Validation of the superior interhemispheric approach for tuberculum sellae meningioma

Clinical article

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Object. The objective of this study was to evaluate the ophthalmological outcome, nonvisual morbidity, and surgical complications after tuberculum sellae meningioma (TSM) removal using a superior interhemispheric approach.

Methods. In the last decade, 20 consecutive patients with TSM underwent operations using the superior interhemispheric approach. Visual acuity, visual field, and ocular fundus examination were assessed both preoperatively and 6-months postoperatively. Nonvisual morbidity was determined at an early postoperative period and at 6 months based on assessment of the Karnofsky Performance Scale score, leakage of CSF, endocrinological status, and olfactory function, which was assessed using a visual analog scale (VAS). The potential brain injury related to the approach was assessed by MRI at 6 months. Magnetic resonance imaging was then performed yearly to detect a recurrence. The mean follow up was 56.3 ± 34 months.

Results. The primary presenting symptom for diagnosis of TSM in 20 patients (female: male ratio of 6.6:1, mean age 59.1 ± 11.1 years) was visual disturbance in 12 patients (60%), headache in 4 (20%), cognitive alteration in 1 (5%), epilepsy in 2 (10%), and accidental in 1 (5%). In a total of 40 eyes, 17 eyes in 11 patients presented with preoperative deterioration of visual acuity. Postoperatively, the visual acuity improved in 13 eyes in 8 patients (72.8%), remained unchanged in 3 eyes in 2 patients (18.2%) and deteriorated in 1 patient (9%). The nonvisual morbidity included olfactory deterioration in 7 patients (35%), and panhypopituitarism in 1 patient (5%). No patients experienced a CSF leak. The impact of olfactory deterioration on the quality of life, as estimated by a VAS score (range 0–10), was a mean of 5.7 ± 2.2 (95% CI 4.1–7.3). On the follow-up MRI, no additional lesions or recurrences were observed on the medial aspect of the frontal lobe along the surgical corridor.

Conclusions. The superior interhemispheric approach appears to be effective in resolving the problem of visual deterioration due to a TSM, without inducing surgical injury on the brain surface along the surgical corridor. Olfactory deterioration remained the challenging predominant nonvisual morbidity using this approach.

Key Words • interhemispheric approach • skull base meningioma • tuberculum sellae • oncology • diagnostic and operative techniques

The tuberculum sellae, a transversal bony prominence between the middle clinoid processes, separates the chiasmatic sulcus from the anterior wall of the pituitary fossa.28 Tuberculum sellae meningiomas arise from the dural midline over the tuberculum sellae, chiasmatic sulcus, and limbus sphenoidale,1,2,3,6,7,13,18,23,30,35 and account for 10% of all intracranial meningiomas. The narrow anatomical relationship between this area and the optic tractus explains the early visual disturbances secondary to the displacement of the optic chiasm and nerves by TSMs,1,6,7,13,18,27,30,39 the most common initial symptom. The resection of TSMs was commonly performed via a lateral subfrontal approach using pterional or supraorbital flap craniotomy,2,18,23,30,35 but an anterior subfrontal approach using free bifrontal flap craniotomy6,25 has also been proposed.

The dissection of the anterior interhemispheric fissure is classically used to expose a variety of midline pathological lesions involving the suprasellar cistern, such as craniopharyngiomas2,13,18 and anterior communicating artery aneurysms,5,15,17,34,36 The interhemispheric approach has rarely been reported for the use of removing midline meningiomas.16,22,23 In addition to the frontobasal interhemispheric approach,26 the superior interhemispheric approach using an osseous flap above the frontal sinus provides an orthogonal view of the anterior cranial base up to the posterior clinoid processes.22,37 Since 1998,

Abbreviations used in this paper: ICA = internal carotid artery; KPS = Karnofsky Performance Scale; TSM = tuberculum sellae meningioma; VAS = visual analog scale.
the Neurosurgery Department of Rouen University Hospital has been using this approach for all anterior cranial base meningiomas.  

The objective of this study was to analyze the ophthalmological outcome, nonvisual morbidity, and traumatic consequences after resection of a TSM using a superior interhemispheric approach in a consecutive series of 20 patients.

Methods

Study Design

This study included all consecutive patients who underwent operations for TSMs via a superior interhemispheric approach that was routinely used in the Neurosurgery Department of Rouen University Hospital over a 10-year period (January 2000 to January 2010). The primary objective of the study was to assess ophthalmological outcome after using this approach. The secondary objective was to analyze surgical complications, including the traumatic consequences of a brain retractor on the medial aspect of the frontal lobes, and nonvisual morbidity.

We collected admission data, preoperative neuroophthalmological and olfactory status, imaging studies, operative records, and follow-up evaluations from the patients’ charts. In the preoperative stage, all patients were studied using MRI involving T1-weighted sequences (axial, coronal, and sagittal plane) with and without Gd injection, T2-weighted and FLAIR sequences (axial plane), and in some cases a CT scan. The maximum tumor diameter (measured in millimeters) permitted us to dichotomize our population into 2 meningioma sizes: those with TSMs > 40 mm, and those with TSMs ≤ 40 mm. At 6 months, the global functional evaluation of each patient was assessed using the KPS score.

Ophthalmological and Endocrinological Assessment

An ophthalmologist assessed visual acuity, visual field, and the ocular fundus for each patient during the preoperative period, immediately postoperatively, and 6 months after surgery. A change of at least 1 line on the Snellen eye chart meant improvement or deterioration of visual acuity. The visual field was improved if any visual defect regression was noted, regardless of the initial deficit (bitemporal visual field defect or quadrantanopsia). Visual deterioration was considered severe when the visual acuity was inferior to 5 on the Snellen chart in at least 1 eye.

In the preoperative and postoperative periods (1 week and 3 months), the endocrinological analysis included the adrenal, gonadal, and thyroid axes by measurement of basal serum levels of prolactin, adrenocorticotropic hormone, morning cortisol, growth hormone, follicle stimulating hormone, testosterone in men, and estradiol in women. Dynamic testing was performed to evaluate the hypothalamic-pituitary-glandular axis and to assess adrenal, thyroidal, and prolactin reserve. Moreover, posterior pituitary function was evaluated by monitoring fluid intake, urinary output, and urine specific gravity.

Resection Using the Superior Interhemispheric Approach

Under general anesthesia, the patient was placed supine with the head in a straight axis above the heart to facilitate venous drainage. The skin was cut posterior to the frontal hairline from zygoma to zygoma. The scalp was pulled forward and separated from the pericranium, therefore preserving the 2 supraorbital nerves. A small free bone flap was detached by a side-cutting drill between the superior limit of the frontal sinus and the coronal suture, 4 cm away from the midline on the right side and 1 cm on the left side. Under an operative microscope, the dural opening was U-shaped with a medial base avoiding the superior sagittal sinus. One unilateral corridor between the falx and the medial aspect of the right frontal lobe (< 1 cm) constituted the interhemispheric approach up to the interhemispheric fissure. Careful attention was given to preserve the bridging veins. The trajectory line of the optical view (axial view allowed by the operative microscope) in the interhemispheric approach is shown in Fig. 1.

By dissecting the interhemispheric fissure between the medial aspects of the right frontal lobe, the optical view permitted us to first expose the superior pole of the meningioma (Fig. 2A, Video 1), and then the jugum sphenoidale just in front of the anterior border of the dural insertion of the meningioma.

Video 1. Clip showing the microsurgical removal of a large TSM via a superior interhemispheric approach. Click here to view with Media Player. Click here to view with Quicktime.

The blood supply to the meningioma from the tuberculum sellae and the jugum sphenoidale was interrupted using bipolar forceps combined with microsuction and microscissors, and/or combined for a debulking of the tumor using an ultrasonic dissector. The access to the lateral aspect of the TSM allowed a careful dissection from the optic chiasm and both optic nerves up to the dihe-dral space with the ICA (Fig. 2B). Avoiding the arachnoid plane around the optic nerves offered the best way to preserve the microvasculature. However, in some instances, the tumor was adherent to the optic nerve and chiasm. In these cases, a thin cuff (or layer) of the tumor was left ad-herent to the chiasm to avoid jeopardizing the microvasculature and the neural structures. In tumors with signifi-cant extension into the optic canal, the falciform ligament was sectioned and the optic canal unroofed by drilling. For large meningiomas, careful dissection of the olfac-tory tracts with arachnoidal membrane was performed to preserve the surface microvasculature (Fig. 2C).

On the posterior aspect of the TSM, the anterior communicating complex and its perforating vessels were gently pushed away to identify the arachnoid veil covering the pituitary stalk, which was pushed backward. The dissection from the sellae dura mater, the distal portion of the pituitary stalk, and possible extension of the TSM into the sellae was performed using the interhemispheric approach (Fig. 2D). The bulk of the tumor was removed until only a superficial thin layer remained, and then dissection of the capsule was carefully performed from the medial aspect of the frontal lobes. The tumor matrix was coagulated and the hyperostosis was drilled using a high-
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...speed diamond drill. The quality of resection was evaluated at the end of the procedure according to the Simpson classification.

Postoperative Complications

The immediate follow-up evaluation was completed during the first 24 hours in the intensive care unit and continued until patient discharge. For each patient the following complications were evaluated: neurological deterioration of all causes (sensorial impairment, brain damage by contusion or ischemic injury), endocrinological dysfunction, postoperative hematoma (whether surgery was required), leakage of CSF, hydrocephalus (transient or definitive), meningeal infection, pulmonary or urinary tract infection, electrolyte disorders, and pulmonary embolus.

Follow-up MRI such as axial T1-weighted sequences with and without Gd injection, coronal T2-weighted sequences, and FLAIR were performed at 3 and 12 months after the resection and then annually thereafter.

On the postoperative MRI, surgical trauma to the brain surface was explored along the surgical corridor required for the tumor resection. The internal aspects of the frontal lobes were analyzed to detect radiological changes corresponding to potential contusions, ischemia, or new hemorrhage. In addition, possible recurrences of the tumor were depicted on T1-weighted MRI sequences with Gd injection. Any increase of residual tumor or occurrences of a new lesion in cases of complete resection was considered a recurrence.

Results

Study Population

Twenty consecutive patients with TSMs (Table 1) were included (female:male ratio of 6.6:1). The mean patient age at the time of operation was 59.1 ± 11.1 years. The primary presenting symptom for diagnosis was a visual disturbance in 12 patients (60%, including visual eclipses in 1 patient [Case 19]), headache in 4 (20%), cognitive alteration in 1 (5%), epilepsy in 2 (10%), and accidental in 1 (5%). The mean duration until diagnosis was 5.8 ± 5.9 months. The ophthalmological examination (Table 1) displayed visual acuity deterioration in 11 (55%), visual field alteration in 8 (40%), and optic atrophy in 8 (40%). Olfactory status was normal in 17 patients (85%), hyposmia was found in 2 (10%) and anosmia was found in 1 (5%). The mean preoperative KPS score was 82.5 ± 9.7. On preoperative MRI, the mean maximum tumor diameter was 32.5 ± 13.8 mm (range 18–53 mm) and a maximum tumor diameter larger than 40 mm was found in 6 patients (30%). Anterior cerebral artery encasement (Fig. 3) was observed in 7 patients (35%). Magnetic resonance imaging redressed the previously erroneous diagnosis established by CT in 2 patients. In the first patient (Case 16), the initial diagnosis was an asymptomatic pituitary macroadenoma, whereas an associated suprasellar meningioma was responsible for compression of the visual tractus. The enclosed macroadenoma was treated by a transsphenoidal approach 9 months later. The second patient (Case 17) was initially admitted for an anterior communicating artery aneurysm.

The mean operating time was 276 ± 92 minutes and the mean operative blood loss was 448 ± 393 ml. During the resection, the optic chiasm appeared to be pushed upwards in 6 patients (30%) and downward in 14 (70%). Despite meningioma extension to the optic canal requiring opening of its roof in 3 patients, complete tumor removal (Simpson Grade I or II) was achieved in 19 patients (95%). The mean follow-up for these patients was 57 ± 33 months and none presented with a recurrence or growth from the insertion base. All patients presented with WHO Grade I meningioma, which was subdivided into meningothelial in 12 (60%), transitional in 5 (25%), fibroblastic in 2 (10%), and psammomatous in 1 (5%).

Neuroophthalmological Outcome

At examination, 11 patients (55%) presented with preoperative visual acuity deterioration, unilateral in 5...
and bilateral in 6. In a total of 40 eyes, preoperative visual acuity deterioration was detected in 17 eyes, qualified as severe in 8 patients and moderate in 3. The severe visual acuity deterioration (n = 8) was not associated with meningioma size or optic chiasm displacement (p > 0.05, Pearson chi-square test).

In these 11 patients, visual acuity improved postoperatively in 13 eyes in 8 patients (72.8%), remained unchanged in 3 eyes in 2 patients (18.2%), and deteriorated in 1 patient (9%). The postoperative deterioration (Case 3) was due to ischemic injury of the right optic nerve encased in an invasive meningioma, in spite of a careful dissection leaving a thin cuff along the nerve. For the 9 other patients, no visual deterioration was found.

Of the 8 patients with visual field defects, 7 improved with recovery of the normal visual field and 1 remained unchanged. The patients with optic atrophy (n = 8, 40%) did not present with any fundal changes after the surgery.

**Nonvisual Morbidity**

Olfactory deterioration was the most common postoperative morbidity, present in 7 patients (35%). In the 17 patients without preoperative olfactory alteration and in the 3 with alteration, deterioration occurred in 6 and 1, respectively. In these 7 patients with postoperative olfactory deterioration, 3 presented with hyposmia (15%) and 4 with anosmia (20%). In these 4 latter patients (Cases 8, 13, 16, and 18), olfactory injury was recorded on the operative report. This deterioration occurred after the removal of a large meningioma in 4 patients and after removal of a medium-sized meningioma in 3. After 6 months, olfactory function was preserved in 10 patients (50%), but was altered due to hyposmia in 3 and anosmia in 7. The impact of this olfactory deterioration on the quality of life was estimated using a VAS, resulting in a mean score of 5.7 ± 2.2 (95% CI 4.1–7.3).

Panhypopituitarism occurred in 1 patient (Case 6).
<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Presenting Symptoms</th>
<th>Right Visual Acuity Preop/Postop</th>
<th>Left Visual Acuity Preop/Postop</th>
<th>Visual Field Preop/Postop</th>
<th>Preop Maximum Tumor Diameter (mm)</th>
<th>Operative Blood Loss (ml)</th>
<th>Histopathological Features</th>
<th>Procedural Complication</th>
<th>Olfactory Outcome</th>
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<tr>
<td>1</td>
<td>50, F</td>
<td>visual</td>
<td>1/2</td>
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<td>anosmia</td>
</tr>
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<td>2</td>
<td>48, F</td>
<td>visual</td>
<td>10/10</td>
<td>0/0</td>
<td>quadrantopsia/normal</td>
<td>25</td>
<td>200</td>
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<td>none</td>
<td>preserved</td>
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<tr>
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<td>63, F</td>
<td>visual</td>
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<td>3/10</td>
<td>normal/normal</td>
<td>48</td>
<td>500</td>
<td>transitional</td>
<td>optic ischemia</td>
<td>hyposmia</td>
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<td>4</td>
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<td>53</td>
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<td>10/10</td>
<td>normal/normal</td>
<td>20</td>
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<td>6/5</td>
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<td>8</td>
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<td>10/10</td>
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<td>52</td>
<td>300</td>
<td>transitional</td>
<td>olfactory tractus trauma</td>
<td>anosmia</td>
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<td>9</td>
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<td>8/8</td>
<td>8/8</td>
<td>normal/normal</td>
<td>20</td>
<td>100</td>
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<td>4/6</td>
<td>10/10</td>
<td>normal/normal</td>
<td>35</td>
<td>1500</td>
<td>transitional</td>
<td>none</td>
<td>preserved</td>
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<td>11</td>
<td>47, F</td>
<td>headaches</td>
<td>10/10</td>
<td>10/10</td>
<td>normal/normal</td>
<td>18</td>
<td>200</td>
<td>meningothelial</td>
<td>none</td>
<td>preserved</td>
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<tr>
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<td>64, F</td>
<td>headaches</td>
<td>10/10</td>
<td>10/10</td>
<td>normal/normal</td>
<td>20</td>
<td>200</td>
<td>meningothelial</td>
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<td>preserved</td>
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<tr>
<td>13</td>
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<td>5/10</td>
<td>2/10</td>
<td>quadrantopsia/normal</td>
<td>52</td>
<td>300</td>
<td>meningothelial</td>
<td>olfactory tractus trauma</td>
<td>anosmia</td>
</tr>
<tr>
<td>14</td>
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<td>headaches</td>
<td>10/10</td>
<td>10/10</td>
<td>normal/normal</td>
<td>30</td>
<td>500</td>
<td>meningothelial</td>
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<td>preserved</td>
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<td>cognitive alteration</td>
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<td>10/10</td>
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<td>650</td>
<td>meningothelial</td>
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<td>hyposmia</td>
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<td>16</td>
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<td>8/8</td>
<td>HBT/normal</td>
<td>22</td>
<td>180</td>
<td>fibroblastic</td>
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<td>anosmia</td>
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<tr>
<td>17</td>
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<td>headaches</td>
<td>10/10</td>
<td>10/10</td>
<td>normal/normal</td>
<td>20</td>
<td>180</td>
<td>fibroblastic</td>
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<td>preserved</td>
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<tr>
<td>18</td>
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<td>epilepsy</td>
<td>7/9</td>
<td>7/9</td>
<td>normal/normal</td>
<td>52</td>
<td>500</td>
<td>meningothelial</td>
<td>olfactory tractus trauma</td>
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<td>8/8</td>
<td>normal/normal</td>
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<td>400</td>
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<tr>
<td>20</td>
<td>44, F</td>
<td>visual</td>
<td>4/8</td>
<td>5/8</td>
<td>HBT/normal</td>
<td>20</td>
<td>400</td>
<td>meningothelial</td>
<td>none</td>
<td>preserved</td>
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</table>

* HBT = hemianopsia bitemporal; HLH = hemianopsia lateral homonym; NA = not applicable.
who underwent treatment for a large meningioma 53 mm in diameter and required adrenocorticotropic, thyroid, and antidiuretic hormone substitution. No CSF leakage or postoperative hematoma was observed. Other medical complications such as electrolyte disturbances and urinary tract infection occurred in 2 patients (10%).

Residual tumor was found on the postoperative CT scan in 1 patient (Case 5). This residual tumor was located on the left side of the falx, that is, contralateral to the right-sided surgical approach, requiring an early re-operation to remove it. After a mean follow-up of 56.3 ± 34 months (95% CI 40–72 months) in all patients, no recurrence was diagnosed on follow-up MRI. On follow-up imaging, the abnormalities were all related to the tumor growth, and no surgical trauma to the brain surface (ischemia or contusion) was observed on the medial aspect of the frontal lobe along the surgical corridor (Fig. 4).

Discussion

As a result of the superior interhemispheric approach used in this series of 20 patients with TSM with no deaths, the visual acuity improved in 72.8%, remained unchanged in 18.2%, and deteriorated in 9%. The nonvisual morbidity in this series included olfactory deterioration in 35% and panhypopituitarism in 5%. These results are in the range of those reported using other approaches (Table 2). In addition, postoperative imaging in our patients revealed no trauma on the brain surface along the surgical corridor required for the interhemispheric dissection. Lateral subfrontal approaches represent the conventional surgical procedures for resection of TSM. The interhemispheric approach, either frontobasal or superior, is rarely reported but the superior interhemispheric approach offers several advantages for such dural midline suprasellar meningiomas.

The first advantage of the superior interhemispheric approach is that it might decrease surgical injury to the olfactory tractus. However, preserving olfactory function continues to be a surgical challenge for this tumor location on the cranial base because these meningiomas grow at a distance from the olfactory bulb, pushing away laterally the olfactory tract and superiorly the olfactory trigone. Few cases of postoperative olfactory deterioration have been reported after TSM resection. Ganna et al. using a frontobasal interhemispheric approach in 24 patients, observed 30% with anosmia. Regarding the pterional or supraorbital subfrontal approaches, no results involving postoperative olfactory function have been reported. In comparison, 42% of patients were reported to suffer anosmia after contralateral clipping of an anterior aneurysm using the pterional approach. In our series, the rate of postoperative anosmia was 20%. Several characteristics of the superior interhemispheric approach could explain this difference.

First, the superior interhemispheric approach required minimal unilateral retraction of the frontal lobe and no elevation from the orbital roof in comparison with the subfrontal approaches. The upward retraction of the frontal lobe determines the risk of sectioning, avulsion, or creating an ischemic lesion on the olfactory nerves, and must be limited to 1.5 cm. In contrast to the anterior or lateral subfrontal approaches, the olfactory nerves were exposed in the operative field during the procedure, exposing the patient to surgical injury. Third, the olfactory tractus appeared progressively in the periphery of the operative field at the end of meningioma debulking. The careful microdissection had to avoid the arachnoid membrane without separating the tract from the inferior aspect of the frontal lobe to pre-
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### TABLE 2: Summary of recent microsurgical series involving TSM treatment

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Patients</th>
<th>Median Age/ F:M Ratio†</th>
<th>Visual Disturbance (%)</th>
<th>Max Tumor Diameter (mm)</th>
<th>Surgical Approach</th>
<th>Mortality Rate (%)</th>
<th>Nonvisual Morbidity (%)</th>
<th>Visual Outcome (%)</th>
<th>Recurrence Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fahlbusch &amp; Schott, 2002</td>
<td>47</td>
<td>54.3/4.1</td>
<td>96</td>
<td>25</td>
<td>pterional</td>
<td>0</td>
<td>15</td>
<td>80/0/20</td>
<td>4.2 (&gt; 5 yrs)</td>
</tr>
<tr>
<td>Jallo &amp; Benjamin, 2002</td>
<td>23</td>
<td>57.1/1.9</td>
<td>96</td>
<td>33</td>
<td>pterional</td>
<td>8.7</td>
<td>4.3</td>
<td>55/26/19</td>
<td>4.3</td>
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<td>Chi &amp; McDermott, 2003</td>
<td>21</td>
<td>52.3/2</td>
<td>90</td>
<td>NA</td>
<td>bifrontal, unifrontal pterional</td>
<td>0</td>
<td>NA</td>
<td>47/42/11</td>
<td>NA</td>
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<tr>
<td>Schick &amp; Hassler, 2005</td>
<td>53</td>
<td>52.6/3.1</td>
<td>83</td>
<td>26</td>
<td>pterional</td>
<td>3.7</td>
<td>39.6</td>
<td>38/47/15</td>
<td>3.7</td>
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<td>Bassiouni et al., 2006</td>
<td>62</td>
<td>53/4</td>
<td>87.1</td>
<td>34</td>
<td>pterional</td>
<td>0</td>
<td>16.1</td>
<td>53/30/17</td>
<td>3.2</td>
</tr>
<tr>
<td>Mathiesen &amp; Kihlström, 2006</td>
<td>29</td>
<td>58.3/3.8</td>
<td>87</td>
<td>25</td>
<td>pterional</td>
<td>0</td>
<td>20.6</td>
<td>91/9/0</td>
<td>NA</td>
</tr>
<tr>
<td>Nakamura et al., 2006</td>
<td>72</td>
<td>54.3/3.2</td>
<td>72</td>
<td>25</td>
<td>bifrontal, pterional, frontolateral</td>
<td>2.7</td>
<td>15.3</td>
<td>68/20/12</td>
<td>2.8</td>
</tr>
<tr>
<td>Ganna et al., 2009</td>
<td>24</td>
<td>53.8/5.1</td>
<td>100</td>
<td>26</td>
<td>frontobasal interhemispheric</td>
<td>0</td>
<td>33</td>
<td>79/17/4</td>
<td>NA</td>
</tr>
<tr>
<td>Sughrue et al., 2011</td>
<td>69</td>
<td>54/NA</td>
<td>87</td>
<td>23.5</td>
<td>pterional</td>
<td>0</td>
<td>11</td>
<td>47/42/11</td>
<td>NA</td>
</tr>
<tr>
<td>Terasaka et al., 2011</td>
<td>9</td>
<td>64.4/8</td>
<td>100</td>
<td>31</td>
<td>superior interhemispheric</td>
<td>0</td>
<td>33</td>
<td>88.9/11.1/0</td>
<td>NA</td>
</tr>
<tr>
<td>present study</td>
<td>20</td>
<td>60.2/6.6</td>
<td>60</td>
<td>32.5</td>
<td>superior interhemispheric</td>
<td>0</td>
<td>40</td>
<td>72.8/18.2/9</td>
<td>0</td>
</tr>
</tbody>
</table>

† All ratios have the same understood second value: 1 male.

serve its microvasculature lying on the dorsal surface of the nerve.\(^{14,15}\)

The second advantage of the superior interhemispheric approach was a decreased surgical risk to the microvasculature. Careful dissection of the anterior communicating artery complex and its branches was achieved by good visualization of the posterior aspect of the tumor. Performed at an early stage of the operative period, this dissection permits one to cut the microvessels from the anterior cerebral artery to the meningioma and to selectively dissect the encased anterior cerebral artery and its branches. In contrast, the interhemispheric or lateral subfrontal approaches offer a late and incomplete exposition of this vascular tree.\(^{2,21}\) Posteriorly, the dissection releases the nerve.\(^{14,15}\) Nevertheless, the unilateral approach respecting the superior sagittal sinus or the bridging veins may occur, especially in the beginning of intervention. To avoid these complications, we used the following precautions: 1) the osseous flap slightly crossing the median line by 2) the medial reflection of the dural flap without excessive tension, and 3) minimal retraction of the frontal lobe (< 15 mm). Nevertheless, the unilateral approach respecting the superior sagittal sinus avoids venous return alteration.\(^{2,13,23,26,30,33,38}\) Continuing downward along the brain falx, the dissection must remain between the cingular gyri without passing through the pia mater up to the superior pole of the meningioma. As in our series, no infarct on the medial face of the frontal lobe has been reported in previous series describing this superior interhemispheric approach.\(^{2,21,37}\)

In contrast to the subfrontal lateral\(^{10,13,21,25,30,35}\) or basal interhemispheric approaches,\(^{16}\) control of the meningioma vascularization by sectioning the branches from the meningohypophyseal arteries and posterior ethmoidal arteries via the superior interhemispheric approach was obtained after tumor debulking. Despite this transoral strategy\(^{2,21,37}\) to control the basal vascularization, the mean
intraoperative blood loss (547 ml, range 0–1700 ml) was similar to that of the lateral subfrontal approach (395 ml, range 0–2000 ml).29,30 Although the operating duration depends on numerous intraoperative factors, our mean value of 276 ± 92 minutes was comparatively higher than the 158 minutes reported for the lateral supraorbital approach,29 but lower than the mean of 230 minutes previously observed in a series of 18 patients operated on using a superior interhemispheric approach.32

The classic pitfall of this unilateral superior interhemispheric approach is the anterior extension of meningioma toward the contralateral side of the crista galli,22,37 which requires sectioning of the inferior part of the falk due to the narrow corridor targeted to the tuberculum and the frontal lobe covering this area.

Conclusions

Tuberculum sellae meningiomas affect the visual prognosis because of their close relationship to the optic apparatus and the suprasellar area, and the involvement of arachnoidal membranes lining the microvasculature. We demonstrate in this patient series that the superior interhemispheric approach is effective in treating the visual deterioration without inducing injury on the brain surface along the surgical corridor in contact with the medial surface of the frontal lobe. Olfactory deterioration remains the predominant nonvisual morbidity that demands further innovative surgical procedures.

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: Proust, D Hannequin, Castel. Acquisition of data: Curey, P Hannequin, Muraine. Analysis and interpretation of data: Curey, Derrey, D Hannequin. Drafting the article: Proust, Curey, Castel. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Proust. Administrative/technical/material support: Curey. Study supervision: Proust.

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