Microcatheter Looping Facilitates Access to Both the Acutely Angled Parent Artery and Cerebral Aneurysms for Effective Embolization

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Summary

Aneurysms with an acutely angled parent artery are difficult to access for coiling. This study aimed to investigate the safety and effectiveness of microcatheter looping for embolization of cerebral aneurysms with access difficulty.

Ten patients (male:female=5:5) with cerebral aneurysms treated with the microcatheter looping technique were analyzed retrospectively. The parent artery formed an acute angle with the major artery in five aneurysms. The microcatheter was looped into a “α” loop for treatment in the anterior temporal artery aneurysm and a “U” loop in the remaining nine aneurysms.

All ten aneurysms were successfully treated with the microcatheter looping technique. The microcatheter tip was successfully navigated into the aneurysm sac and remained stable throughout the embolization process. All aneurysms were occluded with total occlusion in five and near-total occlusion in five, and the parent artery remained patent in all cases. No complications occurred peri-procedurally. The Glasgow Outcome Scale was 5 in all patients before discharge. Follow-up angiography six to 12 months later revealed a good occlusion status of the aneurysms.

The microcatheter looping technique is effective when the conventional embolization technique fails to treat cerebral aneurysms with difficult access especially when the parent artery

forming an acute angle with the major artery exacerbates difficult access to the aneurysms.

Introduction

Cerebral aneurysms have been increasingly treated with endovascular embolization, and better devices and advanced coiling techniques have facilitated the treatment of most cerebral aneurysms with difficult configurations by endovascular embolization.

Due to the delicate nature and tortuous course of the cerebral arteries, access to an aneurysm and the tortuous artery harboring the aneurysm is not always possible especially for small parent arteries forming an acute angle with the major artery. In this case, proper projection of the aneurysm neck, the adjacent arteries and origin of the artery to be navigated can be most helpful, and shaping of the microcatheter or guidewire or both may allow direct access to the parent artery and the aneurysm sac.

Roadmapping with appropriate projection and a properly shaped microcatheter or guidewire often facilitate the access. However, sometimes it is impossible to navigate into the parent artery despite the use of the above techniques, and even if the microcatheter tip can penetrate the aneurysm sac, it cannot stay firm for safe embolization. Some techniques have

been described for access to these difficult arteries, including the microcatheter looping technique^{1,2} and the balloon-guided navigation technique³. The present study used and expanded the microcatheter looping technique in treating cerebral aneurysms for effective access to both the aneurysm and the parent artery forming an acute angle with the major artery.

Materials and Methods

Clinical data

A retrospective study was performed for patients undergoing the microcatheter looping technique for the treatment of cerebral aneurysms at our hospital between January 2009 and January 2013. This study was approved by the Institutional Review Board of our hospital, and all patients provided signed informed consent for the procedure after careful consultation and evaluation of risks, benefits, and alternatives. Ten patients were found to have undergone the microcatheter looping technique for aneurysm embolization. There were five female and five male patients, with an age range of 34-72 years (mean 53.2 ± 11.1) (Table 1). Eleven aneurysms were harbored by these patients, with one unruptured aneurysm and ten ruptured lesions with a Hunt-Hess grade of 0 in one patient, 1 in five, 2 in three, and 3 in one. Among the eleven aneurysms, ten were treated using the microcatheter looping technique. All aneurysms in

these patients had three-dimensional reconstruction imaging for viewing the configuration of the aneurysms, the parent artery, surrounding arteries and angulation of the parent artery. The location of the aneurysm involved the posterior communicating artery (PCoA, $n=4$), the ophthalmic artery ($n=3$), the clinoid segment of the internal carotid artery (ICA, $n=1$), the anterior temporal artery on the M1 segment of the middle cerebral artery (MCA, $n=1$), and the posterior inferior cerebellar artery (PICA, $n=1$). The three ophthalmic artery and one ICA clinoid aneurysms were treated with the microcatheter looping technique because the microcatheter tip could not be positioned stably in the aneurysm sac for coiling, and the remaining six aneurysms had the parent artery forming an acute angle with the major artery exacerbating access difficulty. The diameters of the aneurysms were less than or equal to 3 mm in three aneurysms, 3-5 mm in six, and greater than 5 mm in one, whereas the aneurysm neck was 2-3.7 mm with a neck-to-dome ratio smaller than 2. The angle formed between the aneurysm parent artery and the major artery was 23° - 56° (mean $40.2 \pm 13.3^\circ$).

Treatment approach

The procedure was performed with the patients under general anesthesia. All patients received antiplatelet medications before the procedure. A bolus of 3000 IU of booster was infused at the start of the procedure and another 1000 IU of heparin per hour was additionally

Table 1 Patient data, complications and follow-up.

No./age/sex	Aneurysm	Angle	Loop shape	Stability	Complication	Occlusion	Follow-up (GOS)
1/71/F	MCA M1	28°	—	Stable	None	Near total	5
2/67/F	PCoA	46°	U	Stable	None	Total	5
3/56/F	PICA	23°	U	Stable	None	Total	5
4/34/F	PCoA	43°	U	Stable	None	Near total	5
5/72/M	PCoA	56°	U	Stable	None	Total	Died
6/57/M	PCoA	45°	U	Stable	None	Near total	5
7/58/M	ICA clinoid segment	N/A	U	Stable	None	Total	5
8/46/M	Ophthalmic	N/A	U	Stable	None	Near total	5
9/60/F	Ophthalmic	N/A	U	Stable	None	Near total	5
10/53/M	Ophthalmic	N/A	U	Stable	None	Total	5

Note: F, female; M, male; MCA, middle cerebral artery; PCoA, posterior communicating artery; PICA, posterior inferior cerebellar artery; ICA, internal carotid artery; GOS, Glasgow Outcome Scale. Angle means the angle formed between the parent artery of aneurysm and the major artery.

Figure 1 A 67-year-old woman had a sudden onset of headache together with nausea and vomiting. CT scan of the head revealed subarachnoid hemorrhage and digital subtraction angiography demonstrated an aneurysm measuring 3.1×7.8 mm with a 2 mm neck on the left posterior communicating artery (PCoA) which formed an acute angle of 46° with the internal carotid artery. A) 3D reconstruction showed an aneurysm on the PCoA. B) A loop was formed in the terminal segment of the microcatheter. C) The microcatheter tip was navigated into the aneurysm sac under the guidance of a microguidewire. D) Coiling was started. E) The aneurysm was totally occluded. F) Follow-up 6 months later demonstrated total occlusion of the aneurysm.

infused. The Seldinger technique was used to puncture the femoral artery, and digital subtraction angiography of the cerebral arteries, including high-resolution three-dimensional rotational angiography, was performed. Aneurysmal configuration and arterial architecture were evaluated using conventional digital subtraction angiography, three-dimensional rotational angiography and three-dimensional reconstruction. The best projection position was chosen to show clearly the relation of the aneurysm neck with the parent artery and the angle formed between the aneurysm parent artery and the major artery. Roadmapping was used to demonstrate the angle between the aneurysm parent artery and the major artery. A microguidewire (Traxcess 14 or 10, Microvention, USA) and a microcatheter (Headway 10, Microvention, USA) were used.

The tips of the microguidewire and the microcatheter were shaped to the configuration of “J”, “S” or “C”. After super-selection of the aneurysm cavity using a conventional tip-shaping technique of the microcatheter had failed in all patients, the microcatheter looping technique was used for embolization of the aneurysms. In this study, we used two methods to loop the microcatheter as follows.

Microcatheter looping under the guidance of a microguidewire. This technique was applied in one PICA, two ophthalmic artery and three PCoA aneurysms (Figure 1). In these patients, the tip of the microguidewire was preshaped into a tight “C” curve. After the microguidewire had entered the internal carotid artery (ICA) or the vertebral artery, its tip automatically formed a “C” loop which was elongated

Figure 2 A 71-year-old woman had a sudden onset of severe headache with concurrent nausea and vomiting. CT scan of the head demonstrated subarachnoid hemorrhage (not shown), and digital subtraction angiography revealed one 7.1×4.7 mm aneurysm on the left posterior communicating artery (PCoA) and one 3.2×7 mm aneurysm on the anterior temporal artery on the M1 segment of the left middle cerebral artery (MCA). A) Left angiography showed an aneurysm (arrow) on the M1 segment of the left MCA and an aneurysm on the left PCoA (arrowhead). B) 3D reconstruction demonstrated the parent artery (anterior temporal artery) of the aneurysm formed an acute angle of 28° with the M1 segment. C) After the microcatheter tip was put against the internal carotid artery bifurcation, a further push of the microcatheter enabled the microcatheter to form an “α” loop which was further pushed into the M1 segment of the MCA. D,E) Slight withdrawal of the microcatheter reduced the loop and maneuver of both the microcatheter and the microguidewire enabled the tip of the microcatheter to enter the aneurysm sac. F) Embolization of the M1 aneurysm was started. G) The aneurysm was totally occluded. H) Plain film showed the coils within the two aneurysms (M1 and PCoA). I) At 1-year follow-up, the M1 aneurysm remained totally occluded.

into a “u” shape by further advancement of the microguidewire into the relatively wide arterial lumen. Then, the microcatheter was advanced along the looped microguidewire to form a

loop. After the loop was formed, the microguidewire was used to guide the microcatheter tip to enter the acutely angled parent artery of aneurysms and the aneurysm cavity.

Figure 3 A safe method to withdraw the microcatheter at the end of coil embolization of the aneurysms based on the case in Figure 2. A) At the end of coiling of the aneurysm on the M1 segment. B) Advance the microcatheter distally so that the tip of the microcatheter exits the aneurysm. C) Send a microguidewire into the microcatheter beyond the tip of the microcatheter. D) Keep the microguidewire stable and withdraw the microcatheter so that the microcatheter moves safely back along the microguidewire.

Microcatheter looping alone. This technique was used in the one MCA aneurysm (Figure 2). In this case, we first tried the microcatheter looping technique under the guidance of the

microguidewire in the first segment of MCA. However, it failed due to the small diameter of the M1 segment. The microcatheter tip was then pulled back to the distal end of the ICA,

and the microguidewire was withdrawn into the microcatheter. After the tip of the microcatheter had been put against the top wall of the ICA bifurcation, it was further pushed to form an “ α ” shape in the M1 segment. Then, the looped microcatheter was further navigated into the M1 segment of the MCA. When the looped tip of the microcatheter reached the orifice of the parent artery branching off the M1 segment, slight withdrawal of the microcatheter and maneuver of the microguidewire enabled the microcatheter tip to enter the aneurysm sac for embolization.

Microcatheter safe withdrawal technique. At the end of coiling, it is not appropriate to withdraw the microcatheter directly from the aneurysm sac because direct withdrawal of the microcatheter will cause irregular movement of the microcatheter tip or forward leap to perforate the aneurysm wall, resulting in possible intraprocedural rupture. At this time, the microcatheter should be pushed further distally so that its tip exits from the aneurysm (Figure 3). Then, a microguidewire should be sent beyond the tip of the microcatheter. The microguidewire must be kept stable and the microcatheter carefully withdrawn so that the microcatheter moves safely back along the microguidewire.

Evaluation of the looping technique and clinical outcomes

The safety of the microcatheter looping technique was assessed peri-procedurally, and the stability of the microcatheter tip was evaluated during embolization. The intra- and post-operative complications were recorded and evaluated.

The degree of aneurysm occlusion was also evaluated at completion by angiography as total occlusion (no residual aneurysm filling with contrast medium), near-total occlusion (minimal residual contrast at the aneurysm neck), or subtotal occlusion (any contrast medium in the aneurysm sac).

Clinical outcomes were evaluated with the Glasgow Outcome Scale. Follow-up angiography was performed at six and 12 months post-procedure, and the follow-up outcomes of aneurysm occlusion were categorized as follows: stable occlusion (no filling of the aneurysm), minor recurrence (slight filling at the aneurysm neck), and major recurrence (filling of the aneurysm sac).

Results

Ten cerebral aneurysms in ten patients underwent the microcatheter looping technique for aneurysm embolization. With this looping technique, the tip of the microcatheter successfully entered the aneurysm cavity in all ten aneurysms with access difficulty or access through the acutely angled parent artery of the aneurysm and remained stable with no kicking back during the embolization process. All the aneurysms were successfully occluded with patent parent arteries. No peri-procedural complications occurred. Total occlusion was achieved in five aneurysms and near-total in five. Followed up for six to 12 months, all aneurysms remained in the same occlusion status except for one patient who died of acute myocardial infarction.

Discussion

This study investigated the application of the microcatheter looping technique in the treatment of cerebral aneurysms in which the parent artery formed an acute angle with the major artery or the microcatheter tip could not reach or remain stable in the aneurysm sac for effective embolization. The microcatheter looping technique can successfully circumvent the acute angle formed between the aneurysm parent artery and the major artery and enable the microcatheter tip to stay steadily in the aneurysm sac, facilitating the embolization of aneurysms with access difficulty. No peri-procedural complications occurred in this study.

Endovascular embolization has been increasingly used to treat intracranial aneurysms. For most cerebral aneurysms, proper shaping of both the microguidewire and the microcatheter tips will be sufficient to navigate the microcatheter tip into the aneurysm sac for good performance. Balloon remodeling, stent protection, multiple microcatheters and microcatheter protection techniques have been used to facilitate the embolization of wide-necked aneurysms⁵⁻⁹. However, for small caliber arteries forming an acute angle with the major artery and for some aneurysms incorporating a small artery forming an acute angle with the major artery, it is hard to navigate the microguidewire or the microcatheter from the major artery into the acutely angled artery for further maneuver. For this kind of architecture, a microcatheter looping technique^{1,2} and a balloon-guided naviga-

tion technique have been suggested for endovascular access to the acutely angled branch incorporated in the aneurysm sac. In our study, we used this microcatheter looping technique for easy navigation into the parent artery forming an acute angle with the major artery, and we also further expanded this technique to treat cerebral aneurysms in which the microcatheter tip could not stay steadily within the aneurysm sac for effective embolization.

Methods to create the distal microcatheter loop were: pre-shaping the microcatheter tip to a "C" or "J" configuration, pre-shaping the microguidewire tip to a tight "C" configuration, branch orifice selection by the pre-shaped microcatheter tip for further forward navigation, and lastly, advancing the guiding catheter into the proximal internal carotid artery so as to loop the distal microcatheter tip. In the first technique in our study, we used a pre-shaped microguidewire to create the microcatheter loop and treated nine aneurysms successfully. In the second technique, we put the microcatheter tip against the ICA bifurcation wall, further advancing the microcatheter to enable the distal tip to form a loop in the M1 segment. We used these two techniques in successful treatment of six aneurysms whose parent arteries formed an acute angle with the major artery. In addition, the microcatheter looping technique was also used in one ICA clinoid aneurysm and three ophthalmic artery aneurysms. A conventional embolization technique had first been used in these aneurysms, but the microcatheter tip was not stable and frequently kicked out of the aneurysm sac. Then, the microcatheter looping technique was used to increase the stability of the microcatheter tip within the aneurysm sac, and microcoils were then deployed into the sac very smoothly with good occlusion outcomes.

It is easier to create the microcatheter loop within the ICA or the basal artery where the arterial diameter is large and damage to the endovascular layer of the artery is less likely. Because the MCA has a smaller caliber, vasospasm and damage to the endothelial layer

readily appear if the microcatheter looping technique is tried here. The microcatheter looping technique is suggested only when conventional techniques fail and embolization should be carefully planned beforehand so as to reduce unnecessary maneuvers as well as possible complications. For smaller caliber arteries less than 3 mm in diameter, the microcatheter looping technique is not suggested due to possible damage to the endothelial layer of the vessels. If it is necessary to use the microcatheter looping technique, try some softer microguidewires and microcatheters in order to reduce stimulation to the arteries and avoid vasospasm. At the end of embolization, do not directly withdraw the looped microcatheter because the microcatheter tip may move unexpectedly and perforate the aneurysm wall. First, advance the looped microcatheter further to let the microcatheter tip out of the aneurysm sac, and then send the microguidewire beyond the microcatheter tip. The microcatheter can be safely withdrawn along the microguidewire. There are some limitations in this study. Firstly, we only had a small cohort of patients and a large number of patients may be needed to further test the microcatheter looping technique. Secondly, the safety of this looping technique could not be tested for certain in this study because of the small patient cohort, although no peri-procedural complications were encountered, and more patients are needed for further confirmation.

In conclusion, the microcatheter looping technique can be used to navigate into some acutely angled arteries and enable the microcatheter tip to remain steadily within the aneurysm sac for effective embolization of cerebral aneurysms.

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