# MINI-PTERIONAL CRANIOTOMY FOR CLIPPING OF ANTERIOR CIRCULATION ANEURYSMS

## *Craneotomía minipterional para clipaje de aneurismas de la circulación anterior*

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**ABSTRACT**

**Objectives:** The pterional approach is the most common approach in vascular neurosurgery, but in recent years has been an increasing interest in minimally invasive surgery or keyhole surgery. We present preliminary results from the use of Mini-pterional Craniotomy in surgery for cerebral aneurysms performed in the Cayetano Heredia Hospital in 2009.
**Methods:** We performed a Mini-pterional Craniotomy of 2.5 x 3 cm from a curved incision of approximately 5-6 cm behind the hairline and centered on the orbitofrontal and posterior aneurysm clipping, in patients with PComA, bifurcation ICA and MCA aneurysms, during the late period, Hunt and Hess I-III, without edema, vasospasm or associated hematoma.
**Results:** From January to December 2009 six patients were operated by Mini-pterional Craniotomy, 4 with PComA aneurysms (66%), 1 with ICA (17%) and 1 with MCA (17%). All were operated on late and Hunt and Hess was I in 3 cases (50%) III in 2 cases (33%) and II (17%). There were no operative complications and the outcome was favorable in most cases: Rankin 1 (50%) and Rankin 2 (33%).
**Conclusions:** Mini-pterional Craniotomy is a minimally invasive surgery for brain aneurysms, which maintains the advantages of the standard pterional approach, but it minimizes the exposure of brain parenchyma and soft tissue manipulation. It is a valid surgical alternative in selected cases, mainly from PComA and MCA aneurysms.

*Key words: Intracranial Aneurysm, Craniotomy, Minimally Invasive Surgical Procedures. (source: MeSH NLM)*

**RESUMEN**

**Objetivos:** El abordaje pterional es el abordaje más frecuente en neurocirugía vascular, sin embargo, en los últimos años ha habido un interés creciente en la cirugía mínimamente invasiva o cirugía keyhole. Presentamos los resultados preliminares del uso de la Craneotomía Minipterional en la cirugía de aneurismas cerebrales realizados en el Hospital Cayetano Heredia durante el 2009.
**Métodos:** Se realizó una Craneotomía Minipterional de 2.5 x 3 cm a partir de una incisión curva de aprox 5-6 cm por detrás de la implantación del cabello y centrada en el punto frontoorbitario, seguido del clipaje del aneurisma, en pacientes con aneurismas de ComP, bifurcación de ACI y de ACM, durante el periodo tardío, Hunt y Hess I-III, sin edema, vasoespasmo ni hematoma asociado.
**Resultados:** De enero a diciembre del 2009 se operaron 6 pacientes mediante Craneotomía Minipterional, 4 con aneurismas de ComP(66%), 1 de ACI (17%)y 1 de ACM(17%). Todos fueron operados en tardío y el Hunt y Hess fue I en 3 casos (50%) III en 2 casos (33%) y II (17%). No se presentaron complicaciones operatorias y la evolución fue favorable en la mayoría de los casos: Rankin 1 (50%) y Rankin 2 (33%).
**Conclusiones:** La Craneotomía Minipterional es una técnica mínimamente invasiva en la cirugía de aneurismas cerebrales, que mantiene las ventajas del abordaje pterional estándar, pero minimiza la exposición de parénquima cerebral y la manipulación de tejidos blandos. Constituye una alternativa quirúrgica válida en casos seleccionados, principalmente de aneurismas de ComP y ACM.

*Palabras Clave: Aneurisma Intracraneal, Craneotomía, Procedimientos Quirúrgicos Mínim. Invasivos. (fuente: DeCS Bireme)*

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The pterional approach is used to treat a wide variety of neurosurgical pathologies, both vascular and tumoral, which are located in the anterior fossa, middle fossa and superior part of the posterior fossa[1-7]; only or in combination with other approaches allows the resection of various complex tumors of the skull base[8,9,10]. In vascular pathology, this approach allows access to most of the aneurysms of the anterior circulation and aneurysms of the most proximal and upper part of the posterior circulation, for which it uses the planes and natural corridors of the skull base that allow expose the main structures of the Willis polygon.[11,12] In recent years there has been growing interest in minimally invasive surgery or Keyhole approach (known as minicraneotomy) and in the use of these in specific locations

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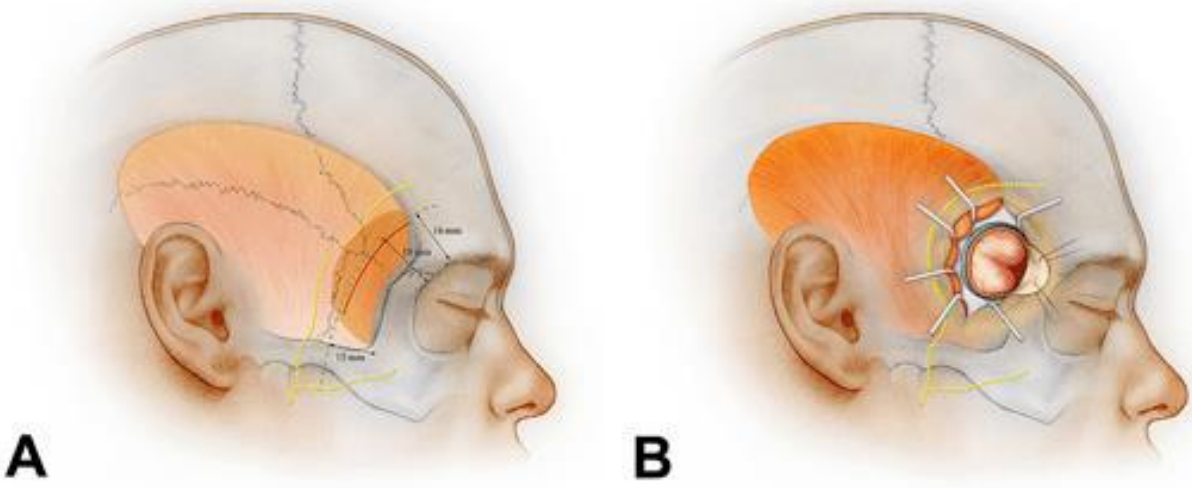


**Fig 1**. Mini-pterional or Pterional Keyhole Craniotomy: **(A)** Incision of skin and its projection on cranial structures, and **(B)** Visualization of intracranial structures such as Silvio Valley after Dural opening.

in cerebral aneurysm surgery [13-20]. Mini-pterional Craniotomy (MPT) or Pterional Keyhole Craniotomy maintains the angle of vision and the advantages of the classical pterional approach, while minimizing craniotomy and brain exposure, thus being able to achieve the advantages of minimally invasive surgery as shorter operative time, shorter hospital stays, with morbidity and mortality similar to standard pterional craniotomy[21]. In this study, we present the preliminary results of the use of the Mini-pterional Craniotomy in the cerebral aneurysm surgery performed at the Cayetano Heredia Hospital during 2009.

## METHODS

During the period from January to December 2009, 22 patients with cerebral aneurysms were operated on in the Neurosurgery Service of the Cayetano Heredia Hospital, Lima-Peru. Of the total number of patients, 6 were selected for Mini-pterional Craniotomy, based on the following criteria: Location of the aneurysm in the circle of Willis, time of bleeding, aneurysm size, neurological status at the time of surgery, as well as the presence of conditions associated pathologies such as vasospasm, hematoma, cerebral edema or severe hydrocephalus. The inclusion criteria were: 1. Aneurysms of posterior communicating artery, carotid bifurcation and middle cerebral. 2. Patients with aneurysms in the late period (> 3 days). 3. Patients in the state of Hunt and Hess, grade I-III. The exclusion criteria were: 1. Patients with aneurysms in other locations such as anterior communicator, anterior cerebral and posterior circulation. 2. Recent aneurysms (<3 days). 3. Giant aneurysms (> 2.5cm) and 4. Presence of intracerebral hematoma, severe edema, cerebral vasospasm or hydrocephalus.

### SURGICAL TECHNIQUE

The patient was placed in the supine position with the head elevated 100º to 150º to keep the head above the heart, rotated 45º to the contralateral side and supported by a 3-point pin head (Mayfield head pins). The hyperextension neck to favor venous drainage.
After asepsis, antisepsis and placement of sterile fields, an incision of 5 to 6 cm was made at approx. 3 cm lateral to the orbital rim (at the level of the hairline), curved forward and centered at the fronto-orbital point (fig 1A, 2A). Skin and subcutaneous cellular tissue were dissected coagulating blood vessels with bipolar to appreciate superficial temporal fascia which was opened according to the indirect subfascial technique: The muscular flap was sectioned at the level of the superior temporal line leaving a small implantation edge to suture the muscle to the moment of closure and, at the anterior end, the fascia was opened following the posterior part of the orbital ridge, taking care to preserve the frontal branch of the facial; In this way, the muscle flap was pulled towards the temporal region (and not forward) allowing a greater angle of vision as basal as possible in the direction of the sphenoid crest.

Then, with the help of the pneumatic drill, a trephination hole (Burr hole) was made from behind and 1cm above the fronto-orbital point, and with the help of a high-speed drill a small craniotomy 2.5 x 3cm in diameter was performed. Oval shaped centered on the sphenoid crest with slight frontal extension, which was carefully separated from the dura using the dissector, achieving appreciation of the depression in the dura mater that covered the Sylvian fissure. The lateral part of the wing of the sphenoid was then removed in the direction of the orbital fissure, with a high-speed diamond drill, to increase the opening at the level of the basal cisterns, (in cases of ACM aneurysm, this step can be not be necessary) Then, the dura was opened in the form of a crescent with a previous base (towards the base) and fixed with simple points. Prior to the Dural opening, indicated administration of 150cc of 20% mannitol or 100cc of 10% hypertonic saline solution (in <65 years) with the objective of achieving adequate relaxation of the cerebral parenchyma. (Fig 1B, 2B)

Then, the intracranial dissection was performed with the help of the surgical microscope, similar to the standard pterional craniotomy. First, the maximum amount of CSF was aspirated by opening the basal cisterns, pre-chiasmatic and optocarotid cisterns. Then, we proceeded to dissect and open the distal part of Silvian Valley, cutting the arachnoid on the front side (avoiding the temporal where the veins are located) with the help of the tip of a hypodermic needle, keeping the dissection in space subarachnoid to minimize trauma to the cerebral cortex. Then, with the help of a spatula, the frontal and temporal were separated slightly to identify the carotid artery which was followed in its distal

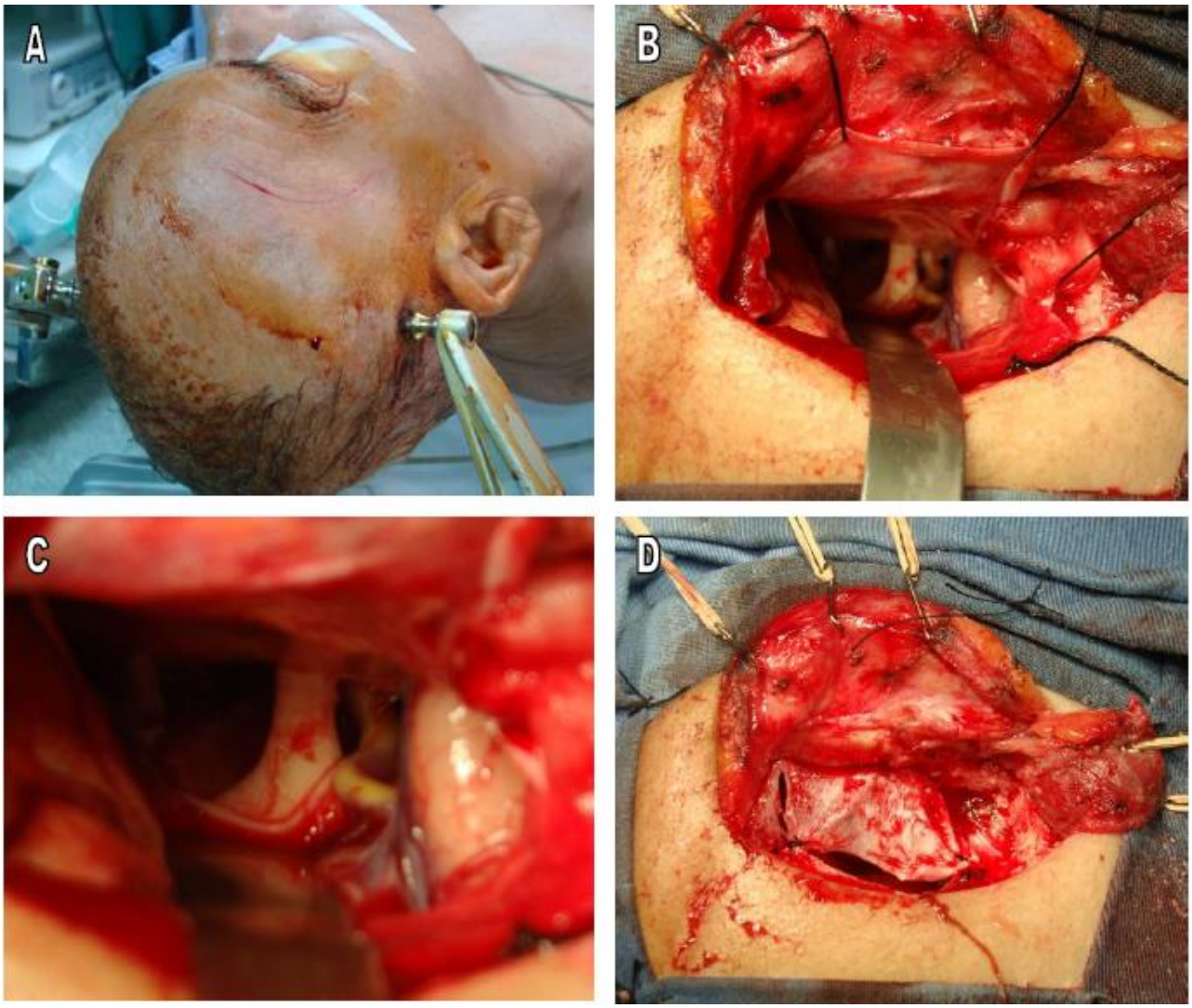


**Fig 2**. Intraoperative photos of the Mini-pterional Craniotomy or Pterional Keyhole Craniotomy in cerebral aneurysm surgery. **(A)** Semi-curved 45 cm skin incision with frontozygomatic point base, **(B)** Dural opening and visualization of skull base structures, **(C)** Optic nerve and carotid bifurcation at higher magnification. **(D)** Dura mater closure.

trajectory until its bifurcation (temporal traction was limited in cases of MCA or PComA aneurysms with lateral projection), achieving in this way proximal control, identifying and performing the clipping of the aneurysm (Fig 2C). In cases of MCA bifurcation aneurysms, dissection of the distal part of the Silvio Valley may allow direct visualization of the MCA bifurcation and the aneurysm itself, which may be clipped after proximal control.

After performing the aneurysm clipping, hemostasis was carried out carefully, cavity was washed with copious saline and closed hermetically dura with 4-0 black silk or nylon. When necessary, small fragments of Hemocollagen or muscle were placed in areas of dura defect to avoid CSF fistula.

The bone plate was fixed with black silk 2/0 placing bone fragments and bone saw dust previously collected in defect areas, all this over a layer of Hemocollagen to prevent intracranial migration. The muscle was confronted with Vicryl 2/0, carefully facing the galea. Finally, the subcutaneous cellular tissue was closed with Vicryl 3/0 and skin with nylon 3/0 separate points.

## RESULTS

From January to December 2009, 6 patients with cerebral aneurysms were operated using a Mini-pterional Craniotomy. All of them were operated on late period (> 3 d) with times that varied between 1 and 4 weeks after bleeding. According to location, the Mini-pterional Craniotomy was used more frequently, 66% (4 cases) in posterior communicating aneurysms, followed by carotid bifurcation aneurysm 17% (1 case) and cerebral aneurysm 17% (1 case).

Regarding lateralization, 50% were on the left side (3 cases, 1 PComA, 1 Bifurcation of ICA and 1 MCA) and the other 3 cases on the right side. (3 of PComA). See Table Nº 1

In relation to the Hunt and Hess scale (HH), 3 patients (50%) had HH grade I, 1 patient HH grade II and 2 patients HH grade III. Patients with HH grade I were 2 with PComA aneurysms and 1 with MCA aneurysm, while patients with HH III were 1 ICA bifurcation aneurysm and 1 PComA aneurysm. The complications related to (SHA) subarachnoid

**Table N⁰ 1:** Characteristics of patients with cerebral aneurysms operated by Mini-pterional Craniotomy o Pterional Keyhole Craniotmy

| | Location | Lateralization | Hunt&Hess Scale | Complications | Glasgow Admission | Glasgow Discharge | Rankin Discharge |
|---|---|---|---|---|---|---|---|
| **Patient 1** | PComA | Right | I | Any | 14 | 15 | 1 |
| **Patient 2** | Bif ICA | Left | III | Any | 14 | 14 | 2 |
| **Patient 3** | PComA | Right | II | Hydrocephalus | 13 | 14 | 1 |
| **Patient 4** | PComA | Right | III | Vasospasm, Hydrocephalus | 12 | 11 | 4 |
| **Patient 5** | MCA | Left | I | Vasospasm | 12 | 14 | 2 |
| **Patient 6** | PComA | Left | I | Any | 14 | 15 | 1 |

hemorrhage was: Vasospasm in 2 patients, 1 patient with mild hemiparesis and another with sequelae of severe hemiparesis; hydrocephalus in 2 patients, which required placement of a ventricle peritoneal shunt system (VPS). One of the patients with VPS had an infection of the system which was withdrawn and after antibiotic treatment repositioned again. There were no complications related to the surgical technique.

The evolution was favorable in most cases (83%) with the same or better Glasgow coma scale on postoperative period compared to the preoperative one. Thus, functional outcome was the most favorable in 3 patients who had high Rankin scale 1 (without significant symptoms) and the least favorable in 1 patient who was discharged with Rankin 4 (moderately severe disability) due to complications related to vasospasm and hydrocephalus.

## DISCUSSION

The advance of endovascular therapy and its growing development in the treatment of cerebral aneurysms is leading a new generation of neurosurgeons to use new concepts based on minimally invasive surgery with increasing frequency.[14,15,16] Keyhole surgery or mini-craniotomy is more than a miniaturization of standard surgery, it constitutes a natural evolution of this to a more refined and accurate technique, which seeks to maintain the advantages of the conventional approach but minimizing the exposure of brain tissue. Based on this concept, numerous techniques of Keyhole surgery appear in both the treatment of tumors and in brain aneurysm surgery.[13-21]

One of the Keyhole approaches most used in the treatment of cerebral aneurysms is the frontolateral approach (transciliar subfrontal approach). superciliary) [14,19,20] which provides access to most aneurysms of the anterior circulation (except those of the distal anterior cerebral) and some aneurysms of the top of the basilar. However, this approach has two important limitations: In bifurcation aneurysms of the middle cerebral artery (MCA), because the dissection is performed in a plane deep to the approach and in a narrow angle of vision, with which the dissection becomes more difficult and extensive.
The other limitation occurs in cases of some aneurysms of the posterior communicating artery (PcomA) with the dome in the posterior and caudal direction, since due to the angle of vision it is not possible to have control of the neck of the aneurysm, then a high probability of leaving a residual neck and the possibility of aneurysm rupture.

In this context, the standard pterional approach provides better access to the bifurcation of the MCA since the dissection is in a more superficial plane, achieving better vascular control; In the same way, the neck of PcomA aneurysms with a caudal direction can be seen better from a more lateral angle. The main disadvantage of the standard pterional approach is functional and cosmetic, since in addition to exposing more brain parenchyma and therefore greater manipulation of the latter, requires a larger incision which generates greater soft tissue edema in the postoperative, shaving of more extensive hair that can be psychologically stressful, problems related to atrophy of the temporal muscle and sometimes injury of the front branch of the facial, all of which can lead to increase the days of hospitalization and discomfort of the patient.

The Pterional Keyhole Approach or Mini-pterional Craniotomy as described by Figuereido et al.[22], avoids the problems associated with the classical pterional approach, while maintaining the excellent angle of vision it offers, as well as some advantages.[20,21] *First*, cosmetic advantage, since it only requires the hair shaving of approx. 1 cm behind the hairline plus a smaller incision that generates less soft tissue edema. *Second*, functional advantage, since there is less manipulation of the temporal muscle which is sectioned following the natural course of its fibers, thereby decreasing the possibility of muscle atrophy, there is also a lower probability of injury to the frontal branch of the facial nerve. *Third*, less manipulation of the cerebral parenchyma and therefore less risk of postoperative cerebral edema, for which optimal drilling of the sphenoid crest is essential (which creates a space in the form of a triangular prism on which the vallecula rests) and the opening of the basal cisterns which contributes in more than 50% of the reduction of the cerebral volume allowing a comfortable dissection of the Silvian Valley, which allows to have an adequate vascular control before facing the aneurysm.

There are 2 main questions that a neurosurgeon asks when preparing to perform a Mini-pterional Craniotomy. *First*, if the surgical field will be large enough to perform the dissection and clipping the aneurysm; and *Second*, if through this approach it is possible to solve a complication that may occur during surgery such as intraoperative rupture of the aneurysm. Regarding the first point, it is essential to have the maximum possible space for which it is necessary an adequate selection of patients, optimum spinach crest drilling and maximum cerebral relaxation, in such a way that adequate vascular control is achieved before facing the aneurysm, that is, at the time of the aneurysm dissection, the depth vision should be the same as in a standard pterional craniotomy. In relation to the second

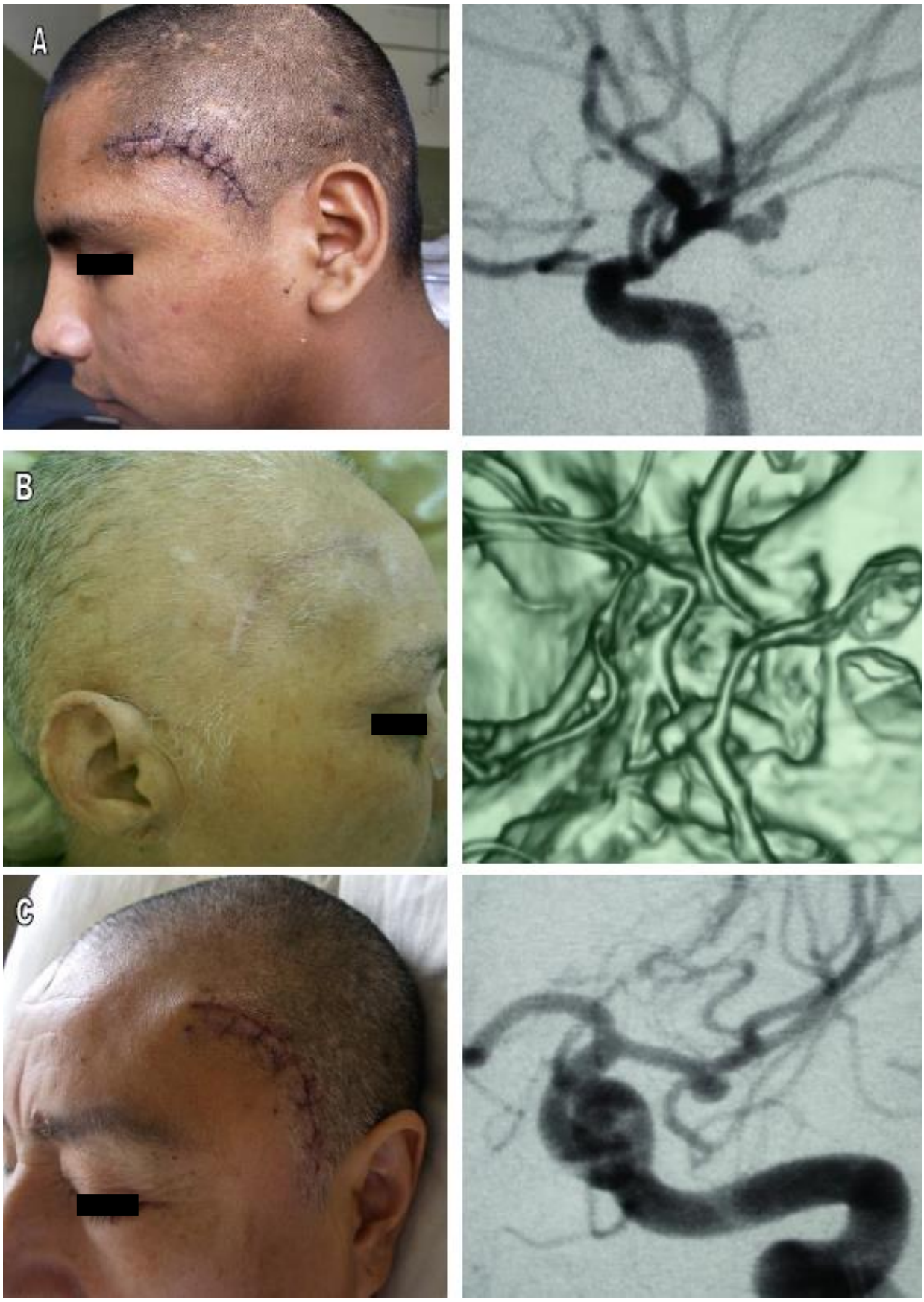


**Fig 3**. Postoperative pictures of patients undergoing Mini-pterional Craniotomy, with their corresponding aneurysms of **(A)** left PComA, **(B)** right PComA and **(C)** left MCA, respectively.

question, if you have a comfortable surgical vision and adequate vascular control, it is possible to handle any unexpected complication such as an intraoperative rupture, similar to a standard craniotomy.**21**

In our study, we had no problems in achieving vascular control and addressing the aneurysm after dissection of the Silvio Valley. Spatulas were used only for slight traction of the parenchyma mainly of the frontal lobe, although the greatest cerebral relaxation was achieved after the opening of the basal cisterns. Vascular control was achieved without major difficulty, but the placement of the clip was in some cases difficult, mainly because the distal end of the classic clipping clamp (large size) obstructed the complete vision of the aneurysm, since it was at an angle similar to the angle of view of the microscope. This problem was solved by varying the angle of the microscope during the placement of the clip, as much as the Mini-pterional Craniotomy allowed (In a classical pterional craniotomy the angulation of the microscope can vary in a greater range). Other alternatives to solve this problem during the mini-pterional approach, is the use of thin coaxial clippers ("in pistol grip") and the use of the endoscope (2.7mm and 30º angle) which also allows a better visualization of the neck of the aneurysm, as well as to avoid that perforating branches are included in this one during the clipping, the same ones that usually are not visible only with the use of the microscope.

Although the size of the sample is the main limitation of the study to draw greater conclusions, we can say that it is technically possible to use this approach in the treatment of PComA, ICA bifurcation and MCA aneurysms (and potentially in AComA aneurysms). In order to achieve this goal is mandatory adequate selection of cases, optimums sphenoid drilling, achieve a good cerebral parenchyma relaxation and the availability of appropriate instruments for this minimally invasive technique.

## CONCLUSION

Mini-pterional Craniotomy is a minimally invasive technique in cerebral aneurysm surgery, which maintains the advantages and excellent viewing angle of the standard pterional approach but minimizes brain parenchyma exposure and soft tissue manipulation. It constitutes a valid surgical alternative in selected cases, mainly of PComA and MCA aneurysms, being essential an adequate drilling of the sphenoidal crest and the maximum cerebral relaxation. Likewise, as it is an evolution of the classical pterional approach, it raises the use of new instruments such as the use of coaxial clippers and the support of the neuroendoscope to optimize the results of surgery.

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**Disclosures**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper. They also report that this article is an update of the article published in the old Spanish version of the Peruvian Journal of Neurosurgery.


**Author Contributions**

*Conception and design:* Flores, Fuentes-Dávila, Alaba. *Drafting the article:* Flores. Critically revising the article: Flores, Alaba. *Reviewed submitted version of manuscript:* Flores. *Approved the final version of the manuscript on behalf of all authors:* Flores.


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