

## Endovascular Rescue Strategies for Nonopening of Pipeline Device: Report of Two Cases

### Abstract

We report two cases of rescue strategies for nonopening of Pipeline flow-diverter device for the treatment of intracranial aneurysm. The first patient, a 65-year-old female, presented with complaints of headache for 3 months and was found to have giant supraclinoid internal carotid artery (ICA) (ophthalmic segment) aneurysm. We planned endovascular partial coiling and flow-diverter placement for the treatment of ICA aneurysm. During the progressive deployment of PED, there was nonopening of Pipeline embolization device (PED) at its proximal end. We tried multiple attempts to navigate Marksman microcatheter over the PED delivery microwire and Echelon microcatheter over the Traxcess microwire across the pinched site, but we were not able to achieve success. After that, we tried opposite transcranial approach across prominent anterior communicating artery with the Synchro and Transcend microguidewire which finally resulted in the opening of the device; however, there was acute extravasation of dye on check angiogram. Thus, our technical success turned into disaster. The second patient, a 55-year-old female, presented with complaint of seizures for 3 months due to mass effect of cavernous sinus aneurysm. Pipeline Flex flow-diverter placement was done across the aneurysm neck. During the progressive deployment of device, there was nonopening of the mid and proximal segment of Pipeline Flex which was successfully managed by intra-Navien deployment of device followed by simultaneous push of Marksman microcatheter and pull of Navien catheter. In our case series, two rescue strategies were applied to successfully open the proximal constricted portion of Pipeline Flex; however, technical success in one case resulted in unmanageable disasters. Thus, transcranial rescue strategy for opening the constricted Pipeline Flex device should be cautiously used in our endovascular practice.

**Keywords:** Aneurysm, flow diverter, internal carotid artery, intra-Navien deployment, Pipeline device, Pipeline Flex embolization device

### Introduction

The Pipeline embolization device (PED) (EV3, Irvine, CA, USA) was approved by the Food and Drug Administration (FDA) for use in the USA in 2011 after the Pipeline for Uncoilable or Failed Aneurysms (PUFS) trial for treatment. The PED is made of 75% nickel–cobalt–chromium alloy and 25% platinum and has a porosity of 65%–70%.<sup>[1]</sup> PUFS trial reported a technical success rate of deployment of PED of 99%.<sup>[2]</sup> The second-generation PED, named Pipeline Flex (ev3/Covidien), was FDA approved in February 2015.<sup>[1]</sup> Deployment of PED device requires special maneuvers to ensure its opening and proper vessel wall apposition.<sup>[3]</sup> Intraprocedural device malfunction has been reported in literature which was successfully managed

by certain maneuvers.<sup>[4,5]</sup> We report two cases of malfunctioning (nonopening of proximal segment) of Pipeline devices which were successfully managed by two different rescue techniques; however, technical success in one case resulted in unmanageable disasters.

### Procedural details

#### *Antiplatelets loading before the procedure*

Both the patients undergoing endovascular treatment (EVT) received dual antiplatelet therapy (150 mg aspirin and 10 mg prasugrel) for 5 days before EVT.

#### *Anticoagulation during the procedure*

Systemic anticoagulation using heparin with a 5000 U bolus was administered intra-arterially at the start of each case followed by an interval intraprocedural rebolus of intravenous heparin to maintain the activated clotting time above 300 s.

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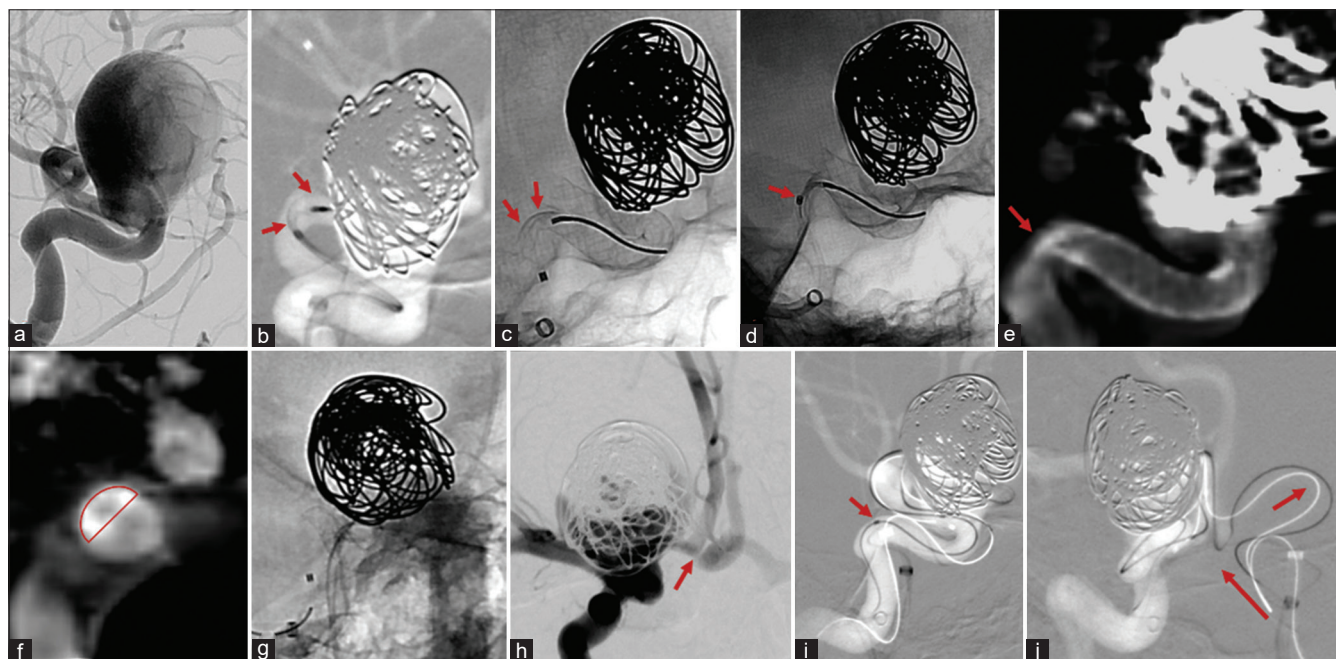
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## Case Reports

### Case 1

A 65-year-old female presented with complaints of headache for 3 months. Noncontrast computed tomography (CT) head shows hyperdense structure in the right paracavernous region. Digital subtraction angiography (DSA) was performed which showed giant supraclinoid internal carotid artery (ICA) (ophthalmic segment) aneurysm [Figure 1a]. Endovascular partial coiling and flow-diverter placement were planned. EVT was performed through transfemoral route under general anesthesia (GA) using six-French Flexor Shuttle sheath (Cook Medical, Bloomington, Indiana, USA) which was placed in the common carotid artery (CCA). Distal access catheter (DAC) 070 (Concentric Medical) 105 cm was navigated and parked in the cavernous ICA over the Marksman microcatheter (Covidien Vascular Therapies, Mansfield, Massachusetts, USA) and Synchro microguidewire (Stryker Neurovascular, Fremont, CA, USA). Type II cavernous ICA was noted according to the classification proposed by Lin *et al.*<sup>[6]</sup> Marksman microcatheter was then navigated across the aneurysm into the proximal middle cerebral artery (MCA) for PED (4.5 mm × 20 mm) deployment. During the progressive deployment of PED, there was nonopening of PED at its proximal end [Figure 1b and c]. We performed multiple attempts to traverse the constricted portion of PED with Marksman microcatheter over the PED delivery

microwire which was ineffective [Figure 1d]. Dyna CT angiography was done to confirm the pinched proximal portion of PED [Figure 1e and f]. Thereafter, Echelon microcatheter (EV3, Irvine, CA, USA) over the Traxcess microwire was also tried to cross the pinched site, but we were not able to achieve success [Figure 1g]. We performed cross-compression of the right ICA with the left ICA injection which revealed a sizeable anterior communicating artery (AcoA) and A1 segment of both anterior cerebral arteries [Figure 1h]. Finally, we tried opposite transcranial approach across prominent AcoA with the Echelon microcatheter over the Synchro microguidewire. While trying to navigate our microcatheter over microwire, the force of the microcatheter was continuously transmitted into the MCA, and there was persistent flopping of the microcatheter into the left MCA [Figure 1i and j]. With multiple attempts, we finally tried to navigate Echelon microcatheter over the relatively stiffer Transcend wire (Boston Scientific/Target Therapeutics) beyond the stenosis which finally resulted in the opening of the device [Figure 2a and b]; however, there was acute extravasation of dye on check angiogram [Figure 2c]. It was unclear from where the intraprocedural rupture occurred. We immediately reversed the heparin by giving intravenous protamine. Transform balloon microcatheter was navigated over the Traxcess microguidewire and inflated in the cavernous ICA [Figure 2d]. The patient continued to have raised blood pressure and bradycardia despite the



**Figure 1:** (a) The right internal carotid artery injection shows large supraclinoid internal carotid artery aneurysm. (b) Partial coiling was done followed by progressive Pipeline deployment. (c) Nonopening of Pipeline device proximally (arrows). (d) Failed attempt to navigate Marksman microcatheter across the constricted site over the Pipeline embolization device delivery microwire. (e and f) Dyna computed tomography shows constricted proximal end of Pipeline embolization device (arrow and semicircle). (g) Attempt to negotiate Echelon microcatheter over Traxcess wire across the proximal Pipeline embolization device. (h) Prominent anterior communicating artery (arrow). (i) Failed crossing the pinched site (arrow) with Echelon microcatheter over Synchro wire through retrograde approach. (j) Microcatheter force continuously transmitted into the middle cerebral artery while trying the pushing microcatheter beyond the constricted site

aggressive medication. Her pupils became dilated and fixed. The patient had persistent severe vasospasm of distal vessels and died on day 2 postprocedure. Thus, our technical success turned into disaster in this case.

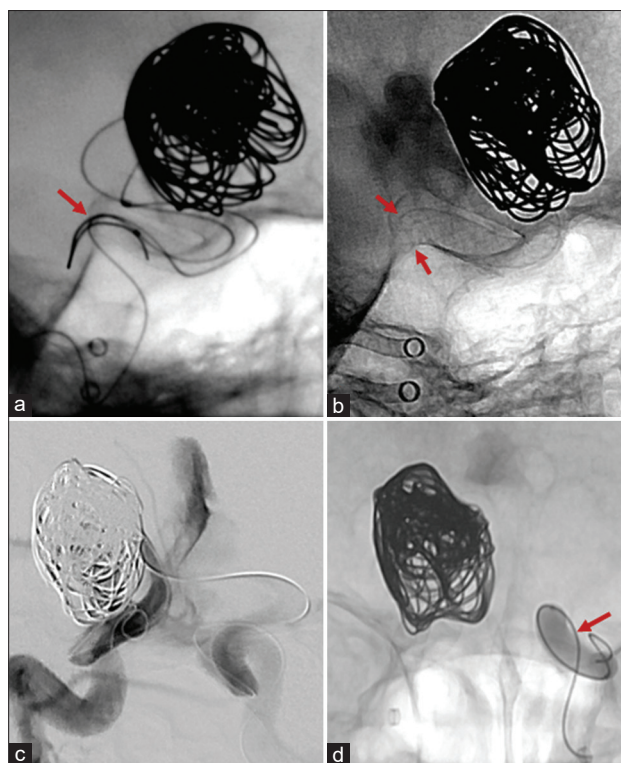
## Case 2

A 55-year-old female presented with complaint of seizures for 3 months. Magnetic resonance imaging brain was done which showed flow void structure in relation to the left cavernous ICA causing mass effect over the temporal region suggestive of aneurysm. DSA revealed the left cavernous ICA aneurysm [Figure 3a and b]. Type II cavernous ICA was noted according to the classification proposed by Lin *et al.*<sup>[6]</sup> EVT was performed through transfemoral route under GA using six-French Flexor Shuttle sheath which was placed in CCA. DAC 070 105 cm was navigated and parked in the cavernous ICA over the Headway 27 microcatheter (MicroVention, Tustin, California, USA) and Synchro microguidewire. Pipeline Flex embolization device (PFED, 4.5 mm × 30 mm) placement was done across the aneurysm neck. Unsheathe and push maneuvers along with wagging of the Pipeline Flex and Headway 27 microcatheter were applied to deploy and open the PFED. During the progressive deployment of device, distal Pipeline Flex was well opened in supraclinoid ICA beyond the aneurysm; however, there was nonopening of the mid and proximal segment of Pipeline Flex [Figure 3c and

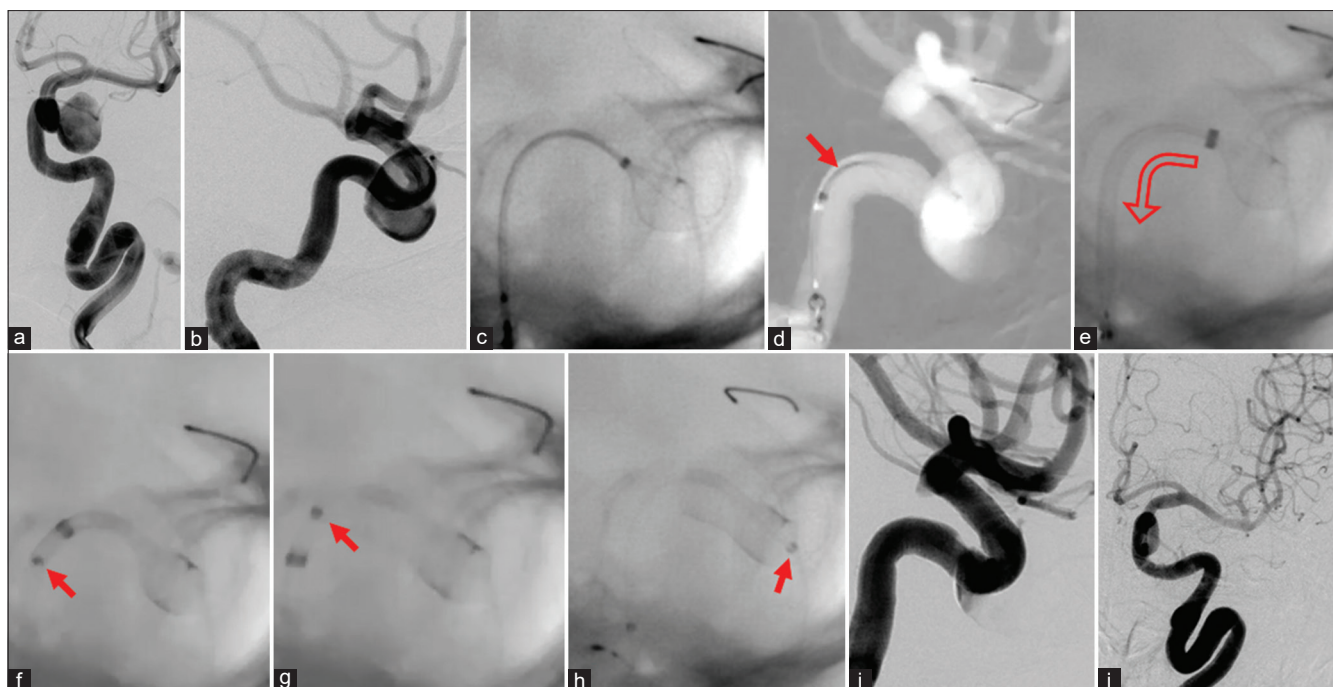
d]. To further facilitate the expansion and opening of the device, unsheathing of device followed by synchronously forward and backward movement of the Headway 27 microcatheter and Pipeline Flex was performed along the curvatures. There was persistent nonopening of the constricted proximal Pipeline Flex device. We planned to do intra-Navien deployment of the Pipeline Flex. Navien guiding catheter was first advanced over the Headway 27 microcatheter to the unopened segment of Pipeline Flex within it. The Pipeline Flex device was then deployed completely within the Navien, thus releasing the Pipeline Flex from the delivery wire and Headway 27 microcatheter now functioned as delivery wire [Figure 3e]. Released Pipeline Flex within the Navien was then successfully deployed by simultaneous push of Headway 27 microcatheter and pull of Navien [Figure 3f, g and h]. Vessel wall apposition of Pipeline Flex device was well achieved, and no balloon angioplasty was done. There was contrast stasis in the aneurysm on final control angiogram [Figure 3i]. Three months follow up angiogram showed complete occlusion of aneurysm.[Figure 3j].

## Discussion

Flow diverter has been widely accepted for the treatment of intracranial aneurysm due to its higher occlusion rate and low recurrences rate. Pipeline flow diverter is a braided cobalt–chromium mesh available in 2.5–5-mm diameters and 10–35-mm lengths.<sup>[2]</sup> The first-generation PED has delivery wire which extends 15 mm distal to the PED. This may require a clockwise turn to release the PED distally. Resheathing and repositioning of this device are not possible. Pipeline Flex device has same stent material, design, and configuration and is almost completely resheathable. It has now two 3-mm protective sleeves of polytetrafluoroethylene in place of capture coil of the first-generation PED. The distal tip has a soft hydrophilic 0.01200 wire with a tip angle of 55°. It has longer and thicker pusher wire than the previous version.<sup>[7]</sup> Both the devices are deployed through 027” inner diameter microcatheters. First, the distal end of the PED is positioned in the landing zone; it is then deployed using a combination of pushing the pusher wire and pulling back the microcatheter to keep the PED and the microcatheter in the isocenter of the vessel which allows spontaneous opening. The 027” microcatheter and PED are moved synchronously forward and backward along the outer and inner curvatures to facilitate the expansion of PED.<sup>[3,7]</sup> Sometimes, coil tip and delivery wire are not able to move forward, and proper expansion of PED is not achieved. The device becomes stretched with continuous attempts to deploy and expand the device by a pushing technique.<sup>[3]</sup> The deployment of PED is difficult, especially in cases with tortuous anatomy. Lin *et al.*<sup>[6]</sup> categorized the cavernous ICA tortuosity into minimal (Type I), moderate (Type II-III), and severe (Type IV) type with more complexity of



**Figure 2:** (a) Transcend microwire was negotiated beyond the pinched proximal segment of Pipeline embolization device. (b) Finally opened proximal Pipeline device (arrows). (c) The right internal carotid artery injection shows contrast extravasation suggestive of rupture. (d) Rescue balloon inflation (arrow) in the left internal carotid artery



**Figure 3:** Intra-Navien Pipeline flex device deployment. (a and b) left ICA (anteroposterior and lateral view injection shows left cavernous ICA segment aneurysm. (c) Single-shot fluoroscopy lateral view of progressive Pipeline flex deployment. (d) Road map image shows nonopening of proximal part of Pipeline flex (arrow). (e) Lateral view shows complete unsheathing of Pipeline flex with in the navien (curved arrow). (f and g) Simultaneous unsheathing of the Navien while pushing on the Headway 27 microcatheter (arrow). (h) Complete opening of pipeline device with Headway 27 microcatheter in situ. (i) Left ICA injection shows stasis of contrast within the aneurysm. (j) 3 months angiographic follow up shows complete occlusion of aneurysm

deployment of PED in high grades as compared to lower grade (minimal). In both of our cases, there was Type II cavernous loop of ICA according to the classification proposed by Lin *et al.*<sup>[6]</sup> The larger PED sizes ( $\geq 4$  mm) have more difficult device openings as a result of the uniform 48-strand device design across all PED diameters.<sup>[3]</sup> PED size was 4.5 mm in diameter in our cases. Thus, large size PED and tortuosity of the vessel favor the difficult deployment of the device and also its malfunctioning. Few cases of rescue strategies for unopening of the PED have been described in literature.<sup>[3-5]</sup> Ding and Liu<sup>[5]</sup> reported a case of microsurgical extraction of unopened PED at its proximal end associated with thrombus formation. Navarro *et al.*<sup>[4]</sup> described a successful retrograde trans-AcoA approach as a rescue for unopened PED. We achieved technical success in the first case of transcranial approach to open the constricted proximal end of the device; however, it was turned into an unmanageable disaster with extravasation of contrast suggestive of vessel rupture. This was probably because of the use of stiffer Transcend wire to navigate our microcatheter which might have resulted in the dissection of vessel. The patient died on day 2 postprocedure. Lin *et al.* reported intra-distal intracranial catheter deployment strategy for failed PED expansion in 11 patients. They encountered failed expansion in two cases of Pipeline Flex device (4.25 mm) in petrocavernous location with moderate to severe tortuosity. The second case in our series also utilized intra-Navien deployment of Pipeline Flex device as a rescue strategy for unopened

proximal Pipeline Flex (4.5 mm  $\times$  30 mm) in cavernous location with moderate tortuosity. Thus, in both of our cases, we adopted different rescue technique for unopened Pipeline device and achieved technical success; however, in the first case, technical success turned into a disaster. In our opinion with consideration of literature,<sup>[3]</sup> transcranial approach should be cautiously used and intra-Navien deployment can be safely used as a rescue strategy for unopened Pipeline device.

#### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

#### Conflicts of interest

There are no conflicts of interest.

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