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A Novel Reconstructive Technique After Endoscopic Expanded Endonasal Approaches: Vascular Pedicle Nasoseptal Flap

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Background: **In patients with large dural defects of the anterior and ventral skull base after endonasal skull base surgery, there is a significant risk of a postoperative cerebrospinal fluid leak after reconstruction. Reconstruction with vascularized tissue is desirable to facilitate rapid healing, especially in irradiated patients.** ***Methods:*** **We developed a neurovascular pedicled flap of the nasal septum mucoperiosteum and mucoperichondrium based on the nasoseptal artery, a branch of the posterior septal artery (Hadad-Bassagasteguy flap [HBF]). A retrospective review of patients undergoing endonasal skull base surgery at the University of Rosario, Argentina, and the University of Pittsburgh Medical Center was performed to identify patients who were reconstructed with a vascularized septal mucosal flap.** ***Results:*** **Forty-three patients undergoing endonasal cranial base surgery were repaired with the septal mucosal flap. Two patients with postoperative cerebrospinal fluid leaks (5%) were successfully treated with focal fat grafts. We encountered no infectious or wound complications in this series of patients. One patient experienced a posterior nose bleed from the posterior nasal artery. This was controlled with electrocautery and the flap blood supply was preserved.** ***Conclusion:*** **The HBF is a versatile and reliable reconstructive technique for defects of the anterior, middle, clival, and parasellar skull base. Its use has resulted in a sharp decrease in the incidence of postoperative cerebrospinal fluid leaks after endonasal skull base surgery and is recommended for the reconstruction of large dural defects and when postoperative radiation therapy is anticipated.** ***Key Words:*** **Pedicle nasoseptal flap, endonasal skull base surgery, cerebrospinal fluid leak, reconstruction, Hadad-Bassagasteguy flap.**

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INTRODUCTION

Over the past decade, there have been significant advances regarding the anatomic understanding of transnasal endoscopic approaches and the development of instrumentation and imaging technology geared to facilitate the exposure and resection of skull base and intradural lesions.[1–4] Reconstruction of the barriers between the arachnoid space and the sinonasal tract, however, continues to be a challenge and a hindrance for the use and acceptance of the expanded endonasal approaches (EEA). Reconstruction of small defects of the ventral skull base is reliably obtained using a variety of techniques with a success rate of greater than 95% in multiple clinical series.[5–8] The use of vascularized tissue does not appear to be necessary in such situations. Larger defects comparable in size to a craniofacial resection have traditionally been repaired using regional vascularized flaps (pericranial, galeal, and temporoparietal flaps).[9–11] With the advent of endonasal approaches, however, these flaps require a separate external approach and add to the morbidity of the procedure.

In this report, we describe a novel technique developed at the University of Rosario, Argentina, using a neurovascular pedicled flap of the nasal septum mucoperiosteum and mucoperichondrium based on the nasoseptal artery, a branch of the posterior septal artery and the terminal branch of the internal maxillary artery (Hadad-Bassagasteguy flap [HBF]). This article describes the technical aspects of the HBF and other adjunctive techniques that

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we have developed in our strife to decrease the incidence of postoperative cerebrospinal fluid (CSF) leaks after EEA.

MATERIALS AND METHODS

We retrospectively reviewed the demographic, surgical, and outcomes data of all patients who underwent reconstruction of the skull base using the HBF after EEAs that involved a communication between the subarachnoid space and the sinonasal tract.

Surgical Technique

The nasal cavity is decongested with oxymetazoline 0.05% and the nasal septum is infiltrated with lidocaine 0.5% to 1% with epinephrine 1/100,000 to 1/200,000. The inferior and middle turbinates are outfractured to allow visualization of the nasal septum from the cribriform plate to the nasal floor. To facilitate a bimanual technique during the EEA, we usually elect to remove one of the middle turbinates, usually on the right. In addition, resection of the middle turbinate facilitates the visualization of the HBF vascular pedicle and elevation of the septal flap ipsilaterally. The flap is designed according to size and shape of the anticipated defect, although it is best to overestimate the size and then trim the flap if needed. Two parallel incisions are performed following the sagittal plane of the septum, one over the maxillary crest and the other 1 to 2 cm below the most superior aspect of the septum (this preserves the olfactory epithelium). These incisions are joined anteriorly by a vertical incision. These incisions may be modified to account for the specific area of reconstruction or to allow adequate oncologic margins (Fig. 1). At the posterior septum, the superior incision is extended laterally and with an inferior slant over the rostrum of the sphenoid sinus crossing it horizontally at the level of the natural ostium. The inferior incision is extended superiorly along the free posterior edge of the nasal septum and then laterally to cross the posterior choana below the floor of the sphenoid sinus. Elevation starts anteriorly with a Cottle dissector or similar instrument. The septal incisions may be completed with scissors or other sharp instrument as necessary. Elevation of the flap from the anterior face of the sphenoid sinus is completed with preservation of a posterolateral neurovascular pedicle (Fig. 2). It is advantageous to complete all incisions before the elevation of the flap because it becomes difficult to orient the tissue and to maintain it at tension once it has been elevated. Elevation of the flap is completed leaving it pedicled on the posterior septal neurovascular bundle. Multiple modifications of the flap regarding length and width are possible. The entire ipsilateral mucoperiosteum and mucoperichondrium may be harvested to cover anterior skull base defects as extensive as those that include the area from the posterior wall of the frontal sinus to the sella turcica and from orbit to orbit (Fig. 3A, B). A wide flap may be harvested extending the incision to include the mucoperiosteum of the floor of the nose. Bilateral flaps are possible using flaps that are harvested in a staggered fashion, harvesting the flaps from the superior half of the septum on one side and from the inferior half on the other side or harvesting one long flap that comprises the entire lining and a short flap that corresponds to the area of the posterior septum that would be sacrificed as part of the EEA. Once harvested, the flap is displaced into the nasopharynx until the extirpative phase of the surgery is concluded. During surgery, it is important to be careful with bone removal lateral to the pterygoid canal so that the vascular pedicle is not injured.

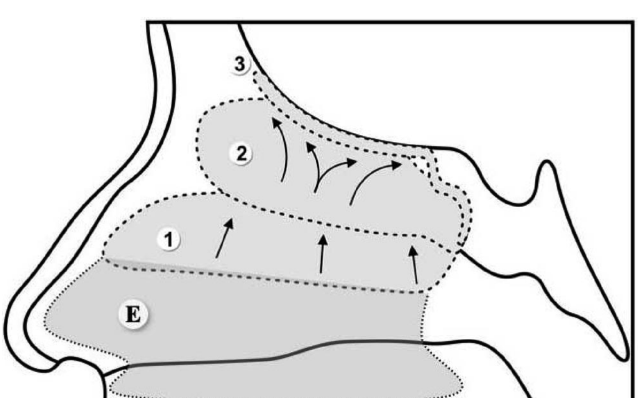

Fig. 1. Drawing of the septum (sagittal view) illustrating the septal incisions and possible modifications.

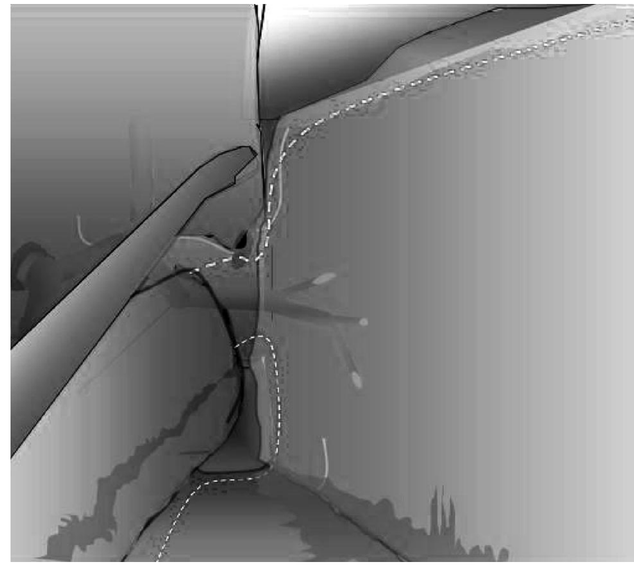

Fig. 2. Drawing illustrating an endoscopic view of the right nasal cavity and the incisions encompassing an extended flap and the relationship of the incisions at the rostrum of the sphenoid sinus with the nasoseptal arteries.

We use a multilayer technique for the reconstruction of the defect. A collagen matrix is placed as an inlay subdural graft. An additional onlay fascial graft may be placed or abdominal free fat may be used to obliterate a dead space (e.g., clival defect) or the sphenoid sinus (after mucosa is stripped). The septal mucosal flap can be applied directly to the dura or placed over a fat graft (Fig. 4). Fibrin glue or other biologic glue is used to help secure the flap and a nasal packing or the balloon of a 12-French Foley catheter is inserted to compress the HBF against the defect. Inflation of the balloon should be monitored by direct observation because overinflation may result in compress of intracranial structures or compromise of the neurovascular pedicle. Silicone splints are used to protect the denuded septum and are left in place for 10 to 14 days.

Postoperative Management

Established general principles of managing a CSF fistula are followed postoperatively to facilitate the healing.[5–8] These include avoidance of nose blowing and activities that raise the intracranial pressure such as straining, leaning forward, or lifting weights greater than 15 pounds. Other measures include stool softeners and sneezing with an open mouth. The use of prophylactic antibiotics for the prevention of meningitis in patients with CSF fistulas is controversial; however, we use a perioperative third-generation cephalosporin until the packing is removed.

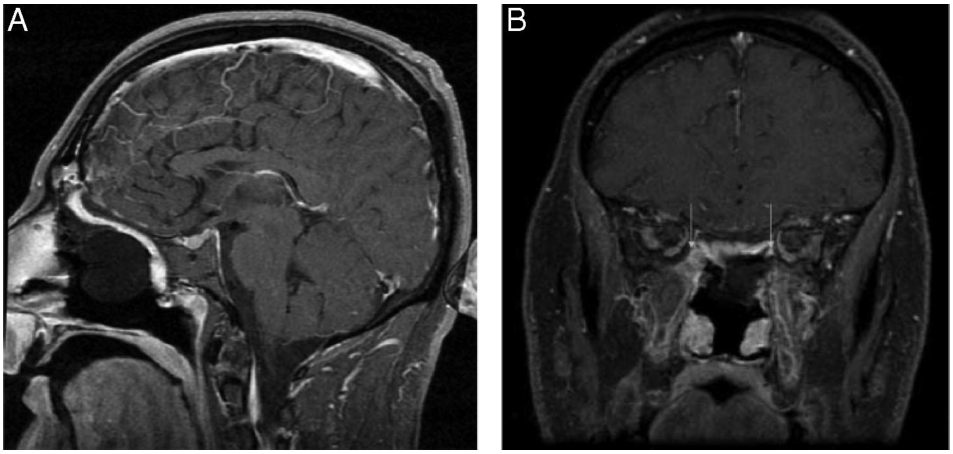

Fig. 3. (A) Sagittal magnetic resonance image of a patient after resection of the anterior skull base. The flap is covering the entire skull base from the inferior palate of the posterior wall of the frontal sinus to the planum sphenoidale. (B) Coronal magnetic resonance image of the same patient. The flap covers the anterior skull base from orbit to orbit.

We favor a routine postoperative computed tomography scan or magnetic resonance image within the first 24 hours after surgery to rule out the presence of intracranial bleeding, parenchymal injury, or tension pneumocephalus even in the absence of any clinical neurologic deficit. The scan also confirms proper inflation and placement of the balloon catheter. A lumbar spinal drain is used in revision cases or when there is high flow of CSF at the time of surgery. The balloon or packing is removed 3 to 5 days later depending on risk factors such as the degree of arachnoid dissection, the opening of a cistern, or the patient's body habitus. The patient is advised to use saline irrigations for nasal toilette and the nasal cavity is debrided as needed until the crusting formation is abated. Is important to avoid debridement over the area of the defect because this may disrupt the flap resulting in a CSF leak.

RESULTS

We had the opportunity to use the HBF on 44 patients, comprising 31 men and 12 women with ages that range from 22 to 74 years of age. These patients presented with a variety of pathologies, including nine posttraumatic and spontaneous CSF leaks, five meningoencephaloceles, five clival chordomas, one esthesioneuroblastoma requiring the removal of the anterior skull base from planum sphenoidale to frontal sinus, one craniopharyngioma requiring a transplantar approach, three meningiomas requiring a transplantar and/or transcribriform approach, and 20 pituitary tumors with extrasellar extension into the suprasellar and/or cavernous sinus area. All of the surgeries involved significant intraoperative CSF leaks. Maximal defects included the entire anterior cranial base from the frontal sinus to the planum sphenoidale and from orbit to orbit. All patients were followed for at least 2 months postoperatively and were monitored with endoscopic examinations and imaging.

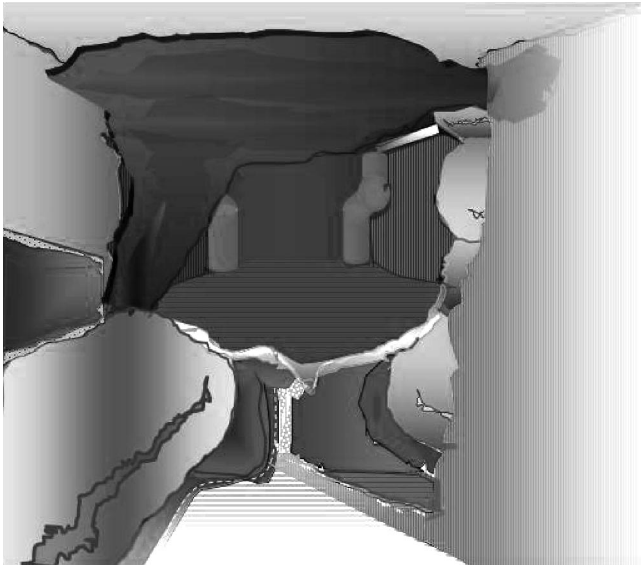

Fig. 4. Drawing illustrating the use of the flap to reconstruct an anterior skull base.

Two patients had transient CSF leaks. One patient experienced a postoperative CSF leak after the balloon had to be removed as a result of compressive complications hours after an EEA. Another patient developed a CSF leak after removal of a large olfactory groove meningioma. These two patients were successfully repaired with focal fat grafts with preservation of the mucosal flap. No other infectious or wound complication such as partial or total loss of the flap was encountered. One patient experienced a posterior nose bleed arising from the posterior nasal artery. This was controlled with electrocautery and the flap blood supply was preserved. Minor asymptomatic synechiae were noted in several patients and no treatment was needed. The donor site on the nasal septum became mucosalized within several weeks and no anterior septal perforations were noted.

DISCUSSION

The goals of reconstruction after an EEA are identical to those after conventional external approaches, to separate the cranial cavity from the sinonasal tract, to obliterate the dead space, and to preserve the neurovascular and ocular function.[9–11] The principle of multilayered reconstruction to reestablish tissue barriers is similar also. Factors that are considered preoperatively and intraoperatively included the estimated area and volume of the resection and subsequent extent of communication between the cranial cavity and the sinonasal tract, presence and geometry of the remaining dural and bony margins, general status of the patient, previous intranasal or maxillofacial surgeries, and the possibility of increased CSF pressure postoperatively.[4,8]

Our initial reconstructive technique represented an intuitive extension of our experience with the endoscopic repair of CSF leaks as well as our experience with the reconstruction of the skull base after oncologic resections using traditional external approaches.[4–11] This resulted in a higher incidence of persistent leaks than we had experienced with the repair of posttraumatic or even spontaneous leaks.[5–8] During the exploration of persistent CSF leaks, we invariably found that the margins of the graft had taken except for a single area that had failed to heal. This area was located most frequently at the most dependent site at the point of maximum pressure or alternatively at its superior margin where the graft is most vulnerable to migration.

We persisted using a multilayered reconstruction but modified it to include a subdural inlay graft followed by an extracranial *onlay* graft fixated by some form of packing.[4] We adopted the use of a collagen matrix as a subdural graft as a result of its pliability and safety within this space to be followed by an onlay graft of acellular dermis and then by free abdominal fat.[4] The latter serves as a biologic dressing and counteracts the forces of gravity and the pulsations of the brain. A 12-French Foley catheter balloon was then used to support the multilayered reconstruction until an adequate take would preclude any shifting, usually 5 days later. We identified that significant shifting of the grafts could occur during the placement of the fat. Attentive vigilance of and securing the edges of the onlay fascial graft with nitinol rings (Medtronic U-clips, Memphis, TN) helped to eliminate this problem. In addition, the use of a Foley balloon to compress the fat against the defect helped to mitigate the risk of graft migration and the development of persistent fluid channels. This technique helped to reduce the incidence postoperative CSF leaks after EEA by 50%. Nonetheless, the incidence remained higher than what we considered acceptable. We surmised that we needed a vascularized flap would promote faster to healing and be less susceptible to migration, thus decreasing the incidence of postoperative CSF leaks to a level that compares with that of a traditional approach (less than 5%).[9–11]

The use of vascularized flaps harvested from the nasal cavity is not a new concept. In 1952, Oscar Hirsch[12] described the use of a septal flap for the endonasal repair of a CSF leak. Others subsequently described modifications of the septal flap or the use of middle turbinate flaps for the extracranial repair of CSF fistulas with uniformly good outcomes.[13–17] These flaps, however, were rotation flaps with a random blood supply and the septal flaps were based in such a way that the torsional forces of the tissue tended to pull the flap apart from the defect. In addition, their random blood supplied the potential for the vascularized surface area of the flap. The HBF is supplied by the posterior nasoseptal arteries, which are branches of the posterior nasal artery, which is one of the terminal branches of the internal maxillary artery. It should be noted that the nomenclature for the arterial supply of this area varies throughout the literature leading to some confusion.[18–23] The posterior nasoseptal arteries supply the entire septum anastomosing with the ethmoidal arteries superiorly, the greater palatine artery inferiorly, and the anterior facial artery anteriorly.[18–23] This rich vascular pedicle and branching is responsible for the fact that the HBF versatility, reliability, arc of rotation, and area of coverage is superior to any other flap previously described. The results are highly reproducible as shown by the similar results obtain by our two different teams in two different institutions and by other anecdotal results. The HBF has the potential of becoming the work horse for the reconstruction of large defects of the skull base and adds a high degree of reliability to the current methods of reconstruction. Its only caveat is that it needs to be anticipated in advance, before a posterior septectomy is performed, because this would destroy the vascular pedicle.

CONCLUSIONS

The HBF is a reliable reconstructive technique for extensive defects of the anterior, middle, clival, and parasellar skull base. Its use has resulted in a sharp decrease in the incidence of postoperative CSF leaks after EEA.

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