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The efficiency of the new Yasargil titanium fenestrated mini-clips for ideal clipping of a cerebral aneurysm

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Abstract

Background: The fenestrated clip is sometimes useful in limited approach angle and narrow working space. However, before the development of the new Yasargil titanium fenestrated mini-clip, the only variations of fenestrated clips were those of larger sizes. And those larger clips have a problem of the triangle-shaped gap at the proximal end of the blade. The authors describe the efficiency, limitations and surgical technique of using the Yasargil titanium fenestrated mini-clip.

Methods: Fifty-nine cases of aneurysms were treated using these mini-clips. Aneurysm location, size and dome neck ratio, mean follow-up period, neck remnant, and recurrence rate were also analyzed. Among these cases, we present eight characteristic cases, including a case with aneurysm recurrence, and we review the problems associated with the triangle-shaped gap at the proximal end of the clip.

Results: The average size of the aneurysms was 5.57 mm, and the dome neck ratio was >2.0 in 1.69%, >1.5 in 11.8%, >1.2 in 35.6%, and <1.2 in 50.8% of cases. The mean follow-up period for the 59 cases was 5.5 months (range, 0.5–16 months). Angiographic recurrence of the treated portion occurred in 1 case (1.7%), including an aneurysm in the basilar artery tip aneurysm.

Conclusion: The availability of the Yasargil titanium fenestrated mini-clip increases the options for clipping to minimize the remnant of the clipped aneurysm. However, there is still concern over the triangular space at the base of the blade, especially when treating an aneurysm with a thin vessel wall. Therefore, modification of the clipping technique is sometimes needed.

Key Words: Closure line clipping, FT 802T, FT 804T, Yasargil titanium fenestrated mini-clip

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BACKGROUND

Clipping for cerebral aneurysms is reliable and can be used to prevent subarachnoid hemorrhage. Although clipping has been performed since the 1950s,[2,11,13] an ideal closure line based on the shape of an aneurysm is a relatively new concept that Ishikawa first described in 2007.[3,4] The closure line is defined as the line on an aneurysm emerging at clipping. If the closure line

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restores the original vascular configuration to that before an aneurysm had developed, the maximal amount of the pathological wall of an aneurysm is included within the clips. If ideal closure line clipping is performed, the remnant of an aneurysm is minimized. To make an ideal closure line, clipping with multiple clips is needed. However, there are sometimes limitations on the approach angle and working space, so not all aneurysm clips can achieve an ideal closure line, especially for aneurysms in deep locations.[4] The fenestrated clip is sometimes useful in such situations. However, before the development of the Yasargil titanium fenestrated mini-clip (e.g., FT 802T, FT 804T), the only variations of fenestrated clips were those of larger sizes (e.g., FT 902T, FT 904T), and these clips could not achieve ideal closure line clipping. Problems with the larger fenestrated clips included the small triangular space at the base of the blade and the fact that a thin aneurysmal wall cannot be occluded. The goal of the present study was to describe the surgical technique of using the Yasargil titanium fenestrated mini-clip and its efficiency.

MATERIALS AND METHODS

From April 2012 to December 2014, 770 cases of ruptured or unruptured cerebral aneurysm were managed with neck clipping. In December 2013, our institution introduced the Yasargil titanium fenestrated mini-clip (FT 802T and FT 804T; Aesculap AG & Co., Tuttlingen, Germany). Fifty-nine cases were treated using fenestrated mini-clips. The number of clips used per an aneurysm, aneurysm location, size and dome neck ratio, mean follow-up period, neck remnant, and recurrence rate were also analyzed.

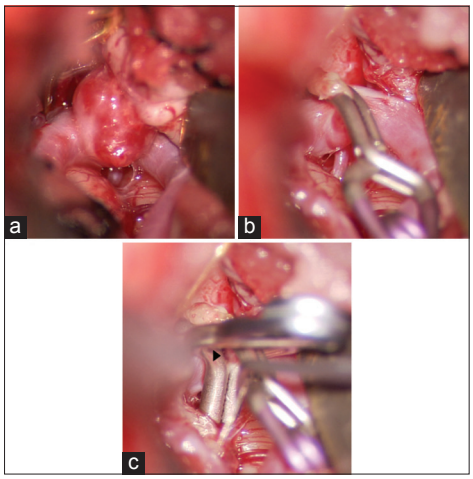


Figure 1: Operative view of the right middle cerebral artery aneurysm. (a) Aneurysm is present at the bifurcation of the middle cerebral artery. (b) First, a slightly curved clip is placed as the closure line. (c) Second, a standard fenestrated clip (FT 902T) is placed. However, the triangular gap at the end prevents complete obliteration (arrowhead)

Surgical indications were determined with reference to the 2009 Japanese guidelines for the management of stroke. Follow-up of the remnant or recurrence of an aneurysm was done using a 320-row computed tomography angiography (CTA) CT scanner (Aquilion ONE ViSION Edition; Toshiba Medical Systems, Tochigi, Japan). Scanning was performed with a collimation of 0.5 mm, and 0.25-mm slice reconstruction. Digital CT data were transferred to the ZIOSTATION2 version 2.1.x (Ziosoft, Redwood City, CA, USA) for review and for three-dimensional analysis.

CTA was performed immediately after finishing the operation as well as at 2 weeks after the operation and at 3–6 months after the operation. Thereafter, annual CTA was performed.

Characteristics of the Yasargil titanium fenestrated mini-clip

In 2013, the first fenestrated mini-clips were developed by Aesculap AG & Co., in cooperation with Dr. Rokuya Tanikawa. Before these mini-clips were introduced, only larger clips (e.g., 902T or 904T) were available. The FT 902T and 904T clips have a triangle-shaped gap at the proximal end and sometimes could not occlude the neck remnants of clipped aneurysms, such as "dog-ear aneurysms" [Figure 1]. FT 802T and FT 804T have a reduced triangle-shaped gap at the proximal end. FT 802T has a slightly curved (120°) blade, a blade length of 3.0 mm, and a fenestration diameter of 3.5 mm. FT 804T has a more curved (90°) blade, a blade length of 3.0 mm, and a fenestration diameter of 3.5 mm. Both clips have a closing force of 110 N and a 3.2-mm maximal opening width [Figure 2]. The triangle-shaped gap of the FT 902T has a 1.23-mm base length and a 1.23-mm height. The triangle-shaped gap of the FT 802T has a 0.95-mm base length and a 0.75-mm height [Figure 3].

RESULTS

Among the 59 cases in which fenestrated mini-clips were used, 9 cases were ruptured aneurysms, and 50 cases

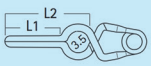
Art. No.		Blade length mm L1/L2	Maximal opening mm	Closing force N	Diameter of fenestration mm
FT802T		3.0/6.9	3.2	110	3.5
FT804T		3.0/5.1	3.2	110	3.5

Figure 2: Basic information regarding the Yasargil titanium fenestrated mini-clip

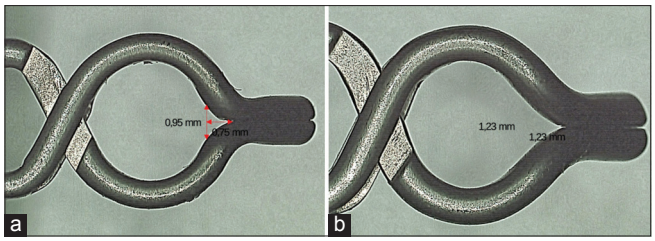


Figure 3:Triangle-shaped gap of the fenestrated clip. (a) The triangle-shaped gap of the FT 802T has a base length of 0.95 mm and a height of 0.75 mm. (b) The triangle-shaped gap of the FT 902T has a base length of 1.23 mm and a height of 1.23 mm

were a unruptured aneurysm. The average size of the aneurysms was 5.57 mm, and the dome neck ratio was >2.0 in 1.69%, >1.5 in 11.8%, >1.2 in 35.6%, and <1.2 in 50.8% of cases. The number of clips used for the treatment of one aneurysm was two clips (38 cases), three clips (17 cases), four clips (2 cases), and five clips (2 cases). The aneurysm locations at which the fenestrated mini-clips used were the middle cerebral artery (MCA) (45%), the anterior communicating artery (AcomA) (28.3%), the internal carotid artery (ICA)-posterior communicating artery (PcomA) (3.3%), the C2 and C3 portion of the ICA (13.3%), the distal anterior cerebral artery (3.3%), basilar artery (BA) tip (3.3%), and the top of the ICA and posterior cerebral artery (1.67%). The mean follow-up period for the 59 cases was 5.5 months (range, 0.5–16 months). Angiographic recurrence of the treated portion occurred in 1 case (1.7%), including an aneurysm in the BA tip aneurysm. The recurrence case was identified by CTA, which was performed at 2 weeks after clipping and re-treatment. The overall recurrence rate among the 770 cases was 1.0% (8 cases); 6 of these cases were diagnosed by CTA and re-clipping was performed, while the other case was a patient with an unruptured aneurysm of the AcomA who suffered subarachnoid hemorrhage at 1-week after the first clipping, and re-clipping was performed.

Clipping variations of FT 802T and FT 804T

Case 1: Right middle cerebral artery aneurysm [Figure 4]
The trans-sylvian approach was performed, and the aneurysm was clipped for complete closure line obliteration aneurysm here. The slightly curved clip (FT 722T) was used as a first clip, and the fenestrated mini-clip (FT 804T) was used as a second clip. This is the most exemplary case of the use of a fenestrated clip for closure line obliteration.

Case 2: Left C2 and internal carotid-posterior communicating artery double aneurysm [Figure 5]
Trapping of the C2 aneurysm was performed after external carotid (EC)-radial artery graft-M2 bypass. The anterograde flow was out to the ophthalmic artery, and retrograde flow was through the EC-M2 bypass to the PcomA. The IC-PcomA aneurysm was obliterated to secure the orifice

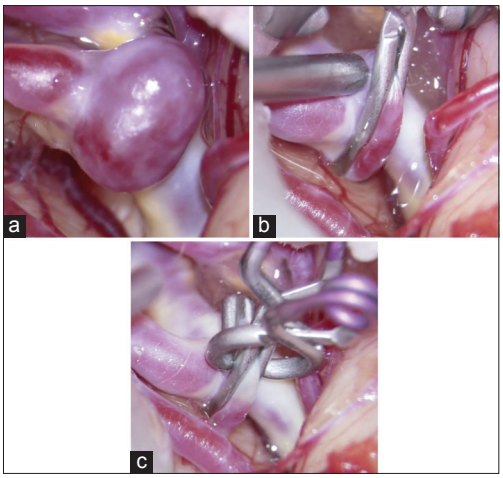


Figure 4: Operative view of the right middle cerebral artery aneurysm. (a) Aneurysm is present at the bifurcation of the middle cerebral artery. (b) First, a slightly curved clip (FT 722T) is placed as the closure line. (c) Second, a fenestrated mini-clip (FT 804T) is placed to achieve complete obliteration

of the PcomA using multiple clips. After the first clip was placed, a dog-ear remnant of an aneurysm was noted, and a fenestrated mini-clip was selected.

Case 3: Left C2 portion of the internal carotid aneurysm [Figure 6]
The extradural anterior clinoidectomy and distal dural ring were opened. A fenestrated mini-clip was placed around the ICA to secure anterograde blood flow.

Case 4: Left basilar artery-superior cerebellar artery aneurysm [Figure 7]
The anterior temporal approach was performed. The oculomotor nerve ran transversely on the aneurysm. First, a standard straight clip was applied for closure line obliteration. Because of the traverse course of oculomotor nerve, clip application through the right side was impossible. Thus, a fenestrated mini-clip was selected and applied through the left side for complete obliteration.

Limitations of the fenestrated mini-clip

Case 5: Anterior communicating artery aneurysm with thin aneurysmal wall [Figure 8]
The interhemispheric approach was performed. After multiple tandem clippings, a fenestrated mini-clip was applied to the dog-ear remnant of an aneurysm. However, the wall of an aneurysm was very thin, and a triangle-shaped gap had formed. Indocyanine green (ICG) videography showed blood filling into this triangular space. Thus, many clips were needed for complete closure line obliteration.

Case 6: Left side middle cerebral artery aneurysm with wall thickness gradient [Figure 9]
The trans-sylvian approach was performed. The first clip was applied for closure line obliteration. A fenestrated

mini-clip was selected as the second clip. However, the blood passed through the triangle-shaped gap due to the wall of an aneurysm at the apex of the clip blade being thicker than that at the base of the blade. The slightly curved mini-clip (FT 682T) was added to address this triangle-shaped gap, and complete obliteration was obtained.

Case 7: Right middle cerebral artery aneurysm [Figure 10]
The trans-sylvian approach was performed. Although the fenestrated mini-clip was applied, blood filled the aneurysm via the triangle-shaped gap. Thus, bipolar coagulation of the dome of an aneurysm was performed. After bipolar coagulation, ICG videography showed no blood filling the aneurysm.

Case 8: Basilar tip aneurysm; aneurysm recurrence [Figure 11]
The anterior temporal approach was performed. An additional aneurysm was found posterior to the main basilar tip aneurysm and the left side P1 portion of the posterior cerebral artery. This additional aneurysm extended to the P1 portion of the posterior cerebral artery longitudinally. Therefore, the fenestrated mini-clip was selected to obliterate this aneurysm. Then, the main component of the basilar tip aneurysm was obliterated

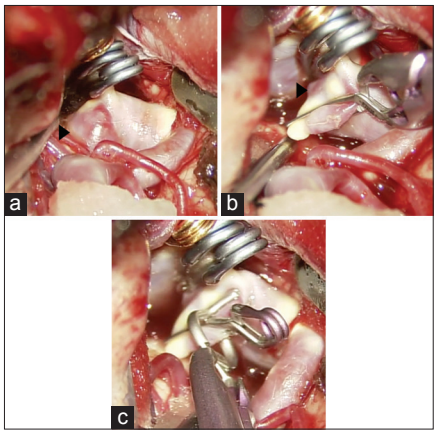


Figure 5: Operative view of the left anterior temporal approach. (a) The C2 portion of the internal carotid artery is trapped by the combined use of the standard clips. The internal carotid artery-posterior communicating artery aneurysm is identified (arrowhead). (b) First, a slightly curved clip is placed to preserve the orifice of the posterior communicating artery (arrowhead). (c) A fenestrated mini-clip (FT 802T) is placed to obliterate the dog-ear remnant of an aneurysm

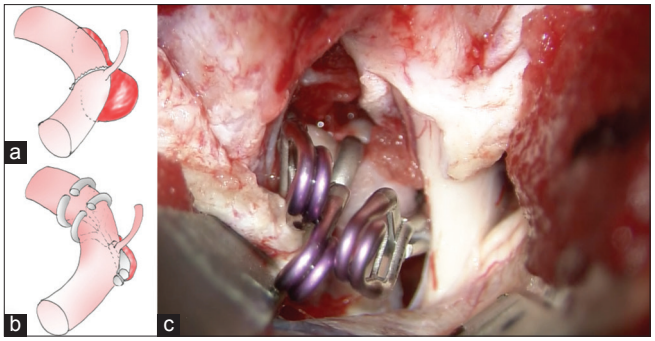


Figure 6: Operative view of the left side after anterior clinoidectomy and after the distal dural ring was opened. (a and b) Scheme of the clipping. (a) An aneurysm extends across the C2 portion to the C3 portion of the internal carotid artery. (b) After clipping. The fenestrated mini-clip is placed around the internal carotid artery. A slightly curved clip was applied to completely obliterate the dog-ear remnant of an aneurysm from distal to the ophthalmic artery. (c) The fenestrated mini-clip encasing the internal carotid artery

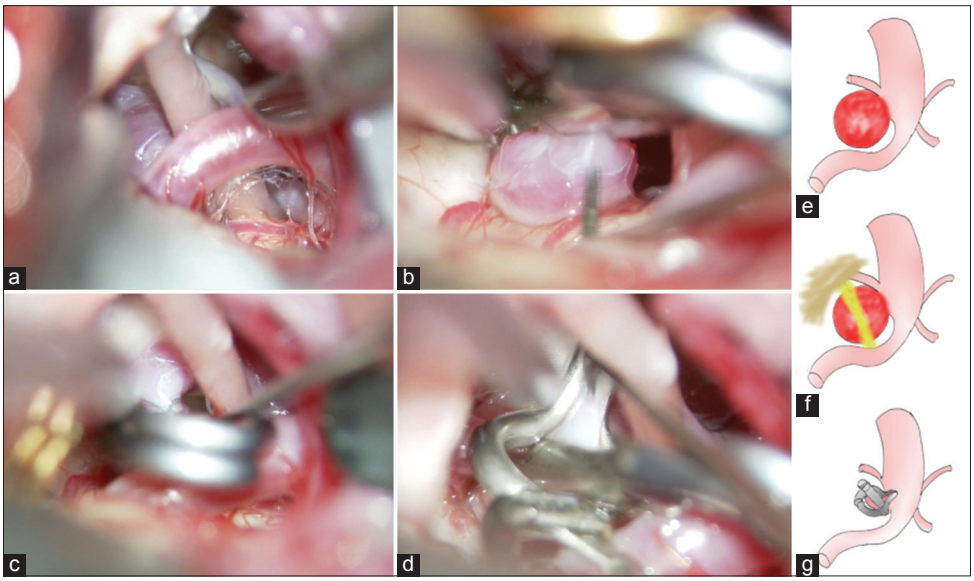


Figure 7: Operative view of the basilar artery-superior cerebellar artery aneurysm from the anterior temporal approach view. (a) The oculomotor nerve runs transversely on the aneurysm. (b) The first standard straight clip was applied for closure line obliteration. (c) A dog-ear-shaped remnant of an aneurysm is obtained. (d) Complete obliteration was obtained using a fenestrated mini-clip (FT 802T). (e-g) Scheme of the clipping. (e) An aneurysm and basilar artery without a surrounding component. (f) The oculomotor nerve runs transversely on the aneurysm. Thus, the clip could not be applied from the right side of the oculomotor nerve. (g) Scheme of the final view of the complete obliteration of an aneurysm

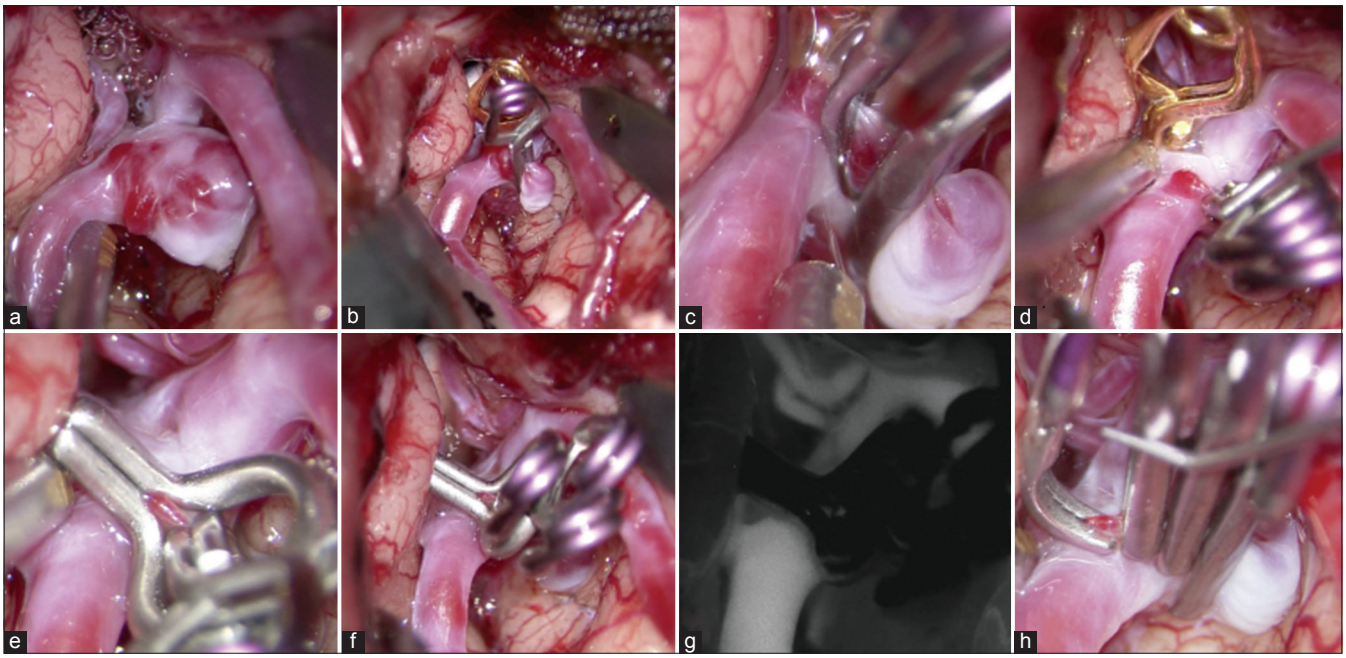


Figure 8: Operative view of the interhemispheric approach. (a) Anterior communicating artery aneurysm. (b) A straight clip is applied. (c) A slightly curved clip is applied as tandem clipping. (d) The dog-ear-shaped remnant of an aneurysm. (e) Though the fenestrated mini-clip (FT 802T) was applied, a triangle-shaped remnant is present. (f) Before indocyanine green videography. (g) Indocyanine green videography shows blood filling the triangle-shaped remnant of an aneurysm. (h) Multiple tandem clipping is performed to complete the closure line obliteration of an aneurysm

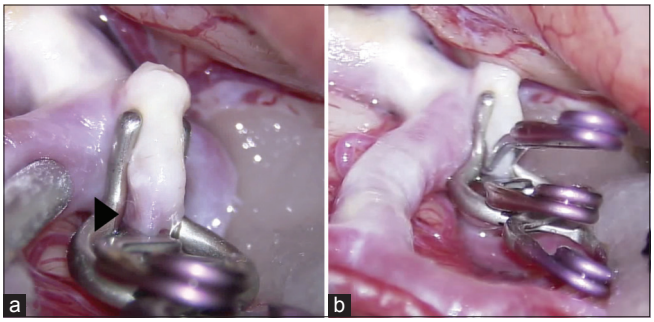


Figure 9: Operative view of the left side trans-sylvian approach. (a) The fenestrated mini-clip is selected as the second clip. However, blood fills the aneurysm through the triangle-shaped gap (arrowhead). Because the wall of an aneurysm at the apex of the clip blade were thicker than that of the base of the blade. (b) The slightly curved mini-clip (FT 682T) is added to address this triangle-shaped gap, and complete obliteration is achieved

using a slightly curved clip. However, CTA at 2 weeks after the operation showed recurrence of an aneurysm distal to this fenestrated clip. A second operation was immediately performed. The assumed cause of the recurrence was a remnant at the triangle-shaped gap of the clip. Furthermore, hemodynamic stress caused the clip to slip medially, or the aneurysm re-grew from this remnant.

DISCUSSION

For ideal closure line clipping of broad neck aneurysms, the use of multiple clips is essential in most cases.

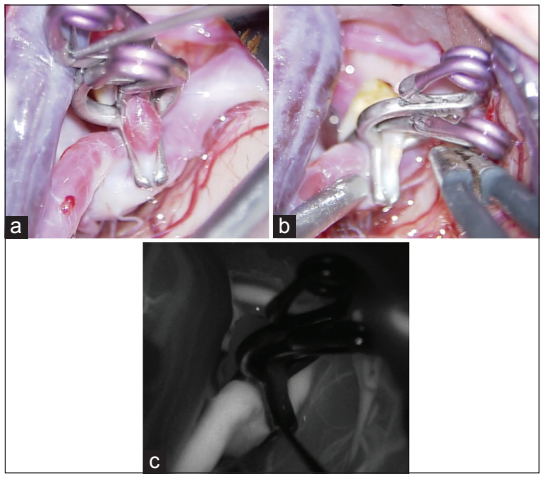


Figure 10: Operative view of the right middle cerebral artery aneurysm. (a) Although the fenestrated mini-clip is applied, blood fills the aneurysm through the triangle-shaped gap. (b) Bipolar coagulation is performed. (c) Indocyanine green videography shows no blood filling into the aneurysm

This can be achieved via tandem clipping or by using fenestrated clips. In our cases, fenestrated mini-clips were most often used for MCA and AcomA aneurysms. Before the fenestrated mini-clip was introduced, we attempted tandem clipping, even if the approach angle was narrow and difficult. The advantage of the fenestrated mini-clip was a smaller triangular space than the standard fenestrated clip and the ability to easily and completely obliterate the aneurysm. This means we can select the safer or easier way for clipping to achieve closure line

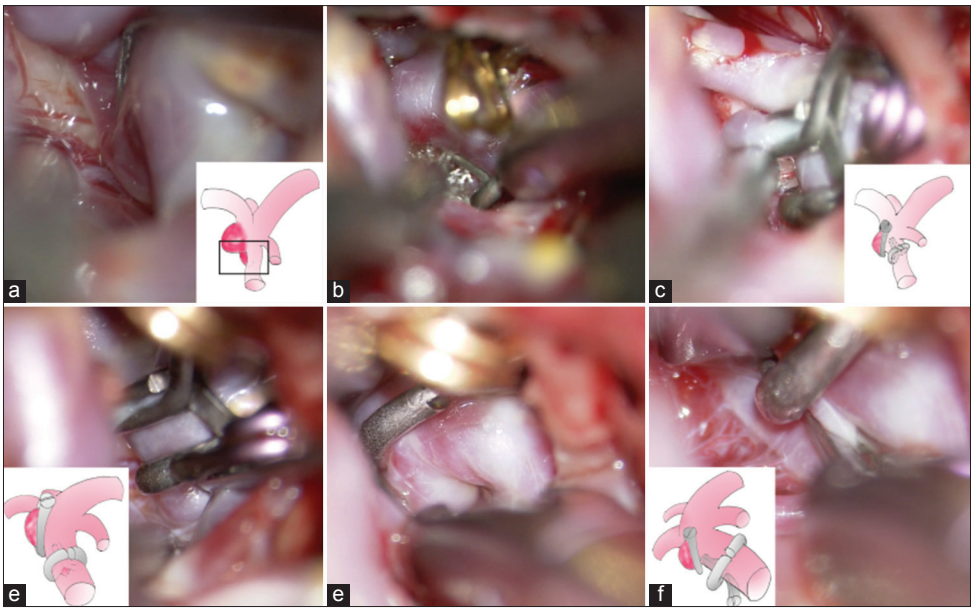


Figure 11: Operative view and schema of the clipping. (a) The additional broad neck aneurysm is identified posterior to the main basilar bifurcation aneurysm. The rectangle of the schema indicates the operative view. (b) The fenestrated mini-clip is applied to the aneurysm posterior to the P1 segment of the posterior cerebral artery. (c) A slightly curved clip is applied to the main component of the basilar tip aneurysm. (d) Operative view of the second operation. Aneurysm recurrence is identified distal to the clipping site. The schematic shows that there may be an aneurysm remnant at the triangle-shaped gap of the end of the blade; this can give rise to aneurysm recurrence. (e) A slightly curved clip is applied. (f) The aneurysm recurrence at the triangle-shaped gap of the fenestrated clip is obliterated by the slightly curved clip

obliteration. If tandem clipping is easier or safer for closure line obliteration, we can choose to use tandem clipping; conversely, if using the fenestrated clip is easier or safer, we can select that method.

After the fenestrated mini-clip was introduced in our institution, the usage rate of the fenestrated clip did not change, but the fenestrated mini-clip was used more frequently than the standard fenestrated clip, such as 902T or 904T. This means that there were many cases in which an aneurysm could be obliterated more easily with the fenestrated mini-clip than with the standard fenestrated clip. This is because the typical function of the mini-clip is to obliterate small dog-ear remnants; thus, a long blade is not necessary in many cases.

However, there are still concerns about the triangular space at the base of the blade. The triangular space of the fenestrated mini-clip has a base length of 0.95 mm and a height of 0.75 mm. Therefore, it is difficult to complete obliteration for aneurysms with thin vessel walls. There are no confirmed reports of aneurysm recurrence resulting from the triangle-shaped gap at the proximal end of the fenestrated clip. However, there are reports that the small orifice located at the junction of the blade and spring portions of Yasargil aneurysm clips can lead to surgery failure or aneurysm recurrence.[1] Furthermore, some studies describe recurrence occurring from the neck remnant even if the remnant is only 1–2 mm in size.[6,10] Thus, aneurysm remnants must be avoided as much as possible. In our experience, it is difficult to completely obliterate a red vessel wall under microscopy when using a fenestrated clip, as illustrated in our case 5. By contrast, complete obliteration is easier in the context of a pink or white vessel wall. However, if the wall of an aneurysm at the apex of the clip blade was thicker than that at the base of the blade, as illustrated in our case 6, complete obliteration cannot always be achieved, and some modification of the technique is therefore needed.

ICG videography can be used to determine whether blood flow is passing through the triangular space.[1] If blood flow is confirmed in this small triangular space, we have to change the approach of the clipping. As showed above, bipolar coagulation of an aneurysm can make the aneurysmal wall thicker, and this is sometimes useful. However, this procedure may result in irreversible injury to the parent and perforating arteries.[9,13] Clipping of the triangular residual dome of an aneurysm is sometimes possible, but, with the exception of tandem clipping, is too difficult; tandem clipping without the use of a fenestrated clip is recommended.

The case of recurrence with the use of a fenestrated clip demonstrated that when a fenestrated clip is placed around an artery, the triangle-shaped gap at the end of the blade cannot be seen because it is located on the back of the ICA. Our case of aneurysm recurrence was identified by postoperative CTA that was performed within 2 weeks. Thus, represents incomplete application of the fenestrated clip rather than true recurrence. In such cases, we have to clip aneurysms with this

triangle-shaped gap in mind to avoid remnants that may cause a recurrence. Therefore, strict follow-up is necessary if a fenestrated clip is placed around the artery, especially immediately after the operation.

Ideal closure line obliteration is possible for an MCA aneurysm.[4] For anterior cerebral artery and AcomA aneurysms, this is also possible by using an interhemispheric approach.[5,8] If clipping is performed through the pterional approach for an anterior communicating aneurysm, it is impossible to achieve closure line obliteration. Closure line obliteration can also sometimes be achieved for IC-PcomA and basilar top aneurysms, and a fenestrated mini-clip is very useful in such narrow conditions with a limited approach angle.

Although the endovascular coiling approach is popular and is associated with good outcomes, clipping is associated with favorable recurrence and re-treatment rates.[7,12] The Yasargil titanium mini-clip might help to improve the quality of clipping.

CONCLUSION

The availability of the Yasargil titanium fenestrated mini-clip increases the number of options for clipping to minimize the remnant of the clipped aneurysm. However, there is still concern about the triangular space at the base of the blade, especially when treating an aneurysm with a thin vessel wall. Therefore, modification of the clipping technique is sometimes needed.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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