

The suboccipital midline approach to foramen magnum meningiomas

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Abstract

Background Anterior and anterolateral meningiomas of the foramen magnum (FM) can be resected either through extensive skull base approaches or through the classical suboccipital midline approach with limited bone removal.

Method This paper describes the suboccipital midline approach focusing on some peculiar technical features that serve

to achieve the necessary space for safe resection of these challenging tumors.

Conclusions In our experience, by adopting appropriate strategies to gain space (some of them natural, others acquired) the suboccipital midline approach can achieve the safe resection of anterior and anterolateral FM meningiomas in the majority of cases.

Key points 1. The suboccipital midline approach is feasible in a large part of cases of anterior and anterolateral FM meningiomas displacing the brainstem. However, confidence of the surgeon with the approach, intraoperative monitoring availability, single case characteristics must be carefully evaluated case by case.
2. Craniocervical stability is maintained.
3. A C-shaped dural opening gains lateral space and avoids the occipital sinus. Intradural VA visualization is promptly achieved.
4. Intraoperative monitoring is mandatory.
5. The tumor creates all the working space needed. In this sense, the larger the tumor the easier the resection.
6. The “clove” tumor resection technique is deployed.
7. Microscope angulation plays a crucial role in optimizing available working space.
8. Good visualization of the tumor, vertebral arteries, cranial nerves, brainstem and clival dura is obtained.
9. There is low risk of postoperative cerebrospinal fistulae, cerebellum spatula contusions, and vertebral artery injury.
10. The tumor cleavage plane is the most important factor determining the surgical outcome. Involvement of these structures is independent of tumor exposure.

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The percentage of all meningiomas that arise at the foramen magnum (FM) is 1.8–3.2 %. Most FM meningiomas (90 %) are located ventrally and ventrolaterally with their dural origin anterior to the dentate ligament displacing the brainstem and spinal cord dorsally or dorsolaterally [2]. The suboccipital midline posterior approach is well known by neurosurgeons and carries a lower morbidity rate than skull base approaches [2].

Relevant surgical anatomy

The foramen magnum area extends anteriorly from the junction of the lower and middle thirds of the clivus to the upper edge of the C2 body, posteriorly from the anterior edge of the occipital bone to the C2 spinous process, and laterally includes the jugular tubercle, occipital condyle, and the lateral mass of C1. The glossopharyngeal, vagus, spinal accessory, and hypoglossal nerves arise from the medulla along the margin of the inferior olive. The vertebral artery (VA) courses anterior to the nerves in the lower neurovascular complex. The posteroinferior cerebellar artery (PICA) has a much more

complex relationship with these nerves because it passes around or between their rootlets [4]. The VA V3 (suboccipital) segment extends from the C2 transverse process to the FM dura mater and has three portions (vertical, horizontal, and oblique). After piercing the lateral aspect of the occipito-atlantal dura mater, the VA V3 segment becomes the V4 segment and then joins the contralateral segment to form the basilar artery. The VA, PICA, and anterior spinal arteries are closely related to this anatomical site and are exposed during surgery.

Description of the surgical technique

The sitting position is preferred when there are no contraindications such as persistent foramen ovale: it allows a nearly bloodless surgical field thereby decreasing venous bleeding, and usually avoiding cerebellum retraction. Continuous monitoring of brainstem electrophysiologic functions is mandatory. Indeed, motor evoked and somatosensory evoked potentials (MEP and SSEPs) monitoring is crucial to check in real time on brainstem

function that could be injured by the surgical maneuvers. Conversely, direct electrostimulation of cranial nerves is needed only in the case of large tumors. A linear midline skin incision is made from the occipital protuberance to the upper cervical region. The midline avascular plane is followed to the spinous process of C2. A small predominantly unilateral suboccipital craniotomy is followed by partial removal of the ipsilateral posterior atlas arch (Fig. 1c). A C-shaped dural incision is then performed (Fig. 1d) with the vertical part paramedian and ipsilateral to the tumor, avoiding the occipital sinus, associated with two small incisions at the ends of main craniocaudal incision, extending laterally (Fig. 2a). This achieves prompt proximal control of the intradural part of the VA, the V4 segment (Fig. 2b). The dentate ligament is seceded (Fig. 2c) to gain more space and to disconnect the brainstem from the dura to reduce medulla damage by surgical maneuvers. The working space is now through the corridors between the nerves and the vessels (Fig. 2d). The tumor is resected using the “clove” technique (Fig. 3) consisting of removal of the most proximal (lateral) clove of the tumor (see the [video](#)) to expose the

Fig. 1 M/Y. Anterolateral (right) foramen magnum (FM) meningioma. Sagittal (a) and axial (b) T1-weighted MR images after gadolinium administration. Intra-operative images: a small suboccipital predominantly right craniotomy and initial ipsilateral posterior C1 laminectomy have been performed in a sitting position. A paramedian right dural opening is carried out starting superiorly (c). After dural opening, bone occipital drilling is then continued at higher magnification (d) as far as needed to achieve the appropriate intradural exposure of both tumor and vertebral artery (C1 posterior arch of C1; C2 spinous process of C2; * lateral dural incisions for C-shaped opening; OS occipital sinus)

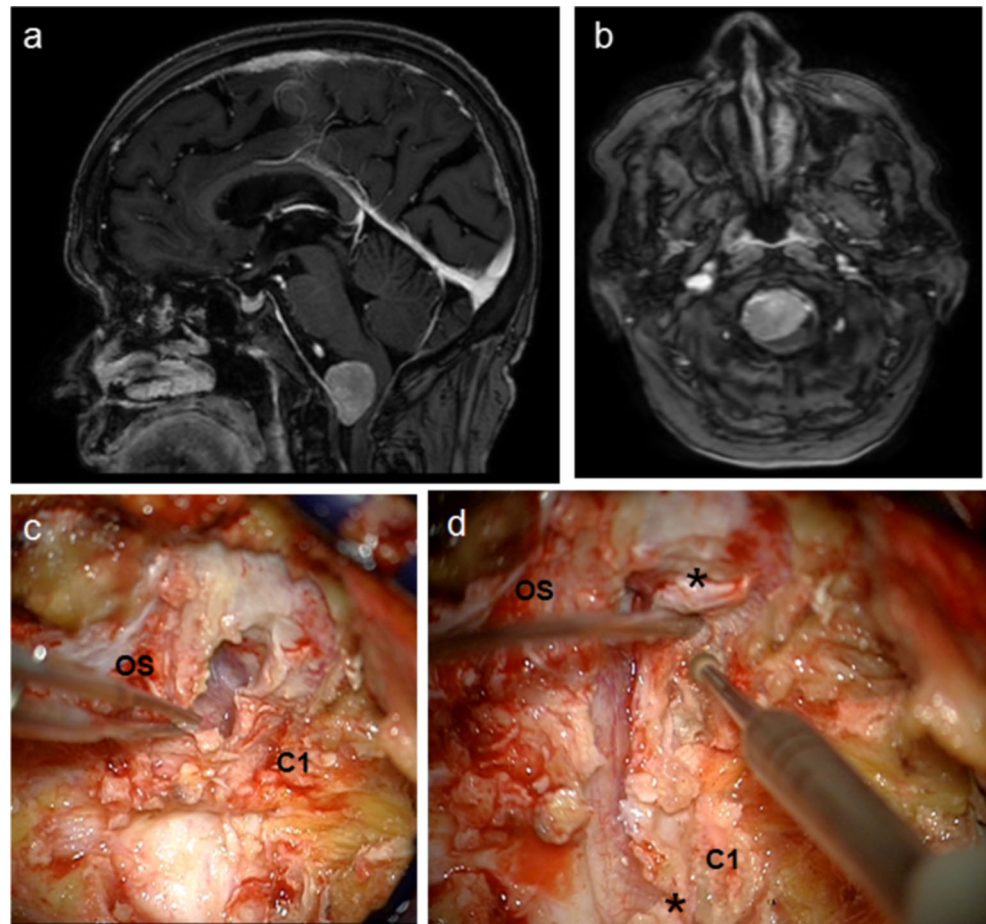
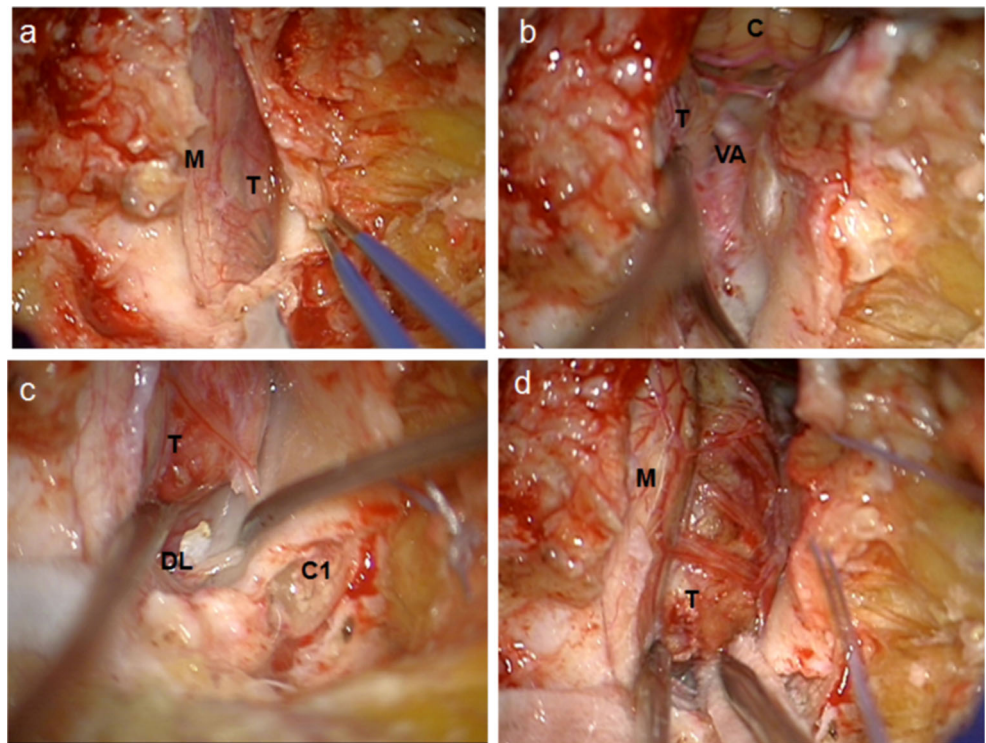


Fig. 2 Dural C-shaped opening (a) and final exposure of V4 tract of the vertebral artery just laterally to the tumor (b). Sectioning of the dentate ligament (c) and final exposure of the tumor covered by the lower cranial nerves after arachnoidal dissection (d) (*M* medulla; *T* tumor; *C* cerebellum; *VA* vertebral artery; *DL* dentate ligament after sectioning; *C1* posterior arch of C1)



adjacent tumoral dural attachment that can thus be easily coagulated and sectioned. The new deafferented clove is then removed. As the resection proceeds, the working space enlarges increasingly because the brainstem remains naturally displaced even without retractors. At the same time, the tumor can easily be pulled progressively into the working space. Proceeding more in depth, the space is larger anteriorly to the brainstem because most of the tumor has already been removed.

Indications

The posterior suboccipital approach is feasible for resection of all anterior and anterolateral FM meningiomas.

Limitations

The main limitation could be the resection of small anteriorly located tumors without brainstem dislocation. However, these tumors are generally asymptomatic and do not usually require surgical resection. In case of purely midline ventral tumors, we suggest the right side approach for right-handed surgeons; indeed, it is more comfortable for a surgeon and safer for a patient in order to avoid brainstem distraction when coagulation of meningioma dural attachment is performed. A minor limitation of this approach is pneumocephalus, which can contribute to

headaches and fatigue in the postoperative course. For this reason, a more cautious and slower mobilization of patient is needed in some cases.

How to avoid complications

Craniocervical stability is preserved through limited bone resection because the posterior suboccipital approach does not require condylar resection. According to the limited amount of bone removal, the extracranial VA cannot be damaged during C1 resection. Moreover, early intradural VA visualization makes the more lateral bone removal safer.

Posterior fossa surgery carries a higher risk of postoperative CSF leakage. To reduce this danger, watertight dural closure is mandatory and an absorbable sealing application can be helpful [1]. The bone operculum should always be repositioned when feasible [3].

The sitting position helps to create a bloodless surgical field. However, air embolism is a hazard and can be managed by stanching with hemostatic materials and careful hemostasis from the muscular layers. A lateral opening of the dura can easily avoid injury to the occipital sinus.

Prompt proximal control of the VA is essential and can be achieved by means of the C-shaped dural opening before starting tumor resection.

The lower cranial nerves are in the surgical field. Detection of singular nerves through direct electrostimulation can be helpful in larger tumors. The view from below in the sitting

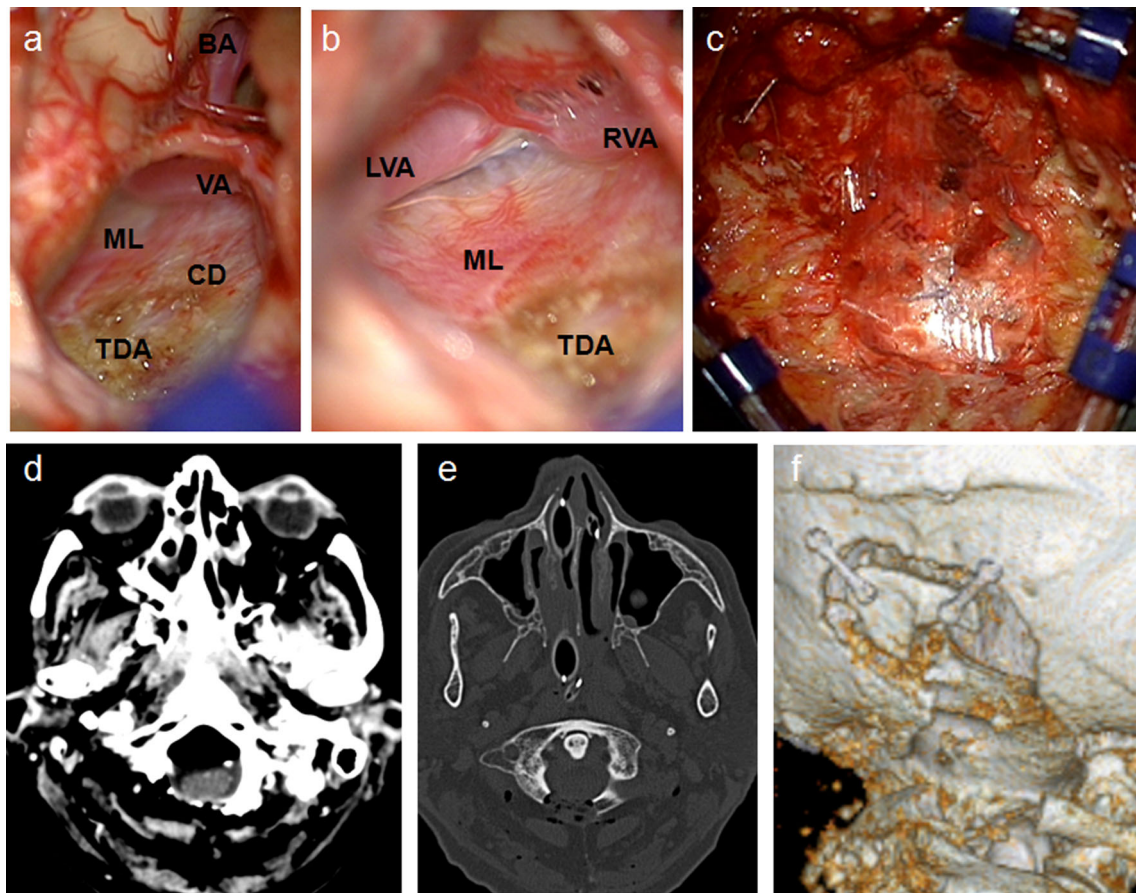


Fig. 3 “Clove” resection technique. After coagulation of the most lateral meningeoma dural attachment (a), the tumor pieces (cloves) are resected (b), providing progressively more space in order to pull the tumor in without medulla retraction (c). The tumor is pulled in staying in front of

the lower cranial nerves and then removed caudally to the cranial nerves. The “clove” resection finally achieves complete tumor removal (d) (*M* medulla; *T* tumor; *C* cerebellum; *BA* basilar artery; *CD* clival dura)

position reduces the need for lateral exposure and allows the debulked tumor to be pulled downward and away from the lower cranial nerves.

Surgical manipulation of the brainstem must be avoided. However, when manipulation is needed, as shown in the video, the early dentate ligament section is a useful maneuver to reduce distraction brainstem injury. Neurophysiologic monitoring of brainstem functions (MEPs and SSEPs) is mandatory. Indeed, the decrease of potential, usually rare in our experience, is the “warning signal”, suggesting that surgery must be immediately stopped. At the normalization of potentials, surgery can restart. In this way, the surgeon must constantly be informed on potentials status and to move according to them”

Finally, low coagulation power and continuous irrigation can reduce brainstem damage.

Specific perioperative considerations

Before surgery, if a sitting position is planned, persistence of foramen ovale must be excluded. Magnetic

resonance imaging (MRI) is mandatory to accurately assess the location of a tumor. An angio-MRI is advisable to evaluate the main artery dislocation by meningioma. After surgery, the patient is kept in the bed for 24 h in the neurointensive care unit. A brain CT scan is performed immediately after surgery to rule out any hematoma in the operative field. Postoperative care is an important stage for the prognosis of patients with FM meningiomas. Early and systematic postoperative assessment of lower cranial nerve functions is mandatory to avoid further respiratory complications, namely from disordered swallowing.

Specific information to give to patients about surgery and potential risks

Informed consent is obtained from the patient about his/her understanding of the principles, the goals, and the risks of surgery. Special consideration is given to the risk of potential lower nerves injury.

Case illustration (video and Figs. 1, 2 and 3)

A 65-year-old man presented with slowly increasing tetraparesis. Cranial MR showed a tumor mass inside the foramen magnum on the right side that was diagnosed as a meningioma. Surgery was performed in the sitting position with the assistance of neurophysiological monitoring. The early postoperative course was uneventful except for a transient disordered swallowing. The patient was discharged at 16 days after surgery. A tumor specimen was diagnosed as a benign meningioma.

Conflict of interest None.

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