The extended direct endonasal transsphenoidal approach for nonadenomatous suprasellar tumors

Joshua R. Dusick, M.D., Felice Esposito, M.D., Daniel F. Kelly, M.D., Pemian Cohan, M.D., Antonio Desalles, M.D., Donald P. Becker, M.D., and Neil A. Martin, M.D.

Departments of Neurosurgery and Endocrinology, University of California at Los Angeles School of Medicine; and UCLA Pituitary Tumor and Neuroendocrine Programs, and UCLA Gonda Diabetes Center, Los Angeles, California

Object. The extended transsphenoidal approach, which requires a bone and dural opening through the tuberculum sellae and posterior planum sphenoidale, is increasingly used for the treatment of nonadenomatous suprasellar tumors. The authors present their experiences in using the direct endonasal approach in patients with nonadenomatous suprasellar tumors.

Methods. Surgery was performed with the aid of an operating microscope and angled endoscopes were used to assess the completeness of resection. Bone and dural defects were repaired using abdominal fat, collagen sponge, titanium mesh, and, in most cases, lumbar drainage of cerebrospinal fluid (CSF).

Twenty-six procedures for tumor removal were performed in 24 patients (ages 9–79 years), including two repeated operations for residual tumor. Gross-total removal could be accomplished in only 46% of patients, with near-gross-total removal or better in 74% of 23 patients (five of eight with craniopharyngiomas, six of seven with meningiomas, five of six with Rathke cleft cysts, and one of two with a dermoid or epidermoid cyst); a patient with a lymphoma only underwent biopsy. Of 13 patients with tumor-related visual loss, 85% improved postoperatively. The complications that occurred included five patients (21%) with postoperative CSF leaks, one patient (4%) with bacterial meningitis; five patients (21%) with new endocrinopathy; and two patients (8%) who needed to undergo repeated operations to downsize suprasellar fat grafts. The only permanent neurological deficit was anosmia in one patient; there were no intracranial vascular injuries.

Conclusions. The direct endonasal skull-base approach provides an effective minimally invasive means for resecting or debulking nonadenomatous suprasellar tumors that have traditionally been approached through a sublabial or transcranial route. Procedures in the supraglandular space can be performed effectively with excellent visualization of the optic apparatus while preserving pituitary function in most cases. The major challenge remains developing consistently effective techniques to prevent postoperative CSF leaks.

Key Words • extended transsphenoidal surgery • endonasal approach • suprasellar tumor • meningioma • craniopharyngioma • Rathke cleft cyst

The transsphenoidal route has been the favored approach for resection of most intrasellar tumors for longer than three decades.46,48 For many nonadenomatous suprasellar tumors, however, the transcranial route, taken either by performing a petrotemporal or subfrontal approach, has continued to be used by a majority of neurosurgeons. More recently, a modification of the transsphenoidal approach that allows additional exposure of the suprasellar space has been followed for various pathological conditions such as tuberculum sellae meningiomas, craniopharyngiomas, and supraglandular Rathke cleft cysts.51,61 Termed the extended transsphenoidal approach and originally described by Weiss41 in 1987, this approach requires removal of additional bone along the tuberculum sellae and the posterior planum sphenoidale with subsequent opening of the dura mater above the diaphragma sellae. This route allows excellent midline access and visibility to the suprasellar space while obviating brain retraction. The technique does require a large opening in the dura mater over the tuberculum sellae and the posterior planum sphenoidale and typically results in large intraoperative CSF leaks, which necessitate precise and effective dural closure to prevent a postoperative CSF fistula and meningitis.

In all early reports of this technique, with the exception of those by de Divitiis, et al.,15 and Jho and Ha,24 who used an endonasal endoscopic approach, the technique is described in conjunction with a sublabial or transcolumellar (transseptal) endonasal route. We recently reported our experience with the extended transsphenoidal approach in which we used a direct endonasal route for three patients with tuberculum sellae meningiomas.32 This more minimally invasive transsphenoidal approach was originally described by Griffith and Veerapen33 in 1987 and is being increasingly used for sellar lesions. Our report and those by others grow on the extended approach have been technical notes or small case series in which the largest included 14 patients. Here we present our initial experience with the extended direct endonasal transsphenoidal route in 24 patients with suprasellar nonadenomatous lesions. Attention is focused on tumor removal rates, visual recovery, technical complications, and postoperative neuroendocrine function.

Abbreviations used in this paper: CA = carotid artery; CSF = cerebrospinal fluid; DI = diabetes insipidus; MR = magnetic resonance.
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Clinical Material and Methods

Patient Population

All patients who had undergone an extended transsphenoidal approach via the direct endonasal approach for tumor removal and who participated in at least 3 months of follow-up review were identified since we began using this technique in June 2000. Patients with a diagnosis of pituitary adenoma were excluded from this analysis. The Institutional Review Board of the University of California at Los Angeles approved the retrospective review and analysis of the patient data.

Surgical Technique

The direct endonasal approach, as described previously, was used in all cases by using the operating microscope and endoscope to guide tumor removal. Surgical navigation was used in all cases; in 21 cases this included only fluoroscopy, whereas more recently computerized surgical navigation (BrainLab VectorVision cranial; Westchester, IL) was used in eight cases. In two cases surgery was performed in an operating–MR imaging suite for intraoperative assessment of completeness of tumor removal.

Endonasal Approach to the Planum. The nostril chosen for the approach was based on the location of the tumor. For tumors projecting more to one side, the contralateral nostril was used, given that a greater contralateral sellar and suprasellar exposure is provided than an ipsilateral exposure. Briefly, the initial approach through the nostril was performed using a hand-held speculum, which was then replaced by a thin, modified Hardy speculum (Aesculap, Tuttingen, Germany, or Mizuho-America, Beverly, MA). The Hardy speculum was placed facing the sphenoid bone and angled more superiorly than one would for a sellar lesion, aiming toward the junction of the sphenoid sellae and the planum sphenoidale. After the sphenoid sinus had been opened widely, the face of the sella turcica was removed. The extent of the bone removal was lengthened anteriorly through the sphenoid sellae and proximal planum sphenoidal by using a Kerrison bone punch and/or a transsphenoidal drill (MicroMax; Anspach, Palm Beach Gardens, FL). The removal of the planum sphenoidale is limited laterally by the optic canals (Fig. 1). During this bone removal, care must be taken to avoid placing the Kerrison bone punch or the drill lateral to the medial border of the optic canals, which could potentially injure an optic nerve. Based on cadaveric dissections performed using this approach by Jho and Ha and by Rhoton’s group the medial edges of the optic canals at their most posterior extent (at the level of the intracranial opening of the optic canal) are 14 to 18 mm apart on average. Immediately inferior to the optic canals, the width-limiting structures are the cavernous CAs and their initial intracranial portions, which on average are 13.9 to 17 mm apart.

Difficulties Encountered With Exposure. Using the direct endonasal approach, the greatest exposure difficulties are encountered in trying to establish adequate visualization of the posterior planum and the ipsilateral intra- and suprasellar spaces. Regarding exposure of the posterior planum, if a difficulty is encountered in establishing a sufficient cephalad trajectory of the speculum, the speculum can be rotated 15 to 30° in either direction until a more stable fit is established in the appropriate trajectory. Additional removal of the sphenoid keel and the mucosa overlying it superiorly will extend the visible field toward the sphenoid roof even if the speculum remains aimed in a somewhat lower trajectory. One or two cottonoids can also be placed inferiorly beneath the speculum blades to help bolster its position in a more cephalad trajectory to prevent slippage in an inferior direction. A final alternative to achieving sufficient cephalad exposure is to wedge the distal end of the speculum blades within the bony edges of the sphenoidotomy. This maneuver, however, is generally not recommended, given the potential risk of fracturing the skull base through the optic canals with forceful opening of the speculum.

Regarding ipsilateral exposure, adequate bone removal of the ipsilateral sphenoid bone, the face of the sella turcica, and the lateral tuberculum sellae and planum is essential.
Image guidance can be very helpful to determine how much additional bone can be removed in these areas. Additionally, the micro-Doppler probe, as noted below, can be used to define the location of the cavernous CAs. If the artery is not audible with a given exposure, more bone can often be removed laterally. Because the approach superiorly is rather narrow and limited laterally by the optic canals and the CAs (averaging 15–16 mm), however, both the ipsilateral and contralateral ends of this exposure have generally been adequate.

**Dural Opening and Tumor Removal.** After adequate bone removal, the micro-Doppler probe was used to locate the cavernous CA before opening the dura mater to demarcate the safe lateral limit of the sellar opening. Depending on the nature and exact location of the tumor, the initial dural opening was either made in the sellar dura and then extended above and through the diaphragma sellae or only above the diaphragma sellae. When the dural opening was extended across the diaphragma sellae, bleeding from the superior circular sinus (also known as the anterior intercavernous sinus) was controlled using Gelfoam and bipolar cautery.

Tumor removal proceeded in the supraglandular space with care being taken to respect the arachnoid planes laterally and superiorly and to avoid injury to the pituitary gland, which in most cases was located inferiorly and posteriorly with respect to the tumor. Given the rubbery, fibrous, and/or partially calcified nature of many tumors in this series, particularly meningiomas and craniopharyngiomas, sharp dissection using curved and straight microscissors along the arachnoid planes and within the tumor cavity itself was often required for removal. An effort was made in every case to identify the pituitary stalk and its site of insertion to the pituitary gland early in the dissection and to avoid traction on the stalk during tumor removal. In some cases, an anterior–superior incision was made in the anterior pituitary gland to facilitate exposure directly above the gland and to minimize traction on the gland and the pituitary stalk. When the tumor or cyst lining remained densely adherent to the stalk or optic chiasm despite attempts to remove them with sharp dissection, these remnants were left in the hopes of preserving pituitary function and avoiding new visual deficits. Angled 30 or 45˚ 4-mm rigid endoscopes (Karl Storz, Tuttingen, Germany) were used to assess the completeness of tumor removal and to help determine the tumor–neurovascular relationships.

Following tumor removal, the bone or dural defects were repaired in all but one case by using an abdominal fat graft placed in the suprasellar space followed by a collagen sponge (Helistat; Integra Life-Sciences Corp., Plainsboro, NJ) and a titanium mesh buttress (MicroMesh 0.2 mm, Styer-Leibinger, Kalamazoo, MI), which was wedged in the epidural space. Additional fat was typically placed in the sphenoid sinus. Tissue glue was used inconsistently (five cases). In most cases, lumbar CSF drainage was also used for 2 to 3 days. Nasal packing was placed for 24 to 48 hours in the first five patients in the series but not in the subsequent 19 patients. A prophylactic intravenous antibiotic agent (cefazolin) was administered for 24 hours after surgery or until the lumbar drain was removed.

**Results**

**Study Population**

Over a 4-year period, 24 patients (median age 45 years [range 9–79 years]; 13 female and 11 male patients) underwent 26 procedures for tumor removal. Diagnoses included eight craniopharyngiomas, seven tuberculum sellae meningiomas, six Rathke cleft cysts, one suprasellar dermoid cyst, one extensive suprasellar/retrostellar/prepontine epidermoid tumor, and one metastatic non-Hodgkin B-cell lymphoma.
Three of the patients with tuberculum sellae meningiomas were previously described by Cook, et al., in a technical note. Two patients, both with craniopharyngiomas, underwent early repeated operations for residual tumor left at the initial surgery. Six patients (25%) had undergone surgery previously at other institutions; four were craniotomies and two were sublabial transsphenoidal procedures. The maximal tumor diameter ranged from 7 to 66 mm (median 20 mm); 62% of patients harbored tumors that were 20 mm or greater in maximal dimension (Table 1).

Tumor Removal Rates

Based on MR images obtained 3 months postoperatively, gross-total tumor removal was accomplished in 11 (46%) of 24 patients (Table 2). Of the 23 patients in whom total removal was the goal, a gross-total or a near-gross-total removal was achieved in 17 (74%).

Patients With Craniopharyngiomas

In only one (12.5%) of eight patients harboring a craniopharyngioma was tumor removal complete; in four patients near-gross-total removal was accomplished and in three subtotal removal was obtained (median follow-up period 7 months; range 3–28 months). All seven patients in whom tumor removal was incomplete had harbored large tumors with a mean maximal diameter of 37 mm, including two who had undergone a prior craniotomy. Of these seven patients, the four in whom near–gross total removal had been accomplished all had minute tumor fragments densely attached to either the optic chiasm (two patients) or the pituitary stalk (two patients) that were intentionally left behind. The three patients in whom subtotal removal was obtained included a 9-year-old girl who had a maximal 60-mm-diameter tumor with a large component invading the left cavernous sinus and a tumor cyst extending into the left temporal lobe. Another patient in whom a subtotal removal had been accomplished was a 79-year-old man with a 40-mm tumor (Fig. 2). Of the seven patients in whom removal was incomplete (except one who was lost to follow up 6 months after surgery), five were eventually treated with fractionated stereotactic radiotherapy with a linear accelerator (Novalis Shaped Beam Surgery; BrainLAB, Inc., Westchester, IL) and one is being followed with serial MR images to monitor for recurrence (Fig. 3).

Patients With Meningiomas

Four (57%) of seven patients with meningiomas underwent complete removal (median follow-up duration 12.5 months; range 3–18 months). Of the three patients in whom incomplete removal was obtained, in two there was near-gross-total removal with at least 95% tumor extirpation and in one who had undergone a prior craniotomy, there was...
tumor debulking with approximately 70% tumor removal (Fig. 4).

**Patients With Rathke Cleft Cysts**

Five (83%) of six patients with suprasellar Rathke cleft cysts underwent complete cyst removal (median follow-up duration 9 months, range 3–13 months; Fig. 5). The one patient with a subtotal removal had dense adhesions of the cyst capsule to the pituitary stalk.

**Patients With Other Tumor Types**

One patient with a dermoid cyst (duration of follow up 30 months) underwent complete removal of the lesion. One patient with a 66 × 55–mm suprasellar and retroclival epidermoid tumor (duration of follow up 4 months) underwent tumor debulking through a combined suprasellar–transclival approach with a significant decrease in mass effect on the brainstem. A 75-year-old man with a suprasellar non-Hodgkin B-cell lymphoma underwent biopsy only for diagnosis before initiation of chemotherapy; that patient subsequently died approximately 2 months after surgery from systemic disease progression.

**Neurological Outcome and Complications**

Preoperatively, 13 patients experienced new tumor-related visual loss. Of these, 11 (85%) noted significant visual improvement after surgery. No patients had a decrease in visual fields or visual acuity following surgery. The patient with the large epidermoid tumor had transient worsening of a preexisting third cranial nerve palsy, which resolved 3 months after surgery. There were no other neurological complications except anosmia in one patient after the removal of a meningioma.

**TABLE 3**

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>surgical/technical</td>
<td>21</td>
</tr>
<tr>
<td>CSF leak, total</td>
<td>3 (17)</td>
</tr>
<tr>
<td>meningioma</td>
<td>1</td>
</tr>
<tr>
<td>craniopharyngioma</td>
<td></td>
</tr>
<tr>
<td>epidermoid tumor</td>
<td></td>
</tr>
<tr>
<td>meningitis</td>
<td>4 (4)</td>
</tr>
<tr>
<td>fat graft too large</td>
<td>2 (8)</td>
</tr>
<tr>
<td>delayed epistaxis</td>
<td>2 (8)</td>
</tr>
<tr>
<td>anosmia</td>
<td>1 (4)</td>
</tr>
<tr>
<td>transient worsening of 3rd cranial nerve palsy</td>
<td>1 (4)</td>
</tr>
<tr>
<td>vascular injury</td>
<td>0</td>
</tr>
<tr>
<td>visual acuity/field deterioration</td>
<td>0</td>
</tr>
<tr>
<td>persistent neurological deficit</td>
<td>0</td>
</tr>
<tr>
<td>endocrinopathy</td>
<td></td>
</tr>
<tr>
<td>permanent DI, total</td>
<td>17</td>
</tr>
<tr>
<td>craniopharyngioma</td>
<td>3</td>
</tr>
<tr>
<td>Rathke cyst</td>
<td>1</td>
</tr>
<tr>
<td>transient DI</td>
<td>8 (8)</td>
</tr>
<tr>
<td>failure or worsening of anterior pituitary functions</td>
<td>2 (8)</td>
</tr>
<tr>
<td>any new permanent endocrinopathy*</td>
<td>21</td>
</tr>
</tbody>
</table>

* Includes new DI and/or new failures in anterior pituitary function.
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TABLE 4
Endocrinological outcome after surgery

<table>
<thead>
<tr>
<th>Function</th>
<th>Craniopharyngioma (8 patients)</th>
<th>Rathke Cyst (6 patients)</th>
<th>Meningioma (7 patients)</th>
<th>Other (5 patients)</th>
<th>Total (24 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>loss of function*</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>loss of 1 ant axis</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>loss of 2 ant axes</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>permanent DI</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4 (17%)</td>
</tr>
<tr>
<td>gain of function</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2 (8%)</td>
</tr>
</tbody>
</table>

* One patient with a craniopharyngioma and preexisting growth hormone and gonadal deficiencies experienced complete failure of anterior pituitary function and DI after surgery.

Cerebrospinal Fluid Leaks, Meningitis, and Other Technical Complications

Five patients (21%), including three with tuberculum sellae meningiomas, one with a craniopharyngioma, and one with an epidermoid tumor, experienced postoperative CSF leaks that required treatment. All had large dural and diaphragmatic defects that had been created at the original surgery. Two patients, both of whom had a tuberculum sellae meningioma, received successful treatment for their CSF leaks with 48 hours of lumbar CSF diversion, which had not been placed at the time of their original surgery. Three patients (12.5%) underwent a repeated operation to repair the CSF leak, including two patients who required a second operation for CSF leak repair. The patient with the epidermoid tumor also experienced severe bacterial meningitis that resolved after a repeated operation and a course of antibiotic therapy. His CSF leak closure was effectively treated on the second attempt with a combination of fascia lata, abdominal fat, titanium mesh, tissue glue, and lumbar CSF diversion.

Two patients with meningiomas who were treated relatively early in the series received excessively generous intrasellar and suprasellar abdominal fat grafts, which caused compression of the optical chiasm as seen on postoperative MR images. Both patients were taken back to the operating room for fat graft revision, which in one case led to a new CSF leak as described earlier. Both patients ultimately attained complete improvement in their preoperative visual statuses (Table 3).

Endocrinological Complications

Five patients (21%) experienced new endocrinopathy including four (17%) with persistent DI and two (8%) with failure of anterior pituitary function (Table 4). Four of these five patients had preexisting anterior pituitary hormone failure in at least two axes. One of these patients who had preoperative gonadal failure and growth hormone deficiency later experienced complete failure of anterior pituitary function and new DI despite anatomical stalk preservation at surgery. Two patients had transient DI lasting less than 4 days in each case. One patient had transient delayed hyponatremia that was successfully treated with fluid restriction and salt supplementation.

Other Complications

Two patients had delayed epistaxis 3 weeks after surgery, which resolved spontaneously in one patient. Both patients had normal cerebral angiograms but were treated with empirical internal maxillary artery embolization without sequelae for presumed bleeding from one of the sphenopalatine arteries. Three patients who had persistent nasal congestion longer than 10 days after surgery were treated presumptively for sinusitis with a 10-day course of oral antibiotics. In two of these patients, the symptoms resolved; in the third, despite initial resolution, persistent complaints 1 year after surgery prompted additional antibiotic treatment and endoscopic sinus surgery with subsequent symptom resolution.

Overall Results

In total, 11 (46%) of 24 patients experienced postoperative complications including five patients (21%) with CSF leaks (one with meningiitis), two requiring repeated operations to decrease fat graft size, two with delayed epistaxis, and five (21%) with new pituitary hormone failure. Nevertheless, there were no intracranial vascular injuries, no deaths, and no persistent neurological deficits, except anosmia in one patient. All 24 patients ultimately had excellent functional recoveries.

Discussion

Advantages, Disadvantages, and Limits of the Extended Transsphenoidal Approach

With the introduction of the extended transsphenoidal skull base approach, wherein the bone of the tuberculum sellae and the posterior planum sphenoidale between the optic canals is removed, suprasellar lesions that have traditionally been approached trancranially, such as tuberculum sellae meningiomas and craniopharyngiomas, have been increasingly removed transsphenoidally. 15,20,29,35,36,39,43,51,61 Provided that the chiasm is not prefixed by the tumor and located directly between the sphenoid sinus and tumor, or that a functional pituitary gland is not directly impeding the transsphenoidal route, the most obvious and significant advantages of this approach are the following: 1) brain retraction is obviated; 2) direct manipulation of the optic apparatus is minimized; and 3) early identification of the pituitary gland and the infundibulum increases the likelihood of preserving pituitary function. Furthermore, by using this approach, because these lesions generally displace the optic apparatus away from the surgeon, tumor removal can begin
and later pop-

The major disadvantage of the direct endonasal
approach for removal of sellar and suprasellar lesions has been shown to be comparable to the traditional sublabial
route in efficacy and neuroendocrine complication rates. This approach requires minimal nasal mucosal dissection,
resulting in fewer sinonasal complications and a more rapid and less painful rhinological recovery than the sublabial
approach. The major disadvantage of the direct endonasal
route is the relatively restricted and slightly off-midline
working channel. This problem has been largely overcome
by several technical innovations including the use of low-
profile microdissection instruments and cutting blades, use
of the micro–Doppler probe to localize the CAs and other
intracranial vessels before opening the dura mater, use of
angled endoscopes for more panoramic cephalad and later-
al visualization beyond the tunnel vision of the microscope,
and the use of intraoperative surgical navigation to confirm
surgical trajectory and key landmarks.

Even with such adjuncts, the direct endonasal
approach—and all transsphenoidal approaches to some de-
gree—provide limited parasellar exposure, particularly for
lesions that extend far superiority or far laterally into the
perimesencephalic cisterns. Although endoscopic visualization
is helpful for assessing the anatomical relationships in
these far reaches of the exposure, safe tumor removal from
these locations remains problematic because the endoscope
itself limits the working space within the speculum for effec-
tive maneuverability of other instruments. Yet, without the
endoscope, the risk of neurovascular injury from “blind
grabs” of tumor in these areas is high. Consequently, we set-
ted for incomplete tumor removal when adequate access
and visualization were not possible. This conservative ap-
proach is reflected in the fact that there were no serious neu-
rological or intracranial vascular injuries in this series. Giv-
en that most of these tumors, such as craniopharyngiomas
and meningiomas, are radiosensitive (control rates of 58–
100%), this approach appears prudent.

Tumor Removal Rates Compared With Prior Series

In this series, complete tumor removal was accomplished
in only 46% of patients and complete or near complete
removal was achieved in 74% of the 23 patients in whom total
removal was the ideal goal. For patients with craniopharyngi-
omas, gross-total or near-gross-total removal was accom-
plished in five of eight patients. Clearly, in the three other
patients, complete removal by any approach was not a real-
istic goal given the size and invasive nature of the tumors.
Previous reports on patients who have undergone trans-
sphenoidal surgery for craniopharyngioma have document-
ed gross-total-removal rates ranging from 7 to 86%. In many of these series, however, the trans-
sphenoidal route was only used for craniopharyngiomas
that were largely cystic and/or intrasellar.

For patients with tuberculum sellae meningiomas, com-
plete resection was possible in four (57%) of seven patients
and near-gross-total removal in two of the remaining three
patients. In earlier series, complete tumor removal rates
have ranged from 45 to 98% for transcranial routes and
from 25 to 100% for the extended transsphenoidal approach. As we recently described, these tumors pose
challenges to removal via an extended approach because of
their firm or rubbery texture and wide dural attachment
along the planum and tuberculum sellae. Our initial ex-
perience, however, indicates that such midline suprasellar
meningiomas that are 3 cm or less in diameter can be effec-
tively removed through an endonasal approach with an ex-
cellent outcome particularly in visual status and preserva-
tion of hormone function. For meningiomas that extend into
the optic canals superiorly and laterally, the transsphenoidal
route will likely not allow safe and complete removal given
inadequate visualization. Even with the use of a transcranial
approach and adequate visualization of the optic canals,
however, total tumor removal may still not be possible
in some patients because of dense tumor adherent to the
nerves. In such instances, subtotal removal and stereotactic
radiotherapy may provide the safest treatment option.

For patients with Rathke cleft cysts, complete resection
was achieved in 83%. Most previous reports on supraglan-
dular Rathke cleft cysts have been small case reports de-
scribing removal via a transcranial route. The location of
these lesions, the extended transsphenoidal approach
appears to be ideal for their removal with a relatively
low risk of new endocrinopathy, as seen in our small series.

Complication Rates Compared With Previous Series

Transcranial Approach. The brain retraction and manipu-
lation of neurovascular structures that are generally required
for all frontal or pterional approaches to the suprasellar
space have been associated with a variety of postoperative
problems and provide one of the strongest rationales for se-
lecting the extended transsphenoidal approach. By using
a transcranial route, complications may include neuropsy-
chological deficits in up to a third of patients, as well as new
visual loss, vascular injuries, and endocrinopathy.

Visual Recovery and Deterioration. In our series, 85% of
patients with preoperative visual loss experienced normalized
vision or significant improvement after surgery and no patient experienced worsening of visual function.
Visual deterioration after transcranial removal of craniopharyngiomas and suprasellar meningiomas ranges from 2 to
30%, as well as visual loss, vascular injuries, and endocrinopathy.

Vascular Injuries. Cavernous carotid, supraclinoid carot-

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id, anterior cerebral, and basilar artery injuries are dreaded but rare complications of transspHENoidal and transcranial procedures. A preliminary report of the extended transspHENoidal approach for meningiomas by Jane, et al., reported no vascular injuries. According to previous reports on the transspHENoidal approach, vascular injuries occur in approximately 0.4 to 1.4% of cases depending on the experience of the surgeon. In our series there were no intracranial vascular injuries, which we attribute to the following: 1) routine use of the micro–Doppler probe before dural opening; 2) use of microscissors and microblades only when direct vision is possible; and 3) sharp dissection of arachnoid–tumor planes to avoid excessive vessel traction.

**New Endocrinopathy.** New permanent endocrinological disturbances occurred in 21% of patients in this series with new DI occurring in 17% and new failure in anterior pituitary function in 8%. Preservation of pituitary function is challenging in patients with craniopharyngiomas, especially those in whom anterior pituitary function has already failed, as was the case in three of the four patients in our series with new DI. Although the rate of endocrinopathy appears to be related to the aggressiveness of resection for craniopharyngioma, literature on the transspHENoidal approach indicates that as many as 75 to 80% of patients with aggressive resection and 38% with partial resection will have new postoperative endocrine deficiencies that are not limited only to DI. In contrast, for patients with suprasellar meningiomas and Rathke cleft cysts in this series, the extended transspHENoidal route allowed preservation of pituitary function in the great majority of patients. Only one patient with a meningioma who had a prior craniotomy, hypothyroidism, and hypogonadism experienced new adrenal insufficiency after surgery; additionally, one patient with a Rathke cleft cyst experienced new DI.

**Cerebrospinal Fluid Leaks and Related Complications.** The most common technical complication in our series was a postoperative CSF leak occurring in 21% of patients, with resultant meningitis in one patient. In two patients with suprasellar meningiomas, overconfidence about the initial repair, which was made using fat, collagen, and titanium mesh, led to the initial omission of lumbar drain CSF diversion. This decision proved to be a poor one because both of these patients experienced postoperative CSF rhinorrhea that ultimately resolved with 48 hours of lumbar drain drainage. Relatively high CSF leak rates, ranging from 0 to 50%, have been previously associated with the extended transspHENoidal route. Our method involving placement of a suprasellar fat graft proved to be problematic in two patients who received grafts that caused chiasmatic compression. This complication illustrates the careful balance required between the prevention of a postoperative CSF leak and the creation of a new mass effect from the repair itself. Fortunately, in both cases, downsizing the fat graft restored normal visual function. Recently Kitano and Taned described a subdural double-layer patch graft composed of fascia lata and Gore-Tex, which is held in place by tacking sutures and has a failure rate of only 9%. Clearly, the optimal repair method for these skull-base defects remains to be defined. Although most would probably trade a higher risk of a CSF leak for a decrease in the risk of brain retraction injuries, new visual loss, and endocrinopathy, which may be more common after craniotomy, more effective strategies to prevent CSF leaks are needed if the transspHENoidal approach is to become the primary route for removing suprasellar tumors.

**Conclusions**

The direct endonasal extended transspHENoidal approach performed with the operating microscope provides a minimally invasive route to remove nonadenomatous suprasellar tumors such as tuberculum sellae meningiomas, craniopharyngiomas, and supragnadal Rathke cleft cysts. When augmented with the panoramic visualization provided by angled endoscopes, it affords an excellent view of the pituitary gland, infundibulum, diaphragma sellae, vascular structures, and optic apparatus, and allows relatively safe removal of these tumors. The direct endonasal approach appears comparable to the sublabial and transeural routes in efficacy, overall safety, and rate of recovery. The primary concern and goal for the future remains the development of more reliable cranial base reconstruction methods to prevent a postoperative CSF leak. Certainly, the overall complication rate in this series is relatively high. Nevertheless, this patient series represents a work in progress toward achieving safer, more effective minimally invasive removal of these challenging suprasellar lesions.

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**References**


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Address reprint requests to: Daniel F. Kelly, M.D., 200 UCLA Medical Plaza, Suite 504, Box 718224, UCLA Medical Center, Los Angeles, California 90095-7182. email: dkelly@mednet.ucla.edu.

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