Use of Endoscopes in Skull Base Surgery

Basics of the Transnasal Endoscopic Approach

Figure 1: Endoscopic illumination of the central skull base can be achieved with a straight endoscope placed within one nostril. Endoscopes permit the visualization of many skull base structures including: sphenoid sinus, planum sphenoidale, sella, pituitary gland, cavernous sinus, dorsum sella, suprasellar region, ethmoid roof, frontal sinus, and cribiform plate.
Figure 2: Efficient endoscopic technique involves binarial endoscopic dissection. The endoscope should be held superiorly within one nostril by one surgeon. This permits a second surgeon to manipulate two dissection instruments, one within the ipsilateral and contralateral nares.
Figure 3: The middle turbinate is removed under endoscopic guidance. The middle turbinate should be preserved during an endonasal procedure if possible, however a hypertrophic turbinate with ipsilateral nasal septal deviation often necessitates removal to permit visualization and instrument manipulation. To perform this removal, the turbinate should be injected with epinephrine and lidocaine to facilitate vasoconstriction and be transected at its root and removed.
Figure 4: The sphenethmoid recess houses the ostium of the sphenoid sinus. The recess is bounded medially by the posterior nasal septum and laterally by the superior turbinate. Remove the posterior third of the nasal septum with a back-biting rongeur. A suction-debrider is used to remove excess mucosa following the removal of the ethmoid perpendicular plate. The ostium is enlarged medially (dashed outline) with a kerrison punch. The enlargement is completed with drilling of the sphenoid rostrum to its base centrally and laterally.
Figure 5: A wide sphenoidotomy is created to permit necessary manipulation by two dissecting instruments within the field. Visualization of the planum sphenoidale, tuberculum sella, sellar face, middle clivus, and the lateral wall of the sphenoid sinus adjacent to the cavernous sinus. Begin the bony resection superficial to the anterior sella dura, which is represented by the lower dashed rectangle. The bony excision is then extended superiorly to remove the tuberculum sella and bone covering the planum sphenoidale, optic canals, and medial optic-carotid recess, which is represented by the upper dashed rectangle. The removal can also be extended inferiorly and laterally.
Figure 6: Completed endoscopic approach to the pituitary gland and optic chiasm

Clival Chordoma
Figure 1: Coronal view of a clival chordoma. Chordomas within this location exert mass effect on the pituitary gland displacing it rostrally and on the brainstem displacing it posteriorly. An anterior approach will require resection of tumor anterior and inferior to the gland to permit elevation of the gland.
Figure 2: Axial view of a clival chordoma.
Figure 3: Sagittal view of a clival chordoma.
Figure 4: Transsphenoidal endoscopic approach to a sphenoid sinus tumor. The wide sphenoidotomy allows for a more optimal exposure of the tumor, the suprasellar region, and planum sphenoidale.
Figure 5: Transsphenoidal endoscopic approach through the sella and planum to expose a sellar tumor. The sellar floor and face can be removed with kerrison punches and a drill. Bone excision can be extended laterally on each side of the sella to the anterior face of the cavernous sinus. Dural incision can be made superior and inferior to the intercavernous sinus, and the sinus can then be coagulated and removed. Proximal pituitary gland and suprasellar exposure can be achieved by widely opening the dura along the sella and suprasellar surface. Distal pituitary gland exposure can be achieved by transecting the diaphragma sella.
Figure 6: Transsphenoidal endoscopic approach to a retrosellar tumor (dashed line). To achieve retrosellar access the pituitary gland must be elevated out of the sella. Tumor resection may require opening of the clival or dorsum sella tumor. Dural infiltration is observed and complicates the resection but preponsine arachnoid is typically spared.

Esthesioneuroblastoma
Figure 1: Coronal view of an esthesioneuroblastoma. Erosion of the cribiform plate is commonly observed leading to extension into the anterior cranial fossa or frontal sinus.
Figure 2: Axial view of an esthesioneuroblastoma.
Figure 3: Sagittal view of an esthesioneuroblastoma.
Figure 4: During an endoscopic approach the tumor can be viewed projecting from the olfactory cleft. The middle turbinate is displaced laterally to accommodate the tumor mass.
Figure 5: Tumor exposure is achieved by performing an ethmoidectomy and middle turbinectomy. This additional exposure is critical to assist in identifying the tumor origin.
Figure 6: Piecemeal resection of the tumor is performed and the origin is identified following skeletonization of the cribiform plate and ethmoid roof.
Figure 7: Following identification of the origin for the esthesioneuroblastoma along the dura and skull base, generous excision margins at the origin should be achieved and verified by intraoperative frozen section analysis.
Figure 8: The closure requires a dural repair at the intradural site of the tumor. The repair substance is placed intradurally and extradurally. The bony defect resulting from the approach should be repaired with a septal bone graft or prosthetic plate. The septal bone graft or prosthetic plate should be large enough to provide overlap with the bony margins (as seen in the illustration). A mucosal flap is also used to superficially overlay on the bony defect. It can be acquired as a pedicled flap or free graft. To ensure competence of the closure an adhesive can be used to prevent leakage of cerebrospinal fluid.
Figure 1: Coronal view of a pituitary microadenoma. The adenoma is most commonly present within the inferior extent of the central portion of the pituitary gland. The adenoma by definition is less than 1cm in diameter, most commonly measures approximately 5mm in diameter. Despite the small size of the adenoma, it is necessary to widely remove the sphenoid bone to allow for instrument manipulation and efficient resection.
Figure 2: Axial view of a pituitary microadenoma.
Figure 3: Sagittal view of a pituitary microadenoma.
Figure 4: Following the standard endoscopic transphenoidal approach, the sellar floor should be removed to permit a durotomy in a rectangular pattern (dashed line). Bipolar forceps can be used to coagulate the corners of the rectangular durotomy to prevent opening between the two layers and formation of a tract to the cavernous sinus. The durotomy can be extended by cutting out from the corners of the initial rectangular durotomy (dashed line).
Figure 5: Following the extension of the durotomy, the anterior portion of the pituitary gland can be visualized. The pituitary gland can be gently displaced from its location within the sella to permit inspection of the circumferential dural interface. Incision into the gland may be necessary to retrieve a small centrally located microadenoma (dashed line).
Figure 6: Locating a microadenoma within the pituitary parenchyma can be challenging. Use of color and texture distinction can be useful in distinguishing adenoma from native tissue. An adenoma will have a soft texture versus the more firm surrounding parenchyma. The adenoma will be tan-gray to purple in color versus the orange surrounding parenchyma.
Figure 7: Pituitary microadenomas can possess surrounding extensions within the adjacent compressed anterior pituitary tissue, termed the pseudocapsule. During the resection of a microadenoma, the pseudocapsule should also be removed to better provide an endocrinologic cure and prevent adenoma recurrence. Removal of this small native pituitary tissue does not impair anterior lobe secretory function.
Figure 8: Following complete resection of the pituitary microadenoma and pseudocapsule, the resection cavity is examined for persistent bleeding or drainage of cerebrospinal fluid. Closure of the sellar floor should begin with placement of an absorbable polyethylene glycol block either intradurally or extradurally with sufficient overhang (dashed lines) over the drilled margin of the sellar floor to prevent herniation into the sphenoid sinus. This block is then covered with an adhesive and free mucosal graft. This multilayered closure decreases the risk of cerebrospinal fluid leakage. Sphenoid sinus packing with adipose tissue is not necessary for a successful closure.
Figure 9: Coronal view of a macroadenoma expanding the sella inferiorly and laterally. These lesions can also demonstrate cavernous sinus extension and mass effect on the optic chiasm or hypophyseal stalk. The transsphenoidal approach should be considered for dome shaped lesions with sellar and midline suprasellar involvement. Lateral extension and irregularity of the superior surface adjacent to the internal carotid artery are contraindications to the transsphenoidal approach.
Figure 10: Axial view of a pituitary macroadenoma.
Figure 11: Sagittal view of a pituitary macroadenoma.
Figure 12: The transsphenoidal approach to macroadenomas is similar to the approach for microadenomas except macroadenomas require more extensive removal of the sphenoid to facilitate surgical exposure. The superior intercavernous and cavernous sinus can be reflected to further enhance visualization. The resection of a macroadenoma begins with central debulking using a ring curettage or suction, and subsequent collapse of the peripheral mass into the resection cavity.
Figure 13: Tumor resection proceeds with removal of the macroadenoma along the sellar floor and on the lateral extent that border the cavernous sinus. The lateral extent of the tumor can usually be removed without opening the cavernous sinus.
Figure 14: The suprasellar portion of the tumor will drop caudally when the adenoma within the sella has been removed. Identification of the native pituitary gland is commonly observed at this stage due to a common superolateral displacement of the gland in the presence of a macroadenoma. An easily entered plane between the tumor and the native gland permits their separation. If during the resection, folds of gland and arachnoid are retained within the periphery, this is a sign of retained tumor fragments.

Meningoencephalocele
Figure 1: Coronal view of an anterior fossa encephalocele. Anterior skull base encephaloceles or meningoceles can be observed by instrumentation of the nose. Optimally the endoscope should be angled 30- to 45-degrees.
Figure 2: Axial view of an anterior fossa encephalocele.
Figure 3: Sagittal view of an anterior fossa encephalocele.
Figure 4: Initially during the endonasal approach the left middle turbinate is in view. Adjacent structures must be removed to allow for the endonasal approach to an encephalocele extending from the ethmoid sinus (deep to dashed line). These structures include the uncinate process, ethmoid bulla, and lateral nasal wall.
Figure 5: The middle turbinate is preserved and retracted medially to permit deeper dissection. An ethmoidectomy and excision of the uncinate process facilitate exposure of the encephalocele.
Figure 6: The encephalocele should be inspected circumferentially to identify the location of the skull base defect. The bony margins of the skull base defect need to be exposed by cautiously removing the mucosa and skeletonizing the ethmoid margins.
Figure 7: Bipolar cauterization is used to shrink the encephalocele until the remnant can be reduced into the adjacent skull base defect.
Figure 8: The adjacent mucosa to the skull base defect is removed to permit visualization of the margins. A bony or cartilagenous plate (dashed line) should be placed intracranially to cover the skull base defect for any dehiscence greater than 5 mm in diameter. The nasal septum or an absorbable prosthetic plate are most commonly used for this purpose.
Figure 9: The closure is completed with placement of a nasal mucosal graft over the dehiscent skull base and plate insert. A nasal sponge can be placed to maintain pressure on the underlying mucosal graft.

**Transphenoidal Drainage of a Petrous Apex Cholesterol Granuloma**
Figure 1: Axial view of a petrous apex cholesterol granuloma that extends medial to the internal carotid artery. The medial abutment of the sphenoid sinus (SS) makes the transsphenoidal route favorable for drainage.
Figure 2: A distortion of the posterolateral wall of the sphenoid sinus is induced by the medial extension of the petrous apex cholesterol granuloma.
Figure 3: A transsphenoid endoscopic approach, permits incision and evacuation of the cholesterol granuloma.
Figure 4: Axial view of a petrous apex cholesterol granuloma that extends medial to the internal carotid artery. Despite not having as extensive abutment with the sphenoid sinus, this lesion can still be incised and evacuated via a transsphenoidal approach.
Figure 5: The posterior wall of the sphenoid sinus must be opened (dashed line) to permit the exposure necessary to evacuate the cholesterol granuloma.
Figure 6: An angled drill is used to remove the bone lining the posterior sphenoid sinus.
Figure 7: An incision in the wall of the cholesterol granuloma should be made widely to avoid a stenotic evacuation route.
Figure 8: Axial view of a petrous apex cholesterol granuloma that does not extend to the medial margin of the internal carotid artery. This makes the transsphenoidal approach to incision and evacuation not an option for this configuration of a cholesterol granuloma.

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