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Intradural versus Extradural Anterior Clinoidectomy: Comparison of Visual Loss in Patients with Paraclinoid Aneurysms

Série de casos: Comparação da perda visual em pacientes submetidos a clinoidectomia intra versus extradural para abordagem de aneurismas paraclinoideos

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Abstract

Introduction Visual deficit after surgical treatment for paraclinoid aneurysms is a problem faced by many neurosurgeons. Anterior clinoidectomy, performed to access the aneurysm, is one the most important steps of the surgery. However, it is also the step related the most with lesions to the optic nerve. The aim of this study was to compare the rate of visual loss between extradural versus intradural clinoidectomy in patients harboring paraclinoid aneurysms which underwent open surgery.

Methods Analysis of 36 patients harboring paraclinoid aneurysms operated by the senior authors between 2020–2022. We compared our results to other series published previously.

Results Fifteen patients underwent intradural clinoidectomy (41.6%), twenty patients extradural clinoidectomy (55.5%) and one patient intra and extradural clinoidectomy (2.7%). The incidence of postoperative visual deterioration was 11.1% (4 patients), all of them were from the extradural clinoidectomy group. Other complications found were cerebrospinal fluid leak (1 patient) and vasospasm followed

Keywords
- vascular
- paraclinoid
- aneurysm
- visual loss
- internal carothid artery

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by diffuse ischemia (1 patient). Visual evoked potential was used in 6 patients (16.6%). In two cases VEP was normal during surgery, however they developed visual deterioration in the postoperative period.

Conclusion Both techniques have advantages and disadvantages, however extradural clinoidectomy showed higher rates of visual deterioration than intradural clinoidectomy. Regardless of the chosen procedure, precise surgical technique is mandatory when dealing with paraclinoid aneurysms.

Resumo

Introdução Déficit visual após abordagem microcirúrgica de aneurismas paraclinoideos é um problema encontrado por diversos neurocirurgiões. Clinoidectomia anterior, realizada para obter acesso aos aneurismas paraclinoideos, é um dos passos fundamentais da abordagem cirúrgica, entretanto pode levar a lesões do nervo óptico. O objetivo deste estudo foi comparar a incidência de déficit visual em pacientes submetidos a clinoidectomia intradural versus aqueles submetidos a técnica extradural.

Métodos Análise de 36 casos operados no servico durante o período de 2020–2022. Os resultados foram comparados com outras séries previamente publicadas.

Resultados Clinoidectomia intradural foi realizada em 15 pacientes (41.6%), clinoidectomia extradural em 20 pacientes (55.5%) e abordagem combinada em 1 paciente (2.7%). A incidência de deficit visual no período pós-operatório foi de 11.1% (4 pacientes), todos do grupo extradural. Outras complicações encontradas foram: fístula liquórica (1 paciente) e vasoespasmo difuso (1 paciente). Potencial evocado visual foi utilizado em 6 pacientes (16.6%). Em dois casos, o potencial permaneceu inalterado durante a cirurgia, entretanto houve deterioração visual no período pós-operatório.

Conclusão Ambas técnicas possuem vantagens e desvantagens, entretanto, a clinoidectomia extradural apresentou maior incidência de deficit visual nesse estudo. Independente da abordagem escolhida, uma técnica cirúrgica exímia é mandatória no manejo desses aneurismas.

Palavras-chave
- vascular
- aneurisma
- paraclinóide
- perda visual
- artéria carótida interna

Introduction

Blindness after surgery for aneurysms in the paraclinoid region may be greater than described.

The major obstacle to these aneurysms at the level of the distal dural annulus was the anterior clinoid process (ACP) that partially or totally concealed the neck (►**Fig. 1**), leading to partial clipping or even untimely rupture during clip placement.[1]

In the 1980s, techniques for clipping paraclinoid aneurysms were described involving the section of the ACP to better identify the aneurysmal neck.[2]

In anatomical studies Dolenc showed that by extradural route it is possible to open the falciform ligament and remove the orbital roof, sphenoid wing, optic pillar and anterior clinoid. That allows an adequate view of the aneurysmal neck and ophthalmic artery outlet. If we open the distal dural ring it facilitates the location of the clip even more.[1,3]

On the other hand, other authors have supported the use of intradural clinoidectomy for paraclinoid aneurysms surgery. This technique showed good results and few descriptions of intraoperative visual loss.[2,4,5]

There is still doubt regarding which approach should be used to decrease visual loss in the postoperative period. We reviewed paraclinoid aneurysm cases operated in our service that underwent intradural or extradural clinoidectomy and investigated the incidence and the factors related to visual loss in those patients.

Materials and Methods

Thirty-six patients harboring paraclinoid aneurysms were included in this review. They were operated by the senior authors during the period of 2020 to 2022.

Localization and number of aneurysms, age, gender, intra or extradural clinoidectomy, visual deterioration, complications and use of visual evoked potential were the parameters evaluated.

A literature review was also done to compare our results with previously published series.

Results

Thirty-six patients were included in our series. All of them harbored carotid-ophthalmic aneurysms. One case also had a

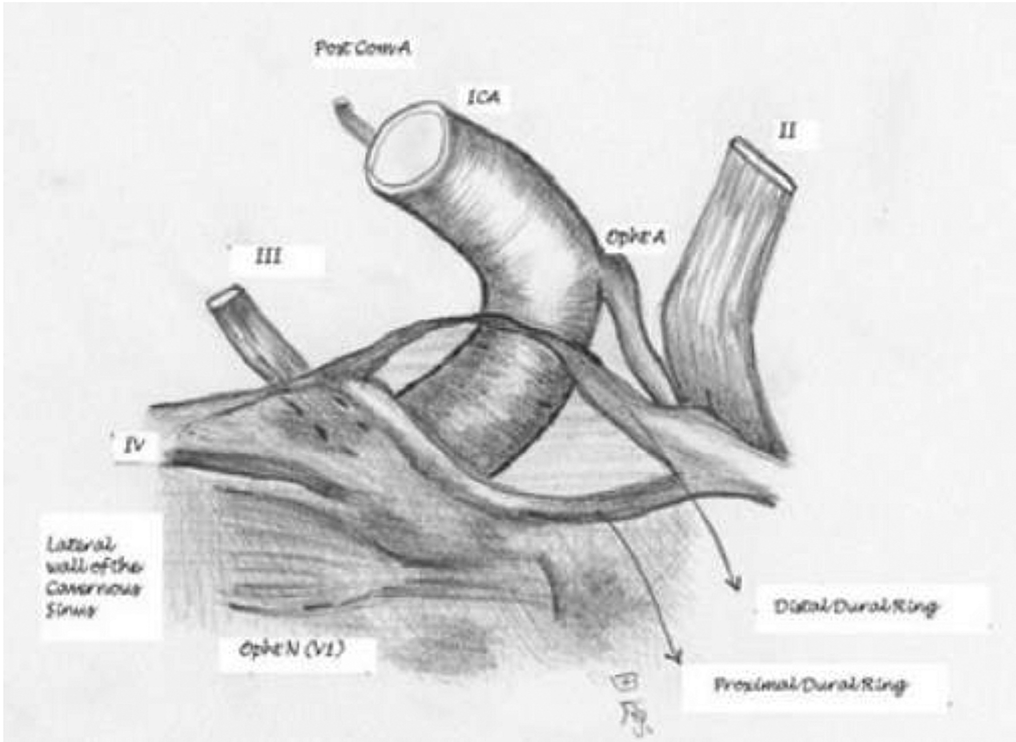


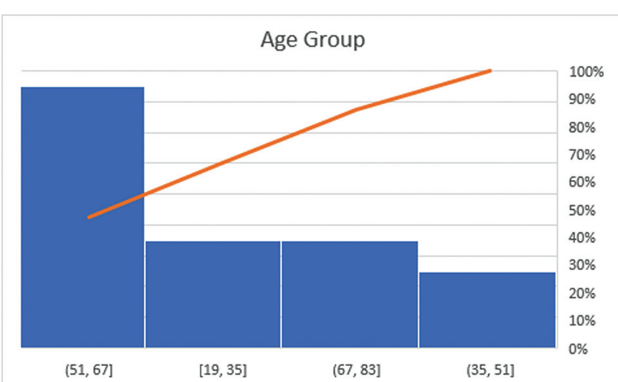
Fig. 1 Anatomical Scheme of the Paraclinoid Region. The scheme shows proximal dural ring, distal dural ring and lateral wall of the cavernous sinus.PostCom A- posterior communicating artery; ICA-Intern carotid artery; Oph A-ophthalmic artery; V1 ophtalmic branch of trigeminal nerve, III-oculomotor nerve and IV -Throclear nerve.

posterior communicating artery aneurysm and another one a hypophyseal artery aneurysm.

We noticed a female predominance (58%). Medium age was 52.5 years-old (range: 19–72). Fifteen patients (41.6%) had multiple aneurysms. Three patients (8.3%) had ruptured aneurysms. (►**Graph 1–3**)

The incidence of multiple aneurysms was almost five times higher in women (►**Graph 2**). Right sided aneurysms were four times more frequent than left sided ones in the male group (►**Graph 3**).

Fifteen patients underwent intradural clinoidectomy (41.6%), twenty patients extradural clinoidectomy (55.5%) and one patient intra and extradural clinoidectomy (2.7%). One of the extradural cases also had a pituitary tumor.



Graph 1 Age at presentation.

The incidence of postoperative visual deterioration was 11.1% (4 patients), all of them were from the extradural clinoidectomy group. The intradural clinoidectomy group had no visual deterioration after surgery. Other complications found were cerebrospinal fluid leak (1 patient) and vasospasm followed by diffuse ischemia (1 patient). (►**Graph 4**)

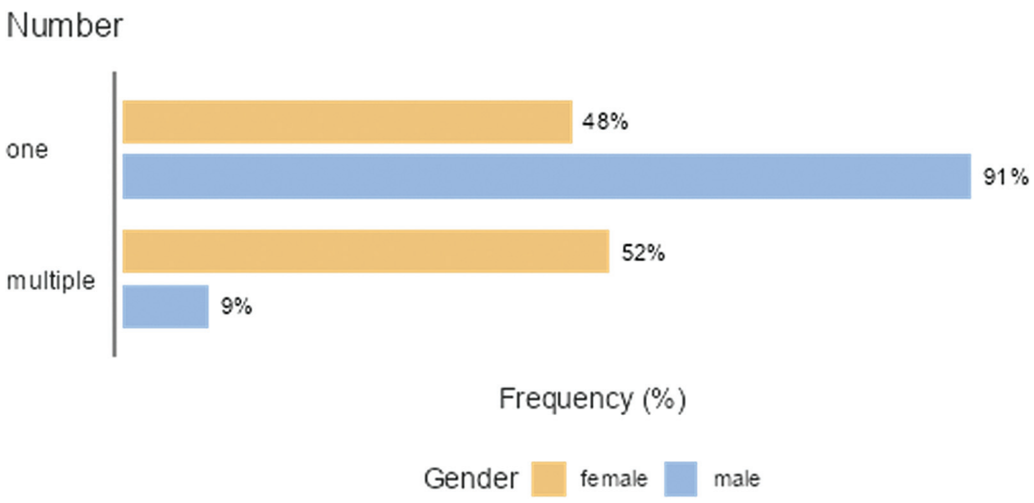
Visual evoked potential was used in 6 patients (16.6%). In two cases VEP was normal during surgery, however they developed visual deterioration in the postoperative period.

Discussion

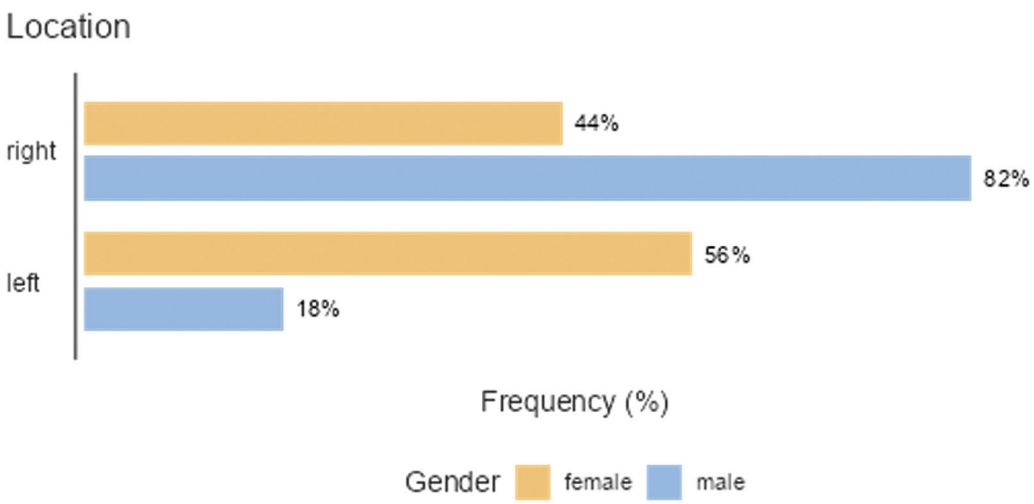
Intradural Clinoidectomy

The intradural clinoidectomy described by Khrist and Fukushima has been frequently used in the last decade. A deeper knowledge of the anatomy of this region is mandatory when performing this technique (►**Figs. 1–3**).[6]

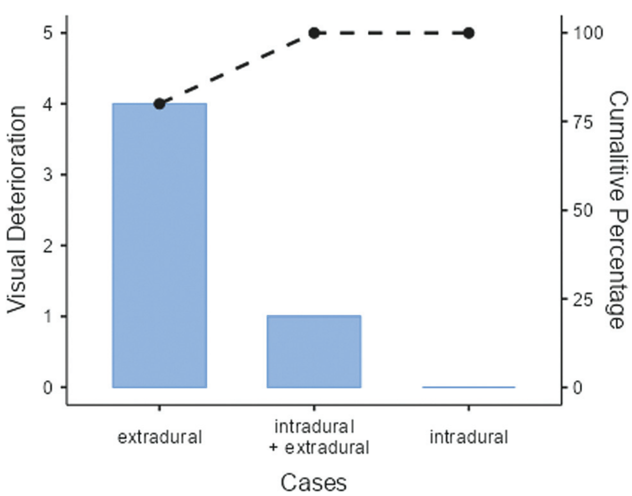
Intradural clinoidectomy can be performed from the dura mater opening, with visualization of the clinoid covered by a thin dura mater mat. We cut out this dural mat with a scalpel and then scissors. With a 3mm diamond drill, we drill the base of the clinoid up to the optic pillar with continuous irrigation so we could check the carotid artery and optic nerve posteriorly. We then remove the clinoid en bloc allowing the visualization of the aneurysm and its neck. The cavernous sinus may bleed soon after clinoid removal, hereby we performed hemostasis as soon as possible with Surgiflow Hemostatic matrix (Ethicon USA) or Floseal (Baxter, USA). (►**Fig. 4**)



Graph 2 Gender x Number of aneurysms.



Graph 3 Gender x laterality.



Graph 4 Visual Deterioration x Clinoidectomy.

Our case series and other studies published before showed that this technique has several advantages, especially for the management of paraclinoid aneurysms. The paraclinoid region contains several delicate structures that demand an extremely precise surgical approach, hereby an open view could make the procedure easier.

Intradural clinoidectomy allows the proper understanding of the relation between the anterior clinoid process and the other structures in the paraclinoid region as the internal carotid artery, the optic nerve, the optic struct and also aneurysms that might be present. All variations of ophthalmic artery aneurysms could be managed through this approach. Another advantage is the proximal control of the internal carothid artery (ICA). If an intrasurgical aneurysm rupture occurs, it could be managed swiftly.

The clinoidectomy extent is also a major concern when discussing surgical technique. Only intradural procedures allow the proper assessment of the anterior clinoid process volume that should be removed.[5] Surgeries may be less detrimental if an incomplete ACP removal is performed. The predictive value of three-dimensional computerised tomography angiography (3D-CTA) on the extent of anterior clinoidectomy still remains unsatisfactory; it is limited by

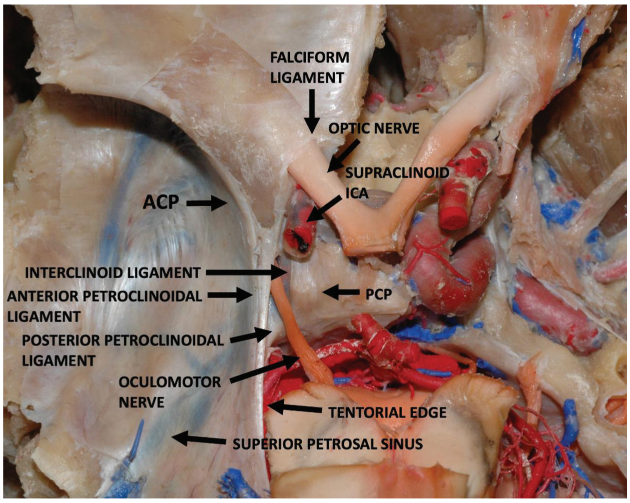


Fig. 2 Superior endocranial view of the skull base, highlighting the anatomical structures most relevant in the anterior clinoidectomy. ACP, anterior clinoid process; PCP, posterior clinoid process; ICA, internal carotid artery.

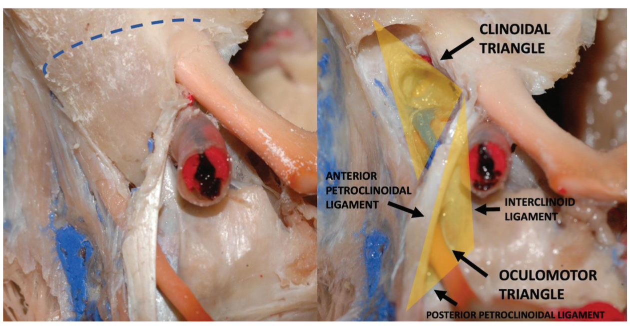


Fig. 3 Superior view of the anterior clinoid process. (**A**) Dotted line demonstrates the clinoidectomy trajectory. (**B**) Same specimen after clinoidectomy, highlighting the anatomical structures of the clinoidal and oculomotor triangles.

the individual variability of carotid-ophthalmic aneurysms (COA) and its surrounding structures.[7]

Possible disadvantages are injury to neurovascular structures durign drilling, lengthy procedure, technical difficulties and complications related to bone dust, such as chronic headache.[8,9]

The protection of the ICA and optic nerve with a dural flap or using gelfoam, as we usually do, minimizes the damage of the adjacent structures. Extensive surgical training allows faster surgeries, which can be as time consuming as the extradural clinoidectomy.[9]

Optic nerve injury is less common with the intradural technique, because of early visualization and drilling further away from the optic nerve. Oculomotor nerve injury is more common in the intradural approach.[7]

Extradural Clinoidectomy

The extradural clinoidectomy described by Dolenc and propagated by several authors[10,11] can be performed using a 3mm diamond drill, under microscopic view. Initially the roof of the orbit and the entire sphenoid wing are removed, followed by cutting the meningo orbital band, which separates the neurovascular structures and the venous plexus inside and meningo orbital artery, and then opening the superior orbital fissure to expose the junction between the dura propria of the temporal lobe and inner membrane of the cavernous sinus. We began to drill the clinoid and optic pillar, leaving the final bone fragment adhered to the carotid artery to be removed with a thin needle holder.

Cavernous sinus hemostasis should be performed with Surgiflo or Floseal, or packaged surgicel. After the epidural procedures, intradural procedures are also performed. The falciform ligament and the distal dural ring are incised to mobilize the optic nerve and the internal carotid artery.[1] Irrigation with cold serum must be constant and we can never fail to move the frontal with a spatula and whenever possible do it with microscopic magnification.

Dolenc's approach requires dividing the meningo-orbital band. Peeling of the dura propria from the inner membrane is continued until the anterior clinoid process is exposed epidurally. Extradural clinoidectomy and optic canal opening are then performed. After the epidural procedures, intradural procedures are also performed. The falciform ligament and the distal dural ring are incised to mobilize the optic nerve and the internal carotid artery.[3,7,9]

We opened the dura mater in an inverted T and moved it aside with prolene stitches as if we were opening a book,[1] then we opened the distal dural ring with microscissors so we could see the aneurysmal neck in all extension.

The extradural approach protects the paraclinoid structures during drilling, which is its greatest advantage. It can also be helpful for removal of medial sphenoid wing meningiomas, pituitary adenomas and craniopharyngiomas. Extradural bone removal increases the devascularization of the tumor and enhances gross tumor resection.[12]

Extradural clinoidectomy is not indicated for ruptured aneurysms or aneurysms in direct contact with the ACP. For those cases, some authors indicate extradural drilling with intradural surveillance and removal of the final portion of the ACP intradurally.[7]

Hybrid Clinoidectomy

Tayebi Meybodi et al. developed a technique that combined extra and intradural steps. Their aim was to avoid the most common disadvantages of both techniques.[13]

Their procedure consists of a standard pterional craniotomy, followed by a 2-step ACP removal. They divided the ACP into anterior and posterior based on the localization of the optic strut. The anterior segment was removed extradurally while the posterior one intradurally, under direct view of the adjacent neurovascular structures.[13]

They concluded that this modified technique allows early decompression of the optic nerve, decreasing visual loss in the postoperative period, while preserving the neurovascular structures. No complications occurred.[13]

Visual Loss

Visual deterioration is one the most discussed complications after clinoidectomy. Several series showed an incidence of

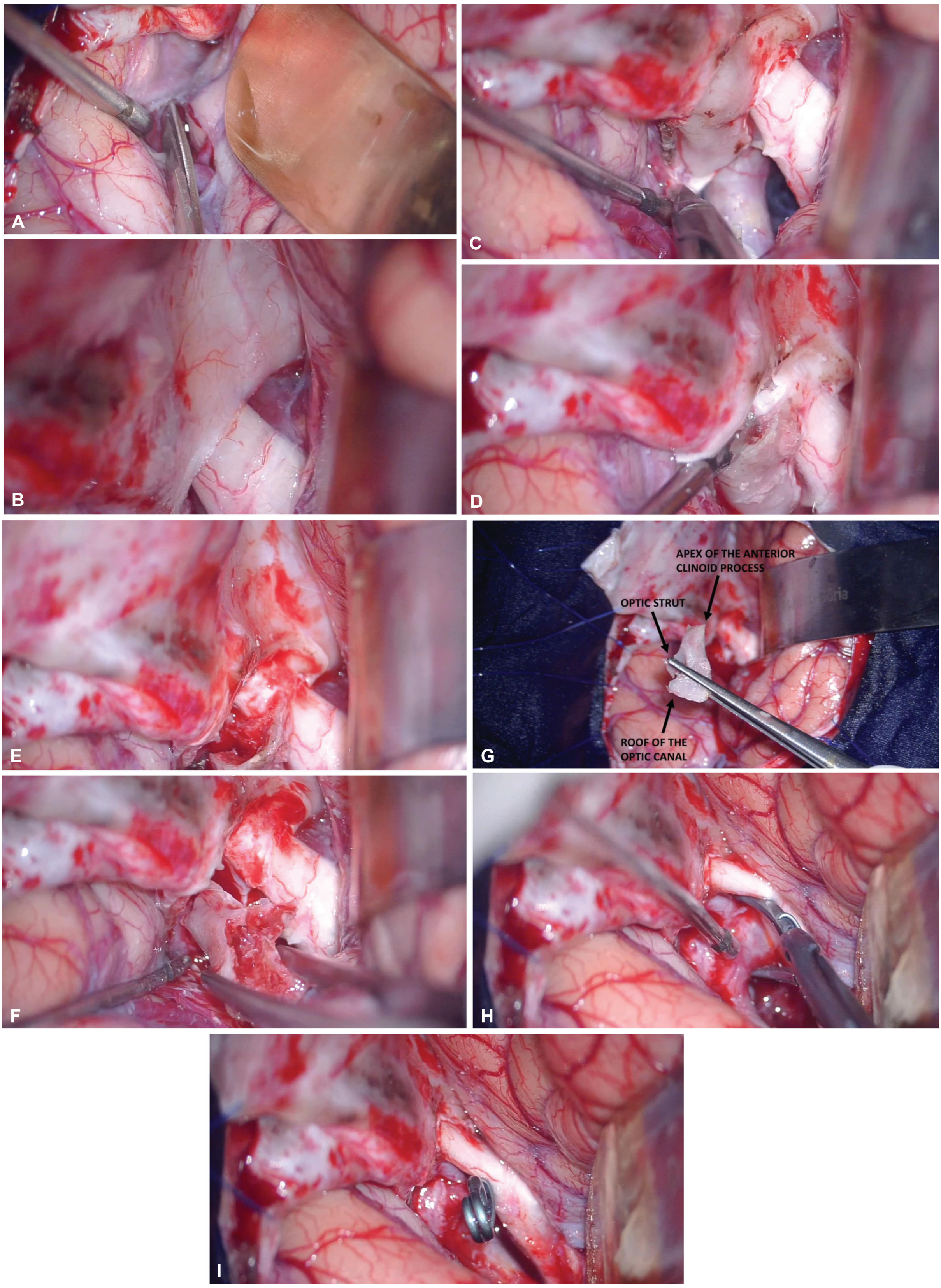


Fig. 4 (**A**) After pterional craniotomy, the Sylvian fissure must be opened with a sharp opening. (**B**) The neck of the aneurysm is hindered by anterior clinoid process. (**C**) The dural surface is cut and removed over the clinoid process exposing the bone surface to be drilled. (**D**) The clinoid process is drilled from the lateral border of the falciform ligament to the lateral border of the clinoid process. (**E**) The optic strut which connects the body of sphenoid bone to anterior clinoid process. (**F**) The optic strut must be removed in bloc by drilling its basal portion. (**G**) Anatomy of clinoid process. (**H**) Clip placement. (**I**) After clipping with total occlusion of the aneurysm while preserving the ophthalmic artery. Intradural removal of anterior clinoid process allowing the view of the aneurysm neck.

visual loss of 0–10% after surgery for COA.[7,14–16] Rates of postoperative visual morbidity in patients with normal vision who underwent elective repair of paraclinoid aneurysms were higher following microsurgical (10.8%; 95% confidence interval [CI] 8.5–13.7) than endovascular (2.0%; 95% CI 1.2–3.2) interventions, $p < 0.001$.[8] Postoperative transient oculomotor palsy also occurred considerably more often in patients undergoing direct clipping and anterior clinoidectomy.

Our series had an incidence of 11.1% of visual loss, discreetly higher than others found in the literature.[3,7,15,16] Yamada et al. had an incidence of 6.2% of visual deterioration in 33 patients operated through the extradural approach.[3]

Several causes could lead to blindness after clinoidectomy, including direct trauma to the optic nerve, heat from drilling without proper cooling by irrigation, devascularization of the ophthalmic artery during dissection and mechanical compression of the clip.

Drill temperature is a point of concern. Drilling close to the optic nerve can lead to several damages to its structure. Nerve tissue can suffer permanent damage around 47°C, the bone temperature around the drill can be up to 70°C.[5]

Direct traumatic injuries are also a problem. Neurovascular structures can suffer mechanical injury during inadvertent drilling. Cottonoids can also get entangled to the rotating drill, injuring the surrounding structures.[7]

Some authors proposed the use of micro-rongeurs instead of a drill for superior projecting paraclinoid ICA aneurysms; they obtained excellent results.[17,18] The 'no drill' technique offers a more conservative approach to anterior clinoidectomy and optic canal unroofing by eliminating the risks of thermal injury and ultrasound-associated cranial neuropathies.[19]

Several procedures during surgery could minimize the risk of visual deterioration. The use of dura mater and gelfoam for protection of ICA and optic nerve are mentioned in almost all surgical reviews. Statistical analysis also showed that piecemeal anterior clinoidectomy was significantly safer than en bloc removal in preserving visual function.[20] Tsukahara showed that postoperative visual complications occurred significantly more often in en bloc clinoidectomy with high-speed drills than in piecemeal clinoidectomy with an ultrasonic bone curette and microrongeurs.[19]

Excess dissection of carotid oculomotor membrane causes postoperative delayed visual worsening. Ota et al. avocated that for small aneurysms, the membrane should not be opened. They also mentioned that microsurgical clipping of asymptomatic medial projecting aneurysms should be avoided; the endovascular approach seems to be more appropriated for those cases.[18]

Intraoperative visual evoked potential is a current trend, however controversial. It may not be effective in cases of aneurysm surgeries with optic nerve compression or optic juxta position. Some authors concluded that it might be useful for preventing postoperative worsening of visual function.[20] Our series did not show this relation. In 2 cases the VEP showed preservation of visual system, although we noticed postoperative visual loss. Tsukahara et al. also found similar results as ours.

Recent studies suggest the use of ultrasonic bone removal instead of the tradicional power-drilling clinoidectomy. However, what we noticed so far is that it could lead to ultrasound-related cranial neuropathies. The cost of the device also decreases its routine use.[19]

Barrenechea et al. evaluated the results of optic nerve mobilization instead of anterior clinoidectomy. They unroofed the optic canal with a diamond drill, made an incision in the falciform ligament and optic sheath and then gently mobilized the optic nerve with a dissector. As a result, they facilitated the aneurysmal neck exposure without the use of clinoidectomy. Patients did not develop any added visual loss. They concluded that this 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.[21]

Conclusion

Visual loss is a relevant and relatively common complication after clinoidectomy. Our series showed a higher incidence of visual loss in the extradural clinoidectomy. Regardless of the approach used, careful use of the drill around neurovascular structures is mandatory. Piecemeal clinoid removal and even partial clinoid removal are recommended.

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Conflict of Interest
None.

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