Comparison of Extended Transsphenoidal Approach and Transcranial Approach for Tuberculum Sellae Meningiomas

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Abstract: Tuberculum sellae meningiomas are usually removed using various transcranial approaches. The extended transsphenoidal approach also indicates for some lesions around the sella turcica. The author primarily approaches supradiaphragmatic tumors through the tuberculum sellae using the extended transsphenoidal approach, termed the “transsphenoidal-transtuberculum sellae approach” even for the tuberculum sellae meningiomas. When a patient complains of visual problems and MRI shows the presence of a tuberculum sellae meningioma, a decision is made as to whether surgical treatment requires using the transcranial or the transsphenoidal-transtuberculum sellae approach. To make the correct choice, 3 radiological factors on MRI are always investigated: (1) degree of sphenoid sinus pneumatization, (2) anterior and/or lateral extension of the tumor, (3) tumor extension into the optic canals. This paper describes personal experience of the transsphenoidal-transtuberculum sellae approach for 3 meningiomas compared to the frontobasal interhemispheric approach for 3 meningiomas.

Key words: Extended transsphenoidal approach, interhemispheric approach, surgical approach, transcranial approach, tuberculum sellae meningioma.

1. Introduction

Recently, a modified transsphenoidal approach, the so-called “extended transsphenoidal approach” for removing extrasellar lesions has been reported with increased frequency. Tumors located in the anterior cranial base and the supradiaphragmatic region, which were once thought to be accessible only with transcranial approaches are now being approached through this extended transsphenoidal approach [1-9]. During the past few years, the endonasal route has been widely used even with the extended transsphenoidal approach [1-6], which provides a more minimally invasive approach than the sublabial route [10], although slightly narrower and off-midline exposure is a potential problem [1]. When using the extended transsphenoidal approach, the author mainly operates using a microscope with a 3-dimensional view under direct vision, and the sublabial route is required for a wider entrance to the speculum than the endonasal route. And additional assistance of an endoscope during operation allows for a more panoramic view and permits widening the approach in all directions.

Tuberculum sellae meningiomas traditionally have been removed using several transcranial approaches [11-18]. But, brain retraction and manipulation of neurovascular structures, which are generally required for all transcranial approaches to the suprasellar space, have been associated with a variety of postoperative problems, such as postoperative seizure, brain contusion, cranial nerve injury, and stroke due to vascular impairment.

The extended transsphenoidal approach, even for tuberculum sellae meningiomas, allows excellent midline access to the tumor origin without brain retraction. Dural incision at the attachment of the tumor after a hemostatic maneuver at this site with electrical coagulation dramatically reduces bleeding during

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subsequent tumor resection. Therefore, the extended transsphenoidal approach is theoretically the best approach for some tuberculum sellae meningiomas.

Several reports have recently presented comparative analyses of tuberculum sellae meningioma removal by a transcranial approach [pterional, unilateral/bilateral frontal, or supraorbital approach] versus an extended transsphenoidal approach (sublabial or endonasal approach) [5, 6, 8]. This paper describes personal experience of the extended transsphenoidal approach for tuberculum sellae meningiomas compared to the frontobasal interhemispheric approach. Reliability of tumor removal, operative time, postoperative complications, and hospitalization for each approach were investigated.

2. Clinical Materials and Methods

Since 1994, 25 patients with supradiaphragmatic tumors, including 10 cases of pituitary adenoma, 7 of Rathke’s cleft cyst, 3 of craniopharyngiomas, 3 of tuberculum sellae meningioma, 1 immature teratoma and 1 metastasis to the pituitary stalk, were removed using the extended transsphenoidal approach, termed the “transsphenoidal-transtuberculum sellae approach”, which was originally described elsewhere [7]. During the past 10 years, 6 patients with tuberculum sellae meningiomas have been treated, including 3 patients resected using this transsphenoidal-transtuberculum sellae approach and 3 resected using the frontobasal interhemispheric approach. All procedures were performed by the author. The patients were 2 woman and 4 men. The mean ages at the time of surgery were 55.3 years ranging from 30 to 71 years in the transsphenoidal-transtuberculum sellae approach group and 66.0 years ranging 61 to 75 years in the frontobasal interhemispheric approach group. Clinical data on the patients treated are detailed in Table 1. Visual impairment was the most common presenting symptom in 5 patients, and 1 patient (case 3) presented with only headache and a large tumor mainly located in the sphenoid sinus with a small intracranial extension incidentally diagnosed.

When presented with a patient complaining of visual problems and magnetic resonance imaging (MRI) showing the presence of a tuberculum sellae meningioma, a decision has to be made as to whether the surgical treatment should take the form of the transcranial or the transsphenoidal-transtuberculum sellae approach. To make the correct choice, 3 radiological factors on MRI are always investigated: (1) degree of sphenoid sinus pneumatization, (2) anterior and/or lateral extension of the tumor, (3) tumor extension into the optic canals. The transsphenoidal-transtuberculum sellae approach was selected in cases with well pneumatization of the sphenoid sinus except in 1 patient (case 3) whose tumor was located mainly in the sphenoid sinus without pneumatization, less extension of the tumor anteriorly to the anterior border of the sphenoid sinus and laterally to the optic canals or the supraclinoid carotid artery, and no tumor extension into the optic canals. The frontobasal interhemispheric approach was selected for cases with midline-located and broad-based tumors, which had an anterior extension of the tumor beyond the anterior border of the sphenoid sinus and/or lateral extension of the tumor beyond the supraclinoid carotid artery, with a tumoral extension into the optic canals.

2.1 Transsphenoidal-Transtuberculum Sellae Approach

The transsphenoidal-transsphenoidal approach as defined by the author in 1998 [7]. This technique is preferentially used to treat supradiaphragmatic lesions with a normal-sized pituitary fossa via the sublabial route with a microscope, because the speculum is easily positioned superior toward the planum sphenoidal without posterior ethmoidectomy and maneuverability of instruments is satisfactory with a wider operative field than the endonasal route, although some modern speculum designs might be allow a wide microscopic endonasal approach. A lumber drain was used for all transsphenoidal operations. Drains were removed on the seventh postoperative day.
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Table 1 Summary of cases.

<table>
<thead>
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<th>Case</th>
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<tr>
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<td>-</td>
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<td>27 days</td>
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</table>

FB-IH: frontobasal interhemispheric approach, TTS: transsphenoidal-transphenoideal approach, ACA: anterior cerebral artery, Lt.: left, Rt.: right, *: MRI findings.

2.2 Frontobasal Interhemispheric Approach

The operative technique of the frontobasal interhemispheric approach using a bilateral dural opening was previously reported in detail [14]. This approach offers wide exposure of the anterior cranial base with a good overview of the sellar, suprasellar, and parasellar areas, even if the tumor extends into both optic canals. It also affords an excellent midline orientation, and this basal midline approach allows for the early devascularization of the tumor at its basal attachment to the tuberculum sellae. For a tumor extending into the optic canals, unroofing and wide opening of the affected optic canals, which can be easily approached by this frontobasal interhemispheric route, are strongly proposed to allow the nerve to better tolerate manipulation.

3. Results

The transsphenoidal-transtuberculum sellae approach was used in 3 patients and the frontobasal interhemispheric approach was used in 3 patients for 6 tuberculum sellae meningiomas. Using the transsphenoidal-transtuberculum sellae approach, total resections were performed for 2 meningiomas (Fig. 1) and subtotal resection was achieved in 1 case. After total removal of the tumor, the anterior communicating artery complex and the optic chiasm were confirmed directly (Fig. 2). The other 3 meningiomas were totally

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Fig. 1 Case 1: Preoperative contrast-enhanced MRI in coronal (A) and sagittal (B) images revealed a tuberculum sellae meningioma located between the supraclinoid carotid arteries with less anterior extension of the tumor to the anterior border of the sphenoid sinus. Postoperative MRI on 3 months later without contrast enhancement in coronal (C) and sagittal (D) images confirmed total removal of the tumor, and showed the shrunken fat graft in the suprasellar space with extension out along the tuberculum sellae (D, arrowheads).
removed using the frontobasal interhemispheric approach with bilateral optic canals unroofing in two cases (Fig. 3). Of 5 patients with impaired vision before surgery, the symptoms improved after surgery, and there were no patients with a deterioration of visual acuity after resection.

As for the operative complications, 1 patient (case 2) for whom the transsphenoidal-transtuberculum sellae approach was used, had an anterior cerebral artery injury during tumor resection that required hemostasis with Gelfoam (Absorbable gelatin sponge, Pfizer USA Inc. Kalamazoo, MI, USA) and fibrin sealant. The same patient experienced pneumocephalus without CSF leakage after 7 postoperative days, which was treated with a lumber drainage for 2 weeks, and he had discharged without any sequelae of these complications. Whereas with the frontobasal interhemispheric approach, unilateral olfactory nerve disruption during operation in three cases and asymptomatic unilateral frontal contusion on postoperative MRI in two cases were observed (Fig. 3).

The mean operative time was 5 hours and 52 minutes for the transsphenoidal-transtuberculum sellae approach and 8 hours and 33 minutes for the frontobasal interhemispheric approach. The hospitalization times averaged 32.7 days, ranging from 17 to 62 days for the transsphenoidal - transtuberculum sellae approach, and 17.7 days, ranging from 13 to 27 days for the frontobasal interhemispheric approach.

4. Discussion

Meningiomas originating from the tuberculum sellae commonly extend into the optic canal, and visual loss in an affected eye is the initial and most common symptom. These tumors derive the majority of their vascular supply from the anterior cranial base deep in the critical neurovascular structures. Such meningiomas traditionally have been removed using various transcranial approaches [11-18]. However, none of these approaches completely eliminates the need for the manipulation of an already compressed optic apparatus around the tumor. Conceptually, a more direct approach to the anterior cranial base via a midline trajectory that completely obviates the need for any manipulation of critical neurovascular structures would be desirable.

The extended transsphenoidal approach, especially the transsphenoidal-transtuberculum sellae approach [7], for tuberculum sellae meningiomas provides such direct access to the vascular supply and enough exposure to allow resection of all involved bone and
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dura, which is ideal to control bleeding from the tumor because the dural attachment supplied blood can be managed at an early stage, and to minimize manipulation of critical neurovascular structures without brain retraction. This extended transsphenoidal approach is theoretically the best approach for some tuberculum sellae meningiomas, although there is limitation of a bone removal in the frontal cranial base anterior to the sella turcica. The ventral extent of the sphenoid sinus anterior to the upper recess under the tuberculum sellae is 14.6 mm on average, ranging from 8.9 to 23.1 mm [19]. The optic canals limit the lateral exposure of this approach. It is noteworthy that the distance between optic canals at the level of the tuberculum sellae (14.0 mm on average) varies remarkably, ranging from 9.0 to 24.0 mm [20]. Therefore, small tumors of less than 20 to 25 mm in diameter, located in the midline, are potential indications for the transsphenoidal-transtuberculum sellae approach.

A comparison of the effects of surgical approach (transcranial versus transsphenoidal surgery) on outcomes is not valid because of selection bias. Several reports recently presented comparative analyses of tuberculum sellae meningioma removal by a transcranial approach [pterional, unilateral/bilateral frontal, or supraorbital approach] versus an extended transsphenoidal approach (sublabial or endonasal approach) [5, 6, 8]. In these reports, the authors describe how transcranial approaches tended to have higher total or near total removal rates and were better suited for larger tumors extending well lateral to the supraclinoid carotid arteries or those with major vascular encasement, whereas the extended transsphenoidal approach might be acceptable for treating small tuberculum sellae meningiomas in some selected cases based on tumor anatomy. Kitano et al. [8] described, when comparing the extended transsphenoidal approach and the transcranial approach, how improvements to visual acuity and intraoperative blood loss were significantly better in the extended transsphenoidal approach group, whereas improvements to visual field defect, operative times, and tumor removal rate were not significantly different between the 2 groups. These results indicate that a direct approach to the tumor attachment and early interception of feeding arteries in the extended transsphenoidal route might result in significantly less intraoperative blood loss. Therefore, the extended transsphenoidal approach is a less invasive operation for treating some tuberculum sellae meningiomas. In my series, the mean operative time was 5 hours 52 minutes for the transsphenoidal-transtuberculum sellae approach and 8 hours 33 minutes for the frontobasal interhemispheric approach, and the mean hospitalization was 32.7 days for the former and 17.7 days for the latter, respectively. The operative times were obviously shorter for the transsphenoidal-transtuberculum sellae approach, which enabled early devascularization of the tumor at its base, but mean hospitalization was longer for the transsphenoidal-transtuberculum sellae approach, contrary to my expectation, because postoperative pneumocephalus occurred as a complication only in 1 patient (case 2).

The operative approach should be carefully examined for tumor-related conditions. Kouri et al. [9] describe how the limitations of the extended transsphenoidal approach are: (1) lateral extension beyond the site of intracranial dural penetration by the internal cerebral arteries or by the optic nerves into the optic canals, (2) a tumor lying behind the pituitary stalk in a patient with a normal pituitary function. De Divitiis et al. [4] described features that might represent contraindications for the transsphenoidal approach including: (1) tumor with a size exceeding 2 to 2.5 cm and an eccentric shape, (2) extension of the tumor inside the optic canal(s), (3) encasement of 1 or both internal carotid arteries with or without extension on the optocarotid triangle, and (4) encasement of the anterior communicating artery complex. He noted several other important points concerning bone-related conditions: (1) degree of pneumatization of the
sphenoid sinus, (2) a small sella, and (3) area of the
dural attachment of the tumor. Cavallo et al. [2] also
reported in a cadaveric study that the anatomic
conditions preventing the extended endonasal
approach from being used were a low level of
sphenoid sinus pneumatization, a small sella with a
small distance between internal carotid arteries, a wide
intercavernous sinus, and a thick tuberculum sellae.

To simply make the correct choice of operative
approach in my series, 3 radiological factors on MRI
were always investigated: (1) degree of sphenoid sinus
pneumatization, (2) anterior and/or lateral extension of
the tumor, and (3) tumor extension into the optic
canals. The transsphenoidal-transtuberculum sellae
approach was selected for cases with well
pneumatization of the sphenoid sinus, less extension
of the tumor anteriorly to the anterior border of the
sphenoid sinus and laterally to the optic canals or the
supraclinoid carotid artery, and no tumor extension
into the optic canals. This approach was selected for 3
patients including 1 who had a tumor located mainly
in the sphenoid sinus without pneumatization. Two
total resections and 1 subtotal resection were
performed, but an anterior cerebral artery injured
during tumor resection that required hemostasis with
Gelfoam and fibrin sealant and pneumocephalus
occurred on the 7th postoperative day, which was
treated with a lumber drainage for 2 weeks, and the
patient had discharged without any sequelae.

With progressive growth, tuberculum sellae
meningiomas develop lateral and superior extension,
resulting in vascular encasement and optic canal
invasion [6]. Although this optic canal invasion has
been thought to be a contraindication for the
transsphenoidal approach [4, 6], Kitano et al. [8]
described that the extended transsphenoidal approach
with posterior ethmoidectomy under microscope
provided direct exposure to the inferomedial surface
of the optic canals, allowing for direct visualization
and early decompression of the optic nerves. In this
report, 16 patients with tuberculum sellae meningioma
had improved visual acuity after tumor removal
including optic canaliculr lesions. This suggests that
tumor extension into the optic canals of tuberculum
sellae meningioma is no longer a contraindication for
the extended transsphenoidal approach, even when
using a microscope. The additional assistance of an
endoscope also permits opening the inferior wall of
the optic canals for a more panoramic view. And
although a poorly pneumatized sphenoid sinus was
listed as a reason for craniotomy, this also might not be
a contraindication for a transsphenoidal approach
in the era of image guidance such as a
neuronavigation using a drill.

As for complications of the extended
transsphenoidal approach including the
transsphenoidal-transtuberculum sellae approach,
Couldwell et al. [3] reported that the most significant
complications included development of CSF fistula
and vascular injury. The risk of CSF leakage may be
reduced by careful dural grafting or watertight sutures
with a patch graft consisting of fascia and expanded
polytetrafluoroethylene (Gore-Tex dural substitute;
Gore & Associates, Flagstaff, AZ, USA) with or
without adjuvant use of postoperative CSF drainage
[21]. In the purely endoscopic techniques,
vascularized flap options such as the nasal septal
mucosal flap was reported as providing the lowest
CSF leak rates [22]. Margalit et al. [17] noted that
heavily T2 weighted reversed MR images could reveal
the relationships of the tumor with the neurovascular
structures and tumor extension into the optic canals,
although standard MRI scans did not always clearly
demonstrate the relationship between the optic nerve
and the meningioma. This heavily T2 weighted
reversed MR images may be useful for preventing
intraoperative neurovascular injuries during tumor
resection as a preoperative evaluation of the
relationship between tumor and surrounding
neurovascular structures, especially optic nerves and
anterior cerebral arteries. Prevention of these
complications may be related to decreased length of
hospital stay.

If the transcranial approaches must be selected for removing tuberculum sellae meningiomas due to the abovementioned several factors, we can use several approaches including unilateral or bilateral subfrontal approaches, frontotemporal or pterional approaches and frontobasal interhemispheric approaches [11-18]. Goel et al. [15] described that a basal unifrontal approach on the side of a more severe visual deficit was superior to pterional exposure in that it provided symmetrical and wide exposure and direct access to both internal carotid arteries. It also had the advantage over a bifrontal exposure of avoiding the handling of and potential damage to the contralateral olfactory nerve, and there was no need to section the anterior part of the superior sagittal sinus or perform a dissection in the interhemispheric region. Jallo et al. [16] recommended the pterional approach, which allowed access to the suprasellar region with minimal brain retraction, with generous removal of the sphenoid ridge and wide dissection of the sylvian fissure. The advantages of this approach were that it minimized injury to the olfactory nerves and the risk of CSF leakage or infection from frontal sinus transgression was minimal. The only disadvantage of the pterional approach was that the undersurface of the ipsilateral optic nerve and chiasm were not as well visualized as by the subfrontal approach. Nakamura et al. [18] reported on operative morbidity and mortality for tuberculum sellae meningiomas with 3 different surgical approaches: frontolateral, pterional, and bifrontal approach. The frontolateral and pterional approach provided a remarkable improvement compared to the bifrontal approach. These approaches allowed quick access to the tumor and were minimally invasive with less brain exposure, but still enabled high rates of total tumor removal. By comparison, the frontolateral approach provided the best results for visual outcome while representing the least invasive surgical approach.

On the other hand, Ganna et al. [14] reported on the long-term visual outcome of patients with tuberculum sellae meningioma using the frontobasal interhemispheric approach, and described how this approach achieved a high rate of tumor removal and visual improvement with safety and a low incidence of complications. The frontobasal interhemispheric approach allows full exposure of the whole height of the tumor, thus minimizing the need for retraction on the superior pole of the tumor, and permits maximal tumor devascularization. Although there is minimal or no manipulation of the optic nerves or chiasm, and it also allows for easy removal of intracanalicular tumor after unroofing of the both optic canals, the most common complication is anosmia. The functional damage to the olfactory nerve may be explained by retraction forces, dryness, or interruption of blood supply. The olfactory nerves are speculatively torn by intra-operative depression due to CSF suction and lateral retraction of the frontal lobes with brain contusion as occurred in my series. Fujiwara et al. [23] found a significantly lower incidence of anosmia caused by olfactory nerve injury with the basal interhemispheric approach (1.9%) compared to the anterior interhemispheric approach (30%) in patients with anterior communicating artery aneurysms. But, it is worth mentioning that they performed the basal interhemispheric approach using unilateral dural opening and unilateral frontal lobe retraction, which was sufficient to expose and clip the aneurysm. I used this frontobasal interhemispheric approach using bilateral dural opening in 3 patients with midline-located and broad-based tumors, as familiarity with this approach for clipping anterior communicating artery aneurysms also encouraged me to decide the operative route. But, unilateral olfactory nerve disruption during operation in three cases and asymptomatic unilateral frontal contusion on postoperative MRI in two cases were observed, whereas the tumors were totally removed without visual impairment. To prevent traction injury to the olfactory nerves and brain contusion, the procedure to
retract upward bilaterally from the frontal base using brain retractor continuously should be avoided, and intermittent rest from bilateral retraction or single use of the retractor might be necessary. To dissect both olfactory nerves from the basal surface of the frontal lobes as long as possible and fix their bulbs in the cranial base with Gelfoam and fibrin sealant also might be required to prevent olfactory nerve disruption caused by bifrontal retraction and frontal depression due to decreased CSF.

5. Conclusion

When a patient complains of visual problems and MRI shows the presence of a tuberculum sellae meningioma, an adequate surgical procedure using the transcranial or transsphenoidal-transtuberculum sellae approach, should be decided due to several radiological factors on MRI. Selected small meningiomas less than 20 to 25 mm in diameter, located in the midline tuberculum sellae region between bilateral supraclinoid carotid arteries and without involvement of vascular structures, may be potential candidates for the transsphenoidal-transtuberculum sellae approach. In contrast, the frontobasal interhemispheric approach is recommended for midline tuberculum sellae meningiomas larger than 25 mm in diameter with a far lateral extension beyond the supraclinoid carotid arteries and optic canal encasement.

Although these results demonstrate the feasibility of the transsphenoidal-transtuberculum sellar approach, further studies including any endonasal approaches are necessary before firm conclusions can be reached regarding the efficacy, morbidity, and appropriate case selection for this procedure. The extended transsphenoidal approach, including the transsphenoidal-transtuberculum sellar approach, for tuberculum sellae meningiomas are not without risk and should be performed only by surgeons with significant experience of traditional transsphenoidal surgery.

References

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