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Results of Y-stent-assisted-coiling with a low-profile Neuroform Atlas stent in complex bifurcation aneurysms

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ABSTRACT

Aim: Neuroform Atlas is a low-profile stent with an open-cell structure that can be deployed via a low-profile microcatheter. This study analyzed the safety, durability, and efficiency of Y-stent-assisted coiling (Y-SAC) with two Neuroform Atlas stents for treating unruptured wide-neck complex bifurcation aneurysms.

Material and method: We retrospectively reviewed patients who were treated for intracranial bifurcation aneurysms using the Y-SAC technique with two Neuroform Atlas stents. A total of 94 consecutive patients were included in the study. Clinical and angiographic results and complications were evaluated before and after the procedure.

Results: Y-SAC was successfully performed (100%) without any technical complications in any case. The mean angiographic follow-up period was 14.6±6.6 months. Follow-up DSA was performed on 93.6% of patients. The last follow-up angiograms demonstrated complete occlusion (RROC I) in 92%, and near-complete occlusion (RROC II) in 7% of the aneurysms. There was no mortality in this study. A procedure-related complication occurred in 4.2% of patients and caused permanent morbidity in 1% of patients.

Conclusion: In the endovascular treatment of wide-neck complex bifurcation aneurysms, the Y-SAC method with two Neuroform Atlas stents is safe and effective with high aneurysm occlusion rates and a low risk of procedural complications.

Keywords: cerebral aneurysm, treatment, embolization

INTRODUCTION

Stent-assisted coiling (SAC) technique for endovascular treatment of wide-neck aneurysms (dome-to-neck ratio of <2 or a neck diameter of >4 mm) prevents coil protrusion into the parental artery, improves aneurysm occlusion, and reduces recurrence (1). Because of wide-neck complex bifurcation aneurysms involving one or more side branches, SAC may be required with two stents in various configurations (2, 3). Y-stent assisted coiling (Y-SAC) has been widely used to treat complex bifurcation aneurysms (4). Previously, Y-SAC could be performed with a large-profile micro-catheter, causing more complications. However, recently, low-profile stents, such as the Neuroform Atlas (Stryker) have been developed that can be loaded onto coil catheters (5–7).

In the current literature, the results of Y-stenting performed with a low-profile stent combination of closed-cell or braided cell with an open-cell stent are reported mostly. The number of Y-SAC series using two Neuroform Atlas stents (open cell-open cell Y-configuration) is a few in the literature (5, 8–9).

In this study, we analyzed the outcomes of unruptured complex bifurcation aneurysms treated with two Neuroform Atlas stent-assisted Y-SAC.

MATERIAL AND METHOD

Study Design and Data Collection

This retrospective study was approved by the Adıyaman University Clinical Researches Ethics Committee (Date 6.01.2021, Decision No: 1358). Informed consent was not obtained as the study was retrospective. All procedures were performed under the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration or comparable ethical standards. Y-SAC patients who were treated with two Neuroform Atlas stents were reviewed between Jan

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2017 and Dec 2020. Single Neuroform Atlas, double Neuroform Atlas but non-Y configuration, or Y stents other than Atlas-Atlas configuration were excluded from the study. A total of 94 consecutive patients were included in the study. Patient demographics, aneurysm characteristics, procedural details, complications, and follow-up outcomes (recanalization or retreatment ratio, parent artery patency) were evaluated. Complications were classified as intraprocedural, early (within 30 days), and late complications (after 30 days). Neurological complications were assessed according to the modified Rankin Scale (mRS) as major (death, major stroke resulting mRS >2) or minor (resulting mRS ≤ 2).

Neuroform Atlas Stent

The Neuroform Atlas stent is a laser-cut, nitinol, self-expandable stent that consists of open and closed cells together. This unique hybrid design permits microcatheter re-crossing and facilitates Y stent configuration. Better wall apposition, reduced shortening ratio, high navigability, and lower complication rates are advantages of the Neuroform Atlas stent. Available stent diameter sizes are 3.0, 4.0, and 4.5 mm and length sizes are 15, 21, 24, and 30 mm. The Neuroform Atlas stent is suitable for use in 2–4.5 mm-sized arteries.

Neuroform Atlas stent could be deployed through the low-profile microcatheters. A low-profile microcatheter helps catheterization of the sharply-angled second branch. The open cells at the mid-portion of the Neuroform Atlas provide an advantage over braided stents, while the microcatheter passes through the open-cell stent struts to create Y-SAC. The second stent can be opened better at the intersection of the stents and complication risks of the parent artery are reduced (5).

Procedure: Y-SAC Technique

The treatment decisions are taken by an endovascular team consisting of neurosurgeons and interventional neuroradiologists depending on the aneurysm's morphometric characteristics in 2D and 3D angiograms. Y-SAC was performed if primary coiling or single stent deployment could not prevent coil protrusion because of the wide neck and complex morphology.

All patients were pretreated with a loading dose of clopidogrel (300–450 mg) or prasugrel (30–60 mg). Intravenous (iv) tirofiban infusion (25 mcg/kg) was administered postoperatively as needed. All procedures were performed under general anesthesia with systemic heparinization (50 to 70 units per kilogram bolus followed by infusion). First, a long introducer placed sheath via the femoral artery route with micropuncture technique. Femoral ultrasonography was performed to guide puncture in case of difficulty to achieve the vascular access. Then through the long sheath, we reached internal carotid artery or distal V2 segment of the vertebral artery using a Fargomini distal access catheter (Balt, France) with an Excelsior SL-10 (Styker, USA) 0.0165" microcatheter over a Synchro (Stryker, USA) 0.014" microguidewire. The sharply angled and difficult-to-access branch was catheterized the first and a Neuroform Atlas stent was deployed into the first branch. Then, the microcatheter was passed through the first stent struts to the second branch and the second low-profile stent was deployed, creating a Y-stent configuration. A coil catheter was placed into the aneurysm with the jailing technique or trans-strut technique. Coiling was performed using bare platinum coils until the aneurysm sac was filled. Aneurysm occlusion and stent patency were evaluated with immediate angiograms according to the Ray Raymond Occlusion Classification (RROC) (10). Dual antiplatelet treatment was maintained for six months with 75 mg clopidogrel or 10 mg prasugrel and acetylsalicylic acid (ASA) 100 mg daily, then continued with ASA.

Follow-up

Postoperative computed tomography (CT) was performed within 24 h to exclude hemorrhagic complications. Angiographic follow-up with digital subtraction angiography (DSA) and/or magnetic resonance angiography (MRA) was performed at 1, 6, and 12 months. Patients were evaluated with MRA to check for asymptomatic ischemic findings in the first month. Follow-up DSA was performed for 9–12 months to assess aneurysm occlusion according to RROC grading (10). Two operators independently evaluated the angiograms. Aneurysm filling was evaluated as RROC I (complete occlusion), RROC II (residual neck filling), and RROC III (residual dome filling). Some patients had been followed up with only MRA because of the patient's reluctance to DSA. The primary efficacy outcome is accepted as the 12 months angiographic complete (100%) aneurysm occlusion rate or RROC I, without retreatment and parent artery stenosis (>50%) at the stent localization. If there was no significant reduction of aneurysm opacification after a one-year follow-up, retreatment was advised.

Neurological evaluation of patients was performed using the modified Rankin scale (mRS) before the procedure, at discharge, at 30 days and 90 days after the procedure.

Statistical Analysis

Descriptive statistical analysis was performed using SPSS statistics (IBM, Armonk, New York).

RESULTS

Baseline Population and Aneurysm Features

A total of 94 unruptured aneurysms in 94 patients (59 female) were included in the study. The median age was 59.2±11.7 years old, with a range of 32 to 88 years. Thirteen (13.8%) aneurysms (4 primary coils and 9 clipped) were treated previously, but the residual filling was observed in the radiologic follow-up, they were re-operated with Y-SAC.

All patients had wide-necked complex aneurysms. The locations of aneurysms were as follows; 43 (45%) middle cerebral artery bifurcation (MCA bifurcation), 27 (28%) anterior communicating artery (Acom), 14 (14%) basilar tip, 3 (3%) internal carotid artery bifurcation (ICA bifurcation), 3 (3%) early cortical branch of MCA (MCA-ECB), 3 (3%) A2-3 segment of the anterior cerebral artery (ACA-A2-3), one aneurysm (1%) the superior cerebellar artery (SSA). The majority (84%) of aneurysms were located in the anterior circulation. According to the diameter, aneurysms were classified as; 47 (50%) aneurysms <7 mm, 27 (29%) aneurysms 7–10 mm, 16 (17%) aneurysms 10-15 mm, and 4 aneurysms (4%) 15-20 mm. The mean dome size was 6.8±2.3 mm (range 4–20 mm), the mean neck width was 4.2±1.3 mm and the mean dome-to-neck ratio was 1.5±0.3 for the aneurysms.

Demographics, presentation, and aneurysm characteristics were summarized in **Table 1**.

Table 1. Demographics, presentation, and aneurysm characteristics

Mean age	59.2±11.7 yr (range 32–88 yr)
Sex	
Female	59 (61%)
Male	37 (39%)
Clinical presentation	
Incidental	36 (38%)
Headache	44 (47%)
SAH	13 (14%)
Recurrence	1 (1%)
Aneurysm location	
MCA bif	43 (46%)
Acom	27 (29%)
Basilar tip	14 (15%)
ICA tip	3 (3%)
M1-ECB	3 (3%)
ACA A2-3	3 (3%)
SSA	1 (1%)
Aneurysm size	
< 7 mm	47 (50%)
7–10 mm	27 (29%)
10–15 mm	16 (17%)
15–20 mm	4 (4%)
Mean dome size	6.8±2.3 mm
Mean neck width	4.2±1.3 mm
Mean dome/neck ratio	1.5±0.3

Procedural Details

In all procedures, Y-SAC was successfully performed without any technical complications in all cases (100%). Immediate post-procedural angiography revealed total aneurysm occlusion (RROC I) in 81 (86%), neck filling (RROC II) in 12 (13%) patients, and sac filling in one patient.

Complications

No mortality occurred in this study group. A procedure-related complication developed in 4 patients (4.2%). Acute stent thrombosis developed in 3 patients during the procedure. A tirofiban infusion was started immediately, but the thrombus did not completely dissolve and the blood flow continued to slow, so a third stent was placed in this segment. They were discharged from the hospital without permanent morbidity (mRS 0–1). In one patient with preprocedural mRS 2, an ischemic infarct developed on the tenth day, early postoperatively. This patient has been followed up with mRS 4. We didn't observe any late complications (>30 days). All 4 patients were administered 450 mg of clopidogrel preoperatively more than two hours before the stent implantation.

Follow-up Results

The mean follow-up time was 14.6±6.6 months (range, 6–34 months). The follow-up mRS was ≤2 in 91 of 94 cases and mRS>2 in the remaining 3 cases. One patient was discharged as mRS 4 because of a thromboembolic event during the early postoperative period. The other two patients had mRS 2 at their presentation. There was no change after surgery.

Follow-up DSA was performed on 88/94 (93.6%) of patients. The last follow-up angiograms demonstrated complete occlusion (RROC I) in 81/88 (92%) and near-complete occlusion (RROC II) in 6 (7%) of the aneurysms. In one patient, the first-year follow-up angiogram revealed persistent aneurysmal sac filling (RROC III), so a second coiling procedure was performed. We did not detect recanalization or in-stent stenosis in the follow-up angiograms. The residual filling was not observed in 6 patients who were followed up with MRA. **Figure 1** shows the preoperative, intraoperative, and follow-up angiograms of a 67-year-old female patient with an aneurysm in the basilar apex.

Follow-up aneurysm occlusion rates (RROC) are summarized in **Table 2**.

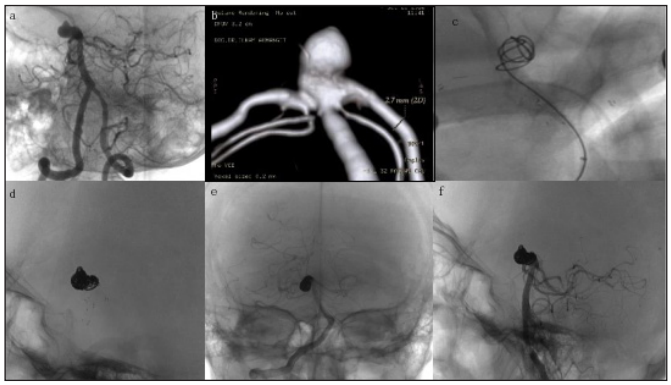

Figure 1. (a) Preoperative DSA of a 67-year-old female patient demonstrating an aneurysm in the basilar apex (b) 3D reconstruction imaging demonstrated aneurysm sizes, PCA and SCA branches clearly (c) Intraoperative lateral angiogram showing how Y configuration stenting was performed by passing from the basilar artery to the right and left PCA and then coiling (d) Postoperative lateral view shows two Neuroform Atlas deployed in Y-configuration and aneurysm sac coiled (e, f) Follow-up AP and lateral angiograms (12th month) demonstrate no residual filling (RROC 1)

Table 2. Followed-up Aneurysm Occlusion Rates (RROC)

RROC	Immediate DSA	Last follow-up DSA
RROC I	81 (86%)	81 (92%)
RROC II	12 (13%)	6 (7%)
RROC III	1 (1%)	1 (1%)

DISCUSSION

Endovascular treatment of distal complex bifurcation aneurysms is a challenging issue. The recently introduced WEB embolization devices may not be suitable for non-spheric amorphous-shaped bifurcation aneurysms incorporating more than one side branch. Amorphous morphology including bleb may impede the definite size selection of the WEB device (5). Inappropriate sized WEBs may also occlude critical branches originating from the aneurysm sac or residual filling may remain because of the undersized device. It has been reported that the PulseRider assisted coiling procedure, which has a much lower metal load compared to Y-stenting, is a safe and applicable device for treating basilar and carotid bifurcation aneurysms. In our patient group, ACom and MCA aneurysms constituted 80% of the group (11,12).

For treating complex bifurcation aneurysms, dual-SAC techniques including in X, T, and Y configurations were previously performed via large-sized microcatheters (3). As described by Chow et al. (4) in 2004, Y-stent assisted coiling (Y-SAC) has been widely used to treat complex bifurcation aneurysms (12). However, because of the technical difficulties, risk of hemorrhage, and necessity of dual antiplatelet treatment Y-SAC technique has a higher complication risk (dissection, vasospasm) than primary coiling (13, 14). Catheterization of narrow-angle and tortuous vessels in Y-stenting can be technically difficult and risky. Complication rates were reported to be higher in previous studies due to the catheterization that had to be performed with a large profile microcatheter. Spiotta et al. (15) reported a 31.6% complication rate for Y-SAC procedures using the older generation Neuroform that can be placed over 0.027 and 0.021 inches. Bartolini et al. (16) reported a complication rate of 18% in their study with double stenting and attributed the high complication rate to difficult parent artery catheterization with large catheters. Akgül et al. (6) reported a morbidity rate of 9.1% in their study with the Neuroform and Enterprise stent combination (open cell-closed cell). Procedural complications were reported as 8.9% and 12% in Y stent meta-analysis studies in the literature (7,17). The complication rate in crossing Y stents has been reported to be lower than in kissing stents, whereas the complication rates were lower with the Enterprise stent (6.5%) than Neuroform and LVIS stents (7).

The risk of complications is reduced, as the low-profile stent can be placed via the low-profile micro-catheter. The number of patients treated with open-cell-open-cell Y-SAC configuration with two Neuroform Atlas stents is few. In the open cell-open cell study by Kubilay et al. (5), Y-SAC was performed using 2 Neuroform Atlas stents, and the complication and permanent morbidity rates were reported as 6.7% and 3.3% respectively. Our complication rate was lower (4.2%) than both the Neuroform Atlas Y-SAC series of Aydın et al. (5) and the Enterprise Y-SAC series of Cognazzo et al. (7).

Y-stenting may increase the risk of device thrombogenicity, and thromboembolic events due to procedural difficulties and increased metal load. In the study reported by Goertz et al. (18) the risk of thromboembolic events due to Y stenting was reported as 10.7% with an ischemic stroke rate of 1.5%. In our series, 3 (3%) acute stent thrombosis developed intraoperatively. In these patients, a third Atlas stent had to be placed in the thrombosed artery. These patients were discharged without any sequel. In our series, one patient had a thromboembolic event on the postoperative tenth day. This patient was followed up with a permanent neurological sequela with mRS 4.

Aneurysm occlusion rates were reported in the range of 60% and 87.5% in immediate angiograms after Y-SAC treatment (5, 8, 19). In studies using open cell-open cell stent combination, Kubilay et al. (5), and Ciccio et al. (8) reported immediate complete occlusion rates of 83.3%, and 60%, respectively. In the closed cell-closed cell combination, Limbucci et al. (19) reported an immediate occlusion rate of 87.5%. In this study, we observed a complete occlusion rate (RROC I) of 86% and a near-complete occlusion rate (RROC II) of 14% in immediate angiograms. In the meta-analysis of Y-SAC treatment, Cognazzo et al. (7) reported the immediate complete occlusion rate as 82.2%. The long-term

occlusion rates were similar between the Enterprise, Neuroform, and LVIS stents. The rate of near-complete/complete occlusion was 95.4% with Enterprise, Neuroform, and LVIS stents (7). There were two recent reports for long-term Y-SAC and two Neuroform Atlas stents. Aydın et al. (5) reported a complete occlusion rate of 93.3%. In the latest study in the literature, Kim D (9) reported a complete occlusion rate of 73.3%, 6.7% neck remnant, and 20% incomplete occlusion. In our series, the complete occlusion rate (RROC I) was 92%, and the near-complete occlusion rate (RROC II) was 7% at the final DSA angiograms.

Recanalization rates are reported to be lower in SAC treatment because the stent facilitates aneurysm thrombosis (20). The recanalization rate was reported as 3% in the Cognazzo et al. (7) series. No recanalization was observed in our series. However, one patient was retreated because of the remaining RROC III grading on control angiograms. The patient underwent a second operation for coiling.

Limitations of the Study

It is single-center series and it is not a population-based study. The data were analyzed retrospectively. But the main limitation in our study is that the follow-up period of patients was limited to less than 3 years.

CONCLUSION

This study demonstrated that Y-SAC configuration deployment by low-profile Neuroform Atlas stents is feasible for treating challenging complex bifurcation aneurysms. This technique is safe and effective with high aneurysm occlusion rates, low complication, and low recurrence rates.

ETHICAL DECLARATIONS

Ethics committee approval: The study was initiated with the approval of the Adıyaman University Clinical Researches Ethics Committee (Date 6.01.2021, Decision No: 1358).

Informed consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Lopes DK, Johnson AK, Kellogg RG, Heiferman DM, Keigher KM. Long-term radiographic results of stent-assisted embolization of cerebral aneurysms. Neurosurgery 2014; 74: 286–91.
2. Cohen JE, Melamed I, Itshayek E. X-microstenting and transmesh coiling in the management of wide-necked tent-like anterior communicating artery aneurysms. J Clin Neurosci 2014; 21: 664–7.
3. Akmangit I, Aydın K, Sencer S, et al. Dual stenting using low-profile LEO baby stents for the endovascular management of challenging intracranial aneurysms. AJNR 2015; 36: 323–9.
4. Chow MM, Woo HH, Masaryk TJ, Rasmussen PA. A novel endovascular treatment of a wide-necked basilar apex aneurysm by using a Y-configuration, double-stent technique. AJNR 2004; 25: 509–12.
5. Aydin K, Balci S, Sencer S, Barburoglu M, Umutlu MR, Arat A. Y-stent-assisted coiling with low-profile Neuroform Atlas stents for endovascular treatment of wide-necked complex ıntracranial bifurcation aneurysms. Neurosurgery 2020; 87: 744–53.
6. Akgul E, Aksungur E, Balli T, et al. Y-stent-assisted coil embolization of wide-neck intracranial aneurysms. a single-center experience. Interv Neuroradiol 2011; 17: 36–48
7. Cagnazzo F, Limbucci N, Nappini S, et al. Y-stent-assisted coiling of wide-neck bifurcation intracranial aneurysms: a meta-analysis. AJNR 2019; 40: 122–8.
8. Ciccio G, Robert T, Smajda S, et al. Double stent-assisted coiling of intracranial bifurcation aneurysms in Y and X configurations with the Neuroform Atlas stent: immediate and mid-term angiographic and clinical follow-up. J NeuroIntervent Surg 2019; 11: 1239–42.
9. Kim D, Chung J. Y-stent-assisted coiling with Neuroform Atlas stents for wide-necked intracranial bifurcation aneurysms: A preliminary report. J Cerebrovasc Endovasc Neurosurg 2022; 24: 1–9.
10. Raymond J, Roy D. Safety and efficacy of endovascular treatment of acutely ruptured aneurysms. Neurosurgery 1997; 41: 1235–46.
11. Gory B, Spiotta AM, Mangiafico S, et al. Pulse rider stent-assisted coiling of wide-neck bifurcation aneurysms: periprocedural results in an international series. AJNR 2016; 37: 130–5.
12. Spiotta AM, Derdeyn CP, Tateshima S, et al. Results of the ANSWER trial using the pulse rider for treating broad-necked, bifurcation aneurysms. Neurosurgery 2017; 81: 56–65.
13. Chung J, Lim YC, Suh SH, et al. Stent-assisted coil embolization of ruptured wide-necked aneurysms in the acute period: incidence of and risk factors for periprocedural complications. J Neurosurg 2014; 121: 4–11.
14. Russo R, Bradac GB, Castellan L, et al. Neuroform Atlas stent-assisted coiling of ruptured intracranial aneurysms: a multicenter study. J Neuroradiol 2021; 48: 479–85.
15. Spiotta AM, Gupta R, Fiorella D et al. Mid-term results of endovascular coiling of wide-necked aneurysms using double stents in a Y configuration. Neurosurgery 2011; 69: 421–9.
16. Bartolini B, Blanc R, Pistocchi S, Redjem H, Piotin M. "Y" and "X" stent-assisted coiling of complex and wide-neck intracranial bifurcation aneurysms. AJNR 2014; 35: 2153–8.
17. Granja MF, Cortez GM, Aguilar-Salinas P, et al. Stent-assisted coiling of cerebral aneurysms using the Y-stenting technique: a systematic review and meta-analysis. J NeuroIntervent Surg 2019; 11: 683–9.
18. Goertz L, Smyk MA, Siebert E, et al. Low-profile laser-cut stents for endovascular treatment of intracranial aneurysms: incidence, clinical presentation and risk factors of thromboembolic events. Clin Neuroradiol 2021; 31: 107–15.
19. Limbucci N, Renieri L, Nappinin S, Consoli A, Rosi A, Mangiafico S. Y-stent assisted coiling of bifurcation aneurysms with Enterprise stent: long-term follow up. J NeuroIntervent Surg 2016; 8: 158–62.
20. Chalouhi N, Starke RM, Koltz MT, et al. Stent-assisted coiling versus balloon remodeling of wide-neck aneurysms: comparison of angiographic outcomes. AJNR 2013; 34: 1987–92.