CASE REPORT

A technical consideration when using flow diversion for recurrent aneurysms following stent-assisted coiling

Justin R Mascitelli, Daniel Wei, Thomas J Oxley, Christopher P Kellner, Hazem Shoirah, Reade A De Leacy, J Mocco, Johanna T Fifi

Department of Neurosurgery,
Icahn School of Medicine at
Mount Sinai, New York,
New York, USA

Correspondence to

Johanna T Fifi,
The Mount Sinai Hospital,
Klingenstein Clinical Center,
1-North, 1450 Madison
Avenue, New York, NY 10029,
USA;
Johanna.Fifi@mountsinai.org

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SUMMARY

Flow diversion (FD) is a treatment option for recurrent aneurysms including following stent-assisted coiling (SAC), although this approach is both 'off-label' and unproven. A technical challenge of FD placement may involve the microwire catching on the tines of the previously placed stent or potentially going 'in-out-in' from the central axis of the stent. We report a case and technique that assures the wire has safely remained within the central axis of the stent. The procedure was performed in standard fashion except that the intermediate catheter was passed completely through the previously placed stent after the microwire/microcatheter had crossed. The large diameter of the intermediate catheter assured that the microwire did not go 'in-out-in'. The intermediate catheter was completely withdrawn from the stent and the FD was placed in standard fashion. This technique may help to achieve complete FD opening and prevent thromboembolic complications associated with incomplete FD opening.

BACKGROUND

Although flow diversion (FD) has recently been shown in small series to be an effective treatment for recurrent aneurysms following coiling¹ and clipping,² its utility in the treatment of aneurysms that have previously been treated with stent-assisted coiling (SAC) is less clear.^{3–7} Many of these studies have suggested a lower rate of aneurysm occlusion and a higher rate of complications. Technically, use of FD after SAC is 'off-label'. The procedure itself can be technically challenging as the microwire can get caught on the tines of the stent or potentially traverse the stent in an 'in-out-in' fashion, which

Figure 2 Initial treatment. The patient was treated with stent-assisted coiling using an Enterprise Stent. (A, B) Digital subtraction angiography, right internal carotid artery injection, anteroposterior (A) and lateral (B) views demonstrate minimal residual aneurysm filling at the end of the procedure.

would ultimately lead to incomplete FD opening and potentially thromboembolic complications. The purpose of this report is to describe a technique to safely cross the previously stented aneurysm and deploy the FD.

CASE PRESENTATION

The patient initially presented with right-sided retro-orbital pain and a right third nerve palsy. A CT head and subsequent diagnostic angiogram demonstrated a large, partially thrombosed aneurysm of the right cavernous internal carotid artery (ICA; figure 1).

TREATMENT

The patient was treated with SAC using an Enterprise Stent 4.5×28 mm (Cordis, Santa Clara, California, USA) with near complete occlusion of

Figure 1 Presenting imaging. (A) Axial CT demonstrating a large mass in the region of the right cavernous internal carotid artery (ICA) with compression of the temporal lobe. (B, C) Digital subtraction angiography, right ICA injection, anteroposterior (B) and lateral (C) views demonstrating the large partially thrombosed cavernous ICA aneurysms.

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Figure 3 Initial follow-up digital subtraction angiography, right internal carotid artery injection, oblique view, subtracted (A) and unsubtracted (B) demonstrate coil compaction and aneurysm recurrence.

Figure 4 Retreatment. Digital subtraction angiography, right internal carotid artery (ICA), oblique anteroposterior (left) and lateral (right) views, unsubtracted. (A, B) The microwire (arrowhead) is first passed through the Enterprise stent (thin arrows), distal ICA and into the middle cerebral artery (MCA). The guide catheter (plus sign) can be seen in the cervical ICA and the microcatheter (asterisk) can be seen entering the stent. During this step the operator must be aware that the microwire (arrowhead) can catch the tines of the stent or possibly traverse the stent in an 'in-out-in' fashion. (C, D) The microcatheter (asterisk) is then passed over the microwire (arrowhead), through the stent, into the MCA. (E, F) The intermediate catheter (thick arrow) is passed over the microwire/microcatheter, through the stent into the MCA. This step is performed to assure that the microwire has traveled down the central axis of the stent. (G, H) Finally, the intermediate catheter (thick arrow) is withdrawn proximal to the stent and the flow diverter is deployed in standard fashion. The lead wire of the flow diverter (hashtag) can be seen just distal to the stent and flow diverter.

the aneurysm at the end of the procedure (figure 2). Within a few months the headaches improved and the third nerve palsy resolved. The 6-month follow-up angiogram, however, demonstrated coil compaction and aneurysm recurrence (figure 3). In addition, the patient had a recurrence of headaches.

The decision was made to re-treat the patient with FD. The procedure was performed with a triaxial system including the Neuron Max guide catheter (Penumbra, Alameda, California, USA), the 5 MAX DDC intermediate catheter (Penumbra), the Marksman microcatheter (Covidien, Irvine, California, USA), and Fathom 16 microwire (Boston Scientific, Marlborough, Massachusetts, USA). Although the patient did not have a difficult aortic arch (type 1) or tortuous ICA anatomy, the Neuron Max was placed in the cervical-petrous ICA for maximal

Figure 5 Illustration of retreatment. In the proposed technique, the large diameter intermediate catheter is passed completely through the stent to test whether the microwire has gone 'in-out-in'. If the intermediate catheter can traverse the entire stent, there is assurance that the microwire has traversed the central axis of the stent and the flow diverter will open completely (top). If the intermediate catheter cannot traverse the entire stent, then it is likely that the microwire has taken an errant 'in-out-in' path outside the central axis of the stent (bottom). If the flow diverter is deployed in the latter scenario or without performing this step, it may open incompletely and lead to a thromboembolic complication. (Figure by Jill Gregory. Printed with permission from Mount Sinai Health System).

Figure 6 Retreatment (continued). Digital subtraction angiography, right internal carotid artery, anteroposterior (A, C) and lateral (B, D), unsubtracted (A, B) and subtracted (C, D). Unsubtracted views demonstrate complete flow diverter opening within the previous stent (A) and early aneurysm stasis (B). The final digital subtraction angiogram demonstrated no evidence of thromboembolic complications.

support. The previously placed Enterprise stent was crossed with the microwire (figure 4A, B) followed by the microcatheter (figure 4C, D). Special attention must be given to a smooth passage of the microwire and microcatheter as this is the time when either can get caught on the Enterprise stent or possibly traverse the stent in an 'in-out-in' fashion. Then, the 5 MAX

DDC was passed through the Enterprise stent completely and into the middle cerebral artery (figure 4E, F). This novel step was performed to assure that the microwire/microcatheter had traversed the central axis of the stent and had not gone 'in-out-in'. The basis of this maneuver is that the 5 MAX DDC is too large to follow an errant path outside the stent. Once this

Figure 7 Final follow-up. Digital subtraction angiography, right internal carotid artery, anteroposterior (A) and lateral (B) views. Six months after treatment there has been progressive aneurysm occlusion.

step was performed, the 5 MAX DDC was withdrawn proximal to the Enterprise stent to the petrous ICA and a Pipeline Embolization Device 4.5×35 mm (PED; Covidien) was successfully placed in standard fashion (figure 4G, H). The technique is illustrated in figure 5. The final angiogram demonstrated good PED wall apposition and early aneurysm stasis (figure 6).

OUTCOME AND FOLLOW-UP

At 6-month follow-up the patient was asymptomatic and the aneurysm had undergone progressive occlusion (figure 7).

DISCUSSION

Previous reports of FD following SAC have been few in number and less enthusiastic regarding overall efficacy.^{3–7} There has been a suggestion of lower aneurysm occlusion and higher complication rates. Nelson *et al* commented in the PED for the Intracranial Treatment of Aneurysms Trial that previous stents not only complicate FD delivery but also decrease efficacy.³

Heiferman *et al*⁶ reported 25 patients treated with FD after failed SAC. In this series there were three technical complications including inability to navigate the microcatheter through the stent in two patients and failure to deploy the FD due to catching on the struts of the previously deployed stent. There were no clinical complications referable to these technical difficulties. At 12 months all aneurysms had decreased filling with 38% complete occlusion.

Daou *et al*⁷ reported 21 patients treated with FD after failed SAC compared with 62 patients treated with FD without previous SAC. The authors encountered technical difficulties in five patients. At least two of these difficulties included difficulty crossing the previous stent and incomplete FD opening. Two ischemic and one hemorrhagic complication were reported, but it is unclear whether these complications were associated with the technical difficulties. The rates of complete aneurysm occlusion at last follow-up were higher in the patients without previous SAC (80.4% vs 55.6%).

Our case illustrates a method of safely assuring that the microwire and microcatheter have traversed the central axis of the stent, allowing for complete FD opening. Although it may appear that the microwire has safely crossed the previous stent, it may have actually gone ‘in-out-in’. The large diameter of the intermediate catheter assures that the microwire did not follow an errant path. This technique may help prevent technical and thromboembolic complications. It is important to keep in mind

that this is ‘off-label’ use of the PED and that FD following SAC has not been proven to be beneficial.

Learning points

- ▶ Flow diversion (FD) is a potential treatment for recurrent aneurysms following stent-assisted coiling (SAC), although efficacy has not been proven.
- ▶ Complete FD opening is paramount to prevent thromboembolic complications.
- ▶ The technique proposed in our report of passing the intermediate catheter completely through the previously placed stent can assure the microwire/microcatheter has traversed the central axis of the stent.
- ▶ This technique can help prevent incomplete FD opening and potentially prevent thromboembolic complications.

Twitter Follow Christopher Kellner at @chriskellner

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