Endovascular Treatment of Distal Cerebral Artery Aneurysms with FRED Jr. Flow-Diverter Stent: A Single-Center Experience

Bige SAYIN[1], Yigit Can SENOL[2], Musa Onur OZBAKIR[2], Gurdal ORHAN[3], Ilkay AKMANGIT[1], Ergun DAGLIOGLU[2]

[1]*Ankara Bilkent City Hospital, Department of Radiology, Ankara*
[2]*Ankara Bilkent City Hospital , Department of Neurosurgery, Ankara*
[3]*Ankara Bilkent City Hospital, Department of Neurology, Ankara*

Introduction

In the past, microsurgical clipping was preferred in the treatment of distal aneurysms because of relatively superficial anatomy and good accessibility. Some studies revealed good outcome in both endovascular and surgical management of distal anterior cerebral artery aneurysms (1). However, approach to the distal circulation by endovascular route is technically challenging and the risk of thromboembolic events are higher, number of endovascular treatments for distally located small vessels and bifurcation aneurysms with flow diverters (FDs) have increased recently (2).

Low-profile FDs are relatively new and they are highly recommended in selected aneurysms such as distal vascular pedicle and bifurcation aneurysms (3). The Flow Re-Direction Endoluminal Device Junior (FRED Jr) (MicroVention, Tustin, California) is one of the low-profile FDs dedicated for endovascular treatment of distally located aneurysms whose parent vessel diameter is less than 3 mm (4). There are limited amount of data about efficacy, safety and follow up outcomes of FRED Jr in small diameter artery aneurysms and even less exist for ruptured aneurysm (5-7).

In this single-center retrospective study, we evaluated long-term safety and efficacy of FRED Jr in ruptured or unruptured distal intracranial aneurysms of various morphologic types. We compared our results with the published FRED Jr and other low profile FD stent series with similar sizes of small vessel aneurysms.

Material and Methods

Study Design and Data Collection

This single-center retrospective study was performed in Ankara Bilkent City Hospital. Twenty-five patients with 31 aneurysms who were treated with FRED Jr by a single research team between February 2019 and October 2021 are retrospectively evaluated.

A written informed consent was taken that implies their medical records and images can be used for research in future. Ethical committee approval was assigned with a reference number of E1-20-1445 at our hospital.

The decision of treatment was taken jointly by at least two neurosurgeons and two interventional neuroradiologists who have more than 10 years' experience in the endovascular era. After examination of 2D and 3D angiograms of the aneurysm morphologic and morphometric criteria, the procedure was planned.

Data about patients demographics (age, sex), aneurysm morphology (location, sizes, shape, vessel branch incorporating aneurysm, ruptured or unruptured), periprocedural details and clinical status, clinical and angiographic follow up outcomes were collected from the hospital database.

Device Description

The FRED Jr (MicroVention, Tustin, California) is a self-expandable, double-layer, flow diverter stent which is suitable for 2.5-3.0 mm diameter small vessels. Unlike other flow diverters, FRED Jr has a unique combination consisting of two nitinol layers including flow diverter (90% of its length) and stent formation. Inner layer is the flow diverter part which has tightly braided 36 wires. The outer layer has wider braided 16 wires and there is no flow diverter effect on the proximal and distal ends. This unique design offers enhanced navigability in tortuous anatomy and apposition to the arterial wall and provides an advantage in protecting critical branches. There are 4 platinum markers on both ends of the stent. In addition, the tantalum spiral wire surrounding the stent enhances its visibility. Available stent sizes are 2.5 to 3 mm in diameter and up to 41 mm length with a dual layer coverage of 8-37 mm. FRED Jr can only be deployed with its unique microcatheter Headway 21 (MicroVention, Tustin, California). The FRED Jr is resheatable and can be repositioned to cover the aneurysm neck.

Antiplatelet regimen

In all patients clopidogrel 75 mg once daily with a 300 to 450 mg loading dose (depending on weight) and Acetylsalicylic acid (ASA) 100 mg were started. Excluding one patient, all had clopidogrel resistance test. Prasugrel was administered two times daily two days before the procedure in patients with high resistance to clopidogrel. Perioperatively 25mcg/kg intravenous (iv) tirofiban infusion was administered in patients with a high risk of thromboembolic events and it was discontinued within 24 hours. Postoperatively dual antiplatelet regimen was continued for 6 months, thereafter with ASA lifelong.

Endovascular Procedure

All procedures were performed under general anesthesia with systemic heparinization (50 to 70 units per kilogram bolus followed by infusion). First, we placed a long introducer sheath via femoral artery. Then through the long sheath, we reached internal carotid artery or distal V2 segment of the vertebral artery using an intermediate guiding catheter. After detailed evaluation of the arterial anatomy and the aneurysm with 2D and 3D rotational angiograms, we decided the size of FRED Jr. FRED Jr was deployed via Headway 21 (Microvention, Terumo, Japan) over a micro guidewire (Synchro 0.014, Stryker Neurovascular, US). If vasospasm occurs, nimodipine (Nimotop, Bayer, Germany) was used via catheter. Haemostasias was maintained at the access site with an arterial closure device.

Follow Up

After the procedure, all patients were monitorized for 12 hours in the neurosurgery intensive care unit. Postoperative computer tomography (CT) was performed at 24 hours to exclude hemorrhagic complications.

Clinical follow up was evaluated with modified Rankin Scale (mRS). Procedure-related morbidity was defined as a mRS (mRS) ≥2. The mRS ranges from 0 (no symptoms) to 6 (death). Major procedural complications were defined as death or a neurologic morbidity resulting mRS ≥ 2.

Radiological follow-up of these patients were performed by a joint team of neuroradiologists. Angiographic follow up was performed at 1, 6, 12 months postoperatively. DSA images were classified according to O'Kelly-Marotta grading scale (OKM). The grades of occlusion were as follows; A=total filling (>95%), B= subtotal filling (5-95%), C= entry remnant (<5%) and D=no filling (0%). Adequate aneurysm occlusion was defined as OKM C and OKM D (8).

Some of the patients had been followed with MRA because of logistic problems or patient's reluctance to DSA. MRA was performed to patients at first and sixth month postoperatively. Studies indicates that MRA is a reliable modality for the follow-up of aneurysms treated using endovascular techniques (9). MRA outcomes were classified according to Raymond-Roy Classification (RROC) (10,11). 54.20±12.54 years; 74% female Radiological follow-ups of these patients were performed by a joint team of neuroradiologists.

Results

Baseline Population and Aneurysm Features

Twenty-five patients with 31 aneurysms were included in this study. Eighteen (72%) patients were female, 7 patients (28%) were male. Median age was 48.8 (age range 9-85). Location of the aneurysms were as follows; 13/31 (41%) in middle cerebral artery (MCA), 7/31 (22%) in anterior cerebral artery (ACA), 4/31 (14.2 %) in posterior cerebral artery (PCA), 3/31 (6%) in true posterior communicating artery (PCom), 2/31 (6%) in anterior communicating artery (ACom), 1/31 (3%) in superior cerebellar artery (SCA), 1/31 (3%) in true ophthalmic artery. One patient has four, one patient has three and one patient has two aneurysms. 22 patients have one aneurysm. There were 21 saccular, 6 fusiform and 4 dissecting aneurysms. Median aneurysm dome height was 5,98 mm, median neck size was 6,18mm. Mean proximal and distal parent artery diameter was 2,43 mm (range 1.7-3.5) and 2,13 mm (range 1.5-3.5) respectively.

Five patients (20%) presented with acute subarachnoid hemorrhage (aSAH) due to ruptured aneurysm. Two true PCom, 2 ACA and a PCA aneurysms were ruptured. Twenty patients had unruptured aneurysms. Four (16%) patients had been treated previously because of ruptured aneurysm. Two of them were surgically clipped *(No 11 and 22)* and 2 had endovascular embolization *(No 6 and 16)*.

*Demographics of patients and aneurysm features were summarized in **Table 1.***

Procedural Technical Details

In all procedures, FRED Jr was successfully deployed.

In three patients, two adjacent aneurysms were treated with a single FRED Jr deployment. In patient *(No 10),* two aneurysms in right ACA A2-3 segment were treated using a single FRED Jr ***(Figure 1)***. This patient also had a left A2-A3 and superior cerebellar artery segment aneurysms that were treated with a second and third FRED Jr deployments. The patient *(No 4)* had two dissecting giant aneurysms located in PCA, they were treated by a single long sized FRED Jr ***(Figure 2)***. Patient *(No 14)* had two aneurysms located in left A2 duplication segment and ACom artery treated with single FRED Jr.

In a 9 years old patient *(No 7)* with ruptured dissecting giant aneurysm in PCA, a second FRED Jr was deployed because of insufficient stasis after the first FRED Jr's deployment ***(Figure 3)***.

In patient *No 20*, the distal part of the FRED Jr didn't open well (fish mouth appearance). Apposition of the distal part of the stent was established by passing a microcatheter through the stent. None of the patients required percutaneous balloon angioplasty (PTA).

Patient *No 21* had two aneurysms in MCA bifurcation and superior trunk close to each other. This patient had to be treated with two FRED Jr because of unpredicted shortening of the first FRED Jr which was planned to cover both aneurysms.

In three patients *(No 9, 18, 23),* we treated true PCom aneurysms ***(Figure 4).*** Patient *No 25* had true ophthalmic aneurysm and was treated with FRED Jr ***(Figure 5).***

In patient *No 17,* coiling was applied in addition to FRED Jr into the large size and irregular contour ACom aneurysm. In patient *No 8* after the FRED Jr deployment, moderate vasospasm occurred at distal ACA. Nimodipine infusion was performed, and vasospasm decreased.

Procedure-Related Complications

In two patients with unruptured aneurysms, 2 (8%) intraoperative in-stent thrombosis occurred after deployment of FRED Jr. We observed intra-stent thrombosis after stent deployment in patient *No 4* who had two giant aneurysms in the left PCA. Intravenous (iv) tirofiban infusion was started immediately and then thrombus resolved. Patient *No 19* with MCA bifurcation aneurysm, parent artery occluded just after stent deployment. We performed thromboaspiration with Sofia 5f (Microvention, Terumo, Japan) aspiration catheter immediately. Vessel lumen was partially opened, therefore we deployed Neuroform Atlas stent (Stryker, USA) into the FRED Jr. Finally normal blood flow was established in the parent artery. Both patients were discharged from the hospital without any significant morbidity (mRS 0).

Patient *No 24* who was successfully discharged from the hospital presented with intraparenchymal hemorrhage two weeks later. It was thought to be due to dual antiplatelet treatment and unregulated blood pressure. Parenchymal hemorrhage was drained surgically, and the patient was followed in the intensive care unit for 1 week with endo-tracheal intubation. Finally, the patient was discharged with mRS 2 from the hospital at the first month of follow-up.

*Procedural details and complications were summarized at **Table 2.***

Periprocedural Outcomes

Immediate periprocedural angiography of 31 aneurysms revealed significant stasis in 21, moderate stasis in 6 and no filling in 4 of the total aneurysms according to OKM classification

Follow Up Outcomes

Our study has a mean follow-up of 23 months. Control DSA imaging was performed on 16/25 (64%) patients and 21/31 (67%) aneurysms. Near complete-complete occlusion (OKM C-D) was observed in 15/16 (93.7%) patients with 20/21 (95.2%) aneurysms on the follow up angiograms. Only one (6.25%) patient had subtotal filling in the aneurysm (OKM B). Nine of twenty-five (36%) patients were followed with MRA, no residual filling was observed in the control MRA.

The clinical outcome scores of the patients were calculated according to the mRS, and at the end of an average of 20 months, 24/25 (96%) patients were evaluated as mRS 0 and one patient's (4%) mRS 2 *(No 24)*. In our series, clinical results were consistent with the literature.

During the follow-up period, one patient died of a hard attack in the seventh month and the other patient died of Covid-19 pneumonia in the nineth month. No residual filling was observed in the control MRA examination of these patients.

*Follow-up outcomes summarized in **Table 3.***

Discussion

Generally, wide-necked, complex, irregular aneurysms and giant fusiform, dissecting, blister-like, or recanalized aneurysms are not suitable for primary coiling or clipping. These type of aneurysms are suitable for endovascular treatment with FDs (5). Flow diversion is an innovative endovascular treatment that uses dense mesh stents named flow diverters (FD) placed in front of the aneurysm neck to divert the flow toward the parent artery and to decrease the flow into the aneurysm subsequently inducing intra-aneurysmal thrombosis (5,12–14). Usage of FDs have increased recently because of its efficacy and safety profile14. In a recent meta-analysis by Briganti et al, results from 18 studies indicated that FD stenting of intracranial aneurysms achieves a good percentage of occlusion (81.5%) with a low incidence of major complications (mean 8.3% range 0–23.1%). In addition, mean mortality was 3.4% (range 0.5-8%) and permanent morbidity related to the procedure was 3.5% (range 1–15%) (15).

Endovascular treatment for distally located small vessels and bifurcation aneurysms with low-profile FDs have increased recently. However, there are a few studies in the literature on the use of FDs in distal arteries with a diameter of < 3mm (1,16–18). The recently produced FRED Jr has a unique design suitable for small arteries. FRED Jr's distinctive design provides the advantage of side branch protection in complex aneurysms and less amount of outer stent wires with respect to similar FDs provide advantage in navigability in tortuous vessels (6). Studies with the FRED Jr stents are few in the literature. The multicenter studies published by Möhlenbruch MA et al. with 42 patients, Jesser J et al. with 150 patients and Rautio R et al. with 15 patients demonstrate the efficacy and safety of the FRED Jr stent in unruptured aneurysms (4,9,10).Using FRED Jr for ruptured aneurysms is rarely reported in the relevant literature. In the series of 15 patients published by Sivasankar R et al., only one patient was treated with FRED Jr during acute SAH (19). In our series, 5 of 25 patients (20%) had acute ruptured aneurysms treated with FRED Jr, all patients were discharged from the hospital without any complication. During their follow up, no residual filling was observed in their angiograms and MRA.

In case of insufficient aneurysmal stasis, overlapped flow diverters could achieve more flow reduction than a single flow diverter (20). This technique is most effective for large orifice fusiform aneurysms. Damiano RJ et al. reported that using overlapping Pipeline Embolization Devices (PED) (Medtronic Neurovascular, Irvine, California, USA) helped reducing an additional aneurysmal flow velocity of 30 % with respect to deploying one device (21). Yu J et al. reported two overlapping PEDs were used to cover the aneurysm neck in 3/22 cases (22). Awad et al. reported 8/17 patients were treated to use two overlapping PEDs (23). Using overlapping FDs were reported in 6/44 patients with Silk Vista Baby

(Balt, France) (3). In one of our patients 1/25, we had to use two overlapping FRED Jr to achieve stasis of the giant, dissecting aneurysm.

To provide occlusion of tandem aneurysms, it is possible to use a single FD. Awad et al reported a series of 9/17 patients with tandem aneurysms treated using a single PED (23). To the best of our knowledge, using a single FRED Jr to cover adjacent aneurysms is not reported in the relevant literature. We deployed a single FRED Jr to cover two aneurysms in three patients. True PCom aneurysms are defined as aneurysms arising from the PCom itself rather than the junction of the internal carotid artery (ICA) and the PCom (24). These aneurysms represent about 1.3% of all intracranial aneurysms and 6.8% of all PCom artery aneurysms (23). True PCom aneurysms are rare and this subtype of aneurysms is more prone to rupture (21). Some authors prefer microsurgical management to endovascular treatment for the PCom aneurysms because of difficulty in navigation of microcatheter and potential risk of intraoperative rupture25,26. Endovascular treatment for true PCom aneurysm is limited in the literature (26–28). Our series included three patients with true PCom artery aneurysms, two of the three were ruptured aneurysms. All three patients were discharged from the hospital without any complication. Intracanalicular true ophthalmic artery aneurysm is rare (29). Only one true ophthalmic aneurysm was previously reported to be treated with FD (30). We deployed FRED Jr into the ophthalmic artery in one patient with true ophthalmic aneurysm. The patient were discharged from the hospital without any complication and no residuel filling (OKM D) in the first month follow up angiograms.

Complications of endovascular FD treatments are ischemic stroke, intraoperative rupture, stent thrombosis, stent restenosis, delayed aneurysm rupture and intraparenchymal hemorrhage. In the literature; Jesser J et al reported a periprocedural complication, technical complication and in-stent thrombosis rate of 24/159 (16%), 6/159 (3%) and 12/159 (7%) respectively. Jesser J et al have reported periprocedural ischemic events with FRED Jr within the first 30 days as 9/159 (6%) including 2 major stroke and 7 minor stroke (TIA) (5). Möhlenbruch et al. have reported 47 aneurysms treated with FRED Jr with a complication rate of 7% and mortality rate of 2% (6). Sivasankar R et al. and Rautio et al. have reported no periprocedural complication and mortality in 15 unruptured aneurysms treated with FRED Jr (7,19). In the literature some studies were including both FRED and FRED Jr. In the study published by Guimaraens L et al., 19.5% (36/185) of aneurysms were treated with FRED Jr, major complications were reported in 12 (6.5%) cases (3 strokes, 6 in-stent thrombosis, 3 hemorrhage) and asymptomatic minor complications in 10 (5.4%) cases (3 stent shortening; 2 arterial dissection, 2 arterial occlusion, and 3 intra-stent stenosis) (31). The intracerebral hemorrhage rate has been reported as 1.42% (0.64-2.49%) with in the series of PED and Silk (32). In the literature some studies were including both FRED and FRED Jr. In the study published by Guimaraens L et al, 19.5% (36/185) of aneurysms were treated with FRED Jr. , major complications were reported in 12 (6.5%) cases (3 strokes, 6 in-stent thrombosis, 3 hemorrhage) and asymptomatic minor complications in 10 (5.4%) cases (3 stent shortening; 2 arterial dissection, 2 arterial occlusion, and 3 intra-stent stenosis) (31). In multi-center SAFE study by Pierot et al, 103 patients were treated with FRED (85%) and FRED Jr (15%) stents, they reported 1.9% mortality, 2.9% morbidity and 6.8% thromboembolic complications rates at 1-year follow-up (2). The meta-analysis published by Xiyang Yao et al, including ten observational studies in distal intracranial artery aneurysms treated with Silk and PED; the procedure-related neurologic mortality, neurologic morbidity and ischemic complication rates has been reported as 0.87% (0.29-1.74%), 5.22% (3.62-7.1%) and 2.35 % (1.31-3.68%) respectively (20). In our series periprocedural mortality, major or minor stroke did not occur. Our complication rate is 3/25 (12%), similar with the biggest series in the given literature (4). Intraoperatively, in two patients with unruptured aneurysm, in-stent thrombosis occurred shortly after the FRED Jr placement (7,6%). These patients were discharged from the hospital with mRS 0. In one patient, delayed intraparenchymal hemorrhage occurred two weeks later post procedurally who was discharged from the hospital with mRS 0, in-stent thrombosis occurred in two patient and within early postoperative period, hemorrhagic complication occurred in one patient.

Large prospective studies and meta-analysis reported a complete occlusion rate of 75 % for different FDs (33). Pierot et al. reported occlusion/near occlusion rate of FRED and FRED Jr series 81% between 6–12 months (2). Xiyang Yao et al. reported complete aneurysm occlusion rate that trated with Silk and PED as 84.23% (80.34-87.76%) (32). Searching about literature for FRED Jr; Rautio et al. reported a complete occlusion rate of 87% between 6 and 24 months of follow-up in 15 patients (7). Möhlenbruch et al. have reported 100% occlusion in the 12 months (6). Sivasankar R et al. have reported that OKM C-D was seen in 80% of the aneurysms on follow up angiograms (19). Jesser J et al. have reported complete occlusion rate as 68% in the first year (5.) In our series, near complete-complete occlusion (OKM C-D) rate was 15/16 (93.7%) patients with 20/21 (95.2%) aneurysms at 12 months angiograms. Nine patients were followed with MRA and no residual filling was observed in the control MRA.

Our cohort, consisting of a rate of 20% acute ruptured aneurysms is the major additive data to the published literature. Including a higher percentage of ruptured aneurysms represents even a riskier patient profile than the average series in the literature. Even with such a cohort, our complication rate was similar to the relevant series (5,19).

Limitations of the Study

Our study has limitations intrinsic to single-center series and it is not a population-based study. The number of patients was relatively small though larger than other reported case series. Further analysis is needed in a larger sample. The data were analyzed retrospectively. In addition, the imaging outcome was assessed by the operators and not independently. A neurosurgeon provided clinical follow-up but was not blinded to the procedure used, and there was no external evaluation of the angiographic results. There was a lack of standardization of radiologic follow-up.

Conclusion

Our results were associated with high near complete-complete aneurysmal occlusion rate with low periprocedural complications. Endovascular treatment of distal cerebral aneurysms with FRED Jr FD is safe and effective allowing high rates of aneurysm occlusion. Larger studies with long-term follow up are needed to draw conclusions about the security and efficacy of these stents especially in acute ruptured aneurysm treated with FRED Jr.

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Table 1: Demographics of patients and aneurysms' feature.

No	Age	Sex	Op. Date	Presentation	Location	Aneurysm Number	Morphology
1	58	M	03.01.2019	Headache	Left MCA	1	Saccular
2	69	F	10.01.2019	Headache	Left MCA	1	Saccular
3	27	F	16.04.2019	SAH-Syncope	Left ACA	1	Saccular
4	13	F	26.04.2019	Seizure	Left PCA	1	Dissecting
4	13	F	26.04.2019	Seizure	Left PCA	1	Dissecting
5	44	F	13.05.2019	Previous SAH	Right MCA	1	Fusiform
6	63	F	03.07.2019	Headache	Right MCA	1	Saccular
7	9	M	17.07.2019	Headache	Left PCA	1	Dissecting
8	85	F	15.08.2019	Headache	Left ACA	1	Saccular
9	69	M	02.09.2019	Headache	Left True Pcom	1	Fusiform
10	53	F	07.10.2019	Previous SAH	Right ACA	2	Saccular
10	53	F	07.10.2019	Previous SAH	Left ACA	1	Fusiform
10	53	F	07.10.2021	Previous SAH	Left SCA	1	Fusiform
11	67	M	30.10.2019	Headache	Right MCA	1	Saccular
12	66	F	03.12.2019	Previous Sah	Right MCA	1	Saccular
13	57	F	10.12.2019	Residueal Filling After clipping	Left MCA	1	Saccular
14	49	M	17.12.2019	Vision blurring	Left ACA	2	Saccular
15	72	F	26.12.2019	Headache	Left ACA	1	Saccular
16	46	F	23.01.2020	Headache	Left MCA	1	Fusiform
17	67	F	29.01.2020	Headache	Acom	1	Saccular
18	41	F	14.01.2021	Previous SAH	Left True Pcom	1	Saccular
19	40	F	22.09.2021	Syncope	Left MCA	1	Saccular
20	15	F	30.09.2021	Headache	Left PCA	1	Fusiform
21	43	F	04.10.2021	Residueal Filling After clipping	Right MCA	2	Saccular
22	52	M	04.10.2021	Headache	Right MCA	1	Saccular
23	32	F	07.10.2021	Syncope	Left True Pcom	1	Saccular
24	73	F	07.10.2021	Headache	Left MCA	1	Saccular
25	38	M	27.10.2021	Incidentally after Head Trauma	Right Ophtalmic	1	Dissecting

Table 2: Aneurysms' sizes and procedural details

No	SAH	Neck width (mm)	Dome width (mm)	Dome height (mm)	Distal PA	Proximal PA	Stent size	Additional Device	Periprocedural Complication
1	-	3.1	3.3	4.7	2.5	3.2	Fred Jr 3x14x19	None	None
2	-	1.9	3	3	2.5	3	Fred Jr 2.5x8x13	None	None
3	+	4.2	4	3	2.6	2.8	Fred Jr 2.5x13x8	None	None
4	-	21	23	21	3.2	3.5	Fred Jr 3x27x32	None	Intra-stent thrombosis/ tirofiban
4	-	16	11	12	3.2	3.5	Fred Jr 3x27x32	None	Intra-stent thrombosis/ tirofiban
5	-	N/A	7	8	2.8	3	Fred Jr 2.5x13x18	None	None
6	-	2.2	3	3.5	2.5	3.2	Fred Jr 2.5x8x13	None	None
7	+	16.4	38	13	1.8	2.1	Fred Jr 3x32x27	Fred Jr 3x27x30	None
8	-	6.1	6	5	1.8	2.2	Fred Jr 2.5x18x13	None	vasospasm/ nimodipine
9	+	N/A	6	7	2.0	2.2	Fred Jr 3x14x19	None	None
10	-	1.9	4	4	1.8	2.1	Fred Jr 2.5x13x18	None	None
10	-	N/A	2	5	1.3	1.5	Fred Jr 2.5x8x13	None	None
10	-	N/A	3	2	2.1	3.1	Fred 2.5x8x13	None	None
11	-	4.5	4	5	2.1	2.5	Fred Jr 3x27x21	None	None
12	-	8.7	13	11	2.3	2.5	Fred Jr 2.5x20x25	None	None
13	-	2.1	3	2	1.7	2.4	Fred Jr 3x9x13	None	None
14	-	3.5	2	1.5	1.7	2	Fred Jr 2.5x30x26	Atlas 3x21 for patency A2	None
15	+	1.5	3	2	2.4	2.9	Fred Jr 2.5x8x13	None	None
16	-	5.9	11	5	2.1	2.7	Fred Jr 3x27x21	None	None
17	-	8.3	11.5	8.5	2.1	2.2	Fred Jr 3x14x19	Coil	None
18	-	1.8	1.3	1.5	1.3	1.7	Fred Jr 2.5x13x8	None	None
19	-	2.8	3.1	3.1	2.1	2.2	Fred Jr 2.5x8x13	Atlas 3x24, catch mini, Sofia 5f aspiration	intra-stent thrombosis/ thrombectomy
20	-	N/A	4.2	2.5	2.7	3.2	Fred Jr 3x18x14	None	distal fish mouth appearance/opened
21	-	3.8	3.3	2.3	2.1	2.5	Fred Jr 2.5x18x13	Fred Jr 2.5x18x13	stent shortened/second stent deployed
22	-	3.5	3.7	6.2	2.2	2.4	Fred Jr 2.5x18x13	None	None
23	+	3.8	5	4	2.1	2.5	Fred Jr 2.5x13x8	None	None
24	-	2.8	3	5	2.8	3.2	Fred Jr 3x18x14	None	Postop hemorrhage/ Surgical Drained
25	-	2.7	2.9	2.5	0.7	1.8	Fred Jr 2.5x13x8	None	None

***SAH:** Subarachnoid Hemorrhage, **PA:** Parent Artery.*

Table 3: Angiographic and Clinical Follow-up Outcomes.

No	Preop OKM	Postop OKM	OKM Last Follow Up	RROC (MRA FU)	Follow-up (months)	Preop Gcs	Postop Gcs	mRS1/6/12
1	A1	A3	-	1	36	15	15	0/0/0
2	A1	A3	-	1	36	15	15	0/0/0
3	A1	A3	D	1	33	15	15	0/0/0
4	A2	C3	D	1	33	15	15	0/0/0
4	A1	B3	D	1	33	15	15	0/0/0
5	B1	B3	D	1	32	15	15	0/0/0
6	A1	A3	-	1	30	15	15	0/0/0
7	A1	B3	D	1	30	15	15	0/0/0
8	A1	B3	-	1	29	15	15	0/0/0
9	A1	C3	-	2	28	15	15	0/0/0
10	A1	A3	D	1	27	15	15	0/0/0
10	A1	A3	D	1	27	15	15	0/0/0
10	A1	A3	D	1	3	15	15	0/0/0
11	A1	A3	B2	2	27	15	15	0/0/0
12	A1	B3	B2	2	25	15	15	0/0/0
13	B2	B2	D (Minimal stent stenosis)	1	25	15	15	0/0/0
14	A1	A3	D	1	25	15	15	0/0/0
15	A1	B3	-	1	25	14	14	0/0/0
16	A1	A3	D	1	24	15	15	0/0/0
17	A1	A3	D	1	24	15	15	0/0/0
18	A1	A3	D	1	12	15	15	0/0/0
19	A1	A3	-	1	4	15	15	0
20	A1	A3	D	1	4	15	15	0
21	B2	C3	C2	1	3	15	15	0
22	A1	A3	D	1	3	15	15	0
23	A1	A2	-	1	3	15	15	0
24	A1	A3	-	1	3	15	15	2
25	A1	A3	D	1	3	15	15	0

***OKM:** O'Kelly Morata Grading Scale, **RROC:** Raymond-Roy Classification, **GCS:** Glasgow Coma Scale, **mRS:** Modified Rankin Scale*

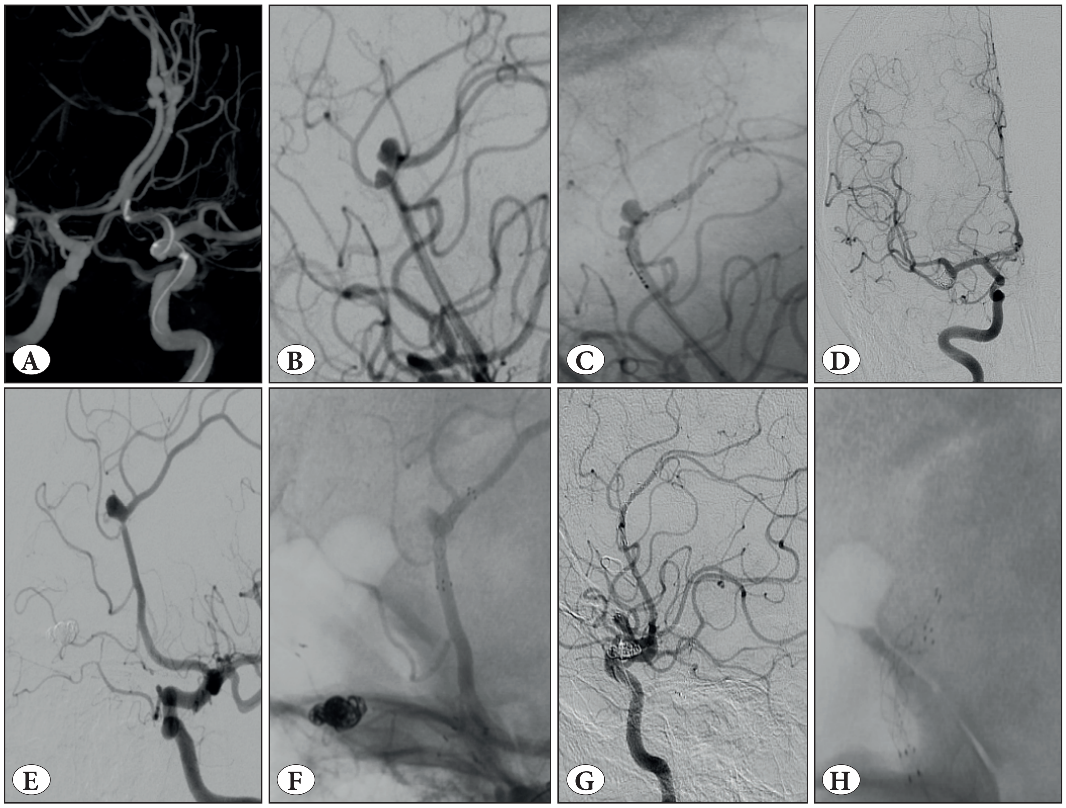

Figure 1

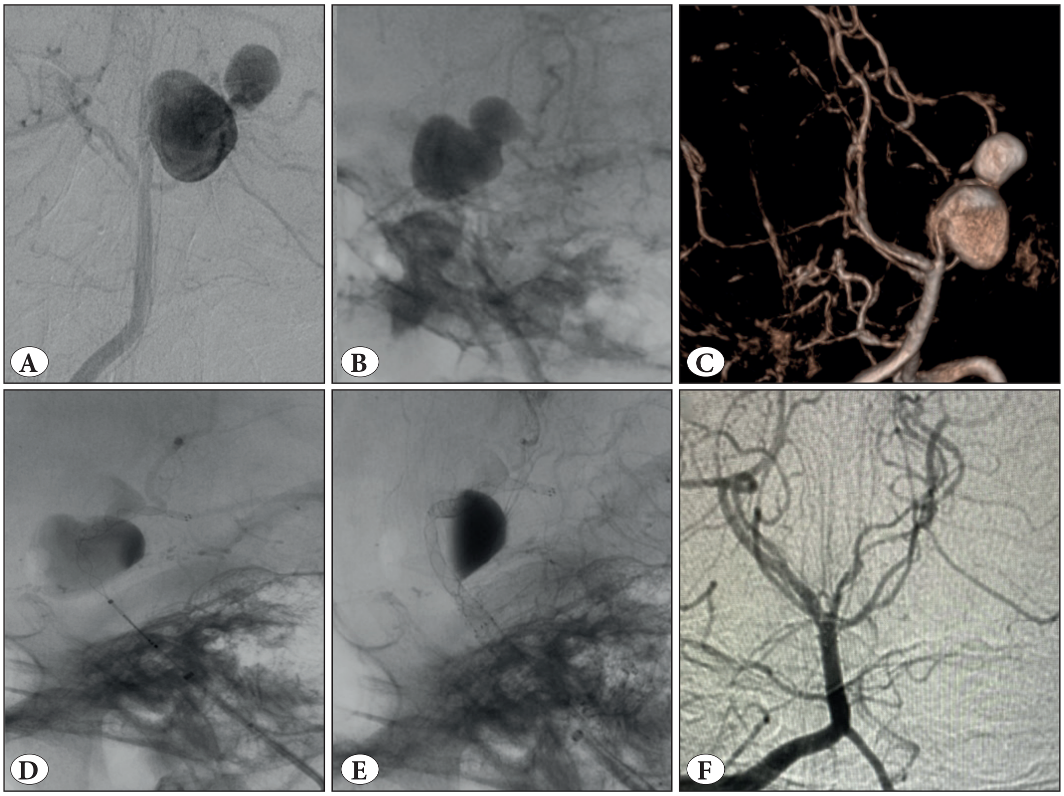

Figure 2

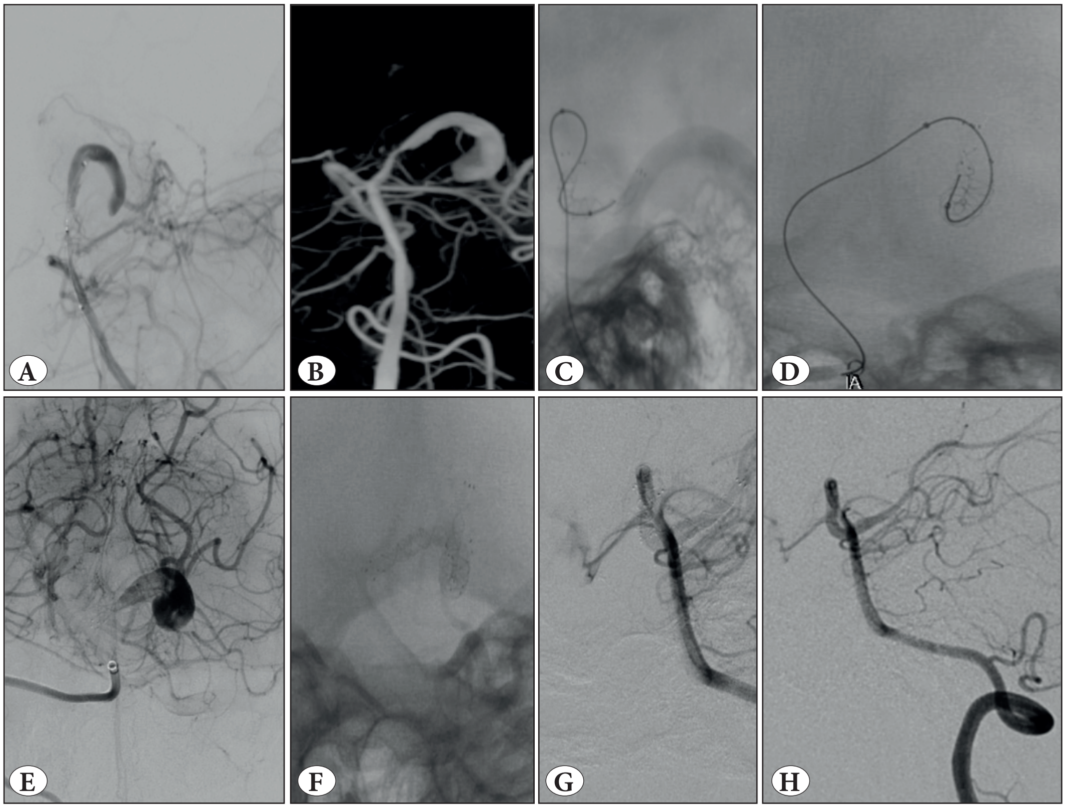

Figure 3

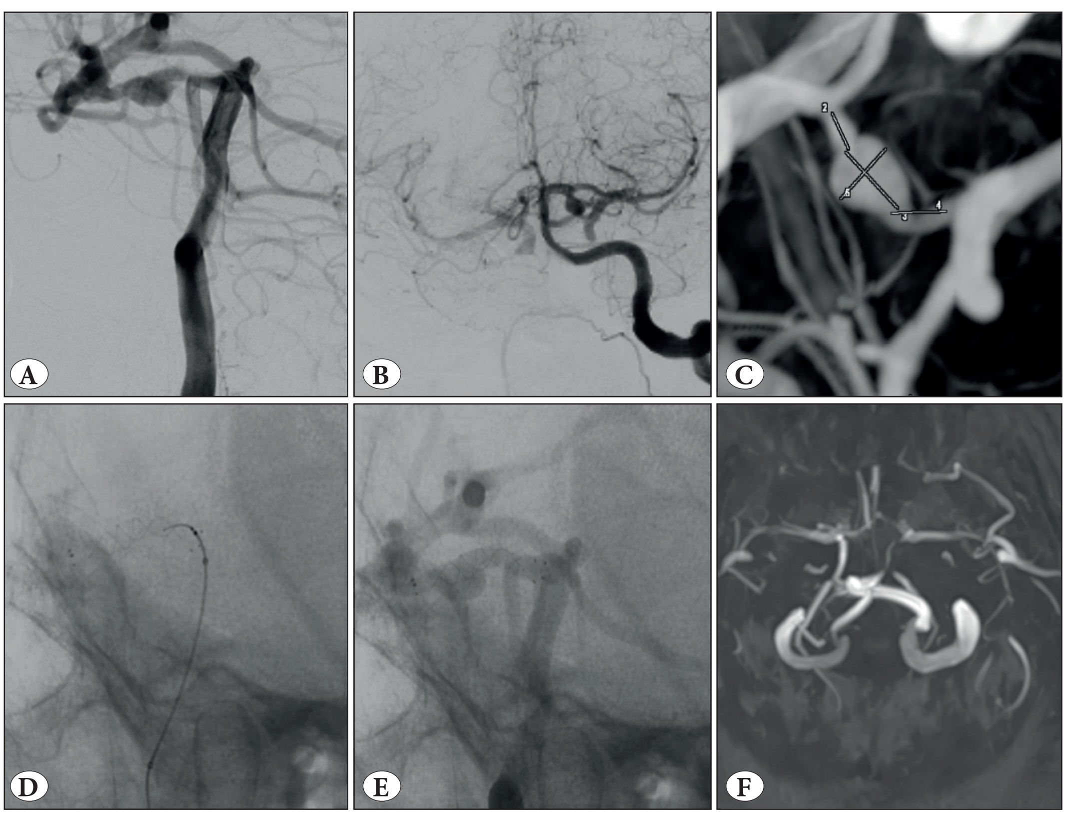

Figure 4

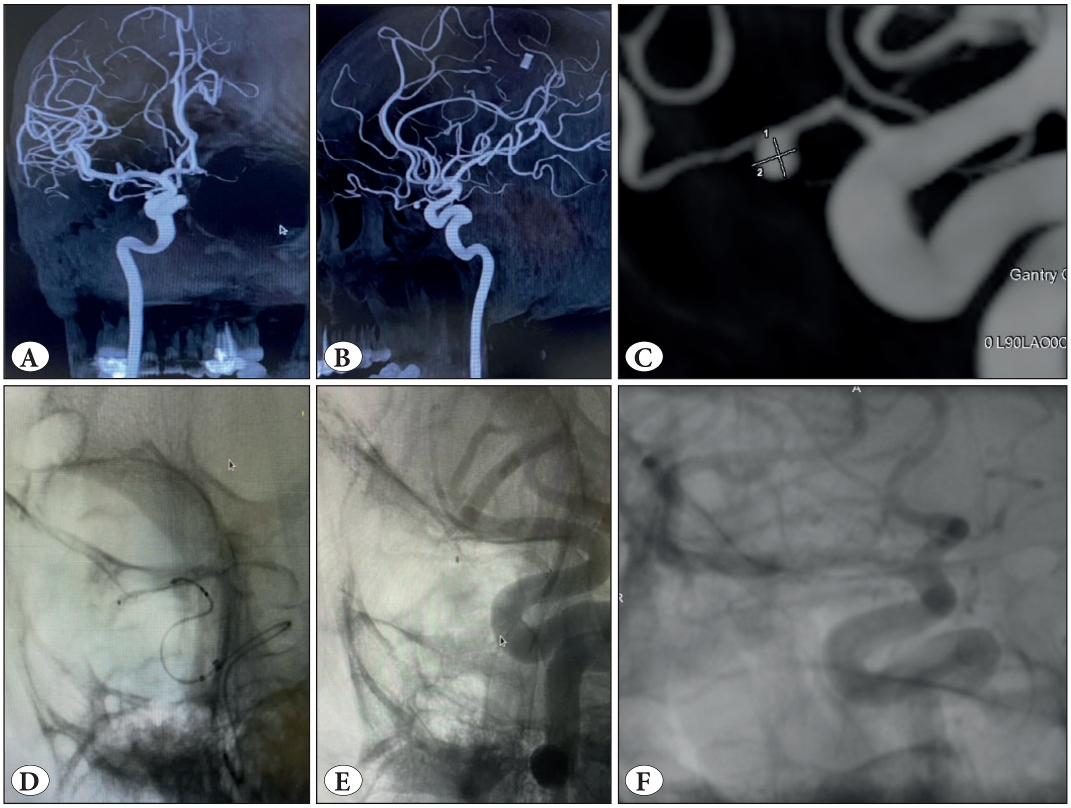

Figure 5