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TECHNICAL NOTE

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Surpass Evolve flow diverter in the treatment for complex wide neck ruptured internal carotid artery aneurysm: technical report of two cases with brief literature review

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Abstract

Background Treatment of complex wide neck internal carotid aneurysm is technically difficult with both surgical as well as endovascular therapy. In this study, we work with flow diverter device to construct vascular lumen which diverts the blood flow from aneurysm sac.

Case presentation We report on two patients with two complex wide neck ruptured aneurysms located in the internal carotid artery associated with two small aneurysms who presented with severe headache and vomiting. All aneurysms were treated with single Surpass Evolve flow diverter (SE-FD) placement. Post-procedural clinical and angiographic outcomes were evaluated

Conclusion This study shows that Surpass Evolve flow diverter is safe and validity for management of complex wide neck internal carotid artery aneurysm and able to terminate all blister aneurysms associated with the parent artery.

Keywords Complex wide neck internal carotid artery aneurysm, Flow diverter, Surpass Evolve, Treatment

Background

Surgical treatment of intracranial aneurysm was gold standard before the establishment of endovascular therapy (EVT) with development of detachable coils by Guglielmi in the early 1990 [1]. EVT has been evolved as new era for treatment of intracranial aneurysm and widely adopted with better outcomes and safety as well efficacy [2]. However, embolization of aneurysmal sac by packing of coils has been disappointed due to higher rate of recurrence (20%) and retreatment (10%) of aneurysm has been described [3]. This disappointment has been raised in EVT mainly due to treatment of large and giant; wide neck associated with blister shaped aneurysms [4]. Large aneurysm (diameter ≥ 10 mm); wide neck aneurysm(neck diameter ≥ 4 mm or dome to neck ratio (less than 2 mm) along with small blister aneurysm on parent vessels nearby large aneurysm can be defined as complex wide neck intracranial aneurysm. Treatment of complex wide necked intracranial aneurysm is technically difficult despite the arrival of intracranial stent and balloon because aneurysms recurrence rate stay serious concern [5].

With the advancement in endovascular technology, a new device called flow diverter was introduced in 2007 to overcome these concern associated with treatment of complex wide necked intracranial aneurysm [6]. Among numerous flow diverters including Pipeline Embolization Device(PED,eV3), Silk (Balt), p64 (Phenox), FRED (Microvention) and Surpass Streamline (SS,Stryker), the surpass Evolve flow diverter (Stryker, Neurovascular) is

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new, self-expandable tubular mesh device approved by Food Drug Administration in 2018, made of cobalt chromium and platinum tungsten brained designed which reconstruct the parent artery and occlude the aneurysm sac [7]. The lower rates of aneurysms recurrence and complications have been described with the application of FD for treatment these complex aneurysm [7, 8]. These all FDs work by diverting blood flow way from aneurysm sac and helping in the thrombus formation in aneurysmal sac which afterward forces to aneurysm occlusion [9].

Technical report and illustrative case

All procedures were performed under general anesthesia using monoplane DSA machine (Siemens, Germany). Both two dimensional and three dimensional images were used to measure the parent artery and aneurysm sizes. 300 mg aspirin and 300 mg clopidogrel were prescribed to the both patients before femoral puncture. Activated clotting time was measured for evaluation of anticoagulation. ACT value (> 250 s) was aimed to double the baseline ACT value after heparin injection. Systemic heparinization was continued for 24 h with ACT control in patients who developed stent thrombosis, distal embolization, or parent artery stenosis during intervention. For all procedures, a 6 F long sheath (guiding sheath,6 × 90 cm; Cook medical) was navigated in common carotid artery with support of 5F, 0.038 inch diagnostic catheter (Vert; Cook medical) and 0.035 inch gliding wire (Terumo; Cook) via femoral approach. Then 5000 IU heparin was administered through femoral sheath. Distal access catheter 0.058Inch (AXS Catalyst 5; Stryker, Freemont, CA, USA) was navigated to the petrous segment of internal carotid artery through guiding sheath with the support of gliding wire. 1000 ml normal saline with 1000 IU heparin was administered through guiding sheath; and 1000 ml normal saline with 10 ml Nimodipine was administered through distal access catheter continuously throughout the procedure. 0.027 inch micro-catheter (Excelsior XT-27; Stryker Neurovascular, USA) was advanced to the target parent artery across aneurysm with help of 0.014 inch microwire (Synchro select; Stryker Neurovascular, USA). Then microwire was removed and Surpass Evolve Flow Diverter was advanced through micro-catheter and deployed in the parent artery across neck of aneurysm. Both cases were discharged well on aspirin 75 mg and clopidogrel 75 mg daily for at least 3 months. Patients were counseled to follow up at 1, 3, 6 and 12 month following discharge from hospital. Angiographic evaluation was decided to obtain at 12 month after procedure until unless patients had any neurological compromise. Clinical and angiographic outcome after procedure and at follow up period were evaluated. Both patients visited to hospital with their first and second follow up at 1 and 3 month, respectively.

Case 1

A 60 year-female patient brought in emergency department with chief complaints of sudden onset of loss of consciousness 24 h prior to admission followed by multiple episodes of vomiting with severe headache and drooping of right eyelid with right pupil was dilated. Patient was conscious, and oriented with all limbs power normal. Computer tomography (CT) scan was done which showed subarachnoid hemorrhage (SAH) seen with hyper-densities with cerebral sulcul spaces and bilateral sylvian fissures (right > left).Digital subtraction angiography (DSA) was done that revealed complex wide necked right posterior communicating artery (PcomA) aneurysm (size: neck 8.22 mm × dome 8.55 mm × height 10.09 mm) with daughter sac directed postero-medially and 5 mm ophthalmic artery aneurysm directed superiorly (Fig. 1A). Both aneurysms need to be treated due to high risk of rupture. A Surpass Evolve Flow Diverter 4.5 × 40 mm was deployed with push pull technique (Fig. 1C). A good opposition of device with both aneurysm's wall and stagnation of blood flow in PcomA and ophthalmic artery aneurysm was achieved. Patient

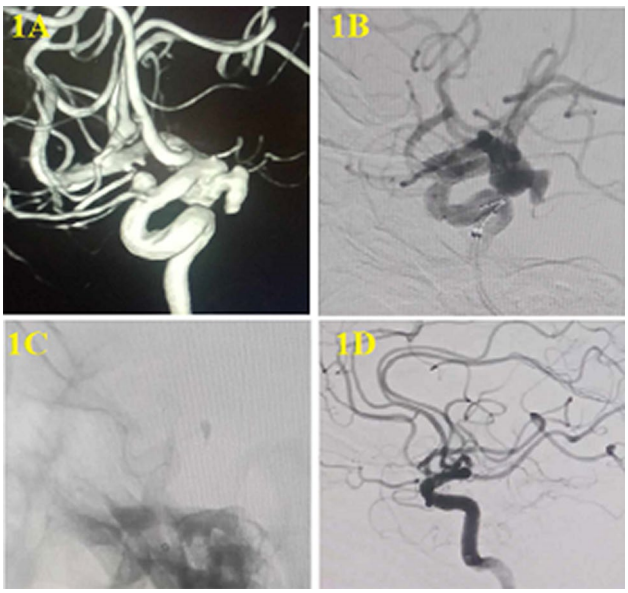

Fig. 1 Case 1 with right wide neck posterior communicating artery (PcomA) aneurysm with daughter sac directed postero-medially and 5 mm ophthalmic artery aneurysm. Three dimensional CT angiography shows right PcomA aneurysm (with size: neck 8.22 mm x dome 8.55 mm x height 10.09 mm) (**1A**), Right ICA angiography shows distal access catheter and micro-catheter with micro wire before FD deployment (**1B**), Right ICA angiography shows deployment of SE-FD (**1C**) and Right ICA angiography shows obliteration of blood flow in to aneurysmal sac (**1D**)

tolerated procedure and shifted to ICU. Except right eye ptosis, patient improved in her symptoms and was discharged well from hospital at 7th day of surgery on aspirin 75 mg and clopidogrel 75 mg daily. During 1st and 2nd follow up, patient had good condition with improved in drooping of right eyelid.

Case 2

A 57 year-old female patient came in emergency department with chief complaints of severe headache and neck pain since 4 days. A head CT scan was done that showed subarachnoid hemorrhage in perimesencephalic cisterns. Digital subtraction angiography was done for further evaluation of hemorrhage. DSA revealed complex wide necked right para-ophthalmic artery aneurysm (size: neck, 6.82 mm × dome, 9.21 mm × height, 10 mm) directed postero-medially with small blister aneurysm in parent artery distal to large aneurysm (Fig. 2A). A Surpass Evolve Flow Diverter 4.5 × 40 mm was deployed with push pull technique (Fig. 2C). A good opposition of device with both large and blister aneurysm's wall and stagnation of blood flow in para-ophthalmic artery aneurysm was noted. Patient tolerated procedure and shifted to ICU. But, patient's GCS dropped suddenly with mild weakness in left upper and lower limb after 2 h of procedure. Then repeat DSA was done. Thrombosis in FD was noted with blood flow in distal artery was not so compromised (Fig. 2E). Systemic heparinization was continued for 24 h until ACT control and LMWH (Clexane) was used until 5 days. Patient was discharged from hospital at 11th day of surgery on aspirin 75 mg and clopidogrel 75 mg daily. During 1st and 2nd follow up, patient had good condition with improved in weakness in limbs.

Discussion

Endovascular therapy has been settled as first line preferred for both ruptured and unruptured intracranial aneurysm [10, 11]. Treatment of complex aneurysm such as large and giant (diameter > 10 mm); wide necked (≥ 4 mm); unfavorable dome to neck ratios (< 2 mm), fusiform and blister- shaped aneurysms by new endovascular techniques including balloon- and stent assisted are still troublesome; and these are associated with 20% poor outcome including recurrence as well as morbidity

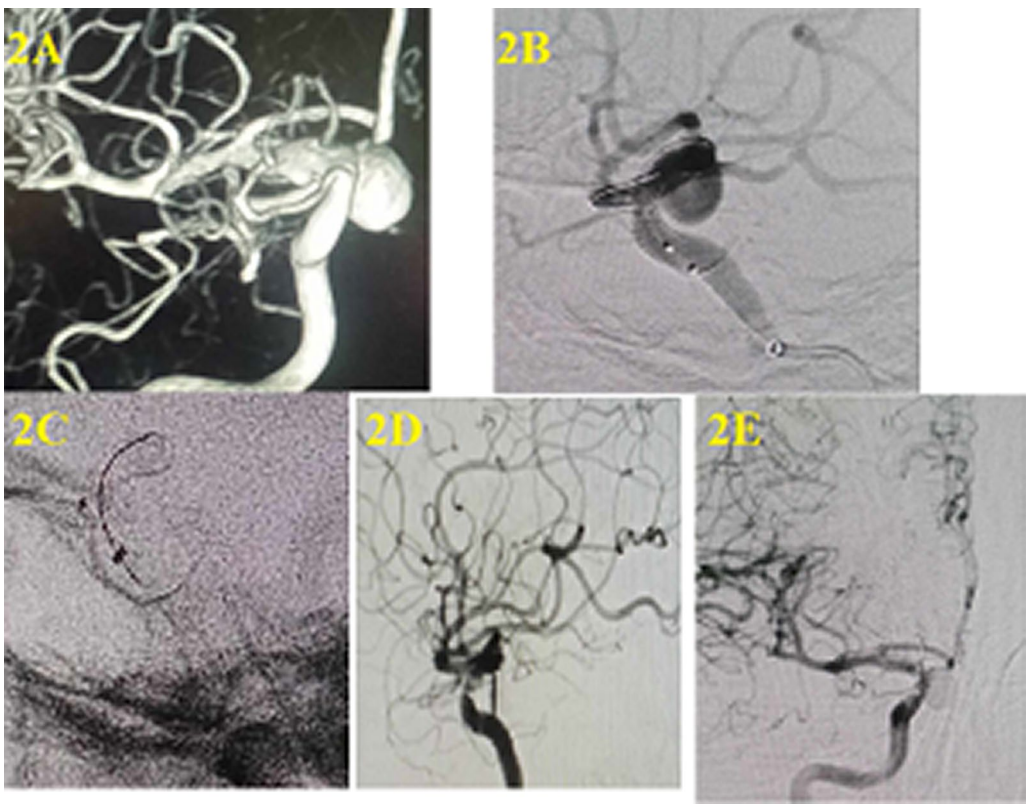

Fig. 2 Case 2 with right wide neck para-ophthalmic artery aneurysm directed posteromedially and blister aneurysm distal to large aneurysm. Three dimensional CT angiography shows right para-ophthalmic (with size: neck, 6.82 mm x dome, 9.21 mm x height, 10 mm) (**2A**), Right ICA angiography shows distal access catheter, micro-catheter with micro wire and advancing SE-FD with blood stasis between FD and parent vessel (**2B**), Right ICA angiography shows deployment of SE-FD (**2C**), Right ICA angiography shows stasis of blood flow in to aneurysmal sac(**2D**) and Right ICA angiography shows thrombus formation is FD with distal blood flow is not limited (**2E**)

and mortality of these aneurysm following procedure [12, 13]. A hypothesis produced by Wakhloo and colleagues, remodeling of blood flow and parent artery with endoluminal device that can be used for aneurysm occlusion [14]. Initially it was called as flow-disrupting device and later was named as flow diverter with employment in endovascular therapy [15] Most commonly used flow diverters are Pipeline Embolization Device (PED, Ev3); Silk (Balt); Flow Redirection Endoluminal Device (FRED, Microvention); Surpass streamline (SS, Stryker); p64 (Phenox) and Surpass Evolve (SE, Stryker) [16–18].

FDs showed a possible choice for treatment of complex and challenging morphologies including large/giant, wide necked, fusiform and blister shaped intracranial aneurysms with good outcome [19]. Flow diverter's function is mainly based on (1) FDs divert blood flow from aneurysm sac from parent artery with feature of their high mesh density and lower porosity, and (2) FDs provides a frame which cut off aneurysm from parent artery and gives as scaffolds for neo-endothelialization which reinforces occlusion of aneurysm over the time [20]. All flow diverter contrast in terms of their intrinsic design, mechanical properties, delivery systems, and composition nevertheless these follow the common mechanism of action. Increased in number of wires (metal coverage) drives to lower porosity of FDs which provides in improving the quality of FDs leading to better and faster occlusion of aneurysm sac [7, 21, 22]. Surpass Evolve (Stryker) is a second generation of surpass FD, has 64 small number of wires with lower porosity and higher braid angle in its design which is able to contribute more flexibility to the device for a better apposition with wall of parent vessel [23] We treated both cases with single placement of SE-FD without coiling technique where as some study described use of flow diverter assisted coiling [24].

However FDs including SE-FD provided remarkably favorable technical outcome and procedural safety, the treatment with FDs were disappointed because of higher rate of procedural accompanying thromboembolic complications has been reported in the early period of flow diverter era. The rate of thrombus formation in FDs between 2% and 7% has been described by some studies [18, 25–27] which are similar to our study where one case also developed thrombus in FD stent. We believe that the following explanations are need to follow to avoid thrombus formation in FD stent placement: (1) Dual antiplatelet therapy (Aspirin and clopidogrel) should be prescribed at least 5-7 days prior to procedure; (2) Systemic heparinization should be continued from procedural time to 12–24 h after procedure under ACT control, and then LMWH till 5 days; (3) FDs should be placed proper uniformity to wall of parent vessels. Intraluminal stent provokes to formation thrombus leading to thromboembolic stroke; therefore, antiplatelet therapy should be authorized [28]. Similarly, improper apposition of FD to vessel wall my cause delayed thrombus formation and stent occlusion even though there is not blood flow restraining [29]. We found that improper apposition with wall of parent vessel distal to aneurysm because of irregular nature of lumen diameter. Blood stasis was noted between wall and SE-FD for the moment until we repositioned with proper apposition (Fig. 2B). We believed that this technical error as a result of vessel morphology (i.e., irregular lumen diameter of vessel) could be reason for delayed thrombus formation after procedure. Furthermore, we could not prescribe antiplatelet therapy before procedures on account of both cases were ruptured aneurysms. We prescribed 300 mg aspirin and 300 mg clopidogrel ten minutes before procedure. Systemic heparinization was discontinued at the end of procedure. But, for thrombus encountered case, systemic heparin was continued till 24 h under ACT control and then LMWH for 5 days similar to other study [30].

In addition, some studies have reported that minor neurological complications were 6.2% [31] and 20% [25] following SE-FD placement. One of our elective patients experienced neurological complication of left sided U/L limb weakness where improvement was noticed progressively at the 2nd follow up period. Proper physiotherapy was given and counseled to continue at home after discharge from hospital. FDs are an effective endovascular device for different morphology of aneurysm. FDs still do not lead to immediate occlusion of aneurysmal sac. The complete occlusion of the most of aneurismal sac (75–85%) have been noticed after 6 month and 1 year after procedure [31, 32]. A study evaluating the safety and effectiveness of FDs (PEP, SILK, FRED); p64; and SS-FD reported complete occlusion of 49% at 3 months, 29% at 6 months, 12% at 12 months, and 1% at 18 months [33]. Rautio et al. [18] described that complete occlusion of aneurysm at 6 month follow up was achieved in 78% cases. We did not have long follow up angiographic result. A study done by Rania et al. [31] described that there was better result with the safety and efficacy by the use of SE-FD. The reported death following SE-FD was 2.8% (4/145) with only one related to the SE-FD procedure [18] whereas no mortality was reported in our study. But, our study has limitations including the patient population is small because it is case report; long term angiographic results are unknown. Therefore large number of case series from various institutions are needed to make comparison with other FDs; and also long term clinical as well as angiographic results are need to evaluate for validity of this device.

Conclusion

Surpass Evolve Flow diverter is safety and effective new device for treatment of complex intracranial aneurysm associated with small/blister aneurysm and abnormal morphology of parent vessels. Proper antiplatelet and antithrombotic therapy should be carried for long term better outcome as per needed. However, large numbers of cases with long term angiographic reports are need to be studied for evaluation of efficacy and safety of complex intracranial aneurysms treatment with SE-FD.

Abbreviations

SEFD	Surpass evolve flow diverter
EVT	Endovascular therapy
PED	Pipeline embolization device
FRED	Flow redirection endoluminal device
SS	Surpass streamline
CT	Computed tomography
SAH	Subarachnoid hemorrhage
DSA	Digital subtraction angiography
PcomA	Posterior communicating artery
GCS	Glasgow coma scale
ACT	Activated clotting time
LMWH	Low molecular weight heparin

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Author contributions
MK conceived and designed study, Data collection and manuscript writing and drafting of manuscript. GR was responsible for editing and providing technical feedback with design and analyses.

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Availability of data and materials
None.

Declarations

Ethical approval and consent to participate
This study was approved by the Ethics Committee of the Max Super Speciality Hospital, and patient's consent for publication was not applicable because of retrospective nature of the study.

Consent for publication
No applicable due to retrospective nature of our study.

Competing interests
None.

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References

1. Guglielmi G, Viñuela F, Dion J, et al. Electrothrombosis of saccular aneurysms via endovascular approach. Part 2: preliminary clinical experience. J Neurosurg. 1991;75:8–14.
2. Spetzler RF, McDougall CG, Zabramski JM, et al. The barrow ruptured aneurysm trial: 6-year results. J Neurosurg. 2015;123:609–17.
3. Ferns SP, Sprengers ME, van Rooij WJ, et al. Late reopening of adequately coiled intracranial aneurysms: frequency and risk factors in 400 patients with 440 aneurysms. Stroke. 2011;42:1331–7.
4. Piotin M, Spelle L, Mounayer C, et al. Intracranial aneurysms: treatment with bare platinum coils–aneurysm packing, complex coils, and angiographic recurrence. Radiology. 2007;243:500–8.
5. Shapiro M, Becske T, Sahlein D, et al. Stent-supported aneurysm coiling: a literature survey of treatment and follow-up. AJNR Am J Neuroradiol. 2012;33:159–63.
6. Brinjikji W, Murad MH, Lanzino G, et al. Endovascular treatment of intracranial aneurysms with flow diverters: a meta-analysis. Stroke. 2013;44:442–7.
7. Kühn AL, Gounis MJ, Puri AS. Introduction: history and development of flow diverter technology and evolution. Neurosurgery. 2020;86:S3-10.
8. Lv X, Yang H, Liu P, et al. Flow-diverter devices in the treatment of intracranial aneurysms: a meta-analysis and systematic review. Neuroradiol J. 2016;29:66–71.
9. Alderazi YJ, Shastri D, Kass-Hout T, et al. Flow diverters for intracranial aneurysms. Stroke Res Treat. 2014;2014: 415653.
10. Molyneux AJ, Kerr RS, Yu LM, et al. International subarachnoid aneurysm trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised comparison of effects on survival, dependency, seizures, rebleeding, subgroups, and aneurysm occlusion. Lancet. 2005;366(9488):809–17.
11. Pierot L, Spelle L, Vitry F, et al. Immediate clinical outcome of patients harboring unruptured intracranial aneurysms treated by endovascular approach: results of the ATENA study. Stroke. 2008;39(9):2497–504.
12. Hauck EF, Welch BG, White JA, et al. Stent/coil treatment of very large and giant unruptured ophthalmic and cavernous aneurysms. Surg Neurol. 2009;71:19–24.
13. Shapiro M, Babb J, Becske T, et al. Safety and efficacy of adjunctive balloon remodeling during endovascular treatment of intracranial aneurysms: a literature review. Am J Neuroradiol. 2008;29(9):1777–81.
14. Wakhloo AK, Schellhammer F, de Vries J, et al. Selfexpanding and balloon-expandable stents in the treatment of carotid aneurysms: an experimental study in a canine model. AJNR Am J Neuroradiol. 1994;15:493–502.
15. Kallmes DF, Ding YH, Dai D, et al. A new endoluminal, flow-disrupting device for treatment of saccular aneurysms. Stroke. 2007;38:2346–52.
16. Saurez JV, Flores JEB, Calienes AR, et al. Flow diverter performance for the treatment of intracranial aneurysms: an international multicenter comparative study. Stroke Vasc Interv Neurol. 2023;3: e000696.
17. Briganti F, Leone G, Ugga L, et al. Mid-term and long-term follow-up of intracranial aneurysms treated by the p64 flow modulation device: a multicenter experience. J Neurointerv Surg. 2017;9:70–6.
18. Rautio R, Alpay K, Sinisalo M, et al. Treatment of intracranial aneurysms using the new Surpass Evolve flow diverter: Safety outcomes and six-month imaging follow-up. J Neuroradiol. 2022;49:80–6.
19. Martin AR, Cruz JP, Matouk CC, et al. The pipeline flow diverting stent for exclusion of ruptured intracranial aneurysms with difficult morphologies. Neurosurgery. 2012;70(1 Suppl Operative):21–8.
20. 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;64:632–43.
21. Cancelliere NM, Nicholson P, Radovanovic I, et al. Comparison of intraaneurysmal flow modification using optical flow imaging to evaluate the performance of Evolve and Pipeline flow diverting stents. J Neurointerv Surg. 2020;12:814–7.
22. Jou L-D, Chintalapani G, Mawad ME. Metal coverage ratio of pipeline embolization device for treatment of unruptured aneurysms: reality check. Interv Neuroradiol. 2016;22:42–8.
23. Dandapat S, Ruiz AN, Galdámez MM. Review of current intracranial aneurysm flow diversion technology and clinical use. J NeuroIntervent Surg. 2020;13:1–10.
24. Ghorbani M, Hejazian E, Bahrami E, et al. Flow diverter-coil technique for endovascular treatment of complex wide neck brain aneurysms, technical point. Caspian J Intern Med. 2021;12(3):350–5.
25. Orru E, Rice H, Villiers De, et al. First clinical experience with the new Surpass Evolve flow diverter: technical and clinical considerations. J Neurointerv Surg. 2020;12:974–80.

26. Jee TK, Yeon JY, Kim KH, et al. Early clinical experience of using the Surpass Evolve flow diverter in the treatment of intracranial aneurysms. Neuroradiology. 2022;64:343–51.
27. Maus V, Weber W, Berlis A, et al. Initial experience with surpass evolve flow diverter in the treatment of intracranial aneurysms. Clin Neuroradiol. 2021;31:681–9.
28. Tähtinen OI, Manninen HI, Vanninen RL, et al. The silk flow-diverting stent in the endovascular treatment of complex intracranial aneurysms: technical aspects and midterm results in 24 consecutive patients. Neurosurgery. 2012;70(3):617–23.
29. Akgul E, Onan HB, Akpinar S, et al. The DERIVO embolization device in the treatment of intracranial aneurysms: short-and midterm results. World Neurosurg. 2016;95:229–40.
30. Briganti F, Napoli M, Tortora F, et al. Italian multicenter experience with flow-diverter devices for intracranial unruptured aneurysm treatment with periprocedural complications–a retrospective data analysis. Neuroradiology. 2012;54(10):1145–52.
31. Issa R, Al-Homedi Z, Syed DH, et al. Surpass Evolve flow diverter for the treatment of intracranial aneurysm: *a systematic review*. Brain Sci. 2022;12:810.
32. Ocal O, Arat A. The exchange-free technique: a novel technique for enhancing surpass flow diverter placement. Asian J Neurosurg. 2020;15:620–6.
33. 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.

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