

# Inadvertent Intraprocedural Complication of a Flow Diverter Device During Treatment of Internal Carotid Artery Aneurysm: A Case Report

Kumar Muthukumar, MBBS, DMRD, DNB, FRCR, EDiR; Vinu Moses, MBBS, MD; Shyamkumar Nidugala Keshava, MBBS, DMRD, DNB, FRCR, FRANZCR; Aswin Padmanabhan, MBBS, MD, FNVIR

From the Christian Medical College, Vellore, Tamil Nadu, India

**Abstract: Background.** The fracture of a delivery wire in a pipeline device is very unusual and only a few cases have been reported. We present a case of delivery-wire fracture encountered during flow-diverter deployment of a pipeline embolization device, which was retrieved using the balloon-sandwich technique. **Summary.** The balloon-sandwich technique was used to retrieve the fractured delivery wire of a flow-diverter delivery system in a 30-year-old woman who had a large saccular left internal carotid artery ophthalmic segment aneurysm while other usual methods, like micro-snaring, failed. **Conclusion.** The balloon-sandwich technique as described is a well-suited method for retrieval of fractured delivery wire while using the triaxial system.

VASCULAR DISEASE MANAGEMENT 2021;18(8):E139-E143.

**Key words:** complications, retrieval technique, stent fracture

Flow-diverter (FD) stent placement for the treatment of cerebral aneurysms is on the rise given the long-term durability and favorable occlusion rates.<sup>1</sup> For occlusion to occur, more metal coverage is required in the stent design for optimal flow diversion compared with regular self-expanding intracranial stents. This makes FD comparatively more rigid than a regular self-expanding braided stent. The anatomies of intracranial vessels are tortuous, requiring a complex delivery system delicately balanced between stability and malleability.

A learning curve of 35–40 cases may be required for the use of FDs with the risk of complications decreasing as operators gain experience with the device.<sup>2</sup> Complications such as non-occlusion of aneurysms and delayed thromboembolic risks are related to good apposition of the stent to vessel wall during deployment. To achieve this, the iterative deployment process often includes a fair bit of pushing and pulling of the delivery wire or the entire system.<sup>3</sup> The stent and its delivery system are designed to sustain significant torque and tension during this pulling and pushing, but inadvertent complications may occur during this process. Wire fracture of the Pipeline Flex stent (Medtronic) delivery system is a rare complication but has been previously reported.

## Clinical Case

A 30-year-old woman presented with occasional episodes of diffuse, dull, aching holocranial headache for the past 2 years. She complained of painless progressive visual deterioration in the left eye for the past 2 months. There was no history of eye

pain or redness of the eye. She was a known hypertensive on regular medications. Contrast-enhanced computed tomography revealed a large aneurysm at the floor of the middle cranial fossa on the left side adjoining the cavernous sinus.

The cerebral angiogram revealed a large saccular aneurysm (measuring 4.2 mm at the neck, 1.3 cm at the dome, and 1.8 cm in length) in the supraclinoid left internal carotid artery (ICA). Because of the size and location of the aneurysm as well as the wide neck, endovascular FD placement was planned.

The patient was adequately pretreated with aspirin 75 mg and prasugrel 10 mg for the procedure as per our institutional protocol. The procedure was done under general anesthesia. Using a 5 Fr sheath and 4 Fr vertebral glide, a preprocedural 3-dimensional angiogram was performed. There was no significant vasospasm.

After priming with nimodipine, the primary system was exchanged for a triaxial system comprising a 6 Fr shuttle guide catheter, a 0.072" Navien intermediate catheter (Medtronic), and a 0.027" Phenom microcatheter (Medtronic). The microcatheter was used to navigate across the neck of the aneurysm. The superior division of the left middle cerebral artery (MCA) was selectively cannulated with Phenom microcatheter and Synchro wire (Stryker Neurovascular).

The Pipeline Flex embolization device (4.25 x 25 mm) was then deployed from the left supraclinoid ICA with an aim to jail the origin of ophthalmic artery, as per the plan (**Figure 1**). The check angiogram showed stasis within the aneurysm with preserved flow in the left ICA and its branches.

In the immediate postdeployment phase of the Pipeline device, the following steps were done successively:



**Figure 1.** (A) Pretreatment 3-dimensional CT angiography image of the left internal carotid artery ophthalmic segment aneurysm. (B) Digital subtraction angiography image – microcatheter (\*) placed distal to the aneurysm at the superior division of the left middle cerebral artery and flow-diverter device taken inside. Tip coil, delivery wire seen within the microcatheter. (C) Initial deployment of the flow diverter (arrow) by unsheathing of the microcatheter.

1. After deployment of the Pipeline stent, we encountered many difficulties trying to recapture the delivery wire while attempting to resheath it. It took a moment to realize that the distal tip of the catheter had gotten stuck between the distal marker and the polytetrafluoroethylene (PTFE) sleeve. Meanwhile, we applied reasonable pull force and maneuvered the catheter to recapture the delivery wire (**Figure 2**).
2. Wire fracture proximal to the proximal marker was recognized by the inability to navigate and the unresponsiveness of the distal delivery wire during torquing and subsequent withdrawal of the wire (**Figure 3**).
3. Microcatheter was withdrawn outside along with the broken delivery wire. Just as the microcatheter was removed, a thin, spiral, thready wire was also noted stretching from the Y connector. At this point, we realized that there was unraveling of part of the delivery wire from just proximal to the distal marker.
4. Microsnare (Amplatzer Goose Neck Snare Kit, comprising 4 mm Loop Snare with true 90° angle, 2.3–3.0 Fr Goose Neck snare catheter) was inserted to pull out the fractured wire by snaring, but was not successful.
5. Subsequently, a Hyperglide balloon catheter (Medtronic) was advanced through the intermediate catheter and placed distal to the resheathing marker of delivery wire. The entire system was pulled out successfully by sandwiching the delivery wire between the inflated balloon and intermediate catheter lumen (**Figure 2** and **Figure 4**).

The Pipeline stent was well apposed to the vessel wall covering the aneurysm neck. Stagnation of contrast was seen in

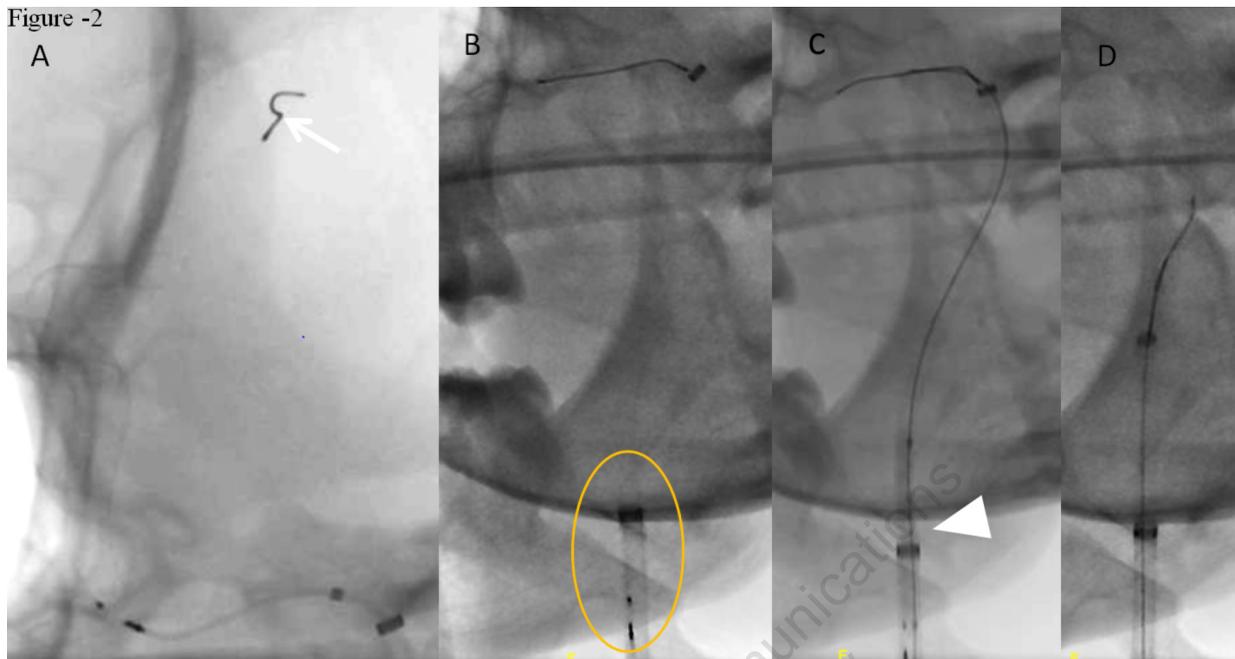
the aneurysm sac post deployment. No thrombus formation on the stent was noted and the patient had a normal neurological exam post procedure.

In a retrospective analysis of our case, the device was resheathed once before deployment, as it slipped from the intended distal landing zone. A moderate difficulty was encountered during the resheathing process while pulling the delivery wire as the distal tip of the catheter was riding over the flipped PTFE sleeve. Resheathing the leading Pipeline device edge might have resulted in the delicate leading edge no longer being protected by the PTFE sleeves during redeployment. A distal support catheter (.072" Navien) was brought as close to the posterior genu to create sustainable additional support for the delivery catheter. The amount of load can be inferred by looking at the shape of the Pipeline device as it comes out of the delivery catheter and by the relationship of the catheter to the vessel.

## Discussion

The Pipeline embolization device (PED) is a flexible, low-porosity, stent-like, self-expanding construct designed to treat intracranial aneurysms through the process of flow diversion and endoluminal parent-vessel reconstruction. A braided device, such as the PED, is housed within its delivery system by elongation and thus foreshortens during deployment.<sup>3</sup> The current-generation PED has been made with substantial revisions of the basic design to make it easier to deliver, particularly around tortuous segments, and easier to resheath.<sup>4</sup>

Based on several published studies about the efficacy and safety of the PED, the range of applications and frequency of use for intracranial aneurysms have increased. Besides well-known traditional complications associated with FDs, some case series



**Figure 2.** (A) During the process of recapturing the delivery wire, the microcatheter manipulation adds to a significant load on the tip coil with resultant kinking (arrow). (B) Broken end of the delivery wire (encircled) with resheathing and proximal marker noted inside the intermediate catheter. (C) Unsubtracted digital subtraction angiography image: balloon catheter is inflated (arrowhead), the delivery wire is sandwiched against the intermediate catheter lumen. (D) Intermediate catheter is pulled into the guide catheter.

have presented device-related periprocedural complications due to unique features and handling methods of PED.

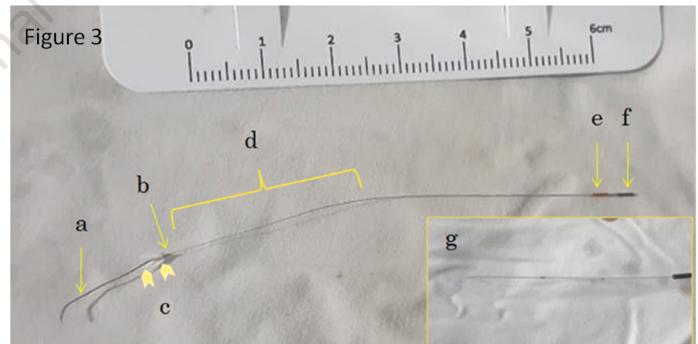
To the best of our knowledge, there have been 5 cases of distal coil fracture of the delivery wire in the literature. All but 1 of these cases occurred during treatment of a posterior circulation aneurysm. In 3 cases, the distal tip was retained within the perforator of the advanced parent vessel, and in one case between the vessel wall and the deployed PED.<sup>3,5-8</sup>

The balloon-sandwich technique has previously been described in interventional cardiology and peripheral vascular literature.<sup>9</sup> A similar situation was encountered in cardiology in which a broken distal segment of a jailed guidewire in the coronary artery was retrieved using the tangling technique with the help of three rescue wires.<sup>10</sup>

We analyzed the sequential steps that could have precipitated and contributed the most to the wire-fracture event:

1. Resheathing the device to deploy at intended distal landing zone confers variable load to the microcatheter and more excessive friction between the resheathing pad and the delivery catheter.
2. During recapturing of the distal delivery wire, a variable amount of pulling force is applied while withdrawing the PTFE sleeve into the microcatheter depending upon angulations, vessel tortuosity, sleeve length, and sleeve deflection.

To minimize the aforementioned factors, FD stents can also be fully unsheathed within a distal intermediate catheter (DIC), as described by Lin et al.<sup>11</sup> In this technique, the DIC is first

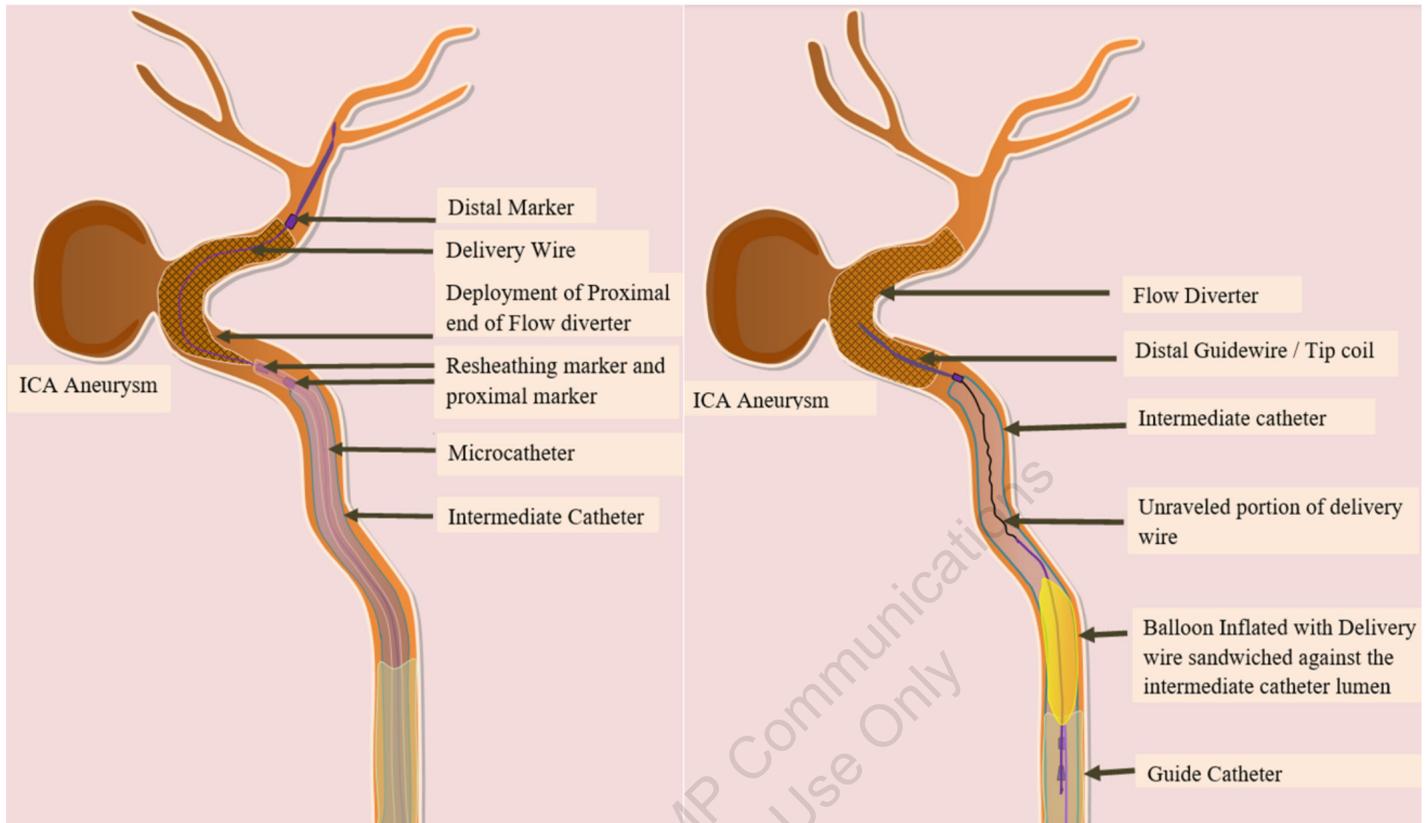


**Figure 3.** Fractured wire with (A) leading wire, (B) distal marker, (C) polytetrafluoroethylene (PTFE) sleeve deflected, (D) unwind portion noted proximal to PTFE sleeve, (E) resheathing, and (F) proximal marker, (G) delivery hypotube.

advanced over the delivery catheter to the unopened part of the FDS. The FDS is then fully unsheathed within the DIC. Since the FDS is completely free from the delivery wire, the progressive opening of the device becomes independent of the delivery wire distal migration.

As PEDs require repetitive pushing and pulling of the microcatheter and delivery microwire, the distal tip might engage in nearby small perforators not visible in angiograms and more pronounced during proximal vessel spasm. This can be prevented by frequent monitoring of movement of the delivery wire.

Of note, unlike a Pipeline Classic device, the leading edge (tip coil) of the wire cannot be manipulated by torquing the



**Figure 4.** Illustrative images. (1) Deployment of flow diverter device by unsheathing and "center and push" method. (2) Balloon-sandwich technique to retrieve fractured wire. ICA = internal carotid artery.

delivery wire. Because of this, the operator should be vigilant of guidewire tip location in terms of its possible entry into perforators or unintended targets. Some recommend gently shaping the guidewire by advancing the device partially out of its protective sheath and then resheathing.

## Conclusion

Flow-diverting stents have revolutionized the endovascular management of complex, wide-necked, and large aneurysms. Mechanical factors, particularly in the setting of tortuous vascular anatomy, create an environment in which the stent is prone to suboptimal deployment or technical failure.

Fortunately, periprocedural complications are rare, but should be promptly identified. This allows swift management of complications. The balloon-sandwich technique is a novel retrieval technique for retrieving a fractured PED wire. A working protocol for intraprocedural technical complications and the appropriate remedies should be available for safe deployment. ■

From the Christian Medical College, Vellore, Tamil Nadu, India.

Disclosure: The authors have completed and returned the ICMJE Form for Disclosure of Potential Conflicts of Interest. The authors report no conflicts of interest regarding the content herein.

Manuscript accepted July 15, 2021.

The authors report patient consent for image used herein.

Address for correspondence: Kumar Muthukumar, MBBS, DMRD, DNB, FRCR, EDiR, Christian Medical College, Room No. 1/13, X-Block, CMC Hospital Main Campus, Vellore, Tamil Nadu 632004, India. Email: drkmr1998@gmail.com.

## REFERENCES

1. Cerejo R, Bain M, Masaryk T, et al. Balloon sandwich technique for retrieval of fractured delivery wire of pipeline stent. *Interv Neuroradiol.* 2018;24:40-42.
2. Jabbour P, Chalouhi N, Tjoumakaris S, et al. The Pipeline Embolization Device: learning curve and predictors of complications and aneurysm obliteration. *Neurosurgery.* 2013;73:113-120.
3. Park JS, Kwak HS, Lee JM. Inadvertent complication of a pipeline embolization device for treatment with vertebral artery dissecting aneurysm: distal tip fracture of delivery wire. *J Korean Neurosurg Soc.* 2016;59:521-524.
4. Shin DS, Carroll CP, Elghareeb M, Hoh BL, Kim BT. The evolution of flow-diverting stents for cerebral aneurysms; historical review, modern application, complications, and future direction. *J Korean Neurosurg Soc.* 2020;63:137-152.
5. Albuquerque FC, Park MS, Abla AA, Crowley RW, Ducruet AF, McDougall CG. A reappraisal of the Pipeline embolization device for the treatment of posterior circulation aneurysms. *J Neurointerv Surg.* 2015;7:641-645.

6. Briganti F, Marseglia M, Leone G, et al. Endovascular treatment of a small aneurysm of the superior cerebellar artery with a flow-diverter device. A case report. *Neuroradiol J*. 2013;26:327-331.
7. Lylyk P, Miranda C, Ceratto R, et al. Curative endovascular reconstruction of cerebral aneurysms with the pipeline embolization device: the Buenos Aires experience. *Neurosurgery*. 2009;64:632-642; discussion 642-643; quiz N6.
8. Park MS, Albuquerque FC, Nanaszko M, et al. Critical assessment of complications associated with use of the Pipeline Embolization Device. *J Neurointerv Surg*. 2015;7:652-659.
9. Rossi M, Citone M, Krokidis M, et al. Percutaneous retrieval of a guidewire fragment with the use of an angioplasty balloon and an angiographic catheter: the sandwich technique. *Cardiovasc Interv Radiol*. 2013;36:1707-1710.
10. Sinha SK, Verma CM, Krishna V, et al. Wondering PTCA wire: retrieval by tangling technique. *Cardiol Res*. 2015;6:257-259.
11. Lin L-M, Colby GP, Jiang B, et al. Intra-DIC (distal intracranial catheter) deployment of the Pipeline embolization device: a novel rescue strategy for failed device expansion. *J Neurointerv Surg*. 2016;8:840-846.

2021 Copyright HMP Communications  
For Personal Use Only