NASAL RECONSTRUCTION

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HISTORY

The history of nasal reconstruction is essentially that of the field of plastic surgery. McDowell et al.1 reviewed the progress of surgery of the nose and included a very extensive bibliography. Antia and Daver2 and Mazzola and Marcus3 focused their historical researches on the forehead flap technique for total nasal reconstruction.

In 1925, Ivy4 discussed the repair of acquired defects of the face, focusing on the restoration of nasal parts. His paper lists various historical firsts in the evolution of nasal reconstructive procedures. Converse5 and Barton and Byrd6 also chronicled the development of reconstructive nasal surgery in their textbooks.

Nasal reconstruction apparently was born in Asia, most likely in India, around 3000 BCE. Because the nose was considered to be the organ of respect and reputation in India, nasal mutilation or amputation often was used to humiliate social offenders. According to Nichter et al.,7 the first detailed surgical description of the repair of an amputated nose is found in the Sushruta Samhita, one of the Brahmin holy books (circa 600 BCE).

The exact chronology of the spread of procedures for nasal reconstruction in Europe is somewhat unclear. Apparently, Buddhist missionaries carried the knowledge to Greece during its Golden Age.7 By 25 CE, Celsus, the great Roman physician, was known to be using parts of the technique.2,7 The initial references to nasal reconstruction were followed by a long silent period in history until the mid-15th century, when the Brancas of Sicily began using the Indian method of reconstruction of the nose. Encouraged by the intellectual climate of the Italian Renaissance, the Brancas went on to use an arm flap in nasal surgery for the first time.8,9

Traditionally, the brachial flap method of nasal reconstruction had been attributed to Gaspar Tagliacozzi in 1597. In 1995, Furlan and Mazzola8 established that the first case of nasal reconstruction by the Italian method was reported in the Western medical literature in 1502, and its author was Alessandro Benedetti. The authors reported that in Benedetti’s work, Anatomie, sive Historia Corporis Humani (Anatomy, or the History of the Human Body), he described nasal reconstruction by means of a skin flap taken from the arm.

In 1794, a letter appeared in the Gentleman’s Magazine of London describing the reconstruction of a mutilated nose with a flap from the central forehead. The communication was simply signed “BL”; evidence suggests that the author was a Mr. Lucas, an English surgeon who was residing in Madras, India, at the time. This now famous note told the story of the hapless Cowasjee, a bullock driver with the English Army in India, who, as a penalty of war, had his nose and one of his hands amputated. This letter effectively introduced the Indian
method of nasal reconstruction to the rest of the world. Many eminent surgeons subsequently used this method for restoration of the nose, among them Joseph Carpue, who, in 1816, reported his experiences with the midline forehead flap technique.

Other investigators were following different paths in their attempts to surgically restore the missing nose or its parts, and throughout the 19th century, French surgeons under the leadership of Dieffenbach used tissue from the cheek to reconstruct noses. In short, the evolution of nasal reconstruction procedures followed three basic lines: 1) the Indian method of midline forehead flap, 2) the French method of lateral cheek flaps, and 3) the Italian method of brachial flap.

In 1925, Blair reviewed the various techniques available for restoration of the nose and concluded that forehead flaps worked best for major defects. Blair is credited with establishing the midline forehead flap as the foremost method for nasal reconstruction. Burget and Menick deserve credit for advancing aesthetic and functional nasal reconstruction to its current level. The most recent textbook by Menick, published in 2008, illustrates advancements that greatly simplify repair of nasal defects requiring lining replacement, including the three-stage forehead flap and the folded forehead flap for lining.

### ANATOMY

The nose can be divided into thirds according to its underlying skeletal structure. The proximal one-third of the nose rests on the nasal bones; the middle one-third lies over the upper lateral cartilages; and the distal one-third or lobule includes the nasal tip with its paired alae overlying the membranous septum. The columella is supported by the medial crura of the alar cartilages, the soft triangle spans the junction of the ala with the columella on either side, and the entrance to the vestibule is the sill (Fig. 1).

From a basilar or worm’s eye view, the nostril should rise only one-half to two-thirds of the total height of the lobule (Fig. 2). The upper and most projecting portion of the lobule is the nasal tip. Millard adapted the concept presented by Gonzales-Ulloa of regional aesthetic units for nasal reconstruction (Fig. 3).
Ethnic Variations

Farkas et al.17 analyzed nostril types of whites, blacks, and Asians. Their study shows racial differences in shape, size, and angulation of the nares and emphasizes the importance of the basilar view in assessing the results of nasal surgery.

A group of plastic surgeons from Japan18 redefined the aesthetic units of the nose to better conform to Asian faces. The authors divided the nose into five topographic units: glabella, nasal dorsum, nasal tip, and two nasal alae. The border of the nasal dorsum unit was extended to above the maxillonasal suture.

Aung et al.18 from Singapore identified three distinct shapes of Asian noses from their studies with three-dimensional laser images. Type A has very prominent alae and a full and rounded nasal tip. Type B has less prominent alae and a well-defined nasal tip. Type C shows little prominence of the alae, resulting in a relatively straight slope from the tip to the alar base. In comparison with other racial groups, Asian noses are broader in relation to nasal height and show less tip protrusion in relation to both height and width of the nose. Additionally, Yotsuyanagi et al.19 showed that the oriental nose is lower, lacks nasal muscle, and has a flat glabella and that the nasal cartilage and bone are not distinctly reflected in appearance.

SURGICAL PLAN

Timing

In a review of the MD Anderson experience with 71 patients, Evans et al.20 reported safe nasal reconstruction immediately after extirpation of skin tumors in selected patients. Reconstruction was delayed under the following circumstances: 1) if the histological margins were questionable, 2) if the tumor histology was aggressive, 3) in cases of perineural or deep bony invasion by tumor, and 4) when radiotherapy was to be administered. Cancer extirpation by Mohs resection allows immediate reconstruction with the luxury of the smallest possible defect. A margin clearance up to 99% is considered by most to be the standard of care. Most melanomas might require negative permanent sections before reconstruction, in which case the wound is dressed and reconstruction is deferred until the histopathological examination is complete. Some Mohs dermatologists, however, excise facial lentigos and melanoma in situ lesions to allow immediate reconstruction by the plastic surgeon.20 Additionally, Mohs micrographic surgery is indicated for dermatofibrosarcoma protuberans, microcystic adnexal carcinomata, malignant fibrous histiocytomata, Merkel cell carcinomata, and some melanomata.20,21

Analysis of the Defect

Accurate analysis of the defect in terms of component layers is essential to the reconstructive plan. When one of the two epithelial surfaces is intact, skeletal support and cover often can be delivered expeditiously and reliably. When substantial amounts of all three layers are lacking, however, the reconstruction becomes more complex and less predictable. From a practical standpoint, the difficulty of the reconstruction grows as the amount of lining remnant diminishes.

The cartilaginous portions of the nose, especially the lobule, are most prominent and therefore most easily severed in traumatic injuries of the nose. Their restoration usually is termed subtotal reconstruction. The nasal bones, on the other hand, lie deeper and are seldom injured or involved with tumor. Millard22 defined a total nasal defect as one involving part or all of the nasal bones, although extensive replacements of only soft tissues and cartilage commonly are characterized as total.

Several factors must be kept in mind when replacing the external nasal skin. The design of the cutaneous model is critical to the success of reconstruction and is facilitated by using a pattern of the defect to trace on the donor area. When possible, the cutaneous pattern is based on the opposite side if the lost volume is to be accurately restored. The difficulty lies in converting a three-dimensional template (the nasal defect) into a two-dimensional pattern (the donor site). Patterns have been fashioned out of paper, cloth, tin foil (from a suture pack that is folded and crimped to mimic the contour of the nasal defect), Steri-Strips (3M Nexcare, St. Paul, MN) hardened with collodium, and an Esmarch bandage. Additionally, bone wax has been described as a template material for
three-dimensional reconstruction. Further refinement of preoperative template reconstruction is described by using three-dimensional laser surface scanning and rapid prototyping. Murrell and Burget constructed an accurate three-dimensional template of the surface defect using Aquaplast (W F R-Aquaplast Corporation, Wyckoff, NJ), a thermally activated plastic. The template is then converted into a two-dimensional foil pattern with releasing cuts and transferred to the forehead. In a series of 42 patients, Shumrick et al. advocated replacing both a dorsum and tip in nasal defects with disparate skin in the dorsum and tip.

The wound depth and the thickness of the surrounding skin influence the choice of reconstructive method. When only skin and dermis are missing and the bed is vascularized, a full-thickness skin graft (FTSG) might be adequate, especially on the upper and lateral nasal dorsum. When the loss of subcutaneous tissue is considerable, skin grafts will leave a contour depression and reconstruction with flaps is preferable.

The color and texture of the remaining nasal skin must also be considered when choosing a donor site. The donor skin must match closely the skin of the recipient area. The size of the defect influences the choice of donor skin for nasal reconstruction, considering that each donor source has its limits. As Limberg indicated, the amount of tissue needed for reconstruction is often underestimated.

In general, skeletal support must be provided early in the operative sequence. The external nasal skin will never be as pliable as when it is first transferred. It is also much easier to maintain projection of the nasal tip than to try to recapture it after it is bound down by scar.

Subunit Reconstruction

One of the most important and most often misunderstood concepts in nasal reconstruction is the subunit principle. In 1985, Burget and Menick described the nasal subunits (Fig. 4).

The borders between the units are transition areas in the contour of the nose where shadows are detected under conditions of normal lighting. The authors championed the concept of entire subunit reconstruction, taking care to place the incisions along the joins of aesthetic subunits to further camouflage the scars and to take advantage of intrinsic scar contracture. Also, the surgical skill in recreating a subunit will become a repeatable learned skill and will not vary among the defect requirements.

The controversy involving subunit reconstruction centers on the management of partial subunit loss. Burget and Menick proposed that when the nasal defect spans >50% of an aesthetic subunit, the remaining portion should be removed to convert it to a full subunit reconstruction. They recommended that when the skin defect is <50% of the aesthetic subunit, the subunit should be ignored rather than converted to a larger defect.

Singh and Bartlett and Rohrich et al. argued against strict adherence to the subunit principle. Singh and Bartlett presented a discussion of instances when modifications of the subunit principle are indicated. On the basis of their experience with 1334 cases, Rohrich et al. advised maximal conservation of native tissue and wound coverage to obliterate only the defect, not the subunit. Dermabrasion is used to blend the edges of the flap into the adjacent nasal skin. Most illuminating are the thoughtful discussions presented by Menick. The serious nasal reconstructive surgeon would do well to study the arguments and counterarguments presented in his reports.

In the context of a discussion on pediatric nasal reconstruction, Menick softened his stance on strict adherence to the subunit principle. While addressing nasal reconstruction in children, Menick wrote that the “subunit principle” had been suggested as a technique to hide scars and harness flap contraction. He advised that if a defect encompasses more than 50% of a subunit, the residual normal tissue within the subunit should be excised and the entire subunit replaced with a flap, as opposed to simply patching the defect. This maneuver was noted to be most effective in the reconstruction of the tip and ala, which are convex subunits. Wound contraction, which occurs in the bed of flaps, augments the “expected” convexity of the subunit. In addition to the contour effect, considering that the tip and alar subunits are outlined by somewhat abrupt and distinct borders, scars at their joins are less obvious than they would be if placed across their
smooth convex surfaces. Menick noted that the subunit principle does not apply when repairing the sidewall or the dorsum at the junction with the radix, because these relatively flat subunits flow indistinctly into adjacent units. A scar placed within the sidewall will have an appearance that is no better or worse than those placed within the subunit or at its join with the cheek. Menick advised that discarding extra skin has important implications. Larger recipient defects require larger forehead flaps and create greater donor defects, requiring additional support grafts. The author reported that he rarely excises additional skin, except within the tip and ala, even in adult patients.

**Patient Age and Reconstructive Method**

*Children*

Based on their experience with 29 cases of nasal reconstruction in children who were 1 to 15 years old, Pittet and Montandon urged surgeons to start the reconstruction early despite possible reoperation later. Although the best results are obtained at the end of growth or at least after the age of 12 years, psychosocial reasons override aesthetic considerations in a pediatric population and many clinicians think it is advisable to reconstruct the noses of young children before they commence school.

Giugliano et al. reported their experience with 10 cases of pediatric nasal reconstruction after traumatic injuries and congenital deformities. The authors presented their results and complications and discussed their philosophy of pediatric nasal reconstruction. They emphasized the differences between children and adults regarding nasal reconstruction, as did Menick in his discussion, particularly the timing of the reconstruction procedure, application of the subunit principle, and limitations. Ultimately Giugliano et al. acknowledged that even a technically successful and appropriate nasal reconstructive procedure in a young child might not hold up over the long-term under forces of facial and nasal growth in the context of scarring, grafts, and flaps (Fig. 5).

Kadlub et al. described subtotal nasal reconstruction performed with a forehead flap and rib auricular cartilage in a 2-year-old child. Building on the experience presented by Giugliano et al., Kadlub et al. avoided using septal cartilage and respected some basic principles: 1) the donor site should be carefully conserved for potential further surgery; 2) careful preservation of
intranasal tissue should be considered to prevent further scarring; and 3) the paramidline forehead flap should be used if possible, as in adults.

Some patients might require second forehead flaps and further nasal reconstruction as adults, when growth has slowed. Menick\textsuperscript{32} recommended preserving the contralateral pedicle forehead flap in case it is needed later. He emphasized the importance of preserving nasal lining and septal cartilage in pediatric nasal cases and noted that disturbing those structures at a young age could further compromise nasal growth in addition to making them unavailable for secondary reconstruction in the adult. The use of rib and ear cartilage at age 6 years or later is preferred in children.\textsuperscript{32}

\textbf{Adult}

Shumrick et al.\textsuperscript{37} assessed patient age as a factor in nasal reconstruction. In a series of 15 patients who were 80 years and older whose nasal defects were repaired using forehead flaps, with cartilage grafts in six and intranasal mucosal grafts in five, no perioperative morbidity or mortality occurred and the aesthetic results were considered good to excellent. The authors concluded that the choice of reconstructive method should not be based on age alone but should also take into account the mental status, preferences, and medical condition of the patient.

Prosthetic reconstruction with Brånemark osseointegrated implants (Nobel Biocare, Zurich, Switzerland) should be considered when treating elderly and high-risk patients who are not candidates for

\textbf{Figure 5.} Tip and alar reconstruction in a child. (Reprinted with permission from Giugliano et al.\textsuperscript{34})
protracted, multistage surgical procedures. The initial reconstructive surgery after radical nasal excision should be limited to preparing the upper lip bed to receive a prosthesis. Craniofacial osseointegration changes patients’ perceptions of a nasal prosthesis and improves quality of life. Any surgeon undertaking pediatric nasal reconstruction would do well to review the beautifully illustrated continuing medical education article and case review of 25 pediatric nasal reconstructions presented by Burget.

SKELETAL SUPPORT

As early as 1861, Ollier included a piece of frontal bone attached by periosteum to a forehead flap used in reconstruction of the nose. At about the turn of the century, Israel grafted autogenous bone and von Mangoldt transplanted costal cartilage for nasal support. Millard suggested that skeletal elements must be an integral part of the initial plan for reconstructing a nose. He emphasized that soft tissue dimensions must be maintained rather than recaptured and warned that once soft tissues collapse and become fixed by scar, secondary elevation is disappointing.

From a skeletal standpoint, the nose is composed of two distinct elements: a rigid central framework and the more flexible lateral walls. The former serves in projecting the nose and maintaining tip elevation, while the alar cartilages tent the vestibule and keep the nostril wings open to permit air flow without fracturing.

Midline

Sullivan et al. showed that the nasal bone is widest at the nasofrontal suture (14 mm), narrowest at the nasofrontal angle (10 mm), and then widens again inferior to the nasofrontal angle (12 mm). The nasal bone is thickest superiorly at the nasofrontal angle (average thickness, 6 mm) and progressively thinner toward the tip. In the critical area where screws are most commonly placed for fixation (5–10 mm inferior to the nasofrontal angle), the nasal bone is 3 to 4 mm thick. In the intact nose, the septal cartilage bridges the gap between the nasal bones above and the vomer and maxilla below while extending outward from the facial plane.

No one questions the need for midline support of the reconstructed nose to prevent tip collapse, but a great deal of disagreement has been expressed regarding which method to use and when to use it. The four most common surgical approaches involve an L strut, a hinged septal flap, a septal pivot flap, and a cantilever bone graft.

L Strut

The L strut technique consists of a longitudinal piece of bone or cartilage that is seated on the nasal radix and extended along the dorsum to the tip, where it is bent sharply to rest on the anterior nasal spine. Gillies was the first to describe the procedure in 1920, and it has been widely practiced since. Chait et al. prefer a costal osteochondral graft from the fifth rib. The cartilage portion is easily carved into the appropriate hockey stick configuration to project the tip and substitute for the medial crura. Its disadvantage is side-to-side instability.

Hinged Septal Flap

Millard described an L-shaped flap of septum hinged superiorly to augment the nasal angle. The septal flap is carved from the remaining septum and hinged on the caudal end of the nasal bones to pivot upward (Fig. 6).
Septal Pivot Flap

Burget and Menick\(^49\) proposed simultaneous lining and some dorsal skeletal support with a composite flap of septum pivoting anteriorly (Fig. 7). The support of the nasal bridge is augmented by a cantilever graft of rib cartilage.

Cantilever Graft

Converse\(^5\) and Millard\(^22\) experimented with cantilever bone grafts for midline nasal support. A strong, longitudinal piece of bone is affixed to the radix and extends along the dorsum down to the tip, which does not need to be further shored up from below (Fig. 8). The cantilever graft is either embedded in the frontal bone, wired to the nasal bones, or both.\(^2\) The remaining nasal bones frequently must be lowered to make room for the bone graft.

Chait et al.\(^47\) suggested an osseocartilaginous rib graft as cantilever, arguing that the bony portion of the graft in contact with the nasal bones solidifies in situ while the distal cartilaginous portion keeps the nasal tip pliable and resists resorption. The authors reported graft adherence and stability by 3 weeks postoperatively in their series. Of 25 patients with various nasal deformities who received these composite grafts, only one showed evidence of subsequent warping of the cartilage.

Daniel\(^50\) reported the use of an osseocartilaginous rib segment for nasal reconstruction. The osseous part of the graft is contoured extensively and affixed to the nasal radix through an open approach, while the cartilaginous segment is minimally altered and adds tip projection and columellar contour.

To obtain a soft nasal tip, Neu\(^51\) combined a cantilever graft of outer calvarial bone with an abbreviated L strut of septal or conchal cartilage. A single onlay cartilage graft or multiple septal grafts sutured to the sides of the L strut completed the reconstruction. Neu reported satisfactory outcomes in 12 patients who had nasal reconstruction with cranial bone grafts for the upper two-thirds of the dorsum and septal or conchal cartilage for the lower one-third. He noted that cranial bone provided more consistent results than did composite rib reconstruction and avoided the problem of cartilage warping. No visible bone or cartilage resorption was reported after 3.5 years of follow-up.

![Figure 7. Septal pivot flap combined with cantilever graft for dorsal support. (Reprinted with permission from Burget and Menick.\(^49\))](image-url)
Thomassin et al.\textsuperscript{52} recommended calvarial bone as a graft source for dorsal nasal support in saddle nose correction on the basis of its superior non-resorptive quality. The authors noted that calvarial bone, being a membranous bone, has many advantages over endochondral bone sources of graft material. They stated that calvarial bone is relatively easy to harvest and has proven to be a versatile and reliable means of reconstructing the cartilaginous and bony nasal pyramid.

Most practitioners now fashion cantilever bone grafts of calvaria or rib and secure them with miniscrew fixation, foregoing the instability of nasal wiring. This technique was well described by Shubailat,\textsuperscript{53} who harvested osseocartilaginous tissue from the 10th rib in a 70:30 bone:cartilage ratio. The author used a 1.5-mm drill bit to make a hole 8 to 10 mm from the proximal bony edge of the graft. The graft is affixed to the bony platform with a 2-mm microscrew introduced through a stab incision in the glabella and countersunk in place. Shubailat reported no warping of the short cartilaginous segment in his series of 48 patients who underwent the procedure.

Periosteal Flap

Brackley and Jones\textsuperscript{54} described a unique application of a periosteal flap harvested from the forehead and transferred to the nasal dorsum after tumor resection. The periosteal flap was used to supply a vascular bed for bilateral conchal cartilage grafts that served as structural scaffolding for a paramedian forehead flap. Because of an absent nasal septum, the periosteal flap with sandwiched conchal cartilage graft provided both adequate midline support and a suitable lining to the nasal cavity.

Conchal Cartilage Graft

Pirsig et al.\textsuperscript{55} reported the long-term results of anterior nasal septum reconstruction with grafts from the cavum conchae. In a series of 26 patients with saddle nose or destroyed septum, the authors carved a graft from the external ear by an anterolateral approach. A layer of perichondrium and soft tissue was preserved on the posterior surface of the graft. The graft was 2.5 to 3 cm long, which was long enough to allow reconstruction of the anterior septum and to correct part of the saddle nose deformity (Fig. 9). The rest of the conchal cartilage was used to fill the remaining saddle. After a mean follow-up of 3 years, the grafts showed no signs of resorption, with adequate projection, position, and shape.

Other

Kobayashi et al.\textsuperscript{56} lengthen a short nose by en bloc osteotomy of the nasal bones with inferior displacement of the osteotomized segment and fixation with a miniplate. The reconstruction is completed with a forehead flap for external cover and a nasalis musculocutaneous island flap for lining (Fig. 10)\textsuperscript{56}.

Experimental studies of osseous reconstruction in the face with type I collagen gel augmented with insulin-like growth factor 1 (IGF-1) have produced encouraging results.\textsuperscript{57} Working in a rodent model, T oung et al.\textsuperscript{58} documented complete coverage of nasal defects with a thin layer of regenerated bone by day 30 in animals treated with this protocol. In contrast, the control group had <10% healing after 6 months. Histological evaluation revealed increased bone density and thickness when IGF-1 was added to the collagen gel.

Lateral

Currently, most plastic surgeons think that an added...
Figure 9. Septal reconstruction with back-to-back conchal cartilage graft. The graft is harvested through an anterolateral approach, preserving the posterior perichondrium, folded on itself, and affixed to the anterior nasal spine and septal remnant with Vicryl sutures. The remaining saddle is filled with remnants of the ear graft deposited in layers. (Modified from Pirsig et al.)
measure of cartilage is necessary to stiffen the nostril wing to ensure adequate air flow. Various methods for integrating cartilage in the reconstruction are discussed herein under the headings of “Lining” and “Skin Cover.”

The patency of the airway should not be compromised for the sake of alar shape and stability. The challenge facing the reconstructive surgeon is to reproduce the delicate contours of the nasal ala while bringing sufficient structural rigidity to prevent collapse.

**Alloplasts**

For cases of total or near-total nasal defects, Bikhazi et al. proposed reconstruction with Vitallium alloy of 60% cobalt, 20% chromium, 5% molybdenum, and other substances or titanium mesh for the dorsal framework, tissue-expanded paramedian forehead flap for soft-tissue coverage, and chondrocutaneous ear grafts for the tip. The combination of alloplastic and autogenous-tissue reconstruction has certain advantages over cranial bone grafts. The Vitallium and titanium meshes are pliable, easily stabilized to both dorsal and lateral nasal walls, and readily accessible without additional morbidity. The primary disadvantage is the risk of implant exposure and local infection. The mesh also interferes with radiological imaging in cancer patients.

Romo et al. described a series of 187 nasal reconstructions with porous polyethylene implants (Medpor Implants; Stryker Corporation, Newnan, GA). Most patients in their series required multiple implants, including columella struts, plumper grafts, dorsal tip implants, and nasal valve battens. During follow-up of 6 months to 3.5 years, infection developed in five patients (2.7%), necessitating implant removal. Another patient was overcorrected and subsequently required implant removal, reduction, and reinsertion. No other complications were noted. The authors concluded that Medpor implants are well tolerated and provide ideal material for nasal reconstruction.

In another article, Niechajev reported using Medpor in reconstruction of the nasal framework in 23 patients. Surgical indications were a depressed nasal dorsum (saddle nose) in eight patients and various types of “catastrophe noses” of insufficient length or projection in 15. For nasal applications, Medpor is available as a strut or sheet. Once implanted, the Medpor becomes rapidly vascularized and both soft-tissue and collagen ingrowth occur. The author reported two complications: one small implant exposure and one infection. After revision and antibiotic treatment, both patients healed without further problem. The reconstructive results were said to be aesthetically and functionally satisfactory, durable, and stable after a mean follow-up of 2 years. Another series concurred.

**Figure 10.** *A,* Reconstructive lining using a nasalis musculocutaneous island flap. *B,* Application of the reconstructive framework and covering. *(Modified from Kobayashi et al.)*
LINING

Indications and Timing

When possible, it is best to provide for nasal lining, skeletal elements, and external cover in one operation. Doing so ensures even healing and offers maximum flexibility of the tissues for shaping the reconstructed part. When the lining defect is very large, however, some surgeons think it wise to stage the reconstruction and attach the proposed lining replacement to the external flap at a preliminary procedure. Staging the operations averts the problems that would ensue if the tissues used in the reconstruction were lost. Once it has been ascertained that the lining graft is viable, the cover flap can be transferred. A certain degree of cicatricial stiffening occurs during prelamination, which limits flexibility of the flap and hinders sculpting later. Some surgeons think that this results in a rigid, fixed shape that seldom fits the new nose when transferred.

In the event of even partial necrosis of either the lining or skeletal elements, secondary contracture inevitably and irreversibly distorts the overlying skin contour. Subsequent salvage or revision procedures rarely return nasal dimensions and contour to their former status. One can argue that adequate lining is the most important element of nasal reconstruction.

History and Techniques

Ivy credits Labat in 1833 with the first attempt to improve the shape of the reconstructed nostril by supplying lining. Many procedures were developed to resurface the interior of the nose, such as hinged flaps of nasal tissue turned inward, infolded tips of other flaps, skin grafts of the undersurface of forehead flaps, composite flaps of nasal septum, and mucosal advancement. Burget and Menick devised clever techniques for bringing vascularized lining to the nasal lobule. Some of the techniques are described below.

Hinged (Turn-in) Nasal Flaps

According to Ivy, Keegan was the first to turn in flaps from the wound margin to replace the missing nasal lining. The flap is hinged on the outer cicatricial edge and flipped over to span the defect. Turn-in flaps are particularly useful when skeletal support needs to be introduced at a later time in that they afford two independently vascularized surfaces that can be separated.

Lee et al. also recommended the hinged flap for one-stage reconstruction in full-thickness defects of the anterior nasal ala. A Bürow triangle is incised just above the defect, and a flap of skin with subcutaneous tissue is raised at the superior apex of the triangle and peeled back inferiorly. The flap is folded on itself and sutured in place to recreate both the inner and outer aspects of the ala. A subunit approach to ala and tip defect reconstruction with turnover skip flaps, based on the superior ala branch (or lateral nasal artery), was performed in 12 patients by Ulug and Kuran.

Folded Extranasal Flaps

Mazzola and Marcus attribute the concept of folding a forehead flap to resurface the interior of the nose to Labat, who is responsible for popularizing the technique in Europe. Ortiz-Monasterio pointed out that Labat’s 1834 book on rhinoplasty credits Delpech in 1821 with first mention of the procedure, which Blair presented in the United States.

In 1949, Gillies introduced bilateral nasolabial flaps turned inward to line the nasal vestibule and columella, a procedure later refined by Millard for additional lining of the alae. Variations on this theme have been reported by Georgiade et al., Santos and Pappas, and Hosaka et al.

Mavili reported rotating a superiorly based upper lip flap on a columellar pivot to line the nasal ala and vestibule. External cover is accomplished with an FTSG, a forehead flap, or a cheek flap. Unfortunately, the method tends to yield asymmetrical nostrils, a constricted airway, and an obvious scar at the donor site.

Skin Graft to Forehead Flap

Millard traced the use of a preliminary graft applied to the undersurface of the reconstructive flap for nasal lining to Lossen in 1898. Gillies expanded the idea by grafting a composite of skin and cartilage from the ear to
the underside of an up-and-down flap for simultaneous replacement of cover, lining, and skeletal support. Some years later, Converse74 grafted a chondromucosal segment from the nasal septum onto the tip of a forehead flap. Barton75 presented an illustration of the grafting of auricular skin and cartilage onto a midline forehead flap before transfer to the nose (Fig. 11). Another useful source of graft tissue for nasal lining is the hard palate mucosa.76

**Septal Door Flap**

Use of the first chondromucosal septal flap for nasal lining was reported by de Quervain77 in 1902. Millard,48 Burget,11 and others78−80 have since reported its use in the repair of unilateral full-thickness nasal defects. Burget and Menick stated that the contralateral septal mucosal flaps are tethered by their base on the septal dorsum and will not reach inferiorly to the level of the alar margin on the side of the defect. The authors noted that the flaps could be used to line the upper vestibule and middle nasal vault but not the alar margin. The technique involves removal of septal mucosa ipsilateral to the defect and dissection of an appropriately sized flap of septal cartilage. This septal door is then made to open on a dorsal hinge toward the reconstructive side, so that the septal mucosa on its far side bridges the wound and lines the airway (Fig. 12).48,80 Enough septum must be left in place along the dorsum to support the midline, prevent collapse, and help with nasal projection. The ipsilateral mucosa of the septal flap is either removed before suturing the septal flap into the defect or raised in hinged-door fashion to line the neonasal vestibule80 or to close the septal perforation.47

**Septal Mucoperichondrial Flap**

Burget and Menick49,65 described a bipedicled mucosal advancement flap based medially on the remaining septum and laterally at the piriform aperture (Fig. 14). The flap is based on the lateral floor of the vestibule and is advanced medially to resurface small defects of alar lining, as originally described by Kazanjian.82 The vascularized mucosa can immediately support an auricular cartilage graft to give the necessary rigidity to the alar rim, eliminating the need for a preliminary lamination step. The residual window of donor lining can be closed secondarily with a contralateral chondromucosal flap as originally described65 or with a longitudinal flap from the ipsilateral nasal septum.80 Many previously difficult lining reconstructions can be satisfactorily addressed with the three-stage forehead flap presented by Menick.11

![Figure 11. Auricular sources of cartilage for nasal reconstruction. Cartilage graft for alar support and full-thickness graft for alar lining are applied to the forehead flap before transfer. (Modified from Barton.75)](image-url)
Free Flaps

For a discussion of free flaps used for nasal lining, see the Free Flap section below.

Split Forehead Flap

Some of the most striking results were obtained in an 11-patient series presented by Li et al. The authors used an obliquely oriented paramedian forehead flap split into a muscle flap and skin flap (Fig. 15).

SKIN COVER

Dorsum, Medial Canthus, and Sidewalls

Skin Grafts

The skin over the upper two-thirds of the nose is generally thin, loose, and mobile, with few sebaceous glands. Repair of defects in that area is relatively simple. Color-matched FTSG from the pre- or postauricular region serve well for the upper two-thirds of the nose, medial canthal region, and upper sidewalls. Preauricular grafts are especially suited to reconstruction in women because of their texture, color, and thickness and because the donor defect is easily hidden. The grafts can also be used in men if the beard pattern allows. Meyers et al. reported the use of dermal grafts under FTSG for the repair of small defects. The purpose of the dermal grafts is to provide support beneath the skin grafts to help prevent hollowing and contour irregularity.
Lacking to date is a comparison of the results obtained with the dermal + skin graft technique versus composite FTSG + fat grafts and FTSG alone.

Gloster\textsuperscript{86} noted that FTSG are viable alternatives to local flaps in the repair of nonperforating defects of the nose. From a review of the literature and his own experience, he lists the best graft sources according to location of nasal defect, as follows:

- upper two-thirds of dorsum or sidewalls
- preauricular area
- lower one-third of dorsum, tip and alae
- auricular concha
- supratip (transition) area
- nasolabial fold
The use of artificial dermis and skin, referred to as dermal substitute, has been described in both full- and split-thickness grafting.87

Cheek Advancement Flaps

Cheek advancement flaps (Fig. 16) have long been used for the repair of lateral nasal defects, particularly in elderly patients. The cheek is best used as replacement for the nasal sidewall, not the dorsum, which is best replaced with forehead skin. Alternatively, the cheek tissue can be used as foundation for the nasal base before forehead flap reconstruction. Laxity of the cheek skin allows straight advancement of a well-designed flap onto the nasal sidewall with minimal undermining. As much as 2.5 cm² of skin from the paranasal and cheek areas can be advanced for nasal reconstruction while closing the donor site by direct approximation.

Rhomboid-shaped flaps from the cheek can also be used to repair defects of the nose.88 The disadvantages of this method are increased length of the scar and visible donor site scars. Nevertheless, with enough laxity in the cheek, well-designed rhomboid flaps can suitably reconstruct the nasal sidewall.88 An alar crease can be fashioned at a second operation to recreate the natural boundary between the lateral nasal wall and the cheek proper.

Figure 16. Cheek advancement flap.

Glabellar Flap

For a glabellar flap, McGregor89 recommended transferring redundant skin from the glabella onto the root and upper bridge of the nose to repair defects in the area.

Dorsal Nasal Flap

The dorsal nasal flap and its variants are also good options for the dorsum. These flaps essentially match like with like in this setting. For dorsal defects, the classic Rieger flap with extension on the forehead usually is required. The modification described by Rohrich et al.,90 without forehead extension, might not provide sufficient laxity for proximal dorsal defects.

Forehead Flap

The forehead flap is another option for larger dorsal defects.91,92 Park92 described a variant that is tunneled as an island flap for effective one-stage reconstruction of the nasal dorsum.

Tip and Alae

The skin of the lower one-third of the nose is thick, oily, and closely attached to the underlying alar cartilages. Aesthetic reconstruction in this area is technically much more difficult than on the dorsum. Humphreys et al.93 reviewed the surgical options for closure of alar defects according to thickness, location, and complexity of the defect.

Reconstruction of shallow, small (<1 cm), lower-third nasal defects with FTSG has been well reported in the dermatology literature but is considered by plastic surgeons to be a poor choice. Hubbard94 described 33 lower-third nasal defects reconstructed with skin and fat composite grafts harvested with the nasolabial fold. Further experience with skin grafting for lower-third nasal defects was reported by McCluskey et al.95 in a series of 55 patients. Good contour and color match was achieved if the following principles were followed.

1. Defect selection should be rigorous and should include only superficial defects
and size-limited defects. Defects $>$1 cm are better treated with alternative reconstruction. Defects that involve cartilage or go deeper are, by definition, complex nasal defects that require onlay cartilage grafting for satisfactory reconstruction. Skin grafting is not offered for these defects.

2. Caution is required when skin grafting defects abutting the alar rim.

3. Graft donor site selection needs to be meticulous; the thicker and better color-matched forehead skin should be used in the majority of cases.

4. Size matching of the graft also needs to be meticulous; a foil pattern template and developmental bolster material from a surgical sponge that provides ideal compression and handling qualities should be used in conjunction with through-and-through central Prolene suture to minimize graft dead space.

5. Liberal use of postoperative dermabrasion optimizes the final color match.95

Contrary to conventional thinking that dictates flap tissue for lower-third nasal reconstruction, Hubbard94 used skin-fat grafts to repair such defects in 29 patients and achieved excellent results. All grafts were harvested with excess fat from the contralateral nasolabial fold. Each was initially sutured along one edge to enable sequential defatting until the graft surface was flush or slightly below the anesthetic-engorged surface of the defect. All grafts were sutured in place with circumferential 6-0 nylon sutures without bolsters. One or two quilting sutures were used for a couple of days in grafts $>$8 to 10 mm in diameter. Of 33 grafts, 29 survived completely and four developed a small area of central necrosis. No grafts were lost. There was one infection that cleared with oral antibiotics. At the 6-month follow-up visits, hypopigmentation was seen in nine cases and hyperpigmentation in one. The author emphasized the no-bolster technique, stating that bolsters prevent normal edema and compress the subdermal plexus that is still present in the grafts.

Chondrocutaneous and Composite Grafts

Small through-and-through defects of the alar rim can be repaired with chondrocutaneous grafts from the ear. Originally described by König96 in 1902, auricular composite grafts for nasal reconstruction were popularized by Gillies44 in Europe and by Brown and Cannon97 in the United States, who used grafts from the helical margin. Argamaso98 preferred the root of the helix for harvesting chondrocutaneous grafts, as did Burget99 at a later date. The maximum safe size of a composite graft is likely approximately 1.5 cm.

In 1946, Dupertuis100 described his experience with free composite grafts of skin and fat from the earlobe in the repair of defects of the nasal lobule. Gloster and Brodland101 reconstruct the nasal tip and nasal ala with a composite graft of skin, subcutaneous tissue, and perichondrium harvested from the auricular concha. They reported achieving excellent cosmetic and functional results with a single-stage, outpatient procedure.

The survival of composite grafts depends on an ideal vascular bed. If the recipient site is scarred from previous surgery or radiation, a composite graft is probably not a wise choice for reconstruction. Various maneuvers have been developed in an attempt to improve the survival of this often-tenuous reconstructive method. Chandawarkar et al.102 create a dermal pedicle on the graft to improve the contact area between the graft and its recipient bed, a technique they call modified composite grafts. In a series of 50 patients, only two showed partial graft loss. Grafts up to 2 cm in diameter were successfully used, perhaps aided by postoperative cooling of grafts $>$1.5 cm, as recommended by Hirasé103 to improve graft survival.

Our experience with large composite grafts has not been as encouraging, and we limit the size of composite grafts to $\leq$1.5 cm. As expected, smaller grafts are significantly more reliable than larger ones.

Banner Flap

The best sources of skin for nasal reconstruction, in descending order, are the face, mastoid region, and neck. A number of flaps from the nose itself have been used to repair small nasal defects. These flaps capitalize on the relative laxity of tissues in the upper two-thirds of the nose and glabella.
In 1969, Elliott\textsuperscript{104} introduced the banner flap, which consists of a transverse narrow triangular flap of skin from the nasal dorsum adjacent to the defect (Fig. 17). The author reported only one partial loss among 70 flaps. The wounds measured 0.7 to 1.2 cm in diameter and ranged as far as the nasal tip. For moderate-sized (1.2–1.9 cm) defects of the tip, Elliott recommended the bilobed design because large banner flaps tend to distort nostril position. The flap donor site is always closed primarily.

Masson and Mendelson\textsuperscript{105} lengthened the banner flap and placed it on the side opposite the defect, effectively increasing flap reach. This modification also serves to elevate both nostrils slightly, which helps with symmetry. The authors reported their experience with 100 banner flaps to cover wounds averaging 1.75 cm in size, with several of them as large as 2.5 cm. Only three unsatisfactory results occurred in that series. The “note flap” presented by Walike and Larrabee\textsuperscript{106} is essentially a modified banner flap that provides easier closure with less dog-ear formation.

Zitelli\textsuperscript{110} emphasized the following points:

1. Allow no more than 50 degrees of rotation for each lobe, a total arc of 100 degrees.
2. Excise a “dog ear” between the defect and the pivot point of the flap before rotating it.
3. Undermine widely, just above the level of the periosteum and perichondrium, on both sides of the incision.
4. Make the first lobe as large as the defect. The second lobe can be narrower but wide enough to cover the donor site.
5. Use the bilobed flap for defects $\leq$1.5 cm in diameter.

According to Burget and Menick,\textsuperscript{11} the medially based design of the bilobed flap is reserved for cases in which the defect is so lateral that the flap design would be crowded off the nose onto the cheek and lower eyelid. In such circumstances, the flap should be based medially so that the second lobe can be traced on the skin of the nasal sidewall, dorsum, or glabella. The authors preferred the Zitelli design as their flap of choice for repair of defects between 0.5 and 1.5 cm in diameter within the thick-skinned zone of the nose. They referred to that method as their “workhorse.” In the dermatology literature, Cook\textsuperscript{111} provided excellent clinical examples of the use of the bilobed flap.

**Dorsal Nasal Flap**

The dorsal nasal flap described by Rieger\textsuperscript{112} is based laterally and elevated on the angular vessels. The entire nasal dorsum is degloved, and the skin flap is rotated and advanced distally. The flap is most useful to correct defects of the lower half of the nose and lobule that are $<2$ cm in diameter, $\geq1$ cm away from the alar rim, and above the tip-defining points (Fig. 19).\textsuperscript{90} It will not reach the columella.\textsuperscript{90,113}

When elevating the dorsal nasal flap described by Rieger,\textsuperscript{112} Rohrich et al.\textsuperscript{90} recommend placing the superior incision across the root of the nose and excising small dog ears at either end of the arc of rotation (Fig. 20). The authors noted that the standard glabellar incision is not
necessary for rotation and advancement of the flap and that the glabellar scar detracts from the final aesthetic result. They reported achieving overall excellent results and no flap loss, hematoma, or dehiscence in 48 patients. Similarly, Rigg\textsuperscript{114} experienced no complications in 32 cases.

**Axial Frontonasal Flap**

Marchac and Toth\textsuperscript{115} reported a modification of the flap described by Rieger,\textsuperscript{112} which they called a *frontonasal flap*. With the frontonasal flap design, the pedicle is backcut to a narrow vascular stalk near the medial canthus (Fig. 21).\textsuperscript{115} Based on cadaver dissections that they performed, the authors concluded that the flap is based on a branch

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*Figure 18.* A, Correct design of the 90° laterally based bilobed flap. B, Technical points in the transfer of the bilobed flap. C, Design and transfer of the 90° medially based bilobed flap. *(Modified from Burget and Menick.\textsuperscript{84})*

*Figure 19.* Typical indications for reconstruction with the dorsal nasal flap. *(Reprinted with permission from Rohrich et al.\textsuperscript{90})*
of the angular artery. The glabellar portion of the flap becomes redundant as the flap is rotated over the defect and can be excised as a Bürow triangle to equalize the two sides of the Y closure. Marchac and Töth presented a report of 50 cases of nasal reconstruction with the use of this flap.

Wee et al.\textsuperscript{116} reported their experience with the axial frontonasal flap in 27 patients. The authors described modifications that extend the flap applications to resurface lateral and central defects of the caudal one-third of the nose and that shorten the scar so that it does not extend into the forehead. In their series, the axial frontonasal flap was combined with island nasalis flap or nasolabial flaps to resurface large defects, and dermabrasion was then performed when dealing with sebaceous skin.

Hardin\textsuperscript{117} suggested closing the donor defect of the flap with an FTSG to transpose the whole of the dorsal nasal skin when reconstructing the lobule. This frees the flap from the limitations of rotation and advancement and obviates any difficulties with dog ears but violates the reconstruct-with-like-tissue rule.

\textbf{Axial Nasal Dorsal Flap}

As its name implies, the axial nasal dorsal flap combines the pedicle of the nasalis flap (the lateral nasal branch of the angular artery at the level of the alar crease) with dorsal nasal branches of the ophthalmic artery to encompass a territory much like that of the frontonasal flap (Fig. 22).\textsuperscript{118}

\textbf{Figure 20.} Elevation and transfer of the dorsal nasal flap. (Reprinted with permission from Rohrich et al.\textsuperscript{90})

\textbf{Figure 21.} Axial frontonasal flap is based on vessels emerging at the level of the inner canthus. (Reprinted with permission from Marchac and Töth.\textsuperscript{119})
The whole of the nasal dorsum skin can be raised and transferred inferiorly for reconstruction of the lobule while respecting the dorsal aesthetic subunit. Bürow triangles cut above the eyebrows increase downward mobility of the flap. Maruyama and Iwahira achieved excellent cosmetic results in seven cases.

V-Y Island Dorsal Nasal Flap

Most of the variants of dorsal nasal flaps seem to be based on ipsilateral angular artery blood supplies. Working on cadavers, Erçöçen et al. designed a variant of the V-Y advancement flap that is pedicled on the angular blood vessels from either side (Fig. 23). Defects of the nasal lobule as large as 2 to 3 cm can be repaired with this flap, and excellent downward mobility of the flap was shown in the one clinical example included in their report. This method has the advantage of reconstruction in one stage and the disadvantage of scars down both sidewalls and the glabella. Ultimately, this flap, like all other proposed methods of nasal tip reconstruction, must be compared with the forehead flap.

Nasalis Flap

Rybka described a sliding nasalis musculocutaneous flap from the upper alar crease that can be advanced approximately 1.25 cm to repair small defects of the lateral tip. Staahl found this method to be particularly useful for defects of the nostril wing ≤2 cm in diameter. Other authors also reported satisfactory clinical experiences.

A similar subcutaneous pedicle flap from the lateral perialar area was described by Suzuki. This small flap can be used to repair defects in the alar base and vestibular floor.

Dissecting through the edge of the defect, O’Hara et al. recommended raising the superficial aponeurosis of the nasalis muscle and rotating it to cover exposed cartilage in the lower one-third of the nose. Once overlaid with well-vascularized tissue, the defect is resurfaced with a skin graft of appropriate color and texture.

An almost identical technique was later described by Ulloa-Gregori et al. The nasal superficial muscular aponeurosis system (“SMAS”) flap is based on the edge of the defect, advanced over the wound, and overlaid with a skin graft to complete the reconstruction in one stage.

Nasolabial Flaps

The redundant skin over the nasolabial fold has been used in a variety of flaps for reconstruction of the lateral nose. Triangular flaps of skin from the nasolabial area have been used for reconstructive rhinoplasty since the time of Dieffenbach. Nasolabial transposition flaps can be based either inferiorly or superiorly. Superiorly based flaps are more common (Fig. 24) and were used extensively by Kilner in the first half of the 20th century.

Nasolabial flaps are perfused by direct cutaneous perforators from extensions of the anterior facial artery or by dermal vessels from the adjacent cheek. Superiorly based flaps are perfused primarily via the angular artery connecting the anterior facial artery to the dorsal branch of the ophthalmic artery. Superiorly based nasolabial transposition flaps are best suited for alar reconstruction in elderly patients and patients who are not demanding about the aesthetic outcome or who do not wish a staged reconstruction.
Figure 23. A, Vascular pedicle and flap. B, Advancement distance of the flap. (Modified from Erçöçen et al.119)
reconstruction. A second operation to recreate the alar crease is often needed. The flap can be prefabricated for moderate- to large-sized alar defects that need lining and cartilage support. If cheek scars are an issue, forehead flap reconstruction is still preferred.

Cameron et al. illustrated the use of nasolabial transposition flaps in nasal surgery. Nasolabial flaps, sometimes accompanied by a cartilage graft, are transferred for alar reconstruction. Flap reach does not extend beyond the midline, and secondary revisions of the alar crease are frequently needed. A delay procedure is recommended when the distal tip of the flap is to be folded in for lining. Although many reports of this method of tip reconstruction have been presented, the illustrated results are inferior to those obtained with forehead flaps. The questionable reliability of the distal aspect of a nasolabial flap rotated to the nasal tip must be weighed against the proven durability of a forehead flap. Conversely, Thornton and Weathers described 38 nasolabial flaps for nasal tip defects with uniformly excellent results achieved. The authors contended that it is still not a first-line choice for nasal tip defects, but for isolated soft triangle defects, it is the preferred technique for reconstruction.

Rohrich and Conrad presented a review of the guidelines for use of the nasolabial flap in alar reconstruction, as follows:

1. Preserve the nasofacial aesthetic line when possible.
2. Restrict it to defects of the alar subunit that are 2 cm in diameter.
3. Consider using a nonanatomic alar contour graft for lesions within 5 mm of the alar rim.
4. Thin the flap (defat) aggressively in nonsmoking patients.
5. Obliterate any dead space with through-and-through sutures.
6. Maintain a 2-mm isthmus of native skin on the cheek lateral to the ala.

Properly beveled, superiorly based nasolabial island flaps elevated on subcutaneous pedicles are reasonable choices for reconstruction in wounds of the high lateral nasal wall (Fig. 25). The base of the pedicle is sited over the infraorbital artery, vein, and nerve to facilitate transfer without kinking the pedicle. The donor defect is closed in a V-Y, S, or kite-like pattern, and the scar is concealed within a skin fold; revision is seldom needed. For technical details of flap elevation and transfer, see Heller, Guéro et al., Noguchi et al., and Singh and Bartlett.

Disadvantages of cheek flaps raised on subcutaneous pedicles are their relatively short range of movement, which means defects of the distal nasal dorsum are beyond their reach; the sometimes difficult dissection; the need for secondary thinning of the flap after centripetal contracture; and the resulting cheek asymmetry. The reconstructive choices for defects of the nasal sidewall are subcutaneous pedicle cheek flaps, bilobed flaps, FTSG, or uncovered subcutaneous hinge flaps allowed to heal by secondary intention.
Forehead Flap

Midline or paramedian forehead flaps can be raised on either the supratrochlear or supraorbital vessels from one or both sides; most surgeons elevate the flap on a single supratrochlear vascular pedicle. McCarthy et al.\textsuperscript{149} showed sufficient collateral blood supply from the angular arteries to sustain a forehead flap even when the supratrochlear and supraorbital vessels are transected; still, it is safer to try to preserve the primary axial vessels whenever possible to ensure flap viability.

Approximately 2.5 to 3.0 cm of skin can be taken from the central forehead, and the wound can still be closed primarily if the edges are slightly undermined and the galea is scored to release the tissues.\textsuperscript{96,97} Larger defects can be approximated by raising bilateral horizontal flaps through parallel incisions along the brows and hairline and advancing them toward each other.\textsuperscript{5} Kazanjian\textsuperscript{150} and Sawhney\textsuperscript{151} recommended large rotation and advancement flaps based on the temples and elevated bilaterally\textsuperscript{152} to close extensive flap donor defects so that the scars are hidden by hair. Burget and Menick\textsuperscript{49} do not close the entire defect but allow it to heal by secondary intention. They report achieving very satisfactory results with this approach.

Patients whose foreheads are <7.5 cm high might not be candidates for the classic forehead flap, particularly if the defect lies on the distal nose. In those cases, the upper end of the flap can be turned along the hairline or into the hair-bearing scalp for 1.5 cm (G. C. Burget, personal communications).

The defect created by the oblique skin paddle is approximated by scoring the galea. If this fails to produce sufficient tissue laxity for primary closure, a counterincision in the scalp is made and allowed to heal spontaneously. Dhawan et al.,\textsuperscript{153} Sawhney,\textsuperscript{154} Barton,\textsuperscript{75} and Zilinsky et al.\textsuperscript{155} recounted their experiences with the extended paramedian forehead flap.

Reece et al.\textsuperscript{156} conducted a detailed anatomic injection study of the paramedian forehead flap and advocated maintaining a three-vessel flow by capturing the periosteal perforators in the flap elevation by preserving periosteum 3 cm above the orbital rim during elevation. Variations of flap design, including a cross-paramedian forehead flap, have been described.\textsuperscript{157} However, the well-criticized cross-paramedian forehead flap is not an axial pattern, destroys any potential contralateral flap, and is not widely recommended. Richardson et al.\textsuperscript{158} suggested carrying frontal scalp with the distal flap down to the nasal tip in one stage. This hair-bearing skin is subsequently removed and replaced by an FTSG. Another option is to thin the distal hair-bearing area essentially to dermis and then snip the base of the hair follicles under loupe magnification.

Larsen\textsuperscript{159} reported using two long paramedian forehead flaps, raised undelayed, de-epithelialized at the base, and tunneled through the nasal root to replace nasal lining, columella, and skin at the same operation. Further refinements were presented by Kim et al.,\textsuperscript{160} who split the myocutaneous single flap into its components for nasal reconstruction.

Critics of the forehead flap indicate the obvious forehead scarring, especially when wide flaps are designed, and the limitations on flap length imposed by a low hairline. However, it is the most useful flap we have for tip, lobule, subtotal, and total nasal reconstruction.

Most criticisms of the paramedian forehead flap are the result of poor flap design. By designing an ipsilateral narrow axial pattern flap that is elevated above the periosteum in its arc of rotation, the incisions, and thus the flap rotation, are allowed to extend below the eyebrow. The majority of nasal defects can be reached by this robust flap with a very acceptable rate of donor site morbidity. In both the continuing medical education article and his latest textbook of nasal reconstruction, Menick\textsuperscript{12,161} outlined his approach.

Turnover Flap

Spear et al.\textsuperscript{162} elevated a flap of nasolabial skin on a superior subcutaneous pedicle based at the piriform aperture. The flap was first turned 180 degrees and rotated at a right angle to its base to furnish lining for the nostril and was then folded on itself to provide external cover (Fig. 26). The flap donor site was closed primarily.

In their experience with four patients, Spear et al.\textsuperscript{162} noted that the pedicle can be raised on a base as narrow
as 10 to 15 mm, yet flaps as long as 4 to 6 cm routinely survive. Similar maneuvers have been described by Pers, Wintsch, and Kroll.

**Reverse Auricular Flap**

Bakhach et al. described a chondrocutaneous island flap from the auricular helix that is elevated on a long pedicle supplied by the superficial temporal artery for reconstruction of the nasal tip and ala. The flap is left in place for 2 weeks after transfer. The donor defect is closed with an advancement flap from the helical rim. The illustrated results in seven patients were only adequate. Disadvantages of this method are the additional deformity of the ear, prolonged morbidity, and long forehead scar. This technique was also described by Hassanpour and Shariati as a tunnel single-stage flap in three cases.

**Lower Eyelid Orbicularis Oculi Musculocutaneous Flap**

Reconstruction of a nasal tip and supratip defect with a musculocutaneous flap based on branches of angular and infraorbital arteries has been described (Fig. 27).

**Frontotemporal Flap**

The frontotemporal flap described by Schmid and Widmajer and modified by Meyer is a tubular flap with an internal supraciliary pedicle that carries lateral forehead skin with embedded ear cartilage to the tip of the nose or ala (Fig. 28). The narrow horizontal pedicle courses just above the brow from glabella to temple. The horizontal flap pedicle helps to minimize the donor scar. Meyer and Kesselring later adopted this method for use in the young and in patients with low hairlines.

This meticulous reconstruction requires four stages that are workable under local anesthesia. The benefits and drawbacks of this technique have been considered by several authors.
When assembling this issue of *Selected Readings in Plastic Surgery*, it became clear that the overall quality of nasal reconstruction would be improved by surgeons adapting and optimizing the use of the forehead flap. There is no other substitute for a properly designed and executed paramidline forehead flap regarding reliability, donor site scar, and quality of reconstructive results.

**The Columella**

Whether presenting as isolated defects or as another missing element in complex wounds of the nose, columellar reconstruction can be exceedingly difficult. In addition to the procedures mentioned herein, other options include tubed flaps from the neck and upper lip. The most complete description of columella reconstruction was offered by Sherris et al.\(^{173}\) Sixteen patients underwent reconstruction with a variety of flaps, including forehead flaps, nasolabial flaps, and the newly described nasofacial sulcus flap (Figs. 29 and 30).

**Nasolabial Flaps**

Millard\(^{69}\) stated that the best columella is formed by distal extension of the gull-wing midline forehead flap; failing this, bilateral nasolabial flaps can be rolled inward to line the vestibules and create a central post.

To date, the best results in columellar surgery have been achieved with bilateral nasolabial flaps, as described by Gillies,\(^{69}\) and transferred on either superior or inferior pedicles. In 1964, da Silva\(^{174}\) raised a superiorly based nasolabial flap and tunneled it under the alar base to emerge in the area of the missing columella (Fig. 31). At a second stage, the flap is divided and the tunnel closed. A shorter and hence more reliable nasolabial flap is thus possible.

Another refinement involves bilateral nasofacial island flaps based either inferiorly\(^{175}\) or superiorly\(^{176}\) and elevated on subcutaneous vascular pedicles. The flaps are transferred by burrowing under the upper lip to the midline, and the reconstruction is completed in a single operation.

**Upper Lip Forked Flaps**

In cases of partial columellar loss, transverse forked flaps from the upper lip\(^{177}\) can be raised unilaterally or bilaterally. Gillies\(^{69}\) originally described this method for lengthening congenitally short columellae, but in acquired deformities, the best indication likely is a superficial columellar loss in an elderly, long-lipped patient. The technique benefits from a reliable blood supply and technical simplicity.
**Figure 28.** Frontotemporal flap. *A*, First stage. Ear cartilage is inserted in a superficial subcutaneous pocket, and two split-skin grafts are sutured into a small pocket at the site of the future alar-columellar commissure on both sides. *B*, Second stage. Prefabricated tip-alar-columellar complex is inserted into the deficit, and the donor area is closed by rotation of the preauricular skin. *(Modified from Meyer.)*

**Figure 29.** Nasofacial sulcus flap. Elliptical incision is made in the nasofacial sulcus just below the medial canthus. Incision is continued down to the periosteum medially and laterally and into the subcutaneous tissues, superficial to the muscular plane. *(Modified from Sherris et al.)*

**Figure 30.** Tunneling the nasofacial sulcus flap into place. A subcutaneous tunnel is created, connecting to the tunnel adjacent to the alar crease. *(Modified from Sherris et al.)*

**Figure 31.** Nasolabial flap tunneled under ala for columellar reconstruction.
Vestibular Flaps

Mavili and Akyürek\textsuperscript{178} presented a report of transfer of an internal nasal vestibular skin flap combined with bilateral labial mucosa flaps for columellar reconstruction without external scars. This method was originally described by Vecchione,\textsuperscript{179} who found it necessary to overgraft the anterior surface of the reconstructed columella with preauricular skin for a better color match and to eliminate unsightly vibrissae. A more recent experience has also been reported in a single case.\textsuperscript{180}

Forehead Flap

Millard\textsuperscript{59} recommended an extension of the forehead skin for columellar reconstruction. With this extension, he adds a distal projection to the gull-shaped flap design, which, at the time of transfer, is pinched and molded to form the columella and line the vestibules.\textsuperscript{35} The second choice presented by Millard,\textsuperscript{59} which is reserved for patients with narrow foreheads, is bilateral nasolabial flaps turned inward.

Chondrocutaneous Graft

Paletta and van Norman\textsuperscript{181} noted that auricular composite grafts are excellent for reconstructing isolated columellar losses because they avoid unsightly donor scars in the central face. The authors presented a review of the history of columellar reconstruction.

Total and Near-Tot al Nasal Reconstruction

Expanded Forehead Flap

Expansion of the forehead overcomes the pedicle width limitation of a paramedian forehead flap.\textsuperscript{182-184} Manders et al.,\textsuperscript{184} Kroll and Rosenfield,\textsuperscript{185} Adamson,\textsuperscript{186} Bikhazi et al.,\textsuperscript{187} Furuta et al.,\textsuperscript{188} and Fan\textsuperscript{189} reported successful nasal reconstruction with expanded flaps from the forehead. The reservoirs ranged from 250 to 400 mL, and the forehead tissues were stretched gradually during 5 to 9 weeks. The capsule around the expander typically is excised at the time of flap transfer.

Hoffman and Baker\textsuperscript{190} reported successful coverage of nasal defects in three patients with forehead flaps that were expanded intraoperatively. The maximum increase in flap width that can be expected from the rapid expansion technique is 20\%.\textsuperscript{191} Rapid expansion obviates the prolonged deformity of gradual inflation and the need for another surgical procedure to insert the expander(s), but flaps expanded by this method have a poorer blood supply than do flaps expanded by a conventional method.\textsuperscript{191}

Two problems have been identified with the use of expanded forehead skin for nasal reconstruction: difficulty with prelamination of the nose and, more important, unpredictable rebound contraction of the transferred flap. The forehead expansion technique, therefore, should not be used when the defect involves nasal lining. Where nasal lining must be provided during the reconstruction, the flap can be folded on itself\textsuperscript{184} or can be combined with skin grafts and turn-in flaps at the time of transfer.

Although some authors\textsuperscript{191} claimed similar flap thickness and increased pliability of the distal flap with tissue expansion, Bolton et al.\textsuperscript{192} reported contraction of the expanded skin after completion of the reconstruction. Immediately postoperatively, aesthetic results were judged to be excellent, but later, shrinkage and distortion of the soft-tissue lobule were noted.

Currently, the main indication for tissue expansion in nasal reconstruction is to expand the lateral forehead to allow primary closure of large paramedian forehead flap defects. However, this seldom is necessary. Burget\textsuperscript{193} noted that expanded forehead skin produces an inferior aesthetic result and stated that tissue expansion for nasal reconstruction should be abandoned.

Gull-Winged Flap

In 1974, Millard\textsuperscript{59} described a gull-shaped modification of the midline forehead flap that combines a generous amount of skin distally for extensive lobular reconstruction and a pedicle that is only 1 inch wide. The “wings” of the flap lie transversely on the forehead, and the scars are thus hidden by the natural skin creases.

Both in 1967 and again in 1976, Millard\textsuperscript{48,59} reported using a hinged septal flap to augment the septal angle and columella in his efforts to refine the alar
contour. The defect created by the pedicle usually can be sutured directly, but if too large for primary closure, the wound can be allowed to granulate for possible later revision. Recalling the admonition offered by Gillies44 that forehead flap noses never look quite as fine after the pedicle has been divided, Millard recommended leaving the neurovascular pedicle intact at the time of flap division and inset to prevent the usual edema.

Although lymphatic and venous drainage is better with the pedicle intact, other nasal reconstructive surgeons154,185 note that an intact pedicle is necessary only through periods of revision and that once thinning of the alar rim is complete, the pedicle can be safely divided. Burget194 and Burget and Menick11,65 reviewed Millard’s contributions to nasal reconstruction.

Up-and-Down Flap

In 1935, Gillies195 described an “up-and-down flap” for reconstruction of the entire nasal lobule. Because the paddle of this flap is longer and wider than that of the paramedian forehead flap, the donor defect cannot not be closed primarily. Two subsequent modifications of the up-and-down flap described by Gillies—the scalping flap and the sickle flap—camouflaged the long pedicle in the hair-bearing scalp and the lateral forehead, respectively.

Scalping Flap

Another reliable way to deliver a large amount of skin from the forehead to the nose for the repair of total and near-total defects is by a scalping flap. The scalping flap technique was originally described by Converse196 in 1942 and was subsequently refined.197-199

The scalping flap is elevated through a coronal incision just behind the superficial temporal artery, extending to a skin paddle in the contralateral forehead. The frontalis muscle is not carried in the distal end of the flap, but the remainder of the pedicle is dissected in the subgaleal plane. The donor site on the forehead is closed with an FTSG, and the temporary defect on the scalp is covered with a non-desiccant dressing or interim split-thickness skin graft.

Converse198 presented his experience with the flap in 76 patients. He attested to the usefulness of the scalping flap technique when tissue from the central forehead is not sufficient.

Sickle Flap

The sickle flap technique presented by New200 placed the donor site of the flap in the lateral forehead, where it is less noticeable. However, because the paddle itself was randomly vascularized, it had to be delayed. In addition, the pedicle tended to kink at the time of transfer201 and had to cross over the eyelid. Later modifications of the sickle flap continued to base the pedicle on the superficial temporal vessels.

Forehead skin has also been carried on a subcutaneous vascular pedicle202−204 that theoretically allows one-stage nasal reconstruction. Kernahan and Littlewood205 raised 10 sickle flaps on subcutaneous pedicles based on the superficial temporal vessels and reported three flap losses: two as a consequence of vascular insufficiency and one from technical difficulties. In retrospect, the subcutaneous pedicle method is clinically impractical, because flap viability is compromised during thinning of the vascular pedicle to avoid secondary debulking.

Song et al.206 proposed a vascular island musculoaponeurotic flap of forehead skin that can be turned down onto the nose and skin grafted. To date, clinical experience with this technique is scarce.

Temporomastoid Flap

Although Loeb207 has received credit for the original description of the temporomastoid flap, which he first used for cheek reconstruction in 1962, the concept of carrying the posterior auricular skin as a flap based on the superficial temporal arteries can be traced to Hunt208 in 1926. Crikelair,209 Washio,210 and Orticcochea211 picked up the idea and contributed technical refinements. For some reason, the flap is commonly called the Washio flap. The most comprehensive account of the temporororetroauricular flap method is that presented by Maillard and Montandon,212 who described their experience in 20 patients with a variety of nasal and paranasal defects.
Maurill and Montandon\textsuperscript{212} listed the following advantages of the temporomastoid flap:

1. thin auricular skin and thicker mastoid skin
2. ample hairless skin from the retroauricular and mastoid area for complete nasal coverage
3. availability of auricular cartilage
4. no flap delay
5. no visible facial scars

For these reasons, the authors concluded that the flap is most useful for heminasal reconstruction in women and young people.

Orticochea\textsuperscript{213,214} reported total reconstruction of the nose with a modified temporomastoid flap that involved translocation of the superficial temporal vessels into the preauricular area. At a second stage, the auricular conchae were transferred on the retrograde flow from the superficial temporal vessels. Galvao\textsuperscript{215} described another variation that carries skin from the postauricular and upper cervical area on the contralateral superficial temporal vessels as a large flap of mostly scalp. Because the flap is so long and the blood supply of the upper posterior cervical skin is unpredictable, a delayed procedure is recommended. The author noted that the advantage of the flap lies in its great pedicle length, which means the flap can reach any cervicofacial area and is able to carry a larger paddle of hairless skin than other available methods without additional scars on the face. The temporomastoid flap should be used only when neither the forehead flap nor the scalping flap is an option.

The radial forearm fasciocutaneous flap is a good choice for nasal reconstruction because of its thin, pliable tissue, excellent blood supply, and long vascular pedicle\textsuperscript{218-223} ($\leq 10$ cm long in patients with a positive Allen test). Combined defects of nasal lining and columella can be repaired effectively with this flap, which, however, is less than ideal when used for skin cover because of poor color match.\textsuperscript{224} Burget and Walton\textsuperscript{217} reported achieving excellent results with the radial forearm flap in cases of internal nasal collapse. In nasal reconstruction, the radial forearm flap can be prefabricated and anastomosed to the facial artery without vein grafts.\textsuperscript{217}

The Free First Dorsal Metacarpal Artery Flap

The free first dorsal metacarpal artery flap for nasal lining as described by Beahm et al.\textsuperscript{225} provides thin supple tissue with acceptable donor site morbidity.

Dorsalis Pedis Free Flap

When used for nasal reconstruction, the dorsalis pedis donor site has the advantage of an ample, thin skin paddle.\textsuperscript{226-230} As with the radial forearm flap, the dorsalis pedis free flap can be harvested as an osseocutaneous unit. Drawbacks include equivocal durability of the secondary skin graft and interruption of the distal collateral supply to the foot, which can be a problem in elderly patients.

Temporoparietal Free Flap

The temporoparietal free flap is supple, thin, and well-vascularized. It reportedly perfuses the underlying framework grafts.\textsuperscript{231} Acikel et al.\textsuperscript{231} used this flap for nasal cover in combination with FTSG from the supraclavicular area. Although the authors achieved acceptable nasal contour, the skin graft detracts from the aesthetic result, particularly when compared with the excellent color match that is possible with a forehead flap. It is unclear whether the temporoparietal free flap should be considered an...
alternative to the radial forearm flap for restoring nasal lining.

Serratus Anterior Free Flap

Thomas and Harris\textsuperscript{232} presented a report of total nasal reconstruction with a serratus anterior muscle with vascularized rib free flap. The rib graft was anchored to the frontal bones with miniplates. Nostrils were carved out of the serratus muscle and lined with tubed FTSG, which subsequently contracted during healing (despite stenting) and narrowed the airway lumen.

Postauricular Free Flap

The postauricular free flap represents the microvascular modification of the Washio technique. As popularized by Swartz,\textsuperscript{216} the postauricular flap avoids reconstruction and probably has a hardier blood supply than its pedicled counterpart. The main disadvantage of the technique is the dermis of the flap, which is smooth and thin and might not resemble the thick, sebaceous skin of the male nose.

Helix Free Flap

Auricular tissue has also been carried on the anterior temporal arteries to bring the full-thickness root of the helix to the nose as a composite helical free flap.\textsuperscript{233} This method is particularly suited to nostril restoration and has the advantages of a thick dermis, actinically exposed skin, and large superficial temporal vessels for a vascular pedicle. Its main limitation is a maximum surface area of $3 \times 3$ cm, which is all that can be harvested without distorting the anterior ear. This technique was used by Zhang et al.\textsuperscript{234} in 63 patients with a wide variety of nasal defects. Good results were achieved.

Deltopectoral Free Flap

Zhou and Hu\textsuperscript{235} presented a report of eight cases of nasal reconstruction with a free flap based on the cutaneous branch of the acromiothoracic arteriovenous system. A skin paddle $8 \times 9$ cm can be raised in this manner. The main disadvantages of the technique are the small (1–2 mm) and short vessels of the flap that frequently require vein grafts.

Other Distant Transfers

These remote sources of skin for nasal reconstruction are now primarily of historical interest: brachial flaps,\textsuperscript{236–242} cervical flaps,\textsuperscript{243,244} abdominal tubed pedicle flaps,\textsuperscript{245–248} deltopectoral flaps,\textsuperscript{248} and pectoralis major musculocutaneous flaps.\textsuperscript{249}

Consensus and Trends in Total Nasal Reconstruction with Free Flaps

Koshima et al.\textsuperscript{250} performed microvascular transfer of radial forearm osteocutaneous flaps for the repair of complex central facial defects. In their experience, the use of nonvascularized free iliac bone grafts to substitute for the nasal bones resulted in scar contraction, with airway obstruction and severe depression of the midface over time.

The practice of integrating lining into the main flap is gaining momentum. Costa et al.\textsuperscript{219} prefabricate the replacement structures on a partially raised radial forearm flap 3 weeks before transfer. Silastic tubes are inserted to maintain proper shape and caliber of the nostrils. The authors reported total nasal reconstruction with an osteocutaneous radial forearm free flap prefabricated in situ.

Burget and Walton\textsuperscript{217} illustrated the prefabrication of nasal airways with a radial forearm flap. The authors use stents wrapped by flap and lined with skin grafts to create fully functional, non-contracting, patent airways and acceptable aesthetic results (Fig. 32). A forehead flap is transferred to cover these constructs, for a stable and cosmetically pleasing reconstructed nose. The authors found the combination of free flaps for lining, grafts for framework, and forehead flaps for cover to be an effective method of total nasal reconstruction.

Pribaz et al.\textsuperscript{251} described their experience with prelaminated free forearm fasciocutaneous flaps for total nasal reconstruction in five patients. Numerous revisions were required for flap debulking and separation of aesthetic subunits. Two patients underwent secondary
Figure 32. Microvascular left radial forearm free flap is designed for repair of the nose and upper lip. Flap has three islands: a large paddle to line the vault of the single nasal airway, a smaller extension of the first paddle to resurface a defect of the nasal floor and right upper lip, and a second paddle to supply vascularized fat and skin lining for reconstruction of the columella. FTSG are applied to the exposed fat of the paddles. Vascular pedicle is tunneled through the cheek, and its vessels are connected end-to-end to the facial vessels. (Reprinted with permission from Burget and Walton.217)
forehead flaps to resurface the nose because the forearm flap was a poor color match. Additional local turndown flaps for lining and multiple cartilage grafts for dorsal support and tip projection were also required in all cases.

Yoleri and Oztan described two cases of total nasal reconstruction with free flaps. They rightly indicated the importance of well-vascularized lining to prevent secondary contraction and acknowledged that free flap skin as cover does not offer the best color match. The authors suggested that free flap skin be used for lining and a forehead flap for skin cover. They stated that it is important to reconstruct the nasal lining with well-vascularized flaps that are not subject to substantial secondary contraction. A bony support of the dorsum along with a well-vascularized lining produces a stable three-dimensional platform in the reconstruction of the total nasal defect. This is best provided with a free flap if the lining is recreated with its cutaneous portion. When this platform is covered by a conforming flap, symmetrical contours and highlights are restored. Reconstruction of the nasal cover is of aesthetic importance regarding the color and texture of the skin. Yoleri and Oztan considered the forehead flap to be the best choice for the nasal cover.

Replantation

In cases of sharp traumatic nasal amputations, replantation should at least be considered. Hammond et al. reported a successful case of nasal replantation and discussed the technical and anticoagulant issues involved. Flores et al. also addressed those topics in a 2007 report.

OUTCOME STUDIES

There is no substitute for immediate, complete, and uncomplicated healing. Goldwyn and Rueckert reminded us of an often overlooked option in the management of nasal lesions: allowing the defect to heal by secondary intention. This is especially applicable around the medial canthus or when the patient’s overall status indicates a compromise.

Becker et al. examined 282 patients who had full-thickness defects of the central face that were allowed to heal by secondary intention. Most deep defects of the alae and nasal tip were associated with frequent alar rim distortion. Defects of the nasal dorsum were somewhat unpredictable, whereas those around the medial canthus and glabella usually yielded favorable outcomes. Even a small, unanticipated degree of contraction, such as might occur when healing by secondary intention, will distort the reconstructed parts.

Regarding nasal framework reconstruction, Gerrie et al. reported 73 bone grafts to the nose by either the cantilever or L strut techniques. Five years postoperatively, the authors noted that grafts of cancellous bone had effectively fused to the recipient bed after producing a cortex during the first 6 months of implantation.

Farina reported an overall failure rate of 9.5% in 169 cases of cortical bone grafts from the tibial crest to the nose. Radiographic examination revealed that the grafts had become rarified for the 1st year after implantation but recalcified during the 2nd year; from the 3rd year onward, the bone grafts seemed to be structurally stable.

Wheeler et al. followed 42 patients with nasal bone grafts for an average of 22.7 months and reported overall good results. Resorption occurred in only one case, and the 30 cancellous bone grafts from the ilium, whether cantilever or L strut, fared well. Patients who underwent nasal reconstruction combined with other facial bone surgery sustained a much higher complication rate.

During the last 10 years, mounting experience with calvarial bone grafts to the nasal dorsum has been encouraging. Compared with rib grafts, calvarial grafts are limited by the thickness and breaking strength of the parietal bone. Because of the relative ease of harvest and the membranous quality of the bone, the calvaria is an excellent source of graft material in small defects of the nose where high bone density and load-bearing capacity are not required.

Jackson et al. described transfer of membranous bone from the parietal portion of the calvaria as cantilever grafts in nasal reconstruction. In their experience with 24 patients followed for 2 to 3 years, the authors noted only minimal bone resorption.

Regarding nasal lining, Hatoko et al. compared the results of nasal alar lining with three different
materials: FTSG, auricular composite graft, and hard palate mucosa graft. The pros and cons of each method regarding graft take, support, shrinkage, color, healing method, healing time, and donor site considerations are listed in Table 1.\textsuperscript{265} The authors concluded that the hard palate mucosa is a useful material in alar reconstruction, especially when the defect is large enough to involve the total unilateral ala nasi.

Schneider et al.\textsuperscript{266} reviewed their experience with the surgical repair of facial defects after Mohs micrographic excision. Simple techniques following aesthetic subunits were preferred and included direct closure, skin grafts, V-to-Y cheek advancement flap, island nasolabial flap for the alae, and forehead flap for the nasal dorsum and tip.

Uchinuma et al.\textsuperscript{267} compared two methods of nasal reconstruction—the medial forehead flap and the nasolabial flap—after surgery for basal cell carcinoma. They found that better aesthetic results were obtained with nasolabial flaps than with median forehead flaps, possibly because of anatomic and histological differences between European and Asian faces.

A careful outcomes analysis of 38 consecutive cases of subtotal nasal reconstruction using standardized semistructured interviews was conducted by Mureau et al.\textsuperscript{268} Results indicated that 80\% of patients were satisfied with nasal function and 79\% were very satisfied with total nasal appearance.

A comparison of outcomes in cases of alar reconstruction with subcutaneous island nasolabial flaps versus paramedian forehead flaps showed clear superiority of nasolabial flaps, both functionally and aesthetically. Objective measures included alar rim thickness and donor scar width and length. Subjective assessment was by patient questionnaire and independent trained observers and included ratings of scars, alar contour, skin texture, and donor site quality.\textsuperscript{269}

In a retrospective review of 76 nasal defects >1.5 cm in diameter, Park\textsuperscript{270} noted reconstruction with a midline or paramedian forehead flap in 55 cases (72\%), with a nasolabial flap in five (7\%), local nasal flap in seven (9\%), and skin graft in nine (12\%). Cartilage grafts were used in 43 patients (57\%), and restoration of the internal nasal lining was required in 18 (24\%). Eleven patients (14\%) experienced some type of complication, although no full-thickness flap necrosis occurred and no secondary flaps were needed. Analysis of the vascular pedicle to the midline and paramedian forehead flaps showed considerable contribution from the angular artery. In

### Table 1

<table>
<thead>
<tr>
<th>Feature</th>
<th>Full-Thickness Skin Graft</th>
<th>Auricular Composite Graft</th>
<th>Hard-Palate Mucosa Graft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graft take</td>
<td>Good</td>
<td>Good*</td>
<td>Good</td>
</tr>
<tr>
<td>Support</td>
<td>Poor</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Degree of shrinkage</td>
<td>Often severe</td>
<td>Slight</td>
<td>Mild</td>
</tr>
<tr>
<td>Color match</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Poor</td>
</tr>
<tr>
<td>Method of donor healing</td>
<td>Primary closure</td>
<td>Skin grafting</td>
<td>Open, spontaneous, epithelialization</td>
</tr>
<tr>
<td>Donor management</td>
<td>Simple and easy</td>
<td>Simple but not easy</td>
<td>Simple and easy</td>
</tr>
<tr>
<td>Donor healing time</td>
<td>Short</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Donor deformity</td>
<td>None</td>
<td>Substantial when harvesting large graft</td>
<td>None</td>
</tr>
</tbody>
</table>

*Occasionally poor when graft is large.
addition, the skin paddles of the midline and paramedian forehead flaps had similar vascular arcades.

From the perspective of his extensive experience, Meyer\textsuperscript{170} summarized his preferred techniques of nasal reconstruction as follows. For partial reconstruction of the nose, particularly the tip-ala-columella complex, Meyer uses the frontotemporal flap (introduced by Schmid and Widmajer\textsuperscript{169}), the compound (subcutaneous pedicle) forehead island flap, and the oblique forehead flap. In the event of more extensive tissue loss of the lower half of the nose, he opts for an oblique or gull-wing forehead flap lined with septal mucoperichondrial flaps, as described by Burget and Menick.\textsuperscript{65} The cartilaginous framework is reconstructed with ear cartilage grafts built into the forehead flap during delay. Other options for near-total nasal reconstruction are a scalping flap and a retroauricular flap.

Menick\textsuperscript{271} reported 90 cases of nasal reconstruction by transferring a forehead flap in three stages. He reported no flap necrosis at the initial or intermediate flap-thinning stage, one infection, and <5% revision rate in full-thickness defects.

THE COCAINE NOSE
Cocaine snorting results in a combination defect consisting of intranasal septal necrosis and absent lining with an intact external cover. Zhou and Hu\textsuperscript{235} described a variation of the median forehead island flap technique to restore nasal lining in such cases. The authors’ experience consists of five patients who had remote intranasal infection that led to massive internal destruction of the nose. After releasing all scar contractures, an island forehead flap was elevated, turned over, and tunneled subcutaneously to the nasal vestibule for lining. The well-vascularized tissue from the forehead could then support bone grafts for skeletal replacement.

This is an excellent technique when the nasal skin is healthy and likely to stay so. However, because alternatives for nasal lining are available and the forehead is the mainstay of external nasal reconstruction, a prudent surgeon reserves the forehead-as-lining option for patients who will not need skin coverage in the future.

Burget and Walton\textsuperscript{217} reported the use of free flaps to rebuild collapsed airways and columella in the cocaine nose. Millard and Mejia\textsuperscript{272} transfer bilateral tunneled nasolabial flaps to provide lining and airway reconstruction in the collapsed nose of cocaine users (Fig. 33). Once these vascularized flaps have healed and softened, they are able to support dorsal onlay cartilage grafting. Effective reconstructions in severe cases of collapsed noses are illustrated in their article.

Conversely, Guyuron and Afrooz\textsuperscript{273} stated that they do not consider repair of massive nasal defects to be necessary in the reconstruction of cocaine-related nasal defects. Acknowledging the current limitation of microvascular free flaps, the authors achieved excellent aesthetic results without repair of massive septal defects.

RHINOPHYMA
Rhinophyma or sebaceous hyperplasia of the nasal skin was first described in print by von Hebra\textsuperscript{274} in 1845. The name derives from the Greek _rhis_, meaning nose, and _phyma_, meaning growth. Clinically, the condition is recognized by bulbous enlargement of the nose and the presence of grossly hyperplastic sebaceous glands and erythematous skin. The lesion usually is confined to the epidermis, skin appendages, and dermis.

Rhinophyma is at least 12 times more common in men than in women. The typical patient is 60 years old, white, and male.\textsuperscript{275} The condition bears no true association with alcohol intake, as has been suggested. Most pathologists agree that rhinophyma represents a severe stage of acne rosacea.\textsuperscript{275} Superficial infection of the foul-smelling sebaceous plugs is characteristic.\textsuperscript{275}

Hypertrophy-hyperplasia of the sebaceous glands, fibrovascular proliferation of the dermis, and acanthosis of the epithelium are the typical histopathological changes. The nasal cartilages and nasal lining are usually spared.\textsuperscript{276} In a definitive histological study of rhinophyma, Acker and Helwig\textsuperscript{276} concluded that the incidence of basal cell carcinoma in a group of 47 patients with rhinophyma was higher than expected in the general population. Other scattered reports of malignant degeneration in rhinophyma have been published and are mostly reports of basal cell carcinoma.\textsuperscript{277–280} Squamous cell carcinoma\textsuperscript{281}
and angiosarcoma\textsuperscript{282} in association with rhinophyma have rarely been described.

Nonsurgical treatment of rhinophyma is the same as for acne vulgaris: good skin hygiene. Orally administered tetracycline\textsuperscript{283} and isotretinoin\textsuperscript{284,285} might also be of benefit. Advanced, disfiguring rhinophyma, however, usually is treated surgically.

The most common surgical approach is tangential excision of the skin and hypertrophic appendages (decortication).\textsuperscript{276,286,287} The origin of this method is attributed to Stromeyer.\textsuperscript{288} Success depends on leaving the fundi of sebaceous glands as the source of re-

epithelialization. A number of approaches to tangential excision have been described. The Shaw electric scalpel,\textsuperscript{289} electrocautery,\textsuperscript{275,287,290} and cold knife surgery\textsuperscript{291,292} have been used most frequently. Once tangential excision is completed, subsequent re-epithelialization is promoted by non-desiccating, bacteriostatic dressings.

Occasionally, the enlarged skin produces such stretching of the nostrils as to require full-thickness excision of a portion of the nasal skin.\textsuperscript{291} Conservative undermining of the nasal skin\textsuperscript{126} can be performed to facilitate closure, but wide undermining should be avoided.

\textbf{Figure 33.} A, Nasolabial flaps based superiorly along the sides of the nose and above the alar bases. 1.5-cm area of the flap base is denuded of epithelium. Each flap is elevated and introduced into the nasal cavity by a through-and-through incision. Flaps fill the defects provided by release of the constricted lining. B, Left flap is fitted and sutured into vestibular release. C, Right flap lining is sutured into position. D, Flap serves to release the lining and to back the columella. (\textit{Reprinted with permission from Millard and Mejia}.\textsuperscript{272})
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