Endoscopic, endonasal extended transsphenoidal, transplanum transtuberculum approach for resection of suprasellar lesions

ILYA LAUER, M.D., VIJAY K. ANAND, M.D., AND THEODORE H. SCHWARTZ, M.D.

Departments of Neurological Surgery and Otolaryngology, Weill Cornell Medical College, New York Presbyterian Hospital, New York, New York

Object. The extended transsphenoidal approach is a less invasive method for removing purely suprasellar lesions compared with traditional transcranial approaches. Most advocates have used a sublabial incision and a microscope and have reported a significant risk of cerebrospinal fluid (CSF) leakage. The authors report on a series of purely endoscopic endonasal surgeries for resection of suprasellar supradiaphragmatic lesions above a normal-sized sella turcica with a low risk of CSF leakage.

Methods. A purely endoscopic endonasal approach was used to remove suprasellar lesions in a series of 10 patients. Five lesions were prechiasmal (three tuberculum sellae and two planum sphenoidale meningiomas) and five were postchiasmal (four craniopharyngiomas and one Rathke cleft cyst). The floor of the planum sphenoidale and the sella turcica was reconstructed using a multilayer closure with autologous and synthetic materials. Spinal drainage was performed in only five cases. Complete resection of the lesions was achieved in all but one patient. The pituitary stalk was preserved in all but one patient, whose stalk was invaded by a craniopharyngioma and who had preoperative diabetes insipidus (DI). Vision improved postoperatively in all patients with preoperative impairment. Six patients had temporary DI; in five, the DI became permanent. Four patients with craniopharyngiomas required cortisone and thyroid replacement. After a mean follow up of 10 months, there was only one transient CSF leak when a lumbar drain was clamped prematurely on postoperative Day 5.

Conclusions. A purely endoscopic endonasal approach to suprasellar supradiaphragmatic lesions is a feasible minimally invasive alternative to craniotomy. With a multilayer closure, the risk of CSF leakage is low and lumbar drainage can be avoided. A larger series will be required to validate this approach.

Key Words • craniopharyngioma • cyst • meningioma • Rathke cleft cyst • endonasal transsphenoidal approach • endoscopy • minimally invasive surgery • planum sphenoidale • skull base • tuberculum sellae

The transsphenoidal approach is a well-established method for the surgical removal of intrasellar pathology.24,38 Lesions located in the suprasellar space, above the diaphragma sellae with no involvement of the sella turcica, have been traditionally approached through a craniotomy.3,8,14,36,43,45 Recently, several authors have described modifications of the microscope-based transsphenoidal approach that extend its reach past the sella into the suprasellar region.9,11,23,30–32,34,40,46

Another recent modification to the transsphenoidal approach has been the use of the endoscope for an endonasal mucosa-preserving approach that circumvents the need for the microscope and postoperative nasal packing.4–6,10,17,18,20,25,27,28,42,44,47 Proponents of this method believe that despite the loss of stereoscopic vision, the field of view is better than that achieved with the microscope because the light source and lens are closer to the lesion. The feasibility of a purely endoscopic extended transsphenoidal approach to remove suprasellar lesions has been reported previously, but few cases have been described in detail.12,20 In fact, in a recent study of endonasal endoscopic resections of Rathke cleft cysts, the authors still recommended the transcranial approach to remove cysts that are completely supradiaphragmatic, without intrasellar extension.17 For this reason we elected to present our early experience with a purely endoscopic, endonasal extended transsphenoidal, transtuberculum transplanum approach in 10 patients with entirely supradiaphragmatic lesions and a normal-sized sella.

Clinical Material and Methods

Patient Population

All patients had suprasellar lesions and a normal-sized sella. The sphenoid sinus was examined and believed adequate to permit a transsphenoidal, transtuberculum transplanum approach to the suprasellar cistern. The demographics, presenting symptoms, lesion type and location, and outcome for each patient are shown in Table 1. There were

Abbreviations used in this paper: ACoA = anterior communicating artery; CSF = cerebrospinal fluid; DI = diabetes insipidus; MR = magnetic resonance.
five meningiomas, four craniopharyngiomas, and one Rathke cleft cyst. All patients had undergone preoperative visual field testing and comprehensive endocrinological evaluation. Three patients with tuberculum sellae meningiomas and one with a planum sphenoidale meningioma presented with progressive visual loss. One meningioma in the planum sphenoidale demonstrated progressive growth on serial MR images. The four patients with craniopharyngiomas all had visual loss and evidence of hormonal/hypothalamic dysfunction—either DI or hyperphagia. The patient with a Rathke cleft cyst had progressive visual loss, and the lesion was enlarged on serial images. Examples of preoperative pathophysiology are presented in Fig. 1.

**Surgical Procedure**

The surgical approach was similar in all cases (Fig. 2). General anesthesia was induced, and the patient was given antibiotics, glucocorticosteroids, and antihistamines. A lumbar drain was placed, and 0.2 ml of 10% fluorescein (AK-Fluor, AKORN) was injected in 10 ml of CSF to help visualize CSF leaks. The nasal mucosa was vasoconstricted with cottonoids soaked in 4 ml of 4% cocaine (topical). Using a 0˚, 18-cm long, 4-mm diameter rigid endoscope (Karl Storz), the sphenopalatine arteries and middle turbinates were injected with a mixture of 1% lidocaine and epinephrine (1:100,000 dilution). Under endoscopic visualization, the middle and superior turbinates were retracted laterally, and the vomer (Fig. 5A). In two patients (Cases 2 and 3) the inner bone was removed using a rongeur forceps. The posterior wall of the sphenoid sinus was thus brought into full view. Localization was confirmed using frameless stereotactic image guidance. A 0˚, 30-cm long, 4-mm diameter rigid endoscope (Karl Storz) was introduced through the left nostril and held in place with a flexible scope holder (Karl Storz). The upper third of the sella was opened through the right nostril by using a high-speed drill, curette, and Kerrison rongeur. The opening was extended above the level of the diaphragm sphenoid rostrum, and the sphenoid sinus rostrum was retracted laterally, and the intersinus sphenoid septum was removed using a rongeur forceps. The resection bed was examined using a 45˚, 18-cm long, 4-mm diameter rigid endoscope (Karl Storz) to ensure the absence of residual tumor after surgery. A postoperative iohexol-enhanced CT scan is featured for the patient in Case 8, who was too obese for MR imaging after surgery. RCC = Rathke cleft cyst.

**Preciasmal Lesions.** The prechiasmal tumors (Cases 1–5) generally meningiomas, were immediately visualized once the dura was opened (Fig. 3A and C). Internal decompression was performed using a Cavitron ultrasonic surgical aspirator (Valleylab) or a monopolar or ring cautery (Ellman), and microscissors. The blood supply was interrupted at the beginning of the dissection via the transsphenoidal, transtuberculum tranplanum approach, and the tumor could be internally decompressed without having to operate around the optic nerves or carotid arteries.

Once decompressed, the tumor capsule could be mobilized, and the ACoA complex and perforating arteries were dissected sharply off the tumor capsule (Fig. 3). The optic nerves and pituitary stalk were clearly seen posterior and inferior to the tumor and were easily dissected off the back of the tumor with preservation of the arachnoidal plane. The remaining capsule was removed completely (Fig. 3D). In one patient (Case 3), the ACoA and A segment were encased by the tumor, and a small remnant was left behind. The resection bed was examined using a 45˚, 18-cm long, 4-mm diameter rigid endoscope (Karl Storz) to ensure the absence of any residual tumor (Fig. 3B and D). Special care was taken to examine the course of the optic nerve to ensure no residual tumor remained in the optic canal. Confirmation was obtained with postoperative coronal MR images with and without contrast (Fig. 4). The closure was performed with abdominal fat, which was buttressed by a rigid piece of the vomer (Fig. 5A). In two patients (Cases 2 and 3) the inlay graft, either fascia lata or dural substitute (Duragen, Integra), was placed under the fat. A watertight closure was attempted with the use of either fibrin matrix (Tisseel, Baxter) or polymerized hydrogel (DuraSeal, Confluent Surgical). The sphenoid sinus was filled with thrombin-infused gelatin matrix (FloSeal, Baxter) to buttress the closure and aid in hemostasis.
Postchiasmal Lesions. The postchiasmal cystic tumors (Cases 6–10), either craniopharyngiomas or Rathke cleft cysts, arose from the back of the pituitary stalk and extended into the third ventricle behind the optic chiasm. After the dura was opened above and below the intercavernous sinus, the arachnoid of the suprasellar cistern was incised, and a corridor was opened between the pituitary gland (below) and the optic chiasm (above; Figs. 6A and 7A). The anterior wall of the cyst was opened sharply to drain the cyst contents. Working on either side of the stalk, the cyst wall and any solid components were carefully dissected free from the optic chiasm, carotid arteries, ACoA complex, and hypothalamic and chiasmal perforating arteries. In one patient (Case 7), the pituitary stalk was sacrificed because the solid component of the tumor had already infiltrated the stalk. This patient had presented with preoperative DI. Once the tumor and cyst wall were completely removed, the resection bed was examined using a 45˚, 18-cm, 4-mm rigid endoscope (Karl Storz) to ensure the absence of residual tumor. In most cases the third ventricle ependyma was clearly seen, including the foramen of Monro and aqueduct of Sylvius (Figs. 6B and C, and 7B and C). The interpeduncular cistern was also apparent, including the basilar tip, posterior cerebral artery, superior cerebellar artery, and third nerve (Figs. 6B and 7B). In four patients (Cases 6–9) in whom the third ventricle was widely open, abdominal fat was not used first in the closure. The dura was repaired with an inlay of either fascia lata or dural substitute (Dura-Guard), buttressed with either the vomer or a miniplate, if no vomer was available (Case 8; Fig. 5B). The application of either Tisseel fibrin glue or DuraSeal followed, which was then buttressed with FloSeal as described previously. In the other patient (Case 10), closure started with fat packing because the third ventricle was not widely open at the end of the surgery.

Results

The mean follow-up period was 10 months (Table 1). Subjective visual field symptoms resolved in all patients, and formal visual field testing demonstrated improvement in all patients with preoperative visual field deficits. One patient (Case 10), the first in our series, had a postoperative Marcus Gunn pupil and blurry vision in her right eye, which resolved within 4 months. In five of the 10 patients a lumbar drain was placed intraoperatively and maintained for at least 3 days. As we became more confident of our closure, we began to avoid lumbar drainage. In the five patients who

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the use of this approach to purely suprasellar lesions has been described previously, but most authors report using a microscope rather than an endoscope, often making a sublabial incision, and applying a transsphenoidal approach.\textsuperscript{11,22,23,30,32–34,40,46} Even in these reports, the lesions often extended into the sella. Nonetheless, authors of a few of these papers described the extended transsphenoidal approach for lesions that were entirely suprasellar.\textsuperscript{31,33,34} In the present study we show that a purely endoscopic extended approach can be used for resection of uniquely suprasellar supradiaphragmatic lesions above a normal-sized sella. We report on the largest series of patients in whom a purely endoscopic, extended transplanum transsphenoidal approach was used to remove purely suprasellar lesions. In most recent case reports of purely endoscopic approaches to suprasellar lesions, there was extensive disease within the sella and an extended approach was not used.\textsuperscript{1,15,17} In fact, Frank et al.\textsuperscript{17} recently reported on 16 endoscopically removed Rathke cleft cysts, many of which extended from the sella into the suprasellar region. Note, however, that these authors cautioned that the endoscopic approach might not be suitable for lesions that are purely suprasellar. Although craniopharyngiomas and Rathke cleft cysts are often managed with a transsphenoidal approach, most authors warn that this approach is appropriate only for tumors with “subdiaphragmatic extension.”\textsuperscript{11,16,35–37}

The advantages of the extended transsphenoidal approach over a traditional craniotomy are the avoidance of frontal or temporal lobe retraction or sylvian fissure dissection and the potential associated brain injury. In one report, 10% of transcranial skull base procedures resulted in some form of retraction injury to the brain.\textsuperscript{2} However, it has been generally thought that safely reaching a suprasellar lesion via the transsphenoidal approach requires the sella to be enlarged and invaded with pathophysiology.\textsuperscript{2,3,36,41} This caveat is partially based on the use of the traditional operating microscope, because the light source and lens are a long distance from the lesion, and visualization is limited by long, narrow retractors.\textsuperscript{34} The endoscope circumvents this problem by bringing the light source and lens closer to the pathophysiology. A panoramic view is provided and can be augmented by the use of angled endoscopes. Authors of two prior publications have described a purely endoscopic, extended transsphenoidal approach to suprasellar pathophysiology, but very few cases were actually presented.\textsuperscript{12,29}

Microscope-based removal of purely suprasellar craniopharyngiomas and meningiomas has been associated with a
20 to 33% rate of CSF leakage\textsuperscript{13,39} and a gross-total resection rate of only 22 to 46%.\textsuperscript{13,39} For craniopharyngiomas, postoperative DI and panhypopituitarism develop in approximately 70% of cases.\textsuperscript{7,21} The presently described purely endoscopic series, although of limited size, appears to have a lower risk of CSF leakage with a higher chance of gross-total resection and comparable endocrinological morbidity. We found that the visualization provided by the endoscope is outstanding for the extended approach to purely suprasellar pathophysiology. This advantage can minimize the risk of morbidity to vital neurovascular structures and also decrease the risk of CSF leakage because closure is more secure, aided by improved visualization. In addition, because the lens and light source are at the tip of the endoscope, the endonasal approach does not limit visibility in the lateral dimension, as occurs with the microscope. Thus, even extended approaches can be performed with the same minimally invasive, mucosa-sparing endonasal approach, as opposed to the microscope-based approaches that require a sublabial incision and submucosal dissection.\textsuperscript{33,34} Note that several authors\textsuperscript{9,13} have recently reported a microscope-based minimally invasive endonasal approach.

Despite the minimally invasive approach and the use of the endoscope, the surgeries we describe were not without morbidity. However, our patients had complex lesions that would be associated with potentially high morbidity and mortality rates even using more traditional microscope-based transsphenoidal and transcranial approaches.\textsuperscript{7,19,21,48} Whether the morbidity rate would have been greater with a microscope-based approach is unknown and will require a larger patient series with a longer follow-up period. Whether the endoscopic approach from below will decrease the

\begin{table}[h]
\centering
\caption{Summary of characteristics and outcome in patients with suprasellar tumors*}
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|}
\hline
Case No. & Age (yrs) & Lesion Location/Type & Presenting Symptoms & Lesion Size (cm) & Stalk Preserved? & Lumbar Drain? & Closure Material & Complications & FU (mos) \\
\hline
1 & 73 & tuberculum sellae/meningioma & visual loss & 3.5 & yes & yes & fat/DuraGen/vomer/DuraGen/FG/FS & DI/CSF leak & 12 \\
2 & 40 & planum sphenoidale/meningioma & visual loss & 3.7 & yes & no & fat/fascia lata/vomer/DuraSeal/FS & none & 5 \\
3 & 51 & tuberculum sellae/meningioma & visual loss & 2.0 & yes & no & fat/fascia lata/vomer/FG/FS & none & 9 \\
4 & 66 & tuberculum sellae/meningioma & visual loss & 2.6 & yes & no & fat/fascia lata/vomer/DuraSeal/FS & none & 6 \\
5 & 48 & planum sphenoidale/meningioma & headache/enlarging mass & 1.2 & yes & yes & fat/vomer/FG/FS & none & 11 \\
6 & 62 & suprasellar/cystic/craniopharyngioma & visual loss/hyperphagia & 3.8 & yes & yes & vomer/fat/FG/FS & DI/cortisol/↓thyroid & 13 \\
7 & 38 & suprasellar/cystic/craniopharyngioma & visual loss/DI & 3.6 & no & no & fascia lata/vomer/DuraSeal/FS & DI/cortisol/↓thyroid/vaso-spasm & 8 \\
8 & 67 & suprasellar/cystic/craniopharyngioma & visual loss/hyperphagia & 4.5 & yes & yes & Dura-Guard/mini-plate/fat/FG/FS & DI/cortisol/↓thyroid/MI & 9 \\
9 & 42 & suprasellar/solid/craniopharyngioma & visual loss/hypopituitarism & 1.6 & yes & no & fascia lata/vomer/DuraSeal/FS & DI/cortisol/↓thyroid & 4 \\
10 & 53 & suprasellar/Rathke cleft cyst & visual loss/enlarging mass & 1.1 & yes & yes & fat/vomer/FG/fat/FG & DI/cortisol/↓thyroid/blurry vision & 23 \\
\hline
\end{tabular}
\label{tab:suprasellar_tumors}
\end{table}

\textsuperscript{*} FG = fibrin glue; FS = FloSeal; FU = follow up; MI = myocardial infarction; SSS = sick sinus syndrome; ↓ = decrease in.
\textsuperscript{†} Largest diameter on MR image.
\textsuperscript{‡} Less than 2 weeks.

Fig. 7. Endoscopic images demonstrating views seen during removal of a craniopharyngioma. A: The planum sphenoidale has been removed, and the tumor (T) is clearly seen behind the stalk (S) and below the optic chiasm (OC) and optic nerve (ON) but above the pituitary gland (P). B: Once the tumor is removed, a look downward with an angled scope reveals the basilar artery (BA) and posterior cerebral arteries (PCA) as well as the aqueduct of Sylvius (AS) in the posterior floor of the third ventricle. C: Looking upward with the angled endoscope reveals complete tumor removal from the third ventricle wall, and the fornices (F) and foramina of Monro (FM) are clearly seen.
Endoscopic transplanum transtuberculum approach

ability to achieve a Simpson Grade I resection of a meningioma is also unclear. Just as there can be fragments of tumor beyond the reach of the endoscope but visible from above, there equally likely can be areas of tumor extension that can be seen from below but not from above. Honest evaluation of postoperative images and reporting of recurrence rates could eventually answer this question.

Although we used spinal drainage liberally in our first few patients, this maneuver can promote slumping of the brain away from the operative site and can be counterproductive if a graft inlay is used for closure. In addition, spinal drainage necessitates a longer postoperative stay. In the most recent five cases, we did not use lumbar drainage, and the risk of CSF leakage was not increased. The success of this maneuver requires meticulous closure with a dural graft inlay (either fascia lata or Dura-Guard), rigid butttressing with either the vomer or a metal plate, and the use of sealants such as DuraSeal. Although we used a fat graft as the first stage of closure in the cases involving meningiomas, we were not able to use fat to close those with craniopharyngiomas because the third ventricle was widely opened. Because the fat emits a high signal on T1-weighted MR images, postoperative follow-up images can be difficult to interpret. One solution would be to use a fat saturation sequence. Alternatively, the use of fat could be completely avoided, as it was in cases with craniopharyngiomas, given that this strategy did not appear to cause an increased risk of CSF leakage.

We emphasize that extended endoscopic transsphenoidal procedures are not without risk and should be performed only by surgeons with significant experience in both transsphenoidal and endoscopic surgery, preferably after practice on a cadaveric specimen. As the learning curve plateaus for these extensive endoscopic approaches, direct comparisons with microscope-based surgeries will be forthcoming.

Conclusions

Minimally invasive endoscopic approaches are being increasingly used in the management of lesions in the anterior or skull base. Potential advantages include increased visualization of neurovascular structures and pathophysiology, increased patient comfort, avoidance of sublabial incision, decreased risk of brain retraction, and decreased length of hospital stay. Endoscopic removal of supradiaphragmatic suprasellar lesions in patients with a normal-sized sella is possible with an acceptable risk of morbidity. Additional cases will be required to validate this approach.

References


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Address reprint requests to: Theodore H. Schwartz, M.D., Department of Neurological Surgery, Weill Cornell Medical College, New York Presbyterian Hospital, 525 East 68th Street, Box 99, New York, New York 10021. email: schwarh@med.cornell.edu.