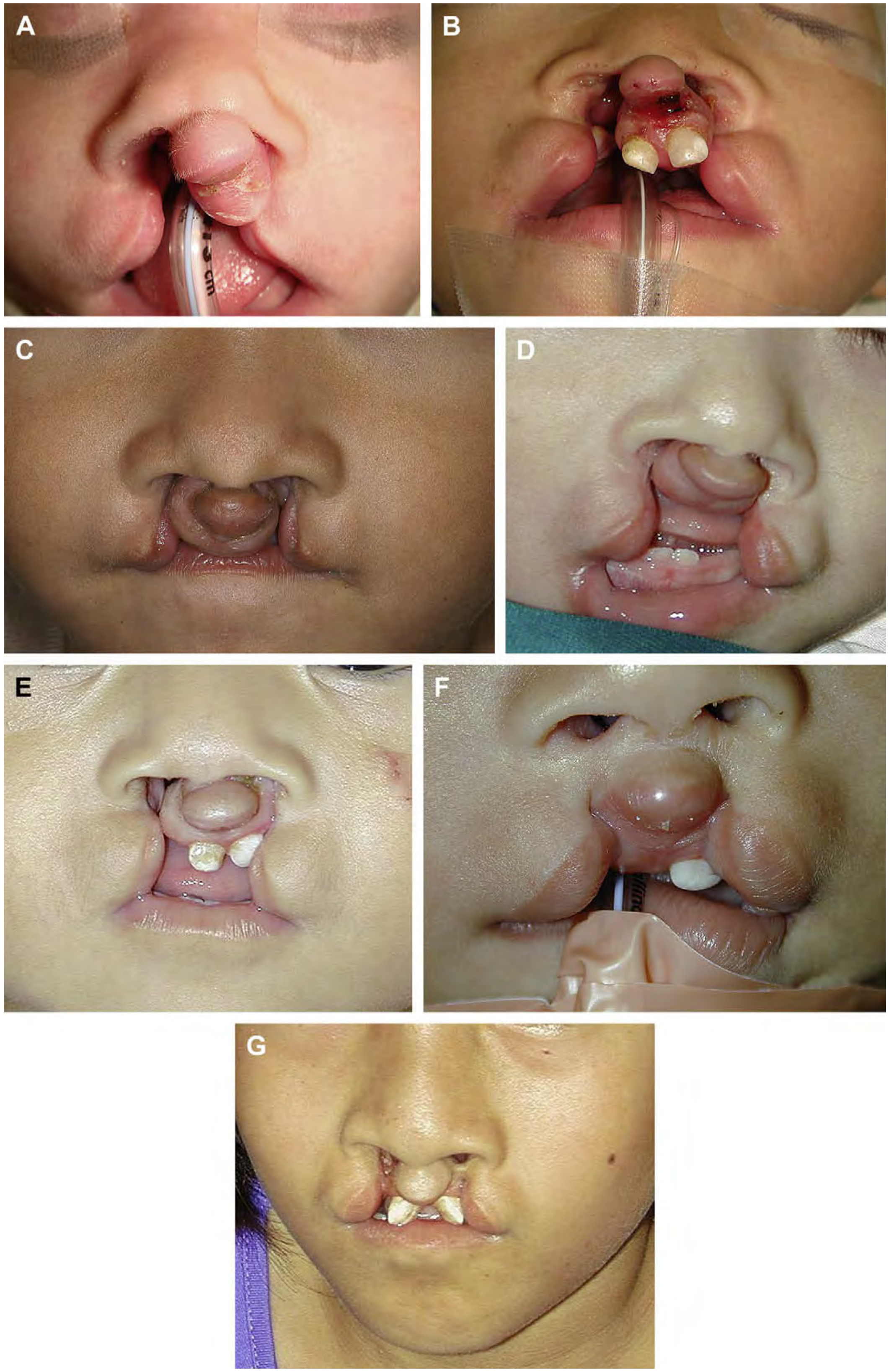

Fig. 1. The clinical presentation of bilateral cleft lip and palate occurs with great morphologic variability. This is one reason why it is preferable to avoid a geometric incision design and to use functional anatomic landmarks. (*A*) Dissymmetric form of complete bilateral cleft lip. (*B*) Moderately wide and relatively symmetric complete bilateral cleft lip with excessive protrusion of the medial elements and premaxilla. (*C*) Vertical and transverse insufficiency of the medial soft tissues of the cleft lip. (*D*) Note the good quantity of muscle in both lateral elements of the cleft lip, which favors sufficient and accurate muscular reconstruction. (*E*) One can see the natural line of demarcation between the nasal skin and the skin of the lip on both lateral elements of the cleft. (*F*, *G*) Incomplete forms of bilateral cleft deformity; these are sometimes erroneously thought to be easier to correct than complete forms.

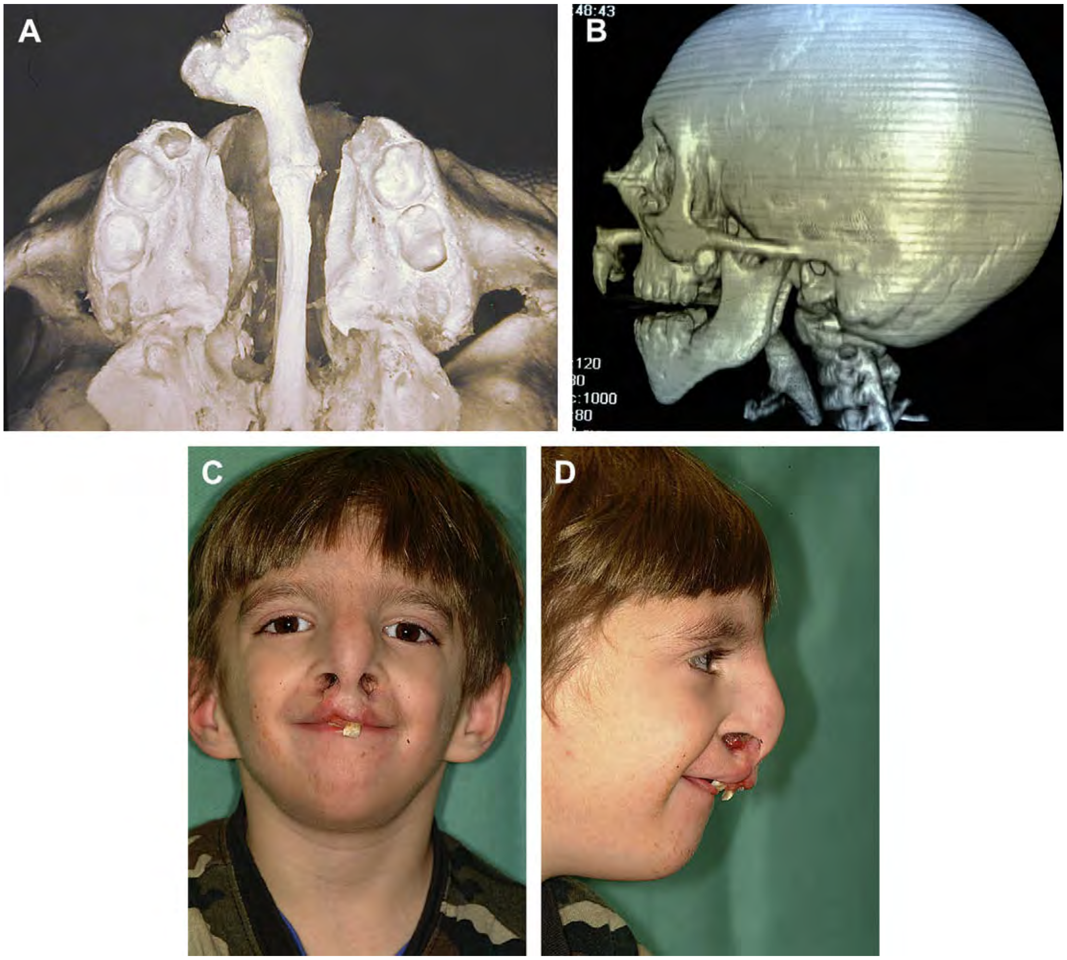

Fig. 2. Facial bones form after facial muscles. As a result, in bilateral cleft lip and palate, the bones form under the influence of dissymmetric muscles with resultant skeletal abnormalities at birth. Unless the muscles are reconstructed properly, the skeletal abnormality continues into adult life. (*A*) Infant dry skull shows the influence of muscles on the position of the premaxilla. (*B*) Note excessive projection of the premaxilla-vomer complex because of the absence of the normal restraining influence of an intact nasolabial muscle complex. (*C*, *D*) Examples of inadequate and inaccurate muscle reconstruction at primary surgery leading to typical associated stigmata.

On the median process, because it is difficult to delineate nasal skin and columella from labial skin, one can consider that these two cutaneous areas each correspond to half the distance separating the superior internal angle of the nostril from the mucocutaneous junction at the inferior part of the median process (Fig. 4). From these two reference points situated at the middle of this distance, aligned with the edges of the columella (see Fig. 4, point 2), two lines are then drawn on each side. One line is perpendicular to the mucocutaneous junction of the side of the cleft, marking the inferior limit of the nasal skin. The other line is arciform, following the mucocutaneous junction to the middle of the process opposite the labial frenum. A subtle badge-like modification at the inferior part of the process facilitates final suturing. This design is similar to that proposed by Millard for incomplete bilateral clefts [2]. It differs from it, however, with respect to the columellar base and the origins of the mucocutaneous surface. The mucosa, which is situated between this arciform incision and the wet mucosa of the median process, is carefully excised, strictly avoiding violation of the frenum of the upper lip (Fig. 5). Frontal cleavage of connective tissue of the median process up to the anterior nasal spine is necessary to allow good anatomic, and thus functional, reconstruction of the nasolabial muscles without which good secondary skin distention cannot take place. All the vermilion thus comes from the lateral processes. Thanks to wide bilateral periosteal undermining, it is usually possible to close both sides of the cleft at the same operation. It is only in some rare and special cases in

Fig. 3. Note how the columella is retracted and that its lower part intrudes onto the median process, where it blends with the skin of the lip.

which there is marked projection of the median process that closure is performed in two stages, one side and then the other or after a wide primary adhesion.

Careful and systematic dissection is the key to complete and stable repair in which muscles and nasal cartilages find their normal relations. On both sides, after a backcut in the labial sulcus, a wide subperiosteal undermining on the lateral segment of the maxilla from the orbital rim to the piriform aperture allows advancement of the cheek and the lateral part of the lip to the midline. Along the piriform aperture, the nasal mucosa is widely undermined from the medial wall of the maxilla. Clinical experience has shown that wide subperiosteal undermining is safe.Subperiosteal undermining is not detrimental to facial growth. Conversely, when the undermining is performed between the periosteum and muscles, excessive scar formation and reduced perfusion of the bones ensue.

In the midline (Fig. 6), the prolabial flap and the posterior mucosal flaps are undermined without touching the periosteum on the anterior aspect of the premaxilla. A short cut is made along the membranous septum, and the perichondrium of the inferior border of the septum is incised to permit wide subperichondrial undermining of the septum and its junction with the two upper lateral cartilages. A precise dissection exposes their two sides and joins the piriform aperture laterally. The mucosa between the upper and lower cartilages is elongated. The dissection is resumed from the piriform aperture and begins on the caudal end of the lower lateral cartilage. The superficial aspects of the lateral crura are separated widely from the skin without exposure, and their inner face is slightly undermined along the cephalic border. The skin between the nasal web and the nostril rim also is undermined to allow complete redraping of the

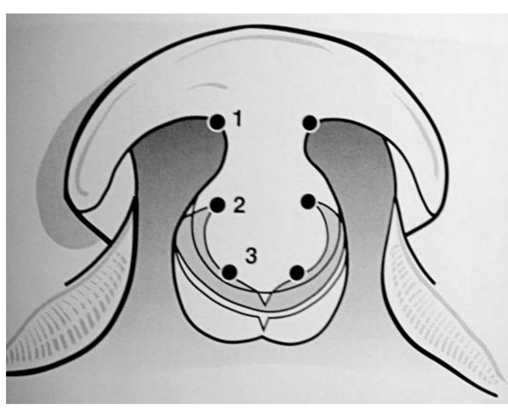

Fig. 4. There are two cutaneous areas, each of which corresponds to half the distance separating the superior internal angle of the nostril from the mucocutaneous junction at the inferior part of the median process.

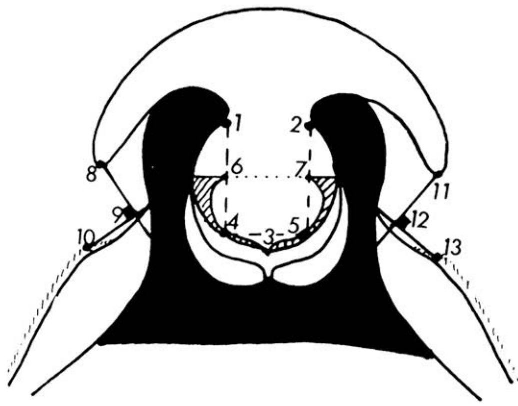

Fig. 5. Anatomic landmarks for the Delaire incision design for primary bilateral functional cheiloplasty. Points 1and 2 define the superior internal angles of the nostrils. Point 3 defines the inferior midpoint of the median process. Points 4 and 5 define the lateral points of Cupid's bow at a width equal to that defined by points 1 and 2. Points 6 and 7 define the line of demarcation between the columella and philtrum. Points 8 and 11 represent the points of implantation of the lateral aspect of the nostril into the facial skin. Points 9 and 12 represent the medial definition of the lateral component of the nasal floor and sill. Points 10 and 13 define the point of disappearance of the white roll of the lip. Hatch marks represent tissue that is excised.

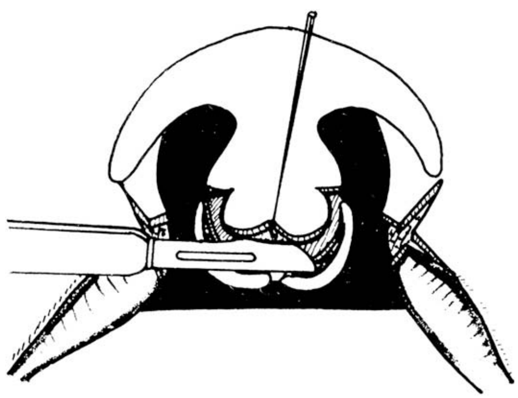

Fig. 6. The prolabial flap and the posterior mucosal flaps are undermined without touching the periosteum on the anterior aspect of the premaxilla.

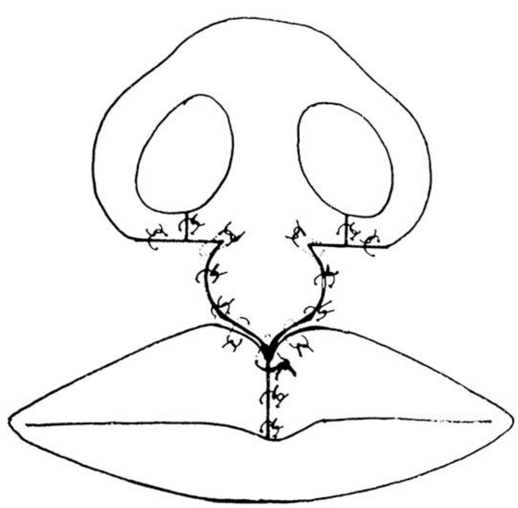

Fig. 7. Final suturing of Delaire technique for bilateral cheiloplasty.

Fig. 8. Nasal retainer sutured in place.

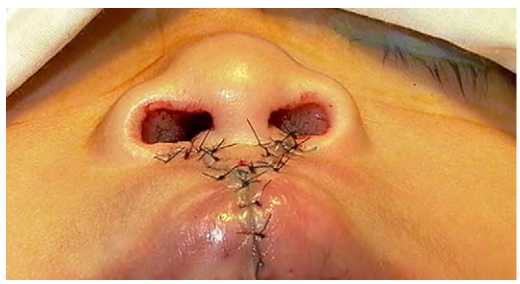

Fig. 9. When the nasal retainer is removed 6 or 7 days after surgery, there is no excess tissue in any of the nasolabial tissues.

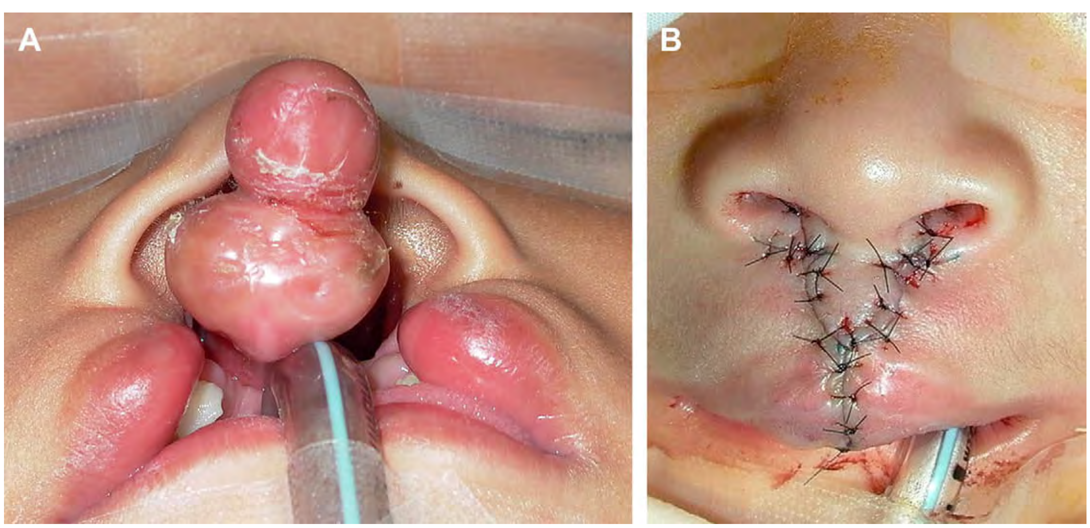

Fig. 10. In most cases, it is possible to perform single-stage primary functional cheilorhinoplasty even when the preoperative condition is grossly distorted: before primary surgery (*A*) and after primary surgery (*B*).

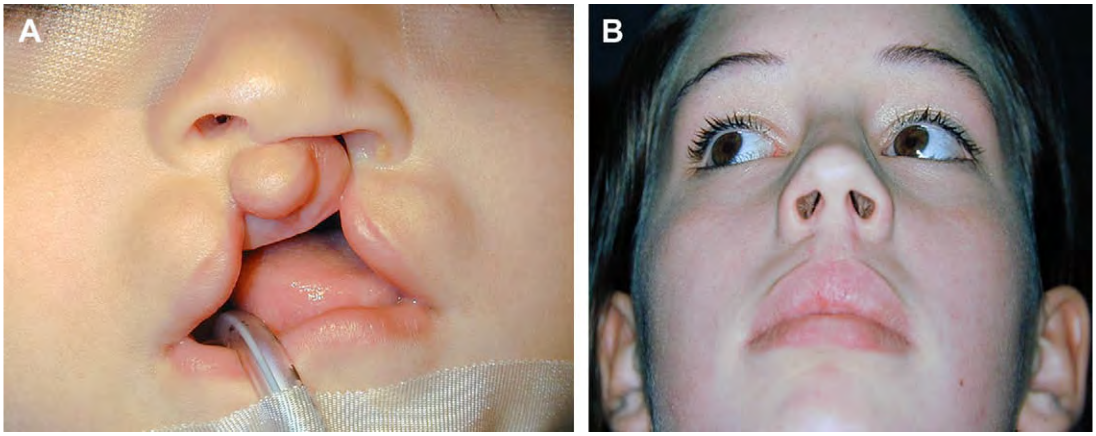

Fig. 11. Before surgery at 6 months of age (*A*) and after treatment (*B*) at 16 years of age.

vestibular lining in this particular area, wherein an excess of connective tissue explains the flared nostrils. With the previous dissection and this mucosal plasty, surgery alone achieves in a few minutes the same lengthening as presurgical nasoalveolar molding of 16 weeks associated with surgical dissection with incisions at least as long. The nasal floor is repaired, and the labial mucosa of the sulcus is sutured laterally and approximated to the mucosa of the premaxilla.

The myrtiform head of the transverse muscle, which is the deeper muscle in front of the nasal fold, is sutured to the lateral aspect of the premaxilla. To secure this suture, it is wise to tighten it on the mucosa of the labial sulcus but only after the more superficial suture of the two orbicularis muscles in front of the midline is completed. At the same time, the suture of the transverse muscle deepens the nasal floor and the labial sulcus. The superior suture of the orbicularis muscle is suspended to the fibrous tissue of the septal area just in front of the anterior nasal spine. A nylon suture takes the dermis of both alar bases and is passed through the fibrous tissue in front of the anterior nasal spine. Care must be taken when tightening this suture to correct as best as possible the interalar width close to 24 mm, which aids in proper vertical positioning of the nostril.After suturing both nasal sills, the freed lower lateral cartilages and elongated vestibular lining are ready to conform to the nasal tip. The principle of correction is to lift the alar cartilage, simultaneously push the transverse muscle out of the web, and prevent relapse by recreating the nasal lining (Fig. 7).

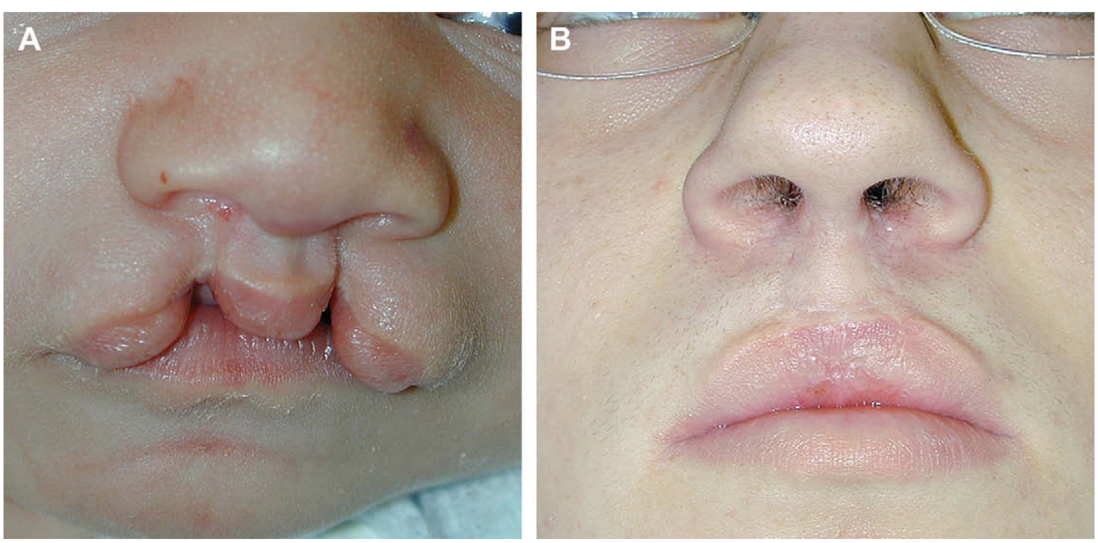

Fig. 12. Clinical photograph shortly after birth (*A*) and at 17 years of age (*B*) of a typical patient treated according to the principles of Delaire.

For a 6-month-old baby, the nasal retainer is placed in the nostrils (Fig. 8). Any trimming of skin and vestibular lining is unnecessary, because it is easy to observe after removal of the retainer, 6 or 7 days later, that there is no excess of tissue (Fig. 9). It is important to respect the vestibular lining and redrape it to stabilize the shape of the nasal tip and to preserve the best nasal valve mechanism possible, with complete independence between the upper and lower lateral cartilages. Another point to consider is that with this technique, the vestibular lining is rolled inside the nose but the external skin can be lengthened. Thus, there is not the shortening of the nose that may accompany the other techniques of correction. Stenosis of the nostril is not seen when prolonged primary nasal splinting (1 year) is feasible.

Summary

Some researchers have stressed that presurgical nasoalveolar molding is less expensive than lip adhesion, does not scar the lip elements, molds the nasal cartilages, lengthens the columella, and prepares the maxillary arch in a more adequate fashion with a precise closure of the alveolar bone gap that allows good repair of the lip and nasal deformity. It is the author's opinion and that of Delaire and others that the best orthopedic treatment remains an anatomic and functional surgical repair achieved in a single stage at approximately 6 months of age. The columella is lengthened at the time of the lip repair by precise repositioning of the lower lateral cartilages and good control of the healing process. The results are good because there is no skin deficiency of the columella, and the nasal retainer preserves the patency of the nasal valve. It is much less expensive to perform surgery alone without presurgical orthopedics or lip adhesion.

For 50 years, presurgical orthopedic treatment has remained a controversial subject. Many teams have claimed that presurgical orthopedic treatment enhances maxillary growth, improves feeding, and restores a normal maxillary arch, which facilitates the primary closure of the cleft with a better esthetic outcome. None of these teams has been able to prove quantitatively a real benefit, however, and no lasting beneficial effect on the esthetics of lip and nose in bilateral clefts has been demonstrated (Fig. 10).The author's goal is to normalize the maxillary arch in early childhood to allow nasal berating and good occlusion. He does not use presurgical orthopedics and prefers a short interceptive orthopedic treatment (if at all) between 5 and 6 years of age to restore the normal relation of the maxillary arch and prepare for an alveolar bone graft with iliac cancellous bone graft at approximately 6 years of age. At this age, the amount of soft tissue that covers the bony cleft is always sufficient and blood supply and plasticity are excellent. The procedure is particularly reliable, and these young patients recover in a short time. This early secondary alveolar bone graft achieves a normal maxillary arch for the time of the mixed dentition and makes the orthodontic treatment easier. This sequence respects the normal width of the anterior maxillary arch and the nasal floor, which allows, together with the associated primary surgical elongation of the columella, good patency of the nasal valve, which is essential for good facial growth (Figs. 11 and 12).

Acknowledgments

The author sincerely thanks Professor Jean Delaire, whose work constitutes a major world contribution to the treatment of patients who have bilateral cleft lip/palate. These patients live better lives as a result of his efforts.

The author also kindly thanks Dr. Brian K. Hall for his collaboration and contribution.

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Primary Palatoplasty Using Bipedicle Flaps (Modified Von Langenbeck Technique)

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Cleft lip and palate is considered to be the most common facial birth defect worldwide. Attempts to repair these deformities date back to the sixteenth century. In 1552, Jacques Houllier proposed that the cleft edges be sutured together, but his operation was unsuccessful. Nearly 200 years later, LeMonnier, a French dentist, successfully completed the repair of a cleft velum. It was not until 1816, however, that the first successful closure of a cleft palate was performed by Carl Ferdinand von Graefe in Germany. An interesting approach was attempted in 1826 by Johan Fredrick Dieffenbach, closing the hard palate and the soft palate. The technique consisted of passing wire through the medial aspect of the cleft, followed by lateral incisions to osteotomize the junction of the palatal bones and the alveolar process; finally, the wires were twisted to close the defect. Unfortunately, this technique had frequent wound breakdowns with subsequent fistula formation.

In the eighteenth century a German surgeon, Bernard Rudolph Conrad von Langenbeck, recognized the potential of periosteum to produce bone. von Langenbeck suggested that inclusion of the periosteum of the palatal bones might produce a stable cleft palate repair. It was not until 1861 that the first cleft palate closures with predictable outcomes were described with a technique that included the use of mucoperiosteal flaps. As a reaction to this, J.B. Hulke, a surgeon at King's College of London, claimed that the repair described by von Langenbeck was already used in England. Nevertheless, von Langenbeck published a detailed description of his surgical technique in *Die Uranoplastikmittelst Ablösung des mucös-periostalen Gaumenuberzuges* [1].

The German triumvirate of von Grafe, Dieffenbach, and von Langenbeck gave birth to the palatoplasty techniques used in modern medicine. Modifications to this technique have been completed, such as that of Billroth in 1868, who thought that fracturing the hamulus would enable better outcomes in surgery. This modification was used for many years and is no longer used because of poor evidence of improvement of the clinical outcome. Victor Veau (1871–1949) made a notable contribution, introducing the pushback technique for the repair of cleft palates. Further modifications of the von Langenbeck technique came from Gillies, Fry, Kilner, Wardill, Dorrance, and Bardach.

Timing and goal

The ultimate goal of the primary repair of a cleft palate is to achieve closure of the hard and soft palates, including any oronasal communication, recreating the natural insertion of the soft palate musculature at the same time. The palatoplasty should create a dynamic soft palate that crosses the lateral and posterior pharyngeal walls to improve velopharyngeal closure. The

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surgical technique and timing of the repair should be determined on an individual basis. The most important factors are the child's language and speech ages. The surgery should be performed before speech development of the individual. If the defect is left unrepaired, the child's intelligibility could develop compensatory articulations that might be difficult to correct.

Comparison of the palatoplasty techniques

Three major surgical techniques used throughout the world for cleft palate repair are the bipedicle flap technique (Von Langenbeck, 1861); opposing Z-plasties technique (Furlow Z-plasty, 1986); and the two-flap technique (Veau-Wardill-Kilner, 1931 and 1937), commonly referred to as the Bardach technique (1987). Each surgical technique has its own technical limitations and theoretic benefits. Studies comparing the techniques showed a wide discrepancy in determining which technique is better. The selection should be performed on an individual basis, considering the age of the patient and the size of the cleft.

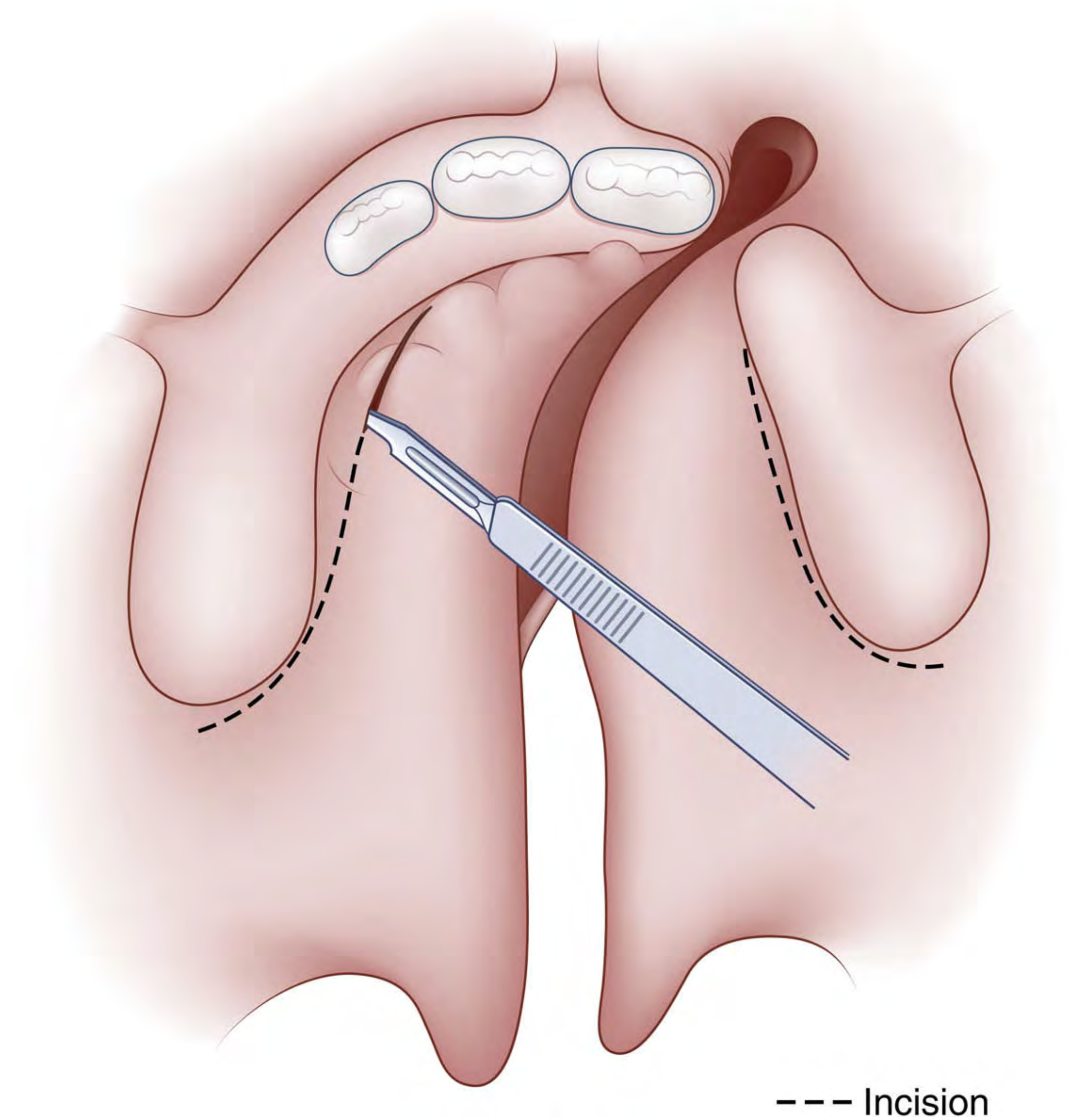

Fig. 1. Lateral full-thickness incisions extending from the hamular notch and carried anterior to the canine area.

The precise cause of maxillary hypoplasia is not clear. Surgical scarring from the cleft palate repair has been reported to cause considerable growth restriction, however. Palmer and colleagues [2] examined the bipedicle flap and two-flap techniques. They concluded that the simpler the surgical technique, the less is the growth restriction.

Jolleys' observation [3] was that maxillary growth after a von Langenbeck palatoplasty was "slightly better" when compared with a two-flap procedure. These results were not statistically significant in a similar study by Farzaneh and coworkers [4], however. Bishara and Tharp [5] compared a cephalometric analysis of 55 individuals with isolated cleft palate who had a bipedicle flap palatoplasty and recognized that the growth restriction was not statistically significant.

Pigott and colleagues [6] reported that maxillary growth and articulation pattern improved with a technique that minimized periosteal undermining and residual exposure of the palatal shelves. Furthermore, a histologic animal study suggests that scar tissue firmly attached to bone by Sharpey fibers can be one of the reasons for growth limitation. Using a surgical technique that minimizes the reflection of periosteum might prevent formation of these strong attachments to bone.

In 1931, Victor Veau was the first to identify that speech outcome could be improved by an earlier repair of the cleft palate. Marrinan and colleagues [7] reported a comparison of the

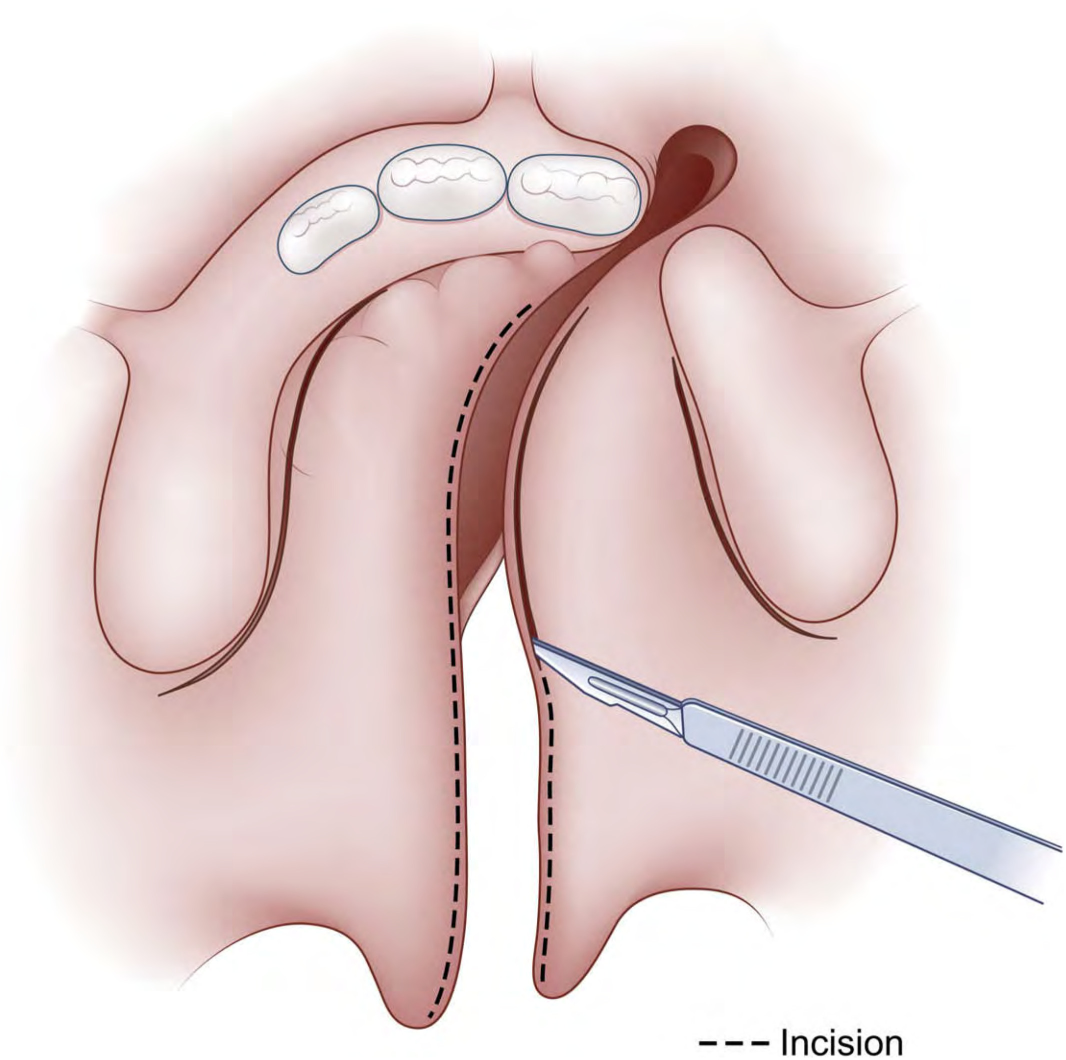

Fig. 2. Medial incisions started at the most anterior area of the palatal cleft and extended posterior to the uvula. The incision should be placed over the palatal shelf, 1 to 1.5 mm laterally to facilitate dissection of the nasal mucosa.

bipedicle flap versus two-flap surgical techniques and their effect on the velopharyngeal function. There was no significant difference for the surgical technique.

The frequency of pharyngoplasties after cleft lip palate repair was assessed by Bicknell and colleagues [8], with no difference in the surgical results. Their observation was that the earlier the repair, the less was the chance of developing velopharyngeal insufficiency. In addition, similar studies have shown comparable results when comparing the different palatoplasty techniques. In contrast, another study demonstrated a similar comparison that the Furlow technique had better speech outcomes.

In summary, any type of palatal surgery performed in a growing child affects maxillary growth. For this reason, the least invasive surgical technique is preferable to minimize scarring and subsequent growth restriction. In addition, the size of the cleft and the experience of the surgeon determine which technique is most appropriate to achieve successful repair of the cleft palate.

Surgical technique

The bipedicle flap palatoplasty involves medial incision to allow approximation of each side of the cleft margins.

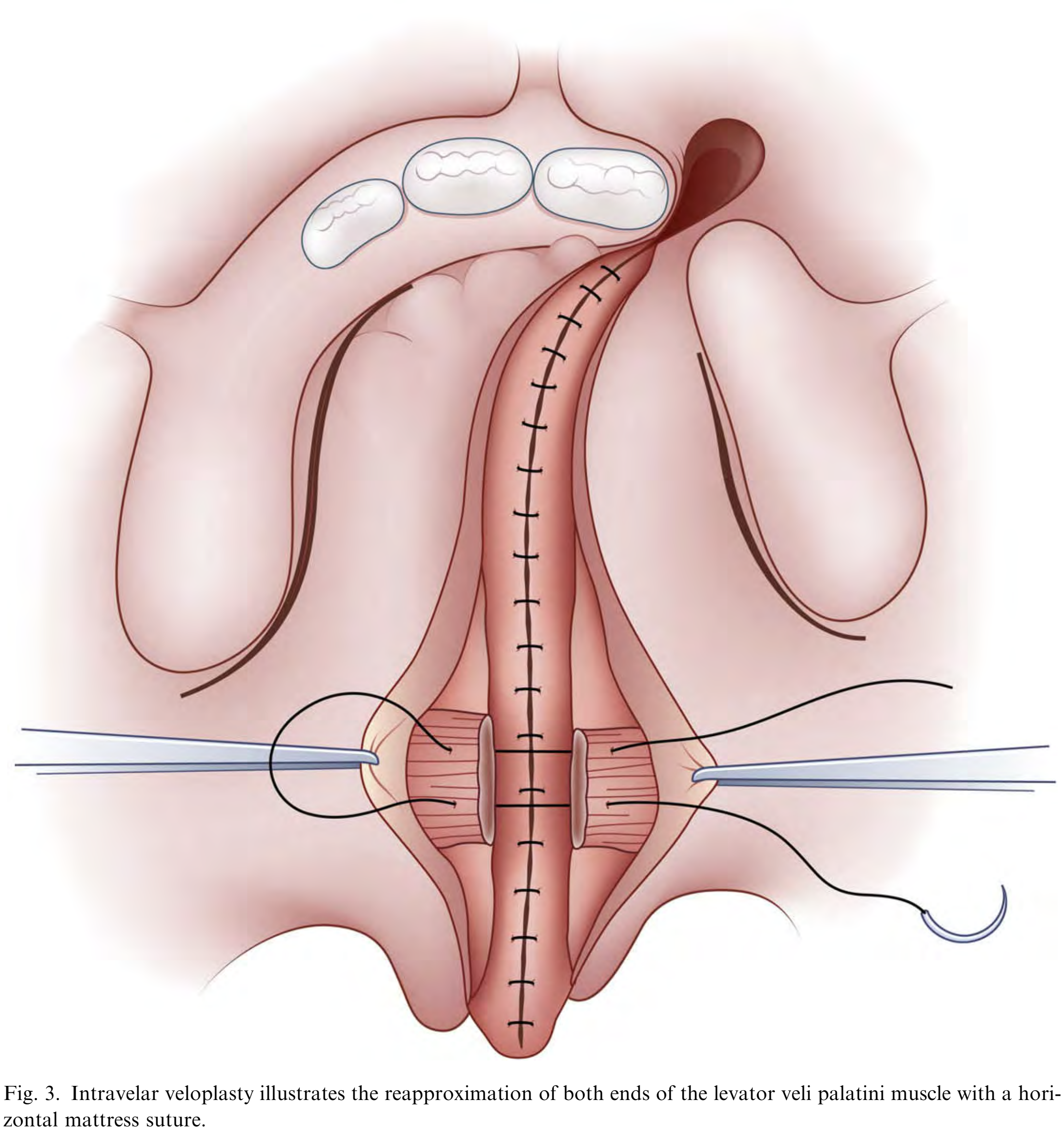

Fig. 3. Intravelar veloplasty illustrates the reapproximation of both ends of the levator veli palatini muscle with a horizontal mattress suture.

The lateral incisions are created with a 15C surgical blade along the alveolar ridge. The hamulus notch is palpated, and the incision is started at this point and carried anteriorly over the junction of the palatal shelf and the alveolar process to end at the level of the canine tooth area. This incision needs to be lateral to the route of the greater palatine artery (Fig. 1).

Next, a number 11 surgical blade on a long handle is used to create the medial incisions along the cleft margin. The incision should be carried onto the palatal shelf, approximately 1 to 1.5 mm lateral to the cleft to obtain enough tissue to facilitate dissection and closure of the nasal mucosa. The incisions are started in the anterior region and extended posteriorly, ending at the uvula (Fig. 2).

The authors recommend the use of sinus lift curettes to elevate a bipedicle full-thickness mucoperiosteal flap on each palatal shelf allowing flap release and advancement. The dissection is carried around the greater palatine neurovascular bundle with care to avoid any damage to this anatomic structure. The levator veli palatini muscle is detached completely from its abnormal insertion into the hard palate, and the dissection is continued until the flap can be mobilized and rotated toward the midline without tension. The greater palatine bundle is not ligated in this palatoplasty technique. Retention of an anterior attachment of the flap is characteristic of the Von Langenbeck repair. The sinus lift curettes facilitate elevation of the nasal floor mucosa and transposition medially to provide a tension- free closure.

The nasal mucosa is closed first with absorbable sutures; the authors' preference is polyglactin 910 suture using a PS-4C needle in an interrupted suturing technique. The oral mucosa layer is closed next using the same suturing technique. The two-layer closure decreases

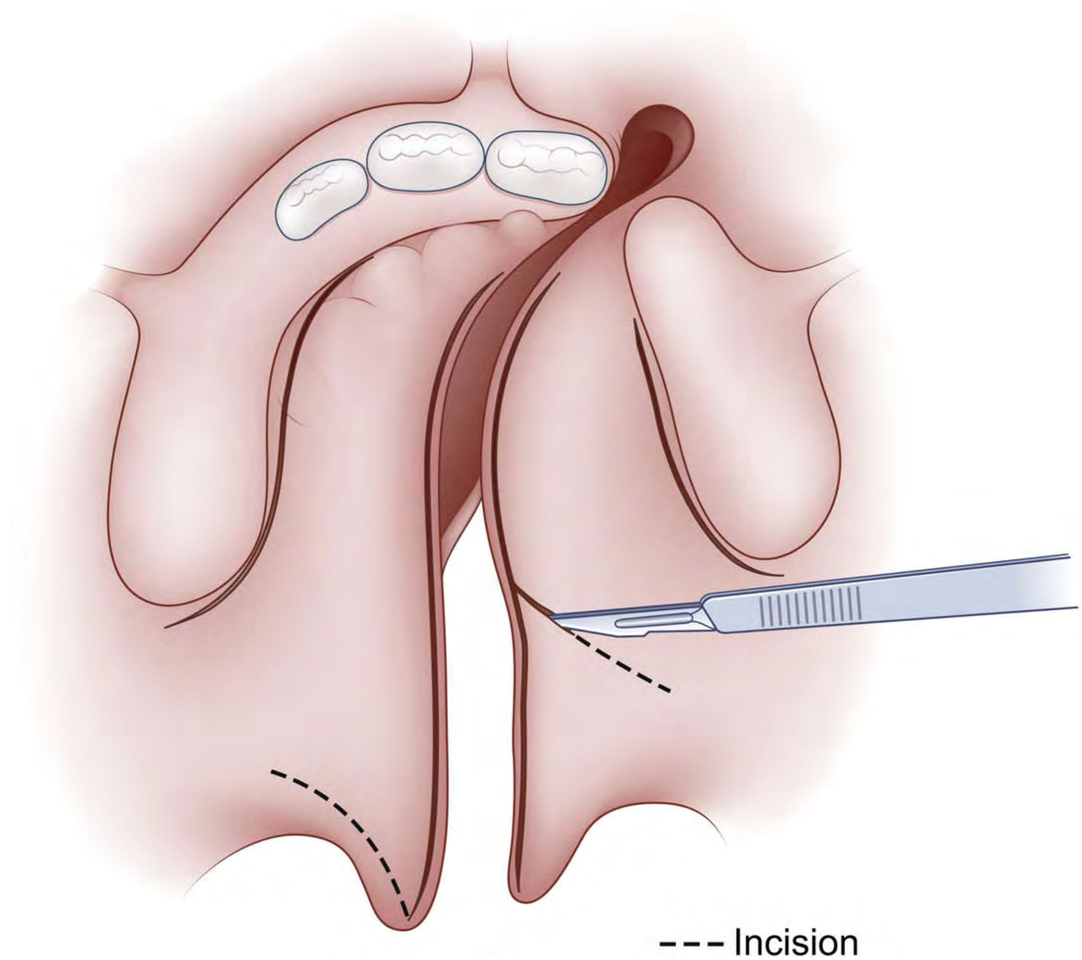

Fig. 4. Two 60° releasing incisions are created along the cleft site. The lateral full-thickness incisions were created previously.

the possibility of a fistula by allowing a second physical barrier in case of a wound breakdown of one of the layers.

Modifications

The most common modifications described in the literature involve an intravelar veloplasty. The authors' experience is that the dissection is facilitated with an angled scalpel blade (''beaver'' blade [69B]). Both muscles are dissected from the nasal mucosa and the oral mucosa.

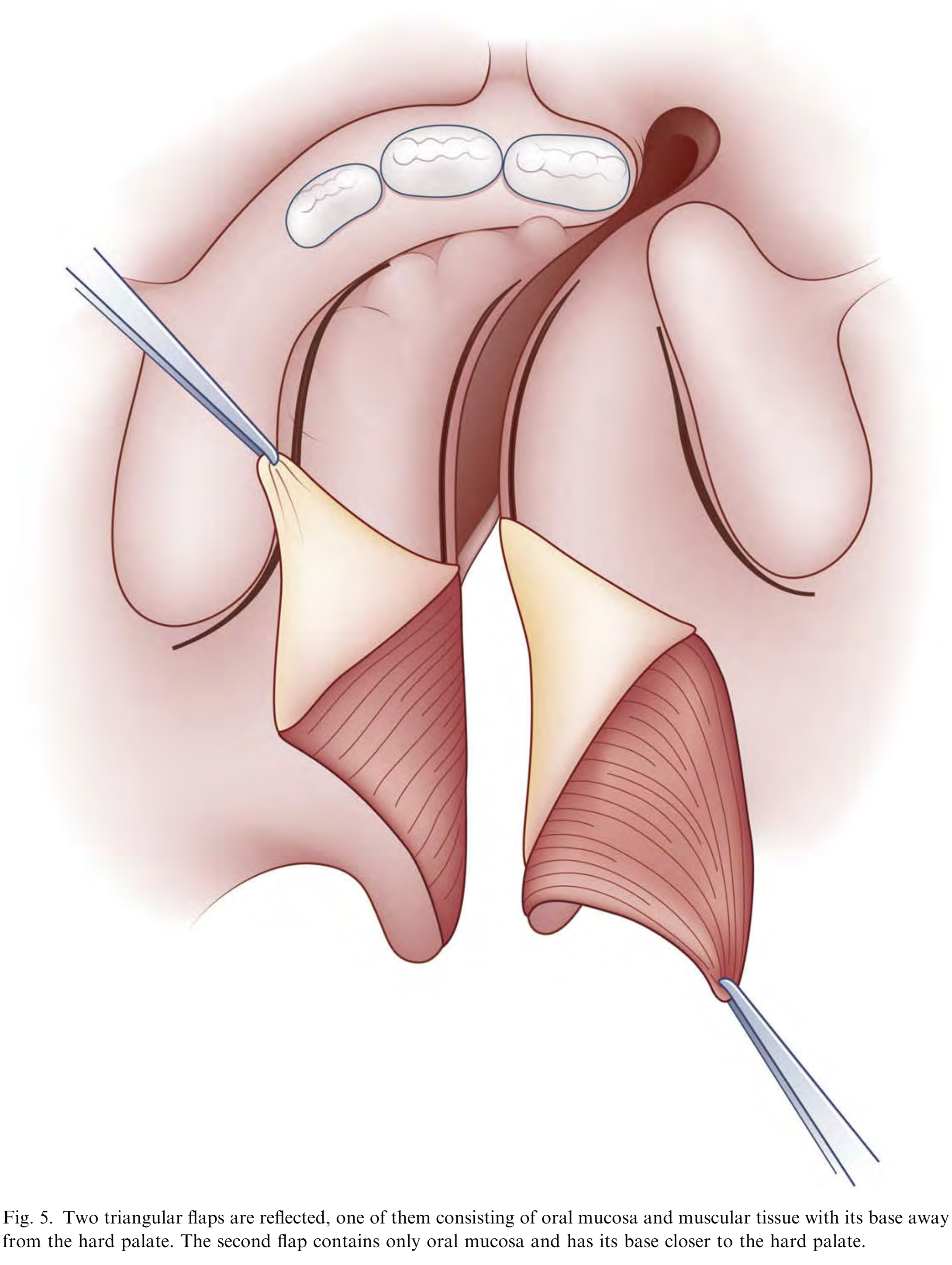

Fig. 5. Two triangular flaps are reflected, one of them consisting of oral mucosa and muscular tissue with its base away from the hard palate. The second flap contains only oral mucosa and has its base closer to the hard palate.

Once the nasal mucosa is dissected, the levator veli palatini is reapproximated using a single horizontal mattress suture (Fig. 3).

Another modification developed by the authors includes a reversing Z-plasties, as described in the Furlow palatoplasty technique. Two 60° releasing incisions are created along the cleft site, one anterior and the second posterior; both must be opposing each other. Two triangular flaps are reflected, with one of them consisting of oral mucosa and muscular tissue. This muscular flap must have its base away from the hard palate. The second flap contains only oral mucosa and has it base closer to the hard palate. Next, an opposing Z-plasty is created with the releasing incision parallel to the bases of the triangular flaps. These new triangular flaps contain nasal mucosa on one side and muscular tissue andnasal mucosa on the opposite side. The deeper Z-plasty is transposed and sutured using Vicryl 4.0 in an interrupted fashion. The initial triangular flaps are also rotated 90° to obtain the transposition and sutured into place with the same suturing techniques (Figs. 4–8).

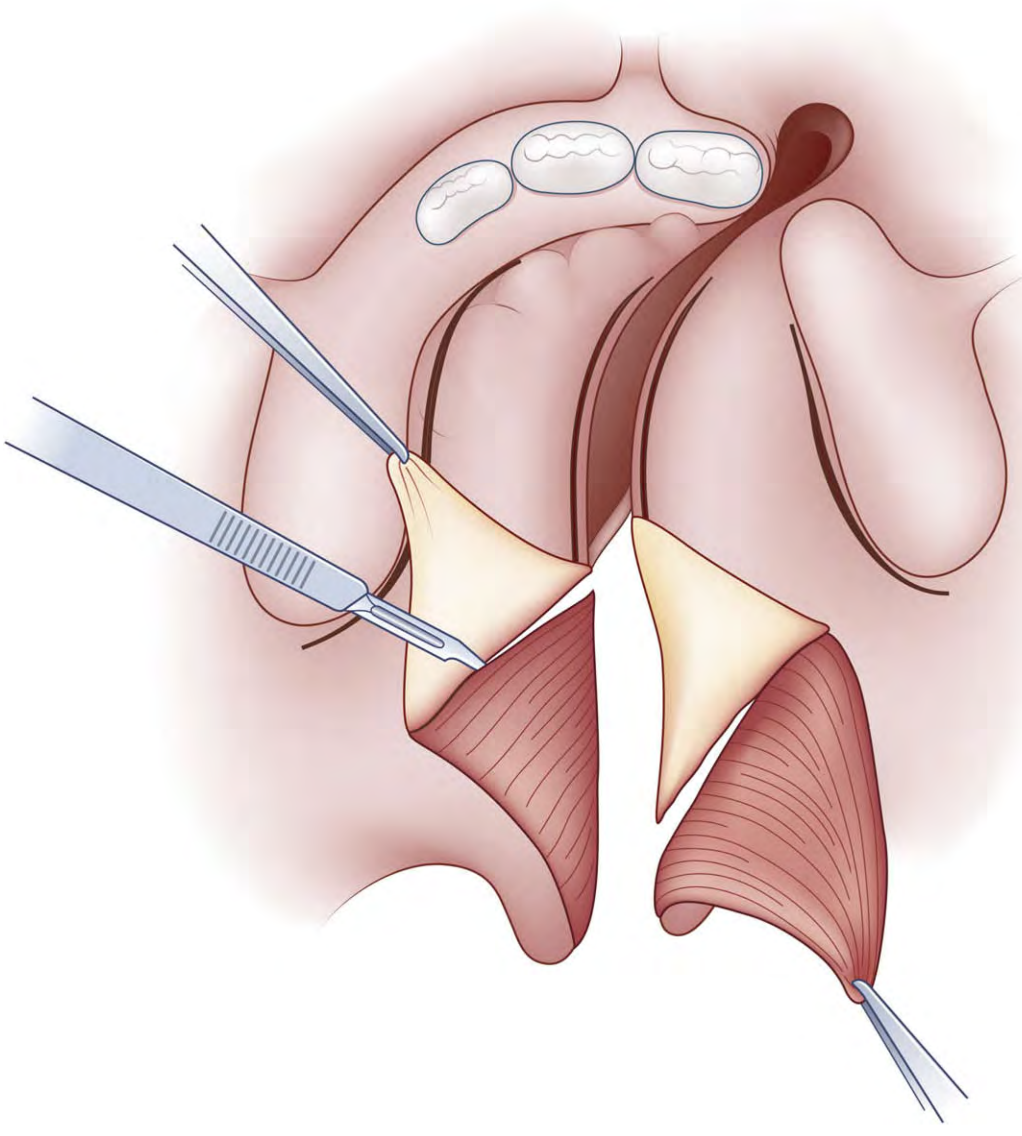

Fig. 6. Opposing Z-plasty is created with the releasing incision parallel to the bases of the triangular flaps. These new triangular flaps contain nasal mucosa on one side and muscular tissue and nasal mucosa on the opposite side.

Complications

Potential problems include short- and long-term complications. Intraoperative difficulties in obtaining primary closure, especially anteriorly, may cause the surgeon to convert to a two-flap technique, thus closing one or both anterior pedicles. Fistula formation may occur at any point of the cleft palate but is most common at the junction of the hard and soft palates. The use of a collagen membrane as a thin layer may help to prevent fistulas in this region. Long-term complications include velopharyngeal insufficiency and maxillary hypoplasia.

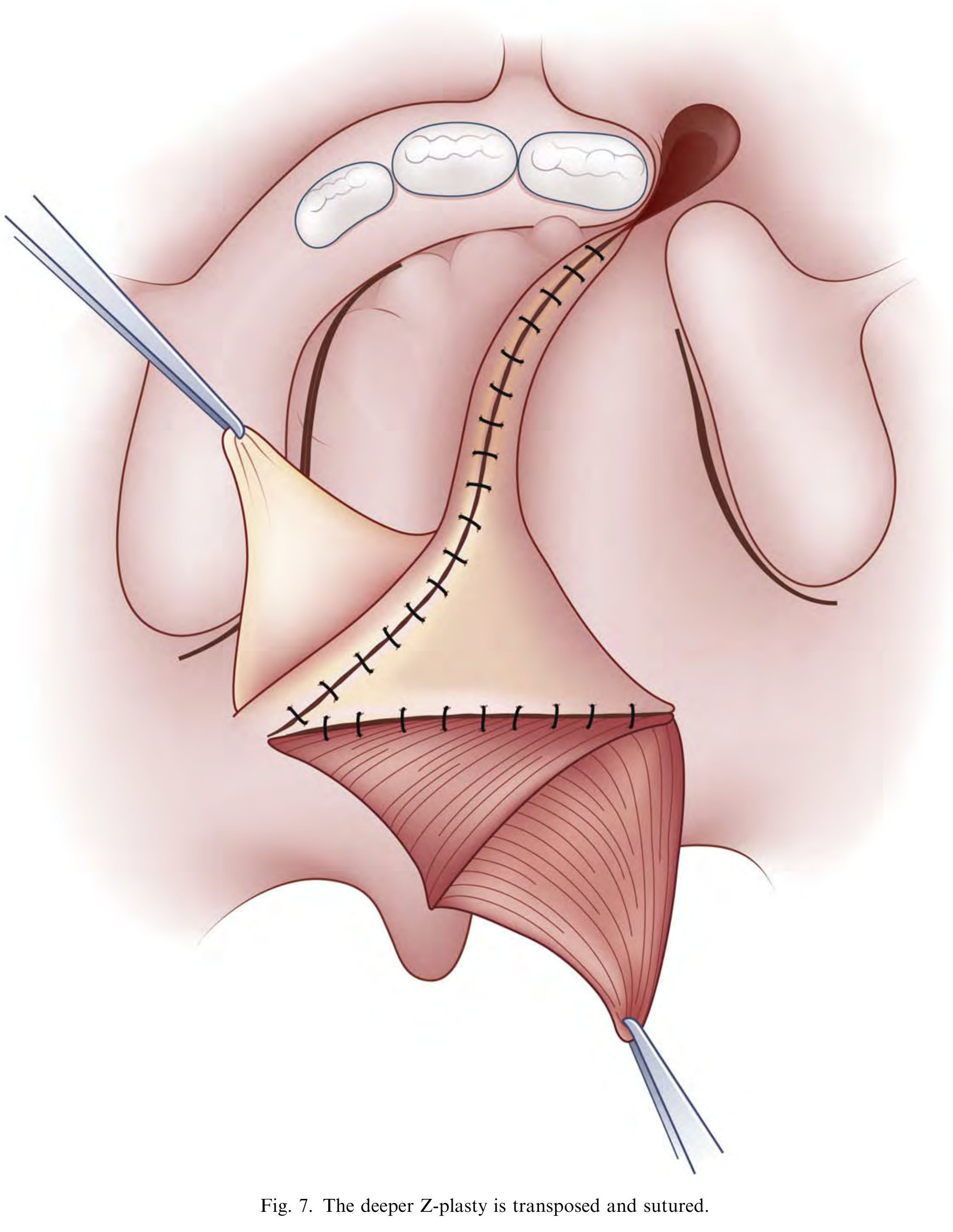

Fig. 7. The deeper Z-plasty is transposed and sutured.

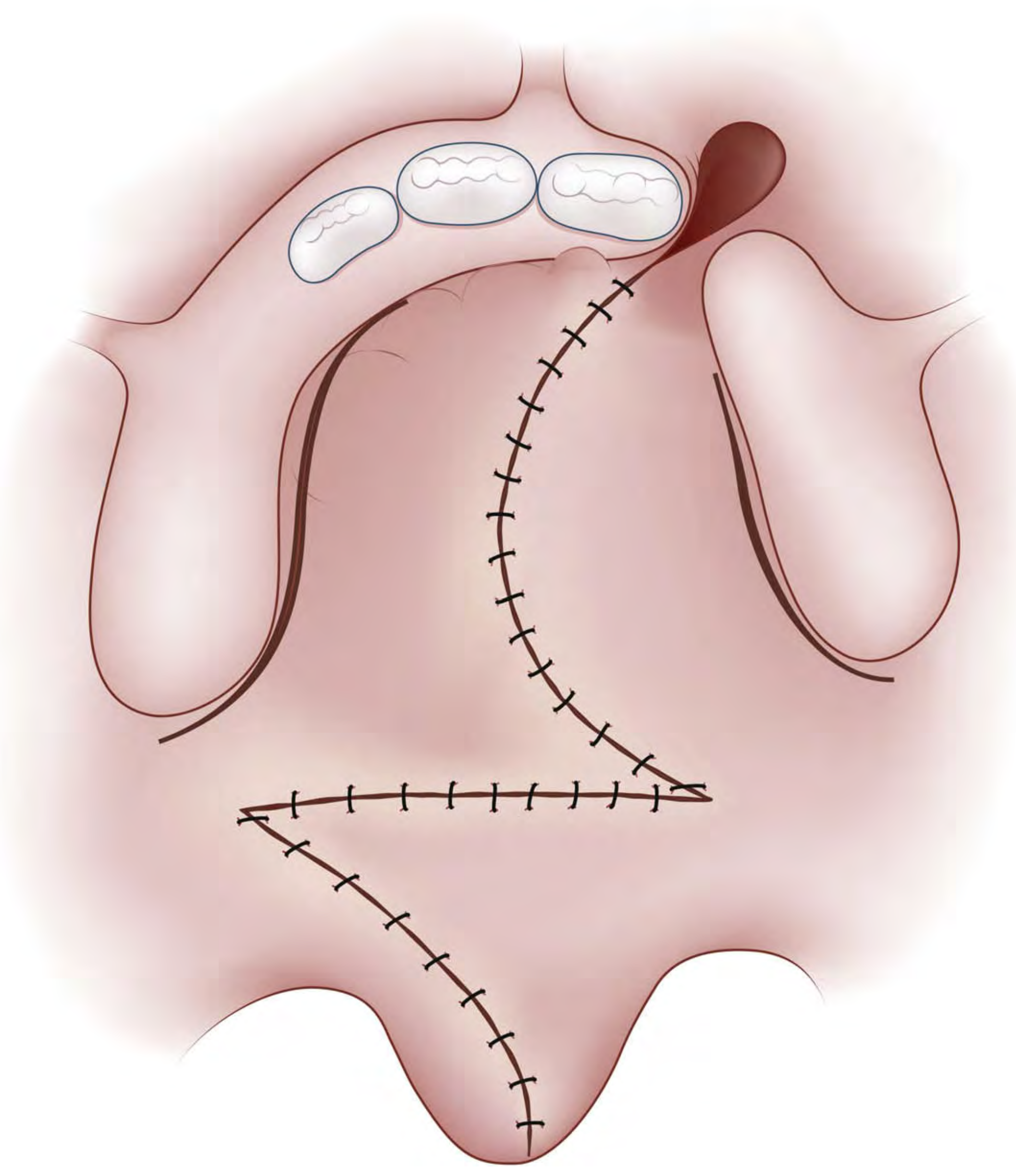

Fig. 8. Final transposition of the initial triangular flaps.

Summary

The key to any palatoplasty is ample dissection and tension-free closure. The levator veli palatini muscle must be released from the hard palate and reapproximated and anastomosed with its opposite pedicle. Traditional use of the bipedicle flap technique involves a standard intravelar veloplasty. The combination of double-reversing Z-plasties with a bipedicle flap has the potential advantage of better speech results. This technique has not been described in reviewed literature; however, as with all cleft techniques, most modifications are combinations of previously described techniques.

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Atlas of the Oral and Maxillofacial Surgery Clinics

Primary Palatoplasty: Double-Opposing Z-Plasty (Furlow Technique)

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Furlow palatoplasty

Introduction

The Furlow double-opposing palatoplasty (FDOP) was first introduced by Leonard Furlow in 1978 and published formally in 1986 by the Children's Hospital of Pennsylvania cleft unit [1]. It has gained acceptance by many surgeons as the preferred technique for cleft palate repair. Although conceptually and procedurally a challenge, the FDOP has the distinct advantage of lengthening the soft palate and restoring normal velar anatomy and function. Since its introduction, the FDOP has undergone several modifications, much like other named cleft lip and palate techniques.

The essential components of the FDOP include oral- and nasal-based mucosal and muscle flaps that are designed as Z-plasty flaps on one side and then reversed in configuration on the underlying side. As is commonly understood in reconstruction, a Z-plasty allows lengthening of a tissue limb and resists tension when interdigitated with a corresponding Z-plasty flap. Two Z-plasties allow transposition of the flaps in such a manner that an incision line does not lie on another during closure, resulting in a reconstructed soft palate that is resistant to dehiscence and breakdown of flaps, a particular problem in wider clefts.

Technique

Cleft palate anatomy must first be understood and appreciated before any palatoplasty. The primary objective of palatoplasty is to dissect and mobilize palatal musculature appropriately, specifically the tensor-levator aponeurosis, and to reposition the muscles correctly, such that function is optimally restored to the velar mechanism. Also, it is important to minimize wounding to the hard palate during palatoplasty to reduce scarring and subsequent growth perturbations of the maxilla. This is primarily achieved through reducing the amount of denuded hard palate during initial palatoplasty, which will be discussed later.

Fig. 1 schematically illustrates the abnormal muscular insertions in the cleft palate condition. The tensor-levator aponeurosis is a confluence of these two principal muscles of the soft palate (the palatal component of the velar mechanism). Note that the muscles are disinserted into the hard palatal margins and the levator is positioned more laterally. Careful dissection of the muscular aponeurosis is paramount in being able to reposition the tensor component (and, to a lesser degree, the levator insertion) across the midline successfully, assuming the correct anatomic position. The FDOP is designed to accomplish this procedural objective.

Design of the initial Z-plasties is shown in Fig. 2. The oral layer is first approached with inscribed Z-incisions incorporating angles of around 60° to 70°. The angles differ according

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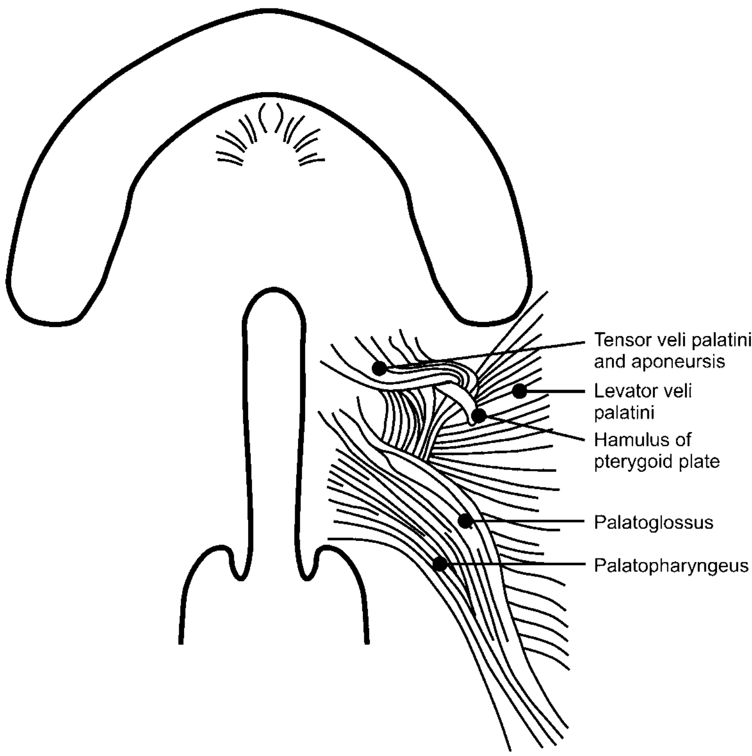

Fig. 1. Diagram illustrates abnormal muscle insertions and orientation in cleft palate.

to soft tissue bulk and cleft width. The wider the cleft defect, the less soft tissue there is available, and, generally, the more obtuse the angles must be to achieve dissection and mobilization of the flaps. As the flaps are raised, great care must be taken to keep one oral layer purely mucosal (the author prefers this to be the right side for ease of dissection) and the opposite oral layer a mucosal-muscle flap (Fig. 3). Dissection of the latter flap is signaled by the appearance of muscle, obviously, in this flap. The underlying nasal mucosa also appears "bluish" because it is thin; care must be exercised in this dissection plane not to tear or shred the underlying nasal

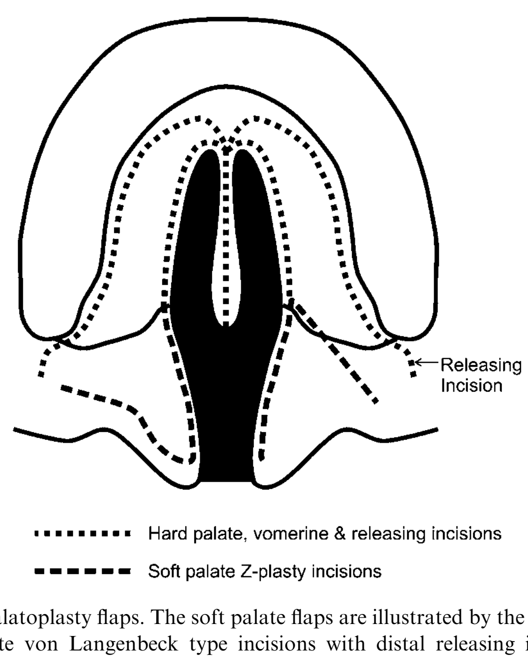

Fig. 2. Design of respective palatoplasty flaps. The soft palate flaps are illustrated by the angled Z-plasties, and the hard palate and vomer demonstrate von Langenbeck type incisions with distal releasing incisions extended beyond the tuberosity.

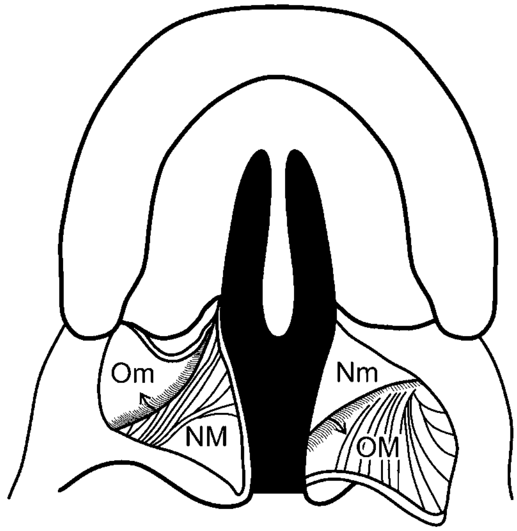

Fig. 3. Diagram demonstrates reflection of each oral Z-flap. The right-sided (patient's left) flap illustrates the oral mucosa and muscle layer (OM) reflected laterally, and the right-sided flap (patient's right) illustrates reflection of the oral mucosa (Om) only, leaving the underlying muscle sling in the nasal layer (NM).

layer inadvertently. To mobilize the oral flaps further, lateral extension into the space of Ernst (a potential small anatomic space deep and posterior to the hamulus and tensor sling) is often necessary. This is easily achieved by blunt dissection with a small peanut. When adequate lateral dissection is achieved, the uvular portion is divided or simply opened with small opening "snips" from curved tenotomy scissors. The oral flaps are then tagged and retracted laterally to reveal the underlying nasal layer, one side (in the author's case, the patient's right side) of which still incorporates the muscular component of the tensor-levator aponeurosis. The Z-flaps are then incised in a reversed configuration from that of the oral flaps, as shown in Fig. 4. The angled limb of the flap on the patient's right side, the nasal myomucosal flap, must initially include the tissue inserted at the hard palatal margin to incorporate the attending muscle. After several millimeters, the Z-plasty limb can then be extended with a scissors at an angle of 60° to 70°. The nasal flaps often need to be dissected quite far laterally onto the palatopharyngeal surface to gain adequate mobilization of tissue.

Once the flaps have been adequately mobilized, closure may commence. After ensuring good hemostasis, particularly laterally, where most of the dissection has taken place, the nasal flaps are transposed in a typical Z-plasty manner. The patient's left-sided nasal flap, composed of mucosa only, is transposed anteromedially to dock at the opposite junction of hard palate and margin of mucosa. A single horizontal mattress suture (the author prefers 3-4 or 4-0 polyglycolic acid suture) is placed at the far corner, the leading edge of the flap, and is sutured to the palatal shelf mucosa (Fig. 5A). The opposite nasal flap of mucosa and muscle is similarly transposed, posterolaterally in this case, and is docked alongside the anterior Z-flap, with the far corner sutured into the lateral recess in the palatopharyngeal tissue, again with a horizontal mattress suture. This places the right-sided musculature into a more horizontally and anatomically correct position (see Fig. 5B). Closure of the nasal side is commenced along the flap margins with 4-0 or 5-0 polyglycolic acid suture in an interrupted or continuous fashion.

Attention is then turned to transposition of the oral flaps. The right-sided flap is repositioned anteromedially and sutured to the hard palatal margin in similar fashion to the opposite nasal flap. The left-sided oral myomucosal Z-flap is then transposed posterolaterally to dock alongside the anterior oral flap. Closure is done in similar fashion to that described previously. Before final closure, one or two 3-0 sutures are placed through nasal and oral layers to reduce any dead space and also to secure the flaps in their new position (Fig. 6). The uvular portions are

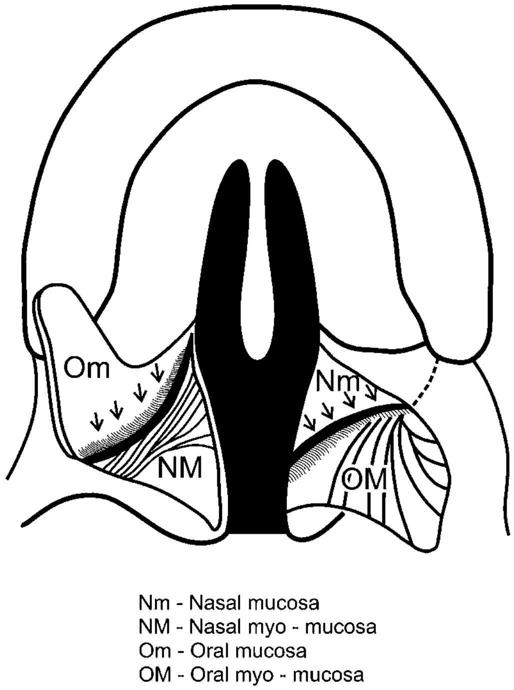

Fig. 4. Diagram illustrates incision of the underlying nasal layer into opposite Z-flaps, with the left side incorporating muscle (NM) and the right side incorporating mucosa only (Nm).

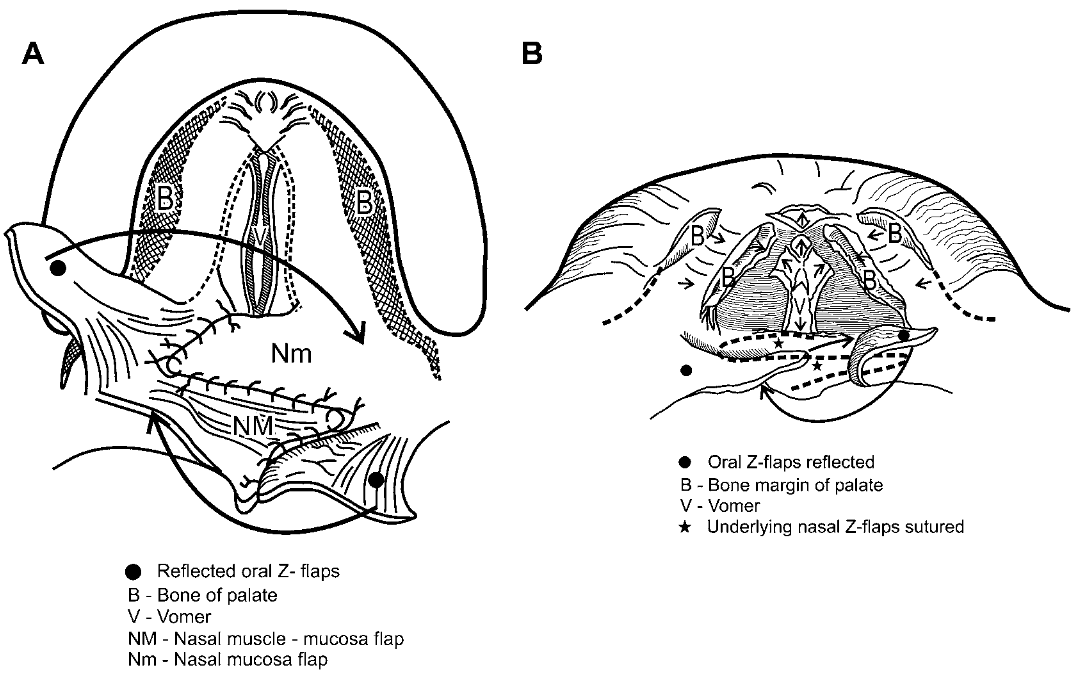

Fig. 5. (*A*) Diagram illustrates the repaired, and now correctly oriented, nasal layer (NM and Nm). The oral Z-flaps are reflected and are transpositioned as opposing Z's across the nasal side. (*B*) Diagram illustrates the reflection of the various hard and soft palatal flaps from a more transverse perspective. The nasal layer (★) is closed under the oral Z-flaps (•). The hard palate has von Langenbeck-type incisions on the lateral aspect (B), demonstrated as being pushed medially to meet the vomerine (V) incisions and flaps.

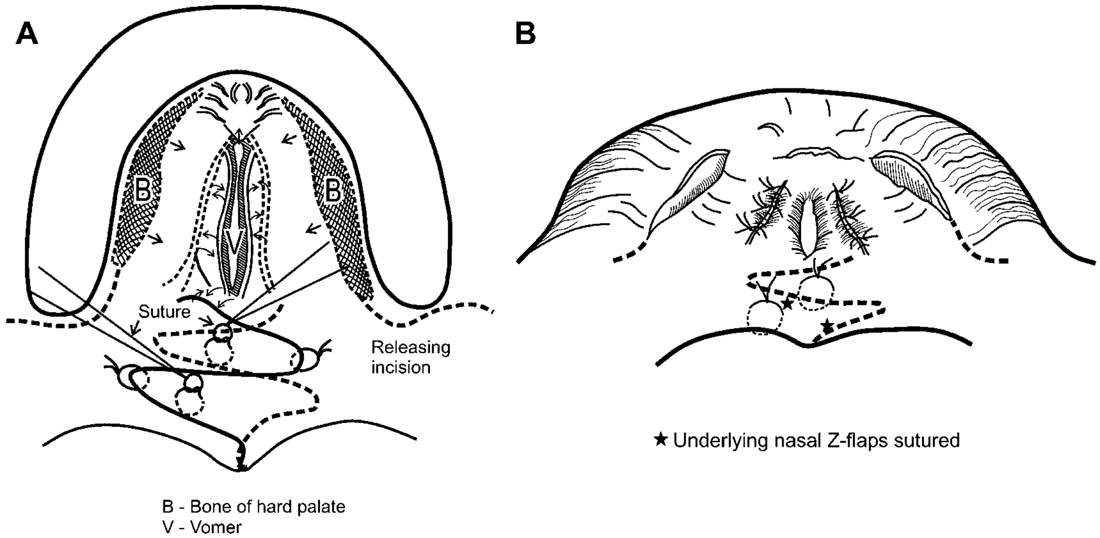

Fig. 6. (*A*) Diagram demonstrates closure of the respective flaps. Note the placement of through-and-through sutures, which coapt the nasal and oral layers and eliminate potential dead space between the oral and nasal layers. (*B*) Diagram of final closure from a transverse perspective, which demonstrates coaptation of hard and soft palatal flaps and placement of through-and-through sutures.

coapted with small 5-0 interrupted sutures placed on the nasal and oral sides. The muscle sling is now united posteriorly in the correct anatomic position.

Simultaneous and Staged Palatoplasties

Many complete cleft palates can be closed as a single staged palatoplasty. The FDOP is designed for soft palate reconstruction; therefore, a hard palatal procedure is necessary if simultaneous repair is undertaken in the complete cleft case. This topic is discussed more thoroughly elsewhere; however, a brief overview is undertaken here to provide a comprehensive demonstration of how the FDOP is incorporated with hard palate repair.

Generally, two types of hard palatal repairs are performed in conjunction with a FDOP procedure. These include the von Langenbeck-type releasing incision technique shown in Fig. 7 and the Wardil-Kilner or "pushback" type of palatoplasty shown in Fig. 8. The merits and concerns of these procedures are discussed elsewhere; both procedures are applicable in the FDOP, although a significant pushback is not necessary with the lengthened soft palate obtained through Z-plasties. For this reason, a von Langenbeck palatoplasty is generally used for the hard palatal repair during simultaneous FDOP. The nasal side closure is accomplished through elevation of hard palatal and vomerine-based flaps, which are turned nasally and sutured as illustrated. The posterior extension of the hard palatal repair, where it meets the transposed and sutured Z-plasty flaps, is often an area of tension or mucosal weakness, and therefore subject to breakdown and fistulization. To prevent such an occurrence, small flaps of nasally based vomerine mucosa or hard palatal mucosa can be elevated to bring across this area of tension. Some researchers have placed allogeneic dermal films across this area before final closure to prevent dehiscence [2]. The author prefers to dissect the buccal fat pads from their lateral position and allow them to herniate medially and across the thin junction of hard and soft palates, where the Z-flaps meet (Fig. 9). This provides another layer of vascularized tissue that remains in the event of flap dehiscence, thereby allowing remucosalization to take place and preventing fistula formation. The reconstructed musculoaponeurosis lies posterior to or under the fat graft and is unaffected by this surgical maneuver.

Some cleft palates are extremely wide; therefore, a staged approach may be desirable. In such cases, the author prefers to repair the soft palate primarily with the FDOP at 6 to 10 months of age and leave the hard palate defect open. Over the ensuing months, the hard palate defect

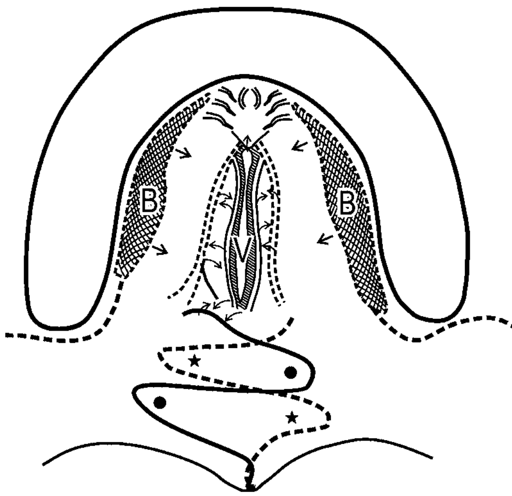

Fig. 7. Diagram of von Langenbeck-type incisions for hard palate closure in a simultaneous one-stage palatoplasty with the FDOP.

typically narrows and, by the age of 12 to 18 months, can undergo a second-stage palatoplasty using simple palatal and vomerine-based mucosal flaps and von Langenbeck-type releasing incisions for a double-layered closure (Fig. 10).

Advantages and Disadvantages

Many cleft surgeons and speech pathologists recognize the advantages of the FDOP [3,4]. These include proper reorientation of the soft palate musculature into a horizontal and slightly posterior sling, improved speech results (less hypernasality), and lower fistula rates. Particularly

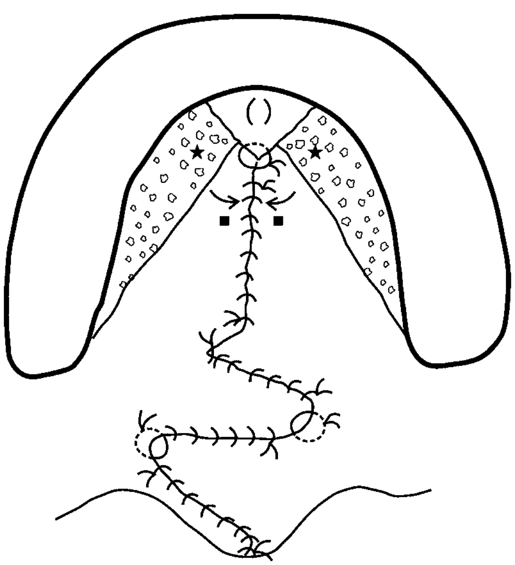

Fig. 8. Diagram of the Wardil-Kilner–type hard palate repair in a simultaneous one-stage palatoplasty with the FDOP. Note the "pushback" of hard palate mucosa, which is generally not necessary with the FDOP.

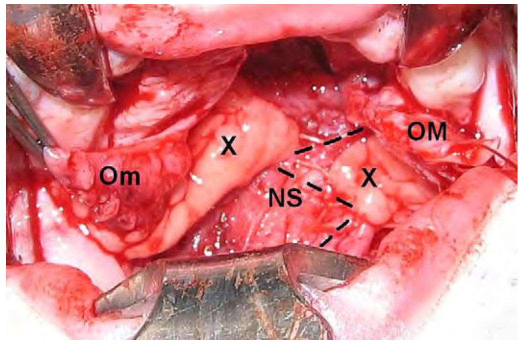

Fig. 9. Photograph of a palatoplasty and placement of buccal fat pads (X) into the lateral dead space (space of Ernst) and across the nasal layer to support the Z-flaps. NS, nasal side; Om, oral mucosa only; OM, oral mucosa and muscle.

satisfying have been the reports from cleft centers of decreased fistula rates after Furlow palatoplasty [5]. This is believed to be a result of flaps that lie across incision lines (ie, the oral and nasal layer incisions do not align with each other), thereby providing an intact tissue layer above or below one layer's incision.

Disadvantages of the FDOP are related to execution of the technique because it involves more geometric configuration in planning and more time spent in creating and transposing the flaps for closure. The Z-flaps have different angles according to the width of the palatal defect and available soft palate tissue. There is a recognized longer learning curve for the FDOP technique, which also may translate into increased operating time initially.

Modifications

Tension during closure of palatal flaps is always a concern, particularly in wide cleft palates. Tension during closure is also a challenge in the FDOP, which relies on adequate bulk and mobilization of soft palate tissues for transposition and final approximation. Modifications have been introduced to reduce tension on the flaps and allow adequate freedom for flap transposition and optimal closure.

For staged or soft palate repair only, many surgeons (the author included) have found that releasing incisions along the palatal aspect of the tuberosity allows access to the posterior palatal margin for muscle dissection and some release of tissue at the medial aspect during transposition. Care must be taken not to injure the palatal neurovascular bundle, which is located near the posterior margin. The resultant tissue space heals quickly and uneventfully.

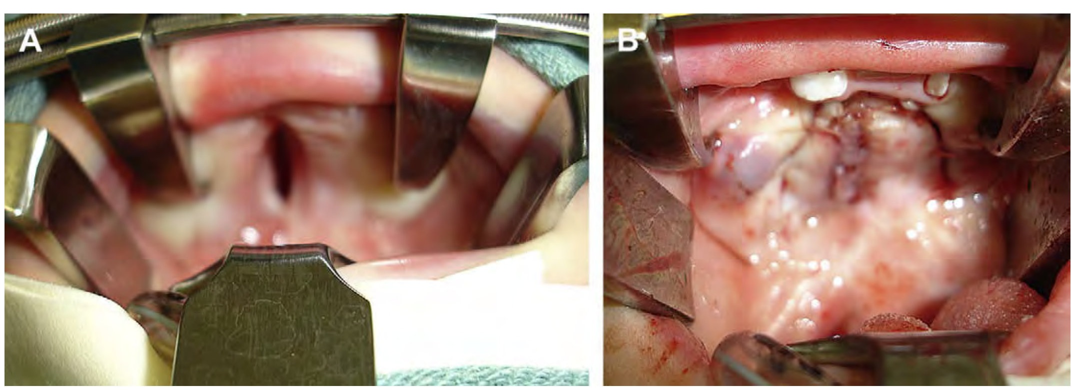

Fig. 10. (*A*) Photograph of a two-stage palatoplasty in which the FDOP was used to close the soft palate defect initially so as to narrow a wide cleft palate. The hard palate defect is pictured 5 months after initial FDOP repair. (*B*) Photograph of repaired hard palate defect as a second stage. The resulting palatal flaps are smaller and there is no lateral denuded bone when a two-staged palatoplasty is used for a wide cleft palate.

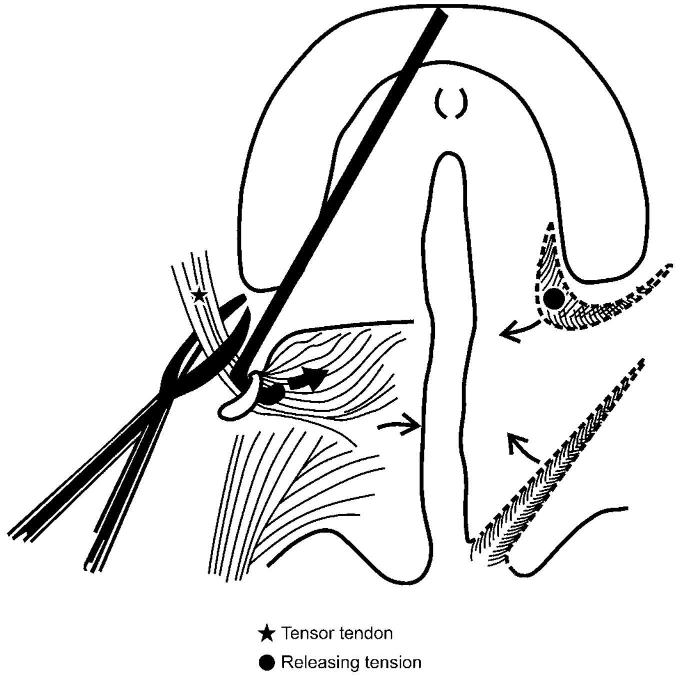

Fig. 11. Diagram of various techniques to relieve tension on soft palate Z-flaps during closure. In-fracturing the hamulus, severing the tensor tendon, or placement of releasing incisions around the tuberosity serves to allow the flaps to transpose medially more easily during closure of the Z-flaps.

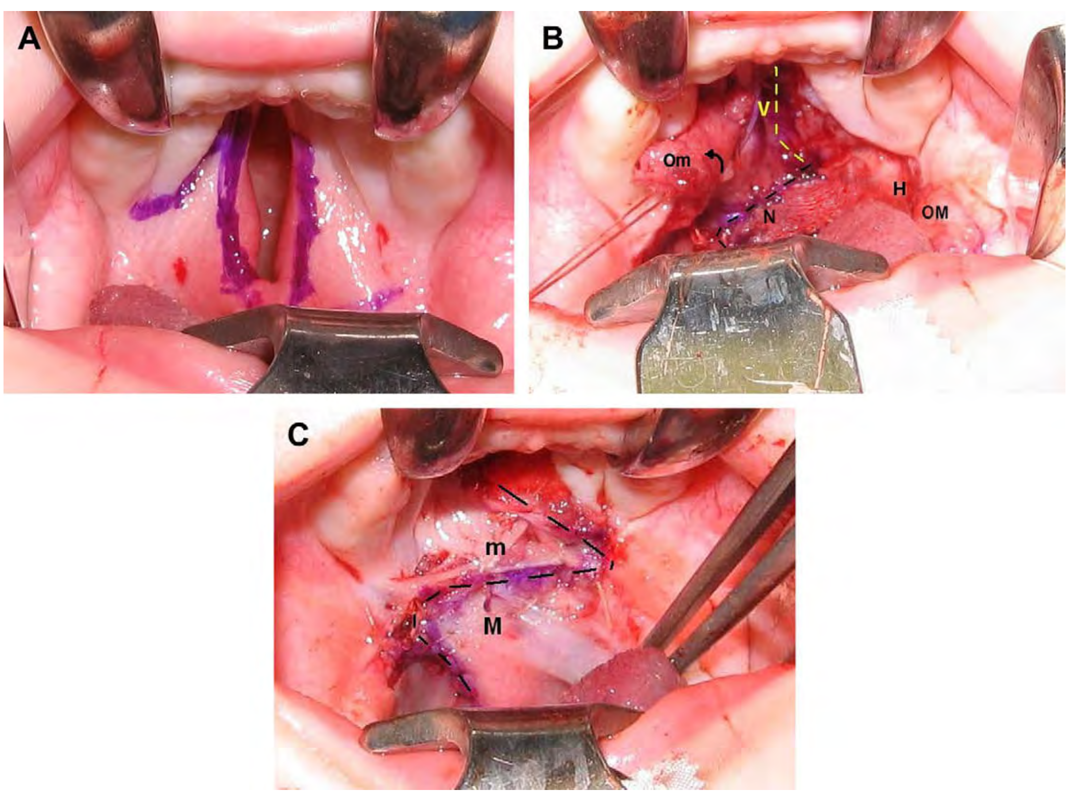

Fig. 12. (*A*) Preoperative photograph of isolated cleft palate with FDOP markings. (*B*) Intraoperative photograph demonstrates nasal side (N) closure. The yellow dashed line represents vomerine flap closure (V), and the black-dashed line represents the nasal Z-flap closure. The oral (Om and OM) flaps are reflected laterally. The tensor tendon and aponeurosis course around the hamulus (H) and onto the nasal aspect, now correctly oriented. (*C*) Photograph of final closure of the oral Z-flaps (m and M).

During simultaneous palatoplasty, these releasing incisions are essentially extensions of the hard palatal flap design.

Also, through the releasing incision or from a medial approach, the hamulus can be in-fractured bilaterally to provide some relief of tension across the tensor sling and aponeurosis (Fig. 11). In conjunction with hamulus fracture, the tensor tendon can be incised to provide additional laxity in the soft palatal flaps. Evidence has demonstrated that these maneuvers are merely temporizing measures with no long-term effect on tensor or Eustachian tube function. Fig. 12 demonstrates the exposed hamulus after nasal side closure. The releasing incision is shown as an extension of the lateral hard palatal flap. Through this exposure, the hamulus may be medially in-fractured and the tensor tendon incised to allow more medial transposition of the nasal Z-flaps and relieve tension in the final closure.

Postoperative Care

Generally, a palatal dressing is not necessary to cover the repaired palate unless there are exposed areas of hard palate or there is tenuous closure of a wide cleft defect. Soft palate repair with the FDOP is a fairly firm repair that resists tension and dehiscence; therefore, normal feeding can resume as soon as the infant is stable. Arm restraints are not routinely used. A single suture of 3-0 silk is placed in the dorsum of the tongue for retraction and suctioning purposes in the early postoperative period. There have been reports of upper airway congestion or obstruction attributable to the increased bulk and length of the soft palate; therefore, monitoring is recommended in the first 24 to 48 hours, particularly in infants with Robin sequence. Perioperative corticosteroids are administered to decrease soft palatal swelling.

Summary

In summary, the FDOP is a sound anatomic and predictable palatoplasty technique for cleft palate repair. Advantages include anatomic reorientation and reconstruction of the tensor-levator sling, lengthening of the soft palate without a pushback of the hard palate tissue, low fistula rates, and predictably good speech results. Disadvantages are related to the technical aspects of creating the respective Z-plasties, which may result in longer operating times initially. Since its introduction almost 20 years ago, it has become one of the most popular palatoplasty techniques of North American cleft surgeons.

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Alveolar-anterior Maxillary Cleft Repair

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The standard of care in patients who have a complete cleft is to perform secondary bone grafting of the absent bone in the alveolus and anterior maxilla with autogenous cancellous bone somewhere between 6 and 9 years of age. Although other treatment regimens have been suggested, no regimen has proved to be equal, and certainly not superior, to this regimen. The exact timing of secondary bone reconstruction has been a source of contention for years, and there is currently good evidence that secondary bone reconstruction is best done somewhere between 6 and 9 years of age. This does not negate later secondary reconstruction; yet, the overall result in terms of toot eruption, orthodontic tooth movements into the grafted area, and periodontal health is superior when it is done at an earlier age. One of the major factors that the author has observed in delayed or late secondary reconstruction occurs when orthodontic treatment is performed in the area before bone grafting. This generally has an adverse effect on the adjacent (central or lateral incisor or cuspid) teeth in that they are moved inadvertently into an area of inadequate bone, and therefore lose significant periodontal support. Conversely, when no orthodontic treatment is performed in the older patient and adequate adjacent periodontal bone support exists, secondary bone grafting can be done with subsequent orthodontic treatment and a successful outcome can be achieved (Fig. 1).

The indications for alveolar anterior maxillary bone reconstruction are multiple, but the primary reason is still, and always has been, to provide a sufficient quantity and quality of bone in the cleft area to allow for eruption of coadjacent teeth and the subsequent orthodontic movement of teeth into the cleft bone grafted area. Additional reasons include closure of the vestibular and oral nasal fistulas, providing adequate support of the nasal base on the unilateral cleft side, and possibly allowing for osseointegrated implants to be placed when teeth are missing.

This article sequentially describes the details of the surgical procedure for reconstruction of the alveolar-anterior maxillary bone defect in unilateral and then bilateral cleft cases. Additional and alternative techniques have been suggested; however, these basic techniques can be used in most instances and have provided the author with ideal results.

Surgical technique: unilateral cleft

About 10 minutes before initiating surgery, infiltration of 2% lidocaine with 1/100,000 epinephrine is performed palatally and throughout the vestibular sulcus in the areas of planned surgery.

Attention is first given to developing soft tissue flaps to reconstruct the nasal floor, palate, and labial mucosa and attached gingiva. The initial incisions are planned to preserve adequate attached gingiva around the erupted teeth and permit the advancement of attached gingiva into the area of future tooth eruption (see Fig. 1). In the region of the molar teeth, this incision is carried superiorly posteriorly into the free mucosa and sulcus approximately 1.0 to 1.5 cm to permit relaxation for advancement of this flap. This is completed bilaterally.

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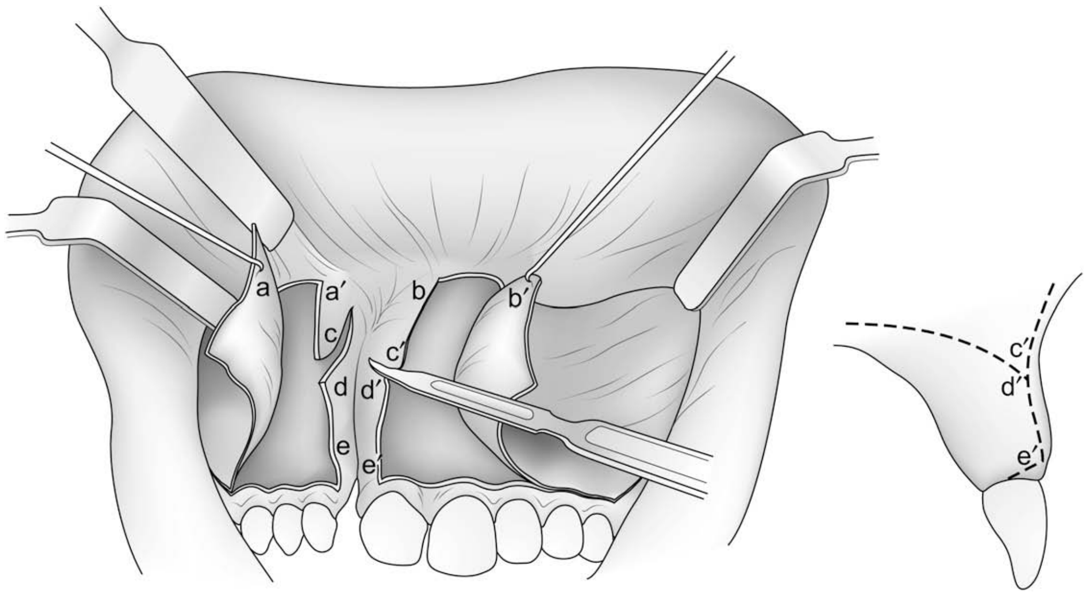

Fig. 1. Incision made for unilateral cleft alveolus-anterior maxilla bone reconstruction.

Incisions are next made along the outer margins of the bony cleft and carried superiorly into the depth of the vestibule. While making these incisions along the cleft margin, the underlying bone is palpated with an instrument to ensure that the incisions remain over bone. At their superior extent in the depth of the vestibule, each of the incisions becomes horizontal and extends laterally approximately 1.0 to 2.0 cm from either side of the cleft (see Fig. 1).

Beginning inferior-medially, the mucoperiosteal tissues are undermined subperiosteally off the outer aspect of the alveolus and anterior maxilla along the entire length of both cleft margins. Medially, this dissection is carried until the anterior nasal spine and the floor of the contralateral (noncleft side) nasal floor are identified. Laterally, the dissection is carried superiorly on the maxilla to the level of the infraorbital neurovascular bundle (see Fig. 1).

Once the labial subperiosteal dissections are completed, the remainder of the soft tissue incisions and flaps necessary to reconstruct the floor of the nose and palatal aspect of the osseous defect are developed. Two additional incisions, following the palatal plane posteriorly approximately 15 mm, are made on each side of the margin (c–d and c′–d′; see Fig. 1). Next, the subperiosteal dissection is extended into the defect on both sides of the bony cleft, beginning inferiorly and proceeding posteriorly. The lateral dissection is extended well up the lateral nasal wall superiorly, and the medial dissection is extended to the base of the cartilaginous nasal septum.

In the final development of the soft tissue flaps to reconstruct the nasal floor and palate, it is important that the flaps extend well into the nasal cavity and onto the horizontal portions of the palatal shelves. This helps to ensure that adequate bony reconstruction of the alveolus and anterior maxilla can be achieved by the subsequent bone grafting. This can often be accomplished from the labial aspect, except when the bony cleft is quite small or narrow. In these instances, their full development needs to be accomplished from a palatal approach.

The superior flaps are sutured to reconstruct the nasal floor (Fig. 2). The inferior flaps are sutured to establish continuity of the palatal soft tissue and can often be sutured from the labial aspect, especially when the bony cleft is wide, rather than from the palatal aspect. Ideally, horizontal mattress sutures are placed to maximize raw tissue interphase, and thereby reduce the risk for dehiscence and secondary healing. When the tissue release or suturing is to be done from the palatal approach, inserting and using a Dingman mouth prop may aid in visualization.

The bony reconstruction must be precise to achieve a good result (piriform fullness and alar base support) and to permit orthodontic movement of the adjacent teeth into the reconstructed alveolus (Fig. 3). The nasal floor is reconstructed by firmly wedging a cortical cancellous strut,

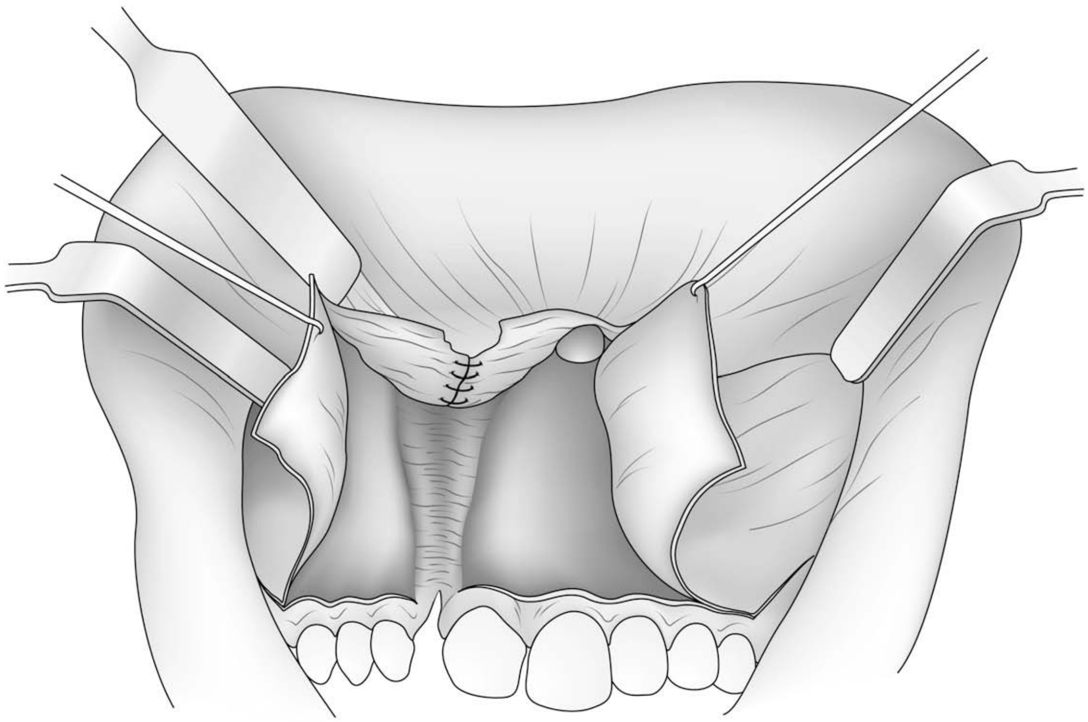

Fig. 2. Elevation of flaps and closure of palatal and nasal floor flaps.

sculptured to the correct shape, between the alveolar margins of the cleft, slightly superior to the contralateral nasal floor, which was previously exposed. Autogenous cancellous bone is the ideal material to fill the bony cleft. Also, it is best to compact this graft before placement. This can be achieved by placing the graft in a 10-cc syringe and compressing it with the plunger. Following this, it can be delivered by cutting of the most distal end of the syringe with a blade.

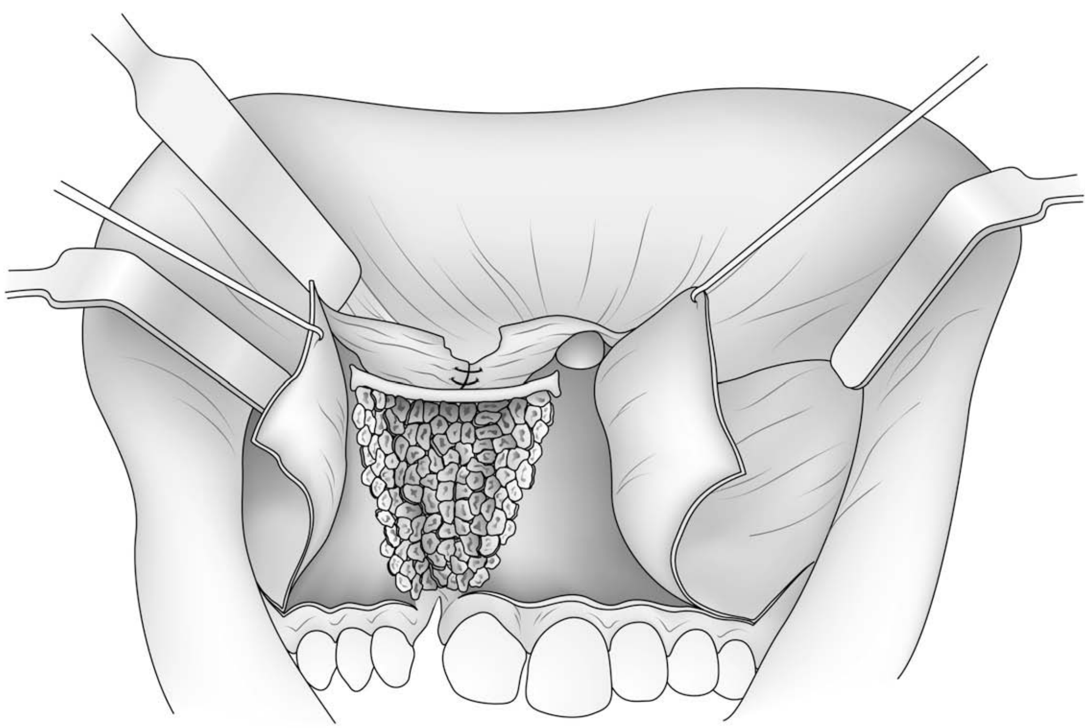

Fig. 3. Bone reconstruction with cortical strut superiorly and cancellous bone.

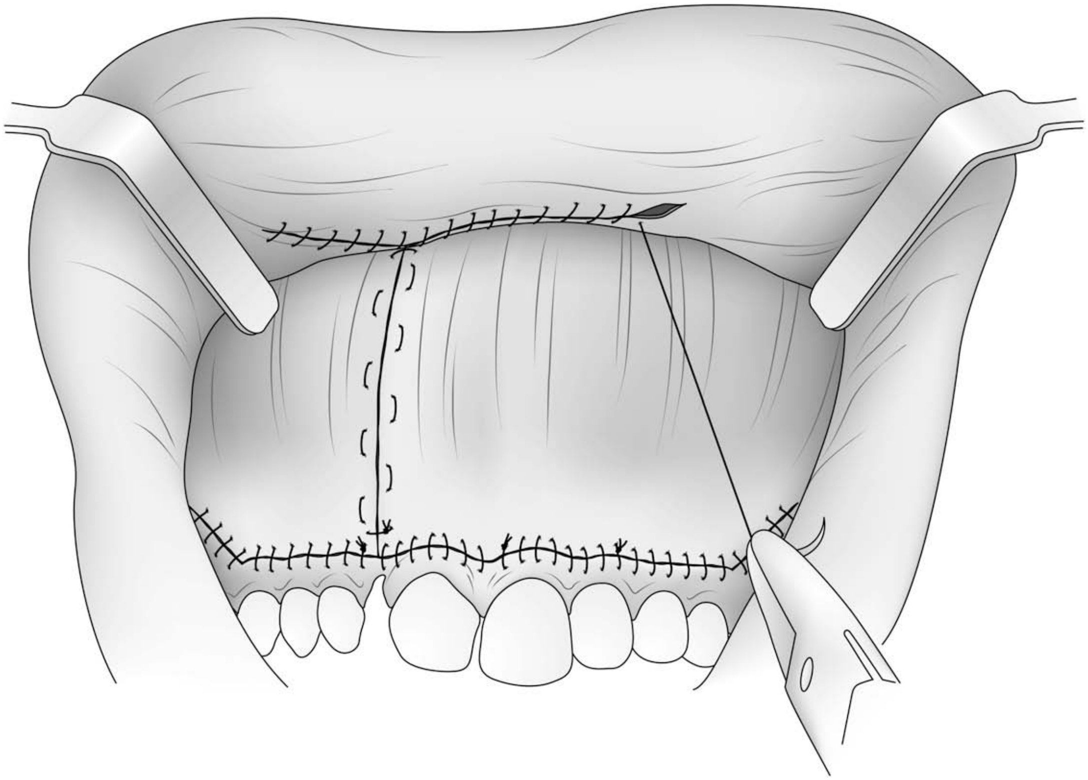

Fig. 4. Closure of labial flaps.

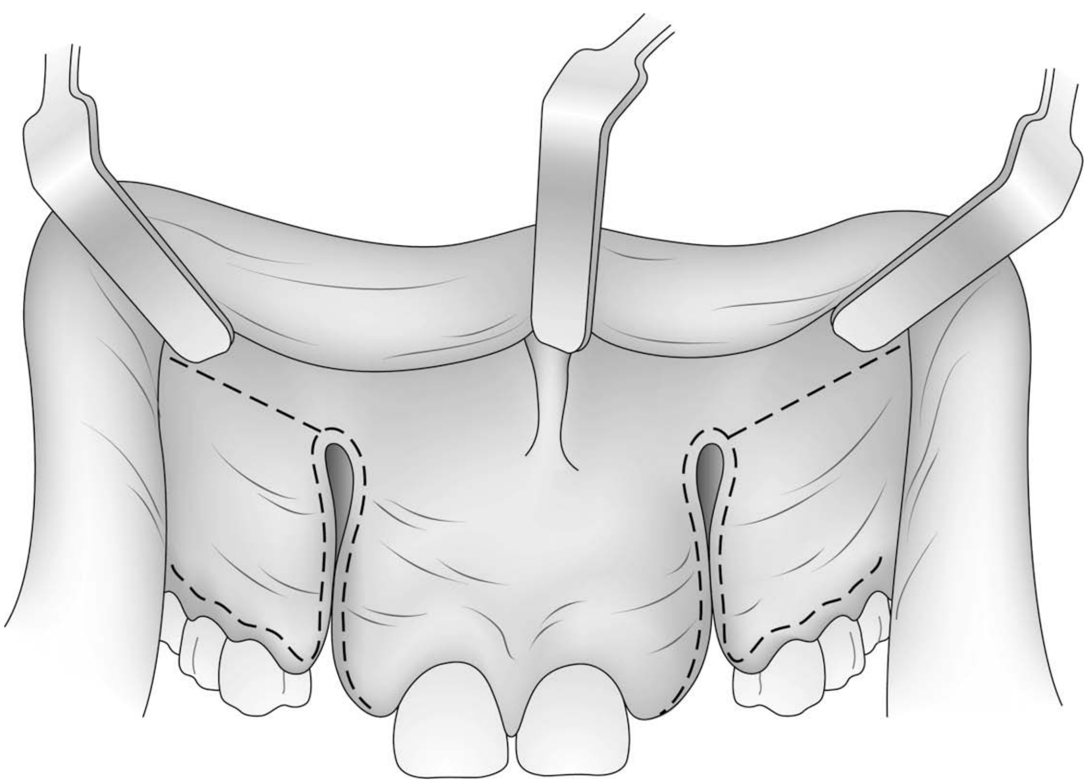

Fig. 5. Labial incisions for bilateral cleft alveolus-anterior maxilla bone reconstruction.

Attached gingival tissue is the optimal labial tissue for covering the inferior aspect of the alveolar bone graft. If additional relaxation is needed to effect a tension-free closure of the lateral flaps in the depth of the subperiosteal dissection, the periosteum is incised. Horizontal mattress, 4-0, slow-absorbing sutures are preferred to close the vertical limb of these incisions, and a running, continuous, slow-absorbing suture is used to close the horizontal limbs of these incisions (Fig. 4).

After surgery, it is helpful to place a layered tape pressure dressing over the upper lip for 24 to 48 hours, and a no-chew diet is recommended for 10 days. Nonsteroidal anti-inflammatory agents are used for 3 to 4 days as needed for pain. Generally, no other medication is required.

Surgical technique: bilateral cleft

The operation for a bilateral cleft deformity is similar to that for a unilateral deformity. Because it is performed bilaterally and simultaneously, however, the differences described in the paragraphs that follow must be noted (Fig. 5).

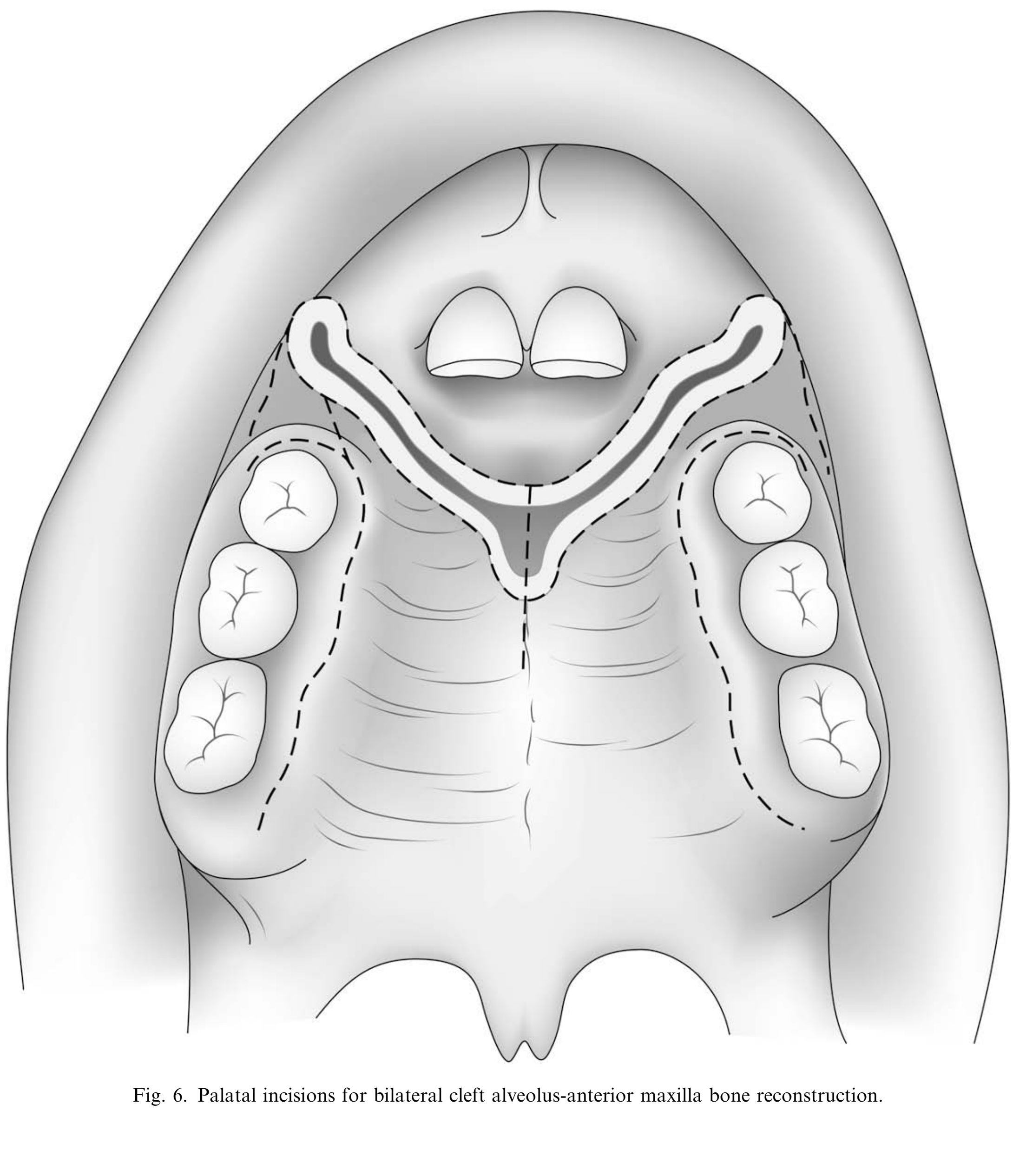

Fig. 6. Palatal incisions for bilateral cleft alveolus-anterior maxilla bone reconstruction.

First, there can be only minimal elevation of the mucoperiosteum on the labial surface of the premaxilla because this soft tissue is the primary vascular supply of this segment. Hence, the lateral flaps need to be adequate (well relieved) for advancement and closure of the entire cleft area.

Second, a surgical occlusal splint may be necessary in some cases to stabilize the premaxillary segment after surgery, especially when the premaxillary segment is quite mobile or the bite mobilizes it. This is determined by the individual patient's occlusion. When the maxillary central incisors are fully erupted and occlude, with jaw movement, with the lower incisors, a splint is beneficial to eliminate unfavorable movement of the premaxilla during the period of osseous remodeling. Stabilizing the premaxillary segment in these instances helps to encourage complication-free bone graft consolidation and healing.

Third, significant lip and nose changes accompany bilateral alveolar-anterior maxillary reconstruction. It is recommended that extensive simultaneous lip-nose revision not be done simultaneously for the patient with a bilateral deformity; a delayed lip-nose revision is suggested.

The operation can begin labially or palatally. Relative to the premaxillary segment, the mucoperiosteal reflection is completed so that the premaxillary soft tissue palatal flaps are elevated only enough to expose the bony cleft and provide enough tissue to suture (see Fig. 5). The mucoperiosteal flaps on the greater segments are completely undermined to be advanced anteriorly and medially.

Incisions are made palatally, along the cleft margins, as extensions from the alveolar crest aspect of each incision that was made from the labial aspect (Fig. 6). It is helpful to use a cleft

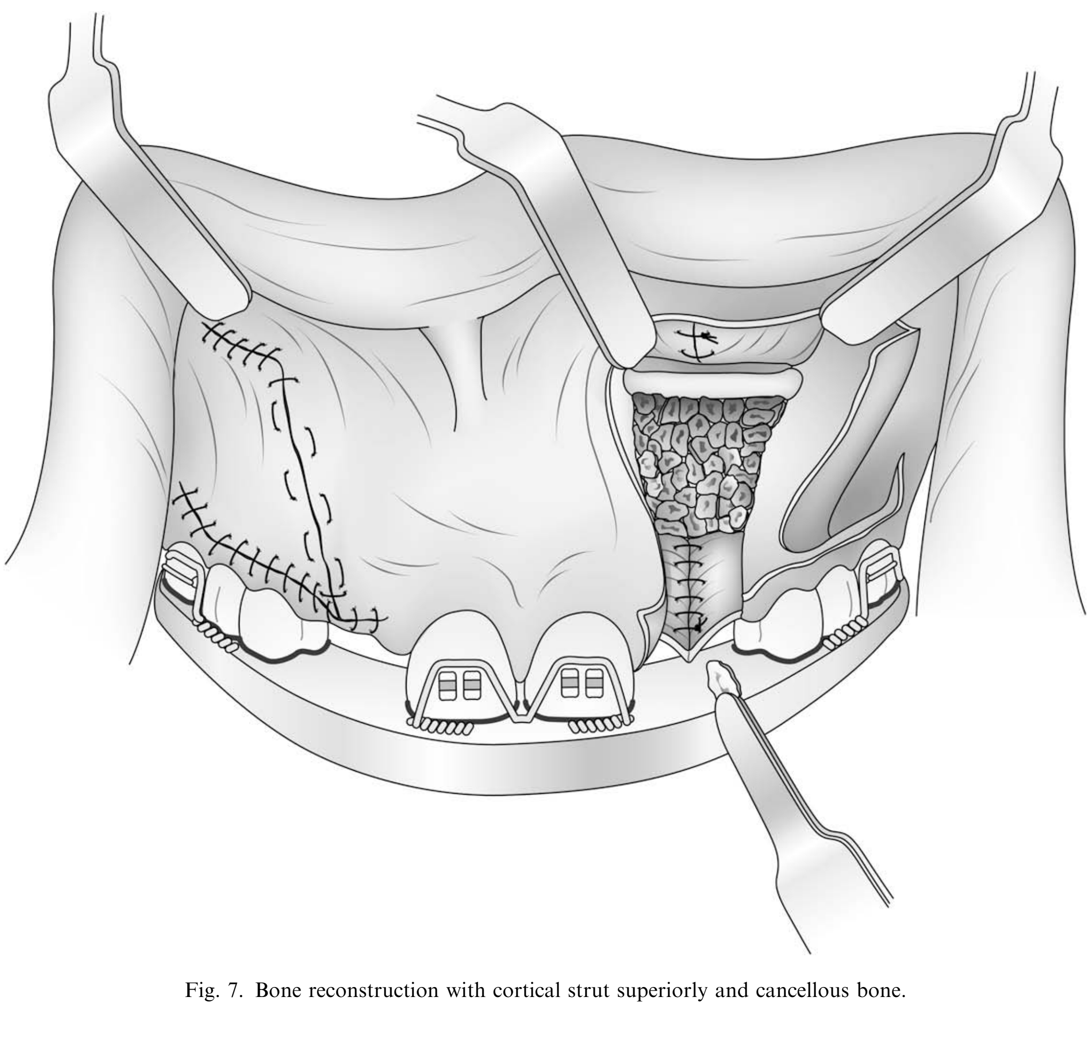

Fig. 7. Bone reconstruction with cortical strut superiorly and cancellous bone.

palate mouth prop while this aspect of the surgery is performed to optimize exposure. On the lateral dentoalveolar segments, additional palatal incisions are carried posteriorly approximately 3 mm from the margins of the attached gingivae to approximately the first molar region so that palatal flaps can be elevated and rotated medially to close the major portion of the soft tissue cleft. On the premaxillary segment, the incisions are carried posteromedially until they meet in the region of the nasal septum. These joined incisions are then extended posteriorly as a single incision along the base of the nasal septum.

The nasal mucosa within each alveolar cleft is closed with a 4-0 slow-absorbing suture from the labial aspect (see Fig. 5). The soft tissue flaps on the palate are closed from the palatal aspect with a slow-resorbing suture, optimally a mattress suture (Fig. 7).

A surgical occlusal splint, when used, is now wired to the maxillary dentition to stabilize the premaxilla when the operation is performed after the anterior dentition is fully erupted (6–7 years of age) or the anterior teeth actually contact on closure; this is used routinely to prevent movement of the premaxilla, which can adversely influence the bone grafts (see Fig. 6). Small cortical cancellous struts are placed bilaterally at the piriform rim base to provide proper alar base support and to add stability to the premaxillary segment. Cancellous bone is judiciously packed into the alveolar cleft sites bilaterally as described with the unilateral cleft. After compression of the particulate cancellous bone, the labial mucosa is now closed using 4-0 slow-resorbing sutures in a running horizontal fashion. Often, the periosteum under the labial flaps of the greater segments must be incised to increase the mobilization of these soft tissue flaps and permit a tension-free closure over the bone grafts. When a splint is used, it is ideally left in place for 4 to 6 weeks.

After surgery, it is helpful to place a layered tape pressure dressing over the upper lip for 24 to 48 hours, and a no-chew diet is recommended for 10 days. Nonsteroidal anti-inflammatory agents are used for 3 to 4 days as needed for pain. Generally, no other medication is required.

Further readings

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