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Falcotentorial Meningiomas: Optimal Surgical Planning and Intraoperative Challenges - Case Report and a Review

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Abstract

Meningiomas arising from the falcotentorial junction are rare, and the selection of the optimal surgical approach is essential. We report a falcotentorial meningioma (FTM) case approached by occipitotranstentorial resection and subtotal tumor resection presenting a satisfactory clinical outcome. The present review sought to reveal the current knowledge regarding the clinical presentation, radiological imaging, and the microsurgical anatomy of FTMs as a form of improving the surgical approach. The selection of the optimal surgical approach is essential for the safe and effective removal of an FTM. Preoperative imaging analysis should identify the anatomical relations of the tumor and guide toward the least disruptive route that preserves the neurovascular structures.

Keywords
- falcotentorial meningioma
- occipital transtentorial approach
- pineal region meningioma
- outcome

Introduction

Among pineal region tumors, meningiomas are a rare entity, corresponding to between 2 and 8% of pineal tumors and to 1% of all intracranial meningiomas.[1–3] Guttmann[4] described the first pineal meningioma in 1930. In 1937, Araki[5] published two cases successfully treated with a posterior transcallosal approach. These tumors originate from the posterior portion of the velum interpositum or falcotentorial union.[3] Falcotentorial meningiomas (FTMs), as with other pineal region tumors, are prevalent in females.[3] These tumors present a different relationship with vital neuroanatomical structures; therefore, it is essential to decide on the ideal surgical approach.[1] It is often difficult to discriminate between FTM and velum interpositum meningiomas, even after significant advances in neuroimaging.[3] However, arterial irrigation is the main difference between these two groups of tumors. The tentorial branches of the meningohypophyseal trunk usually supply FTMs, while branches of the posterior choroidal arteries 4 to 7 irrigate velum interpositum meningiomas. The surgical treatment of these tumors is not well-established in literature, since there are two main controversial issues. First, concerning validating criteria for selection of the optimal surgical approach, and second,

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whether the main infiltrated venous structures can be sacrificed to obtain a radical resection of the tumor or if they should be preserved.[6]

The present review sought to reveal the current knowledge regarding the clinical presentation and radiological imaging of FTMs as a form of improving the surgical approach.

Classification

Falcotentorial meningiomas represent a subgroup of tentorial meningiomas originated from the dura mater junction depending on the posterior cerebral falx and on the convergence of both tentorial folds, projecting anterosuperiorly, inferiorly, or posteriorly depending on their growth pattern.[3] Regarding their classification, the pineal region meningioma group included FTMs with anterosuperior and inferior extension and velum interpositum meningiomas.[1]Yasargil et al. made one of the first tumor descriptions and eight types of tentorial meningiomas (with types T3 and T8 being falcotentorial) were identified.[7] In 1995, Asari et al. described the classification systems for FMTs based on tumor projection that classifies the tumors as anterior, superior, posterior, and inferior types.[8] In 2008, Bassiouni et al. classified FMTs according to tumor base location and included four types (►**Table 1**):

Type I. Type I includes tumors between both dural leaves of the cerebral falx, immediately superior to the junction of the vein of Galen with the straight sinus. In the description by Asari et al., this tumor corresponds to the anterior type.[7]

Type II. Type II originates close to junction of the vein of Galen with the straight sinus, underneath the anterior edge of the tentorium. In the description by Asari et al., this type corresponds to an inferior type.[7]

Type III. Type III is the lateralized type; therefore, it includes tumors with a dural origin in a paramedian location of one of the tentorial leaves and has a medial growing pattern toward the vein of Galen.[7]

Type IV. This type includes tumors from dural adhesion in the falcotentorial junction along the straight sinus with a posterior direction and, as described by Asari et al., it corresponds to the posterior type.[7]

On the other hand, velum interpositum meningiomas are related to the posterior portion of the double pia mater layer that covers the posterior wall of the third ventricle.[9]

Clinical Presentation

Falcotentorial meningiomas occur mostly in patients between 42 and 56 years old, similar to the posterior fossa meningiomas (44.4 years old).[10,11] Previous studies revealed headaches as the most common symptom in pineal region meningiomas (present in 60 to 100% of the cases), followed by ataxia (43 to 62%), personality changes and bradypsychia (37 to 46%), and homonymous hemianopia (20 to 46%).[6]

Ataxia is the most frequent late symptom in type I and II tumors.[6] Personality changes and bradypsychia were mostly associated in obstructive hydrocephalus cases.[6] Nevertheless, bilateral visual acuity deterioration due to progressive papilledema and the subsequent atrophy of the optic nerve is extremely rare.[8,12] Hearing impairment has been occasionally reported in patients with FTM, which improves after surgical removal.[6] The clinical symptoms of meningioma have a propensity to occur insidiously due to their slow growth, thereby explaining the diagnosis delay to ~ 25 months, on average.[3]

Some authors consider the presence of alterations in ocular supraversion (Parinaud syndrome) or oculomotor cranial nerve alterations as an important differential diagnosis because this feature presents a considerably lower rate (10%) in pineal region meningiomas than in other neoplasms in the same location.[13,14]

Surgical Anatomy

Falcotentorial meningiomas present their vascular blood supply originating from the internal carotid artery (ICA), the external carotid artery (ECA), or the posterior cerebral artery (PCA).[15] ►**Table 2** summarizes the blood supply and their distal branches.

Regarding surgical treatment, understanding the relationship between meningiomas of the pineal region and the deep venous system is decisive for better results. Invasive tumor degree or the permeability of the vein of Galen and the straight sinus and the displacement of these vessels are relevant points in view of the mass effect of the tumor.[7,15]

Occlusion and invasion of the vein of Galen and of the straight sinus were described in preoperative angiographic studies; consequently, the development of a secondary collateral venous drainage is frequently found.[8,10,29] It can be explained due to the fact that the posterior half of the vein

Table 1 Bassiouni Falcotentorial Meningioma Classification[7]

Type of Meningioma	Origin	Venous displacement	Surgical approach
FTM type I	Posterior cerebral falx	Inferior	Occipital transtentorial
FTM type II	Inferior margin falcotentorial	Superior	Supracerebellar infratentorial
FTM type III	Paramedian tentorial	Superomedial	Paramedian supracerebellar infratentorial/Occipito transtentorial
		Inferomedial	
FTM type IV	Tentorial toward straight sinus	Contralateral	Occiptotranstentorial

Abbreviation: FTM, falcotentorial meningioma.

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Table 2 Arterial supply and branches of falcotentorial meningiomas

Arterial supply	Distal Branches
ICA	Anterior choroidal artery branches
	Posterior branches from meningohypophyseal trunk
	Middle meningeal artery branches from external carotid artery
ECA	Ophthalmic artery branches
	Middle meningeal artery branches
PCA	Medial choroidal branches
	Lateral choroidal branches

Abbreviations: ECA, external carotid artery; ICA, internal carotid artery; PCA, posterior cerebral artery.

of Galen and the anterior half of the straight sinus are mostly the first vessels affected by meningiomas and are not related to the growth direction of the tumor.

Identifying vessel occlusion and the secondary collateral venous drainage is essential to evaluate the optimal surgical planning for FTMs.[8,10] Many authors have proposed that the displacement of the deep venous system due to the direction of tumor growth is the most important characteristic when deciding the surgical approach.[1,2,6,7] Therefore, Type I FTMs displace the venous complex inferiorly, type II superiorly, type III medially (supero/inferomedial), and type IV to the contralateral side of the meningioma.[6]

Imaging Assessment

Magnetic Resonance Imaging (MRI): Falcotentorial meningiomas are identified as a homogeneous mass, predominantly oval, with homogeneous enhancement after the administration of gadolinium-T1 contrast.[27] In T1 sequences, they are usually hypo/isointense and iso/hyperintense in T2 sequences. Peritumoral edema was observed in 85% of the patients in a case series, whereas obstructive hydrocephalus, mainly revealed in infratentorial lesions, was observed in ~ 32%. In this study, the average diameter of the lesion was 52 mm.[30]

In the preoperative period, knowledge about the patency of the rectal sinus and the displacement of the Galen vein and internal cerebral veins are fundamental to optimal surgical planning, and MRI can provide this information.[6]

Furthermore, MRI is more accurate in enabling the visualization of the straight sinus and the vein of Galen when compared with conventional angiography, since it was able to identify these structures in ~ 20% of the patients.[6]

Cerebral Angiography: Currently, some authors do not indicate cerebral angiography routinely in FTMs because angiomagnetic resonance has advanced in the last years.[6] The direction of the displacement of the medial choroidal artery is one of the most important angiographic features that can be used to differentiate FTMs from other pineal masses.[5,8,31,32] Therefore, medial choroidal artery displaces anteriorly in FTMs and superior and posteriorly in the other pineal tumors.[5,32]

Surgical Approach

The objective of the surgical treatment of FTMs is to achieve a macroscopically complete resection of the lesion, to relieve or solve the neurologic/clinical symptoms, and to acquire a tissue sample for a definitive diagnosis. Therefore, the recommendation to perform an intraoperative biopsy is established, paving the way to obtaining a differential diagnosis from other pineal tumors (for example, germinoma) for which the management may be different, aiming a partial resection after adjuvant therapy.[33]

Classically, preoperative artery embolization is an important adjuvant treatment for meningiomas. However, most FTMs present a short artery caliber, which can difficult preoperative artery embolization.[15]

The anatomical relation between the tumor and the deep venous complex of Galen is the most crucial factor when choosing the surgical approach. Five surgical approaches are described for these tumors:

Transtentorial/Transfalcine Occipital Approach. This is the most frequently used approach for pineal meningiomas. It was first described by Poppen 1968 and was improved afterwards by Jamieson in 1971.[34,35] This approach is more specifically advised in type I and IV FTMs, which originate from the posterior falx immediately above the junction of vein of Galen and the straight sinus. In this location, the growth of the tumor displaces posterior and inferiorly the deep venous complex (►**Table 2**).

The occipital interhemispheric approach is used to reach tumors with a mostly supratentorial and a smaller infratentorial extension. The transfalcine/transtentorial route is used for the removal of the contralateral supratentorial/infratentorial component. The occipital lobe is also gravity-dependent positioned bearing the largest component of the tumor.

This surgical approach is performed with the patient in a prone or three-quarters prone position with the side of the approach depending on the lateralization of the tumor, avoiding excessive occipital retraction (►**Fig. 1A**).[28]

However, this surgical approach has some disadvantages, such as an increased risk of visual cortex damage (due to

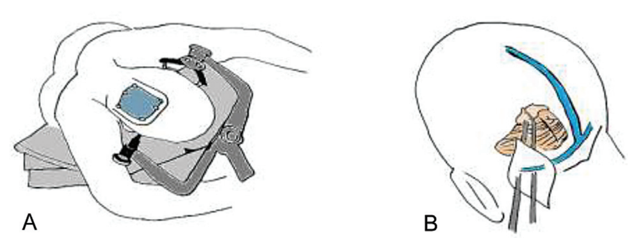

Fig. 1 A. The three-quarter prone position in the transtentorial/transfalcine occipital approach. B. Surgical view of the supracerebellar infratentorial approach. The schematic illustration belongs to the authors.

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cortex retraction), possible trochlear nerve damage at the tentorial opening, and a limitation of the contralateral view of the tumor margin.[28,34,36–38]

Supracerebellar infra-tentorial approach: This is the second most frequently used approach for pineal meningiomas and was the first surgical approach described for these tumors, being reported by Krause et al. in 1913.[39] This approach is recommended for type II and III FTMs according to the Bassiouni classification. It uses the space between the upper surface of the cerebellum and the tentacle (►**Fig. 1B**). Regarding the position of the patient, the sitting position promotes greater cerebral relaxation, but is inappropriate for patients with cardiac comorbidities. Thus, surgery with the patient in a semiseated position seems to be promising in recent studies.[19,33,40,41] A suboccipital craniotomy is performed and centered on the torcula, with a consequent exposure of the two transverse sinuses and retraction of the cerebellum. Currently, some studies suggest that a supracerebellar infratentorial approach could be difficult in patients presenting a steep tentacle and, in these cases, the occipital transtentorial/transfalcine approach seems to be better.[42,43]

Occipital bitranstentorial/falcine approach: This approach was first described by Sekhar et al. in 2002.[15,44] This surgical approach is recommended particularly for large pineal tumors with supra- and infratentorial extension or for those with a significant lateral extension. This technique can be described as a modification of the occipital transtentorial approach, with the division of the falx and the bilateral tentorium. An important advantage of this approach is the better exposition of the contralateral quadrigeminal region.[45]

Anterior interhemispheric trans-splenial approach: This approach was recently described by Yağmurlu et al. and examined cadaveric heads. This surgical approach has several advantages and provides an effective surgery, particularly for patients with supratentorial pineal region tumors with superior extension; for tentorial tumors that displace the deep venous system inferiorly; or for those that originate from the splenium of the corpus callosum.[26] Hendricks et al. described that the anterior interhemispheric approach provides the safest route for accessing the largest portion of the tumor while protecting the deep venous system; however, in this case, the tumor was subtotally removed because of the adherence along the vein of Galen (►**Table 3**).[26]

Posterior interhemispheric retrocallosal transfalcine approach: In 2016, Liu et al. reported this surgical approach using endoscopic assistance to resect a superiorly positioned FTM. In this study, the Galen vein complex was preserved.[18] Lopez-Gonzales et al. described two cases using this approach and achieved a subtotal and a total resection in those cases, respectively[20] (►**Table 3**). However, further studies about this technique are still required.

Adjuvant Radiosurgery

Adjuvant treatments for FTMs are based on histopathological grades and surgical resections. The surgical resection margins are classified using the Simpson classification.[17] Adjuvant radiosurgery is recommended for high-grade histopathological tumor lesions and tumors without Simpson I resection.[43]

Complications and Prognosis

Despite surgical techniques and neuroimaging advances, risks and complications are inherent to FTM procedures, in view of the depth of the location and relationships to important vascular structures. Currently, the attempt to perform a radical tumor resection is not well-established in the literature.[16] Considering that aggressive resections are related to high morbidity rates, a conservative strategy, with subtotal resections, seems to be beneficial in most cases, decreasing a severe neurological deficit rate. The adherence or invasion into the brainstem or the deep venous system by the tumor is an essential factor for a subtotal resection.[16] Surgical mortality was reported in up to 23% of patients, and morbidity, with permanent neurological damage, was recorded in up to 50%. Homonymous hemianopia is the most frequent postoperative deficit.[16] In addition, transient deficits related to the deviation from the conjugated gaze (Parinaud syndrome) and diplopia, being justified by manipulation during the resection of the structure of the dorsal midbrain, such as the collicular plate. This deficit is mostly reversible a few days after the surgery, especially if the arachnoid plan is respected. Permanent cortical amaurosis has been described as a possible surgical complication related to prolonged occipital lobe retraction time.[16] Hemiparesis, hemidysesthesia, tetraparesis, neglectsyndrome, and postoperative intraventricular hemorrhage were described in the literature.[16,43] Our patient developed superior temporal homonymous quadrantanopia in the immediate postoperative period, permanently, without other neurological symptoms. ►**Table 3** summarizes the most relevant reports in the literature from the past 10 years, focusing on the surgical approach, outcomes, and complications.

Conclusion

The selection of an optimal surgical approach is essential for the safe and effective removal of an FTM. Preoperative imaging analysis should identify the anatomical relations of the tumor and guide the least disruptive route that preserves the neurovascular structures.

Ethical Approval
For this type of study, formal consent is not required.

Informed Consent
The authors state that the patient his given their written informed consent for publication of data and images.

Previous Presentation
None.

Disclosure of Funding and Financial Support
None.

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Table 3 Review of the most relevant reports in literature from the past 10 years

Study	Number of patients	Approaches (%)	Outcome	Morbidity or complication
Okada et al., 2020[16]	4	Parieto-occipital interhemispheric transfalcine, transbitentorial approach	GTR	none
Hendricks et al., 2019[17]	1	Anterior interhemispheric	STR	ns
Lopez-Gonzales et al., 2019[18]	2	Retractorless interhemispheric	GTR in two times (1/2)	none
			STR (1/2)	
Zhao et al., 2019[19]	17	SCIT (4/17)	GTR (12/17)	Permanent visual field deficits (2/17)
		O-TT (4/17)		Transient visual field deficits (4/17)
		AITS (3/17)	STR (5/17)	Hemiparesis (2/17)
		PVT (1/17)		Hemidysesthesia (1/17)
		Torcular (2/17)		Cerebellar hematoma (1/17)
Garcia et al., 2019[20]	2	SCIT (1/2)	GTR (2/2)	none
		Parieto-occipital interhemispheric (1/2)		
Mendez-Rosito, 2019[21]	1	SCIT	GTR	none
Talacchi et al., 2018[22]	16	Occipital (5/16)	GTR (8/16)	Hematoma (2/16)
		Parieto-occipital (5/16)		Hydrocephalus (1/16)
		Occipitosuboccipital (3/16)	STR (8/16)	Pleural effusion (1/16)
				Tracheostomy (1/16)
		Suboccipital (3/16)		Tetraparesis (1/16)
				Cranial nerve deficit (1/16)
Couldwell, 2017[23]	1	Occipital interhemispheric	GTR	ns
Gomes et al., 2017[24]	1	Posterior interhemispheric	ns	Neglectsyndrome
Hong et al., 2017[25]	11	Bioccipital transtentorial (1/11)	GTR (10/11)	Occipitocerebellar hemorrhage (1/11)
		O-TT (4/11)		
		Occipital (4/11)	STR (1/11)	
		Occipitoparietal (2/11)		Transient visualfield deficit (1/11)
Liu et al., 2016[26]	1	Posterior interhemispheric retrocallosal transfalcine	STR	none
Liu, 2016[18]	1	Combined bi-occipital suboccipital transsinus transtentorial	STR	ns
Nowak et al., 2014[27]	4	O-TT (4/4)	GTR (3/4)	Temporary homonymous hemianopsia (4/4)
				Upward-gaze palsy (1/4)
			STR (1/4)	Postoperative intraventricular hemorrhage (1/4)
Bahari et al., 2014[20]	2	O-TT (2/2)	STR (2/2)	none
Qiu et al., 2014[28]	15	O-TT (15/15)	GTR (11/15)	Homonymous hemianopia (2/15)
			STR (4/15)	Parinaud syndrome (1/15)
				Dipoplia (1/15)

Abbreviations: AITS, anterior interhemispheric trans-splenial; GTR, gross total resection (Simpson I and II); ns, not specified; O-TT, occipital transtentorial/transfalcine; PTV, parietal transventricular; STR, subtotal resection (Simpson III and IV).

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Contributions of the Authors

1. Bem Junior L. S.: Conceptualization, data curation, formal analysis, visualization, writing, reviewing, and editing.
2. Aquino P. L. R.: Data curation, writing of the original draft, reviewing and editing.
3. Lemos L. E. A. S.: Data curation, writing of the original draft, reviewing and editing.
4. Aquino M. A. R.: Data curation, writing, reviewing, and editing.
5. Valença M. M.: Conceptualization, writing, reviewing, and editing, supervision.
6. Azevedo Filho H. R. C.: Conceptualization, writing, reviewing, and editing, supervision.

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Conflict of Interests

The authors have no conflict of interests to declare.

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