A Novel Technique of Microcatheter Shaping with Cerebral Aneurysmal Coil Embolization: In Vivo Printing Method

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Objective: We report a new microcatheter shaping method that makes consistent and safe microcatheter navigation into cerebral aneurysms possible for coil embolization even in lesions difficult to catheterize.

Case Presentation: The patient was an 83-year-old woman who had been followed-up for unruptured aneurysm of the internal carotid-anterior choroidal bifurcation. Endovascular treatment was performed because a bleb tended to enlarge. A straight microcatheter was guided to the parent artery about 5 mm distal to the target aneurysmal neck. The whole catheter was pressed against the wall of the parent artery, and this state was maintained for about 3 minutes. When the catheter was retrieved out of the body, the 3D shape memorized by the catheter was in agreement with the 3D morphology of the parent artery on 3D-DSA. Two sites of the catheter were steam-shaped, and the catheter tip was further steam-shaped into a shape that is more likely to be stabilized in the aneurysm using a mandrel. The microcatheter could be guided into the aneurysm simply by pulling it from a point distal to the aneurysm. Satisfactory coiling could be achieved. The microcatheter could be guided into the aneurysm by simply pulling it from a point distal to the aneurysm in all five patients to whom this technique was applied (one patient with ruptured and four patients with unruptured aneurysms).

Conclusion: This method was extremely effective in not only aneurysms to which the microcatheter was difficult to guide, but also those in which advancing a Guidewire into the aneurysm in advance was dangerous.

Keywords ► intracranial aneurysms, coil embolization, microcatheter, shaping

Introduction

In coil embolization of cerebral aneurysms, it is very important to guide the microcatheter to an appropriate site in the aneurysm and stabilize it there.^{1–3)} Particularly, in parasellar internal carotid aneurysms, complicated shaping of the microcatheter tip is occasionally required, and various methods and techniques have been reported.^{4–7)} We devised a novel shaping method of guiding a microcatheter once into the patient's body and allowing it to learn the site

and direction to be shaped. The usefulness of this technique was validated.

Case Presentation

A representative case and outcome

Case: The patient was an 83-year-old woman who had been followed-up on an outpatient basis for unruptured aneurysm at the internal carotid-anterior choroidal bifurcation (maximum diameter: 3.5 mm) for 10 years (**Fig. 1**). She had pacemaker implantation 10 years before and was orally administered clopidogrel at 75 mg. About half a year before, bleb formation was noted in the aneurysm (**Fig. 2**). Thereafter, contrast-enhanced CT was performed every 3 months, but as the bleb showed a tendency to enlarge, the patient wished endovascular treatment. Two weeks before the procedure, aspirin at 100 mg was added. Under local anesthesia, an 8 Fr short sheath was inserted via the right femoral artery. Heparin was administered intravenously,

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Fig. 1 A 3D-CT angiogram 2 years before surgery. A small aneurysm was observed at the left internal carotid-anterior choroidal bifurcation. 3D-CT: three-dimensional computed tomography

Fig. 2 A 3D-DSA image half a year before surgery. A small aneurysm was present at the left internal carotid-anterior choroidal bifurcation, and bleb formation was noted. 3D-DSA: three-dimensional-digital subtraction angiography

and the activated clotting time (ACT) was maintained at 250 seconds or longer. 8 Fr Cello (Medtronic, Minneapolis, MN, USA) was guided to the left internal carotid artery. The height of the aneurysm was small, 3.8 mm in diameter including the bleb, and the risk of perforation during microcatheter navigation with previous wire insertion was considered high.

Method for microcatheter tip shaping: Headway 17 microcatheter straight (Terumo, Tokyo, Japan) was guided to about 5 mm distal to the aneurysmal neck by Chikai 14 microguidewire (Asahi Intecc, Aichi, Japan) inserted in advance. The wire was removed, and the microcatheter was gently pressed against the vascular wall on the greater curvature side and left in this state for 3 minutes (**Fig. 3**). Thereafter, when the microcatheter was temporarily recovered

Fig. 3 An intraoperative DSA image. A straight microcatheter was guided to the parent artery about 5 mm distal to the target aneurysmal neck. White arrowhead: tip of the microcatheter; white arrow: aneurysm showing a bleb enlarged compared with half a year before.

Fig. 4 A photograph of a microcatheter withdrawn out of the body after being placed in a vascular model warmed at 37°C for 3 minutes. The vascular morphology is approximately memorized in the areas pointed at by the arrowheads.

out of the body, it retained an approximate shape of the siphon of the internal carotid artery. Since the 3D shape memorized by the catheter was in agreement with the 3D-DSA image of the parent artery, the site and direction of the catheter to be shaped could be determined. **Figures 4–6** show photographs of in vitro validation using a vascular model performed prior to the treatment. When a straight catheter was recovered after placing it in a vascular model warmed to 37°C for 3 minutes, it was curved as in **Fig. 4**. The curved sites were held with both hands and steam-shaped for 30 seconds without using a mandrel (**Fig. 5**). Then, a mandrel was inserted into the tip alone, and the tip was steam-shaped for 30 seconds into a perpendicular bend

Fig. 5 A photograph of steam-shaping of an area pointed at by an arrowhead in **Fig. 4**. A mandrel was not used.

Fig. 6 A photograph after steam-shaping. The portion pointed at by the arrow was shaped using a mandrel.

(**Fig. 6**). In this patient, one part of the siphon was shaped, and 4.0 mm from the tip was shaped perpendicularly using a mandrel in the direction same as the 3D image.

Intraprocedural and postprocedural course: The shaped microcatheter was navigated again to a point distal to the aneurysm by a microguidewire. When the microcatheter was slowly pulled back by withdrawing the wire halfway, the tip readily entered the aneurysm (**Fig. 7**). The course of the microcatheter appeared to have exactly trailed the long axis of the parent artery (**Fig. 8**). Framing was performed by controlling the flow with the balloon of Cello, but as framing was unstable, the aneurysm was embolized by the jailing method by placing a Neuroform stent 4.0 × 20 mm (Stryker Neurovascular, Kalamazoo, MI, USA). Complete occlusion of the aneurysm including the bleb was achieved

Fig. 7 A DSA image. The tip of the microcatheter could be guided into the aneurysm by simply pulling it (white arrowhead).

Fig. 8 Road map imaging during coil insertion. Black arrow: tip of the microcatheter, white arrowheads: the microcatheter trails the long axis of the parent artery.

by inserting HyperSoft 3D 2.5 × 40 mm, 2.0 × 30 mm, and 2.0 × 30 mm (Terumo) and Deltaplus 15 × 20 mm (Johnson & Johnson, Fremont, CA, USA) (**Fig. 9**). No periprocedural complication was observed, and the patient was discharge on the 5th postprocedural day, capable of ambulation without support.

We applied this method to five patients (one patient with ruptured and four patients with unruptured aneurysms).

Fig. 9 Plain radiogram at the end of the procedure. The aneurysm including the bleb was completely occluded.

Table 1 shows the summary. In all patients, the microcatheter could be guided into the aneurysm simply by pulling it from distally to the aneurysm.

Discussion

In coil embolization of cerebral aneurysm, it is very important to safely guide the microcatheter to an appropriate site in the aneurysm and stabilizing it there. There have been reports on the characteristics of various microcatheters, differences in responses to steam-shaping, and techniques to guide it into the aneurysm.¹⁻³⁾ Particularly, in parasellar internal carotid aneurysms, complicated shaping of the microcatheter tip is occasionally required, and a variety of methods including shaping under 3D angiographic guidance and shaping using a 3D printer have recently been reported.⁴⁻⁷⁾

In vivo printing method (our method) does not require a new additional device or a 3D printer or preprocedural sterilization. It can be applied on the spot either to ruptured or unruptured aneurysm and is extremely useful as an option when microcatheter navigation is difficult by a usual technique. Namba et al.⁷⁾ reported a method to 3-dimensionally shape the mandrel by preparing a patient-specific vascular model. They applied this method to 10 patients and succeeded in guiding the microcatheter into the aneurysm in all patients. However, they could guide the catheter into the aneurysm by simply pulling it back from a position distal to the aneurysm in only two patients, and they guided it using a Guidewire in three patients, and pushed the catheter into the aneurysm in five patients. By our method, the catheter

Table 1 Summary of patient and aneurysm characteristics, treatment method, and outcomes

Patient	Sex	Age	Rupture	AN location	AN size, mm	Adjunctive technique	Complication	Aneurysm occlusion
1	F	62	(-)	Paraclinoid	8.0 × 7.0 × 6.1	No	No	RS1
2	F	70	(-)	ICA-PCoA	14.0 × 11.2 × 9.8	No	No	RS3
3	F	83	(-)	ICA-AchA	3.8 × 2.4 × 2.2	Stent	No	RS1
4	F	70	(+)	ICA-PCoA	4.0 × 2.2 × 2.0	No	No	RS1
5	M	54	(-)	Paraclinoid	5.5 × 4.0 × 4.0	No	No	RS1

AchA: anterior choroidal artery; AN: aneurysm; F: female; ICA: internal carotid artery; M: male; PCoA: posterior communicating artery; RS: Raymond score

could be guided into the aneurysm simply by pulling it in all five patients. **Table 1** summarizes the cases. These differences are considered to have occurred because patient-specific vascular models prepared with a 3D printer are not hollow and cannot reproduce the actual curves of the catheter in the body. Catheters shaped by our method are considered to more faithfully trail the long axis of the parent artery.

The microcatheter could be guided into the aneurysm by a simple pulling maneuver from a distal site. During withdrawal of the microcatheter, its tip turned to the aneurysm in all patients in contrast to the tendency of the catheter to turn to the direction opposite to the aneurysmal neck when it is guided according to the primary shape of its tip alone. Also, in entry of the first marker of the microcatheter into the aneurysm, it did not migrate into a deep part of the aneurysm but stayed in a shallow part of the neck. The first coil inserted through a microcatheter was placed at a shallow site and did not escape out of the aneurysm. These results can also be explained by the accurate trailing of the catheter along the long axis of the parent artery. The microcatheter was in tight contact with the parent artery on the opposite side of the aneurysmal neck and was markedly stable during coil insertion. When the microcatheter was advanced slightly when the coil was deployed by 1 to 2 loops in the aneurysm, it could be stabilized at the center of the aneurysm.

We performed this method in five patients and successfully guided the microcatheter into the aneurysm in all patients by simply pulling it from a site distal to the aneurysm. The microcatheter used was Headway 17 straight (Terumo) in three patients and XT-17 straight (Stryker Neurovascular) in two patients. The selection of the catheters was not intentional but depended on which catheter was used in preceding or subsequent emergency procedures and the state of their supply to our hospital. Both products effectively retained the shape given by steam-shaping and felt equally manipulable. We did not examine this using other microcatheters, but any catheters are considered to be suitable for our technique if those retain the shapes of vascular structures after the conventional coil embolizations.

This study was only for experience in a small number of patients by a single surgeon at a single facility, and accumulation of cases is necessary before the technique is firmly established.

Conclusion

We validated a new shaping method by guiding a microcatheter once into the patient's body and determining the site and direction of its shaping according to the 3D morphology it has memorized. This method was very effective not only for aneurysms to which microcatheter navigation was difficult, but also for those in which the insertion of a microguidewire into the aneurysm in advance was considered dangerous.

Disclosure Statement

The first author and all of the coauthors have no conflicts of interest to disclose regarding this paper.

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