Tuberculum sellae meningiomas constitute 5%–10% of all intracranial meningiomas. Visual loss and headaches are the most common presenting symptoms. These tumors occupy a unique space in that they take a subchiasmal position by pushing the optic chiasm superiorly and laterally. Resection of a TSM is surgically challenging because of the proximity of vital neurovascular structures including the carotid artery and optic nerves/chiasm. Resection is further complicated by the fact that TSMs usually have a firm, rubbery consistency and often require sharp dissection rather than simple suctioning for their removal. Various approaches to the tuberculum sellae region have been used for resection. Traditionally, a variety of craniotomies (pterional, unilateral subfrontal, bilateral subfrontal, and so forth) have been used in an attempt to find the most direct route to this region with the fewest potential complications or anatomical limitations.

While transsphenoidal surgery for pituitary adenomas has been practiced successfully for more than 50 years, in the past 25 years there have been many different innovative strategies for extending the transsphenoidal approach to other areas of the cranial base. Since the first description of the ETSA, there has been steady interest in using the transnasal approach to remove tumors of the parasellar area and anterior skull base. Recently, the ETSA has been used to treat TSMs, and studies have shown that tumors can be removed effectively and safely from the tuberculum sellae region via this route. However, there has been much discussion and controversy over when to use the ETSA and when to approach a TSM via the traditional TCR.

In this report, we present a series of 27 consecutive patients with TSMs surgically treated via the TCR or the ETSA, including case descriptions of the ETSA procedures. We describe our experience and compare the advantages and disadvantages of approaching TSMs via the TCR and ETSA. We specifically evaluated pre- and postoperative images from patients who underwent resection via the ETSA as well as, intraoperatively, what tumor characteristics affected TSM resectability with this approach.

Methods

The OpCoder operative database at the University of Utah was queried to identify patients who had surgery for TSM between January 2002 and December 2010. Patients...
with meningiomas arising from the clinoid processes, olfactory groove, or diaphragma sellae were excluded. The hospital charts of included patients were then reviewed to determine patient demographics, surgical approaches used, and patient outcome. This retrospective review was approved by the University of Utah Institutional Review Board. All chart reviews and data acquisition were in compliance with the regulations determined by the University of Utah Institutional Review Board and with the Health Insurance Portability and Accountability Act of 1996. The pre- and postoperative clinical evaluations included a detailed neurological examination with formal visual field and acuity tests (Goldmann perimetry and Snellen chart, respectively). Neuroimaging was also evaluated in considering which approach would be used. Computed tomography and MR imaging were utilized for the initial diagnosis as well as the assessment of postoperative outcome.

Clinical and endocrinological outcomes were evaluated at 3–4 weeks postoperatively. Patients underwent clinical and neuroradiological (MR imaging with and without Gd unless otherwise contraindicated) evaluations at 4–5 months after surgery and annually thereafter.

Transcranial Approach

A standard pterional approach was used preferentially by the senior author (W.T.C.) in all cases. This approach involves a wide pericranial flap preparation and satisfactory removal of the sphenoid ridge as far down as the superior orbital fissure. The dura mater is opened in a curvilinear fashion on the floor of the frontal fossa. Slight frontal retraction is applied, and the tumor is exposed in its entirety on the tuberculum sellae. The tumor is first devascularized, working toward an inferomedial direction on the tuberculum sellae with bipolar coagulation. This step is followed by debulking of the tumor either by piecemeal cutting with microscissors or by ultrasonic surgical aspiration. Then an arachnoidal dissection plane between the tumor and optic nerve is followed, and the tumor is gently dissected away from the optic nerve medially. The remaining portion of the tumor is again cut out in a piecemeal fashion using microscissors. Dura over the anterior clinoid is cut, dissected, and removed. Anterior clinoid is drilled away, and the optic canal is unroofed, which can be performed bilaterally if indicated by tumor extension. All hyperostotic bone is then removed with a high-speed drill. Tumor within the canal is resected away with gentle microdissection. Dural attachment of the tumor is resected and coagulated. The periosteal flap and fat graft are then laid over the tuberculum sellae and pia mater. Then an arachnoidal dissection plane over the anterior sellar wall to expose the anterior circular sinus is then continued by removing the bony sellar wall to expose the anterior circular sinus and then by extending this bony removal rostrally with microrongeurs. If the bone is hyperostotic, the use of a high-speed drill may be necessary. Bony removal in this location also yields additional exposure of the suprasellar region. The surgeon must remain cognizant of the position of the circular sinus, which demarcates the anterior extension of the sella, the anterior communicating artery complex superiorly, the ethmoid sinuses anteriorly, and the optic nerves superolaterally. The optic canals are identified and drilled in their most proximal extent to remove tumor in the inferior and medial canal if necessary. After tumor removal, the dural defect must be carefully repaired. We prefer to use abdominal fascia or fascia lata and fat for this purpose. The sella and sphenoid regions are closed as previously described.

Endoscopic Transsphenoidal Approach

In purely endoscopic cases, we do not place an endonasal retractor but instead work through both nares. The rostrum of the sphenoid sinus is identified, and the sphenoid ostia is located. The rostrum of the sphenoid is removed together with the adjoining perpendicular plate of the ethmoid and the posterior cartilaginous septum. The interior of the sphenoid sinus is then exposed in the usual fashion, and all mucosa is exenterated. Specialized microinstruments, such as curved and angled alligator microscissors, a long monopolar coagulator with a malleable tip, and malleable-tip microring curettes, facilitate resection at the lateral extremes of the exposure. In addition, long, narrow bipolar forceps with up- or down-angled fine tips are used. Access to the anterior cranial base is facilitated by slight extension of the patient’s head and direct viewing more superiority. The bone of the tuberculum sellae is removed by first extracting a small amount of bone over the anterior sellar wall to expose the anterior circular sinus and then by extending this bony removal rostrally with microrongeurs. If the bone is hyperostotic, the use of a high-speed drill may be necessary. Bony removal in this location also yields additional exposure of the suprasellar region. The surgeon must remain cognizant of the position of the circular sinus, which demarcates the anterior extension of the sella, the anterior communicating artery complex superiorly, the ethmoid sinuses anteriorly, and the optic nerves superolaterally. The optic canals are identified and drilled in their most proximal extent to remove tumor in the inferior and medial canal if necessary. After tumor removal, the dural defect must be carefully repaired. We prefer to use abdominal fascia or fascia lata and fat for this purpose. The sella and sphenoid regions are closed as previously described.

Results

Twenty-seven patients were treated by the senior author for specifically located TSMs during the study period (Table 1). Twenty-two of the patients (81.5%) were women, and the ages of all the patients ranged from 23 to 77 years (mean 54 years). The main presenting symptom was vision loss, which occurred in 85.2% of the patients. Of the patients without visual symptoms, 1 presented with a headache, 1 had an incidental TSM, and 1 had cognitive difficulties. Tumor sizes ranged from 1.3 to 5.4 cm.

The ETSA was initially applied in 5 patients (18.5%), and the TCR was used in the remaining 22 (81.5%). Three patients (Cases 13, 17, and 27) who initially underwent the ETSA required a subsequent surgery for treatment of the TSMs. In 1 of these patients (Case 17), the ETSA was converted to a TCR after the TSM was found to be extremely hard and not amenable to resection via the ETSA. Another patient (Case 13) had an NTR except for a tiny portion of tumor capsule along the internal carotid artery; a recurrence of the TSM developed 2 years later. She required a TCR for the recurrent TSM from the NTR performed earlier. The last patient (Case 27) underwent a planned staged procedure with biopsy and debulking of the ethmoidal/sphenoidal sinuses via the ETSA and a subsequent TCR for most of the remaining tumor. The TSM in this case was unusual because it had extension into the cavernous sinus with extensive involvement precluding a GTR by either surgical approach.

The early postoperative outcome was GTR or NTR in 81.5% of the patients (22 of 27) who initially underwent the TCR and in 60% of the patients (3 of 5) who initially underwent the ETSA. These outcomes were confirmed with MR imaging performed 4–5 months after surgery. A postoperative CSF leak requiring subsequent sur-
## TABLE 1: Summary of characteristics and outcomes in 27 patients with TSMs*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Tumor Size (mm)</th>
<th>Presentation</th>
<th>Previous Treatment</th>
<th>Approach</th>
<th>Outcome</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51, F</td>
<td>24 × 55 × 56</td>
<td>bilat blindness</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>23, F</td>
<td>17 × 18 × 18</td>
<td>lt eye visual loss</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>39, F</td>
<td>25 × 20 × 20</td>
<td>incidental finding, optic nerve compression</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>65, M</td>
<td>20 × 15 × 10</td>
<td>lt eye visual loss</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td>46, F</td>
<td>20 × 27 × 37</td>
<td>HA, rt eye visual loss &amp; field cut</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>6</td>
<td>46, F</td>
<td>15 × 18 × 18</td>
<td>lt eye visual loss &amp; field cut</td>
<td>TCR</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>7</td>
<td>41, M</td>
<td>27 × 25 × 22</td>
<td>HAs</td>
<td>none</td>
<td>transiliabial ETSA w/ fat &amp; fascia graft</td>
<td>GTR</td>
<td>CSF leak 1 wk postop after episode of nausea/vomiting; CSF leak resolved after repacking op</td>
</tr>
<tr>
<td>8</td>
<td>48, F</td>
<td>NA</td>
<td>HA, mild lt field cut</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>9</td>
<td>65, F</td>
<td>NA</td>
<td>bitemporal visual field cuts &amp; decreased rt acuity</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>10</td>
<td>65, F</td>
<td>15 × 18 × 18</td>
<td>lt eye visual loss</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>11</td>
<td>72, M</td>
<td>NA</td>
<td>lt eye blindness</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>12</td>
<td>50, F</td>
<td>18 × 28 × 25</td>
<td>bilat vision loss rt&gt;lt</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>13</td>
<td>65, F</td>
<td>15 × 17 × 15</td>
<td>bilat vision loss &amp; bitemporal hemianopia</td>
<td>none</td>
<td>ETSA; TCR resection of recurrent meningioma NTR w/ tiny piece left attached to ICA; tumor recurred &amp; NTR achieved</td>
<td>none; tumor recurred along lt optic nerve 3 yrs later</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>52, F</td>
<td>13 × 24 × 18</td>
<td>lt eye visual loss</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>15</td>
<td>67, M</td>
<td>45 × 44 × 35</td>
<td>bilat severe vision loss for several yrs (blind in rt eye &amp; only light perception in lt eye), HA</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>steroid &amp; thyroid supplementation &amp; DDAVP as needed</td>
</tr>
<tr>
<td>16</td>
<td>36, M</td>
<td>24 × 15 × 20</td>
<td>bitemporal hemianopia</td>
<td>previous cranial biopsy &amp; stereotactic radiosurgery</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>17</td>
<td>39, F</td>
<td>20 × 20 × 21</td>
<td>lt eye vision loss</td>
<td>none</td>
<td>aborted ETSA w/ fat graft; TCR</td>
<td>aborted; GTR</td>
<td>none</td>
</tr>
<tr>
<td>18</td>
<td>77, F</td>
<td>25 × 21 × 17</td>
<td>rt eye complete vision loss &amp; severe vision loss in lt eye</td>
<td>none</td>
<td>ETSA &amp; fat/fascia</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>19</td>
<td>38, F</td>
<td>NA</td>
<td>bilat vision loss &amp; bitemporal hemianopia</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>20</td>
<td>69, F</td>
<td>NA</td>
<td>bilat vision loss (lt&gt;rt)</td>
<td>outside hospital craniotomy 3 mos earlier</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>21</td>
<td>65, F</td>
<td>5.4 × 4.9 × 4.5</td>
<td>cognitive difficulties</td>
<td>none</td>
<td>TCR</td>
<td>GTR</td>
<td>none</td>
</tr>
<tr>
<td>22</td>
<td>66, F</td>
<td>5.0 × 4.0 × 4.0</td>
<td>bilat visual loss (lt&gt;rt)</td>
<td>none</td>
<td>TCR</td>
<td>partial resection meningioma stable for 6 yrs since op</td>
<td>none</td>
</tr>
</tbody>
</table>

(continued)
neurological sphenoid repacking developed in 1 patient (Case 7). Another patient (Case 15) required steroid and thyroid supplementation in addition to occasional desmopressin acetate doses for transient diabetes insipidus after the removal of a massive TSM. The only other complication was multiple wound infections in 1 patient (Case 27) that required plastic surgery to aid in closure of the wound with a flap procedure. However, this patient had already undergone 3 previous craniotomies and radiation therapy before being referred to us for treatment. Of note, no patients had worsening of their preoperative visual symptoms.

**Illustrative Cases**

**Case 7.** This 41-year-old man presented with progressive headaches that worsened in frequency and intensity. Magnetic resonance imaging demonstrated a large TSM with inferior sellar extension (Fig. 1A and B). Because of the midline location and inferior sellar extension of the TSM, an ETSA was performed. The tumor was soft and descended easily, and we were able to resect the tumor inferiorly in the sella while preserving the normal pituitary gland. By using the endoscope at the end of the case, we found and removed a tiny spot of tumor that was difficult to see with just the microscope. A GTR was achieved (Fig. 1C and D), and the patient fared very well despite having to return to the operating room 1 week later to have a CSF leak repaired with repacking of a fat and fascia graft. He has not had any other complications in the 69 months since his surgery.

**Case 13.** This 65-year-old woman presented with bilateral loss of visual acuity and bitemporal hemianopia. Her workup included MR imaging of the brain, which demonstrated a very small TSM centered midline without lateral extension beyond the internal carotid arteries (Fig. 2A and B). Because the tumor size and location were amenable to the approach, an ETSA was begun, but the tumor was found to be extremely hard in consistency and could not be mobilized. Given the difficulty in removing the lesion of the anterior clinoid process as well as left optic nerve compression (Fig. 2E). Resection via TCR was necessary to remove the tumor, and this procedure was complicated by extensive scarring in and around the optic nerve. Therefore, another NTR was performed. The patient has not had any complications since the TCR 13 months ago.

**Case 17.** This 39-year-old woman presented with a several-month history of left eye visual loss and headaches. Her workup included MR imaging of the brain, which demonstrated a small TSM centered midline without lateral extension beyond the internal carotid arteries (Fig. 3A and B). Because the tumor size and location were amenable to the approach, an ETSA was begun, but the tumor was found to be extremely hard in consistency and could not be mobilized. Given the difficulty in removing the lesion...
Choice of approach to tuberculum sellae meningioma resection

via this approach, we aborted the ETSA and instead performed a right pterional craniotomy, approaching the optic nerve using a subfrontal approach. We achieved GTR after a long piecemeal removal of this very hard tumor (Fig. 3C and D). The patient has done well without any complications since her surgery 9 months ago.

**Case 18.** This 77-year-old woman presented with a 3-year history of complete visual loss in her right eye and severe visual loss in her left eye. She was aphasic after a large left middle cerebral artery stroke 5 years earlier, and her aphasia led to a delay in diagnosis resulting in severe bilateral visual loss preoperatively. A TSM was determined to be midline and not large (Fig. 4A and B), and the decision was made to use the ETSA for resection. Intraoperatively, the tumor was found to be very soft and easily dissectible; GTR was achieved (Fig. 4C and D). The patient had no complications from the procedure and was doing well 8 months after surgery.

**Discussion**

In this review, we have focused on the choice of approach (transfacial compared with transcranial) to tumors specifically located at the tuberculum sellae. We have not included tumors of the planum sphenoidale or olfactory groove, in which endonasal approaches may be performed more simply; neither have we included clinoidal lesions or tumors of the diaphragma sellae, for which the senior author would definitely choose a transcranial approach.

**Advantages and Disadvantages of TCR and ETSA**

The ETSA offers several advantages and desirable qualities as compared with the TCR (Table 2). The approach is the most direct to the tuberculum sellae, and the extraarachnoidal plane found in TSMs can be used to aid in tumor removal. For patients with tumors in the midline, the approach does not require any brain retraction for tumor exposure. Thus, the olfactory nerve(s) is exposed to less risk of stretch injury than during the TCR, which is important given that olfactory nerve injury and anosmia...
brain parenchyma with subsequent seizures and hemorrhage in TCR has been shown to occur less frequently with the ETSA. Finally, the ETSA is an attractive option in elderly patients or those who are otherwise not good surgical candidates because the approach is less invasive and can be easier to tolerate given that it has been shown to cause less blood loss. In these patients, even if a GTR is not achieved, meningiomas are usually highly responsive to stereotactic radiosurgery with low associated complication rates, and adjuvant stereotactic radiosurgery can be performed if necessary.

Despite the many advantages offered by the ETSA, the drawbacks are also numerous and significant. Perhaps the most well-known drawback is the chance of CSF leakage, which can occur with the removal of bone and dura underlying the tumor. Bone removal anterior to the tuberculum sellae, as in the ETSA, is associated with a significantly higher risk of CSF fistulas than a standard transsphenoidal approach to the sella. In a series of 4 patients who underwent ETSA, we noted 1 CSF leak (25%); and a recent meta-analysis of transsphenoidal approaches for TSM resection revealed a similar 20% rate of CSF leakage. In contrast, CSF leaks from a TCR are rare. The other main disadvantage of the ETSA is the difficulty in removing tumor or its dural attachment from over the optic nerve in the canal or above and lateral to the anterior clinoid process. For this reason we recommend the ETSA for smaller TSMs, that is, those smaller than 3 cm. As TSMs enlarge, they tend to grow beyond the narrow visual corridor that the ETSA provides. It is also important to make sure that these lesions do not have vascular encasement or that they have not extended laterally on either side of the internal carotid arteries or optic nerves. One must also verify that the brain is free of edema, which suggests that the subdural arachnoidal plane may not be intact. It is also important to note that ETSA has a steep learning curve because of its unique anatomical view, and this is an important point for those deciding whether to use the ETSA.

Choice of Surgical Approach

Our small series of patients who underwent the ETSA for TSM removal demonstrates some important teaching points. Tuberculum sellae meningiomas are vascular lesions that usually receive their blood supply from dural vessels, ethmoidal arteries, and sometimes other branches. The patient in Case 7 had multiple feeding vessels that were easily coagulated and cut, which allowed for devascularization of the tumor at the first step. This early devascularization created a less bloody tumor resection for the rest of the case and demonstrates how the ETSA can offer advantages over the TCR by providing improved visualization during tumor resection. A recent retrospective study showed that surgical blood loss is reduced with the ETSA as compared with the TCR.

Tuberculum sellae meningioma consistency seems to substantially influence resectability via the ETSA. Two (Cases 7 and 18) of our 3 patients in whom gross-total or near-total TSM resections through the ETSA had tumors that were very soft, whereas in the patient (Case 17) in whom the ETSA procedure was aborted, the tumor was incredibly hard. We preoperatively counsel all of our pa-
Choice of approach to tuberculum sellae meningioma resection

Table 2: Advantages and disadvantages of TCR and ETSA for resection of TSM

<table>
<thead>
<tr>
<th>Op Approach</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCR</td>
<td>familiarity allows direct visualization of microneurosurgical dissection of tumor from vessels/nerves critical vessel &amp; nerve anatomy identified early easy removal of anterior clinoid &amp; any tumor superior or lateral to optic nerve</td>
<td>easily visible scar frontal lobe retraction basal approach required for early devascularization of tumor from tuberculum increased potential blood loss tumor medial to ipsilateral carotid artery/optic nerve difficult to resect</td>
</tr>
<tr>
<td>ETSA</td>
<td>easy surgical approach cosmetically pleasing (no scars) more direct access to tumor &amp; bony attachments no brain retraction required early indirect decompression achieved w/ initial tumor removal less chance for olfactory nerve injury hyperostotic bone removed no blind spots from carotid to carotid if sellar extension of tumor, then easy removal preserved arachnoidal plane allows for protected dissection potentially shorter recovery time may be better in older patients who are poorer surgical candidates (less blood loss)</td>
<td>CSF leak/fistulae more likely the more anteriorly the ETSA is extended difficulty removing tumor over the optic nerve or above/lateral to anterior clinoid process larger tumors are much more difficult to resect</td>
</tr>
</tbody>
</table>

Patients that the ETSA procedure can be aborted for a TCR if the intraoperative meningioma consistency will not allow a safe resection. New technologies are being used to resect TSMs of a hard consistency, but we recommend switching to a TCR if this situation is encountered intraoperatively. The disadvantage of using the ETSA for such hard tumors is that there is no opportunity to remove the tumor under direct bimanual endoscopic control if the tumor is so hard or calcified that it does not allow deformation during the dissection process. In the senior author’s opinion, proceeding with the ETSA in such circumstances increases the risk for cranial nerve deficit.

The ETSA can be offered to patients who refuse to have a TCR or who may not be as good surgical candidates since blood loss has been shown to be less with the ETSA and there is no brain retraction. In these patients, even if a GTR or NTR is not achieved, stereotactic radiosurgery has been well proven to provide good control of typical meningiomas, with one recent paper demonstrating 87% control for skull base meningiomas.

Evaluating lateral extension of the TSM is critical in selecting the correct approach. The tumor recurrence in the patient in Case 13 illustrates the importance of selecting tumors for ETSA that remain medial to the supraclinoid internal carotid arteries and optic nerves. When tumors extend into the carotid arteries or optic nerves, the ETSA resection is much more difficult as visualization is significantly compromised (Fig. 5). In the patient in Case 13, there appeared to be a tiny tumor capsule along the carotid artery that could not be comfortably accessed via the ETSA. Our suspicions of residual tumor capsule were confirmed when the tumor recurred after 3 years. The subsequent TCR was much more difficult because of the extensive scarring in the region, and an NTR was achieved. Conversely, when a TSM is located inferiorly or between the optic nerves, it can be very difficult to resect via a TCR, and the ETSA is a much better approach.

There are also occasions, such as with the patient in Case 27 in our series, in which a planned 2-stage procedure is performed because each approach can reach areas that the other approach cannot. The patient had extensive sphenoidal/ethmoidal extension of a TSM that could not be reached via the TCR but also had extreme lateral extension of the meningioma into the cavernous sinus that could not be reached through the ETSA. This case exemplifies the special situations in which each approach may be jointly implemented to achieve their respective goals to provide the patient with the best resection possible.

Conclusions

Because each approach has unique advantages and
disadvantages, the choice to use an ETSA or a TCR for TSM resection must be made based on the specific characteristics of each case. Based on our experience and a review of the literature, we suggest several factors that should be considered when evaluating the surgical options. The ETSA is a safe and effective means of removing a TSM when it is smaller than 3 cm, is located medial to the internal carotid arteries, has dural attachments that are inferior to the optic nerve in the optic canal and do not extend beyond the clinoid processes, or extends inferiorly into the sella. The ETSA can also be an effective strategy in elderly patients with multiple comorbidities who may not be able to tolerate a prolonged craniotomy, as there is less blood loss with the ETSA. However, it is the opinion of the senior author that while the ETSA approach may be suitable for many lesions of the anterior skull base, these cases must be chosen carefully. More anteriorly located lesions of the planum sphenoidale or olfactory groove lend themselves to removal by this technique frequently. However, tumors of the tuberculum sellae must be well chosen, and the approach must not limit the ability to perform a complete Simpson Grade 1 removal.

Disclosure

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

Author contributions to the study and manuscript preparation include the following. Conception and design: Couldwell. Acquisition of data: Bowers, Altay. Analysis and interpretation of data: Bowers, Altay. Drafting the article: Bowers, Altay. Critically revising the article: Couldwell. Reviewed final version of the manuscript and approved it for submission: Couldwell.

Acknowledgments

The authors thank Kristin Kraus, M.Sc., for editorial assistance preparing this paper.

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Manuscript submitted January 15, 2011.
Accepted February 15, 2011.
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