# CONTENTS

## FORTHCOMING ISSUES

September 2007

**Techniques to Treat Snoring and Sleep Apnea**
Mansoor Madani, DMD, *Guest Editor*

March 2008

**Dental Implants in Children, Adolescents, and Young Adults**
George K.B. Sándor, MD, DDS, and
Robert P. Carmichael, BSc, DMD, MSc, FRCDC
*Guest Editors*

## PREVIOUS ISSUES

September 2006

**Mandibular Reconstruction**
Tirbod Fattahi, DDS, MD, and
Rui Fernandes, DMD, MD, *Guest Editors*

March 2006

**Implant Procedures**
Michael S. Block, DMD, *Guest Editor*

September 2005

**Autogenous Bone Grafting**
George M. Kushner, DMD, MD, *Guest Editor*

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) vii

Atlas of the
Oral and
Maxillofacial
Surgery Clinics

# Preface

Tirbod Fattahi, DDS, MD  Rui Fernandes, DMD, MD
*Guest Editors*

Welcome to the second volume of the *Atlas of the Oral and Maxillofacial Surgery Clinics of North America* devoted to maxillofacial reconstruction. In Volume I, published in September 2006, mandibular reconstruction using microvascular tissue transfer, regional flaps, as well as nonvascularized bone grafts was described. Each author presented specific advantages of various techniques following ablative or avulsive mandibular surgery.

In Volume II, our goal is to emphasize maxillary reconstruction. Once again, the *Atlas* commences with the surgical anatomy of the region. Microvascular reconstruction as well as multiple local and regional flaps commonly used for maxillary reconstruction will be highlighted. Two articles are devoted to prosthetic rehabilitation of the maxilla following ablative surgery including use of zygomatic endosseous implants. These articles should allow the reader to gain a comprehensive understanding of the current and contemporary concepts in maxillary reconstruction.

This two-volume project would not have been accomplished without the assistance of many people, including the authors of each article, supporting staff at Elsevier, and guidance from Dr. Richard Haug, the Consulting Editor for the series. We would also like to acknowledge the loving support from our family members in allowing us to complete this endeavor.

Tirbod Fattahi, DDS, MD
Rui Fernandes, DMD, MD
*Division of Oral and Maxillofacial Surgery*
*University of Florida Health Science Center*
*653-1 W. 8th Street*
*Jacksonville, FL 32209, USA*

*E-mail addresses:* Tirbod.Fattahi@jax.ufl.edu;
Rui.Fernandes@jax.ufl.edu

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.12.002

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) 1–6

Atlas of the Oral and Maxillofacial Surgery Clinics

# Surgical Anatomy of the Maxillary Region

Tirbod Fattahi, DDS, MD

*Department of Surgery, Division of Oral & Maxillofacial Surgery, University of Florida Health Science Center, 653-1 West 8th Street, Jacksonville, FL 32209, USA*

Firm understanding of the anatomy of the maxilla and mid-face is a necessity when reconstructing large avulsive or traumatic defects (Fig. 1). Surgical anatomy of the maxillary region often is limited to the description of the bony vertical buttresses of the mid-face. There is no question that the vertical buttresses of the face play an integral role in the foundation of the maxilla and mid-face. There is, however, a specific interplay between the maxilla, surrounding bones, neighboring fascia, and fat pads that must be appreciated to reconstruct a maxillary defect appropriately. This article highlights the pertinent surgical anatomy of maxilla including the bony buttresses, the fascial layout of the mid-face, and the relationship of the fat pads of the area. Clinically significant and surgical anatomy of each area is discussed with an emphasis on reconstruction.

## Bony buttresses of the mid-face

There are three vertical buttresses of the mid face: nasomaxillary, zygomaticomaxillary, and pterygomaxillary (Figs. 2 and 3). The first two are considered the anterior buttresses; the pterygomaxillary is the posterior buttress. The nasomaxillary buttress extends from the piriform aperture and anterior maxillary alveolus and travels cephalad toward the naso-frontal region. The zygomaticomaxillary buttress, the thickest of the three vertical pillars, extends from the posterior maxillary alveolus, includes the body of the zygoma, and terminates around the zygotmatico-frontal suture and posterior extension of the zygomatic arch. The most posterior buttress, the pterygomaxillary buttress, attaches the maxilla posteriorly to the sphenoid bone. These thickened portions of bone dissipate forces placed on the mid-face and transmit them along a vertically oriented vector. They also maintain the spatial position of the maxilla in relation to the cranium above and the mandible below. Because of their function, reconstruction of the vertical buttresses, and specifically the nasomaxillary and zygomaticomaxillary buttresses, is an essential step in maxillary reconstruction (Fig. 4).

## Fascia of the mid-face

There are two basic fascial systems of the mid face: superficial and deep (Fig. 5). The superficial fascia of the maxillary and mid-face is the superficial musculoaponeurotic system (SMAS). Mitz and Peyronie initially described the SMAS in 1976 as a network of dense fibrous and fatty tissues and septae that serves as the cephalad extension of the platysma muscle of the neck (Fig. 6). By definition, the SMAS ends at the zygomatic arch, above which it is known as the temporoparietal (TP) fascia. The TP fascia extends cephalad onto the temporal fossa and eventually becomes the galea aponeurosis of the scalp.

The deep fascia of the mid-face is the parotido-masseteric fascia. This is the facial extension of the investing layer of the deep cervical fascia (the superficial layer of the deep cervical fascia).

*E-mail address:* tirbod.fattahi@jax.ufl.edu

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.10.001

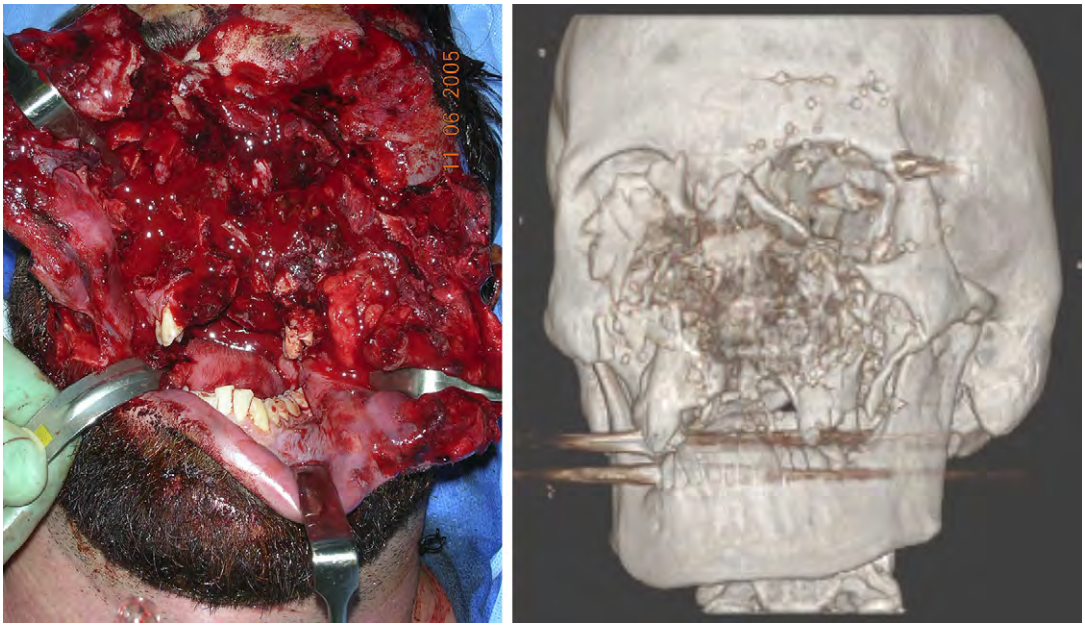



Fig. 1. Severe comminution of the maxilla and the supporting pillars secondary to a gunshot wound.

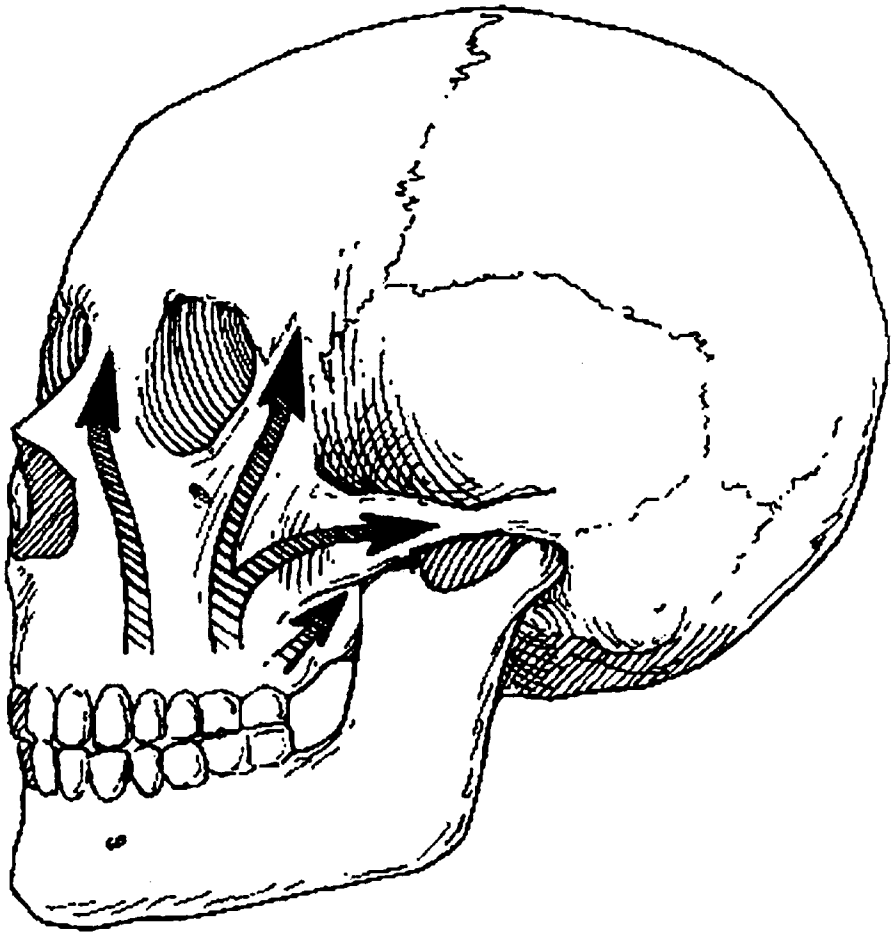


Fig. 2. Vectors of the three vertical buttresses of the maxilla and mid-face. (*From* Grass JS, Mackinnon SE. Complex maxillary fractures: role of buttress reconstruction and immediate bone grafts. Plast Reconstr Surg 1986;78:9–22; with permission.)

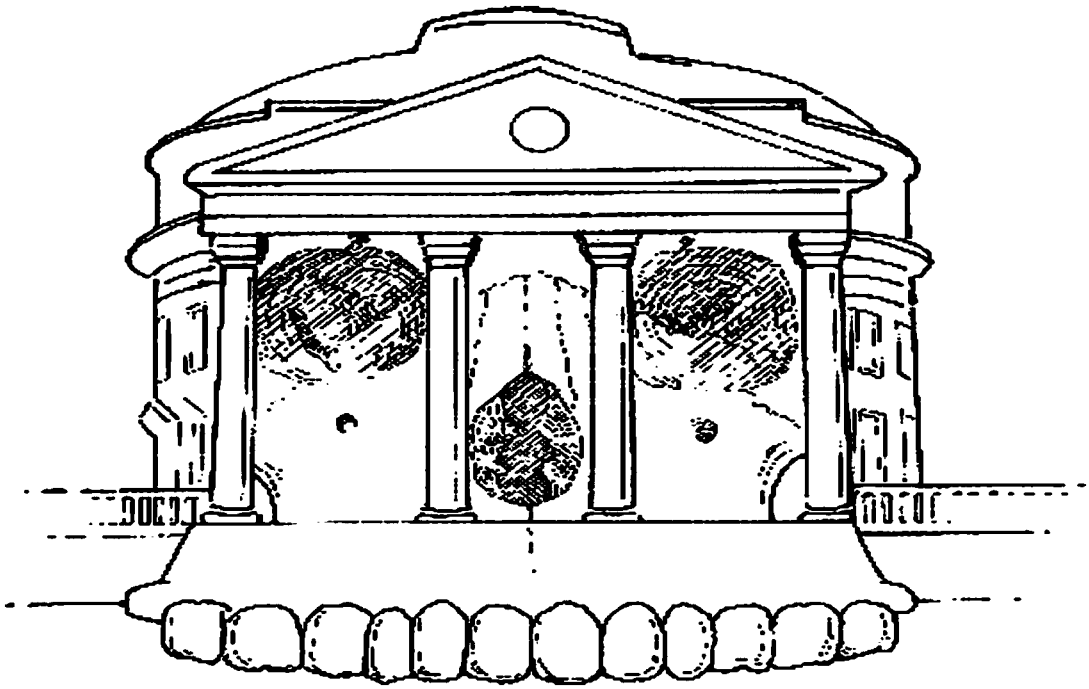


Fig. 3. Nasomaxillary (two central columns) and zgyomaticomaxillary (two lateral columns) buttresses of the mid-face supporting the spatial relationship of the maxilla and the cranium. (*From* Grass JS, Mackinnon SE. Complex maxillary fractures: role of buttress reconstruction and immediate bone grafts. Plast Reconstr Surg 1986;78:9–22; with permission.)

The parotido-masseteric fascia comprises the capsule of the parotid gland and wraps around the masseter muscle. Once it reaches the zygomatic arch, it is designated as the deep temporal fascia, which further subdivides into a superficial and a deep component. The deep temporal fascia covers the temporalis muscle, extends cephalad, and becomes continuous with the pericranium. The temporalis fascial system is discussed further elsewhere in this *Atlas*.

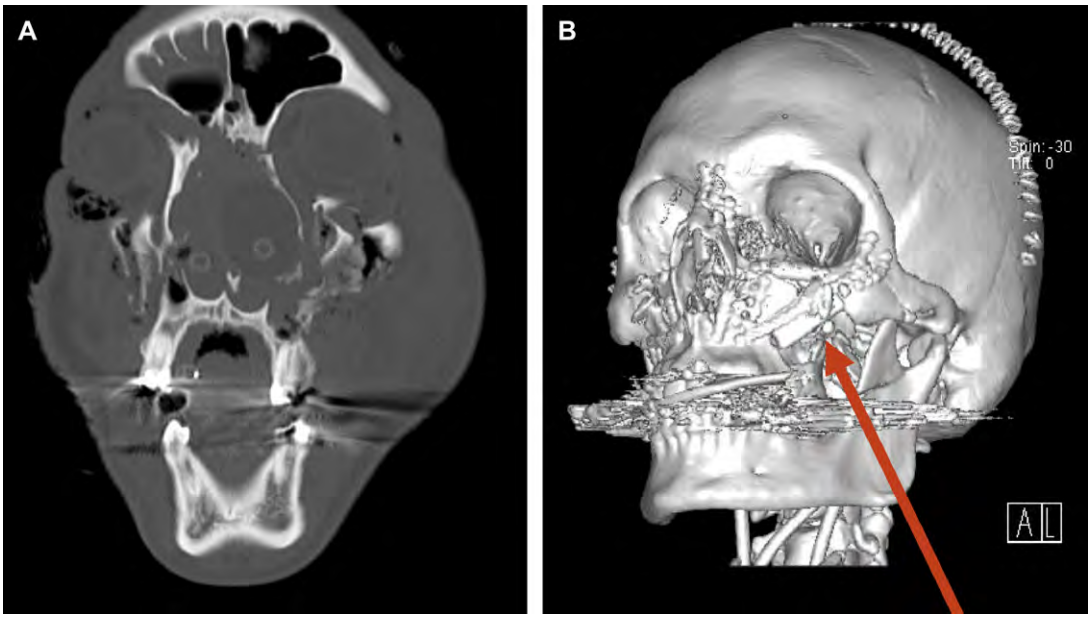



Fig. 4. (*A*) Severe disruption of the anterior buttresses. (*B*) The zygomaticomaxillary buttress has been reconstructed with harvested calvarium (*arrow*).

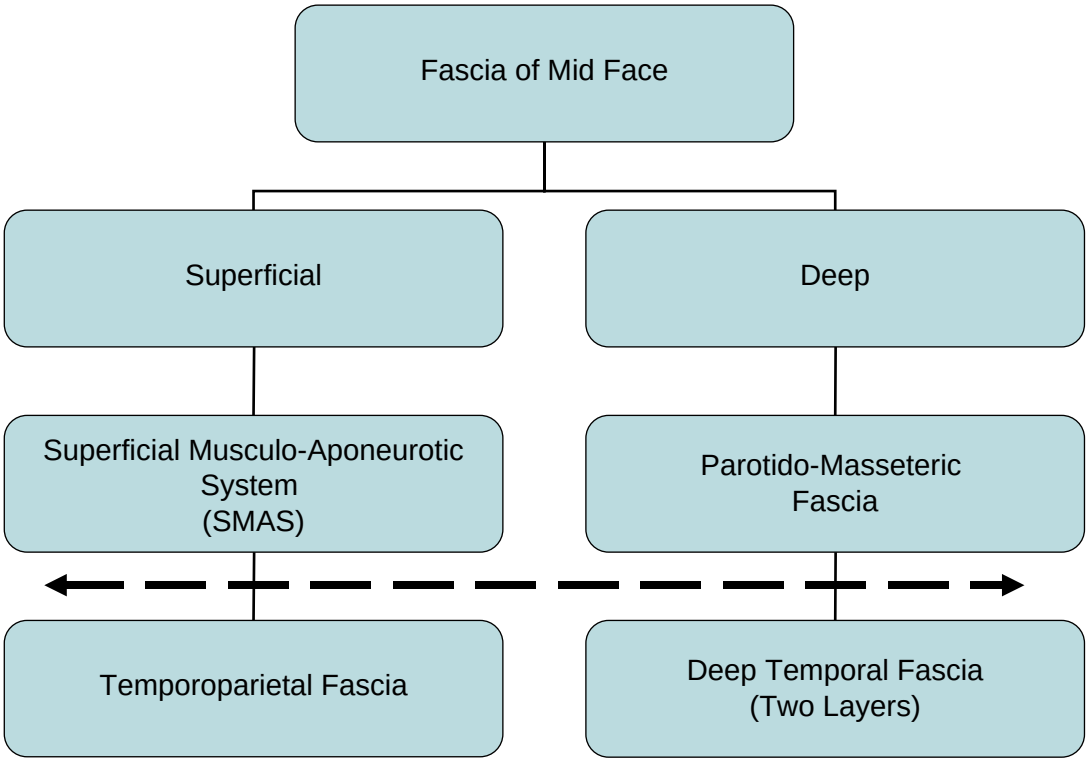



Fig. 5. Fascial layers of the mid-face. The dashed arrow represents the zygomatic arch.

## Fat pads of the mid-face

The fat pads of the mid-face are divided essentially into superficial and deep fat pads. They include the buccal fat pad, malar fat pad, suborbicularis oculi fat pad (SOOF), and Eisler's fat pad. Preaponeurotic fat pads of the upper eyelid and postseptal fat pads of the lower eyelids are not discussed here.

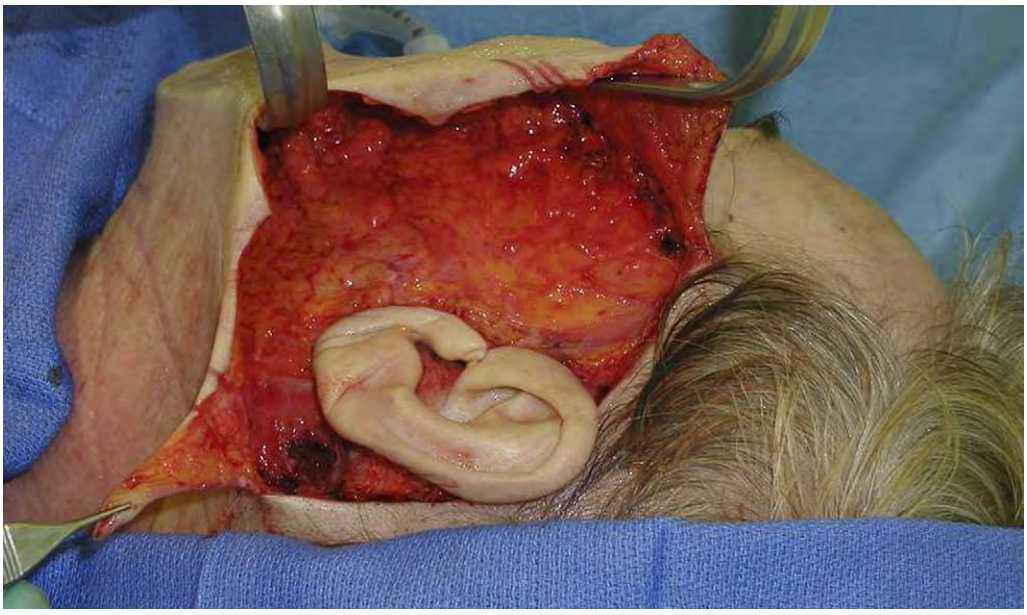


Fig. 6. The superficial musculoaponeurotic system. Note numerous septae running within the fascia.

The buccal fat pad, also known as the fat pad of Bichat's, is the largest fat pad of the mid-face. It has four parts: buccal, temporal, pterygomandibular, and pterygopalatine or palatal. There are other classifications regarding the exact number of extensions of this fat pad. The buccal fat pad has a constant weight in most individuals. It is well vascularized, rendering it an attractive option in reconstruction of the specific maxillary defects. The use of the buccal fat pad for reconstruction of maxilla is described elsewhere in this *Atlas*.

The malar fat pad is one of the superficial fat pads of the mid-face. It is essentially an extension of the SMAS in the infraorbital and naso-jugal region. The malar fat pad or mound is located superficial to the SMAS, bounded by lower eyelid superiorly and the naso-labial groove inferiorly (Fig. 7). The retaining ligaments of the mid-face, known as McGregor's patch, are often seen just lateral to the malar fat pad running in a vertical fashion between the dermis and the periosteum. There have been numerous publications in recent years on rejuvenation of the mid-face by elevating the malar fat pad in a superior and lateral direction.

Unlike the malar fat pad, which is considered a superficial fat pad, the SOOF is a deep fat pad of the mid-face. Originally described in the early 1990s, the SOOF represents the distinct fatty layer found between the orbicularis oculi and the bones of the mid-face region. The bulk of this fat pad is located on the lateral half of the infraorbital rim. The SOOF is analogous to the deep fat pad of the brow, the retro-orbicularis oculi fat pad, which is elevated during a forehead rejuvenation procedure. The SOOF-lift, the surgical procedure indicated to elevate a ptotic mid-face, has gained popularity recently, although complications such as lower eyelid rounding, malposition, and frank ectropion are potential possibilities.

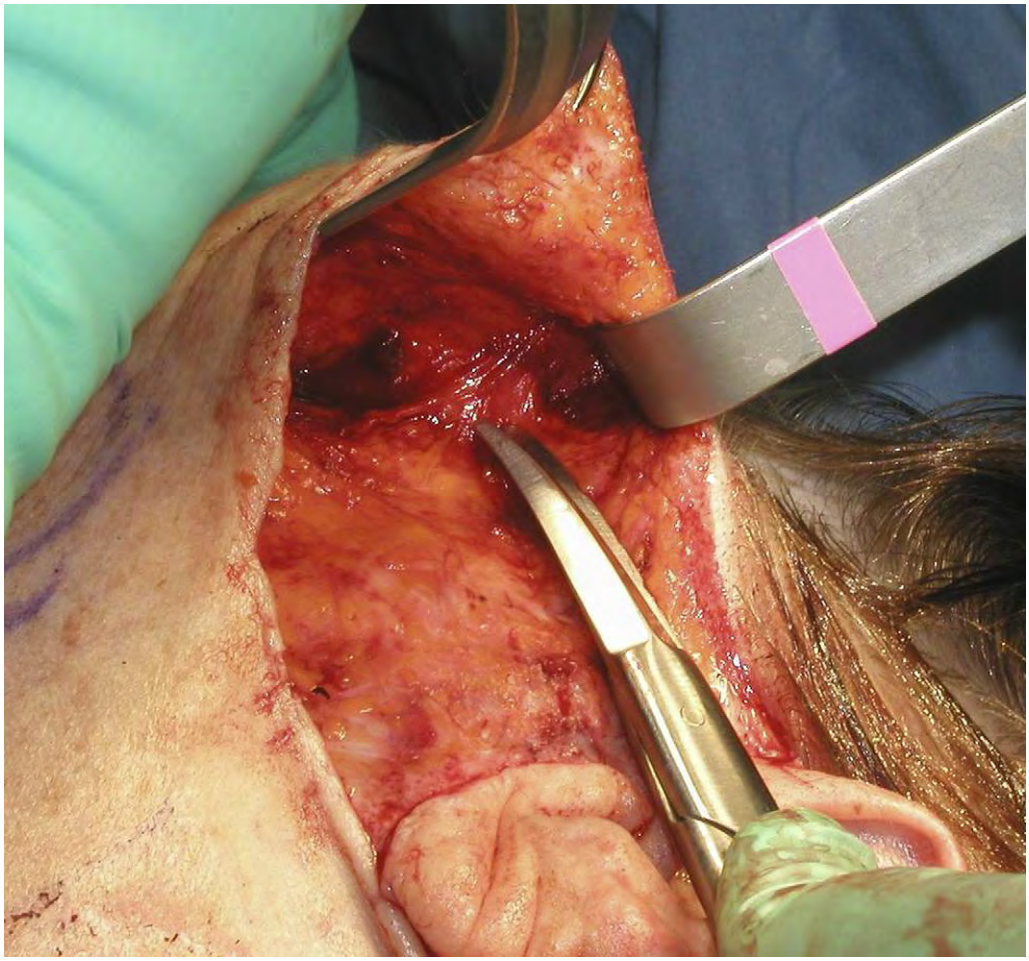


Fig. 7. The scissors point to the malar fat pad. The retaining ligament of the mid-face (Mcgregor's patch) is seen running vertically toward the dermis.

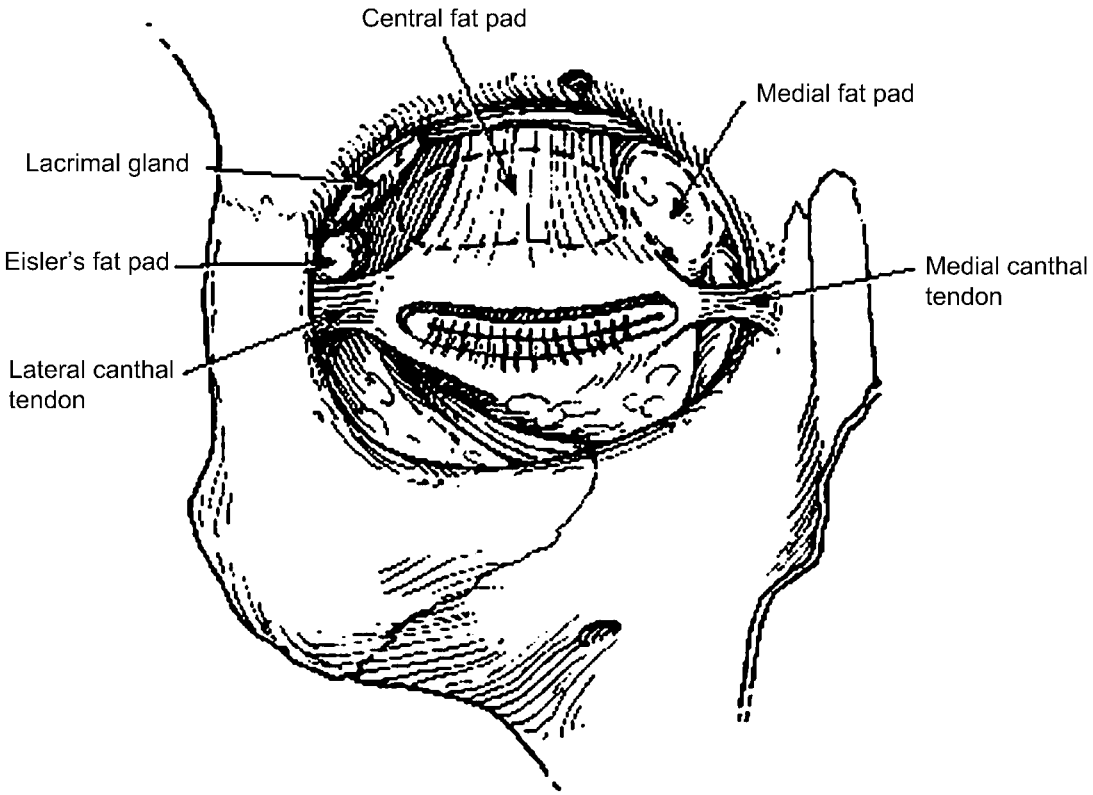



Fig. 8. Eisler's fat pad is located between the lateral canthal tendon and septum (removed). (*From* Persichetti P, Di Lella F, Delfino S, et al. Adipose compartments of the upper eyelid: anatomy applied to blepharoplasty. Plast Reconstr Surg 2004;113:373–8; with permission.)

Eisler's fat pad, located within the Eisler's pocket, is a recently recognized deep fat pad of the face. It is a rather small fat pad located between the orbital septum (anteriorly) and the lateral canthal tendon (posteriorly) in the lateral most aspect of the bony orbit (Fig. 8). This fat pad is commonly encountered during a lateral canthoplasty or canthopexy.

## Summary

Although there are numerous surgical options for the reconstruction of a maxillary defect, the pertinent surgical anatomy of the region remains the same. The specific interplay between the bony foundation of the maxilla with the fascial layers of the mid-face and the surrounding fat pads must be appreciated to maximize the final outcome. Because many avulsive or ablative defects of the maxilla involve a variety of hard and soft tissues, a firm understanding of the entire regional anatomy is imperative.

## Further readings

Aiache AE, Ramirez OH. The suborbicularis oculi fat pads: an anatomic and clinical study. Plast Reconstr Surg 1995;95:37–42.

Gruss JS, Mackinnon SE. Complex maxillary fractures: role of buttress reconstruction and immediate bone grafts. Plast Reconstr Surg 1986;78:9–22.

Mitz V, Peyronie M. The superficial musculoaponeurotic system (SMAS) in the parotid and cheek area. Plast Reconstr Surg 1976;58:80–8.

Persichetti P, Di Lella F, Delfino S, et al. Adipose compartments of the upper eye lid: anatomy applied to blepharoplasty. Plast Reconstr Surg 2004;113:373–8.

Tideman H, Bosanquet A, Scott J. Use of the buccal fat pad as a pedicled graft. J Oral Maxillofac Surg 1986;44:435–40.

Zhang HM, Yan YP, Oi KM, et al. Anatomical structure of the buccal fat pad and its clinical adaptations. Plast Reconstr Surg 2002;102:2509–18.

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) 7–12

Atlas of the Oral and Maxillofacial Surgery Clinics

# Reconstruction of Maxillary Defects with the Radial Forearm Free Flap

Rui Fernandes, DMD, MD

*Division of Oral & Maxillofacial Surgery, University of Florida, 653-1 West 8th Street, Jacksonville, FL 32209, USA*

The reconstruction of the midface and in particular the maxilla is a difficult task to perform with consistently good results. The basic objective of the reconstructive surgeon is to attempt to replace like tissue with like tissue. To that end, when faced with reconstructing ablative or traumatic defects, the first task to be undertaken by the surgeon is a detailed assessment of the missing tissue (eg, bone, mucosa, skin).

This factor should be considered when selecting the flap to be used. The ideal flap should replace the missing tissue while minimizing morbidity to both the donor site and the recipient site.

The microvascular flaps most commonly used for the reconstruction of the maxilla when both bone and soft tissues are to be replaced are the fibula free flap, the deep circumflex iliac artery flap, the scapular system flap, and the radial forearm free flap. The radial forearm flap is used most commonly as a fasciocutaneous free flap and is seldom used as an osteocutaneous free flap.

The return of function and, secondly, esthetics should be of paramount importance to the reconstructive surgeon. The flap used should provide the appropriate substructures to support dental implants and dentures.

When only soft tissue is needed, or when only a small amount of bone is required, the radial forearm free flap may be used as either a fasciocutaneous or an osteocutaneous flap.

## Anatomy of the forearm as it pertains to the harvesting of the radial forearm flap

The radial artery forms the deep palmar arch of the hand. It travels down the forearm between the brachioradialis and flexor carpi radialis muscles. The ulnar artery forms the superficial palmar arch. The anastomosis between the deep and superficial arches allows the safe harvest of the radial artery without causing ischemia and necrosis of the hand and in particular the thumb. The radial artery has many fasciocutaneous perforators to the overlying skin. These perforators increase over the distal forearm. Additionally, the radial artery gives off perforators that pass through the flexor pollicis longus to supply the radius bone. These perforators allow the harvesting of an osteocutaneous flap.

The venous drainage of the forearm is based on a deep and a superficial system. The superficial system is drained by larger-caliber subcutaneous veins that drain into the cephalic, basilic, and median cubital veins. The cephalic vein is the most commonly harvested vein. Numerous interconnections exist between the superficial and the deep system of veins. The deep system is based on the venae commitans of the radial artery.

The sensory innervation of the forearm is by the medial and the lateral antebrachial cutaneous nerves. These nerves can be harvested when a sensate flap is desired.

*E-mail address:* rui.fernandes@jax.ufi.edu

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.10.002

## Preoperative work-up

The work-up for the radial forearm free flap does not involve invasive studies. The most commonly used method is a clinical examination of the extremity to rule out previous trauma or surgeries to the forearm. Allen's test is used to assess the circulation of the palm. The test is administered by occluding both the radial and the ulnar arteries and then asking the patient to squeeze the wrist to exsanguinate the hand. After this, the ulnar artery is released, and the return of blood to the palm of the hand is assessed. Blood should return to the wrist within 3 seconds. Delayed filling should prompt further assessment. An assessment with a color Doppler or a recording of the systolic blood pressure in all digits should be taken to assess objectively the perfusion based on the ulnar artery.

The preferred arm to be used is the nondominant one. Therefore the left forearm is the most common donor site. Once the arm is selected, the author usually warns the patient not to allow any venipunctures in the arm before surgery. As a precautionary measure, the arm is wrapped as soon as the patient arrives at the preoperative center on the morning of surgery.

## Operative approach

On the day of surgery, while the patient is in pre-op holding, a tourniquet then is placed in the upper arm to accentuate the forearm vasculature. The vessels are marked with marking pens to aid in the harvest. Once the patient is transferred to the operating table and intubated, the donor forearm is placed on a cushioned arm board. The arm is prepped and draped along with the head and neck. The upper extremity is prepped and maintained separate from the head and neck site (Fig. 1).

A tourniquet is placed on the upper arm, and the size and shape of the defect to be harvested is drawn on the distal forearm. Care should be taken to design the skin paddle over the artery and to orient the skin paddle so that the vascular pedicle exits the neck in the desired fashion.

Once the design is confirmed to be in the proper orientation, the arm is exsanguinated using an Eshmark bandage. The tourniquet is inflated to about 250 mm Hg. The harvest begins distally and proceeds in a proximal fashion. An incision is made at the most distal point of the flap and is carried to the subcutaneous fascia, directly overlying the muscles and the tendons. The tendons of the flexor carpi radialis, the brachioradialis, and the palmaris longus are identified. A subfascial plane is dissected while maintaining the para-thenon over the tendons. The radial artery and the accompanying venae commitans are identified and isolated using an

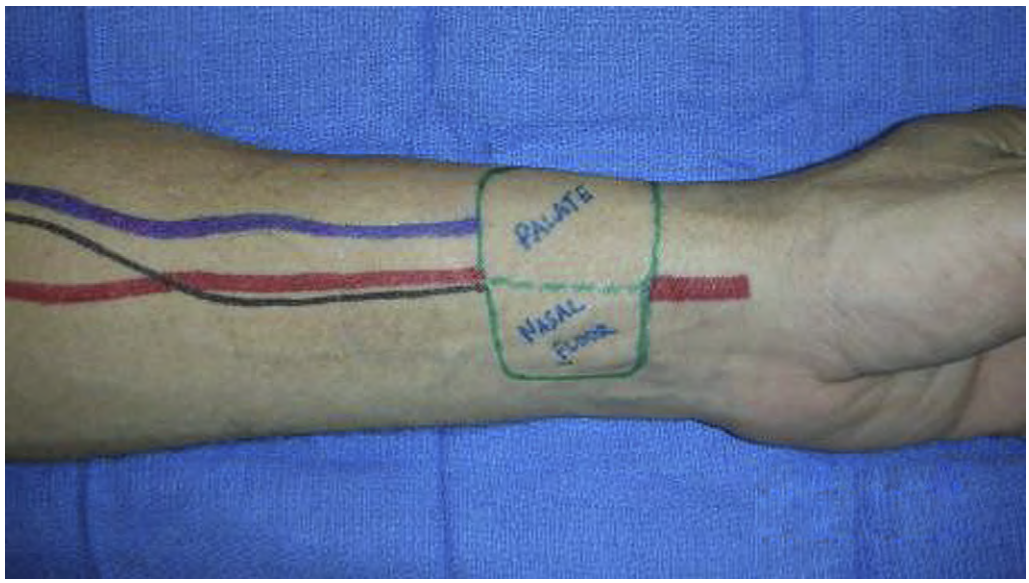



Fig. 1. Preoperative markings before harvesting of the flap.

angled clamp. Two 2-0 silk sutures are passed under the vessels. The vessels then are ligated and divided. Dissection continues on the radial side, and the cephalic vein is identified, ligated, and divided. The author usually harvests the cephalic vein to increase the venous drainage to the flap. Continued subfascial dissection is performed toward the radial pedicle while taking care to identify and preserve the sensory branches of the radial nerve. At this point, attention is turned to the ulnar aspect. The skin paddle on the ulnar side is incised to the fascia, and a subfascial elevation of the flap is similarly performed toward the radial vascular pedicle.

At this point, the proximal portion of the flap is incised, and a subcutaneous flap is elevated toward the antecubital fossa. The cephalic vein is dissected further until the desired length is exposed.

An Alice clamp is used to retract the flexor carpi radialis muscle, and dissection of the vascular bundle is performed between the flexor carpi radialis and the brachioradialis.

Dissection in this region is performed in a meticulous fashion taking care to clip or to cauterize with a bipolar cautery all the perforators to the muscle and the radius (Fig. 2). Once the desired length of pedicle is dissected, the tourniquet is deflated, and the flap is allowed to reperfuse. Hemostasis is achieved with care taken not to injure the artery and vein.

The flap is allowed to reperfuse for 20 minutes before it is harvested and transferred to the head and neck (Fig. 3A, B).

Once the flap is harvested, it is transferred to the head and neck.

In maxillary reconstruction, a tunnel is created from the maxilla to the neck. The tunnel is created from the defect in the soft palate and along the medial aspect of the mandible exiting in the neck. It is dilated to ensure that the pedicle will not be compressed. A 0.5-inch Penrose drain is passed from the neck to the maxilla using the tunnel. The drain is filled with heparinized saline, and the vascular pedicle is inserted into the lumen of the drain. The drain is pulled from the neck, and the pedicle is passed atraumatically into the neck. The flap is then inset. The vessels are oriented toward the recipient vessels, avoiding any twisting and kinking. Once the geometry of the vessels is optimized, the vascular anastomosis is performed. An alternative method is to perform the anastomosis to the superficial temporal vessels (Fig. 4A–C).

## Closure of the donor site

The arm is closed by reapproximating the proximal flap and closing it over a suction drain. The proximal donor-site defect is repaired with a full-thickness skin graft that is sutured in place

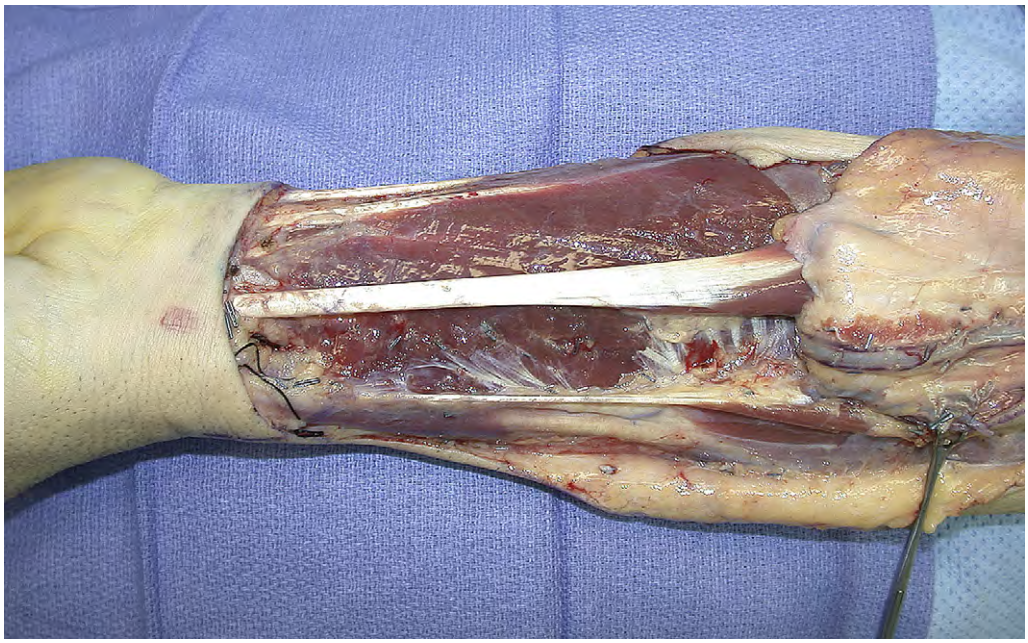


Fig. 2. Flap elevation with dissection of the vascular pedicle between the brachioradialis and the flexor carpi radialis.

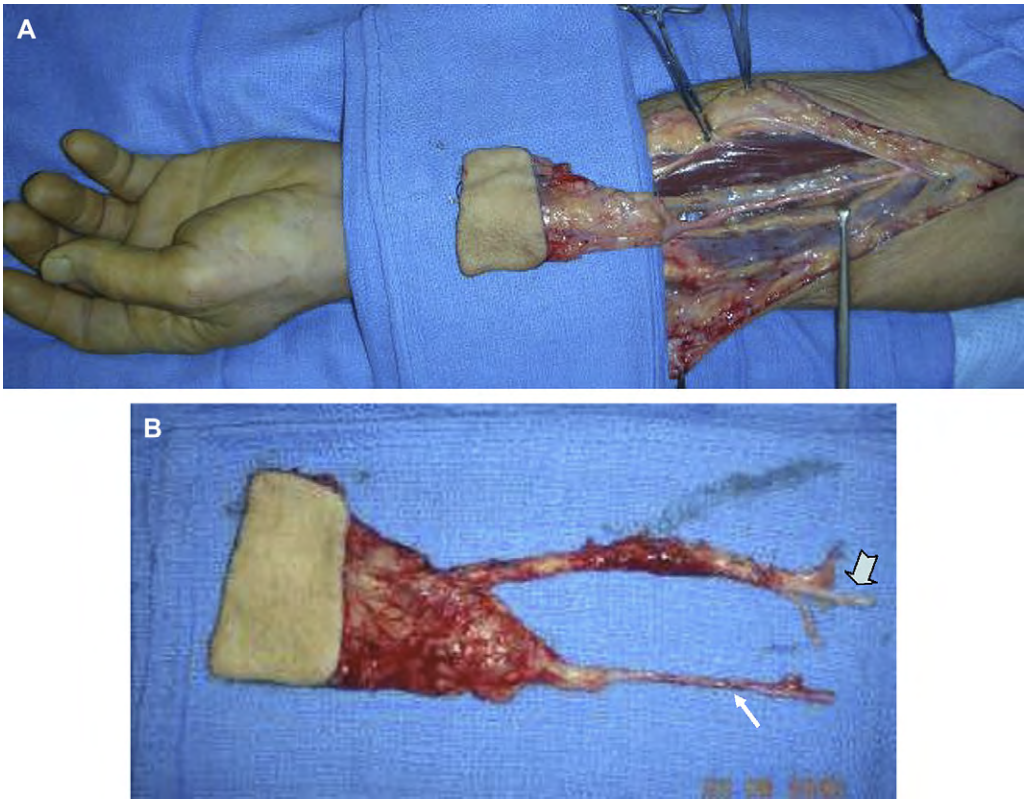



Fig. 3. (*A*) Harvest of the radial forearm fasciocutaneous flap. The vascular pedicle has been dissected to the antecubital fossa. (*B*) The harvested flap. Note the cephalic vein (*arrow*), the radial artery (*arrowhead*), and the accompanying venae commitans.

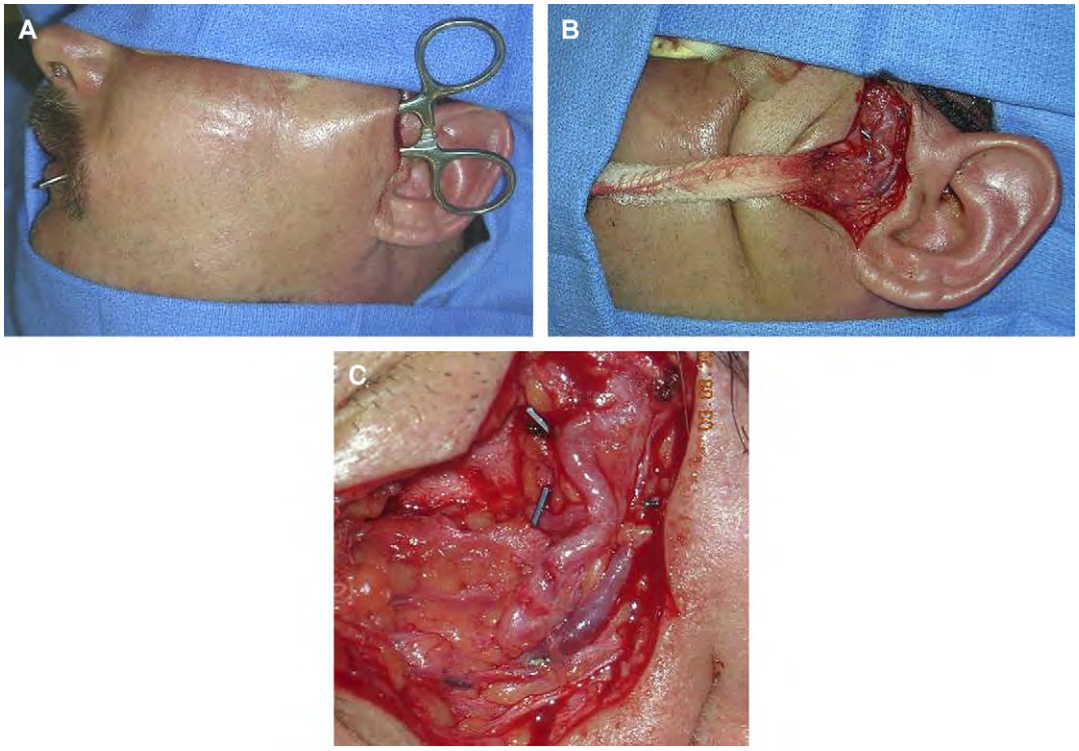



Fig. 4. (*A*) Dissection of a tunnel from the preauricular region to the oral cavity. (*B*) The tunnel is dilated and maintained. (*C*) View of the superficial temporal artery and vein before dividing and anastomosing to the donor vessels.

with 5.0 gut sutures. The arm is dressed by placing Xeroform gauze over the incision and skin graft. Webril is placed between the fingers, and the arm is wrapped. A volar splint is placed with the wrist in a 45° extension.

The splint is left in place for 7 to 10 days before it is removed to assess the percent take of the flap (Fig. 5).

## Advantages of the radial forearm flap

The radial forearm flap allows a simultaneous two-team approach during head and neck resections and reconstruction. It provides thin pliable tissue that is excellent for intraoral lining and a long vascular pedicle that can reach the neck without difficulties. The vessel caliber is of good size, facilitating vascular anastomosis to the recipient vessels in the neck. In select cases, an osseocutaneous radial forearm flap can be used to replace small quantities of bone in the anterior maxilla, and the skin can be used to replace missing mucosa.

## Disadvantages of the radial forearm flap

The main disadvantage of the radial forearm free flap is the appearance of the donor site postoperatively. The defect in the forearm can be reconstructed in several ways. The most commonly used method is a split-thickness skin graft. Another reconstructive option is to rotate the remaining skin flap to obtain primary closure. The author's preferred method is to use a full-thickness skin graft to reconstruct the defect. The healing of the forearm is thought to be much softer and pliable than the split-thickness graft.

## Complications

As with any microvascular flap, there is always a risk of flap loss. This possibility is minimized with meticulous harvest and microvascular anastomosis. The complication most commonly encountered is the partial or full loss of the skin graft, which can lead to exposure of the tendons. This event may require resurfacing of the exposed tendons with another graft or maintaining the area dressed with moist gauze for several weeks before healing.

Some patients experience sensory deficits associated with the loss of sensory branches of the radial nerve. This loss becomes less noticeable over time, however.

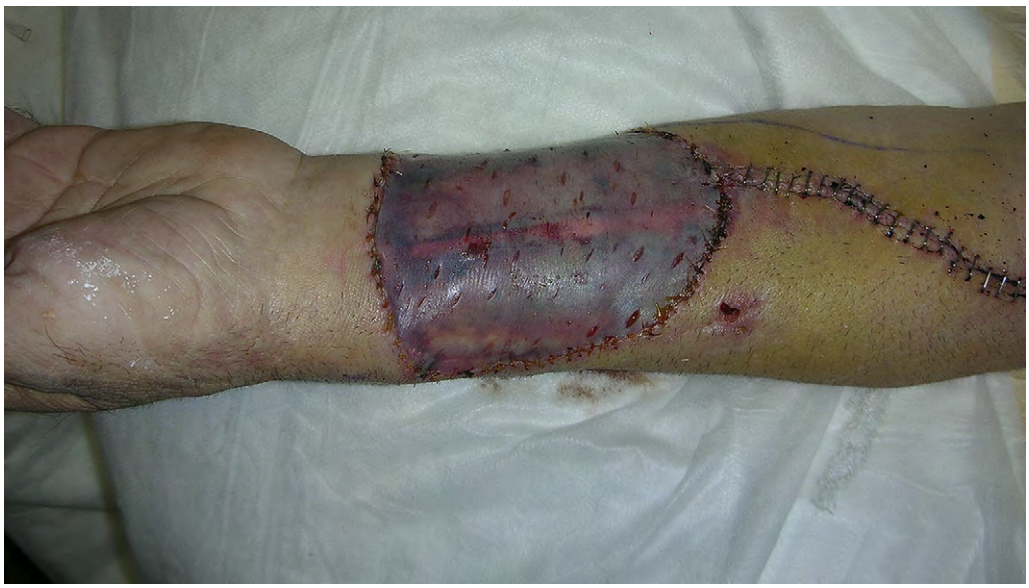


Fig. 5. Appearance of the skin graft to the donor site in the forearm 1 week after surgery. Note the 100% skin graft take.

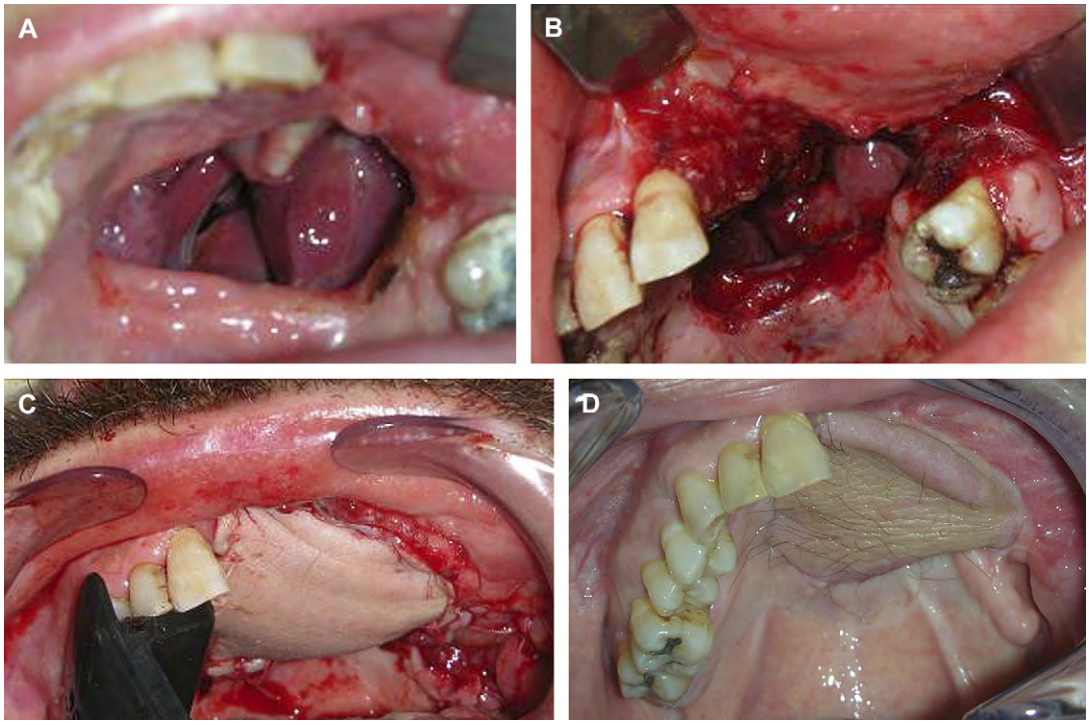



Fig. 6. (*A*) A patient with a large oral antral fistula secondary to a self-inflicted gunshot wound to the face. (*B*) The oral antral defect has been prepared, and access to the recipient vessels also has been created. (*C*) Immediate inset of the flap. (*D*) Appearance of the reconstructed defect about 1 month after surgery.

The major risk associated with the harvest of the radial forearm free flap is potential ischemia of the hand resulting from damage to the ulnar artery in cases of a superficial ulnar artery variant or insufficient collateral flow between the superficial and deep palmar arterial systems. This potentially catastrophic problem can be obviated by the invariable use of the Allen's test, and through the use of the color flow Doppler when the Allen's test is not conclusive.

## Summary

The radial forearm free flap is an excellent flap to use in the reconstruction of defects of the maxilla. The author has used it extensively for the reconstruction of large oral antral defects and traumatic defects of the maxilla and for the reconstruction of postablative defects (Fig. 6A–D). The use of this flap as an osseocutaneous flap has decreased in popularity because of complications from harvesting the bone, which result in morbidity, in fractures in about 25% of reported cases, and in decreased grip and pinch strength. The rate of bone fracture can be diminished with modifications in the osteotomy to decrease stress risers and with immediate plating of the residual radius. Despite these precautions, the morbidity is still much higher with the bone harvest than with the harvest of only a fasciocutaneous flap. The author therefore does not harvest an osseocutaneous radial forearm flap.

## Further readings

Cormack GC, Duncan MJ, Lamberty BGH. The blood supply of the bone component of the compound osteocutaneous radial artery forearm flap—an anatomical study. Br J Plast Surg 1986;39:173–5.

Hsieh CH, Kuo YR, Yao SF, et al. Primary closure of radial forearm flap donor defects with a bilobed flap based on the fasciocutaneous perforator of the ulnar artery. Plast Reconstr Surg 2004;113:1355–60.

Soutar DS, Scheker LR, Tanner NSB, et al. The radial forearm flap: a versatile method for intra-oral reconstruction. Br J Plast Surg 1983;36:1–8.

Timmons MJ. The vascular basis of the radial forearm flap. Plast Reconstr Surg 1986;77:80–92.

Villaret DB, Futran NA. The indications and outcomes in the use of osteocutaneous radial forearm free flap. Head Neck 2003;25:475–81.

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) 13–22

Atlas of the Oral and Maxillofacial Surgery Clinics

# The Fibula Free Flap in Maxillary Reconstruction

D. David Kim, DMD, MD, FACS*, Mark A. Dreher, DDS, MD

*Department of Oral and Maxillofacial/Head and Neck Surgery, LSU Health Sciences Center Shreveport, 1501 Kings Highway, Room 3-215, Shreveport, LA 71115, USA*

Maxillary defects pose considerable challenges to the reconstructive surgeon. The surgeon must be familiar with the complex three-dimensional anatomy and functions of the maxilla. The maxilla is the keystone of the midface. It contributes to mastication, deglutition, and speech; nasal function; support of the globe and orbital contents; and sinonasal function. A successful reconstruction should allow normal stomatognathic function, separation of the oral and nasal/sinus cavities, and restoration of facial contours. Obliteration of dead space and the need for surveillance also must be considered. The patient's ability to use a conventional or an implant-retained dental prosthesis also should be considered a key in determining the success of any maxillary reconstruction.

A classification of maxillary defects is useful for treatment planning and discussion with other professionals. Many classification schemes have been proposed. The present authors find the system by Brown and colleagues that considers the vertical and horizontal components of the defect to be the most useful (Fig. 1). The vertical defect is graded from class 1 to 4. Class 1 defects, or a maxillectomy with no oroantral fistula, result from resection of alveolar bone only. Also included as a class 1 defect is resection of the hard palate that produces an oral-nasal communication but leaves the tooth-bearing portion of the maxilla remains intact. A class 2 defect, or low maxillectomy, is created by resection of the alveolus and antral walls. In a class 3 defect, or high maxillectomy, the orbital floor is sacrificed; this defect also may include resection of the skull base. Finally, class 4 defects, or radical maxillectomy, include exenteration of the globe. The horizontal component is described by the modifiers "a" through "c." Unilateral resections, sparing the nasal septum, are considered "a" defects, resections crossing the midline are "b" defects, and total ablation of the alveolus and hard palate is a "c" defect. This system is particularly useful because the classification implies treatment options. Local flaps are considered sufficient only for class 1 defects. Pedicled flaps such as the temporalis flap usually are adequate for class 1 or 2a defects. Obturators, soft tissue free flaps, or composite free flaps are effectively used for any class 1, 2, or 3, a or b defects. Class 2c or 3c defects or any class 4 defect would benefit from free flap reconstruction because trismus may make obturator fitting difficult and the weight of the prosthesis may make retention problematic.

Maxillary defects can be reconstructed with an obturator, local flaps, pedicled flaps, or free flaps. These options, along with their advantages and disadvantages, have been abundantly described in the literature. Many free flap donor sites have been described for reconstruction, including the fibula, scapula, radial forearm, rectus abdominus, iliac crest, and latisimus dorsi. This article describes the surgical techniques used to harvest and inset a fibula free flap for maxillectomy defects.

## Fibula osteoseptocutaneous free flap

The fibula free flap was first described by Taylor and colleagues in 1975 for lower extremity reconstruction. In 1989 Hidalgo described its use for mandibular reconstruction. Since then, numerous authors have reported use of the fibula free flap for midface reconstruction. This flap

* Corresponding author.
*E-mail address:* dkim1@lsuhsc.edu (D.D. Kim).

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.11.001

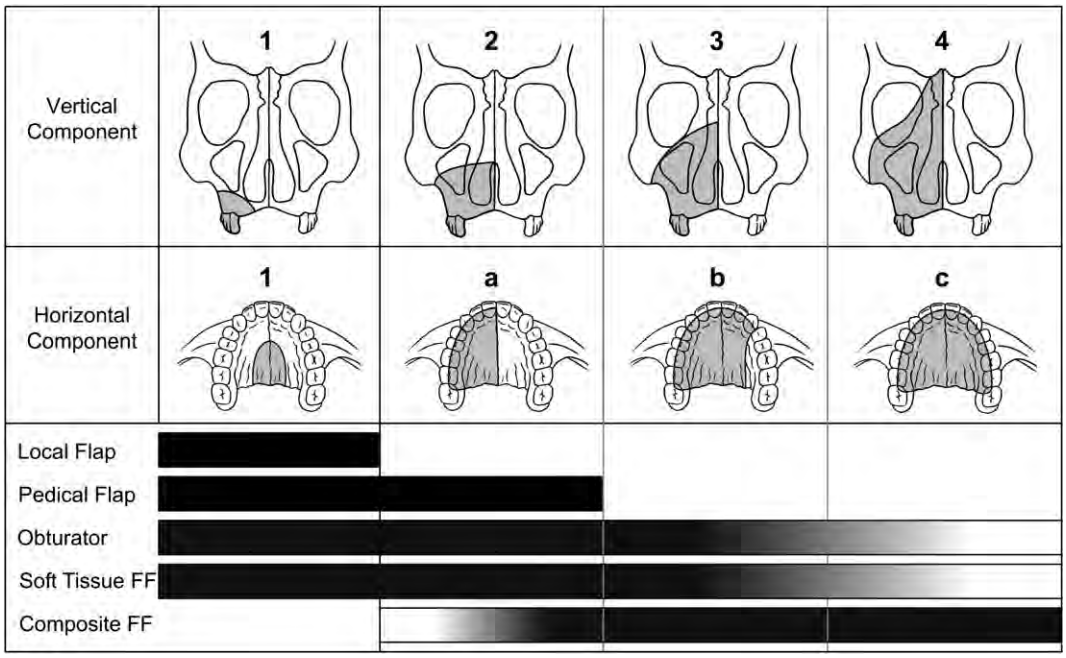



Fig. 1. Maxillectomy defect classification. (*Adapted from* Brown JS, Rogers SN, McNally DN, et al. A modified classification for maxillectomy defect. Head Neck 2000;22:17; with permission.)

offers many advantages. The ability to harvest bone, muscle, and skin simultaneously is beneficial in reconstructing the complex anatomy of the maxilla. Multiple skin paddles can be obtained to line the orbit and separate the oral and nasal cavities. The excellent periosteal blood supply allows multiple osteotomies that facilitate re-establishing the anatomic contours of the maxilla. Finally, the use of vascularized bone allows future rehabilitation with dental implants. The flap is relatively easy to harvest, has low donor-site morbidity, and can be harvested simultaneously with the ablative procedure.

The fibula is a non–weight-bearing bone. The entire length of the fibula can be harvested except for the most proximal and distal 6 to 7 cm to preserve the integrity of the knee and ankle joints. This harvest usually provides 22 to 25 cm of bone with an average diameter of 14 to 15 mm. The vascular pedicle (the peroneal artery and venae comitantes) can be harvested up to the bifurcation of the tibial-peroneal trunk into the peroneal and posterior tibial arteries. The flap can be raised as a bone only or as an osteofasciocutaneous flap with the skin of the lateral calf perfused by fascio-cutaneous or musculo-cutaneous perforators that run along the posterior crural septum or through the soleus muscle. Part of the soleus muscle must be harvested if the perforators are of the musculocutaneous type or if the recipient site requires extra soft tissue bulk.

The preoperative evaluation of the free flap candidate should include a thorough history and physical examination with identification of any conditions that may be a concern for microvascular surgery. A history of hypercoagulable states, estrogen use, or surgical or traumatic insult to the lower extremities should be identified at this time. The site to be reconstructed also should be examined to determine the gross dimensions and extent of the defect. Finally, examination of the lower extremities should begin with simple inspection for the stigmata of peripheral vascular disease, chronic venous insufficiency, or previous surgery, combined with palpation of the popliteal, dorsalis pedis, and posterior tibial pulses. Imaging modalities should be used to evaluate blood flow to the lower extremities and include angiography, MR angiography, and CT angiography. The authors prefer MR angiography because of its noninvasive nature and the quality of the image obtained (Fig. 2), but conventional angiography is considered the standard. If there is adequate three-vessel flow to the foot without significant occlusive disease or congenital abnormalities, the patient may be considered a candidate for a fibula flap. The choice of the leg to serve as the donor site is based on these clinical and radiographic examinations and on patient and surgeon preference. The right leg is more suited to a right-handed surgeon because of the direction of the dissection and orientation of the patient.

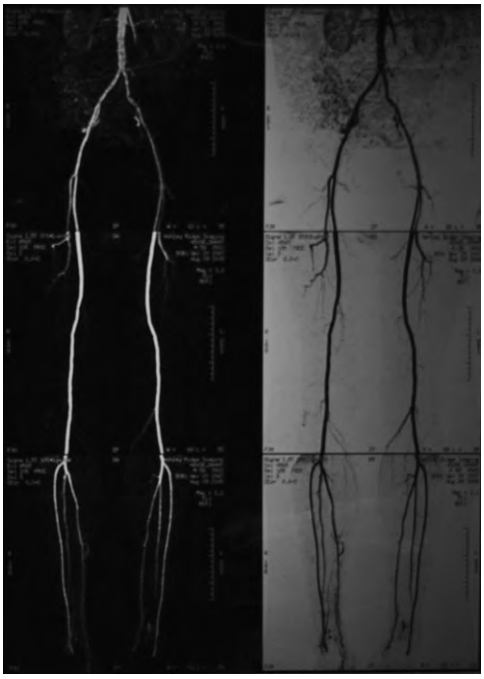


Fig. 2. Typical MR angiogram of bilateral lower extremities used as preoperative screening to identify any vascular anomalies.

## Procedure

The lateral approach to the fibula for free flap harvest was described by Gilbert in 1979 and reiterated by Flemming and colleagues in 1990. The donor leg should be prepped and draped circumferentially from the toes to the hip and the knee flexed at a 90° angle. The lateral epicondyle of the ankle and the fibular head are palpated and marked, and a line between these points is drawn that approximates the position of the posterior crural septum. The proximal and distal 6 to 7 cm of the fibula are identified to be preserved. Next, an appropriately sized skin paddle is marked, centered over the posterior crural septum and the middle and distal thirds of the fibula to capture the dominant septocutaneous or musculocutaneous perforators usually present in this area (Fig. 3). A hand-held Doppler probe may be used to identify these perforators before

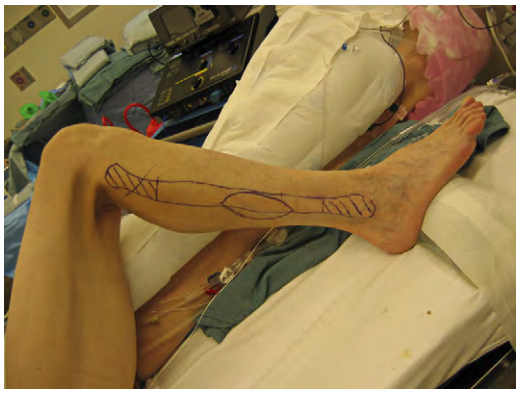


Fig. 3. Markings of the lateral lower leg. The head of the fibula and the lateral malleolus of the ankle are identified by palpation. Six to 7 cm of proximal and distal fibula are marked to be preserved. The skin paddle is centered over the estimated area of the posterior crural septum, which is positioned on a line drawn from the head of the fibula to the lateral malleolus. It also should be positioned over the junction of the middle and distal thirds of the fibula to capture the cutaneous perforators that are usually present in that area.

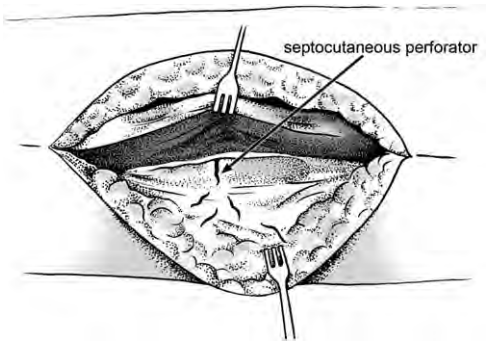



Fig. 4. Posterior dissection in the subfascial plane above the peroneus longus muscle leads to the posterior crural septum where septocutaneous or musculocutaneous perforators can be identified.

marking the proposed skin paddle. Finally, a pneumatic tourniquet is placed on the thigh and inflated to 350 mm Hg.

The skin of the anterior portion of the skin paddle is incised, and the incision is carried through the fascia overlying the peroneous longus muscle. The dissection proceeds in a subfascial plane posteriorly until the posterior crural septum is identified (Fig. 4). At this point, septocutaneous or musculocutaneous perforators should be identified. The posterior crural septum is traced to the fibula, and dissection along the anterior portion of the fibula is performed until the anterior tibial vessels are identified (Fig. 5). The initial skin incision now can be extended proximally and distally to facilitate dissection along the medial portion of the fibula and to identify the interosseous membrane.

At this point, a subperiosteal dissection should be completed circumferentially around the fibula at the proximal and distal ends (Fig. 6). The fibula then is osteotomized at these points with an oscillating, sagittal, reciprocating or Gigli saw while the vascular bundle is protected with a curved instrument. Removal of a small wedge of bone at these osteotomy sites greatly facilitates lateral retraction of the bone while dissecting the vascular pedicle. Once lateral retraction is achieved, the distal portion of the peroneal artery and vein is easily identified on the medial aspect of the fibula. These vessels are ligated and divided (Fig. 7). Next, the posterior portion of the skin paddle is incised down through the fascia overlying the soleus and gastrocnemius muscles. If musculocutaneous perforators are present, a small cuff of soleus muscle is harvested along with the posterior crural septum to preserve the integrity of these small perforators. If septocutaneous perforators are present, it is not necessary to harvest a cuff of soleus with the posterior crural septum.

The distal portion of the fibula can be grasped and retracted laterally to allow medial dissection of the flap. The interosseous septum is divided to allow identification of the tibialis posterior muscle. The peroneal vessels are followed through this muscle until the branching of the posterior tibial artery is identified (Fig. 8). During this dissection, numerous branches will be

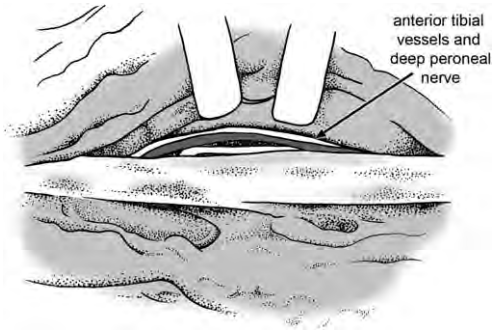



Fig. 5. The posterior crural septum is followed medially to the fibula. The dissection then continues anterior to the fibula in a supraperiosteal plane until the anterior tibial vessels are identified.

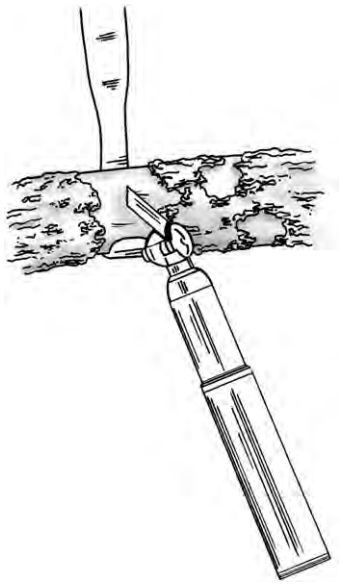


Fig. 6. Circumferential subperiosteal dissection at the osteotomy sites of the fibula is performed with great care, and a curved Freer retractor is placed to protect the vessels from the sagittal saw blade. The same procedure is performed on the proximal end of the fibula.

encountered and should be dissected carefully and ligated with vascular clips. Once the vascular pedicle is dissected completely, the flexor hallicus longus attachments are transected. At this time the tourniquet should be released, allowing the flap to reperfuse for a minimum of 20 minutes while meticulous hemostasis is achieved. The foot should be inspected for pulses, warmth, and capillary refill.

The flap can be harvested and passed to the inset team for insetting and microvascular anastomosis. The leg wound should be irrigated, and two large suction drains should be placed at different tissue levels. The muscle layers should be reapproximated loosely to close dead space. The skin defect can be managed with undermining and primary closure or, as is usually done, a split-thickness skin graft can be harvested and sutured to the skin paddle defect with chromic gut sutures. A posterior lower leg splint should be fabricated to support the ankle in a dorsiflexed position to prevent movement under the skin graft as well as flexor muscle scar contractures. Ambulation with assistance can be anticipated on postoperative day 7.

Before it receives the flap from the harvest site, the recipient site is inspected for adequate recipient vessels, preparation of the recipient site ensuring adequate hemostasis, and creation of a tunnel lateral or medial to the mandibular body to pass the vessels from the midface to the neck (Fig. 9). Generally, when the fibula is used for a Brown class 2 to class 4a or b defect, a vein

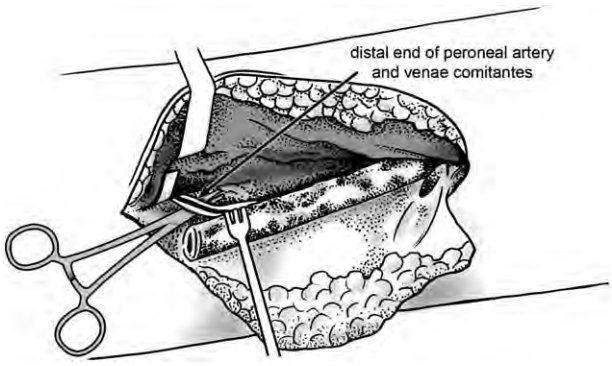



Fig. 7. The distal portion of the peroneal artery and veins are identified and ligated.

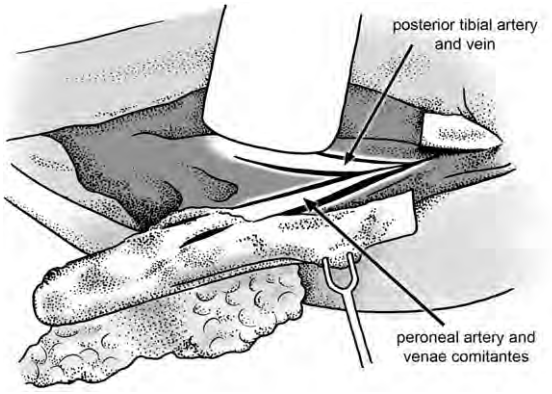



Fig. 8. The peroneal vessels are dissected until the branching of the posterior tibial vessels are identified.

graft is not necessary because the vascular pedicle is lengthened by discarding a length of the proximal fibula bone. Otherwise, for a total maxillary reconstruction (Brown class 2 – 4c), a vein graft may be necessary to reach recipient vessels in the neck, or an anastomosis to the superficial temporal vessels can be attempted. Creating an anastomosis may prove difficult because of the inherent size mismatch between the two vessel systems.

Preparation of the recipient site of a maxillary defect should involve preparation of soft and hard tissues for receiving the fibula flap. The extent of this preparation depends on the extent of the resection and is more involved in secondary than in primary reconstructions. The maxillary soft tissues should be prepared so the edges of the soft tissue defect are ready to receive the skin paddle of the flap. Any attached mucosal surface should be elevated gently from the underlying bone to facilitate suture placement, and the bone should be trimmed back so the interface between native maxilla and fibula is not directly beneath the suture line of the skin paddle. In the case of secondary reconstructions, the edges of the maxillary defect must be incised and freshened to receive the skin paddle (Fig. 10A, B).

Once site preparation is completed, the harvested fibula and skin paddle can be shaped to be received in the defect. The primary difficulty in contouring the fibula for the typical hemimaxillectomy defect is in contouring the straight fibula to recreate the maxillary alveolar arch. Rohner and colleagues have reported a prefabrication technique in which the fibula is shaped to a predetermined model of the desired shape of the maxilla, and an acrylic drilling template is produced to recreate the position of the neomaxilla by guiding the osteotomies of the fibula and simultaneously placing endosseous implants. This prefabrication technique requires multiple operations that culminate in a reconstruction tailored to the predesigned prosthesis. Without the guidance of a prefabricated guide, however, the surgeon and maxillofacial prosthodontist still should use preoperative planning for the best outcome. This planning generally requires the creation of study models and, in many cases, a three-dimensional CT scan with

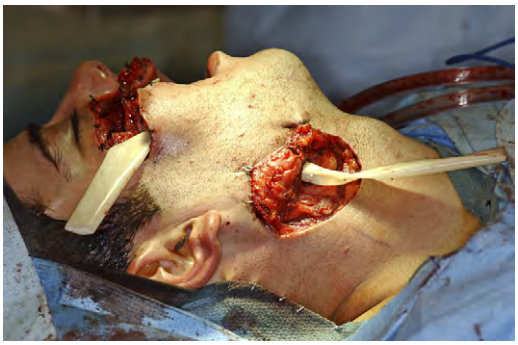


Fig. 9. A tunnel from the maxillectomy defect is created in a plane lateral or medial to the mandibular body depending on the orientation of the defect and the peroneal vessels.

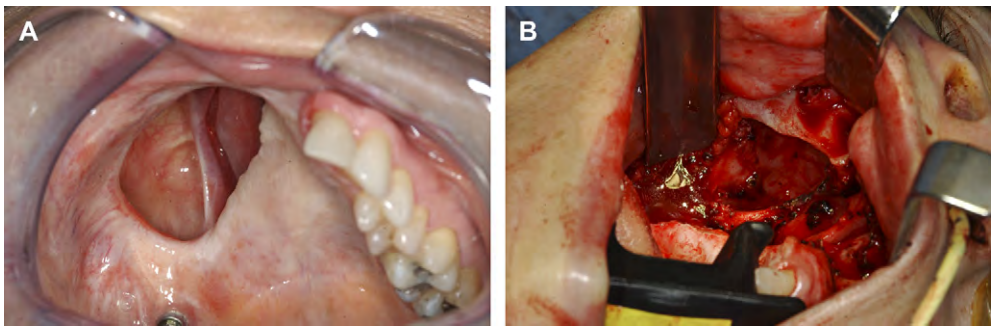



Fig. 10. (*A*) A Brown class 2b maxillectomy defect for secondary reconstruction. (*B*) The defect prepared for receiving the fibula flap.

a stereolithographic model (Figs. 11 and 12). These images usually are sufficient to guide the surgeon in recreating the maxillary alveolus.

In many class 2 a to c defects, the bony architecture of the cheek is spared during the resection so that most of the buttresses remain, including the zygomatic and piriform areas. If so, there is no need to reconstruct these buttresses, and the entire bony portion of the flap is used to recreate a dental arch. In class 3 and 4 defects, when the portions of the zygoma, orbital floor, and lateral nasal walls are removed, use of the fibula flap for reconstruction becomes more difficult. In an attempt to overcome this difficulty, Ferri and colleagues describe a case using the discarded proximal portion of the fibula as a free bone graft to reconstruct the height of the lateral nasal buttress. The iliac crest free flap based on the deep circumflex iliac artery is more suited to reconstruct class 3 and class 4 defects, however, because the entire facial surface of the maxilla can be recreated with the iliac bone. Alternatively, the surgeon may opt to treat these higher maxillectomies by obliterating the dead space with a bulky soft tissue flap such as the rectus abdominus or latissimus dorsi and secondary free bone graft reconstruction (Fig. 13).

As in mandibular reconstruction with the vascularized fibula, bony inset is achieved before the soft tissue. Depending on the extent of the defect, the fibula may require no, one, or two osteotomies to reconstruct the maxillary alveolus (Fig. 14). These osteotomies are performed by subperiosteal dissection at the site of the desired osteotomies with vigilant protection of the vascular pedicle. Once the osteotomies are complete, the fibula bone can be inset to the recipient site using miniplates and monocortical screws (Fig. 15). Soft tissue closure can proceed with careful suturing of the skin paddle to the prepared defect site (Fig. 16). The surgeon may choose to inset the skin paddle only partially and complete the suturing after the microvascular anastomoses have been completed. Doing so will allow inspection of the flap for bleeding before final closure. The nasal surface of the reconstruction is essentially exposed but should re-epithelialize over time. In the immediate postoperative period, the patient should be placed on strict nasal

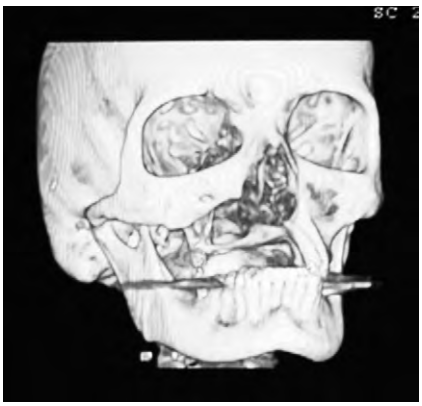


Fig. 11. Three-dimensional CT scan of the patient depicted in Fig. 10.

Fig. 12. Stereolithographic model of the patient depicted in Fig. 10. Note the acrylic mock-up of the desired position of the neomaxilla fabricated by the maxillofacial prosthodontist.

Fig. 13. Reconstruction of a high maxillectomy with a rectus abdominus free flap with the skin paddle used to replace the cheek skin.

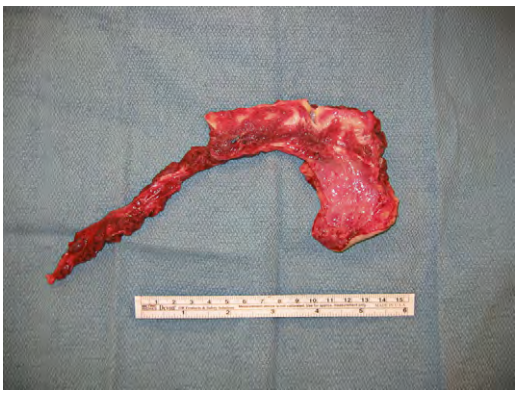


Fig. 14. Fibula bone osteotomized to recreate contours of maxillary alveolus.

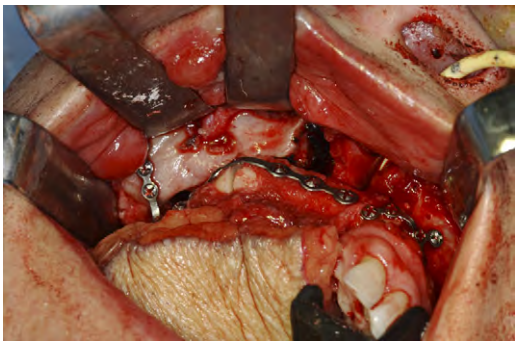


Fig. 15. Inset fibula flap with miniplates and monocortical screws.

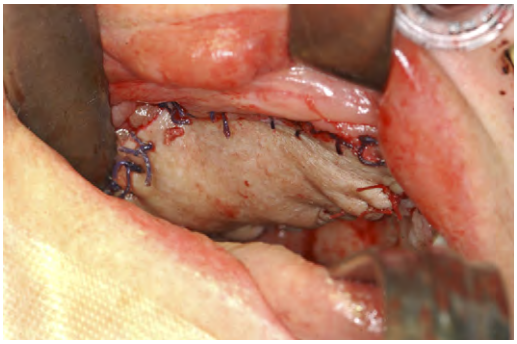


Fig. 16. Soft tissue inset of the fibula flap skin paddle.

precautions to prevent creation of turbulent air flow around the vascular pedicle. A nasal trumpet may be sutured in the nostril to help protect the nasal surface of the flap from irritation.

At this stage, microvascular anastomosis of the peroneal vessels to the selected recipient vessels can be performed in a routine fashion. Generally, a branch of the external carotid, such as the facial artery, and a branch of the internal jugular vein are used for end-to-end anastomosis. Occasionally, when a suitable branch is not identifiable, an end-to-side anastomosis to the internal jugular vein is necessary. 9-0 nylon sutures are used under magnification from an operating microscope or under high-power loupes.

The final stage of reconstruction occurs several months after the primary procedure when the reconstructed maxilla can be prepared for dental implants. Alternatively, many authors have reported placing endosseous implants successfully at the time of the primary reconstruction; however, continued difficulty exists in proper preoperative planning for the ideal position of these implants. It is the authors' preference to delay endosseous implant placement for 4 to 6 months after the primary reconstruction so that adequate implant planning can occur. In addition, the skin paddle may be too thick to serve as an adequate mucosal interface for osseointegrated implants. In these cases, the skin paddle must be trimmed back and replaced with a split-thickness skin graft over the fibula bone. This procedure usually is performed at the time of implant uncovering.

## Summary

The maxillectomy defect can be a daunting reconstructive challenge to many oral and maxillofacial surgeons. Advances in microvascular techniques, however, provide abundant sources of vascularized tissue that can be used to adequately reconstruct defects that otherwise would be left as open cavities. Before these microvascular reconstructive techniques were developed, such defects were relegated to bulky obturators that were difficult to tolerate because of their size and weight. Although the use of obturators still can be a valuable asset in patients who are not candidates for free flap reconstruction, patients now have a choice of maxillary reconstructive techniques that can effectively eliminate the need for these prostheses by carefully planned and well executed procedures.

## Further readings

Brown JS. Deep circumflex iliac artery free flap with internal oblique muscle as a new method of immediate reconstruction of maxillectomy defects. Head Neck Surg 1996;18:412–21.

Brown JS, Rogers SN, McNally DN, et al. A modified classification for maxillectomy defect. Head Neck 2000;22:17–26.

Chang YM, Coskunfirat OK, Wei FC, et al. Maxillary reconstruction with a fibula osteoseptocutaneous free flap and simulataneous insertion of osseointegrated dental implants. Plast Reconstr Surg 2004;113:1140–5.

Cordeiro PG, Santamaria E, Kraus DH, et al. Reconstruction of total maxillectomy defects with preservation of the orbital contents. Plast Reconstr Surg 1998;102:1874–84.

Earley MJ. Primary maxillary reconstruction after cancer excision. Br J Plast Surg 1989;42:628–37.

Ferri J, Caprioli F, Peuvrel G, et al. Use of the fibula free flap in maxillary reconstruction: a report of 3 cases. J Oral Maxillofac Surg 2002;60:567–74.

Flemming A, Brough M, Evans N, et al. Mandibular reconstruction using a vascularized fibula. Br J Plast Surg 1990;43: 403–9.

Futran ND, Haller JR. Considerations for free- flap reconstruction of the hard palate. Arch Otolaryngol Head Neck Surg 1999;125:665–9.

Futran ND, Wadsworth JT, Villaret D, et al. Midface reconstruction with the fibula free flap. Arch Otolaryngol Head Neck Surg 2002;128:161–6.

Gilbert A. Vascularised transfer of the fibular shaft. International Journal of Microsurgery 1979;1:100–3.

Granick MS, Ramasastry SS, Newton ED, et al. Reconstruction of complex maxillectomy defects with the scapular-free flap. Head Neck Surg 1990;12:377–85.

Hidalgo D. Fibular free flap: a new method of mandible reconstruction. Plast Reconstr Surg 1989;84:71–9.

Kazaoka Y, Shinohara A, Yokou K, et al. Functional reconstruction after a total maxillectomy using a fibula osteocutaneous flap with osseointegrated implants. Plast Reconstr Surg 1999;103:1244–6.

Kim DD, Ghali GE. Microvascular free tissue reconstruction of the oral cavity. Selected Readings in Oral and Maxillofacial Surgery 2004;12(4):1–36.

Muzaffar AR, Adams WP, Hartog JM, et al. Maxillary reconstruction: functional and aesthetic considerations. Plast Reconstr Surg 1999;104:2172–83.

Nakayama B, Matsuura H, Hasegawa Y, et al. New reconstruction for total maxillectomy defect with a fibula osteocutaneous free flap. Br J Plast Surg 1994;47:247–9.

Rohner D, Bucher P, Kunz C, et al. Treatment of severe atrophy of the maxilla with the prefabricated free vascularized fibula flap. Clin Oral Implants Res 2002;13:44–52.

Soutar DS, McGregor IA. The radial forearm flap in intraoral reconstruction: the experience of 60 consecutive cases. Plast Reconstr Surg 1986;78:1–8.

Swartz WM, Banis JC, Newton ED, et al. The osteocutaneous scapular flap for mandibular and maxillary reconstruction. Plast Reconstr Surg 1986;77:530–45.

Taylor GI, Miller DH, Ham FJ. The free vascularized bone graft: a clinical extension of microvascular techniques. Plast Reconstr Surg 1975;55:533–44.

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) 23–32

Atlas of the Oral and Maxillofacial Surgery Clinics

# Buccal Fat Pad in Maxillary Reconstruction

Kevin Arce, DMD, MD

*Department of Oral and Maxillofacial Surgery, John Peter Smith Hospital, 1500 S. Main Street, Fort Worth, TX 76104, USA*

Lorenz Heister first identified the buccal fat pad in 1727. He thought it was glandular in nature and identified it as the ''glandula molaris'' in his *Compendium Anatomicum*. Marie-Francois-Xavier Bichat in 1801 was the first to provide its anatomic description as a fatty tissue. Since then it has been referred to in the medical literature by different names including the ''boule de Bichat,'' masticatory fat pad, sucking pad, and sucking cushion.

The buccal fat pad is a mass of specialized fat tissue located anterior to the masseter muscle and deep to the buccinator muscle. Ease of access during oral and maxillofacial procedures has induced interest in its application for reconstruction of defects secondary to tumor resection or resultant oro-antral fistula caused by dentoalveolar surgery or trauma. Advantages include easy harvest, low morbidity, high success rate, and elimination of donor-site skin scars. When Egyedi first described the use of the buccal fat pad for closure of persistent oro-nasal or oro-antral communications in 1977, he applied a split-thickness skin graft over the raw flap. Neder, in 1983, described its successful use without a split-thickness skin graft, revealing consistent oral epithelialization. Numerous subsequent reports supported these original papers, showing complete epithelialization in 4 to 6 weeks. The pedicled buccal fat pad flap now is used to provide bone coverage in primary palatorrhaphy, coverage of maxillary bone grafts, and orbital reconstruction.

## Buccal fat pad anatomy

The buccal fat pad formation begins at 3 months in utero, and the pad increases in size until birth. Its prominence in the midfacial region decreases with the changes in facial proportions brought by aging. Traditional anatomic descriptions state that the buccal fat pad has a central body and four processes: buccal, pterygoid, pterygopalatine and superficial, and deep temporal (Fig. 1). More recently, the buccal fat pad was described as having three lobes—anterior, intermediate, and posterior—as determined by the encapsulation, supporting ligaments, and arterial blood supply (Fig. 2). According to this description, the four processes or extensions traditionally described are derived from the posterior lobe (Fig. 3). Each lobe is supported by two to four ligaments to the surrounding facial bones and ligaments. The blood supply to the buccal fat pad originates from the buccal and deep temporal branches of the maxillary artery, the transverse facial branch of the superficial temporal artery, and branches of the facial artery such as the inferior buccinator artery. This rich vascularity allows a reliable long axial flap and explains the rapid surface re-epithelialization. The buccal and zygomatic branches of the facial nerve and the parotid duct lie lateral to the fat pad and should not be injured during flap mobilization.

The posterior lobe of the buccal fat pad exists throughout life. The buccal process is located deep to the superficial musculoaponeurotic system at the anterior border of the masseter muscle. In children, this lobe may overlie the masseter muscle, producing the characteristic cherubic fullness. With aging the supporting ligaments may become lax, producing a midfacial contour

*E-mail address:* karce1@sbcglobal.net

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.11.003

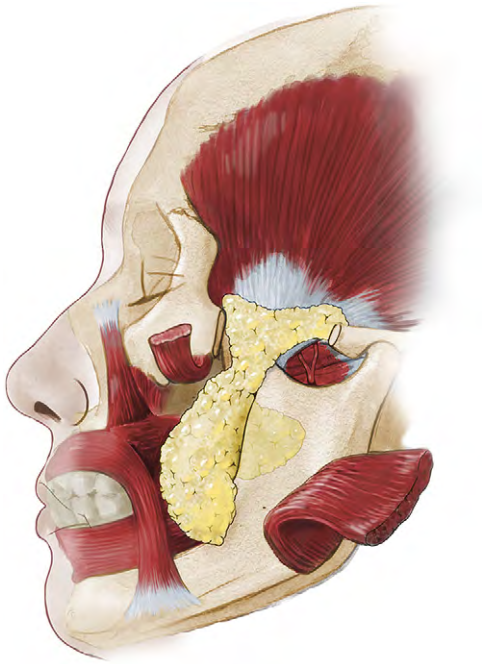


Fig. 1. Traditional description of buccal fat pad with its central body and four processes: buccal, pterygoid, pterygopalatine, superficial and deep temporal.

deformity with pseudoherniation of the buccal fat pad. The temporal process lies under the zygomatic arch and splits into a superficial and a deeper, smaller portion. The superficial portion is located between the temporalis muscle and the deep layer of the temporalis fascia. The deeper portion is located between the fibers of the temporalis muscle. The pterygoid process is located in the pterygoid space and surrounds the lingual and inferior alveolar neurovascular bundles. The pterygopalatine process extends through the pterygomaxillary fissure and into the pterygopalatine fossa where it encapsulates the pterygopalatine vessels.

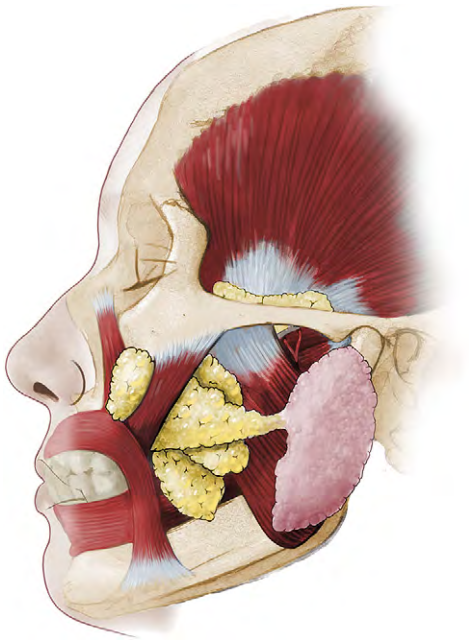


Fig. 2. Zhang's recent anatomic description of the buccal fat pad consisting of three lobes: anterior, intermediate, and posterior.

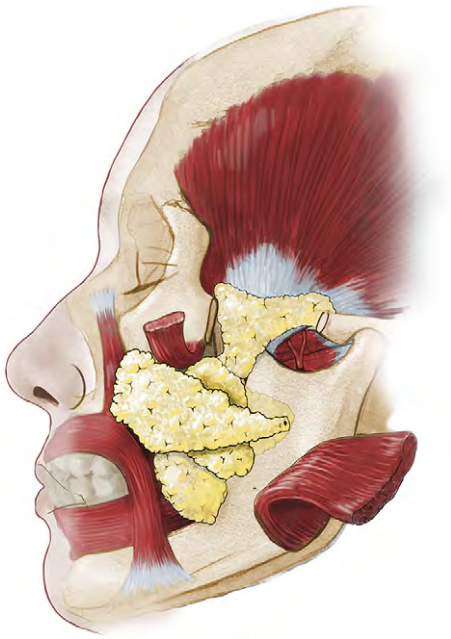


Fig. 3. Anatomic description of the buccal fat pad and its three lobes with the four processes originating from the posterior lobe.

The average volume of the buccal fat pad is approximately 10 mL with a mean thickness of about 6 mm. It seems to be constant throughout life, usually with no direct relationship to the total body fat present in the individual. The fat pad provides separation, allows gliding motion between muscles, and protects the neurovascular bundles from injuries. In the newborn, ligaments of the fat pad provide counteraction to the negative pressure of suckling and maximize the negative pressure needed for effective feeding.

There has been concern related to the available length of the pedicled flap and worry about outstripping its blood supply and producing necrosis. Blunt surgical dissection reveals that the fat pad may be estimated between 7 to 9.34 cm with reproducible vascularity as long as the flap is tension-free. The re-epitheliazation process starts with an initial phase of granulation and subsequent transformation to a parakeratotic stratified squamous epithelium without a lamina propria and submucosa and with an absence of fat cells.

Unilateral buccal fat pad mobilization produces minimal facial asymmetry. Furthermore, the fat pad's versatile blood supply allows concomitant mobilization of other regional pedicle flaps for reconstruction of large defects.

## Buccal fat pad in partial maxillectomy defects

Maxillary tumor resections produce postsurgical and functional deficits of hypernasal speech, food leakage, and poor swallowing function in addition to the cosmetic deformity. The type of maxillectomy defect often indicates a reasonable reconstruction. Controversy still exists as to whether prosthetic obturators or natural flaps provide optimal rehabilitation of patients who have undergone maxillectomy. The flaps may be local flaps, regional pedicled flaps, or microvascular free tissue transfers. Choices hinge on the extent and location of the defect, need for radiation, competency in home care, the periodontal health of existing dentition, the remaining alveolar bone, and the ability to place osseointegrated implants. Patient preferences, esthetic expectations, financial concerns, and the availability of a microvascular surgeon also influence the reconstruction options.

Maxillary obturation has significant advantages besides the obvious reduction of invasive surgery. The prosthesis replaces missing dentition, supports facial structures, and provides

palatal contours that improve speech and swallowing. The prosthesis also allows direct patient analyses of the operative site for recurrent tumor surveillance. Modern imaging modalities such as CT, MRI, and endoscopy have compensated greatly for the lack of direct visualization in reconstructed cases, but at a higher cost. A maxillary prosthesis also allows normal sinus mucosal drainage to evolve. Patient dissatisfaction, however, is common because of inadequate retention and stability, oro-nasal regurgitation, and speech impairment.

The buccal fat pad flap may offer a single-stage, cost-effective reconstruction for some maxillary defects. It is best suited for medium-size defects up to a maximum 4 cm in diameter because of the limited bulk of the flap. Fat flaps may cover class I and IIa maxillectomy defects with extension to the midline (Fig. 4). Larger defects often risk partial dehiscence secondary to the increased tension necessary to cover these large defects. The inadequate volume of the buccal fat pad flap in larger surgical defects encourages the incorporation of an additional local flap or a regional myofascial flap. One additional disadvantage to the buccal fat pad flap is that the lack of vestibular depth and mucosal retention could limit the fabrication of a maxillary full denture.

## Surgical technique

The most direct access to the buccal fat pad is found at the distobuccal depth of the maxillary tuberosity, and it may be dissected through a vestibular incision if it has not been encountered during the resection (Fig. 5). After a single sharp scissor stab through the periosteum and scant buccinator muscle, the buccal fat pad extrudes into the operative site. Blunt dissection with Metzenbaum scissors mobilizes the flap held with tissue forceps (Fig. 6). Pressure also can be applied at the level of the zygomatic arch region to aid in the mobilization of the flap. Once the buccal fat pad is extended past the defect without tension, the tissue is fixed into bone with bur-holes or screws and into adjacent palatal and buccal mucosa with resorbable sutures (Fig. 7). Critical to success for total closure is a natural adherence to raw tissue margin. Therefore, chronic fistulas or communications must be skinned first. A surgical splint may be secured to any remaining dentition or with retention screws to the remaining palate to protect the flap during the healing phase. In reality, the splint is a second-layer closure to prevent air venting around a single-layer closure. Ideally, large defects are closed with a double-layer sealed closure or with a flap bulky enough to obliterate the fistula totally. Sensation to the flap has been noted as early as 4 weeks.

In the first 24 hours, the patient is restricted to clear liquids, followed by 2 weeks of pureed foods. Patients are instructed to not blow their nose forcefully for at least the following 2 to 3 weeks. An antibiotic regimen such as amoxicillin clavunate, which provides coverage for normal

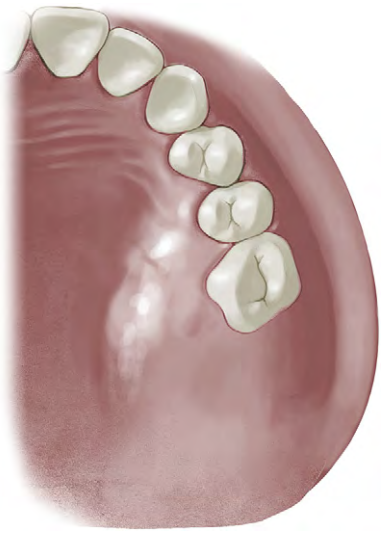


Fig. 4. Posterior maxillary tumor.

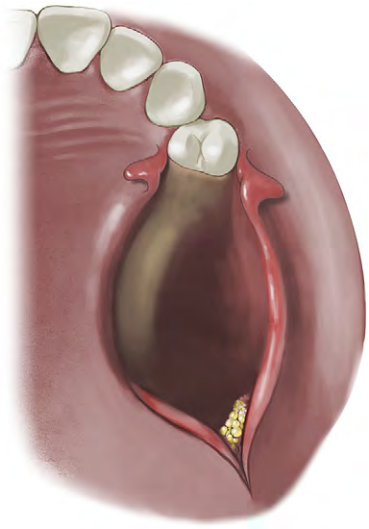


Fig. 5. Maxillectomy defect with buccal fat pad exposed after resection of tumor.

maxillary sinus pathogens, is started. Optionally, a chlorhexidine gluconate 0.12% mouth rinse may be prescribed.

Other technical points in relation to ablative surgery merit comment. Unilateral neck dissections do not seem to compromise the buccal fat flap. The flap also may be used as a pedicle flap when adjuvant radiation treatment is anticipated; however, it should not be considered after a tumoricidal dose of radiation to the area. The surgeon should also note that any drooping fat pad in the surgical defect contracts so that it is almost level with adjacent tissue early in the healing phase.

## Buccal fat pad for closure of oro-antral communications and fistulas

Buccal fat pad closure of iatrogenic oro-antral communication during or after maxillary molar extractions is, no doubt, the most common use of this flap in oral and maxillofacial

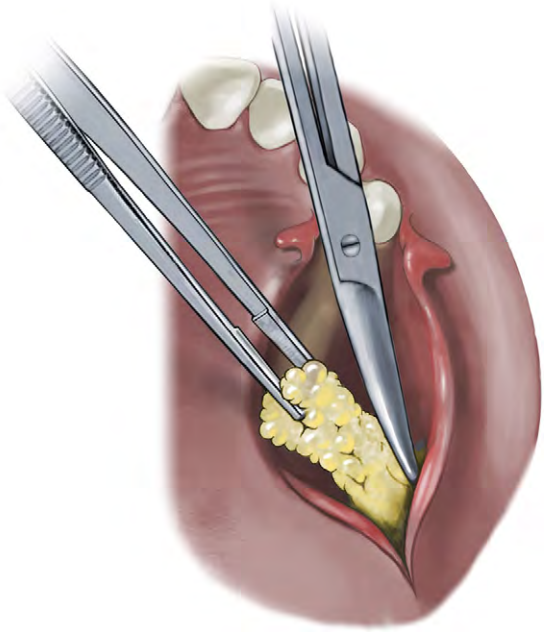


Fig. 6. Blunt dissection of the buccal fat pad to allow mobilization into the surgical defect.

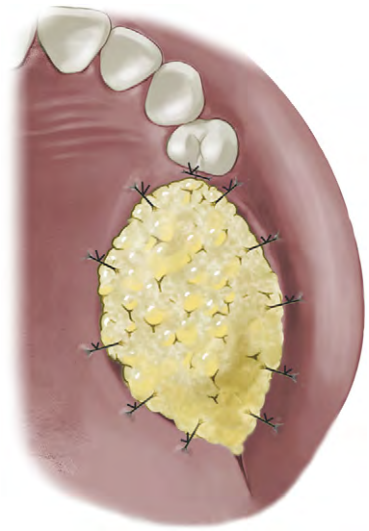


Fig. 7. Buccal fat pad completely mobilized and secured to maxillary defect in a tension-free manner.

surgery (Fig. 8). The prudent surgeon discusses this option preoperatively so as to mobilize the buccal fat pad flap immediately after inadvertent sinus exposure, thus eliminating need for a second surgical procedure. One might question this approach, because it is highly probable that most iatrogenic oro-antral communications less than 6 mm in diameter might close without any surgical intervention. It might be argued equally well, however, that the innocuous procedure of securing of the buccal fat pad into the defect ensures closure without significant adverse effects. Relatively large defects can be closed in an expeditious manner without the need of a separate donor site (Fig. 9). The choice of the buccal fat pad versus a buccal advancement flap closure must weigh the advantages and disadvantages of each, and other available techniques, in regard to location, height of alveolus, sinus membrane status, and obliteration of

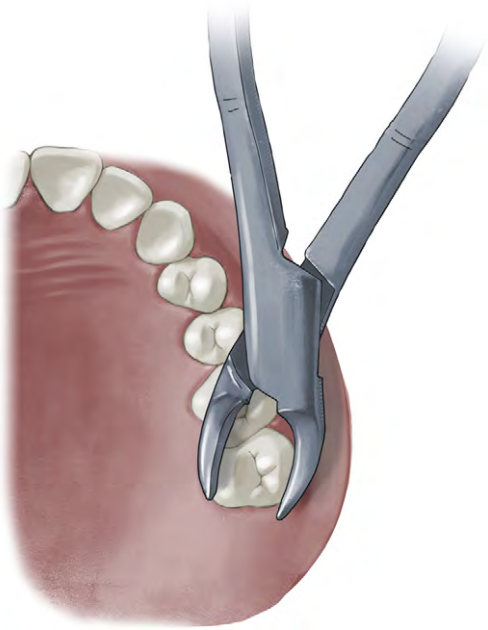


Fig. 8. The most common application of the buccal fat pad is in iatrogenic oro-antral communication resulting from dentoalveolar surgery.

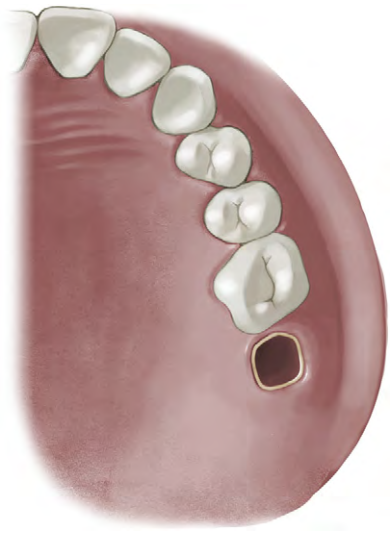


Fig. 9. Oro-antral communication after second molar extraction.

vestibule. Its use also eliminates the need for removal of additional alveolar bone and mobilize a buccal advancement flap, which might obliterate the buccal vestibule. It is also helpful when traumatized surrounding attached gingiva or mucosa preclude the use of a buccal advancement flap for primary closure.

The surgical technique for mobilizing the buccal fat pad lends itself to its use under local anesthesia or sedation. A hockey-stick incision at the tuberosity without an anterior vertical release allows surgical access to the oro-antral communication and the buccal fat pad at the depth of the hockey-stick release (Fig. 10). Mobilization and securing of the buccal fat pad (Figs. 11–14) and postoperative care are the same as described previously.

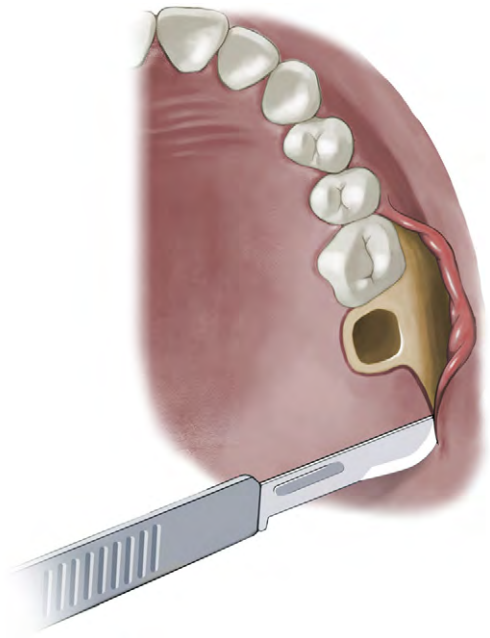


Fig. 10. Full-thickness mucoperiosteal flap elevated to expose the oro-antral communication and allow access to the buccal fat pad.

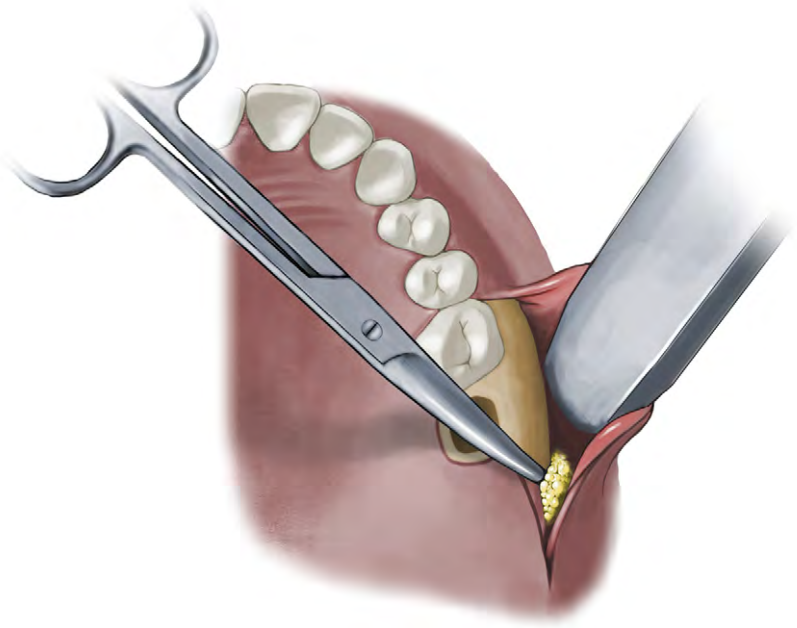


Fig. 11. Buccal fat pad accessed with incision through periosteum at the maxillary tuberosity region.

Closure of chronic oro-antral fistulas must take into consideration other factors, such as the health of the maxillary sinus, which need to be addressed before the closure. CT can be used to evaluate the osteomeatal complex, and a trial of decongestants and systemic antibiotics is made to clear any infection. Irrigation of the maxillary sinus can also be done before the reconstruction. If there is no resolution of symptoms, functional endoscopic sinus surgery should be considered before the closure of the fistula. If there is infection, any reconstruction options will fail. The surgical technique for harvesting the buccal fat pad and closing the defect is the same; the only difference is removing the fistula tract before closure.

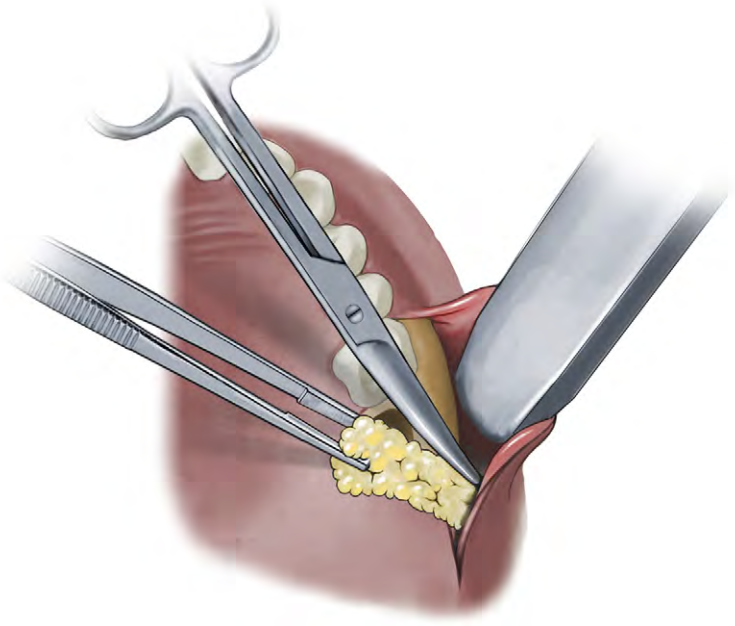


Fig. 12. Blunt dissection of the buccal fat pad to minimize trauma and avoid compromising its blood supply.

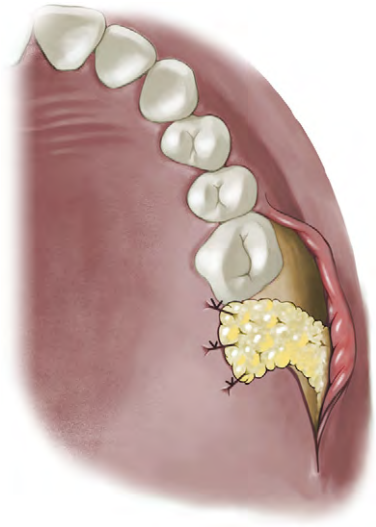


Fig. 13. Buccal fat pad mobilized and secured to the palatal soft tissue.

## Complications

Partial necrosis accounted for the majority of failures involving the use of the buccal fat pad. A small dehiscence can be treated conservatively to see if spontaneous closure occurs. Reattempts at closure involve contralateral buccal fat flaps, palatal flaps, or buccal flaps. Rarely can the same flap be mobilized again, unless the defect was small and the reason for failure is easily identified.

Trismus from scarring has been reported mainly when the buccal fat pad is used for reconstruction of retromolar trigone or buccal mucosa defects. Range of motion should be noted in the few weeks after the use of the flap so that physical therapy, if necessary, is activated as soon as possible. A rare visible change in facial contour has been reported in patients only when the buccal fat pad is used for reconstruction of large defect. A surgeon might consider a contralateral buccal lipectomy to correct this alteration. The low morbidity and failure rate associated with the use of the buccal fat pad in maxillary reconstruction allows this simple reconstructive option to be used in carefully selected defects.

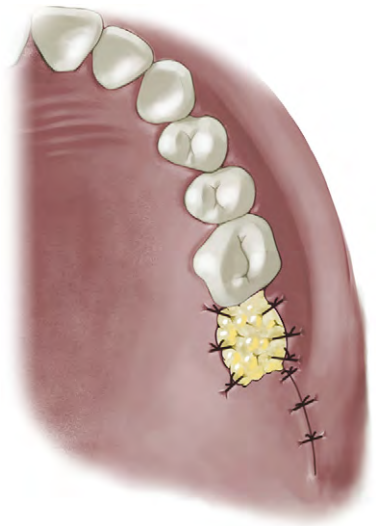


Fig. 14. Mucoperiosteal flap closure with preservation of buccal vestibule. The exposed buccal fat pad will epithelialize in 4 to 6 weeks.

## Further readings


Abuabara A, Cortez LV, Passeri LA, et al. Evaluation of different treatments for oroantral/oronasal communications: experience of 112 cases. Int J Oral Maxillofac Surg 2006;35:155–8.

Amin MA, Bailey BMW, Swinson B, et al. Use of the buccal fat pad in reconstruction and prosthetic rehabilitation of oncological maxillary defects. Br J Oral Maxillofac Surg 2005;43:148–54.

Baumann A, Ewers R. Application of the buccal fat pad in oral reconstruction. J Oral Maxillofac Surg 2000;58:389–92.

Bichat F. Anatomie générale, appliquée a la physiologie et á la médicine. Paris: Brosson, Gabon, et Cie; 1802.

Brown JS, Rogers SN, McNally DN, et al. A modified classification for the maxillectomy defect. Head Neck 2000;22: 17–26.

Chao CK, Chang LC, Liu SY, et al. Histologic examination of pedicled buccal fat pad graft in oral submucous fibrosis. J Oral Maxillofac Surg 2002;60:1131–4.

Colella G, Tartaro G, Giudice A. The buccal fat pad in oral reconstruction. Br J Plast Surg 2004;57:326–9.

Dean A, Alamillos F, García-López A, et al. The buccal fat pad in oral reconstruction. Head Neck 2001;23:383–8.

Dubin B, Jackson IT, Halim A, et al. Anatomy of the buccal fat pad and its clinical significance. Plast Reconstr Surg 1989;83:257–62.

Egyedi P. Utilization of the buccal fat pad for closure of oro-antral and/or oro-nasal communication. J Maxillofac Surg 1977;5:241–4.

Fujimura N, Nagura H, Enomoto S. Grafting of the buccal fat pad into palatal defects. J Craniomaxillofac Surg 1990; 18:219–22.

Futran N. Primary reconstruction of the maxilla following maxillectomy with or without sacrifice of the orbit. J Oral Maxillofac Surg 2005;63:1765–9.

Futran ND, Haller JR. Considerations for free-flap reconstruction of the hard palate. Arch Otolaryngol Head Neck Surg 1999;125:665–9.

Hai HK. Repair of palatal defects with unlined buccal fat pad grafts. Oral Surg Oral Med Oral Pathol 1988;65:523–5.

Hanazawa Y, Itoh K, Mabashi T, et al. Closure of oroantral communications using a pedicled buccal fat pad graft J Oral Maxillofac Surg 1995;53:771–5.

Hao SP. Reconstruction of oral defects with the pedicled buccal fat pad. Otolaryngol Head Neck Surg 2000;122:863–7.

Heister L. Compendium anatomicum. In: Norimberge (Germany): G.C. Weberi; 1732. p. 146.

Holton LH, Rodriguez ED, Silverman RP, et al. The buccal fat pad flap for periorbital reconstruction: a cadaver dissection and report of two cases. Plast Reconstr Surg 2004;114:2529–33.

Khouw YLN, van der Wal KGH, Bartels F, et al. Bilateral palatal reconstruction using 2 pedicled buccal fat pads in rhinolalea aperta after extensive necrotizing tonsillitis: a case report. J Oral Maxillofac Surg 2004;62:749–51.

Kim YK. The use of a pedicled buccal fat pad graft for bone coverage in primary palatorrhaphy: a case report. J Oral Maxillofac Surg 2001;59:1499–501.

Loh FC, Loh HS. Use of the buccal fat pad for correction of intraoral defects: Report of cases. J Oral Maxillofac Surg 1991;49:413–6.

Martín-Granizo R, Naval L, Goizueta F, et al. Use of buccal fat pad to repair intraoral defects: review of 30 cases. Br J Oral Maxillofac Surg 1997;35:81–4.

Marzano UG. Lorenz Heister's ''molar gland''. Plast Reconstr Surg 2005;115:1389–93.

Matarasso A. Pseudoherniation of the buccal fat pad: a new clinical syndrome. Plast Reconstr Surg 1997;100:723–30.

Matarasso A. Pseudoherniation of the buccal fat pad: a new clinical syndrome. Plast Reconstr Surg 2003;112:1716–8.

Neder A. Use of buccal fat pad for grafts. Oral Surg Oral Med Oral Pathol 1983;55:349–50.

Rapidis AD, Alexandridis CA, Eleftheriadis E, et al. The use of the buccal fat pad for reconstruction of oral defects: review of the literature and report of 15 cases. J Oral Maxillofac Surg 2000;58:158–63.

Rogers SN, Lowe D, McNally D, et al. Health-related quality of life after maxillectomy: a comparison between obturation and free flap. J Oral Maxillofac Surg 2003;61:174–81.

Samman N, Cheung LK, Tideman H. The buccal fat pad in oral reconstruction. Int J Oral Maxillofac Surg 1993;22:2–6.

Schmidt BL, Pogrel MA, Young CW, et al. Reconstruction of extensive maxillary defects using zygomaticus implants. J Oral Maxillofac Surg 2004;62(Suppl 2):82–9.

Sharma A, Beumer J. Reconstruction of maxillary defects: the case for prosthetic rehabilitation. J Oral Maxillofac Surg 2005;63:1770–3.

Stajčić Z. The buccal fat pad in the closure of oro-antral communications: a study of 56 cases. J Craniomaxillofac Surg 1992;20:193–7.

Stuzin JM, Wagstrom L, Kawamoto HK, et al. The anatomy and clinical applications of the buccal fat pad. Plast Reconstr Surg 1990;85:29–37.

Tharanon W, Stella JP, Epker BN. Applied surgical anatomy of the buccal fat pad. Oral and Maxillofac Surg Clin North Am 1990;2:377–86.

Tideman H, Bosanquet A, Scott J. Use of the buccal fat pad as a pedicled graft. J Oral Maxillofac Surg 1986;44:435–40.

Vuillemin T, Raveh J, Ramon Y. Reconstruction of the maxilla with bone grafts supported by the buccal fat pad. J Oral Maxillofac Surg 1988;46:100–5.

Zhang HM, Yan YP, Qi KM, et al. Anatomical structures if the buccal fat pad and its clinical adaptations. Plast Reconstr Surg 2002;109:2509–18.

Zhong L, Chen G, Fan L, et al. Immediate reconstruction of maxilla with bone grafts supported by pedicled buccal fat pad graft. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:147–54.

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) 33–42

Atlas of the Oral and Maxillofacial Surgery Clinics

# Temporalis System in Maxillary Reconstruction: Temporalis Muscle and Temporoparietal Galea Flaps

Brent B. Ward, DDS, MD

*Department of Oral and Maxillofacial Surgery, University of Michigan, 1500 E. Medical Center Drive, Ann Arbor, MI 48109-0018, USA*

The temporalis system has been used for maxillofacial reconstruction since the late 1800s and continues to serve as a reservoir of tissue for the contemporary surgeon. Excellent reliability exists with the use of these flaps, making them the procedure of choice for a number of ablative and traumatic surgical defects. This article explores the surgical anatomy and application of these flaps with a focus on technique and perioperative care.

## Temporalis muscle flap

### *Anatomy*

Anatomic considerations in this region often are confusing due to a lack of uniformity in nomenclature. Of paramount importance to the surgeon is the ability to identify fascial layers for appropriate protection of the distributions of the facial nerve (Fig. 1A, B).

The temporalis fascia or deep temporal fascia covers the superficial portion of the temporalis muscle. Its attachment superiorly is along the superior temporal line where it blends into pericranium. Inferiorly the fascia splits approximately 2 cm superior to the zygomatic arch into two layers, deep and superficial, surrounding the temporal fat pad and attaching to the medial and lateral surfaces of the zygomatic arch, respectively. Inferior to the arch, these layers blend with the masseteric fascia.

The temporalis muscle proper lies in the temporal fossa and is bipennate, with superficial fibers arising from the pericranium and deep fibers from the infratemporal fossa. Its thickness varies from 5 to 15 mm. An understanding of the blood supply to this flap is critical, because its duplicate nature allows a number of surgical options including bilobed flap creation. Blood supply is derived from three major sources. The anterior deep and posterior deep temporal arteries enter from the deep side of the temporalis muscle after arising from the internal maxillary artery (Fig. 2).

The anterior deep artery enters at the anteroinferior aspect of the muscle with the posterior deep artery also entering at the inferior aspect of the muscle and supplying its middle portion. The posterior portion of the muscle is supplied primarily by the middle temporal artery, a branch from the superficial temporal. Surgically, because flaps from this muscle are almost exclusively inferiorly based, a one-third anterior muscle/two-thirds posterior muscle rule, preserving both deep temporal arteries, allows bilobed elevation. Venous drainage runs in parallel with arterial supply [1].

*E-mail address:* bward@med.umich.edu

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.12.001

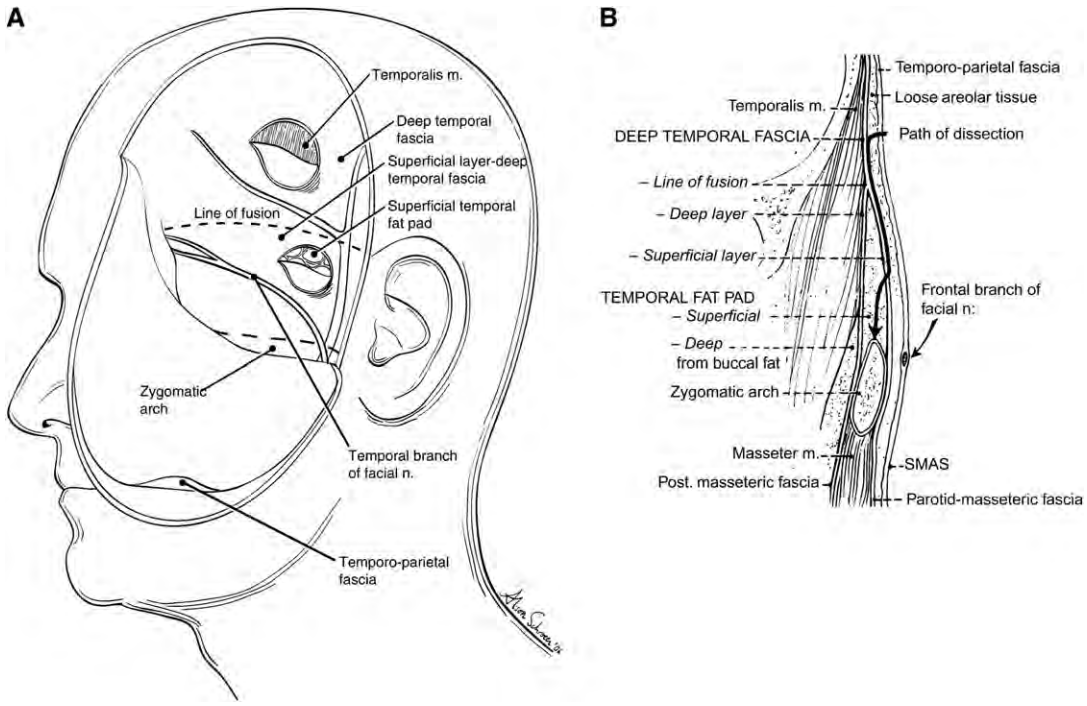



Fig. 1. (*A*) Lateral view of anatomic considerations of the temporalis flap. (*B*) Anatomic considerations of the facial nerve. SMAS, subcutaneous musculoaponeurotic system. (*From:* Stutzin JM, Wagstrom L, Kawamoto HK, et al. Anatomy of the frontal branch of the facial nerve: the significance of the temporal fat pad. Plast Reconstr Surg 1989;83:270; with permission.)

Innervation is from the anterior and posterior deep temporal nerves and is of minimal consideration because the surgical procedure designed to maintain blood supply also maintains these nerves intact.

*Indications for use*

The temporalis muscle flap is used for

1. Obliteration of oral defects [2]
2. Temporomandibular joint reconstruction by gap arthroplasty [3]
3. Cranial base reconstruction [4]
4. Obliteration of orbital defects after enucleation [5]
5. Facial reanimation surgery [6]
6. Midface suspension or orbital repair with the coronoid process, attached to temporalis after maxillectomy

*Surgical techniques*

Surgical technique is similar for all the applications listed above except for muscle use with vascularized coronoid process, which is discussed separately. The patient is prepped and draped, with hair banded when indicated, and a corneal shield on the operated side. An incision is marked with the inferior extent consistent with a standard preauricular or modified endaural incision, per surgeon preference, and carried up into the scalp variably, depending on the length and location of the desired muscle and access needed for defect reconstruction. As a rule, access should be adequate to develop a flap, assess vascular supply, and rotate the flap safely into position without compromise to the facial nerve. The incision in the scalp may range from very minimal (ie, a 3-cm superior extension for gap arthroplasty of the temporomandibular joint

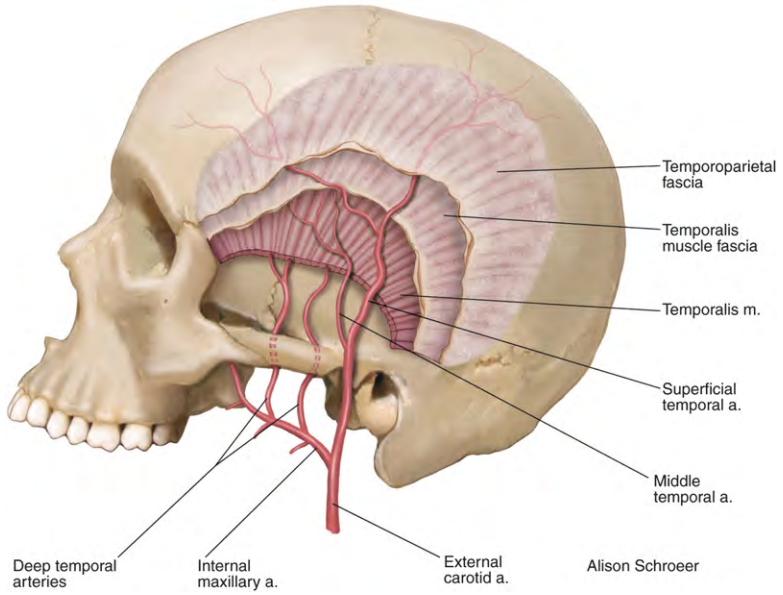



Fig. 2. Vascular supply of the temporalis system.

using only a posterior strip of muscle) to a standard coronal approach for extensive anterior cranial base, orbital, and oral defects. After marking, local anesthetic is injected.

Incision can begin at any location with dissection techniques divided by defined anatomic areas. Above the helix the scalp is incised through the temporoparietal fascia down to the deep temporal fascia, which is easily identified as the glistening firmly attached fascia, while skin and subcutaneous tissue are retracted laterally with skin hooks. Once the deep temporal fascia is identified, finger dissection can be performed in the loose areolar plane and followed with planned additional scalp incisions as indicated. With a preauricular or modified endaural approach the skin is incised with a scalpel followed by sharp and blunt dissection down to the base of the zygomatic arch. A subperiosteal dissection over the arch is created to protect the facial nerve, keeping in mind that the nerve may be encountered as close as 8 mm from the root of the zygomatic arch. The scalp and preauricular incisions then are joined (Fig. 3). With skin flaps reflected, an incision is made at a 45° angle traveling anterosuperiorly from the root of the zygoma within the deep temporal fascia, exposing the muscle and protecting the facial nerve. This incision connects with the subperiosteal dissection over the arch of the zygoma and with a similar subperiosteal dissection at the frontal zygomatic region to expose the arch completely for osteotomy if required. With the muscle exposed the desired flaps may be developed using the one-third/two-thirds rule when a bilobed design is desired (Fig. 4A, B).

Flaps may be rotated freely or inverted and rotated as needed. The zygomatic arch may be osteotomized if required to increase the length of the pedicle and pass the muscle deep to the arch. Alternatively, muscle may be passed through a subcutaneous plane superficial to the facial nerve (Fig. 5).

When the anterior one third of the muscle is used for reconstruction in a bilobed fashion, the posterior two thirds may be rotated anteriorly to fill the defect in attempt to avoid long-term postoperative temporal wasting (Fig. 6).

Posterior defects then can be reconstructed using alloplastic material such as MedPore (Porex Surgical Inc., Nuwnan, GA) (Fig. 7).

In facial reanimation, the length of the flap is increased by raising a deep temporal fascia flap posterior and superior that remains attached to the temporalis muscle flap at the superior edge of both the muscle and fascia (Fig. 8A, B).

This fascia and its attached muscle then can be passed through a subcutaneous tunnel to the corner or the mouth for attachment to the orbicularis oris (Fig. 9A, B).

Alternatively, muscle length may be augmented with fascia lata or Gore-Tex (W. L. Gore & Associates, Inc., Flagstaff, Arizona).

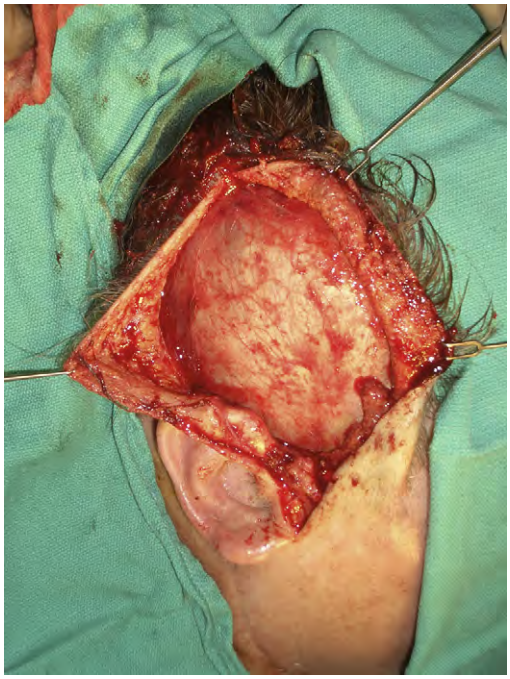


Fig. 3. Exposure of deep temporal fascia with underlying temporalis muscle.

With a similar surgical approach, the reverse temporalis muscle flap may be harvested based on the superficial temporal fascia as the pedicle of blood supply for a regional muscle flap. This approach can allow adequate length for reconstruction of anterior cranial and cranial base defects [2].

A suction drain can be left in place with exit posterior to the auricle with standard skin and scalp closure and normal postoperative care.

*Coronoid process temporalis flap*

The coronoid process attached to temporalis muscle may be used as a sling for midface suspension or orbital floor repair in cases of maxillectomy. After the ablative surgery, the coronoid process is identified and exposed using a subperiosteal dissection in the desired osteotomy locations while leaving as much temporalis attachment as possible. The osteotomy can be created using reciprocating and oscillating saws from the coronoid notch inferiorly to the desired length and then anteriorly to complete the osteotomy. Care should be taken to be anterior

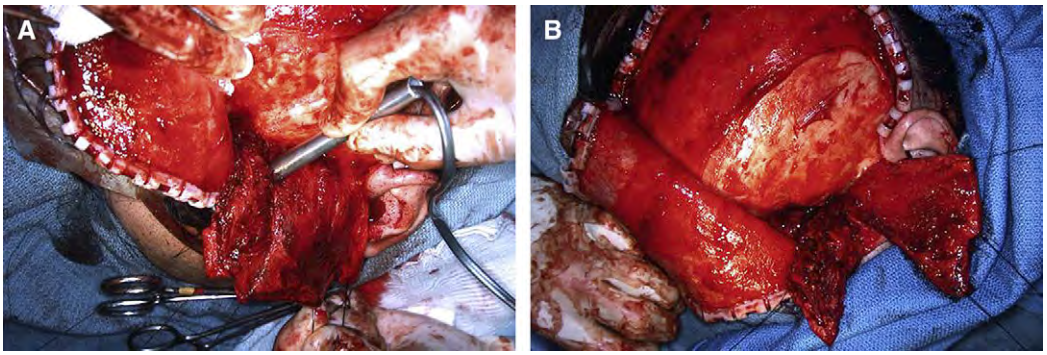



Fig. 4. (*A*) Doppler of the vascular supply to anterior flap of a bilobed design, one third anterior/two thirds posterior. (*B*) Elevation of bilobed flaps.

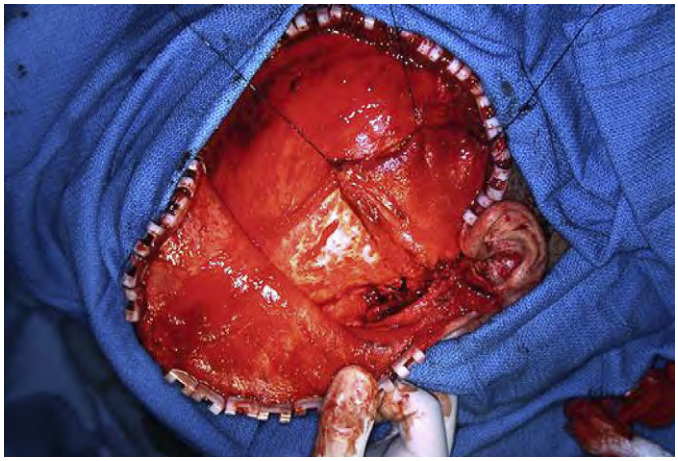


Fig. 5. Rotated anterior flap with posterior flap in place.

to the lingula and the inferior alveolar canal. Once free, the bone with attached muscle can be advanced and plated with miniplates to the infraorbital rim or lateral nasal bone as desired (Fig. 10).

*Postoperative care*

In most cases minimal postoperative care is required. Intraoral defects closed with muscle mucosalize over the period of 3 to 4 weeks without intervention. Similarly, other subcutaneous uses other than gap arthroplasty require observation alone. In gap arthroplasty replaced with temporal muscle, passive movement is recommended during the first postoperative week, after which aggressive myophysiotherapy ensues. In these cases arch bars may be required for occlusion-guiding elastic therapy as well as orthotics; the reader is referred to texts designed that discuss these issues specifically.

## Temporoparietal galea flap

*Anatomy*

The temporoparietal galea is a component of the subcutaneous musculoaponeurotic system (SMAS) tightly adherent to the subcutaneous layer of overlying skin. The loose areolar plane

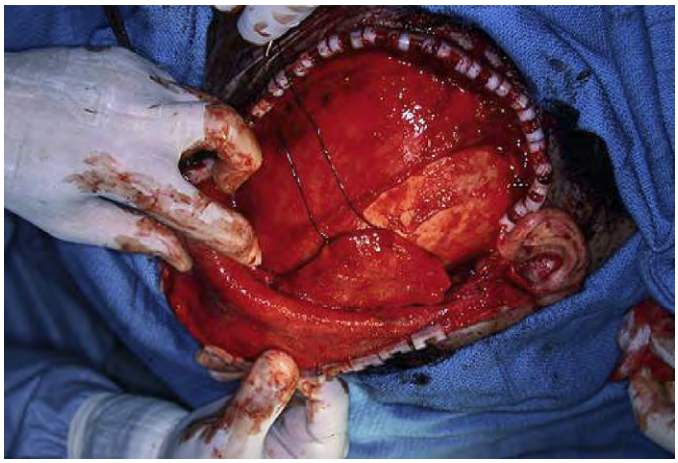


Fig. 6. Rotation of posterior flap to anterior to avoid postoperative appearance of temporal wasting.

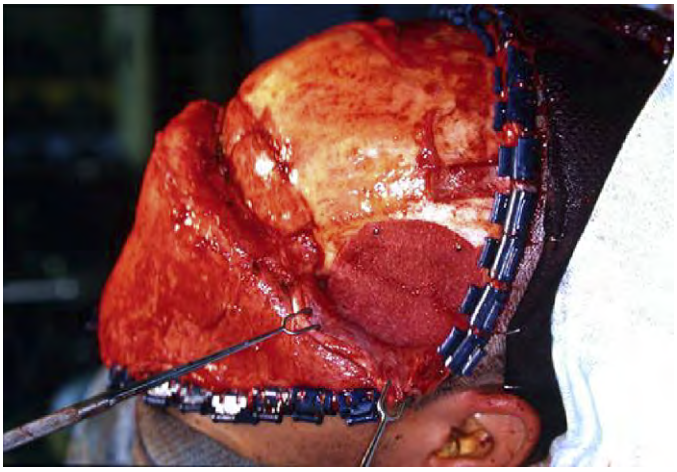


Fig. 7. Alloplastic reconstruction of the posterior temporal defect.

lies deep to the galea, just superficial to the pericranium. From a surgical perspective the dissection of overlying tissues is difficult, because no true surgical plane exists. In contrast, elevation from the deeper tissues is completed without difficulty. Blood supply to the flap for its most common surgical use is from the superficial temporal artery and vein. Approximately 2 to 4 cm superior the zygomatic arch the artery and vein divide into anterior and posterior branches, the latter supplying the galea flap. Of surgical importance, the vein always lies posterior and superior to the artery and therefore is in greater danger of damage during flap harvest.

From a neural perspective the facial nerve, discussed in detail in the section on the temporalis flap, and the auriculotemporal nerve must be taken into account. During dissection care to avoid their damage is critical.

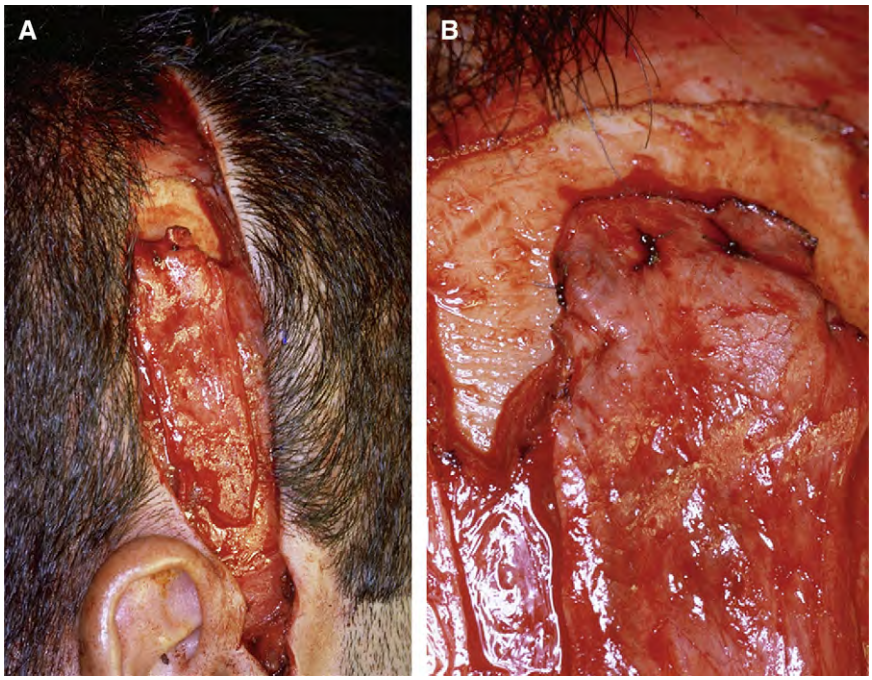



Fig. 8. (*A*, *B*) Lengthened flap for facial reanimation. Fascial flap has been elevated from inferior to superior leaving the superior edge attached to the underlying muscle with suture reinforcement of muscle fascia junction.

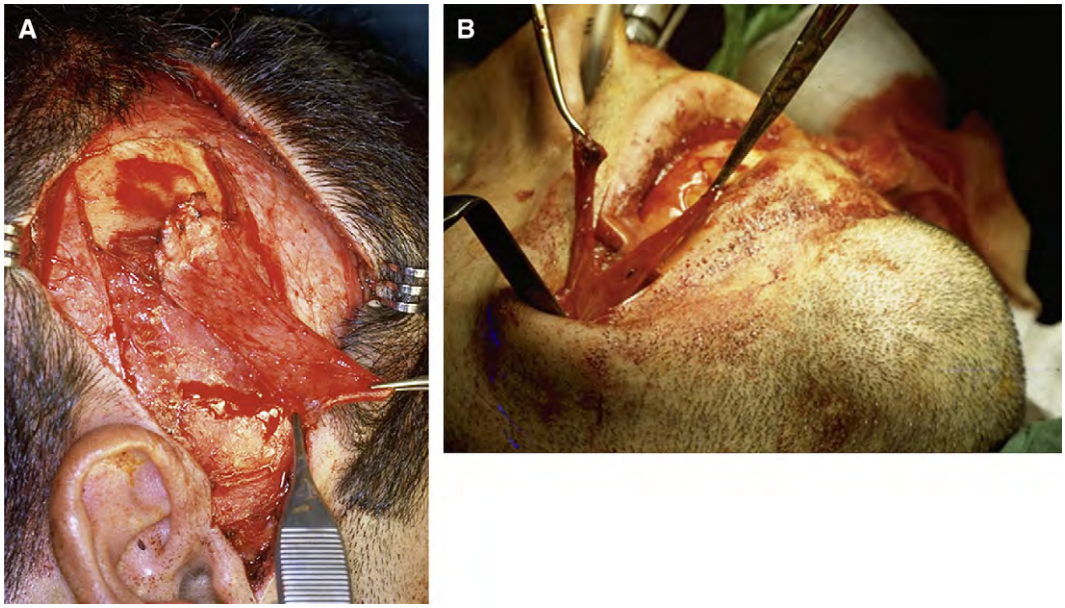



Fig. 9. (*A*) Flap elevation for advancement to the oral commissure. (*B*) Subcutaneous dissection to the oral commissure with subsequent attachment to the orbicularis oris.

*Indications for use*

The temporoparietal galea flap is used for

1. Obliteration of oral defects [7]
2. Cranial base reconstruction [8]
3. Obliteration of orbital defects after enucleation [9]
4. Malar augmentation and maxillary and mandibular reconstruction with vascularized osseous cranial bone [10]

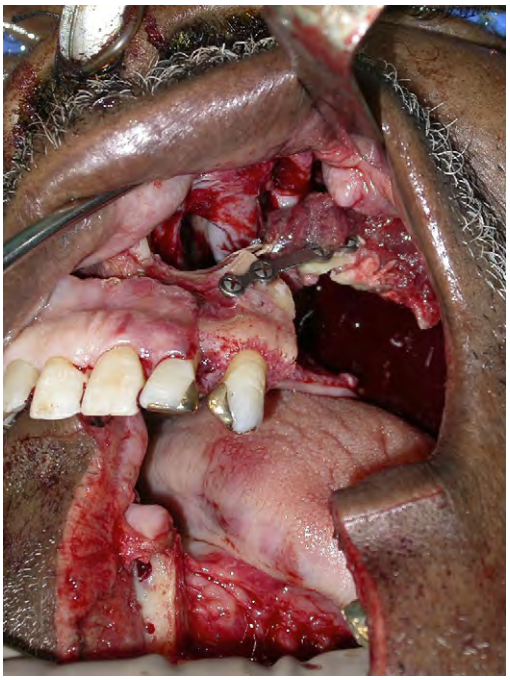


Fig. 10. After maxillectomy a temporalis flap with coronoid process is plated to the residual piriform process for midface support.

5. Reconstruction of the hair-bearing upper lip or brow (flap with skin island)
6. Obliteration of a postparotidectomy defect with preventive treatment for Frey's syndrome [11]

*Preoperative assessment*

Because its location, the vascular supply to the temporoparietal galea flap can be evaluated preoperatively using palpation or Doppler imaging of the superficial temporal artery. Although generally not necessary, this evaluation certainly should take place when a history of parotid surgery, trauma, embolization, or radiation therapy exists. Radiation, especially, may increase the risks of postoperative alopecia as well as the overall viability of the flap.

*Surgical technique*

A hemi-coronal incision parallel to the superficial temporal artery is extended to the root of the helix and carried into a preauricular crease (Fig. 11A, B). The length depends on the length of pedicle needed. The incision travels superficial just below the hair follicles. Usually one dissects posteriorly first. The cartilage is hugged to avoid damaging the posterior branches of the superficial temporal vessels which join with the posterior auricular and occipital arteries. The galea is very adherent to the subcutaneous layer of the superficial skin, and an anatomic plane of dissection is not available, making elevation difficult until one has become familiar with the technique. Only minimal amounts of subcutaneous fat should be left with the overlying skin. Visualization of the hair follicles serves as a landmark for dissection at the appropriate level. Careful dissection should continue just below the follicles to avoid damaging them while still maintaining the venous drainage located just below, which is essential for flap survival. Care always should be taken in regards to the frontal branch of the facial nerve, which travels in a direction from the tragus to approximately 3 cm above and 2 cm lateral to the superior orbital rim. The superficial temporal artery is identified above the zygomatic arch 2 cm anterior to the external auditory meatus visually or by Doppler, and its posterior branches are followed to the extent of the desired flap length. The artery and vein run in the temporoparietal fascia; the vein is always superficial and is likely to be encountered if the plane of dissection is too deep. Once flap dimensions have been obtained, dissection at the edges can be deepened to the temporalis muscle fascia and pericranium in the plane of the loose areolar tissue deep to the facial flap (Fig. 12). The anterior branch of the superficial temporal artery is ligated in this process (Fig. 13). If an osseous component is to be included, care is taken not to disrupt the connection between the flap and the underlying bone to be harvested. Generally, in this case, the additional flap length beyond the area of bone is taken so that after harvest the entirety of bone can be surrounded by vascularized tissue from the galea. For increased length,

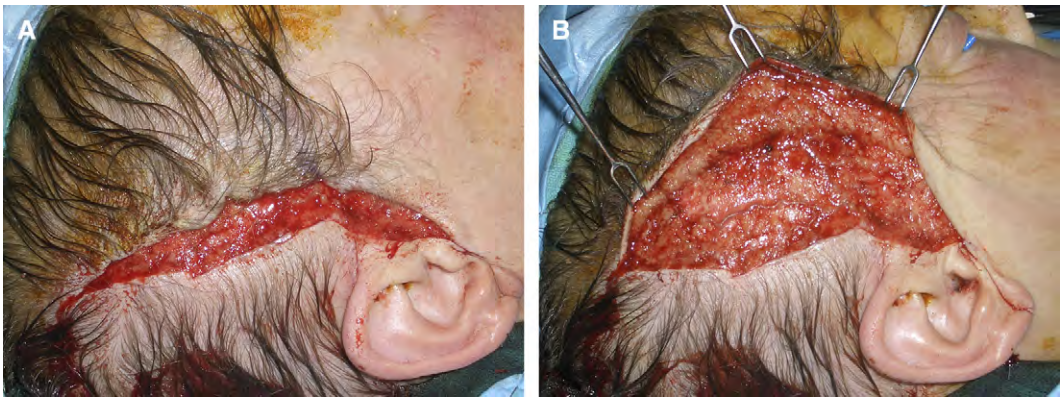



Fig. 11. (*A*) Initial incision for galea flap elevation. (*B*) Initial dissection. Note hair follicles present in plane of dissection and intact veins that are superficial to the arterial supply and most commonly damaged with deeper dissection.

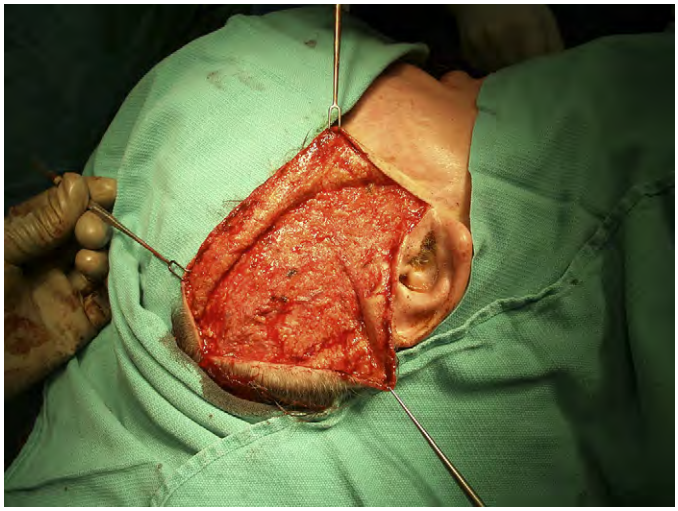


Fig. 12. Skin flap elevation complete in preparation for dissection to deep layer and flap elevation.

the vascular pedicle can be dissected inferior to the tragus to the level of the parotid gland. For passage into the oral or orbital cavities, a subcutaneous tunnel is made superficial to the SMAS containing the facial nerve. The tunnel should be large enough to avoid constricting the flap tissue. For intraoral application, the anterior aspect of the masseter is identified, and a right-angle hemostat is used to perforate the mucosa avoiding Stensen's duct. The flap then can be passed carefully through the tunnel (assuring that lateral rotation does not occur) into the oral cavity and sutured into place (Figs. 13, 14).

Hemostasis can be obtained using bipolar and standard electrocautery with care taken to avoid damage to the thin remaining superficial tissue in the donor site. Sites can be closed over a Penrose or small-caliber suction drain.

*Postoperative care*

Standard postoperative care is adequate for galea flaps. No pressure dressings are used to avoid potentially compromising the vascular pedicle. Drains are removed when output

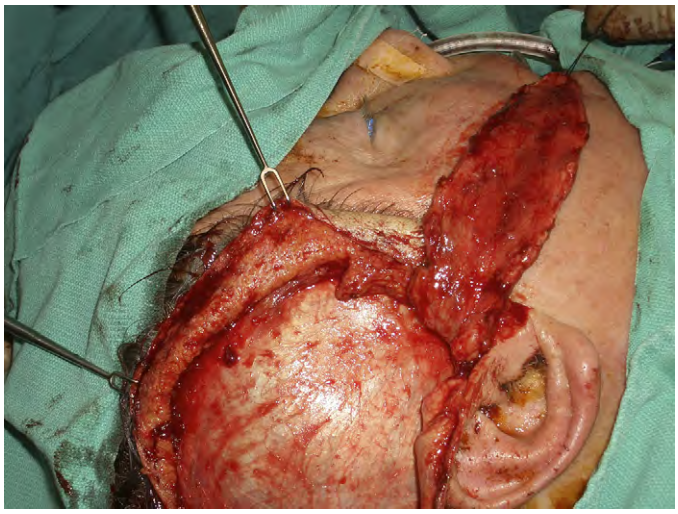


Fig. 13. Elevated flap prepared for passing in a subcutaneous plane to the oral cavity.

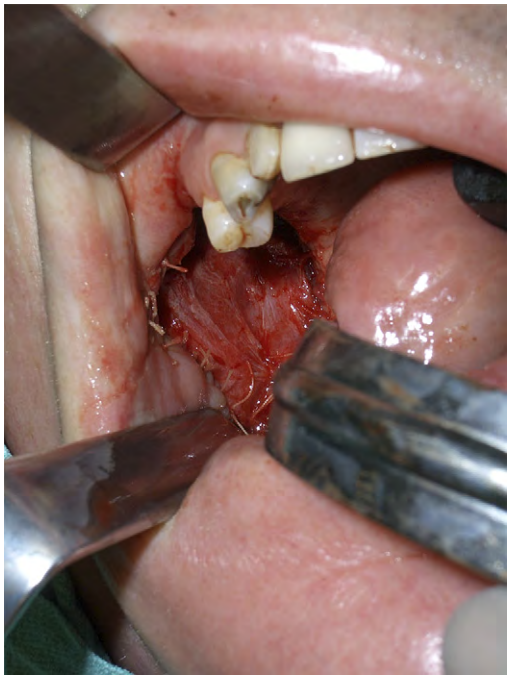


Fig. 14. Inset flap sutured into place within the oral cavity.

decreases, usually on postoperative day 2. Intraoral defects reconstructed with galea mucosalize over a 2- to 3-week period.

## References

[1] Cheung LK. The vascular anatomy of the human temporalis muscle: implications of surgical splitting techniques. Int J Oral Maxillofac Surg 1996;25:414–21.
[2] Abubaker AO, Abouzgia MB. The temporalis muscle flap in reconstruction of intraoral defects: an appraisal of the technique. Oral Surg Oral Med Oral Patholo Oral Radiol Endod 2002;94:24–30.
[3] Feinberg SE. Use of local tissues for temporomandibular joint surgery disc replacement. Atlas Oral Maxillofacial Surg Clin N Am 1996;4:58.
[4] Clauser L, Curioni C, Spanio S. The use of temporalis muscle flap in facial and craniofacial reconstructive surgery: a review of 182 cases. J Craniomaxillofac Surg 1995;23:203–14.
[5] Yucel A, Yazar S, Aydin Y, et al. Temporalis muscle flap for craniofacial reconstruction after tumor resection. J Craniofac Surg 2000;11(3):258–64.
[6] May M, Drucker C. Temporalis muscle for facial reanimation: a 13-year experience with 224 procedures. Arch Otolaryngol Head Neck Surg 1993;119:378–82.
[7] Fallah DM, Baur DA, Ferguson HW, et al. Clinical application of the temporoparietal-galeal flap in closure of a chronic oronasal fistula: review of the anatomy, surgical technique, and report of a case. J Oral Maxillofac Surg 2003;61(10):1228–30.
[8] Cesteleyn L. The temporoparietal galea flap. Oral Maxillofacial Surg Clin N Am 2003;15:537–50.
[9] Ellis DS, Toth AB, Steward WB. Temporoparietal fascial flap for orbital and eyelid reconstruction. Plast Reconstr Surg 1992;89:606–12.
[10] Parhiscar A, Har-El G, Turk J, et al. Temporoparietal osteofascial flap for head and neck reconstruction. J Oral Maxillofac Surg 2002;60:619–22.
[11] Cesteleyn L, Helman JI, King S, et al. Temporoparietal fascia flaps and superficial musculoaponeuritic system plication in parotid surgery reduces Frey's syndrome. J Oral Maxillofac Surg 2002;60:1284–97.

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) 43–49

Atlas of the Oral and Maxillofacial Surgery Clinics

# Maxillary Reconstruction Using Zygomaticus Implants

Brian L. Schmidt, DDS, MD, PhD

*Department of Oral and Maxillofacial Surgery, University of California, 521 Parnassus Avenue, C-522 Box 0440, San Francisco, CA 94143-0440, USA*

Maxillary reconstruction following tumor resection poses one of the greatest challenges for reconstruction of the oral and maxillofacial region. Multiple reconstructive techniques are available, including construction of a prosthetic obturator, local flaps, and microvascular free flaps. Achieving appropriate retention, support, and stability with each of these techniques can be extremely difficult and depends on the amount of soft tissue and bone remaining following resection. Each reconstructive technique has specific indications and advantages depending on the ablative defect, the medical status of the patient, and the patient's prognosis. The maxillary obturator has a long history of effectively managing the functional, cosmetic, and psychologic problems associated with a maxillectomy defect; however, when extensive resections are required, significant problems with obturator retention, support, and stability can be encountered following the ablation of retentive maxillary anatomy. Zygomaticus implants were originally designed for reconstruction of the atrophic edentulous maxilla. Zygomaticus implants can also be used to establish retention and support for a maxillary prosthesis following maxillectomy.

## Technique of placement

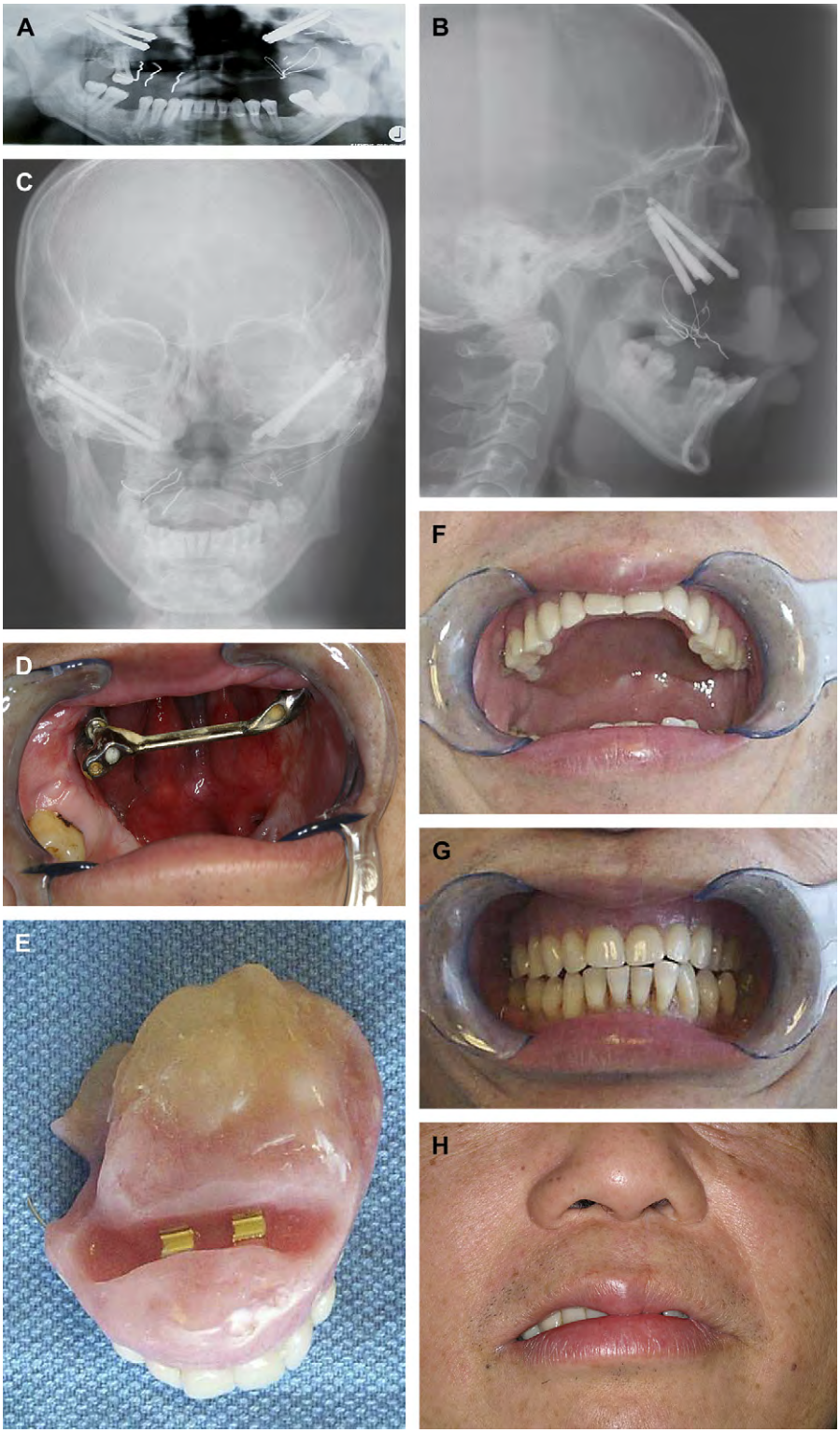
Placement of the zygomaticus implant is simplified if it is inserted at the time of tumor resection. The formation of scar tissue secondary to surgery, radiotherapy, or both can significantly restrict mouth opening and complicate implant placement. Placement is considerably easier with the use of a general anesthetic given the required dissection in the periorbital region. The number, type, and design of implant placement will depend on the location and size of the maxillary defect, as well as the location and amount of remaining bone. Restoration of zygomaticus implants following maxillary resection is complex; therefore, consultation with the maxillofacial prosthodontist during the surgical planning phase is critical. Reconstruction is possible with zygomaticus implants alone (Fig. 1); however, the surgeon should place a combination of zygomaticus and standard endosseous implants if possible (Figs. 2 and 3).

The zygomaticus implant should engage the zygoma and any remaining alveolar bone. If alveolar bone is available, the implant should be placed slightly to the palatal aspect of the alveolar ridge to engage the denser palatal bone. A standard circumvestibular mucosal incision is used. The subperiosteal dissection should start on the maxillary wall and progress superiorly to the angle where the temporal and frontal processes of the zygoma meet (Fig. 4). A lighted channel retractor can then be placed to engage the zygoma at this angle. Once the curved end of the channel retractor engages this junction, the retractor can be palpated extraorally below the skin. The channel provides a stop for the drill during preparation of the implant recipient site. If the antral wall is remaining, the next step is to remove a portion of the lateral antral wall to allow for visualization of the drill shaft while drilling. This window helps with orientation of the drill as well as irrigation during the drilling process.

When reconstructing a total maxillary defect, engagement of the alveolar bone is not possible, and the implant will only be anchored in the zygoma. Such a design places the implant

*E-mail address:* brian.schmidt@ucsf.edu

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.11.004




at a significant biomechanical disadvantage given the long lever arm and the small amount of bone integration. Unfortunately, there are few options available for obturator retention for these patients. Reconstruction of such defects is surgically and prosthodontically difficult. Because of this biomechanical disadvantage, the author and his colleagues place two zygomaticus implants bilaterally, allowing for distribution of occlusal and retentive forces but also

permitting a single implant on one side to be used should one implant fail. We have been able to achieve an acceptable result for reconstruction of a total maxillary defect with placement of bilateral double zygomaticus implants when one implant fails (see Fig. 1). This approach has been used in a small number of patients followed up for a short time, and patients must be counseled about the possibility of implant failure. If bilateral double zygomatic implants are used, the implants should be maximally distributed in the anteroposterior and medial-lateral dimension without compromising engagement of the zygoma (see Fig. 1). Four to 6 months of integration should be allowed. Most failures will be identified at stage II surgery. Prosthodontic planning should include fabrication of a cross-arch bar that incorporates all implants (see Figs. 1–3).

## Outcome

We previously reported on nine patients treated with zygomaticus implants and standard endosseous implants following maxillary resection. In that study, nine patients with extensive maxillary resections were reconstructed with a combination of 28 zygomaticus and 10 standard endosseous implants. Patients were either reconstructed with a combination of zygomaticus and standard endosseous implants or double bilateral zygomaticus implants alone if no maxillary bone was available for placement of standard endosseous implants. Seven of the 28 zygomaticus and 3 of the 10 standard endosseous implants failed. All failures occurred at stage II implant surgery. One patient in this series had 60 Gy of radiation to the anterior maxilla 23 years before implant placement. Four patients had radiotherapy approximately 2 weeks following placement of the implants. Five of the nine patients have been fully reconstructed with a maxillary obturator with excellent speech, swallowing, and esthetics. These five patients have been functioning with the prosthesis for 4 to 5 years with no loss of implants. Two patients have died from malignancy. All of the procedures were performed with general anesthesia in the surgery center or operating room.

We found that the combination of zygomaticus and standard endosseous implants could be used to retain and support a maxillary obturator following extensive resection of the maxilla. Twenty-five percent of zygomaticus and 30% of standard endosseous implants failed. This failure rate is higher than traditionally encountered, and there are several possible explanations for implant failure in patients following extensive maxillectomy. Clearly, radiotherapy impacts on the success of zygomaticus implants. Two of the three patients who experienced zygomaticus implant failure had received radiotherapy. One patient received radiation more than 3 years before implant placement, and three patients had implants placed at the time of resection or within 2 weeks of resection, with radiotherapy started 2 weeks later. Radiation has a clear impact on the reparative capacity of bone. The success rate for standard endosseous implants is lower in the irradiated oral and maxillofacial region. Parel and colleagues reported a success rate of 61.1% for craniofacial implants placed in irradiated bone. No published study has answered the question of whether implants should be placed before or following radiotherapy.

The issue of hyperbaric oxygen therapy in patients having implant reconstruction following radiotherapy is also controversial. Our current protocol is to place the zygomaticus implants at

Fig. 1. Reconstruction of a patient requiring near-total maxillectomy for squamous cell carcinoma using bilateral double zygomaticus implants. There was no remaining bone for standard endosseous implants. (*A*) Postoperative panoramic radiograph demonstrating extensive maxillary defect reconstructed with double bilateral zygomaticus implants. Because the patient required a near-total maxillectomy, there was no remaining palatal bone to engage. The implants engaged the zygoma at the junction of the temporal and frontal process. (*B*) Postoperative lateral cephalogram. An attempt was made to separate the four zygomaticus implants as much as possible in three planes of space. (*C*) Postoperative posteroanterior cephalogram. The zygomaticus implants were placed to capture the maximum amount of bone at the junction of the temporal and frontal processes of the zygoma. (*D*) Following maxillary resection and reconstruction, the patient underwent radiotherapy. Stage II implant surgery was performed following the completion of radiotherapy. At the time of stage II surgery, one zygomaticus implant on the left side was mobile and was removed. Fabrication of the bar was performed using the three remaining implants. In the reconstruction of extensive maxillary defects, cross-arch stabilization is critical for implant stability. (*E*) Intaglio surface of maxillary obturator. The obturator was retained with clips and a clasp using the remaining maxillary molar. (*F*) Maxillary obturator in place. (*G*) Occlusion with maxillary obturator in place. The patient was able to chew and had excellent speech. (*H*) The obturator provided excellent upper lip support.

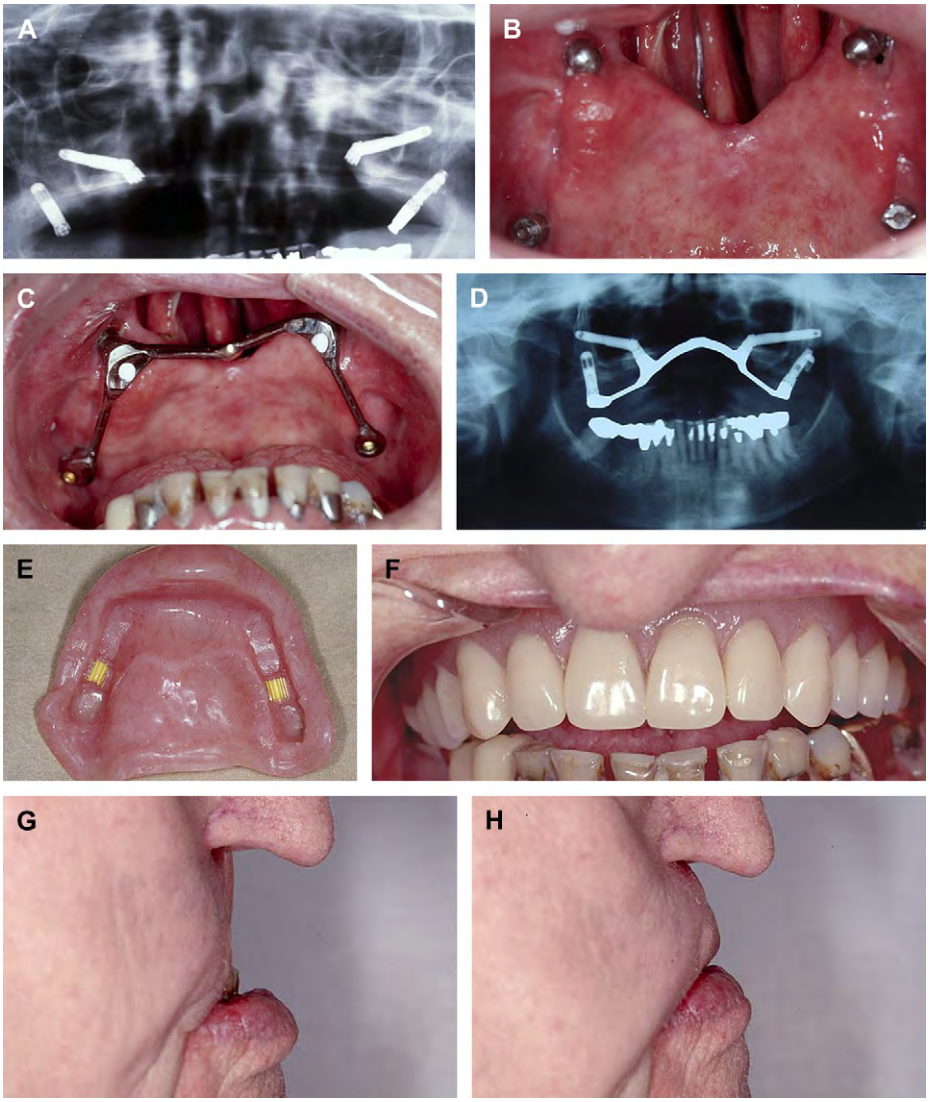



Fig. 2. Reconstruction of a hemimaxillectomy defect following resection for squamous cell carcinoma. (*A*) Panoramic radiograph demonstrating anterior maxillary defect and reconstruction with a combination of standard endosseous and bilateral zygomaticus implants. Because of the existing posterior maxillary bone, bilateral standard endosseous implants were placed as well as bilateral zygomaticus implants. The standard endosseous implant used available bone at the pterygomaxillary junction. (*B*) Occlusal view demonstrates anterior maxillary defect. The zygomaticus implants were placed at the anterior edge of the remaining palatal bone. Every attempt should be made to engage palatal and zygomatic bone with the zygomaticus implants. (*C*) Occlusal view demonstrating cross-arch stabilization with a custom-fabricated bar. (*D*) Panoramic radiograph following placement of custom-fabricated bar. (*E*) Intaglio surface of obturator. Acrylic bulk was placed in the anterior area to increase upper lip support and achieve a mucosal seal to prevent nasal regurgitation. (*F*) Facial view of occlusion with implant-supported obturator in place. (*G*) Lateral view without obturator demonstrating poor upper lip support. (*H*) Lateral view with obturator in place demonstrating improved upper lip support. The patient had normal speech with no nasal leakage.

the time of resection given that most patients will require radiotherapy within 2 to 3 weeks of maxillary resection. In the single patient receiving zygomaticus implants following radiotherapy, the time of implant placement was over 3 years after radiotherapy, and hyperbaric oxygen therapy was not given. Two of four zygomaticus implants and one of two standard endosseous implants failed in this patient. Despite these implant failures, the patient could be reconstructed with the remaining two zygomaticus and one standard endosseous implants. The patient has been functioning with the obturator for 7 years. Given the possibility of implant failure in these patients, we place as many standard and zygomaticus implants as dictated by the available bone.

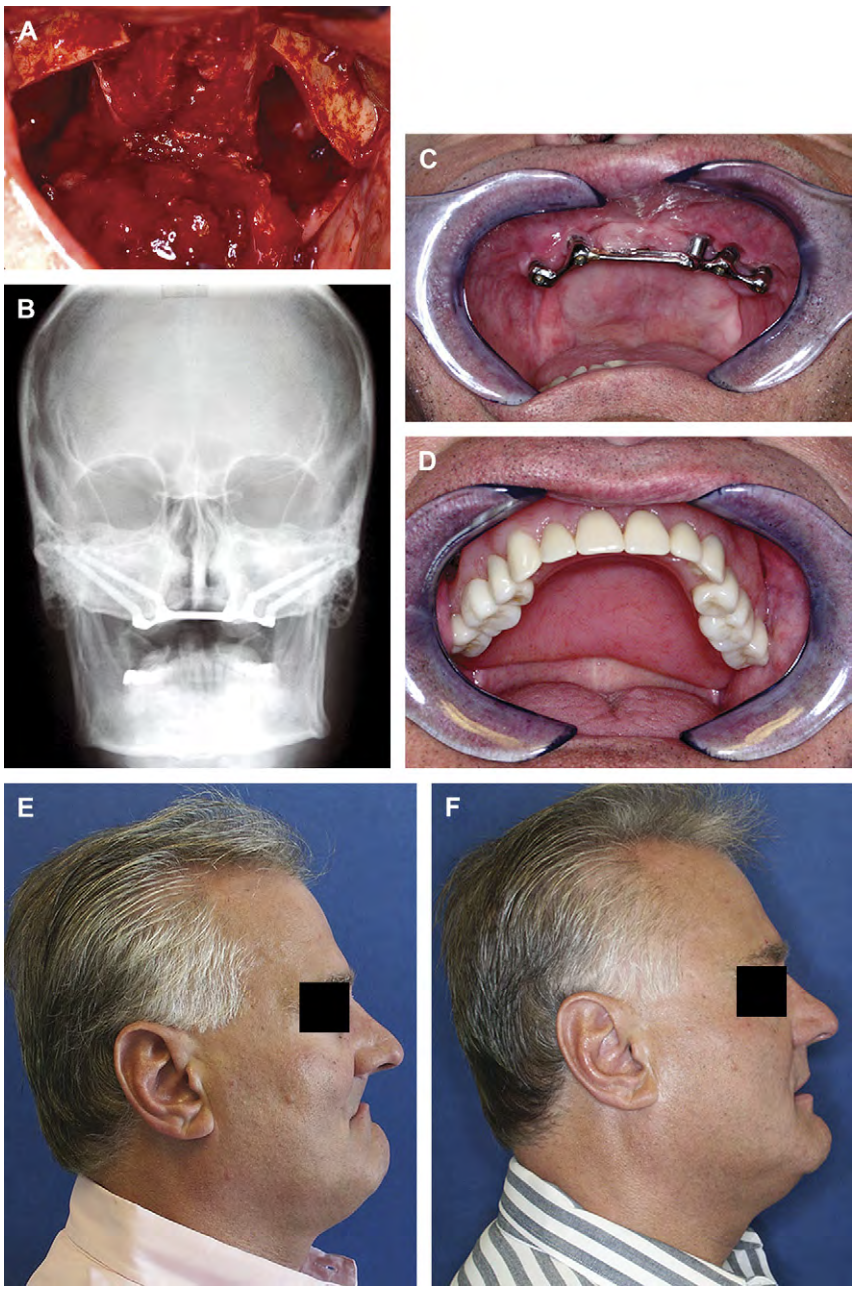



Fig. 3. Reconstruction of an extensive maxillary defect with zygomaticus and standard endosseous implants following resection for maxillary mucormycosis. (*A*) The patient required extensive resection of the maxilla, including the piriform rims and buttress regions, for mucormycosis. Following resection, there was little remaining maxilla, and a denture could not be supported. (*B*) The patient was reconstructed with four zygomaticus implants. One standard endosseous implant was placed in the left piriform rim region. (*C*) The implants were supported with cross-arch stabilization. (*D*) Intraoral view with the obturator in place. (*E*) Posteroanterior view without obturator demonstrating lack of upper lip support. (*F*) With the denture in place, the patient has adequate upper lip support, normal speech, and swallowing.

Careful prosthodontic planning is critical to avoid implant failure. The biomechanical forces placed on zygomaticus and standard implants following an extensive maxillectomy are significantly greater than the forces observed in a conventional implant reconstructive case. The quality and quantity of remaining bone available for osseointegration following an extensive maxillectomy are compromised. The lever arm placed on zygomaticus implants is significantly greater than the lever arm placed on standard endosseous implants. In most cases requiring maxillary resection, a portion of the palatal bone must be resected with the specimen.

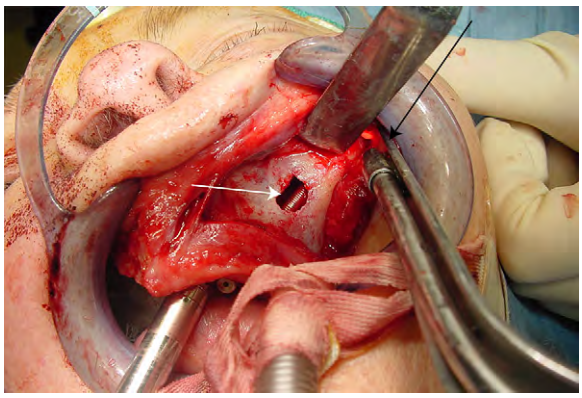


Fig. 4. Technique of placement of zygomaticus implant when a portion of palatal bone is available. A lighted channel retractor is placed by engaging the junction of the temporal and frontal process of the zygoma (*black arrow*). The end of the channel can be palpated below the skin. The end of the channel retractor serves as a stop for the drill. An antral window is created to visualize and irrigate the drill, as well as visualize the implant during placement (*white arrow*).

Often, the only bone available for integration of the zygomaticus implant is the zygomatic bone at the junction of the temporal and frontal process. Generally, with standard endosseous implants, the occlusal force is parallel to the long axis of the implant. In zygomaticus implants, the implant is at a 30- to 60-degree angle relative to the occlusal force. These biomechanical requirements can contribute to zygomaticus implant failures in patients following extensive maxillectomy. In our study, all of the implant failures occurred at stage II surgery before loading. This finding further points to radiotherapy as a contributing factor to implant failures in these cases. Implant failure following loading often requires bar and implant removal and fabrication of a new bar. We believe that careful prosthodontic planning avoids implant failure following loading. Cross-arch stabilization using a bar and clip design helps distribute the occlusal forces (see Figs. 1–3).

When considering the different methods for maxillary reconstruction, quality of life must be considered. Few studies have evaluated quality of life following maxillary reconstruction. A single quality of life study has been performed to evaluate the outcome of maxillary reconstruction with a maxillary prosthetic obturator. More recently, Rogers and colleagues have evaluated quality of life in patients requiring maxillectomy for oncologic reasons. To explore the broad concepts of health-related quality of life and subjective outcome, they used eight quality of life questionnaires, including the Denture Satisfaction and Obturator Functioning Scale.

There was no difference in quality of life between the patients reconstructed with a microvascular free flap and those reconstructed with a prosthetic obturator. Within this quality of life study, 10 of 18 patients who were reconstructed with a free flap were unable to wear a denture. We have demonstrated that zygomaticus and standard endosseous implants offer a reliable method to retain, support, and stabilize a maxillary obturator following maxillary resection. We have found that patients reconstructed with this method are able to wear a maxillary obturator, have highly favorable speech and esthetics, and are able to drink and eat without nasal leakage. Given the complex nature of the ablative maxillary defect following extensive maxillary resection, maxillary reconstruction with zygomaticus implants is acceptable for this challenging patient population.

## Further readings

Brown JS. Deep circumflex iliac artery free flap with internal oblique muscle as a new method of immediate reconstruction of maxillectomy defect. Head Neck 1996;18:412–21.

Cordeiro PG, Santamaria E. A classification system and algorithm for reconstruction of maxillectomy and midfacial defects. Plast Reconstr Surg 2000;105:2331–46.

Davison SP, Sherris DA, Meland NB. An algorithm for maxillectomy defect reconstruction. Laryngoscope 1998;108:215–9.

Granstrom G, Jacobsson M, Tjellstrom A. Titanium implants in irradiated tissue: benefits from hyperbaric oxygen. Int J Oral Maxillofac Implants 1992;7:15–25.

Higuchi KW. The zygomaticus fixture: an alternative approach for implant anchorage in the posterior maxilla. Ann R Australas Coll Dent Surg 2000;15:28–33.

King MA, Casarett GW, Weber DA. A study of irradiated bone. I. Histopathologic and physiologic changes. J Nucl Med 1979;20:1142–9.

Kornblith AB, Zlotolow IM, Gooen J, et al. Quality of life of maxillectomy patients using an obturator prosthesis. Head Neck 1996;18:323–34.

Parel SM, Tjellstrom A. The United States and Swedish experience with osseointegration and facial prostheses. Int J Oral Maxillofac Implants 1991;6:75–9.

Rogers SN, Lowe D, McNally D, et al. Health-related quality of life after maxillectomy: a comparison between prosthetic obturation and free flap. J Oral Maxillofac Surg 2003;61:174–81.

Sakuraba M, Kimata Y, Ota Y, et al. Simple maxillary reconstruction using free tissue transfer and prostheses. Plast Reconstr Surg 2003;111:594–8.

Salinas T, Sadan A, Peterson T, et al. Zygomaticus implants: a new treatment for the edentulous maxilla. Quintessense Dent Technol 2001;24:171–80.

Schmidt BL, Pogrel MA, Young CW, et al. Reconstruction of extensive maxillary defects using zygomaticus implants. J Oral Maxillofac Surg 2004;62:82–9.

Taylor TD, Worthington P. Osseointegrated implant rehabilitation of the previously irradiated mandible: results of a limited trial at 3 to 7 years. J Prosthet Dent 1993;69:60–9.

Vervoorn JM, Duinkerke AS, Luteijn F, et al. Relative importance of psychologic factors in denture satisfaction. Community Dent Oral Epidemiol 1991;19:45–7.

ELSEVIER
SAUNDERS

Atlas Oral Maxillofacial Surg Clin N Am 15 (2007) 51–68

Atlas of the Oral and Maxillofacial Surgery Clinics

# Maxillofacial Prosthetic Management of the Maxillary Resection Patient

Steven P. Haug, DDS, MSD

*Division of Prosthodontics, Restorative Dentistry, Indiana University School of Dentistry, 1121 West Michigan Street, Indianapolis, IN 46202, USA*

The treatment of patients requiring a maxillary resection or maxillectomy usually involves the collaborative efforts of several health care providers with different areas of expertise. This article discusses the classification of maxillectomy surgical sites, commonly referred to as "defects," the surgical enhancement to improve the prognosis of the prosthetic rehabilitation, and the steps of prosthetic rehabilitation. The goal is to improve understanding and communication between the oral surgeon and the maxillofacial prosthodontist.

Maxillofacial prosthetic rehabilitation of the maxillectomy patient with a maxillary obturator prosthesis minimizes leakage of oral fluid into the nasal cavity, improves deglutition by preventing food bolus impaction into the surgical site, improves masticatory function and esthetics by replacing teeth removed during the surgery, and improves speech by allowing separation between oral and nasal resonance and minimizing hypernasality.

## Classification

The location, extent, and diagnosis of the neoplasm requiring ablative surgery varies from patient to patient (Fig. 1), requiring differing surgical management techniques and resulting in surgical defects in varying maxillary sites (Fig. 2). The Aramany classification describes the maxillary defect based on anatomic site (Fig. 3). The class I resection is a resection of most of one maxillary bone with a medial cut down the midline. The class II resection is similar but less extensive, leaving the anterior portion of the maxilla intact but removing a unilateral posterior segment. The class III resection is a mid-palatal resection that leaves the alveolus intact. The class IV resection, like the class I resection, is a resection of one maxillary bone but also includes the anterior segment of the contralateral side. The class V resection is a bilateral posterior resection, and the class VI resection is an anterior resection of the maxilla.

## Maxillectomy

The classic maxillectomy procedure involves sectioning the zygomatic process, the frontal process, and the nasal process of the maxilla as well as the floor of the orbit. The cut continues through the alveolus down the midline, and the specimen is sectioned from the pterygoid plates (Fig. 4). Access to these structures is gained through a Webber-Ferguson incision which is made in skin folds beginning at the midline of the lip, below the nose and around the nasal ala, continuing lateral to the nose, and extending along the fold between the cheek and lower eyelid (Fig. 5). Intraorally, the incision extends down the midline, extending laterally between the hard and soft palate, and continues along the mucobuccal fold.

Once the specimen is removed (Fig. 6), the resulting denuded facial tissue (Fig. 7) is lined with a split-thickness skin graft (Fig. 8). A surgical obturator is placed with screw fixation and is

*E-mail address:* sphaug@iupui.edu

1061-3315/07/$ - see front matter 
doi:10.1016/j.cxom.2006.11.002

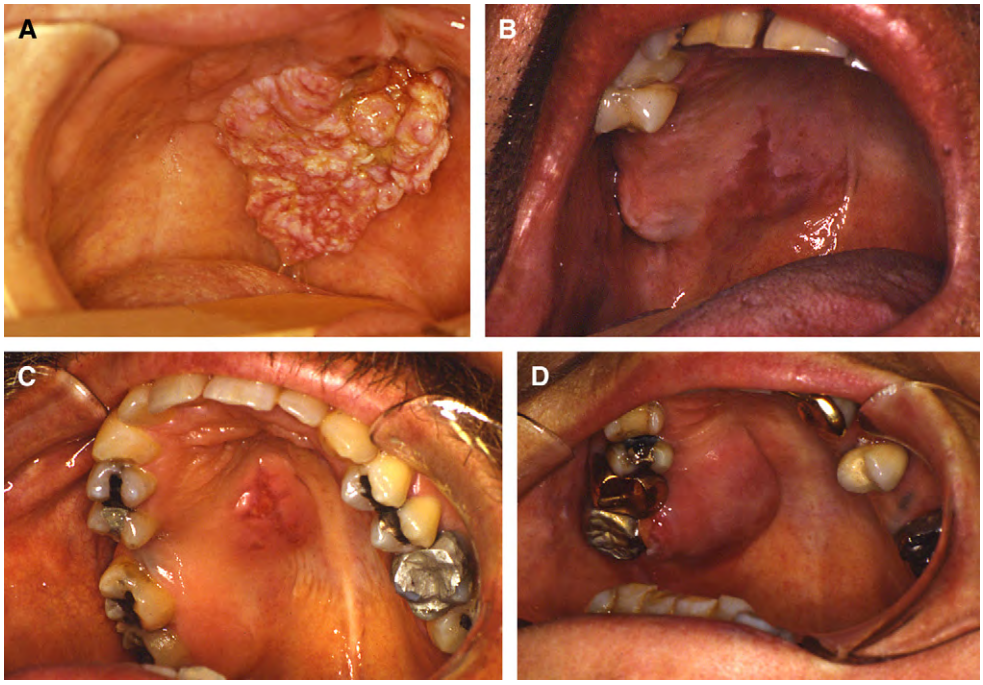



Fig. 1. (*A–D*) Differing location, extent, and diagnosis of tumors of the maxillary bone and sinus.

followed by surgical packing (Fig. 9). The facial flap can be reapproximated, and the incision is closed (Fig. 10).

## Surgical enhancements

Treatment planning by the oral surgeon and maxillofacial prosthodontist should include surgical enhancements that will improve the prognosis of the prosthodontic rehabilitation but not affect the patient's prognosis for cure.

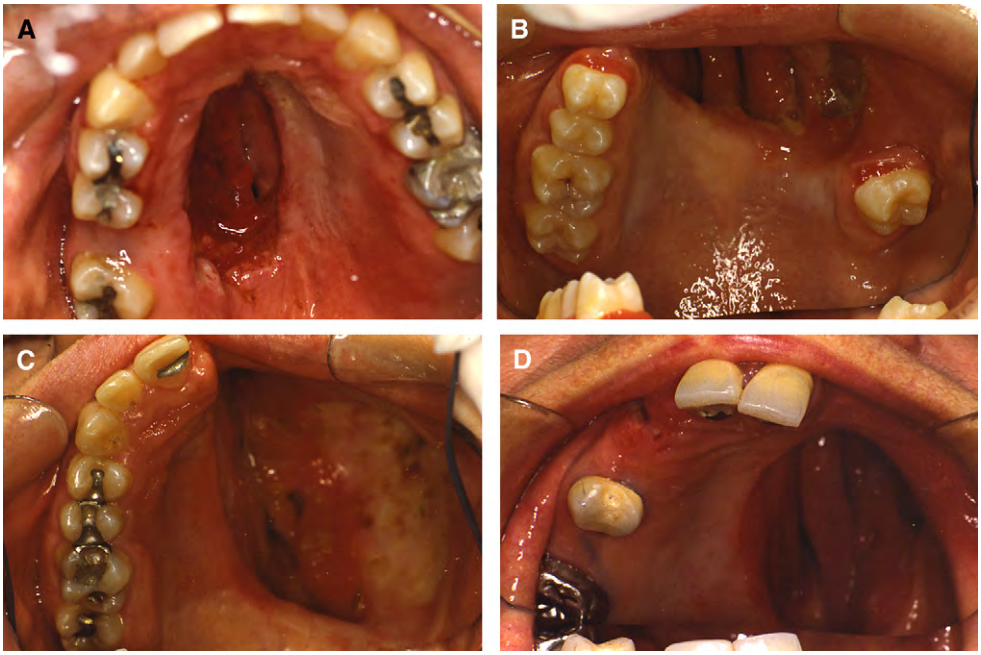



Fig. 2. (*A–D*) Resulting differing locations of the maxillary resection site.

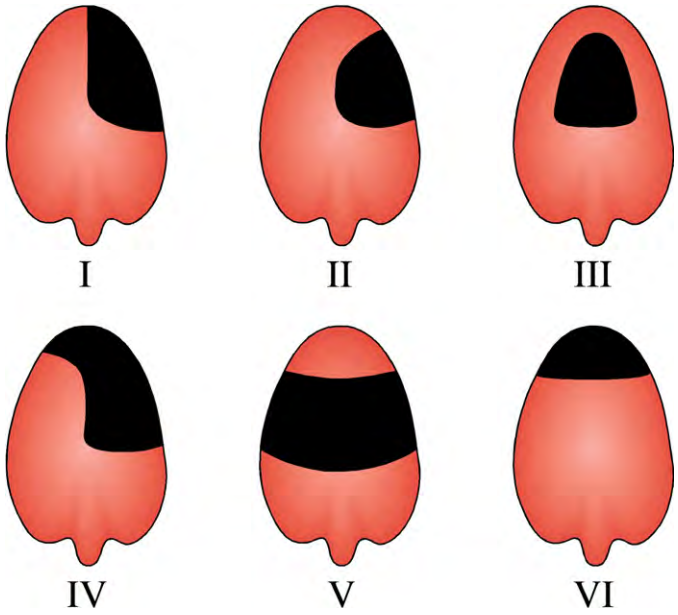



Fig. 3. Aramany classification of maxillary defects. (*Modified from* Aramany MA. Basic principles of obturator design for partially edentulous patients, part I: classification. J Prosthet Dent 1978;40:554–7; with permission from the Editorial Council of the Journal of Prosthetic Dentistry.)

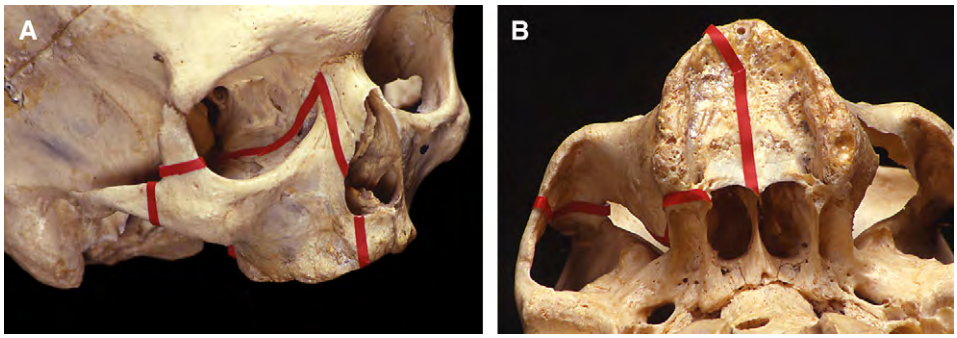



Fig. 4. Boney incisions for the classic maxillectomy. (*A*) Lateral view. (*B*) Inferior view.

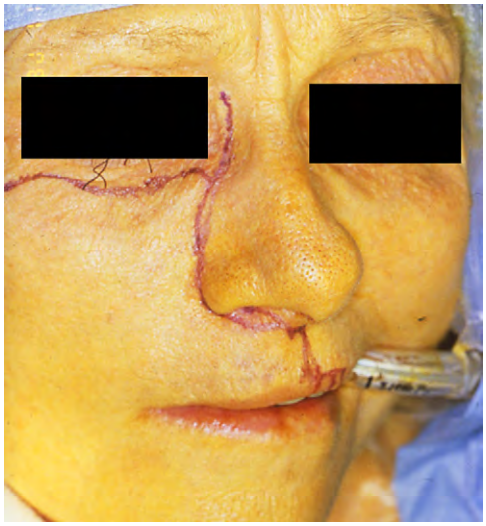


Fig. 5. Webber-Ferguson incision marked in indelible surgical marker.

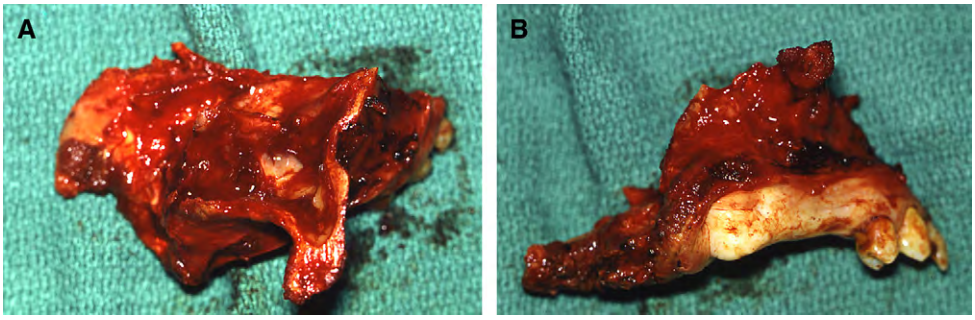



Fig. 6. Maxillectomy specimen. (*A*) Superior view. (*B*) Lateral view.

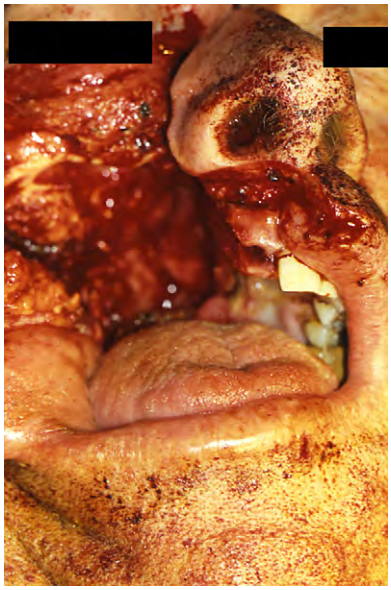


Fig. 7. Maxillectomy site with denuded facial flap.

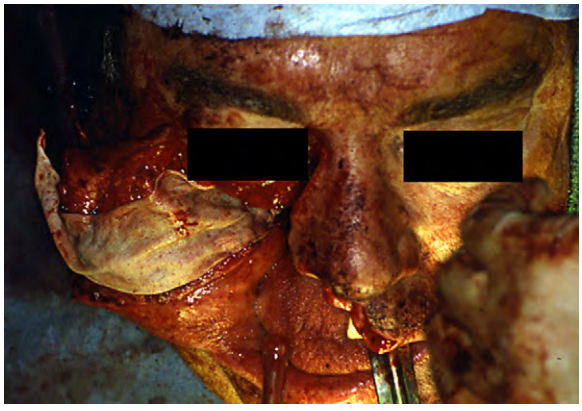


Fig. 8. Split-thickness skin graft in place.

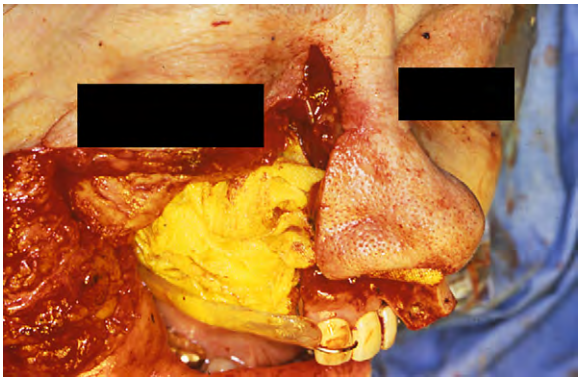


Fig. 9. Surgical obturator and packing in place.

*Retain as many maxillary teeth as possible*. A maxillary obturator prosthesis always will be more retentive and stable if the prosthesis can attach to teeth either by engaging undercuts similar to a removable partial denture or by using overdenture-type attachments. Even periodontally involved teeth should be considered as abutments because their use will improve retention and stability of the prosthesis significantly, even if for only a few years. Maintaining maxillary teeth should be considered even when radiation therapy is planned. Although osteoradionecrosis is a possibility, it is much less frequent in the maxilla than in the mandible. Whenever possible, the maxillary cuspid adjacent to the surgical site should be maintained because the length and morphology of the root usually provide excellent support as an abutment for the maxillary obturator prosthesis.

*Retain the maximum maxillary structures possible*. Whenever possible, the entire anterior maxilla and any tuberosity remnant should be maintained. The small amount of increased surgical time usually is eclipsed by the improvement in support and retention for the prosthesis.

*Remove the coronoid process if the resection extends into the soft palate*. The anterior and medial movement of the coronoid process during inferior and excursive movements of the mandible during opening and chewing will be limited by a properly extended obturator bulb, resulting in irritation of the overlying tissue and soreness. If the bulb is reduced to correct the soreness, the prosthesis will not seal adequately, allowing fluid leakage and hypernasal speech.

*Line the reflected flap with a split-thickness skin graft*. Although its effect on minimizing contracture of the reflected flap has been debated, a split-thickness skin graft offers a better tissue than respiratory mucosa to support a prosthesis. Skin-graft tissue will be less irritated by the constant movement of the prosthesis. More importantly, the junction of the buccal mucosa and skin graft will result in a scar band that will create an undercut that can be used for retention of the prosthesis.

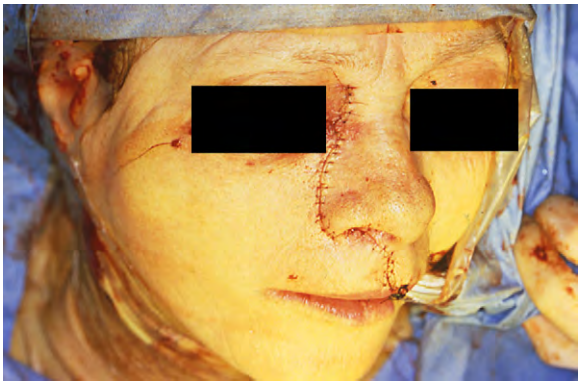


Fig. 10. Wound closure following the maxillectomy.

*Consider removing the soft palate if less than half remains*. When more than half of the soft palate is resected, the remaining tissue lacks function and hangs down on the tongue. This flaccid tissue usually gags the patient and, perhaps more importantly, prevents adequate extension of a bulb into the oropharynx to allow speech and swallowing.

*Cover the boney palatal margins with palatal mucosa*. Because the prosthesis will rock around the medial margin of the surgical resection during function, this site should be covered with palatal mucosa. A covering of palatal mucosa will be less prone to irritation than the nasal mucosa lining that results if healing occurs by secondary intention. Covering with palatal mucosa can be accomplished easily by making the mucosal incision a few millimeters from the anticipated boney resection and reflecting the tissue before the boney cut. This tissue then can be wrapped around the medial margin (Fig. 11).

*Remove the inferior turbinate*. The inferior turbinate usually ends just above the palatal plane. This structure can interfere with adequate bulb height, causing the prosthesis to leak. In addition, according to Brown, because it is anticipated that during inferior displacement of the prosthesis the axis of rotation will be on the nonsurgical side, the higher the bulb can be placed, the less vertical displacement of the prosthesis will occur for any given horizontal flexure of the facial soft tissues (Fig. 12).

*Remove the inferior portion of the vomer bone*. With the inferior portion of the vomer bone removed, the obturator bulb can engage an undercut above the palatal shelf, dramatically improving retention of the prosthesis.

*Make the transalveolor cut through extraction socket*. The surgeon should never attempt to make a transalveolor cut between adjacent teeth because of the likelihood of devitalizing the abutment tooth and, more importantly, because the interproximal bone will be thinned so that the abutment tooth will have little distal osseous support, rendering it useless as an abutment. A tooth at the planned surgical margin should be extracted, and the transalveolor cut should be made through the extraction socket.

## Stages of maxillofacial prosthetic treatment of the patient undergoing maxillary resection

The stages of treatment for the patient undergoing maxillectomy can be described as surgical, interim, and definitive. The surgical phase, during which a surgical obturator is fabricated, lasts from the time of surgery until the prosthesis and surgical packing are removed 5 to 10 days later. The interim phase, during which an interim obturator is worn, usually lasts about 3 months while the patient continues to heal from surgery. Finally, in the definitive phase, the definitive obturator is fabricated. This phase continues throughout the patient's life with the prosthesis being relined or refabricated as needed.

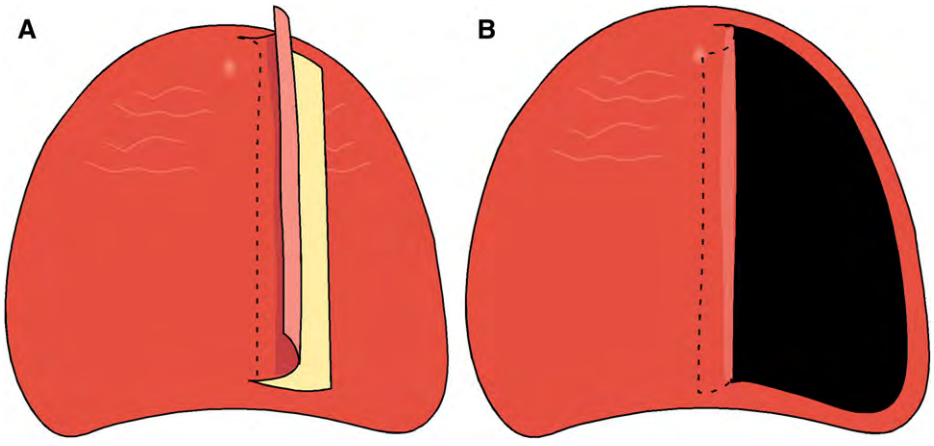



Fig. 11. (*A*) Palatal mucosa reflected before boney cut. (*B*) Palatal mucosa covering midline incision.

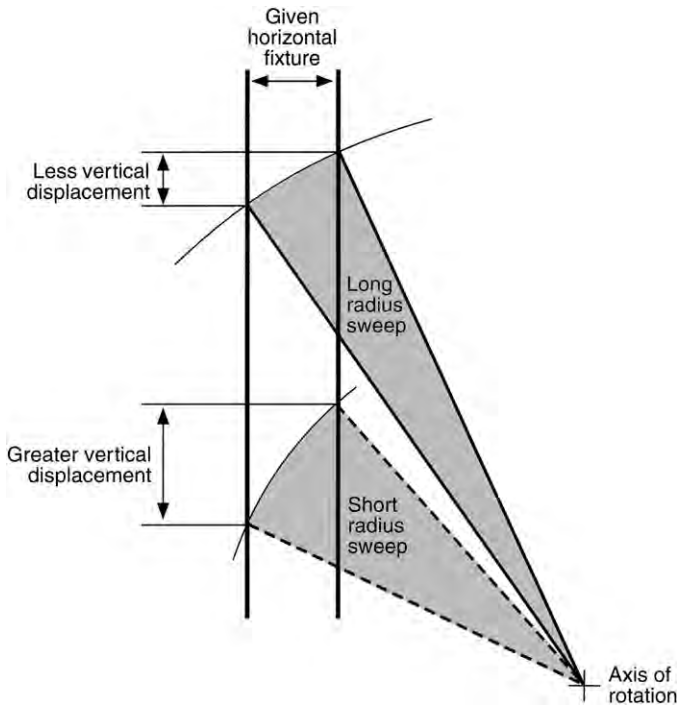



Fig. 12. Geometry of decreased vertical displacement of the maxillary obturator prosthesis with increased obturator bulb height. (*Modified from* Brown KE. Peripheral consideration in improving obturator retention. J Prosthet Dent 1968;20:176–81; with permission from the Editorial Council of the Journal of Prosthetic Dentistry.)

## Surgical obturation

The surgical obturator serves as a matrix for the surgical packing, helping it maintain good adaptation of the split-thickness skin graft to the denuded tissues of the facial flap and resulting in better healing of the graft. Because the surgical obturator separates the oral environment from the nasal cavity, there is less contamination of the wound with food and oral secretions. With the surgical site obturated, speech is more effective, and, more importantly, the patient is able to swallow, minimizing the need for nasogastric tube feedings. Each of these factors decreases the psychologic impact of the surgery for the patient, speeding the patient's recovery and decreasing the length of hospitalization.

The surgical obturator should be kept simple so that it can be modified readily if needed. It should be light weight for patient comfort. The prosthesis should reproduce normal palatal contours to facilitate speech and swallowing. The border of the prosthesis should end before the skin graft–mucosal junction to minimize the possibility of compromising the scar band formation. Posterior occlusion should be avoided to minimize the possibility of transmitting pressure though the surgical packing to the irritated tissues. Occasionally, the exact margins of the resection are not known until the time of surgery. In this case, more than one prosthesis can be fabricated to minimize the need for trimming at surgery and to provide the best possible fit (Fig. 13).

## Surgical obturator fabrication

An alginate impression of the maxillary arch is made in a stock impression tray (Fig. 14). A cast is poured in dental stone and trimmed (Fig. 15). The cast is trimmed with a headpiece and bur back to normal contours. If needed, stone can be added in areas where the contour is deficient (Fig. 16). In the dentate patient, stainless steel wires are adapted to fabricate clasps (used for retention when the surgical obturator is converted to an interim obturator). Wax sheets are adapted to the cast to fabricate a wax pattern for the surgical obturator about

Fig. 13. Two surgical obturators fabricated for surgery when the extent of the resection was unsure.

2 mm thick. The pattern is invested, boiled out, and processed in clear heat-polymerized resin that is finished, polished, and delivered to the oral surgeon (Fig. 17).

Autopolymerizing resin can be used to fabricate the surgical obturator but is more porous and therefore is less hygienic during the postoperative period. Light-polymerized composite resins can be used but are more brittle and can be fractured more easily when being fixed to the maxilla. Should the patient already have a reasonably well-fitting maxillary denture, the denture can be used as the surgical obturator, allowing the patient to wear a prosthesis with which he or she is already accustomed.

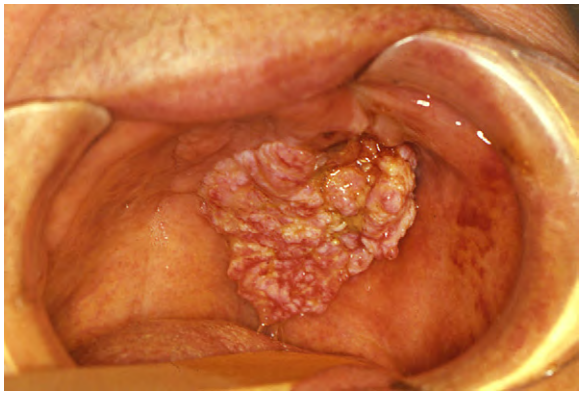


Fig. 14. Malignant lesion of left posterior maxilla.

Fig. 15. Maxillary cast for surgical obturator fabrication.

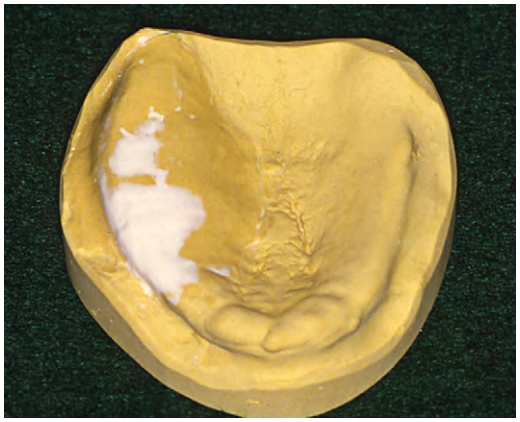


Fig. 16. Modified cast replacing normal palatal contours.

## Interim obturation

Approximately 5 to 10 days after the maxillectomy procedure, the surgical obturator is removed along with the surgical packing. Because of the possibility of complications such as bleeding, it is recommended that the oral surgeon remove the packing and débride the surgical site. The patient is referred immediately to the maxillofacial prosthodontist; the surgical obturator is sent with the patient. Although this procedure may be a little inconvenient for the patient and requires excellent coordination between these offices, it allows both specialists to have available all the armamentarium needed to treat the patient.

Any areas of overextension are trimmed on the surgical obturator, and any clasps are adjusted as needed to maximize retention and stability. The screw holes in the prosthesis can be repaired with an autopolymerizing acrylic resin or light-polymerized composite acrylic resin.

The surgical prosthesis then is converted to the interim obturator with an autopolymerizing soft chairside denture relining material that is mixed to a soft, doughlike consistency and placed on the surgical obturator on the surgical side. The prosthesis is placed in the patient's mouth, impressing the margins of the surgical site. The soft denture liner is adjusted and added in increments until the surgical site is adequately obturated (Figs. 18 and 19).

This visit is also a good time to remind the patient to return to normal hygiene practices. At this time, also, the patient should be instructed in proper hygiene of the surgical site, which includes copious irrigation several times a day, usually accomplished with an irrigation syringe or sinus irrigation bottle. The patient should be instructed in the placement and removal of the prosthesis, which can be complicated and intimidating for some patients. The prosthesis should be worn during waking hours and removed for hygiene, irrigation, and at bedtime for sleep.

The patient should be seen the following week by the maxillofacial prosthodontist to reinforce hygiene and care of the prosthesis and to adjust the prosthesis as needed, by adding

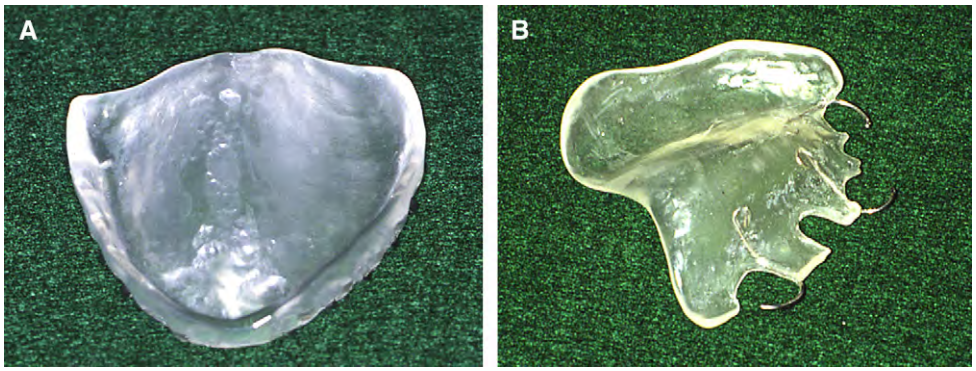



Fig. 17. Clear heat-polymerized acrylic resin surgical obturator. (*A*) For an edentulous patient. (*B*) For a partially edentulous patient.

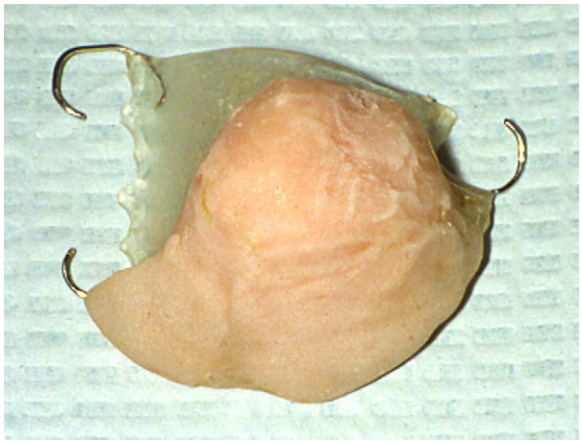


Fig. 18. Surgical obturator converted to an interim obturator for a dentate patient.

additional material or removing material that is overextended. The patient can usually be seen about every 2 weeks for adjustment as indicated. On occasion a patient receiving radiation therapy will discontinue the use of the prosthesis because of discomfort. When use is discontinued, it usually is necessary to remove all of the soft chairside denture relining material from the prosthesis, replacing it with new material when the patient's comfort level permits.

## Definitive obturation

Usually about 3 months of healing after surgery or 3 months after radiation therapy is sufficient to consider beginning fabrication of the definitive obturator. For the dentate or partially edentulous patient, diagnostic impressions can be made with alginate impression material and poured in improved dental stone. Because the anatomy of the surgical site usually is not a consideration in framework design, the surgical site can be blocked out with gauze for patient comfort during the impression. Framework designs in dentistry tend to be based on individual philosophy and can differ widely from one practitioner to another. The reader is referred to two classic articles by Aramany and Parr and colleagues on the design of maxillary obturator prosthesis frameworks. Frameworks should provide as much support, retention, and stability as possible.

Mouth preparation is accomplished through enamel modification and fixed restoration as appropriate, and a framework impression made. Again, the surgical site can be blocked out with gauze because this area will be impressed later, much like the corrected cast technique used in

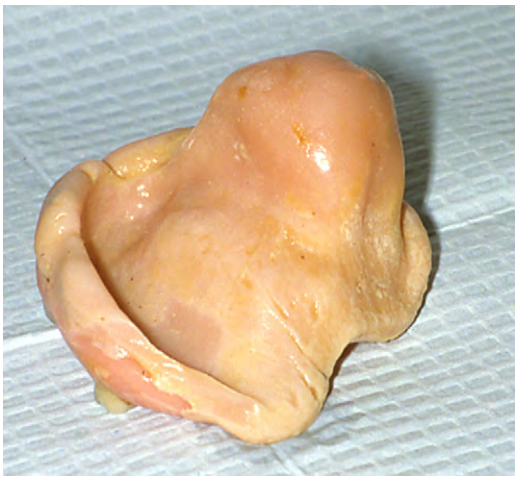


Fig. 19. An existing complete denture used to fabricate an interim obturator prosthesis by the addition of soft chairside denture relining material.

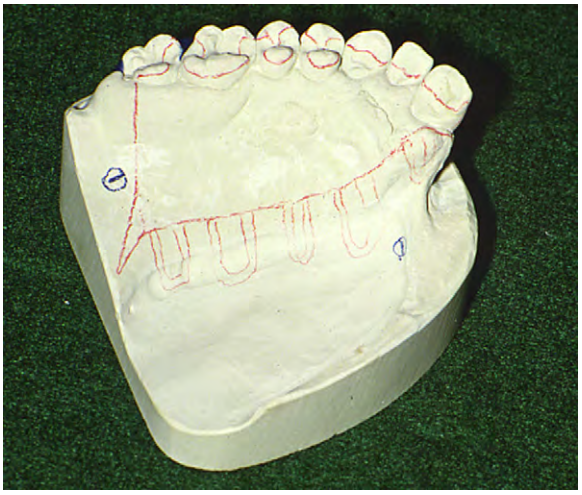


Fig. 20. Master cast for maxillary obturator framework fabrication.

the fabrication of a removable partial denture. The impression is poured in die stone (Fig. 20), and a maxillary obturator framework is fabricated from the cast (Fig. 21). The framework can be tried-in in the patient's mouth and adjusted as needed.

Whether the patient is edentulous, partially edentulous, or dentate, most of the retention and stability of the maxillary obturator prostheses comes from an impression of the surgical site. It is important to engage as many opposing undercuts within the surgical site as possible and to include the anterior portion of the remaining soft palate posteriorly, the anterior nasal aperture anteriorly, the lateral scar band laterally, and the remaining hard palate medially (Fig. 22).

The corrected cast impression of the surgical site is made by adapting a custom ring-tray to the framework made from autopolymerizing resin or light-polymerized composite resin (Fig. 23). Dental modeling compound is placed on the ring-tray and placed in the patient's mouth. The ring allows access for the maxillofacial prosthodontist's finger to conform the compound into the anatomy of the surgical site. Compound is added incrementally until the entire surgical site has been captured. The compound then is trimmed with a sharp scalpel to make room for impression material. Impression material is placed on the compound, the framework-tray-impression assembly is replaced in the patient's mouth, and the corrected cast impression made. In the dental laboratory the surgical side of the cast is removed, the framework-tray-impression assembly is replaced on the cast, and the corrected cast impression is boxed and poured.

The impression for the edentulous patient can be made in one step using a custom ring-tray made on a preliminary impression (Fig. 24). The nonsurgical side is border-molded first to

Fig. 21. Maxillary obturator framework.

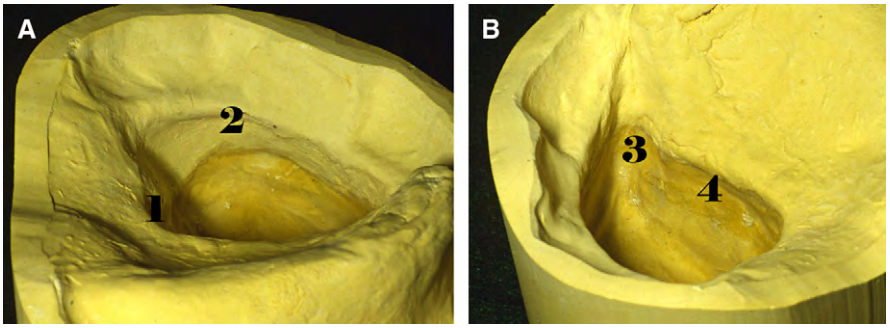



Fig. 22. Cast of an edentulous maxillary patient showing "within-the-defect" support and retention. (*A*) Lateral view of surgical site. 1, anterior portion of the soft palate; 2, lateral scar band. (*B*) Anterior view of surgical site. 3, anterior nasal aperture; 4, remaining hard palate.

obtain better orientation of the tray when replaced in the patient's mouth (Fig. 25), followed by compound adaptation within the surgical site (Fig. 26). The compound then is trimmed, impression material is placed on the tray, and an impression is made (Fig. 27). The cast is poured in dental stone and trimmed (Fig. 28), and the posterior palatal seal is placed (Fig. 29).

A heat-polymerized record base (to which the teeth eventually are processed) is recommended because, if undercuts are blocked out on the cast and a separate record base fabricated, support,

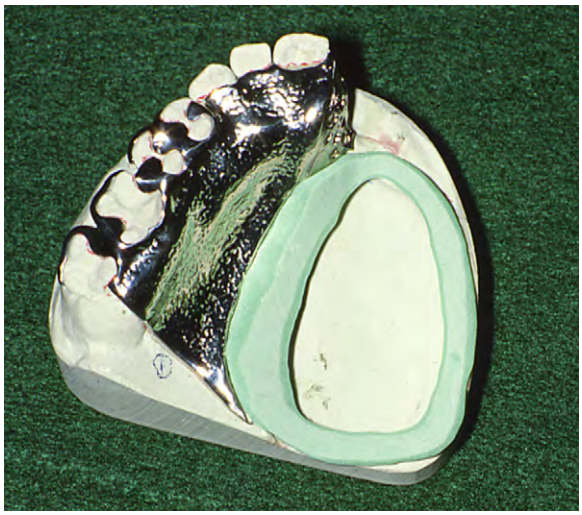


Fig. 23. Custom ring-tray on framework.

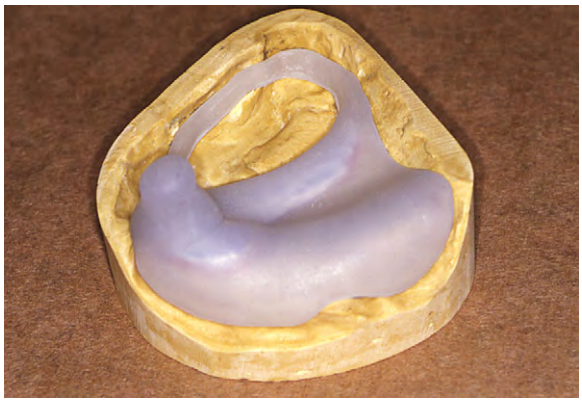


Fig. 24. Custom ring-tray for an edentulous patient.

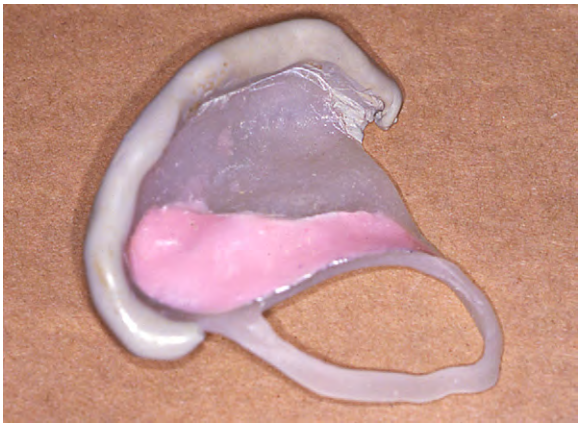


Fig. 25. Border molding, nonsurgical side.

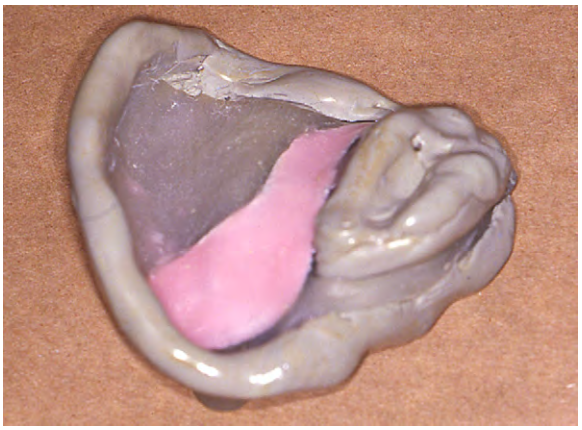


Fig. 26. Border molded tray for an edentulous patient with a maxillary resection.

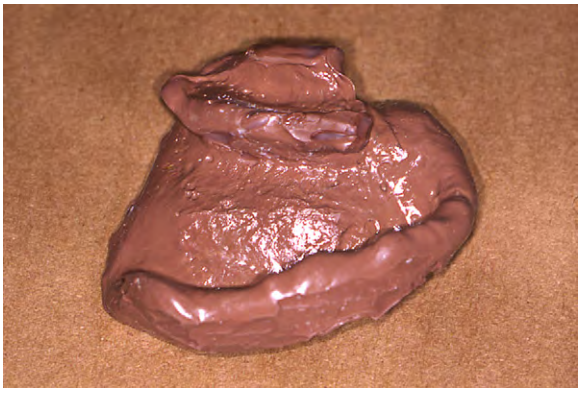


Fig. 27. Final impression for an edentulous patient with a maxillary resection.

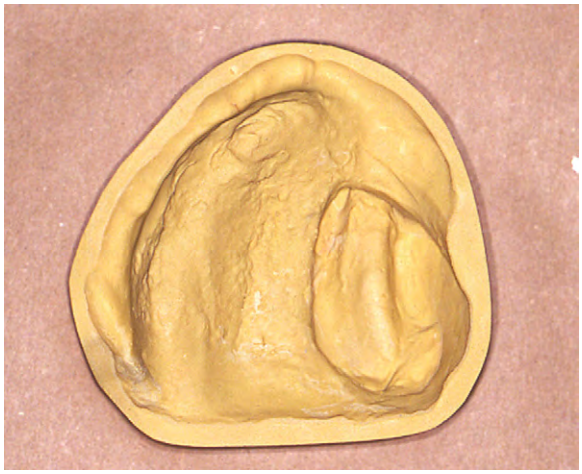


Fig. 28. Master cast for an edentulous patient with a maxillary resection.

retention, and stability usually are not adequate for accurate jaw records. The cast is sent to the laboratory for fabrication of the heat-polymerized record base and placement of the occlusal rim (Fig. 30).

The record base is marked with pressure-indicating paste and is tried in (Fig. 31) and adjusted. Usually this procedure involves rather tedious trial and adjustment to seat the base while maintaining as much undercut within the surgical site as possible. Once the record base is seated, the wax rim is contoured, and interocclusal records are made using the same prosthodontic principles used in treating any edentulous or partially edentulous patient who requires a removable

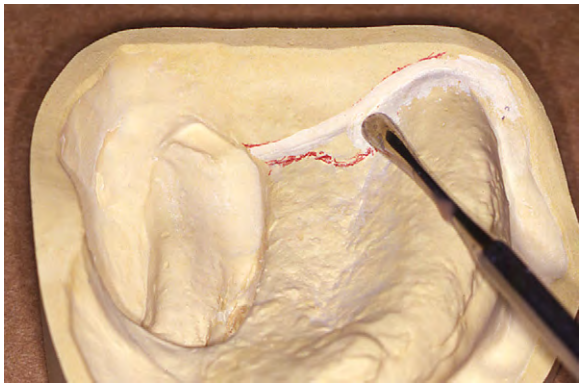


Fig. 29. Posterior palatal seal placed in master cast.

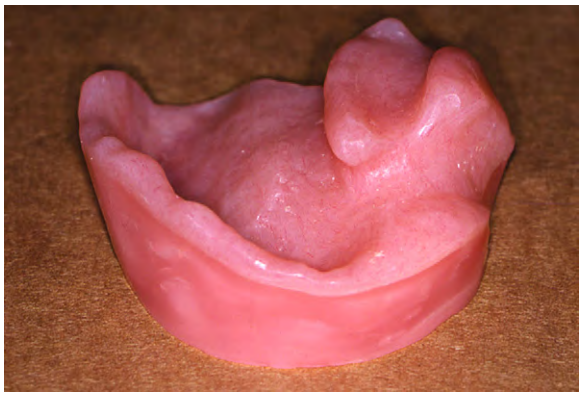


Fig. 30. Heat-processed record base with wax rim for an edentulous patient.

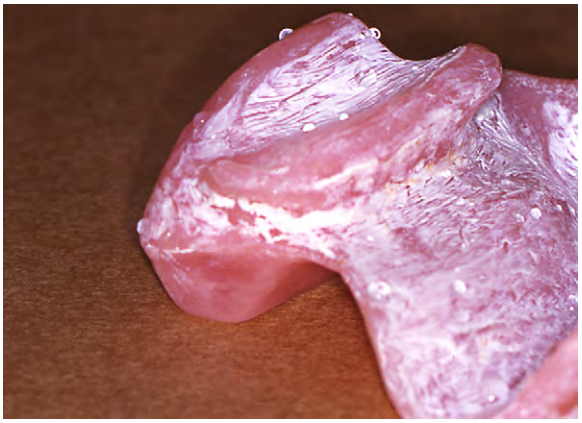


Fig. 31. Record base with pressure-indicating paste applied showing areas of needed adjustment to seat base.

prosthesis. Scar contracture may require a reverse posterior occlusion (or cross-bite) on the surgical side, and muscle fibrosis, especially after radiation, may require a reduced occlusal vertical dimension. Remount casts are fabricated and articulated and teeth set for wax try-in (Fig. 32).

At wax try-in esthetics (Fig. 33), phonetics (Fig. 34), centric relation, and occlusal vertical dimensions are verified again using the principles employed in treating edentulous and partially edentulous prosthodontic patients. The prosthesis can be returned to the laboratory for processing of the teeth to the record base.

Because of the size of the bulb of most obturator prostheses, the bulb is processed hollow to decrease the weight of the prosthesis. After final fitting of the prosthesis, the bulb can be thinned further from the inside to decrease the weight as much as possible. Whether the hollow bulb is left open on top or closed tends to depend on the philosophy of the maxillofacial prosthodontist; proponents of both methods cite hygiene and speech quality as determinants. As a general rule, when nasal secretions are minimal (especially in the patient who has received

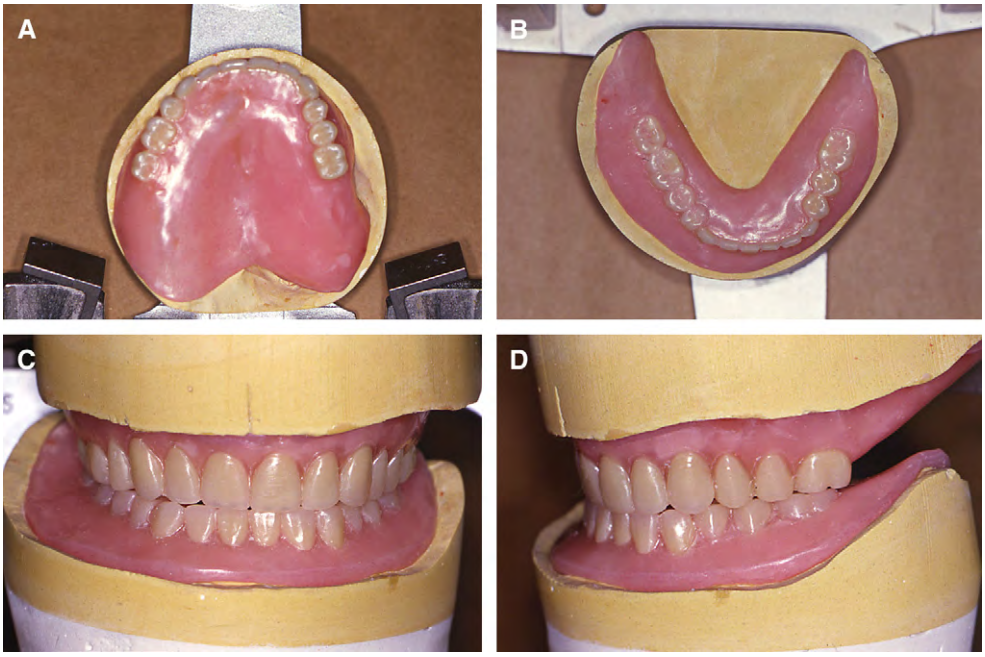



Fig. 32. Wax trial prosthesis for an edentulous patient with a maxillary resection. (*A*) Maxillary occlusal view. (*B*) Mandibular occlusal view. (*C*) Anterior view in occlusion. (*D*) Left posterior view in occlusion. The second molar was omitted on the surgical side because of space limitation resulting from scar contracture.

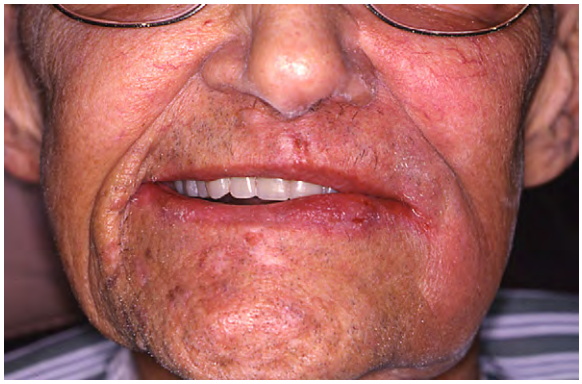


Fig. 33. Esthetic verification at wax try-in. Note the diminished muscle activity of patient's left surgical side.

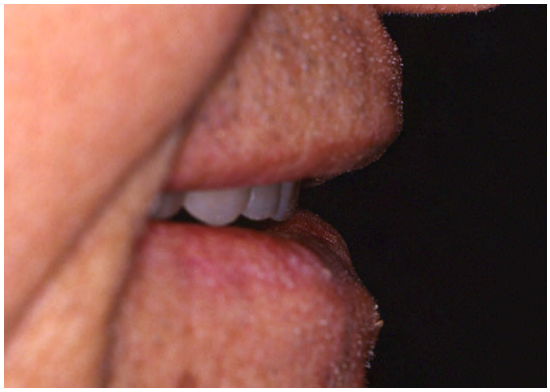


Fig. 34. Verification of phonetics at wax try-in.

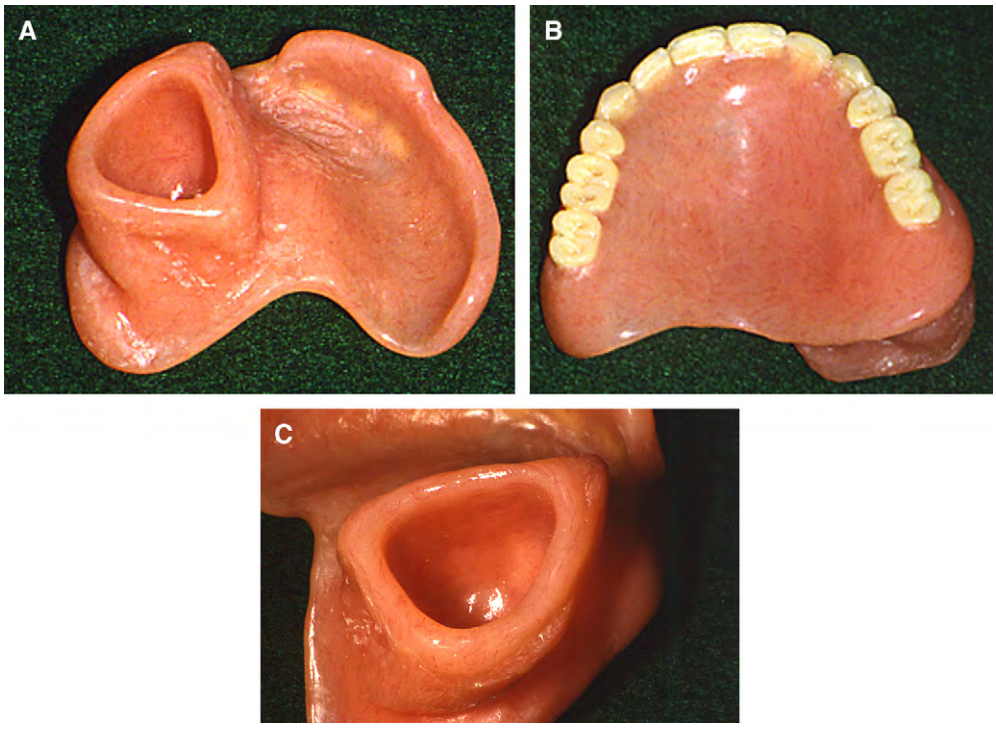



Fig. 35. Open-top obturator. (*A*) Intaglio surface. (*B*) Polished surface. (*C*) Close-up view of open-top bulb.

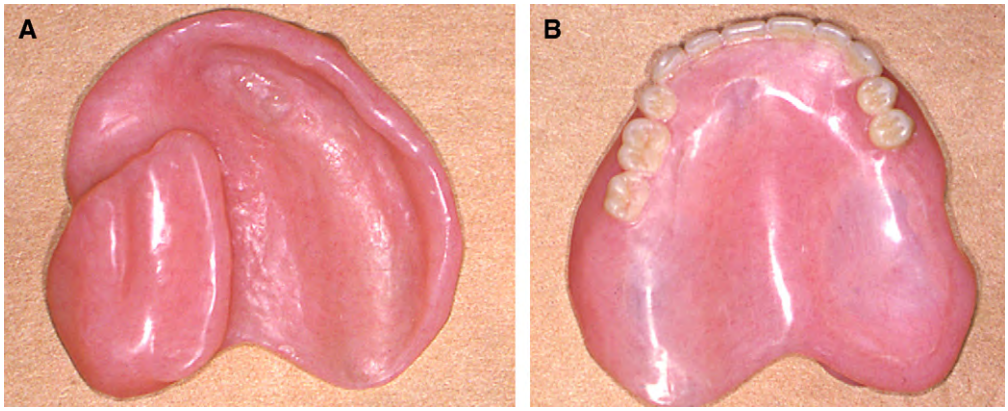



Fig. 36. Closed-top obturator. (*A*) Intaglio surface. (*B*) Polished surface. Note the depression in the superior surface of the bulb to accommodate unresected turbinate, with extensions to engage undercuts.

radiation), a prosthesis that can be extended high into the surgical site can be left open on top (Fig. 35). On the other hand, a prosthesis that does not have much bulb extension superiorly usually needs to be closed on top (Fig. 36). The process of closing the hollow bulb involves sealing a lid to either the superior or inferior surface of the bulb (Fig. 37).

At placement of the prosthesis, the fit is verified using pressure-indicating paste and is adjusted to compensate for any changes that may have occurred as a result of processing. The occlusion then is checked and perfected with articulating paper. Care and wearing instructions are similar to those for any removable prosthesis and include proper hygiene, particularly for open-top prostheses (Fig. 38). Because of the complexity of the path of placement and removal,

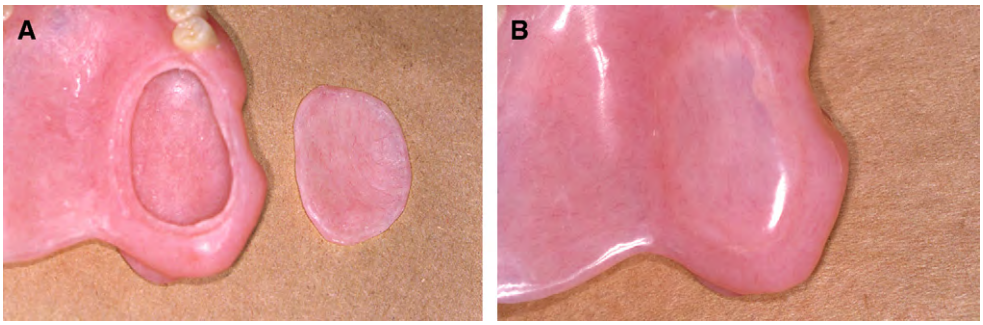



Fig. 37. (*A*) Heat-processed lid ready to be sealed to the hollow bulb. (*B*) Finished lid in place.

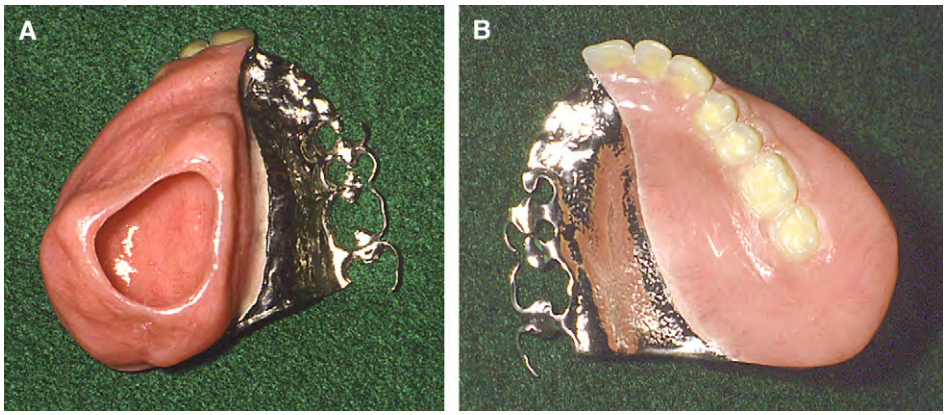



Fig. 38. Open-top maxillary obturator prosthesis for a dentate patient at placement. (*A*) Superior view. (*B*) Inferior view.

considerable time usually is spent educating the patient and practicing this technique until the patient is comfortable.

The patient is seen the next day for follow-up and adjustment as needed and usually is seen once a week thereafter until the patient is comfortable. It is highly recommended that the patient be seen for follow-up every 6 months to once a year to check the fit of the prosthesis and for a thorough soft tissue examination.

## Implants

The patient undergoing maxillary resection may benefit from endosseous implants placed in the surgical site. Unfortunately, the lack of suitable bone quantity and quality brings the prognosis for implants in this location into question. If placed in this location, the implants generally are difficult to use adequately for the prosthetic rehabilitation and are very difficult for the patient to maintain. Implants placed in the unresected alveolus improve retention and stability of the obturator prosthesis. Because of the complex forces of dislodgment and chewing, endosseous implants, when used, should be of sufficient number, length, and distribution to resist these forces. Ideally, at least four implants should be placed in a nonlinear relationship to maximize stability, support, and retention. One implant should be placed adjacent to the surgical site in the anterior, one in the contralateral cuspid region, and two posteriorly. The use of implants in patients who have received or may receive radiation therapy should be considered carefully because the failure rate of the implants may be increased in these patients.

## Summary

The treatment of the patient requiring a maxillectomy involves a multidisciplinary approach. Paramount in that collaboration is communication. This article provides the oral surgeon with some insight into the maxillofacial prosthetic rehabilitation of the patient, surgical enhancements that can improve the prognosis of the rehabilitation, and classification of maxillary surgical defects with the goal of improving that communication.

## Further readings

Aramany MA. Basic principles of obturator design for partially edentulous patients. Part I: classification. J Prosthet Dent 1978;40:554–7.

Aramany MA. Basic principles of obturator design for partially edentulous patients. Part II: design principles. J Prosthet Dent 1978;40:656–62.

Brown KE. Peripheral consideration in improving obturator retention. J Prosthet Dent 1968;20:176–81.

Parr GR, Tharp GE, Rahn AO. Prosthodontic principles in the framework design of maxillary obturator prostheses. J Prosthet Dent 1989;62:205–12.