N-butyl-2-cyanoacrylate (NBCA) embolisation for haemodynamic stress-induced peripheral aneurysm using a superfine microcatheter, DeFrictor Nano: surgical technique

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Abstract: Haemodynamic stress-related peripheral aneurysms are well-recognized in patients with moyamoya disease and are known to occasionally re-rupture. However, endovascular treatment is challenging due to the small diameter of the parent artery. We describe two cases in which aneurysms potentially inaccessible by conventional treatment methods were embolised using a superfine microcatheter, and report on the surgical technique incorporating intraoperative videos and images. Two patients in their 50s presented with intracranial haemorrhage. One patient had already been diagnosed with moyamoya disease, while the other was attending their first consultation. Digital subtraction angiography was cross-referenced with computed tomography, which revealed that the sources of the haemorrhage were likely peripheral aneurysms in the posterior cerebral and anterior choroidal arteries. Endovascular embolisation was planned 3 and 13 days after the haemorrhage occurred to prevent re-rupture. The superfine microcatheter was successfully advanced proximally to the aneurysm, which was then embolised with N-butyl-2-cyanoacrylate. Post-operative angiography confirmed occlusion of the aneurysm. One case demonstrated microinfarcts on post-operative magnetic resonance image, but these were asymptomatic. Both patients were discharged within 1 week of surgery. Endovascular embolisation effectively prevented re-rupture of the peripheral aneurysm in two cases. Consistent with previous reports, access to distal vessels often poses a challenge in endovascular treatment. The superfine microcatheter facilitated navigation, which may result in higher procedural success for treatment of peripheral aneurysm.

Keywords: Peripheral aneurysm; moyamoya disease; DeFrictor Nano; N-butyl-2-cyanoacrylate (NBCA); surgical technique

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Introduction

Background

The various intracranial hemodynamic changes are caused by progressive narrowing of blood vessels in moyamoya disease (1). The prevalence of aneurysms in patients with moyamoya disease is approximately 8% (2), and aneurysm-related cerebral haemorrhage occurs in approximately 16–25% of these cases (2,3). Whilst the treatment to prevent re-rupture is of significance, surgical intervention for distal aneurysms is challenging due to their deep location in the brain (4,5). Aneurysms can be treated with embolisation to prevent re-rupture (6,7). However, the aneurysms associated with moyamoya disease are often located peripherally; they also frequently form on principal arteries.

Rationale

Feng *et al.* reported that, of 28.9% of patients with moyamoya disease who underwent embolisation, favourable outcomes were achieved in 97.1% (6). A further systematic review has indicated that 12.0% of endovascular cases were unsuccessful due to difficulties with access, and that distal aneurysms were significantly associated with treatment failure by univariate analysis (8).

Objective

We report two cases in which a superfine microcatheter (DeFrictor Nano, Medicos Hirata, Osaka, Japan) was successfully and safely used to provide access to peripheral aneurysms. We present this article in accordance with the SUPER reporting checklist (available at https://jni.amegroups.com/article/view/10.21037/jni-25-60/rc).

Highlight box

Surgical highlights

- Endovascular embolisation effectively prevented peripheral aneurysm re-rupture.

What is conventional and what is novel/modified?

- Endovascular treatment is challenging for distal aneurysms due to the small diameter of the parent artery.
- A superfine microcatheter allowed access to the aneurysm-bearing artery that was inaccessible with conventional catheters.

What is the implication, and what should change now?

- The microcatheter improved accessibility to fine distal vessels.
- It may potentially increase success rates for treatment of haemodynamic stress-induced peripheral aneurysm.

Preoperative preparations and requirements

The selection of patients was based on cases where a ruptured peripheral aneurysm was identified by digital subtraction angiography (DSA), and where the patient provided informed consent for endovascular embolisation treatment, taking into account their general condition. Peripheral aneurysms frequently occur in major arterial branches, such as the anterior and posterior choroidal arteries. Because embolisation essentially involves occlusion of the parent artery, it is essential to determine whether occlusion of the parent artery would cause symptomatic perfusion impairment. Vascular cone beam computed tomography (CT) scans during preoperative DSA provide valuable information about both vascular structure and cortical anatomy. Because selective angiography is highly susceptible to body movements, procedures are often conducted under general anaesthesia. In particular, intraoperative motor evoked potential (MEP) monitoring should be considered during embolisation of the anterior choroidal artery (AchA), given its major role in supplying motor pathways. The two cases observed here involved aneurysms arising from distal segments of the posterior and anterior choroidal arteries. In the second case, MEP was monitored during surgery.

In both cases, heparinisation was administered intraoperatively, with adjustments made to maintain an intraoperative activated clotting time (ACT) of approximately 250 seconds.

All procedures performed in this study were in accordance with the ethical standards of the relevant institutional ethics committee and with the Declaration of Helsinki and its subsequent amendments. The study was approved by the institutional ethics board of Showa Medical University (No. CR20224005-B) and written informed consent was obtained from the patients for the publication of this article and accompanying images and videos. A copy of the written consent is available for review by the editorial office of this journal.

Case 1: a 51-year-old man presented with headache that had escalated from mild to severe over the course of the day. He had been diagnosed with moyamoya disease 10 years previously. CT showed intraparenchymal haemorrhage that had extended into the ventricular system (*Figure 1A*). Three-dimensional CT angiography showed occlusion of the distal portion of the left internal carotid artery (ICA), which

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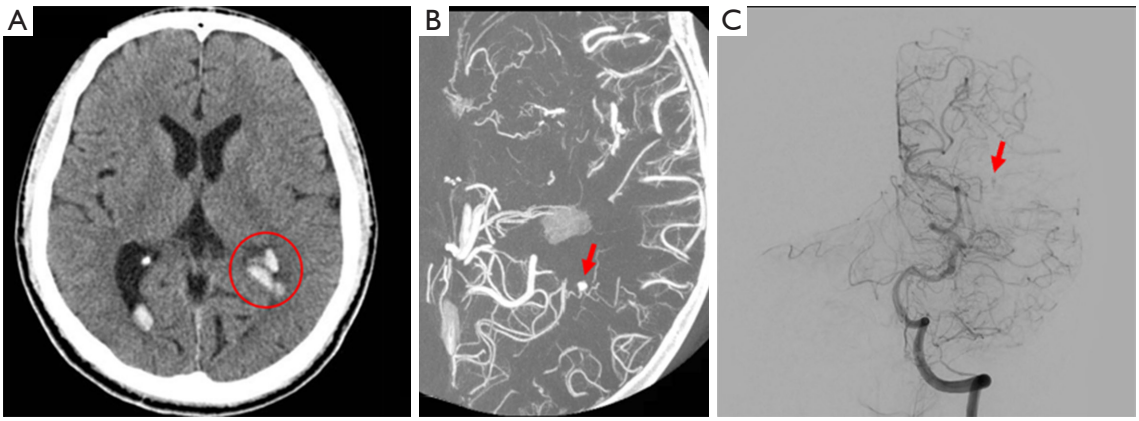


Figure 1 Preoperative images for case 1. (A) Computed tomography on admission showing intraparenchymal and intraventricular haemorrhage (the red circle indicates rupture point). (B) Vascular cone-beam computed tomography indicating the haemorrhage might have been caused by the aneurysm because of its anatomical location (the red arrow indicates aneurysm). (C) Digital subtraction angiography showing a small aneurysm on the distal posterior cerebral artery (the red arrow indicates aneurysm).

indicated moyamoya disease. Because the left carotid canal was very narrow, congenital hypoplasia and haemodynamic stress were suspected. The distal side of the ophthalmic artery was not visible on the left ICA angiogram. The left vertebral artery (VA) angiogram showed collateral flow to the left middle cerebral artery (MCA) and anterior cerebral artery (ACA) through the left posterior cerebral artery (PCA). The cone beam CT revealed a 2.7-mm aneurysm on the left lateral posterior choroidal artery, which was consistent with the bleeding source (*Figure 1B,1C*). Antihypertensive treatment was initiated, and DSA was performed on day 2. The imaging findings and rupture of the distal aneurysm suggested that haemodynamic stress was involved in the condition, and thus bypass surgery was planned. To prevent re-rupture before surgery, endovascular embolisation was performed on day 3.

Case 2: a 55-year-old woman was referred to Showa Medical University Fujigaoka Hospital for headache and left hemisensory disturbance. On admission, CT showed a right intraparenchymal haemorrhage (*Figure 2A*). Right ICA angiography revealed a well-developed AchA with reflux through the MCA and ACA (*Figure 2B*). The cone beam CT showed two peripheral aneurysms in the right distal AchA (*Figure 2C,2D*). After confirming improvement in the patient's symptoms caused by the haemorrhage, embolisation was performed on day 13.

Step-by-step description

The surgical procedure is outlined below. Furthermore, the surgical videos for each case are attached (*Videos 1,2*). The durations of the operations were two hours and three hours respectively.

Selective angiography

Contrast was administered from the digital access catheter during proximal angiography. As the procedure progressed distally, a fine microcatheter and microguidewire were employed to navigate to the target vessels containing the respective aneurysms, and selective angiography was performed. In case 1, a Marathon catheter (Medtronic, Minneapolis, MN, USA) and a 3.2 Fr Guidepost (Tokai Medical Products, Aichi, Japan) were navigated into the P1 segment of the left PCA over a TENROU S1014 microguidewire (Kaneka Medix, Osaka, Japan) and supported by a 6-Fr ASAHI FUBUKI Hard (Asahi Intec, Aichi, Japan) via the right femoral artery (*Figure 3A*). When the aneurysm is located on the feeding capillaries to the pyramidal tract, it is imperative to exercise caution when utilising the distal access catheter (DAC). In case 2, selective angiography of the AchA was performed using a DeFrictor Nano and a 3.2 Fr Guidepost. Whilst advancing the Guidepost distally, we simultaneously confirmed that low blood flow impairment had occurred in the proximal portion of the AchA by frequently confirming MEP.

Selection of parent artery

After confirming the route to the aneurysm, the

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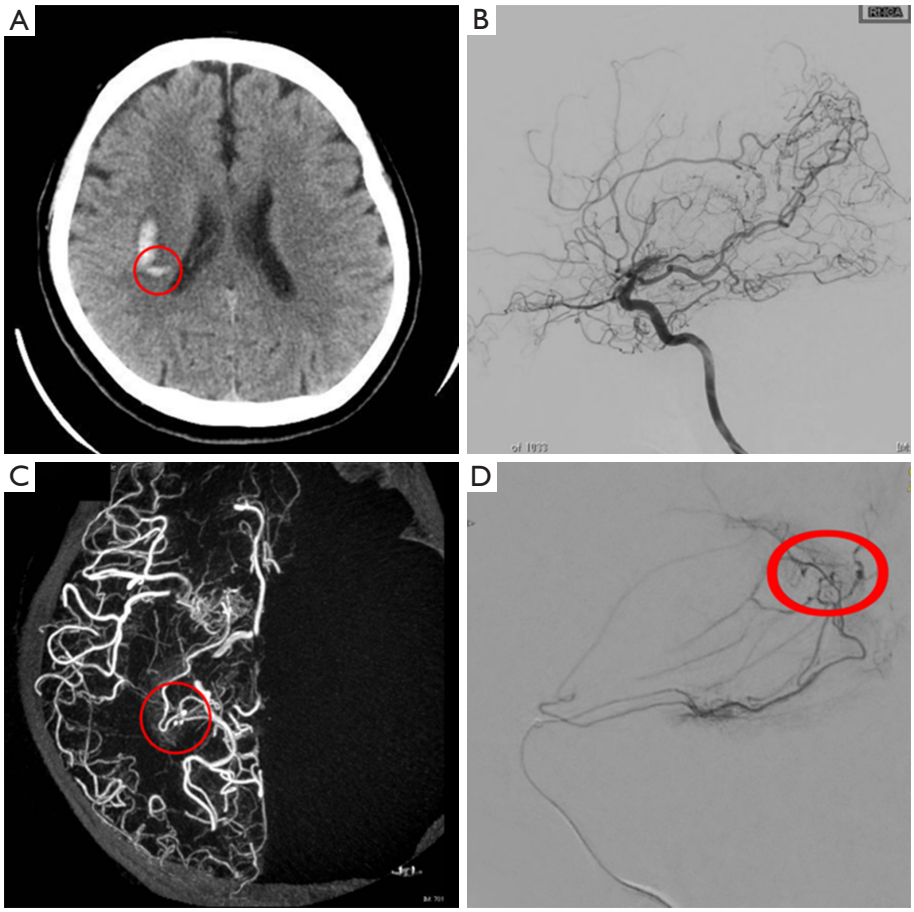


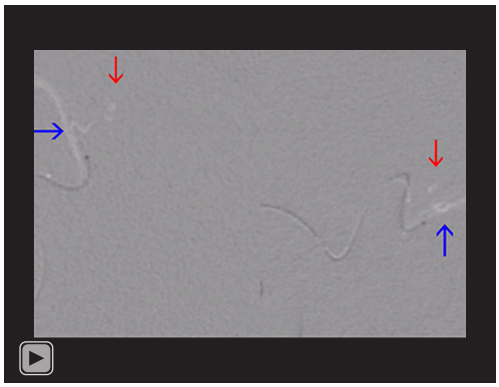
Figure 2 Preoperative images for case 2. (A) Computed tomography on admission showing intraparenchymal haemorrhage (the red circle indicates rupture point). (B) Angiography of right internal carotid artery. (C) Vascular cone-beam computed tomography showing two peripheral aneurysms (the red circle) in the right distal anterior choroidal artery. (D) Selective angiography of the anterior choroidal artery showing the aneurysms (the red circle).

microcatheter was advanced as close as possible to the aneurysm. However, in cases where the diameter of the distal vessel is found to be extremely small, sometimes it may not be possible to guide a microcatheter. In case 1, the Marathon catheter could not traverse the bifurcation into the distal artery. Therefore, it was replaced with the DeFrictor Nano (Medicos Hirata, Osaka, Japan) supported by an ASAHI CHIKAI X 010 (Asahi Intec), which smoothly reached the parent artery (*Figure 3B*). A point to note when using DeFrictor Nano is that it has a radiopaque marker near the tip, with a 5-mm radiolucent segment beyond. That was soft enough to select the parent artery precisely. On the other hand, it is imperative to meticulously verify the tip position and perform angiography to ascertain its relationship with the aneurysm.

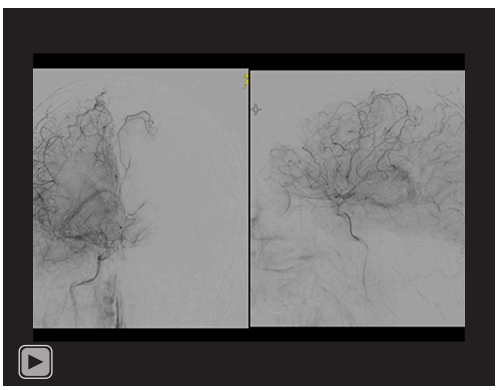
Confirmation of the occlusion point

After confirming that the catheter has reached a sufficiently distal position, it is important to reassess whether the vessel is occludable prior to embolisation. In case 1, because the aneurysm on the left lateral posterior choroidal artery was located peripherally, sufficient collateral circulation was expected even if limited parent vessel occlusion occurred. In case 2, by advancing the catheter sufficiently distally (into the choroidal segment), we prevented the spread of the embolisation material to the pyramidal tract. Although a definitive parent vessel occlusion test at the final occlusion site was not performed, the decision was made to occlude using a minimal amount of embolisation material. This was based on imaging confirmation by contrast from DeFrictor Nano of the anatomically defined distal perfusion territory

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Video 1 Embolisation for a micro aneurysm on the left lateral posterior choroidal artery in Moyamoya disease. Posterior cerebral artery angiography via microcatheter and distal access catheter, demonstrating distal aneurysm. The red arrow indicates the location of the aneurysm. the Marathon catheter (tip outer diameter, 1.5 Fr) was guided toward the aneurysm. However, it was unable to select the branch leading to the aneurysm, and kickback was observed (blue arrow). However, replacement of the Marathon with the DeFricter Nano microcatheter facilitated smooth passage through the previously impassable bifurcation. Zoom-in image shows radiopaque tip (blue arrow) positioned at the parent vessel of the peripheral aneurysm (red arrow). Contrast imaging from DeFricter Nano revealed the aneurysm and distal peripheral vessels. Embolisation was performed from this site after determining that these were not major anatomical vessels. Injection of 20% N-butyl-2-cyanoacrylate (0.01 mL) was administered to occlude the parent vessel, and digital subtraction angiography confirmed that the aneurysm had disappeared.



Video 2 Embolisation for micro aneurysms on the right anterior choroidal artery in Moyamoya disease. Selective angiography of internal carotid artery via distal access catheter showing a distal aneurysm on the anterior choroidal artery. The DeFricter Nano was advanced towards the aneurysm. The microcatheter was gradually advanced distally, and contrast injection from the point closest to both aneurysms confirmed the location of the more distal aneurysm (within the red circle). Following confirmation of the distal vascular distribution, embolisation was performed. Injection of 20% N-butyl-2-cyanoacrylate (0.01 mL) was administered to occlude the parent vessel, and digital subtraction angiography confirmed that the aneurysm had disappeared.

distal to the occlusion site (especially confirming that the capsulothalamic artery was not clearly visualised).

Injection of occluding material

In order to prevent the dispersion of embolisation material and proximal vascular occlusion due to backflow, embolisation was performed using the smallest possible volume. In case 1, we injected only 0.23 mL of 20% N-butyl-2-cyanoacrylate (NBCA) through the DeFrictor Nano, and the catheter was immediately withdrawn after confirming successful embolisation (*Figure 3C*). In case 2,

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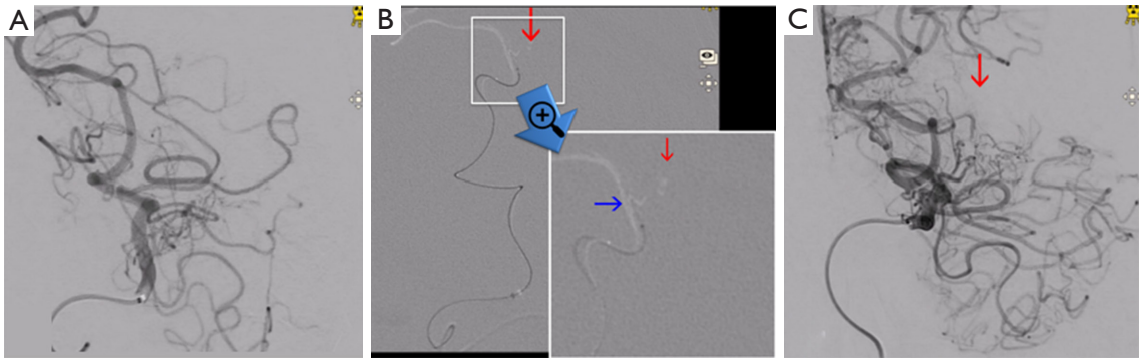


Figure 3 Intraoperative images for case 1. (A) Working angle from distal access catheter. (B) DSA showing the parent artery was reached when the original catheter was switched with the DeFrictor Nano (the red arrows indicate the aneurysm, and the blue arrow indicates the radiopaque tip of DeFrictor Nano). (C) DSA after embolisation (the red arrow indicates the site of the aneurysm, which is no longer visualised on angiography). DSA, digital subtraction angiography.

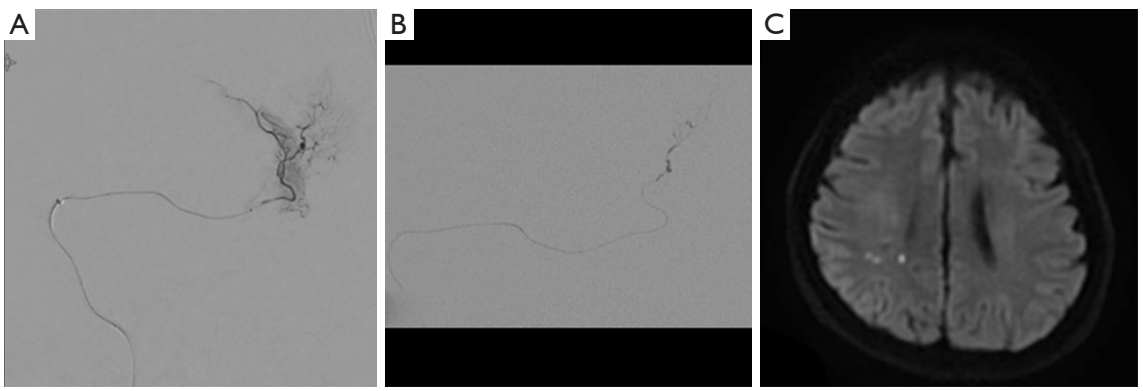


Figure 4 Intraoperative images for case 2. (A) Microcatheter positioned proximal to the aneurysms. (B) Embolisation of aneurysm with injection of N-butyl-2-cyanoacrylate from parent vessel. (C) Scattered cerebral infarcts on the distal side of the parent artery on postoperative magnetic resonance imaging.

as there were two aneurysms on the same parent artery, we injected 0.32 mL of 20% NBCA through the DeFrictor Nano and both aneurysms were embolised and were fully occluded at one time (*Figure 4A*,*4B*).

Postoperative considerations and tasks

It is essential to confirm post-operative bleeding and ischaemia through imaging examinations, a requirement applicable to all endovascular procedures. Moreover, in treatments performed under general anaesthesia, clinical findings upon emergence from anaesthesia are of paramount importance.

In the first case, no new infarction was detected on postoperative magnetic resonance imaging (MRI). In the second case, scattered cerebral infarcts were identified distal to the embolised parent vessel (*Figure 4C*). However, as embolisation was performed by choroidal segment of AchA, the patient did not show neurological symptoms. After that, no rebleeding has been observed in either patient during the 2 years following embolisation.

Tips and pearls

The DeFrictor Nano features a 5-mm non-braided radiolucent region distal to the marker, which is designed for exceptional flexibility. This feature improves the selectivity of the device and enhances its ability to navigate small blood vessels. In case 1, the tip of the catheter reached the aneurysm, enabling super-selective embolisation.

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However, it is important to note that this characteristic is not without its limitations. When utilising this catheter for embolisation, it is imperative to ensure the precise positioning of the tip within the radiolucent region. Accurate angiographic evaluation is essential to confirm optimal positioning before injection.

Discussion

Moyamoya disease is a cerebrovascular disorder characterised by severe stenosis and occlusion of the ICA that results in the formation of a collateral circulation. This altered flow pattern may promote the development of peripheral aneurysms by increasing haemodynamic stress (9-13). Other studies have suggested that inflammation contributes to the formation and rupture of aneurysms (14,15). Peripheral aneurysms in patients with moyamoya disease occur at a younger age (typically 35–44 years) than common cerebral aneurysms (16). Patients with intracranial haemorrhage who have peripheral aneurysms also tend to have poorer neurological prognoses than those who do not (17). Although spontaneous regression after rupture has been reported (18), re-rupture is associated with a poor prognosis (5). Given the relatively young age of onset, measures to prevent re-rupture are warranted. The systematic review revealed that the re-rupture rate was significantly higher in patients who could not be treated due to inaccessibility and were not given additional treatment than in those in whom effective treatment could be performed (8). Traditionally, revascularisation has been considered to lead to aneurysm shrinkage and prevent re-rupture by improving cerebral blood flow (5,19,20). On the other hand, there are reports of aneurysm enlargement following revascularisation surgery who had ruptured aneurysms (21). It should be noted that revascularisation procedures are merely an indirect means of preventing re-rupture; treatment of the aneurysm is considered more ideal for achieving reliable prevention of re-rupture.

In view of the high risk of early re-rupture experienced by patients with moyamoya disease who have suffered a ruptured aneurysm, the recommendation is for the early radical treatment of said aneurysms to be considered as a treatment option (22,23). In our cases, treatment intervention was performed at the earliest opportunity following confirmation of stabilisation of the patient's general condition and a definitive diagnosis. In comparison with surgery, this approach is considered to be less invasive. The capacity for intervention, even during the acute phase of cerebral haemorrhage, is suggested as one of the benefits of endovascular therapy.

Complications in endovascular treatment were reported in 14.6% of cases, comprising 4.2% intraoperative ruptures and 4.2% cerebral infarctions (8). Moreover, the systematic review did not suggest an association between parent vessel occlusion and treatment-related complications. However, in the context of moyamoya disease, distal aneurysms commonly occur in the choroidal arteries, and occlusion of the parent vessel at this site is known to involve branches including those supplying the pyramidal tract, carrying a high risk of symptomatic post-operative cerebral infarction. In this instance, a microcatheter with high distal reachability was utilised, and the injection of a minimal volume of embolic material was employed to minimise dispersion into the branches.

In our two cases, the procedures were performed using a microcatheter with an exceptionally fine diameter. The DeFrictor Nano has an exceptionally narrow tip with an outer diameter (OD) of 1.3 Fr. This catheter is designed for superior reachability and flexibility. The tip is designed to be flexible, with the intention of reducing friction and minimising damage to the vessel wall during navigation through highly curved or distal vessels.

The Defricter series also includes the Defricter Bull, which features a larger tip OD of 1.5 Fr. However, this is offset by a longer tip flexible length compared to the Defricter Nano. While the Bull prioritises tracking ability through vascular tortuosity, the Nano was selected for this procedure due to the need for access to finer peripheral vessels.

In the first case, the Marathon catheter was used initially, but it proved impossible to select the branch. The Marathon catheter is distinguished by its slender 1.5 Fr tip, which facilitates optimal distal reachability. In distal, slender branches such as those observed in case 1, where a micro guidewire has selected the branch, enhanced followability is achieved through the prevention of the catheter being snagged on the ridge. This is achieved by utilising catheters with a reduced OD and superior tip flexibility. In this particular context, the DeFrictor offers a distinct advantage. Conversely, the Marathon offers superior visibility of its tip marker and, being dimethyl sulfoxide (DMSO)-compatible, provides an advantage when performing embolisation using Onyx.

The Magic1.2FM (Balt, Montmorency, France) is also a superfine microcatheter. This catheter features an ultra-thin tip with an OD of 1.2 Fr. However, its inner lumen is

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Table 1 Comparison table of fine-diameter microcatheters

Micro catheter	Distal OD	Distal ID	Guide wire	Effective length
Magic 1.2FM	1.2 Fr/0.40 mm	0.008 inch/0.21 mm	~0.008 inch	159 cm
DeFrictor Nano	1.3 Fr/0.43 mm	0.011 inch/0.29 mm	~0.010 inch	165 cm
Marathon	1.5 Fr/0.50 mm	0.013 inch/0.33 mm	~0.010 inch	165 cm

ID, inner diameter; OD, outer diameter.

0.21 mm, limiting the maximum compatible guidewire to 0.008 inches. The DeFrictor Nano, with its 0.27 mm inner lumen, allows for the use of a 0.010-inch guidewire and incorporates a design optimised for transition of rigidity in the shaft to enhance wire tracking (*Table 1*). Conversely, the Magic concept is that of a flow-dependent catheter; the guidewire is typically employed primarily during tip handling, with the catheter being guided distally by the flow of the parent vessel. In this case, the DeFrictor Nano was selected due to the peripheral lesion presenting with an extremely narrow parent vessel diameter where high flow was not anticipated. Furthermore, vessel selection was performed using wire-first navigation, during the actual procedure, enabling successful advancement to the target site. In order to achieve superior wire support and selectivity, it is recommended that a 0.010-inch wire be used in preference to a 0.008-inch wire. Consequently, in cases of peripheral aneurysms such as the present ones, the DeFrictor Nano may offer a more favourable outcome.

Regarding the DAC, in procedures using microcatheters of such a small diameter as in this case, employing a small-bore DAC and guiding it distally enables enhanced support. In this case, the Guidepost [distal OD 3.2 Fr/distal inner diameter (ID) 0.035 inch] was employed; however, other options selected in Japan include the Defricter ZERO (distal OD 3.2 Fr/distal ID 0.035 inch) and TACTICS Pro (distal OD 3.2 Fr/distal ID 0.035 inch).

Conclusions

The embolisation via endovascular therapy may contribute to the prevention of the re-rupture of peripheral aneurysms caused by haemodynamic stress. The DeFrictor Nano facilitates access to more distal and smaller vessels, which may contribute to higher procedural success rates.

Acknowledgments

None.

Footnote

Reporting Checklist: The authors have completed the SUPER reporting checklist. Available at https://jni.amegroups.com/article/view/10.21037/jni-25-60/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the relevant institutional ethics committee and with the Declaration of Helsinki and its subsequent amendments. The study was approved by the institutional ethics board of Showa Medical University (No. CR20224005-B) and written informed consent was obtained from the patients for the publication of this article and accompanying images and videos. A copy of the written consent is available for review by the editorial office of this journal.

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