A comparative analysis of the endoscopic endonasal and pterional approaches for clipping anterior communicating artery aneurysms on three-dimensional printed models

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Anterior communicating artery (ACoA) aneurysms account for the largest proportion of intracranial aneurysms and are the most likely to rupture.[1] The main treatment methods are endovascular embolization and traditional craniotomy clipping.[2] With the rapid development of interventional materials and technologies in the last two decades, many medical centers have adopted endovascular embolization as the preferred treatment for intracranial aneurysms. However, some aneurysms still require traditional craniotomy clipping. Transsphenoidal endoscopy technology has also developed rapidly in recent years.[3] Because intracranial aneurysms are mostly within the circle of Willis and occur on the ventral side of the skull base, a few neurosurgeons have tried to use an endoscopic endonasal approach (EEA) for clipping.[4-6] However, the number of cases reported in the literature is small and more anatomical studies are needed to deeply analyze the approach and technique.

Three-dimensional (3D) printing is a recently developed technology that can be used to create specialized models for medical teaching and pre-operative preparation. To further analyze intracranial aneurysm clipping via the EEA approach, we first collected raw data from patients with ACoA aneurysms. 3D printing technology was then used to produce models with important, relevant skull base structures, and ACoA aneurysm clipping with conventional pterional approach (PA) and EEA were compared and analyzed using the models.

The study protocol was approved by the Institutional Ethical Committee (No. GDREC2018304H) and adheres to the *Declaration of Helsinki*. The inclusion criteria were patients over 18 years of age admitted to Guangdong Provincial People's Hospital between July 2019 and December 2019 with unruptured ACoA aneurysm. Exclusion criteria were multiple intracranial aneurysms, ruptured ACoA aneurysms, or other intracranial diseases (eg, tumor, inflammation, hydrocephalus, and arteriovenous malformations). The raw data from 35 patients with unruptured ACoA aneurysms were collected, and the patients or their families signed informed consent forms agreeing to use the imaging data in this study.

The basic patient information is shown in Supplementary Table 1, http://links.lww.com/CM9/A634. The mean age of all patients was 59.7 ± 10.1 years. Among them, there were 13 (37.1%) females with an average age of 60.8 ± 12.6 years and 22 (62.9%) males with an average age of 59.0 ± 8.6 years. The characteristics of ACoA aneurysms in our cases are also shown in Supplementary Table 1, http://links.lww.com/CM9/A634. The mean aneurysms size was 5.94 ± 2.87 mm (range 2–13 mm); among them, the mean sizes for small (15/35, 42.9%), medium (16/35, 45.7%), and large (4/35, 11.4%) aneurysms were 3.74 ± 1.14, 6.42 ± 1.25, and 12.25 ± 0.96 mm, respectively. The vast majority (32 cases, 91.4%) were wide-necked aneurysms. The bilateral A2 was in the sagittal position in 18 (51.4%) cases and the horizontal position in 17 (48.6%) cases. ACoA aneurysm projection was as follows: anterior (6/35, 17.1%), posterior (2/35, 5.7%), superior (7/35, 20.0%), inferior (8/35, 22.9%), and lateral (12/35, 34.3%).

The EEA was performed in all aneurysm models. We assessed two major indexes: (1) the exposure rate of the aneurysm neck without instrumental assistance and (2) the clipping success rate. Then, we separately analyzed the two

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indexes from three aspects: aneurysm size, dome projection, and the bilateral A2 position.

There were significant differences in the exposure rate among aneurysms of different sizes ($\chi^2 = 8.245$, $P = 0.016$) [Supplementary Figure 1A, http://links.lww.com/CM9/A634]. The exposure rate was the highest (73.3%) for small aneurysms. There was no significant difference with regard to dome projection and the bilateral A2 position [Supplementary Figure 1B and 1C, http://links.lww.com/CM9/A634].

The success rate was significantly different depending on aneurysm size ($\chi^2 = 13.166$, $P = 0.001$) [Supplementary Figure 1D, http://links.lww.com/CM9/A634]. Small aneurysms had the highest success rate (86.7%). Regarding dome projection, there was also a significant difference in the clipping success rate ($\chi^2 = 9.666$, $P = 0.046$) [Supplementary Figure 1E, http://links.lww.com/CM9/A634], and an aneurysm that projected laterally had the highest success rate (91.7%). There was no significant difference in the success rate of clipping with regard to the bilateral A2 position [Supplementary Figure 1F, http://links.lww.com/CM9/A634].

We separately compared the surgical effect of the two approaches using four main indicators: surgical freedom, bilateral A1 and A2 exposure, aneurysm neck exposure, and simulation clipping. As for surgical freedom, results in the horizontal and vertical directions of freedom are listed [Supplementary Table 2, http://links.lww.com/CM9/A634]; there was a significant difference in both directions. We further compared the exposure lengths of the bilateral A1 and A2 between approaches [Supplementary Table 2, http://links.lww.com/CM9/A634]. The PA had a significantly greater exposure length of the ipsilateral A1 than that of the EEA but a smaller exposure length of the contralateral A1. The exposure length of bilateral A2 was less in EEA than that in PA. In the absence of instrumental assistance, there was no significant difference in the aneurysm neck exposure rate between the EEA and PA. Next, we further compared the following three aspects including aneurysm size, dome projection, and the bilateral A2 position [Supplementary Table 3, http://links.lww.com/CM9/A634].

For aneurysm of different size, there was no significant difference in the exposure rate between approaches. There was a significant difference in the exposure rate between the EEA and ipsilateral PA when the aneurysm projected superiorly ($\chi^2 = 7.143$, $P = 0.008$). There was no significant difference in the exposure rate between the EEA and contralateral PA. There was a significant difference between the EEA and ipsilateral PA when the bilateral A2 was in the sagittal position ($\chi^2 = 4.050$, $P = 0.044$).

There was a significant difference in the simulated ACoA aneurysm clipping success rate between the EEA and ipsilateral PA (74.3% *vs.* 100.0%, $\chi^2 = 10.328$, $P = 0.001$). There was no significant difference between the EEA and contralateral PA. We further compared the following three aspects including aneurysm size, dome projection, and the bilateral A2 position [Supplementary Table 3, http://links.lww.com/CM9/A634].

In small and medium aneurysms, there was no significant difference in the success rates between the EEA and ipsilateral PA or between the EEA and contralateral PA. In large aneurysms, there was a significant difference in the clipping success rate between the EEA and ipsilateral PA ($\chi^2 = 8.000$, $P = 0.005$). When the aneurysm projected any direction, there was no significant difference in the clipping success rate between the EEA and ipsilateral PA. When the bilateral A2 was in the horizontal position, there was a significant difference in the clipping success rate between the EEA and ipsilateral PA ($\chi^2 = 5.862$, $P = 0.015$).

ACoA aneurysms account for the highest proportion of ruptured intracranial aneurysms. Although interventional embolization is currently the main treatment option in many medical centers, clipping of ACoA aneurysms is still commonly used.[7]

With the rapid development of endoscopic techniques and improved nasal reconstruction techniques, endoscopy began to be used for intracranial aneurysm clipping. Some pioneers began to adopt pure EEAs to clip intracranial aneurysms. However, since Kassam's[6] first report of EEA clipping of vertebral artery aneurysms, only 29 cases have been reported. The original authors agreed that this could only be done by selecting the right cases, but identifying suitable cases requires more research on the EEA. The PA is the classic approach for clipping ACoA aneurysms. To better study the EEA, we performed a comparative analysis of these two approaches.

The EEA was found to achieve the same clipping effect as the PA under certain conditions.

In terms of surgical freedom, the PA is bound to have higher values than the EEA because of the larger craniotomy scope and wider corridor. Therefore, the PA allows for easier microdissection of the aneurysm and its surrounding structures.

The PA enables more exposure of the ipsilateral A1, which facilitates proximal control. Although the EEA can expose more of the contralateral A1 and better control the contralateral A1, considering that the aneurysm blood supply is mainly from the ipsilateral A1, it does not significantly improve the proximal control of aneurysms compared with PA.

For small and medium-sized aneurysms, the EEA can achieve the same clipping effect as PA, as shown in Supplementary Figure 2, http://links.lww.com/CM9/A634. Although the EEA has a relatively low degree of surgical freedom, it is sufficient for the range of exposure required for these aneurysms. These disadvantages of the EEA are more pronounced for large aneurysms, and clipping cannot be completed with the same success rate as the PA. As shown in Supplementary Figure 3, http://links.lww.com/CM9/A634, the aneurysm blocked the neck itself in the EEA, whereas the neck could be visualized and clipped with the ipsilateral PA.

For aneurysm dome projection, although there was no statistical difference between the EEA and PA in our cases [Supplementary Table 3, http://links.lww.com/CM9/A634], it would affect the clipping success rate of the EEA [Supplementary Figure 1E, http://links.lww.com/CM9/A634]. When the aneurysm projected posteriorly, as shown in Supplementary Figure 4, http://links.lww.com/CM9/A634, the aneurysm was difficult to visualize through the EEA, whereas it could be visualized and clipped through the PA. When aneurysms project anteriorly, superiorly, inferiorly, and laterally, clipping can be the same as for the PA. More posteriorly projected aneurysms need to be analyzed to determine if the EEA is appropriate.

The position of the bilateral A2 is an influential factor in whether the EEA can achieve the same effect as the PA for clipping aneurysms. When the bilateral A2 twisted into the sagittal position, one side of the A2 was just ahead of the field of view under the EEA. However, if the aneurysm projected superiorly, the A2 obstructed the aneurysm, increasing clipping difficulty [Supplementary Figure 5, http://links.lww.com/CM9/A634]. Upon switching to the PA, the A2 unfolds naturally, and the neck can be identified and clipped relatively easily. However, if the A2 is horizontal, it unfolds naturally through the EEA [Supplementary Figure 6, http://links.lww.com/CM9/A634]. One side of the A2 blocks exposure of the aneurysm neck when using the PA. However, because of the high degree of surgical freedom with that approach, it is easy to dissect and push the vessel blocking the aneurysm to complete clipping.

This study also has some limitations. The models do not completely mimic the real situation because some techniques used in real clipping scenarios could not be employed in the model. For example, it is difficult to produce some of the smaller and more important arteries (eg, the recurrent artery of Heubner) in the models, so the effects of these arteries on the two approaches could not be evaluated. Finally, the number of cases was relatively small, especially for aneurysms that projected posteriorly.

In general, 3D printed models are useful for anatomical studies of craniocerebral surgical approaches. The EEA can provide the same clipping effect as the PA under certain conditions, such as small (<5 mm) and medium aneurysms (5–10 mm) that project anteriorly, superiorly, inferiorly, and laterally. Because of the low degree of surgical freedom, one should be careful when considering the EEA for clipping large aneurysms (>10 mm) or those which projected posteriorly.

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Conflicts of interest

None.

References

1. Steklacova A, Bradac O, de Lacy P, Lacman J, Charvat F, Benes V. Coil mainly" policy in management of intracranial ACoA aneurysms: single-centre experience with the systematic review of literature and meta-analysis. Neurosurg Rev 2018;41:825–839. doi: 10.1007/s10143-017-0932-y.
2. O'Neill AH, Chandra RV, Lai LT. Safety and effectiveness of microsurgical clipping, endovascular coiling, and stent assisted coiling for unruptured anterior communicating artery aneurysms: a systematic analysis of observational studies. J Neurointerv Surg 2017;9:761–765. doi: 10.1136/neurintsurg-2016-012629.
3. García-Garrigós E, Arenas-Jiménez JJ, Monjas-Cánovas I, Abarca-Olivas J, Cortés-Vela JJ, De La Hoz-Rosa J, *et al*. Transsphenoidal approach in endoscopic endonasal surgery for skull base lesions: what radiologists and surgeons need to know. Radiographics 2015;35:1170–1185. doi: 10.1148/rg.2015140105.
4. Gardner PA, Vaz-Guimaraes F, Jankowitz B, Koutourousiou M, Fernandez-Miranda JC, Wang EW, *et al*. Endoscopic endonasal clipping of intracranial aneurysms: surgical technique and results. World Neurosurg 2015;84:1380–1393. doi: 10.1016/j.wneu.2015.06.032.
5. Xiao LM, Tang B, Xie SH, Huang GL, Wang ZG, Zeng EM, *et al*. Endoscopic endonasal clipping of anterior circulation aneurysm: surgical techniques and results. World Neurosurg 2018;115:e33–e44. doi: 10.1016/j.wneu.2018.03.093.
6. Kassam AB, Mintz AH, Gardner PA, Horowitz MB, Carrau RL, Snyderman CH. The expanded endonasal approach for an endoscopic transnasal clipping and aneurysmorrhaphy of a large vertebral artery aneurysm: technical case report. Neurosurgery 2006;59:ONSE162–ONSE165. doi: 10.1227/01.Neu.0000220047.25001.F8.
7. Etminan N, Brown RD Jr, Beseoglu K, Juvela S, Raymond J, Morita A, *et al*. The unruptured intracranial aneurysm treatment score: a multidisciplinary consensus. Neurology 2015;85:881–889. doi: 10.1212/wnl.0000000000001891.

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