Acta Neurochirurgica (2019) 161:2577–2582
https://doi.org/10.1007/s00701-019-04064-3

HOW I DO IT - BRAIN TUMORS

The extradural minipterional pretemporal approach for the treatment of spheno-petro-clival meningiomas

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Received: 5 June 2019 / Accepted: 9 September 2019 / Published online: 17 October 2019

Abstract

Background Cavernous sinus and petroclival region is an anatomically complex region in close relationship with important neurovascular structures. As such, the surgical treatment of spheno-petro-clival (SPC) meningiomas represents an operative challenge, in which several routes and its combinations might be used.

Methods We describe in detail the surgical technique of the extradural minipterional pretemporal approach (eMPT-P) to the SPC region and highlight the main anatomical key elements involved in this approach as well as the technical aspects for avoiding surgical complications.

Conclusion The eMPT-P is a versatile approach that uses the extradural route, and thereby reduces brain retraction, while provides a good angle of exposure of the SPC region.

Keywords Skull base · Petroclival · Extradural · Clinoidectomy · Peeling · Minipterional · Pterional

Abbreviations

SPC	Spheno-petro-clival
eMPT-P	Extradural minipterional pretemporal approach
MOB	Meningo-orbital band
SOF	Superior orbital fissure
ACP	Anterior clinoidal process
(ICA	Internal carotid artery

The article is original, has not been submitted for publication in other journals, and has not yet been published either wholly or in part.

This article is part of the Topical Collection on *Brain Tumors*

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00701-019-04064-3) contains supplementary material, which is available to authorized users.

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Relevant surgical anatomy

Anatomically, the authors would like to highlight two aspects. First, the intracranial dura consists of two layers: the periosteal dura and dura propria [4]. At the fissure, the periosteal dura folds back along the bone, exits the fissure, and continues to extracranial periosteum, whereas the dura propia remains intracranial covering the brain surface. Thereby, there exists a virtual space between two folds that might be used as a cleavage plane by incising the periosteal dura at the level of the meningo-orbital band (MOB) at the lateral margin of the superior orbital fissure (SOF) [2] (Fig. 1). Second, at the lateral surface of the cavernous sinus, epineurums of the oculomotor, trochlear, and ophthalmic (V1) nerves fuse to compose the inner cavernous membrane [8] (Fig. 2).

Description of the technique (video)

Positioning, skin incision (Fig. 3) and craniotomy (Fig. 4).

The position of the patient and fixation of the head are the same as those used in the standard pterional approach [9]. The head rotation might be modified from its original position during some parts of the procedure, by changing the orientation of the rotating bed if needed. An interfascial dissection of the temporal muscle followed by a standard minipterional

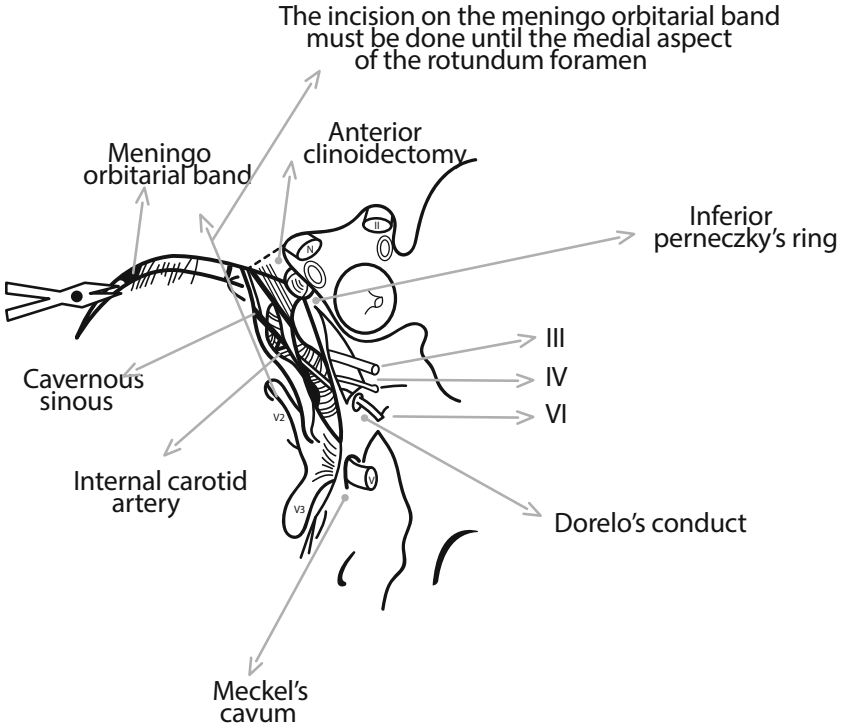

Fig. 1 Peeling of the temporal fossa. Schematic drawing of membranous structures related to the foramen and the superior orbital fissure. By incising the tethered intracranial periosteum properly, the dura propria can be peeled off the epineurium layer of the cranial nerve

craniotomy, as described by Figueireido et al. [1], is performed.

Extradural work

The lateral sphenoid wing is drilled to achieve complete bony decompression of the lateral orbit and SOF. The MOB is cut and the periosteal dura is incised over the lateral membrane of the cavernous sinus. At this point, the temporal tip is retracted and the two dural layers (periosteal and dura) are separated from medial to lateral in the direction of the trigeminal nerve. The anterior clinoidal process (ACP) is exposed and removed after decompressing the optic canal using Rongeurs [5]. Thereafter, anterior petrosectomy within the Kawase

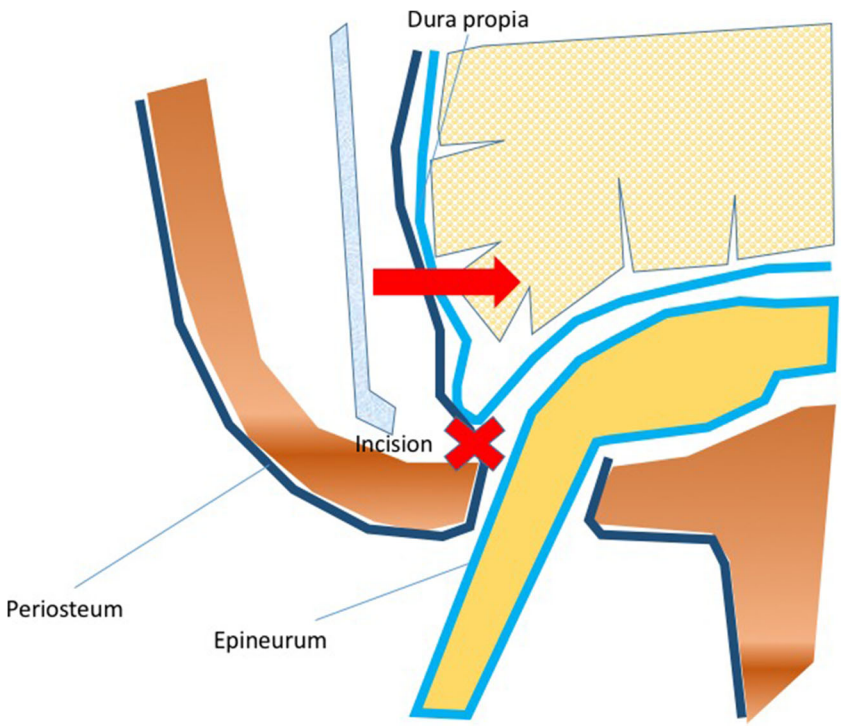

Fig. 2 Drawing representing the structures imbedded in the cavernous sinus. The lateral wall of the cavernous sinus consists of two layers. The superficial one is the dura propia that covers the temporal lobe and the deep one is formed by the fusion of the epineurum of the oculomotor, throclear, and three branches of the trigeminal nerve. The sixth cranial nerve enters the cavernous sinus trough the Dorello's canal and runs within the cavernous sinus in its inferolateral marging, beneath the ophthalmic branch of the trigeminal nerve (V1)

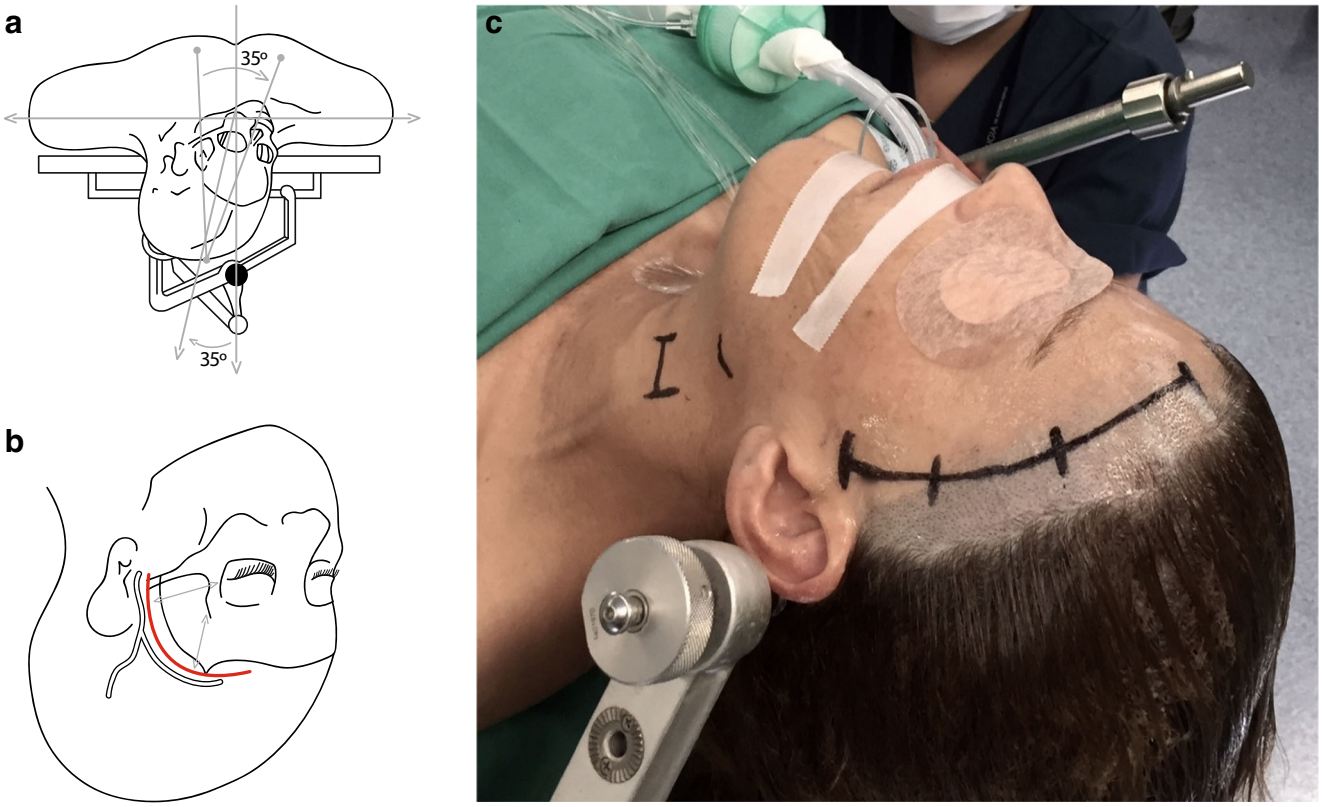

Fig. 3 **a** Positioning: the patient is positioned supine, with the head slightly posteriorly tilted and laterally rotated 30 degrees. The head rotation might be modified from its original position during some parts of the procedure, by changing the orientation of the rotating bed if needed (e.g., a more lateral inclination is needed during partial orbitotomy or anterior clinoidectomy) **b** and **c** An arcuate scalp incision is started 1 cm above the base of the zygomatic arch. It is extended superiorly 1 cm behind the hairline and curved gradually toward the ipsilateral midpupillary line

rhomboid is carried out carefully after ascertain the location of the internal carotid artery (ICA) [6].

Dural incision and tumor removal

The dura is incised in a direction that runs parallel to the longitudinal axis of the ACP. The optic sheath and the first dural ring of the ICA are opened first. Sufficient mobilization of the optic nerve medially and cranially allows the removal of the superior part of the tumor and decompress the optic apparatus. Thereafter, the lateral wall of the cavernous sinus is opened at the anteromedial triangle, and then the incision is followed posteriorly over the third cranial nerve, detaching the epineurum of the oculomotor nerve from the tumor fibers that are encasing the nerve. In a similar manner, a third dural incision is performed over the fourth cranial nerve, releasing at the same time some pressure over the nerve fibers. This cut is followed posteriorly until the tentorium is reached and a small cut is performed at the anterior incisura, providing wider access to the posterior fossa. Dura propia covering, the trigeminal ganglia is incised and the Meckel's cave is opened, allowing the trigeminal nerve to be mobilized and the tumor mass can be excised without much neural tissue retraction.

It is important to remark exposing the cranial nerves along the lateral wall of the cavernous sinus is to decompress these nerves and achieve tumor volume reduction. Any further violation of the cavernous sinus should be avoided, as long as the target is the meningioma.

Closure

Finally, the optic strut is plugged using a small strip of temporal muscle sealed with fibrin glue. The dura is closed in a water tight fashion. Temporal muscle fascia or fascia lata is sutured to periorbital and bone in one side and to the dura in the other. Plugging the dural and bony defects with some material is eventually required. Tack-up sutures of the dura are performed around the bone flap, which is fixed by shallow titanium microplates.

Indications

- Complex petroclival tumors (meningiomas, chondromas, and chondrosarcomas).
- Giant dumbbell-shaped trigeminal tumors.
- Giant complex infra- and supratentorial epidermoid cysts.

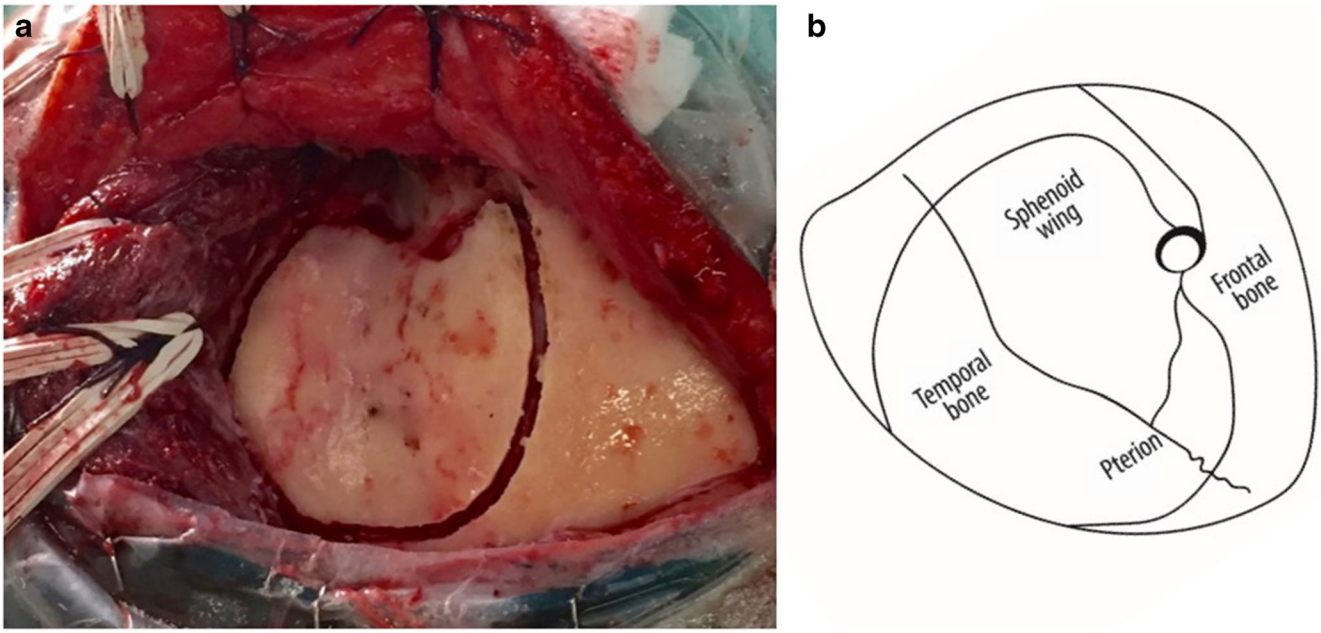

Fig. 4 Surgical image (**a**) and drawing (**b**) showing the minipterional craniotomy. A burr hole is placed anterior to the pterion and beneath the superior temporal line. Craniotomy then is performed mildly superiorly and posteriorly following a line just underneath the superior temporal line. When the craneotome reaches the height of the coronal suture, the osteotomy is smoothly turned down toward the temporal bone. At the lowest part of the temporal bone, the osteotomy is directed anteriorly to connect with the initial burr hole

Limitations

There are some relative contraindications to this technique, such as for those cases in which there is a dominant anterograde drainage of the Sylvian vein into the sphenoparietal sinus, as its interruption might derive in a limited temporal lobe venous infarct. We should highlight that this finding is very unusual in sphenopetroclival meningiomas, since as the tumor grows over time, it acts remodeling the venous drainage pattern into more low-resistance vessels. Limitations to this approach are found in cases where there are large-volume extensions of the tumor into the posterior fossa, specially below the internal acoustic meatus or passing the midline of the clivus.

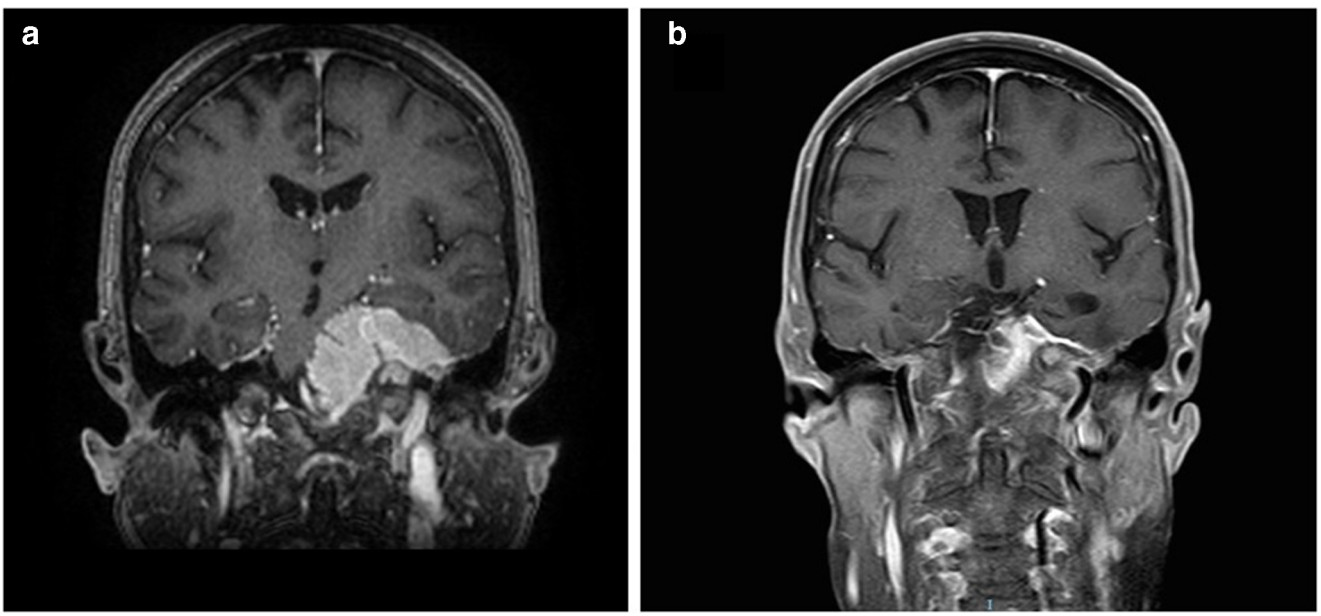

Fig. 5 Coronal contrast-enhanced T1-weighted MR images demonstrating preoperative tumor burden (left) and postoperative intracavernous residual (right) after *extradural minipterional pretemporal approach* for subtotal resection and cavernous sinus decompression

How to avoid complications

1) Intraoperative indocyanine and Doppler ultrasound is recommended to ascertain the distance to the intracavernous ICA;
2) Intraoperative electromyography is helpful to guide cranial nerves decompression whenever they are imbedded within the tumor and cavernous sinus wall, in order to avoid inadvertent injuries during this maneuver;
3) We usually seal the optic strut with a 5-mm muscle free flap to avoid CSF leaks;
4) Cavernous sinus hemostasia is achieved with saline irrigation or fibrin flue (beriplast ©) if needed, avoiding oxidized cellulose (Surgicel ©) as it might compress cranial nerves within the cavernous sinus when the cellulose oxidizes and bloats in contact with blood.

Specific perioperative considerations

Preoperative MR venogram, CT venogram, or cerebral angiogram study should be performed to assess the drainage pattern of the Sylvian vein into the sphenoparietal sinus, as it is discussed earlier. A neuronavigation system is employed with multi-slice MR images. A lumbar drain was often placed prior to incision to allow adequate drainage of CSF during the case and it is removed immediately after the procedure. A postoperative control CT is performed within 48 h after surgery and an MRI with contrast at 3, 6, and 12 months, and then yearly.

Specific information to give to the patient about surgery and potential risks

The patient has to give his written consent to the open craniotomy and tumor removal procedures. He also must know that the risk of developing new cranial nerve deficits is around 20%, and this would affect mostly his oculomotor function [3]. However, in two thirds of cases would resolve at longer follow-up [3]. Potential risk of carotid artery injury is low, but cerebral ischemic events might occur in up to 4% of cases [3]. Postoperative brain edema and temporal lobe infarction is also a concern and might reach up to 10% of cases [7]. Mortality risk varies depending on surgical series, although, since this is a highly demanding surgery with long operative times, this risk should be tailored to the patient basal status and comorbidities (Fig. 5).

A summary of 10 key points

1. Preoperative planning and neuronavigation with angio-MR serves as a consistent intraoperative reference.
2. The ICA must be referenced at its intracavernous segments using the Doppler to facilitate a safe surgery.
3. The MOB is a fundamental landmark for locating the SOF and find the cleavage plane between the two dura layers starting the temporal fossa peeling.
4. Removal of the superior wall of the optic canal and usage of curettes and rotating rongeurs instead of the high-speed drill is mandatory to avoid excessive optic nerve retraction and heath injury.
5. Neurophysiological monitoring of III-VII cranial nerves is key for prevention of its injury.
6. The extradural corridor minimizes brain retraction.
7. Liberate and debride the third and fourth cranial nerve from its attachments to the tumor in the cavernous sinus wall is key to allow function recovery.
8. Following backward, the throclear nerve in the lateral wall of the cavernous sinus is a strategic landmark to find the tentorial incisura.
9. Opening of the Meckel's cave provides a better mobilization of the fifth cranial nerve, as it also helps in its decompression by the tumor mass.
10. Section of the tentorial incisura and the anterior petrosectomy provide a wider corridor to the posterior fossa.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Patient consent The patient has consented to the submission of this How I Do It for submission to the journal.

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