Endoscopic Reconstruction of the Cranial Base Using a Pedicled Nasoseptal Flap

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OBJECTIVE: Reconstruction of the cranial base using vascularized tissue promotes rapid and complete healing, thus avoiding complications caused by persistent communication between the cranial cavity and the sinonasal tract. The Hadad-Bassagasteguy flap (HBF), a neurovascular pedicled flap of the nasal septum mucoperiosteum and mucoperichondrium based on the nasoseptal artery, seems to be advantageous for the reconstruction of the cranial base after endonasal cranial base surgery.

METHODS: We performed a retrospective review of patients who underwent endonasal cranial base surgery at the University of Pittsburgh Medical Center from January 30, 2006 to January 30, 2007, identifying patients who experienced reconstruction with a vascularized septal mucosal flap (HBF). We analyzed the demographic data, pathological characteristics, site and extent of resection, use of cerebrospinal fluid (CSF) diversion techniques, and outcome.

RESULTS: Seventy-five patients who underwent endonasal cranial base endoscopic surgery received repair with the HBF. In this population, we encountered eight postoperative CSF leaks (10.66%), all in patients who required intra-arachnoidal dissection. When we correct the statistical analysis to include only patients with intra-arachnoidal lesions, the postoperative CSF leak rate is 14.5% (eight of 55 patients). It is notable that six CSF (33%) leaks occurred in our first 25 repairs, whereas we encountered only two postoperative leaks (4%) in the last 50 patients. The corrected CSF leak rate, considering only intra-arachnoidal lesions, was two (5.4%) of 37 patients. This improvement in the CSF leak rate reflects our growing experience and comfort with this reconstructive technique. All of our failures could be matched to a specific technical mistake. In addition, we modified the flap-harvesting technique to allow for staged procedures and the removal of caudal lesions. These special circumstances require storage of the flap in the antrum during the removal of caudal lesions, and suturing of the flap in its original position for staged procedures. One patient experienced a posterior nose bleed from the posterior nasal artery. This was controlled with bipolar electrocautery, thereby preserving the flap blood supply. We encountered no infectious or wound complications in this series of patients. The donor site accumulates crusting, which requires debridement until mucosalization is complete; this usually occurs 6 to 12 weeks after surgery.

CONCLUSION: The HBF is a versatile and reliable reconstructive technique for repairing defects of the anterior, middle, clival, and parasellar cranial base. Its use has resulted in a significant decrease in our incidence of CSF leaks after endonasal cranial base surgery. Attention to technical details is of paramount importance to achieve the best outcomes.

KEY WORDS: Cerebrospinal fluid leak, Cranial base, Endoscopy, Hadad-Bassagasteguy flap, Nasoseptal flap, Reconstruction

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Endonasal approaches, both microscopic and endoscopic, are being used increasingly in the management of ventral cranial base, sellar, and parasellar lesions (6, 10–12, 15, 16, 23, 33). Reconstruction of the barriers separating the subarachnoid space from the sinonasal tract may be the greatest obstacle to the standardization and acceptance of expanded endonasal approaches (EEAs) for the resection of cranial base and intradural lesions. Various techniques have been used to reconstruct the ventral cranial base and especially the sella (3–5, 22, 24, 26, 32). Synthetic materials have been used extensively, but problems with host-tissue reaction and magnetic resonance imaging interference remain (26, 32). Free grafting of these defects is feasible; however, this technique is associated with a significant incidence of postoperative cerebrospinal fluid (CSF) leaks (20, 38, 39). In EEAs, the larger resulting defects compared with transsellar approaches necessitate different closure techniques to prevent postoperative CSF leaks.

Vascularized tissue promotes fast and complete healing. For this reason, pedicled flaps such as the temporoparietal fascia, pericranial, and galeopericranial flaps are frequently used to reconstruct the cranial base after a craniofacial resection (30, 34). These flaps require an external incision, however; therefore, their use for reconstruction of defects after EEAs is counter to the goals of minimal access techniques. A vascular pedicled flap of the nasal septum mucoperiosteum and mucoperichondrium based on the nasoseptal artery (Hadad-Bassagasteguy flap [HBF]) may be harvested and used via an endonasal approach (19, 31). This sturdy but pliable flap is highly vascularized and provides a large surface area with a superior arc of rotation, qualities that are advantageous for the reconstruction of defects produced by EEAs. This article describes our experience with the HBF and presents several technical modifications developed to optimize the use of the HBF and decrease the incidence of postoperative CSF leaks after EEAs.

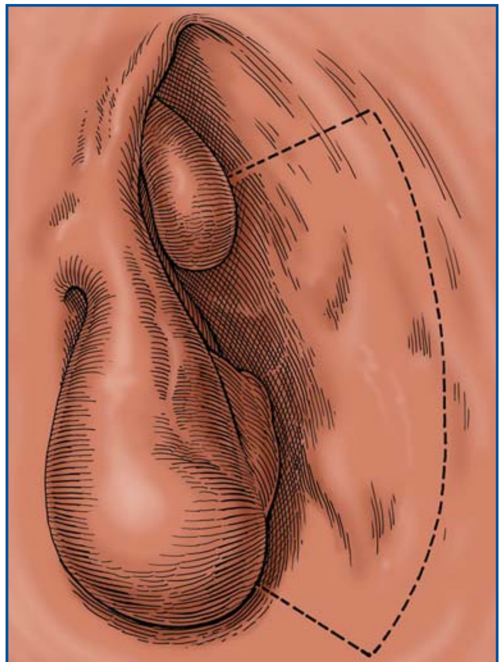

FIGURE 1. *The nasoseptal flap incisions at the anterior nasal cavity. Two parallel incisions are joined by a vertical incision anterior to the inferior turbinate.*

PATIENTS AND METHODS

We retrospectively reviewed the demographic, pathological, and surgical outcome data of all patients who underwent reconstruction of the cranial base with the HBF after EEA from January 30, 2006 to January 30, 2007. All patients were followed for at least 2 months postoperatively and were monitored with endoscopic examinations and imaging.

Surgical Technique

The nasal cavity is decongested with 0.05% oxymetazoline, and the anterior nasal septum is infiltrated with 0.5 to 1% lidocaine with epinephrine in a 1/100,000 dilution. The inferior and middle turbinates are outfractured to facilitate visualization of the entire nasal septum. We usually remove one of the middle turbinates (most commonly on the right side) to facilitate two-nostril/two-surgeon/four-hand access during the EEA procedure. Resection of the middle turbinate ipsilateral to the flap also facilitates visualization of the HBF vascular pedicle and its dissection. The flap is designed according to the size and shape of the anticipated defect, although this requires overestimation of the dimensions of the flap because we harvest it before the extirpative phase of the surgery. Harvesting the HBF during the initial steps of the surgical approach is a requirement because our usual approach requires a posterior septectomy that would destroy the vascular pedicle of the flap. We base our decision to harvest a nasoseptal flap on the need for intra-arachnoidal dissection, the possibility of an unplanned CSF leak, the need to expose the internal carotid artery, a history of radiation therapy, and the need for postoperative radiation. Of course, this decision is based on the judgment of the surgeons and is not infallible. A few patients have undergone a flap dissection when we could have used an alternative technique. Crusting, however, seems to be less common in patients who undergo the HBF compared with those who undergo free grafting. The HBF may be harvested from either side, but several factors must be considered. It is advantageous to harvest it ipsilateral to the middle turbinectomy (for better visualization), contralateral to the side of the lesion (for less interference with the dissecting instruments), or contralateral to a lesion involving the pterygopalatine fossa or rostrum of the sphenoid (to avoid compromise of the HBF blood supply).

We use unipolar electrocautery with an insulated needle tip to incise the septal soft tissues. Two parallel incisions are performed following the sagittal plane of the septum. One follows the maxillary crest, and a parallel incision follows a line 1 to 2 cm below the most superior aspect of the septum (olfactory sulcus). Preservation of this most cephalic strip of septal mucosa may preserve the olfactory epithelium and function. These parallel incisions are joined anteriorly by a vertical incision that is usually placed rostral to the anterior head of the inferior turbinate (*Fig. 1*). Posteriorly, the superior incision is extended laterally to cross the rostrum of the sphenoid sinus at the level of the inferior aspect of the natural ostium (*Fig. 2*). The inferior incision extends cephalad following the free edge of the posterior nasal septum and, then, laterally crossing the posterior choana just below the floor of the sphenoid sinus. These incisions may be modified to account for specific areas of reconstruction or to provide adequate oncological margins (*Fig. 2*).

Elevation of the mucoperichondrium, by use of a Cottle dissector, proceeds in an anterior to posterior direction after the surgeon ascertains that all incisions have been carried through the periosteum and perichondrium (*Fig. 3*). It is useful to elevate the incised mucosal edges by 1 to 2 mm to ensure that the incisions are of adequate depth. After it has been elevated, it is difficult to maintain the orientation and tension of the flap to complete the incisions. Elevation of the flap from the anterior face of the sphenoid sinus is completed, while the neurovascu-

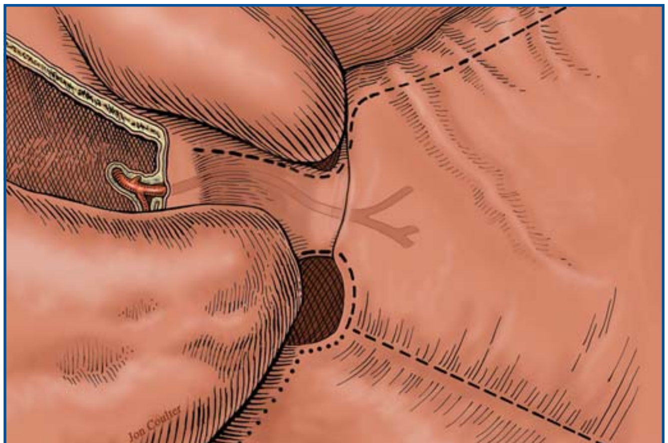

FIGURE 2. *The nasoseptal flap incisions at the right posterior nasal cavity. Two parallel incisions (*dashed lines*), one following the maxillary crest and the other 1 to 2 cm inferior to the olfactory cleft, are extended to reach the lateral nasal wall. The inferior incision follows the free edge of the posterior septum and then crosses the posterior choana. The inferior incision may be designed to include the mucoperiosteum of the floor of the nose. The superior incision extends laterally to cross the rostrum of the sphenoid sinus at the level of its natural ostium. A large middle antrostomy and exposure of the terminal internal maxillary artery are illustrated. This is only necessary if the flap will be stored in the maxillary sinus so as to approach the clival and paraclival areas.*

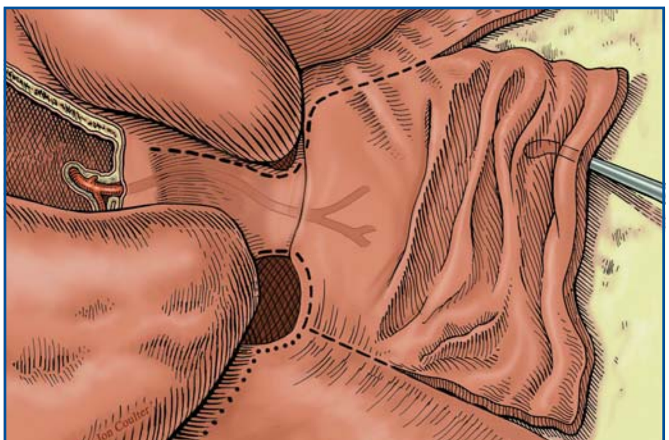

FIGURE 3. *Elevation of the nasoseptal flap following a subperichondrial and subperiosteal plane.*

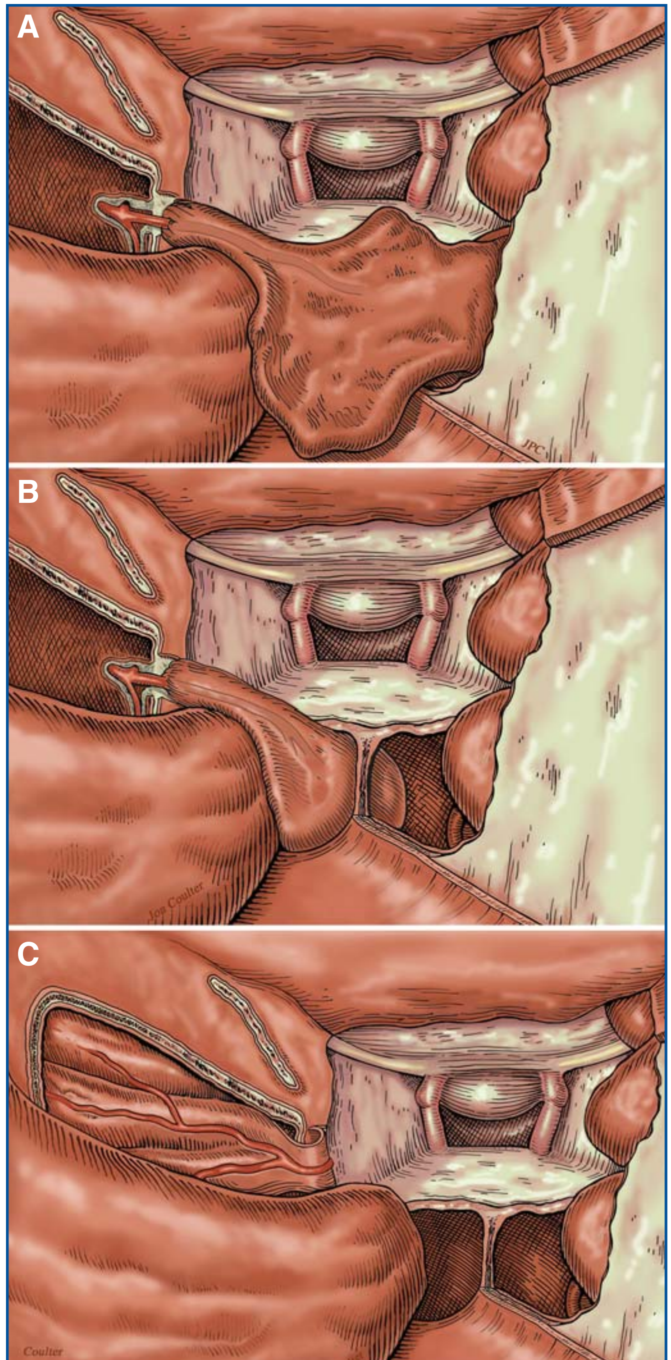

FIGURE 4. **A**, *the nasoseptal flap is mobilized posteriorly after a posterior septectomy.* **B**, *the nasoseptal flap is "stored" at the nasopharynx.* **C**, *the nasoseptal flap is "stored" inside the maxillary sinus.*

lar pedicle, contained within the strip of mucosa that is between the natural ostium of the sphenoid sinus and the posterior choana, is preserved (*Fig. 4A*). The design and elevation of the flap require an extra 10 to 45 minutes of surgery, depending on the complexity of the anatomy of the nasal cavity and the presence of septal scarring from previous operations. This additional time is at least partially recovered at the conclusion of the procedure because there is no need to harvest additional fat or fascia, and the placement of the flap is easier than the placement of inlay grafts.

The longest possible flap includes the entire anteroposterior dimension of the nasal septum, which includes the entire ipsilateral mucoperiosteum and mucoperichondrium extending anteriorly to a level that is just posterior to the columella (*Fig. 1*). It is also important to raise the pedicle to a level that is as close as possible to the sphenopalatine foramen to gain maximum length. Extending the inferior incision laterally to include the mucoperiosteum of the floor of the nose yields a wider

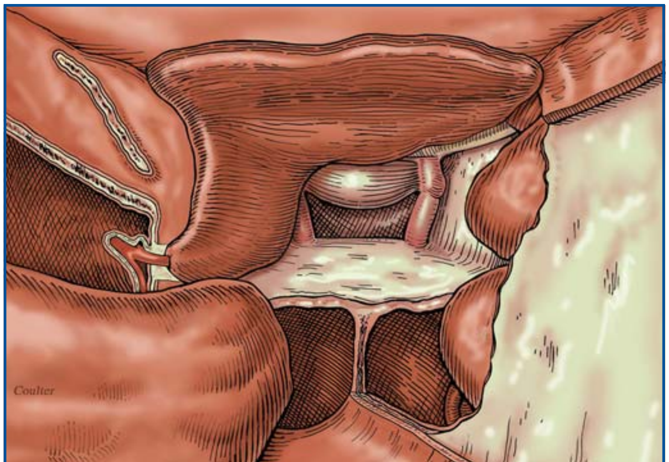

FIGURE 5. *The nasoseptal flap is shown covering a defect at the planum sphenoidale.*

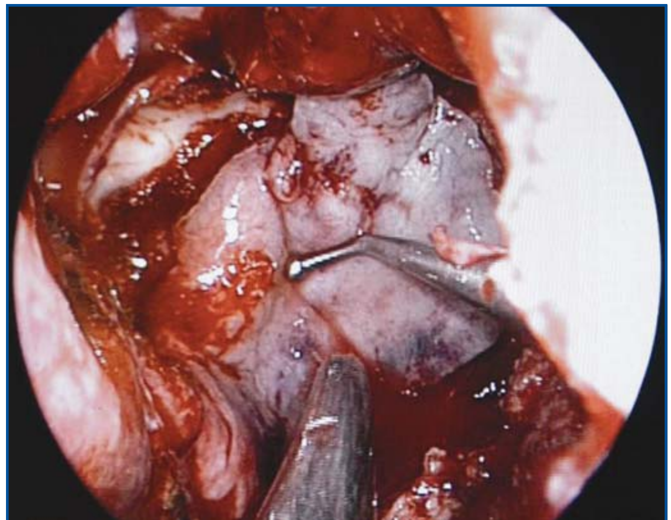

FIGURE 6. *Endoscopic view showing the flap placed over the sella and planum area.*

flap (*Fig. 2*). Bilateral flaps are obtainable by harvesting the flaps in a staggered fashion, namely, by harvesting a flap from the superior half of the septum on one side and then harvesting the other flap from the inferior half on the contralateral side. Alternatively, the surgeon may harvest a long flap that comprises the entire lining of the septum on one side and a short flap that corresponds to the area of the posterior septectomy on the contralateral side. The HBF may also be harvested as a composite flap comprising mucoperichondrium and cartilage; however, we have not found it necessary to use the cartilage, and this complicates storage of the cartilage.

We usually store the flap in the nasopharynx until the extirpative phase of the surgery is concluded (*Fig. 4B*). During the resection of clival or nasopharyngeal lesions, however, the flap is stored in the maxillary sinus because its placement in the nasopharynx would interfere with the visualization of the target area (*Fig. 4C*). We create a wide nasoantral window after removing the uncinate and identifying the natural ostium of the maxillary sinus. The ostium is enlarged inferiorly and posteriorly until the window is flush with the posterior wall of the antrum. Elevation of the remaining mucoperiosteum of the lateral wall of the nose just posterior to the window reveals the sphenopalatine foramen and the sphenopalatine and posterior nasal arteries. The sphenopalatine artery is usually sacrificed, and the posterior nasal artery can be mobilized out of the foramen after the posterior wall of the antrum that is anterior to the arteries is removed (*Fig. 2*). This step improves the pedicle's arc of rotation, and, thereby, facilitates the storage of the entire flap inside the antrum (the vidian and descending palatine arteries remain tethered to the pedicle to some degree).

Another important modification is necessary for staged procedures, when the approach and the resection are performed on different days. In our practice, we occasionally stage large meningiomas and clival chordomas. After completing the approach, the flap must be sutured back in place and protected with silicone septal splints. Failure to suture the flap at its original position results in significant contraction of the flap, thus yielding a flap with inadequate dimensions for the reconstruction.

During the reconstruction, the flap must be in contact with the denuded walls of the sinonasal tract as it approximates the defect. Failure to place the periosteal surface of the flap against denuded walls and advancing it across the nasal air space subjects the flap to the force of gravity and allows desiccation of the pedicle. Exposed periosteum will need to heal by secondary intention, and the resulting contraction combined with the force of gravity may pull the flap away from the defect and lead to a CSF fistula.

We favor multilayer reconstruction of the defect. In addition to the HBF, we use an inlay subdural graft of collagen matrix. Occasionally, an additional onlay fascial graft and/or abdominal free fat may be used. The nasoseptal mucosal flap can be applied directly to the remaining dura and/or brain or may be placed over a fat graft (*Figs. 5* and *6*) as long as the flap covers and overlaps the entire defect to lie over denuded bone or soft tissue surrounding the nasal side of the defect. It is imperative not to allow any foreign body or nonvascularized tissue to remain between the flap and the surrounding edges of the defect.

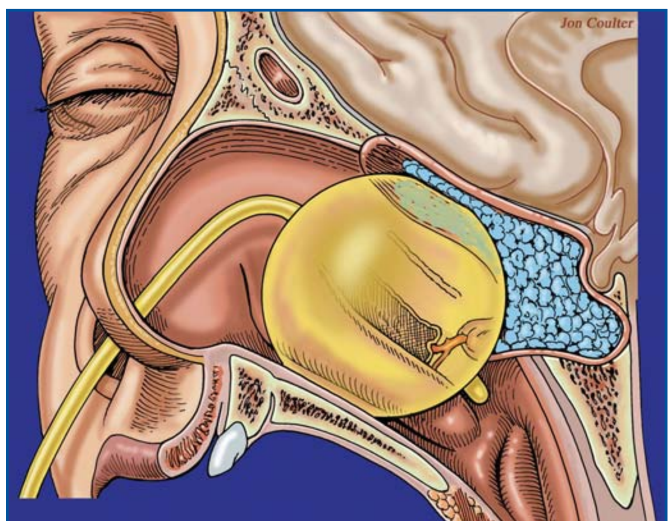

FIGURE 7. *The nasoseptal flap is fixed in place by the balloon of a 12-French Foley catheter.*

Application of biological glue helps to fix the flap and nasal sponge packing, or the balloon of a 12-French Foley catheter may be inserted to press the HBF against the defect (*Fig. 7*). Inflation of the Foley balloon should be under endoscopic observation because overinflation may result in compression of intracranial structures or compromise of the neurovascular pedicle. Silicone splints, left in place for 10 to 14 days, will protect the denuded septum.

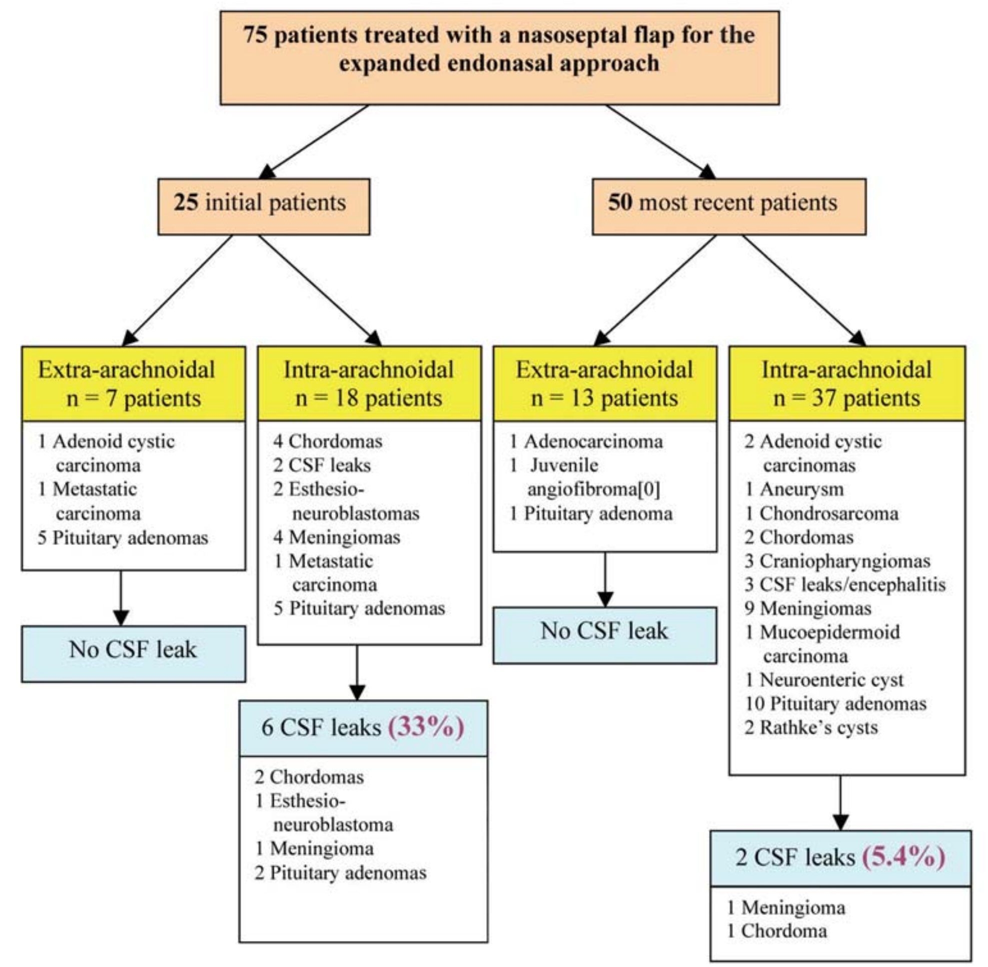

FIGURE 8. *Flow chart illustrating the outcomes of our first 75 patients reconstructed with a pedicled nasoseptal flap. CSF, cerebrospinal fluid.*

Postoperative Management

General principles of managing a CSF fistula include advising the patient to avoid nose blowing and any activity that may increase intracranial pressure, such as abdominal straining, leaning forward, or lifting anything heavier than 15 pounds. Stool softeners may also be administered, and the patient should be counseled to sneeze with an open mouth. The use of prophylactic antibiotics for the prevention of meningitis in patients with CSF fistulae is controversial; however, we administer a perioperative third-generation cephalosporin until we remove the patient's packing.

A lumbar spinal drain is used when there is high rate of CSF flow at the time of surgery (e.g., opening of a cistern or ventricles, or suspected high ventricular pressure). We remove the balloon or packing 3 to 5 days later depending on risk factors such as the degree of arachnoid dissection, the opening of a cistern, or the habitus of the patient. Silicone septal splints are removed 2 to 4 weeks postoperatively. The patient is advised to irrigate the nasal cavity with normal saline solution. We debride the nasal cavity in our office every 1 to 2 weeks until the crusting stops. We avoid debridement of crusting that accumulates over the defect because this may disrupt the flap and result in a CSF leak.

RESULTS

We have had the opportunity to use the HBF in 75 patients, including 47 men and 28 women with ages ranging from 4 to 80 years (mean, 47 yr). These patients presented with a variety of pathological entities (*Fig. 8*). Seventy-one (95%) of the 75 patients had a potential communication between the subarachnoid space and sinonasal tract (intraoperative CSF leaks).

These lesions required a variety of approaches, some in combination, including nine transcribiform, 26 transplanar, 22 transsellar, 12 transclival, five transpterygoid, and one transodontoid. The largest defect resulted from the resection of the anterior cranial base from the frontal sinus to the planum sphenoidale and from orbit to orbit.

Eight patients (10.6%) had postoperative CSF leaks. One patient had a postoperative CSF leak after the balloon had to be removed as a result of compressive optic neuropathy symptoms hours after an EEA. Other technical mistakes leading to a postoperative CSF leak included leaving bone wax between the flap and the defect; placing a U-clip between the flap and the defect and thereby tenting the flap away; reversal of the flap, which placed the mucosal surface against the defect and left a septal bone spicule that penetrated and burst the Foley balloon in the immediate postoperative period; and trying to reach the defect across the nasal airspace and leaving the pedicle to heal by secondary intention, which led to contraction of the flap away from the defect. It is important to recognize that six of the eight leaks occurred in the first 25 patients in whom

TABLE 1. The initial 25 patients treated with a nasoseptal flap after expanded endonasal approach

	No. of patients	No. of patients with cerebrospinal fluid leak (%)
No intraoperative cerebrospinal fluid	7	0 (0%)
Adenoid cystic carcinoma	1	0
Metastatic breast	1	0
Pituitary adenoma	6	0
Intraoperative cerebrospinal fluid exposure	18	6 (33%)
Chordoma	4	2[a]
Cerebrospinal fluid leak	2	0
Esthesioneuroblastoma	2	1[b]
Meningioma	4	1[b]
Metastatic breast	1	0
Pituitary adenoma	5	2[c]
Total	25	6 (24%)

[a] Transclival approach.
[b] Transcribriform/transplanum approach.
[c] Transsellar approach.

TABLE 2. The last 50 patients treated with a nasoseptal flap for the expanded endonasal approach reconstruction

	No. of patients	No. of patients with cerebrospinal fluid leak (%)
No intraoperative cerebrospinal fluid	13	0 (0%)
Adenocarcinoma	1	0
Juvenile angiofibroma	1	0
Pituitary	11	0
Intraoperative cerebrospinal fluid exposure	37	2 (5.4%)
Adenoid cystic carcinoma	2	0
Aneurysm	1	0
Chondrosarcoma	1	0
Chordoma	2	1[a]
Craniopharyngioma	3	0
Cerebrospinal fluid leak/ esthesioneuroblastoma	3	0
Meningioma	9	1[b]
Mucoepidermoid	1	0
Neuroenteric cyst	1	0
Pituitary	10	0
Rathke's cyst	2	0
Total	50	2 (4%)

[a] Tranclival approach (clival chordoma).
[b] Transplanum approach (tuberculum sellae meningioma).

we used the flap (*Table 1*). Three of these six leaks occurred quickly after we expanded the use of the flap after a successful initial experience in which we encountered three leaks in 20 patients. In the last 50 patients in whom we used the flap, 37 cases involved surgery in which the arachnoid was breached (*Table 2*), and we encountered two CSF leaks (5.4%), one in a patient with clival chordoma and another in a patient with a tuberculum sella meningioma.

On the basis of the pathological diagnosis, we encountered three CSF leaks associated with clival chordomas, two associated meningiomas approached via a transplanar route, one pituitary adenoma approached with a transplanar extension, and one esthesioneuroblastoma that required resection of the entire anterior cranial base. Repositioning the flap and/or using focal fat grafts at the specific fistula site with preservation of the mucosal flap was successful in repairing these problems.

We encountered no infectious or wound complication such as partial or total loss of the flap. 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. Crusting was observed for the first 6 to 12 weeks. Patients reported nasal obstruction while the splints were in place but experienced no significant pain. We have not studied this issue in an objective fashion, but patients who undergo nasoseptal flap harvesting have no more symptoms regarding pain or crusting than patients who did not undergo this procedure. Minor asymptomatic synechiae were noted in several patients, but no treatment was needed. These were more common in the side contralateral to the flap harvesting. The nasal septum donor site was mucosalized within 6 to 12 weeks (*Fig. 9*). At this time, patients did not have any symptoms referable to the harvesting of the flap. Five of our patients had undergone resection of their pituitary tumor elsewhere via a transseptal approach. All presented with posterior septal perforations that complicated but did not impede the design and elevation of the HBF. Three of our own patients required additional surgery as part of staged procedures for tumor removal, and the flap was dissected off the original defect, stored during the operation, and then reused for the reconstruction. The period between the first and second operations in these patients varied from 2 weeks to 3 months.

DISCUSSION

Isolation of the intracranial space is a critical goal during reconstruction after cranial base surgery. Multiple factors may influence the choice of reconstructive technique and its outcome. These include the specific target area, extent of resection, and consequent extent of communication between the cranial cavity and the sinonasal tract, presence and geometry of

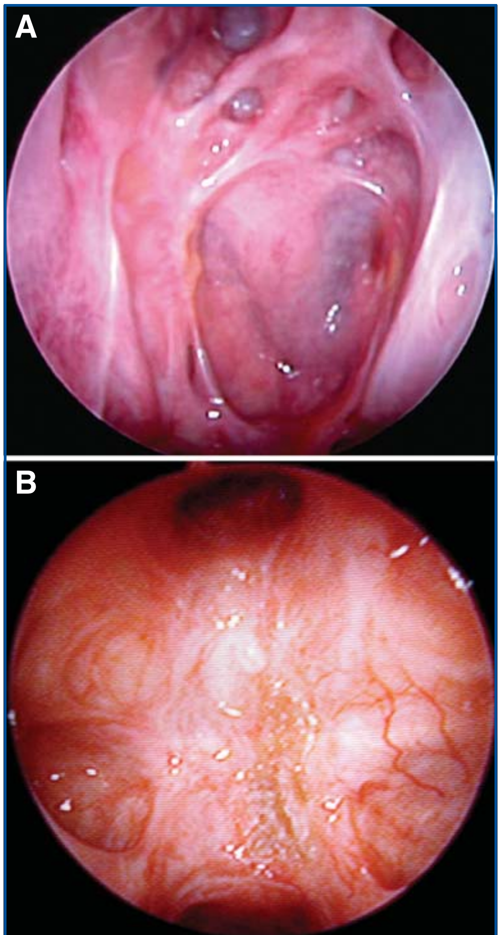

FIGURE 9. A, *endoscopic view of the anterior cranial base 3 months after flap placement showing a completely mucosalized anterior cranial base.* **B**, *endoscopic view of the anterior cranial base showing a completely healed flap at 3 months; the opening of the frontal sinus is in the rostral aspect of the image.*

the remaining dural and bony margins, general status of the patient, previous intranasal or maxillofacial operations or irradiation, the possibility of increased CSF pressure postoperatively, and the need for prompt adjunctive therapies (chemotherapy or radiation therapy [7, 19, 20, 38, 39]).

Since the advent of transsphenoidal surgery, multiple reconstructive procedures have been used for the reconstruction of the sella and ventral cranial base. This has involved the use of autologous tissue and synthetic substitutes (3–5, 17, 24, 26, 32). Our initial reconstructive efforts mimicked endoscopic techniques used to repair limited defects of the cranial base (7, 19, 20, 35, 38, 39). As opposed to our experience treating posttraumatic or spontaneous leaks, these techniques were fraught with a high incidence of postoperative CSF leaks when used for defects resulting from EEAs. Persistent CSF leaks were invariably associated with displacement or failure to heal of a small part of the graft, commonly located at the most dependent area, at the point of maximum pressure, or alternatively at its superior margin, where the graft is most vulnerable to migration.

Subsequently, we modified our multilayer reconstruction to include a subdural collagen matrix inlay graft and then an extracranial acellular dermis onlay graft supported by free abdominal fat (7, 23, 35). We adopted the use of the balloon of a 12-French Foley catheter to support the multilayered reconstruction, pressing the fat against the defect, to counteract gravity and the pulsations of the brain, therefore mitigating graft migration and the development of persistent fluid channels. To avoid shifting even further, we sutured the edges of the onlay fascial graft with nonabsorbable stitches and subsequently nitinol rings (U-clips; Medtronic, Memphis, TN). Each of these techniques contributed to a reduction of the incidence of postoperative CSF leaks after EEA, but its incidence remained higher than that after conventional approaches.

We started using the HBF to promote faster and more complete healing of defects resulting after EEA. In situations in which there is a limited opening of the sella, a simple multilayered reconstruction suffices, and the HBF is not necessary. This means that we do not use the HBF routinely in patients with microadenomas or other small sellar lesions such as Rathke's cysts. We have found the HBF useful when surgery with a high risk of postoperative CSF leak is undertaken. In general, this involves patients who have a wide opening of the arachnoid cistern (as occurs in meningiomas and craniopharyngiomas), high intracranial pressure (encountered in encephaloceles), wide dural removal (as in esthesioneuroblastomas), extensive opening of the ventral cranial base (as occurs in large chordomas of the clivus and tuberculum sellae meningiomas), and large pituitary tumors with suprasellar extension. In extradural approaches, if the petrous carotid or ascending cavernous carotid is exposed, the HBF is used to cover the exposed carotid.

As previously stated, because the decision needs to be made at the start of the surgical approach, we harvest a nasoseptal flap in patients who require intra-arachnoidal dissection, those with a high risk for an unplanned CSF leak, and those in whom we need to expose the internal carotid artery. We also favor the use of a nasoseptal flap in patients with a history of radiation therapy to the surgical field or those who will need postoperative irradiation. These indications are in flux. In this series of 75 patients, 55 underwent an EEA for intra-arachnoidal lesions; thus, they had large cranial base defects associated with intraoperative CSF leaks that required repair. A significant number of the remaining 20 patients had exposed internal carotid arteries, a history of radiation therapy, or a need for postoperative irradiation.

In 1952, Oscar Hirsch (21) was the first to describe the successful use of a septal rotation flap for the endonasal repair of a CSF leak. Others modified his original description and/or designed other intranasal flaps such as that based on the middle turbinate for the extracranial repair of CSF fistulae (2, 27, 28, 36, 37). All of these flaps have a random blood supply that limits their potential surface area and mandates the preservation of a broad base that creates torsional forces to retract the flap apart from the defect.

The HBF is a vascular pedicle flap supplied by the posterior nasoseptal arteries (19). These arteries arise from the posterior nasal artery, which is one of the terminal branches of the internal maxillary artery. The posterior nasoseptal arteries supply the entire length of the nasal septum and anastomose with the ethmoidal arteries (superiorly), the greater palatine artery (inferiorly), and the anterior facial artery (anteriorly) (1, 8, 9, 18, 19, 25, 29). The nasoseptal artery provides a pedicle and branching that avails the HBF with reliability, a wide arc of rotation, a long reach, and a total surface area superior to any other nasal flap. Furthermore, the HBF provides enough surface area to reconstruct any part of the cranial base resected by a single EEA. One significant caveat is that it needs to be anticipated in advance, before a posterior septectomy is performed, because this would destroy the vascular pedicle. A previous posterior septectomy, previous wide sphenoidotomy, previous surgery, or the presence of tumor in the pterygopalatine fossa may compromise its blood supply. Any of these scenarios may eliminate the possibility of using the HBF, thus mandating the use of alternative reconstructions such as the pedicled transpterygoid temporoparietal fascia and inferior turbinate flaps (13, 14).

CONCLUSION

The HBF is a reliable reconstructive technique for extensive defects of the anterior, middle, clival, and parasellar cranial base. Its use has resulted in a sharp decrease in the incidence of postoperative CSF leaks after EEA. Meticulous attention to technical aspects of its harvesting and use is paramount to a favorable outcome.

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COMMENTS

This interesting article follows the series of articles that, for several years, have provided solutions for adequate reconstruction of the sella and the cranial base after transsphenoidal surgery and prevention of postoperative cerebrospinal fluid (CSF) leaks. More recently, the same problem has been solved for intradural lesions of the midline cranial base after extended endoscopic endonasal surgery.

Kassam et al. describe their experience with the use of the nasoseptal flap clearly and honestly, and the "lessons learned from mistakes" could be of great value for those who are involved in this continuously evolving surgery. Cranial base reconstruction techniques after extended approaches that require a 3-, 4-, or 5-cm osteodural opening are being developing very quickly. The increased, almost unacceptable, rate of CSF leaks, reported early, has led to this fast development of reconstruction techniques, stimulating surgeons in their attempt to definitively fix the problem. Foley catheter balloons, U-clips, and finally nasoseptal flaps are only some examples of the extraordinary strategies proposed by the Pittsburgh group that clearly show their abilities and experience in the field of endoscopic endonasal cranial base surgery. However, although the nasoseptal flap has decreased the postoperative CSF leak rate, we cannot assess whether it could be considered the solution. In our experience, we noticed that how to pack sphenoidal sinus and even how to fill the dead spaces and accurately seal the actual osteodural defect are important issues.

To better manage high-risk situations for postoperative CSF leaks, i.e., craniopharyngiomas and in particular those invading the third ventricle, we are actually using a film of fibrin glue inside the surgical field. This technique seems to create a watertight barrier against the CSF, and, in contrast with the use of the autologous fat, it does not affect interpretation of magnetic resonance imaging scans.

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One of the main criticisms of the new minimal access transnasal approaches to the cranial base has been the relatively high rates of CSF leaks. Initially, authors published CSF leak rates as high as 20% (2). Although rates as low as 5% have also been reported (1), the critical factor is patient selection. Obese patients with large openings in the cranial base, significant arachnoid violation, and/or ventricular entry will always be at higher risk. Likewise, prior surgery, radiation therapy or a history of diabetes or chronic steroid use may predispose to poor wound healing. Surgeons who choose not to offer these patients transnasal surgery can expect lower rates of CSF leaks. If minimal access cranial base surgery or the "expanded endonasal approach" is being offered as an improvement over transcranial approaches, effective methods for closing the cranial base are required. In this article, Kassam et al. have provided an excellent description of their preliminary experience with a vascularized nasoseptal flap that effectively reduces the risk of CSF leak in high-risk patients. This technique is particularly useful in patients who have undergone prior radiation or are going to receive radiation, thereby increasing the appeal of the expanded endonasal approaches in the treatment of malignant disease. It is unclear whether all patients undergoing transnasal endoscopic cranial base surgery benefit from a vascularized flap, as similar CSF leak rates can be achieved with an avascular multilayered closure in nonirradiated patients with normal wound healing abilities (3, 4). Nevertheless, this technique is certainly useful in a subgroup of patients.

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Since the beginning of this millennium, the transnasal endoscopic approach has become more and more popular in neurosurgery and its use had not been limited to pituitary lesions such as hypophyseal tumors. Using different angles of view of the endoscope and high-resolution camera, almost all areas of anterior cranial base and of the clivus can now be approached with the endoscope with much better visualization and illumination than with the microscope alone. In addition, intradural lesions from behind the frontal sinus almost down to the foramen magnum can be dissected in a minimally invasive way without touching the brain much, and the basal arteries may be exposed. Thus, this approach would be perfect also for rigid tumors such as frontobasal and presellar meningiomas, for tumors extending from the clivus into the posterior fossa, and for basilar aneurysms from the middle to the tip.

However, up to now the large basal dura opening has been difficult to close. With conventional methods using nonvascularized fascia or synthetic materials, the risk of significant CSF leak exceeds 50% in honestly reported statistics, and often the leaks require multiple revisions and are associated with significant mortality; in addition, the coverage of exposed carotid arteries may be difficult, so the final result is often not minimally invasive at all.

The future of these approaches, therefore, depends on more reliable methods for closing the dura and cranial base. For this purpose, the Hadad-Bassagasteguy flap (HBF), developed from Hirsch's (the absolute pioneer in transnasal pituitary surgery!) early septal mucoperiostal flap, promises to be a milestone. This vascular pedicle nasoseptal flap, consisting of nasal septum mucoperiosteum and mucoperichondrium based on the nasoseptal artery (2), can be prepared in the vicinity of the leak and turned in for a vital vascularized closure; in patients with posterior septectomy, the flap has to be dissected initially.

Use of this procedure certainly benefits from some experience as is shown by the leak rates in the first 25 patients (>30%), which are still relatively high; after this workout phase, the leak rates in the following 50 patients dropped down to 4% and were also quite acceptable (5.4%) in the later 37 patients with intra-arachnoidal dissection. Infectious or wound complications were not reported; this result may also be attributed to the anti-infectious barrier qualities of nasal mucoperiosteum that are well known to ear, nose, and throat surgeons.

This technique may further be refined and diversified to also allow closure of large openings for all areas of transnasal approaches after extended septectomy, such as the posterior pedicle inferior turbinate flap and the more conventional, but vascularized, transpterygoid temporoparietal fascial flap proposed by the same group of authors (1). Therefore, we also now use this technique in these approaches with good success, but the preparation of a flap of adequate size is not easy for beginners. This technique should therefore be included in transnasal endoscopy training courses.

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1. Fortes FS, Carrau RL, Snyderman CH, Prevedello D, Vescan A, Mintz A, Gardner P, Kassam AB: The posterior pedicle inferior turbinate flap: A new vascularized flap for skull base reconstruction. **Laryngoscope** 117:1329–1332, 2007.
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The present article of Kassam et al. deals with an innovative endoscopic technique to repair wide cranial base defects: the Hadad-Bassagasteguy flap (HBF), a neurovascular pedicled flap of the nasal septum. The vascularized tissue promotes fast and complete healing of the cranial base defect separating the subarachnoid space from the sinonasal tract. This technical advancement may overcome the main limiting factor of the use of endonasal endoscopic surgery to treat cranial base pathological lesions, namely the difficulty of repairing the resulting defects. The specific experience of the Pittsburgh group is unique and the series of pathological lesions they treated during 1 year is representative of the spectrum of cranial base lesions they can treat using endoscopic surgery. The HBF flap is a little traumatic for the nose: the transitory crusting phase requires prolonged medications and frequently results in nonfunctional synechiae. The HBF flap needs to be prepared in advance, and, therefore, careful selection of patients requiring this procedure. I agree with the use of the HBF flap in tumors requiring intra-arachnoidal dissection. In situations in which a multilayered reconstruction suffices, such as extradural-extra-arachnoidal tumors (pituitary adenomas and Rathke's cleft cysts), the HBF flap is not necessary. I warn that wide and sometimes unjustified use of the present technique may risk the loss of one of the main favorable characteristics of endoscopic surgery, namely its minimal invasiveness.

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Kassam et al. present their experience using a pedicled nasoseptal flap for cranial base reconstruction and CSF leak prevention in patients undergoing endonasal endoscopic surgery. Of 75 patients, 8 had a postoperative CSF leak; the repair failure rate decreased to 4% in the last 50 patients and was 5% in patients with intra-arachnoidal lesions. The use of a readily available and expansive vascularized flap makes excellent sense in dealing with this "Achilles' heel" of endonasal cranial base surgery. Their experience over the last decade shows the relatively steep learning curve that many neurosurgeons and their colleagues in head and neck surgery have encountered as the reach of endonasal surgery has expanded. It is indeed encouraging to see the admittedly unacceptably high CSF leak rate of this groups and others fall so precipitously over a relatively short period of time. However, as they emphasize, attention to detail and cumulative experience with the flap are paramount to its successful implementation. In addition, as they indicate, not all patients who develop an intraoperative CSF leak during endonasal surgery require this vascularized flap. As we have shown in our endonasal patient series, the majority of large (Grade 3) cranial base defects can be effectively repaired using a multilayered nonvascularized construct of fat, collagen sponge, and a buttress (1). That said, this pedicled flap technique appears to be highly effective for avoiding postoperative CSF leaks and is a welcome addition to the endonasal repair armamentarium. In some patients such as those who have had prior surgery or radiotherapy, it may indeed be the best, if not the only, solution. Kassam et al. have shown persistence and ingenuity in helping redefine cranial base surgery in the 21st century.

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