"Mass Reduction" Clipping Technique for Large and Complex Intracranial Middle Cerebral Artery Aneurysm

Ririko Takeda[1,2] and Hiroki Kurita[2]

Key words
- Cerebral aneurysm
- Clipping
- Middle cerebral artery
- Multiple clipping
- Surgical technique
- Tandem clipping

Abbreviations and Acronyms
ICG: Indocyanine green
MCA: Middle cerebral artery
STA: Superficial temporal artery

From the Departments of [1]Neurosurgery, Mizonokuchi Hospital, Teikyo University, School of Medicine, Kawasaki, and [2]Cerebrovascular Surgery, International Medical Center, Saitama Medical University, Hidaka, Japan

To whom correspondence should be addressed: Ririko Takeda, M.D., Ph.D. [E-mail: rtakeda@med.teikyo-u.ac.jp]

Supplementary digital content available online.

Citation: World Neurosurg. (2019) 125:150-155.
https://doi.org/10.1016/j.wneu.2019.01.191
Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

BACKGROUND: **Treatment of complex unruptured middle cerebral artery (MCA) aneurysms that are untreatable with conventional surgical techniques are rare, and direct aneurysmal clipping usually remains the first-line treatment for large and giant saccular MCA aneurysms. Tandem clipping and multiple clipping techniques represent neck reconstruction in direct clipping surgeries that address these aneurysms.**

CASE DESCRIPTION: **The authors describe a simple variation of neck reconstructive clipping techniques for the large MCA unruptured aneurysm in a patient with an unruptured 20-mm MCA bifurcation aneurysm. The key of this technique is the application of an appropriate initial clip, the "mass reduction clip"; this clip is inserted not into the aneurysmal neck but on the center of the aneurysmal dome so as to compress the dome at first, which yields a change in the aneurysm's shape and reduces the size of the whole aneurysmal mass. This technique facilitates the ensuing neck reconstruction according to the concept of the ideal closure line using few clips.**

CONCLUSIONS: **"Mass reduction" clipping, which changes the shape of the aneurysm and reduces the size of the whole aneurysmal mass, is a useful variation for the treatment of large aneurysms when conventional clipping across the neck is feasible.**

INTRODUCTION

The treatment of complex middle cerebral artery (MCA) aneurysms, which cannot be treated with conventional surgical techniques, is so challenging that many papers have been published about the treatment with the combination of bypass and vessel occlusion for these lesions.[1-3] However, these complex MCA aneurysms are rare, and direct aneurysmal clipping usually remains the first-line treatment for large and giant saccular MCA aneurysms. Tandem clipping and multiple clipping techniques[4-7] represent neck reconstruction in the direct clipping surgery addressing these aneurysms. In this study, we propose a simple variation of the neck reconstructive clipping techniques for the large MCA unruptured aneurysm.

CASE DESCRIPTION

A 64-year-old man incidentally presented with a right unruptured MCA bifurcation aneurysm (Figure 1). Digital subtraction angiography revealed a large saccular aneurysm (dome size 20 mm, neck size 8.7 mm) and M2 branches that originated from the aneurysmal neck closed to the aneurysmal dome. Magnetic resonance imaging sequences and computed tomography scan conducted before the surgery (Figure 2) showed that this aneurysm was neither calcified nor thrombotic. We surmised that a superficial temporal artery (STA)–MCA bypass could be necessary for the aneurysmal obliteration because of the incorporation of the M2 branch into the aneurysm. However, on the basis of the aneurysmal morphology ascertained via the preoperative imaging and our own experience, we determined that the aneurysm could be treated without a bypass; moreover, the estimated need of an STA-MCA bypass was sufficiently low. We therefore preserved the STA branch in preparation for the bypass during the craniotomy and decided to harvest a graft and perform the bypass after the intraoperative inspection of the anatomy of the aneurysm. A right pterional approach was managed, and the sylvian fissure was widely opened. The bilateral M2 branches were exposed, revealing that they adhered to the aneurysmal dome at the aneurysmal neck (Figure 3A). The dissection of the adhesion between M2 and the dome was attempted, but the M2 branches were incorporated in the aneurysmal dome and the common adventitia appeared to be lodged between them. If more decompression had been gained in the procedure, the more dissection would have progressed; however, the total dissection would have increased the risk of the procedure—even after more decompression—on account of the severe adhesion. Hence we decided to perform the neck reconstructing clipping. Insertion of the temporary clip into the parent artery was attempted to decompress the aneurysm. As the

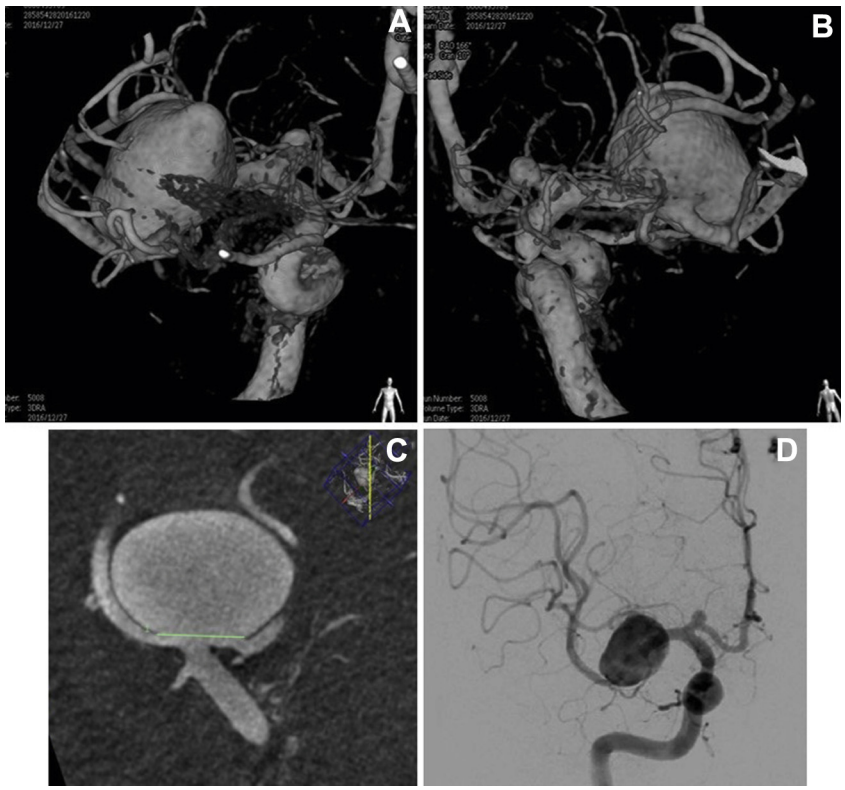

Figure 1. Preoperative right ICA digital subtraction angiogram demonstrating a large right middle cerebral artery aneurysm **(A–D)**.

configuration of the M1 was atherosclerotic and perforators were present, we needed to insert the temporary clip in the internal carotid artery. However, on assessing the decompression of the aneurysm only after the internal carotid artery occlusion, we found that enough decompression was achieved to place the first clip. The first permanent clip was placed on the center of the dome with the fenestrated clip (Figure 3B). This clip placement prompted a change in the aneurysm's configuration and reduced the aneurysmal mass, which had been expanding spherically before. One more fenestrated straight clip was put on the center, adjacent to the first clip, in order to reinforce the mass reduction of the dome (Figure 3C and D). A third light curved clip was placed to reconstruct the neck on its temporal side (Figure 3E). At first, the clip was applied along the inferior trunk of M2; however, the Doppler flow imaging showed poor flow of the inferior trunk, which indicated kinking of the inferior trunk of M2. Hence the clip was released, and the second application was adjusted to allow for sufficient flow of the M2. Good patency of the M2 could be assessed with Doppler flow imaging and intraoperative ICG angiography. The next clip (the fourth clip) was applied to reconstruct the frontal side of the neck (Figure 3F). To preserve the flow of the superior trunk of M2, which was adhered to the dome, and considering the calcification of the dome at this lesion, the fenestrated L-shaped clip was applied. An additional fenestrated straight clip was applied to cover the residual part of the frontal side of the neck as the fifth clip (Figure 3G). Finally, patency of the

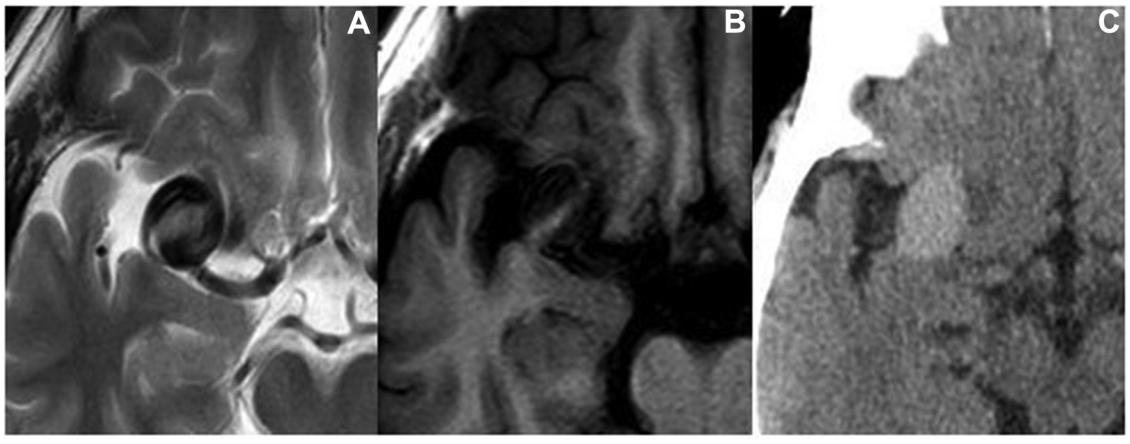

Figure 2. Preoperative magnetic resonance imaging sequences (**A,** T2-weighted imaging; **B,** T1-weighted imaging) and computed tomography scan (**C**) showing that the aneurysm was neither calcified nor thrombotic.

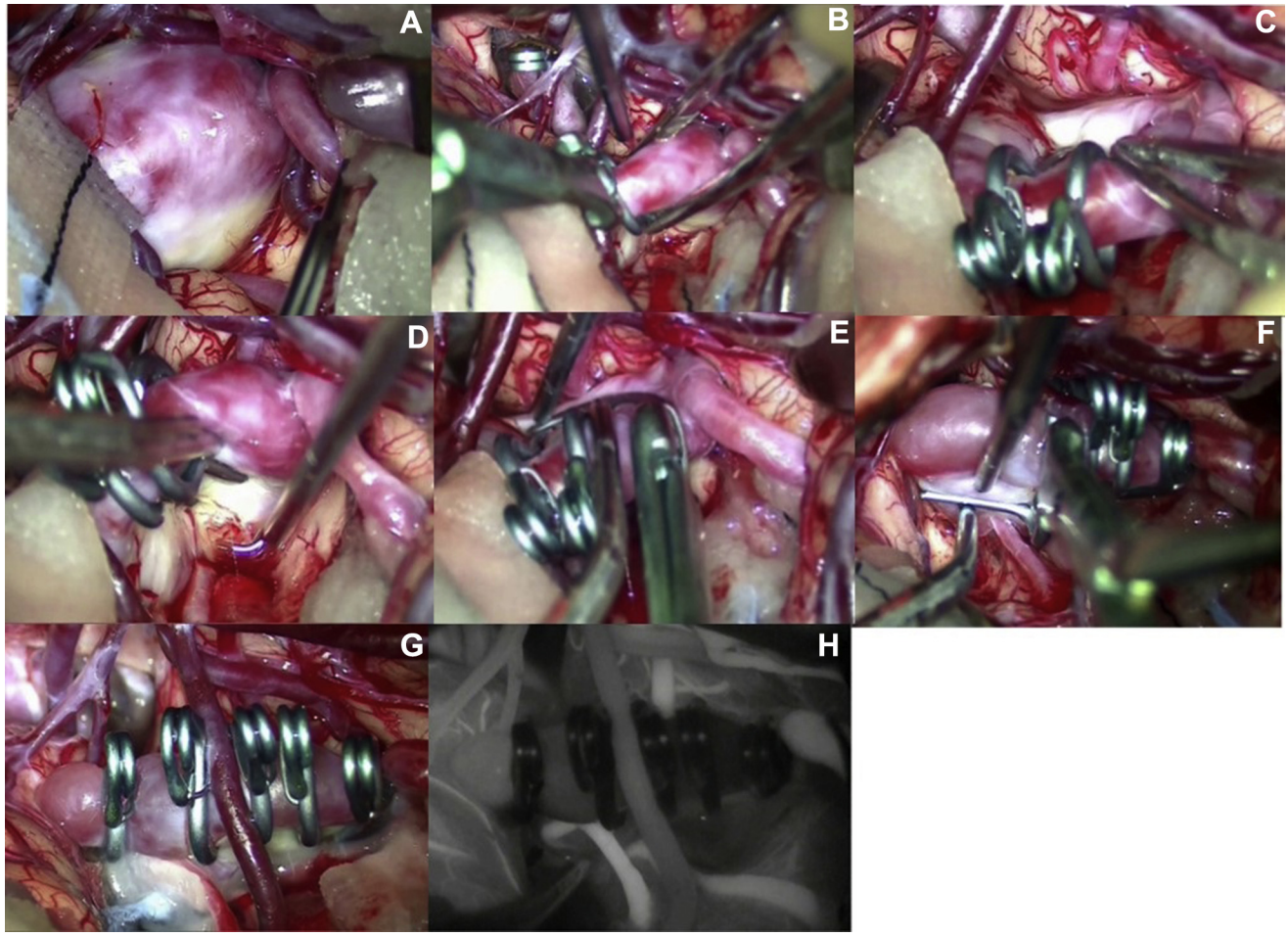

Figure 3. Intraoperative photograph of the aneurysm (**A**). The first permanent, fenestrated clip is placed on the center of the dome ("mass reduction clip") (**B**–**D**). The following clips are applied reconstructed parallel to the neck with the clip blade to take advantage of the wide space and improved visualization gained by the first clips (**E**–**F**). Patency of the bilateral M2 and devascularization of the aneurysm are assessed with the Doppler flow and intraoperative ICG video angiograph (**G** and **H**).

bilateral M2 and devascularization of the aneurysm could be assessed with Doppler flow imaging and intraoperative ICG video angiography (Figure 3H) (Video 1).

Postoperative angiography (Figure 4A) showed complete clipping preserving bilateral M2 flow except for intentional remnant in which the superior trunk of M2 adhered to the aneurysm. The postoperative clinical course and imaging showed no complications (Figure 4B).

Video

Video available at www.sciencedirect.com

DISCUSSION

The aneurysmal neck reconstruction technique using multiple clips is a useful method for clipping large aneurysms when conventional clipping across the neck is not feasible, either due to complex anatomy, atherosclerosis, calcification, or adhesion of branches. Tandem clipping and multiple clipping techniques represented neck reconstruction treatments. Davies et al[4] presented "picket fence" clipping as a tandem clipping technique in which parallel straight clips, simple and/or fenestrated, are stacked vertically from the dome to neck with the tips reconstructing the neck (Figure 5A). This technique is simple but requires numerous clips to reconstruct the neck.[7] On the other hand, Sano presented surgical techniques that involved the use of multiple clips with the initial clip securing the deepest neck part and the others successively occluding the rest by remnant clips (Figure 5B).[6] However, this technique requires sufficient decompression of the aneurysm via parent artery occlusion and the aneurysmal trapping using temporary clips to achieve a successful outcome.

Hence, we proposed a variation of neck reconstruction techniques for the treatment of a large MCA aneurysm to address the aforementioned problems of other techniques.

Concept of Technique

The key of this technique is the application of an appropriate initial clip, which

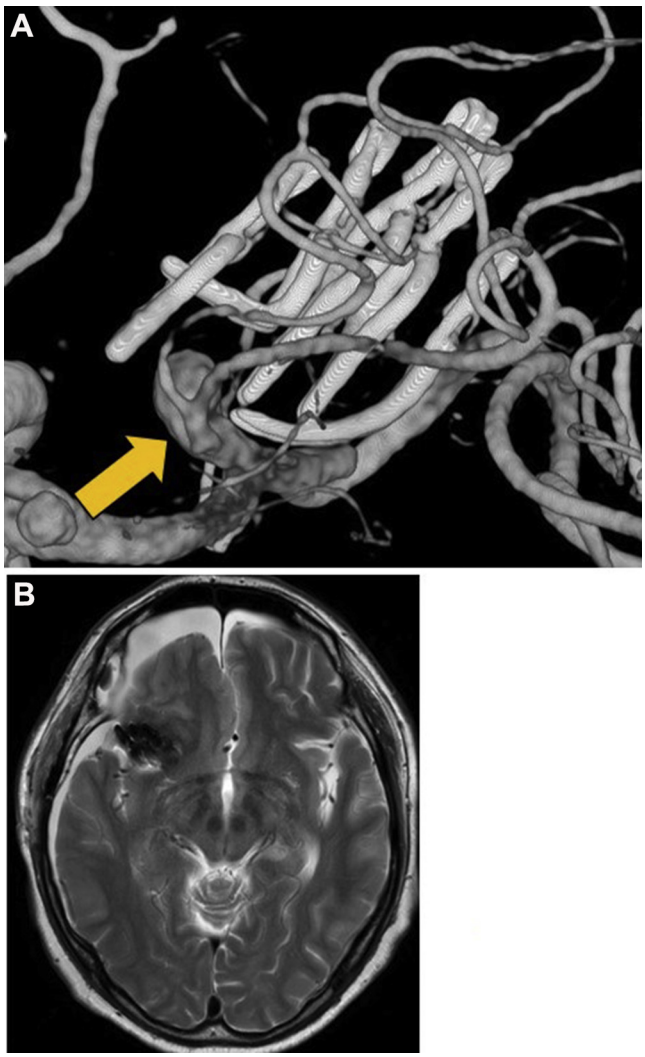

Figure 4. Postoperative right internal carotid artery digital subtraction angiography showing complete clipping preserving bilateral M2 flow except for intentional remnant (*arrow*) in which the superior trunk of M2 adhered to the aneurysm **(A)**. Postoperative computed tomography scan showing no complications **(B)**.

we call the "mass reduction clip" (Figure 5C). This clip is inserted not into the aneurysmal neck but on the center of the aneurysmal dome to initially compress the dome and thereby induce a change in the shape of the aneurysm and reduce the size of the entire aneurysmal mass. This simultaneously widens the workable space and makes visible the rest of the aneurysm including the neck.

Merit of This Technique

In this technique, clips following the mass reduction clip can be applied parallel to the neck with the clip blade to take advantage of the broadened work space and improve wide visualization gained by the initial clip; this contrasts with the aforementioned stacking of clips from dome to neck with clip tips as the tandem clipping.[4,7] This technique thus facilitates the following neck reconstruction along the concept of the ideal closure line.[8]

Compared with conventional tandem clipping technique, this technique helps to reduce medical costs by using fewer clips: indeed, only 5 clips were used in this case. If this aneurysm was treated with the tandem clip method, >10 clips would have been required to achieve the aneurysmal devascularization. The proposed method is also useful in precluding the kinking of the M2, which occurs as a consequence of the considerable cumulative weight of multiple clips applied when the tandem clipping technique is employed.[9]

Furthermore, this technique may render it possible to shorten the duration for which the temporary clip is used. Even though this technique used a temporary clip to decompress the aneurysm when the first clip is applied, it is not necessarily needed for clipping subsequent to the achievement of the aneurysmal mass reduction via the placement of the mass reduction clip. The temporary clip employed for a shorter duration and with a lower frequency can contribute to preventing dissection of the parent artery, ischemic stroke, and injury of perforators.

Utilization of Fenestrated Clips

In this technique, a fenestrated clip is useful as the mass reduction clip, which compresses the center of the aneurysm. If a straight clip was used as the first clip instead, the clip would have to be longer to achieve the same result. However, clips, especially standard long clips, sometimes cannot close the blade tip and compress the large MCA aneurysmal dome, whose wall is often thick with atheroma and calcification. This is because the closing force of aneurysmal clips decreases as it leaves the coil spring[10]; the closing force in the clip is therefore weakest at its tip and strongest at its crossover part.[10] By using the fenestrated clip in this technique, it is possible for the fenestration to skip the upper part of the dome, allowing the center of the dome to be sufficiently compressed by the crossover of the clip with highest closing force (Figure 4C).

Complication Avoidance and Limitations of This Technique

As aforementioned, the key to this technique is that the first clip is inserted not into the aneurysmal neck but on the center of the aneurysmal dome. Therefore it is not necessary to place the first clip in a deep or radical position because the purpose of this clip is just to provide for an initial compression of the dome and facilitate the subsequent neck reconstruction. The first clip is, if possible, placed on a portion of the dome without

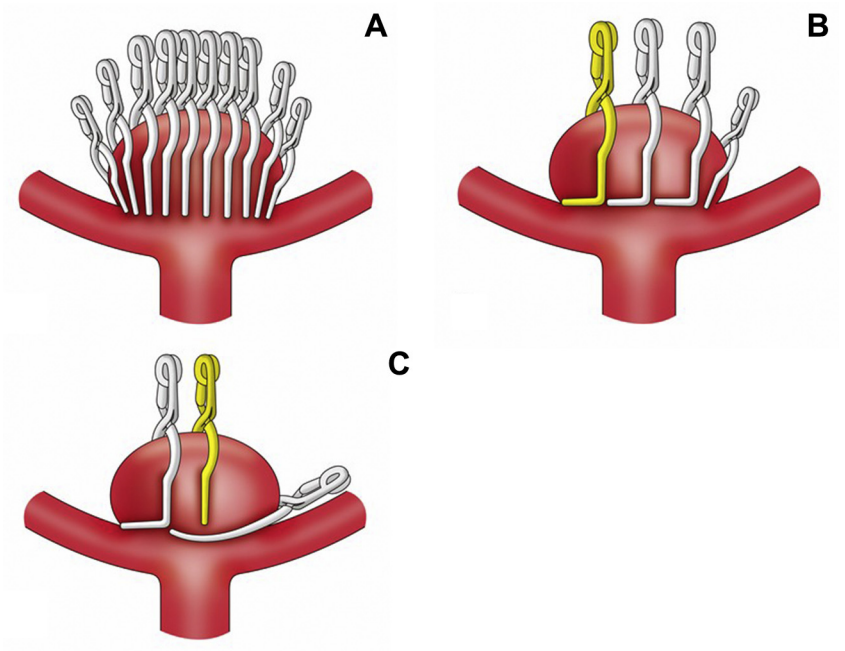

Figure 5. A tandem clipping technique in which multiple parallel straight clips are stacked vertically from dome to neck with the tips to reconstruct the neck **(A)**. A multiple clipping technique with the initial clip (*yellow clip*) securing the deepest part of the neck part and the others occluding successively shallower segments **(B)**. A multiple clipping technique with the initial "mass reduction clip" (*yellow clip*) on the center of the aneurysmal dome, which reduces the size of the whole aneurysmal mass and facilitates the following neck reconstruction **(C)**.

atherosclerosis or calcification; such conditions could impede the closing of the clip blades, and placing the clip there may narrow the origin of the M2, compromising outflow. Most importantly, in not only the first clip but following neck reconstructing clip, the surgeon must be appropriately generous with the clip application to avoid inadvertent arterial occlusions, as reported in the previous paper concerning the tandem clipping technique.[7] A luminal channel must be envisioned and created with the careful clip placement that protects the origin of the branch artery and preserves blood flow through it, and which is particularly important in case of atherosclerotic aneurysms. Furthermore, severe atherosclerotic or calcified aneurysms would not be amenable to this technique because these aneurysms often prevent the closing of the clip blades and easily compromise outflow by narrowing the origin of the M2. As a matter of course, this technique is also not feasible to partial thrombosed aneurysms or ruptured aneurysms.

In addition, complex aneurysms that cannot be treated with complex clip reconstructions often require bypass techniques as the next option.[7] The surgeon should estimate this possibility and prepare accordingly in advance.

Tips for This Technique

Tips regarding the application of this technique include the following:

1. It is important to appreciate the thickness of the wall of the aneurysm before performing the clipping and reduce the tension of the aneurysm with a temporary clip to prevent premature rupture during the procedure.
2. When reconstructing the neck after the mass reduction achieved with the initial clip, it is important to place the clips reconstructing the M2 branch. This is because the aneurysm often features the adhesion between the neck of the aneurysm and the wall of the M2 branch.
3. ICG video angiography and Doppler flow imaging are absolutely necessary—an intraoperative angiogram would be an even better approach if available—to confirm the flow of M2 branches and devascularization of the aneurysm.

CONCLUSIONS

"Mass reduction" clipping, which changes the shape of the aneurysm and reduces the size of the whole aneurysmal mass, is a useful technical variation for the treatment of large aneurysms when conventional clipping across the neck is infeasible.

ACKNOWLEDGMENTS

We would like to acknowledge Mr. John Catton for assistance with checking English language of this manuscript.

REFERENCES

1. Kivipelto L, Niemelä M, Meling T, Lehecka M, Lehto H, Hernesniemi J. Bypass surgery for complex middle cerebral artery aneurysms: impact of the exact location in the MCA tree. *J Neurosurg*. 2014;120:398-408.
2. Meybodi AT, Huang W, Benet A, Kola O, Lawton M. Bypass surgery for complex middle cerebral artery aneurysms: an algorithmic approach to revascularization. *J Neurosurg*. 2017;127:463-479.
3. Kalani MY, Zabramski JM, Hu YC, Spetzler RF. Extracranial-intracranial bypass and vessel occlusion for the treatment of unclippable giant middle cerebral artery aneurysms. *Neurosurgery*. 2013;72:428-435.
4. Davies JM, Lawton MT. "Picket fence" clipping technique for large and complex aneurysms. *Neurosurg Focus*. 2015;39:V17.
5. Kato Y, Sano H, Imizu S, et al. Surgical strategies for treatment of giant or large intracranial aneurysms: our experience with 139 cases. *Minim Invasive Neurosurg*. 2003;46:339-343.
6. Sano H. Treatment of complex intracranial aneurysms of anterior circulation using multiple clips. *Acta Neurochir Suppl*. 2010;107:27-31.
7. Yang I, Lawton MT. Clipping of complex aneurysms with fenestration tubes: application and

assessment of three types of clip techniques. *Neurosurgery*. 2008;62(suppl 2):ONS371-ONS379.

8. Ishikawa T, Nakayama N, Moroi J, et al. Concept of ideal closure line for clipping of middle cerebral artery aneurysms. *Neurol Med Chir (Tokyo)*. 2009;49:273-278.

9. Rayan T, Amin-Hanjani S. Suture retraction technique to prevent parent vessel obstruction following aneurysm tandem clipping. *J Neurosurg*. 2015;123:472-474.

10. Horiuchi T, Rahmah NN, Yanagawa T, Hongo K. Revisit of aneurysm clip closing forces: comparison of titanium versus cobalt alloy clip. *Neurosurg Rev*. 2013;36:133-138.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 6 November 2018; accepted 28 January 2019

Citation: World Neurosurg. (2019) 125:150-155.
https://doi.org/10.1016/j.wneu.2019.01.191

Journal homepage: ***www.journals.elsevier.com/world-neurosurgery***

Available online: ***www.sciencedirect.com***