

The Transconjunctival Transorbital Approach: A Keyhole Approach to the Midline Anterior Skull Base

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Key words

- Anterior cranial fossa
- Keyhole craniotomy
- Transconjunctival
- Transorbital

Abbreviations and Acronyms

CSF: Cerebrospinal fluid

CT: Computed tomography



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INTRODUCTION

Numerous craniofacial approaches have been developed to address the anatomic challenges of approaching the anterior skull base (5, 19, 20, 24, 26). Anatomically, there are multiple osseous compartments (e.g., frontal sinus, the orbits) that can limit direct access to the anterior cranial fossa. These compartments must also be visualized to resect pathology extending into these regions from the anterior cranial fossa. These different approaches (i.e., frontotemporal sphenoidal craniotomy, extended bifrontal craniotomy, transfacial approaches) provide advantages and corridors appropriate for selected lesions (19, 20, 24, 26). Characteristics that influence the type of approach include the malignant potential of the lesion, lesion epicenter, goals of surgery (negative margins, en bloc resection, neural decompression), and involvement of the paranasal sinuses and surrounding compartments.

These traditional craniofacial approaches are associated with risks, and although they are tolerated for the resection of malignant pathology, they may not be considered ac-

■ **OBJECTIVE:** To report an initial experience with a medial transorbital approach to the midline skull base performed via a transconjunctival incision.

■ **METHODS:** The authors retrospectively reviewed their clinical experience with this approach in the management of benign cranial base pathology. Preoperative imaging, intraoperative records, hospitalization charts, and postoperative records were reviewed for relevant data.

■ **RESULTS:** During the period 2009–2011, six patients underwent a transconjunctival craniotomy performed by a neurosurgeon and otolaryngologist–head and neck surgeon working together. The indications for surgery were esthesioneuroblastoma in one patient, juvenile angiofibroma in one patient, Paget disease in one patient, and recalcitrant cerebrospinal fluid leaks in three patients. Three patients had prior cranial base surgery (either open craniotomy or an endonasal approach) done at another institution. The mean length of stay was 3.8 days; mean follow-up was 6 months. Surgery was considered successful in all cases (negative margins or no leak recurrence); diplopia was noted in one patient postoperatively.

■ **CONCLUSIONS:** The transconjunctival medial orbital craniectomy provides a minimally invasive keyhole approach to lesions located anteriorly along the anterior cranial fossa that are in the midline with lateral extension over the orbital roof. Based on our initial experience with this technique, the working space afforded limits complex surgical dissection; this approach is primarily well suited for less extensive pathology.

ceptable for benign pathology (i.e., CSF leaks, meningiomas) or malignant disease with less extensive anatomic involvement. In an effort to minimize these risks for such lesions, minimally invasive approaches, such as endonasal endoscopy and keyhole craniotomies, are now increasingly used (18, 20, 21). Although endonasal approaches have reduced the morbidity of accessing pathology in the nasal cavity, they have limitations in dealing with the anterior skull base, including the inability to perform microsurgical dissection with complex lesions, adequate dural closure, access to the anterior cranial fossa laterally over the orbits away from the midline, and limited working space when multiple surgeons are working (23). Supraorbital craniotomy with an orbital ridge osteotomy has been described through various incisions (supraciliary, transciliary, and transpalpebral) to

the anterior cranial fossa, suprasellar region, and interpeduncular cistern (3, 8, 9, 18, 20, 21, 22). However, these approaches are restricted by their anterolateral trajectory to the midline anterior skull base; the angulation of the orbital roof can be variable restricting access to the cribriform plate region.

The transconjunctival incision, first described by Bourguet in 1924 (2) for cosmetic surgery, could provide an alternative, direct route to selected lesions in the anterior cranial fossa, while avoiding risks with traditional craniofacial approaches and circumventing obstacles with currently available keyhole craniotomies. Currently used for intraorbital lesions and orbital fractures (14, 15), an incision made in the conjunctiva could provide not only direct access to the orbital ridge but also a more medially based trajectory to the cribriform plate region and

laterally over the orbits. In addition, the transconjunctival approach can be supplemented with endonasal endoscopy to permit improved access to lesions in the anterior cranial fossa also involving the paranasal sinuses. We present our initial experience with the transconjunctival approach in the management of anterior cranial base pathology.

METHODS

We describe our technique for transconjunctival medial orbital craniectomy for accessing the anterior cranial fossa. Depending on lesion location, an endonasal approach can be combined with the transconjunctival craniectomy. For the clinical portion of this study, all patients treated via a transconjunctival craniectomy during the period 2009–2011 at The Johns Hopkins Medical Institutions were included in the cohort study. Approval was obtained from The Johns Hopkins Institutional Review Board for this study. All patient charts, medical records, imaging, and clinical notes were reviewed retrospectively for pertinent surgical and study variables (target lesion location, reconstructive method, surgical outcome, complications, length of hospital stay, and follow-up).

Surgical Technique

In addition to standard magnetic resonance imaging for navigation, all patients undergo preoperative computed tomography (CT) to delineate the bony structures of the paranasal sinuses in relation to the anterior cranial fossa in addition to the extent of the frontal sinus. After anesthesia induction, patients are positioned in a Mayfield head holder with the head slightly extended and rotated such that the surgeon is working directly perpendicular to the floor. A corneal shield is placed, and then the face and nose are prepared in a standard and sterile fashion. The conjunctiva, upper eyelid, and medial canthal region are infiltrated with anesthetic; the lacrimal glands are subsequently protected with small probes. An incision is made in the conjunctiva in front of the caruncle and extended superiorly and inferiorly into the upper and lower palpebral conjunctivae avoiding the lacrimal system (Figure 1A). Lacrimal probes placed in the lacrimal canaliculi aid in avoiding injury of the lacrimal canaliculi. After incision, the plane of dissection remains in the loose areolar tissue deep to the medial canthal tendon. The me-

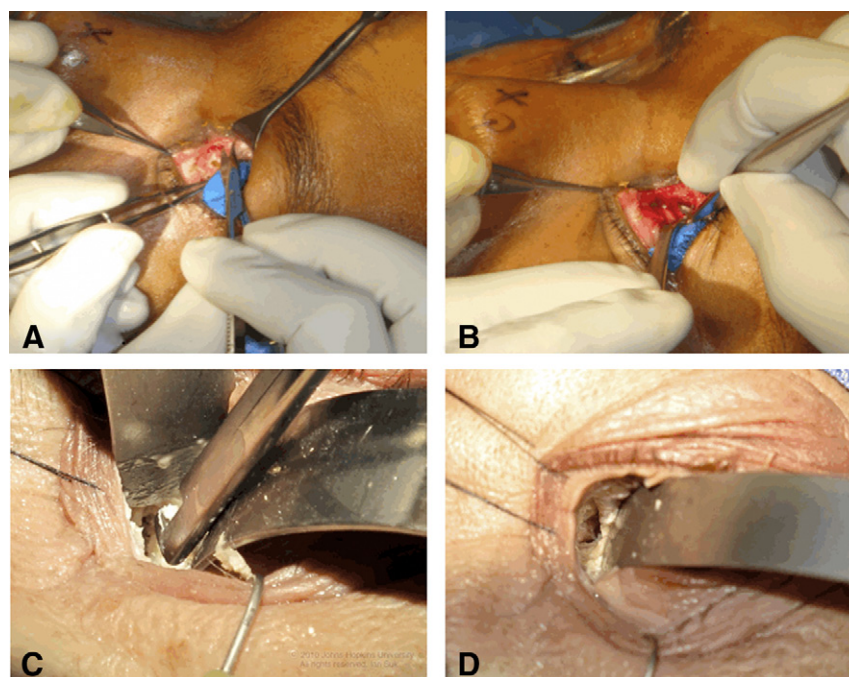
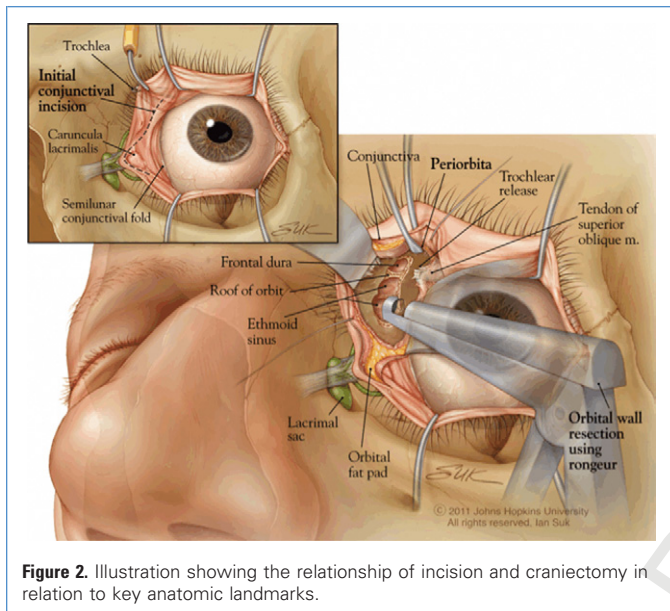


Figure 1. Demonstration of initial soft tissue dissection for transconjunctival craniectomy done in the left orbit. The red marking notes the location of the nose in all images. (The images are a combination of actual patient surgery and cadaver dissection.) (A) Initial conjunctival incision in the left orbit. (B) Subperiosteal dissection and exposure of the superior and medial orbital walls. (C) After verification of the anterior cranial fossa floor with neuronavigation and identification of the ethmoidal arteries, a craniectomy is performed with combined drilling and rongeur. (D) Exposure of basal frontal lobe dura after bony removal.

dial orbital wall and supraorbital roof are exposed in a subperiosteal plane back to the orbital apex. In the process of visualizing the lamina papyracea, the anterior and posterior ethmoidal arteries are identified and ligated to aid with further exposure by allowing the orbital contents to fall away laterally; identification of the ethmoidal arteries further serves as a landmark for the anterior cranial fossa floor and the subsequent craniectomy (Figure 1B). An additional osseous landmark that can be used is the frontoethmoidal suture, which lies in the same plane as the ethmoidal arteries and the optic canal (4). If necessary to expand lateral and posterior exposure along the orbital roof, the trochlea can be subperiosteally dissected and detached to increase bony exposure; however, as experienced in one patient, this can be associated with postoperative dysfunction of the superior oblique muscle. After this soft tissue dissection, a minicraniectomy along the superomedial aspect of the orbit is created to expose the polar and basal dura of the anterior cranial fossa (Figure 1C). The navigation probe is used to outline the location and size of the orbital window needed to cre-

ate an adequate corridor to the target lesion or defect in addition to ensuring the craniotomy is located appropriately in relation to the floor of the anterior skull base. The frontoethmoidal suture and the associated ethmoidal arteries help determine the superior-inferior aspects of the opening. Placement of the craniotomy above these structures gains access to the anterior cranial fossa and intracranial space, whereas opening below these structures creates exposure into the nasal cavity and posteriorly toward the sphenoid sinus and sella. Figure 2 shows the overall relationship of the conjunctival incision and craniectomy in relation to the anterior skull base and ethmoid sinus. At this point, the remainder of the surgery is performed according to the pathology of interest; for the intracranial portion of the surgery, either microscopic or endoscopic illumination can be used for visualization (Figure 3). If necessary, concurrently, an endonasal endoscopic approach can be performed to resect any portion of a lesion extending into the nasal cavity and paranasal sinuses.



For closure and dural reconstruction, any dural incisions can be closed primarily with direct sutures. If necessary for reinforcement of smaller defects along the anterior skull base, a fascia lata graft can be placed through the minicraniotomy; concurrent endoscopic endonasal visualization is used to confirm if

an entire defect is covered. For larger defects, a pericranial graft harvested endoscopically can be transposed through the orbital window and placed along the floor of the anterior cranial fossa (13). As previously described, this is done by separating the pericranium from the scalp and skull via two 1-inch post-

trichial incisions. Once released posteriorly, an endoscopic brow elevator set where the endoscope is introduced via the transconjunctival incision to dissect the flap in a posterior-to-anterior fashion. A pericranial flap ultimately is created with a supraorbital neurovascular pedicle. After any such reconstruction, a lumbar drain is left in place post-operatively for 24–48 hours depending on the underlying pathologic lesion or the size of the defect. After the dura is closed, the incision is closed with loosely approximated absorbable sutures.

RESULTS

Clinical Analysis

Six minicraniotomies via a transconjunctival approach were performed on three male and three female patients ranging in age from 11–62 years (Table 1). Two patients underwent surgery for an oncologic process (juvenile angiofibroma, esthesioneuroblastoma); there was intracranial involvement in both patients and evidence of additional dural disease in the patient with esthesioneuroblastoma. The patient undergoing resection of a juvenile angiofibroma had disease involvement of the

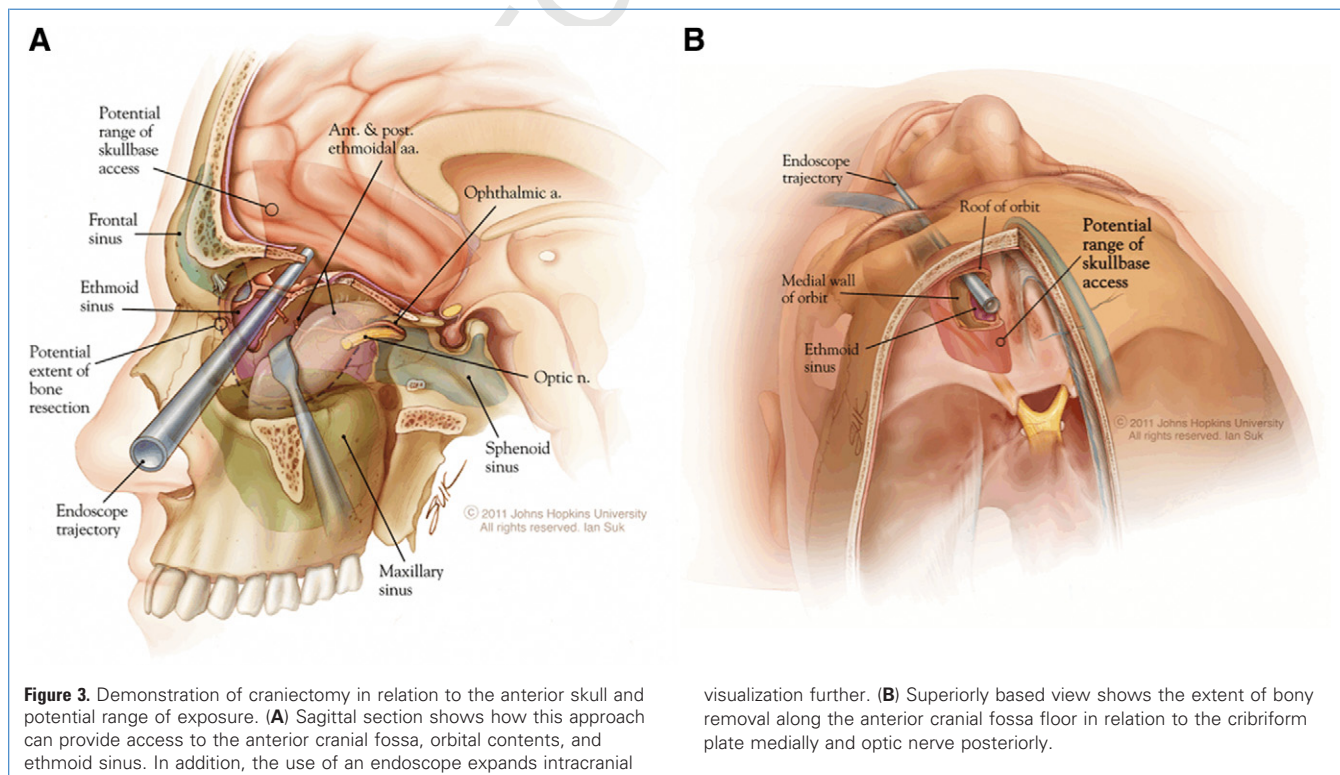


Table 1. Overview of Patients Treated via the Transconjunctival Approach

Patient	Age/Sex	Adjunct Surgical Approach	Lesion	Lesion Location	Lumbar Drain?	Reconstruction	Surgical Outcome	Length of Hospital Stay
1	11/M	Midfacial degloving	Juvenile angiofibroma	Anterior cranial fossa/orbit/maxilla	No	None	GTR	3
2	58/M	Endoscopic endonasal	Esthesioneuroblastoma	Kadish C (nasal cavity, ethmoid sinus, frontal dura)	Yes	Fascia lata	Negative margins	4
3	38/F	Endoscopic endonasal	CSF leak	Planum sphenoidale	Yes	Fascia lata	No CSF leak recurrence	6
4	33/M	Endoscopic endonasal	CSF leak	Planum sphenoidale	Yes	Fascia lata	No CSF leak recurrence	4
5	62/F	Endonasal endoscopic	CSF leak	Cribriform plate/ethmoid sinus	Yes	Fascia lata	No CSF leak recurrence	3
6	60/F	None	Paget disease	Medial orbital roof	No	None	GTR	3

CSF, cerebrospinal fluid; M, male; F, female; GTR, gross total resection.

pterygomaxillary fossa in addition to the maxillary sinus, ethmoid sinus, orbits, and extension up to the epidural space of the anterior cranial fossa. Three patients underwent surgery for the repair of a CSF leak. All three patients who underwent repair for fistulas had prior surgery at other centers—transsphenoidal and bifrontal craniotomy—and the fistulas were a result of defects over the fovea ethmoidalis or planum sphenoidale. The remaining patient presented with diplopia and retroorbital pain and had a lesion along the medial orbital roof; surgery, done for biopsy and resection, led to the diagnosis of Paget disease.

In all patients, surgery was considered successful (either gross total resection with negative margins or obliteration of the CSF fistula without recurrence) with no orbital, local soft tissue or wound healing, or neurologic complications noted. The mean length of hospital stay was 4 days. In patients requiring dural reconstruction along the floor of the anterior fossa, this was done with a fascia lata graft, followed by 24–48 hours of postoperative lumbar drainage.

The mean length of follow-up in the cohort was 6 months. Follow-up consisted of documented neurologic and ophthalmologic examinations (including extraocular movements) and cosmetic assessment (including ocular examination). One patient experienced postoperative diplopia lasting approximately 8 weeks; in this patient, the trochlea was intentionally detached during surgery to expand the lateral extent of the exposure. Otherwise, no other neurologic or wound healing complications were noted. Surgery was consid-

ered successful in all patients with either gross total resection and negative margins (for patients with tumors) or no CSF leak recurrence at last follow-up.

Case Illustration: Esthesioneuroblastoma (Patient 2)

A 55-year-old man presented with epistaxis to an outside institution, where work-up showed a midline intranasal nasal mass with erosion of the cribriform plate and dural enhancement extending from the midline to approximately 5 mm laterally over the orbit from the intersection of cribriform plate and orbit (Figure 4A and B). The patient underwent a transnasal biopsy before presentation to our institution; the mass was determined to be an esthesioneuroblastoma (Kadish stage C). In light of negative lymph node involvement or distant metastases (based on positron emission tomography imaging), the patient was taken to surgery for resection. With regard to operative planning, most of the tumor was thought to be within the midline nasal cavity eroding the cribriform plate and involved the dura in the midline with extension laterally over the fovea ethmoidalis and left orbital roof. The endonasal approach was employed to access the midline and the lateral extent of the ethmoid sinus, and the transconjunctival approach was used to obtain negative margins from the dura along the lateral extent of the disease over the orbit (Figure 4C). After intraoperative exposure, it was thought that a pure endonasal approach would not provide adequate access to the disease dura laterally over the orbital roof. No intraoperative com-

plications were encountered, and negative margins were obtained (Figure 4D). The patient was discharged to home on postoperative day 2.

Case Illustration: CSF Fistula Repair (Patient 5)

A 62-year-old woman presented to us with a history of sinus surgery approximately 5 years prior. Consequent to the surgery, the patient developed a CSF leak with recurrent episodes of meningitis for which she underwent an attempt at a transnasal repair at another institution. On presentation to our institution, she underwent CT cisternography, which showed a leak into her right ethmoid sinus; a maxillofacial CT scan (Figure 5A and B) showed a small defect in her fovea ethmoidalis. The surgical options for this patient included a pure endonasal endoscopic repair of the leak with a wide ethmoidectomy on the right side and placement of a graft or a right-sided transconjunctival approach with placement of a free graft (i.e., fascia lata). Although we thought that a pure endonasal approach would be successful, in light of the patient's prior nasal surgery, there was concern that a healthy nasoseptal flap could not be harvested. A transconjunctival approach was ultimately selected because it was thought that minimal bone work (i.e., ethmoidectomy) would be needed to repair the defect. The rationale was that an approach from above the defect would not involve removing the anterior cranial fossa floor—a buttress necessary for graft placement; expansion of this defect

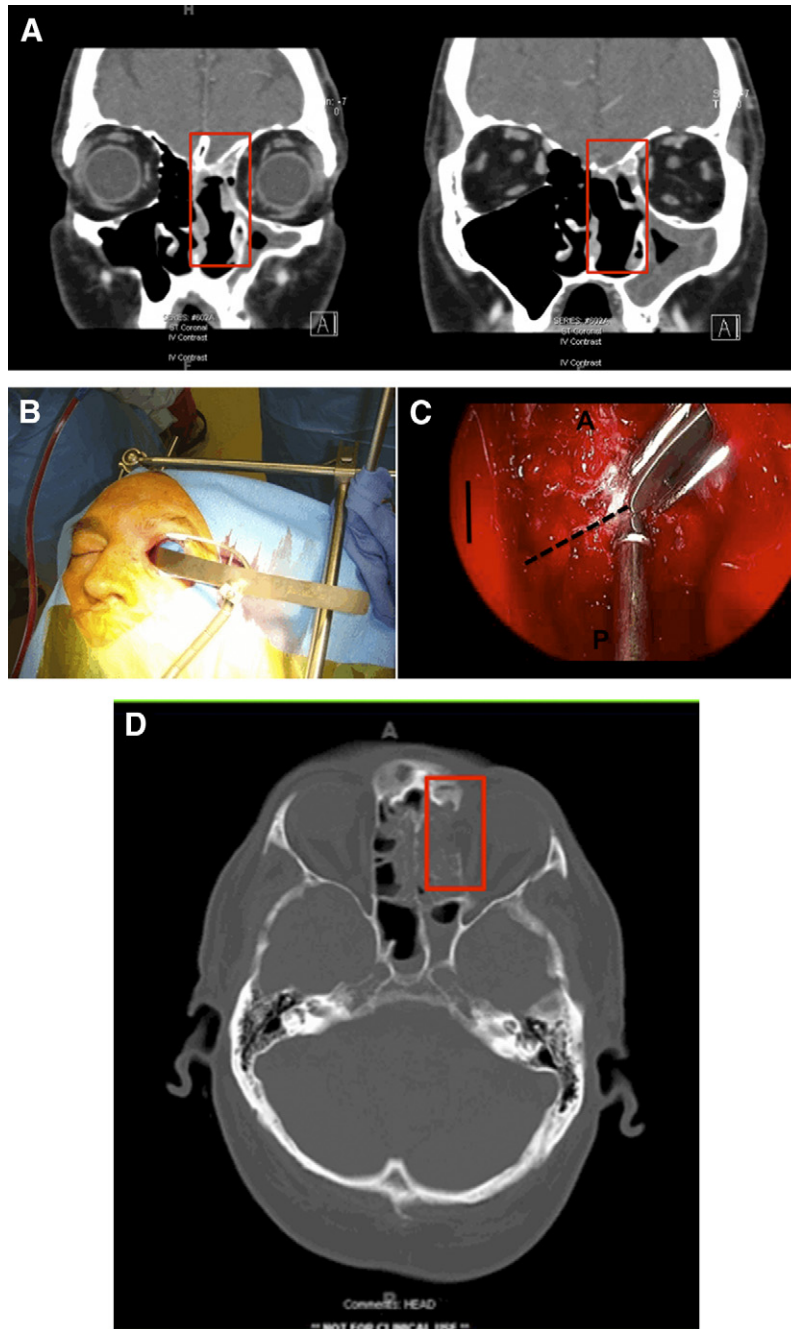


Figure 4. Case illustration. Kadish C esthesioneuroblastoma resected via a combined left-sided transconjunctival-endonasal approach. **(A)** Coronal computed tomography images show a primarily midline intranasal mass with erosion through the cribriform plate and slight lateral extension over the orbital roof. **(B)** Intraoperative image shows the setup for a combined approach; a left-sided transconjunctival craniectomy has already been performed, and a self-retaining retractor has been placed gently on the orbital contents. **(C)** Endoscopic image obtained endonasally shows a two-surgeon, four-handed technique where one surgeon is operating via a transconjunctival incision (upper right hand), and the primary surgeon is operating endonasally. The solid line marks the nasal septum; A is the anterior aspect of the skull base visualized, and P is the posterior extent of the skull base visualized. The dashed line indicates the interface between the diseased dura (anteriorly) and normal cribriform plate (posteriorly). **(D)** Postoperative axial computed tomography image shows the extent of the bony defect created via the transconjunctival approach to provide lateral access.

would have been necessary to place a graft endonasally.

The patient was taken to surgery for a right-sided transconjunctival craniectomy (**Figure 5C**) for placement of a fascia lata graft. Intraoperatively, she also underwent lumbar drain placement; visualization via endonasal endoscopy with fluorescein injection confirmed successful repair of the CSF leak. The lumbar drain remained in place for temporary CSF diversion for 24 hours and was then removed. The patient was discharged home on postoperative day 3 with no issues.

DISCUSSION

Recognizing that the approach should match the pathology of the lesion and the goals of surgery, minimally invasive approaches have been developed to minimize morbidity associated with the surgical approach. Interest has increased in minimally invasive approaches (open and endoscopic) to pathology in the anterior cranial fossa. Transorbital approaches as a means for emergency access to the ventricle have been described (25). The concept of the orbit as a natural corridor to the anterior cranial fossa has been described in the neurosurgical literature; the transpalpebral approach has been reported in the management of anterior circulation aneurysms and benign neoplasms in the anterior skull base and suprasellar regions (1, 3, 18). Such approaches provide adequate access for appropriately selected lesions and provide a direct trajectory to the superolateral orbital ridge. In an effort to provide a cosmetically hidden incision, the transconjunctival approach is a natural progression of the spectrum of transorbital approaches.

The transconjunctival approach to the orbit was described more than a century ago by Bourguet for the aesthetic repair of eyelid defects (2). Over subsequent decades, numerous reports in the literature have described this incision in the treatment of intraorbital tumors, orbital malformations, and orbital fractures. Via the lower eyelid, this approach provides the soft tissue access necessary for a maxillectomy (6). Several studies have compared complications between subciliary incisions in the eyelid and the transconjunctival approach and found a significantly higher rate of eyelid-related complications with transcutaneous incisions. The differences are



Figure 5. Case illustration. Cerebrospinal fluid fistula resulting from a bony defect over the fovea ethmoidalis that is recalcitrant despite a prior attempt at endonasal repair. **(A)** Coronal computed tomography (CT) image shows the defect located slightly paramedian over the right ethmoid sinus.

(B) Sagittal CT image shows the location of the defect in the anteroposterior axis. **(C)** Postoperative coronal CT scan shows the orbital window created via the transconjunctival approach to repair the defect with a fascia lata graft.

sometimes striking with one review detailing a 40% rate of eyelid retraction for subciliary incisions compared with only 3% for transconjunctival incisions (7, 10-12). Recognizing these relative advantages, the transconjunctival incision could logically be applied to neurosurgical approaches to the anterior cranial fossa. Moe et al. (14, 16) reported their initial experience with transorbital neuroendoscopic approaches for accessing laterally placed anterior skull base lesions; in their experience, they applied this technique to the management of CSF leaks, optic nerve decompression, cranial base fractures, and skull base tumors. In addition to extradural pathology, we have applied this technique to management of selected anterior cranial fossa pathology. In light of previously published articles that introduced the concept of this approach, we also explored its role in the treatment of various intradural and extradural pathology.

Anatomic Considerations

Compared with the transciliary incision and traditional unilateral approaches, such as the pterional craniotomy, the dissection plane of the transconjunctival incision eliminates the risk of injuring the facial nerve branches by eliminating the need for temporalis dissection and avoiding dissection of the brow elevators. In addition, when combined with appropriate osteotomies, this approach preserves sensation of the forehead, while still allowing removal of bone anteriorly along the orbital roof.

Anatomically, this approach combines advantages of traditional midline techniques, anterolaterally based keyhole approaches, and transnasal endoscopic techniques in a

minimally invasive manner. The more medial nature of the craniotomy as opposed to other keyhole approaches permits a more direct route to the cribriform plate region. Although traditional keyhole craniotomies provide a subfrontal trajectory, visualization of the midline skull base is hindered as a result of the anterolateral location of the craniotomy and the angulation of the orbital roof. In pathologic lesions that derive their vascular supply from the skull base, this access is crucial in safe resection of the pathologic lesion. This near-midline trajectory is provided without the risk of venous injury owing to exposure of the superior sagittal sinus needed with bifrontal craniotomies or retraction injury on the frontal lobe noted with unilateral approaches. All risks, although acceptable for malignant pathology or complicated benign pathology, should be avoided for benign processes such as encephaloceles and CSF leaks. The other advantage of this technique compared with midline approaches is the trajectory afforded in relation to the olfactory apparatus. Because the access to the cribriform plate is gained intraorbitally (as opposed to intranasally), the olfactory epithelium in the nasal mucosa is not disrupted; access to the posterior aspect of the cribriform plate and planum sphenoidale can be gained by working posteriorly to the olfactory bulbs. Another anatomic consideration of this approach deals with the issue of detaching the trochlear pulley. Detaching this structure primarily provides additional exposure posterior-lateral to this structure; for lesions anterior to this structure, detachment and the risk of postoperative (transient) diplopia is unnecessary.

This approach also overcomes limitations seen with pure endoscopic approaches to the anterior skull base. Endonasal (including

transthemoidal variants) approaches are limited in their access to parts of the anterior cranial fossa floor lateral to the cribriform plate overlying the orbits; accessing these regions endoscopically requires traversing neurovascular structures, which breaks a fundamental tenet of skull base surgery. In addition, for more anteriorly located lesions, transnasal endoscopy may become limited by difficult working angles. In contrast, a transconjunctival approach provides access to the lateral anterior skull base restricted in access by endonasal endoscopic approaches.

Surgical Considerations and Indications

The approach described combines the beneficial aspects of traditional open approaches and endonasal endoscopic approaches in a minimally invasive fashion. As with traditional craniotomies, microsurgical technique under the microscope for neoplastic processes is possible; however, the working space is limited compared with more conventional open approaches. This trajectory also allows for direct watertight dural repair by suturing and reinforcement with pedicled pericranial flaps or free fascia lata grafts. Although bimanual instrumentation working under the microscope is possible, the endoscope can also be used as an adjunct to improve visualization further in the lateral and superior directions.

Based on our preliminary experience, when used alone, this technique is suited for anatomically straightforward lesions located along the paramedian skull base. Although this technique provides direct access to an elusive region of the anterior skull base (between the cribriform plate and the orbital roof up to the midpupillary line), it does not provide

working space for the management of complex lesions (i.e., anterior cranial fossa meningiomas or malignancies with intraparenchymal extension). It is well suited for less complicated pathology (i.e., encephaloceles and CSF fistulas) where there is only a small cranial base defect that can be managed with a free or pedicled flap.

When paired with endonasal endoscopy, the transconjunctival transorbital approach can also provide a combined approach to any anterior skull base pathology, while avoiding the use of visible facial incisions and large scalp flaps. This concept was also demonstrated by Ciporen et al. (4). For neoplastic processes, a combined transorbital-endonasal technique not only allows for two surgeons to work synchronously but also facilitates dissection of any tumor extending out of the anterior cranial fossa into the nasal cavity and paranasal sinuses (14). Although endoscopic approaches have been shown to be effective for low-grade and intermediate-grade malignancies restricted to the nasal cavity, they have been limited in their efficacy in the management of disease extending intracranially. This limitation is likely a consequence of the inability to perform extensive intracranial dissection with endoscopic approaches. This ability is critical when the goal of surgical resection is to obtain negative margins and achieve good dural coverage. A transconjunctival approach could be employed for malignancies eroding through the cribriform plate but not having extending dural or intraparenchymal involvement, as shown by the case illustration presented earlier.

Although we have attempted to use this technique for malignant pathology, we recognize that this approach would be unsuitable for anatomically extensive malignancies. This approach ultimately does not provide the wide anatomic access that is often necessary to obtain negative margins and good reconstruction of larger skull base defects. The management of CSF leaks and similar pathologies such as meningoencephaloceles could also benefit from combined transorbital-endonasal techniques. Endonasal techniques face difficulties when managing extensive skull base defects of the anterior fossa floor. The primary challenges of repairing such leaks are due to the need for a large underlay graft that sits intracranially-extradurally or sometimes intradurally and the need for a vascularized flap to prevent recurrence after

such large repairs, particularly after adjuvant radiation. The use of this approach combined with endonasal techniques further avoids the need to open prior scar tissue in situations involving repair of postoperative CSF leaks (whether from a craniotomy or an expanded endonasal approach). Via the transconjunctival transorbital approach, a pedicled pericranial graft can be harvested and placed along the floor of the anterior cranial fossa through the same incision (13, 17, 27). Endoscopy can be used concurrently to ensure that the graft adequately covers the entire defect and to mobilize a nasoseptal flap to buttress the graft from below. This technique not only could be employed for CSF leaks but also meningoencephaloceles.

An additional consideration is the use of this techniques after a prior surgery (either open or endoscopic-endonasal) has been performed. The primary issue is that in these patients the standard dural closure techniques have already been used and exhausted—the pericranial flap in prior open cases and the Haddad nasoseptal flap in prior endoscopic approaches. With reoperation in these areas, the goal is not to disrupt the vascular supply and the integrity for the prior flaps while attaining the goal of the surgery (repair of the CSF fistula was the most common indication in the reoperation cases). Avoiding vascular supply to the prior pedicled flap is primarily one of the reasons we employ the transconjunctival approach when possible. There is a theoretical risk of devascularizing any viable component of the prior flap when the same approach is employed as before for a delayed CSF fistula repair. Instead of removing the entire flap to repair a small defect, we believe that using a different approach (i.e., transconjunctival) provides another trajectory to the lesion without going through prior tissue planes. The other issue in these situations is with regard to the closure. Because the first-line pedicled flap options have already been employed, free grafts (e.g., fascia lata) are then used; this may be acceptable for smaller defects, but nonpedicled flaps pose the risk of failure for larger defects.

Limitations and Orbital Complications

A relative limitation of the use of the transconjunctival incision for minicraniotomies is entry into the frontal sinus in a fraction of patients with the associated consequences of mucocele formation. Although not encountered in our relatively early experience

with this technique, the size and posterior extent of the frontal sinus should be considered preoperatively when selecting the operative approach. To minimize this risk, the use of neuronavigation is essential in positioning the orbitotomy posterior to the frontal sinus. Occasionally, violation of the ethmoid sinuses may occur resulting in communication of the sinuses with the orbital cavity and the intracranial cavity. Purposefully opening the ethmoid sinuses may be desirable with this approach to expose sinonasal pathology. Otherwise, undesired violation of the ethmoid sinuses can be addressed by placing a fascia barrier or a formal ethmoidectomy to minimize future ethmoid sinusitis. Several theoretical orbital complications are associated with the transconjunctival incision that must be highlighted. Injury to the lacrimal system is the major complication inherent to the location and placement of the pericranial conjunctival incision. Lacrimal canaliculi injury results in varying degrees of epiphora that may need subsequent intervention. Familiarity with the delicate anatomy around the lacrimal crest is essential in avoiding lacrimal injury. Placing lacrimal probes also aids in avoiding canaliculi injury. Precaruncular versus postcaruncular placement of the transconjunctival incision is a matter of familiarity and can be used to minimize further risk to the canaliculi.

Traction on the orbital contents over a prolonged period increases intraorbital pressure and can be detrimental. We have used the Greenberg retractor in our experience alternating approximately 10 to 15 minutes of retraction with relaxation; this can be cumbersome and disrupt the flow of longer cases. Orbital traction should be minimized and the retractor released periodically. Working along the medial quadrant of the orbit theoretically puts the medial rectus at risk. Injury to the medial rectus is most likely to occur during the initial drilling and is best avoided by protecting the periorbita with a malleable retractor. The primary orbital complication noted in our series was superior oblique dysfunction as a result of intentional trochlea detachment to expand the lateral extent of the exposure. Trochlear detachment with craniofacial approaches has been reported and employed with more extensive transbasal approaches where extensive orbital osteotomies are included. When this technique is employed, the trochlea must be detached in a

subperiosteal fashion to ensure that it reattaches properly in a delayed fashion. Although the diplopia experienced postoperatively in one patient of our cohort eventually resolved, since then we have avoided performing this maneuver.

CONCLUSIONS

The concept of “minimally invasive” neurosurgery does not simply refer to the incision or soft tissue dissection performed but ultimately the “collateral damage” created by neural manipulation and vascular sacrifice and whether or not the goals of surgery (i.e., negative margins for a sinonasal malignancy) have been effectively achieved. Ultimately, these considerations are important in deciding whether or not an open or endoscopic surgical approach should be performed and whether or not tailored craniotomies (as the one described in this article) are employed.

The transconjunctival transorbital craniectomy provides a keyhole approach to the anterior cranial fossa and is well suited primarily for lesions located anteriorly along the cranial fossa floor that involve the midline and extend laterally over the orbits. The working space of this technique facilitates either endoscopic or microsurgical dissection but limits the complexity of dissection that can be performed. We believe this is most appropriately suited for benign pathologies (i.e., encephaloceles, CSF leaks) or less extensive oncologic processes. Although no major complications were encountered in our initial experience, theoretical risks primarily include orbital complications (i.e., orbital hematoma, extraocular muscle dysfunction). Lastly, this technique can be combined with endonasal approaches to provide multiple trajectories of access to the anterior cranial fossa floor, nasal cavity, and surrounding anatomic compartments. Ultimately, application of this technique to larger case series with careful scrutiny of oncologic, orbital, neurologic, and quality-of-life-outcomes will provide a better understanding of the true utility of this approach.

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