Surgical nuances for removal of retrochiasmatic craniopharyngioma via the endoscopic endonasal extended transsphenoidal transplanum transtuberculum approach

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Retrochiasmatic craniopharyngiomas are challenging tumors to remove given their deep location and proximity to critical neurovascular structures. Complete surgical removal offers the best chance of cure and prevention of recurrence. The endoscopic endonasal extended transsphenoidal approach offers direct midline access to the retrochiasmatic space through a transplanum transtuberculum corridor. Excellent visualization of the undersurface of the optic chiasm and hypothalamus can be obtained to facilitate bimanual extracapsular dissection to permit complete removal of these formidable tumors. In this report the authors review the endoscopic endonasal extended transsphenoidal approach, with specific emphasis on technical operative nuances in removing retrochiasmatic craniopharyngiomas. An illustrative intraoperative video demonstrating the technique is also presented. (DOI: 10.3171/2011.1.FOCUS10297)

**Key Words** • endoscopic endonasal approach • skull base • extended transsphenoidal approach • transplanum transtuberculum • retrochiasmatic craniopharyngioma

**Abbreviation used in this paper:** ON = optic nerve.
Weiss,\textsuperscript{56} which involves removing the tuberculum sellae and planum sphenoidale, has allowed surgeons to access suprasellar supradiaphragmatic craniopharyngiomas with normal-sized sellae.\textsuperscript{13–15,18,23,34} More recently, the endoscope has played an increasing role in the surgical removal of craniopharyngioma.\textsuperscript{4,5,11–15,18,19,22,25,26,31,32,34,35,37,38,56}\textsuperscript{13} and several authors have reported a purely endonasal endoscopic technique with favorable results comparable to microsurgical series.\textsuperscript{12,25,32,38} However, only a few reports specifically address retrochiasmatic craniopharyngiomas resected using the endoscopic endonasal approach.\textsuperscript{23}

The endoscopic endonasal extended transsphenoidal approach provides a direct midline exposure for access to retrochiasmatic craniopharyngiomas. This purely endonasal endoscopic technique offers excellent visualization of the retrochiasmatic region and allows for 2-handed tumor dissection off of the undersurface of the optic chiasm and hypothalamus by using microsurgical principles. We have adopted this technique as described by Kassam et al.,\textsuperscript{35} Cappabianca et al.,\textsuperscript{4} and Cavallo et al.\textsuperscript{10} In this report, we review our surgical technique and describe the operative nuances for removal of retrochiasmatic craniopharyngiomas via the endoscopic endonasal extended transsphenoidal (transplanum transtuberculum) approach. We also present an illustrative intraoperative video demonstrating the technique (Video 1).

\textbf{Surgical Technique}

\textit{Patient Positioning}

After induction of general anesthesia, the endotracheal tube is secured to the left side of the patient. Although a lumbar drain can be placed at this time for temporary postoperative CSF diversion, we prefer not to use postoperative lumbar drainage because of potential complications arising from intracranial hypotension. The patient is placed supine on the operating table with the head fixed in a 3-point Mayfield head holder. The bed is slightly flexed to keep the head slightly elevated above the heart to facilitate venous return. The head is slightly flexed toward the left shoulder and slightly rotated toward the right to enhance the surgeon’s comfort in accessing the nose from the patient’s right side. The head is also slightly extended to facilitate access to the anterior skull base. Frameless stereotactic imaging guidance is used for intraoperative navigation. This helps guide the extent of bone removal from the planum sphenoidale to gain an adequate trajectory toward the suprasellar target. The nose and nostrils are prepared with betadine and the nasal cavity is packed with Afrin-soaked pledgets. The thigh is also prepared for harvest of autologous fascia lata for dural repair and reconstruction. Intravenous antibiotics and 10 mg of dexamethasone are administered prior to incision.

\textbf{Endoscopic Endonasal Transsphenoidal Approach}

In our center we use a team approach, with a skull base neurosurgeon (J.K.L.) and an otolaryngologist specializing in rhinology, sinus, and endoscopic skull base surgery (J.A.E.). With both surgeons working together simultaneously, a 3- to 4-handed binostil technique is used without a traditional nasal speculum. The initial endonasal exposure to the sphenoid sinus is performed primarily by the otolaryngologist, who uses a 4-mm-diameter, 18-cm-long, 30° endoscope (Karl Storz). We prefer to start the exposure and resection with a 30° endoscope because it has the versatility to allow us to accomplish the same degree of exposure as with a 0° endoscope, but with the added benefits of additional angled viewing capabilities around corners, without repeatedly interchanging the endoscopes. The tail and anterosuperior attachment of the middle turbinates as well as the nasal septum are infiltrated with 1% lidocaine with epinephrine (1:100,000 dilution). Both middle and inferior turbinates are mobilized laterally. In some cases, the right middle turbinate can be removed, if necessary, to allow more room for multiple instruments in the right nostril. The sphenoid ostia are identified bilaterally, and a wide sphenoidotomy and posterior ethmoidectomy are performed with a microdebrider and Kerrison rongeurs.

At this juncture, we prefer to harvest a pedicled, vascularized, nasoseptal flap, which is rotated inferiorly into the nasopharynx. Further panoramic exposure of the skull base by maximizing the sphenoidotomy, posterior ethmoidectomy, and posterior septectomy can be continued while protecting the vascular pedicle to the nasoseptal flap. A posterior ethmoidectomy is performed with a microdebrider so that adequate exposure of the planum sphenoidale is obtained without any obstructive overhang of tissue. It is important to recognize the presence of an Onodi cell, a posterior ethmoid cell that is positioned superolateral to the sphenoid sinus, because the ON and carotid artery may often course through the lateral aspect of that cell. The posterior septectomy (approximately 1.5–2 cm) allows triangulation of surgical instruments through both nostrils so that bimanual dissection can be performed.

\textit{Transplanum Transtuberculum Exposure (Extended Transsphenoidal)}

At this juncture, the otolaryngologist and neurosurgeon work simultaneously using a 3- to 4-handed binostil technique for the remainder of the operation. The otolaryngologist provides dynamic guidance and optimal visualization of the surgical target, with the endoscope primarily positioned in the right nostril. We do not use the endoscope holder, and prefer dynamic movements of the endoscope to facilitate depth perception of the anatomical target. The neurosurgeon uses continuous bimanual microsurgical technique, with a suction device primarily in the left hand inserted into the right nostril, and a drill, dissector, scissors, bipolar device, or tissue aspirator in the right hand inserted into the left nostril.

During the bone drilling and removal, we prefer to use a double-barrel suction-irrigating instrument in the right nostril. The self-irrigating system keeps the surgical field clear of bone dust during bone drilling, and also cools the drill tip from overheating. The sphenoidotomy is maximally widened with a high-speed diamond drill so that there is no bony overhang inhibiting the surgical freedom of the instrument (maneuverability) and no obstruction in the line of sight to the transplanum transtuberculum target. The bone over the sella turcica, tuberculum sellae, and planum
sphenoidale is carefully removed. It is important to identify the medial optocarotid recess, which is an indentation in the bone that is formed at the medial junction of the parasellar carotid canal and the optic canal. This recess represents the pneumatization of the middle clinoid and lateral aspects of the tuberculum sellae as viewed from the endonasal perspective.\textsuperscript{35} The tuberculum strut along with both medial optocarotid recesses are carefully thinned down to eggshell thickness with a high-speed diamond drill, with copious irrigation. Care is taken to avoid thermal injury to the ON. After the bone has been adequately thinned to eggshell thickness, the remaining tuberculum strut is removed with an up-angled 5–0 curette. By removing the medial optocarotid recesses, the medial aspect of the optic canals are unroofed, which facilitates exposure of the ONs and paraclinoid carotid arteries in the optocarotid cistern.\textsuperscript{35} Venous bleeding from the cavernous and intercavernous sinuses can be readily controlled with Gelfoam or Surgifo (Ethicon, Inc.).

**Tumor Resection**

We prefer to open the dura mater in a transdiaphragmatic fashion similar to the technique described by Weiss.\textsuperscript{36} A size 15 blade is used to make a cruciate incision over the sellar dura, and a second horizontal incision is made in the dura of the planum sphenoidale above the intercavernous sinus. The intercavernous sinus is coagulated with a pistol-grip endoscopic bipolar device, and subsequently divided with scissors to obtain direct access to the supraellar cistern. Care is taken to identify the pituitary gland and stalk, to preserve it whenever possible. Kassam et al.\textsuperscript{35} have classified craniopharyngiomas based on the anatomical relationship of the tumor and the infundibulum, as follows: Type I, preinfundibular; Type II, transinfundibular; Type III, retroinfundibular; and Type IV, intraventricular. Although the location of the tumor in relation to the stalk can sometimes be predicted on preoperative MR imaging, larger craniopharyngiomas can obscure the location of the stalk, and the only way to confirm the location is at the time of surgery.\textsuperscript{30} In cases of Type II transinfundibular craniopharyngiomas, the tumor expands and widens the stalk as it grows. In these cases, anatomical preservation of the stalk is difficult to achieve, perhaps at the cost of incomplete tumor removal. We therefore agree with Oldfield\textsuperscript{37} that if the difference in complete and incomplete removal is based on anatomical preservation of the pituitary stalk (the preservation of which does not always retain pituitary function), it is better to choose complete tumor removal at the cost of sacrificing the stalk and accepting hormone replacement therapy. Therefore, in cases of Type II transinfundibular craniopharyngiomas, we prefer to perform a low stalk section to achieve a more aggressive removal of the tumor.

By using bimanual microsurgical dissection techniques, the tumor capsule in relation to the optic chiasm and ONs is identified. In retrochiasmatic craniopharyngiomas, the tumor is located underneath and posterior to the optic chiasm. It can often be adherent to the undersurface of the optic apparatus and hypothalamus, with tumor extension superiorly into the third ventricle and posteriorly into the interpeduncular fossa and retrostellar space. The anterior communicating artery complex is located superior to the optic chiasm and is therefore protected from the plane of dissection in retrochiasmatic craniopharyngiomas. A 30° endoscope allows a direct “looking-up” view of the retrochiasmatic space for extracapsular dissection. When 3–4 instruments are used at deep intradural targets, the 2 surgeons are often “fighting for space” with their instruments. We therefore recommend placing the endoscope at the 6 o’clock position, with the suction placed in the 12 o’clock position in the right nostril when using the 30° endoscope to look up into the retrochiasmatic space. The neurosurgeon is therefore working “above” the endoscope while maintaining the optimal surgical exposure. When using a 0° endoscope, we prefer to do the opposite and place the endoscope at the 12 o’clock and the suction instrument at the 6 o’clock position.

In larger tumors, initial debulking of solid components and/or aspiration of cystic fluid allows for decompression of the tumor capsule. Once the tumor is adequately debulked and decompressed, extracapsular dissection of the tumor capsule away from the optic chiasm and hypothalamus is performed with careful bimanual microdissection. Care is taken not to amputate the tumor capsule prematurly, so that enough tumor capsule serves as a “handle” to provide countertraction for extracapsular dissection. It is important to identify the double arachnoid layer and to distinguish the tumor arachnoidal plane from the cisternal arachnoid plane, if possible. The optimal plane of safe dissection is between the tumor capsule and the tumor arachnoid, not the cisternal arachnoid plane.\textsuperscript{43} In most virgin cases, the Liliequist membrane is intact and serves as a protective barrier for the basal artery, posterior cerebral arteries, and P\textsubscript{7} perforating vessels.\textsuperscript{7,9} Once the tumor capsule is dissected free from the undersurface of the optic chiasm, hypothalamus, and surrounding vascular structures, the remaining tumor capsule can be delivered. If the floor of the third ventricle is open, a 30° and 70° endoscope can be used to look inside the walls of the third ventricle to inspect for residual tumor.

**Closure and Skull Base Reconstruction**

Closure is of critical importance in preventing a postoperative CSF leak. We prefer to place an initial autologous fascia lata graft harvested just slightly larger than the dural defect. The fascia lata graft is placed intradurally as an underlay graft, with its edges tucked underneath the dural edges. Several pieces of Surgicel are placed over the bone defect to hold the fascia graft in place temporarily. The vascularized nasoseptal flap is then rotated superiorly to cover the dural closure and bony skull base defect. Care is taken to ensure that the edges of the nasoseptal flap are in contact with the bone. A thin layer of DuraSeal (Covidien) or Tisseel (Baxter Healthcare Corp.) fibrin glue is spread over the nasoseptal flap, followed by gentamicin-soaked Gelfoam pledges to buttress the flap repair. A Merocel (Medtronic Xomed) nasal pack is then placed in the nasal cavity to bolster the Gelfoam layer, and is left in place for approximately 10 days. The patient is maintained on antibiotics until the packs are removed. Because the patient is already in a CSF hypovolemic state.
at the end of surgery, we do not use postoperative lumbar drainage to avoid complications of CSF hypotension. Absence of a lumbar drain allows the patient to recover quicker and mobilize sooner, thus avoiding thromboembolic and pulmonary complications.

Illustrative Cases

Case 1

This 53-year-old woman presented with worsening headaches and visual loss. Visual acuity was 20/60 bilaterally, with bitemporal hemianopia. Admission MR imaging studies demonstrated a cystic intrasellar and suprasellar retrochiasmatic craniopharyngioma exerting significant compression on the ONs and optic chiasm (Fig. 1). A transplanum transtuberculum endoscopic endonasal extended transsphenoidal approach was used to remove the tumor. Careful bimanual extracapsular dissection freed the adherent tumor from the hypothalamus (Fig. 2). Because the tumor had infiltrated and expanded the pituitary stalk (Type II transinfundibular), the stalk could not be preserved and was, therefore, divided to allow gross-total removal of the tumor. Inspection of the resection cavity with a 30° angled endoscope allowed excellent visualization of the entrance into the third ventricle and the basilar artery complex. Postoperatively, her visual acuity improved to 20/20, with resolution of bitemporal hemianopia. Hormone replacement therapy was initiated because of postoperative panhypopituitarism and diabetes insipidus. There was no postoperative CSF leakage.

Case 2

This 52-year-old woman presented with progressive visual loss and bitemporal hemianopia. Her visual acuity was 20/40 in the right eye and 20/200 in the left eye. Admission MR imaging studies demonstrated a cystic intrasellar and suprasellar retrochiasmatic craniopharyngioma exerting significant compression on the ONs and optic chiasm (Fig. 3). A transplanum transtuberculum endoscopic endonasal transsphenoidal approach (Video 1) was performed using 3D endoscopy (Visionsense, Ltd.).

Video 1. Intraoperative video showing removal of a retrochiasmatic craniopharyngioma by using the endoscopic endonasal extended transsphenoidal approach (Case 2). Click here to view with Windows Media Player. Click here to view with Quicktime.

The tumor capsule was very adherent to the undersurface of the optic chiasm and left ON (Fig. 4). The tumor was noted to be a Type II transinfundibular variant intraoperatively, and a low stalk section was performed to release and deliver the tumor. A near-total resection was performed, with a small microscopic remnant of calcified capsule that was adherent to the undersurface of the left ON. The postoperative visual examination showed improvement, and the patient was maintained on hormone replacement therapy for panhypopituitarism and diabetes insipidus. There was no postoperative CSF leakage.

Discussion

Surgical Approaches for Retrochiasmatic Craniopharyngioma

The surgical removal of retrochiasmatic craniopharyngiomas presents a formidable challenge because of their deep location and intimate involvement with critical neurovascular structures. When a transcranial approach is used, such as a midline transbasal subfrontal, bifrontal interhemispheric, perional, orbitopterional, supraorbital, or orbitozygomatic approach, the conventional operative corridors through the interoptic and optiocarotid cisterns allow limited exposure and inadequate visualization of the infra- and retrochiasmatic regions. Because these tumors are hidden behind an anteriorly displaced or prefixed chiasm, it is often necessary to open the lamina terminalis to access these lesions in the retrochiasmatic space. The transamina terminalis exposure is an effective route in experienced hands; however, the undersurface of the optic chiasm and ONs remains a blind spot from the transcranial view. Al-Mefty et al.1 and Hakuba et al.29 have advocated the posterior petrosal approach for retrochiasmatic craniopharyngiomas because of its upward projection to dissect the upper pole of the tumor with direct visualization of the hypothalamus and pituitary stalk. However, this approach has the disadvantages of prolonged temporal lobe retraction, potential injury to the vein of Labbé, and loss of midline orientation with a lateral projection.

The transnasal transsphenoidal route provides a direct midline approach to the suprasellar region without any brain retraction.17,18 In the past, this approach was generally reserved for craniopharyngiomas that were primarily subdiaphragmatic in origin, with an enlarged sella. However, with the refinement of the extended trans-
sphenoidal approach that involves creating a transplanum transtuberculum corridor through the anterior skull base, purely suprasellar tumors of supradiaphragmatic origin became accessible with a normal-sized sella. Successful tumor removal has been reported when using the speculum-based microsurgical extended transsphenoidal approach. However, visualization at the highest magnification of the microscope limits the amount of illumination of the surgical target. The surgical field of view is limited by the corridor and aperture of the distal end of the speculum. Surgical freedom (that is, the range of instrument maneuverability) and line of sight are also compromised with a deep and narrow working channel formed by the blades of the nasal speculum.

The endoscope offers the advantages of better illumination of the surgical target, with a much wider field
of view. A panoramic view from the planum sphenoidale to the clival recess and from one medial opticocarotid recess to the other can be obtained. Unlike the microscope, the endoscope allows high magnification of the surgical target without loss of illumination by bringing the light source and lens directly up to the target. The purely endonasal endoscopic approach allows a direct view of the undersurface of the optic chiasm and the retrochiasmatic region because the approach originates below the chiasm. Direct extracapsular dissection of the tumor off of the visual apparatus, hypothalamus, pituitary stalk, and perforating vessels can be performed with bimanual microsurgical technique. The use of angled endoscopes allows visualization of lesions “around corners,” which can then be removed under direct visualization. Lesions extending into the third ventricle and interpeduncular space can be easily accessed and visualized. By using a binosorial technique, there is a larger range of motion for instrument maneuverability that was previously encumbered by the nasal speculum.\textsuperscript{17,18,33} This working space is largely created by maximizing the sphenoidotomy, posterior ethmoidectomy, posterior septectomy, and sometimes a middle turbinectomy.

One of the major criticisms of endonasal surgery for craniopharyngiomas and other intradural tumors is the rate of CSF leakage. This has been significantly reduced by the application of the vascularized nasoseptal flap.\textsuperscript{28,36} The flap tissue is robust and provides excellent coverage of skull base defects. The major advantage is that the tissue is vascularized to optimize healing and prevent CSF leaks.

Limitations of the Endoscopic Endonasal Approach

The endoscopic endonasal approach becomes more difficult and technically demanding in tumors that extend laterally into the sylvian fissure with intimate involvement of the middle cerebral artery and its perforating vessels. This area is difficult to access with angled instruments, and it is also difficult to achieve adequate control in the event of neurovascular injury. In cases with lateral extension, we prefer to choose a transcranial approach, such as an extended frontotemporal orbitozygomatic approach that allows transsylvian and translamina terminalis access. For Type IV purely intraventricular craniopharyngiomas, we prefer the transbasal subfrontal translamina terminalis approach.\textsuperscript{43}

A conchal nonpneumatized sphenoid sinus can make the endonasal approach more difficult because there is a lack of natural bony landmarks as seen in a well-aerated sinus.\textsuperscript{12} Creating the working corridor can be more laborious. In this setting, neuronavigation, which can help confirm surgical landmarks, is indispensable. Although an endoscopic endonasal approach can still be safely performed in experienced hands, one may consider a transcranial approach depending on the size, location, and consistency (solid vs cystic) of the tumor.

The 2D view provided by the endoscope has been considered a limitation compared with the 3D view afforded by the microscope.\textsuperscript{33} We would argue, however, that the dynamic mobility of the endoscope allows the lens to move closer and further away from the target, conveying a sense of depth perception. Placement of the suction in the clival recess also provides tactile feedback to the operating surgeon to give a sense of depth as well. The panoramic view afforded by the endoscope also assists in defining 3D relationships. The availability of recently developed 3D endoscopes (Visionsense, Ltd.) has now greatly improved subjective depth perception for the operating surgeon.\textsuperscript{53} These endoscopes are based on dual channel technology that incorporates information from 2 distinct perspectives to render a single 3D view, similar to human vision. A recent report of a study performed using the 3D endoscope for pituitary tumor removal demonstrated subjective improvement in depth perception without increased complications or operating time.\textsuperscript{53}

Conclusions

The endoscopic endonasal extended transplanum transtuberculum approach provides direct midline access to retrochiasmatic craniopharyngiomas. Excellent visualization of the undersurface of the optic chiasm and hypothalamus can be obtained to facilitate bimanual extracapsular dissection, to permit complete removal of these formidable tumors.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Liu, Eloy. Acquisition
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Fig. 4. Case 2. Intraoperative photographs taken through a 3D endoscope. A and B: Endoscopic view of extracapsular tumor dissection off of the undersurface of the optic chiasm using bimanual microsurgical technique. The mammillary bodies and entrance into the third ventricle (*) are identified. This tumor was noted to be a Type II transinfundibular craniopharyngioma with infiltration and expansion of the pituitary stalk (S). A low division of the stalk was performed to allow near-total removal of the tumor. A small calcified remnant was adherent to the undersurface of the left ON. C: Endoscopic view of the undersurface of the optic chiasm and ONs after tumor removal. The A1 and A2 segments of the anterior cerebral arteries and the recurrent artery of Heubner (H) are identified. D: Endoscopic view of the skull base repair with a nasoseptal flap at 2 months after surgery demonstrates a well-healed nasoseptal flap and vascular pedicle with reconstitution of the mucosal lining overlying the skull base defect (SBD) and the posterior ethmoids (PE). See Fig. 2 for definitions of abbreviations.

References
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Supplemental online information:

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