ACFS ARCHIVES OF CRANIOFACIAL SURGERY
Arch Craniofac Surg Vol.23 No.3, 95-102
https://doi.org/10.7181/acfs.2022.00689

Review Article

Current strategies for aesthetic soft tissue refinement in nasal reconstruction

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The challenges of successful nasal reconstruction, which are related to the anatomical complexity of the region, have been extensively studied. Revisional operations are often required to achieve proper nasal reconstruction, with results resembling the premorbid nasal status. This is necessary to ensure the quality of life of skin cancer patients. Fundamental nasal reconstruction requires both proper soft tissue coverage and proper function. However, earlier studies in the field primarily focused on the functional aspect of nose reconstruction, although the cosmetic aspect is also an important factor to consider. In response to this need, many recent studies on nose reconstruction have proposed various refinement strategies to improve aesthetic satisfaction. Most plastic surgeons accept the nasal aesthetic subunit principle as a standard for nasal reconstruction. This review outlines the commonly used surgical refinement options and management strategies for postoperative complications based on the subunit principle. In patients with nasal defects, a proper technical strategy might help minimize revision operations and optimize the long-term results.

Keywords: Nose / Reconstructive surgical procedures / Rhinoplasty / Skin neoplasms / Surgery / Surgical flaps

INTRODUCTION

Due to the anatomical location of the nose in the center of the face, cutaneous malignancies involving the nose affect patients' quality of life after surgery. The challenges involved in successful nasal reconstruction have long been studied because the presence of a large deformity after nasal reconstruction has a negative effect on patients' social life. Complete wide excision is required to achieve cancer remission; however, postoperative decreases in patients' quality of life should also be a consideration. It is difficult to balance these concerns. To overcome these challenges, Mohs surgery has been proposed as an option to minimize defects. However, a more aggressive alternative is needed for large nasal defects [1]. In particular, for recurrent or extensive cancer, both functional restoration and soft tissue reconstruction should be considered at the same time when deciding whether to perform primary surgery for cancer. With proper preparation for nasal reconstruction after complete cancer resection, we can control the surgical extent of pathologic lesions [2]. Functionally, it is essential to maintain airflow patency and a secure barrier between soft tissue and the internal nasal structure. As destroying this barrier leads to necrosis and skin infections [3]. Aesthetically, the nose needs to be reconstructed with the nasal sidewalls and both alar grooves [4]. Taking steps to achieve an aesthetically favorable outcome of nasal reconstruction is no longer an additional technique performed upon patients' request, but a fundamental component of the procedure that requires planning before the primary skin cancer operation. Since even the most experienced surgeons have received patient complaints after nasal reconstruction, several methods to achieve successful results have been developed. Despite the wealth of knowledge on this subject, obtaining satis-

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How to cite this article:
Kim MJ, Lim H, Park DH. Current strategies for aesthetic soft tissue refinement in nasal reconstruction. Arch Craniofac Surg 2022;23(3):95-102. https://doi.org/10.7181/acfs.2022.00689

Received May 31, 2022 / Revised May 31, 2022 / Accepted June 18, 2022

www.e-acfs.org
pISSN 2287-1152
eISSN 2287-5603

factory results has remained a challenge. This review describes the surgical soft tissue refinement procedures developed beyond basic nasal reconstruction principles.

NASAL AESTHETIC SUBUNIT PRINCIPLE

The first step toward successful nasal reconstruction is to understand the nasal subunit principle proposed by Burget and Menick in 1985 (Fig. 1) [5]. In this framework, the nose is divided into aesthetic subunits, consisting of the nasal dorsum, nasal sidewalls, nasal tip, alae, soft triangles, and columella. A nasal defect should be fully evaluated and the subunits should be identified. Then, a plan is made to cover the involved subunits, replacing them with reconstructed structures. Making an incision along the subunit boundary and replacing it with new tissue results in an aesthetically pleasing reconstruction. Within the scope of the safety margin for cancer, subunits should be reconstructed separately. Following this principle means reconstructing nasal subunits while maintaining distinctions among subunit boundaries. The newly established nasal sidewall and alar groove result in an improved anatomical line [5]. A plan should be made for reconstruction along the aesthetic contour line to obtain aesthetic and functional improvements; this can reduce further revision operations and enable patients to resume their social life [4].

DECISION-MAKING FOR THE COVERAGE EXTENT

Following the nasal subunit principle in nasal reconstruction is widely accepted as fundamental. However, its application in cases of large defects that extend to over half of the nose is a matter of debate [6]. The choice between partial subunit reconstruction and total nasal reconstruction is challenging in these situations. Some surgeons have attempted to follow the subunit principles even for large defects to avoid normal tissue excision. However, forgoing healthy tissue in reconstruction procedures is challenging, as sacrificing normal structures is often required for whole nasal resurfacing to obtain an appropriate-looking nose. When covering the entire nasal defect, it is important to maintain patent blood flow in the pedicle in flap coverage. Therefore, surgeons are reluctant to select options such as reconstruction of the entire nose. However, despite these surgical issues, defects involving three or more nasal subunits treated with total replacement reconstruction have been reported to be aesthetically superior to partial reconstruction [7]. In particular, better results can be obtained for nasal contour and nasal symmetry than in defect-only reconstruction. Instead of viewing total nasal reconstruction as an option to avoid due to its invasive nature, it can be an option for aesthetic refinement. When a nasal defect extends to more than half of the nasal tissues or involves three or more nasal subunits, total nasal reconstruction would be a better strategy despite the concomitant sacrifice of the remnant healthy tissues, regardless of whether the classical nasal aesthetic subunit principle is followed.

In contrast, for minor defects that only involve one or two nasal subunits, the anatomical complexity should be considered [8]. Obtaining a natural convexity in the lower third of the nose, involving the ala, tip, columella, and soft triangle, can be achieved by adhering to the subunit principle. Otherwise, the boundary is easily noticeable within the subunit. Thus, replac-

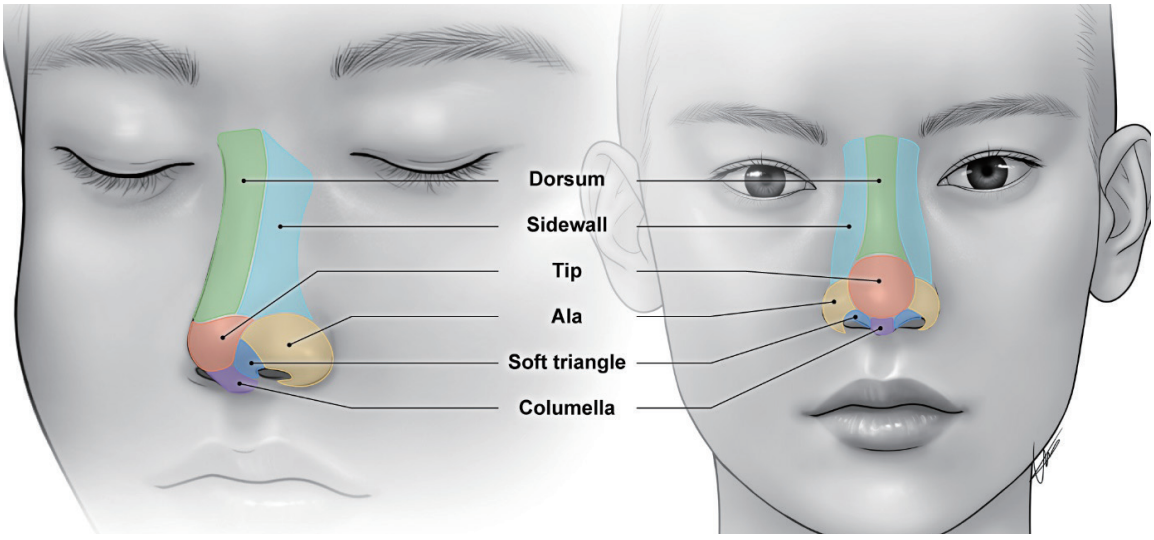

Fig. 1. The nasal subunit principle. The nasal subunits are the dorsum, nasal sidewalls, nasal tip, alar subunits, soft triangle, and columella.

ing the tissue with proper thickness is more important than constructing the nasal subunit boundaries together [9]. The upper two-thirds of the nose consists of the nasal sidewall and dorsum, which are flat; the flat contour of the dorsum and sidewall can hide scarring within the subunit.

ANATOMICAL CONSIDERATIONS

Nasal dorsum and sidewall

Small defects of the nasal dorsum and nasal sidewall (less than 2 cm) can be covered with a bilobed flap or a similar local flap. Defects closer to the medial canthus can be repaired more successfully with a full-thickness skin graft using postauricular skin, which shows acceptable color matching. The preoperative design of the local flap should be considered with nasal dorsum aesthetic lines, a medial brow position, and nasolabial tip angulation [10]. Care should be taken because cephalad rotation distorts the nasal tip and disrupts the nasal dorsal line. The bilobed flap is a well-known flap that has proven to be very useful in sidewall reconstruction. However, its cicatricial tourniquet effect commonly leads to pin-cushioning (Fig. 2) [10,11]. Despite successful soft tissue coverage, these symptoms can result in aesthetically unpleasant noses due to venous congestion, swelling, and scar contracture. Designing the bilobed flap with a wider and inferiorly based pedicle can reduce swelling and help overcome this challenge [12]. Moreover, aggressive thinning of the flap is crucial, and prophylactic massaging can be beneficial. Aesthetically, preserving the definition of the nasal-facial junction is important for nasal side wall refinements. Proper deepening of the nasolabial fold makes the nasal sidewall look flat and thinner. Thus, in reconstructing this area, its boundary should be made clear according to the nasal subunit.

Fig. 2. The common pin-cushioning effect following the use of a bilobed flap.

Nasal tip

Defects larger than 1.5 cm should be repaired with a paramedian forehead flap [13]. Smaller defects can be covered with bilobed flaps, dorsal nasal flaps, or skin grafts; however, large defects covered in this manner can distort the nose. It is important to ensure that the nasal tip subunit is completely resurfaced before proceeding further with reconstruction. Its boundary extends from the alar creases and supra-tip break-down to the tip-columellar junction [14]. In addition, to avoid scar contracture on the tip, a design with a round tip enhances the circular contracture. Thus, before resurfacing the area of nasal tip excision, the shape of the premorbid nasal tip should be drawn on a piece of paper, and the tip boundary area should be drawn following the line, reflecting the flap design.

Ala

In alar reconstruction, securing the proper alar rim skin is important. The alar rim is vital to the nostril shape, which is of considerable aesthetic importance. Retaining 2 mm of alar rim skin has been recommended. If this is not possible under the circumstances, the subunit can be removed from the alar-sidewall junction to the alar-tip junction and alar-cheek junction [8]. Once the alar rim skin is preserved, the other lateral area of the ala can be covered with various rotation flaps. However, to maintain the convexity of the ala, a proper rotation design should be considered to prevent postoperative trap-door deformity. Superiorly based nasolabial flaps are preferred, but the boundary should be hidden in the nasolabial fold to prevent sidewall distraction.

Soft triangle

Reconstruction of the soft triangle is an extremely important skill for aesthetic refinement. In the nasal subunit, the soft triangle is an independent subunit, even though it is a small fragment (Fig. 3). This area near the tip lacks cartilage support and is extremely prone to notching or retraction when the tip cartilages around it are manipulated. In addition, scar contracture in this area leads to an uncomfortable and visible scar on the nose. Thick bulging leads to notching, while thickness deficiency leads to soft triangle recession. Thus, maintaining a proper contour is a major concern in reconstruction. Color mismatch with the nasal tip should also be considered. More than any other area, we recommend a rotation flap rather than a composite graft from the auricular helical root. In long-term follow-up, a

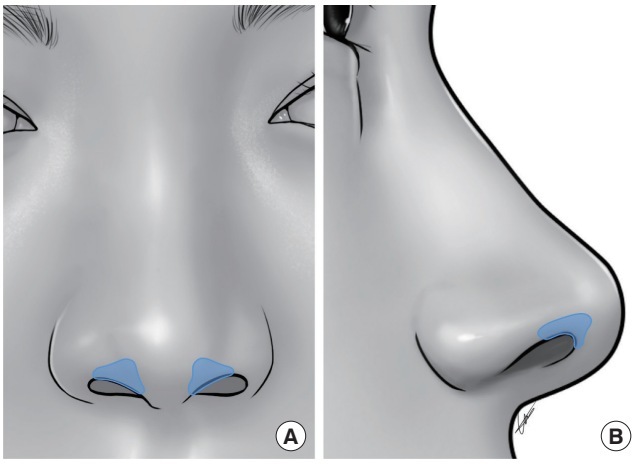

Fig. 3. The aesthetic importance of the soft triangle. The area near the tip lacks cartilage support and is prone to notching or retraction. This, combined with scar contracture, can result in soft triangle recession, often referred to as a nasal deformity. (A) Front view. (B) Lateral view. Blue areas represent soft triangles.

transferred graft often leads to color mismatch and alar distortion [15]. A mucosa-based total alar V-Y advancement flap with lower lateral cartilage mucosal perfusion can be rotated from the lateral to caudal aspects, leading to a deficiency in the nasal sill area, and the tissue can be transferred towards the soft triangle [16,17].

Columella

Columella reconstruction involves several technical difficulties. There are no surrounding remnant tissues, and it has a superficial barrier with the nasal mucosa and skin. In addition, the columella plays an important role in maintaining the shape of the nostril. To compensate for tissue deficiency, columellar defects can be repaired with remote tissue transfer. Among various flap options, including unilateral or paired nasolabial flaps, V-Y advancement flaps, and composite grafts, the paramedian forehead flap is a commonly proposed option [18,19]. To provide structural support in a forehead flap, a cartilage graft is preferred to create a proper nasolabial angle (Fig. 4). The harvested cartilage must be able to serve as a framework for the entire nasal structure. Thus, stability is extremely important. Septal or costal cartilage is preferable to conchal cartilage. A combined defect of the nasal tip and columella, regardless of defect size, should be considered as a large major defect; therefore, it requires a paramedian forehead flap [20].

SURGICAL CONSIDERATIONS

Timing of aesthetic refinement

Preoperative planning is crucial for successful nasal reconstruction. A proper surgical goal must be set according to the purpose of nasal reconstruction. The surgical goal can be clearly defined depending on patients' circumstances. In patients with disruption of the nasal structure following cosmetic procedure complications, wound healing is the top priority. For these patients, the reconstruction of the nasal tip projection or proper nasal shape is secondary. Completion of wound healing in those patients can be a precondition for considering a secondary revisional operation. Preventing further procedure-related complications is crucial for maintaining nasal function.

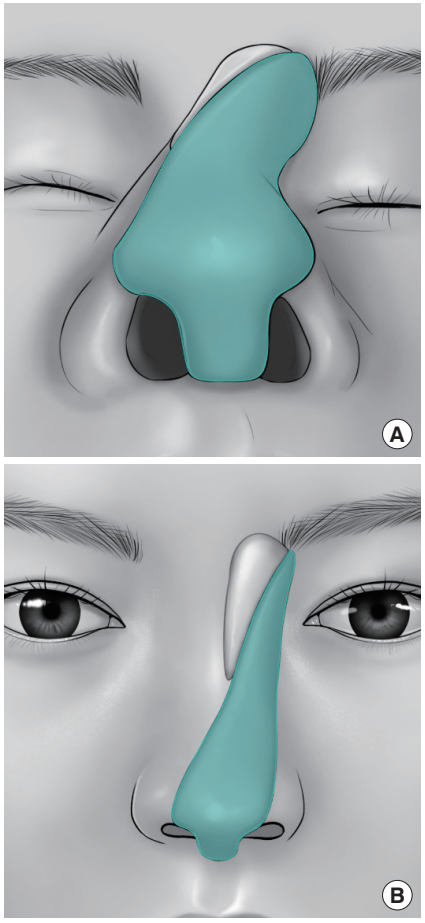

Fig. 4. (A, B) A columella defect can be covered with a paramedian forehead flap. Using costal cartilage, the graft can obtain more rigid nasal tip stability. Blue areas represent transpositioned forehead flap.

However, skin cancer patients expected to have wide nasal defects after cancer treatment require nasal restoration. For these patients, functionality and aesthetics should be evaluated concurrently. The missing components of the nasal structure should be identified when evaluating the nasal defect. The number of subunits involved should be determined to categorize a defect as small or large. Furthermore, whether the defect involves over half of the nose should be determined. Based on this information, surgeons can determine the coverage extent

and concurrently decide on the skin cancer resurfacing area. A concurrent consideration of function and aesthetic nasal reconstruction involves layer-by-layer reconstruction. A proper flap option should be selected that matches the surrounding tissue in each missing anatomical layer, with the correct skin quality and three-dimensional contours. In a forehead flap, a three-stage operation can consist of three soft tissue coverage steps: skin coverage, structural support, and nasal lining [21]. At each operation step, the surgeon should attempt to make the results as aesthetically refined as possible. After achieving proper soft tissue coverage, a maximal blood supply should be maintained, starting with the initial flap elevation step and continuing for further secondary procedures. Then the next step is to manufacture a framework that can be sufficiently covered by the soft tissue subunit. By integrating the cartilage graft and transferred flap, establishing a stable framework should provide a comfortable circumference. Finally, optimizing the final nasal contour can be attempted in the aesthetic steps.

Forehead flap design

Several options exist for reconstructing the nasal lining, including mucosal flaps, skin grafting, local flaps, a prefabricated forehead flap, a three-stage forehead flap, forehead flap turnover, and free tissue transfer. The forehead flap, which is one of the oldest recorded surgical techniques for nasal reconstruction [22], provides the reconstructive surgeon with a robust pedicle and large amount of tissue to reconstruct almost any defect. Aesthetic considerations with the forehead flap start from the flap design. Menick [23] described manually drawing an intraoperative template used to guide patterning between a three-dimensional defect and two-dimensional skin to shape the flap precisely. These templates are traced onto the patient's nose before rhinectomy and then used in reconstruction, with notches cut to permit unfolding of the three-dimensional pattern. To date, this process has been templated manually, with its accuracy highly dependent on surgical experience and skill. Recent advances in CAD-CAM (computer aided design and computer aided manufacturing) technology have enabled three-dimensional preoperative planning for three-dimensional anatomical nasal defects [24]. These technologies help to design the two-dimensional flap shape for a three-dimensional nasal defect. Once the surgeon decides the extent of nose resection preoperatively, three-dimensional mirroring imaging can be easily generated and applied to two-dimensional forehead flap design. There are many three-dimensional preoperative surgical guides that provide this service. The only prerequisites for the clinical application of this method are collaboration with a computer technician and the patient's agreement [25].

Utility of indocyanine green angiography

Understanding the external nasal anatomy and its blood supply is crucial for achieving optimal nasal reconstruction [26]. Local flaps, such as paramedian forehead flaps, require sufficient vascularity to simultaneously vascularize associated grafts, such as cartilage or chondromucosal grafts. In particular, a staged reconstruction procedure needs to provide sufficient time for neovascularization of the flap independent of the pedicle. Neovascularization develops from the vascular bed and/or the peripheral edges of the recipient site. Although several patient-related and anatomical defect-related characteristics may affect neovascularization, quantitative studies assessing forehead flap perfusion have been limited. In recent years, indocyanine green angiography with an infrared-sensitive camera has been frequently used as a minimally invasive technique to assess flap perfusion. Indocyanine green is a water-soluble dye that fluoresces maximally at 835 nm, which lies within the optical window of skin. The system uses an infrared-sensitive camera to detect intravascular-injected fluorescent dye [27]. In nasal reconstruction procedures, indocyanine green angiography was first introduced as a qualitative assessment method in a few case reports and as a comparative quantitative assessment method in a case series by Woodard and Most [28]. Identifying flap sites with poor perfusion allows the flap to be trimmed to improve survival. This technology makes it possible to avoid necrosis in the flap after nasal reconstruction. In particular, columella flap necrosis following nasal reconstruction negatively affects the final reconstruction results. Therefore, these anatomically special lesions benefit particularly from the adoption of this recent technique (Fig. 5).

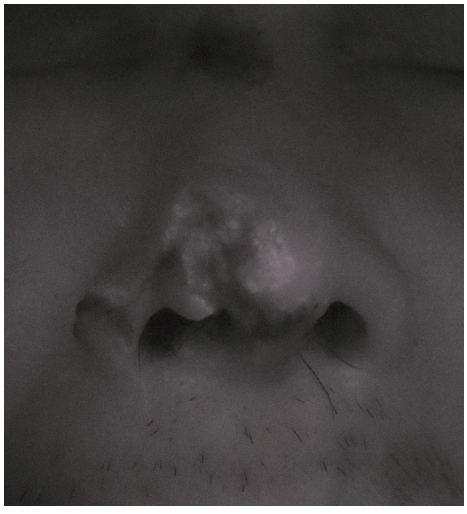

Fig. 5. Intraoperative use of indocyanine green angiography in nasal reconstruction. After transferring tissue towards nasal tip, gray hypoperfusion status can be easily visualized.

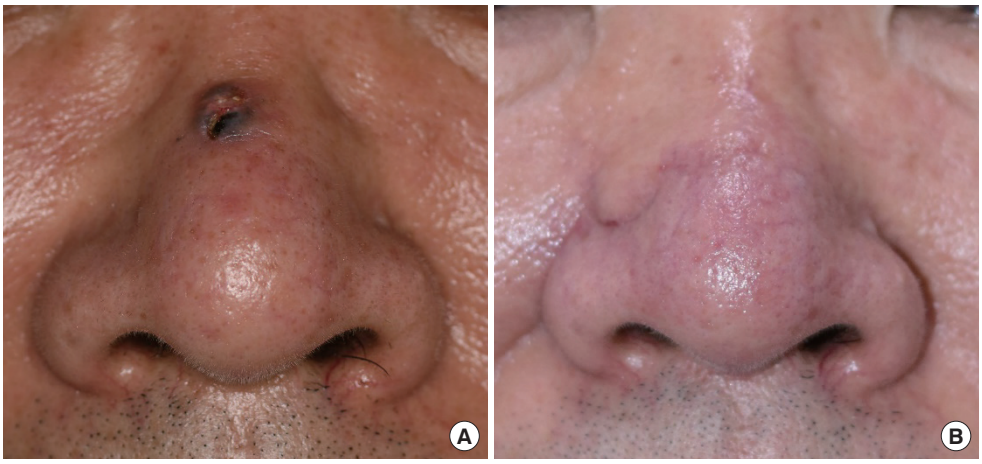

Fig. 6. Bilobed flap coverage for basal cell carcinoma on the nose. To avoid secondary flap debulking, elevation with a thin flap is required in the first operation. (A) Preoperative photograph. (B) Postoperative photograph after 1 year.

Flap debulking

Bulkiness is a particularly important issue for forehead flaps, followed by nasolabial flaps. The appropriate timing for debulking forehead flaps is a matter of debate. Preventing further scar contracture requires primary and secondary flap thinning in both stages. At the division stage, primary flap thinning can be tried before flap insertion. Then, secondary flap thinning–focused on recreating the alar groove and maintaining the nasal sidewall–can be performed 6 weeks after the division to achieve the final nasal contour [29]. A surgical endpoint must be set for the debulking procedure. Primary debulking can eliminate all subcutaneous tissue while preserving the dermal plexus. Patient-related factors associated with smoking should be screened before the operation to obtain maximal flap perfusion (Fig. 6) [30].

The nasolabial fold flap also necessitates a secondary division operation. Maintaining or reconstructing the alar-facial groove is a key step in debulking to achieve aesthetically acceptable outcomes. Even though the nasolabial fold can hide the donor site, a bilobed flap with the nasolabial fold has a high risk of the pin-cushioning effect [31]. Thus, it is important to secure proper venous drainage, for which an inferiorly based flap design is superior [32,33].

Scar management

Various degrees of dog ear deformity or scar hypertrophy can be visualized even in successful nasal reconstruction. The optimal timing of hypertrophic scar revision is 2–3 months postoperatively, and steroid injections can also be useful. In the operation field, aggressive flap thinning is a cause of postoperative contracture. It is permissible to wait for 6 weeks for flap stabilization and then consider secondary revision. Prophylactic massages can start 2 weeks after the operation. However, preoperative preparation is required to prevent these unexpected results. In a forehead flap, brow distortion or trap-door deformity can be identified after the first flap division. During supratrochlear pedicle division, an inverted V-design should be avoided. A persistently inverted V-design shape causes brow alopecia and makes it more evident [21]. This is because, after division, the medial brow is strengthened medially. Instead of this design, the medial 5–7 mm of the eyebrow can be sacrificed and closure can be performed by only creating a vertical shape. This vertical scar can hide the internal part of the vertical rhytid. Additionally, the primary forehead donor site should heal by secondary intention. Primary closure can be performed only for certain permitted parts, wherein there are no concerns about flap congestion and the tension is comfortable. The long-term results of secondarily healed forehead flaps are usually as acceptable as the results of any other procedure.

CONCLUSION

In the surgical treatment of skin cancer, in particular, the nose needs special consideration for successful reconstruction, for which it is necessary to predict the results of surgery in advance and make a surgical plan. The problems of extensive nasal defects with cosmetic deterioration after surgery cannot be solved by simple soft tissue transfer. It is essential to select an appropriate reconstructive option based on the anticipated nasal defect. Partial or total nasal resurfacing is an important decision to make. From the standpoint of functional restoration with three-layered coverage, skin coverage, structural support, and a nasal lining result in a nose with a patent airway. Next, the integration of soft tissue aesthetic refinement strategies contributes to

successful nasal reconstruction. Replacing the resected skin with skin of similar color and thickness and considering the nasal sidewall, soft triangle, and alar groove are important factors for achieving an aesthetically satisfactory appearance of the nose. The actual clinical application of these various techniques combined with the latest technology contributes to more successful results. Based on the fundamental reconstruction principles, the application of soft tissue refinement skills can yield satisfactory results for both the surgeon and the patient.

NOTES

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Patient consent

The patients provided written informed consent for the publication and use of their images.

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