

# Morphometric Comparison of the Pterional Trans-Sylvian and the Pretemporal Trans-Clinoidal Approaches to the Posterior Communicating Artery

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**BACKGROUND:** Posterior communicating (Pcom) aneurysms in the modern era have tended toward increased complexity and technical difficulties. The pretemporal approach is a valuable extension to the pterional approach for basilar apex aneurysms, but its advantages for Pcom aneurysms have not been previously elucidated.

**OBJECTIVE:** To quantify characteristics of the pretemporal approach to the Pcom.

**METHODS:** We dissected 6 cadaveric heads (12 sides) with a pretemporal transclinoidal approach and measured the following variables: (1) exposed length of internal carotid artery (ICA) proximal to the Pcom artery; (2) exposed circumference of ICA at the origin of Pcom; (3) deep working area between the optic nerve and tentorium/oculomotor nerve; (4) superficial working area; (5) exposure depth; and (6) the frontotemporal (superior posterolateral) and (7) orbito-sphenoidal (inferior anterolateral) angles of exposure.

**RESULTS:** Compared with pterional craniotomy, the pretemporal transclinoidal approach increased the exposed length of the proximal ICA from 3.3 to 11.7 mm ( $P = .0001$ ) and its circumference from 5.1 to 7.8 mm ( $P = .0003$ ), allowing a 210° view of the ICA (vs 137.9°). The deep and superficial working areas also significantly widened from 53.7 to 92.4 mm<sup>2</sup> ( $P = .0048$ ) and 252.8 to 418.2 mm<sup>2</sup> ( $P = .0001$ ), respectively; the depth of the exposure was equivalent. The frontotemporal and sphenoid-Sylvian angles increased by 17° ( $P = .0006$ ) and 10° ( $P = .0037$ ), respectively.

**CONCLUSION:** The pretemporal approach can be useful for complex Pcom aneurysms by providing easier proximal control, wider working space, improved aneurysm visualization, and more versatile clipping angles. Enhanced exposure results in a potentially higher rate of complete aneurysm obliteration and complication avoidance.

**KEY WORDS:** Pterional approach, Posterior communicating aneurysm, Pretemporal approach, Anterior clinoid process, Optic nerve, Oculomotor nerve, Anatomy, Sylvian fissure

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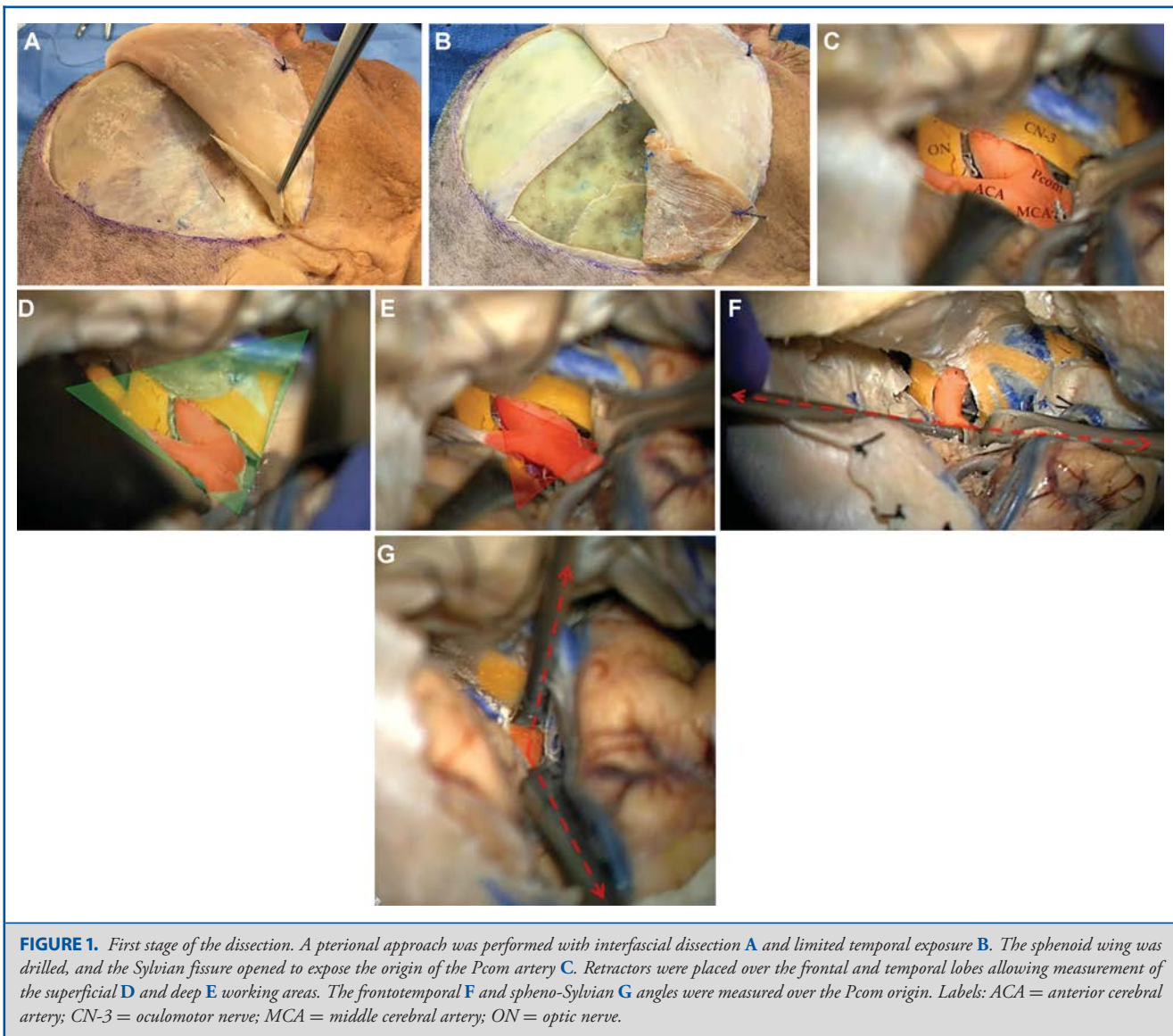
**A**neurysms arising from the posterior communicating (Pcom) segment of the internal carotid artery (ICA) are the second-most common intracranial aneurysms.<sup>1,2</sup> The advent of the endovascular approach to address morphologically favorable aneurysms has shifted the use of open surgery to more technically challenging aneurysms.<sup>3</sup>

Different surgical approaches have been described for the treatment of Pcom aneurysms, which mainly include the pterional trans-Sylvian

approach,<sup>4</sup> the subtemporal approach, the lateral supraorbital approach,<sup>5</sup> and their variations. The pretemporal transcavernous approach was introduced for the treatment of basilar apex aneurysms.<sup>6–8</sup> A limited version of the approach, with restricted transcavernous and trans-Sylvian components, has been increasingly used by the senior author of our manuscript for clipping Pcom aneurysms.<sup>8,9</sup>

In the pterional approach, the orbito-frontal cortex and the temporal pole hinder the exposure. The carotid artery also obscures the laterally projecting Pcom, its perforators, and – in many cases – a part of the aneurysm. The aim of the pretemporal transclinoidal approach is to achieve a more direct

**ABBREVIATIONS:** **ACP**, anterior clinoid process; **COZ**, cranio-orbitozygomatic; **ICA**, internal carotid artery; **Pcom**, posterior communicating



**FIGURE 1.** First stage of the dissection. A pterional approach was performed with interfascial dissection **A** and limited temporal exposure **B**. The sphenoid wing was drilled, and the Sylvian fissure opened to expose the origin of the Pcom artery **C**. Retractors were placed over the frontal and temporal lobes allowing measurement of the superficial **D** and deep **E** working areas. The frontotemporal **F** and sphenoid-Sylvian **G** angles were measured over the Pcom origin. Labels: ACA = anterior cerebral artery; CN-3 = oculomotor nerve; MCA = middle cerebral artery; ON = optic nerve.

and circumferential exposure of the aneurysm and the parent artery.

A recent retrospective study showed a significantly reduced risk of silent and symptomatic strokes in ruptured aneurysms treated with a pretemporal approach compared to the pterional approach.<sup>9</sup> The superior results were thought to be related to a better visualization of the Pcom complex and the surrounding perforators. To better understand the anatomical advantages of the approach, we performed an anatomical morphometric study focused on the Pcom region in comparison to the classic pterional approach.

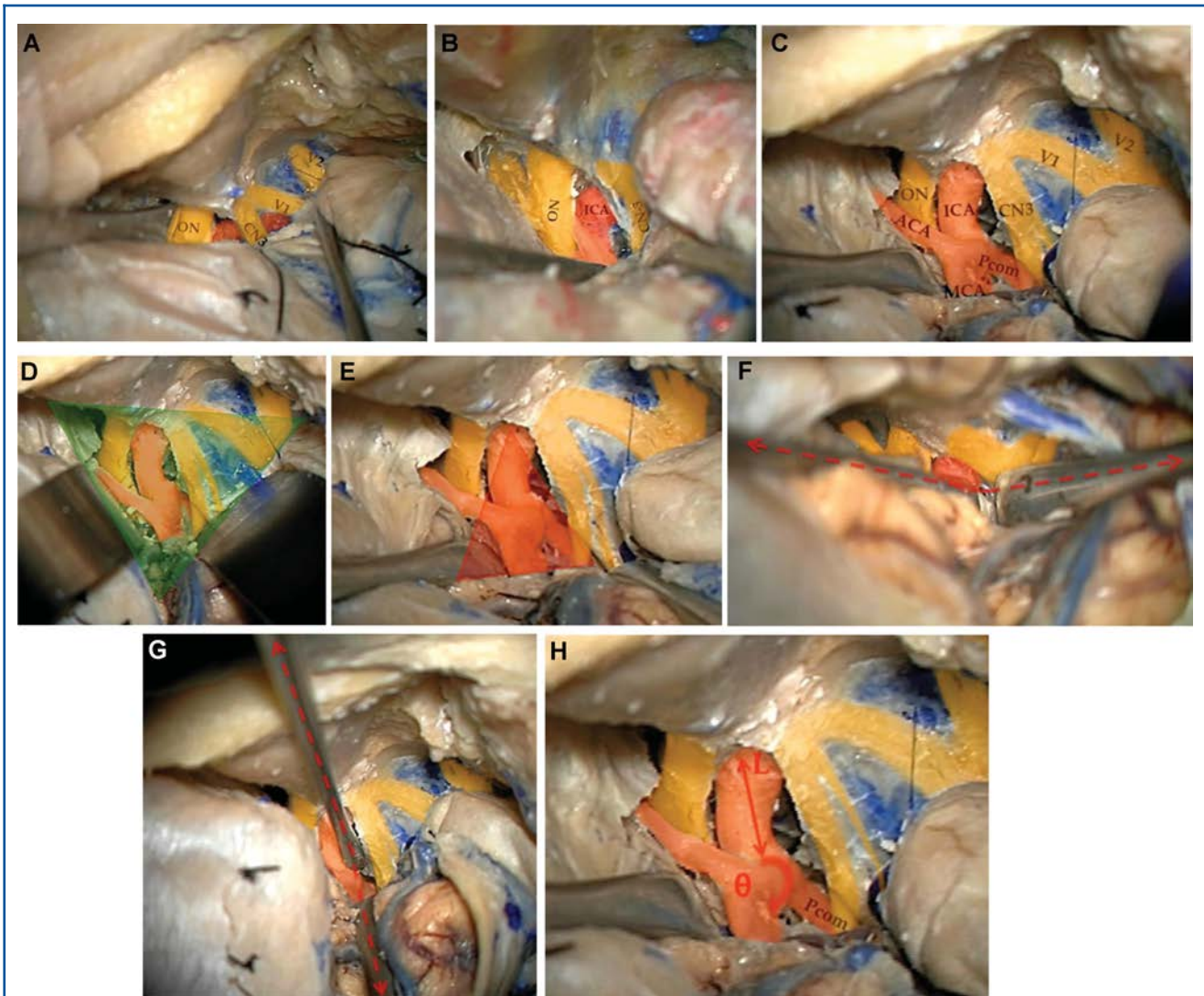
## METHODS

The following is a cadaveric study; no appropriate study checklist is available. Institutional review board approval was waived. Intraoperative

images and descriptions of patients depicted in the figures are completely deidentified; consent was therefore not obtained.

### Stages of the Dissection

A total of 6 embalmed cadaveric heads (12 sides) with no known intracranial lesions were injected with colored silicon. The cadavers were positioned similarly to a standard surgery for a pretemporal or a pterional approach.<sup>8</sup> In the first stage of the dissection, we performed a pterional approach as described by Yasargil<sup>4</sup> (Figure 1). The temporalis muscle was retracted anteriorly and inferiorly after an interfascial dissection. Following a standard craniotomy centered on the Sylvian fissure, the sphenoid wing was drilled to the level of the meningo-orbital band. The dura was opened and the Sylvian fissure was split from distal to proximal.<sup>4</sup> Care was taken to preserve the cortex and the arachnoid tissue using high magnification and wet cottonoids to maintain the brain's consistency for the next steps of the dissection.

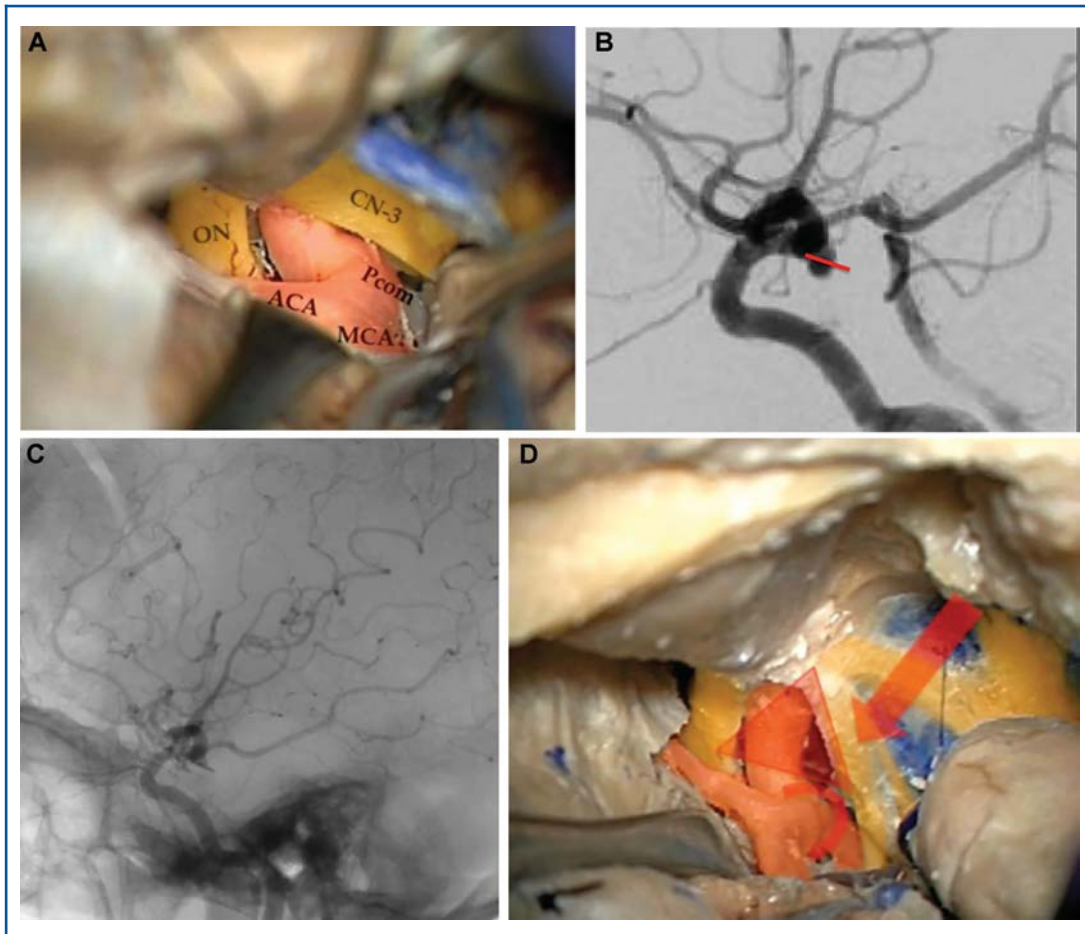


**FIGURE 2.** Second stage of the dissection. The dura was closed, and the temporalis muscle mobilized further to extend the craniotomy over the temporal pole. The lateral wall of the orbit was drilled, and the temporal dura was peeled, exposing the superior orbital fissure **A**. We exposed the clinoidal ICA after performing an extradural clinoidectomy **B**. We reopened the dura to visualize the Pcom region **C**. Again, the superficial **D** and deep **E** working areas, and the frontotemporal **F** and spheno-Sylvian **G** angles were measured. We also measure the length ( $L$ ) of the ICA proximal to the origin of the Pcom available for temporary clipping, and the exposed of the ICA circumference just distal to Pcom (arc angle  $\theta$ ) **H**. Labels: ACA = anterior cerebral artery; CN-3 = oculomotor nerve; ICA = internal carotid artery; MCA = middle cerebral artery; ON = optic nerve; V1 = ophthalmic branch of the trigeminal nerve; V2 = maxillary branch of the trigeminal nerve.

The frontal and temporal lobes were retracted to maximize exposure of the Pcom complex, without disturbing the integrity of the cerebral cortex. The optic nerve was also dissected and mobilized to enhance proximal exposure of the ICA. Measurements for the pterional approach were done at this point (see below).

The second stage of the dissection was to perform a pretemporal approach (Figure 2),<sup>8,9</sup> which was initiated by closing the dura using 4.0 silk sutures. Interfascial dissection of the temporalis muscle was completed to expose parts of the zygoma and frontal process of the zygoma. This step allowed for a more posterior and inferior retraction

of the temporalis muscle, exposing the anterior temporal pole. The squamous part of the temporal bone was further removed. A partial orbitotomy was accomplished by drilling part of the orbital roof and lateral orbital wall, exposing the periorbita. Drilling of the sphenoid bone was further continued to remove the anterior clinoid process (ACP) by disconnecting its 3 attachments: sphenoid wing, optic strut, and roof of the optic canal. This was facilitated by retracting the temporal dura and dissecting its dura propria from the superior orbital fissure and from a limited portion of the anterior-most aspect of the lateral wall of the cavernous sinus (down to the second division of the trigeminal nerve



**FIGURE 3.** Anatomical analysis. The pterional approach, centered over the Sylvian fissure and sphenoid wing, provides a “top-down” view of the Pcom region **A**, where at least part of the aneurysm (underbelly) could be hidden by the ICA while the aneurysm itself is hiding the course of the Pcom and its perforators. Residual Pcom aneurysm after surgery at an outlying facility **B**, and **C** illustrating a common blind spot of the pterional approach. This required retreatment with a pretemporal exposure. (Images courtesy of the Arkansas Neuroscience Institute.) The pretemporal approach **D** provides additional working space and available temporary clipping through the clinoidal triangle (red triangle) and increases the exposed circumference of the ICA (curved arrow). It also shifts the exposure inferior and lateral, unraveling the ICA-aneurysm-Pcom complex (straight arrow).

[V2]). After performing our clinoidectomy and exposing the clinoidal segment of the ICA, the distal dural ring was opened.

We then cut the dura overlying the proximal limb of the Sylvian fissure in a Y-shape fashion with the leg of the Y orthogonal to the midpoint of the clinoid process. Further opening along the remaining 2 limbs of the Y was carried medially over the optic nerve and laterally over the oculomotor nerve, respectively. The carotid collar was then fully dissected, and the carotid-oculomotor membrane cut, allowing for further mobilization of the ICA. A tack-up stitch on the temporal dural cut of the Y opening allowed for retraction of temporal pole away from the Pcom region, producing a more horizontal and leveled view of the surgical anatomy.

### Measurements

In both the pretemporal transclinoidal and the pterional trans-Sylvian approaches, the degree of brain retraction was standardized by using the

maximal possible pressure that would not sink the retractors into brain parenchyma. The retractor blades were checked and adjusted to avoid any disruption of the cortex.

### Superficial Surface and Depth of Exposure

In each approach, we identified and approximated to a triangle the points of the superficial surgical field at the level of the dura from which the target (ie, the origin of Pcom) is visualized through the microscope. The borders of the triangle were the superior temporal gyrus inferiorly, the inferior frontal gyrus superiorly, and a line joining both along the sphenoid wing anteriorly. Surface areas were calculated using Heron’s formula. The depth of the surgical field, from the surface area to the target, was measured from the center of the triangle at the dura to the Pcom origin.

### Deep Working Area

This was approximated to a triangle centered at the Pcom, limited by the optic nerve superiorly, the oculomotor nerve and tentorium/petroclinoid folds inferiorly, and a line joining both posteriorly.

### Exposed Length and Circumference of the ICA

Using fine calipers, the length of the exposed ICA proximal to Pcom was measured in millimeters. The circumference of the exposed ICA was estimated in degrees by measuring the length of the exposed arc of the ICA ( $L$ ) and deducing the angle using the following formula: arc (degrees) =  $180 L/\pi r$ , where  $r$  is the radius of the ICA.

### Angles of Exposure

For each approach, and after applying the retractor blades, we measured with a protractor a medio-lateral angle between the frontal and temporal lobes, which we termed the *frontotemporal angle*. In the same manner, we measured an anteroposterior angle, the *spheno-Sylvian angle*.

### Statistical Analysis

Averages of the different variables were compared using the Student's  $t$ -test, and a value of  $P \leq .05$  was determined to be statistically significant.

## RESULTS

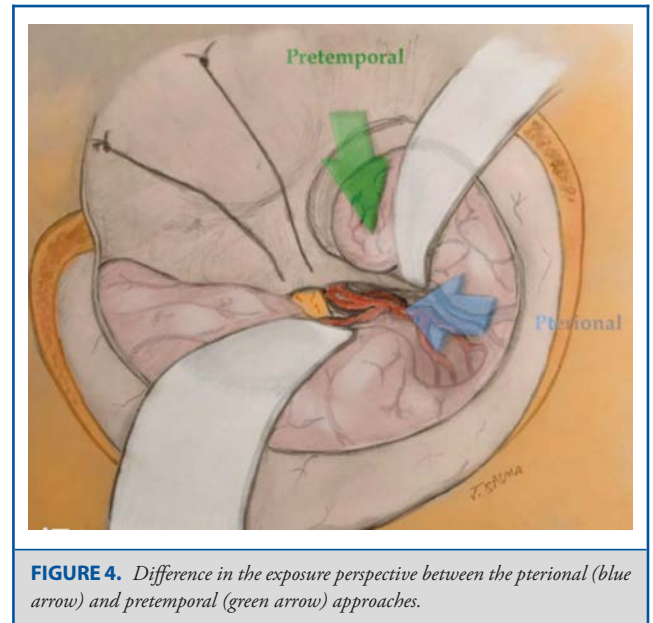
The average ICA perimeter was 13.3 mm, with an average radius of 2.13 mm. Compared with the pterional craniotomy, the pretemporal transclinoid approach increased the exposed length of the proximal ICA from 3.3 to 11.7 mm ( $P = .0001$ ), and its circumference increased from 5.1 to 7.8 mm ( $P = .0003$ ), allowing a  $210^\circ$  view of the ICA (vs  $137.9^\circ$  for pterional craniotomy). The pretemporal approach provided a more lateral and inferior angle of exposure to the Pcom complex, and it unraveled the Pcom artery behind the ICA from its origin to its further early distal course (Figure 3).

The deep working areas significantly widened from  $53.7 \text{ mm}^2$  with the pterional approach to  $92.4 \text{ mm}^2$  using a pretemporal exposure ( $P = .0048$ ), which was mainly due to the space gained in the clinoid triangle and that obtained from cutting the petroclinoid folds. The superficial area of exposure increased from  $252.8$  to  $418.2 \text{ mm}^2$  ( $P = .0001$ ), most notably on the temporal side. There was no significant difference in the depth of the exposure between the 2 approaches ( $43.1 \text{ mm}$  vs  $42.7 \text{ mm}$ ). The frontotemporal and spheno-Sylvian angles increased significantly from  $50.8^\circ$  to  $67.6^\circ$  ( $P = .0006$ ) and from  $43.1^\circ$  to  $53.4^\circ$  ( $P = .0037$ ), respectively (Figure 4).

Table summarizes the results of the different variables measured after a pterional and a pretemporal approach.

## DISCUSSION

A basic dictum of a successful aneurysm clipping is enhanced visualization of the aneurysm dome and neck, parent artery, and nearby branching arteries and perforators.<sup>4,10</sup> Through a traditional pterional trans-Sylvian route, the anteroposterior axis



**FIGURE 4.** Difference in the exposure perspective between the pterional (blue arrow) and pretemporal (green arrow) approaches.

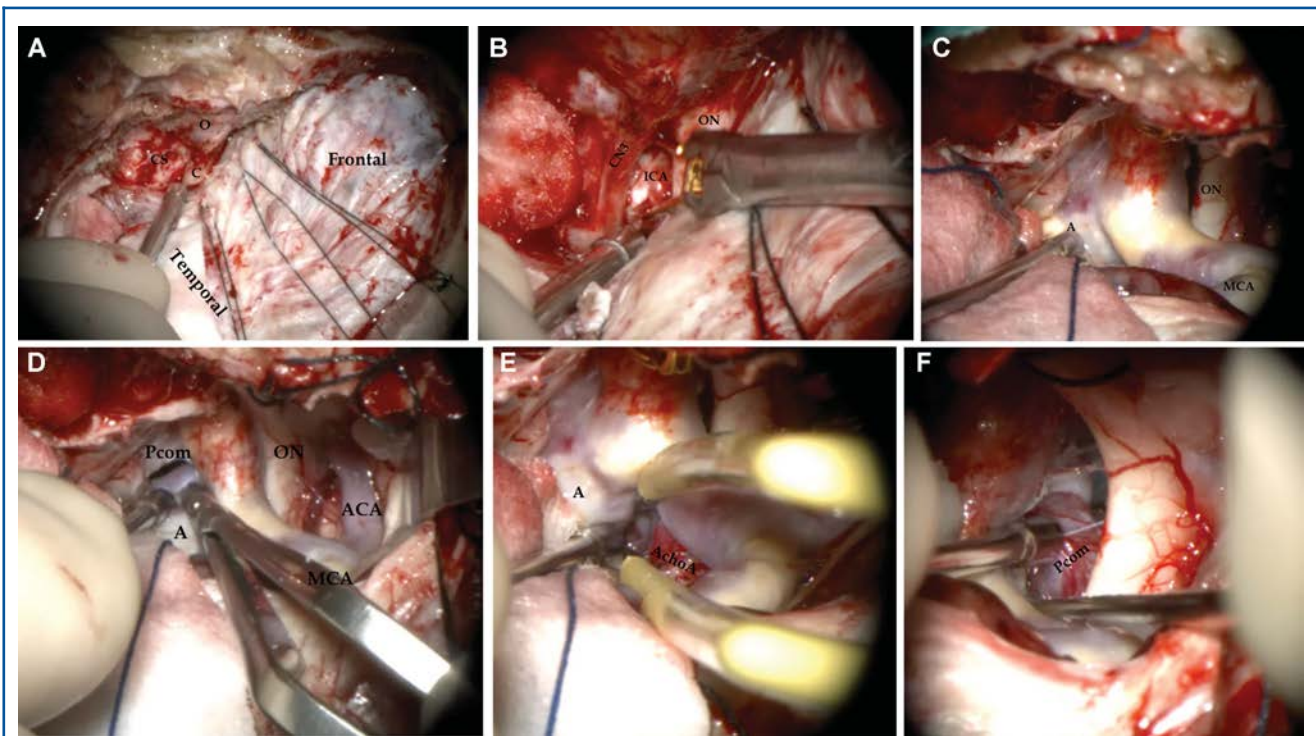
of exposure of the Pcom is commonly found along the supraclinoid ICA, thus hiding the Pcom artery behind the aneurysm.<sup>11</sup> Yasargil overcame this difficulty by opening the aneurysm dome and partially resecting it in order to improve visualization of the Pcom artery. However, this maneuver is performed at the end and is often not undertaken by most inexperienced neurosurgeons. The pretemporal transclinoid approach provides enhanced exposure of the Pcom takeoff and its perforators prior to clipping (Figures 5 and 6), which may confer a lower risk of strokes in surgically treated ruptured Pcom aneurysms.<sup>9</sup>

In the pretemporal approach, a limited dural opening and Sylvian fissure split are required to access the carotid cistern and the clinoid and oculomotor triangles. This is largely related to the added anterior and inferior angles of attack to the Pcom area. These angles enlarge the  $360^\circ$  exposure of the aneurysm and the parent artery, thus bringing any hidden “aneurysm under-belly” into view (Figure 3). Furthermore, constant proximal control is provided by removing the ACP and exposing the clinoid segment of the ICA.<sup>12</sup> Exposure of the Pcom along its distal course toward the posterior fossa also permits distal control to be available if necessary. Lastly, clipping of the aneurysm neck can be performed parallel to the course of the parent vessel. As opposed to low-lying basilar apex aneurysms, removing the posterior clinoid process is not required.<sup>8</sup>

Drilling the ACP for Pcom aneurysm surgery has proven to be a very valuable step for complex Pcom aneurysms.<sup>3,4,6,13</sup> However, its preoperative indications in the setting of the traditional pterional approach continue to be a matter of debate. Among the suggested variables are aneurysm size, distance from the ACP to aneurysm neck, and the angle between the supraclinoid ICA and skull base.<sup>14-16</sup> We did not compare the pretemporal transclinoid approach to a pterional approach with an added intradural

TABLE. Anatomical Results				
Variable	Pterional	Pretemporal	t-test	P value
Superficial area (mm <sup>2</sup> )	252.8	418.2	5.8	.0001 <sup>a</sup>
Deep area (mm <sup>2</sup> )	53.7	92.4	3.3	.0048 <sup>a</sup>
Distance to surface (mm)	42.7	43.1	0.08	.93
Frontotemporal angle (degrees)	50.8	67.7	4.4	.0006 <sup>a</sup>
Spheno-Sylvian angle (degrees)	43.1	53.4	3.5	.0037 <sup>a</sup>
Proximal ICA (mm)	3.3	11.7	12.3	.0001 <sup>a</sup>
Exposed ICA circumference (mm)	5.1	7.8	4.7	.0003 <sup>a</sup>
Exposed ICA arc angle (degrees)	137.9	210.3	4.7	.0003 <sup>a</sup>

ICA = internal carotid artery.  
<sup>a</sup>Statistically significant difference.

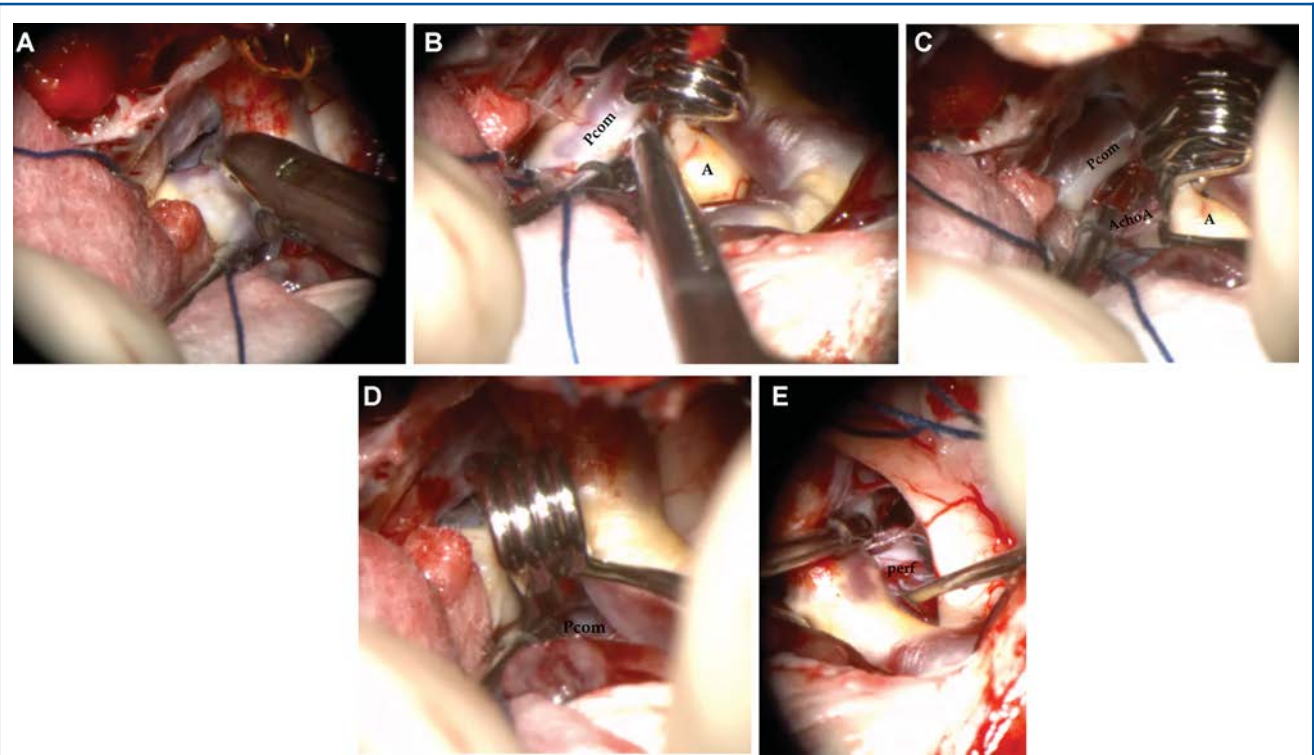


**FIGURE 5.** Case illustration of a pretemporal exposure of a left-sided Pcom aneurysm. **A**, The clinoid (C) is exposed and removed extradurally. **B**, allowing for early available temporary clipping. **C**, A limited dural opening and proximal Sylvian fissure dissection are done to expose the aneurysm, origin of the Pcom artery **D**, anterior choroidal artery (AchoA) **E**, and the distal course of the Pcom artery **F**. (Images courtesy of the Arkansas Neuroscience Institute.) Labels: A = aneurysm; ACA = anterior cerebral artery; CN-3 = oculomotor nerve; CS = anterior-most of the lateral wall of the cavernous sinus; ICA = internal carotid artery; MCA = middle cerebral artery; O = orbit/superior orbital fissure; ON = optic nerve.

clinoidectomy. However, we believe that a clinoidectomy can be performed with more ease through an extradural pretemporal dissection. The extradural exposure of the temporal pole and its gentle retraction brings the ACP to the surface, which makes drilling it more straightforward.

Advantages of clinoidectomy for the Pcom region during a mini-pterional craniotomy were previously described in

terms of increased working space.<sup>13</sup> However, combining the clinoidectomy with a pretemporal dissection further shifts the entire perspective of exposure to the Pcom origin. Thus, drilling the ACP also makes the surgical route predominantly extradural and in a more direct trajectory toward the Pcom origin (Figure 4). The advantage of an anterior clinoidectomy may be amplified by cutting the petroclinoid folds and the tentorial edge. This



**FIGURE 6.** Clipping of a left-sided Pcom aneurysm (same case continued from Figure 5). A side-curved clip is applied parallel to the parent artery **A**. The origin of the Pcom artery **B** and anterior choroidal artery (AchoA) **C** are inspected. The Pcom's course is inspected further distally as it curves around the ICA **D** and gives off perforators (perf) in the optic-carotid triangle **E**.

further increases the deep working area and releases the attachments of the oculomotor nerve, increasing the chances of its recovery.<sup>17</sup>

Orbitotomy involving the roof and lateral wall of the orbit without incorporating the orbital rim and extending it toward the optic canal helps early in the exposure to dearticulate the medial portion of the anterior clinoid extradurally. It also allows for stitch-facilitated anterior retraction of the periorbita, which provides for greater visualization of the parasellar and supraclinoid spaces. The increase in the sphenoid-Sylvian angle compared with the pterional approach in our study can be attributed to the orbitotomy step of the approach.

The cranio-orbitozygomatic (COZ) approach and its variations have been widely used for the surgical treatment of complex aneurysms. The advantages of the COZ include a significant working angle of exposure afforded by removing the orbital bar and zygoma while minimizing frontal lobe retraction. We feel that the added surgical time and the steps necessary could be mitigated with the use of the pretemporal approach. The pretemporal approach is, in fact, an uninterrupted extension of the pterional approach compared with the COZ. In addition, the risks of enophthalmos and eye injury, as well as injury

to the supraorbital nerve and branches of the facial nerve are higher with the COZ.

As with all cadaveric studies, a limitation of our study is that exposure in cadaveric specimens does not account for real-life brain consistency, cerebrospinal fluid release, and hemostasis. Nonetheless, the *relative* difference between the 2 approaches performed sequentially on the same side of the same cadaveric specimen is well validated. The exact pressure of brain retraction was not quantitatively measured. We did not provide clinical data to demonstrate the superiority of the pretemporal approach. A previous retrospective report has shown a significantly reduced risk of ischemic complications using this approach for ruptured Pcom aneurysms over a pterional approach,<sup>9</sup> and this benefit will need further prospective studies.

## CONCLUSION

The pretemporal transclinoid augments the deep and superficial working areas, allows for earlier temporary clipping, and shifts the surgical exposure to a more lateral/temporal perspective, unraveling the ICA-aneurysm-Pcom-artery complex.

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## Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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Tennessee Health Science Center, Memphis, Tennessee) for technical and copy editing, preparation of the manuscript, figures and tables for publishing, and publication assistance. They also thank Dr Cai Lee for his professional artistic contributions to the figures.

## COMMENTS

**A**uthors of this manuscript discuss the benefits of performing an anterior clinoidectomy for the treatment of posterior communicating (PComm) aneurysms. Based on a meritorious anatomical analysis, they demonstrated that removal of the anterior clinoid process through a pretemporal approach increases the circumferential exposure of the PComm and internal carotid artery. As the authors concluded, the pretemporal route is a very straightforward route that allows good exposure of PComm aneurysms, while minimal or no Sylvian dissection is required.<sup>1</sup> Nevertheless, despite the benefits in improving the working angle, it requires of further bone drilling, larger exposure of the temporal dura, and increased operative times.

Likewise, ACP removal has demonstrated to provide enhanced exposure and improvement of the surgical maneuverability along the paraclinoid region.<sup>2</sup> As a consequence, it has been suggested that an anterior clinoidectomy can be performed in some PComm aneurysms, such as those that are pointing posteriorly or in cases in which the dome is located at a distance inferior to 4 mm from the tip of the ACP.<sup>3</sup> An anterior clinoidectomy can be done with a reasonable risk in experienced hands. However, complications such as transient oculomotor palsy and CSF leaks have been reported and its use should be reserved for selected cases.

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**T**his is an excellent anatomical paper that reinforces a very important concept: the properly applied neuroanatomy and the mastery microsurgery are the keys for a successful treatment of the more complex neurosurgery cases. We agree completely with all the concepts showed in this paper. Our group share a very similar philosophy with the authors, we applied the same concepts but using an extradural minipterional and minipretemporal approaches to deal with the same complex cases including paraclinoid and sphenopetroclival lesions.<sup>1-5</sup> One important point stressed by the authors is the versatility of the approach and the fact that in vivo conditions are much better to improve the exposure, based in the CSF extraction, the mobilization of the structures and the gently compression of the arteries that is not possible in the cadaveric models. This is a very interesting paper that show again that the modern microsurgery plus rationale applied neuroanatomy are



the clues for the success in complex skull base tumoral and vascular lesions.

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