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Intentional Staged Clipping Following Previous Coil Embolization of Ruptured Aneurysm with a Branch Arising from the Neck: Technical Note

Seiei TORAZAWA, Daisuke SATO, Shotaro OGAWA, Shogo DOFUKU, Masayuki SATO, Takahiro OTA

Tokyo Metropolitan Tama Medical Center, Department of Neurosurgery, Fuchu, Japan

Corresponding author: Seiei TORAZAWA ✉ tora.xxx.001@gmail.com

ABSTRACT

AIM: To present a substitute strategy for clipping: coil embolization of the ruptured aneurysm followed by intentional, staged clipping.

CASE DESCRIPTION: We treated five cases of ruptured intracranial aneurysms with branches arising from the neck. The mean aneurysm diameter was 4.4 mm. In the acute rupture phase, coiling was performed without adjunctive endovascular techniques with intentional preservation of the neck in all cases. To treat recurrence during follow-up, the previously coiled aneurysm was clipped, which did not occasion any complications. Postoperative imaging showed completely obliterated aneurysms and preserved branches. No rebleeding occurred during the interval between coiling and clipping, and no rebleeding or recurrence occurred after clipping. No treatment-related complications occurred after coiling and clipping.

CONCLUSION: This two-stage strategy may be effective for hemostasis and branch preservation for small- and medium-sized ruptured aneurysms with a branch arising from the neck. This intentional two-stage strategy can be a substitute strategy for clipping in the acute rupture phase with an acceptable outcome if the patient cannot undergo clipping as the first-line treatment.

KEYWORDS: Intracranial ruptured aneurysms, Clipping, Coil embolization, Endovascular treatment

ABBREVIATIONS: ACA: Anterior cerebral artery, **CE:** Coil embolization, **Cm:** Callosomarginal artery, **DSA:** Digital subtraction angiography, **IC-PC:** Internal carotid-posterior communicating artery, **MRI:** Magnetic resonance imaging, **mRS:** Modified Rankin Scale, **Pcom:** Posterior communicating artery, **SAH:** Subarachnoid hemorrhage, **WFNS:** World Federation of Neurological Surgeons

INTRODUCTION

Recent years have seen the introduction of advanced devices and embolization techniques for the endovascular treatment of complex aneurysms. However, endovascular treatment of a small- or medium-sized aneurysms with a branch arising from the neck remains a challenge. An increased risk of branch occlusion has been reported for these cases even with current progress in endovascular treatment (5,7). For aneurysms with a branch, microsurgical clipping may be preferable to coil embolization (CE) for preserving the branch. However, in the acute phase of aneurysm rupture, the patient cannot always undergo microsurgery for several unavoidable reasons, e.g., a risk of severe systemic complications from general anesthesia, severe vasospasm on admission, or difficulty in identifying the ruptured aneurysm due to the presence of multiple aneurysms. In this report, we present a substitute for clipping in the acute phase called the "two-stage strategy," which involves intentional, staged clipping of the recurrent aneurysm previously coiled in the

Seiei TORAZAWA : 0000-0001-8447-8287
Daisuke SATO : 0000-0002-8672-2383
Shotaro OGAWA : 0000-0002-2919-2224
Shogo DOFUKU : 0000-0002-3064-8858
Masayuki SATO : 0000-0001-8695-2966
Takahiro OTA : 0000-0002-5108-6719

acute phase. Although it is just an alternative to clipping as the first-line treatment, this two-stage strategy may be effective in preserving a branch arising from the neck while achieving hemostasis. We report our experiences with this two-stage strategy and clarify the feasibility and acceptability of this substitute strategy.

MATERIAL and METHODS

Of the 192 patients treated for ruptured cerebral saccular aneurysms from January 2017 to September 2020 at our institution, we treated five with our two-stage strategy. In this consecutive case series, anatomical features of the aneurysms, complications of CE and clipping, and post-coiling and post-clipping outcomes were assessed retrospectively. This retrospective study was approved by our institutional review board.

RESULTS

All patients were women, with a mean age of 65 years (range, 53–71 years) (Table I). The aneurysms involved the middle cerebral artery in two patients and the internal carotid-posterior communicating artery (IC-PC), distal anterior cerebral artery (ACA), and vertebral artery in the remaining three patients, respectively. The mean aneurysm diameter at the initial presentation was 4.4 mm (range, 3.1–5.6 mm). In all cases, the aneurysm had a branch arising from the neck. According to the treatment guidelines of our facility (Figure 1), coiling is the first-choice treatment except in cases where hematoma evacuation or external decompression is required. Exceptionally, in these five cases, clipping was considered the best option due to the anatomical features described above. However, for various reasons, we chose the two-stage strategy for the acute phase instead of clipping. All angiographic outcomes of the initial coiling were classified as having a residual neck because of preservation of the branch arising from the neck. No complications occurred during CE, and no rebleeding occurred after CE. Recurrence of the aneurysm due to aneurysm regrowth was observed in three cases (1, 4, and 5). Recurrence due to coil compaction and aneurysm

Table I: Clinical Characteristics and Treatment Results of Five Cases of Ruptured Aneurysms Treated with Staged Clipping Following Prior Coil Embolization

Case	**1**	**2**	**3**	**4**	**5**
Age/Sex	71/F	70/F	60/F	69/F	53/F
Location	IC-PC	MCA	MCA	ACA	VA-PICA
Size (Neck x Dome x Height) (mm)	2.6×3.6×4.0	4.0×5.6×5.2	4.0×2.6×4.0	2.4×2.0×3.1	3.2×4.0×5.3
D/N ratio (Dome/Neck)	1.38	1.4	0.65	0.83	1.25
Branch	+	+	+	+	+
	from neck	from neck	from neck	from neck	from neck
Bleb	+	+	+	-	+
Coil embolization	Neck remnant	Neck remnant	Neck remnant	Neck remnant	Neck remnant
Adjunctive technique	-	-	-	-	-
Total coil (cm)	8	18	11	4	21
Complication with coiling	-	-	-	-	-
Cause of retreat	aneurysm regrowth	coil compaction	coil compaction	aneurysm regrowth	aneurysm regrowth
Height of residual neck (mm)	2.1	2.5	2.1	1.8	2.4
Interval		2 mo >		2 mo <	
	12 day	24 day	57 day	6.5 mo	14 mo
Coil extraction	-	-	-	-	-
clip	mini clip	mini clip	mini clip	mini clip	standard clip
Complication with clipping	-	-	-	-	-
Pre clipping mRS	2	0	0	0	1
Post clipping mRS	2	0	0	0	1

***F:** Female, **IC-PC:** Internal carotid-posterior communicating artery, **MCA:** Middle cerebral artery, **ACA:** Anterior cerebral artery, **VA-PICA:** Vertebral-posterior inferior cerebellar artery, **mo=month:** mRS= modified Rankin Scale.*

recanalization was identified in the remaining two cases (cases 2 and 3). For recurrent aneurysms, we determined the treatment strategy according to the flowchart of Figure 1. In aneurysms recurrent due to coil compaction (cases 2 and 3), additional coiling was contraindicated because of the possibility of branch occlusion. All aneurysms were considered to have residual neck amenable to direct clipping (mean height of the residual neck, 2.2 mm; range, 1.8–2.5 mm). Therefore, microsurgical clipping was chosen and performed in all patients without treatment-related complications. We determined that clipping retreatment should be performed as soon as possible after the observation of regrowth or recanalization. We routinely confirm with digital subtraction angiography (DSA) within 2 weeks of onset and then follow up with magnetic resonance angiography and an x-ray before discharge (at around 1–2 months after onset). Further follow ups are performed at 6 months and 1 year after onset. The mean interval between CE and clipping was 91 days (range, 12 days to 14 months). In no case did the modified Rankin Scale (mRS) score worsen after clipping surgery. The mean postoperative follow-up period was 18.8 months (range, 3–33 months), and no rebleeding or recurrence after clipping was observed.

CASE DESCRIPTIONS

Case 1

A 71-year-old woman was referred to our neurosurgical department complaining of a headache. She was diagnosed with subarachnoid hemorrhage (SAH) due to a ruptured left IC-PC aneurysm (World Federation of Neurological Surgeons [WFNS] grade 2). The aneurysm was 2.6 x 3.6 x 4.0 mm (neck x dome x height) in size, elongated in shape, and with the posterior communicating artery (PcomA) bifurcating from the neck (Figure 2A). On day 1, endovascular CE was performed without adjunctive techniques. Our strategy was to occlude the aneurysm sac but leave a residual neck to preserve the PcomA (Figure 2B). Follow-up cerebral DSA performed on day 6 revealed significant regrowth of the neck to a height of 2.1 mm (Figure 2C). On day 12, microsurgical clipping was performed. Using a left frontotemporal craniotomy and pterional approach, this recurrent aneurysm was clipped with two Yasargil titanium mini-clips to preserve the patency of the PcomA. No additional deficits appeared after clipping, and postoperative magnetic resonance imaging (MRI) showed no ischemic lesions. Postoperative DSA demonstrated complete clipping of the recurrent aneurysm (Figure 2D) and the postoperative mRS score was unchanged from the preoperative value of 2. The patient was last seen 8 months after clipping, at which time her mRS score was 0.

Case 4

A 69-year-old woman presented with a WFNS grade-1 SAH due to a ruptured right distal ACA aneurysm. The aneurysm was 2.4 x 2.0 x 3.1 mm (neck x dome x height) in size with the callosomarginal artery (CmA) arising from the neck (Figure 3A). CE was performed on day 1 using a simple technique that occluded the small aneurysm sac while leaving residual neck to preserve the CmA (Figure 3B). As a result, no neurological deficits were observed after coiling. Follow-up magnetic resonance angiography showed that the slight residual neck had not enlarged, and the patient was discharged home on day 18. However, follow-up cerebral DSA performed 6 months after coiling demonstrated significant regrowth of the neck to 1.8 mm (Figure 3C). Microsurgical clipping was performed using a right frontal craniotomy 6.5 months after the initial rupture of the aneurysm. The recurrent aneurysm was clipped with two Yasargil titanium mini-clips to preserve the patency of the CmA. Postoperative computed tomography angiography demonstrated complete clipping (Figure 3D), and MRI revealed no new ischemic lesions. She was last seen 14 months after clipping, at which time her mRS score was 0.

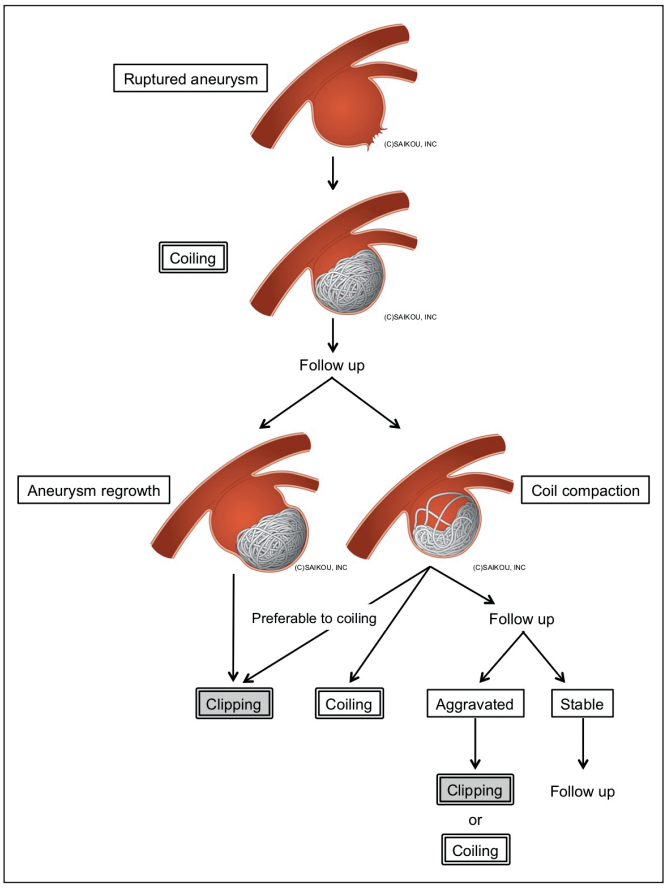

Figure 1: The treatment flowchart of our institution for a ruptured aneurysm with a branch arising from the neck. Initially, coil embolization was performed to preserve the branch. If the recurrence is caused by aneurysm regrowth, retreatment with clipping is preferable to coiling. In case of recurrence due to compaction, retreatment with coiling is basically considered, but clipping should be considered if coiling is considered likely to result in suboptimal occlusion. If the recurrence aggravates further during follow-up, clipping should be considered.

DISCUSSION

Effectiveness of Our Two-Stage Strategy

Although it is only a substitute for the first-line strategy of clipping, we showed that our two-stage strategy might be

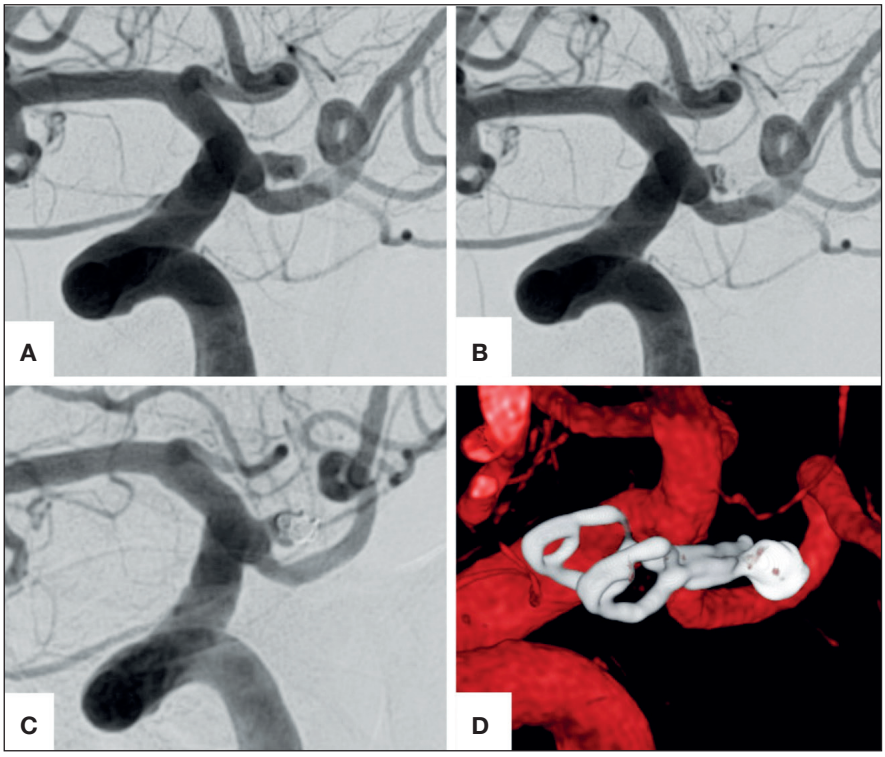

Figure 2: Case 1. 71-year-old women with ruptured left internal carotid-posterior communicating artery (IC-PC) aneurysm. **A)** The initial cerebral digital subtraction angiography (DSA) showed ruptured left IC-PC aneurysm with posterior communicating artery (PcomA) bifurcated from the neck. **B)** Post-coiling DSA on day 1 illustrated the residual neck and occlusion of tip of the aneurysm sac. PcomA was preserved without any thromboembolic complications. **C)** Follow-up DSA on day 6 revealed regrowth of the neck and partial aneurysm recanalization. The height of residual neck was 2.1 mm. **D)** Postoperative three-dimensional rotational angiography demonstrated successfully clipped aneurysm and preserved PcomA.

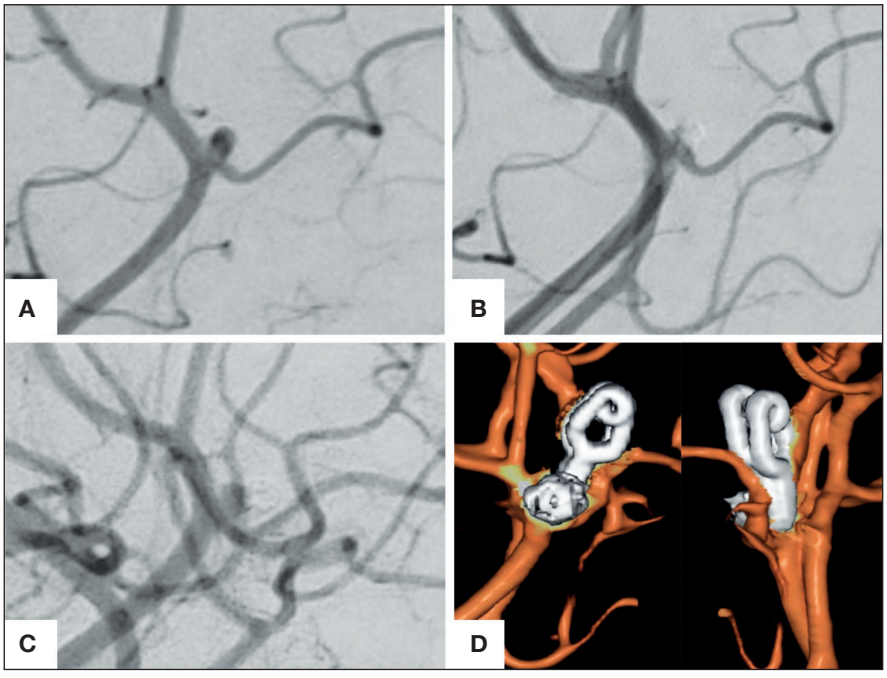

Figure 3: Case 4. 69-year-old women with ruptured right anterior cerebral artery (ACA) aneurysm. **A)** The initial cerebral digital subtraction angiography (DSA) showed ruptured right ACA aneurysm with callosomarginal artery (CmA) arising from the neck. **B)** Post-coiling DSA on day 1 illustrated the residual neck and occlusion of tip of the aneurysm sac. CmA was preserved without any thromboembolic complications. **C)** Follow-up DSA after 6 months revealed neck regrowth. The height of residual neck was 1.8 mm. **D)** Postoperative computed tomography angiography demonstrated successfully clipped aneurysm and preserved CmA.

useful for obtaining aneurysm hemostasis in the acute phase while preserving vulnerable artery branches.

Endovascular treatment is expected to carry elevated risk in the treatment of aneurysms with a branch arising from the neck. Although several endovascular adjunctive techniques designed to preserve such branches have been reported, the overall incidence of thromboembolic complications with both balloon-assisted and stent-assisted techniques is reportedly high at about 10% (10,12). Additionally, in the acute phase of aneurysm rupture, improper use of antiplatelet agents can further increase the risk of thromboembolic complications. Hence, the strategy of allowing a residual neck in the first endovascular session and avoiding adjunctive techniques could contribute to a reduced risk of branch occlusion.

However, it has been reported that the rates of recurrence and retreatment after CE are greater than those after clipping (8,11,14,18). The CARAT study revealed a significantly high re-rupture rate in cases with partial (<70%) occlusion (6). Additionally, the rebleeding rate in coiled ruptured aneurysms has been reported to be 0.4% if the aneurysm is stable but 7.9% if it exhibits recurrence (1). Therefore, we believe that achieving the highest occlusion rate possible and closely following up the patient are essential for lowering rerupture rates. When recurrence is observed, immediate retreatment should be considered. In our present series, the protocol described in the Results section was used to detect recurrence and permit timely retreatment.

Generally, when considering retreatment, it should be recognized that recurrence of an aneurysm can have two distinct causes: aneurysm regrowth and coil compaction. Aneurysm regrowth is characterized by a change in the morphology of the aneurysm relative to its initial structure (9). Coil compaction is a change in the configuration of the coil compared with the baseline appearance of the coil mass after CE, without changes in the morphology of the aneurysm itself (9). It is important to differentiate between the two types of recurrence because some previous reports have found that aneurysm regrowth is more dangerous than coil compaction (2,11). Owen et al. reported that clipping was preferable when the cause of recurrence was not simple compaction but regrowth, because regrowing aneurysms have diseased walls that increase the risk of further recurrences after coiling (11). Dorfer et al. claimed that 85.7% of aneurysms that recur due to regrowth require multiple re-coiling, compared with 21.3% of aneurysms that recur due to coil compaction (4). In our facility, we use the flowchart shown in Figure 1 as a guideline to determine the retreatment strategy. If the cause of recurrence is coil compaction, additional embolization may be considered. However, to preserve a branch, some residual neck must remain after the first CE session, and recurrence is thus to be expected. Therefore, to avoid multiple re-coiling, clipping an aneurysm that recurs due to coil compaction is preferred. For aneurysms with a branch arising from the neck, we selected clipping as the retreatment regardless of the cause of recurrence.

In the current endovascular era, stent-assisted coiling and flow-diverter stents have also been reported as effective retreatment methods, (3,19) but they unavoidably require prolonged antiplatelet therapy. However, CE treatments not requiring antiplatelet therapy, such as stent retrievers and temporary bridging devices, have recently been reported (16, 17). These techniques are worth considering as advanced CE capable of preserving branches arising from the neck, and further reports of good results are expected.

Feasibility of Clipping Previously Coiled Aneurysms

Previous reports have demonstrated that the outcomes of neck clipping of coiled aneurysms are mostly good in adequately selected cases (15). Some coiled aneurysms can be unclippable and must be opened to mobilize the coils out of the area to be clipped or extract them. In other cases of unclippable aneurysms, a bypass strategy may be needed involving trapping or proximal occlusion (11). Large and giant recurrent aneurysms can often be treated with these maneuvers; however, the incidence of complications is reportedly greater than in conventional clipping (11,13). Direct clipping without these techniques requires the residual neck to be of sufficient height and the aneurysm to be of adequate size. Waldron et al. reported that more than 2 mm of residual neck was required for neck clipping of a coiled aneurysm (20). Shtaya et al. clarified that the average residual height of coiled aneurysms that could be treated with direct clipping was 1.99 mm (15). The Yasargil titanium clips we used here had a width of either 1.2 mm (standard clip) or 1.0 mm (mini-clip). We assessed the possibility of direct clipping pragmatically based on these dimensions. Overall, we consider our two-stage strategy to be safe and feasible for aneurysms <10 mm in size (non-large) that have a branch and a residual neck of at least about 2 mm in height after prior coiling. However, we believe that it is important for the surgical team to be prepared for combined bypass surgery in the event that branch preservation is not possible. Additional cases should be studied to define the optimal indications of direct clipping.

Limitations

This study has a few limitations. First, the number of cases in our series was very small; thus, the investigation of additional cases is required. Second, this was a single-center study, and a multi-center, randomized controlled study should be considered. Third, confirmation that the initial coiling can prevent re-rupture is required, as well as better definition of the indications for additional treatment by clipping. In the future, this study will be expanded to include a larger number of patients.

CONCLUSION

A small- or medium-sized ruptured aneurysm with a branch arising from the neck can be treated with good outcomes with a two-stage strategy: CE followed by intentional, staged clipping. This intentional two-stage treatment can be a substitute strategy for clipping in the acute phase. However, patients treated with CE remain at risk of aneurysm recurrence and rerupture. Therefore, following CE, close follow up and careful surveillance are necessary.

AUTHORSHIP CONTRIBUTION

Study conception and design: ST, TO

Data collection: ST, TO

Analysis and interpretation of results: ST, TO

Draft manuscript preparation: ST, TO

Critical revision of the article: DS, SO, SD, MS

Other (study supervision, fundings, materials, etc...): TO

All authors (ST, DS, SO, SD, MS, TO) reviewed the results and approved the final version of the manuscript.

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