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Anatomical Step-by-Step Dissection of Complex Skull Base Approaches for Trainees: Surgical Anatomy of the Bifrontal Transbasal Approach, Surgical Principles, and Illustrative Cases

Larissa Vilany[1,2] Danielle D. Dang[1,2] Edoardo Agosti[1,2,3] Pedro Plou[1,2,4] Luciano C. P. C. Leonel[1,2] Stephen Graepel[1] Carlos D. Pinheiro-Neto[1,2,5] Giuseppe Lanzino[1,2] Michael J. Link[1,2] Maria Peris-Celda[1,2,5]

[1] Department of Neurologic Surgery, Mayo Clinic, Rochester, Minnesota, United States
[2] Rhoton Neurosurgery and Otolaryngology Surgical Anatomy Program, Mayo Clinic, Rochester, Minnesota, United States
[3] Division of Neurosurgery, Department of Medical and Surgical Specialties, Radiological Sciences and Public Health, University of Brescia, Brescia, Italy
[4] Hospital Italiano de Buenos Aires, Buenos Aires, Argentina
[5] Department of Otolaryngology-Head and Neck Surgery, Mayo Clinic, Rochester, Minnesota, United States

Address for correspondence Maria Peris-Celda, MD, PhD, Department of Neurosurgery and Otolaryngology, Rhoton Neurosurgery and Otolaryngology Anatomy Program, Mayo Clinic, 200 1st St SW, Rochester, MN 55902, United States (e-mail: periscelda.maria@mayo.edu).

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Abstract

Introduction The transbasal approach traditionally uses a bicoronal scalp incision with bifrontal craniotomy to establish an extradural midline skull base working corridor. Depending on additional craniofacial osteotomies, this approach can expand its reach to the nasal cavity and paranasal sinuses and may be employed for the resection of particularly complex sinonasal and midline skull base tumors. Given its discrepancy in nomenclature and differences in interoperator technique, we propose a practical, operatively oriented guide for trainees performing this approach.

Methods Three formalin-fixed, latex-injected specimens were dissected under microscopic magnification and endoscopic-assisted visualization. Stepwise dissections of the transcranial-transbasal approach with common modifications were performed, documented with three-dimensional photography, and supplemented with representative case applications.

Results The traditional transbasal approach via bifrontal craniotomy affords wide extradural access to the anterior cranial fossa and central skull base. The addition of craniofacial osteotomies further expands access into the sinonasal cavities, clivus, and craniocervical junction. Key steps described include patient positioning, bicoronal skin incision, pericranial graft harvest, bifrontal craniotomy, orbital rim osteotomy, sphenoidotomy, bilateral ethmoidectomies, and microsurgical dissection of the sellar region. Basal superior sagittal sinus ligation and durotomy allow for intradural exposure. Reconstruction techniques are also discussed.

Keywords
- transbasal
- bifrontal
- central skull base
- anterior cranial fossa
- tumor
- step-by-step
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Conclusion While the transbasal approach is rich with historical descriptions, illustrations, and modifications, its stepwise performance may be relatively unknown and unclear to younger generations of trainees. We present a comprehensive guide to optimize familiarity with the transbasal approach and its indications in the surgical anatomy laboratory, mastery of the relevant microsurgical anatomy, and simultaneous preparation for learning and participation in the operating room.

Introduction

The transbasal approach, meaning "through or across the base [of the skull]," traditionally employs a bicoronal scalp incision with bifrontal craniotomy alone to achieve a transcranial extradural working corridor from the anterior cranial fossa into the central skull base. First named by Derome and Guiot in 1972 for the resection of anterior midline skull base tumors, this concept initially evolved from attempts to reach the hypophysis in 1905 by Krause et al and espouses a rich history of surgical innovation across multiple disciplines.[1–7]

By definition, the traditional transbasal approach is a transcranial extradural anterior approach to the midline without additional osteotomies or entry into the temporal fossa[1,6] where the bifrontal craniotomy includes the frontal sinus, borders the floor of the anterior cranial fossa, and the orbital rim is left intact.[1] Limitations of the traditional transbasal approach include a shallow operative field with decreased vertical access to midline structures in the middle and posterior fossa such as the cavernous sinus and clivus.[8] Traditional disadvantages entail anosmia and postoperative complications such as cerebrospinal fluid (CSF) leak, meningitis, pseudomeningocele, and in rare instances, cerebral vasospasm.[8]

Throughout the 20th century, this approach has evolved with numerous variations. Treatable pathologies now span from benign and malignant skull base tumors, frontoethmoidal encephaloceles, vascular pathologies, and CSF fistulae. The most common tumors include, but are not limited to, meningioma, chordoma, fibrous dysplasia, invasive pituitary adenomas, craniopharyngioma, epidermoids, and sinonasal tumors.[3,8] The endoscopic endonasal techniques offer new ways to approach the ventral skull base but are limited laterally, especially in anterior cranial fossa pathologies that are located beyond the medial limits of the orbits or the optic nerves or encase neurovascular structures. Both techniques are regarded as complementary and in some cases adjuvant.

Selection of the transcranial–transbasal approach and its many possible open and endoscopic modifications should ultimately be tailored to the tumor location, histopathology, oncologic goal of surgery, risk minimization, and patient selection. While numerous historical descriptions and recent publications depict this approach in part or in whole, the present literature lacks content targeted toward the education of the skull base trainee. Therefore, the objective of the present study was to create a comprehensive educational resource using a high-quality, operatively oriented, dissection-based neuroanatomic model supplemented by illustrative case studies to enhance the understanding of the transcranial–transbasal approach for trainees at all levels.

Methods

All aspects of this study were approved by the Mayo Clinic institutional review board and biospecimens committee, as required by standard protocols. Three formalin-fixed specimens were injected with colored latex using a six-vessel technique previously published by the study authors.[9] The transcranial-transbasal approach was performed on all specimens and dissected under microscopic magnification with a Leica M525 F40 OptiChrome microscope (Leica Microsystems, Weltzlar, Germany) by a neurosurgeon (L.V.) under the guidance of a senior skull base neurosurgeon (M.P.C.). For illustration purposes, orbital rim osteotomies in one additional specimen and opening toward the nose on a third specimen were also performed. The anatomical dissections were documented in a stepwise fashion using three-dimensional photographic image acquisition techniques. Endoscopic three-dimensional images were obtained of the intradural and intranasal steps performed, utilizing a Storz endoscope (0-, 30-, 45-degree scopes and a Storz Endoscopy Tower—KARL STORZ SE & Co. KG, Tuttlingen, Germany). Following dissection, representative case applications were reviewed to highlight important principles of approach selection, modification, and surgical planning.

Results

Common Steps of the Transcranial–Transbasal Approach

Positioning and Skin Incision

The specimen was placed in a simulated supine position with the frontal convexity and nasion at the apex of the dissecting field. The head was placed in a neutral position, slightly flexed, and supported.

In adult patients, after general anesthesia induction and endotracheal intubation, the skull is placed in three-point pinion fixation in a Mayfield head holder to achieve the positioning described. A single pin is placed in the retromastoid area with the double-pin arm fixed to the temporoparietal area on the contralateral side, as far as possible from the incision. The amount of flexion will vary according to the sagittal reach required for the pathology in question.

After successful positioning, a bicoronal incision was performed (►**Fig. 1A**). The incision selected for the dissection originated and terminated approximately 1 centimeter anterior to the tragus bilaterally, perpendicular to the superior temporal line with continued curvature behind the hairline and parallel to the coronal suture.

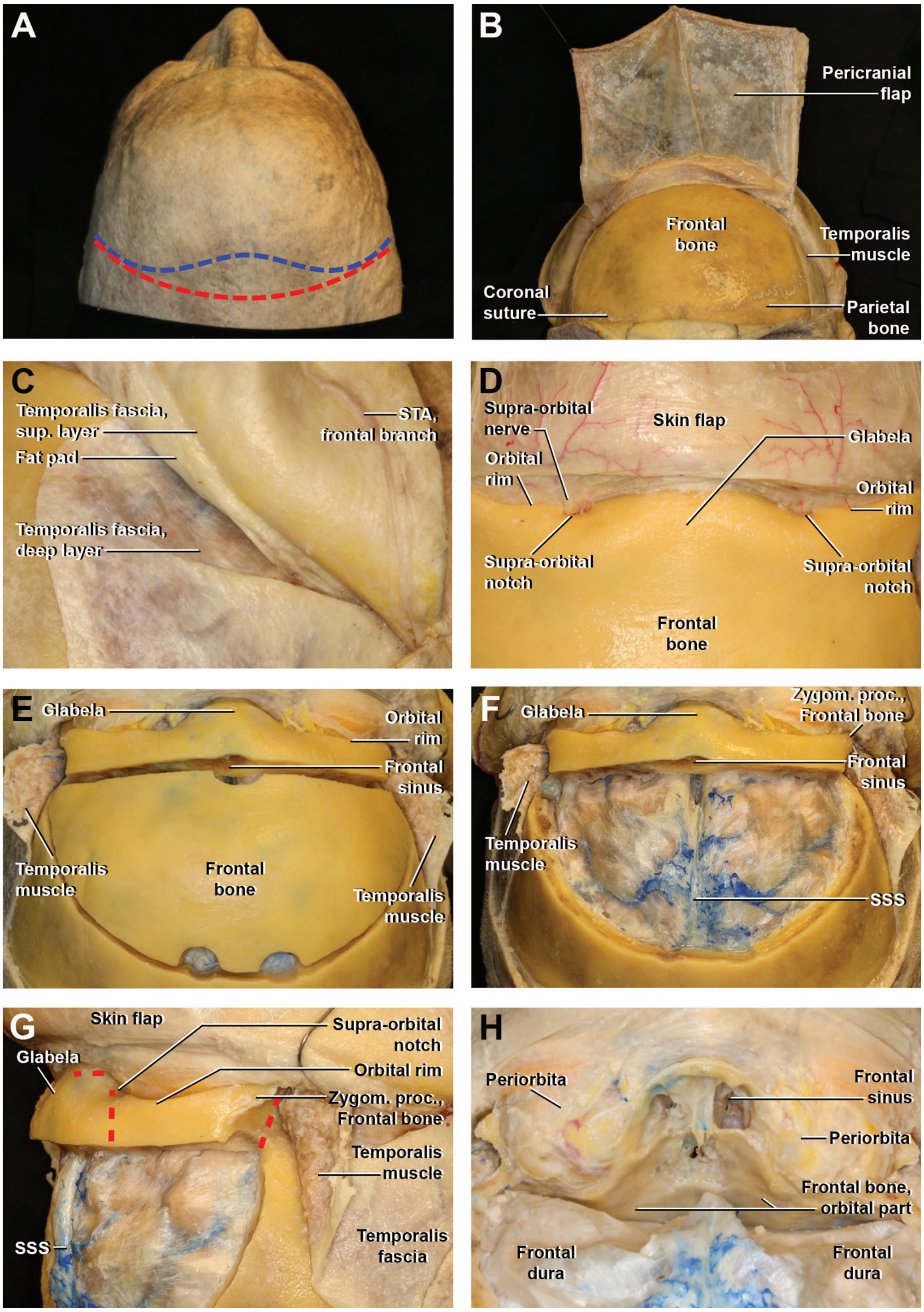

Fig. 1 Step by step of the transbasal approach. (**A–F**) Without supraorbital bar removal, (**G–H**) with additional removal of the orbital bar. (**A**) Bicoronal skin incision modifications behind the hairline. (**B**) Pericranium flap harvested beyond skin incision for reconstruction. (**C**) Interfacial dissection—a cut between the superficial and the deep layer of the temporal fascia, preserving the frontal branches of the facial nerve. (**D**) Exposure of the supraorbital and supratrochlear nerves if the orbital bar removal is intended. (**E**) Bifrontal craniotomy, burr holes placed. (**F**) Dural exposure after bifrontal craniotomy. (**G**) Possible extensions of osteotomies to include the orbital bar. For a limited 2-piece transbasal, one can include an osteotomy on the red dashed lines on the frontonasal suture and just medial to the supraorbital nerve exit. For an extended transbasal approach, the osteotomies should follow the red dashed lines on the nasofrontal suture and the more lateral ones, just lateral to the frontozygomatic suture. H. Exposure after removal of the orbital bar with the extended transbasal.

Myofascial Dissection

The skin and subcutaneous layers were sharply incised to the depth of the loose adipose tissue above the pericranium. A No. 15 scalpel was used to extend the dissection between these two layers posteriorly, with care to avoid the violation of the intended pericranial graft. This dissection was performed beyond the limits of the skin incision posteriorly to maximize procurement of pericranium for skull base reconstruction.

Upon reaching the temporalis muscles anteriorly, an interfascial dissection was performed to protect the frontal branches of the facial nerve.

For the interfascial, an incision was made on the superficial temporal fascia approximately 3 centimeters posterior to the posterior aspect of the orbital rim. Dissection proceeded within the fat between the superficial and deep temporalis fascia. The flap was subsequently raised using a Penfield dissector. The dissection spans the entire length of the exposed temporalis muscle, toward the zygomatic root allowing for the elevation of the pericranium flap (►**Fig. 1C**).

Once the temporalis muscle was reflected in the specimen, a scalpel was used to outline the pericranial flap and blunt periosteal dissection was performed with a periosteal elevator to protect its vascularity and promote graft continuity (►**Fig. 1B**).

Burr Hole Placement

After harvesting the pedicled pericranial flap, leaving it vascularized at its base by the supratrochlear and supraorbital arteries, four burr holes were fashioned with a high-speed drill. The anterior portion of the superior attachment of the temporal muscle was first detached with a No. 1 Penfield dissector from the superior temporal line, exposing some of the frontozygomatic suture bilaterally. Two burr holes were placed just below the superior temporal line anteriorly to expose the frontal dura. Two additional burr holes were placed at the posterior limit of the frontal craniotomy, approximately 7 to 9 centimeters posterior to the orbital bar, and 1 centimeter lateral to the midline on either side to avoid iatrogenic superior sagittal sinus injury. Similarly, it is optimal to be at least 1 centimeter away from the midline to avoid arachnoid granulations which may be directly adjacent to the superior sagittal sinus (►**Fig. 1E**). Additional burr holes may be placed at the anterior limit of the bifrontal craniotomy above the orbital rim to facilitate drilling the basal aspect of the frontal sinus close to the crista galli.

Bifrontal Craniotomy and Sinus Mucosa Exenteration

To perform the traditional, standard transbasal approach, a bifrontal craniotomy without removal of the orbital bar was first performed. Upon completion of the burr holes, the dura was dissected from the inner calvarium utilizing a No. 3 Penfield. A craniotome was then used to connect the burr holes with the anterior and posterior midline cuts performed last. The anterobasal part of the craniotomy was completed with a cutting drill bit, and a final piece of it was removed with a rongeur. After further separation of the dura from the calvarium, the bifrontal craniotomy flap was elevated and secured (►**Fig. 1F**).

Finally, frontal sinus mucosal exenteration was performed in the specimen with a curette. A round cutting drill bit was utilized to drill the frontal sinus septations and part of the posterior sinus wall, thereby allowing for a greater working angle to the central skull base (►**Fig. 2A, B**). In the operating room, the frontal sinus could be plugged with betadine-soaked gelfoam to mitigate contamination of the intracranial space from the exposed, adjacent sinonasal mucosa. Of note, residual frontal sinus mucosa and septations should be drilled or rongeured on the elevated bone flap prior to replacement, fixation, and closure of the defect, a step that can be performed immediately after craniotomy or during closure.

Durotomy and Intradural Dissection

To create an intradural corridor to access intradural frontal lobe pathologies, a linear durotomy was made parallel along the length of the orbital bar on either side of the superior sagittal sinus. The superior sagittal sinus was ligated at its anterior portion using 2–0 silk sutures as close as possible to the crista galli, with knots proximally and distally to the division in its anterior portion, where it receives fewer tributary veins (►**Fig. 2C**). The falx was divided toward the anterior skull base, allowing bilateral visualization.

Microsurgical dissection proceeded with the opening of the interhemispheric fissure. Microscissors were used to sharply incise the arachnoid adhesions surrounding the mesial frontal lobes and related vasculature. The olfactory nerves were then detached along the longitudinal axis of the inferior frontal lobes up to their transition into the olfactory tracts, thus facilitating mobilization from the anterior skull base. Upon completion of this step, the olfactory nerves were visualized lying over the cribriform plate. A corridor from the anterior cranial fossa floor bilaterally to the lamina terminalis was thereby established without obstruction (►**Fig. 2D–F**). We also inserted the endoscope for assisted pictures, entering up to the third ventricle (►**Fig. 3A–G**).

Nasal and Paranasal Sinus Access from the Transbasal Approach

In a different specimen, after the bifrontal craniotomy was performed, a combined intra and extradural approach was adopted. The dura was opened in a linear fashion, with a straight division, parallel to the orbital bar. The superior sagittal sinus was ligated inferiorly with proximal and distal sutures using a 4–0 prolene and divided in between. Part of the falx was divided parallel to the skull base to increase the exposure of the anterior fossa floor. We then delineated the contour of the drilling into the nose. Dural incisions were then made as follows: laterally, at the lamina papyracea, anteriorly just posterior to the frontal sinus, and posteriorly at the limbus sphenoidale (►**Fig. 4.A**). For the dissection, the olfactory nerve filaments were divided from the cribriform plate. Extradurally, we performed an anterior

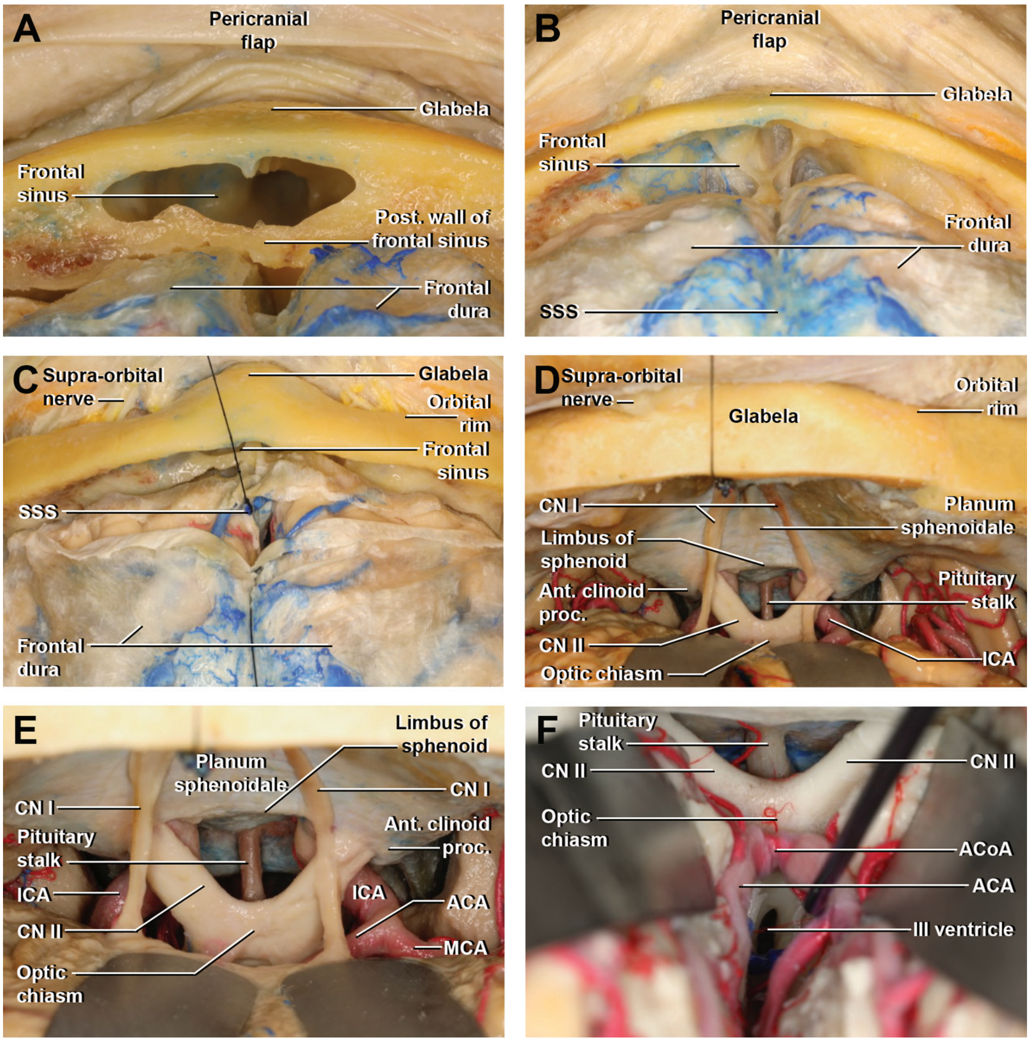

Fig. 2 Intradural dissection. (**A**) Detail showing the crista galli divided and the posterior wall of the frontal sinus, which should be drilled. Its mucosa should be exenterated to prevent later complications (e.g., mucocele). (**B**) Exposure after drilling the posterior wall of the frontal sinus. (**C**) The dura mater is opened in a linear fashion, parallel to the orbital bar axis. The superior sagittal sinus is ligated inferiorly. (**D**) Intradural view with the bifrontal craniotomy. The olfactory nerve was released from the frontal lobe surface, to preserve olfaction. We can see the planum sphenoidale, followed by the limbus sphenoidale, anterior clinoid and internal carotid artery. (**E**) On this closer look, we can see the pituitary stalk, anterior and middle cerebral artery, optic nerve and optic chiasm, and the beginning of lamina terminalis. (**F**) On this interhemispheric perspective, we can see the lamina terminalis open, allowing access to the intraventricular area.

fossa dissection detaching the dura from the anterior skull base, except for our divided rectangle of dura mater. (►**Fig. 4B**)

The dural rectangle was then stripped from the bone and drilling was performed. After the first layer of the skull base bone was drilled away a thin layer of mucosa was observed, as we entered the ethmoid cells and the sphenoid sinus. In the operating room, once identified, the anterior and posterior ethmoidal arteries should be coagulated and divided. The anterior ethmoidal arteries can be seen entering the anterior fossa between the lateral lamina and the cribriform plate, toward the anterior ethmoidal cells. The posterior ethmoidal arteries can be seen in the posterior ethmoidal canal, at the roof of the middle turbinate, toward the nasal fossa.[10] After drilling the posterior, middle, and anterior ethmoid air cells, and opening the roof of the sphenoid sinus, the nasal conchae insertions were visualized. We removed the superior concha and its attachment and proceeded to remove the middle conchae fracturing its attachments. The inferior turbinates were preserved (►**Fig. 4C–F**).

Orbital Rim Osteotomy Modification

Another anatomical specimen was utilized to perform an orbital rim osteotomy. After the bifrontal craniotomy bone flap was elevated, an osteotome and mallet were used for an osteotomy on the nasofrontal suture. An additional osteotomy was made to include the entire orbital roofs bilaterally (►**Fig. 1G**). After completing the nasofrontal osteotomy, osteotomies were fashioned just lateral to the frontozygomatic suture bilaterally and across the orbital roofs, thus removing the entire orbital bar. Prior to its removal, it is important to release and protect the supraorbital and suprathroclear nerves which was achieved with the dissection of the nerves from their respective foramina. We can see the area exposed in ►**Fig. 1H**. Alternatives are further discussed in the discussion section.

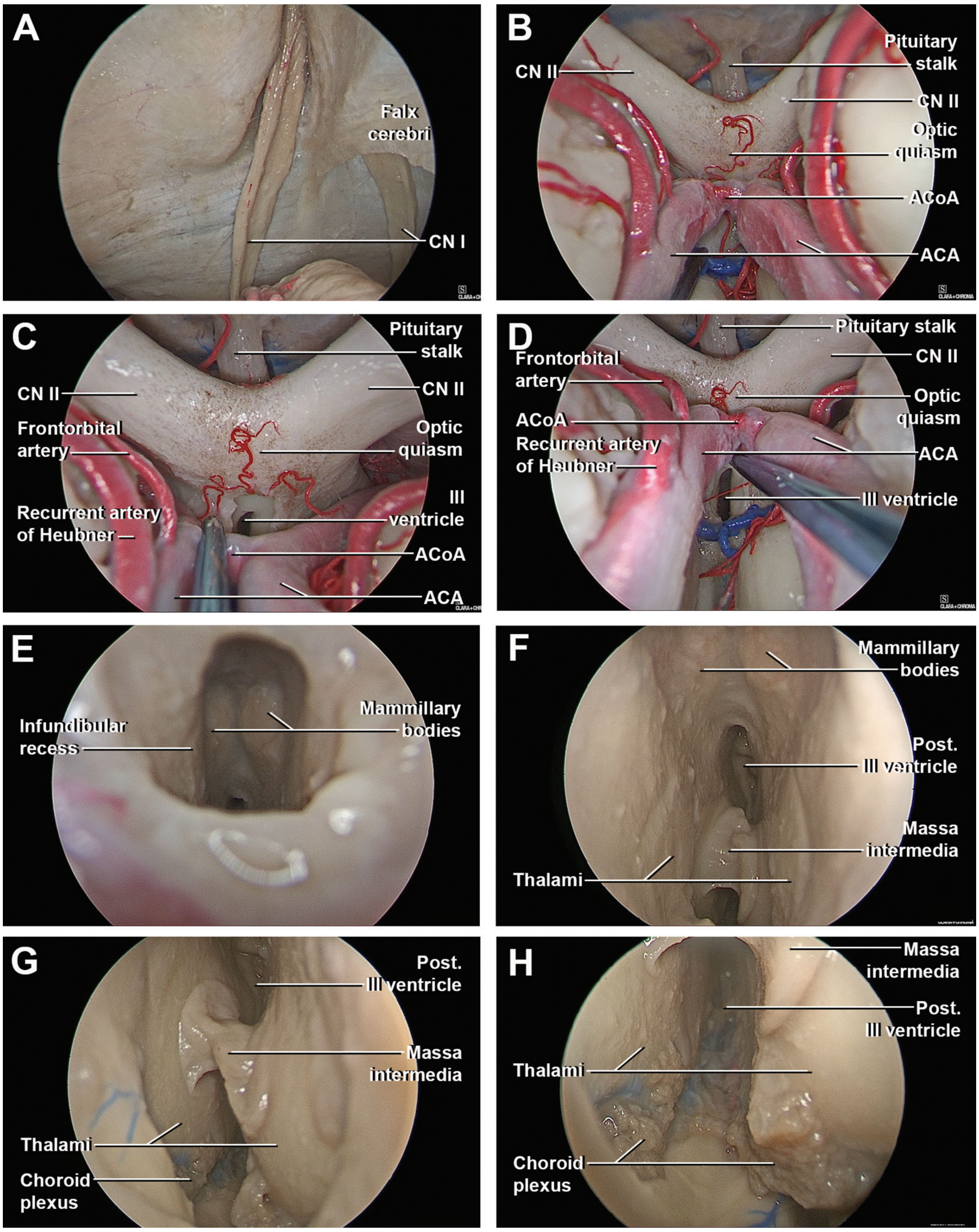

Fig. 3 Endoscopic-assisted pictures through the craniotomy. (**A**) Endoscopic picture of the olfactory nerves and the falx cerebri. (**B**) Here, we can see the lamina terminalis, the anterior cerebral artery and the anterior communicating artery (ACoA). (**C**) The infundibular recess, anterior to the ACoA. (**D**) In this detail, we can see the opening toward the third ventricle. (**E**) Intraventricular view, mammillary bodies on the floor of the third ventricle. (**F**) Thalami, massa intermedia, posterior wall of the third ventricle. (**G**) Choroid plexus along the choroidal fissure. (**H**) In this detail, we can see the foramen of Monro.

Skull Base Reconstruction

Skull base reconstruction was performed transcranially and endonasally in the specimen. A fascia lata graft was sutured with 4–0 prolene for closure of the dural defect. If no additional intradural manipulation is needed, closure can be done before proceeding with the opening toward the nose, to minimize contamination.

The communication of the nose cavity and the cranium was covered with an extended nasoseptal flap harvested endonasally, according to the technique described by Peris-Celda et al (2013).[11] Fat was introduced to obliterate the remnants of the frontal sinus. The pericranium flap was placed covering the whole area of the skull base exposed (►**Fig. 4G, H**).

Representative Case Review

Case 1—Bifrontal Approach for an Olfactory Groove Meningioma

A 64-year-old male presented with personality changes in recent years and two episodes of loss of consciousness. He also reported loss of smell and taste. A brain magnetic resonance imaging (MRI) was performed and documented a large extra-

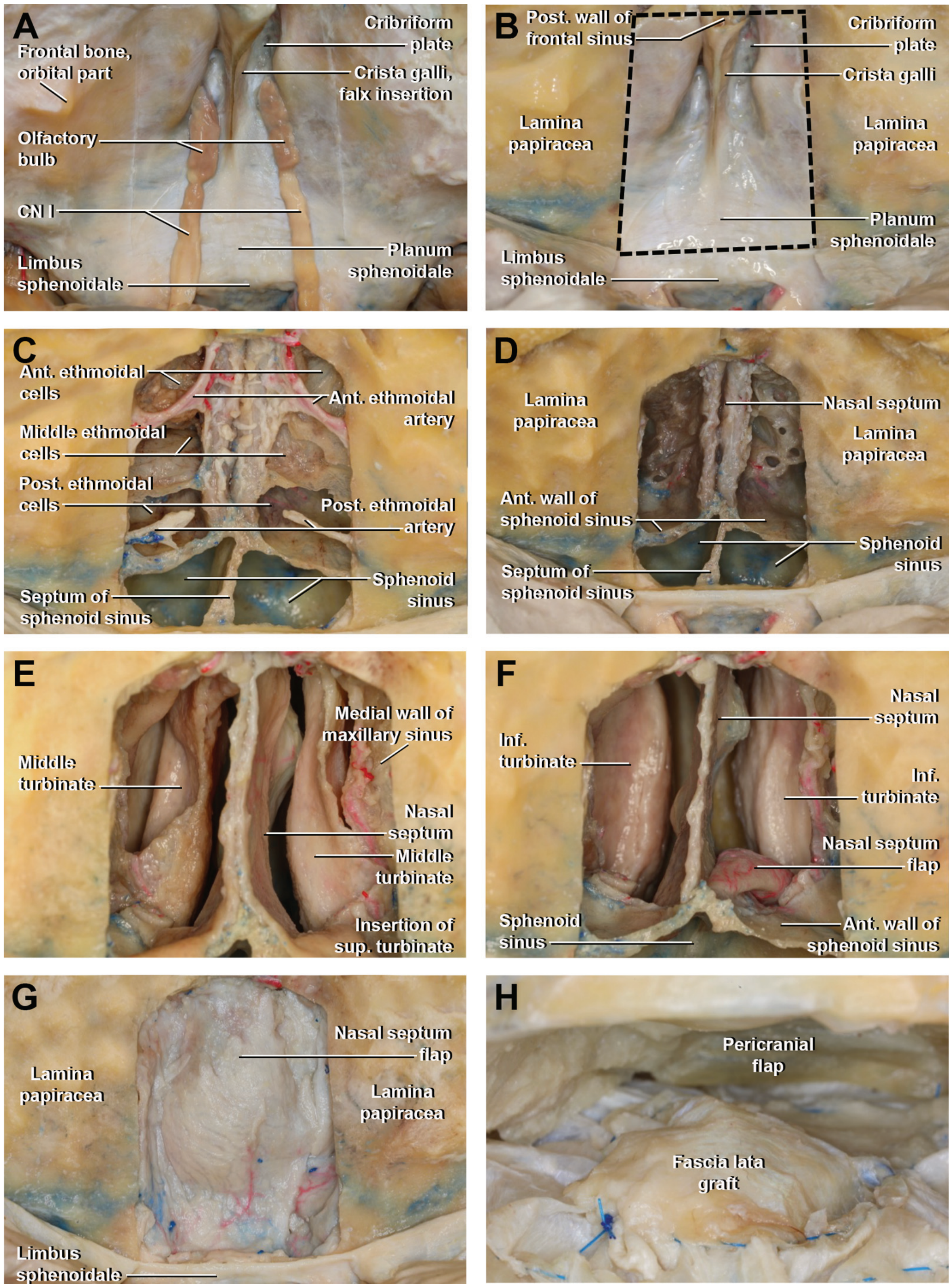

Fig. 4 Nasal cavity access. (**A**) The olfactory nerves, cribriform plate, falx insertion. (**B**) The limits of the osteotomy toward the nose are traced within the dura—lamina papyracea (*medial orbital wall*), posterior wall of the frontal sinus, planum sphenoidale. Dura is cut and the remaining flap flipped. (**C**) Drilling of the anterior fossa floor proceeds. Ethmoidal arteries are coagulated and cut. (**D**) The nose cavity is open. (**E**) Superior turbinate is removed. (**F**) Nasoseptal or an extended nasoseptal flap is harvested. The middle turbinate is removed. (**G**) Covering of the defect with the extended nasoseptal flap. (**H**) Multilayer closure. The frontal sinus is occluded with fat harvested from the abdomen, the dural defect is closed with a fascia lata graft, and the pericranial flap is folded covering the skull base.

axial lesion located in the anterior cranial fossa with vasogenic edema in the frontal lobe and mass effect, suggesting an olfactory groove meningioma (►**Fig. 5A, B**). The patient underwent a bifrontal craniotomy with cranialization of the frontal sinus, fat graft placement and pericranial flap reconstruction after the tumor removal. No postoperative complications were reported. The histopathologic analysis confirmed a World Health Organization II grade meningioma. The postoperative MRI shows gross total resection of the lesion (►**Fig. 5C, D**). In the medium-term follow-up (3 months), the patient shows an improvement in all aspects of the cognitive sphere.

Case 2—Transbasal–Translaminar Approach for Cavernous Malformation

A 33-year-old female with a past medical history of an isolated, small hypothalamic hemorrhage was referred for

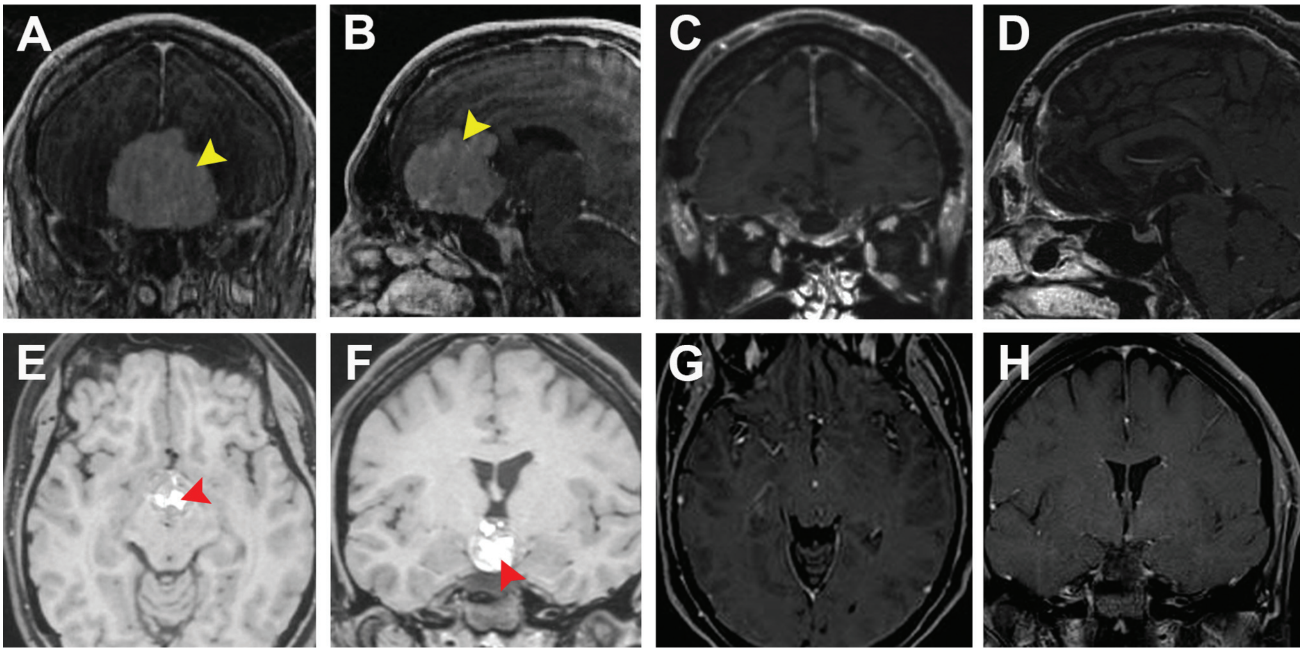

Fig. 5 Illustrative cases superior row—Case 1, olfactory groove meningioma. Preoperative (**A**) coronal, (**B**) sagittal T1-gadolinium, showing a large homogeneous enhancing lesion, lobulated, in the olfactory groove, suggesting a meningioma (*yellow arrow head*). Postoperative (**C**) coronal, (**D**) sagittal, T1-gadolinium showing no residual lesion. Inferior row—Case 2, hypothalamic cavernous malformation. Preoperative (**E**) axial, (**F**) coronal flair MRI of the bleeding of the cavernous malformation on the topography of the hypothalamus (retrochiasmatic and retroinfundibular) (*red arrow head*). Long-term follow-up (**G**) axial, (**H**) coronal T1-gadolinium MRI images with no residual lesion.

headaches and short-term memory decline. MRI revealed a single, mulberry-like retrochiasmatic and retroinfundibular lesion inside the third ventricle (►**Fig. 5E, F**). This lesion was associated with bilateral thalamic venous development anomalies suggestive of a cavernous malformation. Further work-up excluded endocrine dysfunction, visual field deficits, or abnormalities on neurological exam. Given the small size of the lesion and favored pathology, the patient initially underwent serial imaging surveillance for management.

After a recurrent hemorrhage some months later, a transbasal translaminar approach for resection of the third ventricular cavernous malformation was recommended. This approach was selected as it allowed for a less extensive surgical corridor to the lesion when compared with the endonasal route and afforded better visualization and control of close vascular structure (e.g., anterior cerebral arteries and anterior communicating complex).

A traditional transbasal approach was utilized via bicoronal scalp incision, bifrontal craniotomy without additional craniofacial osteotomies, and extradural microsurgical dissection to the third ventricle. Typical hemosiderin stain and recent hemorrhage were easily visualized abutting between the optic chiasm and the anterior communicating artery in the lamina terminalis. After opening the lamina terminalis, gross total resection was achieved while respecting the radicles of the DVA.

The patient presented with some transient nausea in the immediate postoperative period which quickly resolved. Her neurological exam remained at baseline without deficit, her short-term memory decline improved, and no recurrence of the lesion was evident at 15-month follow-up (►**Fig. 5G, H**).

Discussion

Modifications for Extended Skull Base Access

While the transbasal approach was designed for transcranial access to tumors that invaded the anterior cranial fossa, a plethora of modifications has been devised to allow for greater access to the lateral anterior cranial base including the superior orbits, sphenoethmoid sinuses, sella, clivus, and even as caudally as the anterior rim of the foramen magnum depending on modifications used.[3,4,6] These variations generally include osteotomies of the orbital bar, zygoma, orbital walls or roof, nasion, and/or ethmoidectomies and sphenoidotomies. The endoscopic endonasal approaches have also evolved to treat many pathologies that include the nasal cavities and paranasal sinuses with variable degrees of intracranial extension.

If olfaction preservation is desired, careful preservation of the olfactory filaments is paramount; however, in many pathologies that require this kind of approach, the anatomy of this area will be distorted due to tumor invasion, and olfaction is often already compromised.

Depending on the modification chosen, some particularities should be considered. For instance, the anterior extent of the dissection and elevation of the cutaneous flap will vary according to the approach intended with most of the pathologies not requiring supraorbital bar osteotomies. With over 60 distinct names to describe these modifications, classifications have since been proposed to standardize terminology and improve understanding of the approach's versatility.[6] Beyond the aforementioned conventional technique where the supraorbital rim is undisturbed, one of such proposals classifies the addition of naso-orbital osteotomies, detachment of medial canthal ligaments, and lateral orbital wall osteotomies incorporating the infraorbital fissure with the detachment of the lateral canthal ligaments into level 1, 2, or 3 approaches, respectively.[6] Another author proposes to keep the medial palpebral ligament intact and vary the lateral extent of the orbital osteotomy—limited, extended, and extensive transbasal approach (►**Fig. 6**).[12] In one of the most recent modifications, Liu et al (2010)[13] propose a one-piece craniotomy including a lower midline frontal cut at the nasofrontal suture. The authors suggest that it allows for a wider working angle to the lamina terminalis and the third ventricle, minimizing brain retraction and avoiding the whole orbital bar manipulation.

Historically used to reach down to the clivus, this approach has changed over time. Since the advent of endoscopic approaches, a search for minimally invasive techniques when compared with ample facial osteotomies has been rising.[14,15] To complement the approach, authors used endonasal endoscopy and neck dissection when necessary. Liu et al (2018)[16] analyze outcomes for olfactory groove meningiomas resected via transbasal versus endoscopic versus combined approach. The transbasal variant used was its modification by Liu, with a one-piece craniotomy removing the anterior part of the frontal sinus. The paper highlights the importance of patient selection. Tumors with vascular involvement, lateral extent, and greater volumes were more favorable to open or combined approach. It is important for the skull base surgeon today to master the different approaches to offer/select the best option for each patient.

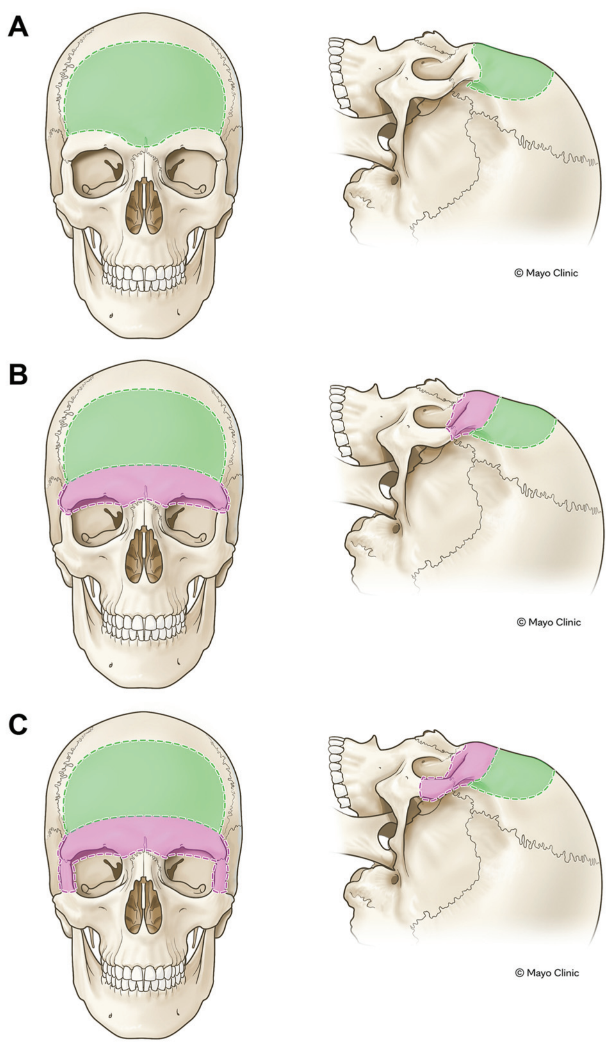

Fig. 6 Main modifications of the transbasal approach. (**A**) Limited bifrontal transbasal craniotomy, removal of the central part of the orbital bar only. (**B**) Extended transbasal, with removal of the supraorbital bar. (**C**) Extensive transbasal, removal of the supraorbital and the lateral orbital rim.

For craniopharyngiomas, the transbasal approach provides favorable access to large retrochiasmatic lesions, with extension into the third ventricle.[13] For olfactory groove meningiomas, it provides a safe access for tumors extending over the orbital roof or optic canals, involving vascular structures and accompanied by cerebral edema. It is also an alternative in the attempt to spare the olfaction in patients that still present it. In this authors' series, transbasal approach provided a good extent of resection with a low incidence of complications (80% GTR, 20% NTR due to vascular adherence, no CSF fistula).[16] When necessary, such as in cases of re-operation with previous use of the pericranium flap, a combined endoscopic approach may be proposed for reconstruction.[16]

When considering the choice between a bilateral approach, as the transbasal, versus a unilateral approach, as a pterional or an orbitozygomatic, surgeons will take into consideration aspects such as the extent of the surgical corridor, extent of resection made possible, surgeon familiarity/ability with the approach, and complication rates. For anterior fossa lesions, such as olfactory groove and planum meningiomas both strategies can be successfully applied.

Unilateral approaches will make it harder to visualize contralateral structures due to the long surgical corridor, provide a narrow working space, and have limited maneuverability in the most anteriorly located lesions involving the falx, especially with bilateral extension. On the other hand, they allow early cistern opening with CSF drainage, no opening of the frontal sinus or ligation of the superior sagittal sinus, and shorter operative time. Bilateral approaches may present with longer surgical time, and in some cases, higher complication rates (e.g.: CSF leak and meningitis) but provide wider access to the tumors, ample visualization of vascularization and direct access for repair of the cranial fossa, which can be especially useful in larger tumors. Endoscopic approaches allow for early devascularization of the tumor, osseous drilling, easier access to ethmoidal invasion, but limited access to higher and more lateral extents of the tumor (e.g., over the orbits), besides not sparing olfaction if still present.[17] Feng et al (2020)[18] compare both approaches for olfactory groove meningiomas through a meta-analysis and show similar extent of resection for unilateral and bilateral approaches, although those tumor volumes were overall smaller than the cohort of the latter, as well as similar complication rates when analyzed statistically instead of absolute numbers (except for meningitis and death outcomes).

One of the possible complications of the transbasal is the occurrence of CSF leak. Therefore, it is important to achieve robust reconstruction. If available, a double flap for reconstruction (pericranium + extended nasoseptal flap) may be performed, especially in cases of ample opening into the nasal cavity beyond the frontal sinus. This allows for better vascularization and healing capacity of the reconstruction, lowering the odds of complications.[19] The extended nasoseptal flap adds to the multilayer reconstruction. Another possibility is to add free mucosal grafts if the nasal septum is compromised (e.g., sinonasal tumor invasion). As alternatives, grafts can be obtained from middle turbinates[20] or intact nasal floor.[21] Gabriel et al (2020)[22] reviewed nine cases submitted to the double reconstruction technique after a combined approach to anterior skull base tumors and sinonasal malignancies, followed by radiotherapy. Patients presented with no CSF leak and no flap necrosis. Previously to the placement of the flap, some authors[13] also propose filling the nasolacrimal ducts with betadine-soaked pledgets of gelfoam, in the rationale of sealing communications and decreasing the risk of infection.

Conclusion

While the transbasal approach has been described in many preceding atlases in its many variations, they have not been optimized for the education of junior-level trainees via a dissection-based neuroanatomic model. Further, the nonstandardized terminology and diverse set of modifications detailed for a more experienced audience lead to increased confusion regarding the basic technique and utility of a very versatile skull base approach. Herein, we create a novel educational resource using a high-quality, cadaver-based, operatively oriented dissection to parallel the operative experience for the junior trainee. Illustrative cases were described to optimize the understanding of the conventional transbasal approach and its potential for extensive skull base exposure.

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Conflict of Interest
None declared.

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