

ONLINE FIRST

Outcomes of Paramedian Forehead and Nasolabial Interpolation Flaps in Nasal Reconstruction

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Objective: To determine the factors contributing to failure of interpolation flaps in nasal reconstruction.

Design: Retrospective medical chart review.

Setting: Tertiary care academic center.

Patients: A total of 107 patients with nasal defects needing reconstruction, performed at the University of Arkansas for Medical Sciences, Little Rock.

Intervention: Patients underwent nasal reconstruction with 2-stage paramedian forehead or nasolabial flaps (PMFF and NLF, respectively) from 2002 to 2011. Defect thickness, location, flap type, use of cartilage grafts, and comorbidities, including diabetes mellitus, peripheral vascular or coronary artery disease, and smoking habits, were recorded.

Main Outcome Measures: Full success, partial failure, or full failure of the respective flap.

Results: Eighty-two of the patients (77%) underwent 2-stage PMFF repair and 25 (23%) underwent 2-stage NLF repair. Fifty-eight defects (54%) were full thickness, in which 46 repairs used PMFF and 12 used NLF for reconstruction. The overall failure rate was 6%. Five PMFF failed (6%); 3 of these were used for full-thickness repairs. There was only 1 NLF failure (4%), which was also performed for the repair of a full-thickness defect. Use of cartilage in the reconstruction did not affect failure rates of the different soft tissue flaps. No single comorbidity was noted to have a statistically significant effect on failure rates, although 83% of failures were observed in smokers.

Conclusions: The overall success rate of interpolation flaps in nasal reconstruction was 94.4%. Defect thickness, use of a cartilage graft, type of flap used, and presence of comorbidities did not affect outcome. Although the comparison was not statistically significant ($P = .21$), flap failures were more commonly observed in smokers.

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I NTERPOLATION FLAPS ARE FREQUENTLY used in nasal reconstruction. Although much has been written about the nasolabial flap (NLF) as well as the paramedian forehead interpolation flap (PMFF) and their use in the reconstruction of nasal defects, most of the literature concerning these flaps focus on surgical techniques, their modifications, and/ or the usefulness of either flap for specific subsites of the nose.¹⁻⁸ Since both NLF and PMFF are used in the reconstruction of relatively larger and/or through-and-through defects of the nose, their failure may have an important impact on the cosmetic and functional outcomes. Therefore, patients who undergo such repairs should be appropriately counseled regarding the potential cosmetic and/or functional deficits in case the flap fails. To provide such counseling, the surgeon should be aware of patient factors or reconstruction needs that may potentially have ill effects on the

outcome of the interpolation flap. The purpose of this study was to determine whether the type of interpolation flap used, thickness of the defect (full vs partial), use of cartilage graft, smoking status, or the presence of relatively common comorbid conditions such as diabetes mellitus, coronary artery disease, hypertension, hyperlipidemia, gastroesophageal reflux, or chronic obstructive pulmonary disorder play a role in take rates of interpolation flaps in nasal reconstruction. This information will provide better counseling for patients undergoing nasal reconstruction with PMFF or NLF.

METHODS

A retrospective medical chart review was performed for patients who had undergone nasal reconstruction by either a PMFF or a NLF by 2 of us (E.V. and J.M.K.) in the department of otolaryngology-head and neck surgery at the University of Arkansas for Medical Sciences

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Table. Demographics and Details of 107 Patients Who Underwent Nasal Reconstruction With Interpolation Flaps

Characteristic	Group, No. (%)	
	NLF	PMFF
Age, mean (range), y	65.4 (47-85)	65.5 (23-82)
Sex		
Male	5	43
Female	20	39
Total	25 (23.4)	82 (76.6)
Etiology		
Basal cell carcinoma	20 (80)	64 (78.0)
Squamous cell carcinoma	4 (16.0)	12 (14.6)
Other	1 (4.0)	6 (7.3)
Defect thickness		
Full	12 (48.0)	46 (56.1)
Partial	13 (52.0)	36 (43.9)
Cartilage graft use	10 (40.0)	35 (42.7)
Smoker	13 (52.0)	43 (52.4)
Failure	1 (4.0)	5 (6.1)
Comorbidities		
Hypertension	11 (44.0)	31 (37.8)
Diabetes mellitus	2 (8.0)	10 (12.2)
Coronary artery disease	1 (4.0)	8 (9.8)
Chronic obstructive pulmonary disease	5 (20.0)	5 (6.0)
Gastroesophageal reflux disease	2 (8.0)	7 (8.5)
Hyperlipidemia	7 (28.0)	11 (13.4)

Abbreviations: NLF, nasolabial flap; PMFF, paramedian forehead flap.

(UAMS), Little Rock. Approval from the internal review board at UAMS was obtained prior to data collection. All patients who underwent nasal reconstruction with a 2-stage PMFF or a 2-stage NLF were included. Patients who underwent nasal reconstruction using any other modality, as well as patients who had insufficient follow-up, were excluded.

Patient demographics; histopathologic diagnosis of the excised specimen; defect characteristics, including thickness, size, and location; specific flap type used for repair; use of cartilage grafts; and comorbidities, including hypertension, diabetes mellitus, coronary artery disease, hyperlipidemia, chronic obstructive pulmonary disorder, as well as smoking habits, were recorded. Although it was not one of the primary data points analyzed, complications other than flap failure, such as bulkiness of the flap, alar rim notching, nasal obstruction and such, were also recorded.

Outcomes were recorded as successful if the entire flap was viable at the time of pedicle division; partial failure, if there was full-thickness loss involving less than 50% of the entire flap at the time of pedicle division; or complete failure, if the loss was full thickness and involving more than 50% of the entire flap at the time of pedicle division. If there was either type of failure, the management of the failure was recorded. The defects that were through-and-through were considered as full-thickness defects, and the ones sparing nasal mucosal lining were considered as partial-thickness defects, even if they involved a portion of the osteocartilaginous nasal framework.

Although decision-making in reconstruction of the nasal defects may have shown some variations, surgical techniques did not vary between surgeons. Briefly, the defect was evaluated for its size, depth, and the need for cartilage graft or inner lining before beginning reconstruction with either technique. If any extension of the defect into adjacent subunits of the face was noted, adjacent subunit defects were managed accord-

ingly by using secondary healing, skin grafts, or cervicofacial flaps. If the nasal mucosal lining was missing, a primary repair of the lining defect, septal mucosal flap, septal mucocartilaginous hinged composite flap, or a bipediced mucosal flap from the septum and the sidewall was used, based on the site and size of the defect. When a cartilage graft was needed, auricular conchal cartilage, nasal septal cartilage, or costal cartilage was used.

If a PMFF was used, the supratrochlear artery was identified by the aid of a Doppler probe, and the pedicle length was determined. A template cut from a suture pack was typically used to transfer the size and shape of the defect exactly to the donor site during the design of each flap. The flap was elevated initially either in the subcutaneous plane or subgaleal plane, depending on the thickness needed, until the pedicle portion of the flap was reached. At this point, the flap was elevated in a subgaleal plane, including the frontalis muscle with the pedicle. If more pedicle length was needed by extending the pedicle toward the orbital socket, elevation of the pedicle was typically continued subperiosteally as an additional safety measure. After elevation, the flap was judiciously trimmed and inset under minimal tension into the recipient site. The PMFF donor sites were managed by primary closure, with or without leaving a defect for secondary healing.

If an NLF was used, then the flap was designed in a way to leave the final donor site closure scar in the nasolabial fold. The NLF was elevated in the subcutaneous fat plane by leaving adequate fatty tissue underneath the flap depending on the need for thickness. Flap thickness was modified as needed based on the depth of the defect, either following completion of flap elevation or during the flap elevation process. These donor sites were exclusively closed primarily.

Typically, the second stage of either of these flaps took place 3 to 4 weeks after the first stage. If needed, the flaps were thinned again at the time of pedicle division up to the junction of their proximal and distal halves. In either case, the pedicle was amputated, and closure was performed in a way to enhance symmetry and allow the most cosmetically pleasing outcome. If additional sculpturing needed in either flap type, that is usually performed as a third stage. If a flap failure necessitated the use of another interpolation flap, these salvage flaps were not included in the study group because of the altered state of the recipient site by the original reconstructive attempt.

Statistical analysis was performed to determine significance of failure rates between NLFs and PMFFs, use of cartilage grafts, between full- and partial-thickness defects, and the significance of certain comorbidities, including smoking status. Multiple χ^2 tests were used to analyze most of the data except cases in which cell counts were less than 5, in which case Fisher exact test was used. We did not make adjustment for multiple comparisons.

RESULTS

A total of 107 patients were identified for inclusion in the study. Demographics and the details of the recorded parameters of these patients are summarized in the **Table**. Eighty-two patients (76.6%) underwent reconstruction of defects with a PMFF and 25 (23.4%) with an NLF.

A total of 6 flap failures (4 partial and 2 complete) were identified among 107 procedures, which brought the overall failure rate to 5.6%. Complete failure of interpolation flaps in this series was rare, with a 2.0% occurrence. Both of the complete failures occurred after reconstructing full-thickness defects, 1 using a PMFF and

the other using an NLF. All partially failed flaps were PMFFs. When broken into flap types, our series showed a 4.0% failure rate (1 of 25) in the NLF group and a 6.1% failure rate (5 of 82) in the PMFF group. However, when partial flap losses were excluded, our complete PMFF failure rate was 1.2% (1 of 82). There was no statistically significant difference in overall failure rate (partial or total) between the PMFF and NLF groups ($P > .99$).

Fifty-eight of the flaps (54.2%) were performed for through-and-through defects, whereas 49 (45.7%) were performed for partial-thickness defects. Within the NLF, 12 were used to repair full-thickness defects, and 13 used for partial-thickness defects. The PMFFs were used for reconstruction for full-thickness defects in 46 patients (56.1%) and for partial-thickness defects in 36 patients (43.9%). Although 5 of 6 failed flaps were used in repairing full-thickness defects, the difference in flap failure rates was not statistically significant between full-thickness and partial-thickness defect groups ($P = .21$). Also, flap failure rates were not different among surgeons ($P = .35$).

Forty-five of the reconstructions (42.1%) included cartilage grafts. Ten patients in the NLF group (40.0%) involved cartilage graft use, whereas 35 patients (42.7%) of PMFF reconstructions necessitated cartilage grafts. Of the total of 6 flap failures, 3 were associated with use of cartilage grafts, whereas the other 3 were not. Flap failure rates showed no statistically significant difference based on cartilage graft usage during repair ($P = .69$).

No statistically significant association was found between flap failure and any specific comorbidity such as hypertension ($P = .40$), diabetes mellitus ($P = .51$), coronary artery disease ($P = .41$), hyperlipidemia ($P > .99$), gastroesophageal reflux disease ($P = .43$), or chronic obstructive pulmonary disease ($P > .99$). Fifty-six of 107 patients (52.3%) were smokers. There were 13 smokers (52.0%) in the NLF group, whereas the number of smokers was 43 in the PMFF group (52.4%). Smoking status was similar between the 2 flap groups ($P > .99$). Although 5 of 6 failures were observed in smokers (83.3%), smoking was not found to be a statistically significant factor in flap failure ($P = .20$).

Complications that were most common in both types of flaps were nasal obstruction, 6.5% (NLF, 2; PMFF, 5), thick scars or bulky flaps requiring debulking, 11.2% (NLF, 4; PMFF, 8), mild alar notching, 4.7% (NLF, 2; PMFF, 3), and pin cushioning, 6.5% (NLF, 4; PMFF, 3). These occurred in both types of flaps, although bulky flaps, nasal obstruction, and alar notching were slightly more common in PMFF, whereas pin cushioning was more common in NLF (as shown by the numbers herein). Trapdoor deformities occurred in only 2 patients, both of whom underwent a PMFF (1.9%).

Of those flaps that failed, only 1 of the 6 was treated conservatively, which consisted of leaving the failed portion for secondary healing, without any further surgical intervention. The other 5 patients with flap failures (83.0%) needed further surgical treatment to finalize the reconstruction. Of those who needed surgical treatment for their flap failures, 2 patients underwent another PMFF from the opposite side, and 1 patient underwent a single-stage NLF. One patient with necrosis and contracture underwent a flap revision with continued dehiscence and

contracture requiring excision of the flap, followed by primary closure with secondary healing resulting in a partial-rhinectomy defect. One patient who was a smoker underwent a single-stage NLF flap for the failure of the initial reconstruction, followed by another PMFF procedure for the repair of the failed NLF.

COMMENT

Nasal reconstruction using advancement, advancement-rotation, or transposition flaps are usually performed in relatively smaller defects without through-and-through involvement. Therefore, failure of these flaps can still be managed successfully by using additional flaps, interpolation flaps, or leaving the persistent portion of the defects for secondary healing, usually with acceptable or negligible cosmetic and/or functional morbidity. However, nasal defects necessitating an interpolation flap in the initial surgery tend to be larger and/or with full thickness, which makes reconstruction more complicated; even more so when these flaps fail. Failure of interpolation flaps in such cases may cause considerable adverse effects on functional and/or cosmetic outcomes, in addition to the disappointment and frustration of the patients after carrying an unsightly pedicle for weeks during the period of waiting for the second stage. Therefore, preoperative discussion about potentially contributing factors in interpolation flap failure with the patients who need nasal reconstruction after ablative surgery or trauma has utmost importance. The surgeon should be aware of factors, if there are any, that could contribute to the failure of interpolation flaps in order to provide their patients better counseling. There is a wealth of literature concerning nasal reconstruction, although there is less information about complications, factors that affect success, or studies comparing reconstruction techniques. To our knowledge, the current study is the first describing failure rates and analyzing potential factors contributing to the failure of interpolation flaps as a whole, considering both PMFF and NLF in nasal reconstruction.

Overall, interpolation flaps can be used successfully in the reconstruction of nasal defects, as shown by our finding of an overall failure rate of 5.6%. Our 6.1% overall PMFF failure rate was in agreement with the rate reported in a previously published study by Little et al,⁸ who found an overall PMFF flap failure rate of 4.9% in a series formed by 205 cases. They reported a complete PMFF failure rate of 1%, which is almost identical to our 1.2% complete PMFF failure rate. These results suggest that PMFFs are very reliable, with an extremely low complete failure rate of about 1%.

Overall NLF failure rates were reported as high as 17% in a series formed by 18 consecutive patients who underwent nasal alar reconstruction with single-stage "island" NLFs; however, all 3 failures in this analysis were reported to be partial.¹ Another study performed on single-stage nasolabial transposition flaps revealed no complete failures and 6.7% partial failures.⁴ Considering the results from these 2 studies in conjunction with zero partial failures in our series, one may assume that partial failures may be more likely in NLFs when they were used

as transposition or island flaps rather than 2-stage interpolation flaps. This may be explained by possible deleterious effects of tension or compression at the base of the pedicle of these flaps in addition to necessary arc of rotation, when the surgeon used a single-stage island or transposition flap rather than a 2-stage interpolation flap. However, it is highly likely that our single complete NLF failure might be more technique related, since 2 previously mentioned studies revealed complete NLF failure rates of zero.^{1,4}

It has commonly been felt that local flaps with a random blood supply are more vulnerable than those flaps that have an axial blood supply, especially for large defects.⁷ We could not demonstrate any significant difference in failure rates between PMFF and NLF groups in our study. As discussed herein, complete failure rates reported for NLFs are even lower than complete failure rates reported for PMFFs (0 vs 1%). This could imply that a random blood supply might not have as notable adverse effects on the outcome as once thought, when compared with an axial blood supply in the reconstruction of nasal defects.

Theoretically, placement of a cartilage graft underneath an interpolation flap may limit its neovascularization, causing the periphery of the recipient bed to be more important when this is done. The cartilage graft may act as a barrier for neovascularization, at least for the flap's deep surface, and the flap may be dependent on neovascularization through the peripheral edges of the recipient bed. Neovascularization through the undersurface of the interpolation flaps may not be an important source of blood supply until pedicle division, since the flaps continue to receive their blood supply through the pedicle. However, interpolation flaps with borderline peripheral neovascularization through the edges of the recipient bed may suffer after pedicle division, if neovascularization from the recipient bed into the deep surface of the flap was diminished owing to the barrier effect of the cartilage graft. We were not able to show any difference in flap failure rates among those who used a cartilage graft underneath the flap. Based on this finding, it seems that interpolation flaps may not be dependent on vascular in-growth from their undersurface by the time of pedicle division, and that peripheral neovascularization would be sufficient for their viability.

Although we were not able to demonstrate a statistically significant difference in failure rates among full- and partial-thickness defects, both complete failures in our series were observed after repairing full-thickness defects. This finding shows at least a trend of increased risk of failure in reconstruction of full-thickness defects, which is congruent with the findings of Little et al,⁸ who demonstrated a statistically significant difference in failure rates between full- and partial-thickness defects. Therefore, patients with full-thickness defects should be made aware of higher possibility of flap failure in full-thickness defects. This fact may be explained by the necessity of nasal mucosal lining repair, which may pose an additional risk to the overlying interpolation flap by exposing its undersurface to the contaminated nasal cavity environment, which may cause a potentially harmful infection in the flap.

None of the recorded comorbidities were found to be a statistically significant factor affecting failure rates in our series. Little et al⁸ reported similar results in that dia-

betes mellitus, peripheral vascular disease and age were not associated with an increased rate of major complications. These findings run contrary to previously held philosophies regarding such cardiovascular and pulmonary comorbidities, and their lack of association with major complications is relevant for physicians when determining which patients are candidates for repair of defects via interpolation flaps.

Smoking status has traditionally been associated with flap failures, and it was found to be significantly associated with flap failure in animal models.^{9,10} It was also shown that smoking was significantly associated with failures of PMFFs in a previous study.⁸ Although 5 of 6 flap failures in our series were associated with smoking, we were not able to demonstrate a statistically significant increase in flap failure rates in smokers. This may be due to variations in smoking habits of patients between study groups, since it has been previously shown in an animal model that the flap loss was correlated with the intensity of smoke exposure.¹¹ Therefore, it is not surprising to see contradictory results among studies comparing flap failure rates between smokers and nonsmokers. The amount of smoking is usually not analyzed in detail in such studies, which may even be a more important factor than smoking itself.

Although it has inherent limitations due to its retrospective nature, our study compared failure rates of interpolation flaps based on the type of flap used, defect thickness, presence of a cartilage graft underlying the flap, smoking status, and the presence of certain comorbidities. A statistically significant correlation could not be demonstrated for any of these factors. However, this study demonstrated that overall survival for interpolation flaps used in nasal reconstruction is still very high, with a success rate of 94.4%. Discouraging the patient from smoking in the perioperative period may still help the viability of these flaps, although a statistically significant correlation could not be shown. Comorbidities that were once thought to be potentially negative factors interfering with the blood supply and/or oxygenation of the interpolation flaps used in nasal reconstruction may not be as important in obtaining successful outcomes.

In conclusion, 2-staged PMFF and NLF have an acceptable overall failure rate of 5.6%. Although not statistically significant, a trend was observed toward interpolation flap failures in smokers and patients with full-thickness nasal defects. Use of a cartilage graft, diabetes mellitus, coronary artery disease, hypertension, chronic obstructive pulmonary disorders, or hyperlipidemia did not increase the risk of flap failure in nasal reconstruction using interpolation flaps in our study.

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