Modification of the Subunit Principle for Reconstruction of Nasal Tip and Dorsum Defects

Kevin A. Shumrick, MD; Andrew Campbell, MD; Ferdinand F. Becker, MD; Ira D. Papel, MD

This article reports our observations on, and modification of, the subunit principle with regard to reconstruction of nasal tip and dorsum defects. Forty-two patients who underwent reconstruction of a nasal tip and/or dorsum defect with a forehead flap were reviewed. These patients were categorized by how the subunit principle was used in their reconstruction and graded on the aesthetic outcome of the reconstruction. We found that the patients who had both the nasal tip and dorsum replaced obtained better results than those who had just 1 subunit replaced ($P = .008$). Review of postoperative photographs shows that the reason for this discrepancy in aesthetic outcomes is the line of transition between the forehead skin and remaining nasal skin if only 1 subunit is replaced. With this observation in mind, we feel that patients undergoing reconstruction of the nasal tip and/or dorsum should be evaluated for discrepancies in tissue type between the recipient nasal site and forehead donor site. If the tissues are noted to be significantly disparate, the reconstructive surgeon may consider replacing both subunits with a single forehead flap.

In the early days of modern nasal and facial reconstruction, surgeons were content to simply provide viable tissue to the site of the defect with little discussion regarding contour or tissue match. However, in the 1950s several surgeons began to advocate not only supplying viable tissue for facial and nasal defects, but also contouring this tissue accurately enough that key visual cues were provided so that the viewing eye would be more inclined to perceive the reconstructed area as normal. These authors noted that if a reconstructive effort did not blend in with the normal architecture and topography of the face, it caught the eye and detracted from the final result. Gonzalez-Ulloa et al$^{1}$ laid the groundwork for improving facial reconstruction when they made the observation that there were distinct regions (or units) of the face with lines of transition between them. Gonzalez-Ulloa et al felt that the underlying reason for these lines of transition and the various units was the histological variation of the surface epithelium covering the different facial units. They postulated that placing the borders of a reconstructive effort along these lines of transition between facial units (where the eye expected to see a disparity between the 2 regions) would render the reconstructive effort less conspicuous. Millard$^{2}$ took the theory of facial units and put it into practice. Millard wrote strongly and compellingly against simply filling holes with tissue, advocating instead replacing entire facial units or planning the reconstruction so that the scars run within the lines of transition.

See Practice Commentary on page 16

Building on Millard’s foundation, Burget and Menick$^{3,4}$ further defined the utility of the unit theory of facial reconstruction and in particular how the unit theory could be applied to nasal reconstruction. Gonzalez-Ulloa et al$^{1}$ had considered the nose a single unit of the face, but when Burget and Menick examined the nose they
PATIENTS AND METHODS

There is no universally accepted method of judging the aesthetic success of a proposed nasal reconstructive procedure. Observations on flap survival or failure are of little importance in trying to determine whether a nasal reconstruction has achieved a successful aesthetic result. The ultimate success of a nasal reconstruction is determined by how closely the reconstructed nose resembles a normal nose. Obviously, whether a reconstructive effort achieves a satisfactory result is a subjective determination. Therefore, there are inherent difficulties in designing a study to assess the aesthetic outcomes of a reconstructive procedure.

In large part, the readers must make their own determination on the merits of a proposed procedure based on 3 considerations: (1) knowledge and experience with the reconstructive problem and the theoretical soundness of the proposed procedure, (2) supporting basic science material, and (3) consistent, high-quality photographic documentation. If these 3 criteria are met, then informed readers may be able to agree or disagree with an author's proposal, but it is only after applying the technique to their own patients that a final opinion will be possible. In an attempt to meet these requirements, this study was designed with both subjective and objective criteria.

The first portion of this study consisted of reviewing the results of a series of nasal reconstructions from the practices of the 3 senior authors (K.A.S., A.C., and F.F.B.). The requirements for inclusion in the study were that the patients had to have a cutaneous defect of the nasal tip and/or dorsum large enough to require a forehead flap for repair. Defects extending to additional nasal or facial subunits or involving skeletal components or mucosa were excluded. Additionally, to be included, the patients had to have adequate preoperative and 6-month postoperative photographs.

The patients' postoperative photographs were then reviewed by 7 board-certified surgeons involved in the management of cutaneous facial carcinomas and defects (4 board-certified plastic surgeons, 1 Mohs surgeon, and 2 facial plastic surgeons) and scored on a scale of 1 to 4 for the aesthetic success of the reconstruction (1 being a poor result with the reconstructive effort obvious and 4 being an excellent result with the reconstructive effort noticeable only on close inspection). The patients were then placed in 1 of 3 groups according to how the subunit principle had been used to direct their reconstruction: group 1, patients in whom the standard subunit principle of nasal reconstruction was not followed (Figure 2, A and B); group 2, patients in whom just 1 nasal subunit (tip or dorsum) was replaced (Figure 3 and Figure 4); group 3, patients in whom both nasal subunits (tip and dorsum) were replaced (Figure 5 and Figure 6).

The decision as to which form of the subunit principle was to be employed on each patient was left to the individual surgeon's judgment, and patients were not randomized in the treatment groups. It is noted that as experience was gained and the improved results were noted, the replacement of both subunits became our preferred modality for patients with notable nasal tip or dorsal defects.

The scores for each patient evaluation were averaged and ranked. The Mann-Whitney U test was then used to determine the statistical significance of the variations between groups. To lend objective support to our contention that there is a visual discrepancy between forehead skin and nasal skin, 6 specimens of nasal skin and forehead skin from patients undergoing nasal reconstruction were submitted for histological examination and microphotographic documentation.

Figure 1. Nasal subunits marked out on fresh cadaver specimen (A and B). Heminasal skin removed from fresh cadaver specimen demonstrating that the transition from the nasal dorsum subunit to tip subunit is brought about by the lower lateral cartilages raising the nasal tip skin above the septal angle, not from a clinically significant change in histological characteristics (C and D).
found several visual topographic regions they referred to as “subunits” of the nose (Figure 1, A and B). Burget and Menick showed convincing clinical evidence that reconstructing nasal defects by replacing entire subunits provided consistently better aesthetic results. They also provided supportive data from the field of perceptive psychology to strengthen their observations. The subunit theory of nasal reconstruction, as described by Burget and Menick, stated that if a nasal defect involved more than 50% of a nasal subunit, then the defect should be enlarged to encompass the entire subunit and then the entire subunit replaced. For defects that are less than 50% of a nasal subunit, Burget and Menick felt that the reconstruction should be accomplished with local tissues in the standard fashion.

We have found the subunit concept of nasal reconstruction valuable and agree with its general theory. However, several years ago, one of us (K.A.S.), while reviewing the results of a series of nasal reconstructions with defects large enough to require forehead flaps, noted that the nasal defects that required replacement of both the nasal dorsum and tip subunits consistently obtained better aesthetic results than smaller nasal defects in which just a single subunit (tip or dorsum) was replaced with a forehead flap. On critical review of these cases, it became clear that the reason for the improved results in patients with larger nasal defects was that when a forehead flap was used to replace just a nasal tip or nasal dorsum, the junction between the forehead flap and remaining nasal skin was noticeable and detracted from the final aesthetic result. This clinical observation, confirmed over a large group of patients with nasal defects, has led us to reexamine the subunit principle of nasal reconstruction (as described by Burget and Menick) and propose a modification that, in our hands, has improved the aesthetic results of our nasal reconstructions.

Gonzalez-Ulloa et al had originally proposed that the determining factor for the lines of transition between facial units was due to changes in the underlying histological characteristics of the 2 areas. A good example of how changing histological makeup gives rise to a line of transition would be the cheek and lower eye-
Histologically, the cheek skin has a thick dermis with a moderate amount of sebaceous glands and a distinct subcutaneous layer. Conversely, the lower eyelid skin has a thin dermis with a paucity of sebaceous glands, and it lies virtually on top of the underlying orbicularis muscle with no intervening subcutaneous tissue. Looking at these 2 histological landscapes, it is not difficult to appreciate that the external visual appearance of these units would be quite distinct.

However, when one considers the nose and the histological basis for distinguishing between the nasal subunits, the situation is less clear. In fact, the actual point of transition between the different nasal subunits (eg, the nasal dorsum and nasal side wall) is much more subjective than the other facial units, and the location of a clear line of demarcation between the nasal subunits may vary substantially among observers. Close examination of the nose shows that in actuality the lines of transition between the nasal subunits are due to surface highlights determined by the underlying skeletal architecture rather than substantial changes in the histological characteristics of the tissue. For example, the line of transition between the nasal tip and nasal dorsum is not due to a change in histological structure; instead, the transition between the tip subunit and the dorsal subunit is primarily determined by the lower lateral cartilages raising the nasal tip skin above the septal angle and creating the supratip depression (Figure 1, C and D). Patients with poor tip projection typically do not have a distinct line of transition between the nasal tip and dorsal subunits. In our review of nasal reconstructions, we noticed that the major

Figure 4. A, Patient with nasal defect confined to the nasal tip. B, Postoperative result showing replacement of the nasal tip with a forehead flap. Aesthetic failure is primarily due to the disparity between the forehead flap and remaining skin of the dorsum.

Figure 5. A and B, Patient with nasal defect confined to the nasal tip. C and D, Postoperative result with replacement of both the nasal tip and dorsum subunits with a forehead flap. Note that the tip and dorsum are covered by a single unbroken sheet of skin without a line of transition between the forehead skin and nasal skin.
shortcoming of the subunit principle in achieving an aesthetic result occurred when reconstructing a single nasal tip or dorsum subunit with a forehead flap. In each case, the reason for this aesthetic failure was owing to a failure of the forehead skin to blend with the remaining nasal skin of the other subunit. Furthermore, we found that patients who had both subunits replaced with a forehead flap (who presumably had larger initial defects) obtained superior aesthetic results compared with those patients who had only 1 subunit replaced.

Based on these observations, we have proposed a modification of the subunit principle which states that if a forehead flap is to be used for reconstruction of a nasal tip or dorsum defect, and there is a noticeable difference between the forehead skin and nasal skin, then a superior aesthetic result will be achieved if both subunits are replaced en bloc. Thus, the visual disparity between forehead skin and nasal skin is avoided as seen when a single subunit is replaced with a forehead flap.

The purpose of this report is to expand on our original observations with additional patients, a more formal review of the patient series, and histological observations of the disparity between nasal and forehead skin.

RESULTS

A total of 42 patients had appropriate defects and suitable documentation for inclusion in this study. There were 17 women and 25 men. Five patients did not have the subunit principle followed; 14 patients had 1 subunit replaced; 23 had 2 subunits replaced. Analysis of the aesthetic results showed the following average (or mean) scores (1 being a poor result with the reconstruction obvious and 4 an excellent result): 1.65 for patients who did not have the subunit principle followed; 2.22 for patients with 1 subunit replaced; 2.61 for patients with 2 subunits (tip and dorsum) replaced.

Statistical analysis showed that patients in whom the subunit principle was not followed had a significantly poorer result than both the groups for whom the subunit principle was followed ($P = .005$). Additionally, patients who had 2 subunits replaced had a significantly better result than those patients who had just 1 subunit replaced ($P = .008$).

Review of the histological sections of forehead and nasal skin (Figure 7) confirmed the visual impression that a forehead flap was used. The comparison of forehead skin and nasal skin revealed differences in texture, thickness, and color. This difference in skin properties is likely responsible for the aesthetic disparity seen when the forehead flap was used for reconstruction.
that there is a significant histological difference between forehead and nasal skin. The nasal skin, in all 6 cases where histological material was available, was seen to have a considerably thicker dermis than forehead skin with markedly increased content of sebaceous and sweat glands. In addition, the nasal skin was noted to have increased vascularity compared with forehead skin based on the number and size of vessels seen in the dermis and subdermis. Visually, these disparities would be expected to manifest in nasal skin as a more irregular surface (owing to gland pores) and redder coloration than forehead skin, which has a smoother and paler appearance.

Figure 7. Photomicrograph showing comparison of forehead skin (A) and skin from the nasal tip region (B) harvested from the same patient with similar magnification (hematoxylin-eosin stain). Note the increased thickness of the nasal skin dermis with an increased number of blood vessels (small arrow) and sebaceous glands (large arrow). This histological picture would be expected to make forehead skin appear paler and smoother when placed next to nasal skin, and this is what is commonly encountered in clinical situations (Figures 2, B, 3, B, and 4, B).

The human eye and mind are designed to deal with the visually complex world we live in by pattern grouping and recognition rather than focusing on each detail.\textsuperscript{5,7} We focus on the unexpected and gloss over, or take for normal, the expected. This ability to consider normal that which fits within the expected is important because one can never truly re-create a nose (or any part of the body). We can, however, “fool” the viewing eye (and attached mind) into assuming a reconstructive effort is normal by providing the proper visual cues for one to assume that the visible scars and replacement tissue are normal, and avoiding stimuli (prominent scars, incorrect contour, and lines of transition out of the expected position) that would be perceived as abnormal. To accomplish this goal, the subunit principle was developed and holds that the surgeon should repair nasal defects by replacing complete topographic subunits rather than simply “plugging holes.”\textsuperscript{1,2,4,6}

In a major article dealing with the subunit principle of nasal reconstruction, Burget and Menick\textsuperscript{4} stated that they excised the tissue remaining in a subunit and replaced the entire subunit only if the defect was more than 50% of the subunit. We feel that the subunit principle is an important concept in nasal reconstruction and strive to employ it in most of our patients. However, we have noted a discrepancy in our results with regard to the success of the subunit principle in achieving an aesthetic result for defects of the nasal tip and dorsum that require a forehead flap for reconstruction. Specifically, we have observed that patients who had both subunits replaced with a single forehead flap achieved a better overall result than those who had just a single subunit replaced, even though the patients with both subunits replaced generally had larger initial defects. On review of postoperative photographs, the explanation for this discrepancy in results between patients with replacement of 1 vs 2 subunits is caused by the excessively prominent junction at the supratip region between the forehead flap and the nasal skin of the remaining subunit. This junction is less noticeable at the interface with the alar and side wall subunits. Patients who had both subunits replaced with a forehead flap contoured to the nostril rims, columella, alar creases, and side wall achieved a much more natural-appearing result primarily because of the unbroken skin coverage of the tip and dorsum.

Objective evidence for the superiority of replacing both subunits is found in the results of this patient review where patients who had both subunits replaced scored 2.61 of 4 for overall aesthetic result of the reconstruction and patients who had only 1 subunit replaced scored 2.22 ($P = .008$). Both groups of patients in whom the subunit principle was employed scored higher than the group in whom it was not ($P = .005$). These results should not be too surprising because forehead skin, while one of the closer matches to nasal skin, is still relatively histologically distinct from nasal skin, and a noticeable line of transition is inevitable. As noted in the “Results” section, forehead skin is microscopically quite different from nasal skin and, visually, this results in forehead skin appearing smoother and paler than nasal skin.
Based on these observations, we have modified our approach to nasal defects such that if a defect of the tip and/or dorsum is large enough to require a forehead flap for coverage, and there is a substantial difference between forehead skin and nasal skin, then the skin of the remaining subunit(s) is excised and the tip and dorsum subunits are replaced en bloc. Care is taken to place the anterior scar over the nasal tip and onto the columella, contouring the flap to the nostril rims and alar crease. The forehead flap is left in place for 2 1/2 to 3 weeks and then divided close to its pedicle in the medial brow region; the donor site is closed primarily. The distal portion of the flap (previously the proximal portion) is then debulked and contoured to the remaining portion of nasal dorsum. The distal end of the forehead flap can be substantially thinned without fear of vascular compromise because the supplying vessels lie in the superficial subcutaneous tissue.9,10 The remaining skin of the dorsal subunit is then excised and the flap inset.

At first thought, excision of a large portion of ostensibly normal skin may seem a somewhat radical notion, but further reflection shows that this approach has merit, providing advantages beyond just aesthetic considerations. First, the nasal tip and dorsum are replaced by a continuous, unbroken sheet of forehead tissue with the scars hidden anteriorly on the columella, or camouflaged by following the nasal rim, alar crease, and side wall crease. The underlying cartilaginous and bony framework provide surface contouring that preserves the appearance of separate tip and dorsal subunits without a scar or juxtaposed nasal and forehead skin. Second, with standardization of techniques for harvesting forehead flaps, provision of a flap with adequate length and volume should not be a difficulty. Third, replacement of both tip and dorsum subunits for a defect that primarily involves the tip makes better use of the proximal portion of the forehead flap, which would otherwise be discarded if just the tip were to be replaced. Fourth, removing the remaining nasal skin and submitting it for histological examination has revealed inadequately excised carcinomas and second primaries. Fifth, while not advocated on a routine prophylactic basis, removal of the remaining nasal subunit(s) and resurfacing both the nasal tip and dorsum with a forehead flap replaces actually compromised nasal skin with forehead skin that is at less risk for developing subsequent carcinomas. While none of these advantages alone would be an indication for excision of normal tissue, when combined with the aesthetic improvements achieved, we feel they offer ample justification for this approach.

This approach may not be appropriate for patients who are not particularly concerned with aesthetic results or who have risk factors for wound healing problems or difficulties with safe forehead flap transfer. Such patients would include those with dementia, those who smoke, those with diabetes or peripheral vascular disease, and those with short foreheads or compromised forehead skin (from radiation, previous surgery, etc).

**CONCLUSIONS**

A successful nasal reconstruction provides not only the 3 layers of the nose but assembles them in such a way that an aesthetic result is achieved. A major advance in nasal reconstruction has been the development of the subunit principle. We have presented evidence to support the concept that in selected cases where there is a significant histological variation between forehead skin and nasal skin, a better final result may be achieved by replacing both subunits en bloc with a single forehead flap.

**REFERENCES**