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Review Article

Endovascular Treatments for Aneurysms Involving a Major Branch

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Remarkable advances have been made in the endovascular treatment of intracranial cerebral aneurysms. These advances include various adjunctive techniques, increased indications for endovascular treatment, and improved treatment results. Furthermore, the number of cerebral aneurysm treatments using flow diverters (FDs) is expected to increase. However, the reported long-term rate of branch artery occlusion after FD treatment has been reported is 15.8%. Moreover, the complete aneurysm obliteration rate is low if normal branches arise from an aneurysm neck or dome. Flow diverter placement for ophthalmic artery, posterior communicating artery, and anterior choroidal artery aneurysms is often difficult because these normal branches often arise from the aneurysm neck or dome. Therefore, in many cases, coil embolization, which can occlude the aneurysm while preserving branch vessels, should be selected. Although not yet established, various adjunctive techniques and other endovascular treatments that can be performed safely have been reported. Treatment must be planned after understanding the advantages and disadvantages of each treatment method.

Keywords endovascular treatments, major branch, aneurysm

Introduction

The development of the interlocking detachable coil (IDC) in 1995 and the Gugulielmi detachable coil in 1997 provided additional endovascular options for the treatment of cerebral aneurysms. Various adjunctive techniques, such as the double-catheter technique,[1)] balloon neck remodeling,[2)] and neck bridge stent,[3)] have also been developed. The indications for endovascular treatment are increasing, and treatment results are improving. Flow diverters (FDs)[4,5)] and intra-aneurysmal devices[6)] have been introduced as important treatments for intracranial cerebral aneurysms. FDs do not require coil placement within the aneurysm. Furthermore, simply placing a stent in the aneurysm neck can block blood flow within the aneurysm while maintaining blood flow in the parent blood and branch vessels. Therefore, FDs are an innovative treatment option for aneurysms. When an FD is placed for a sidewall aneurysm, complete occlusion can be achieved in 91% of cases one year after surgery.[7)] However, the FD is a stent with a very high metal coverage rate, and the risk of thrombosis must be considered. Theoretical concerns exist that flow stagnation may also occur in branch vessels covered by FDs, particularly in small perforators, resulting in branch vessel thrombosis. Furthermore, in cases where branches originate from the neck or dome of the aneurysm, aneurysmal occlusion is difficult to achieve, even with FD placement.[8,9)] Therefore, FD is not an optimal treatment for such cases. In many cases, coil embolization, which occludes the aneurysm while preserving the branch vessels, should be performed.

This study focused on internal carotid artery aneurysms to discuss treatment strategies for aneurysm obliteration while sparing each branch. The internal carotid artery has branches, including the ophthalmic artery (OphA), pituitary artery, posterior communicating artery (PCoA), and anterior choroidal artery (AChA). The results of FD treatment

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for aneurysms with branched arteries are described in the below sections.

FD Treatment for Aneurysms with Branched Arteries

Ophthalmic artery

Rangel-Castilla et al.[10] reported that the OphA was obstructed in 8 of 76 cases (10.5%) and that the number of FDs used could contribute to branch artery occlusion. Four other studies reported OphA occlusion rates ranging from 0% to 21% after FD deployment.[11–14] Radiographic outcomes were available for 54 aneurysms, with complete, near-complete, and incomplete occlusion rates of 81.5%, 5.6%, and 12.9%, respectively.[15] The OphA has collateral anastomoses with the external carotid artery branches that could contribute to proximal OphA occlusion if the FD decreases the flow and the distal anastomosis takes over the end-organ arterial supply. All occlusions were clinically asymptomatic and found only on follow-up angiography.

Kim et al. stratified the risk of visual loss during endovascular coiling of OphA aneurysms using temporary balloon occlusion of the ICA. The authors examined the alterations in visual acuity during balloon occlusion as a marker of insufficient collateral supply to the retina. Furthermore, the authors documented limitations in assessing visual acuity alone during the test and proposed angiographic confirmation of retrograde flow in the OphA as a marker of collateral vascularity.[16] Occlusion of the OphA is rarely a problem during FD placement. Balloon occlusion test and angiography can determine whether the OphA can be occluded.

Anterior choroid artery

In recent decades, several classifications of AChA aneurysms have been proposed. Some are used for clipping[17,18] and used only for endovascular treatment.[19,20] Duan reported that AChAs have a high probability of branching from the neck or the dome, occurring in 46.2% and 28.8% of cases, respectively.[21]

In 1905, von Monakow reported that the AChA supplies blood to the lateral geniculate body. In 1933, Abbie reported hemimotor, hemisensory, and visual field deficits as symptoms of AChA occlusion.[22] The syndrome caused by AChA occlusion is currently known as Monakow or Abbie syndrome.

In patients with Parkinson's disease, deliberate ligation of the AChA is often followed by stupor and hemiplegia or death in 20% of cases.[23] However, because the AChA has collateral circulation, not all cases show symptoms such as Monakow syndrome and Abbie syndrome. However, the symptoms are severe, and the AChA must be preserved.

Four studies reported AChA occlusion rates ranging between 0% and 7% after flow diversion.[5,11,13,14] No patients exhibited any signs or symptoms of neurological deterioration following this treatment.

Raz et al. reported that the AChA remained patent, with the antegrade flow in 28/29 aneurysms (96.5%), whereas 24/29 (82.7%) of the aneurysms were angiographically occluded on 1-year follow-up angiography (mean = 15.1 months).[24] In OphA occlusion, collateral flow determines the potential and clinical significance of vessel occlusion. The lateral posterior choroidal artery, posterior cerebral artery, and PCoA contribute collateral flow to the AChA territory.

Posterior communicating artery

PCoA aneurysms are often treated as ruptured or unruptured. The PCoA usually branches from 2 to 14 (mean: 7) anterior thalamoperforating arteries (mean: 7) from the bifurcation side.[25] PCoA occlusion may cause thalamic infarction. Thalamic infarction may occur in cases with a poorly developed posterior cerebral artery P1, thick PCoA, and large aneurysm.[26] Complete occlusion can be achieved in 63%–83% of PCoA aneurysms after FD placement.[27] A large PCoA incorporated into the neck or dome of the aneurysm may maintain the flow to the aneurysm and prevent occlusion.[28]

Of the 11 cases of PCoA covered by an FD, Brinjikji et al. observed five cases (45%) in which the PCoA was occluded or flow was diminished at a mean follow-up of 12.6 months.[4] None of the patients exhibited clinical symptoms. Vedantam et al.[13] observed one (7.1%) instance of PCoA occlusion among 11 arteries covered by FD. Moreover, Rinaldo et al. reported that among patients with and without fetal-type PCoA (FPCA), the median times to occlusion were 51 and 6 months, respectively.[8] FPCA aneurysms require more time to achieve complete occlusion. These findings may influence the treatment selection for aneurysms in this branch. Conventional endovascular treatments other than FD should also be considered.

Treatment strategy when reliable branch preservation is required

As mentioned above, FD placement causes branch occlusion; however, the occlusion rates of the OphA and AChA are relatively low, and collateral blood circulation is

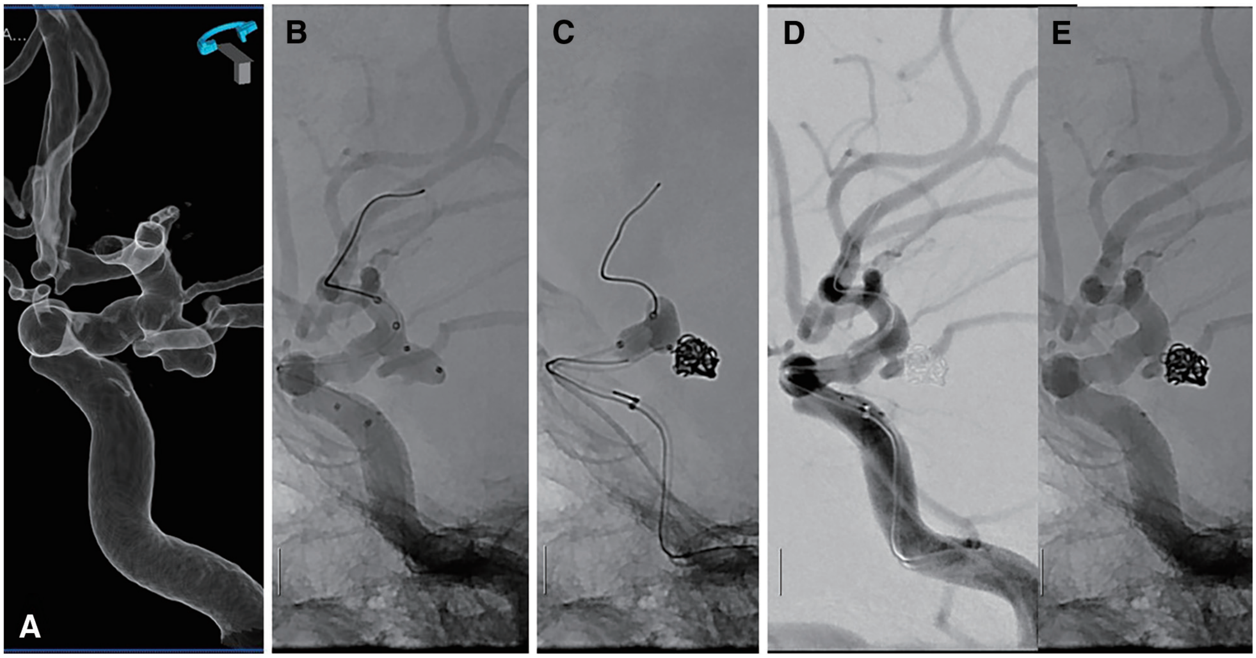

Fig. 1 Embolization performed using a super-compliant balloon to protect the PCoA bifurcation. (**A**) 3D DSA. (**B**) Headway 17 and SL-10 microcatheters are placed inside the aneurysm, and a 7 × 7 Shoryu balloon is placed in the neck. (**C**) The balloon is inflated to protect the PCoA bifurcation. (**D, E**) Angiogram obtained just after the insertion of the last coil. PCoA: posterior communicating artery

present; therefore, neurological symptoms rarely occur. However, complications such as motor paralysis and blindness must not occur. In cases with concerns about complications, efforts should be made to preserve the branch using the most available treatment methods.

As mentioned above, in the PCoA in particular, the rate of branch occlusion due to FD placement is high, and caution is required. The PCoA usually branches from the internal carotid artery just proximal to the aneurysm neck, in which case, it can be safely treated with FD. However, absolute preservation is necessary when the PCoA branches from the neck or dome or when the PCoA is an FPCA, especially in cases where the P1 segment is absent. Usually, these cases can be treated with the double-catheter technique, balloon-assisted coiling, stent-assisted coiling, etc. However, in the case of the PCoA, some cases may require dual-stenting techniques such as half-T, Y, or T stents. Various adjunctive techniques have been reported; thus, the appropriate treatment method should be selected depending on the case. The adjunctive techniques are described below, along with our case.

Double-catheter technique

In some aneurysms with an unfavorable angioarchitecture, it may be safer and easier to navigate an additional microcatheter into the aneurysm sac than to use a balloon or stent. The main advantage of the double-microcatheter technique is its small profile. This allows easier and safer manipulation of vessels compared with balloons and stents. In addition, the small caliber of the microcatheter allows adjuvant therapy flexibility when necessary. The treatment of wide-necked and low-height small aneurysms may be technically challenging. The double-microcatheter technique may be a safe and effective method for the treatment of these aneurysms.[29]

Balloon-assisted coiling

Super-compliant balloons are useful in neck plasty, especially bulging neck plasty, for wide-neck aneurysms.[30] When using a super-compliant balloon, even if the balloon is inserted into the parent artery because it is inflated so that it reaches the space on its own, it is inflated at the entrance of the vessel that the surgeon wants to preserve (**Fig. 1**). Internal carotid–PCoA (IC–PC) aneurysms often branch several millimeters away from the neck. In such cases, treatment with balloon neck remodeling alone is difficult. Additionally, blood vessels with large diameters in the PCoA can be preserved by placing a balloon in the PCoA (**Fig. 2**).

Stent-assisted coiling

The stent-assisted technique has a lower complication rate than the balloon-assisted technique but requires

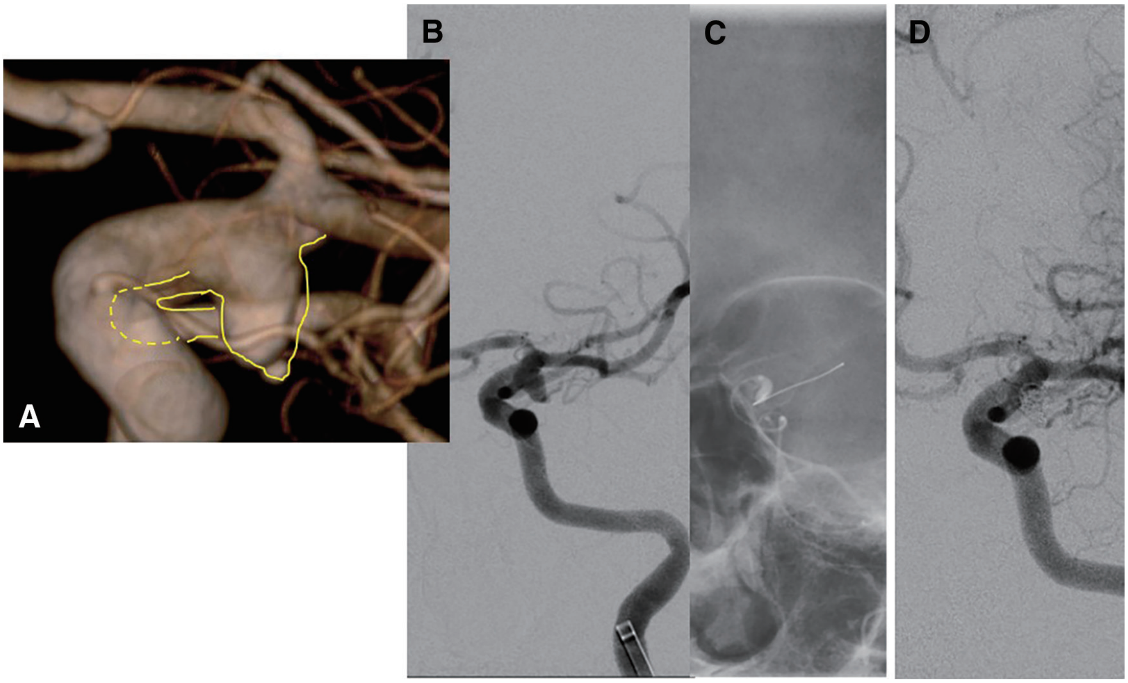

Fig. 2 (**A**) 3D DSA. (**B**) Working-angle DSA. (**C**) A Shoryu balloon measuring 4 × 10 is placed from the internal carotid artery to the PCoA. The balloon is then inflated into the PCoA. (**D**) Angiogram obtained just after the insertion of the last coil. PCoA: posterior communicating artery

long-term antiplatelet drug use. Kwon et al. reported a modified stent-assisted coil embolization technique using the far proximal part of a self-expanding open-cell stent. This technique was used to cover the neck of the aneurysm while preserving the IC–PC branches.[31,32] A stent placed in the parent artery can protrude into the intra-aneurysmal space to protect the branch vessels (**Fig. 3**). However, even with this method, treatment is difficult when the PCoA originates far from the neck. Although more reports on the usefulness and of safety dual-stenting techniques are required,[33–35] those methods may be useful because they can be performed using common neck bridging stents.

Dual-stenting technique

Among dual-stenting techniques, overlapping[36] and non-overlapping Y-configuration (in which the stent partially overlaps) stenting techniques have been reported (**Fig. 4**). One reported non-overlapping Y-configuration stenting technique is the T-stent,[37] which is expected to reduce thrombotic complications by not overlapping stents. However, no differences were observed between the patients receiving Y-stents and those receiving T-stents (Y-stent: morbidity, 4%; mortality, 2%; CO, 91%; T-stent: morbidity, 1.9%; mortality, 1%; CO, 90%).[36,37]

The half-T-stent technique involves covering the neck of an aneurysm with a single stent placed in the branch artery. This method is called the T-stent technique because it partially involves the T-stent technique (**Fig. 5**).[38] Although dual stenting techniques are not considered completely safe or not well established to replace FD placement, they are necessary in some cases. Dual-stenting techniques cannot be performed on small branches such as the AChA; therefore, the branch must be preserved using balloon neck remodeling technique (BNR), double-catheter technique (DC), and herniated stents.

Discussion

Intracranial aneurysms are the leading cause of stroke. Treatment has evolved over the past two decades. The Internal Subarachnoid Trial (ISAT), completed in 2002, showed that transluminal coiling had a better treatment outcome than surgical clipping.[39] American Stroke Association (ASA) and National Institute for Clinical Excellence (NICE) guidelines currently recognize both surgical clipping and endovascular coiling as effective treatments for ruptured and unruptured aneurysms (class I; level of evidence B) and recommend a “coil first” strategy for both. The development of endovascular treatments for intracranial cerebral aneurysms has been remarkable, and FD has

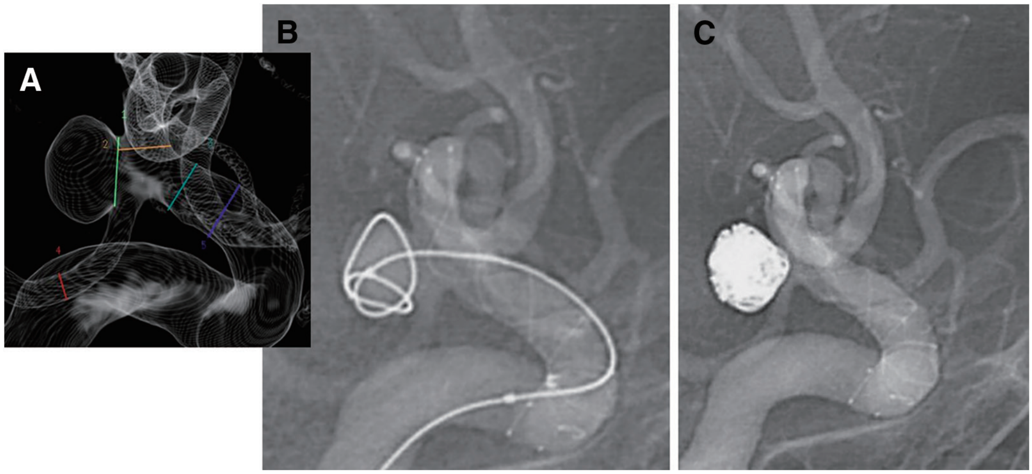

Fig. 3 (**A**) 3D DSA. (**B**) A Headway 17 microcatheter is placed inside the aneurysm, and a 4.5 × 23 LVIS (Microvention Terumo, Tustin, CA, USA) stent is placed in the internal carotid artery in the neck using a Headway 21 microcatheter. (**C**) Angiogram obtained just after the insertion of the last coil.

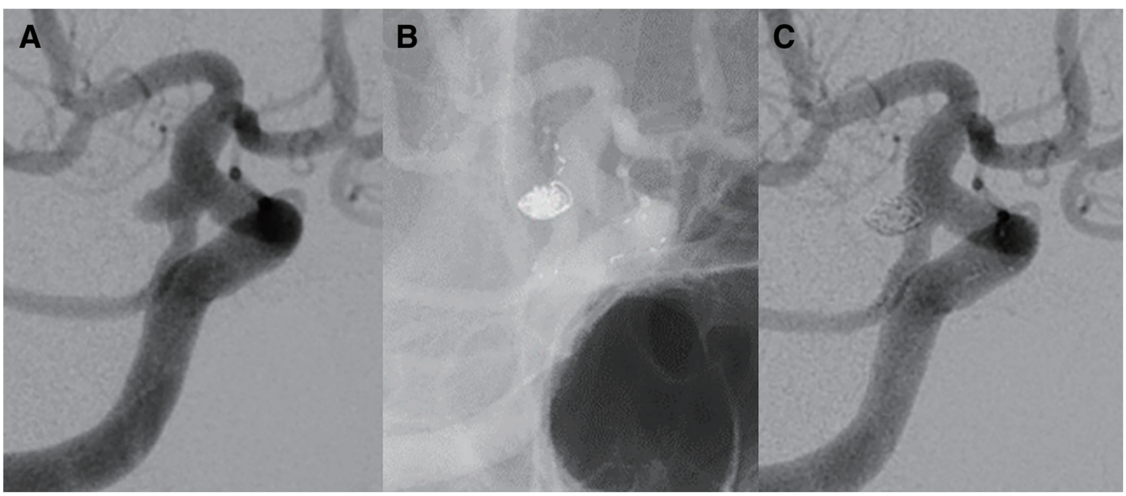

Fig. 4 (**A**) Working-angle DSA. (**B**) A Headway 17 microcatheter is placed inside the aneurysm, and a Neuroform Atlas stent system measuring 4.5 × 21 is placed from the PCoA to the internal carotid artery using an SL-10 microcatheter. The SL-10 is guided to the distal side of the internal carotid artery by passing through the stent strut, and a Neuroform Atlas stent system (4.5 × 30) is placed in the internal carotid artery. (**C**) Angiogram obtained just after the insertion of the last coil. PCoA: posterior communicating artery

become an effective treatment method. FD is a new generation of stents designed to treat intracranial aneurysms by isolating the aneurysmal lumen from circulation.[40] The main concern with FD is the risk of perforator blockage, which makes it undesirable for the treatment of wide-neck intracranial aneurysms.

Rangel-Castilla reported a 15.8% rate of radiographic side-branch arterial occlusion after coverage with FD. These branches included the ACA, OphA, and PCoA. No AChA occlusions were observed. These instances were not associated with new neurological deficits.[10] While some reports suggest that branch obstruction is unlikely to be a problem, caution is required in cases with FPCA. Walace et al. reported that FD was largely ineffective in treating PCoA aneurysms associated with the FPCA and should only be considered when conventional treatment options, including microsurgical clipping, are unfeasible.[9] Cai et al. reported that the incidence of postoperative cerebral ischemia was higher after PCoA aneurysm clipping than after coiling. On the other hand, in cases of fetal PCoA, coiling was associated with significantly more ischemic complications; therefore, clipping was recommended.[41] Not all cases of fetal PCoA are suitable for clipping, which is not possible in cases such as those involving large aneurysms with AChA attached. The treatment method must be selected depending on the case.

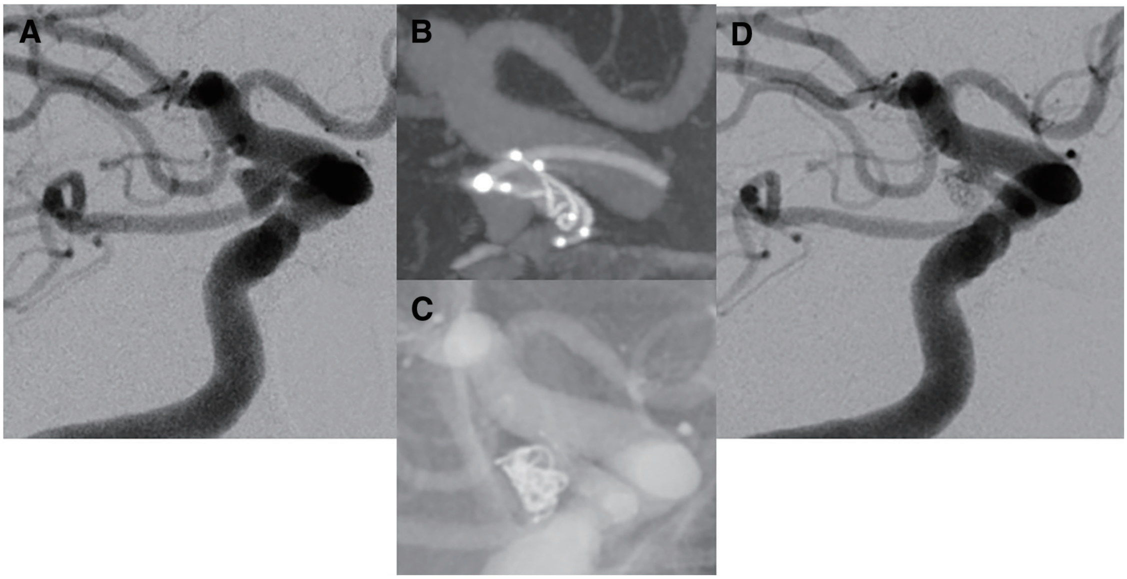

Fig. 5 (**A**) Working-angle DSA. (**B**) Cone beam computed tomography performed after stent placement. (**C**) Angiogram obtained after coil embolization. An LVIS (Microvention Terumo) Jr. stent measuring 2.5 × 13 is placed from the PCoA to the aneurysmal neck using a Headway 17 microcatheter. (**D**) Angiogram obtained just after the insertion of the last coil. DSA: digital subtraction angiography; PCoA: posterior communicating artery

Zada et al. reviewed the treatment of 30 FPCA aneurysms among 273 PCoA aneurysms at a high-volume center over a 15-year period. In the FPCA aneurysm group, 24 patients underwent surgical clipping, and six underwent endovascular coiling. The overall patency of the FPCA was 96% in the surgical group and 100% in the coiling group after treatment.[42] Although not yet established, reports suggest that various adjunctive techniques and other endovascular treatments can be performed safely. As intracranial aneurysmal coiling requires tight packing, the risk of rupture complications is higher than that of FD. Appropriate aneurysm treatment requires an understanding of the characteristics, advantages, and disadvantages of each device.

Limitations

This study does not present cases of large aneurysms, and recanalization may occur in cases of large PCoA aneurysms even when various adjunctive techniques are used. Therefore, further consideration of treatment methods is necessary.

Conclusion

FD is a novel and effective treatment method. However, some situations require the use of conventional endovascular treatment methods.

Disclosure Statement

The authors declare that they have no conflicts of interest.

References

1) Baxter BW, Rosso D, Lownie SP. Double microcatheter technique for detachable coil treatment of large, wide-necked intracranial aneurysms. *AJNR Am J Neuroradiol* 1998; 19: 1176–1178.
2) Moret J, Cognard C, Weill A, et al. The “Remodelling Technique” in the treatment of wide neck intracranial aneurysms. Angiographic results and clinical follow-up in 56 cases. *Interv Neuroradiol* 1997; 3: 21–35.
3) McLaughlin N, McArthur DL, Martin NA. Use of stent-assisted coil embolization for the treatment of wide-necked aneurysms:a systematic review. *Surg Neurol Int* 2013; 4: 43.
4) Brinjikji W, Lanzino G, Cloft HJ, et al. Patency of the posterior communicating artery after flow diversion treatment of internal carotid artery aneurysms. *Clin Neurol Neurosurg* 2014; 120: 84–88.
5) Brinjikji W, Murad MH, Lanzino G, et al. Endovascular treatment of intracranial aneurysms with flow diverters: a meta-analysis. *Stroke* 2013; 44: 442–447.
6) Ding YH, Lewis DA, Kadirvel R, et al. The Woven EndoBridge: a new aneurysm occlusion device. *AJNR Am J Neuroradiol* 2011; 32: 607–611.
7) Briganti F, Leone G, Cirillo L, et al. Postprocedural, midterm, and long-term results of cerebral aneurysms treated

with flow-diverter devices: 7-year experience at a single center. *Neurosurg Focus* 2017; 42: E3.
8) Rinaldo L, Brinjikji W, Cloft H, et al. Effect of fetal posterior circulation on efficacy of flow diversion for treatment of posterior communicating artery aneurysms: a multi-institutional study. *World Neurosurg* 2019; 127: e1232–e1236.
9) Wallace AN, Kayan Y, Austin MJ, et al. Pipeline embolization of posterior communicating artery aneurysms associated with a fetal origin posterior cerebral artery. *Clin Neurol Neurosurg* 2017; 160: 83–87.
10) Rangel-Castilla L, Munich SA, Jaleel N, et al. Patency of anterior circulation branch vessels after Pipeline embolization: longer-term results from 82 aneurysm cases. *J Neurosurg* 2017; 126: 1064–1069.
11) Puffer RC, Kallmes DF, Cloft HJ, et al. Patency of the ophthalmic artery after flow diversion treatment of paraclinoid aneurysms. *J Neurosurg* 2012; 116: 892–896.
12) Szikora I, Berentei Z, Kulcsar Z, et al. Treatment of intracranial aneurysms by functional reconstruction of the parent artery: the Budapest experience with the pipeline embolization device. *AJNR Am J Neuroradiol* 2010; 31: 1139–1147.
13) Vedantam A, Rao VY, Shaltoni HM, et al. Incidence and clinical implications of carotid branch occlusion following treatment of internal carotid artery aneurysms with the pipeline embolization device. *Neurosurgery* 2015; 76: 173–178; discussion, 178.
14) Yu SC, Kwok CK, Cheng PW, et al. Intracranial aneurysms: midterm outcome of pipeline embolization device—a prospective study in 143 patients with 178 aneurysms. *Radiology* 2012; 265: 893–901.
15) Griessenauer CJ, Ogilvy CS, Foreman PM, et al. Pipeline embolization device for small paraophthalmic artery aneurysms with an emphasis on the anatomical relationship of ophthalmic artery origin and aneurysm. *J Neurosurg* 2016; 125: 1352–1359.
16) Kim B, Jeon P, Kim K, et al. Endovascular treatment of unruptured ophthalmic artery aneurysms: clinical usefulness of the balloon occlusion test in predicting vision outcomes after coil embolization. *J Neurointerv Surg* 2016; 8: 696–701.
17) Friedman JA, Pichelmann MA, Piepgras DG, et al. Ischemic complications of surgery for anterior choroidal artery aneurysms. *J Neurosurg* 2001; 94: 565–572.
18) Heros RC. Microneurosurgical management of anterior choroidal artery aneurysms. *World Neurosurg* 2010; 73: 459–460.
19) Kim BM, Park SI, Kim DJ, et al. Endovascular coil embolization of aneurysms with a branch incorporated into the sac. *AJNR Am J Neuroradiol* 2010; 31: 145–151.
20) Kang HS, Kwon BJ, Kwon OK, et al. Endovascular coil embolization of anterior choroidal artery aneurysms. Clinical article., *Article J Neurosurg* 2009; 111: 963–969.
21) Duan Y, Qin X, An Q, et al. A new classification of anterior choroidal artery aneurysms and its clinical application. *Front Aging Neurosci eCollection* 2021; 13: 596829.
22) Abbie AA. The clinical significance of the anterior choroidal artery. *Brain* 1933; 56: 233–246.
23) Drake CG, Vanderlinden RG, Amacher AL. Carotid-choroidal aneurysms. *J Neurosurg* 1968; 29: 32–36.
24) Raz E, Shapiro M, Becske T, et al. Anterior choroidal artery patency and clinical follow-up after coverage with the pipeline embolization device. *AJNR Am J Neuroradiol* 2015; 36: 937–942.
25) Saeki N, Rhoton AL Jr. Microsurgical anatomy of the upper basilar artery and the posterior circle of Willis. *J Neurosurg* 1977; 46: 563–578.
26) Kim MJ, Chung J, Park KY, et al. Recurrence and risk factors of posterior communicating artery aneurysms after endvascular treatment. *Acta Neurochir (Wien)* 2021; 163: 2319–2326.
27) Daou B, Valle-Giler EP, Chalouhi N, et al. Patency of the posterior communicating artery following treatment with the Pipeline Embolization Device. *J Neurosurg* 2017; 126: 564–569.
28) Chiu AHY, Cheung AK, Wenderoth JD, et al. Long-term follow-up results following elective treatment of unruptured intracranial aneurysms with the pipeline embolization device. *AJNR Am J Neuroradiol* 2015; 36: 1728–1734.
29) Kim DJ, Kim BM, Park KY, et al. Coil embolization of overwide and undertall small intracranial aneurysms with double microcatheter technique. *Acta Neurochir (Wien)* 2014; 156: 839–846.
30) Sakata H, Ezura M, Kimura N, et al. Preservation of branching vessel using super compliant double-lumen balloon microcatheter: bulging neck plasty technique and other options. *J Neuroendovasc Ther* 2021; 15: 310–315.
31) Kwon H-J, You SH, Lim JW, et al. Simultaneous neck coverage and branch preservation using the proximal portion of a self-expandable open-cell stent for embolization of distal internal carotid artery aneurysms: multi-center, long-term results. *Neuroradiology* 2020; 62: 883–890.
32) Kuramoto Y, Mikami K, Bando T, et al. Intentional herniation technique with the neuroform EZ stent system for preservation of aneurysmal neck branch: a case report. *Turk Neurosurg* 2019; 29: 950–953.
33) Kuwajima T, Kazekawa K, Maruyama K, et al. Usefulness and problems of Y-Stent and T-Stent assisted coiling for unruptured cerebral aneurysms. *J Stroke Cerebrovasc Dis* 2022; 31: 106668.
34) Cagnazzo F, Limbucci N, Nappini S, et al. Y-stent-assisted coiling of wide-neck bifurcation intracranial aneurysms: a meta-analysis. *AJNR Am J Neuroradiol* 2019; 40: 122–128.
35) Aydin K, Balci S, Sencer S, et al. Y-stent-assisted coiling with low-profile neuroform atlas stents for endovascular treatment of wide-necked complex intracranial bifurcation aneurysms. *Neurosurgery* 2020; 87: 744–753.

36) Chow MM, Woo HH, Masaryk TJ, et al. A novel endvascular treatment of a wide-necked basilar apex aneurysm by using a Y-configuration, double-stent technique. *AJNR Am J Neuroradiol* 2004; 25: 509–512.

37) Cho YD, Park SW, Lee JY, et al. Nonoverlapping Y-configuration stenting technique with dual closed-cell stents in wide-neck basilar tip aneurysms. *Neurosurgery* 2012; 70(2 Suppl Operative): 244–249.

38) Granja MF, Cortez GM, Aguilar-Salinas P, et al. Stent-assisted coiling of cerebral aneurysms using the Y-stenting technique: a systematic review and metaanalysis. *J Neurointerv Surg* 2019; 11: 683–689.

39) Aydin K, Stracke CP, Barburoglu M, et al. Long-term outcomes of wide-necked intracranial bifurcation aneurysms treated with T-stent-assisted coiling. *J Neurosurg* 2019; 134: 39–48.

40) Nakajo T, Terada T, Okada H, et al. T-stent or half T-stent-assisted embolization of wide-necked aneurysms at the internal carotid-posterior communicating artery bifurcation. *J Neuroendovasc Ther* 2021; 15: 681–687.

41) Cai Y, Zhang T, Zhao J, et al. Cerebral ischemia after treatment of posterior communicating artery aneurysms: clipping versus coiling. *BMC Neurol* 2022; 22: 436.

42) Zada G, Breault J, Liu CY, et al. Internal carotid artery aneurysms occurring at the origin of fetal variant posterior cerebral arteries: surgical and endovascular experience. *Neurosurgery* 2008; 63(suppl 1): ONS55–61; discussion ONS61:ONS55-ONS61; discussion ONS61-ONS52.