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Optic Nerve Mobilization as an Alternative to Anterior Clinoidectomy for Superior Carotid–Ophthalmic Aneurysms: Operative Technique

Ignacio J. Barrenechea[1], Matías Baldoncini[2], Pablo González-López[3], Álvaro Campero[4]

■ BACKGROUND: **Carotid–ophthalmic aneurysms arise from the internal carotid artery between the distal dural ring and the origin of the posterior communicating artery. The surgical treatment of these aneurysms usually requires anterior clinoidectomy. However, this procedure is not without complications. In the present report, we have described optic nerve mobilization after optic foraminotomy as an alternative to anterior clinoidectomy to clip superior carotid–ophthalmic aneurysms.**

■ METHODS: **We have reported the cases of 3 patients with superior carotid–ophthalmic aneurysms who had undergone surgical clipping. Instead of an anterior clinoidectomy, the optic nerve was mobilized after performing optic foraminotomy. The optic canal was carefully unroofed with a 3-mm, high-speed, diamond drill under constant cold saline irrigation to avoid thermal damage to the optic nerve. After incision of the falciform ligament and optic sheath, the optic nerve was gently mobilized with a No. 6 Penfield dissector, facilitating aneurysmal neck exposure and clipping through a widened opticocarotid triangle.**

■ RESULTS: **The postoperative course was uneventful for all 3 patients, without any added visual defect. Optic nerve mobilization allowed us to safely widen the opticocarotid triangle and dissect the aneurysm off the optic nerve, without the need for clinoidectomy. This alternative technique permitted, not only early decompression of the optic nerve, but also dissection of the arachnoid between the inferior surface of the optic nerve and the superior surface of the ophthalmic–carotid artery and aneurysm dome.**

■ CONCLUSIONS: **Optic nerve mobilization after optic foraminotomy proved to be a safe and relatively easy technique for exposing and treating superior carotid–ophthalmic aneurysms.**

INTRODUCTION

Carotid–ophthalmic aneurysms arise from the internal carotid artery (ICA) between the distal dural ring and the origin of the posterior communicating artery at any point along its diameter.[1] They are relatively rare and account for only 0.5%–11% of all intracranial aneurysms.[2-5] A higher incidence in women and a left-sided predominance have been reported.[2,3,6-9] They are frequently large or giant and have a high association (21%–64%) with multiple aneurysms.[6,8-10] Aneurysms occurring at the origin of the ophthalmic artery usually point upward toward the optic nerve. Hence, they can cause visual deficits owing to optic nerve compression.

The surgical treatment of these aneurysms will usually require clinoidectomy. However, clinoidectomy is not without complications, some of them severe.[1,11] To overcome this issue, we performed optic nerve mobilization as an alternative to anterior clinoidectomy to clip superior carotid–ophthalmic aneurysms for 3 patients. We have reported our initial experience with these 3 patients, describing our technique and results. The pre- and postoperative images, visual computed campimetry measures, and intraoperative photographs are presented to highlight the advantages of the described technique.

METHODS

We report the cases of 3 patients with a diagnosis of a superior carotid–ophthalmic aneurysm treated by surgical

Key words
- Carotid–ophthalmic artery aneurysm
- Microsurgery
- Optic nerve mobilization
- Outcome
- Surgical clipping

Abbreviations and Acronyms
AR: Aspect ratio
ICA: Internal carotid artery

From the [1]Department of Neurosurgery, Hospital Privado de Rosario, Santa Fe, Argentina; [2]Department of Neurosurgery, San Fernando Hospital, Buenos Aires, Argentina; [3]Department of Neurosurgery, Hospital General Universitario Alicante, Institute for Health and Biomedical Research of Alicante, Alicante, Spain; and [4]Department of Neurosurgery, Padilla Hospital, Tucumán, Argentina

To whom correspondence should be addressed: Matías Baldoncini, M.D. [E-mail: drbaldoncinimatias@gmail.com]

Ignacio J. Barrenechea, Matías Baldoncini, Pablo González-López and Álvaro Campero has contributed equally to the present study.

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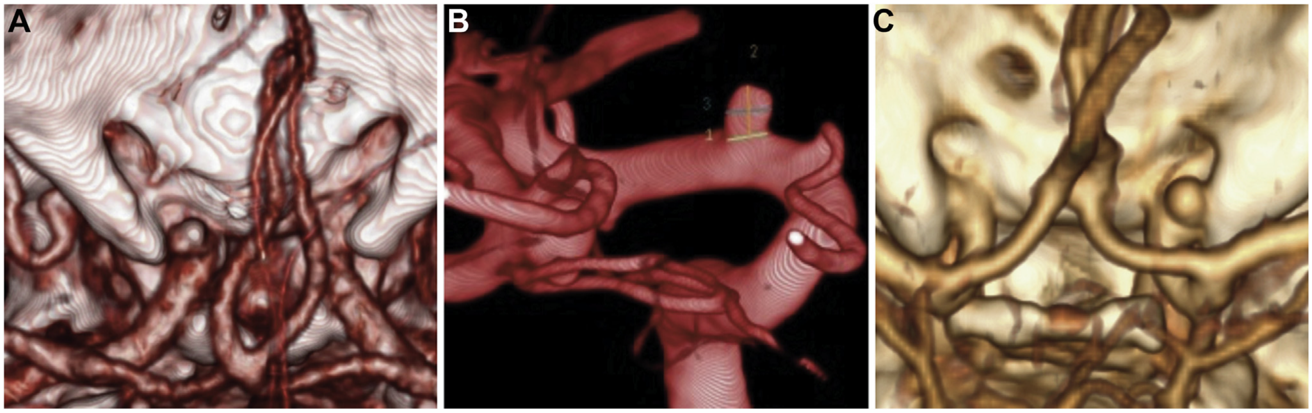

Figure 1. (**A**) Preoperative computed tomography angiographic reconstruction of patient 1 showing a left superior carotid–ophthalmic aneurysm (aspect ratio [AR], 1.25). (**B**) Preoperative digital subtraction angiogram of patient 2 showing 2 right carotid aneurysms: a superior carotid–ophthalmic and medial cerebral artery aneurysm (AR, 2.3). (**C**) Preoperative computed tomography angiographic reconstruction of patient 3 showing a right superior carotid–ophthalmic aneurysm (AR, 1.5).

clipping. Instead of anterior clinoidectomy, the optic nerve was mobilized after performing optic foraminotomy, which allowed for the placement of the clip and concurrent decompression of the nerve. The first patient was a 64-year-old man who had presented with headache and advanced left visual field loss, with only a small superior temporal area spared. Computed tomography angiography showed a left superior 5-mm carotid–ophthalmic saccular aneurysm with an aspect ratio (AR) of 1.25. The second patient was a 43-year-old woman with subarachnoid hemorrhage, classified as Fisher class I and Hunt-Hess class II. The initial digital 3-dimensional angiogram performed at admission showed a right M1 aneurysm and a 7-mm superior carotid–ophthalmic aneurysm with an AR of 2.3. Preoperative computed visual field testing of her right eye showed superior nasal quadrantanopia. The third patient was a 58-year-old woman who had presented with headaches. A screening magnetic resonance angiogram showed a right 6-mm superior carotid–ophthalmic saccular aneurysm with an AR of 1.5 (**Figure 1**). Both endovascular and surgical clipping were thoroughly discussed with all 3 patients and their relatives. For patients 1 and 2, because the patients had had visual deficits, surgical clipping was chosen to increase their chance of visual recovery. Patient 3 chose surgical clipping over endovascular treatment after a careful discussion of the benefits and risks of both

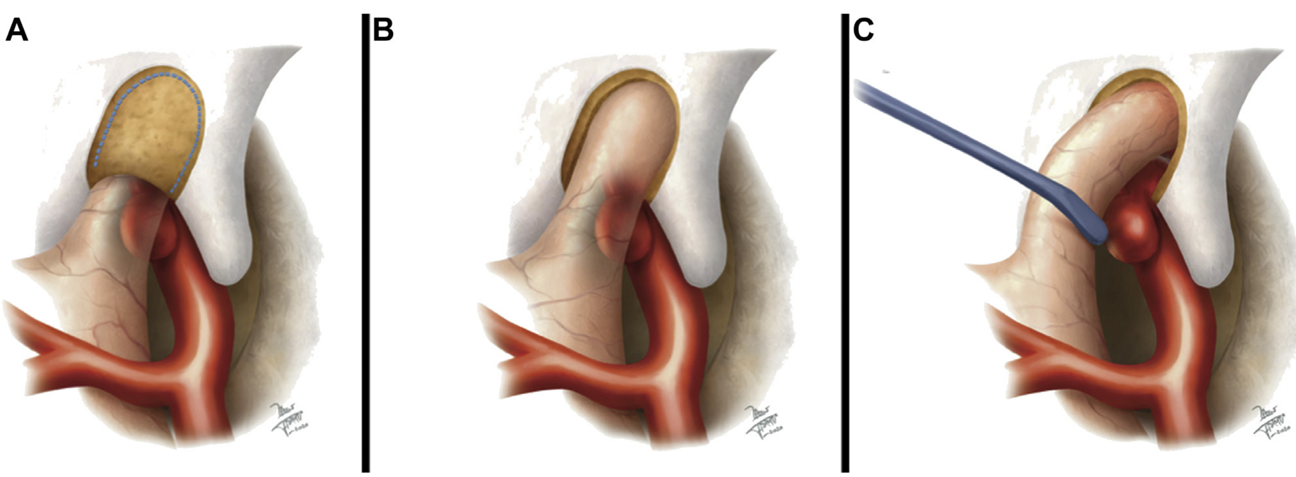

Figure 2. Artistic drawing showing the surgical technique. (**A**) Step 1: incising the dura over the optic canal. The optic canal length was measured from the falciform ligament. (**B**) Step 2: unroofing the optic canal. The optic sheath was opened to expose the intracanalicular portion of the optic nerve. (**C**) Step 3: once the optic nerve sheath was opened, the optic nerve was gently mobilized medially using a No. 6 Penfield dissector to expose the aneurysm dome and ophthalmic artery.

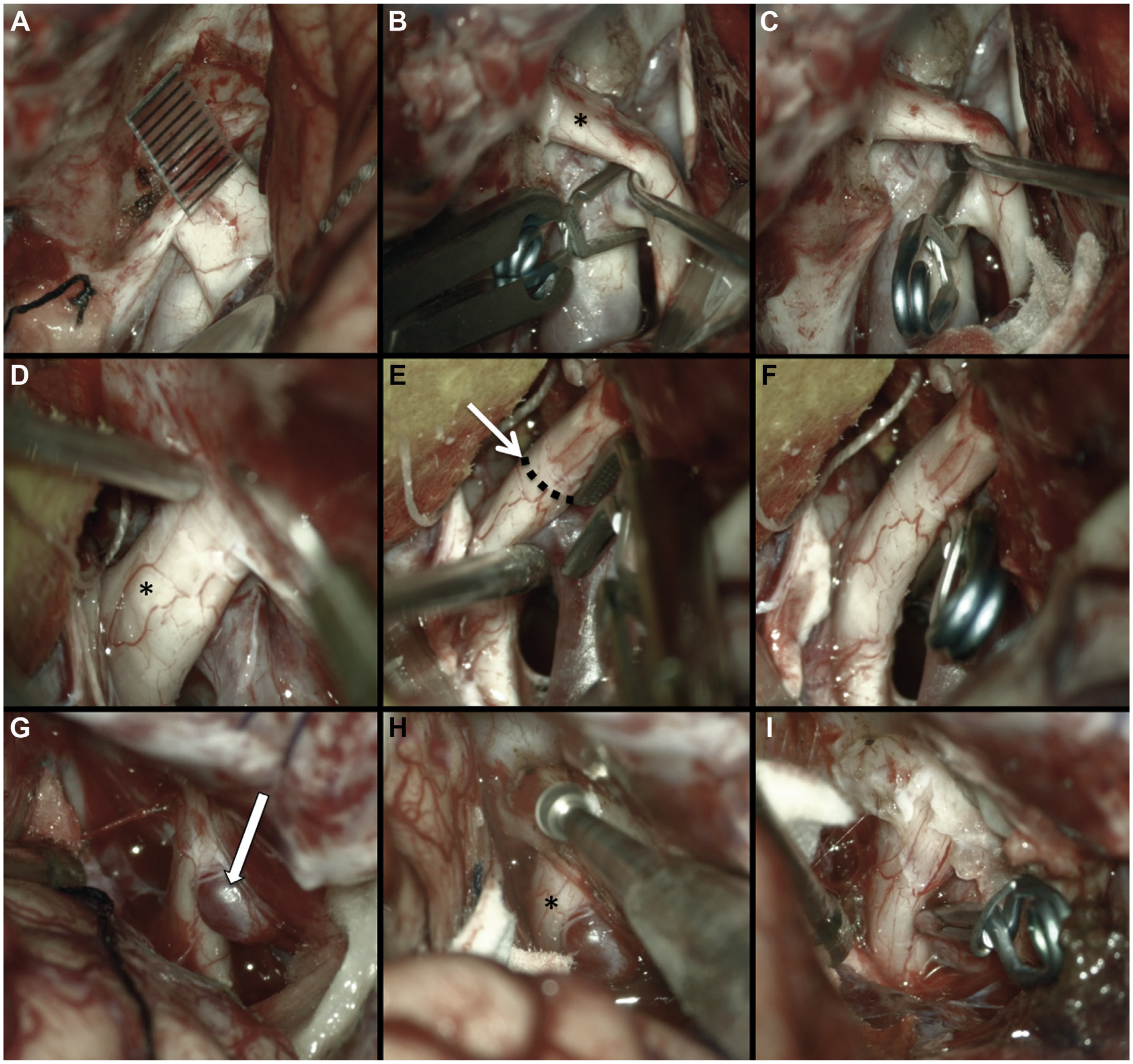

Figure 3. Surgical images from patient 1 showing (**A**) exposure of the optic nerve and carotid artery using a circumferential incision over the optic canal with a No. 11 blade. (**B**) Surgical view after optic foraminotomy. The optic nerve was gently retracted from the carotid artery with a No. 6 Penfield dissector, rendering the aneurysmal neck easily exposed for final clipping. (**C**) Final image of the carotid–ophthalmic clipped aneurysm, with decompression of the optic nerve. Surgical images from patient 2 showing (**D**) exposure of the optic nerve (*black asterisk*) and carotid artery, with the optic canal roof and falciform ligament clearly visible. A circumferential incision above the optic canal was made with a No. 11 blade. (**E**) The optic nerve was gently retracted from the carotid artery, and the aneurysmal neck was easily exposed for clipping. The *white arrow* and *dotted line* mark the location of the falciform ligament. (**F**) Final image of the carotid–ophthalmic clipped aneurysm, with decompression of the optic nerve. Surgical images from patient 3 showing (**G**) initial exposure of the optic nerve and carotid–ophthalmic aneurysm. (**H**) Drilling the roof of the optic canal. Constant cool saline irrigation should be used at this stage to avoid thermal damage to the optic nerve. (**I**) Final image of the carotid–ophthalmic clipped aneurysm.

methods. All 3 patients provided written informed consent, and our institutional review board approved the present study (approval no. 1/0022).

Surgical Technique

The patients were positioned supine, with the head fixed in a 4-pin head holder and rotated 15° to the contralateral side. The

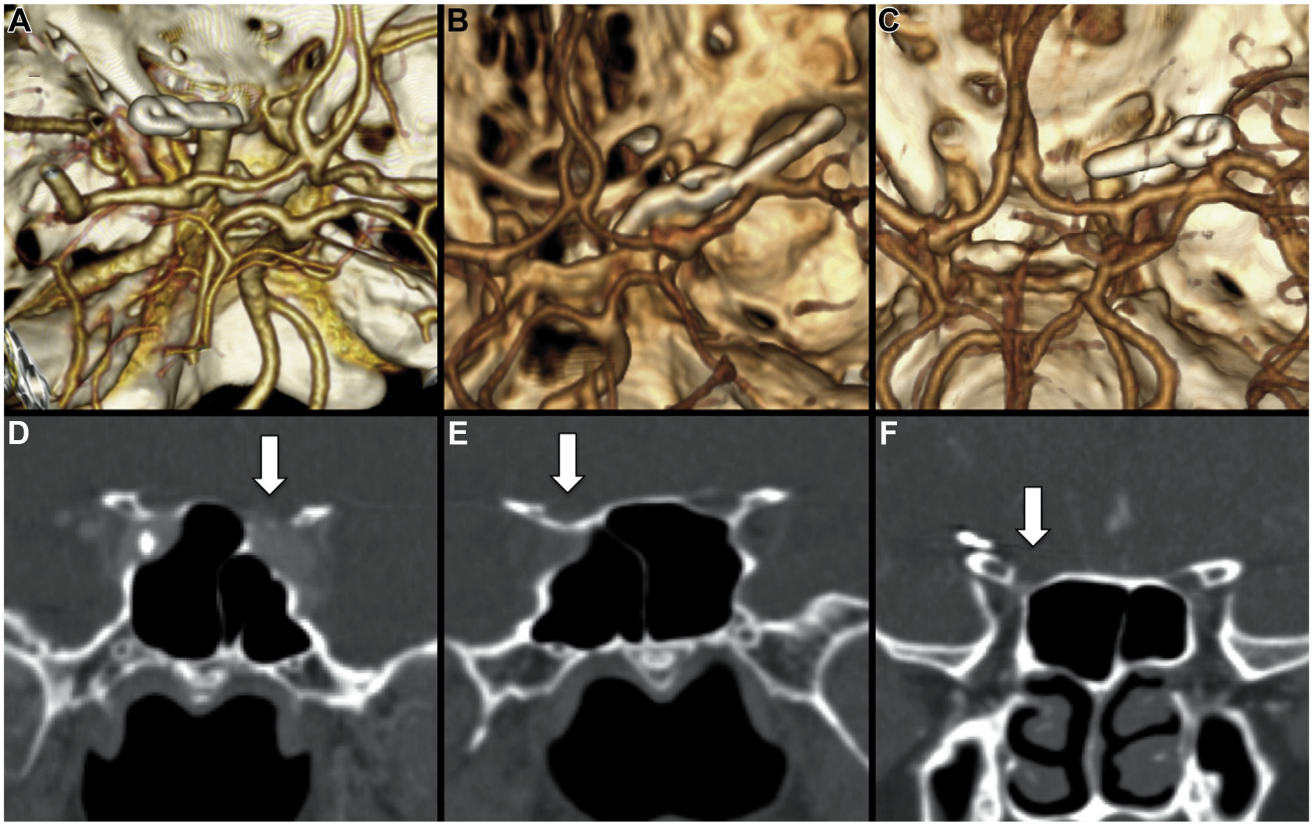

Figure 4. Postoperative computed tomography reconstructions of patient 1: (**A**) postoperative computed tomography (CT) angiographic reconstruction showing a straight clip occluding the left superior carotid–ophthalmic aneurysm and (**D**) postoperative coronal 1-mm-cut CT reconstruction showing optic foraminotomy on the left side (*white arrow*). Postoperative CT reconstructions of patient 2: (**B**) postoperative CT angiographic reconstruction showing a straight clip occluding the right superior carotid–ophthalmic aneurysm and (**E**) postoperative coronal 1-mm-cut CT reconstruction showing optic foraminotomy on the right side (*white arrow*). Postoperative CT reconstructions of patient 3: (**C**) postoperative CT angiographic reconstruction showing a straight clip occluding the right superior carotid–ophthalmic aneurysm and (**F**) postoperative coronal 1-mm-cut CT reconstruction showing optic foraminotomy on the right side (*white arrow*).

cervical ICA was exposed for proximal control. A curvilinear-shaped frontotemporal incision behind the hairline and interfascial dissection of the temporal muscle were performed.[3,4] Next, pterional craniotomy and flattening of the sphenoid ridge with a high-speed drill were performed. After arciform durotomy, opening of the Sylvian fissure down to the carotid cistern was performed under the microscope. The dura mater of the anterior cranial base, optic nerve, and carotid artery and its bifurcation were exposed. Next, a circumferential dural incision was made above the optic canal. The length used to cut the dura mater was ∼10 mm in front of the free edge of the falciform ligament. The ligament was dissected and removed to avoid rolling it into the drill and eventually damaging the optic nerve. To perform complete optic foraminotomy, the optic canal was carefully unroofed using a 3-mm high-speed diamond drill under constant cold saline irrigation to avoid thermal damage to the optic nerve. Care was taken not to open the ethmoid sinus on the medial wall of the optic nerve. After incision of the falciform ligament and optic sheath, the optic nerve was gently mobilized with a No. 6 Penfield dissector (**Figures 2** and **3**), facilitating aneurysmal neck exposure and clipping through a widened opticocarotid triangle. The optic nerve became decompressed after mobilization off the ICA (**Figure 3**). Once the aneurysm was secured, the craniotomy was closed in the usual manner. Patients 1 and 3 were transferred to the intensive care unit for the first 24 hours. After 48 hours in the ward, these 2 patients were discharged home. Patient 2 had undergone surgery 2 days after the initial bleeding episode and remained for 7 days in the intensive care unit and 3 days in the general ward. Postoperative clinical follow-up examinations were performed at 2 weeks, 2 months, and 6 months after the procedure. The postoperative visual field examinations were performed 1 year after the procedure.

RESULTS

The postoperative course was uneventful for all 3 patients, without any added visual defects. Optic nerve mobilization allowed us to safely widen the opticocarotid triangle and dissect

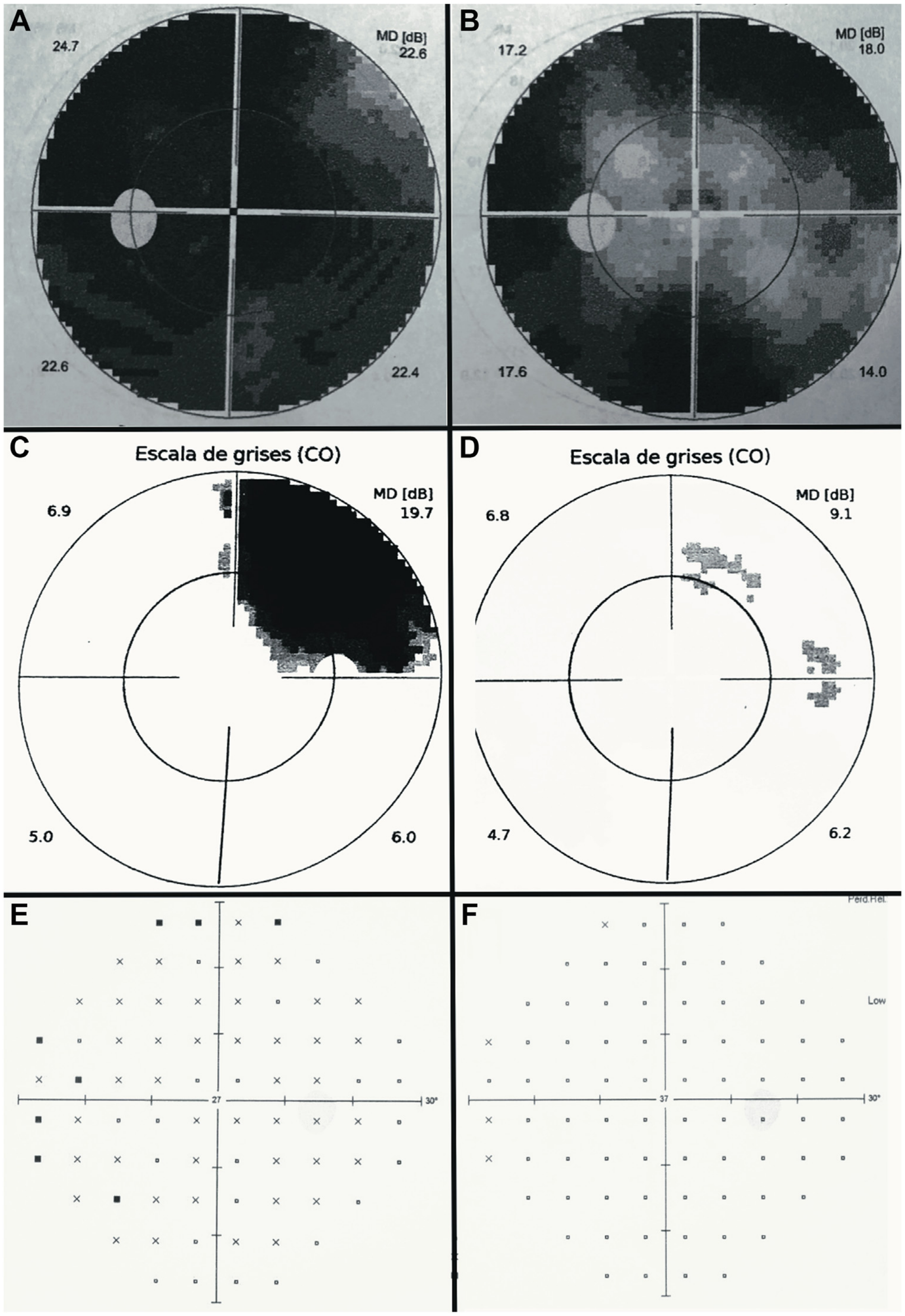

Figure 5. Computed visual field testing of the left eye of patient 1 showing (**A**) advanced visual field loss preoperatively, with only a small superior temporal area spared, and (**B**) central vision recovery in all quadrants postoperatively, with clear improvement in the peripheral part of the lower temporal quadrant. Computed visual field testing of the right eye of patient 2 showing (**C**) superior nasal quadrantanopia preoperatively and (**D**) significant improvement postoperatively. Computed visual field testing of the right eye of patient 3 showing (**E**) normal examination findings preoperatively, with (**F**) no visual field deterioration recorded postoperatively.

the aneurysms off the optic nerve, without the need for clinoidectomy. This maneuver also permitted inspection of the clip's blades under the optic nerve. Because the ethmoid sinus mucosa was not seen, no fat graft was required around the optic foramen. After the foraminotomy, the optic nerve became mobile, allowing us to gently explore its inferior surface and dissect it off the aneurysm dome. Furthermore, because no major bleeding was encountered, no fibrin glue was required. This maneuver was performed within <25 minutes. Postoperative computed tomography angiograms showed complete obliteration of the aneurysms, with adequate carotid permeability (Figure 4). The postoperative neurological examination performed at 1 year postoperatively showed improvement of the visual deficits for the first 2 patients (Figure 5). No changes in the visual field examination findings were recorded for the third patient (Figure 5).

DISCUSSION

Carotid—ophthalmic aneurysms represent a true microsurgical challenge owing to their anatomically close relationship with important surrounding structures such as the optic nerve and cavernous sinus. Although most of these aneurysms will benefit from anterior clinoidectomy with optic nerve unroofing to completely expose the aneurysm neck and ophthalmic artery,[9] a subset can be managed with optic nerve mobilization without the need for anterior clinoidectomy.[12,13] Clinoidectomy is not without risks and complications. The described major complications related to anterior clinoidectomy in modern series include postoperative cerebrospinal fluid leakage, damage to the optic nerve in the form of visual field deficits (either direct neural damage or ischemia due to ophthalmic artery manipulation), oculomotor palsy, and intraoperative aneurysm rupture.[9,11,14-16] Hence, we have proposed a less-invasive alternative to this maneuver to treat superior carotid—ophthalmic aneurysms.

Unroofing of the optic canal is a well-established procedure, especially during resection of tuberculum sellae meningiomas for decompression of the optic nerve and removal of tumor extension into the optic canal.[17] However, and although optic nerve mobilization has been proposed as a method to enhance the exposure of the pituitary stalk during craniopharyngioma resection,[18] it has not been previously reported, to the best of our knowledge, as a sole maneuver to treat ophthalmic segment aneurysms. It not only allows for aneurysm neck visualization but also for direct visualization of the ophthalmic artery. This maneuver results in initial optic nerve decompression, releasing the pressure produced by the aneurysm beating below this visual structure. This objective is adequately achieved by removing the bony and dural structures that fix the intracanalicular segment of the optic nerve.

Optic nerve mobilization after optic foraminotomy has several advantages compared with the anterior clinoidectomy technique. First, unlike on the curved surface of the anterior clinoid process, drilling is performed over a flat surface, lowering the risk of injuring either the optic nerve or the ICA. Second, it allows for dissection between the inferior surface of the optic nerve and the superior surface of the ophthalmic—carotid artery segment. Thus, complete exposure of the superior wall of the ICA and aneurysm dome is possible, allowing one to clip the aneurysm more securely. Third, the risk of bleeding is lower when performing optic foraminotomy than when performing clinoidectomy, because the latter structure is adjacent to the cavernous sinus. However, the close relationship of the upper surface of the optic nerve to the optic canal roof should be noted and protected during the drilling maneuvers to avoid accidental injury. Furthermore, this technique is not suitable for carotid—ophthalmic aneurysms that project anteriorly, laterally, or inferiorly.

CONCLUSIONS

In our series of 3 patients, optic nerve mobilization after optic foraminotomy proved to be a safe, quick, and relatively easy technique for exposing and treating superior carotid—ophthalmic aneurysms. It not only allows for decompression of the optic nerve during the first stages of the procedure but also for dissection of the arachnoid between the inferior surface of the optic nerve and the superior surface of the ophthalmic—carotid artery segment and aneurysm dome. Moreover, by releasing the superior wall of the ICA, it allows for inspection of the final clip position. Finally, it is important to emphasize that anterior clinoidectomy represents the standard surgical maneuver to clip carotid—ophthalmic artery aneurysms and mobilization of the optic nerve should be reserved for selected cases.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Ignacio J. Barrenechea: Conceptualization, Project administration, Formal analysis, Writing - original draft. **Matías Baldoncini:** Conceptualization, Project administration, Formal analysis, Writing - original draft. **Pablo González-López:** Visualization, Methodology, Writing - review & editing. **Álvaro Campero:** Visualization, Methodology, Writing - review & editing.

REFERENCES

1. Beatty RA. Splitting of the optic nerve by a carotid-ophthalmic artery aneurysm: case report. *J Neurosurg*. 1986;65:560-562.
2. Bouthillier A, Van Loveren HR, Keller JT. Segments of the internal carotid artery: a new classification. *Neurosurgery*. 1996;38:425-432.
3. Campero A, Ajler P, Paíz M, López-Elizalde R. Microsurgical anatomy of the interfascial vein: its significance in the interfascial dissection of the pterional approach. *Oper Neurosurg (Hagerstown)*. 2017;13:622-626.
4. Coscarella E, Vishteh AG, Spetzler RF, Seoane E, Zabramski JM. Subfascial and submuscular methods of temporal muscle dissection and their relationship to the frontal branch of the facial nerve. *J Neurosurg*. 2000;92:877-880.
5. Dolenc VV. A combined epi- and subdural direct approach to carotid-ophthalmic artery aneurysms. *J Neurosurg*. 1985;62:667-672.
6. Drake CG, Vanderlinden RG, Amacher AL. Carotid-ophthalmic aneurysms. *J Neurosurg*. 1968;29:24-31.
7. Guidetti B, La Torre E. Carotid-ophthalmic aneurysms: a series of 16 cases treated by direct approach. *Acta Neurochir*. 1970;22:289-304.
8. Guidetti B, La Torre E. Management of carotid-ophthalmic aneurysms. *J Neurosurg*. 1975;42:438-442.
9. Sai Kiran NA, Furtado SV, Hegde AS. How I do it: anterior clinoidectomy and optic canal unroofing for microneurosurgical management of ophthalmic

segment aneurysms. *Acta Neurochir*. 2013;155: 1025-1029.

10. Wang J, Kan Z, Wang S. Microsurgical treatment of carotid-ophthalmic aneurysm associated with multiple anterior and posterior circulation aneurysms: a case report. *Medicine (Baltimore)*. 2017;96:e6672.

11. Rizzo JF III. Visual loss after neurosurgical repair of paraclinoid aneurysms. *Ophthalmology*. 1995;102: 905-910.

12. Hauser MJ, Gass H. Optic nerve pressure by aneurysm relieved by decompression of optic nerve. *Arch Ophthalmol*. 1952;48:627-631.

13. Iwabuchi T, Suzuki S, Sobata E. Intracranial direct operation for carotid-ophthalmic aneurysm by unroofing of the optic canal. *Acta Neurochir*. 1978; 43:163-169.

14. Spektor S, Dotan S, Mizrahi CJ. Safety of drilling for clinoidectomy and optic canal unroofing in anterior skull base surgery. *Acta Neurochir*. 2013;155: 1017-1024.

15. Kulwin C, Tubbs RS, Cohen-Gadol AA. Anterior clinoidectomy: description of an alternative hybrid method and a review of the current techniques with an emphasis on complication avoidance. *Surg Neurol Int*. 2011;2:140.

16. Kothandaram MS, Dawson BH, Kruyt RC. Carotid-ophthalmic aneurysms: a study of 19 patients. *J Neurosurg*. 1971;34:544-548.

17. Mariniello G, de Divitiis O, Bonavolontà G, Maiuri F. Surgical unroofing of the optic canal and visual outcome in basal meningiomas. *Acta Neurochir*. 2013;155:77-84.

18. Metwali H, Gerganov V, Fahlbusch R. Optic nerve mobilization to enhance the exposure of the pituitary stalk during craniopharyngioma resection: early experience. *J Neurosurg*. 2016;125: 683-688.

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