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Original Article

Foramen magnum meningiomas: To drill or not to drill the occipital condyle? A series of 12 patients

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Abstract

Background: Despite the development of microsurgery and cranial base techniques, the surgical management of Foramen Magnum Meningiomas (FMM) continues to be a technical challenge to neurosurgeons. Controversy concerning the utility of systematic condyle drilling for approaching FMM has been raised. Our aim was to describe the surgical technique, analyze its safety, and the postoperative outcome in 12 consecutive FMM patients.

Methods: From 1986 to 2011, 12 patients with FMM underwent operations in the Department of Neurosurgery at Servidores do Estado Hospital and in a private clinic. All patients were operated using a standard suboccipital craniectomy, preserving the occipital condyle, opening of the Foramen Magnum, and ipsilateral removal of the posterior arch of C1.

Results: There was no operative mortality, nine patients achieved Glasgow Outcome Scale 4 or 5. Condylar resection was not deemed necessary in any case. Gross total resection was achieved in nine patients. After surgery, four patients developed lower cranial nerve weakness. There was no significant postoperative complication in the remaining patients. The average follow-up is 8.2 years.

Conclusion: The vast majority of FMM can be safely removed with a retrocondylar lateral suboccipital approach without condylar resection, using meticulous microsurgical techniques.

Key Words: Foramen magnum, foramen magnum meningiomas, meningiomas, microsurgery, retrocondylar suboccipital approach

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INTRODUCTION

Foramen Magnum Meningiomas (FMM) account for 1.8-4% of all intracranial meningiomas and constitute about 6.5% of the meningiomas located in the posterior cranial fossa.[1,7,10] Cushing and Eisenhardt divided FMM into craniospinal and spinocranial tumors. The craniospinal type arose above the foramen magnum (FM) and project downward into the spinal canal pushing the medulla chiefly backward. The spinocranial type lie posterior or posterolateral lateral to the spinal cord and project up into the cerebelar cisterna.[9] The first successful removal of FMM was accomplished by Elsberg[12] in 1927 via a suboccipital craniotomy and C1-C3 laminectomy. Despite the development of microsurgery and cranial base techniques, the surgical management of FMM continues to be a technical challenge to neurosurgeons. They still raise controversies in the neurosurgical literature because they grow in close contact with osteoarticular, nervous, and vascular structures that cannot be sacrificed or retracted. Recently, a controversial discussion has been raised concerning the utility of systematic condyle drilling for approaching FMM.[2-6,8,11,13-30,32-36]

The current paper presents our experience with the surgery of 12 consecutive FFM patients using the Lateral Suboccipital Retrocondilar approach without drilling the occipital condyle.

MATERIALS AND METHODS

Data collection

A retrospective study was carried out with 12 consecutive patients with FMM diagnosed, evaluated, and operated on at the Neurosurgical Department of Servidores do Estado Hospital (10 patients) and a private clinic (2 patients) from 1986 to 2001. The patient's files, operative notes, pre- and postoperative imaging studies, pathological reports, and intraoperative videos, when available, were used for the analysis. A database was created from which information pertinent to the present study was collected. As this paper is a retrospective study, it has inherent biases and drawbacks that only a prospective study can overcome. In each case, the grade of tumor removal was determined using a combination of the surgeon's assessment and postoperative images. Pathological review was performed based on the World Health Organization (WHO) guidelines. The need for informed consent was waived due to the retrospective character of the study [Table 1].

Table 1: Characteristics of 12 patients with FMM

Age at treatment: 33-61 years (mean 48.3 years)
Female sex: 9 (75%)
Male sex: 3 (25%)
Clinical-neurological picture: Headache: 10 (83.3%)
LCN deficits: 7 (53.8%)
Motor deficit: 7 (53.8%)
Gait disturbance: 6 (50%)
Pathology (WHO): Grade 1: 12 (100%)
Follow-up: 1-23 years (mean, 8.2 years)
Multiples: 1 (8.3%)
Surgical mortality: Zero
Tumor size: 2.1-4.8 cm (mean, 3.51 cm).
Recurrence: 1 (8.3%)
Radiotherapy: 1 (8.3%)
Simpson 2: 10 (83.3%)
GOS 1 or 2: 9 (75%)

WHO: World Health Organization, GOS: Glasgow outcome scale, FMM: Foramen magnum meningiomas

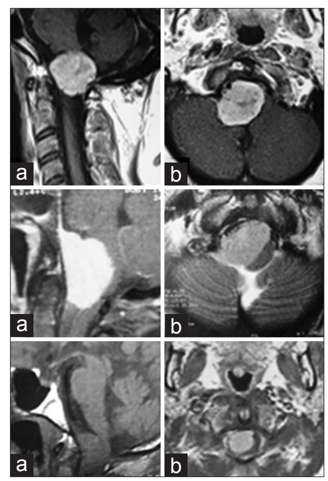

Figure 1: (a) Sagittal and (b) axial T1-weighted MRI with contrast enhancement of different types of FMMM found in this series

Clinical characteristics

Chronic headache and/or neck and arm pain were observed in nine patients (75%). Gait disturbance was reported in six patients (50.0%). Pyramidal syndrome was found in seven patients (58.3%) and lower cranial nerve (LCN) dysfunction was diagnosed in five (41.6%).

Imaging

All patients underwent a computed tomography (CT) scan and/or magnetic resonance imaging (MRI) [Figure 1a and b]. Ten (83%) lesions showed enhancement after contrast injection. Two (16.6%) of them showed calcifications. Eleven (91.6%) of the tumors were inserted anteriorly or anterolaterally to the dentate ligament, only one lesion (8.3%) was postero-lateral. Seven (58.3%) crossed the midline.

Follow-up

The follow-up varied from 1 to 21.5 years (mean, 8.2 years). The first clinic visit was about 15 days after hospital discharge and then at 2 and 6 months. Thereafter, patients were reexamined at 1-year interval. Patients who were alive were contacted for imaging and clinic visits or interviewed by telephone. The Glasgow Outcome Scale (GOS) defined the outcome.

Surgical technique

All 12 patients underwent microsurgery for tumor removal, and the same technique was used following these steps: General anesthesia was induced with a carefully endotracheal intubation and standard anesthetic equipment to detect and treat air embolism was employed. Eight patients were positioned on a semi-sitting position with the head slightly flexed and secured in the Mayfield head holder. In three patients, the lateral decubitus (surgeon preference) was preferred. A paramedian strait vertical skin incision initiated at the level of the superior nuchal line is carried down through the galea and the periosteum over the occipital bone and then down through the posterior border of the sternocleidomastoid and trapezius muscles paravertebrally and proceeding to the level of C3.

Muscular dissection

The spinous process of the second cervical vertebra is a palpatory guide to the position of the FM and permits the subperiosteal dissection of the suboccipital region to be carried along the posterior arch of C1. The paravertebral muscles are detached from their attachment to the occipital squama and progressively sectioned with scalpel. Careful hemostasis is obtained with bipolar under saline irrigation. A self retain retractor is progressively inserted in the wound, exposing the sub occipital triangle and maintaining the paravertebral muscle in the appropriate position. At this point the posterior arch of C1 is identified and dissected free with a periosteum elevator until exposure of the mastoid process. The vertebral artery (VA) is kept undisturbed in the Sulcus Arteriosus. The ipsilateral half of the arch of the atlas is then resected with the Laksell rongeur.

Craniotomy

The suboccipital craniectomy is created unilaterally, using a high-speed drill to thin the squama of the occipital bone. The occipital craniectomy is performed with a Leksell rongeur, including the FM and extending to the posterior edge of the occipital condyle. This access provides sufficient midline and lateral suboccipital exposure to the tumor. If more exposure is needed, C2 and C3 laminectomy can be included. The occipital condyle was persevered in all instances. Emissary veins opened during subperiosteally dissection should be bipolar coagulated and waxed immediately and waxed again at the end of the procedure. The surgical microscopy is introduced in the operative field and the operation is done with magnification that varies from 10 to 16× until the end of the procedure.

Opening the dura

Spinal dura is opened longitudinally, medial from the VA entry. Extreme care must be taken when opening the circular sinus because large venous plexus make the homeostasis much more difficult and the risk of embolism grows. The dural edges are tented up. The cisterna magna was opened to drain the cerebrospinal fluid (CSF). The tumor is exposed under the arachnoid. The brainstem, LCN, and the VA are identified. The exposure is improved after gentle elevation of the cerebellum. In the anteriorly placed tumors, the spinal cord was displaced posteriorly and laterally, to the opposite side by the tumor. The spinal portion of the accessory nerve and the posterior rootlets of the first two cervical spinal nerves are identified on the posterior aspect of the meningioma. The LCN group was located on the superior pole of the tumor. The dentate ligament, C1 and C2 rootlets are sectioned whenever necessary, but the vessel traveling along the nerve root should be preserved to avoid spinal cord ischemia.

Debulking the tumor

After bipolar coagulation with low current under saline irrigation, the tumor is partially devascularized; the capsule was incised with scalpel, penetrated, and progressively debulked from within, with piece meal tissue removal techniques. Rigorous homeostasis is maintained throughout the operation. A careful attention was paid to identify and respect the arachnoid plane at the tumor brain stain interface, which facilitates complete tumor resection and minimizes small vessel and brain stain injury. Ultrasonic aspirator has been introduced in the last four patients.

Dissecting the tumor

The surgery proceeds within the space provided by the tumor growth. The meningioma is then dissected away from the LCN and the blood vessels by gentle meticulous microsurgical techniques. We use micro scissors and dissectors, in a bloodless field, and multiples microscope angulations, rotation of the operative table, and different magnifications. As tumor debulking proceeds, the brain stem progressively relaxes and provides additional working space for dissection. Then, the site of tumor attachment is identified, coagulated, and sectioned. Gross total resection (GTR) is always attempted, but if the arachnoid cleavage plane could not be defined during surgery or if dissection of the tumor from the VA, its branches, the brain stem or LCN could entail risk of damage, we left a thin rim of tumor attached to these structures. No attempts were made to resect the dura or to excise the involved bone.

Before closure, the patient's blood pressure must be brought to a normotensive level for at least 10-15 minutes and observed for oozing. The dura is closed primary or either with a free pericranial graft or the artificial dural substitute. The suture line is covered with fibrin glue. The closure of superficial planes consisted of three layers of suture, with nylon stitches on the skin. Postoperatively, all patients were cared for in an intensive care unit before returning to the ward. If swallow deficits is noted in the postoperative period an early traqueostomy is performed.

Illustrative cases

Patient 1

A 54-year-old female presented with a history of a slow progressive severe tetraparesis for the past 3 years. She also developed hoarseness and difficulty in swallowing due to unilateral paralysis of the IX and X cranial nerves during this period. The CT scan showed a lesion located anteriorly in the FM compressing and displacing posteriorly the spinal medullary junction [Figure 2a]. The meningioma was totally resected through a lateral suboccipital craniectomy without condylar

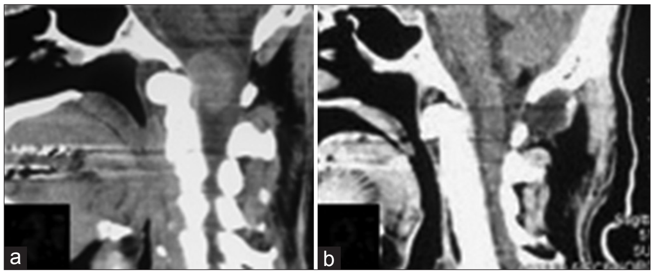

Figure 2: (a) Sagittal CT scan revealing a homogeneously enhancing tumor located anterior to the FM. The medulla is dislocated in a posterior direction. (b) Postoperative sagittal CT scan demonstrating a complete resection of the tumor via a suboccipital retrocondylar craniotomy in addition to a partial removal of the posterior arch of C1. The spinal medullary junction returned to the normal position

drilling [Figure 2b]. The patient made a GOS 4 recovery.

Patient 2

This patient is a 61-year-old male who developed spastic tetraparesis and occipital headaches during a 2-year period. MRI detected a tumor mass that occupied the spinal canal from the FM to C3 [Figure 3a]. A cervical CT scan revealed a heavy calcified tumor [Figure 3b]. The meningioma was completed removed through a suboccipital retrocondylar approach. We added removal of the posterior arch of C1 and laminectomy of C2 and C3. He did a very good recovery but could not retour for his former job as a carpenter due to the lack of normal sensation in both hands. Postoperative MRI detected a stable small residue that has been following for 5 years, without any change [Figure 3c].

RESULTS

In this series, there were nine (75%) women and three (25%) men, ranging in age from 33 to 61 years (average, 52.2 years). The maximum diameter of the tumors ranged from 2.1 to 4.8 cm (mean, 3.51 cm).

Mortality, morbidity, and outcome

There was no operative mortality (until 30 days after surgery), but two patients (16.6%) died at 60 and 180 days following surgery, which resulted from aspiration pneumonia and its consequences. Immediate postoperative dysfunction or aggravation of previous LCN was observed in five (41.6%) patients, consisting of: IX and X CN deficit in four patients, XII CN deficit in one patient, VII CN deficit in one patient. Three of such patient's recovered from the LCN deficits during the follow up period. One patient presented a partial brachial plexus paralysis and two patients presented a transient CSF fistula. Difficulty with dissection of tumor from the brain stem and from encased vessels due to an absent arachnoid plane occurred in four instances (33.3%). We obtained Simpson grade 2 in 10 patients (83.3%) and grade 3 in 2 (16.6%) others. Nine patients (75%) achieved

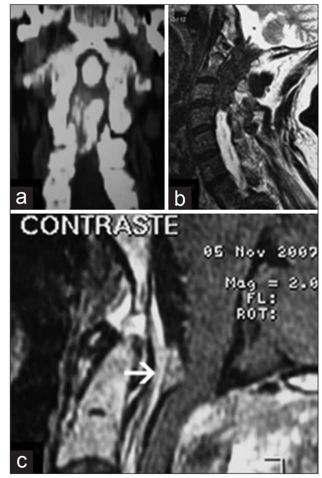

Figure 3: (a) Cervical CT scan detected a heavy calcified lesion. (b) Sagittal T1-weighted MRI showing a tumor located anterior to the FM extending inferior to the body of C3. (c) A contrast-enhanced T1-weighted MRI obtained at the 5-year follow-up examination showing an almost complete tumor resection. There is a minimal extra dural residual tumor. The patient made a GOS 4 recovery

GOS 4 or 5. We observed recurrence of one lesion that was treated with radiotherapy.

Histological features

The pathology, as defined by the WHO classification of mengiomas, was benign in all 12 cases. Among them, six were transitional subtype, three were meningothelial, and three showed fibroblastic features. We did not find correlation among the meningiomas subtypes and clinical outcome and extension of tumor removal.

DISCUSSION

Surgical aspects

Surgery of FMM, located anterior or anterolateral to the brainstem still constitutes a formidable challenge to neurosurgeons. Recently, a controversial discussion has risen concerning the utility of systematic condyle drilling for approaching anterolateral FMM. The extreme lateral or far lateral approaches with partial or total condylar drilling,[2,4,19,24,25,28,29,35] and the lateral or the conventional posterior approach without condylar drilling[3,13-15,18,23,27] have been described to treat these lesions. The anterior transoral and anterolateral transcervical approaches did not reach popularity among neurosurgeons due to CSF fistula, infection, and surgery restricted lateral field.[8,21,22] Sen and Sekhar[29] stated that in anterior or anterolateral located FMM, the extreme lateral or far lateral approach associating VA medial transposition with total or partial condylectomy, improves the angle of visualization of the area ventral to the lower brainstem, facilitating the dissection of the interface between the neuroaxis and the tumor.[2,4,5,19,24,25,28,35] In contrast, George, *et al.*,[13,14] Bassiouni, *et al.*,[3] and others[15,23,27] concluded that, as the tumors progressively displace the medulla posteriorly, a space is created and through this space the tumor can be safely and completely resected via a posterolateral sub occipital craniectomy, without condylar drilling. They believed that removal of the occipital condyle and mobilization of the VA to obtain sufficient access is not necessary for a safe and complete resection of anterior intradural FMM. They recommended that only in small tumors anteriorly placed it might be necessary to drill the posterior third of the occipital condyle. Most cases of incomplete tumor resection are due to the invasion of the brainstem pia mater or to the involvement of the VA or LCN by the tumor. In such patients, a subtotal tumor resection is recommended.[3,28] Furthermore, anatomic studies reveal controversial data. Wanebo and Chicoine[34] concluded that in patients with a small FM, with a short distance between the anterior rim of the FM and the brainstem and relatively large occipital condyles, the transcondylar approaches would be helpful. On the contrary, Spektor *et al*.[32] reported that total resection of the condyle provide very little additional exposure to the anterior FM and do not compensate for the significant level of possible additional morbidity. Silveira and Gusmão[31] concluded that the extensions of bone removal should be adapted to the topography of the lesion: The retrocondylar approach for the lateral area of the FM, the partial transcondylar for the anterolateral portion and the complete transcondylar for the anterior part of the FM.

Bassiouni *et al*.[3] showed data that do not support superiority of the transcondylar approach regarding clinical outcome. They observed that the retrocondylar approach had a permanent morbidity and mortality rate ranging from 0% to 5.9% and from 0% to 6.1%, respectively. Series applying the transcondylar approach had a permanent surgical morbidity and mortality rate ranging from 0% to 60% and from 0% to 29%, respectively. Publications in which resection of the FMM was accomplished via the transcondylar approach, reported GTR varying from 66% to 100% of cases. Results almost identical to series that the retrocondylar approach was elected. In this former group the GTR varies from 63% to 100%.

A recent review on surgery of FMM in the world literature found 657 cases from 29 different neurosurgical centers. In six of this centers they performed routinely condylar resection, in four they tailored the drilling of the condyle, and in seven other centers they never resected.[10]

The aforementioned studies clearly demonstrated that optimal surgical management of FMM is still unsolved. The approach that we use in this present series was the retrocondylar without resection of the occipital condyle and neither opening of the periosteal sheath or mobilization of the VA. The retrocondylar approach provided satisfactory exposure, since most of these tumors grow predominantly to one side, providing a corridor of exposure without need of condylar resection. These lesions belong to the group of tumors in which, paradoxically, it is easier to excise a large tumor than a small one because larger tumors provides more space anteriorly and thus lessens the need for a more lateral exposure. Extensive drilling of the occipital condyle, lateral mass of the atlas, and jugular tubercle can lead to injury of the hypoglossal nerve, VA, and can promote spinal instability.[3,13-15,23,27]

Our objective was always to keep patient's quality of life a priority, so a subtotal removal might represent a very acceptable goal in fibrous or calcified tumors encasing the VA and perforating vessels or adhering to LCN.

From our experience, we can conclude that most FMM can be removed using meticulous microsurgery techniques and posterolateral retrocondylar approach without condylar drilling or vertebral transposition. This surgical technique is safe and effective. We obtained Simpson grade 2 in 10 individuals (83.3%) and grade 3 in other 2 individuals (16.6%). Nine patients (75%) achieved GOS 4 or 5, without surgical mortality. However, tailoring surgery including drilling of the occipital condyle, based on the size and the location of the dural origin of the meningioma, also seems a reasonable option. Radiosurgery might be considered as alternative therapy for residues or recurrences or even in patients deemed poor candidates for resection.[25,32,34]

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