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Real-World Angiographic and Clinical Outcomes of WEB, Coiling, and Stent-Assisted Coiling for Patients with Unruptured Saccular Intracranial Aneurysms: A Multicenter Study

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Abstract

INTRODUCTION

Endovascular treatment has become the dominant therapeutic approach for unruptured intracranial aneurysms. However, real world comparative data evaluating the relative safety and efficacy of coiling, stent-assisted coiling (SAC), and intrasaccular flow disruption with the Woven EndoBridge (WEB) device remain limited, particularly in Latin American populations.

MATERIALS AND METHODS

We conducted a retrospective multicenter study across high-volume neurointerventional centers in Colombia (January 2014–January 2025), including adults with unruptured saccular intracranial aneurysms treated with coiling, WEB, or SAC. Clinical, anatomical, procedural, angiographic, and functional outcomes were evaluated at 12 months. Bivariable and multivariable logistic regression analyses, a wide-neck subgroup analysis, and a temporal sensitivity analysis restricted to aneurysms treated from 2024 onward were performed.

RESULTS

A total of 377 patients with 410 aneurysms were included; mean age was 63.37 years, and 73.4% were women. SAC was used in 228 aneurysms, coiling with or without balloon assistance in 111, and WEB in 71. In the overall cohort, complete and adequate occlusion rates were 83.77% and 96.46% with SAC, 75.22% and 94.44% with coiling, and 67.60% and 71.42% with WEB, respectively. Retreatment rates were low and comparable ($p = 0.596$). Global ischemic complications differed among groups (SAC, 11.84%; coiling, 2.70%; WEB, 4.22%; $p = 0.006$), whereas hemorrhagic complications, morbidity, and functional outcomes did not. No evaluated patient or aneurysm characteristic was independently associated with complete or adequate occlusion in the multivariable models. In the contemporary sensitivity cohort ($n = 118$), between-group differences were not significant for complete occlusion ($p = 0.707$) or global ischemic complications ($p = 0.174$), whereas adequate occlusion remained different ($p = 0.023$).

CONCLUSIONS

Favorable functional outcomes were observed across all three strategies. In unadjusted overall-cohort comparisons, SAC had the highest occlusion rates and a higher rate of global ischemic complications; however, these differences were attenuated in the contemporary sensitivity analysis, except for adequate occlusion. Given nonrandom treatment allocation and anatomical heterogeneity, the findings should be interpreted as descriptive rather than as evidence of comparative superiority.

INTRODUCTION

Intracranial aneurysms are focal dilatations of the cerebral arteries and remain clinically relevant because of the potential for rupture, the burden of aneurysmal subarachnoid hemorrhage (aSAH), and the risks inherent to preventive treatment. With the widespread use of cross-sectional neuroimaging, most unruptured intracranial aneurysms are now detected incidentally; however, their natural history remains heterogeneous and is influenced by aneurysm size, location, morphology, and individual risk factors. (1, 2) Although aSAH represents only a minority of cerebrovascular events, it disproportionately affects younger patients than ischemic stroke and continues to carry substantial mortality, long term neurological disability, and healthcare cost. (2–4)

Over the last two decades, endovascular therapy has become the dominant treatment paradigm for many unruptured intracranial aneurysms, supported by lower early morbidity than microsurgical clipping in appropriately selected patients and by continuous expansion of endovascular technology.(2, 5) Within this therapeutic spectrum, three strategies are most frequently used in contemporary practice: simple coiling, stent-assisted coiling (SAC), and intrasaccular flow disruption with the Woven EndoBridge (WEB) device.

Simple coiling remains an established option, particularly in aneurysms with favorable sac to neck anatomy and is associated with a favorable periprocedural safety profile. (6) Its principal limitation, however, is durability in wide neck, morphologically complex, or larger aneurysms, in which recurrence and retreatment remain more frequent. (7–9) SAC was developed to overcome some of these limitations by providing neck scaffolding, reducing coil prolapse, and promoting progressive thrombosis and neointimal reconstruction across the aneurysm neck. Comparative studies and meta-analyses have shown improved angiographic durability and lower recurrence with SAC relative to coiling alone, although at the expense of greater technical complexity, longer procedural demands, and the need for dual antiplatelet therapy. (7, 8, 10)

The WEB device was introduced as an intrasaccular alternative for wide neck aneurysms, particularly bifurcation lesions, with the aim of achieving flow disruption without leaving a permanent implant within the parent artery, potentially reducing dependence on prolonged dual antiplatelet therapy. (11) Recent meta-analyses, matched comparisons, and multicenter series suggest that WEB can achieve angiographic outcomes comparable to coiling alone and SAC in selected cases, with low retreatment rates and potential advantages in thromboembolic profile, procedural duration, fluoroscopy exposure, and hospital stay. (11–16, 20)

Direct real-world comparisons among simple coiling, SAC, and WEB remain limited, particularly in Latin America. We therefore characterized 12-month angiographic, safety, and functional outcomes across these strategies in patients with unruptured saccular intracranial aneurysms treated at Colombian neurointerventional centers. Given the nonrandomized, clinically and anatomically driven treatment allocation, these comparisons were intended to characterize differences among treatment groups rather than establish the superiority of one technique over another.

MATERIALS AND METHODS

We conducted a retrospective multicenter cohort study at high-volume neurointerventional centers in Colombia between January 2014 and January 2025. This study was conducted in accordance with the Declaration of Helsinki, CIOMS ethical guidelines, and Colombian Resolution 8430 of 1993. Due to its retrospective nature, the requirement for written informed consent was waived, and data were obtained from anonymized clinical databases at each center. The study was approved by the institutional's research ethics committees.

Study Population

We included adults (≥ 18 years) diagnosed with unruptured saccular intracranial aneurysms at participating institutions and treated with endovascular management. Three treatment groups were analyzed according to the endovascular strategy used: WEB, coiling and SAC. Treatment allocation was based on clinical and anatomical considerations as well as operator decision.

Clinical and Aneurysms Variables

Baseline clinical variables included relevant patient comorbidities and prior medical history. Aneurysm characteristics were also recorded, including anatomical topography and a dichotomized classification into bifurcation aneurysms (middle cerebral artery bifurcation, carotid terminus, basilar tip, and anterior communicating artery) and lateral aneurysms (all other locations), as well as maximum size, dome-to-neck ratio, and aneurysm regularity.

Outcomes and Follow-up

Clinical follow-up was assessed at hospital discharge, 6 months, and 12 months after treatment. Functional outcomes were evaluated using the modified Rankin Scale (mRS). Angiographic outcomes, including aneurysm occlusion and recanalization, were assessed using the Raymond–Roy classification for coiling and SAC, and the WEB Occlusion Scale for WEB-treated aneurysms. Complete occlusion was defined as Raymond–Roy class I for coiling-based techniques and WEB Occlusion Scale grade A for WEB. Adequate occlusion was defined as Raymond–Roy classes I and II for coiling and SAC, and WEB Occlusion Scale grades A and B for WEB-treated aneurysms.

Safety Assessment

Adverse events were recorded during hospitalization and throughout the 12-month follow-up period. Ischemic complications were defined as device- or procedure-related events, including coil or intrasaccular device protrusion and stent thrombosis resulting in acute neurological deficit requiring thrombolytic management, and were further classified according to timing as intraprocedural,

periprocedural (within 30 days after treatment), delayed and global events. Hemorrhagic complications were defined as intraprocedural aneurysm or vessel rupture resulting in subarachnoid or intraparenchymal hemorrhage and were classified as intraprocedural or early periprocedural, defined as occurring within 72 hours after treatment. Morbidity and mortality analysis were also performed between treatment groups.

Statistical analysis

Continuous variables were summarized as mean (SD) or median (IQR), according to Kolmogorov–Smirnov testing; categorical variables as counts and percentages. Across-group comparisons used one-way ANOVA or Kruskal–Wallis tests for continuous variables and chi-square or Fisher exact tests for categorical variables, as appropriate. Bivariable and multivariable logistic regression evaluated associations of aneurysm type (bifurcation versus side-wall), age, smoking, alcohol consumption, dome-to-neck ratio, and regularity with complete and adequate occlusion. Variables showing potential bivariable associations were included in multivariable models. Analyses also included a wide-neck subgroup and a contemporary sensitivity cohort restricted to aneurysms treated from 2024 onward, using the same outcomes and statistical methods. Significance was set at $\alpha = .05$. Data were managed in Microsoft Excel Office LTSC Professional Plus 2021 and analyzed in Stata 16.

RESULTS

We included 377 patients with 410 aneurysms. (Fig. 1) Mean age was 63.37 years (range, 23–87), and 73.4% were women (Supplemental Table 1). A family history of aneurysms was present in 94 patients (22.8%), and 6.5% had a prior history of aSAH. Smoking was more frequent in the WEB group (39.43%) than in the coiling (16.21%) and SAC groups (19.73%) ($p = 0.0004$), as was alcohol use (9.85%; $p = 0.006$). Mean age was higher in the WEB group, without significant differences ($p = 0.08$) (Table 1).

Aneurysm Characteristics

Multiple aneurysms were identified in 169 patients (41.2%): 26.7% had two aneurysms, 8.8% had three, and 5.9% had more than three. The most common locations were MCA (35.77%), AComA (23.11%), ICA-T (9.25%), PComA (8.27%), and ophthalmic ICA (7.79%) (Supplemental Table 1). MCA aneurysms were more frequent in the SAC (43.1%) and WEB (38%) groups, ophthalmic aneurysms in the coiling group, and posterior circulation aneurysms in the WEB group. Aneurysm topography differed significantly among groups ($p < 0.0001$) (Table 1).

The dome-to-neck ratio was lower in the SAC group ($p = 0.047$), whereas irregular aneurysms were more frequent in the WEB group (61.97%; $p < 0.0001$). Overall, 50% of aneurysms measured < 5 mm, 41.7% measured 5–10 mm, and 8.2% measured 11–25 mm (Supplemental Table 1). No differences were observed in aneurysm size ($p = 0.236$), longitudinal diameter, transverse diameter, or neck size (Table 1).

Procedural and Therapeutic Approach

SAC was the most common treatment (55.61%), followed by coiling (27.07%) and WEB (17.32%) (Supplemental Table 1). Among stent-assisted procedures, Neuroform Atlas (31.72%), Leo Baby (25.11%), and Solitaire (18.50%) were the most frequently used stents. Femoral access predominated (89.54% vs. 10.46% radial) and differed among groups ($p = 0.0044$), with radial access used more frequently in the WEB group (21.12%) (Table 1).

Antiplatelet therapy

Antiplatelet regimens differed significantly among groups ($p < 0.0001$). Aspirin plus clopidogrel was the most common regimen (51.4%), followed by aspirin plus ticagrelor (19.5%), aspirin monotherapy (14.1%), no antiplatelet therapy (10.2%), and ticagrelor monotherapy (2.9%). In the SAC group, aspirin plus clopidogrel (69.73%) and aspirin plus ticagrelor (25.43%) predominated. In the WEB group, aspirin plus clopidogrel (29.57%) and aspirin monotherapy (25.35%) were most common. No antiplatelet therapy was used in 23.94% of WEB cases and 22.52% of coiling cases (Table 1).

VerifyNow testing was performed in 158 patients (mean 138.5 PRU) and was more common in the SAC group. Mean PRU values did not differ significantly among groups; the lowest values were observed in SAC (135.5, 95% CI 125.6–145.4) and the highest in coiling (162.2, 95% CI 116.4–207.9).

Table 1
Baseline Demographic, Clinical, and Aneurysm Characteristics Across Treatment Groups

Variable	Coiling (n = 111) (%)	WEB device (n = 71) (%) (CI 95%)	Sent-assisted coiling (n = 228) (%) (CI 95%)	P value
Age	64.27(61.76–66.79)	65.52(63.00-68.03)	62.29(60.81–63.77)	0.087
Sex				
Female	81 (72.97)	45 (63.38)	175 (76.75)	0.083
Male	30 (27.02)	26 (36.61)	53 (23.24)	
Medical history				
Hypertension	54 (48.64)	45 (63.38)	133 (58.33)	0.107
Diabetes mellitus	11 (9.90)	8 (11.26)	27 (11.84)	0.869
Smoking	18 (16.21)	28 (39.43)	45 (19.73)	**< 0.001**
Alcoholism	4 (3.60)	7 (9.85)	4 (1.75)	**0.006**
Family history of aneurysm	31 (27.92)	8 (11.26)	55 (24.12)	**0.02**
Previous aSAH	6 (5.40)	3 (4.22)	18 (7.89)	0.46
Multiple aneurysms				0.80
2 aneurysms	29 (26.12)	21 (29.57)	59 (25.99)	
3 aneurysms	10 (9.00)	7 (9.85)	19 (8.37)	
>3 aneurysms	9 (8.10)	5 (7.04)	10 (4.40)	
Aneurysm Type				
Bifurcation	62 (55.86)	54 (76.06)	181 (79.39)	**< 0.001**
Side-wall	49 (44.14)	17 (23.94)	47 (20.61)	
Location				
Anterior circulation				
MCA	21 (18.91)	27 (38.02)	98 (43.17)	**< 0.001**
ACA	11 (9.90)	6 (8.45)	16 (7.04)	
AComA	15 (13.51)	10 (14.08)	49 (21.58)	

Variable	Coiling (n = 111) (%)	WEB device (n = 71) (%) (CI 95%)	Sent-assisted coiling (n = 228) (%) (CI 95%)	P value
Ophthalmic ICA	10 (9.00)	10 (14.08)	7 (3.08)	
Anterior choroidal artery	8 (7.20)	0 (0)	5 (2.20)	
Cavernous ICA	3 (2.70)	1 (1.40)	1 (0.44)	
Terminal ICA	8 (7.20)	1 (1.40)	4 (1.76)	
Pericallosal artery	0 (0)	1 (1.40)	0 (0)	
Posterior circulation				
Vertebral artery	24 (21.62)	3 (4.22)	29 (12.77)	
Basilar trunk	7 (6.30)	2 (2.81)	2 (0.88)	
Basilar tip	2 (1.80)	8 (11.26)	10 (4.40)	
SCA	0 (0)	2 (2.81)	0 (0)	
PCA	0 (0)	0 (0)	1 (0.44)	
Other	1 (0.90)	0 (0)	1 (0.44)	
Morphology				
Regular	78 (70.27)	27 (38.02)	148 (65.19)	**< 0.001**
Irregular	33 (29.72)	44 (61.97)	79 (34.80)	
Measurements				
Width (mm)	5.00 (4.46–5.54)	5.52 (5.04–6.00)	5.20 (4.84–5.56)	0.43
Height (mm)	5.48 (4.82–6.14)	5.36 (4.83–5.89)	4.99 (4.58–5.40)	0.34
Neck diameter (mm)	3.69 (3.05–4.33)	4.18 (3.61–4.75)	4.11 (3.76–4.46)	0.36
Dome-to-neck ratio	1.58 (1.41–1.75)	1.51 (1.37–1.64)	1.37 (1.26–1.47)	**0.04**
Size				
<5 mm	58 (53.21)	30 (42.85)	114 (50.66)	0.23
5–10 mm	40 (36.69)	37 (52.85)	92 (40.88)	
11–25 mm	11 (10.09)	3 (4.28)	19 (8.44)	

Variable	Coiling (n = 111) (%)	WEB device (n = 71) (%) (CI 95%)	Sent-assisted coiling (n = 228) (%) (CI 95%)	P value
Vascular access Approach				
Radial	11 (9.90)	15 (21.12)	17(7.45)	**0.004**
Femoral	100 (90.09)	56 (78.87)	211 (92.54)	
Antiplatelet scheme				
Aspirin (ASA)	35 (31.53)	18 (25.35)	5 (2.19)	**< 0.001**
Clopidogrel	4 (3.60)	2 (2.81)	1 (0.43)	
Ticagrelor	0 (0)	7 (9.85)	5 (2.19)	
Aspirin + Clopidogrel	31 (27.92)	21 (29.57)	159 (69.73)	
Aspirin + Ticagrelor	16 (14.41)	6 (8.45)	58 (25.43)	
Not used	25 (22.52)	24 (33.80)	0 (0)	
VerifyNow (mean P.R.U)	162.2(116.4-207.9)	121.5(87.47–155.5)	135.5(125.6-145.4)	0.10

ACA: *anterior cerebral artery;* **AComA**: *anterior communicating artery;* **aSAH**: *aneurysmal subarachnoid hemorrhage;* **ASA**: *acetylsalicylic acid;* **ICA**: *internal carotid artery;* **MCA**: *middle cerebral artery;* **PCA**: *posterior cerebral artery;* **PRU**: *P2Y12 reaction units;* **SCA**: *superior cerebellar artery.*

Angiographic follow up at 12 months

Angiographic outcomes differed among groups for complete ($p = 0.0087$) and adequate occlusion ($p < 0.001$). Complete occlusion was highest with SAC (83.77%), followed by coiling (75.22%) and WEB (67.60%). Adequate occlusion rates were 96.46%, 94.44%, and 71.42%, respectively. Retreatment rates were low and comparable (3.60%, 4.22%, and 2.19%; $p = 0.596$). Among recanalized aneurysms, 10/12 (83.3%) measured > 5 mm, including five in the SAC group, four in the coiling group, and one in the WEB group (Table 2).

In the wide-neck subgroup, complete occlusion rates were similar for SAC (85.71%) and coiling (84.21%; n = 19), but lower with WEB (57.14%; $p = 0.019$). Adequate occlusion showed a similar pattern (96.43%, 94.74%, and 61.90%, respectively; $p < 0.001$).

Multivariable logistic regression analysis

Given that aneurysm characteristics may influence both treatment selection and angiographic outcomes, bivariable and multivariable logistic regression analyses were performed separately for complete occlusion and adequate occlusion. The variables evaluated included aneurysm type (bifurcation vs. side-wall), age, smoking status, alcohol consumption, dome-to-neck ratio, and aneurysm regularity. Few variables showed associations in the bivariable analyses, but none remained statistically significant after adjustment. Therefore, no independent predictors of complete or adequate occlusion were identified.

Complications

Ischemic complications occurred in 33 patients (8.03%), including 24 intraoperative (5.84%), seven early perioperative (1.70%), and two late perioperative events (0.49%). The two late events occurred in the SAC and coiling groups under dual antiplatelet therapy. Hemorrhagic complications included hematoma in three patients (0.73%) and subarachnoid hemorrhage in four (0.9%); Fisher grades III and IV were observed in two patients each (0.49%) (Supplemental Table 1). No differences were found in hemorrhagic complications ($p = 0.836$), cerebral edema ($p = 0.513$), or overall morbidity ($p = 0.143$) (Table 2). Intraoperative ischemic complications showed a trend toward significance ($p = 0.066$), being more frequent in the SAC group (8.77%). Global ischemic complications were significantly higher in SAC (11.84%) than in coiling (2.70%) and WEB (4.22%) ($p = 0.006$). Hospital stay also differed significantly ($p = 0.0011$), being longest in the coiling group (5.21 days) and shortest in the WEB group (2.82 days).

Clinical outcomes

At discharge, 96.81% of patients had mRS ≤ 2. At 6 months, 96.81% maintained favorable outcomes (mRS ≤ 2). At 12 months, 97.49% had mRS ≤ 2, including mRS 0 (71.03%), mRS 1 (22.28%), and mRS 2 (4.18%). Two deaths (0.49%) occurred during follow-up (Supplemental Table 2).

Table 2
Efficacy and Safety Outcomes at 12-Month Follow-up by Treatment Group

Efficacy Variables	**Coiling n = 111 (%)**	**WEB device n = 71 (%)**	**Sent-assisted coiling n = 228 (%)**	**P value**
Anatomic results				
Complete occlusion	82 (75.22)	48 (67.60)	191 (83.77)	**0.008**
Adequate occlusion	102 (94.44)	50 (71.42)	218 (96.46)	**< 0.001**
Unstable recanalization (requiring reintervention)	4 (3.60)	3 (4.22)	5 (2.19)	0.59
Anatomic results (Wide Neck Subanalysis) n = 91	**Coiling n = 19 (%)**	**WEB n = 21 (%)**	**Coils + Stent n = 56 (%)**	**P value**
Complete occlusion	16 (84.21)	12 (57.14)	48 (85.71)	**0.01**
Adequate occlusion	18 (94.74)	13 (61.90)	54 (96.43)	**< 0.001**
Unstable recanalization (requiring reintervention)	1 (5.26)	0 (0.00)	2 (3.57)	0.60
Safety Variables	**Coiling n = 111 (%)**	**WEB n = 71 (%)**	**Coils + Stent n = 228 (%)**	**P value**
Ischemic				
Intraoperative	2 (1.8)	2 (2.8)	20 (8.8)	0.06
Early periprocedural	1 (0.9)	0 (0.0)	6 (2.6)	
Late periprocedural	0 (0.0)	1 (1.4)	1 (0.4)	
Global ischemic	3 (2.7)	3 (4.2)	27 (11.8)	**0.006**
Hemorrhagic				
Intraoperative	0 (0.0)	0 (0.0)	4 (1.8)	0.38
Early periprocedural	1 (1.2)	0 (0.0)	0 (0.0)	
Global hemorrhagic	1 (1.2)	0 (0.0)	4 (1.8)	0.83

Efficacy Variables	Coiling n = 111 (%)	WEB device n = 71 (%)	Sent-assisted coiling n = 228 (%)	P value	
Anatomic results					
Hemorrhagic complications (detailed)					
Hematoma	1 (0.9)	0 (0.0)	2 (0.9)	0.72	
Subarachnoid hemorrhage	0 (0.0)	0 (0)	4 (1.8)		
Fisher grade 2	0 (0.0)	0 (0)	0 (0.0)		
Fisher grade 3	0 (0.0)	0 (0.0)	2 (0.9)		
Fisher grade 4	0 (0.0)	0 (0.0)	2 (0.9)		
Cerebral edema	0 (0.0)	0 (0)	2 (0.9)	0.51	
Global Morbidity	1 (0.90)	0 (0)	10 (4.38)	0.14	

Temporal sensitivity analysis

In the temporal sensitivity analysis restricted to aneurysms treated from 2024 onward, 118 aneurysms were included: 35 treated with coiling, 38 with WEB, and 45 with SAC. Complete occlusion rates were 85.71%, 78.95%, and 84.44%, respectively (p = 0.707), while adequate occlusion rates were 100.00%, 86.49%, and 97.78% (p = 0.023). Retreatment rates remained low and comparable across groups (2.86%, 0.00%, and 2.22%; p = 0.752). Global ischemic complications were numerically more frequent with SAC (11.11%) than with coiling (2.86%) or WEB (2.63%), although the difference was not statistically significant (p = 0.174). Global hemorrhagic complications and morbidity also did not differ significantly among groups (Supplemental Table 3).

DISCUSSION

General results

Our cohort reflects contemporary neurointerventional practice, with a predominance of women, frequent aneurysm multiplicity, anterior circulation lesions, and anatomical heterogeneity across treatment groups. These findings are consistent with current epidemiological data. (1) Differences in aneurysm location and morphology indicate that treatment allocation was anatomy driven. The higher proportion of smokers and irregular aneurysms in the WEB group likely reflects treatment of more complex lesions. Therefore, these findings should be interpreted as a real-world comparative analysis of outcomes across treatment groups rather than as evidence of direct device superiority.

Antiplatelet therapy

Antiplatelet therapy followed the expected requirements of each strategy. Dual antiplatelet therapy was concentrated in the SAC group, whereas absence of antiplatelet therapy was observed at similar frequencies in the WEB and coiling groups. This distribution is consistent with current literature, as intraluminal scaffolds require systematic platelet inhibition, whereas intrasaccular flow disruption reduces dependence on prolonged dual antiplatelet therapy. Consequently, avoidance of mandatory prolonged dual antiplatelet therapy remains one of the main practical advantages of WEB over stent-assisted techniques. (11, 12)

Angiographic outcomes

At 12-month follow-up, higher complete and adequate occlusion rates were observed among aneurysms treated with SAC than among those treated with coiling or WEB. This pattern is consistent with previous studies reporting an association between SAC and higher angiographic occlusion rates in wide-neck aneurysms.similarly, (17). Although Nabizadeh et al. did not find a statistically significant difference between SAC and coiling (RR 1.13, 95% CI 0.87–1.39; P = 0.08), complete occlusion rates were numerically higher with SAC. (18) Similarly, in our cohort, higher complete (83.77% vs. 75.22%) and adequate occlusion rates (96.46% vs. 94.44%) were observed among aneurysms treated with SAC compared with those treated with coiling. In the temporal sensitivity analysis differences in complete occlusion were no longer statistically significant (p = 0.707), whereas the difference in adequate occlusion persisted (p = 0.023).

Recent WEB studies have reported 1-year occlusion outcomes generally more favorable than those observed in our cohort, and meta-analyses have suggested noninferiority compared with coil-based approaches in selected anatomies. (10, 13, 14). In WEB-IT, the 5-year complete occlusion rate was 67.5%, similar to our findings, although adequate occlusion rates were higher. (18) Likewise, WEBCAST-2 reported lower complete occlusion (54%) but higher adequate occlusion (80%) than our cohort. (19)

The lower adequate occlusion rate observed in our WEB group should not be interpreted as evidence of device inferiority but rather as a finding likely influenced by case selection and anatomical complexity. Notably, despite intergroup differences in occlusion, unstable recanalization requiring retreatment remained low and comparable across the three techniques, suggesting that the angiographic disadvantage of WEB did not translate into a substantially greater short-term reintervention burden within 12 months. In our cohort, three patients required intraprocedural rescue stenting due to WEB device protrusion (Fig. 2), further indicating that WEB cases in our cohort were more challenging.

Wide neck sub analysis

After restricting the comparison to wide neck aneurysms, SAC preserved high complete and adequate occlusion rates, and the coiling group also performed well, although in a substantially smaller sample, which was expected, as all cases corresponded to balloon assisted coiling. A specific meta-analysis comparing coiling and SAC in wide neck aneurysms showed significantly higher occlusion rates at final follow-up with SAC, although at the cost of higher overall and ischemic complication rates (17). In this

subgroup, SAC was the only technique associated with ischemic thromboembolic complications (8.92%), whereas no such events were observed in the coiling group, and neither technique showed hemorrhagic complications.

In the wide-neck subgroup, lower complete and adequate occlusion rates were observed among WEB-treated aneurysms. This finding differs from some recent matched comparisons of unruptured wide-neck bifurcation aneurysms, in which WEB and SAC achieved similar short-term angiographic results, and from recent literature reporting comparable follow-up occlusion outcomes for WEB in selected wide neck lesions. (11, 12) The most plausible explanation is that neck width alone does not fully homogenize aneurysm complexity. Branch incorporation, bifurcation geometry, neck configuration, and irregular sac morphology likely remain decisive determinants of treatment performance, particularly for intrasaccular flow disruption. This interpretation is also supported by recent multicenter analyses showing that morphological complexity and selected baseline factors are associated with incomplete occlusion after WEB treatment. (12, 13) Thus, our data suggests that wide neck characteristic should not be considered a sufficient surrogate for anatomical equivalence across endovascular modalities, and that lesion selection remains critical when WEB is chosen.

Complications

No significant between-group differences were observed in timing-specific ischemic events, hemorrhagic complications, vasospasm, edema, or overall morbidity. However, global ischemic events were more frequent with SAC (11.84%) than coiling (2.70%) or WEB (4.22%; P=.006). Unlike our findings, Nabizadeh et al. found no significant difference between SAC and coiling for unruptured aneurysms (RR, 1.39; 95% CI, 0.81–1.97) (18). SAC events were predominantly thromboembolic and related to in-stent thrombosis.

Among SAC-treated patients, two with thrombophilia developed intraprocedural thrombosis, one with residual hemiparesis. Another patient had incomplete Leo stent expansion requiring parent-vessel occlusion after balloon occlusion testing, and an MCA in-stent occlusion required thrombectomy (TICI 3) but resulted in severe residual deficits. Early ACA occlusion responded to tirofiban, while chronic stent occlusion at 1 year remained asymptomatic because of collateral flow. Other distal or in-stent thrombi and slow-flow events resolved after intra-arterial or intravenous tirofiban. Overall, only two SAC ischemic events caused clinically significant morbidity (Fig. 2).

Three ischemic events occurred after coiling: a small neck thrombus treated with tirofiban, precentral and postcentral artery thrombosis treated with thrombectomy (TICI 3), and a minor ischemic stroke treated with tirofiban; none caused residual deficit. No hemorrhagic events occurred with WEB; rates were 1.75% with SAC and 1.17% with coiling, lower than previously reported (12, 16, 18). SAC included two fatal events—aneurysm rupture requiring carotid occlusion and distal ICA rupture after stent deployment—and two nonfatal ruptures with residual morbidity. The single coiling-related intraparenchymal hemorrhage required drainage without lasting deficit.

Three WEB ischemic events were related to device displacement and small thrombus, without residual functional sequelae. This pattern suggests a potential trade-off between higher angiographic occlusion with SAC and lower ischemic and hospital burden with WEB. Treatment should therefore be individualized according to aneurysm morphology, bifurcation anatomy, antiplatelet tolerance, and the relative priority of angiographic durability versus procedural simplicity.

Clinical outcomes

These outcomes were excellent across all treatment groups, with favorable functional status in more than 96% of patients and low mortality. The absence of meaningful differences in mRS distribution suggests that all three strategies can achieve highly favorable outcomes when performed in experienced centers. This finding is consistent with contemporary series showing that differences between modalities are more evident in angiographic durability, antiplatelet requirements, and procedural metrics than in disability or mortality. (11, 12, 15) Therefore, treatment selection should focus on balancing anatomical efficacy, pharmacological burden, and procedural risk.

Interpretation of Findings and Residual Confounding

This multicenter real-world study describes the efficacy and safety outcomes of three endovascular techniques in a population underrepresented in previous registries. The findings should not be interpreted as direct comparisons of treatment effectiveness, given the nonrandom treatment allocation and differences in aneurysm anatomy and center-level practice. Bivariate analyses were conducted to evaluate measured anatomical differences; however, no variables met the prespecified criteria for inclusion in a multivariable model. A temporal sensitivity analysis was also performed to examine changes in practice over time. In the temporal analysis, differences in complete occlusion and ischemic complications were attenuated and no longer statistically significant, whereas the difference in adequate occlusion persisted. Residual confounding related to treatment selection, unmeasured anatomical factors, and center or operator practices remains possible. These results may help inform the design of future prospective studies and randomized trials focused on identifying which clinical and aneurysm characteristics are most relevant when selecting the safest and most effective treatment strategy.

CONCLUSION

All three endovascular treatment strategies achieved favorable functional outcomes and low rates of disability and mortality at 12 months. Differences in angiographic occlusion and ischemic complications were observed across treatment groups; however, these differences were attenuated in the contemporary sensitivity analysis, except for adequate occlusion. These findings likely reflect treatment selection, aneurysm complexity, and routine clinical practice and should not be interpreted as evidence of the comparative superiority of any technique.

Abbreviations

ACA: anterior cerebral artery; AComA: anterior communicating artery; aSAH: aneurysmal subarachnoid hemorrhage; ASA: acetylsalicylic acid; CI: confidence interval; CIOMS: Council for International Organizations of Medical Sciences; ICA: internal carotid artery; MCA: middle cerebral artery; mRS: modified Rankin Scale; PCA: posterior cerebral artery; PRU: P2Y12 reaction units; SAC: stent-assisted coiling; SCA: superior cerebellar artery; WEB: Woven EndoBridge.

Declarations

Limitations

The retrospective design, nonrandom treatment selection, anatomical differences between groups, and the use of device-specific occlusion scales, which limit direct comparisons. Despite subgroup and temporal sensitivity analyses, residual confounding remains possible. Prospective randomized controlled trials studies are needed to confirm these findings.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki, the ethical guidelines of the Council for International Organizations of Medical Sciences (CIOMS), and Colombian Resolution 8430 of 1993. The study was approved by the institutional research ethics committees of Fundación Oftalmológica de Santander – FOSCAL, Fundación Valle del Lili, and Fundación Santa Fe de Bogotá. Due to the retrospective nature of the study, the requirement for written informed consent was waived. Data were obtained from anonymized clinical databases at the participating centers.

Consent for publication

No applicable

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Author Contributions Statement

B.L.C. and C.A.L.N. prepared the initial manuscript and contributed to data organization, analysis, and interpretation of the findings. D.M. provided overall scientific supervision. D.M., O.V., and C.A.F.P. critically revised the manuscript for important intellectual content. C.A.L.N. and A.J.C.I. contributed to manuscript review and revision. C.A.B., M.F.E.O., O.E.G.L., V.M.Q., W.A.P.G., A.H.R., J.A.M., L.O., I.A.B.B., B.L.P.G., M.G.V.G., F.B., J.A.M.O., V.T., M.C., S.S., J.J.L.J., S.M., and A.F.O.G. contributed to data collection and review. All authors reviewed and approved the final manuscript and agree to be accountable for the work.

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Figures

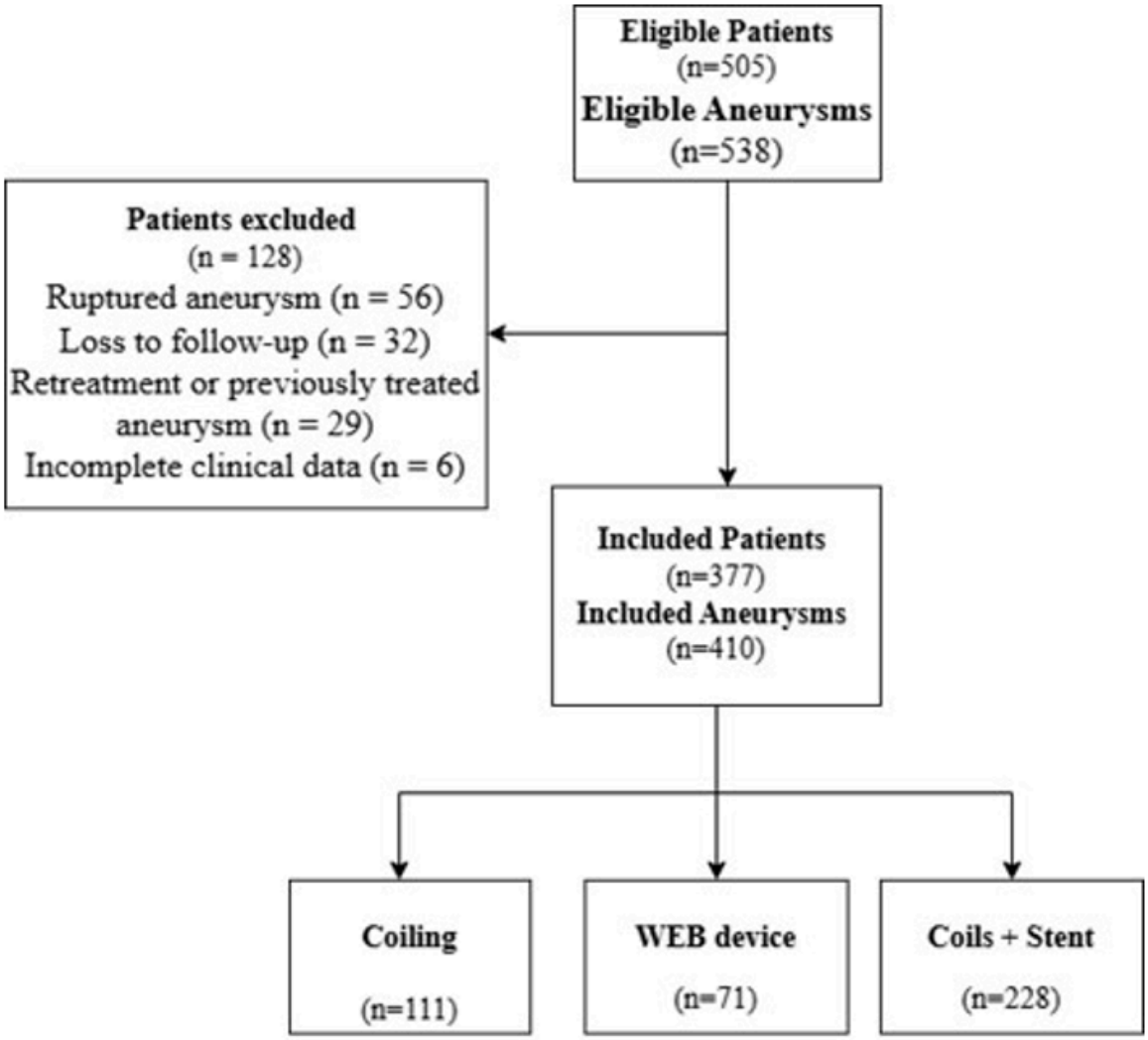


Figure 1

Study flow diagram. The final analysis was performed at the aneurysm level and included 410 aneurysms from 377 patients.

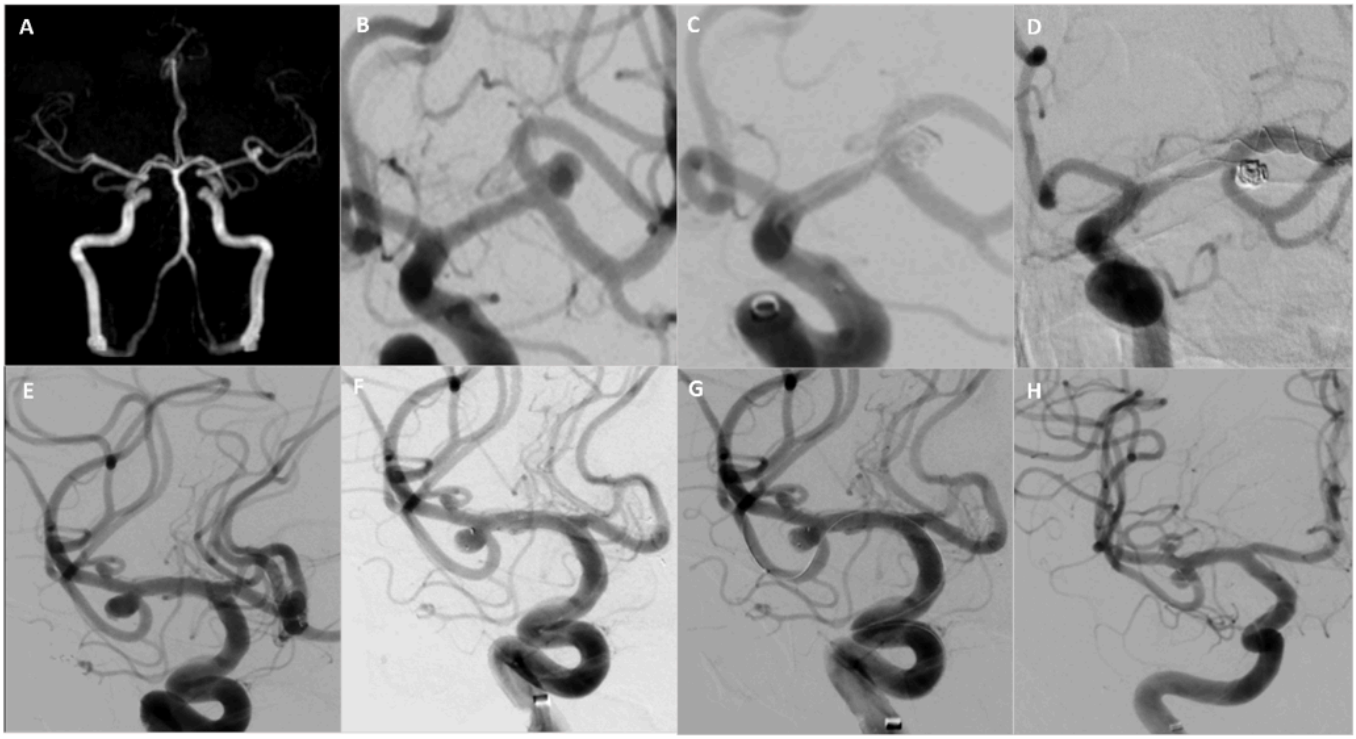


Figure 2

Representative procedural complications and rescue management during endovascular treatment of unruptured intracranial aneurysms. (A–D) A 66-year-old woman with a left MCA bifurcation aneurysm treated with stent-assisted coiling. Partial in-stent thrombosis and incomplete distal stent expansion occurred during the procedure and were successfully managed with intra-arterial tirofiban and angioplasty, resulting in durable aneurysm occlusion at 2-year follow-up. (E–H) A 55-year-old woman with a right MCA bifurcation aneurysm treated with a WEB device. Device protrusion into the inferior MCA division required rescue stent placement, achieving preservation of parent vessel patency and satisfactory aneurysm occlusion.

Supplementary Files

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