Article
Arq Neuropsiquiatr 2010;68(3):424-429

Tuberculum sellae meningiomas

Surgical considerations

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ABSTRACT

We report our experience on the treatment of tuberculum sellae meningiomas (TSMs) regarding the involvement of the optic canal and clinical outcomes. We reviewed 23 patients who were operated on between January 1997 and December 2008. The surgical approach was unilateral subfrontal supraorbital osteotomy in one piece. Attempts were made to improve visual function via extra/intradural unroofing of the optic canal, which released the optic nerve. Visual symptoms were present preoperatively in 21 patients, and two patients were asymptomatic. Visual acuity remained intact in 6 patients, improved in 10, was unchanged in 5 patients, and worsened in 2 patients. The postoperative visual field was normal or improved in 17 patients, unchanged in four patients, and worsened in two patients. The optic canal and clinoid were drilled extradurally in eight patients and intradurally in nine patients. Total resection of TSMs was achieved in 19 patients. Incomplete resection occurred in two patients. Decompression of the optic canal seemed to increase the visual outcome.

Key words: tuberculum sellae meningioma, optic canal, visual symptoms.

Meningiomas do tuberculo selar: aspectos cirúrgicos

RESUMO

Apresentamos nossa experiência em 23 pacientes operados com meningiomas do tubérculo da sela, com enfoque na descompressão do nervo óptico e nos sintomas visuais do pós-operatório. Vinte e três pacientes com meningiomas do tubérculo da sela foram operados entre janeiro de 1997 e dezembro de 2008, através do acesso subfrontal via ostetomia supraorbital. Remoção do teto do canal óptico por via extra ou intradural foi realizada em 17 pacientes. Sintomas visuais no pré-operatório ocorreram em 21 pacientes, 2 eram assintomáticos. Melhora visual ocorreu em 10, permaneceu inalterada em 5 e piorou em 2 pacientes. No pós-operatório o campo visual normalizou-se em 17 pacientes, permaneceu inalterado em 4 e diminuiu em 2. Descompressão dos nervos ópticos foi realizada em 17 pacientes. Ressecção total dos meningiomas do tubérculo da sela foi possível em 19 pacientes. Abertura do canal óptico permitiu a manipulação do nervo óptico sem novos déficites.

Palavras-chave: meningioma, tubérculo selar, nervo óptico, sintomas visuais.

Meningiomas of the tuberculum sellae (TSMs) arise from the limbus sphenoidale, chiasmatic sulcus, and tuberculum sellae[1]. TSMs are surrounded by the optic nerves and chiasma, the pituitary stalk, and the carotid arteries. They may extend into both optic canals. These tumors tend to displace the optic chiasm backwardly and the optic nerves superiorly and laterally.

Classically, patients present with visual

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Received 7 September 2009
Received in final form 17 November 2009
Accepted 29 November 2009

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deterioration because of optic nerve compression. Large tumors extend frequently toward the planum sphenoidale, onto the diaphragma sellae, the anterior clinoid process, and the sphenoid wing and can be difficult to differentiate from TSM[2]. Different techniques for resection have been used, including the pterional approach, the subfrontal unilateral approach, and the bifrontal approach[3-6].

We summarize a retrospective analysis of 23 patients harboring TSMs who were operated on during the past 12 years. We discuss clinical presentation and outcome, surgical approach, and the need for bony decompression of the optic canal.

METHOD

Twenty-three patients with TSM were operated on by the senior author (JAL) between 1997 and 2008.

Preoperative neuroimaging investigations consisted of computerized tomography (CT) with tridimensional reconstruction and magnetic resonance imaging (MRI) using a 1.5-tesla unit, with and without contrast. The surgery was planned according to the relationship between the tumor and the optic chiasma, the optic nerve, and the carotid artery.

CT scans were also obtained 24 h after surgery to identify immediately the presence of postoperative hematomas, pneumocephalus, or other surgical complications. Postoperative control MRI was performed three and six months after surgery, and then annually, if necessary.

All patients underwent an evaluation of visual acuity and visual fields, the results of which were analyzed using the score system proposed by Cohen et al.[7]. This scale can be applied simply and easily to the quantification of both visual acuity and visual fields.

We used the Simpson[8] scale to grade the extent of resection, based on operative reports and postoperative images.

Full endocrinological tests (adrenal, thyroid, and gonadal axes) were performed preoperatively, one and six months after surgery and, if necessary, yearly.

For this study, we collected the informed consent of all patients.

Surgical procedure - technical details

The patient was placed in the supine position with the body flexed and the head slightly extended, minimizing frontal lobe retraction. The head was located 30 degrees above the heart and secured in the Mayfield support using a three-point skull fixation. The head was rotated 30 degrees to the contralateral side, and in elderly patients, a shoulder roll was used to help rotate the head. A unilateral subfrontal approach with supraorbital osteotomy in one piece, as described by Al-Mefty[9], was performed. A craniotomy was performed on the side exhibiting more compromised visual function. In cases of bilateral involvement (or in patients without visual deficit), the nondominant side was preferred. The dura was opened parallel to the orbit, and the frontal lobe was retracted slightly. To allow the frontal lobe base to fall away from the anterior fossa, the pterional portion of the sylvian fissure was opened and connected to the carotid cistern. After the sylvian fissure was opened and the carotid cistern was located, the lateral portion of the tumor was identified and removed. At this point, the olfactory nerve was dissected and left free. Debulking was completed first in cases of large tumors in which the optic nerves were identified. In cases of tumors that encased or displaced the optic nerve, the nerve could not be identified. Therefore, we used the extradural clinoidectomy method, unroofed the optic canal and released the optic nerve after the falciform ligament and dural sheet were opened. The clinoidectomy and the unroofing of the optic canal were performed using a pneumatic foot-pedal control drill with a 3 mm carbide burr. The drill power was reduced during this maneuver, and a large amount of irrigation was used. This maneuver allows complete mobilization of the optic nerve, exposure of the carotid artery, and partial devascularization of the tumor[10,11]. Tumor debulking was performed in the piecemeal fashion after identification of the ipsilateral optic nerves. Intradural resection of the tumor was executed, and careful dissection of the small perforator arteries to the optic structures, hypothalamus, and pituitary stalk should be performed, with as much structure preservation as possible.

RESULTS

Tables 1 and 2 list the clinical features and the postoperative evaluation of patients. We analyzed 23 patients, which included 15 females and eight males with ages from 38 to 77 years (average, 56.2 years), who were operated on between January 1997 and December 2008. Follow-up ranged from six to 124 months (mean, 31.2 months). There were no operative deaths, and all patients are alive at present. Table 3 lists the surgical characteristics of the tumors.

For all patients, the surgical approach was a subfrontal craniotomy with supraorbital osteotomy in one piece. The tumor involved the optic canal (OC) unilaterally in 13 patients, and bilaterally in two patients (Figs 1,2,3). The tumor extended to the planum sphenoidale (PS) in 15 cases, to the diaphragma sellae (DS) in eight patients, and to the anterior clinoid process (ACP) in 11 patients. The bone of the optic canal was removed in 17 cases. The bone covering the TS was removed in 14 patients. Extradural unroofing of the optic nerve was performed in eight cases, and intradural unroofing was carried out in nine patients. In an attempt to obtain a Simpson grade I or II, the sphenoidal sinus was entered in two cases, and the anterior ethmoidal cells were entered in two cases. In

Table 1. Clinical data of 23 patients.

	Nº of cases (%)
Age (yrs)	56.2 , range 38-77
Sex	
Female	15 (60.8)
Male	8 (39.1)
Symptoms	
Visual deterioration	21 (91.3)
Headache	14 (60.8)
Headache alone	4 (17.4)
Endocrinal symptoms	3 (13)
Duration of symptoms	5m-6yrs

Table 2. Clinical outcomes: 23 patients.

	Nº of cases (%)
Approaches	
Frontoorbital	23 (100)
Grade resection	
Simpson I	7 (30.4)
Simpson II	12 (52.1)
Simpson III	2 (8.7)
Simpson IV	2 (8.7)

Table 3. Surgical characteristics.

	Nº of cases (%)
Extension to DS	8
Extension to PS	15
Extension to the ACP	11
Extension to the OC	13
Extension to the OC bilaterally	2

DS: diaphragma sellae; PS: planum sphenoidale; ACP: anterior clinoid; OC: optic canal.

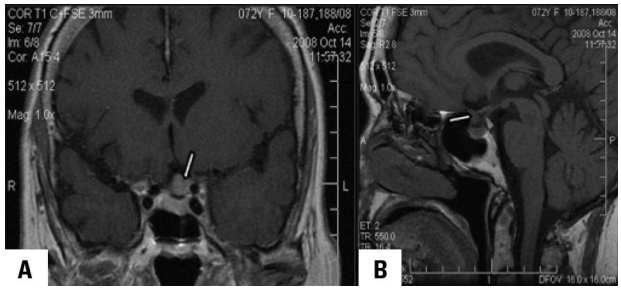

Fig 1. [A] Preoperative coronal T1W MRI showing an enhanced suprasellar lesion (white arrow), medial to the left optic nerve and left ICA; [B] Preoperative sagital T1W MRI (no contrast) showing an (white arrow) in the chiasmatic cistern, anterior–inferior to the optic chiasma.

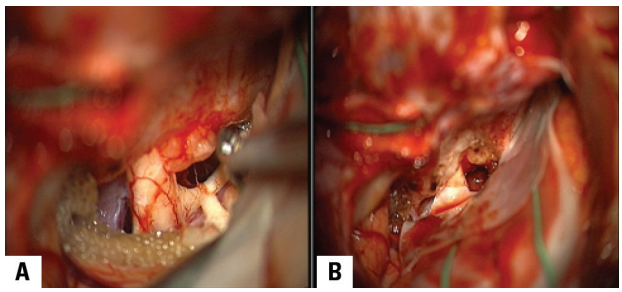

Fig 2. [A] Meningioma inside the optic channel compressing the left optic nerve; [B] Postoperative left optic nerve after drilling the roof of the optic channel.

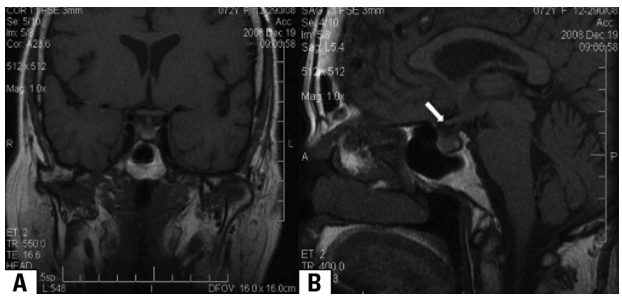

Fig 3. [A] Postoperative coronal T1W MRI showing the optic chiasma and the pituitary stalk without displacement; [B] Postoperative sagittal T1W MRI showing the chiasmatic cistern without the tumor; the white arrow indicates the optic chiasma with no displacement.

all cases, the mucosa was left intact and was covered with muscle, which was kept in place with fibrin glue.

Simpson grade I or II was achieved in 19 patients, and grade III or IV was attained in four cases. A tumoral remnant (grade III or IV resection) was intentionally left in four patients. These four patients included one patient with invasion of the pituitary stalk, two patients who had tumors that were adherent to the supraclinoid internal carotid artery ICA and anterior cerebral artery (ACA), and one patient who had a tumor that was encased firmly in the optic nerve. The pituitary stalk was preserved in all patients.

Visual outcomes

Six patients presented with normal visual acuity preoperatively, and the examination of the remaining 17 patients revealed the presence of decreased visual acuity. Postoperative visual acuity was normal or improved in 16 patients, was unchanged in five patients, and worsened in two patients. Preoperative visual fields were ranked as normal in nine patients, mildly impaired in 12 patients, and severely impaired in two patients. The postoperative visual field was normal or improved in 17 patients, unchanged in four patients, and worsened in two patients, when compared with the preoperative visual field examinations. One patient in our series lost vision in the in-

volved eye immediately after surgery. This patient had a tumor that invaded the optic canal. The patients who exhibited worsened visual field and visual acuity after surgery had poor visual function prior to the surgery. These patients had symptoms for a longer period of time and had larger tumors.

Complications

None of the patients developed postoperative cranial nerve deficits. Two patients developed postoperative cerebrospinal fluid fistulae, which resolved by lumbar subarachnoid drainage. One patient developed transitory diabetes insipidus. Three patients suffered from severe hyponatremia, and one of these experienced seizures. Three patients developed endocrine deficits and required hormone replacement therapy.

DISCUSSION

Meningiomas of the TS represent 25% of all anterior skull-base meningiomas[1]. They extend to the PS, ACP, and DS, and the symptoms are quite similar[2]. These tumors are surrounded by structures such as the optic nerve, chiasma, pituitary stalk, carotid arteries, and their branches. TSMs often cause visual symptoms and remain undiagnosed until they reach a large size and symptoms worsen. The principal objective of surgical treatment for TSMs is to remove the tumor microsurgically, replace the dural attachments and the infiltrated bone, prevent recurrence, decompress optoquiasmatic structures, and promote improvement or stabilization of visual function.

Classically, the access routes used to resect meningiomas of the TS are bicoronal subfrontal and pterional[3-6]. However, to reduce brain retraction, some cranial-base procedures have been used as alternative access routes: subfrontal bilateral orbital osteotomy[6], fronto-orbito-zigomatic (FOZ) osteotomy[9], unilateral fronto-orbital (FOR) osteotomy[9], and a classical subfrontal approach with drilling in the prominence of the orbital roof. The bicoronal subfrontal route provides a direct view of both optic nerves, of the internal carotid arteries, and of both anterior cerebral arteries. Nevertheless, this route presents disadvantages, which include ligation of the most anterior portion of the longitudinal sinus and, consequentially, of tributary veins, dissection with possible injury to the olfactory nerves, risk of opening of the frontal sinus, development of cerebrospinal fluid (CSF) fistulae, and meningitis. Many authors prefer the pterional route, as it provides lateral access between the optic nerves (ipsilateral to the optic nerve), with preservation of the olfactory tracts, and represents a short distance to the tuberculum sellae after removal of the greater wing of the sphenoid[3-5].

Recently, several authors have proposed the resection of these lesions using minimally invasive ways or with the aid of a surgical microscope or endoscopically guided vision[12-16]. Although these authors reported successful results, the risk of complications was increased. Couldwell[12] operated on a series of 105 patients with pituitary tumors, craniopharyngiomas, chordomas, and TSMs, among others, using the extended transsphenoidal approach. This author reported a 6% incidence of CSF leakage and four cases of bleeding in the ICA that resulted in one case of cervical carotid ligation. Kabil and Shahinian[13] reported on a series of 28 patients with different pathologies of the sellar region, including craniopharingiomas, meningiomas, and pituitary adenomas. These authors achieved total removal in all but one case, in which a small amount of tumor adherent to the optic nerve remained. Kitano et al.[14] reported on 28 patients with TSMs; 12 patients were operated on using the transcranial route and 16 patients were operated on using the extended transsphenoidal route. CSF leakage was observed in two patients, anosmia was present in two patients, and infarct from injury in perforantes arteries was observed in two cases. These authors developed a technique in which the fascia graft was placed subdurally to cover the defect, and in some cases, they managed to suture the fascia the hard left. De Divitiis et al.[16] operated on seven patients with TSMs using the transsphenoidal route under endoscopic vision; two (28.6%) patients developed CSF fistulae, both requiring reoperations to occlude the fistulae.

We used a subfrontal lateral approach with supraorbital osteotomy including the orbital roof in one piece. This approach allowed us to eliminate the necessity of retraction of the frontal lobe, shortened the distance to the TS, improved the lighting of the operative field, and dissected the ipsilateral olfactory tract. In addition, we obtained a direct view of both optic nerves, broad access to the cisterns (particularly to a pterional portion of the Sylvius fissure), and easy access to the extradural optic channels, which facilitated optical inspection and possible removal of parts of the tumor that invaded the optic channel. Furthermore, single-piece fronto-orbital craniotomy provides excellent reconstruction and a superb cosmetic effect. The operations were carried out on the side of visual deterioration. In cases of bilateral involvement, the nondominant side was preferred. Simpson grade I or II was achieved in 19 patients, and one patient developed CSF leakage, which was treated with lumbar subarachnoid drainage. Olfactory tract anatomical preservation was achieved in all patients. We could not complete the removal of the lesion in four of the patients in our series. Two patients had lesions involving arteries, one patient had a lesion that invaded the pituitary stalk, and one patient had a tumor involving both optic nerves. The extension of tumoral resection according to Simpson I and II classification varies from 62% to over 90%[5,17-20] and, gen-

erally, depends on the consistency of the tumor, vascular encasement, tumor size, and clinical condition of the patients[17,19]. Large tumors seem to be a crucial factor for prediction of surgical outcome[17,19].

Complications associated with vascular lesions can impair the radical removal of tumors or induce permanent damage. Margalit et al.[11] reported a case of stroke secondary to supraclinoid ICA occlusion. Bassiouni et al.[18] described a patient who presented bilateral deterioration of visual acuity after injury of one segment of the ACA and another patient who suffered a stroke in the dominant hemisphere and whose ICA was lacerated and had to be clipped. The risk of lesion to the arteries involved by the tumor is higher in patients with hard tumors. In the present series, we indexed 12 cases in which the tumor involved the ACA complex and the supraclinoid ICA. Radical resection could not be performed in two of these patients.

The mortality and morbidity levels associated with TSM surgery are small. The main objective of the surgery is to preserve or improve visual function. Improvement of visual function, according to several reports, varies from 32% to 91%[3,5,19,21]. Fahlbusch et al.[3] obtained an improvement of 80% in their patients and stated that the best prognoses were found in patients younger than 50 years and in patients who presented symptoms for less than one year. Nakamura et al.[5] reported on a series of 72 patients for whom there was no significant difference in improvement of visual function between subjects with tumors larger or smaller than 3 cm. However, the percentage of improvement was significantly higher in patients who presented symptoms for less than six months compared with those whose symptoms had lasted for one year. Schick and Hassler[21] reported on a series of 53 patients with TSMs; 20 patients improved, 25 patients remained unchanged, and seven patients worsened. Statistical analyses allowed these authors to conclude that postoperative recovery of the visual deficit was worst in older patients and in patients in whom the duration of symptoms was longer than six months. Some authors believe that the postoperative improvement of visual function and acuity is related to the preoperative severity of visual deficits[18,19].

Park et al.[22] reported on a series of 30 surgically treated patients with TSM and diaphragma sellae meningioma (DSM) in which short-term favorable visual outcome was achieved in 80% of patients. These authors concluded that the short-term visual outcome is a strong indicator of permanent visual outcome after surgery.

Several authors have added procedures of the skull-base surgery to the treatment of TSMs. Together with the removal of the orbital bar and orbital roof, the decompression of the optic nerve via clinoidectomy, the unroofing of the optic canal, and the opening of the falciform ligament have contributed to the significant postoperative improvement of the visual function of these patients[11,17,18,21,23-25].

Ohta et al.[10] reported on 21 cases of complete resection of TSMs in a series of 33 patients. These authors affirmed that skull-base approaches increase the rate of resection without increasing the rate of complications. They performed optic-canal decompression in several patients. Sade and Lee[26] reported on a series of 52 patients who had clinoidal meningiomas. Anterior extradural clinoidectomy with opening of the falciform ligament and optic nerve sheet was accomplished in 47 of these patients. A Simpson Grade I or II was achieved in 37 patients (71%). Among the 22 patients with visual deficits, 17 patients improved and five patients remained unchanged in the postoperative period.

Mathiesen and Kihlström[23] reported on a series of 29 patients with TSMs, which included 23 primary cases and six recurrences. These authors reported on extradural clinoidectomy and unroofing of the optic nerve and of the optic canal followed by intradural release of the optic nerve. Visual improvement was observed in 22 (91%) out of 24 patients, and five patients with normal preoperative vision remained unchanged. Two patients with cerebral fluid leaks were reoperated on using a transsphenoidal approach. Total removal was possible in 23 cases. Otani et al.[24] used selective anterior extradural clinoidectomy to treat 20 cases in a series of 32 patients and achieved improvement of the visual function in 78% of the cases.

Nosaki et al.[25] reviewed the clinical records of 20 patients with TSMs and of two patients with PS meningiomas. These authors analyzed a series of factors that may affect postoperative visual recovery, such as sex, age, duration of visual symptoms, preoperative visual acuity, tumor size, tumor consistency, tumor extension into the optic canal, timing of optic canal unroofing, and tumor resection rate. Optic canal unroofing was performed intradurally before manipulation of the tumor in nine patients, and after dissection of the tumor in seven patients. Six months after surgery, visual symptoms improved in 10 patients, remained unchanged in seven patients, and worsened in five patients. The authors concluded that early optic canal unroofing may enhance the postoperative improvement of visual symptoms.

Surgical removal of TSMs represents a high risk of decreasing or losing visual function. The size of the lesion, arterial encasement, tumor consistency, encasement of optic nerves, and lesion of the normal vascular supply to the optic nerve during the procedure represent mechanical causes of the lesion. Other risk factors include the patient's age, the duration of symptoms, and visual status in the preoperative period. In our series, a combination of fronto-orbital craniotomy, removal of the orbital roof

and optic canal, and opening of the falciform ligament allowed considerable postoperative improvement in visual function and acuity. Postoperative visual acuity was normal or improved in 16 patients, remained unchanged in five patients, and worsened in two patients. The visual field improved postoperatively in 17 patients, was unchanged in four patients, and worsened in two patients. The patients who showed a decrease in visual function were older and presented more severe preoperative visual deficits and longer duration of symptoms. The removal of the optic canal with opening of the falciform ligament, which is advocated by various authors, seemed to have a positive effect on the recovery of the patients' visual function. Mathiesen and Kihlström propose extradural opening with dissection of the dura from the anterior wall of the cavernous sinus. However, in our opinion, it is not ideal to expose the anterior wall of the cavernous sinus because of a high risk of damage to the cranial nerves. In our series, the tumor extended to the optic canal in 13 patients. Two of the patients did not exhibit involvement of both canals. Although the unroofing of the optic nerve was performed extradurally in nine patients, the main indication of this route is to facilitate the location of the normal segment of the optic nerve. Intraoperative inspection is the only method that can be used to assess the best approach to decompress the optic nerve. Early intradural decompression of the optic nerve presents advantages, such as the inspection of the optic canal and the dissection of the tumor from the optic nerve, most importantly at the edge of the optic canal and of the falciform ligament, where the nerve can be discolored and thin.

No recurrence or regrowth was observed after a mean follow-up of 31.2 months, although residual tumor was left in four patients. Those patients with incomplete resection are followed with image control.

In conclusion, a Simpson grade I or II was attained in the majority of cases that were operated on using the fronto-orbital approach. This skull-base approach, combined with the unroofing of the optic canal, seemed to provide significant improvement of the visual function outcome. The unroofing of the optic canal facilitated the location of the normal segment of the nerve. The rate of complication was very low and did not alter the successful course of the patients.

ACKNOWLEDGMENTS – We thank Hillary Ann Williams for preparation of the text.

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