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Technical Notes

Limitation of fenestrated clips during clipping of middle cerebral artery aneurysm: Technical note

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ABSTRACT

Background: The middle cerebral artery (MCA) is a common site of cerebral aneurysms and 82.6% occur at the bifurcation. When surgery is selected as a therapeutic option, it intends to clip the neck completely because if some remnant occurs, there exists the possibility of regrowth and bleeding in the short- or long-term.

Methods: We analyzed one drawback of the fenestrated clips of Yasargil and Sugita types to occlude the neck totally at a specific point formed by the union of the fenestra with the blades, creating a triangular space where the aneurysm can protrude, giving place to a remnant that can lead to a future recurrence and rebleeding. We show two cases of ruptured MCA aneurysms in which a cross-clipping technique occluded a broad base and dysmorphic aneurysm using straight fenestrated clips.

Results: In both cases (one using a Yasargil clip and the other with a Sugita clip), a small remnant was visualized when fluorescein videoangiography (FL-VAG) was used. In both cases, the small remnant was clipped with a 3 mm straight miniclip.

Conclusion: We should be aware of this drawback when clipping aneurysms using fenestrated clips to ensure a complete obliteration of the aneurysm's neck.

Keywords: Aneurysm remnant, Cerebral aneurysm, Clipping surgery, Closure line technique, Middle cerebral artery

INTRODUCTION

Anterior circulation aneurysms represent approximately 85% of all cerebral aneurysms and the middle cerebral artery (MCA) is one of the most common sites of occurrence. About 82.6% of MCA aneurysms occur at the bifurcation.[4,20] These aneurysms can be dysmorphic, with a broad neck, and sometimes, the origins of the M2 segments can be included in the base of the neck. The surgery intends to clip the neck completely, without remnants ("dog ears"), while preserving the bifurcation flow.[15,17] Late follow-up angiography suggests that 25% of aneurysms with dog-ear remnant and 75% with broad-base remnant show regrowth, sometimes with aggressive behavior in a short time. Several methods have been recommended to achieve optimum clip placement for aneurysms with irregular bases and atherosclerotic or thrombotic sacs, such as temporary clipping, bipolar coagulation, and step-wise elimination.[3] In the same way, many clipping techniques have been described, and concepts like the ideal closure line have come

from optimizing the surgical clipping and avoiding surgical complications and future recurrence.[6]

Yasargil aneurysm clips

The first generation was made in 1968. Subsequently, the clips have been improved to provide safety, efficacy, stability, and closure force.[2,21] Modern Yasargil clips for brain aneurysms are composed of an alloy of 90% titanium, 6% aluminum, 4% vanadium, and phynox,[13,14] to achieve correct biocompatibility and reduce the number of artifacts in the magnetic resonance imaging (MRI) and computed tomography (CT).[1,2,13,14]

In 2013, the Yasargil fenestrated mini-clips were introduced to the market, leading to a more precise vascular reconstruction in complex cases, reducing the triangle-shaped gap of the large clips and the formation of residual "dog ear" aneurysms at this point.[12,21]

Sugita aneurysm clips

Sugita titanium aneurysm clips are made of a titanium alloy termed 6-aluminium-4-vanadiun-titanium (90% titanium, 6% aluminum, and 4% vanadium). A double-coiled flat spring mechanism maintains a stable spring pressure and wide opening of the blades.[18]

One of the principal differences between Sugita and Yasargil titanium clips is related to their designs. The Sugita clip has a single stabilizing wire to prevent scissoring and maintain the clamping surfaces opposition. The stabilizing wire has no pinching effect of closing. On the other hand, in the Yasargil clips, the blades are welded onto the spring in a "box lock" structure to prevent scissoring.[5]

MATERIALS AND METHODS

Closure line

The closure line is above the aneurysm that emerges at the time of clipping.[6] Clipping parallel to the efferent artery necessarily results in a wide-based residual neck in the case of the bifurcation-type aneurysm [Figures 1a and b]. On the other side, clipping perpendicular to the efferent artery may result in a dog-eared residual neck [Figure 1c]. Therefore, it should be noted that the actual aneurysm orifices have a curved surface, especially in bifurcation and combined-type aneurysms. Therefore, the ideal closure line is curved for these types of aneurysms. Tandem clipping has been combined with primary clipping to remove these dog-eared remnants. There are different technics: under-clipping, cross-clipping, and back-to-back clipping, to place the second or third clip, depending on the relationship with the primary clip. Another similar instance occurs when we use fenestrated clips because, at the point where the fenestra ends, there is a triangular shape space that may favor the presence of small residual necks.

RESULTS

Case 1: Yasargil clip

This 56-year-old male with a history of arterial hypertension was admitted to the hospital because of a sudden onset of a severe headache. CT revealed a right temporal subarachnoid hemorrhage (SAH) [Figure 2a]. In addition, a CT angiography (CT-Angio) was completed, revealing a presence of a saccular aneurysm of 11 mm at the bifurcation of the right MCA [Figure 2b].

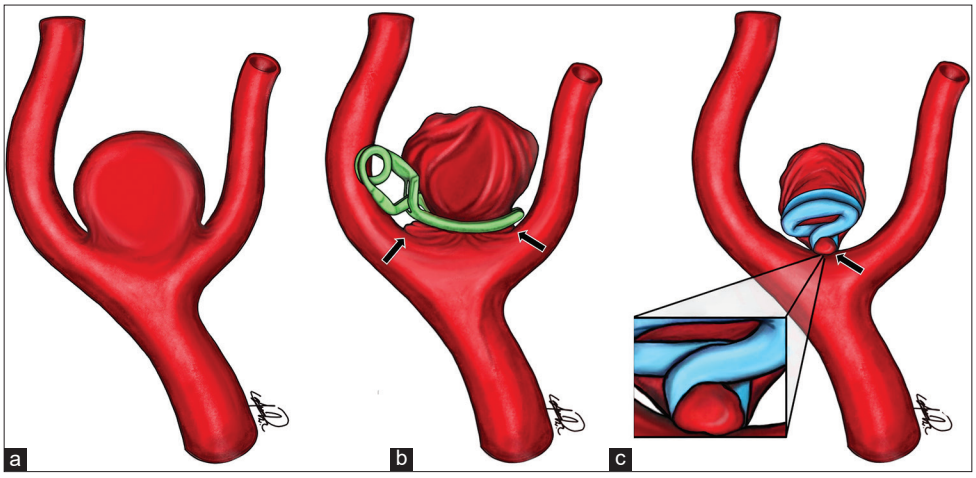

Figure 1: Illustrations showing parallel and perpendicular clipping in a wide neck middle cerebral artery (MCA) aneurysm. Aneurysm of the MCA bifurcation (a). Parallel clipping to the efferent arteries shows a wide-based residual neck (arrows) (b). Perpendicular clipping to the efferent arteries showing a "dog-ear" shaped residual neck (arrow) (c).

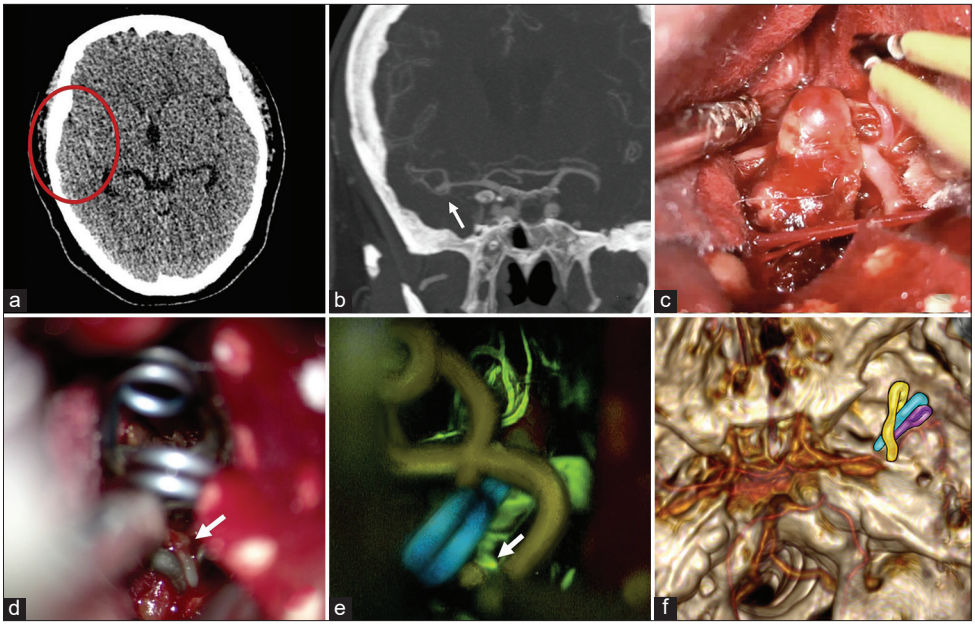

Figure 2: Computed tomography (CT) scan showing a subarachnoid hemorrhage Fisher 1 in the right middle cerebral artery (MCA) territory (red circle) (a). CT angiography reveals a saccular aneurysm of 11 mm at the bifurcation of the right MCA (arrow) (b). Intraoperative image demonstrating the aneurysm at the MCA's bifurcation (c). Initial clipping of the aneurysm using a cross-clipping technique with a 7 mm straight clip and a 5 mm straight fenestrated clip, showing a small neck remnant (arrow) (d). Closure confirmation using intraoperative FL-VAG demonstrating a small filling of the aneurysm through the orifice located at the junction of the blades and the fenestra portion of the clip (arrow) (e). A 3 mm straight mini-clip was placed in this small remnant to occlude the aneurysm completely. Postoperative CT angiography displays the three clips' final arrangement (yellow, blue, and purple structures) (f).

The patient was operated on through a right-side minipterional approach, as Nathal and Gomez-Amador described.[10] After opening the Sylvian fissure, the aneurysm was exposed at the MCA's bifurcation. It was considered a bifurcation type according to the classification of Ishikawa *et al*.[6] [Figure 2c]. After complete dissection and mobilization of the dome, a 7 mm Yasargil-type straight clip was placed in the neck parallel to the M1 segment; after, a second 5 mm straight fenestrated Yasargil clip was set for the ventral remnant, as the closure line concept suggests. We observed an apparent total occlusion of the aneurysm and no space between the blades of the clip; we confirmed the total occlusion using intraoperative Fluorescein-Videoangiography (FL-VAG). However, at the junction between the fenestra and the blades of the clip, there was a small triangular space with the remaining flow that was additionally clipped with a 3 mm straight miniclip [Figures 2d and e]. Total occlusion was confirmed again with the FL-VAG. The postoperative course was uneventful and the patient fully recovered from the initial preoperative neurologic deficit in the next few days. Postoperative CT-Angio showed the disappearance of the aneurysm [Figure 2f] and the perfusion MRI did not show any ischemic area. The patient will be maintained in a long-term follow-up to evaluate the possibility of recurrence or the appearance of "*de novo*" aneurysms. In Figure 3, it is illustrated the sequential cross-clipping technique used in this case.

Case 2: Sugita clip

A 47-year-old female with SAH, Fisher IV, Hunt-Hess II, was admitted to the hospital. Computed tomography showed a right temporal SAH [Figure 4a]. A CT-Angio revealed a 9 mm saccular aneurysm at the bifurcation of the right MCA [Figure 4b]. Surgical treatment was selected. The aneurysm was exposed through a minipterional approach and was considered as a bifurcation-type, according to Ishikawa *et al*.[6] A Sugita 7 mm straight clip was placed in the neck perpendicular to the M1 segment. Then, a 5 mm straight fenestrated Sugita clip was used for the dorsal part of the dome [Figure 4c]. We observed a little remnant between the blades of the clip and the fenestra with the FL-VAG, which was treated with a 3 mm straight mini clip [Figures 4d and e]. Postoperative cerebral a CT-Angio showed the disappearance of the aneurysm [Figure 4f].

DISCUSSION

Closure line concept

Multiple clipping techniques have been reported, such as the tandem technique to eliminate dog-ear remnants.[19] The

ideal closure line concept of Ishikawa describes the placement of additional clips on the primary clip as a complement to obliterate the aneurysm and exclude it from circulation.[6] Different methods have been reported to place the second or third clips, such as the under, cross, and back-to-back clipping, depending on the relationship with the primary clip. In this sense, Ishikawa's ideal closure line concept (fenestrated clip across the primary clip, or "cross clipping") does not always closely match the shape of the neck using the Yasargil clips.[11]

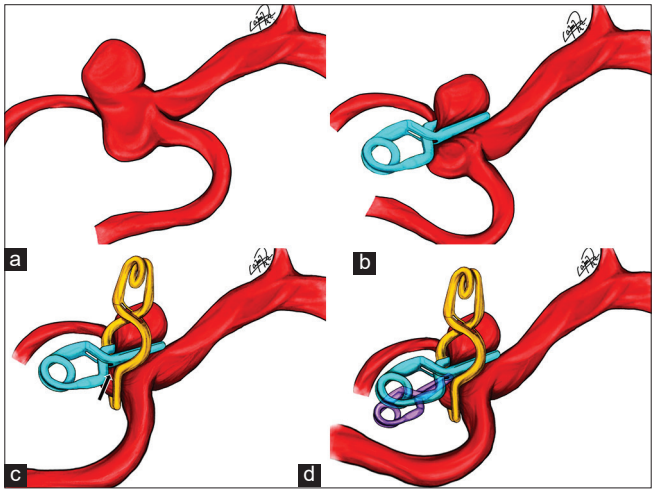

Figure 3: Illustration showing the clipping of the middle cerebral artery (MCA) bifurcation aneurysm. Bi-lobulated dysmorphic MCA bifurcation aneurysm (a). Initial clipping of the neck using a 7 mm straight clip parallel to M1 segment (b). A second fenestrated clip was set across the primary clip, noticing a small remnant in the fenestra area (arrow) with the fluorescein videoangiography (c). A third straight miniclip was placed to close the remnant left by the fenestrated clip (d).

Surgical approach

Dissecting the dome entirely before applying the pilot clip is not advisable, but a sharp dissection of the arteries around and adjacent to the base is crucial. The M1-M2 segments and adjacent and perforating branches near the bifurcation should be unhurriedly, clearly, and painstakingly visualized before the final clipping of a bifurcation-type aneurysm neck; the duration of each temporary occlusion should be kept as short as possible (maximum intervals of 5 min). The proximal clip can be close to the bifurcation, but the distal ones should be at a distance so as not to interfere with the visualization and permanent clipping of the neck. A proper selection of clips with different shapes and lengths and applicators, suiting the imaging anatomy of the neck, should be ready for use. If reshaping is not considered, the blade of a single occluding clip should be 1.5 times longer than

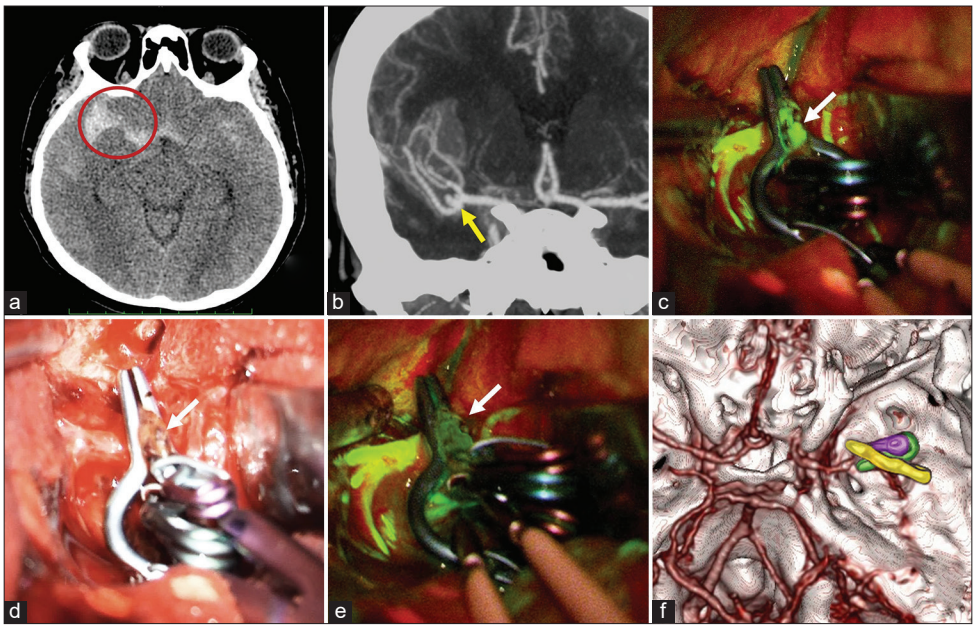

Figure 4: Computed tomography (CT) scan showing subarachnoid hemorrhage Fisher grade IV in the right middle cerebral artery (MCA) territory (red circle) (a). CT angiography shows a saccular aneurysm of 6 mm at the bifurcation of the right MCA (arrow)(b). Intraoperative view shows the initial clipping of the aneurysm with a 7 mm straight clip in the ventral part of the aneurysm and a 5 mm straight fenestrated clip to the dorsal part, showing a small neck remnant (arrow) that still fills with FL-VAG (c). Total closure with a 3 mm mini clip placed in the filling area through the blades and the fenestration (arrow) (d). Confirmation of the closure using intraoperative FL-VAG (arrow) (e). Postoperative CT angiography shows the three clips' final arrangement (yellow, green, and purple structures) (f).

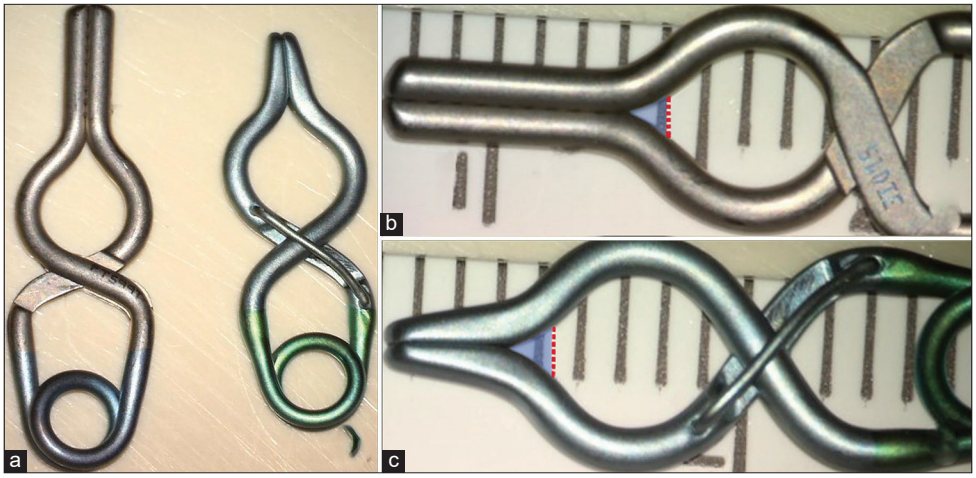

Figure 5: Comparison of a fenestrated Yasargil (left) and Sugita clip (right) (a). Yasargil and Sugita fenestrated clip showing the triangular-shaped gap in the blue shade (b and c). Notice that the space in both clips is around 1 mm, a little bit larger in the Sugita clips. This area should be revised after clipping to confirm the absence of some remnant.

the width of the base. Temporary clipping of M1 and M2 segments reduces intraluminal pressure; it softens the dome with minimal reduction of the arterial lumen, and a thin portion of the healthy arterial wall is taken inside the clip for safe neck closure. Double tandem clips may be applied if the first clip slides, exposing some part of the neck.[9]

Although aneurysm recurrence after a technically perfect neck clipping is rare, it can be seen in all large series with careful long-term follow-up. Various clip systems are currently available, but the most popular nowadays are Yasargil and Sugita-type clips; the two blades of an aneurysm clip are responsible for the proper and permanent occlusion of the aneurysm neck while preserving sufficient blood flow through the parent vessel.[8,12]

Fenestrated clips drawback

One limitation of Yasargil and Sugita fenestrated clips is the geometric design that produces a small space located at the junction of the blades and spring portions [Figure 5], preventing the total occlusion of the neck, despite an otherwise optimal clipping; this failure may be more evident after repeated application because the weakening of the closing force.[8] The closing force of the Sugita clip is about 80 g, and 120 g for the Yasargil clip.[16]

Neurosurgeons usually pay particular attention to the tip of the clip blades during the clipping procedure, ensuring that all parts of the aneurysm neck are inside the clip. Because of this, there is a general tendency to push the clip too far, resulting in a substantial risk of aneurysm refilling and recurrence at this potentially untreated point during the early postoperative or long-term follow-up.[7] [Figure 5].

Practical solutions to avoid such adverse events might be to use clips with slightly longer blades to prevent placing the clip close to this weak point (triangular-shaped gap) or to apply an additional clip to close the untreated part.

CONCLUSION

When clipping a dysmorphic aneurysm with a wide neck, we should consider the weak points of the fenestrated clips. In this sense, using an intraoperative image, modality such as FL-VAG will help to demonstrate small remnants. These residual necks should be obliterated to avoid the possibility of recurrence in the future. Our proposal for these cases is to place a straight mini clip of 3 mm, closing directly the remnant "dog ear" that sometimes is underestimated, achieving a complete obliteration of the aneurysm.

The closure line concept is a good way of reconstructing the neck anatomically and hemodynamically because, in addition to a complete neck occlusion, it rebuilds the bifurcation from a "T" to a "Y" shape improving the flow dynamics. Due to the complexity and variation of the necks of aneurysms, the selection of clips during surgery is of utmost importance. We should take into account that every clip has some particularities. In this report, we want to bring into focus the triangular area of Yasargil and Sugita fenestrated clip as a possible source of "dog ears" causing a potential aneurysm recurrence.

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Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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