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

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*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 pathophysiology.[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.[12,26] 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.

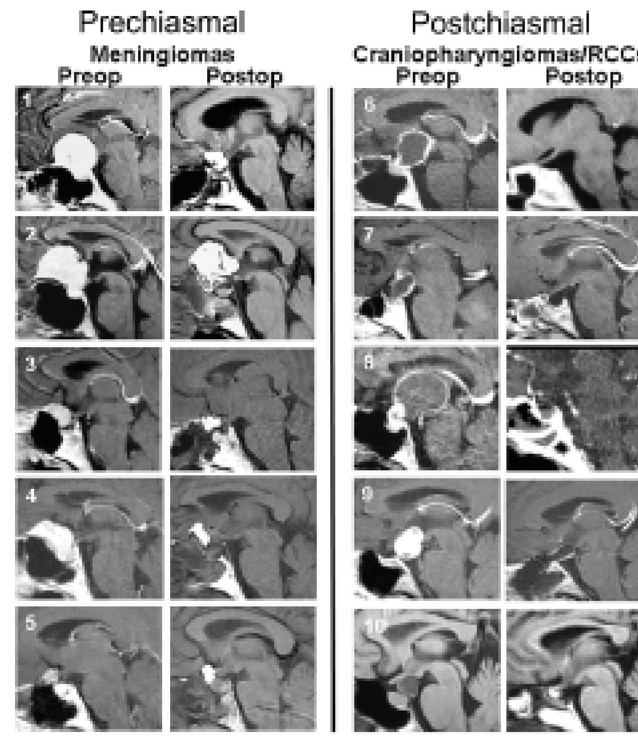


FIG. 1. Sagittal $T_1$-weighted MR images and computed tomography (CT) scan obtained in patients with suprasellar tumors, showing their pre- and postoperative status. The preoperative images are all contrast enhanced, except in the patient in Case 10 who had a nonenhancing cyst. The postoperative images are without Gd for the meningiomas (Cases 1–5) and the Rathke cleft cyst (Case 10) because a fat graft was placed, which could be mistaken for residual tumor. The postoperative images obtained in patients with craniopharyngiomas (Cases 6–9) were all Gd-enhanced to demonstrate 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.

*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 sphenoid ostia were identified bilaterally. The posterior 1 cm of the nasal septum adjacent to the vomer bone and maxillary crest was resected using a tissue shaver. This resection provided a panoramic view of the sphenoid sinus rostrum and the ostia bilaterally and allowed the use of four separate instruments, two through each nostril, for the remainder of the procedure. The mucosa of the sphenoid sinus rostrum was retracted laterally, and the intersinus sphenoid septum 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 diaphragma sellae, and the planum sphenoidale was removed. The extent of planum sphenoidale removal was determined with image guidance to ensure adequate exposure of the tumor. The dura above and below the intercavernous sinus was opened using a sickle knife, and the sinus was cauterized and transected.

*Prechiasmal 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 transplanum 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 $A_2$ 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.

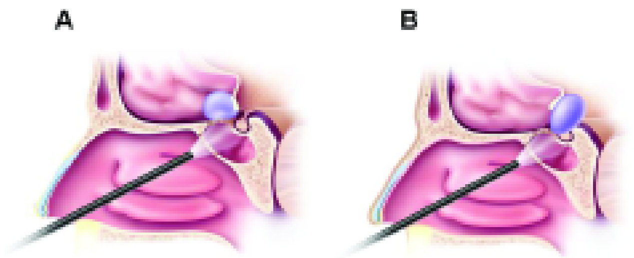


FIG. 2. Schematics demonstrating the endoscopic approach to prechiasmal (A) and postchiasmal (B) suprasellar tumors that do not extend into the sella.

*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 (DuraGuard), 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.

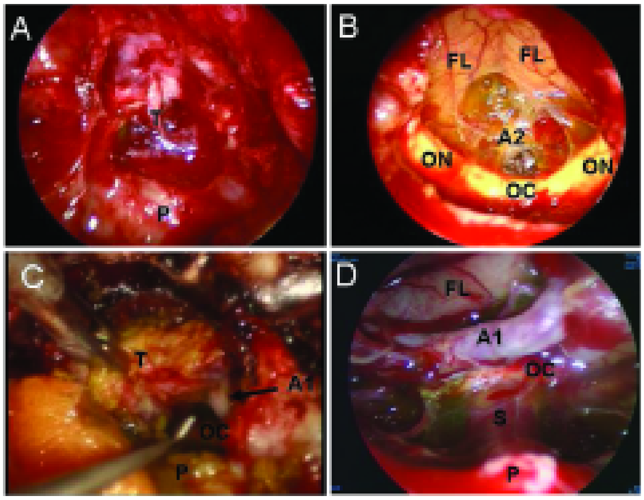


FIG. 3. Endoscopic images revealing the view seen during removal of tuberculum sellae meningiomas. A: The planum sphenoidale has been removed, and the tumor (T) can be seen above the normal pituitary (P). B: Once the tumor has been removed, the optic chiasm (OC), optic nerves (ON), and $A_2$ segment of the anterior cerebral artery branch (A2) can be seen underneath the frontal lobes (FL). C: In a separate case, the tumor is being dissected off the $A_1$ segment (A1) of the anterior cerebral artery, revealing the optic chiasm and pituitary gland. D: Once the tumor is completely removed, the $A_1$ segment is clearly seen, as is the stalk (S) and pituitary gland.

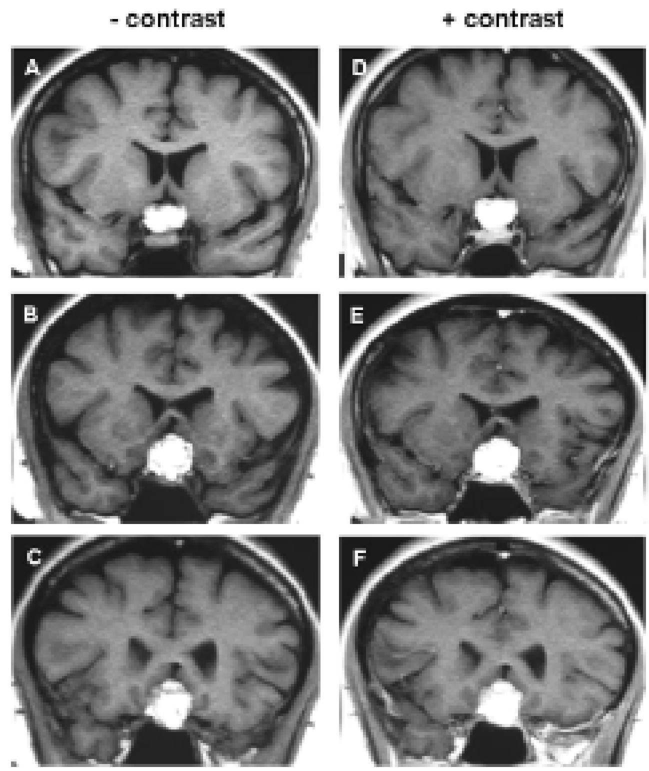


FIG. 4. Case 2. Postoperative coronal MR images without (A–C) and with (D–F) contrast demonstrating complete resection of a large planum sphenoidale meningioma. Although the fat graft fills the resection cavity, there is no residual tumor within the optic canals.

## 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

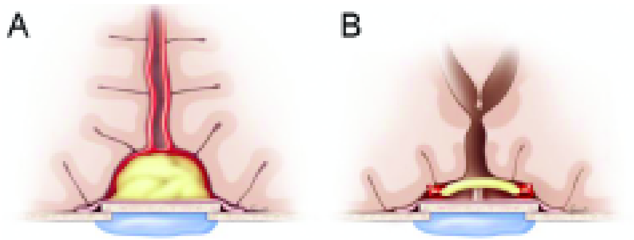


FIG. 5. Schematics showing an anterior skull base multilayer closure. A: Closure of prechiasmal defects. Fat is placed in the tumor cavity to fill the dead space. An inlay graft is held in place with a piece of bone or firm synthetic material. A watertight onlay of DuraSeal completes the closure. B: Closure of postchiasmal defects. Because the third ventricle is open, fat packing is avoided to prevent dislodgment and possible hydrocephalus. An inlay graft is held in place with a piece of bone or firm synthetic material. Care must be taken to avoid pressure on the carotid arteries or optic nerves. A watertight onlay of DuraSeal completes the closure.

had undergone surgery most recently and in whom a lumbar drain was not placed (Cases 2, 3, 4, 7 and 9), there were no CSF leaks. Only one patient (Case 1) experienced a temporary CSF leak after 5 days of lumbar drainage when the drain was temporarily clamped. The drain was reopened and the leak stopped. In this patient we used DuraGen as an inlay and onlay, but we have since abandoned this material because we believed it to be inadequately rigid for closure. We now prefer fascia lata or Dura-Guard. In addition, we routinely use DuraSeal rather than fibrin glue, which we believe produces a more watertight closure. There were no delayed CSF leaks, and no lumbar drains were placed after surgery. The four patients with large craniopharyngiomas extending into the third ventricle (Cases 6–9) displayed panhypopituitarism and DI postoperatively, although the stalk was preserved in three of these patients. The patient with the Rathke cleft cyst (Case 10) experienced transient DI and hypocortisolemia, which resolved. One patient (Case 1) with a 4-cm tuberculum sellae meningioma also had DI, likely from trauma to a hypothalamic perforating artery.

## Discussion

The extended transsphenoidal approach expands operative exposure beyond the sella by removing the tuberculum sellae and the planum sphenoidale.[11,46] 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 transseptal approach.[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.[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.[1,15,17] In fact, Frank et al.[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."[9,16,35–37]

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.[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.[2,8,36,41] 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.[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.[12,29]

Microscope-based removal of purely suprasellar craniopharyngiomas and meningiomas has been associated with a

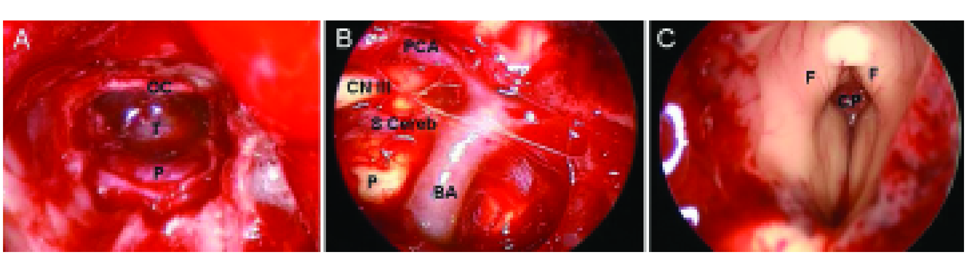


FIG. 6. Endoscopic images showing views seen during removal of a craniopharyngioma. A: The planum has been removed, and the tumor (T) is clearly seen between the optic chiasm (OC) and pituitary gland (P). B: Once the tumor is removed, a look downward with an angled scope reveals the pons (P) and the basilar artery (BA) and its branches, the posterior cerebral artery (PCA) and superior cerebellar artery (S Cereb) with the third cranial nerve (CN III). C: Looking upward with the angled endoscope reveals complete tumor removal from the third ventricle wall, and the fornices (F) and choroid plexus (CP) are clearly seen.

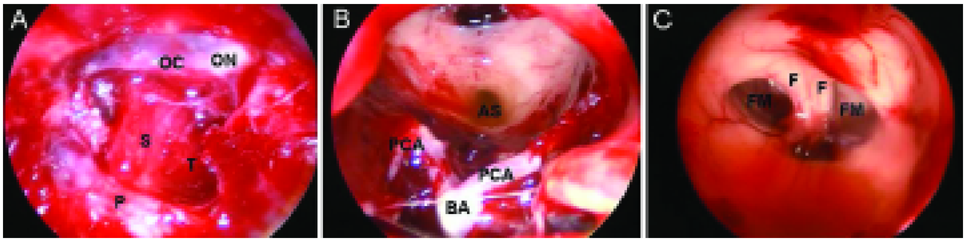


FIG. 7. Endoscopic images demonstrating views seen during removal of a craniopharyngioma. A: The planum sphenoidale has been removed, and the tumor (T) is clearly seen behind the stalk (S) and below the optic chiasm (OC) and optic nerve (ON) but above the pituitary gland (P). B: Once the tumor is removed, 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.

20 to 33% rate of CSF leakage[13,39] and a gross-total resection rate of only 22 to 46%.[13,39] For craniopharyngiomas, postoperative DI and panhypopituitarism develop in approximately 70% of cases.[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.[33,34] Note that several authors[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.[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

TABLE 1

*Summary of characteristics and outcome in patients with suprasellar tumors**

| Case No. | Age (yrs) | Lesion Location/Type | Presenting Symptoms | Lesion Size (cm)† | Stalk Preserved? | Lumbar Drain? | Closure Material | Complications: Short-Term‡ | Complications: Long-Term | FU (mos) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 73 | tuberculum sellae/ meningioma | visual loss | 3.5 | yes | yes | fat/DuraGen/vomer/ DuraGen/FG/FS | DI/CSF leak | DI | 12 |
| 2 | 40 | planum sphenoidale/ meningioma | visual loss | 3.7 | yes | no | fat/fascia lata/vomer/ DuraSeal/FS | none | none | 5 |
| 3 | 51 | tuberculum sellae/ meningioma | visual loss | 2.0 | yes | no | fat/fascia lata/vomer/ FG/FS | none | none | 9 |
| 4 | 66 | tuberculum sellae/ meningioma | visual loss | 2.6 | yes | no | fat/fascia lata/vomer/ DuraSeal/FS | none | none | 6 |
| 5 | 48 | planum sphenoidale/ meningioma | headache/enlarging mass | 1.2 | yes | yes | fat/vomer/FG/FS | none | none | 11 |
| 6 | 62 | suprasellar/cystic/ craniopharyngioma | visual loss/hyperphagia | 3.8 | yes | yes | vomer/fat/FG/FS | DI/↓cortisol/ ↓thyroid | DI/↓cortisol/ ↓thyroid | 13 |
| 7 | 38 | suprasellar/cystic/ craniopharyngioma | visual loss/DI | 3.6 | no | no | fascia lata/vomer/ DuraSeal/FS | DI/↓cortisol/ ↓thyroid/vasospasm | DI/↓cortisol/ ↓thyroid | 8 |
| 8 | 67 | suprasellar/cystic/ craniopharyngioma | visual loss/hyperphagia | 4.5 | yes | yes | Dura-Guard/mini-plate/fat/FG/FS | DI/↓cortisol/ ↓thyroid/MI | DI/↓cortisol/ ↓thyroid/SSS | 9 |
| 9 | 42 | suprasellar/solid/ craniopharyngioma | visual loss/hypopituitarism | 1.6 | yes | no | fascia lata/vomer/ DuraSeal/FS | DI/↓cortisol/ ↓thyroid | 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/ blurry vision | none | 23 |

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

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 buttressing 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 $T_1$-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 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


1. Alfieri A, Schettino R, Tarfani A, Bonzi O, Rossi GA, Monolo L: Endoscopic endonasal removal of an intra-suprasellar Rathke's cleft cyst: case report and surgical considerations. **Minim Invasive Neurosurg 45:**47–51, 2002
2. Andrews RJ, Bringas JR: A review of brain retraction and recommendations for minimizing intraoperative brain injury. **Neurosurgery 33:**1052–1064, 1993
3. Barrow DL, Spector RH, Takei Y, Tindall GT: Symptomatic Rathke's cleft cysts located entirely in the suprasellar region: review of diagnosis, management, and pathogenesis. **Neurosurgery 16:**766–772, 1985
4. Cappabianca P, Alfieri A, de Divitiis E: Endoscopic endonasal transsphenoidal approach to the sella: towards functional endoscopic pituitary surgery (FEPS). **Minim Invasive Neurosurg 41:** 66–73, 1998
5. Cappabianca P, Cavallo LM, Colao A, de Divitiis E: Surgical complications associated with the endoscopic endonasal transsphenoidal approach for pituitary adenomas. **J Neurosurg 97:** 293–298, 2002
6. Carrau RL, Jho HD, Ko Y: Transnasal-transsphenoidal endoscopic surgery of the pituitary gland. **Laryngoscope 106:**914–918, 1996
7. Chakrabarti I, Amar AP, Couldwell W, Weiss MH: Long-term neurological, visual, and endocrine outcomes following transnasal resection of craniopharyngioma. **J Neurosurg 102:**650–657, 2005
8. Ciric IS, Cozzens JW: Craniopharyngiomas: transsphenoidal method of approach—for the virtuoso only? **Clin Neurosurg 27:** 169–187, 1980
9. Cook SW, Smith Z, Kelly DF: Endonasal transsphenoidal removal of tuberculum sellae meningiomas: technical note. **Neurosurgery 55:**239–246, 2004
10. Cooke RS, Jones RA: Experience with the direct transnasal transsphenoidal approach to the pituitary fossa. **Br J Neurosurg 8:** 193–196, 1994
11. Couldwell WT, Weiss MH, Rabb C, Liu JK, Apfelbaum RI, Fukushima T: Variations on the standard transsphenoidal approach to the sellar region, with emphasis on the extended approaches and parasellar approaches: surgical experience in 105 cases. **Neurosurgery 55:**539–550, 2004
12. de Divitiis E, Cappabianca P, Cavallo LM: Endoscopic transsphenoidal approach: adaptability of the procedure to different sellar lesions. **Neurosurgery 51:**699–707, 2002
13. Dusick JR, Esposito F, Kelly DF, Cohan P, DeSalles A, Becker DP, et al: The extended direct endonasal transsphenoidal approach for nonadenomatous suprasellar tumors. **J Neurosurg 102:**832–841, 2005
14. Dyer EH, Civit T, Abecassis JP, Derome PJ: Functioning ectopic supradiaphragmatic pituitary adenomas. **Neurosurgery 34:** 529–532, 1994
15. Esposito F, Cappabianca P, Del Basso De Caro M, Cavallo LM, Rinaldi C, De Divitiis E: Endoscopic endonasal transsphenoidal removal of an intra-suprasellar schwannoma mimicking a pituitary adenoma. **Minim Invasive Neurosurg 47:**230–234, 2004
16. Fahlbusch R, Honegger J, Paulus W, Huk W, Buchfelder M: Surgical treatment of craniopharyngiomas: experience with 168 patients. **J Neurosurg 90:**237–250, 1999
17. Frank G, Sciarretta V, Mazzatenta D, Farneti G, Modugno GC, Pasquini E: Transsphenoidal endoscopic approach in the treatment of Rathke's cleft cyst. **Neurosurgery 56:**124–129, 2005
18. Gamea A, Fathi M, el-Guindy A: The use of the rigid endoscope in trans-sphenoidal pituitary surgery. **J Laryngol Otol 108:** 19–22, 1994
19. Gokalp HZ, Arasil E, Kanpolat Y, Balim T: Meningiomas of the tuberculum sella. **Neurosurg Rev 16:**111–114, 1993
20. Heilman CB, Shucart WA, Rebeiz EE: Endoscopic sphenoidotomy approach to the sella. **Neurosurgery 41:**602–607, 1997
21. Honegger J, Buchfelder M, Fahlbusch R: Surgical treatment of craniopharyngiomas: endocrinological results. **J Neurosurg 90:** 251–257, 1999
22. Jane JA Jr, Dumont AS, Vance ML, Laws ER Jr: The transsphenoidal transtuberculum sellae approach for suprasellar meningiomas. **Semin Neurosurg 14:**211–218, 2003
23. Jane JA Jr, Thapar K, Kaptain GJ, Laws ER Jr: The transsphenoidal transtuberculum sellae approach for suprasellar and midline anterior cranial fossa tumors. **Oper Techn Neurosurg 5:** 226–230, 2002
24. Jane JA Jr, Thapar K, Kaptain GJ, Maartens N, Laws ER Jr: Pituitary surgery: transsphenoidal approach. **Neurosurgery 51:** 435–434, 2002
25. Jankowski R, Auque J, Simon C, Marchal JC, Hepner H, Wayoff

M: Endoscopic pituitary tumor surgery. **Laryngoscope 102:** 198–202, 1992
26. Jho HD: Endoscopic transsphenoidal surgery. **J Neurooncol 54:** 187–195, 2001
27. Jho HD, Carrau RL: Endoscopic endonasal transsphenoidal surgery: experience with 50 patients. **J Neurosurg 87:**44–51, 1997
28. Jho HD, Carrau RL, Ko Y, Daly MA: Endoscopic pituitary surgery: an early experience. **Surg Neurol 47:**213–223, 1997
29. Jho HD, Ha HG: Endoscopic endonasal skull base surgery: Part 1—The midline anterior fossa skull base. **Minim Invasive Neurosurg 47:**1–8, 2004
30. Kaptain GJ, Vincent DA, Sheehan JP, Laws ER Jr: Transsphenoidal approaches for the extracapsular resection of midline suprasellar and anterior cranial base lesions. **Neurosurgery 49:** 94–101, 2001
31. Kato T, Sawamura Y, Abe H, Nagashima M: Transsphenoidal-transtuberculum sellae approach for supradiaphragmatic tumors: technical note. **Acta Neurochir (Wien) 140:**715– 719, 1998
32. Kim J, Choe I, Bak K, Kim C, Kim N, Jang Y: Transsphenoidal supradiaphragmatic intradural approach: technical note. **Minim Invasive Neurosurg 43:**33–37, 2000
33. Kitano M, Taneda M: Extended transsphenoidal approach with submucosal posterior ethmoidectomy for parasellar tumors. Technical note. **J Neurosurg 94:**999–1004, 2001
34. Kouri JG, Chen MY, Watson JC, Oldfield EH: Resection of suprasellar tumors by using a modified transsphenoidal approach. Report of four cases. **J Neurosurg 92:**1028–1035, 2000
35. Landolt AM, Zachmann M: Results of transsphenoidal extirpation of craniopharyngiomas and Rathke's cysts. **Neurosurgery 28:** 410–415, 1991
36. Laws ER Jr: Transsphenoidal microsurgery in the management of craniopharyngioma. **J Neurosurg 52:**661–666, 1980
37. Laws ER Jr: Transsphenoidal removal of craniopharyngioma. **Pediatr Neurosurg 21 (1 Suppl):**57–63, 1994
38. Liu JK, Das K, Weiss MH, Laws ER Jr, Couldwell WT: The history and evolution of transsphenoidal surgery. **J Neurosurg 95:** 1083–1096, 2001
39. Maira G, Anile C, Albanese A, Cabezas D, Pardi F, Vignati A: The role of transsphenoidal surgery in the treatment of craniopharyngiomas. **J Neurosurg 100:**445–451, 2004
40. Mason RB, Nieman LK, Doppman JL, Oldfield EH: Selective excision of adenomas originating in or extending into the pituitary stalk with preservation of pituitary function. **J Neurosurg 87:** 343–351, 1997
41. Page RB: Craniopharyngioma: indications for transsphenoidal surgery. **Curr Ther Endocrinol Metab 5:**33–34, 1994
42. Rodziewicz GS, Kelley RT, Kellman RM, Smith MV: Transnasal endoscopic surgery of the pituitary gland: technical note. **Neurosurgery 39:**189–193, 1996
43. Ross DA, Norman D, Wilson CB: Radiologic characteristics and results of surgical management of Rathke's cysts in 43 patients. **Neurosurgery 30:**173–179, 1992
44. Shikani AH, Kelly JH: Endoscopic debulking of a pituitary tumor. **Am J Otolaryngol 14:**254–256, 1993
45. Shillito J Jr: Craniopharyngiomas: the subfrontal approach, or none at all? **Clin Neurosurg 27:**188–205, 1980
46. Weiss M: Transnasal transsphenoidal approach, in Apuzzo MLJ (ed): **Surgery of the Third Ventricle.** Baltimore: Williams & Wilkins, 1987, pp 476–494
47. Wurster CF, Smith DE: The endoscopic approach to the pituitary gland. **Arch Otolaryngol Head Neck Surg 120:**674, 1994
48. Yaşargil MG, Curcic M, Kis M, Siegenthaler G, Teddy PJ, Roth P: Total removal of craniopharyngiomas. Approaches and long-term results in 144 patients. **J Neurosurg 73:**3–11, 1990

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