Update on Major Reconstruction of the Head and Neck

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Reconstruction of soft-tissue defects in the head and neck is best accomplished using similar composite tissue. In the head and neck, this tissue is usually available in the form of adjacent tissue transfer. The local adjacent tissue resembles the resected tissue in color and composition. In some circumstances, the local tissue is not suitable for transfer. This may be due to previous surgery, exposure to radiation, or a defect that is too large for local tissue transfer. In these cases, free tissue transfer may be needed. Free tissue transfer allows for the replacement of similar composite tissue that has not seen previous treatment. The diversity of sites that may be harvested allows a relatively similar tissue match. This article discusses recent advances in the reconstruction of 3 areas that in the past have presented many problems to the reconstructive surgeon. Total nasal and lip reconstruction have been problematic. In heavily pretreated patients, the reconstruction often results in suboptimal outcomes. Large scalp defects in the setting of previous excisions or irradiation are difficult to reconstruct and rehabilitate. In all of these cases, the ability to transfer composite tissue has improved the functional and cosmetic outcomes.

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TOTAL LOWER LIP RECONSTRUCTION USING FREE TISSUE TRANSFER

Squamous cell carcinoma is, by far, the most common type of cancer affecting the lower lip, and basal cell carcinoma is more common on the upper lip. Although reconstruction of the upper lip requires more functional and aesthetic considerations, lower lip reconstruction can be challenging and difficult as well. In repairing defects that include the lower lip in a full-thickness manner, the reconstructive surgeon should consider restoration of sensation, function, and aesthetics.

Many isolated near-total lower lip defects can be reconstructed using various types of local advancement or rotational flaps. The Karapandzic flap has proved to be useful and efficacious in these reconstructions (**Figure 1**).[1] One major advantage is that oral competence is maintained using this reconstructive technique. The Gillies[2] and McGregor[3] flaps are considered random, fan-shaped, local flaps. The Karapandzic,[1] a rotational flap, and the Bernard, an advancement flap, are considered sensate flaps with intact neurovascular bundles. The Webster flap[4] is another type of advancement flap where the cheek tissue is advanced after excision of a Burow triangle to facilitate the advancement. For lateral or oral commissure defects, an Estlander (a cross-lip flap) or a Zisser flap[5] is ideal. With many of these options, commissuroplasty is eventually needed to combat microstomia and to optimize functional outcome. For a quick review of various local flaps, refer to a textbook on facial plastic and reconstructive surgery.

All these techniques allow reconstruction of near-total lower lip defects. The method used depends on the size and location of the defect and on the availability of innervated local tissue for rotation or advancement. Sensate local flaps have the advantage of earlier return of function and sensation. However, in the long term, there may not be much difference. In fact, Civelek et al[6] compared innervated local flaps and denervated random

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local flaps for function and sensation. They used objective and subjective measures, such as speech and drooling, to compare function and found that there was no significant difference. The advanced, rotated, or transposed tissues have the ability to function, as evidenced on electromyography. Moreover, there were no differences in the 2 groups in sensation (eg, pain, touch, and temperature). It is thought that the tissues form sensation via neurotization. However, the innervated flaps require more delicate and time-consuming dissection.

When lip resection is combined with neck dissection, especially bilateral neck dissection, or in elderly patients who smoke, the vascularity of the local tissue and flaps can be rather tenuous. Preservation of 1 or both facial arteries allows the flaps to be more robust. The facial artery is almost always sacrificed during a neck dissection. In these patients, a local flap may not be possible. There also exists a subset of patients who have been previously treated by surgery with local flap reconstruction or radiation. These patients also may no longer be amenable to local tissue reconstruction. Free tissue transfer is an option in such patients. Another indication may be large labiomental, cheek, and mucosal defects.

Total lower lip reconstruction using free tissue transfer is a relatively new and evolving concept. Only a few articles,[6-13] mostly case series, have described the use of free tissue transfer for restoring large lower lip defects, with the radial forearm flap being the most common. Other flaps, such as the gracilis[14] and the anterolateral thigh,[15] have been used as well. Before the advent of free tissue transfer, regional flaps (deltopectoral, trapezius, and others) were used to reconstruct lower lip defects. The more supple composite free tissue that is available has replaced these regional flaps.

The radial forearm free flap was first introduced in 1978. Since then, free radial forearm tissue has been the workhorse for much of the head and neck reconstruction requiring skin or soft-tissue coverage. Radial forearm tissue is thin and pliable, allowing for easy 3-dimensional molding into the defect. It has a reliable vascular supply, with relative ease of harvesting. Moreover, donor site morbidity is minimal and acceptable. Sakai et al[7] first introduced the concept of using this free tissue transfer to reconstruct lower lip defects. They pointed out that using this flap to merely cover the lip defect without addressing the function of the lower lip would not benefit patients.

That is, reconstruction must create stable and adequate lip height and a deep labial sulcus to maintain oral competence. Providing this with a soft-tissue flap, such as the radial forearm flap, requires firm tissue support, which harvesting the palmaris longus tendon with the flap can provide. The soft tissue is draped over the tendon, providing inner and outer tissue coverage, and the tendon itself provides passive support. Moreover, the palmaris longus tendon provides transfer of motion from the facial muscles when attached to the commissural modiolus.

Different methods of attaching the tendon to various perioral tissues, muscles, and the periosteum have been described. Sakai et al[7] and Carroll et al[11] essentially secure the tendon to the orbicularis oris or to the modiolus. In 10 patients, Carroll et al[11] demonstrated an adequate cosmetic outcome, with no drooling and good

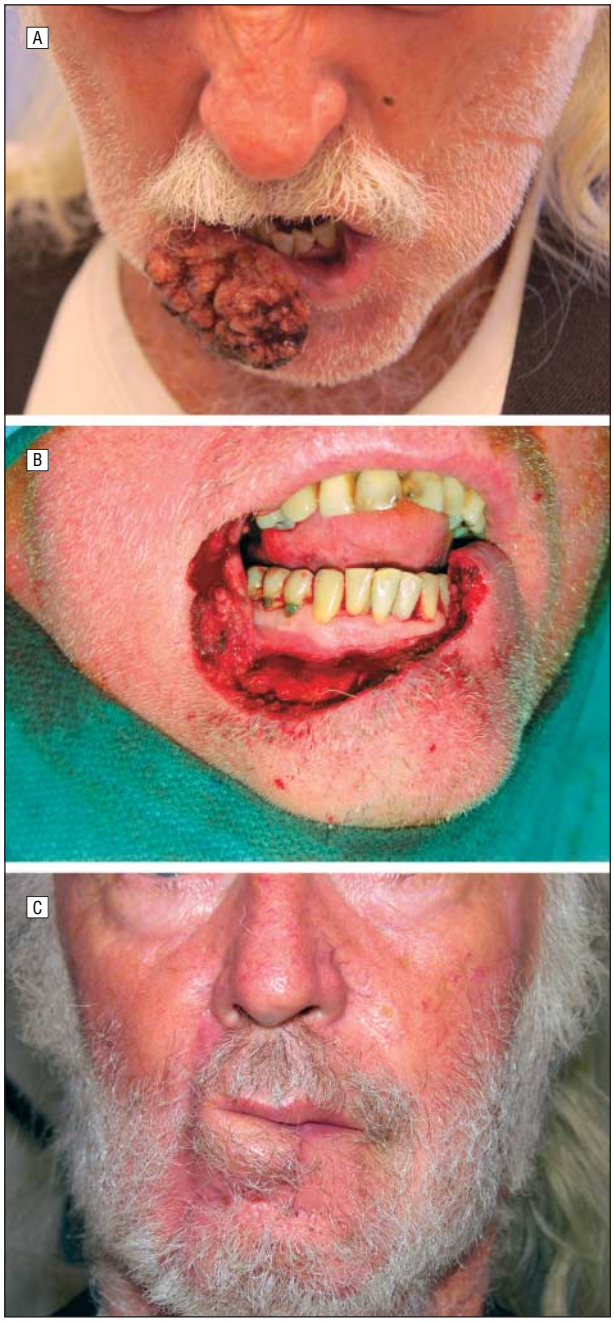

Figure 1. Isolated near-total lower lip reconstruction using the Karapandzic flap. A, This patient demonstrates a large lower lip in a previously untreated field. B, A subtotal lower lip resection is performed, and the defect is demonstrated here. C, The postoperative results demonstrate adequate cosmesis and function.

articulation. They maintained oral competence in all their patients. Serletti et al[16] secure the tendon in 2 places: to the muscle and to the periosteum. Jeng et al[17] described yet another method of securing the tendon to the upper orbicularis near the philtrum. They described 12 patients with near-total lip reconstruction. All the patients maintained oral competence, with near-normal speech.

Securing the palmaris tendon to the remaining orbicularis oris or to the modiolus yields the best dynamic results. However, when the distal ends of the tendon are then secured onto the periosteum of the zygoma using nonabsorbable sutures, a longer-lasting and more robust suspen-

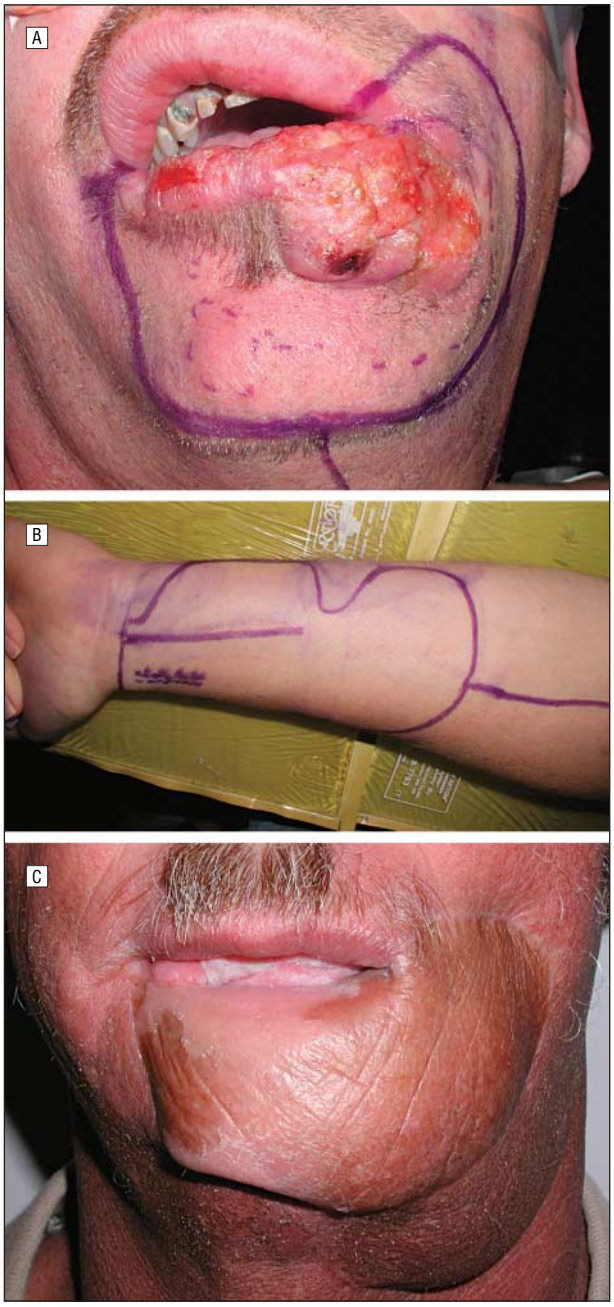

Figure 2. Total lip reconstruction. A, This patient demonstrates a large lower lip lesion that recurred after previous surgical excision. B, A template made of the defect was drawn on the radial forearm tissue before harvest of the free flap. C, The postoperative result demonstrates an adequate functional and cosmetic outcome.

sion to the neolip is formed (**Figure 2**). The disadvantage may be that movement or motion may be impaired because of "static" fixation to the nonmobile periosteum. However, if the patient is to receive postoperative radiation, the suspension has to be sturdy enough to withstand the contracture, shrinkage, and scarring from the normal healing process and the radiation itself. Figure 1B shows a patient whose neolip, although highly functional in terms of speech, eating, and sensation via neurotization, retracted after irradiation and reveals the lower gum at rest. The patient has to make a conscious effort to close his lips where the upper lip essentially compensates and closes the gap.

An important component of lip reconstruction is the restoration of sensation. Several studies have shown that a denervated radial forearm flap can be sensate with time using the process of neurotization. Carroll et al[11] found that this is true in lower lip reconstruction as well, where the neolip will become sensate to touch, pain, and temperature. There is most likely neural ingrowth from the remaining mental nerve or its branches.

Other forms of free tissue transfer have been used. Lengelé et al[14] described a prefabricated gracilis free flap to achieve a functional lower lip. The procedure was performed in 2 stages with a good result. Yildirim et al[15] used an anterolateral thigh free flap for lower lip reconstruction. In the North American population, this flap may be too bulky and may require several revisions. Ultimately, the choice of tissue type depends on the size and location of the defect and on the surgeons' preference.

The emphasis of any reconstruction is on the restoration of function, sensation, and cosmetic appearance regardless of what tissue is used. Speech, eating, and salivary continence cannot be sacrificed for cosmesis. In most patients, this can be accomplished with local tissue rearrangements. In the pretreated or total defect, a free flap may be required. Strategic replacement of the inner and outer oral linings, deep labial sulcus, commissure, and oral sphincter is possible.

MICROVASCULAR RECONSTRUCTION OF SCALP DEFECTS

The scalp is composed of 5 layers. The first layer of skin is the thickest on the body and can measure up to 7 mm deep at the level of the occiput. Deep to the skin is a dense connective tissue–filled subcutaneous layer that is adherent to the next layer, the galea. The galea aponeurotica is a dense layer of fibrous tissue continuous with the frontalis muscle anteriorly and the occipitalis muscle posteriorly. At the temporal line, the galea becomes continuous with the temporoparietal fascia, which continues inferiorly into the superficial musculoaponeurotic system of the face. The subgaleal layer is composed of a loose connective tissue matrix that allows for scalp mobility over the underlying bone. The pericranium is the periosteum of the calvaria. The supraorbital, supratrochlear, superficial temporal, greater auricular, and occipital arteries and veins, with significant crossover flow,[18] supply the scalp.

Reconstruction of the scalp must fulfill a variety of requirements. In order of importance, reconstruction should provide protection of the underlying calvaria and brain, have a good color match, and have appropriate hair distribution or acceptable scar camouflage. In most cases, local flaps can be performed.[19,20] Usually, a rotation flap, a transposition flap with or without adjunctive tissue expansion, or an Orticochea-type flap can be performed and represents the ideal reconstructive option in terms of tissue thickness, hair distribution, and color match. Limitations of local tissue transfer are usually related to the size of the defect, the scalp "tightness," and previous treatment (irradiation or surgery).[19] When any combination of these factors is present, local tissue transfer may not be possible, and the physician must consider alternative techniques using distant tissue.

Tissue expansion represents an excellent option in that, through the process of biologic creep, it essentially creates more similar-appearing tissue locally. The difficulty lies in patients in whom planned postoperative irradiation is contemplated. In such cases, prolonged tissue expansion (often 8-12 weeks, including the consolidation phase in major scalp reconstruction) may result in unacceptable delays in some oncologic resections. The issue of tissue expansion in the heavily pretreated scalp is somewhat controversial, with some researchers believing that it is safe and others that it is contraindicated. In general, we prefer to use free tissue transfer when patients have had previous irradiation or multiple scalp flaps.

In the traditional reconstructive algorithm, once local reserves of tissue have been depleted or are nonusable, one often turns to skin grafting techniques. Skin grafting of scalp defects gives a reasonable result in cases where the underlying pericranium centrally or the temporalis fascia laterally has been preserved. Skin grafting directly onto the calvaria or even the dura mater is feasible, but the resulting reconstruction is quite fragile, exposing the underlying calvaria with relatively minor trauma.[19]

Microvascular surgery allows for the transfer of large amounts of composite tissue to almost any recipient area.[19-23] As in other areas of the head and neck, the ability to match the resected tissue with a similar composite tissue allows for the best rehabilitative potential. In an area as visible as the scalp, the cosmetic outcome is also of paramount importance.

One caveat that must be remembered with free flap transfer is that restoration of the normal hair contour is not possible. Hair transplants in the transferred tissue have met with limited success. Thus, in a normally hair-bearing area of the scalp, tissue expansion and rotation/transposition flaps may represent the best alternatives for reconstruction. Rotation flaps generally should always be considered. These allow for the delivery of large amounts of hair-bearing scalp. In addition, they may be used in the forehead of balding individuals to bring appropriately non–hair-bearing skin to fill a defect. Generally, if a rotation flap can be designed with an arc of rotation 1.5 to 1.75 times the dimension of the defect, then primary advancement closure of the donor area and an excellent aesthetic and functional outcome can be assured.

Free tissue transfer is ideal in normally non–hair-bearing areas of the scalp, such as the forehead and temple regions. A fasciocutaneous flap is best in this area. Radial forearm, scapula, and anterolateral thigh donor sites have all been used. The anterolateral thigh flap is often too thick and has a poor color match. The scapula is a good option, but the need for intraoperative repositioning and the thickness of the back skin make it less ideal. The 1 exception that overcomes the inconvenience of repositioning for the scapula is when there is a significant forehead defect. Replacement of the forehead subunit with a scapula flap is the best reconstructive method for this location.[19] When there is a small forehead defect (<20 cm^2), the radial forearm is an excellent option (**Figure 3**). We prefer the radial forearm free flap owing to texture, color, pedicle length, and reliability. It provides for outstanding coverage of the forehead and temple and, in the patient with significant alopecia, for vertex reconstruction. It is thin and pliable, with an excellent color match. It accepts hair transplants reasonably well compared with other distant flaps. This is important in eyebrow reconstruction and in frontal hairline restoration.

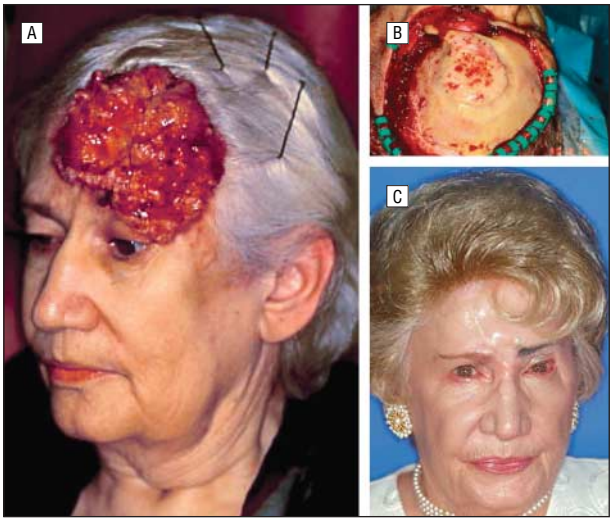

Figure 3. Forehead reconstruction. A, A patient with a large forehead lesion that required almost complete excision of the forehead. B, The operative defect is considerable, and it is not believed to be reconstructable using local flaps. C, A radial forearm free flap was used to reconstruct the forehead, with an acceptable result.

When larger amounts of soft-tissue coverage are required or there is a significant bony defect, latissimus dorsi or rectus abdominis free flaps provide ample tissue for coverage. In the occasional thin patient, a myocutaneous flap may be used, otherwise a muscle-only flap is harvested and primarily skin grafted. The ultimate texture and color match is not as good as with the radial forearm donor site, but it is acceptable (**Figure 4**).[19,22]

Salvaging a patient with radiation failure or local flap failure with exposure of the underlying dura mater or calvaria is generally also an excellent indication for free tissue transfer.[20] In these patients, the surrounding skin is often thin and tenuous far beyond the apparent obvious defect. Thus, removing the surrounding poorly vascularized tissue until viable tissue is found often leaves a large soft-tissue and bony defect. Latissimus dorsi and rectus abdominis free flaps represent excellent choices here as they offer enough bulk and thickness to adequately cover the exposed dura mater and the remaining calvaria. The aesthetic result is usually not bad as the skin color and texture match the hairless scalp.

Although osteocutaneous flaps can be used for composite defects of the scalp and underlying bone, it is generally difficult to achieve the proper orientation of the bone segment to make it ideal. Autograft (iliac, rib, or calvaria) or alloplast (titanium mesh or preformed, computed tomography–driven prefabricated construct) cranioplasty with rigid fixation and coverage with a well-vascularized soft-tissue envelope is preferable and allows for more precise reconstruction. The issue of timing the replacement of the underlying calvaria is somewhat controversial. Some surgeons prefer primary definitive cranioplasty to prevent overlying tissue contraction. Others believe that allowing the tissues to heal provides a better result, and they will secondarily reconstruct the

Figure 4. Scalp reconstruction. A, This patient has a large neglected tumor of the scalp. B, A subtotal scalp excision and a near-total forehead excision were performed. C, The defect was reconstructed using a free latissimus dorsi flap with skin grafts.

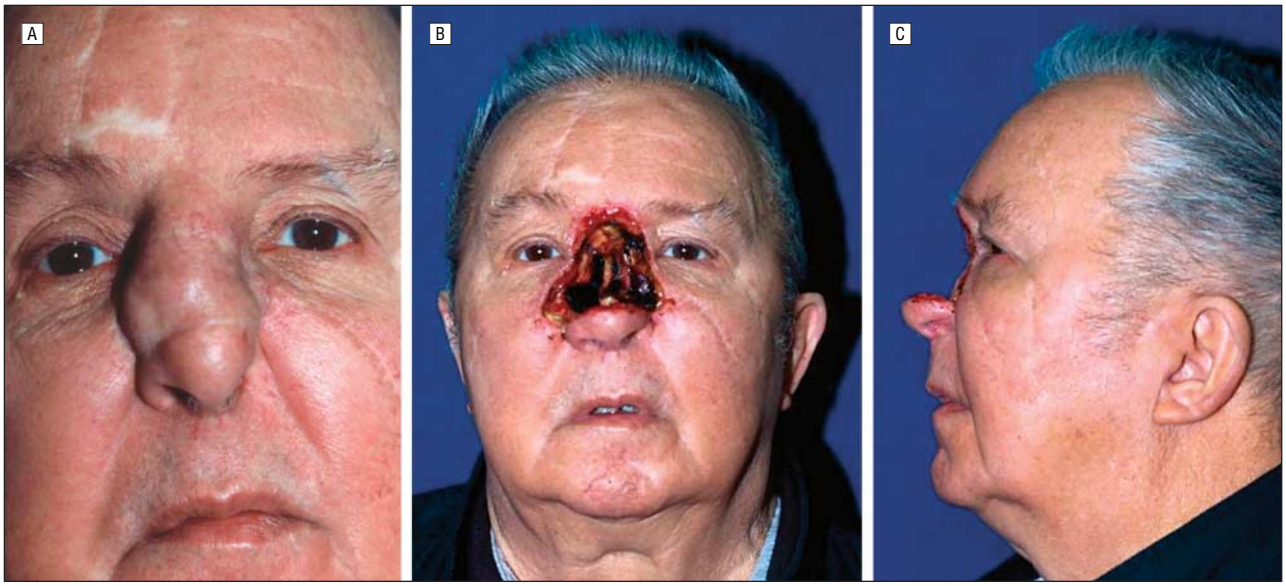

Figure 5. Nasal reconstruction. A, This patient has had a recurrence of his nasal cancer. He had previous surgical resection and irradiation. B and C, The resection involved most of his nasal structures. B, Anteroposterior view. C, Lateral view.

defect 3 to 6 months later. Both options are reasonable. In radionecrosis or an infective process, we prefer to wait 3 to 6 months to reconstruct the bony defect.[20]

Using adjunctive local flaps combined with free tissue transfer may optimize the ultimate aesthetic outcome and should always be considered. In addition, surgeons can perform primary free tissue transfer reconstruction to close a complex wound or expedite planned irradiation and secondarily perform tissue expansion to allow for movement of hair-bearing skin over an underlying well-healed soft-tissue envelope. Patient and surgeon preference, positive Allen test results, previous abdominal surgery, and other comorbidities all contribute to donor site selection.

TOTAL NASAL RECONSTRUCTION

The nose represents an example of a vitally important structure cosmetically and functionally. Situated as it is on the most prominent part of the face, it is often the first thing that others see. This primary position makes the cosmetic appearance and especially the reconstruction so important to body image and social interaction. The nose not only serves a vital cosmetic purpose, but it also has functional aspects. The ability to breathe through a nasal passage is an inborn need. In fact, nasal surgery to correct nasal obstruction is one of the most common procedures performed by otolaryngologists in the United States. Reconstruction of the nose presents a unique surgical challenge that must address the cosmetic and functional aspects of the nose. Subtotal defects have been well addressed in the literature using a variety of techniques.[24-30] Functional and cosmetic outcomes are excellent. Most of these techniques depend on the forehead flap for external coverage.[26] Reconstruction of the middle and internal layers must then be considered. The middle layer provides mechanical support for the nasal skeleton. The middle structural component of the nose is well reconstructed using various cartilage or alloplastic materials.[25,28] The internal lining can be problematic, yet it is of vital importance. Without robust, thin, and well-vascularized tissue that will support an epithelial lining, the reconstruction will be doomed as the internal lining contracts and destroys the

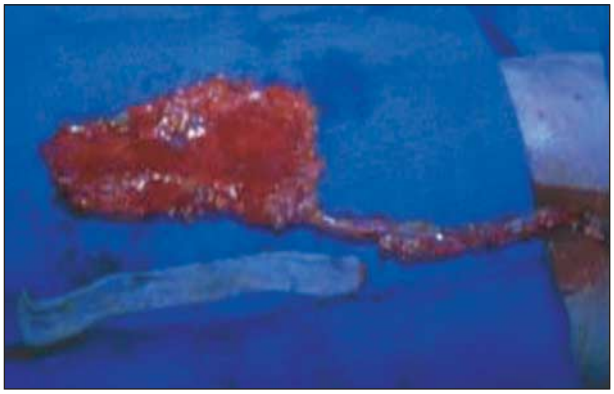

Figure 6. A facial free flap was harvested. No cutaneous components were included.

cosmetic and functional reconstruction. Many different techniques have been proposed for the internal nasal lining.[27] One technique is the robust inferior turbinate flap. Other options include turn-in flaps and rotation flaps. There exists a small segment of the nasal reconstruction population that has little available tissue for internal nasal reconstruction. In these patients, the only option other than prosthesis may be free vascularized tissue.

Although the definition of a total nasal defect is controversial, we consider that a total nasal defect refers to a loss of all 3 components of the nose: the external envelope, the middle structural components, and the internal nasal lining.[29] Reconstruction of this defect can be daunting. If the entire soft-tissue structures of the nose, along with the septum and inferior turbinates, has been removed, then the patient will have little tissue available to reconstruct the internal lining.

Another issue that can be seen in these patients is that they often have been heavily pretreated with multiple surgical procedures or irradiation. This makes the adjacent intranasal tissues poor material for reconstruction (**Figure 5**). The ability to harvest septal cartilage or even ear cartilage may be limited owing to previous surgical resections. This review does not discuss the external nasal envelope or the structural support because these have been well described in the surgical literature and in multiple textbooks.

The ability to reconstruct the internal nasal lining is often the most limiting factor.[27,29,30] Without an adequate internal lining, a scarring contracture will lead to stenosis and, ultimately, a poor functional outcome. In the past, skin grafts and turn-in flaps have been used. Skin grafts are often associated with dryness, crusting, and contracture. The ability to use turn-in flaps, whether they are from the turbinates, buccal mucosa, or septum, allows for excellent reconstructions when these tissues are available.[27] This tissue is healthy and, because it is normal mucosa, will not crust. It supports a middle structural layer, isolating it from the nose and allowing for revascularization of the cartilaginous structures. Furthermore, contracture is limited, and the functional results have been described as excellent. Occasionally, physicians encounter a patient whose turbinates have been resected, whose septal mucosa is unavailable, and, in general, who has a lack of mucosa that can be used for internal reconstruction.

Recently, Winslow et al[29] and Moore et al[30] described their experience with vascularized radial forearm free tissue transfer for lining in a total nasal reconstruction. The tissue of the radial forearm can be transferred as a fascial flap with a buccal mucosal free graft on top of it or as a fascia cutaneous flap with the native skin. The skin, when transferred, is frequently bulky, and multiple procedures are usually required to debulk the flap to allow for restoration of the nasal airway. Use of the flap and its vascular supply has allowed for placement of a middle structural support and a forehead flap for external coverage. Cosmesis has been judged as acceptable, with good functional outcomes in these patients. The radial forearm free flap is a well-described flap used by most reconstructive surgeons. It can be harvested using a 2-team approach. One team harvests the middle structural supporting structures and elevates the forehead flap and the other team harvests the forearm (**Figure 6**). Both teams then inset the free flap. The radial forearm flap may be harvested as an osteocutaneous free flap. The bone has been used to reconstruct the nasal dorsum as a bony strut. When used in this manner, the dynamics of the skin are tethered, and much flexibility in positioning of the skin is lost owing to the way the perforators to the skin travel. Thus, we have migrated toward using harvested rib cartilage for the dorsal support. A premaxilla defect is suitable for bony reconstruction with this flap. Again, care must be taken in designing the flap so that the skin orientation is adequate. Once the flap is inset, it is suspended to the bony strut to provide vascularized tissue to the strut and to open

Figure 7. View of the free flap being used for the internal lining. It is tacked to the bony strut that is used to reconstruct the nasal dorsum.

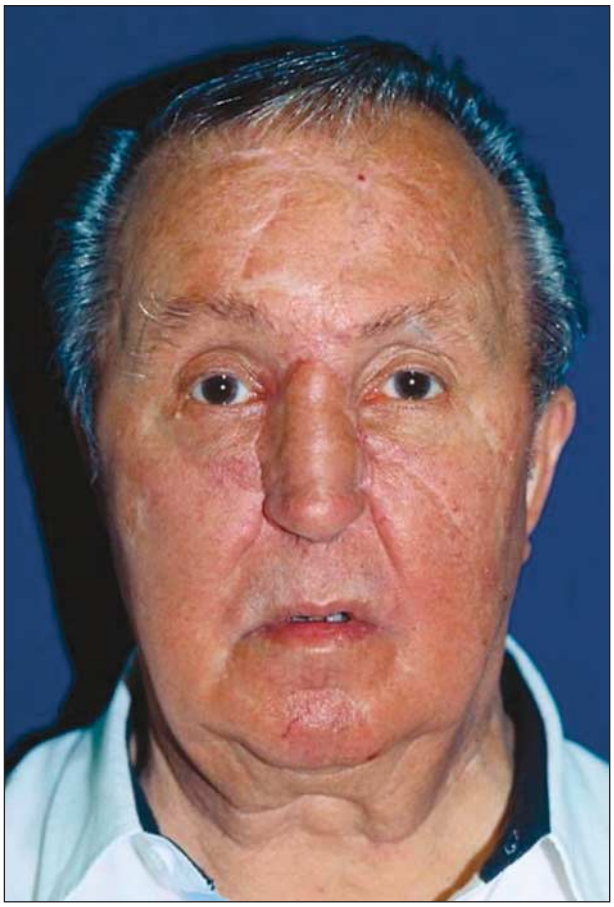

Figure 8. The 1-year postoperative photograph shows an acceptable cosmetic and functional result.

the nasal passage (**Figure 7**). The middle layer supporting structures are placed on this well-vascularized tissue, and a forehead flap is used to provide external coverage. These patients require a variety of revisions. The forearm flap is bulky, and even when harvested as a facial flap with no cutaneous portions it will block the nasal passage. We start revision surgery at 6 weeks to allow revascularization to take place. This way, if the pedicle is divided during the revision, the flap will still survive.

Reconstruction with the free flap allows for replacement of an internal lining that will not contract (**Figure 8**). The lining, while it is keratinizing squamous epithelium, loses this characteristic. The flap can be draped and fashioned to provide a complete internal lining. Refinements in total nasal reconstruction continue. Use of the forehead flap has been established as an excellent method of external nasal reconstruction.

Middle structural support from cartilage, either from the ear or costal cartilage, or various bony structures, either from the patient or alloplastic, has been reliable for reproduction of this important component. The internal lining, which has been more problematic, can be reconstructed using a radial forearm flap. Owing to the bulkiness and lack of natural mucosal coverage, this flap should be used only when other local tissues are not available. Patients must be cautioned that multiple revision procedures will be required to allow for debulking of the tissue.

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Announcement

Identifiable Patient Photographs

Please do not send masked photographs of patients.

Until the late 1980s, placing black bars over the eyes of patients in photographs was accepted as a way to protect the identities of patients. However, journals began to discontinue this practice when it became apparent that bars across eyes do not protect identities. Photographs with bars placed over the eyes of patients should not be used in publication.[1]

Authors may obtain the Patient Consent Form from www.archfacial.com. The patient should be offered the opportunity to see the manuscript before submission. When the manuscript is submitted electronically, send the patient consent by fax to the editorial office: (206) 386-3553.

1. Iverson C, Christiansen S, Flanagin A, et al. *AMA Manual of Style*. 10th ed. New York, NY: Oxford University Press; 2007:229.