Neurochirurgie xxx (2017) xxx–xxx

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Technical note

Extradural resection of the anterior clinoid process: How I do it☆

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INFO ARTICLE

Historique de l'article :
Reçu le 7 octobre 2016
Reçu sous la forme révisée
le 21 mars 2017
Accepté le 25 mars 2017
Disponible sur Internet le xxx

Keywords:
Anterior clinoid process
Neurosurgery
Optic canal
Paraclinoid space
Skull base

ABSTRACT

Background. – The anterior clinoid process shares a close relationship with the optic canal, the internal carotid artery, the superior orbital fissure and the cavernous sinus. These structures may be involved in diseases whose surgical exposure requires prior clinoid process resection.
Method. – Based on operative cases we describe the different steps of this surgical technique and illustrate our surgical procedure with a video. Dividing the orbito-temporal periosteal fold is a key-step in order to optimize the elevation of the periosteal dural layer at the level of the superior orbital fissure to expose the contours of the anterior clinoid process. The clinoid tip is removed after "debulking" the bony content inside the anterior clinoid process in order to leave only a thin shell of bony contour. The bony shell is then detached from the dura, twisted and pulled out. The indications and limitations of the technique are presented.
Conclusion. – The extradural approach of the anterior clinoid process totally provides a full resection of the anterior clinoid process and safety for the paraclinoid space structures. Meticulous stepwise bony resection and optimized dura opening contribute to reduce the risk inherent to this technique.
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1. Introduction

Anterior clinoid process (ACP) shares a close relationship with the optic canal (OC), internal carotid artery (ICA), superior orbital fissure (SOF) and cavernous sinus (CS). These structures may be involved in diseases whose surgical exposure requires ACP resection. The aim of this technical note is to describe a stepwise and reproducible method of extradural ACP resection.

2. Relevant anatomy

The ACP is the medial part of the lesser sphenoid wing (LSW) that marks the limit between the anterior and middle fossa (Fig. 1). The ACP is nearly shaped like a canine "tooth" (Fig. 1a) and is medially attached to the body of sphenoid bone (jugum sphenoidale) by 2 bony thin plates that constitute respectively the roof superiorly and the floor (so-called optic strut) inferiorly to the OC (Fig. 1b and c) [1,2]. Depending on individual factors, both plates display a variable thickness.

The ACP is covered with two layers of dura mater. This dura describes a complex regional organization. The superficial periosteal dural layer penetrates into the orbit through the SOF to become the periorbita while the inner meningeal layer remains intracranial. At the level of the external part of the SOF the transition between the periosteal dural layer and the periorbita forms a fibrous thick fold of dura, variably named as meningo-orbital band or orbito-temporal periosteal fold [3]. This band is devoid of any critical neurovascular content and is a key landmark to proceed at the early stage of the ACP exposure. Viewed intradurally, the dura that covers the tip of the ACP constitutes the superolateral limit of the CS and is also called the anterior petroclinoid ligament that gives birth to the free edge of the tentorium posteriorly.

The ACP hides a narrow interdural space called the paraclinoid space limited laterally by the SOF and medially by the lateral circumference of the OC. This space is occupied by the paraclinoid segment of the ICA that describes its anterior loop and gives birth to the ophthalmic artery (Fig. 1c). In this region, the ICA leaves the roof of the CS through the proximal ring and enters the intradural space through the distal ring and then becomes the supraclinoid ICA.

Abbreviations: ACP, Anterior clinoid processCS, cavernous sinusICA, internal carotid arteryLSW, lesser sphenoid wingOC, optic canalOTPF, orbito-temporal periosteal foldSOF, superior orbital fissure.

☆ The authors confirm that the manuscript has not been previously published in whole or in part or submitted elsewhere for review.

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http://dx.doi.org/10.1016/j.neuchi.2017.03.001
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Pour citer cet article : Troude L, et al. Extradural resection of the anterior clinoid process: How I do it. Neurochirurgie (2017), http://dx.doi.org/10.1016/j.neuchi.2017.03.001

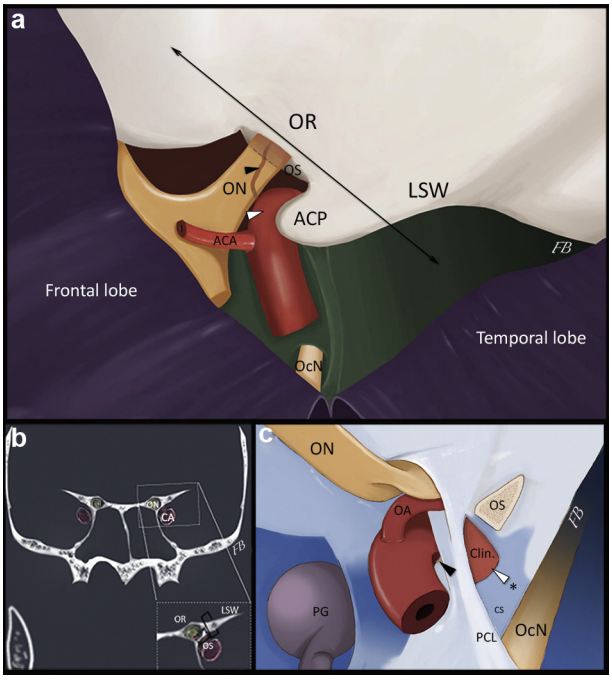

Fig. 1. Relevant anatomy: a: schematic view of the bony attachments of a right anterior clinoid process (ACP). The supraclinoid segment of the internal carotid artery (ICA) (white arrowhead) describes its anterior loop and gives birth to the ophthalmic artery (black arrowhead). Note the ACP sites of attachments to the sphenoid bone: the LSW, the optic roof (OR), the optic strut (OS). Anterior cerebral artery (ACA), cavernous sinus (CS), oculomotor nerve (OcN), optic nerve (ON). Double arrow: coronal section through bony attachments of the ACP (b); b: schematic coronal section through the ACP at the level of the optic canal (OC) (cf. double arrow – a). Note the close vicinity with the paraclinoid internal carotid artery (ICA) (CA). The ACP is attached to the skull base by three bony roots. The medial edge of the LSW anteriorly and laterally [1]. The ACP is medially attached to the body of sphenoid bone (jugum sphenoidale) by 2 bony thin plates that constitute respectively the roof [2] superiorly and the floor [3] (so-called optic strut) of the OC inferiorly. The medial edge of the base of the ACP forms the lateral edge of the OC. The medial margin of the OC is formed by the adjacent part of the body of the sphenoid bone. C. Superior view of the right paraclinoid space after removing the ACP. The ON and chiasm have been reflected forward to expose the ophthalmic artery. The ICA leaves the roof of the CS through the proximal ring (white arrowhead) and enters the intradural space through the distal ring [black arrowhead], to become the supraclinoid ICA. The paraclinoid space is defined proximally by the carotid oculomotor membrane (asterisk) formed by the dura separating the lower surface of the clinoid from OcN (and extends medially to form the proximal ring), and distally by the dura extending medially from the upper surface of the clinoid to form the distal ring. OS: optic strut; CS: cavernous sinus; PCL: anterior petroclinoid ligament; Clin.: paraclinoid carotid artery; OA: ophthalmic artery; PG: pituitary gland.

3. Variations of the ACP

The "tooth like" ACP displays significant variations in size that usually do not affect the surgery (Fig. 2). The texture of the ACP may change from a compact bone to a full pneumatization (Fig. 2a) [4]. The infiltration of the ACP by the disease itself may change the texture. The attachment of the ACP may be reinforced by a bony bridge joining its tip to the posterior clinoid process (Fig. 2b) [1,2,4]. In some cases, the tip may be connected to a middle clinoid process that will constitute a full ring around the ICA into the paraclinoid space. These bony variations are identified on a bone-window CT-scan and should always be checked before starting the surgical stage.

4. Surgical technique

The patient is placed in a supine position, the head is turned 30° toward the opposite side and fixed in a 3-pin Mayfield holder (Video). The malar eminence is positioned at the zenith. A curvilinear skin incision is then carried-out, soft tissues are dissected according to the interfacial technique in order to prevent any facial nerve damage and to mobilize the temporal muscle. A regular pterional approach is then shaped, with size variations that will depend on the task that has to be done intradurally. The dura mater is gradually elevated from the orbital roof and from the anterior pole of the middle fossa in order to expose the remnant of the LSW that marks the Sylvian fissure laterally. The LSW is cracked and pulled out using a rongeur.

The pterion is now carefully drilled using a 5-mm cutting drill during the initial step. While approaching the periorbita and the medial part of the LSW, it is advised to proceed with a 5-mm diamond tip. The meningo-orbital band is now identified in the depth (Fig. 3a). This dural band is divided using microscissors on a length of 5 to 8 mm all the way to the SOF. This step permits an optimized retraction of the fronto-orbital and temporopolar dura to expose the contours of the ACP. Since the exposure of the ACP cannot be fully achieved by this manoeuvre, another valuable step is to identify the SOF and elevate its periosteal dural layer on a short segment, which will contribute to identify the bony contours of the ACP (Fig. 3b).

We previously mentioned that the ACP is attached to the skull base by three bony roots. The lateral one is automatically removed by the regular pterional approach (resection of the LSW). The superomedial bony plate corresponds to the roof of the OC and this root should be now gradually shaved using a 3-mm diamond drill under copious irrigation and optic magnification (Fig. 3c). The thickness of this roof is more accurately assessed when looking at the bone-window CT with coronal slides. This step is essential since it represents the first stage of the optic nerve decompression. Moreover, it will favor later mobilization of the ACP. In our experience, the en bloc mobilization of the ACP is not yet achievable safely; therefore we recommend to resect the bony content inside the ACP and to keep a thin shell of bony contour. The key point is to stay within the vicinity of the lateral border of the OC. In an attempt to broadly decompress the OC, it is valuable to drill medially to the canal; depending on the degree of pneumatisation of the sphenoid sinus, excessive drilling may open the mucosa and generate a potential corridor for CSF leak. While gradually shaving the lateral wall of the OC, from the roof to the floor, the drill will approach the inferomedial ACP root (optic strut) (Fig. 3c). Using a thin sharp dissector the dura is elevated from the contours of the ACP. The bony shell is gradually pushed inside the space that has been created by the "debulking" step. The ACP becomes now more compact and amenable to its final resection. Mostly, pulling the ACP with a rongeur is ineffective in itself and therefore there is a need to twist it simultaneously; this is due to the fact that the tip of the ACP is stuck to the dura by several tiny fibrous bands. At this stage, it is not uncommon to observe some venous bleeding oozing from the CS. It can be stopped by temporary application of a hemostatic material (oxycellulose).

Intradural exposure (Fig. 3d): the paraclinoid space structures are exposed: optic nerve, CN III from the lateral wall of the CS to the SOF, CN IV and V1, and the paraclinoid segment of the ICA (which gives birth to the ophthalmic artery).

About closure: at the end of surgery there is no need to plug the space created by the ACP resection unless the ACP was occupied by an air cell. In such case, care will be taken to fill this space with a small piece of temporal muscle that will be maintained with fibrin glue.

5. Illustrative case

A 36-year-old man harboring a neurofibromatosis type 2 (NF2) was referred to our department for the management of a left sided ACP meningioma (Video and Fig. 4). In his past medical history the

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