Endoscopic Endonasal Transethmoidal Transcribriform Transfovea Ethmoidalis Approach to the Anterior Cranial Fossa and Skull Base

OBJECTIVE: The anterior skull base, in front of the sphenoid sinus, can be approached using a variety of techniques including extended subfrontal, transfacial, and craniofacial approaches. These methods include risks of brain retraction, contusion, cerebrospinal fluid leak, meningitis, and cosmetic deformity. An alternate and more direct approach is the endonasal, transethmoidal, transcribriform, transfovea ethmoidalis approach.

METHODS: An endoscopic, endonasal approach was used to treat a variety of conditions of the anterior skull base arising in front of the sphenoid sinus and between the orbits in a series of 44 patients. A prospective database was used to detail the corridor of approach, closure technique, use of intraoperative lumbar drainage, operative time, and postoperative complications. Extent of resection was determined by a radiologist using volumetric analysis.

RESULTS: Pathology included meningo/encephaloceles (19), benign tumors (14), malignant tumors (9), and infectious lesions (2). Lumbar drains were placed intraoperatively in 20 patients. The CSF leak rate was 6.8% for the whole series and 9% for intradural cases. Leaks were effectively managed with lumbar drainage. Early reoperation for cerebrospinal fluid (CSF) leak occurred in 1 patient (2.2%). There were no intracranial infections. Greater than 98% resection was achieved in 12 of 14 benign and 5 of 9 malignant tumors.

CONCLUSION: The endoscopic, endonasal, transethmoidal, transcribriform, transfovea ethmoidalis approach is versatile and suitable for managing a variety of pathological entities. This minimal access surgery is a feasible alternative to transeptal, transfacial, or combined craniofacial approaches to the anterior skull base and anterior cranial fossa in front of the sphenoid sinus. The risk of CSF leak and infection are reasonably low and decrease with experience. Longer follow-up and larger series of patients will be required to validate the long-term efficacy of this minimally invasive approach.

KEY WORDS: Cribriform plate, Encephalocele, Endoscopic, Esthesioneuroblastoma, Fovea ethmoidalis, Olfactory groove meningioma, Transethmoidal, Transcribriform
anatomic dissections as well as case series,9,18-21 the endonasal approach through the ethmoids and cribiform plate developed as an extension of endonasal endoscopic sinus surgery to the repair of small frontoethmoidal encephaloceles.22 This approach is well-described in previous articles.9,15,17,23-25 However, the versatility of this approach to manage a variety of pathologies in a large series is not well-documented.

Although technically appealing, endonasal approaches pass through the nasal cavity, which is unsterile and carries a theoretical risk of intracranial infection. Likewise, cranial base reconstruction through the nose is not a trivial task and the risk of CSF leak is ever present. For this reason, we present our experience by using the endonasal, endoscopic transcryptiform, transfovea ethmoidalis approach to treat a variety of benign and malignant pathology of the anterior skull base and discuss its indications, limitations, and complications. The surgical technique is described in a graded fashion, based on a division of the approach into 4 separate compartments created by the locations of the septum and vertical attachments of the middle turbinates. The approach can be modified accordingly depending on the location and size of the pathology.

PATIENTS AND METHODS

We reviewed a prospectively collected database of all endoscopic, endonasal cases performed by the senior authors (THS, VKA, AK) between January 2004 and May 2009. Approaches were categorized based on a system of corridors, approaches, and targets presented in a previous publication.16 Of 262 total cases, we chose only cases in which the transnasal and transethmoidal corridors were used to pass either through the cribiform plate or fovea ethmoidalis as the central approach. This resulted in a series of 44 patients. Occasionally, pathology extended into other target areas, and additional corridors and approaches were required such as the transsphenoidal18 and transmaxillary (3) corridors and the transorbital (4), transplanum (2), and transcavernous sinus (1) approaches. Some patients have been included in other articles that were submitted for publication. Institutional review board approval was obtained for this study.

Surgical Technique

Patient Positioning for Surgery

The patient is placed under general anesthesia and given antibiotics, glucocorticoids, and antihistamines. We routinely use cefazolin (2 g, intravenous), dexamethasone (10 mg, intravenous), and diphenhydramine (50 mg, intravenous). A Foley catheter and an arterial line are placed if a tumor is being removed. For shorter operations or repair of meningoencephaloceles, the Foley and arterial line can be avoided. A lumbar puncture is performed, and 0.2 mL of 10% fluorescein (AK-Fluor, Akorn, IL) is injected in 10 mL of CSF to help visualize CSF leaks at the start of the operation and to ensure there is no leak after closure.26,27 In certain cases we place a lumbar drain intraoperatively at the start of the operation. These are cases with a high risk of postoperative CSF leak, as in patients with obesity, compromised healing (diabetes, chronic steroid use, renal failure, chemotherapy, radiation), or patients in whom a large dural opening is expected. The nasal mucosa is vasoconstricted with cotonoids soaked in 4 mL of 4% topical cocaine. The patient’s head is pinned in a Mayfield head-holder and turned slightly to the right and extended almost 30° to facilitate exposure of the subfrontal anterior cranial compartment. The head is elevated above the heart to facilitate venous drainage. The lateral thigh is prepped for autologous fat and fascia lata grafts. Using a 0°, 18-cm, 4-mm rigid endoscope (Karl Storz, Tuttingen, Germany), the mucosa adjacent to the sphenopalatine, anterior and posterior ethmoidal arteries are injected with a mixture of 1% lidocaine and epinephrine (1:100 000).

Nasal and Sinus Portion

The transethmoidal, transcryptiform approach can be performed unilaterally or bilaterally, depending on the lesion. The unilateral approach is generally indicated for CSF leak or meningocele, whereas the bilateral approach is generally required for tumors. In the unilateral approach, the septum can usually be preserved, although a submucosal resection of the cartilage can facilitate medial retraction and intranasal passage and exposure. The critical decision is whether the approach will be medial or lateral to the vertical attachment of the middle turbinate, which extends into the perpendicular lamella of the ethmoid bone or the medial wall of the ethmoid labyrinths (Figure 2). In some situations the approach will be both medial and lateral, in which case the middle turbinate may need to be removed. This decision is guided by the location of the pathology (Figure 3). If the pathology is medial
to the middle turbinate the approach is performed purely through a transnasal corridor. If the pathology is lateral to the middle turbinate an uncinectomy and anterior and/or posterior ethmoidectomy must be performed, and a transethmoidal corridor must be opened. Uncinectomy is performed with a sickle knife beginning at the anterior attachment of the uncinate process. The incision should be performed with the knife blade parallel to the lamina papyracea to avoid entry into the orbit and continues inferiorly and laterally toward the ostium of the maxillary sinus. The uncinate process is then removed to expose the anterior wall of the ethmoid bulla. The anterior ethmoid cells are opened and, depending on the location of the pathology, the basal lamella of the middle turbinate is transected to expose the posterior ethmoid cells, which can also be opened. In some circumstances, part of the vertical attachment of the middle turbinate (perpendicular lamella of ethmoid) can be removed to identify the edges of the defect, whereas for larger lesions the entire middle turbinate may be removed. If a large concha bullosa exists, partial or complete resection may facilitate exposure. Depending on the anterior extent of the pathology, the approach can be performed with either a 0°, 30°, or 45° 18-cm, 4-mm rigid endoscope (Karl Storz, Tuttingen, Germany), held in the left hand while dissecting with the right.

Unilateral Approach

If a unilateral approach is indicated for repair of a unilateral CSF leak, the roof of the nasal cavity and cribriform plate are inspected carefully with fluorescein filters to identify the site of CSF egress. Although fluorescein can be seen without the blue filter, the filters make a significant difference in some instances. If the pathology is lateral to the middle turbinate, the ethmoid air cells may need to be removed before the CSF leak can be fully appreciated. In other cases, the meningocele is immediately apparent at the roof of the nasal cavity, medial to the turbinate. The meningocele is sometimes lateral to the middle turbinate and sometimes it is medial to the middle turbinate (Figure 2). Although the attachment of the middle turbinate may need to be transected, we try to preserve as much of the turbinate as possible to preserve laminar flow of air, mucosal ciliary transport, and the olfactory and immune functions of the nasal conchae. The meningocele is opened sharply and removed. In the case of an encephalocele, any brain that has herniated into the nasal cavity is resected. The bone edges are defined by scraping with a curette to determine the size of the graft required for closure (Figure 4).

Bilateral Approach

The approach to olfactory groove meningiomas, esthesioneuroblastomas, and other malignant pathology is generally performed bilaterally (Figure 5). A decision must be made whether to approach the pathology medial or lateral to the middle turbinate, or whether one can proceed medial to the middle turbinate on 1 side but remove the middle turbinate on the other side if more exposure is required on 1 or the other side. We try to preserve at least 1 middle turbinate, although with malignant pathology, negative margins must be confirmed. Some smaller olfactory groove meningiomas can be removed through a transnasal, transcribriform approach with preservation of 1 or even both middle turbinates. However,
FIGURE 3. Meningocele through the cribriform plate can project either medial (A) or lateral (B) to the vertical attachment of the middle turbinate. Endoscopic view of each of the meningoceles shown in (A) and (B) demonstrate the lesion medial (C) or lateral (D) to middle turbinate.

FIGURE 4. A, the thin gossamer lining of the meningocele is being drawn into the intracranial cavity with the pulsations of CSF. B, the meningocele is sucked into the nasal cavity and removed to expose the bony edges. C, The defect in the cribriform plate leading into the intracranial cavity is exposed. D, closer view of the defect in the cribriform plate.

FIGURE 5. Preoperative coronal contrast enhanced MRI of an esthesioneuroblastoma (A) and a sagittal contrast enhanced MRI of an olfactory groove meningioma (C). The postoperative scans are shown in (B) and (D). Note the fat graft that is bright in image (D).

A wide opening of the ethmoid sinuses is often required for adequate exposure.

A submucosal resection of the cartilaginous septum and removal of the upper third of the septal attachment to the roof of the nose creates a single, large cavity (Figure 6). The endoscope can be placed through 1 nostril, while the instruments are placed through the other, or both nostrils. Following uncinectomy, the bulla ethmoidalis and anterior and posterior ethmoid air cells are removed on 1 or both sides depending on the required exposure. The anterior and posterior ethmoidal arteries are identified, coagulated, and transected (Figure 6). These can be identified between the lamina papyracea and the fovea ethmoidalis (Figure 7). The posterior ethmoidal artery lies 8.3 mm anterior to where the optic nerve leaves its canal and runs for 9 mm toward the cribriform plate. The anterior ethmoidal artery passes through the anterior ethmoidal foramen and runs just behind the frontal recess and agar nasi cell for a length of 10 mm. In some cases the lamina papyracea can be removed to gain lateral exposure, although the periorbital fascia should not be disturbed unless invaded by tumor. The mucosa and olfactory epithelia are cauterized and removed from the cribriform plate. A drill and suction are placed through each nostril, and the cribriform plate is removed bilaterally with a high-speed drill. The drilling begins at the posterior portion of the frontoethmoidal recess and continues posteriorly to the sphenoid sinus. The lateral extent of the removal is the border between the cribiform plate and the lamina papyracea. Intraoperative neuronavigation is critical to ensure adequate exposure of the intracranial anatomy and pathology. If the tumor extends back to the planum, the sphenoid sinus is opened widely. The crista galli is then drilled out in the midline (Figure 6). Residual
of the intradural compartment for residual tumor is important even if it appears that the dura is not breached. In particular, esthesioneuroblastomas may have an intradural component along the olfactory nerve that cannot be recognized from within the nasal cavity.

**Intracranial Portion**

**Bilateral Approach**

The tumor is internally decompressed in standard neurosurgical fashion (Figure 8). Bimanual suction is useful if the tumor is soft.23 The Cavitar ultrasonic surgical aspirator (Valleylab, CO) or an Elliquence monopolar or ring cautery (Oceanside, NY) are useful for firmer tumors. Internal removal piecemeal with a pituitary rongeur is also possible, although care must be taken to avoid traction on the tumor and inadvertent grasping of vital neurovascular structures. Once the tumor is decompressed, the capsule can be mobilized, and sharp dissection is used to cut neurovascular structures off the capsule. If the nostrils are sufficiently large a standard bayoneted bipolar can be used, otherwise pistol-grip bipolars are required.

**Figure 7.** Intraoperative endoscopic view of the approach lateral to the middle turbinate (MT) after uncinctomy and opening of the ethmoid bulla to expose the fovea ethmoidalis (FE) (A). B, the posterior ethmoid artery (PEA) can be seen after its canal has been opened prior to ligation.

thin pieces of bone can be freed with a curette and removed with a micropituitary rongeur. If an olfactory groove meningioma is being removed, the dura is cauterized with a monopolar to devascularize the tumor. In the case of an esthesioneuroblastoma, squamous cell carcinoma, or juvenile angiofibroma, the tumor may already have destroyed the ethmoid sinuses and cribriform plate, and the anatomic landmarks may be ambiguous. If the ethmoids are involved, a medial maxillectomy is usually required.

To remove these tumors completely, it is often necessary to combine the transethmoid, transcribriform approach with other approaches. The transorbital approach may require removal of the lamina papyracea to remove tumor from the medial orbital wall. In some cases the transpterygoid approach is required, in which the maxillary sinus is opened and the pterygoid is drilled to enter into the pterygopateline fossa. In general, the adjacent sinus or compartment must be removed to obtain adequate margins. Exploration of the intradural compartment for residual tumor is important even if it appears that the dura is not breached. In particular, esthesioneuroblastomas may have an intradural component along the olfactory nerve that cannot be recognized from within the nasal cavity.

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The olfactory nerves can sometimes be preserved, although preservation of smell is unlikely given the removal of the epithelia. In many cases, smell already has been compromised by the lesion.28 The A2 branches of the anterior cerebral artery often adhere to the posterosuperior aspect of the tumor and must be sharply dissected off the capsule and preserved (Figure 8). In some circumstances a frontopolar branch may be encountered.

If an esthesioneuroblastoma is being removed, it is important to obtain a gross-total resection with margins if possible. These tumors generally penetrate the dura, and dural resection is mandatory. Intraoperative biopsies can be performed to ensure the absence of residual tumor. Even if the dura appears uninvolved, it should be opened for examination of the olfactory nerves to ensure the absence of intracranial disease.

**Closure**

**Unilateral Approach**

If a CSF leak is being repaired, the edges of the bone opening must be identified. Gentle dissection of the mucosa with an angled dissector and judicious coagulation generally suffices. If a dural
Finally, a watertight closure is achieved with the use of either fibrin matrix (Tisseel; Baxter, IL) or polymerized hydrogel (DuraSeal; Confluent Surgical, MA); the latter product is preferable. Recently, we combined the gasket-seal closure with a nasoseptal vascularized flap.30 In this case, the duraseal is placed on top of the flap rather than below to facilitate neovascularity between the flap and the gasket seal. The sphenoid sinus, ethmoid sinuses, and roof of the nose are filled with thrombin-infused gelatin matrix (FloSeal; Baxter, IL) to facilitate hemostasis. A small piece of Telfa is placed in each nostril overnight to absorb any drainage and is removed in the morning.

**Postoperative Care**

Patients are extubated atraumatically to avoid a sudden increase in intracranial pressure and are brought to the recovery room with the head elevated to 30°. For tumor resections, the patient is admitted to the intensive care unit overnight for frequent neurological examination, and for monitoring blood pressure, urine output, and specific gravity if the pituitary-hypothalamic axis has potentially been injured. Patients with small encephaloceles are observed in the recovery room for a few hours and then transferred to the floor overnight and discharged in the morning. If a lumbar drain is in place, we drain no more than 5 mL/h for the first 24 h and remove it the night of the second postoperative day. Heparin is administered subcutaneously until the patient is ambulatory, and patients are encouraged to get out of bed on the second postoperative day. A postoperative magnetic resonance imaging (MRI) scan is obtained on the second postoperative day and 3 months after surgery. A fat-suppressed MRI scan may be helpful in differentiating residual tumor from fat graft, although the latter does not enhance with intravenous contrast. Patients can be discharged home on the second or third postoperative day or as soon as they are ambulating and eating comfortably.

**Follow-up**

Patients with tumors received pre- and postoperative MRI scans, and the extent of resection was determined by a radiologist as >98%, <98%, or by biopsy, the latter if there was no appreciable change in the size of the tumor. The reason the maximal resec-
tion category was classified as >98% was that there was often inflammatory, tissue in the roof of the ethmoid sinus that could not be distinguished from residual tumor thereby confusing a precise determination of a complete resection. Placement of lumbar drainage, CSF leak, and postoperative complications were assessed based on review of a prospective database cross-referenced with chart review and patient phone calls.

RESULTS

The average patient age was 55.4 years with a range of 17 to 85. There were 17 males and 27 females. The diagnoses are presented in Table 1. The average follow-up was 29 months. Overall, lumbar drains were placed intraoperatively in 20 (45%). Thirty-three of the cases were “intradural” and a large CSF leak was encountered intraoperatively. Of these cases, there were 3 early postoperative CSF leaks (9%), all occurring in patients that did not receive a lumbar drain intraoperatively. Two occurred after encephalocele repair and 1 after meningioma resection. Two of these leaks occurred in the first half of the series. We have only had 1 leak using this approach in the past 3 years. Two of these leaks were successfully managed by placing a lumbar drain, and 1 patient with a large defect from an olfactory groove meningioma was repaired with a craniotomy. The decision to perform a craniotomy, rather than repeat endonasal surgery, as advocated by others, was based on the location of the leak just behind the frontal sinus. This area can be difficult to reach endonasally but is easily reached transcranially. Thus, the rate of early reoperation for CSF leak was 2.2% for the whole series and 3% for the intradural cases. One delayed leak occurred 9 months after endoscopic repair in a patient with large meningoencephalocele arising from the posterior wall of the frontal sinus, extending through the fovea ethmoidalis into the middle turbinate, following a car accident. Given the location of the defect and its proximity to the frontal recess, we elected to repair the leak through a craniotomy, because we did not think we could close the defect from below and maintain the patency of the frontal recess, although a Draf III procedure may also be used in this situation to access the posterior wall of the frontal sinus. Hence, the overall rate of reoperation for CSF leak was 4.4%. For patients undergoing CSF leak repair, the average length of surgery was 119 minutes.

In patients with benign tumors, >98% resection was achieved in 12 patients and <98% in 2 patients. The average length of surgery was 287 minutes. Patients with <98% resection included 1 patient with a recurrent irradiated invasive pituitary adenoma with disease in the cavernous sinus and a giant invasive olfactory groove meningioma in an elderly patient in whom the tumor was internally decompressed endonasally, followed by further debulking transeptally. The initial endonasal procedure was performed to decrease the amount of brain retraction and to devascularize the tumor from below. After an average follow-up of 39 months 1 patient with an olfactory groove meningioma showed progressive growth and was brought back to the operating room for a craniotomy and further resection.

In patients with malignant tumors the average length of surgery was 175 minutes. One patient had a biopsy for diagnostic purposes, 4 had >98%, and 4 had <98% resection. All patients received postoperative fractionated radiation therapy and 1 also received chemotherapy. Three patients died (1 who had a biopsy and 2 with subtotal resection) and 1 had a recurrence after an average follow-up of 28 months. The 2 patients with infectious processes (mucocele and aspergiloma) were debrided and treated with antibiotics and antifungals. The average length of surgery was 103 minutes.

There were no postoperative intracranial infections, although 5 patients had sinusitis, which resolved with oral antibiotics. Two patients with imaging suspicious for postoperative infections underwent exploratory transcranial surgery, but cultures were negative and the imaging changes resolved spontaneously.

DISCUSSION

The endoscopic endonasal transethmoidal, transcribriform approach is a useful, safe, minimally invasive alternative to reach pathology in the midline of the anterior cranial fossa skull base. The anterior limits of the approach are the frontal sinus and the posterior limits are the planum sphenoidale. However, the posterior extent can be increased by opening the transphenoidal corridor and performing a transplanum or transtuberculum approach.16 The lateral limits are the lamina papyracea and the medial orbits. The distance between the lamina papyracea is ∼25 mm. Intracranially, the gyrus recti and orbitofrontal gyri are easily exposed, as well as the olfactory nerves bilaterally.

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a CSF, cerebrospinal fluid.
We demonstrate the versatility of this approach in managing a variety of pathologies. Although surgery for a meningocele is not the same as surgery for an olfactory groove meningioma, which is not the same as an ethesioneuroblastoma, the purpose of this article is to describe the approach in graded steps, each of which is part of the same spectrum. The approach can be modified depending on the location and size of the pathology. We divide the transethmoidal transcribriform, transfovea ethmoidalis approach into 4 compartments, each bounded by the following vertical structures: the lamina papyracea, the vertical attachment of the middle turbinates, and the septum. The first compartment lies between the lamina papyracea and the vertical attachment of the middle turbinate. This approach requires a transethmoid dissection and uses the ethmoid sinuses as a corridor to the fovea ethmoidalis and anterior fossa. The second compartment lies between the vertical attachment of the middle turbinate and the septum. This corridor lies medial to the ethmoids and uses a transnasal corridor to the cribiform plate and olfactory nerves. Mirror images of these same 2 compartments exist on either side of the septum. These corridors can be opened individually or combined for a larger opening, which requires resection of the middle turbinate or septum as needed. Once the anatomy of the approaches is conceptually appreciated, the next issue becomes the indications, contraindications, and risks of the approach for various pathology.

**Indications and Contraindications**

The transethmoidal, transcribriform, transfovea ethmoidalis approach is useful for encephaloceles and CSF leaks as well as benign and malignant tumors. Our experience over the past 5 years helped us conceptualize not only the appropriate pathology but also the limitations of this approach.

Encephaloceles and meningoencephaloceles of the cribiform plate and fovea ethmoidalis are easily repaired through this approach; very rarely has a craniotomy been required to control a CSF leak. These results are consistent with other reports in the literature. The goal of this surgery is to create a multilayer watertight closure of the skull base. To achieve this, the protrusion of brain and/or dura must be removed and the free bone edges identified. Successful closure can be achieved regardless of the size of the defect. Placement of a lumbar drain intraoperatively is optional, although we find it helpful in patients who are obese or unlikely to heal based on preoperative risk factors such as smoking, diabetes, chronic renal failure, or steroid use. Frank hydrocephalus may require shunting in addition to endoscopic closure because shunting alone may cause pneumocephalus if the defect is not closed. The instance where endonasal surgery was inadequate was in a patient with a CSF leak arising from the posterior wall of the frontal sinus, just behind the nasofrontal duct, from a large meningoencephalocele. Although we initially resected the encephalocele and repaired the defect endonasally, it would not have been impossible to repair the back of the frontal sinus without occluding the nasofrontal duct. Because we did not want to put the patient at risk of a delayed mucocele, we performed the repair transcranially.

Benign tumors such as meningiomas, osteomas, and papillomas of the sinuses and anterior skull base are also amenable to resection through the transcribriform, transfovea ethmoidalis approach. The most controversial of these pathologies are the meningiomas. Advantages of the endonasal approach include the ability to devascularize the tumor early in the operation by controlling the ethmoidal arteries, remove the tumor without retraction on the frontal lobe and without sacrificing the sagittal sinus, and the ease of removing any infiltrated bone at the cranial base, which is the primary site of recurrence. Endovascular occlusion of the ethmoidal arteries is often difficult if not impossible because the ophthalmic artery must be cannulated. Hence, the endonasal approach permits early devascularization that could not otherwise be achieved. The major disadvantage is the inability to remove a dural tail that extends beyond the attachment of the tumor at the skull base. For this reason patient selection is critical. Large tumors that attach beyond the lamina papyracea or extend up behind the frontal sinus are difficult to remove completely. Thus, if gross-total resection of the tumor with the associated dural tail is the goal of surgery, the endonasal approach may not be appropriate unless the tumor is small with a limited dural tail. Nevertheless, in certain patients, aggressive debulking to alleviate symptoms may be adequate treatment followed by radiosurgery, fractionated radiation therapy, or observation. In a recent series, bifrontal craniotomy for olfactory groove meningiomas was associated with a −30% morbidity and 5% mortality from frontal lobe retraction, venous infarct, hemorrhage, CSF leak, or infection. Although this series involved removal of large, complex skull base tumors, which was not always the case in our series, the endonasal approach as it evolves and becomes more refined can potentially avoid many of these complications. In prior endonasal series for olfactory groove meningiomas, gross-total resection rates have varied from 58 to 100% with a CSF leak rate of 25 to 27%.

Conversely, loss of olfaction is necessitated by the bilateral endonasal approach for olfactory groove meningiomas, which can be preserved with a transcranial approach.

Equally controversial are malignant tumors. The current standard of care is a craniofacial approach to achieve en bloc resection with negative margins. Craniofacial surgery, however, is not without risk, and rates of mortality of 5% and of morbidity of 35% are often reported. Although the extent of resection or survival should never be compromised for cosmesis, there are no data that demonstrate unequivocally that piecemeal removal with negative margins is any less efficacious than en bloc resection. Likewise, even aggressive craniofacial surgery only successfully achieves negative margins in 70% of patients so there may be a subset of patients in whom negative margins can never be achieved regardless of how aggressive the surgery is. In addition, there is recent evidence that endoscopic, endonasal surgery in combination with stereotactic radiosurgery or fractionated radiotherapy may be as efficacious as en bloc craniofacial resection, particularly for esthesioneuroblastoma. A cranial nasal endoscopic surgery that avoids a facial incision may be as effective as the craniofacial approach. Last, if the surgeon knows preoperatively that a gross-total resection with
negative margins is unlikely to be performed successfully and safely, a minimally invasive, aggressive debulking followed by radiation and/or chemotherapy may be more practical and better tolerated than a subtotal craniofacial resection.

The endonasal endoscopic approach is not appropriate to attempt gross-total en bloc resection. If this is the oncologic goal of the surgeon, an anterior craniofacial approach should be utilized. However, it is possible to achieve a piecemeal gross-total resection with negative margins endoscopically followed by fractionated radiation or radiosurgery and achieve results that may be comparable to those achieved with en bloc resection.13,14,25,42,45 The decision to approach malignant tumors through a minimally invasive endoscopic approach should be carefully considered by the team, including the oncologist, neurosurgeon, and otolaryngologist in consultation with the patient, and the alternative craniofacial option should be openly discussed.

Complications

Critics of endonasal approaches argue that the risk of CSF leak is too high to justify the approach. Although early studies reported leak rates of 20 to 30%,19,21 most groups are currently achieving rates of 5 to 10%30,46 or even less.29 This number is decreasing as experience is gained. We report 3 CSF leaks, or a rate of 9% for intradural pathology during our experience with the transfosa ethmoidalis, transcribiform approach. However, 2 of these occurred in the first 2 years of our endonasal skull base experience and only 1 of these patients required an early reoperation to repair the leak. Postoperative leaks can be managed in several ways. Some authors recommend repeat endonasal surgery to repair the leak.31 We agree with this philosophy, and emphasize that the location of the leak is critical. Leaks that are very anterior, just behind the frontal recess or in the back wall of the frontal sinus, are difficult to reach endonasally and more easily managed through a craniotomy. In addition, we have successfully managed leaks with placement of a lumbar drain. One must be cautious not to induce pneumocephalus with this technique, and it is only viable if there is a small volume leak and a meticulous multilayer closure has been performed. Based on the success of lumbar drainage in this situation, we have increased our placement of lumbar drains prophylactically at the time of surgery, assuming there is no large intracranial mass causing increased intracranial pressure. We have also routinely adopted the use of Medpore as part of our gasket-seal closure to buttress the fascia lata before placing a nasoseptal flap, although one could argue that the Medpore may prevent early vascularization of the flap. However, Medpore is a porous structure that allows tissue ingrowth, which should not impair early vascularization. Although CSF leak may increase the length of stay, the feared risk is meningitis or abscess. Infectious risks are often raised as an argument against using an endonasal approach that traverses a dirty cavity as opposed to a transcranial route that passes through sterilized skin. We encountered no intracranial infectious complications in our series, further justifying the validity and safety of this approach. While sinusitis may be bothersome in the short run, frequent nasal rinsing and appropriate antibiotic therapy as well as frequent rhinologic follow-up can reduce this complication dramatically.

CONCLUSIONS

A purely endoscopic, endonasal, transethmoidal, transcribiform, transfovea ethmoidalis approach is a feasible alternative to transcranial, transfacial, or combined craniofacial approaches to the anterior skull base and anterior cranial fossa. This approach is versatile and can be used to manage a variety of diseases from small meningiocytes to benign and malignant tumors. We present a series of patients, all of whom were treated with variations of this approach, based on the extent of the pathology. The risk of CSF leak and intracranial infection are low and decrease with experience. Longer follow-up and larger series of patients will be required to validate the long-term efficacy of this approach.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES


**COMMENT**

In this paper article, the authors have presented their experience with endonasal endoscopic surgery for anterior basal, midline lesions. These were in three 3 categories: cerebrospinal fluid (CSF) leaks, and encephaloceles: benign benign tumors, particularly olfactory groove meningiomas; and malignant sinonasal tumors.

For the first category, the endoscopic approach is clearly beneficial. For olfactory groove/planum meningiomas, a standard cranial base approach nowadays involves a unilateral frontotemporal craniotomy with a unilateral orbitotomy for large and giant tumors, or a small craniotomy, with drilling of the roof of the orbit (minimal access craniotomy) for small and medium sized tumors. CSF leak and infection can occasionally be seen after such surgery, although less than in less than 5% of cases. It is very rare to see damage to critical structures such as the anterior cerebral artery, or the optic nerves, and mortality is extraordinarily rare. More importantly, “damage to the brain from retraction” is avoidable in all cases when good operative techniques are used, and in many patients, Olfaction olfaction can be saved, at least on one side (contralateral). Some of these tumors will extend into the ethmoids, and these tumors can be removed simultaneously. The tumor can be removed completely in 95% of the cases, and the surgeon can usually also remove some dura mater adjacent to the tumor, which appears to be hypervascular, and may contain the tumor. This should be compared to the results reported by the authors. Although we are at an early stage of development with respect to endonasal approaches, it is very hard to justify them by saying that craniotomy damages the brain by retraction. The same standards of morbidity, and extent of tumor resection need to be used for comparison.

For malignant tumors, it appears that the endonasal endoscopic approach falls quite short. Although the authors’ experience was small in this regard, total resection was accomplished only in one one-half of the patients, and, in the one patients with total resection, it is not clear if whether negative margins were achieved. Total tumor resection with negative margins has been the goal of surgery for malignant tumors, and it remains to be shown if the endoscopic approach is equally effective.

In summary, the endonasal approach to midline anterior basal tumors is still in the stage of development. The authors need to carefully review and report their results, especially in regards to recurrences of tumors. Patients should be adequately informed of the good results of the cranial base approaches as alternative treatment, rather than about how cranioectomy can “damage the brain.”

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