

## REVIEW / MISE AU POINT

## FORAMEN MAGNUM MENINGIOMAS: A REPORT OF 10 CASES AND REVIEW OF LITERATURE

## LES MENINGIOMES DU TROU OCCIPITAL: A PROPOS DE 10 CAS ET REVUE DE LA LITTERATURE

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## ABSTRACT

**Introduction**

Foramen magnum meningiomas are uncommon skull basal meningiomas. Although there has been great development of the anatomical knowledge for this region, several controversies still exist regarding aspects of tumor location, rate of vertebral artery (VA) encasement, rate of tumor recurrence, and surgical approaches. We report a series of patients with foramen magnum meningioma treated in our institution.

**Methods**

We reviewed 10 consecutive cases of foramen magnum meningioma operated between January 2002 and December 2010 in the neurosurgery department of Avicenne Teaching Hospital.

**Results**

There were 6 female and 4 male patients (mean age  $41.7 \pm 6.4$  years; range, 32-68 years).

Foramen magnum meningiomas were classified as anterior (1 case), anterolateral (2 cases), and posterolateral (7 cases). Headache and dizziness (90%), and cervico-occipital pain (50%) were the most common presenting symptoms. Eight patients were operated on in the sitting position and 2 patients in the park-bench position due to the presence of a patent foramen ovale. The posterior midline approach was performed in 7 cases, far-lateral approach in 3 cases. Gross total resection was achieved in 70% of patients. Surgical mortality was 0 %.

**Conclusion**

Foramen magnum meningiomas are challenging tumors in the vicinity of the brainstem, the vertebral artery, and lower cranial nerves. Several surgical approaches are possible, each one with specific indication.

## RESUME

**Introduction**

Les méningiomes du foramen magnum sont rares. Leur prise en charge chirurgicale dépend du siège, de la taille et de l'extension vers les structures anatomiques de cette région. Nous rapportons une série de patients ayant eu un méningiome du foramen magnum, traités dans notre institution.

**Matériel et méthode**

Il s'agit d'une étude rétrospective de 2002 à 2010, concernant des patients opérés pour un méningiome du trou occipital.

**Résultats**

L'âge moyen de la série est de  $41,7 \pm 6,4$  ans avec des extrêmes allant de 32 à 68 ans. Le sex ratio était de 4 hommes pour 6 femmes. La clinique a été dominée par un syndrome d'hypertension intra crânienne (90%) et un syndrome de la charnière cervico-occipitale (90%). Tous les patients ont bénéficié d'un abord

chirurgical : sous occipitale médian (7 cas), latéral (3 cas). Huit patients ont été opérés en position assise et 2 en décubitus ventral. L'exérèse chirurgicale a été totale dans 7 cas et subtotale dans 3 cas. L'évolution post opératoire a été satisfaisante, sans complications neurologiques chez 8 patients. Le taux de mortalité est nul pour l'ensemble de cette série.

### **Conclusion**

Les méningiomes du trou occipital constituent un challenge chirurgical pour le neurochirurgien. La voie d'abord doit être choisie en fonction de l'extension de la tumeur.

## **INTRODUCTION**

Meningiomas account for 14.3 to 19% of all intracranial tumors and only 1.8 to 3.2% of meningiomas arise at the foramen magnum (FM) level (38, 3). However, meningiomas represent 70% of benign tumors of the FM (11, 12, 13, 15, 33, 40). Because of the complex anatomy of this area, which includes the brain stem, vertebral artery, and lower cranial nerves, complete resection of FM meningioma is challenging for the neurosurgeons. Despite improved knowledge of the anatomy of this region and development of operative techniques for skull base tumors, controversy still exists regarding the optimal approach for anterior and anterolateral FM meningiomas (5, 6).

This is a retrospective analysis of clinical characteristics and outcomes of surgery, as well as review of literature, in patients with FM meningiomas, at our teaching hospital setting.

## **PATIENTS AND METHOD**

From January 2002 to December 2010, a total of 10 consecutive adult FM meningiomas patients underwent operation at the neurosurgery department of Avicenne Teaching Hospital, Rabat-Morocco.

### **Neuroimaging Studies**

All patients were evaluated preoperatively with computerised tomography and contrast-enhanced magnetic resonance imaging (MRI). In some patients with large tumors, cerebral angiography was used to evaluate the blood supply to the tumor. Encasement and narrowing of the vertebral artery (VA) were assessed using both MRI scans and cerebral angiography. Three main criteria were used for the classification of the FM meningiomas: the compartment involved, dural attachment, and the relation to the VA. The extent of tumor removal was assessed with postoperative MRI.

### **Surgical Procedure**

Patients were operated upon in the sitting position when there was no contraindication. Electrophysiologic monitoring of the lower cranial nerves, somatosensory evoked potentials, and brainstem auditory evoked potentials were used in all operations.

The posterior midline approach was performed for posterolateral FM meningioma; thus, the lower part of the occipital bone and the posterior arch of the atlas were resected and widened on the side of the tumor. For anterior and anterolateral tumors, a far-lateral approach was chosen. The VA was identified and the posterior arch of C1 was resected as far as lateral mass. C2 laminectomy was carried out when necessary to expose the caudal extent of the tumor in the upper cervical spinal canal. The occipital rim to one third of the occipital condyle, especially the medial margin, was drilled away to expose small anterior tumors or those encasing the VA.

### **Postoperative Management**

Patients were sent to the intensive care unit after the operation and endotracheal intubation was continued for at least 12 hours. After surgery, careful assessment of the caudal cranial nerves is paramount to the patient's successful recovery. Aspiration precautions should be taken before the patient is allowed oral intake, and the diet is advanced gradually from a dysphagia diet to a regular one as indicated. Intensive pulmonary care, aggressive pulmonary toilet, and antibiotic prophylaxis are used to prevent fatal respiratory complications in patients with deficits of the lower cranial nerves. Patients with a deficit of the glossopharyngeal and vagus nerves may need an aggressive tracheostomy to protect the airway and manage secretions, and also may require a gastric tube.

### **Patients Follow up**

Clinical neurological examination and MRI scans were performed at 6 months and 1 year after surgery. Long-term out-patient follow up data were obtained from patients' files.

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## RESULTS

### Clinical Data

Four patients were 4 males and 6 were females. The ages ranged from 32 to 68 years (mean:  $41.7 \pm 6.4$  years). Preoperative symptoms and neurologic signs are presented in Table 1. Cervico-occipital pain was present in 50% cases, and one patient had any symptom before admission.

### Tumor Characteristics and Surgical Aspects

Anterior FM meningioma was found in 1 patient, anterolateral in 2 and posterolateral in 7 (Figures 1, 2). The mean diameter of the tumors on MRI was  $3.35 \pm 0.85$  cm (range, 1.0 to 4.7 cm). The VA was encased in 3 patients. Eight patients were operated upon in the sitting position and 2 in the park-bench position due to the presence of patent foramen ovale. Gross total excision was achieved in all 7 patients who had posterior midline approach (Table 2).

### Outcomes

The mean stay in intensive care unit was  $2.5 \pm 0.5$  days and ranged from 1 to 35 days. Postoperative complications included persistent dysphagia, haematoma, pneumonia, cerebrospinal fluid (CSF) leak and hydrocephalus (requiring ventriculoperitoneal shunt). None died.

## DISCUSSION

FM meningiomas are relatively rare. Nine of the patients studied presented with motor deficits, lower cranial nerve involvement and intracranial hypertension. The onset of the clinical signs was mainly insidious. In one case the meningioma was a fortuitous discovery after a benign head trauma. FM meningiomas are uncommon skull base meningiomas. Much has been achieved in the understanding of the anatomy of this region, but controversies still exist regarding aspects of tumor location, rates of VA encasement, rate of tumor recurrence, as well as surgical approaches. Table 3 summarizes the high variability of tumor location, rate of VA encasement, rate of tumor recurrence, and surgical approaches. The incidence of anterior FM meningiomas is 12.5 to 100% (3, 22, 28). Studies show that the demarcation between anterior and lateral FM meningiomas is not always clear and, also, posterior FM meningiomas may be included with anterior or antero lateral lesions in 2.5 to 50% (4-7, 16, 24, 29, 30, 36). The rate of VA encasement may be higher than 59% and the rate of tumor recurrence up to 80% (17, 35). In our series this encasement was present in 3 cases. Operations for FM meningiomas may be carried out in the sitting or lateral oblique positions (20, 26, 37). Our patients were operated on in the sitting position. This position has the advantage of decompressing the neuraxis upon opening of the posterior bone and dura (14). The disadvantage of this position is risk of air embolism in the sitting position unlike in the lateral oblique position (39). FM meningiomas are undoubtedly challenging tumors, requiring special considerations because of they are located in the vicinity of the brainstem, lower cranial nerves, and VA. Several approaches have been advocated. The goals of surgery include maximizing tumor resection with the minimum morbidity. This is attained by choosing the appropriate approach to allow adequate control of important neurovascular structures, without unnecessary risks (8).

The posterior approach is the best option for posterior FM meningiomas; it is associated with a low morbidity. All patients with posterior FM meningiomas, in our series, had posterior approach.

For lateral and anterior FM meningiomas, the transoral approach has been several drawbacks, especially for intradural lesions, including cerebro-spinal fluid fistula and meningitis (8, 10, 27). The two main surgical approaches reported in the literature are the far-lateral approach (also called posterolateral approach or lateral suboccipital approach), and the extreme-lateral approach (also named anterolateral approach) (23). Both approaches permit drilling of the occipital condyle but provide a different exposure because of the differences in the approach direction.

Another confusing aspect concerns the resection of the occipital condyle for anterior and anterolateral FM meningiomas (1, 8, 11, 21, 29). Arnautovic reported that drilling of the condyle is important for safe and radical tumor resection of anterior FM meningiomas via a transcondylar approach (3). None of the patients in our study had the transcondylar approach. Factors which may increase morbidity include anterior tumor location, tumor size (smaller lesions are more difficult to resect because the surgical corridor is small), tumor

invasiveness, extradural extension, VA encasement, absence of arachnoid sheath, and adherences in recurrent lesions (4, 5, 11, 14, 18, 33, 35, 40).

Factors limiting the completeness of resection are adherences to vital structures, VA encasement and invasiveness of the lesion. In our series, the resection was limited by VA artery in one case, and existence of adherence in two cases. In our series, there was subtotal resection in 30%. This rate is comparable to Samii's and Salas' series (Table 3). In surgical series in which a high rate of recurrent tumors are included, Simpson grade 1 resection is achieved in 60-75% (3, 33, 35).

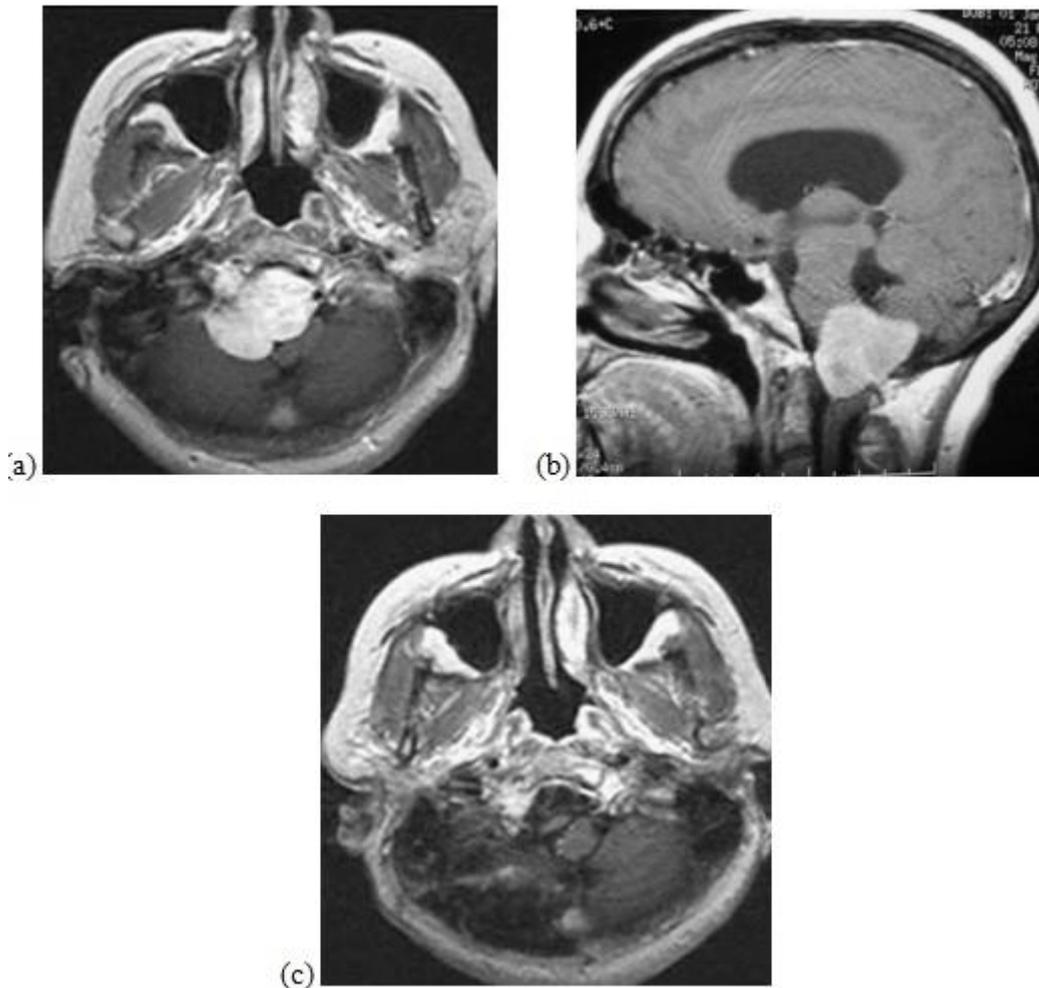
The rate of complications in the treatment of foramen magnum meningiomas is relatively high, and it is higher for anterior tumors than for posterior ones (3). Complications rate in anterior tumors in our series is 57.14%. Morbidity ensues primarily from deficits of lower cranial nerves, specifically the glossopharyngeal, the vagus, and the hypoglossal. Such complications may lead to aspiration pneumonia as seen in one of our patients. Other important complications are leakage of cerebrospinal fluid and meningitis. In cerebrospinal fluid leak, additional stitches and compressive dressing, and external lumbar drainage may be used. If the leak persists, operative revision may be indicated. In hydrocephalus, a ventriculoperitoneal shunt is indicated as performed in one of our patients (39). Paralysis of the vocal cords early in the postoperative course may be treated by vocal cord medialization, or the cord can be injected with Gelfoam or Teflon. Such treatment protects the airway until the nerve recovers or the patient learns to compensate for the deficit, which may take up to 8 months (3).

It is more difficult to resect recurrent FM meningioma after incomplete resection in the first operation (39). None of the 3 cases in our series with subtotal resection had been reoperated. They had radiotherapy after the first surgery. The tumor remnants always involved important structures that might increase risk of complications after radiotherapy. Follow-up data were available for all patients, with a mean follow-up of  $90.5 \pm 8.3$  months (range, 1-120 months). There was no mortality in our series.

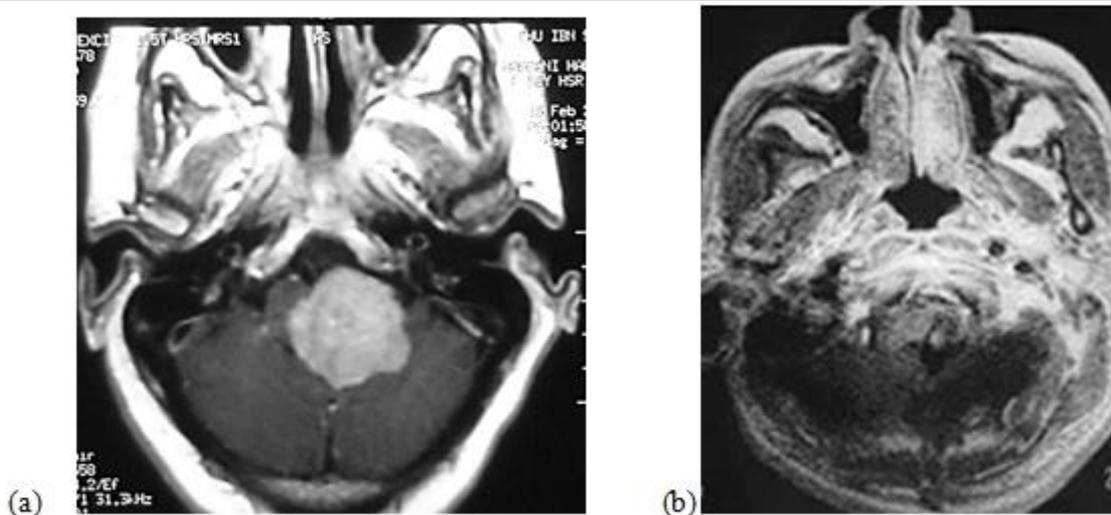
## CONCLUSION

FM meningiomas are challenging tumors in the vicinity of the brainstem, the VA, and lower cranial nerves. Several surgical approaches are possible, each one with specific indications. Postoperative complications can be dramatic and must be anticipated.

**Conflicts of interest: None**



**Figure 1 a-c**  
 Preoperative T1-weighted axial (a) and sagittal (b) MRI images of an anterolateral foramen magnum meningioma. Figure 1c shows axial MRI in the same patient one month after surgery.



**Figure 2**  
 Pre- (a) and two months postoperative (b) MRI T1-weighted of a patient with posterolateral foramen magnum meningioma.

Table 1: Preoperative clinical features in patients with FM meningioma.

	Number of patients
Asymptomatic	1
Cervico-occipital pain	5
Headache and dizziness	9
Dysphagia	1
Hoarseness	2
Paraparesis	5
Ataxic gait	5
Hypoaesthesia	2

Table 2: Operative approach and results in patients with FM meningioma.

	Anterior	Anterolateral	Posterolateral
Approach :			
Posterior midline	0	0	7
Far-lateral	1	2	0
Degree of resection :			
Simpson 1	0	0	1
Simpson 2	0	2	4
Simpson 3	1	0	2
Complication :			
Dysphagia	1	0	0
Dyspnea	0	0	1
CSF leak	0	0	1
Hematoma (tumor bed)	0	1	1
Pneumonia	1	0	0
Hydrocephalus	1	0	0
Mortality	0	0	0

Table 3: Review of the literature of published series of FM meningiomas.

	Year	Nb	FM meningioma location (%)			Recurrence (%)	VA encasement (%)	Approach	Resection %		Permanent morbidity (%)	Mortality (%)
			Anterior	Lateral	Posterior				Total	Subtotal		
Gilsbach (16)	1987	5	Pt	100		-	-	FL	100	0	20	0
Guidetti (18)	1988	17	82.4			-	-		100	0	12	11
Sen, Sekhar (35)	1990	5	80		20	80	-	EL	60	40	60	20
Crockard (10)	1991	3	100			33	33	TO	0	66	100	66
Kratimenos (22)	1993	8	100			12.5	-	FL	87.5	12.5	0	25
Babu (4)	1994	9		100		-	-	EL	88.8	11.2	56	11.1
Akalan (2)	1994	8	12.5		87.5	-	-	PM	100	0	0	0
Bertalanffy (6)	1996	19		100		-	-	FL SO	100	0	0	0

	Year	Nb		FM meningioma location (%)		Recurrence	VA	Approach	Resection %		Permanent	Mortality
								TC				
Samii (33)	1996	38		95	5	5	40	PM, LSO	63.0	30	5	6
George (14)	1997	40	45	52.5	2.5	-	38	-	87.5	10.0	0	7.5
Pirotte (30)	1998	6		100		-	-	-	100	0	17	17
Sharma (36)	1999	10	50		50	-	-	PM, FL	100	0	-	15
Salas (32)	1999	24		100		-	-	TC/ELJT	66	33	-	0
Arnautovic (3)	2000	18	100			11.1	-	TC	75	12.5	11.1	16.6
Roberti (31)	2001	21				-	-	EL TC	76	24	21.5	9.5
Goel (17)	2001	17		100		-	59	SO	82	18	6	0
Nanda (28)	2002	6	100			-	-	FL	100	0	0	0
Marin Sanabria (25)	2002	7		72.5		-	-	TO, SO, TC	100	0	5	14
Boulton (7)	2003	10	60	10	30	-	-	-	90	10	10	0
Pamir (29)	2004	22		91	9	-	40	-	95.5	4.5	4.5	0
Margalit (24)	2005	18		100		-	-	Lat	-	-	-	0
Bassiouni (5)	2006	25	32	57	11	4	43	FL	96	4	8	4
Wu Z (39)	2009	114	80	24	10	-	-	PM, FL	86	14	-	1,8
Our series		10		30	70	0	3	PM, FL	70	30	10	0

*EL* externe lateral, *FL* far lateral/ potero lateral, *JT* jugular tubercule, *mast* mastoidectomy, *Lat* lateral, *LSO* lateral suboccipital *Nb* number, *PM* posterior midline, *pt* patient, *SO* suboccipital, *TC* transcondylar, *TO* trans oral.

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