

Usefulness of modified pigtail-shaped microguidewire guidance for microcatheter navigation in difficult vasculatures during neuroendovascular interventions

Tomotaka Ohshima¹, Shamim Ul Haq Siddiqi^{2,4}, Shigeru Miyachi¹, Naoki Matsuo³,
Reo Kawaguchi³, Yoko Kato⁴, and Masakazu Takayasu³

¹Neuroendovascular Therapy Center, Aichi Medical University, Nagakute, Japan

²Department of Brain, Spine and Functional Neurosurgery, Neurospinal and Cancer Care Institute, Karachi, Pakistan

³Department of Neurosurgery, Aichi Medical University, Nagakute, Japan

⁴Department of Neurosurgery, Fujita Health University Banbuntane Hotokukai Hospital, Nagoya, Japan

ABSTRACT

We previously reported using a microguidewire with a curved, pigtail-shaped tip as an anchor for navigating a microcatheter. However, we considered that the microcatheter could follow even if the tip of wire did not advance so far distally. The present study assessed the usefulness of a modified version of this pigtail-shaped microguidewire for navigating microcatheters to difficult vasculatures during neuro-interventions. The microguidewire was repeatedly evaluated using a silicon tube vascular model. We also employed this method as the first choice for some patients. In both the in vitro tests and clinical use, the round curved tip could be used to position the microguidewire at the entry of a sharply angled vessel or aneurysmal neck, and the following catheter could then be advanced gently and easily. This technique allowed navigation of the microcatheter without inserting the guidewire into the distal vasculature.

Keywords: catheterization, endovascular treatment, intracranial aneurysms, shaping, microguidewire

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INTRODUCTION

Some patients with intracranial aneurysms have tortuous anatomy or a parent branch originating at an acute angle, conditions that make treatment by endovascular coil embolization difficult because of the difficult access to the target site. In coil embolization or stent placement for intracranial aneurysms, it is extremely important that the microguidewire is steered safely to the appropriate location for navigating and stabilizing the microcatheter. Previous reports have described the characteristics of various microcatheters to achieve this, including differences in responses to steam-shaping, and different techniques to guide the microcatheter to the aneurysm.¹⁻³⁾ One report described three-dimensional printing the microcatheter in a predetermined optimal

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Corresponding Author: Tomotaka Ohshima, MD, PhD

Neuroendovascular Therapy Center, Aichi Medical University,

1-1 Yazakokarimata, Nagakute, Aichi 480-1195, Japan

Tel: +81-561-62-3311, Fax: +81-561-62-2879, Email: tmtkoh@gmail.com

shape based on the anatomy and configuration of the aneurysm,⁴⁾ and recently we reported an *in vivo* method for printing a microcatheter.⁵⁾

Here, we have described a new technique for navigating a microcatheter in difficult vasculatures. Previously, we reported that the use of a modified pigtail-shaped microguidewire (MPMGW, i.e., a microguidewire with the tip curved into a small spiral, similar to the shape of a pig's tail; Fig. 1), which helped us to navigate sharply angled vessel branches and to avoid unexpected migration of the tip of the wire into perforating arteries or aneurysmal blebs.⁶⁾ We confirmed that when the pigtailed tip of the microguidewire was navigated in the distal portion, it acted as a strong anchor and the microcatheter then followed the guidewire without bending distally toward the parent artery (Fig. 2).

In the present study, we report a new modification to this technical tip and assess its value for navigating microcatheters in difficult vasculatures.

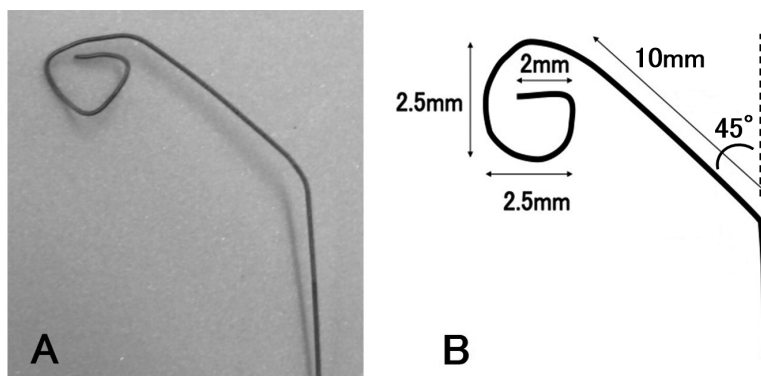


Fig. 1 Modified pigtail-shaped microguidewire
A: The modified pigtail shape. B: Schema of an ideal modified pigtail shape for standard usage.

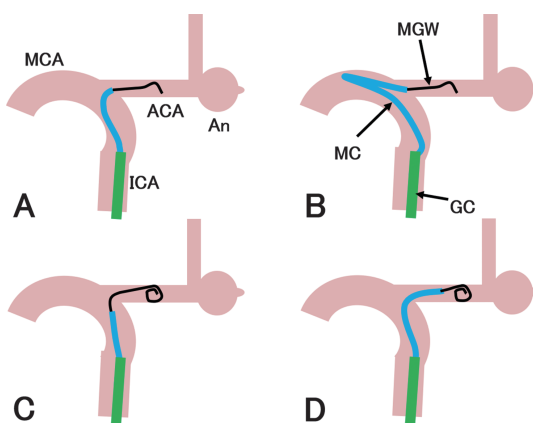


Fig. 2 Schematic illustration of the previously reported modified pigtail method for the sharply angled vasculature
A, B: With a microguidewire with a tip shaped at 90°, the microcatheter advanced in the opposite direction. C, D: A microguidewire with a tip shaped into a modified pigtail provided an anchoring effect at the vascular bifurcation. The rigid part of the wire secured the tracking of the microcatheter even through sharp curves.

METHODS

In general, the microguidewire used was a Chikai 14 (Asahi Intecc Co. Ltd., Aichi, Japan), with its tip shaped into a modified pigtail (Fig. 1). The microcatheter was selected according to the operator's preference. We usually used a Headway 17 microcatheter (Terumo Corp., Tokyo, Japan).

The performance of the microguidewire and microcatheter at sharp bifurcations was assessed using a silicon tube model. In this modified technique, the tip of the MPMGW set the entry of sharply angled vessels. We also used this method for some patients, including for inserting a catheter into aneurysms where the parent arteries were tortuous (Fig. 3).

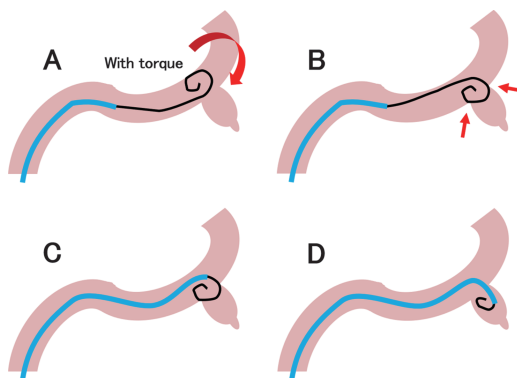


Fig. 3 Schematic drawing of the revised modified pigtail method described in this report

A: Using this modified pigtail-shaped guidewire, it is not necessary to advance the wire into the aneurysm. By applying the torque as shown (red curved arrow), the tip of the wire can be turned to face the orifice of the aneurysm. B: The round tip of the wire is set in the orifice of the aneurysm (red arrows). C, D: The microcatheter advances with the position of the wire maintained. The microcatheter can be navigated to the desired position without contact with the bleb of the aneurysm.

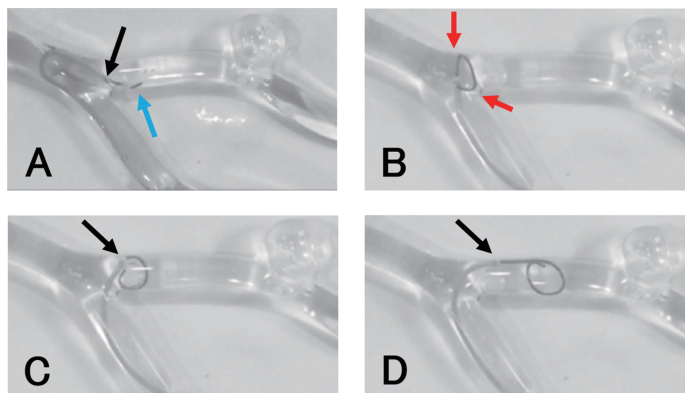


Fig. 4 Experiments using a silicon tube model

A: With a microguidewire curved at 90° at the tip (blue arrow), the microcatheter could not follow the microguidewire and instead advanced toward the opposite side, resulting in failure to select the correct vessel at the bifurcation. (black arrow: the tip of the microcatheter.) B: With the revised method, the tip of the microguidewire could be positioned at the orifice of the branch (red arrows). C: The microcatheter could be advanced while maintaining the position of the wire. D: The microcatheter was able to follow the microguidewire without being misguided in the antegrade direction.

RESULTS

In the *in vitro* evaluations, the curved tip of the MPMGW was able to set the entry of sharply angled vessels without navigating distally, and the following catheter could then be advanced gently and easily (Fig. 4). The flexible pigtailed tip worked well to prevent maldirection of the microcatheter and to mitigate the ledge effect between the vascular wall and the catheter.

Similar success was experienced when the method was used in patients. Two representative cases illustrate this.

Representative case 1

A 70-year-old man underwent a second endovascular coil embolization for a recurrent unruptured anterior communication artery aneurysm. We wanted to use a straight microcatheter for the aneurysmal coiling, but during the initial operation, we had trouble with navigating the microcatheter through the sharply angled origin of the left anterior cerebral artery (Fig. 5). We therefore used the MPMGW, which put the just origin of the left anterior cerebral artery. A Headway 17 straight microcatheter was then advanced while maintaining the position of the wire. The microcatheter was navigated without any trouble and inserted into the aneurysm, and the complete occlusion was achieved by placing three detachable bare platinum coils. No perioperative complication was noted.

Representative case 2

A 30-year-old woman underwent endovascular coil embolization for an incidentally discovered left internal carotid artery superior hypophyseal artery aneurysm (Fig. 6). We attempted to navigate a Headway 17 microcatheter with a preshaped 90° bend by using a 90° Chikai 14 microguidewire; however, the microcatheter showed a tendency to face in the opposite direction

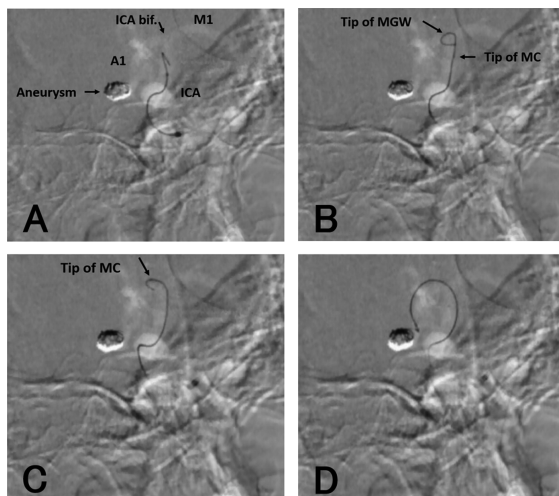


Fig. 5 Intraoperative road map images

A: The origin of the anterior cerebral artery with a relatively sharp branch. B: The pigtail tip of the wire was positioned at the origin of the anterior cerebral artery. C: The microcatheter followed the microguidewire without being misguided to the middle cerebral artery. D: The tip of the microcatheter could be navigated to the desired position. (ICA: internal carotid artery; M1: middle cerebral artery; A1: anterior cerebral artery; bif.: bifurcation; MC: microcatheter; MGW: microguidewire)

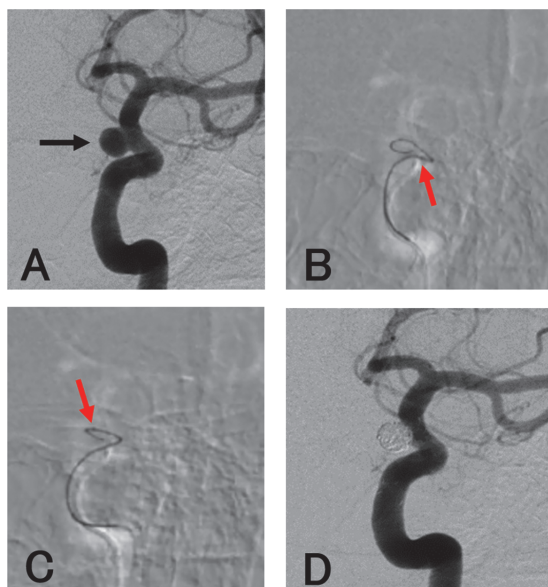


Fig. 6 Modified pigtail-shaped microguidewire

A: The preoperative left carotid angiogram of a 30-year-old woman showing an aneurysm (black arrow). The tortuosity of the proximal parent artery prevented the microcatheter from being stabilized in the aneurysm. B, C: The microcatheter was navigated into the aneurysm using the modified pigtail microguidewire. (The red arrows indicate the tip of the microcatheter.) D: The postoperative left carotid angiogram showing the complete occlusion of the aneurysm by detachable coils and a stent.

to the aneurysmal neck. We therefore used the MPMGW, which set the aneurysmal neck orifice, and the microcatheter could then be advanced while maintaining the position of the wire. The microcatheter was navigated to the desired position without touching the fundus of the aneurysm, and complete occlusion was achieved by placing eight detachable bare platinum coils and a stent. There was no perioperative complication.

DISCUSSION

Although there have been considerable advances in endovascular techniques and technologies for coil embolization for intracranial aneurysms, some fundamental problems remain. In particular, it is not straightforward to approach the target site in patients with complicated vascular anatomy, tortuous vessels, or vessels that originate at an acute angle. To address this problem, endovascular interventionists are continuously evolving new techniques that are simple, easy to adopt, and universally acceptable, with minimal complication rates. Several techniques are available, such as steam shaping the microcatheter according to the patient's angiographic studies.¹⁻³ Interventionists have described diverse techniques for accessing the desired site, such as a recent introduction to the three-dimensional printing of a microcatheter based on the patient's complex cerebrovascular anatomy acquired from the rotational angiography.⁴ Recently, we reported a method for printing a microcatheter *in vivo*.⁵ However, we have not been able to find any previous reports of evaluations of the shape of microguidewire tips other than our own.⁷

To ensure patient safety when using a microguidewire, the microguidewire tip should have a shape that prevents unintended entry into perforating branches or blebs of the aneurysm, and that reduces the risk of their perforation if these are entered erroneously. Recently, we reported that the MPMGW could provide clot quality during thrombectomy for acute ischemic stroke.⁶⁾ The MPMGW was able to provide navigation even into invisible occluded vessels. For the microguidewire to have sufficient versatility and high vessel selectivity is required. The proximal part of the tip of the MPMGW is therefore bent at 135° to allow the microguidewire to adapt to all angles (Fig. 1). The round shape of the tip prevents the MPMGW from erroneously entering into perforating branches and blebs of the aneurysm and provides an anchoring effect and microcatheter trackability, in addition to the high vessel selectivity. The combination of these features allows the catheter to be guided to the aneurysm with a single microguidewire.

In our previous report, we concluded that the MPMGW has sufficient supportability to ensure trailing of the microcatheter even into vessels that divide sharply, because the relatively rigid shaft of the microguidewire can be applied to the vascular bifurcation by shaping the flexible tip into a pigtail. This supportability can prevent maldirection of the catheter and can mitigate the ledge effect between the vascular wall and the catheter. In the present study, the MPMGW did not have to navigate so far distally through the bifurcation. When the tip of the MPMGW set only the entry of the sharply angled vessel or aneurysmal neck, the catheter could be advanced gently and easily. The pigtail-shaped tip and the 135° curve of the microguidewire played important roles in navigating the orifices of vessels and positioning in the aneurysm. Even when the proximal portion of the targeted orifice bent considerably to the opposite side, the MPMGW could be turned to face the target.

In cases of a small artery segment, we create a smaller diameter of the pigtail tip than usual. Although the minimum diameter of the shaped MPMGW was approximately 2.0 mm, it was suitable for navigating the microcatheter into the small branches, with diameters of approximately 1.5 mm. Once the tip of the microcatheter was bent and rested on the branch, MPMGW could be distally navigated. The blueprint (Fig. 1) is ideal as it seemingly provides a universal shape that is between the internal carotid artery and the horizontal segment of the middle cerebral artery (M1). When the fur distal artery has to be selected, the diameter of the tip is made approximately 2.0 mm smaller. Conversely, it is rare to have a diameter > 3.0 mm.

Chikai 14, Chikai 10, and Tenrou 1014 (Kaneka Corporation, Osaka, Japan) were able to be shaped as a modified pigtail, whereas Chikai black was slightly difficult to shape. Conversely, as Traxcess (Terumo Corp., Tokyo, Japan) comprised a core wire, it could not be shaped into the MPMGW. The Chikai series provides the opportunity to re-shape using the attached mandrel. This technique is suitable for all microcatheters. We often use the Headway 17 microcatheter and SL-10 microcatheter (Stryker Neurovascular, Fremont, CA, USA) for coiling and the Rebar 18 microcatheter (Medtronic, Minneapolis, MN, US), and Marksman microcatheter (Medtronic) for thrombectomy.

A limitation of this method is that some experience is necessary to shape the modified pigtail tip according to the individual size of the targeted vasculatures. If the pigtail shape is too narrow, it does not fit properly into the orifice. Use of a pigtail-shaped microguidewire is not necessary for all patients, and the indication for this technique should be evaluated for each patient individually in clinical practice.

CONCLUSIONS

The curved tip of the MPMGW allowed entry into sharply angled vessels or aneurysmal necks, and the microcatheter could then be advanced gently and easily. The MPMGW worked well in preventing maldirection of the microcatheter and mitigating the ledge effect between the vascular wall and the microcatheter. This technique provides safe navigation of the microcatheter without inserting a microguidewire into far distal vasculatures. The indication for this technique should be evaluated individually for each patient in the clinical setting.

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DECLARATION OF INTEREST

None. The authors who are members of the Japan Neurosurgical Society (JNS) have registered online self-reported COI disclosure statement forms through the website for JNS members.

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