

Abnormal foreshortening of a Flow Re-Direction Endoluminal Device caused by in-stent thrombosis immediately after deployment

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ABSTRACT

Thromboembolic complications are a concern in the treatment of cerebral aneurysms using a flow diverter. In this study, we report a case of abnormal foreshortening of a Flow Re-Direction Endoluminal Device (FRED) caused by in-stent thrombosis immediately after its deployment. A 72-year-old woman had a large cavernous carotid aneurysm, which caused ptosis and diplopia. FRED deployment was planned, and dual antiplatelet therapy was initiated 2 weeks before the procedure. Under systemic heparinization, FRED was deployed with local compaction over the aneurysm orifice. Cone-beam computed tomography subsequently revealed slightly poor wall apposition at the proximal side. While the balloon catheter was prepared for angioplasty, the stent became abnormally foreshortened, the proximal side slipped into the aneurysm, and the internal carotid artery became occluded. FRED was removed using a snare wire, and recanalization was obtained. The lumen of the removed FRED was filled with thrombus. The antiplatelet therapy was changed to triple regimen, and a Pipeline Flex embolization device was placed 1 month later. At that time, no thromboembolic complications were noted. It was considered that thrombotic occlusion was followed by foreshortening of FRED on the distal side because of antegrade blood flow. Multiple factors, such as increased mesh density by locally compacted stent deployment, slightly poor wall apposition, clopidogrel resistance, and the dual-layer structure of FRED, may have been involved in thrombus formation.

Keywords: flow diverter, Flow Re-Direction Endoluminal Device, thromboembolic complications

Abbreviations:

FRED: Flow Re-Direction Endoluminal Device

FD: flow diverter

ICA: internal carotid artery

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INTRODUCTION

Flow Re-Direction Endoluminal Device (FRED; MicroVention, Tustin, CA, USA) is a dual layer flow diverter (FD) stent device. Only the middle part of this device has a dual-layer structure, which provides a flow-diverting effect. The proximal and distal ends of the device are composed of a single layer of the outer stent, which provides wall apposition. FRED has been reported to be as effective and safe as other FDs. In this study, we describe a case of abnormal foreshortening of FRED caused by in-stent thrombosis immediately after its deployment.

CASE PRESENTATION

A 72-year-old woman presented to a hospital with right ptosis and diplopia that had lasted for a year. Close examination revealed a large aneurysm in the right cavernous portion of the internal carotid artery (ICA), with a maximum diameter of 17 mm (Fig. 1A). The patient was referred to our hospital for flow-diverting treatment. Treatment using FRED was planned. Two weeks before the procedure, the patient began dual antiplatelet therapy with 100 mg of aspirin and 75 mg of clopidogrel. A platelet aggregation test using Thromboelastograph® (TEG6s®) immediately before the procedure revealed an arachidonic acid inhibition rate of 97.2% (cutoff value, 50%¹) and an adenosine diphosphate inhibition rate of 22.1% (cutoff value, 30%²), meaning a normal response to aspirin and hyporesponse to clopidogrel.

FRED implantation

The procedure was performed under local anesthesia. Heparin was administered to achieve an intraprocedural activated clotting time of ≥ 300 s. An 8-Fr Roadmaster catheter (Goodman, Aichi, Japan) was placed in the right ICA. A SOFIA 6-Fr (MicroVention) was used as an intermediate catheter, and a Headway27 microcatheter (MicroVention) was guided through the aneurysm to the middle cerebral artery using a Chikai 14 guide wire (Asahi Intecc Co, Ltd, Aichi, Japan).

According to three-dimensional digital subtraction angiography, the diameter of the neck of the aneurysm was 7.7 mm, the distal ICA was 5.3 mm \times 4.0 mm, and the proximal ICA was 5.6 mm \times 3.4 mm. On the basis of these measurements, we selected a FRED measuring 5.0 mm \times 21 mm. FRED was deployed from the cavernous portion to the petrous portion, locally compacted over the aneurysm orifice to increase the mesh density (Fig. 1B). Cone-beam computed tomography performed immediately after the deployment revealed that the total length of the implanted FRED was 21 mm. The pitch of the spirally arranged nitinol wires was 4.9 mm in the parent artery and 2.6 mm in the aneurysm orifice; therefore, we estimated that the FRED was locally compacted by approximately 50% (Fig. 1C). In addition, slightly poor wall apposition was observed on the proximal side of FRED (Fig. 1D). Therefore, we prepared a Scepter C 4 mm \times 10 mm balloon catheter (MicroVention) for angioplasty.

However, while preparing the balloon catheter, the stent became abnormally foreshortened to a total length of 12 mm, the proximal side slipped into the aneurysm (Fig. 1E), and the ICA became occluded (Fig. 1F).

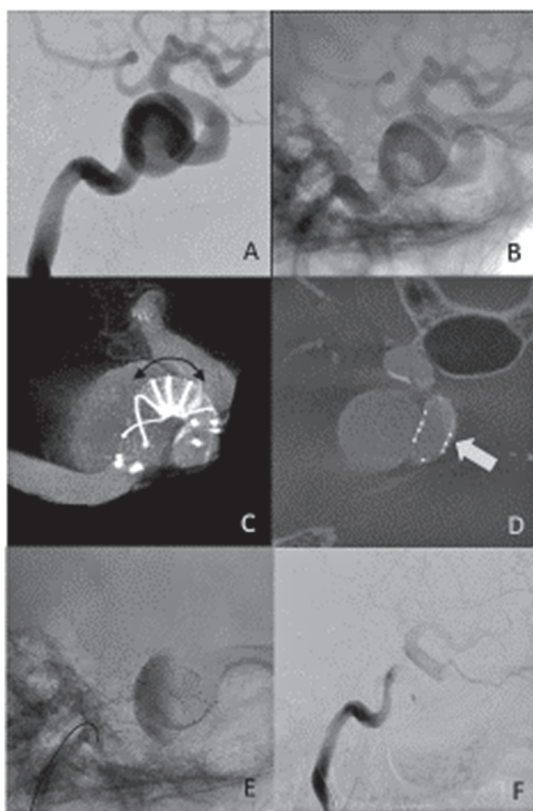


Fig. 1 FRED deployment

Fig. 1A: Right ICA angiography revealed a large cavernous carotid aneurysm, which was treated using FRED deployment.

Fig. 1B: Results of unsubtracted angiography immediately after FRED deployment.

Fig. 1C–1D: Enhanced cone-beam computed tomography images immediately after FRED deployment. The nitinol wire shows that the stent was compacted at the aneurysm neck (C). Axial view showing slightly poor wall apposition of FRED (D, arrow).

Fig. 1E–1F: Unsubtracted (E) and subtracted (F) angiography a few minutes after FRED deployment revealing abnormal foreshortening of FRED, with the proximal side slipping into the aneurysm and occlusion of the ICA.

ICA: internal carotid artery

FRED: Flow Re-Direction Endoluminal Device

An additional dose of heparin (3000 U) was administered. Because passing a micro-guide wire through the true lumen of the implanted FRED was difficult, we decided to remove the FRED. A micro-guide wire (GT12; Terumo, Tokyo, Japan) guided through an SL-10 microcatheter (Stryker, Kalamazoo, MI, USA) was caught by a gooseneck snare (Amplatz, 4 mm; Medtronic, Minneapolis, MN, USA) guided through an Excelsior 1018 microcatheter (Stryker) penetrating the stent flare (Fig. 2A). Both microcatheters were simultaneously pulled to remove the FRED (Fig. 2B). The ICA was then recanalized.

We found that the lumen of the removed FRED was filled with thrombus; however, no obvious issues with the device itself were noted (Fig. 2C). Repeating the procedure on the same day was thought to entail a high risk of thromboembolic complications; therefore, no further treatment was performed.

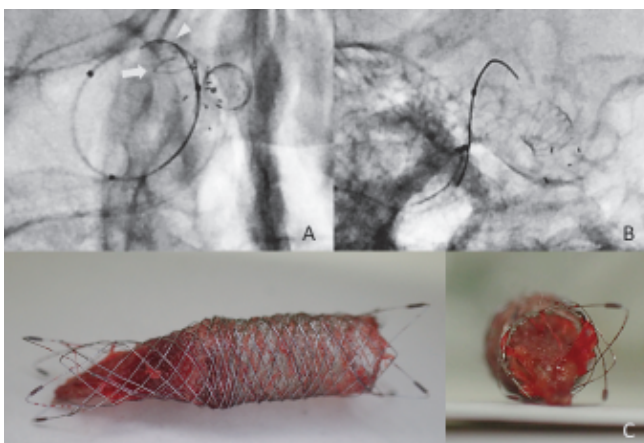


Fig. 2 Stentectomy

Fig. 2A: A micro-guide wire (GT12; arrowhead) guided through an SL-10 microcatheter was caught by a gooseneck snare (arrow) guided through the Excelsior 1018 microcatheter penetrating the stent flare.

Fig. 2B: Both microcatheters were simultaneously pulled to remove the stent.

Fig. 2C: The lumen of the removed FRED was filled with thrombus.

FRED: Flow Re-Direction Endoluminal Device

Retreatment with Pipeline Flex

After 1 month, we performed the procedure again. After the initial procedure, the dose of clopidogrel was increased to 150 mg, and 200 mg of cilostazol was added to the antiplatelet regimen. TEG6s® testing immediately before the second procedure revealed an arachidonic acid inhibition rate of 96.5% and an adenosine diphosphate inhibition rate of 19.6%, meaning a hyporesponse to clopidogrel. A 5.0 mm × 30 mm Pipeline Flex embolization device (Medtronic) was deployed, also locally compacted over the aneurysm orifice. During this second procedure, no thromboembolic complications were observed. Further, no new neurological symptoms appeared during the course of the two treatments.

DISCUSSION

The flow-diverter stent has a higher metal density than other neck-bridge stents, and prevention of perioperative thrombosis is extremely important. In the present case, in-stent thrombotic occlusion and abnormal foreshortening were observed immediately after FRED deployment. In another reported case, an undersized FRED deployed for a wide-neck aneurysm became shortened 1 day after the procedure.³ However, to the best of our knowledge, no report of abnormal foreshortening immediately after FRED deployment has been published. Postoperative cone-beam computed tomography in our patient revealed that the total length of FRED immediately after deployment was 21 mm, which is the same as its original length, and locally compacted by approximately 50% at the aneurysm orifice in comparison with the other parts. The averages of the maximum and minimum diameters of the parent artery were 4.7 mm on the distal side and 4.5 mm on the proximal side. On preoperative simulation, a 5 mm × 21 mm FRED was expected to extend to a total length of 26 mm when deployed in a parent artery with a 4.5-mm diameter, which was long enough to cover the distal and proximal sides of the aneurysm even if compacted at the aneurysm orifice. Moreover, postoperative cone-beam computed tomography revealed that a

sufficient length of 7 mm was deployed in both the distal and proximal sides of the parent artery. However, it shortened to a total length of 12 mm after a few minutes. Unless an external force is applied, such abnormal shortening should not have occurred. Therefore, we speculated that in-stent thrombotic occlusion had occurred, followed by foreshortening of FRED to the distal side as a result of antegrade blood flow.

FRED has a dual-layer structure composed of an outer layer with higher porosity providing wall apposition and an inner layer with low porosity to enable flow diversion. Only 80% of the middle part has a dual-layer structure, which covers the aneurysm neck and exerts a flow-diverting effect. The proximal and distal ends of the device are composed of a single layer of the outer stent, which is designed to protect the perforating vessels from the parent artery.³⁻⁸ FRED also has the advantage of being easier to navigate and deploy than other FDs.³ However, in several case series, the incidence of thromboembolic complications with FRED was reported to be approximately 15%,^{4,7,8} which is higher than that with other FDs.^{9,5} An in vitro study demonstrated higher thrombogenicity of FRED relative to that of the Pipeline device.⁵ The approximately 100- μ m separation between the dual layers of the device could disrupt flow, increase stasis, trap activated platelets, and serve as a nidus for further thrombus accumulation.⁵ In our case as well, the dual-layer structure of FRED might have been involved in thrombus formation.

Reported risk factors for thromboembolic complications in FD treatment include long procedure times, use of multiple FDs, and poor wall apposition.¹⁰ In the present case, slightly poor wall apposition was observed on the proximal side of the parent artery. Further, increased mesh density resulting from local compaction procedure at the aneurysm orifice might have been contributed to thrombus formation.

Hyporesponse to clopidogrel was observed from the time of the initial procedure. Clopidogrel hyporesponse in FD treatment has been reported in many studies wherein the P2Y12 reaction unit value using VerifyNow (Accumetrics, San Diego, CA, USA). A recent meta-analysis suggested an association between clopidogrel hyporesponse based on the P2Y12 reaction unit value and thromboembolic complications in FD treatment.¹¹ At our facility, TEG6s® is used for testing platelet aggregation. TEG6s®, like VerifyNow, can test clopidogrel response within a short time. In the cardiovascular field, an adenosine diphosphate inhibition rate of 30% according to TEG6s® has been reported as a cutoff value for clopidogrel hyporesponse.² In the field of cerebral endovascular treatment, low adenosine diphosphate inhibition rate has been reported to be associated with thromboembolic events after stent-assisted coiling for aneurysms and stenting for intracranial and extracranial stenotic lesions.^{12,13} In the second procedure of our patient, with Pipeline Flex, the antiplatelet regimen increased from two to three drugs. As a result, the second procedure did not cause any thromboembolic event; however, immediately before the second treatment, TEG6s® revealed clopidogrel hyporesponse. Although the stent used in the second procedure differed from that used in the first, clopidogrel hyporesponse may have been involved in thrombus formation.

In conclusion, multiple factors, such as increased mesh density by locally compacted stent deployment, slightly poor wall apposition, clopidogrel hyporesponse, and the dual-layer structure of FRED, may have been involved in thrombus formation in the present case. To determine the risk factors for thromboembolic complications in FD treatment, studying more cases of FD deployment is warranted.

DISCLOSURE STATEMENT

All authors declare that they have no conflicts of interest.

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