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Reducing Nasal Morbidity After Skull Base Reconstruction with the Nasoseptal Flap: Free Middle Turbinate Mucosal Grafts

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Abstract

Introduction—The nasoseptal flap provides hearty, vascularized tissue for reconstruction of Expanded Endonasal Approaches (EEA); however, it produces donor site morbidity due to exposed cartilage. Mucosalization of the septum requires 12 weeks, multiple debridements, and frequent saline rinses. This study addresses the reduction of nasal morbidity by grafting middle turbinate mucosa onto the exposed septum.

Methods—15 patients undergoing EEA of the ventral skull base were prospectively enrolled. In seven cases, the sacrificed middle turbinate mucosa was harvested and placed as a free mucosal graft on the septal cartilage. In eight controls middle turbinate grafting was not performed due to tumor involvement. Septal mucosalization and crusting of all patients was quantified at follow-up appointments. An additional 46 patients were retrospectively identified who received middle turbinate grating on their exposed septal cartilage and mucosalization rates determined from clinical records.

Results—Three weeks after initial operation, the mucosalization rate was 70% versus 5% in the graft and non-graft groups, respectively. At post-operative week six, the mucosalization and crusting were 97% and 5% for the graft group versus 60% and 85% for the non-graft group. Mucosalization rates in the retrospective graft series agreed with the prospective series.

Conclusions—Despite donor site morbidity, the nasoseptal flap is becoming the standard of care for skull base reconstruction due to its reliability in reestablishing a barrier between the subarachnoid space and the sinonasal tract. It is possible to dramatically increase the rate of septal mucosalization and decrease crusting by using a middle turbinate free mucosal graft.

Level of Evidence—1b

Keywords

Skull base reconstruction; nasoseptal flap; free mucosal graft; middle turbinate graft

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INTRODUCTION

The use of an Expanded Endonasal Approach (EEA) to the anterior skull base has become a viable approach for the treatment of benign and malignant pathology of the base of skull.[1–4] Unfortunately, this approach results in the creation of large skull base and dural defects. Until recently, reconstruction of these defects and reestablishment of a barrier between the subarachnoid space and the sinonasal tract have been the limiting factors in the advancement of EEA.[3,5] Multiple approaches to provide reconstruction coverage have been tried including allografts, mucosal, fascial, and regional pedicled flaps;[6,7] however, the pedicled nasoseptal flap, which provides hearty, vascularized tissue for reconstruction, is quickly becoming the standard of care for large skull base and dural defects.[8,9] With the adoption of pedicled nasoseptal flaps, control of high flow intraoperative cerebrospinal fluid (CSF) leaks by experienced surgeons have been greater than 95%, consistent with results seen in traditional open approaches.[8–11] Although the pedicled flap provides an excellent reconstructive source, flap harvest results in significant donor site morbidity along the cartilage of the septum that can take up to three months to heal.[12] Functional nasal mucosa is critical for the maintenance of mucociliary clearance and to limit bacterial overgrowth.[13]

Following harvest of the pedicled nasoseptal flap, both secretions and blood flow directly onto the exposed cartilage and bone of the septum. The absence of a ciliated mucosal surface allows the material to stagnate and dry. This crusting on the septal surface, creates a rhinitis which causes significant patient discomfort and quality of life disturbance in the postoperative period.[14] These dried secretions may also produce turbulent airflow that increases nasal dryness and causes an increase in symptomatic rhinitis in the remainder of the operated sinuses. Dried secretions cause patient discomfort due to a sense of fullness, pain, poor nasal airflow, propensity for infection, and the need for frequent debridements. The rhinitis continues as long as exposed cartilage remains a nidus for the stagnation of secretions. Since the nasoseptal flap donor site must mucosalize from the free edges of the surrounding mucosa, the healing time is directly related to the size of the defect and the ability to keep the cartilage clean to optimize healing in the postoperative setting.

Complete remucosalization of the nasal septum after nasoseptal flap reconstruction requires an average 10–12 weeks.[12] EEA using a nasoseptal flap for skull base reconstruction requires a large nasal corridor and often necessitates the removal of one, and rarely both, middle turbinates.[8,15] If the middle turbinates are uninvolved in the pathological process, there is approximately 5.5 cm^2 of mucosa on each turbinate that would otherwise be discarded.[16] While mucosal grafts placed on bone are successfully used for the repair of small skull base defects such as encephaloceles and CSF leaks, the use of mucosal grafts on septal cartilage is not widely performed. The theoretical advantage of placing a mucosal graft along the cartilage of the septum is the early return of a functioning mucosa, improved mucociliary clearance, and decreased nasal morbidity after EEA. The present study describes our use of a free mucosal graft harvested from a resected middle turbinate to increase the healing rate of the septal mucosa and decrease associated morbidity (Figure 1).

METHODS

Approval for this study was obtained from the University of North Carolina (UNC) Biomedical Institutional Review Board. Fifteen patients undergoing EEA with a nasoseptal flap for lesions of the anterior ventral skull base were prospectively enrolled. These procedures were either endoscopic anterior craniofacial resections or some combination of trans-cribriform, trans-planar, and trans-sellar approaches for skull base neoplasms (Table 1). Seven were candidates for middle turbinate graft. These patients were compared to a group of eight patients who underwent similar procedures but were not middle turbinate

graft candidates, usually due to tumor involvement of the middle turbinates. To support the results of this small-scale prospective study, we also retrospectively identified 46 patients treated between July 2008 and July 2011 who were operated on by the senior author, received middle turbinate grafts, and had sufficient documented follow-up.

Surgical procedure

In both the prospective and retrospective phases, a middle turbinate was sacrificed to establish the nasal corridor. A standard Hadad-Bassagasteguy nasoseptal flap was raised and used to reconstruct the resultant skull base defect, as previously described.[8,9] Historically, the removed middle turbinate was discarded at the end of the case. At the conclusion of each procedure in the experimental arm, the previously sacrificed middle turbinate was denuded of its mucosa and mucoperiostem on the back table using a number 15 blade, cottle elevator, and tissue forceps. This was accomplished by incising on the head and inferior margin of the turbinate and elevating the mucosa in a superio-anterior direction. The medial and lateral mucosa was completely elevated on each side before detaching the mucosa from the superior portion of the turbinate. Prior to removal, the mucosal surface was marked with a marking pen to avoid inadvertently misplacing (mucosa down) the graft on the septum. Any uneven strands of mucosa were then trimmed from the grafts, and the resultant free mucosal grafts were then placed on the exposed cartilage on the nasal septum and spread out under endoscopic guidance using the ball-tipped sinus seeker and the blunt end of the cottle elevator (Figure 2A). Bilateral Doyle splints were then applied and secured across the graft and cartilage with 3-0 prolene sutures. In the seven control cases in the prospective study, splints were applied, but no turbinate graft was utilized. Doyle splints are left in place for two and a half to three weeks for both cases. Patients were instructed to use saline spray four to five times per day until the splints are removed, then saline irrigation was started three times per day. After the splints are removed at three weeks and again at five to six weeks the nose is lightly debrided (being careful to not disturb the graft). The patients routinely follow up at 10–12 weeks and then every three months thereafter. Patients are instructed to abstain from strenuous activity and nose blowing for six weeks. Long-term saline irrigation is continued once per day.

Assessment of mucosal recovery and crusting

Study patients were seen at three, six, and twelve weeks for routine follow-up and assessment of mucosal recovery and crusting. Splints were removed at week three. Photo and video documentation of the degree of mucosalization was obtained for all cases at each visit. The percentage of mucosal recovery and crusting was estimated. In the retrospective portion of this study, clinic notes of the senior author were utilized to quantify the percentage of mucosalization at each visit. Statistical analysis – Statistical and graphical analyses were performed using Prism v. 5.0a (GraphPad Software; La Jolla, CA).

RESULTS

In the prospective phase of this study, all patients in the graft group had over 50% mucosalization rates at the first postoperative visit (Table 1 and Figure 3A). The overall mucosalization rate three weeks after the operation in the graft group was 70% versus 5% in the non-graft group (Figure 3A). At six weeks after the initial operation, all patients in the graft group were at least 90% mucosalized with a mean mucosalization of 97% compared to a mean mucosalization of 60% in the non-grafted group. The crusting rate in the graft group was 5% compared to 85% in non-graft group (Figure 3B). At 12 weeks, both groups were completely mucosalized and the crusting was 0% and 15% for the grafted and non-grafted groups respectively.

In the retrospective phase of this study, 46 patients who underwent middle turbinate mucosal grafting were identified. At three weeks after the initial operation, one of 46 grafts (2%) was adherent to the Doyle splints and was removed with the Doyle splints. Of the remaining 45 patients, at least 50% mucosalization was present at 3 weeks with a mean of 80% (95% C.I. 75–86%; Figure 4). Between three and five weeks the mean mucosalization was 84% (95% C.I. 76–91%), and between weeks five and six the mean mucosalization was 99% (95% C.I. 98–100%). After six weeks post-operatively all patient had 100% mucosalization.

DISCUSSION

The nasoseptal flap is rapidly becoming the workhorse for skull base reconstruction. Although the overall morbidity of EEA is much less than traditional open approaches to skull base tumors,[11] exposed cartilage along the septum after nasoseptal flap harvest can lead to chronic rhinitis and nasal morbidity. While the mucosal surface of the septum does slowly recover, this immature mucosa can contain areas of squamous metaplasia and has overall poor ciliary function compared to native mucosa.[17] Multiple intranasal grafting methods have been reported in the contexts of endoscopic skull base repair, nasal septal perforation repair, and total nasal reconstruction.[18–20] In addition to closure of the defect, each technique aims to restore normal nasal physiology as quickly as possible. Winslow *et al.* (2003) reported excellent ultimate respiratory function, without contracture or stenosis, in a case report of one patient with a fascial forearm free flap reconstruction of the internal nasal lining.[21] The radial forearm free flap has also been used successfully to resurface the nasal and maxillary cavities in two cases of refractory epistaxis in patients with Osler-Rendu-Weber disease.[22] While fascial free flap transfers have commendable outcomes, albeit with significant risk of free tissue transfer, nasal mucosal flaps have the benefit of replacing nasal mucosa with native nasal mucosal, theoretically reducing the crust formation associated with non-self-clearing skin and the need for intranasal lavage.[22–25]

The mucosal tissue overlying the middle turbinate has proved to be an excellent donor material for intranasal grafting.[23,26,27] Previous studies have demonstrated that an inferiorly-based middle turbinate mucosal graft can be rotated widely and serve as reconstruction material for surgical defects after sellar, transtuberculum/transplanum, or unilateral transcribiform approaches, as well as treatment of post-traumatic and spontaneous CSF leaks.[16,23] The use of middle turbinate mucosa as a free graft has also been successfully reported for managing CSF leaks and to reconstruct skull base defects created by minimally invasive pituitary surgery and to repair CSF rhinorrhea, meningoceles, and meningiomas.[26–29] The middle turbinate nasal mucosa graft has been shown to be reliable and cost efficient.[28] We describe a novel use of this native mucosa to increase the rate of mucosalization of the septum after harvest of a nasal septal flap. This free mucosal graft provides a mature, functional layer of mucosa at earlier time points in the patients' postoperative recovery. In our retrospective series one patient's (2%) mucosal flap was not viable at three weeks. The remainder of our cohort had a mean mucosalization rate of 80% at three weeks and 99% mucosalization at five to six weeks postoperatively. This is faster, more complete, and earlier mucosalization than both our control group (with no graft) and prior reports of healing after nasoseptal flap skull base reconstruction.[12] In addition to the faster rate of mucosalization, we also report decreased crusting at 6 and 12 weeks after the initial operation. While we suspect this faster rate of septal mucosalization and diminution of crusting will decrease sinonasal morbidity, the need for nasal saline lavage and the amount of debridement at follow-up visits, while increasing quality of life, future prospective studies will be necessary to confirm these assumptions.

CONCLUSIONS

While our study has several limitations including the small size, the use of one surgeon (AZ), and a selection bias for patients in the control group that did not receive mucosal grafting, this study provides initial data that middle turbinate mucosal grafts can increase the rate of mucosalization and decrease the crusting of the septum after harvest of a nasal septal flap.

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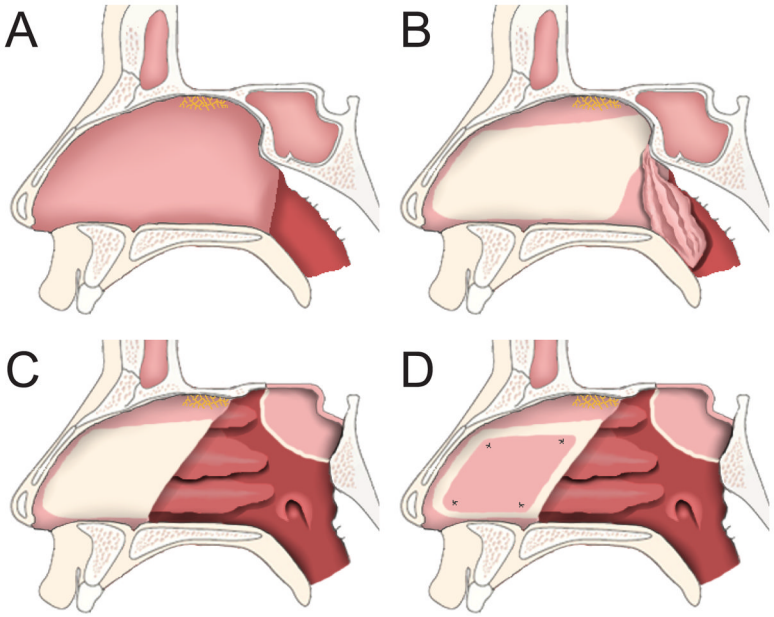

Figure 1. Schematic Representation of Middle Turbinate Graft

(A) Normal nasal mucosa covering septal cartilage prior to harvest of the pedicled nasoseptal flap. **(B)** The pedicled nasoseptal flap has been harvested and temporarily stored in the nasopharynx. The underlying septal cartilage is exposed. **(C)** The pedicled nasoseptal flap has been used to reconstruct the transsphenoidal defect. **(D)** Nasal mucosa graft harvested from middle turbinate has been grafted onto exposed septal cartilage.

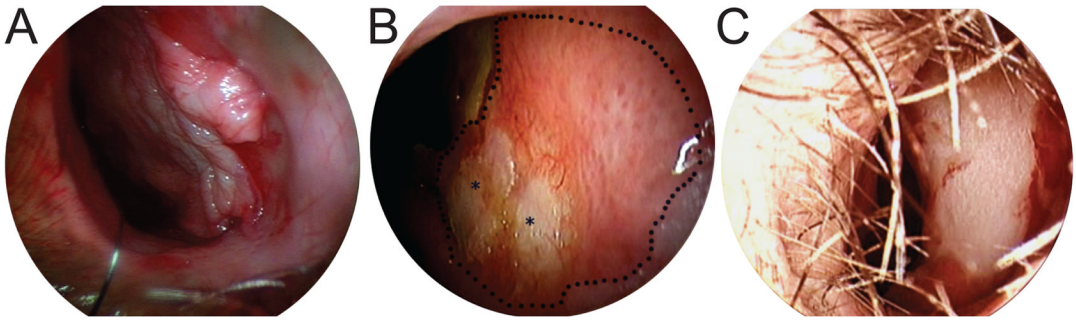

Figure 2. Endoscopic view of middle turbinate septal graft

(A) Middle turbinate graft placed on nasal septum. **(B)** Typical appearance of middle turbinate mucosal graft three weeks after initial operation. Asterisks denote areas of incomplete graft take. **(C)** Typical appearance of ungrafted septum 3 weeks after nasoseptal flap harvest. Septal mucosalization is absent.

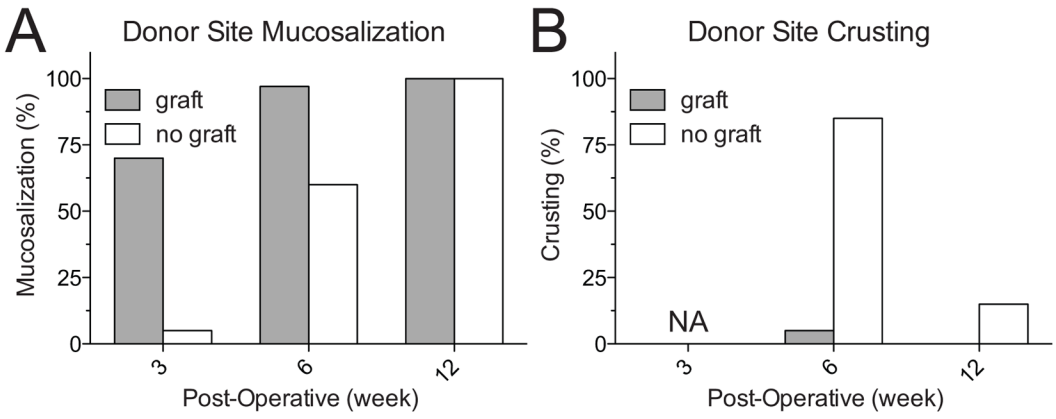

Figure 3. Prospective mucosalization and crusting rates in grafted versus non-grafted patients

(A) At three weeks grafted patients had a 70% mucosalization compared to 5% in patients who did not receive mucosal graft. At 6 weeks the rates were 97% and 60% for grafted and non-grafted patients respectively. At 12 weeks both groups had complete mucosalization. **(B)** At 6 weeks the rate of crusting was 5% for the grafted group versus 85% for the non-grafted group. At 12 weeks the rates were 0% and 15% for the grafted and non-grafted patients respectively.

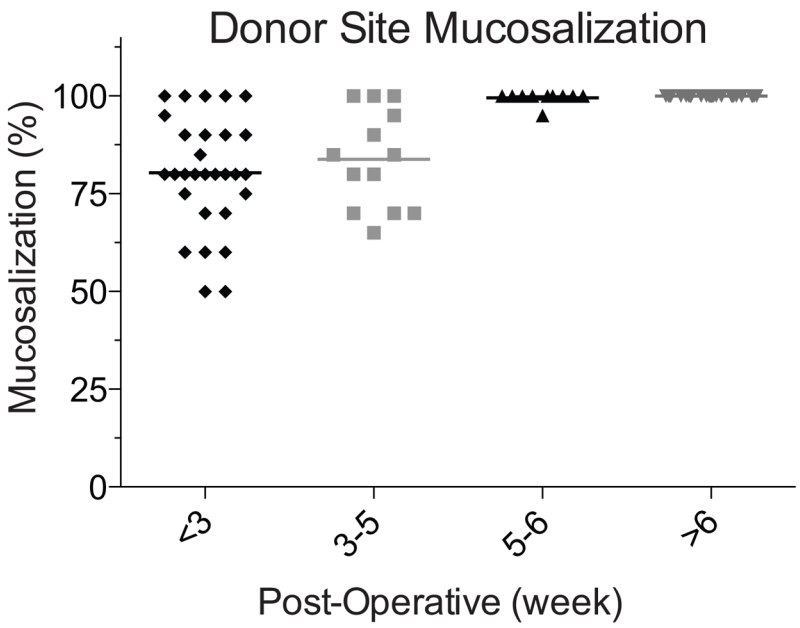

Figure 4. Retrospective mucosalization rates in 45 grafted patients

Three weeks after the initial operation the mean mucosalization rate was 80% (95% C.I. 75–86%). Between three and five weeks, five and six weeks, and greater than six weeks the mean mucosalization rates were 84% (95% C.I. 76–91%), 99% (95% C.I. 98–100%), and 100% respectively.

Table 1

Middle turbinate graft cohort with type of operation, and mucosalization rates at 3, 6, and 12 week follow up visits

All procedures were transnasal endoscopic skull base surgeries with unilateral middle turbinectomy and nasoseptal flap.

Procedure	Mucosalization (%)		
	3 weeks	6 weeks	12 weeks
TS/TP	70	100	100
TS/TP	65	100	100
TC	60	100	100
TC/TP	50	90	100
TP/TS	70	90	100
ECFR	80	100	100
TS	100	100	100

TS= Trans-Sellar approach, TP=Trans-Planar approach, TC=Trans-Cribriform approach, ECFR= Endoscopic Craniofacial Resection.