Resection of suprasellar tumors by using a modified transsphenoidal approach

Report of four cases

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Generally accepted contraindications to using a transsphenoidal approach for resection of tumors that arise in or extend into the suprasellar region include a normal-sized sella turcica, normal pituitary function, and adherence of tumor to vital intracranial structures. Thus, the transsphenoidal approach has traditionally been restricted to the removal of tumors involving the pituitary fossa and, occasionally, to suprasellar extensions of such tumors if the sella is enlarged. However, conventional transcranial approaches to the suprasellar region require significant brain retraction and offer limited visualization of contralateral tumor extension and the interface between the tumor and adjacent structures, such as the hypothalamus, third ventricle, optic apparatus, and major arteries. In this paper the authors describe successful removal of suprasellar tumors by using a modified transsphenoidal approach that circumvents some of the traditional contraindications to transsphenoidal surgery, while avoiding some of the disadvantages of transcranial surgery.

Four patients harbored tumors (two craniopharyngiomas and two hemangioblastomas) that arose in the suprasellar region and were located either entirely (three patients) or primarily (one patient) within the suprasellar space. All patients had a normal-sized sella turcica. Preoperatively, three of the four patients had significant endocrinological deficits signifying involvement of the hypothalamus, pituitary stalk, or pituitary gland. Two patients exhibited preoperative visual field defects. For tumor excision, a recently described modification of the traditional transsphenoidal approach was used. Using this modification, one removes the posterior portion of the planum sphenoidale, allowing access to the suprasellar region. Total resection of tumor was achieved (including absence of residual tumor on follow-up imaging) in three of the four patients. In the remaining patient, total removal was not possible because of adherence of tumor to the hypothalamus and midbrain. One postoperative cerebrospinal fluid leak occurred. Postoperative endocrinological function was worse than preoperative function in one patient. No other new postoperative endocrinological or neurological deficits were encountered.

This study demonstrates the feasibility of using a modified transsphenoidal approach for resection of certain suprasellar, nonpituitary tumors.

Key Words • suprasellar tumor • craniopharyngioma • hemangioblastoma • von Hippel-Lindau disease • transsphenoidal approach

Abbreviations used in this paper: CNS = central nervous system; CSF = cerebrospinal fluid; CT = computerized tomography; DI = diabetes insipidus; ICA = internal carotid artery; MR = magnetic resonance.
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cica of normal size and nonadenomatous tumors located either entirely (three patients) or predominantly (one patient) within the suprasellar region underwent transsphenoidal tumor resection at our institution. Two of the four patients had craniopharyngiomas. One of these tumors was entirely suprasellar and the other was both intrasellar and suprasellar. The other two patients each had von Hippel–Lindau disease and suprasellar CNS hemangioblastomas.

Imaging Studies

All four patients underwent standard preoperative and follow-up MR imaging with a 1.5-tesla imaging system (Signa; General Electric, Minneapolis, MN) with and without administration of an intravenous contrast agent (gadolinium–diethylenetriamine pentaacetic acid [Magnevist, 0.1 mmol/kg body weight; Burlex Lab, Wayne, NJ]). All follow-up images were reviewed for evidence of residual tumor by the surgical team and by a staff neuroradiologist.

Surgical Technique

All surgical procedures were performed by the same surgeon (E.H.O.). A sublabial transeptal transsphenoidal approach was used to reach the sella. In contrast to traditional transsphenoidal surgery directed at intrasellar lesions, a modified version of this approach was used, as previously described. This involved wide bone exposure of the anterior surface of the sella to expose the medial portion of each cavernous sinus, followed by removal of the posterior portion (approximately 4–10 mm) of the planum sphenoidale. The removal of the planum sphenoidale was accomplished by thinning the bone with a high-speed drill and, subsequently, using a 2-mm-thin-footplate Kerrison rongeur to remove the remaining bone. The dura overlying the planum sphenoidale was opened, providing access to the suprasellar cistern. For additional exposure (required in all cases except Case 4, in which the most posterior aspect of the tumor was anterior to the optic chiasm), the dura covering the anterior surface of the pituitary gland was also opened. The anterosuperior intercavernous portion of the circular sinus was divided and either coagulated or filled with small pieces of Gelfoam; the exposed diaphragma sellae was incised in an anteroposterior direction along the midline to the anterior surface of the pituitary stalk. The remainder of the tumor dissection was performed under direct vision by using standard microsurgical technique to separate the tumor margin from adjacent vascular and neural structures. The lateral limits to this exposure in the region of the tuberculum sellae are the medial margins of the optic nerves as they enter the optic canal. Depending on the position of the intracavernous portion of the ICA, the most medial portion of the superior segment of the intracavernous ICA may also limit the lateral extent of the exposure in some patients. Following dissection, the defect left by the dural opening was plugged with a graft of autologous abdominal fat that was held in place by a strut of the vomer. Several days (4–days) of postoperative CSF drainage were required in all patients.

Summary of Cases

Case 1

This 14-year-old girl was referred to our institution for treatment of an enlarging suprasellar mass, diagnosed as a craniopharyngioma. The tumor had first been discovered on a CT scan obtained 5 years before admission during evaluation of a learning disability.

Examination. Additional evaluation revealed mild bilateral quadrantanopsia and growth failure with laboratory evidence of growth hormone deficiency. The patient’s neurological function and endocrinological axes were otherwise intact. A preoperative MR image (Fig. 1) revealed a normal-sized sella and a 2.6 × 2.3 × 2-cm heterogeneously enhancing suprasellar mass that extended from the diaphragma sellae to the hypothalamus and compressed the optic chiasm.

Operation. During surgery a normal-sized sella was not evident and exposure of the craniopharyngioma was achieved using the modified transsphenoidal approach described earlier. The tumor was located posterior and lateral to the pituitary stalk. It thus displaced the stalk superiorly and to the left and impinged on the inferior surface of the optic chiasm. Areas of significant calcification were evident and, because of its large size, the tumor was resected in a piecemeal fashion. The dissection was aided by direct visualization of the interface between the tumor and both the optic chiasm and pituitary stalk. Anatomical preservation of the pituitary gland and stalk was attained and total removal of the tumor was achieved (Table 1).
Postoperative Course. After surgery, the patient’s mild bitemporal quadrantanopsia remained unchanged. In addition, she experienced panhypopituitarism, including persistent DI. This condition remained at the time of her most recent follow-up visit (7 months postoperatively). Magnetic resonance images obtained 7 months postoperatively (Fig. 1) demonstrated no evidence of residual tumor (Table 2).

Case 2

This 9-year-old boy was referred for treatment of an intra- and suprasellar mass that had been diagnosed as a craniopharyngioma. The patient’s initial symptoms included polydipsia and polyuria, which had begun 4 years previously.

Examination. By the time the tumor was discovered on a CT scan obtained 4 months preoperatively, the patient’s deficits included a bitemporal hemianopsia, DI, and panhypopituitarism. The preoperative contrast-enhanced T2-weighted MR image (Fig. 2) revealed a 3.1 × 3.1 × 2-cm (longest axis 3.5 cm) intra- and suprasellar multilobulated hyperintense mass.

Operation. Because of the rather significant anterior extension of the tumor (along the inferior surface of the frontal lobes), it was necessary during surgery to extend bone removal of the planum sphenoidale anteriorly approximately 5 to 10 mm (for a total of 10–15 mm). Using this additional exposure, the anterior margin of the tumor was reached. In addition, because of the patient’s preoperative panhypopituitarism and to gain exposure to the posterior aspect of the tumor, hypophysectomy was performed. During the dissection, dense adhesions were encountered between the tumor and the carotid arteries, the A1 segments of the anterior cerebral arteries, the optic chiasm and nerves, the hypothalamus, and the midbrain. Sharp and blunt microdissection allowed separation of the tumor from the hypothalamus and other intracranial structures under direct vision. However, a definitive surgical plane could not be established along the deepest portion of the tumor. Thus, although no gross residual tumor was evident, the surgeon believed the dissection to be subtotal (with likely residual tumor).

Postoperative Course. After surgery the patient exhibited no new neurological or endocrinological deficits. As expected, residual tumor along the roof of the suprasellar cistern (just inferior to the hypothalamus and frontal lobes) was evident on MR imaging (Fig. 2). As a result, serial follow-up MR imaging is planned, depending on the presence and rate of tumor growth; when the patient is older a course of external-beam radiotherapy may be planned.

Case 3

This 20-year-old woman with von Hippel–Lindau disease was referred for treatment of a suprasellar mass.

Examination. The patient initially presented with secondary amenorrhea and polydipsia. Further workup confirmed DI and panhypopituitarism. Preoperative MR im-

### TABLE 1

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Surgical Findings</th>
<th>Anatomical Tumor Dissection From Pituitary Gland &amp; Stalk or Chiasm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>partially calcified craniopharyngioma causing optic chiasm impingement &amp; pituitary stalk displacement</td>
<td>normal</td>
</tr>
<tr>
<td>2</td>
<td>craniopharyngioma causing pituitary gland compression &amp; dense adherence to vital intracranial structures (necesitating sharp dissection); hypophysectomy &amp; extension of planum sphenoidale bone removal were required</td>
<td>normal</td>
</tr>
<tr>
<td>3</td>
<td>1.2- to 1.5-cm hemangioblastoma at base of hypothalamus involving third ventricle &amp; causing pituitary stalk attenuation; removal required sectioning of anterior half of pituitary stalk</td>
<td>normal (partial stalk preservation)</td>
</tr>
<tr>
<td>4</td>
<td>hemangioblastoma embedded in inferior portion of lt optic nerve</td>
<td>normal</td>
</tr>
</tbody>
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### TABLE 2

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Preoperative Deficits</th>
<th>New Postop Deficits</th>
<th>Complications</th>
<th>Extent of Resection (intraop judgment)</th>
<th>Follow-Up MR Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GH deficiency, learning disorder, mild bitemporal quadrantanopsia</td>
<td>panhypopituitarism, DI</td>
<td>none</td>
<td>total</td>
<td>no residual tumor at 7 mos postop</td>
</tr>
<tr>
<td>2</td>
<td>panhypopituitarism, DI, bitemporal hemianopsia</td>
<td>none</td>
<td>none</td>
<td>subtotal</td>
<td>minimal residual tumor at 5 days postop</td>
</tr>
<tr>
<td>3</td>
<td>panhypopituitarism, DI</td>
<td>none</td>
<td>none</td>
<td>total</td>
<td>no residual tumor at 53 mos postop</td>
</tr>
<tr>
<td>4</td>
<td>none</td>
<td>none</td>
<td>CSF leak</td>
<td>total</td>
<td>no residual tumor at 12 mos postop</td>
</tr>
</tbody>
</table>

* GH = growth hormone.
aging (Fig. 3) revealed a 6-mm contrast-enhancing mass of the tuber cinereum, located immediately posterior to the optic chiasm. Also noted were two small contrast-enhancing masses in the right cerebellar hemisphere, which were consistent with a diagnosis of hemangioblastoma. The size of the sella appeared normal on sagittal MR imaging.

**Operation.** During surgery a 1.2- to 1.5-cm hemangioblastoma was found at the base of the patient’s hypothalamus, extending superiorly into the third ventricle. The tumor displaced an attenuated pituitary stalk at the level of the tuber cinereum. An operative corridor was achieved.

**Postoperative Course.** After surgery the patient continued to have panhypopituitarism and DI. Follow-up MR imaging performed postoperatively and 7 and 53 months later revealed no evidence of residual tumor.

**Case 4**

This 15-year-old girl with von Hippel–Lindau disease was referred for evaluation of multiple CNS lesions. She had initially presented with multiple retinal hemangioblastomas, which were discovered during a routine eye examination.

**Examination.** Subsequent workup confirmed the presence of von Hippel–Lindau disease. Preoperatively, the patient did not experience any neurological or endocrinological deficits. Magnetic resonance imaging revealed a 1-cm contrast-enhancing lesion in the vermis and another 7 × 14-mm contrast-enhancing lesion in the suprasellar region, along the inferior surface of the left optic nerve and compressing it (Fig. 4). The size of the sella appeared normal on sagittal MR imaging.

**Operation.** During surgery a hemangioblastoma was identified in the suprasellar space (Fig. 5). The tumor’s superior margin was embedded in the inferior surface of the left optic nerve and appeared to arise from the pia of the inferior surface of the nerve. The tumor extended laterally to the medial margin of the left ICA, medially to the pituitary stalk, and posteriorly to the optic chiasm. The transsphenoidal exposure allowed for dissection of the interface between the tumor and the optic nerve, while these structures could be directly observed without retraction of the optic system. Total removal of tumor was achieved.

**Postoperative Course.** This patient’s postoperative course was complicated by CSF rhinorrhea, which required an additional transsphenoidal procedure to repair the leak (performed on postoperative Day 6). Her postoperative course was otherwise unremarkable and the patient remained free from neurological or endocrinological deficits. No residual tumor was detected on immediate postoperative MR images or on follow-up MR images obtained 12 months postoperatively (Fig. 4).

**Discussion**

We recently reported on the use of a modified transsphenoidal approach in the treatment of 10 patients with...
contrast-enhanced T1-weighted MR images. The preoperative images resulting in infarction, hematoma, or regional brain atrophy. This is a major source of iatrogenic brain injury, potentially retraction of the temporal lobe. Brain retraction continues to be a major source of iatrogenic brain injury, potentially resulting in infarction, hematoma, or regional brain atrophy.

The postoperative images (B and D) confirm total removal of the enhancing mass along the inferior surface of the left optic nerve. (A and C) reveal a 1.4-cm-diameter densely and homogeneously enhancing mass along the inferior surface of the left optic nerve. The postoperative images (B and D) confirm total removal of the hemangioblastoma.

pituitary adenomas involving the pituitary stalk. In a subsequent technical note, Kato, et al., described application of this approach to the resection of other types of suprasellar tumors. The four cases discussed in the present report provide additional evidence, with details of visual and endocrinological functions, demonstrating the feasibility of using this technique to remove nonpituitary tumors that arise in the suprasellar region. In this section we will discuss several theoretical advantages of this transsphenoidal route over traditional transcranial approaches. For the sake of discussion, we will separate these advantages into two groups: those associated with the safety of the approach and those concerning the superior exposure that can be achieved. Last, we discuss the significance and potential applications of the procedure.

Safety of the Modified Transsphenoidal Approach

Because of the nature and location (infra-diaphragmatic) of the select group of tumors that previously have been removed transsphenoidally, we cannot directly compare the results of these operations with those obtained through transcranial surgery. However, it is clear that transcranial approaches to the suprasellar region involve certain risks. For instance, the midline subfrontal approach necessitates retraction of the frontal lobes. The perional approach requires separation of the sylvian fissure and retraction of the frontal and temporal lobes. Likewise, the subtemporal approach requires significant retraction of the temporal lobe. Brain retraction continues to be a major source of iatrogenic brain injury, potentially resulting in infarction, hematoma, or regional brain atrophy. It has been estimated that approximately 10% of all major cranial base tumor procedures result in some form of retraction-induced injury. Transsphenoidal procedures carry their own inherent risks. These include persistent postoperative CSF rhinorrhea and postoperative meningitis. Because the subarachnoid space is deliberately entered during this modified procedure, the surgeon must manage the large opening in the arachnoid made at surgery. However, the consequences of these complications are, in general, less significant and less permanent than those of transcranial surgery. This is supported by the minimal risks of perioperative morbidity and mortality associated with transsphenoidal surgery. In addition, transsphenoidal procedures are generally more direct and less time consuming than transcranial operations. These observations have led to the generally accepted notion that, when safe removal is possible through a transsphenoidal approach, it is preferred over a transcranial one.

Although supratentorial hemangioblastomas are rare in general, suprasellar (Cases 3 and 4) and intracranial optic nerve (Case 4) hemangioblastomas are exceedingly rare, even in patients with von Hippel–Lindau disease. When diagnosed antemortem, these tumors have been removed transcranially. For resection of craniopharyngiomas that arise in the sella and are associated with sellar enlargement, many surgeons prefer a transsphenoidal route for tumor removal. However, transsphenoidal surgery is generally avoided in patients with a normal-sized sella, in growing children, and in patients with normal preoperative pituitary function. This avoidance stems from fears of damage to the hypothalamopituitary axis that can occur with an entirely transsellar exposure of the suprasellar space. Unfortunately, transcranial surgery also produces endocrinological deficiency. Using the modified transsphenoidal approach in the present cases demonstrated that it is possible to remove supra-diaphragmatic tumors while preserving remaining normal pituitary tissue, even in the context of a normal-sized sella.

Surgical Exposure

It has generally been agreed that an enlarged sella is an absolute requirement for safe transsphenoidal access to the suprasellar region. This rationale stems from the need for a wide operative exposure to allow visualization of vital neurovascular structures in the region. Accordingly, it is the limitation of exposure (even with an enlarged sella) that is attained via the conventional transsphenoidal route that has been the primary basis for resorting to transcranial approaches. This is especially so in cases in which the tumor arises or extends superior to the diaphragma sella and, thus, directly interfaces with vital intracranial structures such as the optic apparatus, the hypothalamus, or the vessels of the circle of Willis. Our modification of the transsphenoidal approach allows for sufficient exposure and removal of certain suprasellar tumors regardless of sellar size or the presence of supra-diaphragmatic involvement.

Although detailed descriptions are beyond the scope of this report, all available transcranial approaches to the su-
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**Fig. 5.** Case 5. Operative photographs and corresponding drawings from Case 4. A: Following removal of the arachnoid, the hemangioblastoma and its relationship to surrounding structures is evident. Note the tumor, diaphragm sellae, left optic nerve, optic chiasm, right optic nerve, and base of the frontal lobes. Also note Gelfoam (asterisk) providing hemostasis in the superior intercavernous sinus at its junction with the left cavernous sinus. B: The surgical exposure allowed direct visualization of the interfaces between the tumor and the left optic nerve and between the tumor’s lateral edge and the left ICA. A microsuction device and cottonoid are used to retract the tumor.
prasedellar region carry limitations in the degree of exposure that can be attained, primarily because of the angle of approach. Furthermore, in general, transcranial surgery may result in difficulties due to confusing anatomical relationships (secondary to the oblique angle of approach), poor visualization of contralateral structures or the posterior aspect of ipsilateral structures, and the need to perform surgery over or between nerves and arteries. In contrast, the modified transsphenoidal approach described here offers unparalleled exposure of some suprasellar lesions. For instance, the exposure achieved through this route is not only bilateral, but is also directed straight to the inferior aspect of the base of the brain. Thus, the anatomical relationships are placed in a familiar orientation and problems with visualization can be avoided. By placing these structures under the surgeon’s direct view, the risks of dissecting and tearing tumor involving the optic system, pituitary stalk, hypothalamus, third ventricle, and brainstem.

**Potential Applications of the Modified Transsphenoidal Approach**

The tumors removed using this modified transsphenoidal approach were carefully chosen. Each tumor was relatively small and had a reasonably direct suprasellar extension. Despite this selectivity, the potential applications of the procedure remain significant, especially for treatment of craniopharyngiomas. Of all tumors in the sellar–chiasmatic region, craniopharyngiomas account for the majority of those in children and approximately 20% of those in adults. Approximately two thirds of craniopharyngiomas arise above the diaphragma sellae, thereby leaving the sella normal in size (or even smaller than normal due to impairment in hypophysiotrophic stimulation). Thus, a significant percentage of tumors that previously would have been considered unapproachable transsphenoidally may be ideally situated for removal using this technique. Moreover, several other, less common suprasellar lesions can be approached for excision or direct biopsy by using a transsphenoidal route. These include Rathke’s cleft cysts, optic chiasm or posterior optic nerve gliomas, hypothalamic-chiasmatic tumors of childhood, germomas, granular cell tumors, meningiomas, pituitary adenomas, hemangioblastomas, metastatic lesions, and even certain aneurysms in critical positions.

The limitations of the approach will become more apparent with increasing experience. Among those evident from the cases presented here are: 1) lateral extension beyond the site of intracranial dural penetration by the ICA or by the optic nerves into the optic canals; and 2) a tumor lying behind the pituitary stalk in a patient with normal pituitary function in whom tumor removal may be successful with preservation of pituitary function when a lateral approach is used.

Conclusions

Four patients who underwent a modified transsphenoidal procedure for resection of entirely or primarily suprasellar tumors are presented to illustrate the feasibility and possible advantages this approach has over traditional transcranial approaches. This modification circumvents several commonly cited contraindications to transsphenoidal surgery, including those of a normal-sized sella, normal pituitary function, and adherence of the tumor to vital intracranial structures. In addition, it offers several advantages over transcranial surgery, including lack of brain retraction and a wide bilateral operative exposure that allows for direct visualization of suprasellar neurovascular structures. We believe this modified transsphenoidal approach is the preferred method for removing certain of these tumors. Although these results demonstrate its feasibility, further study is necessary before firm conclusions can be reached regarding the efficacy, morbidity, and appropriate case selection for this procedure.

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**References**

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