Acta Neurochir (Wien) (2000) 142: 751–757

Acta Neurochirurgica

Transcranial Transsphenoidal Approach for Tuberculum Sellae Meningiomas

H. Arai, K. Sato, O. Okuda, M. Miyajima, M. Hishii, H. Nakanishi, and **H. Ishii**

Department of Neurosurgery, Juntendo University, Tokyo, Japan

Summary

Objective. A series of 21 patients with tuberculum sellae meningioma who received surgical treatment is reported.

Patients and Methods. All 9 females and 12 males (mean age 49 years) presented visual disturbances of varying degrees in either one or both eyes. Eighteen of the tumours were less than 3 cm in size, and 3 were larger. Tumour resection of uniform surgical technique was performed in all cases. Following a bicoronal scalp incision, bifrontal craniotomy combined with removal of the orbital rim bilaterally was performed. The frontal dura was opened bilaterally, and the most anterior portion of the superior sagittal sinus was transected. Bifrontal retraction and arachnoid dissection along the proximal olfactory tracts brought the tumour into view. Additional dissection of the interhemispheric fissure extended the operative field to the anterior communicating artery. The anterior skull base was drilled out to resect the basal part of the tumour. In all cases, the optic canal and sphenoid sinus, and additionally in some cases the ethmoid sinus were opened. The tumour uniformly extended inferomedially to the optic nerve, and direct visualization of this portion of the tumour was possible with our approach. The opened paranasal sinuses were reconstructed with adipose tissue harvested from the patient's abdomen and the pericranial flap.

Results. In all patients, total or almost total resection of the tumour was accomplished. Postoperatively, visual function was improved in 11 patients, was unchanged in 8, and worsened in 2. There were no operative deaths. Cerebrospinal fluid leakage was occurred in two patients but could be conservatively managed. In a mean 3-year follow-up, tumour recurrence was observed in only one patient who presented a malignant histology.

Conclusions. We are confident that our surgical approach has great clinical value in surgical resection of tuberculum sellae meningioma. The good accessibility to a tumour extending inferomedially to the optic nerve should, in particular, be stressed.

Keywords: Tuberculum sellae; meningioma; bifrontal approach; transsphenoidal approach.

Introduction

Tuberculum sellae meningiomas frequently originate from the tuberculum sellae, chiasmatic sulcus and limbus sphenoidale, but also may originate from the diaphragma sellae or anterior clinoid region. The most common presenting symptoms and signs on admission are visual disturbances that are asymmetric, starting in one eye, worsen, and then spread to the other eye. Enhanced magnetic resonance imaging (MRI) usually reveals a homogeneously enhanced lesion centered on the tuberculum sellae and chiasmatic sulcus. A standard technique for resection of tuberculum sellae meningiomas is a unilateral subfrontal or frontotemopral approach, or a bifrontal approach [1, 2, 3, 4, 5, 7, 8, 9, 10, 11], although a transsphenoidal approach was reportedly used recently [6]. We report 21 patients with tuberculum sellae meningioma who underwent tumour resection utilizing a uniform surgical technique. Bilateral orbitofrontal craniotomy was utilized, and opening of the optic canal and sphenoid sinus was required in all cases to resect the tumour and its dural attachment. The tumour then was resected transcranially and transsphenoidally. Following tumour resection, the skull base defect was reconstructed using adipose tissue and a pericranial flap. The advantages and complications associated with our surgical approach are described, and its clinical value is discussed.

Cases

Clinical Material

During the period from 1991 to 1998, we treated surgically 21 patients [9 female and 12 male] diagnosed as having tuberculum sellae meningiomas at Juntendo University Hospital. Magnetic resonance imaging (MRI) indicated the tumours originated from the tuberculum sellae, chiasmatic sulcus and limbus sphenoidale, extended superiorly and laterally, and compressed optic apparatus (Figs. 1, 2). Eighteen of the tumours were less than 3 cm in diameter, and three were larger. The 21 patients ranged in age from 21 to 71 years (mean, 49). All presented decreasing visual acuity and various types of visual field defect. Thirteen of the 21 involved monocular, and 8 binocular

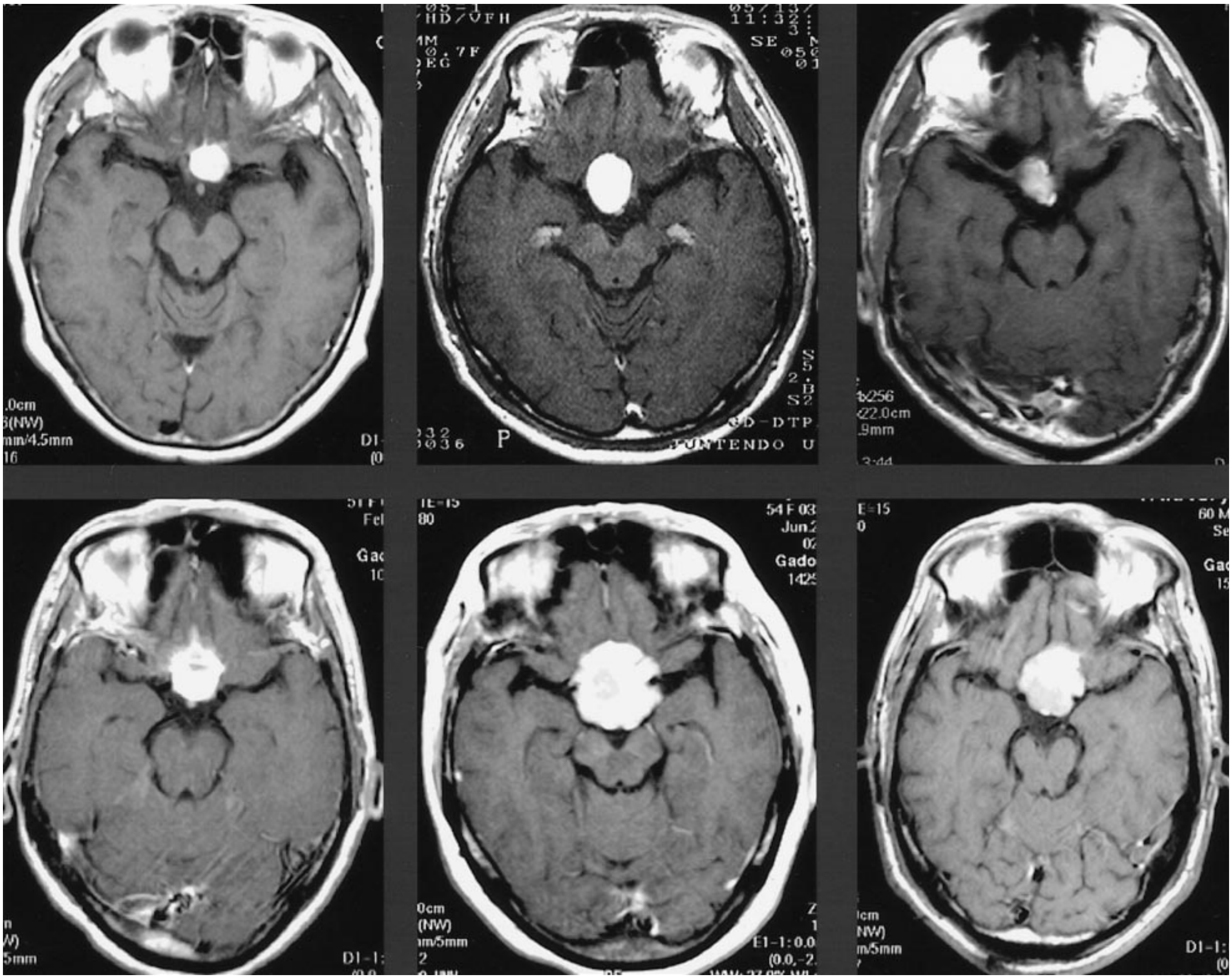

Fig. 1. Gadolinium-DTPA (Gd)-enhanced T1-weighted magnetic resonance imagings (MRI) of tuberculum sellae meningiomas. *Upper and lower rows,* respectively, indicate unilateral and bilateral visual signs of three different patients. Rather small tumours tended to be located off-midline in patients with monocular visual disturbance, and larger tumours midline in patients with binocular disturbances

complaints. There was a tendency for rather small tumours to be located off-midline in patients with monocular visual disturbances, and larger tumours midline in those with binocular signs (Fig. 1). All patients underwent tumour resection by means of the following uniform surgical technique. The interval from onset to surgery ranged from 2 to 36 months, for an average of 16 months.

Operation

Prior to a scalp incision, a spinal catheter is inserted and connected to a sterile collection bag, and adipose tissue is harvested from the patient's abdomen for postsurgical skull base reconstruction. The patient is placed supine, and the operating table is adjusted so that the patient's head and trunk are elevated 20 degrees. The head is maintained straight and moderately hyperextended, and fixed in a Mayfield headrest. A bicoronal scalp incision is followed by dissection and elevation of a pericranial flap from the frontal bone in preparation for postsurgical skull base reconstruction. The orbital rims are removed bilaterally following ordinary bifrontal craniotomy. After the frontal dura is opened bilaterally and the most anterior portion of the superior sagittal sinus is transected, 30 to 50 ml of cerebrospinal fluid is slowly drained through the previously positioned spinal catheter. Arachnoid dissection along the proximal olfactory tracts and minimum brain retraction bring the tumour into view. Additional dissection of the interhemispheric fissure extends the operative field to the anterior communicating artery. A key procedure involves dissecting the arachnoid membrane along the olfactory tract as deeply as possible because the optic nerves always are located behind the deepest part of the olfactory tract even though the tumor is sufficiently large to elevate and displace the optic nerve. Before internal debulking of the tumour is performed, the basal aspect of the tumour is devacularized with a bipolar coagulator. This procedure allows early interception of tumour feeders, but should be limited to the mid-portion of the tumour to avoid injury to the optic nerve. After the tumour is debulked, the laterally displaced optic nerves are identified. The tumour is slowly and carefully dissected from the flattened or engulfed nerve. To preserve any remaining vision, dissection of the optic nerve and its blood supply should be meticulous. In most cases, the internal carotid artery is simply displaced laterally by the tumour, and preservation of an arachnoid

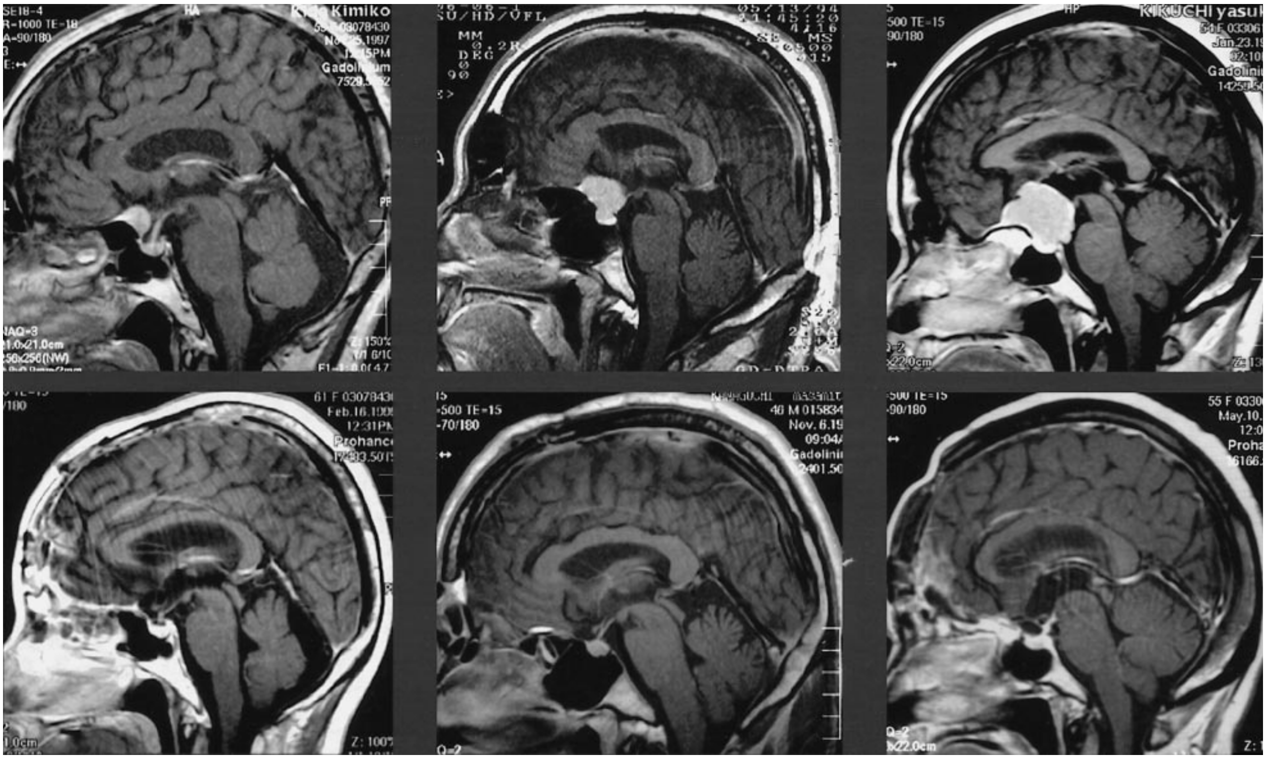

Fig. 2. Pre- (*upper row*) and postoperative (*lower row*) Gd-enhanced T1-weighted MR images of three different patients (*columns, left to right*) with tuberculum sellae meningioma. Anterior skull base was drilled out to remove basal portion of tumor in all 3 cases

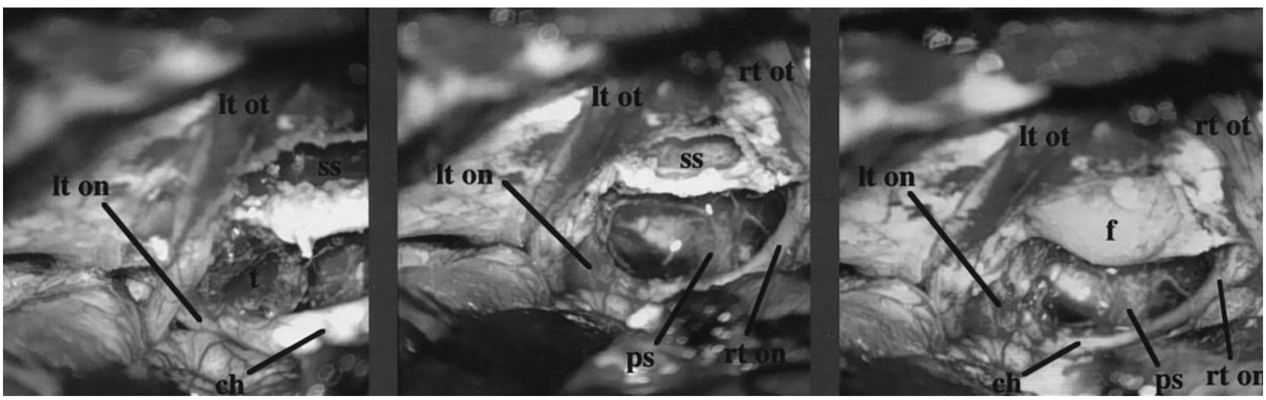

Fig. 3. Intra-operative photographs of patient with tuberculum sellae meningioma. Opening sphenoid sinus (*ss*) and unroofing left optic canal brings tumour (*t*) extending inferomeidally to left optic nerve (*lt on*) into operative view (left). Following tumour resection (center), hole into sphenoid sinus is reconstructed with adipose tissue (*f*) harvested from patient's abdomen and pericranial flap (right). *lt ot* Left olfactory tract; *ch* optic chiasm; *rt ot* right olfactory tract; *rt on* right optic nerve; *ps* pituitary stalk

plane facilitated so that the posterior communicating artery, anterior choroidal artery and their perforating arteries are kept intact. Most tumours extend back under the hypothalamus, displacing the preserved pituitary stalk backwards and to one side. Meticulous dissection and removal of a tumour from the hypothalamus and pituitary stalk are mandatory. In order to resect the basal part of the tumour and its dural attachment, the anterior skull base is drilled out. In all cases, the optic canal and sphenoid sinus, and additionally in some cases the ethmoid sinus are opened. The tumour uniformly extends inferomedially to the optic nerve, and direct visualization and resection of this portion of the tumour easily could be achieved with our approach (Fig. 3). Opened paranasal sinuses basically are reconstructed with adipose tissue harvested from the patient's abdomen and a pericranial flap. When the hole into the paranasal sinuses is not too large and the mucosa is intact, a piece of fat is stuffed into the hole with fibrin glue, but a pericranial flap is not utilized. Post-

Table 1. *Results of Visual Function in Relationship to Tumour Size*

Size of tumour	Improved	Unchanged	Worsened
Less than 3 cm (18 cases)	11/18	6/18	1/18
Larger than 3 cm (3 cases)	–	2/3	1/3

Table 2. *Surgical Complications Among 21 Patients*

Complication	No. of cases
CSF leak	2
Transient	2
Requiring repair	0
Anosmia/hyposmia (permanent)	5
Diabetes insipidus	5
Transient	5
Permanent	0
Early postoperative seizures	2

operatively, continuous drainage of cerebrospinal fluid through the spinal catheter, and bed rest for 4 to 5 days is required.

Results

Total or almost total resection of the tumour was accomplished in all 21 cases (Fig. 2). Although a small section of the tumour was left in a few cases because the tumor tightly adhered to the optic nerve and/or chiasm, anterior skull base drilling facilitated radical resection of the basal part of the tumour and its dural attachment in all cases. The sphenoid sinus was opened in all 21 cases, and the ethmoid sinus additionally in some cases. The optic canal was unroofed unilaterally in 11 cases with monocular visual disturbance and in 4 cases with binocular disturbances. In the remaining 6 cases, both optic canals were unroofed even though 2 of the 6 only presented monocular visual disturbance. Postoperatively, visual function was improved in 11 patients, unchanged in 8, and worsened in 2 (Table 1). Table 2 lists the complications for the series. Although either one or both olfactory tracts were preserved in 18 cases, almost all patients presented anosmia just after the operation. However, the olfactory function returned to normal or almost normal in 16 patients. The pituitary stalk was preserved in all 21 cases, but postoperatively some patients presented transient diabetes insipidus. None of 21 patients, however, required any kind of hormone replacement therapy at one postoperative month. Cerebrospinal fluid leakage occurred in two cases but could be managed with additional cerebrospinal fluid drainage for one week. None of our patients presented postoperative meningitis. In a 3-year follow-up, tumour recurrence was observed in one patient only who presented an atypical meningioma.

Discussion

One of the surgical approaches preferred for tuberculum sellae meningiomas is subfrontal elevation of the right frontal lobe just in front of the sphenoid wing [5, 8]. Andrew and Wilson have used the right subfrontal approach for most patients unless visual loss is greater on the left side [2]. Symon and Rosenstein reached the tumour subfrontally along the midline following right frontal craniotomy, and resected the most anterior portion of the frontal lobe in large tumours [11]. MacCarty *et al.* utilized the frontotemporal approach, the side being determined by the major bulk of the tumour or by the side of greatest visual loss, and reserved bifrontal craniotomy for only very large tumours [7]. Al-Mefty *et al.* chose unilateral or bifrontal craniotomy depending on the tumour's size, and stressed the versatility of the bifrontal approach for large tumours [1]. Samii and Ammirati stated that, since the tuberculum sellae meningiomas originated from the planum sphenoidale and tuberculum sellae in the midline, they were best and most safely approached through bifrontal craniotomy with elevation of both frontal lobes, reaching the tumours along the sagittal and parasagittal plane, and recommended the bifrontal approach for the tuberculum sellae meningiomas irrespective of the tumour's size [10]. Patterson, on the other hand, pointed out such disadvantages of the bifrontal approach as bifrontal lobe injury. They suggested that exposure of the tumour and surrounding anatomy was not as good as indicated by proponents of the bifrontal approach, and that a unilateral subfrontal approach was just as satisfactory as a bilateral exposure and spared one frontal lobe from manipulation [9]. In our series, a bifrontal approach was uniformly utilized regardless of the tumour size because we were confident this approach allowed surgeons to deal with a tumour from the midline as well as from the right and left. In addition, approaching to the tumour along the midline facilitated removal of the roof of the optic canal, particularly when bilateral unroofings were required, and provided good visualization of the tumour extending inferomedially to the optic nerve. Removal of the orbital rim bilaterally, untethering of the olfactory tracts bilaterally, and additional dissection of the basal portion of

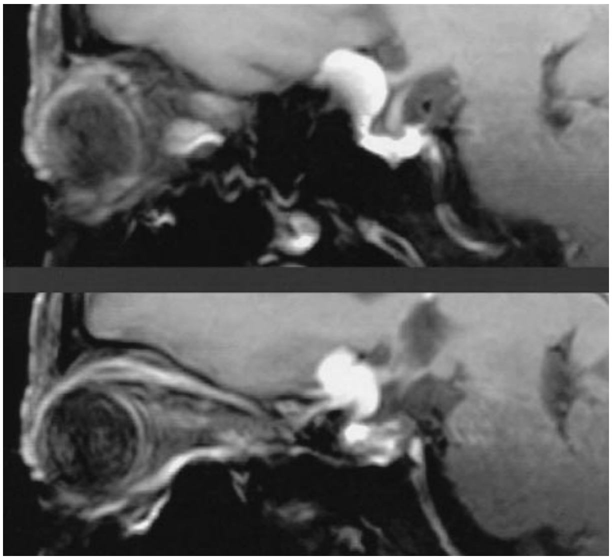

Fig. 4. Gd-enhanced fat suppression MR images parallel to course of optic nerve in tuberculum sellae meningioma. Tumour extension into optic canal is shown, and this finding implies necessity for optic canal unroofing

the interhemispheric fissure provided us with a good operative view with minimum brain retraction. We believe that such skull base techniques and meticulous microsurgical dissection minimize risk of bifrontal lobe injury.

All that is required to cure meningiomas is removal of affected dura and bone. What we found during our surgical procedures was that the basal portion of a tumour and its dural attachment were always hidden by the limbus sphenoidale. Therefore, in all cases the optic canal and sphenoid sinus, and additionally in some cases, the ethmoid sinus are opened, and the chiasmatic sulcus and tuberculum sellae are drilled away to remove the tumor and dura attached to these regions. As long as precautions are taken, entering the sphenoid or ethmoid sinus does not necessarily lead to cerebrospinal fluid leakage or infectious complications. In bilateral exposure, dissection of the olfactory tracts often, but not always, is successful in preventing anosmia. There is some difficulty in preserving olfactory tracts when optic canal unroofing is attempted. The deepest area of the olfactory tract always crosses over the optic nerve and disturbs exposure of the roof of the optic canal. Therefore, it is necessary to dissect the olfactory tract as deeply as possible and mobilize it in order to avoid injury during drilling of the optic canal. The presence of preoperative visual disturbance generally implies necessity of optic canal unroofing on the side of the sign. However, 2 of 13 cases with unilateral visual disturbance required optic canal unroofing on both sides because the tumor extended into the optic canal on the non-symptom side. On the other hand, 4 of 8 cases with bilateral visual disturbance required optic canal unroofing on both sides. In other words, direct intra-operative observation of the tumour extension is essential to determine how extensively the anterior skull base should be drilled. In this respect, pre-operative MRI sections parallel to the course of the optic nerve were of use because they often indicated tumour extension into the optic canal (Fig. 4). This finding implied a necessity of optic canal unroofing whether or not visual symptom were presented.

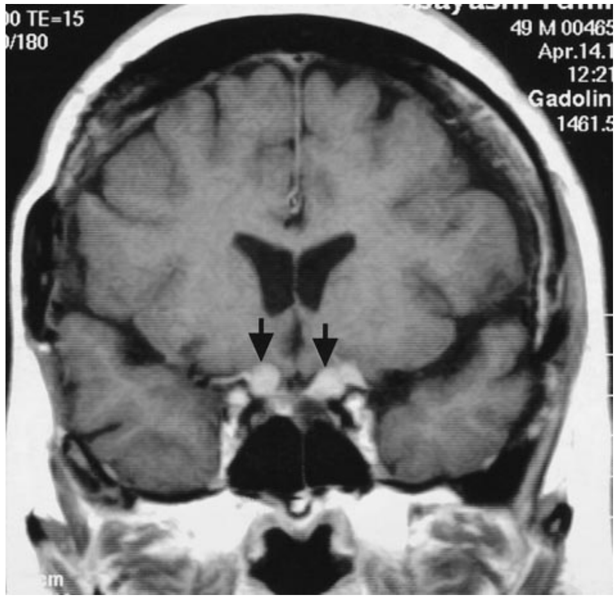

Fig. 5. Gd-enhanced T1-weighted MRI of patient with recurrent tuberculum sellae meningioma. Female 49-year-old patient underwent tumour resection without skull base drilling 10 years ago. Tumour recurrence (arrows) is observed medially in relation to both optic nerves

Once sufficient drilling of the anterior skull base was accomplished, there was no difficulty in resecting the basal portion of the tumour, its extension into the optic canal, and the dural attachment. Unexpectedly large tumours extending into the optic canal like a tongue were found in some cases, and such an extension could be the source of a recurrence that sometimes occurs after tumour resection without skull base drilling (Fig. 5). It should again be stressed that a tumour within the optic canal could easily be removed because there were no adhesions in our cases. In some cases, however, we found it difficult to dissect the tumour from the optic chiasm and nerves within the cistern. When the tumour is densely adherent to the optic apparatus, the better choice is to leave tumour fragments on the nerves rather than strip the nerves clean because the nerves stretched and distorted by a mass poorly withstand manipulation. The problem is that the vascular supply to the nerves may be stripped away along with the tumour. It is possible that this had occurred in our patients who experienced postoperative deterioration in visual function.

Conclusion

We report a series of 21 patients with tuberculum sellae meningioma who underwent tumour resection via a transcranial transsphenoidal approach. The anterior skull base was drilled out in all cases, and the optic canal and the sphenoid sinus were opened to remove the basal portion of the tumour. We consider our surgical approach to the resection of tuberculum sellae meningioma to be of great clinical value. In particular, the accessibility to a tumour extending inferomedially to the optic nerve is stressed.

References

1. Al-Mefty O, Holoubi A, Rifai A, Fox JL (1985) Microsurgical removal of suprasellar meningiomas. Neurosurgery 16: 364–372
2. Andrew BT, Wilson CB (1998) Suprasellar meningiomas. The effect of tumor location on postoperative visual outcome. J Neurosurg 69: 523–528
3. Gökalp HZ, Arasil E, Kanpolat Y, Balim T (1993) Meningiomas of the tuberculum sella. Neurosurg Rev 16: 111–114
4. Grisoli F, Diaz-Vasquez P, Riss M, Vincentelli F, Leclercq TA, Hassoun J, Salamon G (1986) Microsurgical management of tuberculum sellae meningiomas. Results in 28 consecutive cases. Surg Neurol 26: 37–44
5. Kempe L (1968) Operative neurosurgery, vol. 1. Springer, Berlin Heidelberg New York, pp 94–97
6. Kinjo T, Al-Mefty O, Ciric I (1995) Diaphragma sellae meningioma. Neurosurgery 36: 1082–1092
7. MacCarty CS, Piepgras DG, Ebersold NJ (1982) Meningeal tumors of the brain. In: Youmans J (ed) Neurological surgery, 2nd edn. W.B. Saunders Co., Philadelphia, pp 2936–2966
8. Ojemann RG, Swann KW (1991) Surgical management of olfactory groove, suprasellar, and medial sphenoid wing meningiomas. In: Schmidek HN (ed) Meningiomas and their surgical management. W.B. Saunders Co., Philadelphia, pp 242–259
9. Patterson Jr RH (1993) Parasellar meningiomas. In: Apuzzo MLJ (ed) Brain surgery, vol. 1. Churchill Livingstone, New York, pp 219–230
10. Samii M, Ammirati M (1992) Surgery of skull base meningiomas. Springer, Berlin Heidelberg New York Tokyo pp 27–33
11. Symon L, Rosenstein J (1984) Surgical management of suprasellar meningioma. I. The influence of tumor size, duration symptoms and microsurgery on surgical outcome in 101 patients. J Neurosurg 61: 633–641

Comments

The authors present a series of 21 patients with tuberculum sellae meningioma, operated on by the transcranial transsphenoidal approach. Tuberculum sellae meningiomas may be of various sizes, as well as of various locations. The size is usually not a problem, unless they are really large or giant. The origin of the lesion from the dura of the skull base might be from the central superior side of the tuberculum sellae or, more seldom, the tumour may originate (also) from the diaphragm sellae. The laterality of the origin also has a very important impact on the radicality of the surgical removal of the tumour. It is true that the tuberculum sellae meningioma, when it extends into the infero-medial side of the optic canal on one or both side(s), represents a rather tricky problem regarding complete excision of the rumour together with the dura involved. As shown in the already published literature, the dura infiltrated by meningioma should be resected to such an extent that the borders of the dura are of normal appearance, and this also holds for the dura around the optic nerve in the optic canal(s). When the tumour is in the optic canal, it should be followed and removed completely together with the dura involved. To achieve this, it is necessary to open the optic canal, so that the gentle mobilization of the optic nerve is possible and the tumour totally excised from the canal. It is also generally agreed that devasculization of the tumour – the detachment of the tumour from the skull base – allows later on for much easier debulking of the tumour, and also reduces the blood loss during the later phase of surgery. It is also generally accepted that a meningioma should preferably be resected completely together with the involved dura. The approach to the meningioma of the tuberculum sellae may be subfrontal or fronto-temporal or ever interhemispheric, as was practiced by the authors. Any additional trauma to both frontal lobes, as well as the olfactory nerve(s) should be avoided in all cases.

The bony destruction of the tuberculum sellae is surgically not necessary in cases where the bone is not yet infiltrated by the tumour, and hence the preserved bone is the best protection against CSF leaks. When the tumour itself has traversed both: the dural and the bony layers of the skull base, then in some cases complete resection of the involved bone might be as good as postoperative Gamma Knife and/or Lineracc for the residual tumour.

It is difficult to agree with the statement that «in most cases, the internal carotid artery simply is displaced laterally by the tumour...». In large tuberculum sellae meningioma the optic nerves are displaced laterally and the chiasm posteriorly prior to displacement of the ICA which is under the optic nerve(s). One would also expect that the approach from above; whether it be unilateral, subfrontal or interhemispheric, does carry more risk for the olfactory nerve than does the fronto-temporal approach, where the tumour can be detached and debulked from underneath the olfactory nerve(s), and no brain retraction is necessary. In Figures 1, 2, 4, 5 the bone of the skull base was not invaded and hence in such cases it is not necessary to remove the bone and to create the possibility for postoperative CSF leaks. The approach to the tuberculum sellae meningiomas is individual, and it is experience dependent regarding the approaches to this region, so that different approaches can be accepted. On the other hand, to destroy the normal bone in cases where the tumour has not invaded it is not necessary, it is also risky, and therefore cannot be accepted.

V. Dolenc

Question: Why should so much non-invaded bone be removed?

Author's Reply

It is true that most of the skull base bone which was removed in our cases was not invaded by the tumour. However, what we found during our surgical procedures was that the basal portion of a tumour and its dural attachment were always hidden by the limbus sphenoidale. Therefore, we think the anterior skull base should be drilled out in order to resect the basal part of the tumour and its dural attachment. In addition, the tuberculum sellae meningioma uniformly extends inferomedially to the optic nerve, and direct visualization and resection of this portion of the tumour could be easily achieved with our approach.

H. Arai

Correspondence: Hajime Arai, M.D., Department of Neurosurgery, Juntendo University, 2-1-1 Hongo, Bunkyo-ku, Tokyo 113-8421 Japan.