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Anterior interhemispheric approach for tuberculum sellae meningioma

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ABSTRACT

Objective: We retrospectively analyzed patients with tuberculum sellae meningiomas (TSM) who underwent surgery via an anterior interhemispheric approach with special attention to visual outcomes.

Patients and Methods: Nine consecutive patients between April 2004 and December 2009 were examined. Visual impairment score (VIS) was used to analyze the visual status of the patients. A VIS is the sum of the scores in specific tables for visual acuity and visual field defects. Visual status was sequentially evaluated in the preoperative period and within two weeks of the operation. Any change in the VIS was considered to be an improvement or deterioration of visual function. All tumors were removed via an anterior interhemispheric approach. Following the wide dissection of the interhemispheric fissure, the tumor was first detached from its origin and debulked with the ultrasonic aspirator starting at the midline. The debulking continued until the arachnoid plane separating the nerve and tumor was visualized.

Results: Gross total resection (Simpson I+II) was achieved in all nine patients. The average VIS was 56.1 preoperatively and 26.3 in the postoperative period. Among nine patients, eight patients had an improvement of the VIS after surgery. VIS was unchanged in one patient and no patients experienced visual deterioration. Other non-visual complications, such as rhinoliquorrhea, venous infarction and permanent anosmia occurred in three patients.

Conclusion: Despite the small number of patients, a high resection rate and favorable visual outcome support the suitability of this approach for resection of TSM.

KEY WORDS: anterior interhemispheric approach, surgical removal, tuberculum sellae meningioma, visual impairment score, visual outcome

INTRODUCTION

The tuberculum sellae meningioma (TSM) arises from the tuberculum sellae, chiasmatic sulcus, and limbus sphenoidale. They represent approximately 3 to 10% of all intracranial meningiomas[1-5]. Patients harboring TSMs typically present with a history of uni- or bilateral progressive visual loss. The extent of visual deficit is the single most important reason for surgical treatment, and visual outcome is the major concern after surgery. Preservation or improvement of visual function is the most important goal of treatment; however worsened vision has been reported in 10 to 27%[2, 6-14]. Although many papers have proposed possible prognostic factors for visual outcomes, definitive prognostic factors remain unknown[10, 12, 15-17].

Most authors agree that meticulous surgical technique is the most essential element in determining visual outcome after resection of TSM, with particular care being taken to preserve the arachnoid plane and the vascular supply around the optic nerves and chiasm. Several surgical approaches including the pterional, unilateral subfrontal, and bifrontal approaches were applied for this lesion according to a variety of tumor sizes and attachments in this area[2, 7, 8, 12, 18, 19]. Recently, the endonasal transsphenoidal route was developed for small midline TSMs[20-23]. In the TSMs, the path for tumor growth tends to be over the planum sphenoidale anteriorly, around the optic nerves laterally, above the chiasm, displacing it superiorly, and down over the sella inferiorly. Based on the anatomical point of view, a safe and direct surgical access can be provided anteriorly.

The anterior interhemispheric approach was originally developed for anterior communicating artery aneurysms[24, 25]. With several technical modifications, this approach yields minimal morbidity and maximizes visualization around the tuberculum sellae. We retrospectively analyzed nine patients with TSMs who underwent surgery via the anterior interhemispheric approach with special attention to visual outcomes.

PATIENTS AND METHODS

Between April 2004 and December 2009, nine consecutive patients with TSMs underwent surgery via the anterior interhemispheric approach. All of the tumors strictly originated from the tuberculum sellae dura. Clinical and visual examinations, operative findings, imaging studies from these patients were reviewed retrospectively. The patients included a man and eight women ranging in age from 56 to 83 years (mean, 64.4 yr). The mean follow-up period was 25.2 months (range, 6-71 mos).

Radiological investigations included computed tomography and magnetic resonance imaging (MRI). In addition to the conventional MRI sequences, contrast enhanced 3D MP-RAGE (magnetization prepared rapid gradient echo) and 3D CISS (constructive interference in steady state) were performed for the evaluation of anatomical detail of the optic nerves and chiasm. The mean maximum tumor diameter was 30.6 mm (range: 20.5-45 mm). Angiography was performed in three patients and embolization of the tumor was not performed in any patients.

All patients presented with visual loss as their chief complaint. The mean duration of their symptoms was 11.6 months (range, 2-48 mos). Visual examinations consisted of testing the patient’s visual acuity with the best-correcting glasses for both eyes and funduscopy. Goldman perimetry was performed for the evaluation of visual field defects. Visual impairment score (VIS), the guideline of the German Ophthalmological Society, was used to analyze the visual status of the patients. Fahlbush and Schott [12] originally applied this score to the evaluation of surgical outcomes of tuberculum sellae and planum sphenoidale meningiomas. A VIS is provided by adding the scores in specific tables given for visual acuity and visual field defects. The score ranges from 0 (best) to 100 (worst). Visual status was sequentially evaluated in the preoperative period and within two weeks of surgery. Any change in the VIS was considered to be an improvement or deterioration of visual function.

All patients had normal endocrine function and were otherwise neurologically intact.

Surgical technique

All tumors were removed via the anterior interhemispheric approach. The patient was positioned supine and the back was elevated about 20 degrees to reduce venous pressure. The head was placed in the horizontal position. A coronal skin incision behind the hairline was utilized. The scalp was elevated, preserving vascularized pericranium medial to the linea temporalis of each side. Four burr holes were made and a bifrontal craniotomy was performed. The initial two holes were made at the orbitotemporal

region and the other two holes were at the midline. The medial inferior osteotomy was made close to the nasofrontal suture; therefore the frontal sinus must be opened. Next the frontal sinus mucosa was removed as completely as possible and was packed by tiny pieces of abdominal fat grafts soaked with the fibrin glue. A living flap of pericranium was swung over the frontal sinus and stitched to the frontal base dura at the end of the procedure. Then the dura was opened in a W-shaped fashion and reversed anteriorly. The superior sagittal sinus was ligated and divided at its most anterior part. The surgeon must preserve bridging veins from both frontal lobes during this maneuver.

Next the interhemispheric fissure just above the knee portion of the anterior cerebral arteries (ACA) was dissected until both callosomarginal arteries meet, with a vertex-down position of the head to allow easy opening of the fissure. Dissection was continued towards the A2 portion of the ACAs and the posterior part of the pericallosal cistern was opened. Then, after elevating the head, the interhemispheric fissure was dissected anteriorly and inferiorly toward the planum sphenoidale. Prior to this procedure, dissection of the both olfactory nerves from the frontal lobe was performed to avoid traction injuries. In most patients, a part of the tumor was exposed during this surgical step and special attention was required to preserve the arachnoid plane between the tumor and both rectal gyri. Then the head position was returned to horizontal, the suprachiasmatic cistern was widely dissected and the TSM was now exposed. (Fig.1A)

The tumor resection was conducted according to the following steps. The tumor was first detached from its origin with bipolar cautery and debulked with the ultrasonic aspirator. This procedure was started at the planum sphenoidale in the midline, taking down the tuberculum sellae and working straight back and repeating just off the midline. During this step, main tumor feeders from the posterior ethmoidal artery and the superior hypophyseal artery were interrupted in most patients and devascularization of the tumor was also accomplished. Then both optic nerves were identified at the optic canals and the tumor was debulked to allow dissection of the arachnoid plane separating the nerve and tumor. The side of the optic nerve with better visual function was first dissected because of a better arachnoid plane. (Fig. 1B) By tracing this arachnoid plane, the chiasm and the anterior communicating artery were gently dissected from the tumor. After sufficient debulking of the tumor, the compromised optic nerve was dissected while preserving the arachnoid plane and the vascular supplies. Then the tumor was dissected from the pituitary stalk and from the interpeduncular cistern. Damage to the small superior hypophyseal branches to the optic apparatus and small perforators from the posterior communicating artery was avoided. (Fig.1C) Finally, the proximal medial aspect of the optic canal was observed by the endoscope (EndoArm, Olympus, Tokyo,

Japan) where the tumor would occasionally extend and the tumor was resected with pituitary curettes. (Fig. 1D) Unroofing of the optic canal and drilling of the tuberculum sellae were not performed in any patients.

RESULTS

A summary of clinical data is shown in Table 1. Gross total resection (Simpson I+II) was achieved in all nine patients. The dural attachment at the tuberculum sellae was not removed except in one patient; however, the meningeal layer was thoroughly coagulated with bipolar cautery. The tumor was well devascularized in all patients and tumor consistency was soft in seven and intermediate in two patients. Preoperative MRI depicted tumor extension into the optic canal in four patients. These tumors were well visualized and removed under the endoscope. Histological examination revealed meningothelial meningioma; WHO grade I, in all patients. During the mean follow-up period of 25.2 months (range, 6-71 mos), radiological recurrence was not observed in any patient.

The average VIS was 56.1 preoperatively and 26.3 in the postoperative period. There was a statistically significance for VIS improvement from 56.1 to 26.3. (p-value=0.011, Wilcoxon signed-rank tests) Among nine patients, eight patients had an improvement of the VIS after surgery but visual function was not normalized in any patient. VIS was unchanged in one patient and no patient showed visual deterioration. If the visual function improved, it did so within the first postoperative week and continued to remain stable during the follow-up period.

There was no instance of perioperative mortality. Non-visual morbidity occurred in three patients. One patient had a second operation for rhinoliquorrhea; the site of the CSF leakage was the frontal sinus. One patient experienced asymptomatic venous infarction in the right frontal lobe because of a cortical vein injury during the procedure of dural opening. One patient showed permanent anosmia despite having anatomical preservation of olfactory nerves. There were no ischemic and endocrinological complications in our series.

DISCUSSION

Although preservation of vision is the most important goal in the treatment of TSM, the prognostic factors for visual outcome remain controversial[1, 7, 11-14, 17, 26, 27]. Whether surgical manipulation is the most important factor in determining the fate of vision or not, most authors agree that preserving vision is achieved by minimizing direct trauma to the optic nerve and avoiding injury to the vascular supply of the optic apparatus. The key to success for surgical excision of the TSM is maintaining the arachnoid plane. Therefore the best surgical approach requires the following factors: improving visualization of the tumor and the surrounding vital structures safely and enabling a bloodless surgical field.

The TSM has been removed by several surgical routes including the pterional, the unilateral subfrontal, the bifrontal, the basal interhemispheric and the transsphenoidal approaches[2, 7-12, 17, 19, 20, 28]. The pterional approach with wide dissection of the sylvian fissure allows good access to the suprasellar region. However the ipsilateral optic nerve and the branches of the internal carotid artery are sometimes disturbed safe tumor resection. The unilateral subfrontal approach provides short and direct surgical access with relative frontal lobe retraction. The disadvantage of this approach is that the medial aspect of the ipsilateral optic canal is not visualized as well as the undersurface of the ipsilateral optic nerve and chiasma. The bifrontal approach shows excellent surgical views of the entire optic apparatus and surrounding vital structures, whereas the tuberculum sellae where the tumor originates cannot be adequately exposed unless excessive frontal lobe retraction is performed. To overcome the disadvantage of the traditional bifrontal approach, the frontobasal interhemispheric approach was proposed by Ganna et al. This approach provided the midline orientation which allowed for full exposure of the entire tumor height. They described their surgical techniques and reported a favorable long term visual outcome. The transsphenoidal approach has some advantages; it obviates brain retraction and minimizes the need for optic nerve or chiasm manipulation, for relatively small midline TSMs[20-23]. The potential risk of rhinoliquorrhea is still high and the extent of tumor resection by this approach is unknown. There are few papers discussing the visual outcome of different surgical approaches. Although Nakamura et al reported the visual improvement rate was significantly better with the unilateral subfrontal than the bifrontal approach, reasonable explanations for this visual outcome remain unclear[8].

The anterior interhemispheric approach has prevailed for the treatment of anterior communicating artery aneurysms in Japan[24, 25]. Although this approach requires fine microsurgical techniques and prolonged operative time for dissection of the anterior

interhemispheric fissure, the above mentioned surgical steps provide a wide and direct anterior surgical avenue, allowing for visualization of the entire optic apparatus and surrounding structures including the tuberculum sellae without excessive frontal lobe retraction. The anterior interhemispheric approach has not been widely used, however this approach showed definitive good surgical results and no instances of postoperative visual deterioration in our series. In surgical resection of the meningioma, devascularization and detachment of the tumor from its origination prior to the tumor debulking are crucial procedures especially in deep sites. Tumor debulking without bleeding is the most reliable method to preserve the arachnoid plane and small vessels supplying the optic apparatus. Debulking of the tumor should be started midline even if the tumor extends laterally beyond the internal carotid artery. The arachnoid plane is usually kept intact even in such cases. Although this is a small series, our high resection rate and favorable visual outcome suggest the suitability of this approach for TSM. The incidence of olfaction loss in the anterior interhemispheric approach was high and functional damage to the nerve may be explained by retraction forces, dryness or interruption of its blood supply[19, 29]. Anosmia and rhinoliquorrhea are potential risks of this approach.

Early optic canal unroofing, which several authors have emphasized to improve visual outcome, is hard to perform in this approach[14, 15, 18, 26, 30]. Anatomically the orifice of the optic canal is not parallel to the coronal plane, and the proximal medial aspect exists more anteriorly than the lateral aspect of the optic canal. Therefore true tumor extension to the optic canal is rarely encountered. This finding is well confirmed by intraoperative observations under the endoscope. In tumors with significant extension into the canal, the falciform ligament is incised and unroofing of the proximal optic canal is required to remove the tumor with attention taken not to penetrate the sphenoid sinus mucosa.

CONCLUSION

The anterior interhemispheric approach was applied for nine patients with TSM. Gross total resection (Simpson grade I + II) was achieved in all patients. Postoperative visual function was improved in eight patients and unchanged in one patient. Despite the small number of patients, the high resection rate and favorable visual outcome suggest the suitability of this approach for TSM.

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Figure Legend

Figure 1. Intraoperative photograph of a tuberculum sellae meningioma via the anterior interhemispheric approach. A, After dissection of the anterior interhemispheric fissure, the tumor was found to extend to the planum sphenoidale and was exposed in the center of the surgical field. B, The side of the optic nerve with better visual function was first dissected because of a better arachnoid plane. C, The tumor was totally removed while preserving the arachnoid plane and the small vessels supplying the optic apparatus. (Black arrows) D, The proximal medial aspect of the optic canal (asterisk) is well visualized by the angled endoscope.

Table 1. Summary of clinical data

Patient no.	Age(yr)/sex	Size, mm	Duration of symptom, mo	Simpson's grade	Preop VIS	Postop VIS	Outcome
1	57/F	26	48	2	15	10	Improved
2	70/F	32	6	2	51	51	Unchanged
3	56/F	22	3	2	44	25	Improved
4	68/F	35	12	2	100	41	Improved
5	58/F	35	12	2	100	42	Improved
6	62/M	30	2	2	43	4	Improved
7	57/F	45	12	2	77	26	Improved
8	69/F	30	4	2	17	15	Improved
9	83/F	20.5	6	1	58	22	Improved