The Single-Stage Forehead Flap in Nasal Reconstruction

An Alternative With Advantages

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Objective: To review the single-stage forehead flap for patient selection, technique, and main outcome measures.

Methods: Patients undergoing nasal reconstruction between January 1, 1995, and June 30, 2000, were reviewed from medical records, photographs, and personal communication. All work was performed in an academic medical center.

Results: Fifty-one patients had a forehead flap for nasal reconstruction, of which 10 (20%) were repaired in a single stage. All patients had no evidence of small vessel disease, eg, hypertension, diabetes mellitus, or tobacco use. Nasal defects were limited to the upper two thirds of the nose. The technique is modified from the original description by creating a unilateral, subcutaneous pedicle, wide undermining, and partial resection of the procerus muscle. One patient had superficial epidermolysis at the distal tip of the flap. The remaining 9 patients maintained complete viability with satisfactory outcomes. One debulking procedure was performed to the glabellar area for aesthetic reasons. The average interval for returning to work was 6.6 days compared with the minimal 3 weeks for conventional interpolated flaps.

Conclusion: In select cases, a single-stage, island midline forehead flap can be used safely as an advantageous alternative to the conventional interpolated forehead flap.

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The forehead has served as a source of tissue for nasal reconstruction for centuries and many different flaps have been designed with distinct advantages and disadvantages. The classic Indian forehead flap became popular in the United States when Blair in 1925 and Kazanjian in 1946 described the median forehead flap for nasal repair. This flap was based on a wide pedicle, capturing both supratrochlear vessels and, occasionally, the supraorbital artery. Unfortunately, this pedicle design could not extend below the eyebrows, thus limiting the arc of rotation and flap reach. Furthermore, the wide pedicle created greater torsion on vessels, thus jeopardizing flap viability with venous congestion. It was later shown that the forehead flap could be based on a solitary supratrochlear vessel and that this paramedian design afforded greater flap length and significantly enhanced the versatility of the forehead flap. The midline forehead flap combined features of both flaps with a narrow, unilateral pedicle but with the skin paddle centered in the forehead. The midline forehead flap can leave a less conspicuous donor site scar running obliquely within the glabellar furrows and vertically in the precise center of the forehead. All 3 forehead flap designs are of interpolated flaps, necessitating an interval with an external pedicle and a second-stage procedure for pedicle division.

A single-stage, island flap from the forehead was first described by Converse and Wood-Smith in 1963, during an era when the traditional, interpolated forehead flap was of a median design. His hope was that this modification would enhance the inferior reach for distal nasal defects. This island flap also used a wide pedicle that could not extend below the brows, creating similar problems with flap congestion, inadequate reach, and marked fullness along the glabella and nasion, all of which led him later to abandon this design.

Based on our current understanding of the robust nature of the midline forehead flap and the perfusion pressure of the medial brow area, a single-stage, island, midline forehead flap has been designed.

From January 1, 1995, through June 30, 2000, there were 51 patients with nasal de-
MATERIALS AND METHODS

DESIGN

A retrospective review was performed from January 1, 1995, to June 30, 2000, of all patients with nasal defects repaired with a forehead flap. Data were collected from medical records as well as preoperative, intraoperative, and postoperative photographs. For those patients who were repaired with a single-stage forehead flap, the following data were collected: age, sex, subunits involved, defect dimension, defect depth, risk factors (ie, tobacco use, diabetes mellitus, hypertension, or a history of radiotherapy), follow-up, interval for returning to work, and surgical outcome. The surgical outcome was described in terms of percent of viability, percent of flap congestion, areas of epidermolysis, and need for revision or debulking.

SURGICAL TECHNIQUE

All internal lining deficits as well as the need for structural grafting are addressed prior to the resurfacing portion of the procedure. In every case, the internal lining is repaired as needed and liberal cartilaginous grafting is used for framework support. Patient selection for the single-stage flap includes only those without risk of small vessel disease. Specifically, those persons with a history of tobacco use, diabetes mellitus, hypertension, previous radiotherapy to the face, peripheral vascular disease, and collagen vascular disease, are excluded for consideration of this single-stage repair. The primary cutaneous defect is modified in each case to conform to the principle of aesthetic subunits (Figure 1).

When a suspicious cutaneous lesion or scar exists in the midline forehead area, template position can be adjusted laterally to avoid this. In each case a template is made of the cutaneous defect and transferred to the midline of the forehead (Figure 2). The vertical position of the template is determined by careful measurement from the medial brow area. This vertical position can also be adjusted based on the hairline; a low hairline may require a lower pedicle with clear extension below the level of the eyebrows to maintain adequate reach. The subcutaneous pedicle is carefully outlined although a Doppler ultrasound is not typically used for identification of the supratrochlear artery. The skin paddle is elevated in the subdermal plane rather than the subgaleal layer. This dissection must be done meticulously to avoid inadvertent devascularization of the skin paddle. Following this elevation, however, we frequently perform additional selective flap thinning to match the native skin of the nose. As the dissection reaches the pedicle, the plane drops to the subgaleal layer and continues toward the medial brow region. A W-plasty is often incorporated along the inferior border of the cutaneous closure to avoid the standing cutaneous deformities. This resultant scar often lies along preexisting glabellar furrows. The skin is then carefully excised and dissected off the pedicle. Once the superficial and deep layers of the subcutaneous pedicle have been defined, the vertical incisions are made through the subcutaneous tissue ensuring a 1- to 1.3-mm pedicle centered on the medial brow region (Figure 3).

If the skin paddle does not appear as robust as anticipated, one can avoid the deepithelializing portion of the pedicle dissection and convert this to a conventional interpolated flap. Once the island forehead flap is created, the glabellar region is elevated to create the tunnel with the nasal defect. The procerus muscle is partially resected to create adequate space for the subcutaneous pedicle. This muscle can also be mobilized as a flap and transposed into the donor site of the forehead flap pedicle, thus improving forehead contour. Without this, one often finds a subtle depression in the glabellar region. The skin paddle is sewn to the nasal skin in the usual fashion with particularly superficial bites along the superior border of the skin paddle as this area also represents the flap pedicle (Figure 4A-B). While a head wrap is applied to the forehead, great care is observed to minimize pressure on the subcutaneous pedicle as flap congestion is probably the greatest risk of this procedure. Most donor sites can be closed primarily with wide undermining.

The interpolated forehead flap remains the standard method for resurfacing larger nasal defects and was used with most patients in this series. Recent modifications of this flap have contributed to a more versatile and aesthetic method of repair, yet each continues to push the envelope for viability. One recurring feature is the robust nature of this flap, eg, unilateral supratrochlear artery, narrow pedicle, aggressive thinning, and now, conversion to an island flap. One reason for the dependable nature of the forehead flap, one that may have been less appreciated years ago, is the sig-
nificance of perfusion pressure at its pedicle base, ie, along the medial brow region. The understanding of flap physiology has evolved and the length-width ratio, once thought to be dictum for ensuring viability, has been shown to be fallacy.\textsuperscript{11} Perfusion pressure is the dominant variable when designing cutaneous flaps and this may explain the unusual versatility of the contemporary forehead flap. By capturing the supratrochlear artery along with the rich collaterals from the terminal angular artery, the forehead flap is uniquely designed to withstand a lengthy and narrow pedicle. This occurs despite the fact that the supratrochlear vascular trunk is rarely incorporated for more than a few centimeters within the flap. Inflow from the facial artery, via the angular vessel, is a significant contributor to the perfusion pressure and allows the pedicle to extend well below the brow. This has been demonstrated by selective perfusion of the facial artery with a silicone rubber case (Microphil; Flow Tech, Carver, Mass) following elevation of a midline forehead flap.\textsuperscript{9} Dissection of the vascular arcade along the pedicle base demonstrates an extensive collateral network from the angular artery, this occurring without the supratrochlear artery being cannulated. Some surgeons have reported harvesting 3 separate flaps from a given patient, the third presumably based on collateral flow from the angular artery alone (Ted A. Cook, MD, oral communication, September 23, 2000). The axial orientation of small subdermal vessels also contributes toward the robust nature of this flap, occurring in both the conventional interpolated and single-stage designs.

Deepithelializing the pedicle and transferring it as a single-stage, island forehead flap has been described by others,\textsuperscript{12} including the repair of full-thickness nasal defects. This modification is the extreme toward pushing the limits of flap viability and has been performed in low-risk patients only. Those with small vessel disease or with inferior subunit involvement, eg, columella or distal nasal tip, have been avoided. Earlier problems with the island flap related to the width of the subcutaneous pedicle and the necessary arc of rotation with subsequent venous congestion of the skin paddle. By creating a unilateral, narrow pedicle less than 1.5 cm wide, and basing it off the medial brow region, one can transfer the flap with less rotation at the pedicle base. This seems to minimize the venous congestion seen with earlier attempts. Using the patient selection criteria described, it appears that the single-stage forehead flap designed similar to the current interpolated flap can be performed successfully and dependably.
The other criticism of the original single-stage flap related to the disfiguring bulk at the nasal root. A narrow pedicle, wide undermining, and resection of the procerus muscle, all help to minimize this contour problem. Furthermore, natural regression occurs over several months and can be accelerated with incremental injections of triamcinolone acetonide. Surgical debulking is easily accomplished when necessary, although only 1 patient (10%) requested it.

The most significant advantage of this flap is the ability to bury the pedicle and obviate the second stage. While it is not a major procedure, some persons suffer significantly during the interim period with the interpolated pedicle and the obligatory second procedure. The necessity of transportation, time off work, and wound care, all play into their anxiety and inconveniences. On occasion, it has been this consideration alone that has persuaded some to select a local transposition flap or skin graft for a large nasal defect and accept the compromised aesthetic and functional outcomes. A buried subcutaneous pedicle has several advantages over the conventional interpolated flap: (1) The pedicle undersurface is often a source of bleeding and drainage that continues for a couple days postoperatively. Those who are in a public workplace or dusty environment are obligated to stay off work until pedicle division has been completed. Placing a small skin graft to the pedicle undersurface can reduce this problem, and may be worthwhile when the source of skin is normally discarded, eg, standing cutaneous deformities from donor site closure. (2) Those who are dependent on eyeglasses for daily activities are significantly impaired by the pedicle; the inability to use eyeglasses can be the sole reason for

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**Figure 4.** A, Island flap is transposed under intact glabellar skin. B, Nine-month postoperative view of the same island flap.

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### Characteristics of 10 Patients Who Underwent Single-Stage Forehead Flap

<table>
<thead>
<tr>
<th>Patient No./ Sex/Age, y</th>
<th>Dimension of Defect, mm</th>
<th>Subunits Involved</th>
<th>Duration of Follow-up</th>
<th>Interval Off From Work, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/65</td>
<td>22</td>
<td>Dorsal</td>
<td>5 y</td>
<td>8</td>
</tr>
<tr>
<td>2/F/65†</td>
<td>18</td>
<td>Dorsal (20% tip)</td>
<td>4 y</td>
<td>NA*</td>
</tr>
<tr>
<td>3/M/62</td>
<td>18</td>
<td>Lateral</td>
<td>4 y</td>
<td>4</td>
</tr>
<tr>
<td>4/F/47</td>
<td>20</td>
<td>Lateral</td>
<td>3 y</td>
<td>14</td>
</tr>
<tr>
<td>5/M/48‡</td>
<td>12</td>
<td>Lateral</td>
<td>2 y</td>
<td>6</td>
</tr>
<tr>
<td>6/M/46†</td>
<td>22</td>
<td>Dorsal lateral</td>
<td>2 y</td>
<td>5</td>
</tr>
<tr>
<td>7/F/59§</td>
<td>18</td>
<td>Lateral</td>
<td>1 y</td>
<td>7</td>
</tr>
<tr>
<td>8/F/52</td>
<td>16</td>
<td>Lateral (10% ala)</td>
<td>1 y</td>
<td>NA</td>
</tr>
<tr>
<td>9/F/62</td>
<td>18</td>
<td>Dorsal lateral</td>
<td>3 mo</td>
<td>3</td>
</tr>
<tr>
<td>10/M/60</td>
<td>13</td>
<td>Lateral</td>
<td>6 mo</td>
<td>6</td>
</tr>
</tbody>
</table>

*NA indicates does not apply.
†A cartilage defect was detected.
‡Patient underwent a debulking procedure to the glabellar area for aesthetic reasons.
§Patient had a superficial epidermolysis at the distal tip of the flap.
employment disability. A single-stage flap allows the use of eyeglasses but pressure on the skin paddle must still be avoided by taping the bridge of the eyeglasses to the forehead. (3) Finally, the pedicle creates sufficient aesthetic peculiarity that most people remain out of the public eye for the interval 3-week period. The buried pedicle allows the patient to return sooner to the public eye although periorbital ecchymosis often remains.

The average duration of time off work for this group was 6.6 days, excluding the 2 patients who were unemployed. Although those patients repaired with an interpolated forehead flap were not formally reviewed, it is exceedingly unusual for a patient to work in the public eye with such an external deformity. Moreover, the disability of not using eyeglasses can be underappreciated in the elderly population, especially when many do not use contact lenses. Finally, it is recognized that those patients repaired with a single-stage flap and in dire need of uninterrupted work may have continued to do so even with an interpolated forehead flap.

There are disadvantages of the single-stage forehead flap. First, the procedure is technically more challenging and adds surgical time to an already lengthy procedure. Elevating skin off the pedicle and creating the subcutaneous tunnel under intact glabellar skin is tedious; inadvertently dissecting in the wrong plane runs the risk of amputating the flap. Transposing the procerus muscle as a small muscular flap to fill the donor site defect is also an additional step not needed with the conventional, interpolated method.

Second, the island design is logically more tenuous than traditional methods; pedicle rotation and compression from overlying skin can compromise viability. One patient suffered a superficial epidermolysis along the distal border of the skin paddle, which resulted in a slightly wider scar than expected. No further intervention or revision was selected. In general, arterial inflow is probably adequate from the strong perfusion pressure. Venous congestion, however, is more ominous and every effort is observed to monitor for this. Although we have not seen significant congestion in this patient group, it has occurred with interpolated flaps and prompt intervention is prudent. Multiple options exist including release of suture lines, serial pin pricks, medicinal leeches, or hyperbaric oxygen. In addition, the skin paddle of the flap is elevated in a similar manner for both the single-stage and interpolated flaps, preserving the option of converting to an interpolated design intraoperatively. If the flap margins do not bleed briskly or unexpected scar is encountered, the pedicle can be elevated in a standard fashion with preservation of overlying skin. This did not occur in this series but all patients provided informed consent for both methods of repair.

Finally, even a narrow subcutaneous pedicle can leave an unnatural fullness to the glabellar region, which may be distracting as a blunted nasofrontal angle. As previously discussed, the tissue tends to regress and gradual improvement in profile contour can be expected. The pedicle occasionally carries intact neural sensation where light touch to the nose is interpreted as from the forehead. This is resolved with the surgical debulking.

The retrospective design and subjective evaluations are intrinsic limitations that are recognized. An objective study of such a technique would require a blinded, randomized, and prospective analysis comparing results with a control group, ie, two-staged interpolated flap. There are practical difficulties with such a design. This series does demonstrate, however, that with the patient criteria used, the single-stage flap is an alternative to the conventional interpolated flap. It is our practice to limit this method of repair only for those candidates without evidence of small vessel disease and in whom an interval with an external pedicle poses significant hardship that cannot be easily overcome.

CONCLUSIONS

The single-stage midline forehead flap is an addition to the multiple refinements of the forehead flap that have occurred over the last several decades. The contemporary flap can be aggressively thinned, harvested from the midline of the forehead, and based on a narrow pedicle that extends well below the level of the brow. Deepithelializing the pedicle with conversion to an island flap further pushes the envelope of a robust and versatile flap. This single-stage flap is an alternative method of nasal reconstruction with some advantages. The review suggests that, with careful patient selection, the forehead flap pedicle can be deepithelialized and tunneled under glabellar skin, preserving a viable flap and completing the nasal resurfacing in a single-stage procedure.

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