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Flow-Diverter Stents Combine Flow-T stenting Assisted Coiling for Treatment of Large Basilar Apex Aneurysm: A Case Report with 9-Month Follow-up

Wang H[1], Yang H[1], Zeng S[2], Guo T[3], Xu L[1] and Yang D[1*]

[1]Department of neurosurgery, Daping Hospital, Army Medical University, Chongqing, China

[2]Department of Neurosurgery, People's Hospital of Chongqing Banan District, Chongqing, China

[3]Department of Neurosurgery, the First Affiliated Hospital of Chongqing Medical University, Chongqing, China

[*]Corresponding author:

Donghong Yang,

Department of neurosurgery, Daping Hospital, Army Medical University, Chongqing, China

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Flow-Diverter devices; Aneurysm; Basilar apex aneurysms; Supraclinoid aneurysms; Endovascular

1. Abstract

1.1. Background: The treatment of wide-neck, large basilar apex aneurysm is challenging either endovascular or surgical. We present a novel concept for the treatment of complex basilar apex aneurysms using flow-diverter stents combined with flow-T stenting assisted coiling technique. Assess the efficacy and safety profile of the technique in this specific anatomic condition.

1.2. Case description: A patient with multiple unruptured intracranial aneurysms underwent staged treatment. A large basilar apex aneurysm was treated with a flow-diverter stent combined with a flow-T stenting assisted coiling technique in the first stage, and a giant supraclinoid aneurysm was treated with a flow-diverter stent applied in the second stage. Clinical presentations, technical details, intra- and perioperative complications, clinical and angiographic outcomes were recorded, with mid-term follow-up.

1.3. Results: The patient achieved full neurologic recovery postoperatively. Cerebral angiography performed postoperatively showed revascularization, good laminar flow, and no in-stent or adjacent stenosis.

1.4. Conclusions: Flow-diverter stents combined with flow-T stenting assisted coiling for the treatment of giant basilar apex aneurysm is a feasible technique with efficacy demonstrated at mid-term follow-up. Staged endovascular treatment of multiple intracranial aneurysms may be a safe and viable option.

2. Introduction

The proportion of Basilar Apex Aneurysms (BAA) among posterior circulation aneurysms ranges from 20% to 40% [1]. It usually presents with rupture, signs and symptoms of mass effect or thromboembolism, or is found incidentally. For these complex BAA cases, surgical treatment with bypass surgery and aneurysm clipping was a possible treatment in the past, but it requires surgical experience and has a high complication rate [2].

The advent of flow-diverter devices has allowed the treatment of wide-neck, large aneurysms with promising clinical and angiographic outcomes [3-5]. However, there are still some limitations when it comes to its use in the management of aneurysms in posterior circulation. These problems are mostly related to their anatomic location and include the risk of occlusion of the posterior cerebral artery (PCA) and superior cerebellar arteries, ischemic lesions of the brain stem caused by perforator artery coverage, and delayed rupture of the treated aneurysm [6-8].

The purpose of this case was to report the successful completion of definitive coil embolization of wide-neck, large basilar apex aneurysms using flow-diverter stents combine flow-T stenting technique, and the effectiveness of this technique was confirmed by mid-term follow-up. We describe our experience of the feasibility, safety, and efficacy of the procedure in this specific anatomic condition.

3. Case Description

A 65-year-old woman was admitted to the neurosurgery department of our hospital in September 2021, presenting with headache. No other neurological abnormalities were observed. In 1998, due to rupture of the right posterior communicating aneurysm with subarachnoid hemorrhage, the aneurysm was clipped, no other aneurysms were found, Unfortunately, the imaging data were missing. Computed Tomography Angiography (CTA) and Diagnostic Digital Subtraction Angiography (DSA) showed a giant supraclinoid aneurysm of left internal carotid artery (Dmax 26.4 mm × neck 10.0 mm) and a large basilar apex aneurysm (Dmax 20.9 mm × neck 18.1 mm). The basilar apex aneurysm with quadrifurcation of arteries, both posterior cerebral arteries and superior cerebellar artery, emanates from the neck of the basilar apex aneurysm (Figure 1).

Because the aneurysm was not capable of coiling or neck clippings and given the risks of sacrificing basilar perforators and recurrence, we decided to treat the aneurysm with flow diversion to address these issues by diverting the flow from the aneurysm while allowing the aneurysm to thrombose slowly. The aneurysm located at the basilar apex was the initial focus of treatment. The chosen approach involved utilizing a Pipeline Embolization Device (PED, Medtronic, CA, United States) combination with Flow-T stenting assisted coil embolization. A depiction of the procedure can be seen in Figure 2. Treatment for the supraclinoid aneurysm was initiated via PED assisted coil embolization two weeks following the first therapeutic intervention for the patient. The reason is that simultaneous treatment of anterior and posterior circulation aneurysms can be fatal in the event of related thrombotic or bleeding complications. Moreover, the patient is old, the physical condition is general, and the operation time is too long, which will increase the incidence of complications. After discussion of off-label use of the device, the patient agreed to the staged treatment regimen with flow diversion.

The patient administered with dual anti-platelet therapy, 100mg aspirin and 75mg clopidogrel 7days before the procedure. Treatment on thrombosis elastic figure detection Arachidonic Acid (AA) pathway and diphosphate gland yesterday (ADP) receptor pathway induced by blood plate inhibition rate meet the requirements.

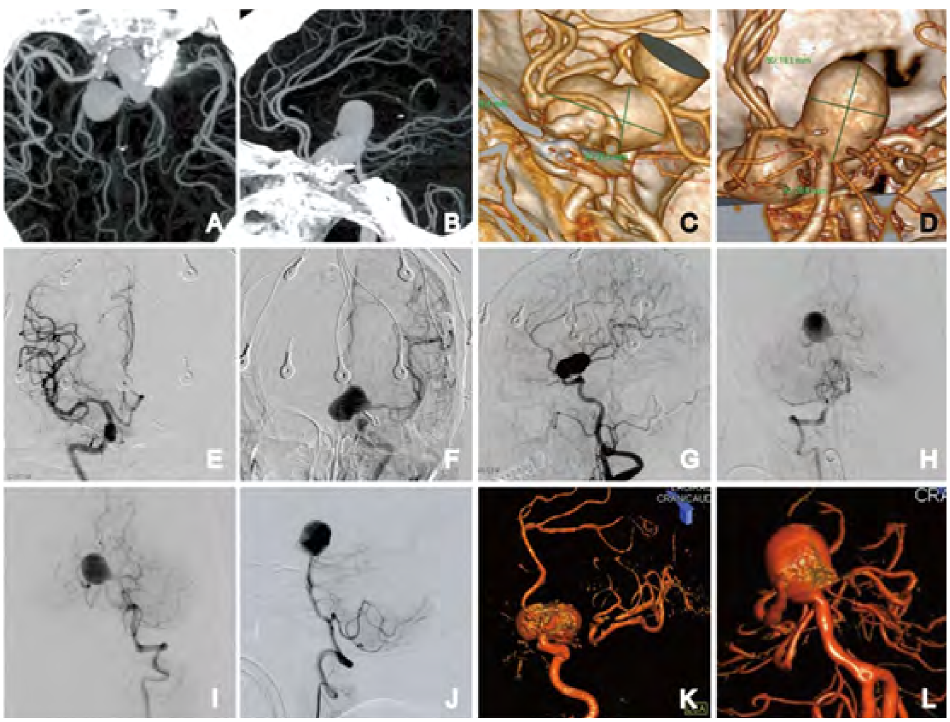

Figure 1: Initial diagnostic workup. A - D: Axial and sagittal CT angiogram images showed the left ICA supraclinoid aneurysm and the basilar apex aneurysm (A and B). 3D reconstruction measurement the aneurysm size was 26.4×21.3 mm in left ICA supraclinoid aneurysm (C) and 20.9×18.1 mm in basilar apex aneurysm (D). E - J: Angiographic images: Anteroposterior right ICA (E). Anteroposterior and lateral views of the left ICA supraclinoid aneurysm (F and G). Anteroposterior bilateral vertebral arteries (H and I) and lateral views of the basilar apex aneurysm (J). I and J: 3D rotational angiography of the supraclinoid aneurysm (K) and the basilar apex aneurysm (L).

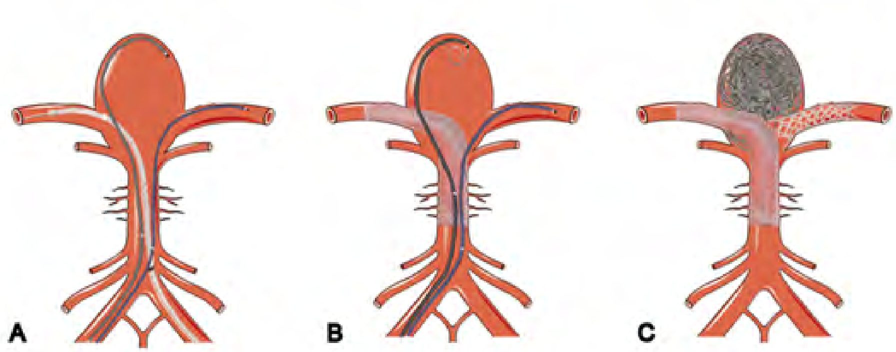

Figure 2: Schematic illustration of Flow-diverter stents combined with flow-T stenting assisted coiling technique. (A) Microcatheter deployed into aneurysm and bilateral posterior cerebral arteries. (B) Pipeline Embolization Device being deployed into PCA and coils deployed through microcatheter in aneurysm. (C) Stent placed in a T-shape after aneurysm is embolized.

4. Intervention

The patient underwent general anesthesia and had bilateral femoral artery punctures using the Seldinger method. A 5-Fr Navien (Medtronic, Irvine, California, USA) was placed in segment V3 of the left vertebral artery via a 6-Fr long sheath (Cook Medical, Indianapolis, IN), while an ENVOY 6F distal access (DA) guiding catheter (Codman Neuro, Raynham, MA) was inserted into segment V4 of the right vertebral artery (Figure 3A). Heparin was given intravenously based on the patient's weight to achieve a therapeutic activated coagulation time of 2-3 times the baseline, with maintenance infusion of tirofiban during surgery. Use 5-second Digital Subtraction Angiography (5s-DSA) to select multiple working angles that show both distal and proximal ends of the aneurysm parent artery, and choose the appropriate working projection accordingly. Select the first working position. we utilized a microcatheter (Synchro-14, Boston Scientific, Natick, MA) assisted by a looping technique with the Echelon-10 microcatheter (Medtronic, Minnesota, USA) to achieve super-selectivity of the right PCA. The Echelon-10 catheter support force facilitated exchange of a Phenom 27 microcatheter (Medtronic) to reach the distal end of the right PCA (Figure 3 C). At the second operating angle, the Prowler Select Plus microcatheter (Cordis Corporation, Bridgewater, NJ) was successfully selected for the distal left posterior cerebral artery, then the Echelon 10 microcatheter was brought up and positioned in the dome of the aneurysm (Figure 3 D, E).

Using a Phenom 27 microcatheter, a 4.0 × 35-mm PED was slowly advanced to the distal portion of the right posterior cerebral artery, anchored in place, and then gently semi-deployed under fluoroscopic guidance to the middle segment of the basilar artery (Figure 3 F).

The coil was carefully embolized within the BBA. The middle and upper part of the aneurysm was densely packed and the lower part near the branch was loosely packed. To avoid the coils entering the branch vessels, a 4.0 × 23-mm Enterprise-2 stent (E2, Cordis Corporation, Bridgewater, NJ) was selected which deployed into the left PCA. The E2 tail end was placed in a T-shape close to the side of the PED, so that the E2 stent and PED were almost in contact without direct metal intersection. Repeated angiography confirmed no direct blood flow were found and the bilateral PCA and SCA were patent. The Echelon 10 microcatheter was then slowly removed, and the PED was thoroughly deployed (Figure 3H).

A control angiogram showed contrast stasis in the aneurysm dome but preserved flow through the perforator. The patient had an uneventful procedure and recovery, remaining neurologically intact (Figure 3 I-L). Dual antiplatelet therapy was continued post-treatment.

The patient underwent treatment for a supraclinoid aneurysm 14 days later, under general anesthesia and systemic heparinization. A triaxial system was used via femoral access, with a Flexor Shuttle sheath (Cook Medical, Bloomington, Indiana, USA) intrasheath 5 Fr Navien catheter advanced to the cavernous segment of the left ICA, and then a Phenom micocatheter was manipulated over a 0.014" 200-cm Synchro-2 microwire through the left anterior circulation and ultimately positioned within an M2 segment of the MCA under high magnification fluoroscopic roadmap control. In addition, an additional microcatheter application for a two-catheter technique, two Echelon-10 microcatheter were sent to the aneurysm cavity under microwave guidance. A 4.25 × 22-mm PED was partially deployed to cover the part of aneurysm neck, and the distal end was located in the M1 segment of the LMCA. Three EV3 AXIUM QC25-50-3D and five 22-50 coils were sequentially packed into the aneurysm, and then the PED was thoroughly deployed. Angiographic images revealed direct blood flow to the upper part of the aneurysm. The direct blood flow disappeared after densely packed. Finally, the microcatheter was slowly removed. Using Synchro-2 microwire and Phenom microcatheter massage the PED with satisfactory stent apposition to the vessel wall. A control angiogram showed contrast stasis within the aneurysm dome with preserved flow through the perforator. The procedure and postoperative course were uneventful, and the patient remained neurologically intact. The patient was told to maintain dual antiplatelet therapy for 6 months after treatment and aspirin for life (Figure 4).

5. Results

At 9-month follow-up, the patient was asymptomatic and remained neurologically intact, Modified Rankin Scale (MRS) 0 score. DSA follow-ups showed complete occlusion of the aneurysm, Raymond - Roy Occlusion ClassificationI. Patient has provided informed consent for publication of the case. The protocol was approved by the Ethics Committee of Daping Hospital, Army Medical University (Figure 5).

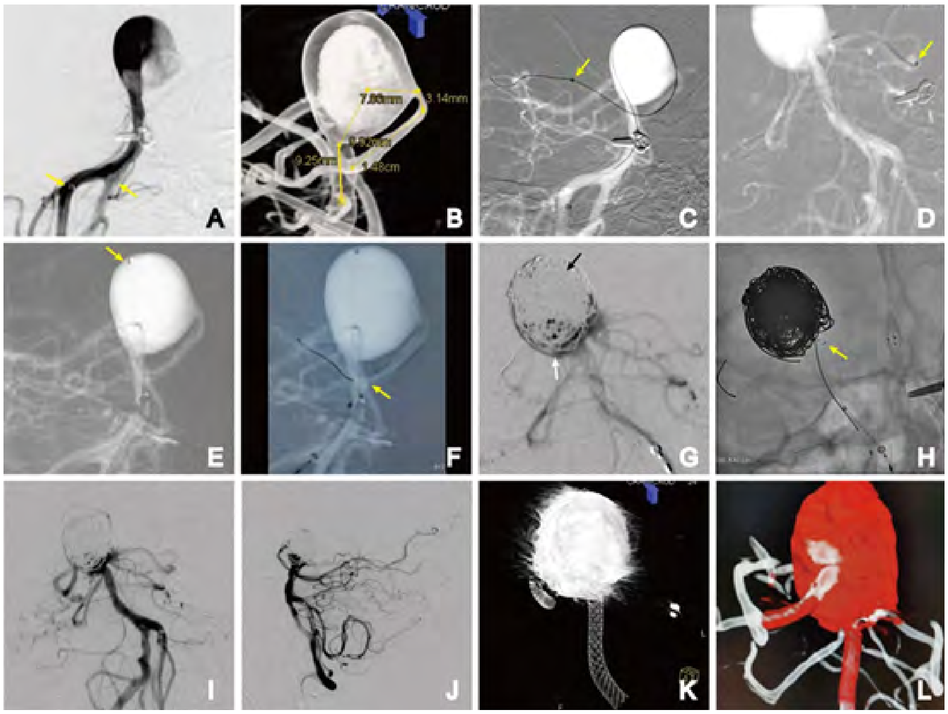

Figure 3: Stage 1. A Bilateral vertebral artery access (yellow arrows); B The parent artery length, proximal and distal diameter and aneurysm neck width were measured; C Microguidewire assisted microcatheter looping technique for super-select right posterior cerebral artery. The distal end of the Phenom catheter (yellow arrow); D The distal end of the stent catheter in the left posterior cerebral artery (yellow arrow); E The position of the coil catheter (yellow arrow); F PED semi-deploying in the middle segment of the basilar artery. The anchor point of the distal end of the PED (yellow arrow); G Dense packing Upper part (black arrow) and slack coiling lower part (white arrow) of the aneurysm ; H Implanted E2 stent, achieving full expansion in front of the aneurysm neck in a T-fashion. AP (I) and Lateral (J) DSA images; K Dyna-CT volume imaging showed the PED was fully deployed; L Dual-volume reconstruction imaging showed that all the vessels were patent.

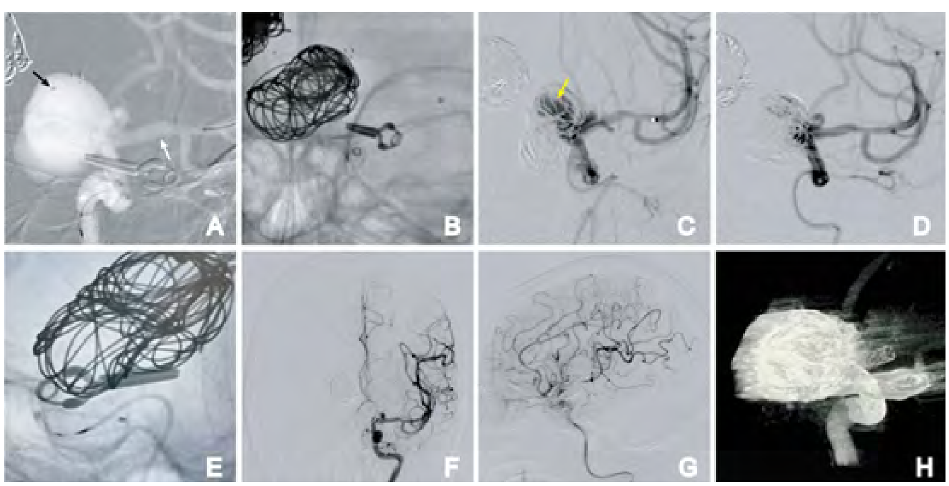

Figure 4: Stage 2. A Semi-deploying PED; The PED anchor point (white arrow); The coil catheter position (black arrow); B large-sized coil embolisation was performed then complete deployment of the PED. C Angiographic images revealed direct blood flow (arrow); D Direct blood flow disappeared after further embolization of the aneurysm; E The PED was fully deployed. F, G Post-operative frontal (F) and lateral (G) DSA Images. H Dyna-CT showed the PED was fully deployed.

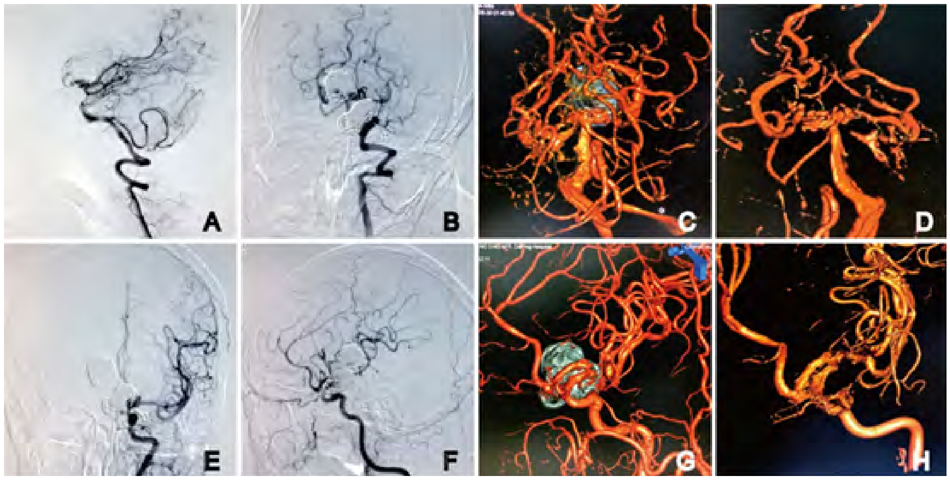

Figure 5: DSA at 9 months after embolization. Angiography showed complete occlusion of the basilar apex aneurysm (A and B) with preservation of four channels on 3D DSA (C and D). The parent artery was unobstructed in the (E) anteroposterior and (F) lateral angiography images of the left ICA. No stenosis or residual aneurysm neck were observed on 3D DSA (G and H). dual-volume (C, G) and single-volume reconstruction imaging (D, H).

6. Discussion

Large and complex wide-necked basilar apex aneurysm and involving many important branches, especially the posterior cerebral artery originating from the distal end of the aneurysm present significant technical challenges that require a different approach to treatment [9, 10]. The stent-assisted coiling treatment for common basilar apex aneurysms involves deploying a single stent into the posterior cerebral artery, with the proximal end positioned in the basilar artery. This effectively confines the aneurysm and safeguards the contralateral posterior cerebral artery. However, this technique only affords partial protection against coil herniation into the parent vessel and is not suitable for treating larger aneurysms [11, 12]. While there are various flow diverters such as Pipeline, Silk, Surpass, and Tubridge, PulseRider as well as WEB stents and other new materials available, they are not viable remedies for giant aneurysms, and employing them off-label presents certain issues [13-17].

In order to maintain the blood flow of the branch artery, the traditional Y or T stent-assisted coil embolization often has to be used to loosely fill the aneurysm cavity, resulting in incomplete embolization of the aneurysm and recurrence [18, 19]. Moreover, the characteristics of the Y-shaped stent make it very difficult to reintervene for recurrent aneurysms. The significance of Y-shaped stent-assisted coil embolization of BAA is not to make the embolization more dense and complete, but to support, protect branch and blood flow reconstruction, and avoid coil protrusion into the branch leading to severe TOBS (Top of Basilar Artery Syndrome) [20].

For the past few years, Off-label use of flow diversion in the basilar apex aneurysm has been attempted in some cases. More delayed aneurysm bleeding complications were reported in the literature, all because the jet sign did not solve [21]. Therefore, we adopted the method of pipeline combined with coil relatively dense packing. Because the contralateral PCA emanates from the aneurysm, a single flow diversion is not sufficient to reconstruct the PCA and SCA, and may lead to the escape of the coil to the PCA or SCA after embolization. In that way, if another PED is deployed to the left PCA, the diameter of the pathway needs to be enlarged, which is bound to affect the blood flow of the posterior circulation and increase the risk of ischemia. At the same time, the pipeline is actually a braid stent, which is difficult to locate and operate. Once it cannot be fully connected, it will lose the role of blood flow reconstruction and increase the risk of perforator occlusion.

To solve the problem of perforator of the other side, placing a different stent on the lateral side of the PED and keeping them almost in contact without direct metal intersection may allow reconstruction of the basilar artery apex. So we designed this way of "Pipeline embolization device combine Flow-T stenting" to reconstruction blood flow, this asymmetric stent deployment would be the alteration of flow favoring the PCA in which the distal end of the stent was deployed. The Enterprise 2 (E2) stent has better compliance and operability, and the supporting micro-guide tube is relatively thin, so that the E2 stent is easier to place and deploy, and the end of the E2 stent can be deployed in parallel or "kissing". The E2 stent is a flexible closed - cell design that allows it to be retrieved and repositioned when up to 70% of the system is deployed [22]. Finally, the PED combined E2 stent assisted coiling for treatment is our decision.

A technical caveat in achieving this configuration involves deploying the more challenging stent first. We measured the distal diameter of the PCA at 2.2 mm and the basilar artery at 3.0 mm. The length from the distal anchor to the proximal landing was measured to be about 40-mm, and 4.0×35-mm was selected through the segmented calculation. At the same time, it was also considered that the choice of a stent with a larger diameter could reduce the metal coverage rate, thereby reducing the risk of perforator occlusion. In this fashion, all major parent vessels were successfully reconstructed and the entire aneurysm neck was protected from coil herniation.

In addition, to reduce the incidence of delayed thromboembolism and long-term stenosis within the stent, patients are maintained on dual antiplatelet therapy for 6 months in addition to life-long aspirin therapy.

We feel that the implications of this technique are significant. To date, there have been many reports of off-label use of flow diverters in posterior circulation aneurysms. More complex basilar apex aneurysms could potentially be safely treated by endovascular means. The Pipeline embolization device combined with Flow-T stenting technology provides a new approach to basilar apex aneurysm

7. Conclusion

Any technology has its limitations, and although this individual case currently has no postoperative complications, longer-term clinical follow-up is still necessary. The technological and clinical outcomes attained so far are very encouraging, and we feel the Pipeline embolization device combine Flow-T stenting technique may significantly contribute to the endovascular treatment of intracranial aneurysms. This article offers treatment options as references for similar diseases. We hope to develop new types of interventional materials or a simpler way for the treatment of complex basal aneurysms.

8. Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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