Anterior Communicating Artery Aneurysm Clipped Via an Endoscopic Endonasal Approach: Technical Note

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BACKGROUND: The anterior communicating artery (AcoA) aneurysm is one of the most challenging aneurysms. As endovascular techniques evolve, a remaining challenge is the reduction of complications related to the surgical approach. Although the endonasal approach is widely used for pituitary adenomas and is increasingly popular for suprasellar tumors, only 2 aneurysm cases have been reported.

OBJECTIVE: To the best of our knowledge, we are reporting the first case of successful endoscopic endonasal clipping of an unruptured ACoA aneurysm.

METHODS: An ACoA aneurysm was discovered in a 55-year-old man before he was to undergo an endoscopic biopsy of an orbital lesion. Because of the operative corridor formed during this first operation and ideal conformation of the aneurysm for this line of sight, we formulated an endoscopic route for this ACoA aneurysm.

RESULTS: An endoscopic endonasal transplanum-transtuberculum approach was performed. Proximal and distal control was obtained, and the AcoA aneurysm was successfully clipped. The postoperative course was uneventful with a rapid recovery.

CONCLUSION: On the road of innovation in the treatment of intracranial aneurysms, the endoscopic approach provided another option whose value must be weighed in terms not only of feasibility but in the patient's best interest. We caution extreme prudence if considering this procedure as an alternative to well-established techniques. Yet its upward route offers limited retraction for deep-seated lesions. Rapid progress of endoscopic techniques may prove promising for well-selected cases of ACoA aneurysms.

KEY WORDS: Aneurysm, Anterior communicating artery, Endonasal approach, Endoscopic

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The road to innovation for the treatment of intracranial aneurysms is paved with many steps and missteps as surgeons determine not only what can be done, but more importantly, what should be done in the patient's best interest. For anterior communicating artery (ACoA) aneurysms, which represent 30% to 37% of intracranial aneurysms, treatment options include coiling and microsurgical approaches. Considering the surgical approaches, specifically the pterional transsylvian, pterional subfrontal, and interhemispheric approach, the pterional approach offers excellent results and is the gold standard of treatment of ACoA aneurysms. However, sylvian fissure dissection, frontal lobe retraction, and partial gyrectomy are often necessary to improve the exposure of the ACoA complex; these steps risk injury to the brain, contributing to the patient's neuropsychological morbidity.

During the past 20 years, the use of cranial base techniques and keyhole approaches, such as the supraorbital craniotomy, have been used to reduce brain exposure and retraction for treatment of ACoA aneurysms. The main drawback of such approaches is the narrow surgical corridor through which an intraoperative rupture can be difficult to manage, particularly in the case of

ABBREVIATIONS: AcoA, anterior communicating artery

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a tight and/or swollen brain. Building on the keyhole approach to reduce brain retraction, the endonasal route appears to offer an even more refined line of sight for a midline lesion located under the brain and frontal lobes. Using the endonasal approach, the surgical corridor is certainly narrow but is not created by the retraction of the brain, and the panoramic view offered by the endoscope is an advantage that may compensate partially this narrow corridor. Although the endonasal approach is now widely used for pituitary adenomas and is increasingly popular for anterior cranial base and suprasellar lesions, its application remains controversial for vascular lesions. To date, we found only 2 reports of endoscopic endonasal clipping of aneurysms,[1,2] and 1 report of a microscopic transsphenoidal approach for an ACoA aneurysm.[3] The main criticisms of this corridor are its narrowness, the difficulty to achieve proximal vascular control, and the risk of cerebrospinal fluid (CSF) leak.

In this case report, we report on a patient who underwent successful clipping of an unruptured ACoA aneurysm via an endoscopic endonasal transplanum-transtuberculum approach. To the best of our knowledge, this is the first reported case of an ACoA aneurysm surgically treated using this technique. We evaluate the potential for this innovation as an endonasal technique for well-selected cases of ACoA aneurysms with favorable anatomy.

CASE REPORT

A 55-year-old man initially presented with progressive decreased visual acuity on the right side. Computed tomography and magnetic resonance imaging identified a lesion along the medial aspect of the orbital apex and optic canal. A systemic workup identified no other site of involvement or systemic diseases. When symptoms worsened after 2 months of steroid therapy, the patient underwent an endoscopic biopsy with optic nerve decompression. During localization of this small tumor with a neuronavigation system (BrainLAB, Feldkirchen, Germany), computed tomography with contrast coincidentally identified an ACoA aneurysm; this was subsequently confirmed by computed tomography angiography. After discussions with the patient, we opted to postpone treatment of the aneurysm until after tumor resection. After the endoscopic biopsy, histopathological diagnosis revealed an inflammatory pseudotumor, and the patient underwent further treatment with steroids.

After tumor resection, 4-vessel cerebral angiography with 3-dimensional reconstruction was performed to define the aneurysmal anatomy. A 7-mm ACoA aneurysm projecting superiorly was identified with a daughter lobule at the base (Figure 1), and the right A1 segment was absent. In formulating treatment options with the endovascular team, we determined that coiling would be inappropriate because of the aneurysm's small size and its relatively broad neck. Because the endoscopic biopsy of the orbital apex lesion formed a potential corridor to the aneurysm, we then considered endoscopic endonasal clipping. In preparation, we used 3-dimensional reconstruction to envision the surgical view of the aneurysm and ACoA complex and to plan clip application[4] (Figure 1). Additional factors that provided the impetus for this endoscopic approach included the following: our experience using the endonasal route for suprasellar lesions, the superior projection of the aneurysm, a left A1 that gave rise to both A2 segments that would facilitate proximal control, the anteroposterior orientation of the aneurysm neck and A2 fork with the aneurysm bending on the left side

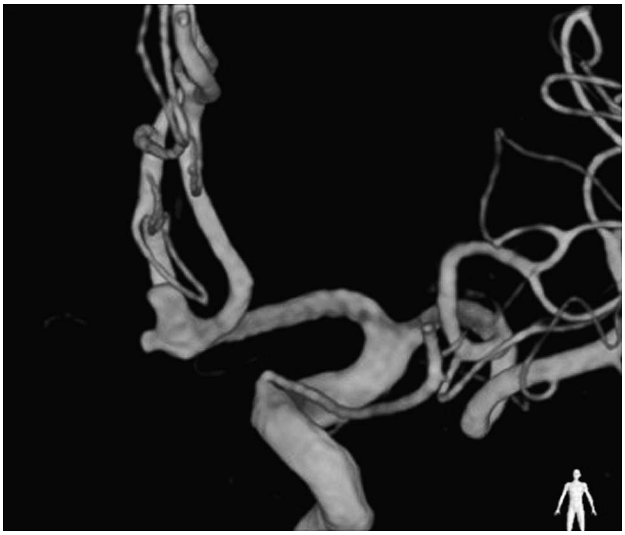

FIGURE 1. *Three-dimensional subtraction angiography to envision the surgical view of the aneurysm.*

offering a clear pass for clip application (Figure 1), and finally the absence of perforators on the back of the aneurysm neck.

After a thorough discussion involving a cranial base surgeon familiar with endoscopic approaches and an experienced vascular neurosurgeon, agreement was reached to offer this alternative to the patient. The details of the surgery were explained and understood by the patient and his family during several discussions. They were made aware of the novelty of this approach, its potential advantages and limitations, including a higher risk of CSF leak. The main advantage that we sought for our patient in this situation was minimal manipulation of the brain and gyrus rectus.

Because of the novelty of this approach and the low morbidity rate of traditional approaches, we also informed the patient that we might change to a transcranial approach in case of difficulties.

Patient Preparation

After placement of the lumbar drain, the patient was positioned supine with the head fixed in a Mayfield headholder. With elevation of the thorax approximately 20 degrees, the patient's neck was slightly flexed and the head turned right toward the surgeon. As a precaution in case of difficulty during the endonasal approach that would necessitate a switch to a transcranial approach, including an uncontrollable bleeding, we marked a right-sided frontotemporal skin incision for a pterional craniotomy and simulated quick repositioning of the patient's head.

Bispectral index monitoring was used to achieve burst suppression in case of aneurysm rupture and temporary vessel occlusion.

The nasal mucosa was vasoconstricted with cottonoids soaked in 5% xylocaine with naphazoline. The abdomen was prepared for fat grafting. Under endoscopic control, the sphenopalatine artery areas and the middle turbinates were infiltrated with a mixture of 1% xylocaine and epinephrine.

Endoscopic Transplanum-Transtuberculum Approach

A 0-degree endoscope, 4 mm in diameter and 18 cm in length, a Cappabianca set of instruments, and Sepehrnia microscissors (Karl Storz, Tuttlingen, Germany) were used. We also used an intraoperative cleaning device of the front lens that avoids any need to remove the endoscope from the surgical field during the challenging steps of the procedure. During an earlier biopsy of the orbital apex lesion, steps included a right middle and superior turbinectomy, posterior ethmoidectomy, and large opening of the right part of the sphenoid sinus. Therefore, we completed this endoscopic preparation by opening the left part of the sphenoid sinus and prepared a mucosal septal flap on the left side turned downward into the nasopharynx (see Video 1, Supplemental Digital Content 1, http://links.lww.com/NEU/A384). Next, the upper third of the sellar wall, tuberculum sellae, and planum sphenoidale were removed. The bone opening of the planum was extended in a posteroanterior direction for approximately 1.5 cm. From this point, the assistant held the endoscope to allow the surgeon use of both hands. The dura mater was opened in a semilunar fashion, pediculated posteriorly, and the dural flap was pushed inferiorly over the sella (Figure 2).

Aneurysm Exposure and Clipping

During exposure and surgical clipping of the aneurysm, the endoscope was held in place with a flexible endoscope holder (Karl Storz). A 3-mm Redon drain tube was placed in the sphenoid sinus through the right nostril (B. Braun Medical, Boulogne Billancourt, France) and was ready to be connected to an emergency suction in case of rupture. The arachnoid of the lamina terminalis cistern and the arachnoid between the optic nerves and gyrus rectus were opened using sharp dissection (Figure 2). Both the left A2 segment and the aneurysm neck were immediately visible (Figure 3). The left A1 segment was identified to gain proximal control, and temporary clip access was confirmed before dissection of the aneurysm. The dome was progressively freed from the medial aspect of the right gyrus rectus, and the right A2 segment was exposed.

As a dissector, held by the assistant, was used to slightly retract the right gyrus rectus, a 7-mm straight titanium aneurysm clip was applied using Yasargil pistol-grip applying forceps (B. Braun, Aesculap, Tuttlingen, Germany) across the neck of the aneurysm (Figure 4). Its dome was then further mobilized to control the clip position and ensure complete occlusion of the aneurysm (see Video 1, Supplemental Digital Content 1, http://links.lww.com/NEU/A384, in which the operation is summarized).

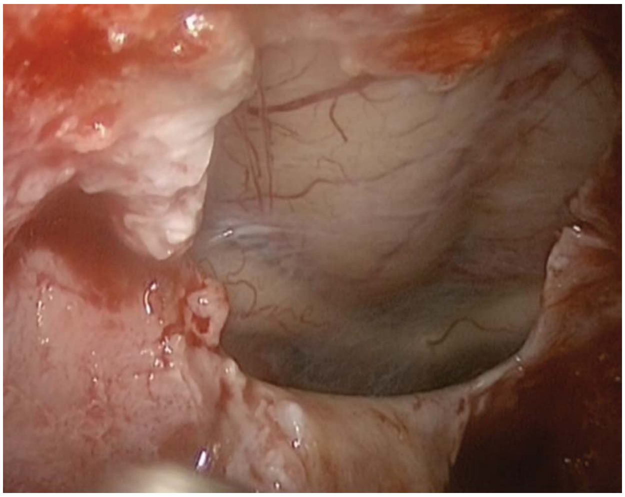

FIGURE 2. *Endoscopic transplanum-transtuberculum approach. The dura mater is opened in a semilunar fashion, pediculated posteriorly, and the dural flap was pushed inferiorly over the sella. Both optic nerves, the chiasma, and both gyrus rectus come into view.*

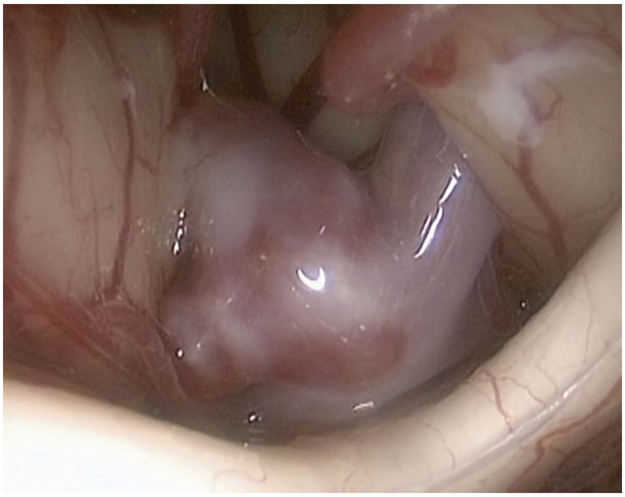

FIGURE 3. *Once the interhemispheric fissure is opened, the left A2 segment and the aneurysm with a daughter lobule are identified. The left A1 segment is also visible.*

Closure

Because the aneurysm clip slightly protruded into the sphenoid sinus, we made sure that slightly pushing the clip up would not create any torsion and stenosis of a segment of the AcoA complex. A piece of Duragen (Integra Neuroscience, Plainsboro, New Jersey), followed with a piece of woven mesh copolymer of 90% polyglycolic acid and 10% polylactic acid (Ethicon, Inc., Somerville, New Jersey) were placed intradurally avoiding

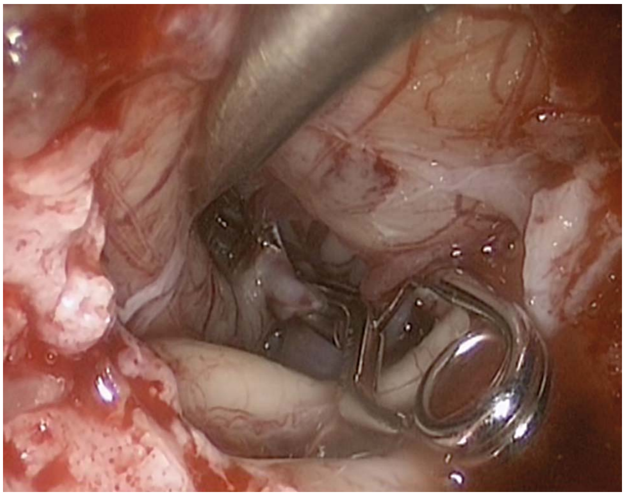

FIGURE 4. *A 7-mm straight titanium aneurysm clip is applied across the neck of the aneurysm. The dome is further mobilized to control the clip position and ensure complete occlusion of the aneurysm.*

excessive pressure on the clip. A monobloc piece of bone obtained from the nasal septum was placed over the bone opening with parts of its borders placed intracranially and sprayed with a layer of polymerized hydrogel (DuraSeal; Confluent Surgical, Waltham, Massachusetts). Finally, the vascularized septal flap was laid over the posterosuperior aspect of the sphenoid sinus and secured with polymerized hydrogel (see Video 1, Supplemental Digital Content 1, http://links.lww.com/NEU/A384).

Postoperative Course

The postoperative course was uneventful with a rapid recovery. The lumbar drain was removed after 48 hours postoperatively, and the patient did not experience a CSF leak. An angiogram obtained 1 month postoperatively indicated a complete exclusion of the aneurysm (Figure 5).

DISCUSSION

On the road to innovation in the treatment of intracranial aneurysms, our endoscopic approach provided another option the value of which must be weighed in terms not only of technical feasibility but the patient's best interest, especially surgery-related morbidity. Furthermore, in cases of an unruptured aneurysm, the expected morbidity of a new treatment option must be balanced against the very low morbidity rate of endovascular treatment and transcranial approaches. In our case, the endoscopic endonasal approach was proposed because of a very particular setting. An ACoA aneurysm was discovered in our patient just before he was to undergo an endoscopic endonasal resection of an orbital apex tumor. Because of the operative corridor formed during the endonasal approach to the tumor and the ideal line of sight that was feasible to view this aneurysmal anatomy on 3-dimensional angiography, we then formulated an endoscopic route for treatment of this ACoA aneurysm. Other factors that influenced our operative plan and ultimately promoted the technical success of this operation include the presence of a single A1 segment, which would facilitate proximal control in case of rupture, the ability to have a rapid access to both A2 segments, and the absence of significant perforators on the back of the aneurysm.

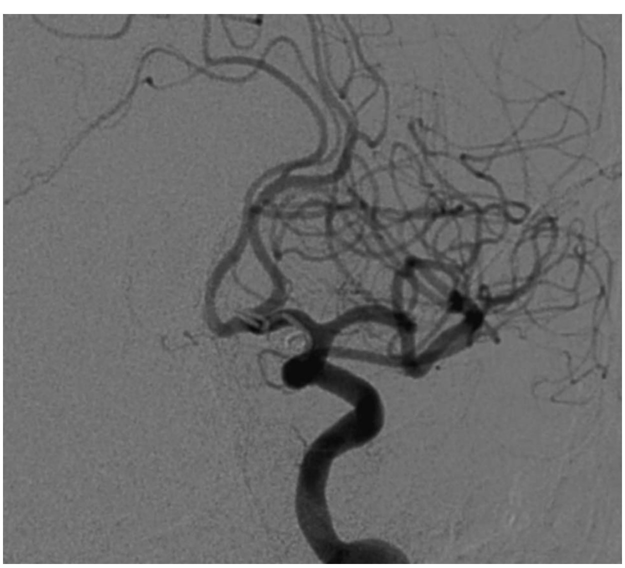

FIGURE 5. *Postoperative angiogram confirmed the complete exclusion of the aneurysm.*

Road to Innovation for Surgical Approaches to ACoA Aneurysms

ACoA aneurysms continue to pose treatment challenges because of their complexity and variations of the ACoA complex, the location in the interhemispheric fissure, and the risk of injuries to perforators.[5-9] Neuropsychological morbidity, a common complication of ACoA aneurysms,[10] is related to the subarachnoid hemorrhage and its consequences as well as brain retraction injury, the addition of partial gyrectomy for aneurysm exposure, and injury to perforating arteries. As endovascular techniques evolve, a remaining challenge is the reduction of neuropsychological complications related to the surgical approach and treatment of these aneurysms.

The pterional approach, popularized by Yasargil[11] and the most commonly used for ACoA aneurysms, often requires extensive dissection of the sylvian fissure and frontal lobe retraction and partial gyrectomy for aneurysms within the interhemispheric fissure. The interhemispheric approach is often used, especially for superiorly or posteriorly projecting aneurysms and the high-located ACoA complex. Gyrus rectus resection is usually unnecessary and the risk of anosmia is lower.[7,11-13] Variations of this approach (eg, low interhemispheric approach, unilateral approach) can reduce the amount of brain retraction.[14,15]

Within the past 20 years, the trend has focused on reduction of brain exposure and retraction by minimally invasive keyhole approaches and cranial base techniques.[6-8,16-22] The approach most often used for ACoA aneurysms is the supraorbital subfrontal keyhole approach popularized by Perneczky and Boecher-Schwarz [20] and its numerous variations using either an eyebrow or a palpebral incision and including part of the superior and lateral rim of the orbit.[6-8,16,17,19,21,22] Such approaches reduce the amount of brain exposure and relocate the cone of work medial to the gyrus rectus with a more basal exposure of both A1 that facilitates proximal control. However, in cases of a tight brain or swelling, adequate surgical exposure may still depend on extensive brain retraction with partial gyrectomy. In such patients, intraoperative rupture can be difficult to manage through this narrow surgical corridor. Cranial base techniques can also significantly lower the need for brain retraction and partial gyrectomy so that the ACoA complex can be approached from a more basal line of sight. Many authors have advocated for the use of orbitopterional or orbitozygomatic approaches for ACoA aneurysms.[6-8,18,22] As dissection progresses from the pterional to the orbitopterional to the orbitozygomatic approach, the less is the effect and the need of frontal lobe retraction and gyrus rectus resection.[18]

Building on the keyhole approach to reduce brain exposure and retraction, the endonasal route may provide an even more logical line of sight for midline lesions located on or above the central cranial base.[23] Using the endoscopic route, the surgical corridor is narrow, but is not created by the retraction of the brain as it is for transcranial approaches and even more for a keyhole approach. The panoramic view, offered by the endoscope, is also an advantage that may partially compensate for this narrow corridor.

However, its use for vascular lesions has not yet been evaluated and only 3 cases have been reported, including 2 endoscopic approaches and 1 microscopic transsphenoidal approach.[1-3] Kassam et al[1] reported on a 56-year-old patient diagnosed with both an ACoA and superior hypophyseal artery aneurysms, both considered unsuitable for coiling. To avoid optic nerve manipulation, the patient underwent an endonasal approach for the superior hypophyseal artery aneurysm; the operation began with a pterional craniotomy without dura opening as a precaution in case of uncontrollable aneurysm rupture via this route. With exposure of the paraclival internal carotid artery, proximal control was gained and the superior hypophyseal artery was clipped; opening the cavernous sinus exposed the aneurysm neck. Because of anatomic features of the suprasellar region, optic chiasm, and anatomy of the aneurysm, the authors clipped the ACoA aneurysm via the pterional approach.

Kitano et al[3] reported the case of successful clipping of an ACoA aneurysm discovered incidentally during a microscopic extended transsphenoidal approach for a pituitary macroadenoma. The proximal and distal ACA was exposed before clipping, which was certainly facilitated by the distension of the vessel by the tumor mass.

Potential of the Endoscopic Route

If deemed to be a valid approach, the endoscopic endonasal approach in the treatment of aneurysms will provide these essential criteria: first, adequate exposure of the aneurysm, the adjacent vessels, and perforators, and second, proximal control as well as enough space and visibility to manage intraoperative rupture.[5,7,8] Furthermore, the rate of complications (eg, CSF leakage) related to the endoscopic approach will have to be equal to or lower than that achieved by classic transcranial approaches and endovascular treatment. Closure of cranial base defect via an endoscopic approach is challenging and requires a complex and rigorous technique that does not meet the criteria for a mini-invasive procedure. However, one could expect that with more experience with this approach and progress with the instrumentation and closure material, closure will be easer. The rate of CSF leak has already been reduced significantly with the introduction of new closure techniques (eg, mucosal flap) and will certainly continue to improve with new biological glues and closure devices.[24]

The endoscopic endonasal approach is not indicated for all types of ACoA aneurysms. Contraindications include patients with ruptured aneurysms whose risk of intraoperative rupture is significantly higher. In some cases, the A1 segment is located deeper in the sulcus between the optic chiasma and the gyrus rectus, and proximal control may be more difficult to obtain using the endoscopic route. Such configuration can be anticipated on sagittal magnetic resonance imaging, and anatomic studies of the relationship between the A1 segments and the optic apparatus using an endonasal approach would be necessary. Aneurysms pointing anteriorly and posteriorly are also not suitable for the endoscopic approach and a 3-dimensional reconstruction to envision the surgical view of the aneurysm via this route is mandatory for the final decision.[4,21] In our case, the use of a longer clip pointing out in the nasal cavity could have been an issue during the closure of the defect. Furthermore, if temporary clips have to be place around the aneurysm, the space needed for the dissection of the aneurysm would be significantly reduced and some newly designed clip would be certainly helpful for this type of approach.

In cases of uncontrollable bleeding using the endoscopic endonasal approach, the salvage procedure has yet to be determined. We prepared our patient for the scenario in which a pterional approach could be performed rapidly if needed. We also considered the option of a paralateronasal approach; it can be executed quickly by an experienced ENT surgeon, requires no change in the patient's position, provides a sufficient working space for the operative microscope, and achieves a fair cosmetic result.

CONCLUSION

This case report describes the successful clipping of an ACoA aneurysm via an endoscopic endonasal approach. Where this report of a single case will fall on or off the road to innovation remains to be determined. A single success such as the case reported here defines an approach as feasible but not necessarily efficacious or desirable. We advise extreme prudence and adequate experience and skills if considering this procedure as a possible alternative to other well-established techniques. At this point, aneurysm clipping via this endoscopic endonasal route remains anecdotal. Yet its upward route is promising and clearly offers limited brain retraction for deep-seated lesions. Rapid progress in the evolution of endoscopic techniques may prove promising for well-selected cases of ACoA aneurysms with favorable anatomy.

Disclosure

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

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COMMENTS

Froelich et al report the case of an unruptured anterior communicating aneurysm successfully clipped via a transnasal endoscopic approach. This aneurysm presented favorable anatomic features for the transnasal endoscopic approach, and coiling was considered inappropriate by the endovascular team. This article presents an innovative but very controversial technique of treating unruptured intracranial aneurysms. There are some ethical concerns to propose an unproven method for treatment of unruptured aneurysm when it is known that morbidity and mortality of surgical or endovascular treatment of these lesions are very low.[1,2] As the authors have pointed out that it is difficult to obtain proximal control because the A1 segment is hidden above the optic nerves and chiasm. If 2 or 3 temporary clips are needed, probably dissection of the aneurysm and clipping of the neck with preservation of the perforators will be difficult. Another concern is whether it is fair to submit a patient with an unruptured aneurysm to an endoscopic approach with potential of intraoperative rupture and the need to switch the surgical access to a pterional or paralateronasal approach (as the authors have proposed) as a salvage procedure. A procedure that requires removal of the upper third of the sellar wall, tuberculum sellae, and planum sphenoidale; closure of the dura with dura substitute (Duragen); a layer of polymerized hydrogel; and a lumbar drain for 48 hours is not less invasive than a small pterional or fronto-orbital craniotomy. Despite these considerations, this interesting article will promote discussions on the indication and value of endoscopic approaches to intracranial vascular lesions.

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1. Aghakhani N, Vaz G, David P, et al. Surgical management of unruptured intracranial aneurysms that are inappropriate for endovascular treatment: experience based on two academic centers. *Neurosurgery*. 2008;62(6):1227-1235.
2. Krisht AF, Gomez J, Partington S. Outcome of surgical clipping of unruptured aneurysms as it compares with a 10-year nonclipping survival period. *Neurosurgery*. 2006;58(2):207-216.

Froelich et al present a detailed case report describing surgical clipping of a complex unruptured anterior communicating artery aneurysm via an endoscopic transnasal approach. The authors succeed in using innovative techniques in endoscopic cranial base surgery, while carefully maintaining core principles regarding aneurysm clipping. They define their surgical steps to ensure adequate proximal and distal control, careful dissection of the aneurysm, and stepwise clip application. As the authors note, recent publications have emboldened debate about the best surgical approaches to these types of aneurysms. Although the pterional approach has been most commonly used, it often requires significant dissection including resection of the gyrus rectus. To that end, supraorbital subfrontal approaches are gaining in popularity. By comparison, the endoscopic transtubercular approach offers a similarly minimally invasive corridor designed to minimize brain retraction. Its advantages include its midline trajectory, its line-of-sight from underneath the brain directly to the anterior communicating artery complex, and the ability to avoid a craniotomy scar. Conversely, the current central limitation is the lack of instrumentation designed specifically for endoscopic transnasal approaches to vascular lesions. Although smaller cranial approaches represent important innovations, they use the same dissectors, clip applicators, and other instruments used in larger craniotomies. By comparison, endoscopic cranial base surgery uses differently designed instruments that have yet to be formally modified for vascular cases. Likewise, the possibility that the back of the clip may protrude into the sphenoid sinus could make the closure very challenging.

Despite such limitations, the efforts of Froelich et al to use this approach for access to the anterior communicating artery complex are innovative. The authors are conservative in their discussion, noting the specific reasons why this approach was selected for the particular patient and clearly noting that such an approach is not yet ready for common use without further study. However, their technical report supports the need for such studies and illustrates how to use a novel technique while adhering to principles of surgical safety.

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Froelich et al present the technique for an endonasal approach for clipping a 7-mm unruptured anterior communicating artery aneurysm. An endonasal approach has advantages and disadvantages relative to standard microsurgical approaches. The advantages include no brain retraction and an excellent panoramic detailed view of the vessel complex. The disadvantages are that the approach may place olfaction at risk from disruption of the olfactory epithelia, a long surgical reach increasing the difficulty of surgery, an inability to address downward-pointing aneurysms when the dome is adherent to the optic chiasm or may obstruct the view of the neck, and spinal fluid leakage.

Their report demonstrates that it is technically possible to treat an anterior communicating artery aneurysm in this fashion, but should it be done? Microsurgical techniques are well established, allow prompt vascular control in the case of intraoperative rupture, and are associated with limited morbidity in experienced hands.

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Froelich et al demonstrate that it is possible to endoscopically clip a small anterior communicating artery (ACoA) aneurysm with a favorable anatomy. It is important to recognize, however, that an endoscopic approach may not be safe for either most ACoA aneurysms in particular or most aneurysms in general. Although intracranial endoscopy for tumors has proven advantageous in a wide variety of locations, its use in aneurysm surgery has been met with limited enthusiasm. The main reason for this is that a standard microsurgical dissection creates an access corridor that is a shallow and wide "exposure cone," but an endoscopic approach can create only a long and narrow "exposure cylinder," which limits the clipping options and could be detrimental if the aneurysm were to rupture. If the aneurysm is small, has a favorable neck that is orthogonal to the endoscopic trajectory, and no temporary clips are required (which would further narrow the endoscopic "exposure cylinder"), then an endoscopic approach could be adequate, as in this case. If any of these 3 requirements are not met, however, an endoscopic approach could prove dangerous.

Whether this approach can be labeled minimally invasive compared with a standard pterional craniotomy is also open to discussion. This patient required insertion of a lumbar drain for 48 hours, middle and superior turbinectomies, a posterior ethmoidectomy, a "large opening of the right part of the sphenoid sinus," removal of "the upper third of the sellar wall, tuberculum sellae, and planum sphenoidale," and could have required an abdominal incision had an adipose graft been necessary. Leakage of cerebrospinal fluid, which is exceedingly rare after a pterional craniotomy, appears to be an unresolved problem in cranial base endoscopic approaches and can lead to serious complications, multiple reoperations, and even death.

Given the excellent current results of standard microsurgical clipping and endovascular coiling of most aneurysms, the role of endoscopic clipping of aneurysms remains to be defined, but I anticipate it is going to be narrow.

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