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Surgical Neurology International

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SNI: Neuroanatomy and Neurophysiology

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Technical Notes

Bone anatomic variations of the parasellar region and its technical implications in para clinoid and posterior communicating segment aneurysms microsurgical clipping – Technical note

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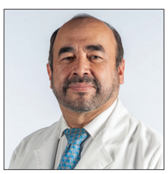

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Received: 31 January 2024
Accepted: 10 February 2024
Published: 08 March 2024

DOI
10.25259/SNI_75_2024

Quick Response Code:

ABSTRACT

Background: Microsurgical treatment of paraclinoid aneurysms is a complex task that generally requires anterior clinoid process (ACP) removal to obtain adequate surgical exposure. This procedure poses a considerable technical difficulty due to the association of the ACP to critical neurovascular structures. Furthermore, anatomical variations in the parasellar region, such as the caroticoclinoid foramen (CCF) or an interclinoid bridge (ICB), may impose additional challenges and increase surgical complications. The present study aims to briefly review some anatomic variations in the parasellar region and describe a step-by-step surgical technique for a hybrid anterior clinoidectomy based on the senior author's experience.

Methods: We present two cases with bone variations on the parasellar region in patients with a paraclinoid aneurysm and another with a posterior communicating segment aneurysm treated by microsurgical clipping at our hospital.

Results: We focused on safely dealing with these variations during surgery, without further complications, and with good postoperative results. Patients were discharged with no significant deficit. Postoperative control, computed tomography angiography showed complete exclusion of aneurysms.

Conclusion: Although anatomical variations in the parasellar region can complicate surgical clipping of these aneurysms, it is essential to ensure the best possible surgical outcome to conduct thorough preoperative and radiological evaluations.

Keywords: Anterior clinoidectomy, Caroticoclinoid bridge, Caroticoclinoid foramen, Interclinoid bridge, Paraclinoid aneurysm

INTRODUCTION

The parasellar region is defined by all the structures that border the sella turcica and represents a crucial crossroad of essential neural and vascular structures.[10] The caroticoclinoid ligament (CCL) usually joins the anterior clinoid process (ACP) with the middle clinoid process

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(MCP), which is an inconsistently small projection in the anterolateral margin of the sella turcica.[1,6,7,13,15] The presence of a CCL and its ossification results in the formation of an anatomic variation called caroticoclinoid bridge or bar (CCB) as well as a caroticolinoid foramen (CCF) through which the internal carotid artery (ICA) passes. The incidence of CCF varies from 6.27% to 35.6%, for inter clinoid bridge (ICB) varies from 1% to 15%, and for MCP, 15–60%.[3,4,14,16] Mobilization or retraction of the ICA and the microsurgical anatomy are compromised by a CCB, complicating anterior clinoidectomy. Pre and intraoperative evaluation of possible osseous variants is essential in preventing catastrophic complications such as inadvertently damaging the ICA.[13,14,15] Microsurgical clipping of anterior circulation aneurysms is challenging due to the meeting of critical neurovascular structures, especially in the paraclinoid region, and, therefore, requires a well-developed microsurgical technique.[1] Although the size, location, and projection of the aneurysm have surgical implications on the exposure, removing the ACP is generally a cardinal step to obtain an adequate surgical exposure that allows dissection of the aneurysm neck and dome.[9] In these cases, *en bloc* removal of the ACP is inappropriate and almost always requires a hybrid anterior clinoidectomy (combination of extradural and intradural removal) to ensure a safe approach.[7,9]

CASE DESCRIPTION

Case 1

A 71-year-old female with diabetes mellitus and systemic arterial hypertension arrived at the emergency room with exacerbated bilateral frontal thunderclap headache, associated nausea, emesis, and increased blood pressure (220/120 mmHg). On physical examination, she was awake and oriented, without motor or sensory deficit, with no abnormal findings (Glasgow Coma Scale 15 points). A head computed tomography (CT) scan showed subarachnoid hemorrhage Fisher II. CT angiography (CTA) showed three aneurysms, one of them in the right ICA posterior communicating segment, another bleb aneurysm in the choroidal segment, and another saccular aneurysm in the right M1-M2 bifurcation. Surgical clipping was performed.

Positioning

The patient is lying supine with the head angled 20° downward the vertex and rotated approximately 30° to the contralateral side. This positioning allows for an unobstructed visual axis along the sphenoid ridge to the ACP and the parasellar region.

Incision, soft-tissue dissection, craniotomy, anterior clinoidectomy

A Yasargil's type incision was marked; an 8 cm incision at the skin-hair transition line was made, focused at the sphenoid ridge. Next, a C-shaped incision was completed in the superficial temporalis fascia and muscle, elevated, and retracted with fishhooks to expose the orbital rim and pterion. A burr hole was created at the most inferior aspect of the surgical exposure, centered over the bony indentation representing the sphenoid ridge. An oval-shaped craniotomy of 7 cm in diameter was completed, and finally, a bone chisel was used to complete the cut over the sphenoid ridge to achieve better esthetic outcomes. The sphenoid ridge and the lateral bony edge of the superior orbital fissure were removed to expose the meningo-orbital band. Then, the frontal dura is freed, and the middle fossa peeling is made using Hakuba's technique. After that, the temporal dura propria is retracted, and the lateral dura wall of the cavernous sinus and ACP is progressively exposed. To minimize optic nerve damage by heat, a 1-mm diamond drill and Friedman and Kerrison rongeurs were used to detach the ACP from its superomedial and inferomedial attachments, exposing the optic sheath and the ICA, all this extradurally; here, we encountered a CCB, so we proceeded to remove this structure with the drill and rongeurs and constant irrigation to avoid damaging surrounding structures. Using a 1-mm diamond drill, we completed the ACP removal intradurally. Finally, distal and proximal dural rings were dissected, and the clinoid triangle was opened to completely free ICA. Adequate proximal control was obtained if necessary, and this allowed visualization of the origin and course of the posterior communicating artery. We encountered the ruptured aneurysm in the posterior communicating segment, and we employed a 15 mm permanent aneurysm clip in addition to coagulate a bleb aneurysm of the choroidal segment. Then, microdissection continued until we found the M1-M2 bifurcation aneurysm, for which we used a 6 mm curved miniclip [Figure 1].

Closure

The dura was achieved using a 4-0 nylon suture. The skull base and clinoid defects were closed using a hemostatic sponge and fibrin glue. The bone flap was fixed using silk or a bone fixation device. The rest of the layers were closed with 2-0 absorbable sutures, and the skin was closed with subdermal nylon.

The patient was discharged seven days later without cranial nerve deficits, only braquiocrural hemiparesis 3-/5. Wound without signs of infection and no esthetic defects. Postoperative CTA showed complete aneurysm occlusion.

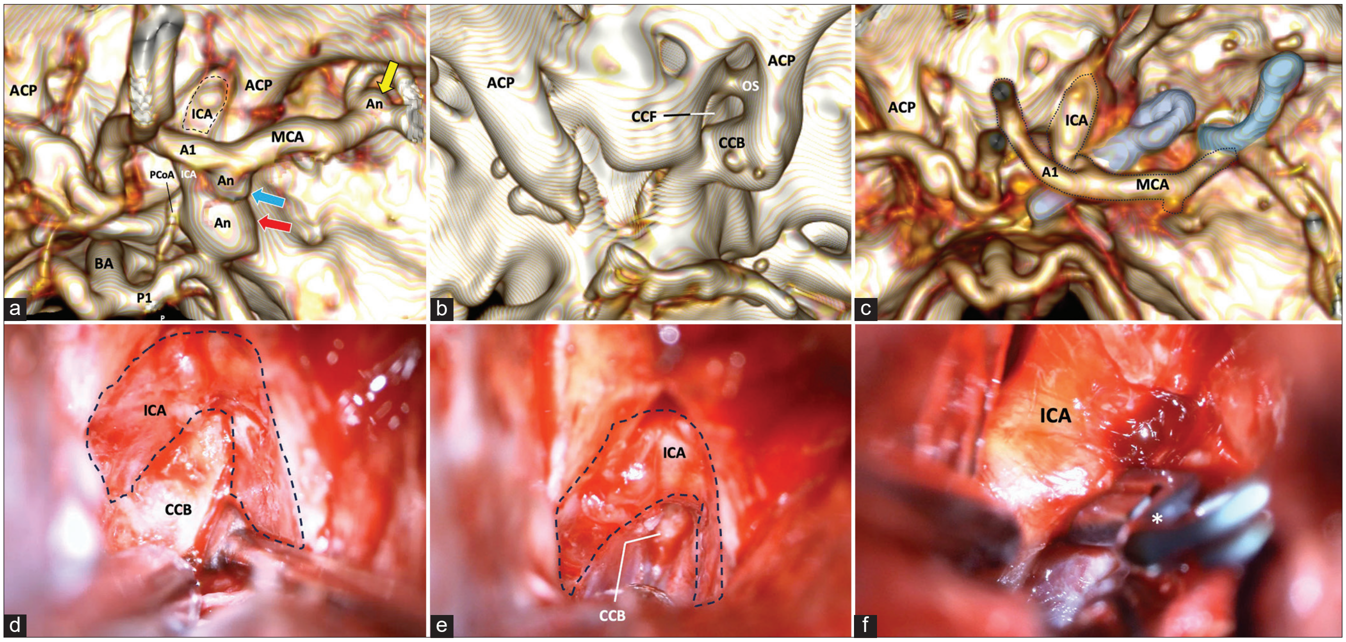

Figure 1: (a) 3-D reconstruction of cerebral CT angiography. The location of three different aneurysms is shown. First, a saccular aneurysm (red arrow) of the ICA in the posterior communicating segment is shown, another bleb aneurysm in the ICA choroidal segment (blue arrow), and another aneurysm in the M1-M2 bifurcation (yellow arrow). (b) 3-D reconstruction of a simple CT scan of the skull. Lateral to the sellar region, we observe the presence of a CCF product of the complete closure of the CCB that circumscribes the trajectory of the ICA in its clinoid segment. (c) Postoperative 3-D reconstruction of simple CT scan. Right anterior clinoidectomy with resection of the CCB. A 15 mm straight clip occluding the aneurysm of the posterior communicating segment is observed, in addition to a 6 mm curved clip occluding the aneurysm of the M1 bifurcation. (d) Extradural approach to the sphenoidal ridge. An extradural view shows a surgical image after reaming the sphenoidal ridge with the removal of the ACP, exposing the CCB medially and circumscribing the course of the ICA in its clinoid segment. (e) In an extradural view, the fixation of the CCB on the sella turcica is observed. (f) In an intradural view, the course of the ICA is seen in its ophthalmic and posterior communicating segments. A 15 mm straight clip (asterisk) is occluding the neck of the aneurysm. CT: Computed tomography, A1: A1 segment of the anterior cerebral artery, ACP: Anterior clinoid process, An: Aneurysm, CCB: Caroticoclinoid bridge, CCF: Caroticoclinoid foramen, ICA: Internal carotid artery, ICB: Interclinoid bridge, M1: M1 segment of the middle cerebral artery, M2: M2 segment of the middle cerebral artery, MCA: Middle cerebral artery, ON: Optic nerve, OS: Optic strut, P1: P1 segment of the posterior cerebral artery, PCoA: Posterior communicating artery, BA: Basilar artery, PCP: Posterior clinoid process.

Case 2

A 49-year-old woman with systemic arterial hypertension arrived at the emergency room with an oppressive headache. She started with otalgia and tinnitus one month before. On physical examination, she was awake, oriented, and without motor or sensory deficit; CTA showed a right ventromedial paraclinoid aneurysm. Surgical treatment was performed.

Positioning

We used a similar position described in Case 1.

Craniotomy, anterior clinoidectomy

An asymmetrical oval-shaped craniotomy measuring 7 cm in diameter is completed. The superior orbital fissure border was removed to expose the meningo-orbital band. Then, the middle fossa peeling was performed using Hakuba's technique to retract the lateral dura wall of the cavernous sinus and progressively expose the ACP. Friedman and Kerrison Rongeurs were used to detach the ACP from its superomedial and inferomedial attachments, exposing the optic sheath and the ICA. A linear dural incision toward the optic sheath, followed by cerebrospinal fluid drainage from the optico-carotid cistern for brain relaxation. Using a 1-mm diamond drill, we completed the ACP removal intradural. Here, we encountered an ICB and proceeded to drill this to have a full view of the aneurysm neck with ventromedial dome projection in addition to opening the distal dural ring for carotid luxation and adequate clipping of the aneurysm, preserving the patency of the carotid artery; this maneuver allowed us to put 290°-angulated fenestrated 5 mm clips. A visual control with fluorescein confirmed the patency of parent vessels and complete closure of aneurysms [Figure 2].

Closure

The closure technique is similar to that described in Case 1.

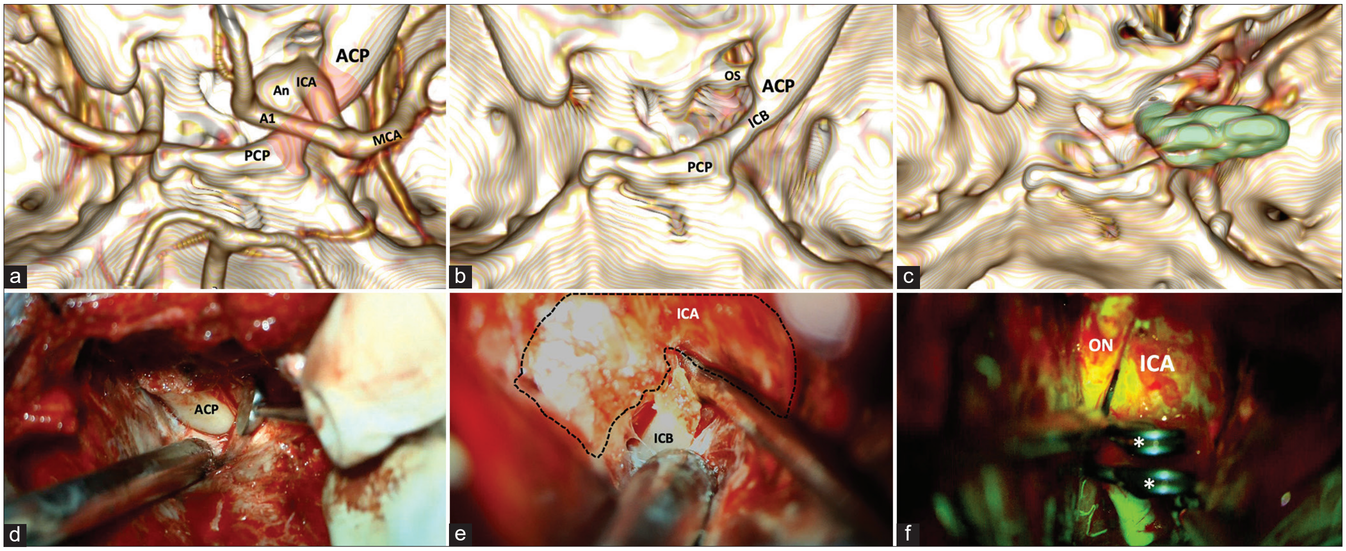

Figure 2: (a) 3-D reconstruction of cerebral CT angiography. The vascular relationships concerning the ICB (red shading) on the right side are highlighted from a panoramic view centered on the middle fossa. (b) 3-D reconstruction of a simple CT scan of the skull. The complete course of the ICB is seen in the absence of vascular components. (c) Postoperative 3-D reconstruction of simple CT scan. Right anterior clinoidectomy with resection of the ICB. The placement of 2 right-angled 5 mm fenestrated clips with the tips pointing toward the OS is observed (green shading). (d) Extradural approach to the sphenoidal ridge. An extradural view shows a surgical image after reaming the sphenoidal ridge. (e) Intradural view. A surgical image exposes the ICB and its relation with the ICA in its ophthalmic segment. (f) Fluorescein video angiography (FL-VAG) post clipping. Two 5-mm right-angled fenestrated clips placed over the ICA in its ophthalmic segment with adequate patency are observed. CT: Computed tomography, A1: A1 segment of the anterior cerebral artery, ACP: Anterior clinoid process, An: Aneurysm, ICA: Internal carotid artery, ICB: Interclinoid bridge, M1: M1 segment of the middle cerebral artery, MCA: Middle cerebral artery, ON: Optic nerve, OS: Optic strut, PCP: Posterior clinoid process.

The patient was discharged six days later, remaining only with incomplete III nerve palsy. No defects or complications regarding the wound. Postoperative CTA control also showed complete exclusion of aneurysms.

DISCUSSION

The presence of anatomic variations in the parasellar region, such as a CCF, ICB, and/or pneumatization of the ACP, may further increase the complexity of this procedure, and modifications of the technique are usually necessary to avoid surgical complications.[1,6,7,13] ACP is lateral to the ICA, so variations such as the CCF or CCB can result in artery compression, subsequent ischemic changes, or neurological symptoms such as headaches due to inadequate blood supply.[12] In the case of a para clinoid aneurysm, an anterior clinoidectomy is the treatment of choice, which becomes risky and challenging due to the presence of a bony CCF, as it may lead to heavy hemorrhage in the vicinity of the ACP.[12] In the presence of CCB, it is impossible to retract or mobilize the cavernous segment of the carotid artery even after releasing the proximal and distal carotid rings.[4,13,15] These anatomical variations may result during the development of the sphenoid bone with the pneumatization of the ACP or by the ossification of the ligamentous connections between the ACP and other parts of the sphenoid bone.[5,13] The ossification of these structures cannot be exclusively age-dependent and can occur at any age.[5,13] The surgeon should always remain aware of these possible anatomic variations. A thorough evaluation of the parasellar anatomy employing preoperative image studies is mandatory for optimal surgical planning and safer surgical access.[6] The preoperative imaging protocol for aneurysms in this region should include fine-cut CT angiography with 3-D reconstructions, emphasizing axial cuts at the level of the upper paraclinoid region.[8] The studies pay special attention to the presence of the CCF and/or ICB, as each of these variants may limit the complete resection of the ACP by the extradural approach. However, removing the ACP entails considerable technical complexity due to its vicinity to the ICA and the second and third cranial nerves, potentially leading to catastrophic complications.[6] Since Dolenc[2] first described extradural anterior clinoidectomy, several techniques and modifications have been described, including hybrid anterior clinoidectomy (combination of extradural and intradural removal), as in the cases presented.

CONCLUSION

Conducting thorough preoperative assessments and radiological evaluations is essential to ensuring the best surgical outcome in cases of microsurgical aneurysm clipping. Each of these variants may limit the complete resection of the

ACP by the extradural approach. Based on CT angiographic observations, the authors recommend modifications to the standard anterior clinoidectomy procedure to enhance surgical access, reduce the risk of complications, and achieve improved patient outcomes.

Ethical approval

Institutional Review Board approval is not required.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Serrano-Rubio A, López-Rodríguez R, Riley-Moguel A, Benavides-Burbano C, Nuñez-Lupaca J, Becerril-Mejía A, *et al.* Bone anatomic variations of the parasellar region and its technical implications in para clinoid and posterior communicating segment aneurysms microsurgical clipping – Technical note. Surg Neurol Int. 2024;15:81. doi: 10.25259/SNI_75_2024

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