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Neuroanatomical study

# Meningo-orbital band detachment: A key step for the extradural exposure of the cavernous sinus and anterior clinoid process

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ABSTRACT

The meningo-orbital band (MOB) is the most superficial dural band that tethers the fronto-temporal dura to the periorbita. It is usually encountered when performing a pterional or fronto-temporo-sphenoidal approach, and it disrupts surgical access to deeper regions.

Our objective was to perform a detailed anatomy study and a stepwise method to successfully detach the MOB using cadaveric specimens. We used six formalin-fixed, silicone-injected cadaveric heads. On each side, we performed a pterional approach plus mini-peeling of the anterior third of the middle fossa and/or extradural anterior clinoidectomy. We also applied this technique in three clinical cases to prove its safety and efficacy. The detachment of the MOB consists in four steps, 1) detachment of the temporal and frontal dura, 2) cutting of the MOB, 3) exposure and drilling of the anterior clinoid process, and 4) pealing of the lateral wall of the cavernous sinus. Using clinical cases, we explain how to adapt the technique depending on the localization of the lesion. The detachment of the MOB is the key to safely expose the cavernous sinus and the anterior clinoid process. The authors proposed a step-by-step method for the safe and effective detachment of the MOB. It is recommended, particularly to less experienced neurosurgeons that are starting with skull base surgery, and also to experts that want to expand their knowledge.
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## 1. Introduction

The meningo-orbital band (MOB) is the most superficial dural band which tethers the fronto-temporal dura with the periorbita [1]. It is usually encountered when performing a pterional or fronto-temporo-sphenoidal approach and it disrupts surgical access to deeper regions [2]. The MOB is attached to the lateral border of the superior orbital fissure (SOF); therefore, it is necessary to have an extensive knowledge of the anatomy of this region to avoid vascular or cranial nerve damage during detaching [3]. Experienced skull base neurosurgeons know this anatomical landmark very well, but it is an unfamiliar region for less experienced ones.

We have performed a detailed anatomic study and a step-by-step method to detach the MOB using cadaveric specimens. We have also applied this technique to three clinical cases to prove its safety and efficacy.

## 2. Materials and methods

Six formalin-fixed, silicone-injected cadaveric heads have been used. On each side, we have performed a pterional approach plus mini-peeling of the anterior third of the middle fossa and/or an extradural anterior clinoidectomy. All dissections have been performed in an operating room setting using standard microsurgical instruments and neurosurgical microscope.

We have also selected three clinical cases to illustrate the technique. Age, gender, images, preoperative symptoms, resection grade, and postoperative complications have been recorded and each patient has been followed up for at least two years. All patients have provided informed consent to use their images and information for research purposes. Approval from the Institutional Review Board has been obtained before data collection.

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## 3. Results

### 3.1. Anatomy structures related to the MOB

#### 3.1.1. Superior orbital fissure [2,4–8]

At the lateral level of the SOF, it can be appreciated the division between the outer and the inner layer of the lateral wall of the cavernous sinus. The inner layer, formed by the cranial nerve epineurium and surrounding connective tissue, extends into the posterior orbit. The outer layer, formed by the temporal dura (i.e., dura propria), extends into the periorbita. We have defined the MOB as the periosteal fold stretched between the periorbita and temporal dura that works as a bridge of periosteum in the lateral edge of the SOF.

The SOF can be divided into four lines: line "a", the lateral/inferior border of the medial SOF; line "b", the inferior border of the lateral SOF; line "c", the superior border of the lateral SOF; and line "d", the medial/superior border of the medial SOF. Conventionally, the MOB is located between lines "b" and "c" (Fig. 1A-B).

#### 3.1.2. Lateral wall of the cavernous sinus [3,9–12]

The lateral wall of the cavernous sinus is formed by two dural layers: a thin inner layer, the periosteal dura, containing the III, IV and V cranial nerve on their way to the SOF; and an outer layer, the meningeal dura, which is thicker with a pearly grey color. At the lower lateral edge of the cavernous sinus the two layers usually divide, with the meningeal layer and the outer part of the periosteal layer extending upward to form the lateral wall of the cavernous sinus, whereas the periosteal layer continues medially to form part of the medial sinus wall. Dissections on the lateral sinus wall reveal that the thicker outer layer (a continuation of the meningeal layer) peels away, leaving the thin inner layer (an extension of the periosteal layer) covering the nerves in the lateral wall. The two layers are only loosely attached and it is easy to recognize a cleavage plane between them.

The limits of the lateral wall of the cavernous sinus are: above, the petroclinoid dura fold; below, the superior margin of the second division of the trigeminal nerve (maxillary nerve); anterior, the SOF; and posterior, the clinoid process above and the junction of the petrous apex with the body of the sphenoid bone below. (Fig. 1C-D)

#### 3.1.3. Anterior clinoid process [2,13–17]

The ACP is a spine of bone in the posteromedial border of the lesser wing of the sphenoid bone. This bone projection bridges the roof of the cavernous sinus and overhangs the proximal portion of the intradural carotid artery. The oculomotor, trochlear, abducens, and ophthalmic divisions of the trigeminal nerve run together in a dural fold from the lateral wall of the cavernous sinus, located just below the lateral border of the ACP to the medial wall of the SOF. Among these nerves, the oculomotor is the closest one to the body and base of the ACP.

The dura mater, extending medially from the upper surface of the ACP, forms the upper dural ring, which is an upper margin of the clinoid segment of the carotid artery. The carotidoculomotor membrane is the layer of dura which lines in the lower margin of the ACP and extends medially to form the lower dural ring. This membrane separates the lower margin of the clinoid process from the oculomotor nerve and extends medially around the carotid artery. (Fig. 1E-F)

### 3.2. Surgical management of the MOB

#### 3.2.1. Surgical approach to expose the MOB

The MOB could be exposed through different skull base approaches [18]. The classical pterional or fronto-temporo-sphenoidal approach, which was first described by Yasargil [19,20] provides excellent brain exposure at the level of the anterior Sylvian fissure. However, if access to the floor of the middle fossa is necessary, the zygoma can be removed, thereby turning the pterional approach into a transzygomatic approach [21–23]. Conversely, when lesions are located farther, either medially or basally, as is the case when the hypothalamus is involved, or lesions that affect the posterior fossa, a part of the lateral orbital wall needs to be removed. Thus, it becomes an orbitozygomatic approach [6,18,24,25]. Despite the type of approach selected, the critical step is drilling the great sphenoid wing in order to allow a good exposure of the MOB (Fig. 2).

#### 3.2.2. Stepwise detachment of the MOB

1) The dura fold attached to the lateral margin of the SOF is called the MOB. It becomes thick and tough at the point it blends into the periorbita. Hence, it is necessary to make a sharp shallow cut, no deeper than 4 mm, in the lateral margin of the SOF to continue with the middle fossa peeling. Once the MOB is cut, it reveals a cleavage plane between the meningeal dura and the periosteal dura in the lateral wall of the cavernous sinus. It is essential to coagulate the MOB before cutting because the meningo orbital artery and vein pass through it. There are no cranial nerves on the most lateral border of the SOF, hence, cutting the MOB on the lateral edge does not produce any cranial nerve deficit (Fig. 3).
2) Once the MOB is cut, the next step is the detachment of the temporal dura from the bone. The temporal dura is formed by the periosteal dura and the meningeal dura. The pealing begins with a sharp dissector and it follows with a blunt dissector until a clear view of the MOB and the lateral edge of the SOF is accomplished. The frontal dura covering the lesser wing of the sphenoid bone is dissected until the MOB posed an obstacle to further exposure. (Fig. 3)
3) After the two layers of dura are peeled away, the ACP is exposed. This maneuver is essential because it facilitates further dura elevation along the lateral border of the ACP. At this point, an extradural anterior clinoidectomy could be performed to allow further access. The first step is hollowing the dense cortical bone of the ACP with the aid of a diamond burr. During this procedure, care is required to avoid damage of the optic and the oculomotor nerve. Also, it is important to remember that the carotid artery passes not only along the medial edge of the ACP, but also courses upward against, often grooving, the medial half of the lower surface of the ACP. A circumferential dissection plane is performed between the surrounding dural folds and the ACP. The final step is resecting the ACP by using fine rongeurs. The optic sheath and the distal dural ring are excised following the dura opening; this allows further access to the medial sphenoid ridge region with minimal brain retraction and decompression and mobilization of the optic nerve (Fig. 4).
4) Once the MOB has been cut, a complete peeling of the anterior third of the middle fossa could be performed safely. First, the lateral border of the temporal dura needs to be dissected so as to find the cleavage plane between the periosteal dura and the meningeal dura; with a blunt dissector, the two layers could be separated along the middle fossa. This peeling is undertaken from anterior to posterior. At the level of the lateral wall of the cavernous sinus, the outer layer of the dura is peeled back, and we can observe the lateral margin of the oculomotor, trochlear nerves and trigeminal divisions covered by thin inner periosteal layer. It is useful to identify the foramen rotundum to locate the

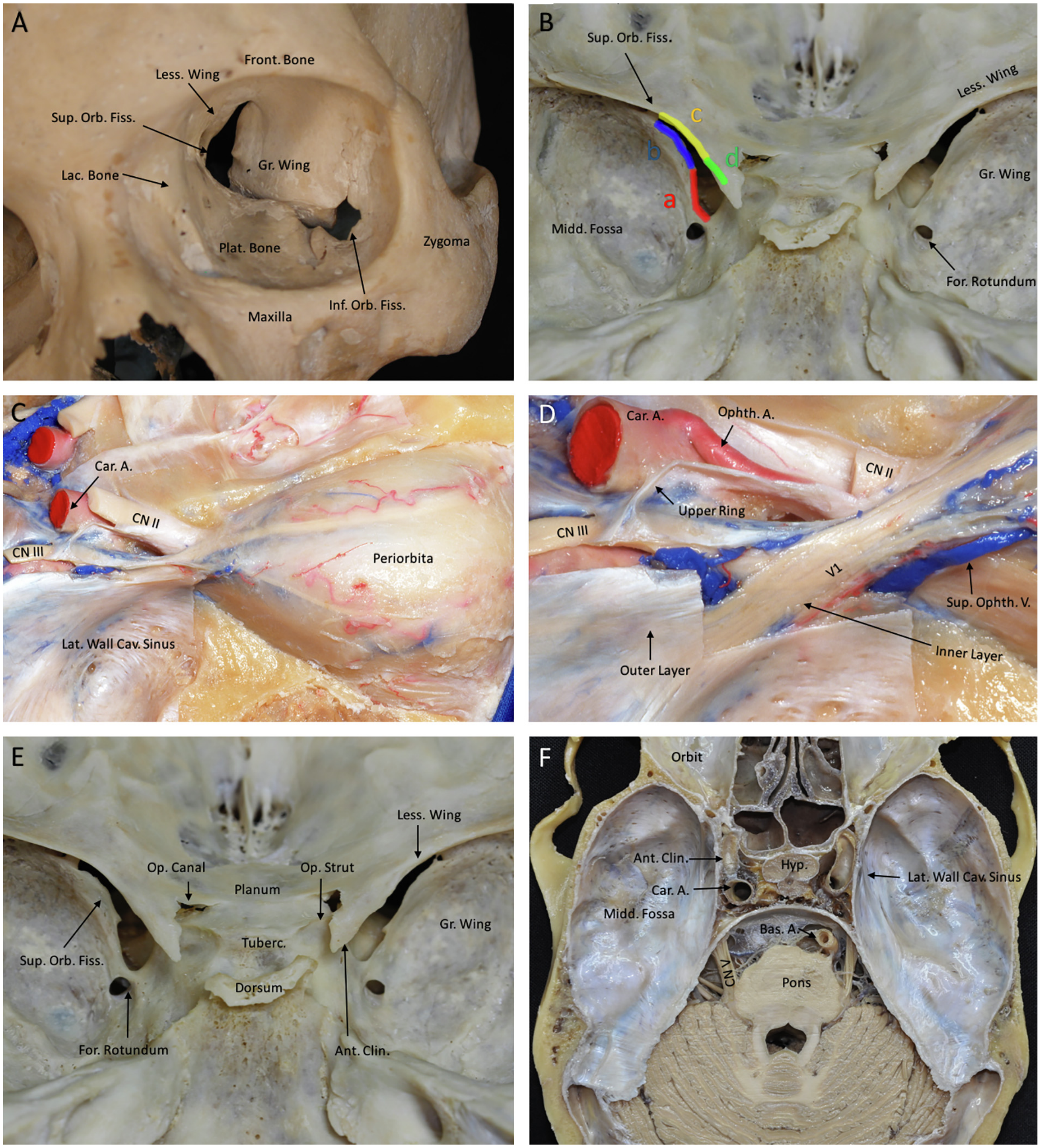


**Fig. 1.** Anatomy structures related to the meningo orbital band. A-B: Photographs illustrating the superior orbital fissure (SOF). C-D: Photographs illustrating the lateral wall of the cavernous sinus. E-F: Photographs illustrating the anterior clinoid process (ACP). A: Anterior view of the left orbit. The SOF is bounded above by the lesser wing of the sphenoid bone, below by the greater wing, and medially by the sphenoid body. The frontal bone forms the narrow lateral apex of the superior orbital fissure. B: Superior view of the anterior and middle fossa. The SOF is divided by four lines: line "a", the lateral/inferior border of the medial SOF; line "b", the inferior border of the lateral SOF; line "c", the superior border of the lateral SOF; and line "d", the medial/superior border of the medial SOF. Conventionally, the meningo orbital band is located between lines "b" and "c". C: Lateral view showing the cavernous sinus. The oculomotor nerve penetrates the roof of the cavernous sinus. The carotid artery and the ophthalmic nerve cross superiorly to the oculomotor nerve. The nerves coursing in the lateral wall of the cavernous sinus are barely visible through the dura. D: Lateral view of the outer layer of the lateral wall of the cavernous sinus back to the level of proximal part of the V. The inner layer of dura in which the nerves course in the anterior part of the lateral wall has been preserved. The dura covering the upper surface of the ACP extends medially to form the upper dural ring. V1 as well as the oculomotor nerve can be observed through the semitransparent inner layer of the lateral wall. E: Superior view of the anterior and middle fossa. The ACP is connected anteriorly to lesser wing, medially to the optic canal, inferiorly to the optic strut and laterally to the SOF. F: Superior view of the anterior, middle fossa and posterior fossa. The left ACP is resected to show the relationship between the carotid artery and the lateral wall of the cavernous sinus. *A., Artery; Ant., Anterior; Bas., Basilar; Car., Carotid; Clin., Clinoid; CN., Cranial Nerve; Fiss., Fissure; For., Foramen; Front., Frontal; Gr., Greater; Hyp., Hypophysis; Inf., Inferior; Lac., Lacrimal; Less., Lesser; Midd., Middle; Ophth., Ophthalmic; Op., Optic; Orb., Orbital; Plat., Platine; Sup., Superior; V., Vein.*

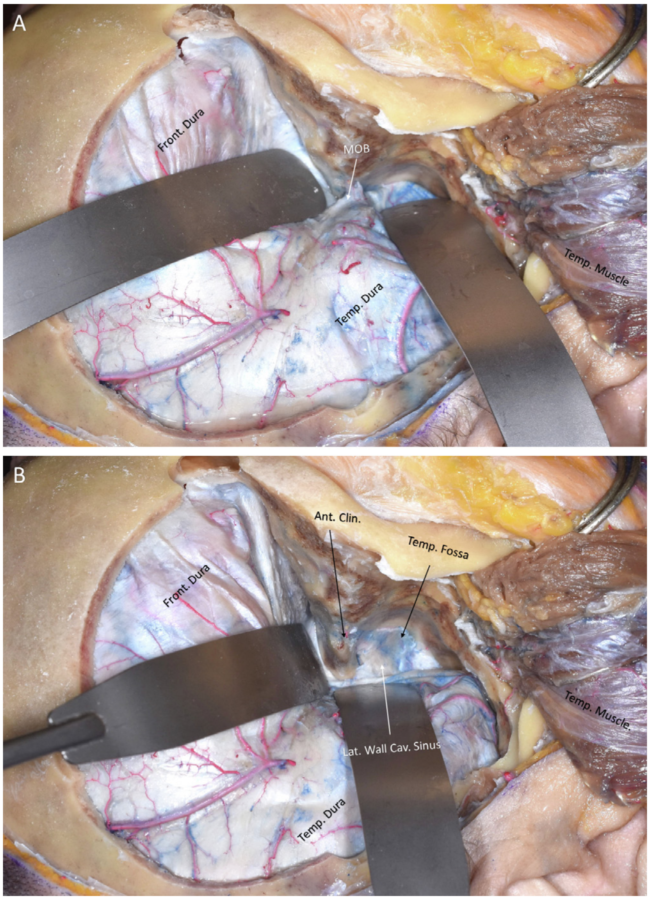


**Fig. 2.** Transzygomatic approach to expose the meningo orbital band (MOB). A: The MOB is exposed after drilling the great sphenoid wing. The MOB tethers the fronto-temporal basal dura to the periorbita, and it disrupts surgical access to the anterior clinoid process and temporal fossa. B: After the MOB is cut, a clear access to deeper regions is achieved like the temporal fossa, lateral wall of the cavernous sinus and anterior clinoid process. *Ant., Anterior; Cav., Cavernous; Clin., Clinoid; Front., Frontal; Lat., Lateral; Temp., Temporal.*

inferior edge of the SOF. If access to Meckel's cave is necessary, the inner dura between the branches of the trigeminal nerve could be cut to allow deeper access (Fig. 5).

### 3.3. Illustrative cases

#### 3.3.1. Case 1 (Fig. 6)

A 43-year-old woman presented with mild right vision loss and headaches. She had been diagnosed with a Neurofibromatosis type 1 and had needed prior surgery for a pterional meningioma. A magnetic resonance (MR) with gadolinium showed two enhancing parasellar lesions in intimate contact with the carotid arteries and the optic nerves. We performed a right pterional approach with MOB detachment. The temporal and frontal lobes were retracted, and the ACP was resected, allowing visualization of the parasellar and suprasellar regions. Both tumors were resected by this approach. The histopathological study informed meningothelial meningioma. Post-operative MR showed complete tumor excision. The patient regained complete normal vision after surgery and her headache improved.

#### 3.3.2. Case 2 (Fig. 7)

A 32-year-old man presented with headache and symptoms of trigeminal neuralgia. A MR with gadolinium had shown an enhancing posterior and middle fossa lesion extending over the Meckel's cave. First, we performed a retrosigmoid approach to excise the posterior fossa lesion. The histopathological study informed clear-cell meningioma. We made a second transzygomatic approach to access the residual lesion located over the Meckel's cave. Once we had retracted the fronto-temporal dura, we incised and detached the MOB. We found the cleavage plane between the periosteal dura and the meningeal dura and we peeled off the lateral wall of the cavernous sinus. We had to cut the inner dura between the branches of the V cranial nerve with microscissors to expose the tumor located in Meckel's cave. The postoperative MR showed complete tumor resection. The symptoms have been completely relieved and the patient presented no complications after surgery.

#### 3.3.3. Case 3 (Fig. 8)

A 58-year-old woman presented with left blindness. An MR had shown an enhancing anterior and middle skull base tumor with orbital compression. The lesion was located in the tuberculum sellae, ACP, cavernous sinus, optic canal and orbital cavity. We performed a left transzygomatic approach plus a mini-peeling of the temporal fossa. Once retracting the fronto-temporal dura, the MOB emerged in the lateral border of the SOF. After careful coagulation we cut the MOB allowing further exposure of ACP. With a blunt dissector, the surroundings dura folds of the ACP were peeled off and an anterior extradural clinoidectomy was performed, allowing further resection of the middle inferior part of the lesion. As the ACP had been removed, we resected the tumor in the intercarotid and interoptic spaces achieving an adequate excision of the lesion. The histopathological study informed meningothelial meningioma. The control MR with gadolinium showed almost complete tumor excision. Left blindness improved after surgery, allowing the patient partial vision with her left eye.

## 4. Discussion

The lateral wall of the cavernous sinus, the ACP and the SOF are challenging structures for a novel neurosurgeon who starts exploring skull base surgery. We believe that total exposure of these structures gives neurosurgeons control during surgery and reduces complications. The MOB is the dural fold attached to the lateral border of the SOF and contains the meningo orbital artery and vein. It is responsible for tethering the fronto-temporal dura to the periorbita, and it disrupts surgical access to deeper regions [12,26].

Previous articles [13,15] described the extradural anterior clinoidectomy and mentioned the MOB as part of the procedure, but not as a separate entity. Dolenc et al. [13] explained the extradural anterior clinoidectomy without detachment of the MOB, but recent reports comparing both techniques [7,17] highlight the benefits of the detachment of the MOB in the bone exposure. The ACP is surrounded by vital nerves and vascular structures [2]; thus, the detachment of the MOB allows safer dissection and exposure of the ACP, with complete control of the adjacent structures during hollowing of the dense cortical bone [15].

Fukuda et al. [5] and Cherian et al. [1] have also presented a stepwise detachment of the MOB; unlike us, they have recommended dissection and partial removal of the lateral wall of the SOF. We believe that this step is unnecessary and increases the risk of cranial nerve lesion. As long as a 4 mm depth cut is made in the MOB and then a blunt dissector is used for further detachment, the structures inside the periosteal dura will be safe from lesions. We consider that the first step in the detachment should be cutting the MOB because extensive dissection in the temporal fossa without proper vision of the surrounding structures could end up in nerve or vascular damage.

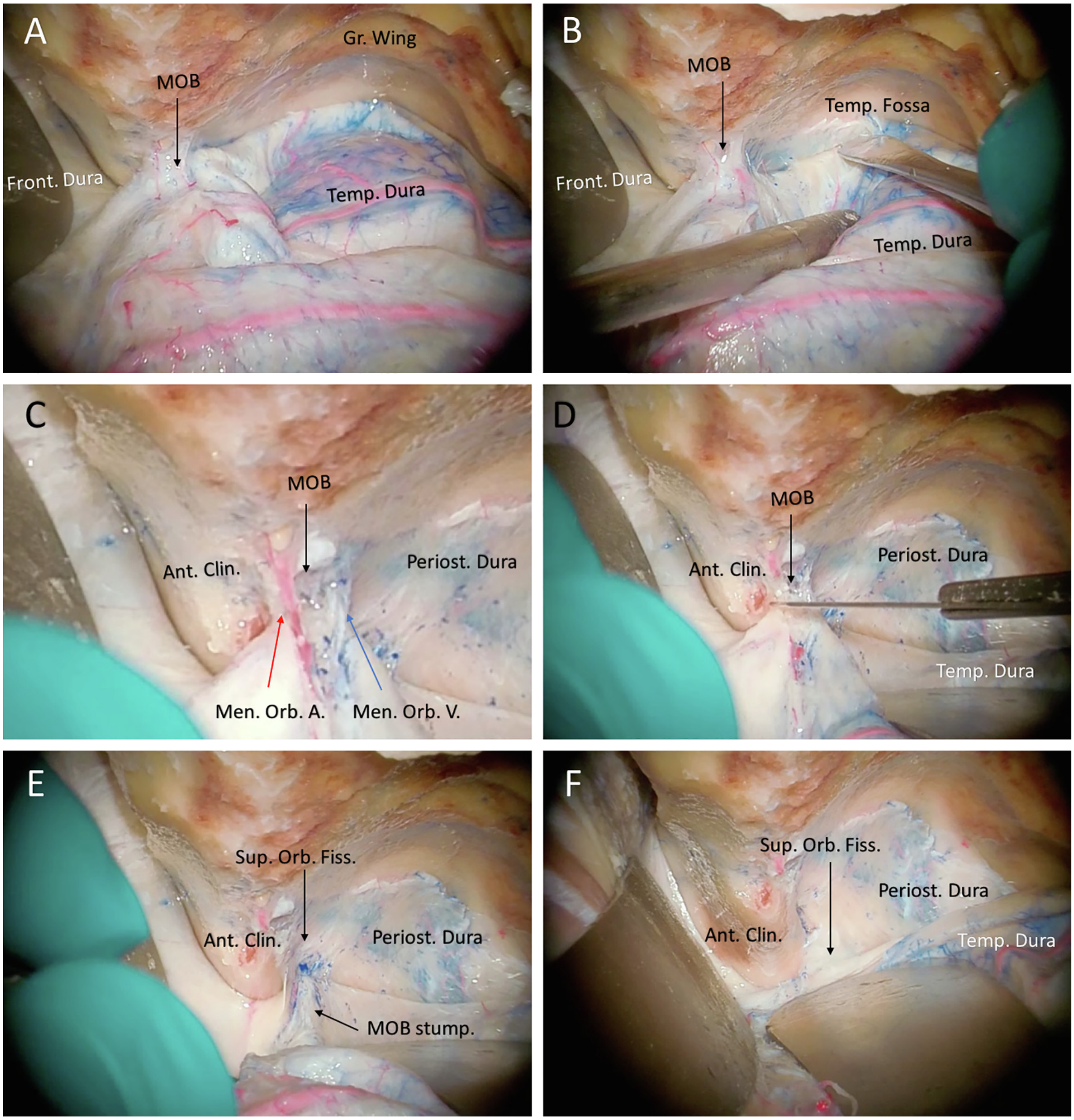


**Fig. 3.** Right transzygomatic approach and stepwise detachment of the meningo orbital band (MOB). A: The great sphenoid wing is drilled, and the frontal lobe is retracted so the MOB could be exposed. B: Detachment of the temporal dura from the periosteal dura with a blunt dissector. C: The temporal and frontal dura are dissected so the MOB is exposed. The meningo orbital artery and vein pass through the MOB. D: Sharp 4 mm depth cut in the lateral side of the MOB. E: Once the MOB is cut, it reveals a cleavage plane between the temporal dura and the periosteal dura. F: Without the MOB, the temporal lobe could be retracted, and deeper structures appears, like the superior orbital fissure and the anterior clinoid process. *A., Artery; Ant., Anterior; Clinoid; Fiss., Fissure; Front., Frontal; Men., Meningo; Orb., Orbital; Periost., Periosteal; Temp., Temporal; V., Vein.*

The authors believe that the MOB is the key to enter both the anterior and middle fossa safely. For lesions located in the suprasellar region, the detachment of the MOB allows a safe extradural anterior clinoidectomy without unnecessary exposure of the lateral wall of the cavernous sinus, as shown in case one. At the same time, if the lesion is located in the temporal fossa or the cavernous sinus, complete peeling of the lateral wall of the cavernous sinus could be performed without unnecessary drilling of the ACP, as shown in case two. But if the lesion is located both in the sellar region, ACP and cavernous sinus, we need to use the complete stepwise method described by the authors to allow an extradural anterior clinoidectomy and total peeling of the lateral wall of the cavernous sinus, as shown in case three.

The authors reported a step-by-step method to carefully detach the MOB so less experienced neurosurgeons could read the article and find everything they need to know about the MOB, from the basic anatomy, approaches and stepwise detachment. We have also applied this method to clinical cases, achieving total exposure of vital structures and safe and complete resection of the lesions.

## 5. Conclusions

The detachment of the MOB is the key to safely expose the cavernous sinus and the anterior clinoid process. The authors have proposed a step-by-step method for a safe and effective detachment of the MOB, adapting the technique to suit different pur-

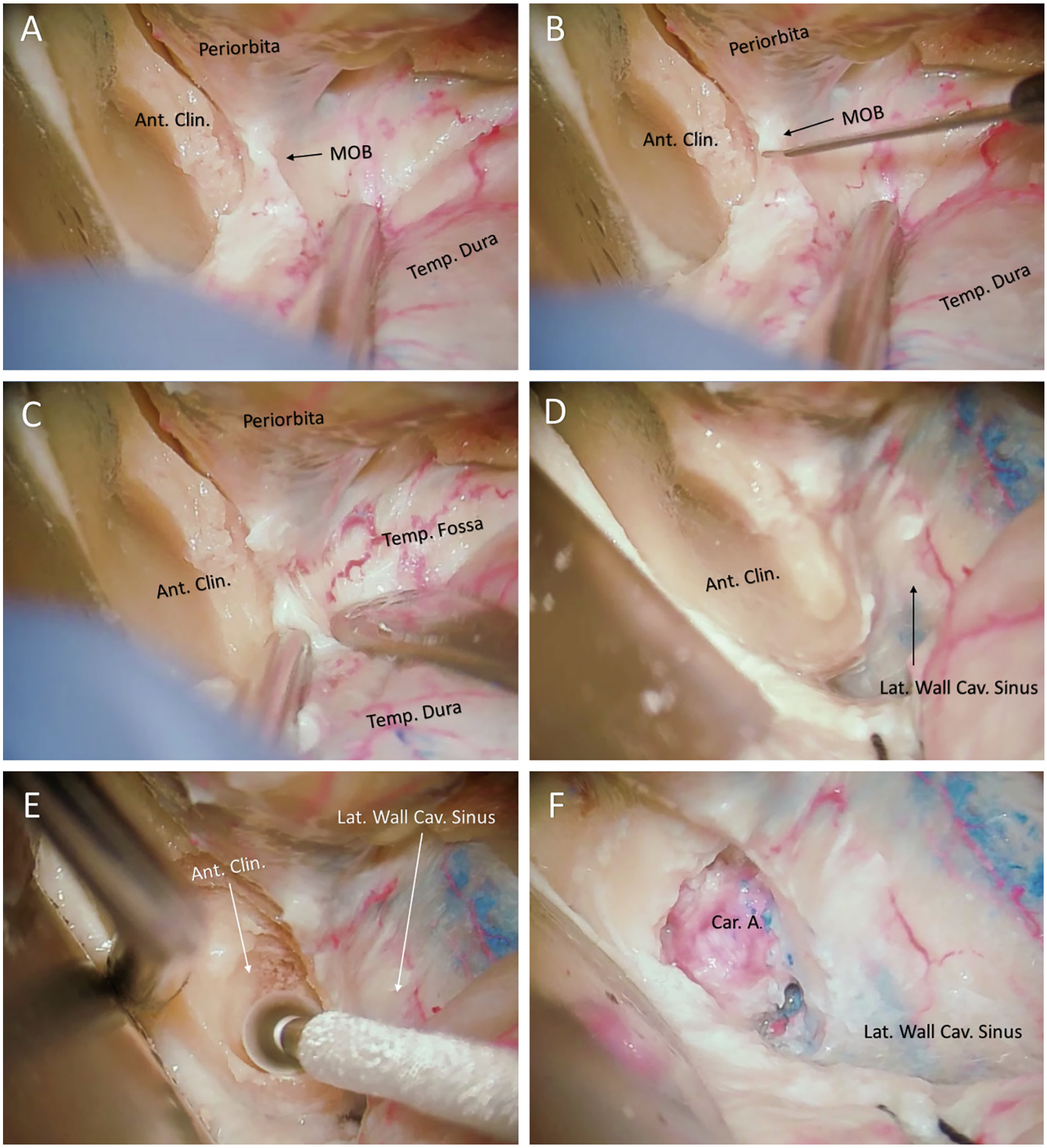


**Fig. 4.** Right pterional approach. Meningo orbital band (MOB) detachment and drilling of the anterior clinoid process (ACP). A: Lateral view of the MOB attached to the periorbita. The temporal dura is retracted, and the ACP is covered by the MOB. B: Cutting of the MOB. C: The lateral border of the ACP is separated from the MOB with a blunt dissector. D: The ACP is exposed and part of the lateral wall of the cavernous sinus. E: Once the temporal lobe is retracted, hollowing out the dense cortical bone of the ACP could be done. F: After resection of the ACP further access to the carotid region is achieved with minimal brain retraction. *Ant., Anterior; Car., Carotid; Cav., Cavernous; Clin., Clinoid; Lat., Lateral; Temp., Temporal.*

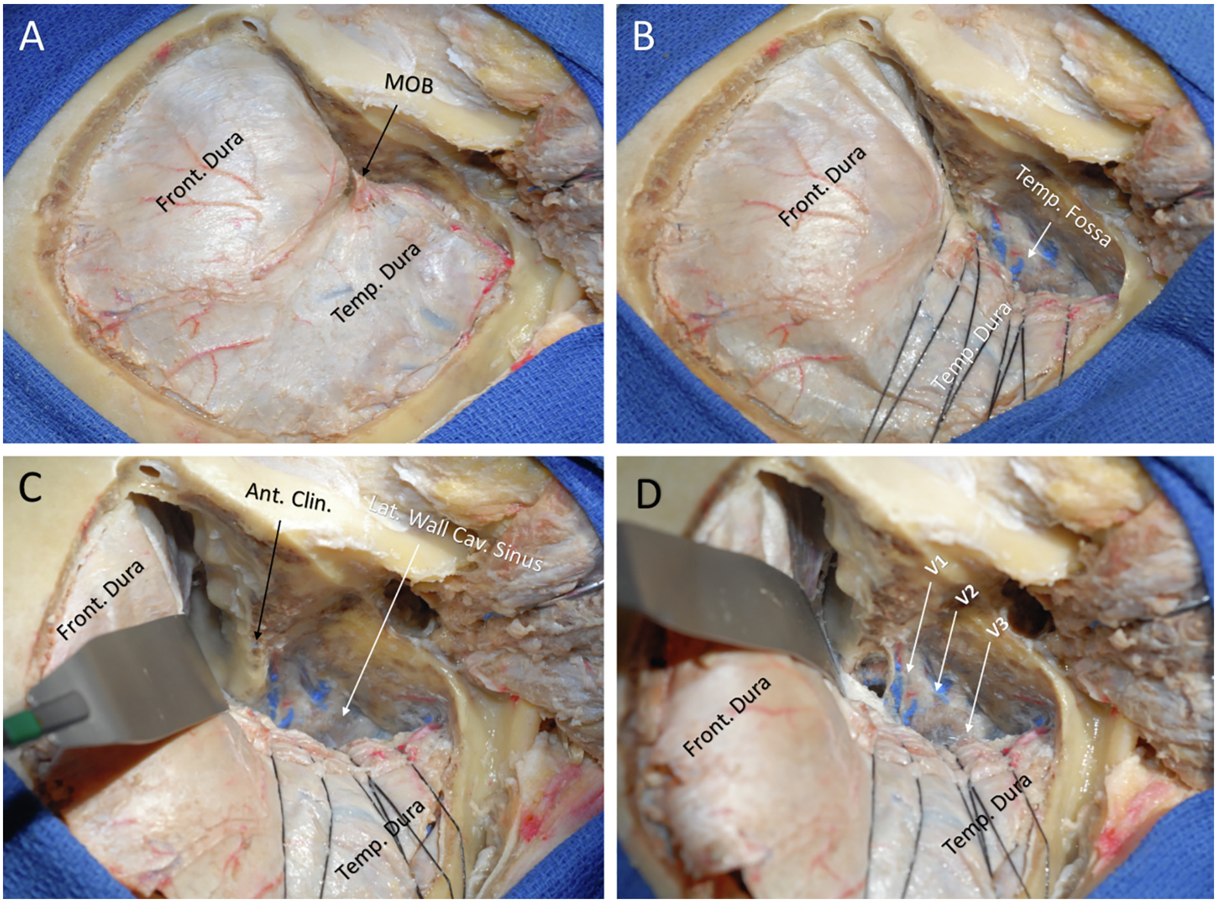


**Fig. 5.** Right transzygomatic approach, meningo orbital band (MOB) detachment and peeling of the lateral wall of the cavernous sinus. A: Lateral view of the MOB, the temporal and frontal dura. B: The MOB is cut, and the temporal dura is dissected from the periosteal dura allowing access to the temporal fossa. C: The frontal and temporal lobes are retracted and the outer layer of the lateral wall of the cavernous sinus is visualized. D: The outer layer of the dura is peeled off and the branches of the V cranial nerve are visualized covered by the inner layer of the dura. *Ant., Anterior; Cav., Cavernous; Clin., Clinoid; Front., Frontal; Lat., Lateral; Temp., Temporal.*

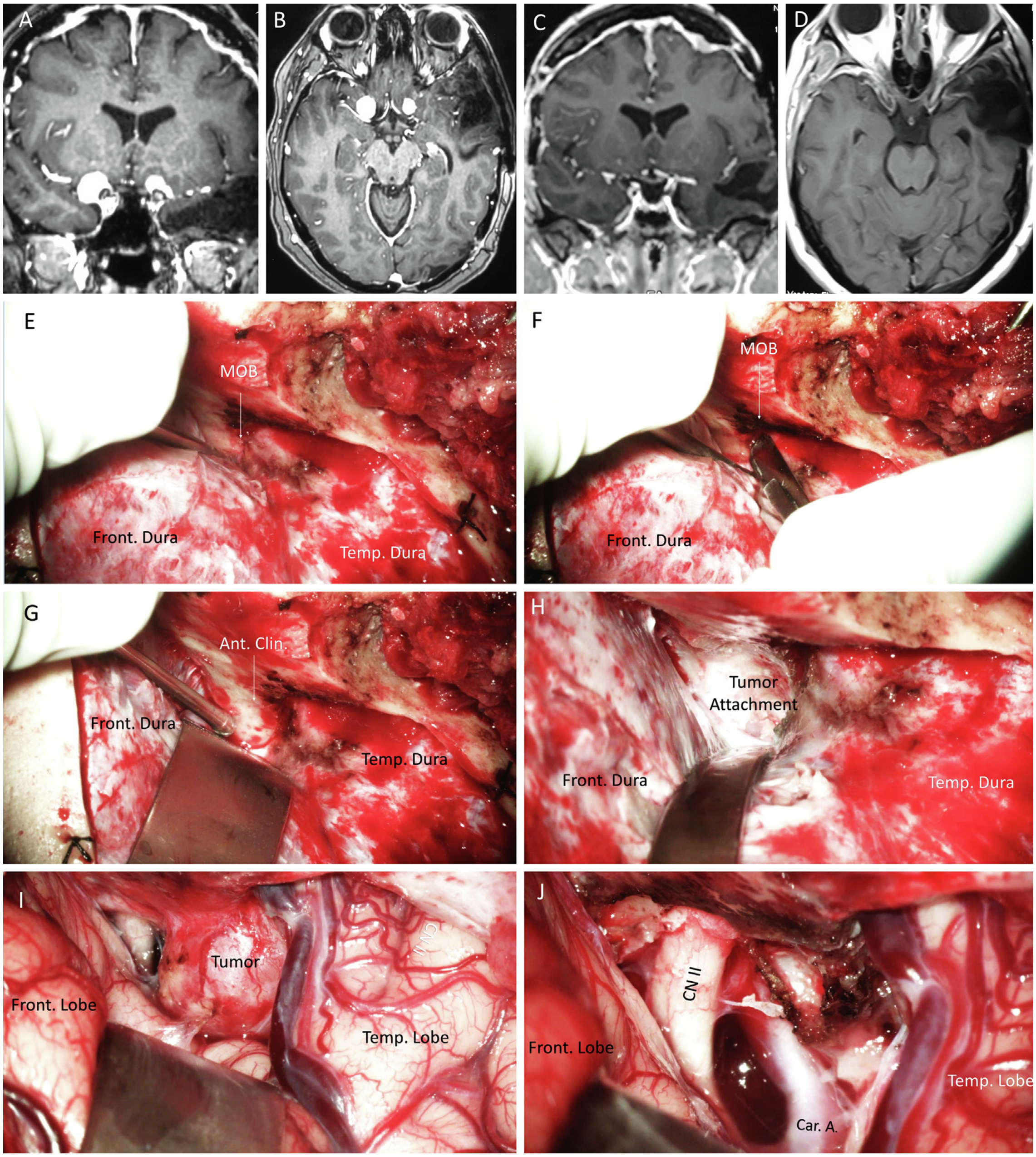


**Fig. 6.** Case one. A-B: Preoperative magnetic resonance (MR) T1 coronal and axial sequences showing bilateral enhancing parasellar lesions. C-D: Postoperative MR T1 coronal and axial sequence showing complete excision of both lesions. E: Right pterional approach with exposure of the meningo orbital band (MOB). F: Cutting of the MOB to allow access to deeper regions. G: Exposure of the anterior clinoid process (ACP). H: The ACP was resected and the parasellar region is exposed. I: The tumor surrounding the carotid artery is exposed. J: Complete tumor excision and visualization of the II cranial nerve and the carotid artery. *Ant., Anterior; Clin., Clinoid; CN., Cranial nerve; Front., Frontal; Temp., Temporal.*

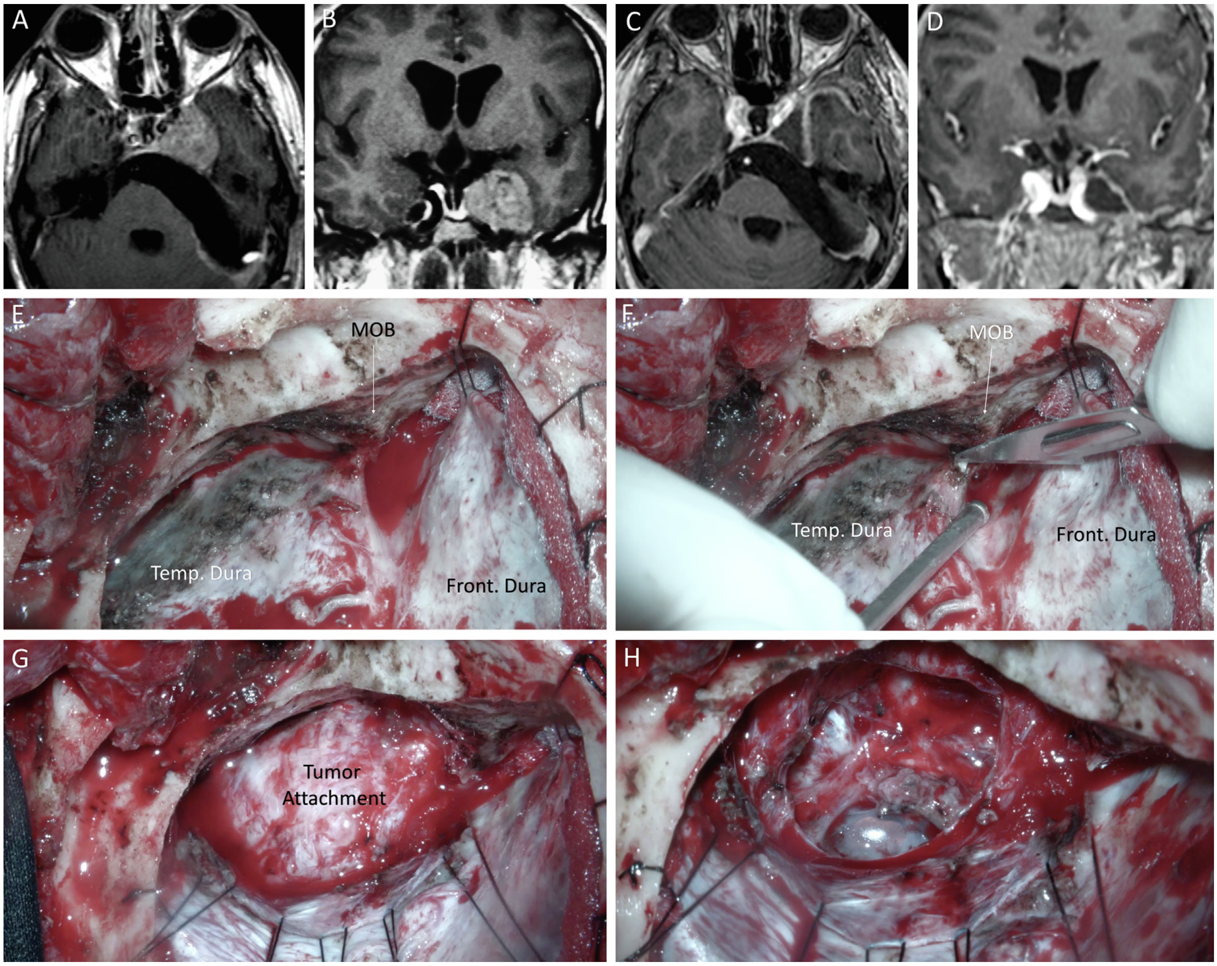


**Fig. 7.** Case two. A-B: Preoperative magnetic resonance (MR) T1 axial and coronal sequences showing an enhancing posterior and middle fossa lesion extending over the Meckel's cave. C-D: Postoperative MR T1 sequence showing complete excision of both lesions. E: Left transzygomatic approach showing the meningo orbital band (MOB) tethering the frontal and temporal dura. F: Cutting of the MOB with a sharp knife. G: Complete exposure of the lateral wall of the cavernous sinus after peeling the temporal dura from the periosteal dura. The inner layer of the lateral wall of the cavernous sinus is preserved. H: After cutting the inner layer of the cavernous sinus between the branches of the V cranial nerve, the tumor was resected. The image shows the complete excision of the lesion. *Cav., Cavernous; Front., Frontal; Lat., Lateral; Temp., Temporal.*

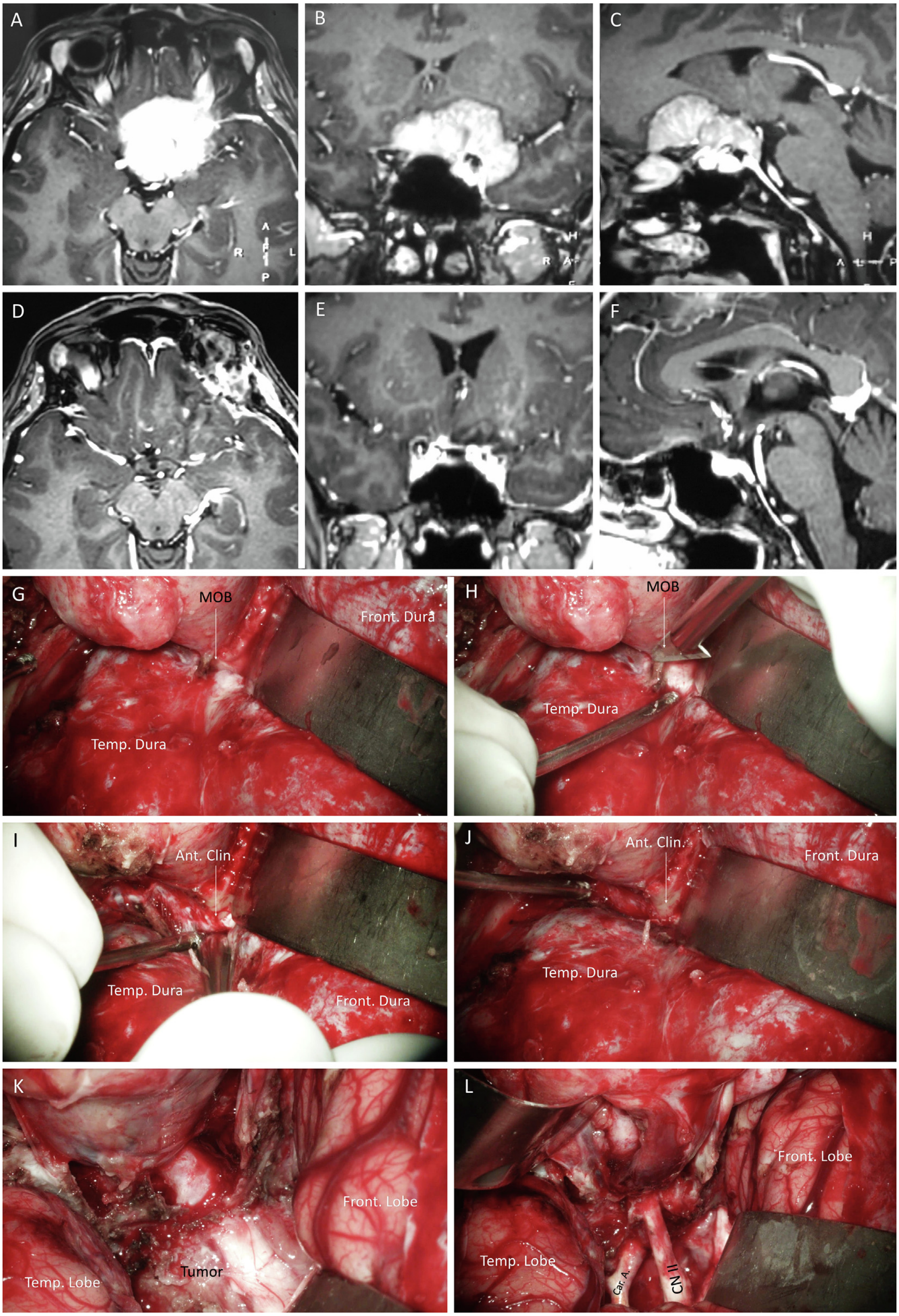


**Fig. 8.** Case three. A–C: Preoperative magnetic resonance (MR) T1 axial, coronal and sagittal sequences showing an enhancing anterior and middle skull base tumor with orbital compression. D–F: Postoperative MR T1 sequence showing almost complete tumor excision. G: Left orbitozygomatic approach showing the meningo orbital band (MOB) disrupting access to deeper regions. H: Cutting off the MOB with sharp knife wile retracting the frontal lobe. I: Circumferential dissection plane between the surrounding dural folds and the anterior clinoid process (ACP). J: The ACP is exposed, and the temporal dura is retracted to allow visualization of the lateral wall of the cavernous sinus. K: The ACP is removed, and the lesion is exposed. L: Complete resection of the lesion and exposure of the II cranial nerve and the carotid artery. *A., Artery; Ant., Anterior; Car., Carotid; Clin., Clinoid; CN., Cranial nerve; Front., Frontal; Temp., Temporal.*

poses. It is recommended, particularly to less experienced neurosurgeons who are starting with skull base surgery, and also to experts who choose to expand their knowledge.

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Conflict of interest

None.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jocn.2020.09.055.

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