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Endoscopic transnasal approach to anterior and middle cranial base lesions

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ABSTRACT

We present our experience in managing pathologies involving the anterior and middle cranial base using an endoscopic transnasal approach, highlighting the surgical technique, indications, and complications. The different types of endoscopic approaches used include the transtuberculum/transplanum, transcribiform, transsellar, and cavernous sinus approaches. The common indications include repair of cerebrospinal fluid leaks (both spontaneous and post traumatic) and excision of pituitary adenomas, meningiomas, craniopharyngiomas, esthesioneuroblastomas, and other malignancies of the anterior cranial base. Careful reconstruction is performed with the multilayer technique utilizing fat, fascia lata, and fibrin sealant. The endoscopic transnasal approach, coupled with the present-day sophisticated neuronavigation systems, allows access to lesions in the midline extending from the cribiform plate to the craniovertebral junction. However, preoperative planning and careful selection of cases with evaluation of each case on an individual basis with regard to the lateral extension of the lesion are imperative.

Key words: Cerebrospinal fluid leak; craniopharyngioma; endoscopy; meningioma; pituitary neoplasms; skull base

Introduction

The minimally invasive endoscopic transnasal approach, coupled with sophisticated neuronavigation systems, allows direct access to midline skull base pathologies with less manipulation of neurovascular structures while avoiding brain retraction. The endoscope provides excellent visualization under magnification and in hidden angles, which aids in assessing the completeness of tumor dissection. In addition, the concept of team surgery and collaboration between neurosurgeons and otorhinolaryngologists play an important role. We present our experience in managing pathologies involving the anterior and middle cranial base using an endoscopic transnasal approach, highlighting the surgical technique, indications, and complications.

Preoperative Planning and Case Selection

The endoscopic transnasal approach allows access to the midline lesions extending from the cribiform plate to the craniovertebral junction. The lateral access in the anterior and middle cranial fossa extends to the medial orbital walls, the cavernous sinus, and the medial aspect of the temporal lobe for selected lesions.

Prior to surgery, all patients undergo the following:

- A computed tomography (CT) scan for evaluation of the bony structures and bony anatomy. This is also important

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to assess for any potential skull defects in patients with cerebrospinal fluid (CSF) leak

- A magnetic resonance imaging (MRI) scan for preoperative diagnosis of the pathology and a better understanding of the relationship of the lesion with its surrounding structures such as the pituitary gland and stalk, the circle of Willis, the various cranial nerves, and other important structures. In addition, the consistency of a lesion can be determined based on its appearance on T2-weighted imaging. This is important because softer tumors are easily removed endoscopically compared to firm or calcified lesions
- Pituitary hormone assessment for lesions around the sella and the necessary hormonal corrections prior to surgery
- Visual field assessment for lesions that may be in direct contact with the optic nerve.

Neuronavigation is used in all our skull base surgeries as it provides better intraoperative anatomic orientation, allowing a more extensive and complete resection. It ensures that one is forewarned regarding the proximity of the important neurovascular structures in the vicinity of the surgical dissection and identifies the possible location of residual tumors. Neuronavigation is especially useful as the error due to brain shift is not a very important consideration for skull base lesions provided the operator references his or her instruments to the normal anatomical structures at the skull base.

We also routinely use devices such as a microdebrider for removal of soft tissues of the nasal passages and an ultrasonic aspirator with a long nozzle for removal of intracranial tumors.

Indications

The common indications for endoscopic transnasal approach are as follows:

- Repair of CSF leaks (both spontaneous and post traumatic)
- Pituitary adenomas
- Meningiomas
- Craniopharyngiomas
- Esthesioneuroblastomas and other malignancies of the anterior cranial base.

Cerebrospinal Fluid Leaks

Endoscopic repair of CSF leaks has evolved so substantially that its safety and efficacy have exceeded that of traditional open methods. The endoscopic transnasal approach allows adequate exposure of the site of CSF leak to facilitate not only the intraoperative localization of the defect, but also to create enough working space to seal the CSF leak. The transcribriform, transtuberculum, and transsellar approaches are excellent for midline structures. However, as one moves further away from the midline skull base, the degree of difficulty, and required expertise increases. Nonetheless, endoscopic repair of almost all skull base defects is now possible through the four endonasal corridors: Transnasal, transsphenoidal, transethmoidal, and transmaxillary.

Pituitary Adenomas

Endoscopic removal of pituitary adenomas has at least similar results in terms of tumor removal, relief of endocrinologic or visual symptoms, and cure of the underlying disease as the conventional microsurgical technique. The extended endoscopic approach is particularly beneficial for managing tumors with suprasellar or parasellar extension. For adenomas that do not descend into the sella (fibrous, dumbbell-shaped, previous radiation or pharmacological therapy) or with cavernous sinus invasion, the endoscopic approach allows greater access and improved visualization.

Craniopharyngiomas

For craniopharyngiomas, the transsphenoidal approach is classically limited to the intrasellar or infra-suprasellar subdiaphragmatic tumors with the results being comparable with the microscopic and open transcranial methods. With the expanded endoscopic approach now offering better visualization of anatomical structures, the risk of injury to vital structures is reduced. Nevertheless, the endoscopic technique is generally reserved for small and medium-sized suprasellar lesions located primarily in the midline without encasement of vascular structures. With sufficient experience, it is possible to access larger lesions that extend into the floor of the third ventricle provided the...
inferior extent reaches either the sella or the planum sphenoidale [Figure 3d].

**Meningiomas**

In well-chosen cases of meningiomas, the endoscopic approach attains rates of gross total resection equal to that seen in transcranial approaches.\[^{23-28}\] The endoscopic technique is suitable for small meningiomas restricted to the midline with limited lateral extension, not going beyond the internal carotid artery bifurcation or the optic nerves [Figure 4]. Contraindications include an extension to the anterior clinoid processes and clear encasement of the internal carotid artery, anterior cerebral artery complex, or optic nerves.\[^{29}\] Occasionally, with large tumors and in the presence of significant brain edema, debulking is done first endoscopically, followed by a transcranial approach to achieve total excision.

**Esthesioneuroblastomas and other Malignancies of the Anterior Cranial Base**

When choosing the optimal surgical approach for neoplasms of the anterior cranial base, the tumor features and its anatomic extensions are important. A purely endoscopic transnasal approach is suitable for lesions restricted entirely in nasal passages without dural breach or lateral bony involvement. Intracranial extension of the tumor can be resected as long as it is not extensive, and it is possible to remove a cuff of the normal dura. In these cases, reconstruction is always necessary. However, the prognosis of these malignancies is poor. Huge, irregularly shaped tumors, with significant lateral extension and encasement of major vessels, or those spreading beyond the pia mater usually require a combination of endoscopic and transcranial approaches.

**Endoscopic Equipment and Instruments**

Visualization is achieved using rigid-rod endoscopes 4 mm in diameter and 18 cm in length with lens angles of 0° and 30°. The electromagnetic navigation system and a recording high definition system for documentation are crucial. High-speed electric microdrills with long handpieces and microdebriders are utilized. Over the last decade, special instrumentation for skull base surgery has been developed.
Hemostasis is achieved using clips, bipolar diathermy, or absorbable hemostat packing. Alternatively, hemostatic matrices can also be used. At the end of the procedure, we usually pack both nasal cavities with nasal tampons.

**Surgical Technique**

After orotracheal intubation under general anesthesia, the patient is positioned supine, and the head is placed in a Mayfield head fixation device. The nasal passages are prepared with Moffat’s solution (1 ml of 1:1000 adrenaline, 2 ml of 10% cocaine, and 4 ml of 8.4% sodium bicarbonate). In our center, we adopt a “two nostril and 4-handed” technique. It is important to create a wide surgical corridor for exposure and instrument maneuverability. This is achieved by performing a unilateral inferior turbinectomy and posterior septectomy. The remaining contralateral inferior turbinate and bilateral middle turbinates are preserved to retain moisture of the nasal cavity, maintain the normal laminar flow of air and decrease postoperative crusting. The exposure required is modified according to the surgical target areas and pathology.

However, in the management of pituitary adenomas, we prefer to employ a single nostril approach. The otorhinolaryngologist manages the endoscope while the neurosurgeon uses both hands to deal with the tumor. The exception is when the operation is a redo surgery, where a binostril approach is preferred.

**Transtuberculum/Transplanum Approach**

First, complete posterior ethmoidectomies are carried out whereby the bony septae are resected up to the ethmoid roof and the cribriform plate. This is followed by the drilling of the planum sphenoidale at the rostral portion of the sella. The bone covering the superior intercavernous sinus is then removed to provide access to the suprasellar segments of the tumor up to the prechiasmatic cistern [Figures 5a and 6]. For intradural resection, the extracapsular resection of extracranial tumors can be achieved through the parachiasmatic cistern. The paracarotid carotid artery emerges intradurally at the level of the medial opticocarotid recess (OCR) and when followed, will enable identification of the optic nerve. There should be adequate thinning of the capsule to aid in sharp dissection of the arachnoidal fibers. The boundaries are denoted by the falciorm ligament and the posterior ethmoidal arteries anteriorly, the upper half of the sella posteriorly and the OCR laterally.

**Transcribriform Approach**

Complete ethmoidectomies and removal of the superior nasal septum at the skull base are performed. The lamina papyracea...
may be removed, but care should be taken to preserve the periorbital fascia. Upon coagulation of the anterior and posterior ethmoidal arteries, the cribriform plate and crista galli are removed. The dura is opened by incisions on bilateral sides of the falx because opening it anteriorly to the tumor can result in herniation of brain parenchyma. After resection of the tumor separately on both sides, the falx is incised to attain a single working area followed by debulking of the tumor medially [Figures 5a, b and 7]. Injury to the vessels at the interhemispheric fissure during the extracapsular dissection should be prevented.\[32\] The boundaries include the frontal sinuses anteriorly, the medial wall of the orbits laterally and the anterior part of the planum sphenoidale at the level of the posterior ethmoidal arteries posteriorly.\[33\]

The Transsellar Approach

Septations of the sphenoid sinus should be resected carefully and the sinus floor can be drilled down to the level of the clivus to maximize the trajectory in the direction of the supra- and retrosellar region. The mucosa below the sella is stripped off to expose the bony anterior face of the sella. Removal of bone of the sella above the medial part of the cavernous sinus is continued in a cranial and caudal direction until the superior and inferior intercavernous sinuses are visible. If the tumor spreads to the suprasellar and lateral opticoocarotid cisterns, exposure of the medial OCR then becomes necessary. After opening of the dura with a cruciate incision, the inferior portion is maintained in a caudal position to prevent obstruction of vision by a suprasellar tumor. The posterolateral portion of the tumor is removed first, followed by the superior opening of the dura and continuation of the tumor resection superiorly and laterally [Figures 2 and 5c]. Attention is given to the area posterior to the carotid genu in the cavernous sinus, the medial OCR, and the anterior aspect of the dura at the level of the superior intercavernous sinus for tumor remnants.\[32\]

The Cavernous Sinus Approach

The medial pterygoid process is drilled to reach the lateral recess of the sphenoid sinus. The sella is then opened and drilled laterally to display the carotid prominence [Figure 2]. Depending on the extension of the tumor, the opening of the dura is performed either medial or lateral to the internal carotid artery.\[33\]

Figure 6: Transplanum approach in the patient seen in Figure 3. (a) On both sides, a pedicled vascularized septal flap was raised, and the sphenoid sinus has been opened. Next, the planum was drilled (b) and the dura exposed (c). The tumor was identified between the optic chiasm and the pituitary (d and e) and successfully removed (f). The cerebrospinal fluid leak was closed using a multilayer seal with fat, fascia lata, tissue glue, and vascularized pedicled septal flaps.

Figure 7: Transcribiform approach in a patient with an olfactory groove meningioma. (a) On the right, the dura and the periorbita are exposed. Olfactory fibers can be seen exiting the cribriform plate. (b) Exposing the dura on the left side after drilling to allow access to the meningioma. (c) Exposure of the tumor (meningioma). (d) Successful removal of the meningioma results in a cerebrospinal fluid leak.
Reconstruction

The fundamental objectives for reconstruction are the prevention of postoperative CSF leaks and intracranial infections, protection of neurovascular structures, and maintenance of function. Materials available include synthetic materials (dural substitute) or autologous materials (fat, mucosa or nasal septum, conchal cartilage, temporalis fascia and fascia lata). Fibrin sealants hold the graft in place and ensure a temporary watertight seal.[34]

At our center, we prefer a multilayer closure consisting of an underlay graft, overlay graft, and overlying support [Figure 8].

Underlay

For small defects following the excision of a pituitary tumor, a piece of fat harvested from the periumbilical region is inserted and glued into position. For larger defects, a sheet of fascia lata is inserted into the dural layer. This fascia layer should be sufficiently large to cover the entire defect with an area of overlap. Care should be taken to ensure that this layer is laid “flat” so that a tunnel does not exist. Following this, a layer of tissue glue is used to hold it in place.

Overlay

The underlay graft is then covered with either another layer of fascia lata or fat. This layer should cover the entire defect with sufficient overlap and is glued in place.

Overlying Support

Finally, the defect is supported by fat followed by 2 types of absorbable hemostatic agents. The entire repair is then held in position by a vascularized turbinate flap or nasoseptal flap.

Complications

Reported rates of postoperative CSF leaks after conventional approaches range from 13% to 29%[35-38] compared to those of endoscopic approaches varying from 1.5% to 6.4%.[39] Meningitis and intracranial abscesses are also well-recognized complications. Nonetheless, the incidence rate is relatively low, ranging from 0.5% to 10%.[38-42] Other concerns include effectively managing vascular injuries owing to a limited working space, intraoperative neural injury, and delayed neurological deficits.

In our center, the rates of postoperative CSF leaks are minimal after careful reconstruction with the multilayer technique. Creation of a wide surgical corridor ensures adequate exposure and instrumentation to successfully secure hemostasis via the endoscopic technique. We have also developed our own device that enables the delivery of hemostatic agents with a patty accurately over the site of brisk bleeding to maintain simultaneous compression and suction for a more effective hemostasis.[43] We believe these limitations can be overcome with experience and improvement in the surgical technique. In fact, a promising overall permanent morbidity and mortality rates of 1.8% and 0.9%, respectively, has been reported using the endoscopic approach.[38]

Conclusion

The endoscopic transnasal approach allows access to lesions in the anterior and central cranial fossa in most cases. However, each case must be evaluated individually with regard to the lateral extension.

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Conflicts of interest

There are no conflicts of interest.


