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Reconstruction of Nasal Defects: Contemporary Approaches

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Abstract

Purpose of review—There are many well-established principles and surgical techniques for nasal reconstruction. The purpose of this paper is to describe contemporary reconstruction of nasal defects. The unique anatomic features of the nose make this a challenging task. While obtaining an optimal aesthetic result is always the goal of reconstruction, maintenance and restoration of nasal function are of equal importance.

Recent findings—The first step of nasal reconstruction is a thoughtful analysis of the defect. The best surgical option will provide the patient with an excellent aesthetic result and nasal function. Depending upon the extent of the defect as well as the anatomic site, a local flap, full-thickness skin graft, composite graft, or interpolated flap will provide the optimal result. The decision will depend on surgeon's experience and expertise, as well as expectations and desires of the patient. Many cutaneous defects will require not only reconstruction of the defect, but also cartilage grafts to provide nasal contour and support. Most large or complex defects will require a paramedian forehead flap for reconstruction along with cartilaginous and/or bony support, as well as a lining flap.

Summary—This article will highlight recent advances in nasal reconstruction and novel modifications of well-accepted traditional techniques.

Keywords

aesthetic nasal subunits; flaps; grafts; nasal lining; nasal reconstruction

Introduction

The goals of nasal reconstruction are to achieve refined aesthetic outcomes while preserving nasal function. Advancements are based on fundamental concepts including respecting aesthetic subunits and replacing defects with similar tissue. The structure of the nose is reconstructed in layers: lining, nasal architecture, and skin coverage. The contemporary facial plastic surgeon has a variety of technical options when considering nasal reconstruction.

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Principles of Reconstruction

Burget and Menick originally conceptualized the subunit principle to describe that the perceived shape of the nose is based on contours created by the highlights and shadows [1]. Although the anatomy of the nose is extremely important, the surface characteristics make a nose look “normal” or “abnormal.” The basis of the subunit principle is that it is better to reconstruct the nasal defect by subunits. It was originally proposed that when greater than 50% of the subunit is missing, it is best to resect the remainder of the involved subunit in order to achieve an optimal result in reconstruction. It is now widely accepted that the subunit principle does not apply to skin grafts or local flaps. Furthermore, it only applies to subunits that have inherent convexity, specifically the nasal tip and ala [2*]. The nasal dorsum and sidewall can be reconstructed without applying the subunit principle.

Analysis of the nasal defect

Before decisions about nasal reconstruction can be made, it is important to perform a detailed analysis of the defect. The surgeon should carefully examine the shape, size, location, and depth of the defect. It is also important to determine which subunits are involved.

Smaller defects less than 1.5 cm are often amenable to reconstruction using a full-thickness skin graft or local flap. Defects larger than 2 cm typically require the use of an interpolated flap.

The depth of the defect has a direct bearing on the options available for reconstruction. If cartilage is exposed, a local or interpolated flap will be necessary. If the defect involves the ala or nasal sidewall, then the degree of support that remains will be important to identify. Under most circumstances, the ala and sidewall need to be supported with cartilage to avoid nasal valve collapse. Full-thickness defects raise the bar with respect to the complexity of reconstruction. For these defects, it is necessary to re-create the anatomy of the nose by reconstructing in three layers: lining, nasal architecture, and skin coverage.

The location of the defect impacts the preferred method of reconstruction. In patients with thick sebaceous skin especially over the nasal tip and ala, a full-thickness skin graft will not be a good tissue match. In patients with deep defects, a full-thickness skin graft may provide sufficient coverage but will create a noticeable deficit with a deep indentation of the healed graft. This can be ameliorated by a secondary procedure to augment this deficit with a cartilage or soft tissue graft. However, it may be avoided by using a local or interpolated flap, transferring skin with enough soft tissue thickness to efface the defect.

Once the nasal analysis is complete, the surgeon should provide a plan to the patient for reconstruction. At this point is important to incorporate the patient's medical status, comorbidities, risks for complications, expectations, and desires as it relates to the method of reconstruction. Having an open and frank discussion with the patient is critical in the planning process. The surgeon should outline the planned procedures, alternatives, anticipated results, risks, and degree of difficulty involved. It is important to emphasize that complex reconstructive procedures often require revision surgery.

Lining

All full-thickness defects will require lining as part of the reconstruction. Depending on the size, extent, and location of the defect, different sources for lining are available. For example, small defects of the alar margin may be repaired using the bipedicle mucosal flap (i.e., bucket handle flap). This is raised from the nasal vestibular skin and can be rotated into an inferior location to reconstruct the lining of the alar defect [3].

One of the most common flaps utilized for lining reconstruction is the septal hinge flap [4]. This flap is based on the anterior septal artery and is useful for defects of the ala, tip and sidewall. A superiorly based septal flap can also be created [5] such that the flap is based on the dorsal septum and raised with the distal portion of the flap along the floor of the nose. The width of the flap is based on the size of the defect. This flap can be delivered through a small defect created below the most dorsal aspect of the nasal septum. Septal flaps can also incorporate the septal cartilage. The de Quervain flap is created following elevation of a contralateral septal flap, in such a way that the vertically-oriented septal flap and attached cartilage are rotated into the contralateral defect so that the septal cartilage provides structure for the nasal sidewall [6, 7]. Using a combination of these flaps leaves a large septal perforation, but patients are usually asymptomatic.

In order to avoid more complicated lining flaps, Hessam et al. offer a two-stage solution by creating inner lining using a scar hinge flap [8]. The authors had 21 patients with full-thickness defects of the ala with an average defect size of 1.9 cm². These small to medium size full-thickness defects of the ala were allowed to heal by second intention. At the time of the procedure, the surrounding scar tissue was cut in a circular fashion and a hinge flap was created. If needed, a cartilage graft was applied. The cutaneous defect was then closed using a local flap (52.4%), interpolated melolabial flap (19%), full-thickness skin graft (19%), or paramedian forehead flap (9.5%). The aesthetic results were judged as excellent in 23%, very good in 38%, and good in 24%.

The composite septal flap is described for defects involving the nasal tip and columella in which a portion of the septum is missing [9, 10]. In this circumstance, the septum and attached mucosa are released and tilted out so that the quadrangular cartilage is transposed into a position caudal to the original defect. The resultant vertical composite flap can be utilized as a foundation for nasal tip reconstruction. Bilateral septal flaps are raised and turned down to provide lining for the ala and nasal vestibule.

The inferior turbinate flap, as described by Murakami [11], is a versatile and valuable option for reconstruction of full-thickness defects. It can be used as a primary lining flap or in conjunction with other techniques. Based on anatomical cadaver dissections, the average flap length was 2.8 cm and average width was 1.7cm [11]. Baker recommends the turbinate flap for defects of limited size and a lateral location [10].

The folded forehead flap, as described by Menick [12, 13], has become a reliable alternative to lining flaps in situations when the septal hinge flap and inferior turbinate flap have been compromised by prior surgery or radiation. In fact, many surgeons have adopted the use of

this three-stage technique as their primary method of reconstruction of full-thickness defects.

In reconstruction of total or subtotal nasal defects, lining is almost always the most critical issue. Except under rare circumstances, there is usually enough forehead skin to manage a total nasal defect, as well as sufficient bone and cartilage grafts, even if nasal septum and ear cartilage have been depleted. Restoring the lining of the nose becomes the most critical aspect of the reconstruction. The source of lining must be thin, supple, and well vascularized. The lining tissue also needs to accommodate multiple grafts necessary to rebuild the nose. For many years, cutaneous free flaps have been used for reconstruction [14-16]. However, these flaps have the inherent disadvantages of creating a nose lined with thick keratinized squamous epithelium, donor site morbidity, and the inherent disadvantage of requiring multiple stages.

Seth et al. have published a landmark article that offers a solution to this significant clinical problem [17**]. In their series of 5 patients, the authors transferred thin vascularized tissue for total and near total nasal defects using free anterolateral thigh fascia lata flaps. This prevents the nasal obstruction associated with thicker cutaneous flaps and obviates additional stages imposed when using cutaneous free flaps. All patients had satisfactory nasal contour and patent nasal airways with negligible donor site morbidity. In a subsequent study, they also described the use of anterolateral thigh adipofascial flaps for larger mucosal defects [18].

Menick and Salibian offer an excellent review of management options for the primary lining injuries caused by trauma, infections, cocaine use, and vasculitis [19].

Structure

One of the most important tenets in nasal reconstruction is to establish and maintain support of the soft tissues to minimize functional sequelae such as nasal obstruction, as well as to diminish the risk of contraction and migration of the reconstructed nasal segments.

Cartilage grafts are used liberally in nasal reconstruction because they help prevent contraction of the overlying soft tissues, reduce nasal obstruction, minimize pincushion deformity, and serve as a rigid framework to prevent movement of subunit structures. The best example is the non-anatomic placement of cartilage grafts in the alar and supra-alar region, restoring the shape of the ala subunit while preventing alar collapse and alar retraction. Cartilage grafts play a vital role in the reconstruction of virtually all full-thickness defects. They provide structure to support the reconstruction and contour for optimal esthetic results. In these circumstances, the grafts are sutured to the underlying lining tissues to minimize dead space that might occur.

In reconstruction of total or subtotal nasal defects, it may be necessary to use costal cartilage or calvarial bone grafts for adequate restoration of contour and support. However, most nasal defects can be reconstructed with septal and/or conchal cartilage. Alar defects lend themselves to reconstruction with conchal cartilage due to inherent curvature of the graft

[Figure 1]. Using the opposite ear for alar reconstruction has been observed to provide better contour for the alar subunit.

Cutaneous reconstruction

Reconstruction of a nasal cutaneous defect is directly reflective of the surgeon's experience and knowledge of the options most applicable. Generally this represents a balance between using adjacent tissue, a full-thickness skin graft, or deciding that an interpolated flap will provide the best result. Whenever possible it is ideal to create incisions along boundaries between nasal subunits. Reconstruction using a local flap by necessity will not follow the subunit principle, but provides a good result because the defect is resurfaced by adjacent tissue with similar color, texture and thickness. For superficial defects, a skin graft may be an ideal choice and avoids additional incisions. For more advanced defects, a two or three-staged interpolated flap may provide the best result. The subunit principle is applied when using interpolated flaps in locations with inherent convexity such as the nasal tip and ala.

Primary closure and healing by secondary intention

There is still a role for healing by second intention especially for small, superficial defects. In addition, patients may choose this option to avoid further procedures or if they have significant medical comorbidities that preclude additional surgery. It is well known that areas that are naturally concave heal better with second intention healing than convex sites [20].

Full-thickness skin grafts

Many surgeons feel that local flaps provide a superior result to full-thickness skin grafts. However, this may be related to the process of selection. In a recent paper by Sapthavee, Munaretto, and Toriumi, the authors reviewed the results of 103 patients who underwent nasal reconstruction with either a full-thickness skin graft or local flap for defects less than 30×35 mm [21**]. Skin grafts provided aesthetic outcomes comparable to those of local flap procedures in properly selected nasal defects. The authors point out that skin grafts were used in patients with thin, less sebaceous skin and were more likely to be used in patients with Fitzpatrick types I or type II skin. Lastly, the authors used preauricular skin because it offers a better tissue match than other donor sites [Figure 2].

Although not typically thought of as an ideal site for skin grafts, Tan, Mortimer and Salmon reviewed their case series of 186 full-thickness skin grafts for surgical defects of the nasal ala [22]. The average defect diameter was 1.0–1.2 cm. They judged their aesthetic and functional outcomes to be good to excellent in all patients.

One of the principles of skin graft reconstruction is to defat the graft before applying it to the wound bed to allow better inosculation and revascularization of the graft. However, some authors have challenged this principle by using skin grafts leaving the fat attached, thus allowing the ability to adjust the thickness of the graft to fill the defect [23]. Kreutzer, von Gregory and Fischer recently reviewed their results using “skin-fat-grafts” for small deep defects of the nose [24]. Their case series demonstrates 46 grafts used to reconstruct defects with a median area of 83 mm^2 . As part of their protocol, the authors treated the defects with

wound care for an average of 8 days before applying the skin-fat-graft. In 80% of the cases the results were rated as excellent to satisfactory while 20% were fair to poor.

To overcome the limitation that skin grafts cannot be used for deep defects, Almeyda, van der Eerden, and Vuyk studied skin grafts applied to soft tissue flaps in 28 patients [25]. They used nasalis muscle flaps for middle third defects and subcutaneous hinge flaps for lower third defects. Average defect size was 1.5 cm². While the overall graft success rate was 79%, total graft failure occurred in 14%. They found that perichondrial-cutaneous graft survival was better than full-thickness skin grafts (90% vs 72%). In a similar series, Lindsay and Morton described a case series of 21 patients in which the nasal alar defect was reconstructed using the combination of a subcutaneous hinge flap from the adjacent cheek and an overlying full thickness skin graft [26].

Contrary to traditional concepts, Zopf et al. published a case series of 20 patients in whom a full-thickness graft was applied overlying a separately harvested auricular cartilage graft for nasal alar reconstruction [27]. Although it is generally considered a contraindication to place one free graft over another, the investigators created a large recipient pocket for the cartilage graft (average size 1.5 × 3.0 cm) and were careful to maximize contact between the full-thickness skin graft and the surrounding vascularized tissue. Using a Likert scale of 1 through 5 with 1 being excellent and 5 being poor, the average score for their results was 2.3.

Composite grafts

Chua and Park outline the application and surgical technique for the use of a two-layered composite graft [28]. Specifically, the authors indicate that if a composite graft is used for cutaneous reconstruction such as reconstructing the nasal ala, the graft is harvested from the root of the helix (skin on the convex side). However if the two-layered composite graft is used to provide internal lining (skin on the concave side), the conchal bowl is the preferred donor site. One technical point that is emphasized is that the cartilage segment should be longer than the skin component since it will be inserted into pockets on either side of the defect. To enhance revascularization, small perforations can be made within the cartilage graft using a 2 mm punch biopsy instrument. Finally, a bolster was applied to obliterate any dead space between the graft and recipient bed.

There are limited indications for the classic 3-layered composite graft. Figure 2 demonstrates an example of using a three-layered composite graft for a small alar-columellar marginal defect [Figure 3]. In a retrospective study of 91 patients who underwent cavum conchae composite grafts, 32 were used in conjunction with different flaps [29].

Local flaps

Bilobed flap

The bilobed flap is considered one of the primary methods of nasal reconstruction especially for nasal tip and ala. Since its description, the Zitelli modification of the bilobed flap has become the most popular rendition to be adopted [30]. It is generally reserved for defects 1.5

cm or less, but unnecessary for defects smaller than 0.8 cm as these may be closed primarily or with a local flap. As the bilobed flap can be prone to the development of pincushion deformity, wide undermining is performed in a sub-SMAS plane.

In a recent article by Akdali, Lee and Most, 7 patients in whom auricular cartilage grafts were used in combination with an overlying bilobed flap were reviewed [31]. Average defect size was 1.1 cm and all defects were within 5 mm of the alar margin. No patients developed alar retraction or notching, no cases of flap loss occurred, and all patients were satisfied with the aesthetic outcome.

Dorsal nasal flap

Helml et al. provide an excellent overview of one-stage nasal soft tissue reconstruction using local rotation and advancement flaps. The emphasis is on planning and execution of the hemi-nose rotation flap, Reiger flap, Marchac flap, glabella rotation flap, glabella V-Y rotation flap and the Rintala flap [32**]. The authors provide detailed information on the blood supply, design, and indications for each of these flaps.

Interpolated flaps

Melolabial flap

The melolabial flap continues to be ideal for reconstruction of the nasal ala. It can be constructed as either an island pedicle flap or a superiorly based pedicle flap [33, 34]. It can be utilized for cutaneous defects of the ala in which cartilage grafts provide contour and support. It can also be applied to full-thickness defects of the ala with the use of a lining flap and cartilage graft. Drisco and Baker et al. have pointed out that this flap is best utilized for defects less than 4 cm² without the need for secondary debulking procedures [3]. Although primarily used for alar defects, it can provide predictable results for alar defects with modest extensions onto the tip and nasal sidewall [Figure 4].

Forehead flap

The paramedian forehead flap remains the primary workhorse for any significant nasal defect. These defects may range from small full-thickness defects to major defects requiring total or subtotal nasal reconstruction.

The recent article by Menick highlights the major principles and key concepts in the contemporary use of the forehead flap [2*]. This paper also covers the indications for a two versus three-staged forehead flap. The midline forehead flap is a modification that places the donor site scar in the midline of the forehead [35].

It is important to reconstruct adjacent facial defects independently of the nasal reconstruction. Thus major nasal defects that extend into the cheek, upper lip, medial canthus, or eyelid need to be reconstructed separately from the nose. For extensive defects involving the cheek and lip, it is recommended that these areas be reconstructed prior to nasal reconstruction in order to provide a solid and stable foundation for the nose [36]. Maxillary reconstruction may need to be a part of this process. Autologous bone or cartilage

is ideal for this structural deficit, but on occasion an implant material may be chosen [Figure 5].

Contemporary Concepts in nasal reconstruction

With advances in nasal reconstruction, the paradigm for management has become more sophisticated.

Recent articles provide contemporary algorithms for nasal reconstruction. Konofaos et al offers guidelines for nasal reconstruction with their review of 419 patients [37]. Yong, Christophel, and Park provide an algorithm for approaching intermediate (1.5-2.5 cm) nasal defects at different subsites in 315 patients [38*]. Similarly, Woodard CR and Park SS review 213 small nasal defects (1.5 cm or less) to demonstrate a variety of flap or graft design by subsites [39]. Fischer presents detailed surgical techniques for the use of the paramedian forehead flap applied to different nasal defects [40*].

Many major reconstructions will require revision procedures. Menick offers his approach to problems and complications such as imperfect nasal contour, retraction of soft tissue, and nostril stenosis [41, 42]. Corrections may consist of soft tissue debulking, use of secondary cartilage grafts, tissue rearrangement, or a second regional flap.

Nasal reconstruction has been studied extensively in adults. Fortunately, pediatric nasal defects are rare. But when a young child has a badly deformed nose, special considerations are required to enable the child to grow and develop without psychological repercussions. High aesthetic standards and timing are critical. Burget discusses special considerations in this population [43, 44*].

Conclusion

It is important to maintain the highest level of expertise on nasal reconstruction to provide the best aesthetic and functional results for patients. This article provides an update on the application of the principles of nasal reconstruction, variety of surgical approaches available and latest developments in nasal reconstruction. It remains incumbent upon the surgeon to provide a thorough analysis of the nasal defect, formulate a surgical plan that provides an optimal result, and anticipate problems that may be avoided by thoughtful preoperative planning. Nasal reconstruction remains a rewarding but challenging field of reconstructive surgery.

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Key Points

1. Reconstruction of small nasal defects can often be accomplished with a local flap or a full-thickness skin graft, depending upon the anatomic site, depth of the defect, and surface characteristics of the skin.
2. Many cutaneous nasal defects will also require cartilage graft reconstruction in order to provide optimal contour, support of the nasal ala and sidewall, and to act as a brace against soft tissue contraction
3. Full-thickness nasal defects require three-layered reconstruction in order to provide restoration of the nasal lining, skeletal support, and cutaneous cover.
4. The subunit principle continues to be an important reconstructive principle but only applies to convex surfaces such as the nasal tip and ala.
5. Composite defects require thoughtful planning and commonly require reconstruction of the cheek and lip defects be performed prior to definitive nasal reconstruction, thus providing a solid foundation for the nose.

Figure 1. Conchal cartilage has inherent curvature that helps to reconstruct alar defects. (A) Right nasal alar and sidewall defect. (B) Conchal cartilage graft to support and contour right nasal ala. (C) One year result following reconstruction with conchal cartilage graft and forehead flap.

Figure 2.

Preauricular skin graft offers a good tissue match for nasal tip defects. (A) Preoperative nasal defect involving nasal tip and dorsum. (B) Excision of skin to create symmetric defect with partial primary closure of dorsal component. (C) Preauricular full-thickness skin graft, (D) Postoperative result.

Figure 3.

A three-layered composite graft used for a small alar margin defect. (A) Nasal defect involving the infratip lobule and alar-columellar margin. (B) Reconstruction with a three-layered composite graft from the right ear. (C) Three month postoperative result.

Figure 4.

The melolabial flap may be used for alar defects. (A) Mohs defect involving right nasal ala, sidewall, and cheek. Outline of planned melolabial island flap. (B) Preoperative nasal-cheek defect. (C) Three-year postoperative result following cheek advancement flap, conchal cartilage graft and melolabial island flap.

Figure 5.

An example of a Medpor® (Stryker, Kalamazoo, MI) implant used to reconstruct the defect of the maxilla. (A) Medpor implant to restore medial maxillary wall, (B, D) Preoperative nasomaxillary defect, frontal and base view, respectively. (C, E) Postoperative result following cheek, maxillary, and lip reconstruction with restoration of lip and maxillary height, providing a foundation for the planned nasal reconstruction.