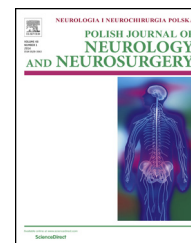


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Original research article

Falcotentorial and velum interpositum meningiomas: Two distinct entities of the pineal region



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ABSTRACT

Objective: Among pineal region lesions meningiomas are extremely rare and include falcotentorial and velum interpositum meningiomas. It is very difficult to discriminate between these two lesions and description of the clinical presentation and the surgical technique in approaching these tumors is limited. We respectively analyzed a series of patients harboring pineal region meningiomas with regard to clinical features, neuroimaging studies, and results of surgical treatment.

Methods: Clinical data of 5 women and 1 man with pineal region meningiomas treated between January 1993 and December 2012 were retrospectively reviewed. All patients were assessed preoperatively with MRI and cerebral angiography. The only surgical approach we used was occipital transtentorial route.

Results: There were four falcotentorial and two velum interpositum meningiomas. The main presenting symptom was headache, dizziness and gait disturbance. The angiogram revealed that these tumors were fed by tentorial artery, posterior choroidal arteries, and branches of the posterior cerebral artery and in four cases additional evidence of occlusion of the galenic venous system was seen. Two patients had total resection (Simpson Grade I and Grade II) and in four patients small remnants of tumor were left (Simpson Grade III). No death occurred in this series. The most common complication after surgery was homonymous hemianopsia which fully recovered in all patients in the follow-up.

Conclusion: The falcotentorial and velum interpositum meningiomas can be safely managed with the use of occipital transtentorial approach. Homonymous hemianopsia is the most common although always transient complication of surgery.

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1. Introduction

Pineal region meningiomas are rare and account for 2–8% of all tumors located in this area [1–3]. Under the heading of “pineal meningiomas” two distinct entities are grouped such as falcotentorial meningiomas and velum interpositum meningiomas [2,4–6]. Meningiomas arising from the falcotentorial junction occur at the junction of the dural folds of the tentorium and falx cerebri, projecting either anteriorly (superiorly), inferiorly or posteriorly [7–9]. Velum interpositum meningiomas are extremely rare [10] and correspond to meningiomas occupying the pineal region that have no dural attachment [5]. These tumors arise from the posterior portion of the velum interpositum, the double layer of pia mater that forms the roof of the third ventricle. Prior to the introduction of MR imaging it was very difficult to discriminate between these two lesions. In the past anteriorly and inferiorly projecting falcotentorial meningiomas and velum interpositum meningiomas were grouped together as pineal region meningiomas. Current MR imaging and angiography help to differentiate falcotentorial meningioma from the rarer velum interpositum subtype, however, it is still difficult. Although several reports nicely presented clinical presentation, neuroimaging and surgical management of falcotentorial meningiomas, the literature on velum interpositum meningiomas is poor and mainly based on case reports. Pineal region tumor series comprising higher number of velum interpositum cases likely include falcotentorial meningioma cases [11]. The focus of this article is to evaluate our surgical experience with falcotentorial and velum interpositum meningiomas and provide understanding of the differences in diagnosis and surgical management of these two challenging lesions.

2. Material and methods

2.1. Patient population

From 1993 to 2012, we operated on six patients with pineal region meningiomas. We have retrospectively reviewed the clinical records, neuroimaging studies, and follow-up data of the treated patients. There were five women and one man whose ages ranged from 42 to 64 years (mean 52 years). All meningiomas were verified by histological examination.

2.2. Neuroimaging studies

The lesions in all patients were evaluated using magnetic resonance imaging (MRI) and digital subtraction angiography (DSA). For MRI all patients underwent T1- and T2-weighted imaging, and T1-contrast-enhanced sequences. Cerebral angiography was performed in all cases to evaluate the feeding arteries, displacement of vessels and patency of the deep venous system (straight sinus, great vein of Galen, internal cerebral veins), and development of collateral venous channels. In addition magnetic resonance angiography (MRA) was obtained in two patients.

2.3. Surgical approach

The obstructive type of hydrocephalus had been treated before surgery in two patients: one of our patients received a ventriculo-peritoneal shunt and the other patient underwent endoscopic third ventriculostomy. All six patients were operated on in the $\frac{3}{4}$ prone position via the right occipital transtentorial approach. In this position, the head is flexed on the extended neck and the torso elevated about 20°. During the surgery an external ventricular drain was routinely placed in the right occipital horn to reduce intracranial pressure and facilitate retraction of the occipital lobe. The dura was incised in a L-shaped fashion along the superior sagittal sinus and transverse sinus. The right occipital pole was gently elevated and retracted superiorly and laterally. The tentorium was incised 1 cm paramedian and parallel to the straight sinus beginning immediately in front of the right transverse sinus to its free edge anteriorly at the hiatus. The cerebellar tentorium was often hyperemic and dural clips were used during its incision to prevent from bleeding. In all four cases of falcotentorial meningioma posterior part of the falx was incised to create a window for access to the contralateral tumor portion and to enable resection of the tumor origin in between the leaflets of the falx. Then, the tentorium was cut on the left side to eliminate the arterial supply from the tentorial arteries and allow a wider operative view. This surgical maneuver was not needed in the two cases of the velum interpositum meningioma. After tumor debulking the galenic venous system was carefully identified. In two cases the great vein of Galen and straight sinus has been confirmed to be occluded by angiography, however during the surgery it was found that they were both still patent. Then, a subtotal resection preserving flow must be accepted. Care should be taken to keep the medial occipital veins draining into the superior sagittal sinus intact, as they are an alternative route of venous circulation.

2.4. Patient's follow-up

The scope of resection was evaluated based on the intraoperative observation and the result of postoperative brain MRI imaging according to Simpson's classification scheme [12]. The patient's condition was assessed at discharge from the department along with a long-term follow-up based on neurological examination and brain MRI in all of the patients. The postoperative outcome was analyzed using the Karnofsky Performance Status (KPS) to measure the degree of disability [13]. One patient was lost to follow-up. The postoperative follow-up period ranged from 24 months to 15 years (mean 8.5 years).

3. Results

3.1. Patient characteristics

The main presenting symptoms were headache in six (100%), followed by gait disturbance and dizziness in four (67%) and mental deterioration in three (50%). The average duration of symptoms before admission was 9 months. Physical examination at admission disclosed papilledema (five cases), gait

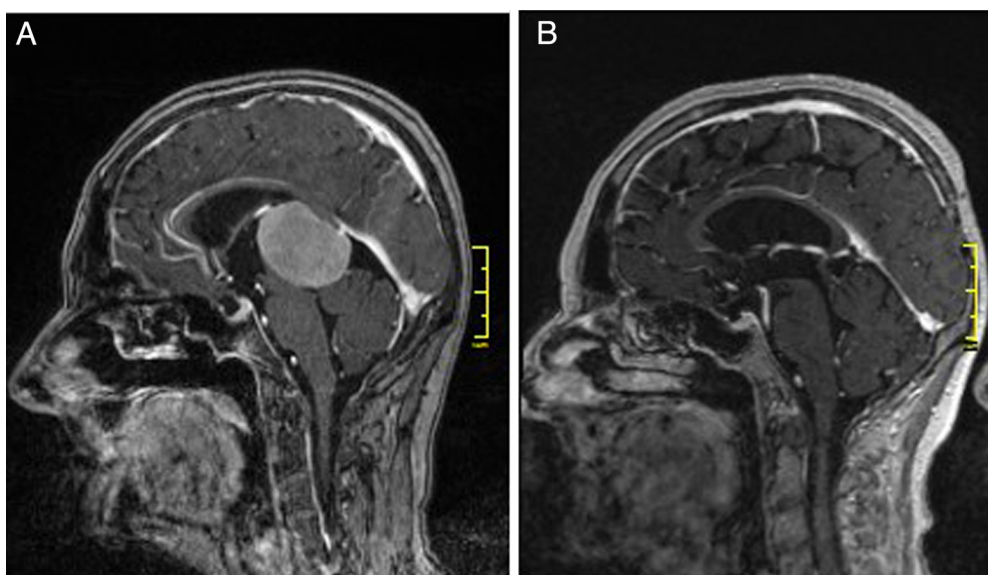


Fig. 1 – (A) Preoperative sagittal T1 contrast enhanced MR image demonstrating velum interpositum meningioma. (B) Postoperative sagittal T1 contrast enhanced MR image obtained after complete resection of the tumor.

ataxia (four cases), and hemiparesis (two cases). Upward-gaze palsy was noted only in one patient.

3.2. Radiographic findings

All tumors were found to have marked homogeneous enhancement after gadolinium administration and we found no differences in the pattern of signal characteristics and enhancement between falcotentorial and velum interpositum cases (Figs. 1 and 2). MRI imaging revealed the relationship of the tumor to the internal cerebral veins and the vein of Galen. Depending on the relationship of the tumor to the vein of Galen, tumors were classified into the superior type when located superior to the vein and compressing it downward and the inferior type that displaced it superiorly. The superior

types of tumor were seen in five patients, but one velum interpositum tumor was the inferior type. In the two cases of velum interpositum meningioma the tumor mass was contiguous with the falcotentorial junction and tumors were considered the falcotentorial meningioma preoperatively. On preoperative angiography the tumors in three patients were fed by the tentorial artery, in three patients by the medial and lateral posterior choroidal arteries, in two patients by small branches of the posterior cerebral artery. In one patient tumors' arterial supply was not visualized. The velum interpositum meningiomas were fed only by choroidal arteries. The straight sinus and the vein of Galen were occluded in four patients. Collateral venous channels were developed through the lateral mesencephalic vein to the petrosal vein, through veins on the medial surface of the occipital lobe to the

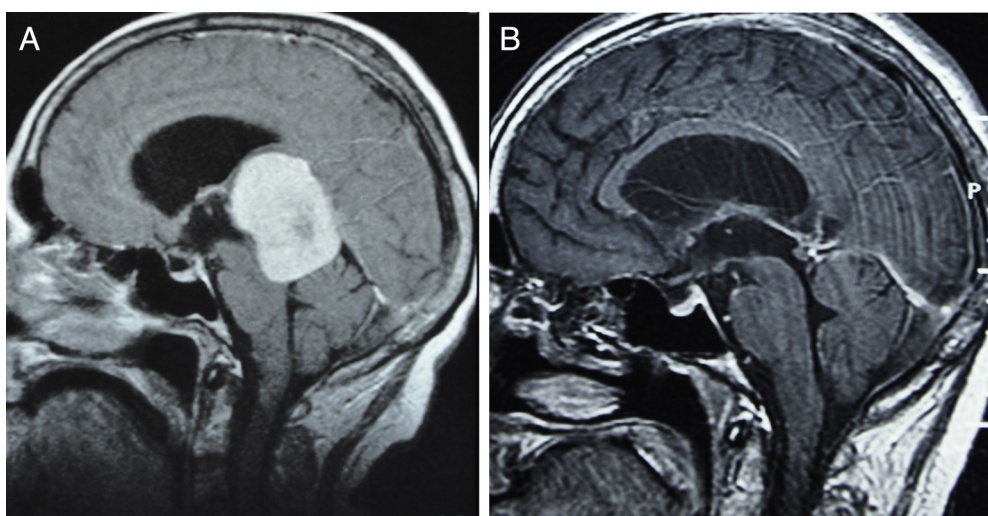


Fig. 2 – (A) Preoperative sagittal T1 contrast enhanced MR image demonstrating falcotentorial meningioma. (B) Postoperative sagittal T1 contrast enhanced MR image obtained after complete resection of the tumor.

superior sagittal sinus, and through venous channels in the tentorium.

3.3. Operative results and outcome

In four patients meningiomas arise from the falcotentorial junction, in the two others tumors correspond to velum interpositum meningiomas. The origin of the tumor was confirmed during surgery in all patients. Surgical results are summarized in Table 1. Simpson grade I resection was achieved in one patient with velum interpositum meningioma and Simpson grade II resection was performed in one patient with falcotentorial tumor. In the other four cases a tumor remnant was left on the vein of Galen or in the tentorium along the anterior half of the straight sinus (Simpson grade III resection). In cases No. 4 and No. 6 during the surgery the vein of Galen and the straight sinus not visible on preoperative angiography demonstrated patency which resulted in subsequent subtotal resection.

No operative death we noted. However, all but one patients showed transient homonymous hemianopsia, which resolved over 1 month. One patient experienced postoperative intraventricular hemorrhage and underwent repeated surgery. This patient required then ventriculoperitoneal shunt placement because of the hydrocephalus development. In another patient transient left hemiparesis developed after surgery and fully recovered within 2 weeks. In one patient upward-gaze palsy persisted after surgery and proved permanent in the follow-up. One patient was lost to follow-up. Of the remaining five patients, none of the tumors recurred during the follow-up period.

4. Discussion

4.1. Clinical presentation

Meningiomas of the pineal region are rare. In our 20-year experience, we encountered only six such cases, involving meningiomas of different origin. We report our experience with four patients with falcotentorial meningiomas and two patients with velum interpositum meningiomas. We found that there were no differences in clinical presentation between these two groups of meningioma. Like other meningiomas, those of the pineal region show predominance in females

[7,9,14]. Symptoms usually developed insidiously and its average duration before admission was 25 months which approximates that of reported in the literature [2,14,15]. The most common signs and symptoms included headache, papilledema, gait disturbances, and altered mental status, which were due to increased intracranial pressure and hydrocephalus, and were encountered in other reports [2,4,9,15]. Parinaud syndrome (upward gaze paresis) was uncommon finding and is reported in up to 10% of patients harboring a meningioma of the pineal region [2,4]. The rarity of extraocular movement abnormalities help to distinguish pineal region meningiomas from other pineal region tumors, where this phenomenon occurs frequently [4,16].

4.2. Radiological imaging

Despite significant advances in neuroimaging during the last two decades it is often difficult to discriminate between falcotentorial and velum interpositum meningiomas. Falcotentorial meningiomas usually derive their vascular supply from the tentorial branch of the meningohypophyseal trunk [2,9,17,18]. In some cases predominant supply comes from meningeal branches of the external carotid artery [15,17] and the medial and posterior choroidal arteries [15,19]. On the other hand the velum interpositum meningioma is fed only by branches of the posterior choroids [3,4,20,21] which is consistent with our findings. Furthermore, some authors suggest that vessels displacement characteristics helps in distinguishing velum interpositum tumors from those of falcotentorial junction: in tumors of the falcotentorial junction the medial posterior choroidal arteries are usually compressed anteroinferiorly, whereas in cases of velum interpositum tumors they are displaced posterosuperiorly [21,22]. However, in our experience, the displacement of the choroidal arteries on preoperative angiography is difficult to visualize. Occlusion of the galenic system and development of collateral venous channels is often reported in cases of falcotentorial meningioma [9], however, a common intraoperative finding is a patent vein or sinus which were not visualized preoperatively [15]. Interestingly, in one of our velum interpositum cases the vein of Galen and the straight sinus seemed to be occluded and the tumor was preoperatively qualified of falcotentorial origin. This indicates that lack of opacification of major deep veins does not determine the status

Table 1 – Surgical results in six patients with falcotentorial and velum interpositum meningiomas.

Case No.	Tumor type	Resection rate (Simpson's classification)	KPS score preoperative/postoperative	Complications
1	FT	III	70/80	a,d
2	FT	II	60/80	a
3	VI	I	70/80	a
4	FT	III	80/70	a,b
5	FT	III	90/90	a
6	VI	III	70/90	c

KPS = Karnofsky performance scale.

^a Temporary homonymous hemianopsia.

^b Postoperative intraventricular hemorrhage.

^c Transient hemiparesis.

^d Upward-gaze palsy.

of the venous sinuses and cannot help to differentiate pineal region meningiomas.

4.3. Surgical approach

We prefer the occipital transtentorial/transfalci approach for the pineal region tumors. Advantages of this approach include good visualization of the internal cerebral veins and posterior and lateral midbrain, low risk of air embolism, and wide exposure of the lesion. The bioccipital approach is reported to be used for unusually large tumors [14,23,24]. The choice of surgical approach depends on the relationship of the tumor to the deep venous system and surrounding structures. The occipital transtentorial approach is performed in tumors that originates from the falx immediately above the junction of the vein of Galen with the straight sinus. During its growth the tumor displaces the galenic venous system inferiorly [9,25,26]. Similarly meningiomas that arise from the dorsal leaf of the tela choroidea and displace the internal cerebral veins ventrally are best approached via the occipitotranstentorial route [20]. The infratentorial supracerebellar approach is preferred when the tumor originates from underneath the tentorium near the junction of the vein of Galen with the straight sinus, and the galenic venous system is elevated [7,26,27], thus opening a surgical corridor between the tentorial edge and quadrigeminal plate. This approach is also favored for velum interpositum meningiomas that arise from the ventral half of the tela choroidea and displace the internal cerebral veins dorsally [20]. Regardless of the choice of surgical approach the galenic venous system and collateral circulation should be preserved during surgery which is more important than achieving gross-total removal [9,15]. Although collateral venous channels may withstand a temporary galenic system occlusion, a venous infarction remains a frequent long-term risk. Even when intraoperative occlusion of the part of the venous system seems feasible since the preoperative angiogram shows its functional occlusion at surgery it may prove patent [15]. Furthermore when performing transtentorial/transfalci approach in cases of the straight sinus occlusion care should be taken to avoid damaging dural channels located in the tentorium which serve as collateral venous drainage [15,28,29].

4.4. Surgical complications and tumor recurrence

There was no surgical fatality in this study and recent series of falcotentorial meningiomas had a mortality rate of 0% [7,9,14] to 23% [15]. When the occipital transtentorial approach is used, contralateral homonymous hemianopsia is observed immediately postoperatively due to the occipital lobe compression. To minimize this risk excessive retraction and prolonged pressure of the spatula on the medial occipital lobe should be avoided to prevent vascular compromise of the calcarine area [7]. However, the visual field deficits return to normal in most patients [30]. In the series of falcotentorial meningioma treated via the combined bilateral occipital transtentorial route, all patients with postoperative cortical blindness demonstrated improvement in the follow-up [14]. Some patients display impairment of extraocular movements, particularly up-gaze and difficulty with convergence [30].

Fortunately, these problems are usually transient, although a mild limitation of up-gaze may persist, however.

Recurrences are observed in patients after subtotal resection and with atypical and anaplastic meningiomas. Because severe neurological compromise have been reported in the literature after occlusion of the galenic venous system [2,31,32] incomplete tumor resection is justified when there is tumor adherence to the deep venous system, particularly the great vein of Galen [9,15]. On the other hand there was no difference in tumor recurrence rate when radical tumor removal with resection of infiltrated parts of the deep venous system was performed [2,9,15,32]. It seems that radiosurgery should be considered for residual tumors and in patients with local recurrences [7,14,15]. In the study of Raco et al. [15] recurrent tumors responded well to radiosurgery and Okami et al. [33] reported decrease in tumor size and even complete disappearance after radiosurgery in subtotally resected falcotentorial meningiomas.

5. Conclusions

1. The falcotentorial and velum interpositum meningiomas are a rare subset of pineal region tumors whose clinical and radiological features, do not allow for a definitive preoperative diagnosis.
2. These tumors can be safely managed with the use of occipital transtentorial approach. Postoperative visual field deficits are common but usually reversible complication.

Conflict of interest

None declared.

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None declared.

Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

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