ORIGINAL RESEARCH

WEB embolization versus stent-assisted coiling: comparison of complication rates and angiographic outcomes

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Received 5 November 2018
Revised 27 December 2018
Accepted 29 December 2018
Published Online First 23 January 2019

To cite: Kabbasch C, Goertz L, Siebert E, *et al*. *J NeuroIntervent Surg* 2019;**11**:812–816.

ABSTRACT

Background Intrasaccular flow disruption represents a new paradigm in endovascular treatment of wide-necked bifurcation aneurysms.

Objective To perform a matched case–control study comparing complications and angiographic outcome using the Woven Endobridge (WEB) device and stent-assisted coiling (SAC).

Methods Sixty-six patients treated with the WEB at three German tertiary care centers were included and matched with 66 patients treated with SAC based on aneurysm location and unruptured/ruptured aneurysm status. Parameters were retrospectively analysed and compared between the treatment groups using inverse probability of treatment weighting (IPTW) with propensity scores.

Results Procedural complication rates were 12.1% in the WEB group and 21.2% in the SAC group, which was statistically significant after IPTW adjustment (OR=2.2, 95% CI 1.08 to 4.4, p=0.03). Favourable outcome (modified Rankin scale score ≤2) was achieved by 57/66 (86.4%) in the WEB group and 57/66 (86.4%) in the SAC group (p=1.0). At mid-term follow-up, a similar number of aneurysms achieved adequate occlusion (complete occlusion or neck remnant) in the WEB group (93.9%) and in the SAC group (93.9%, p=1.0). Re-treatment was performed in 10.6% after WEB embolization and 12.1% after SAC (p=1.0).

Conclusions The WEB provides similar mid-term aneurysm occlusion rates to those of SAC, with no additional morbidity and potentially lower complication rates. Long-term outcome analysis will provide a definite conclusion on the use of WEB for intracranial aneurysms.

INTRODUCTION

Intrasaccular flow-disruption represents a new paradigm in the endovascular treatment of wide-necked and bifurcation aneurysms.[1–3] The Woven Endobridge (WEB; Sequent Medical, Aliso Viejo, California, USA) is an intrasaccular device consisting of a dense nitinol mesh that provides immediate flow disruption through the aneurysm ostium, resulting in subsequent thrombosis of the aneurysm sac.[4] After detachment of the device from the microcatheter, the WEB seals the aneurysm neck and leaves the parent artery unaffected. Therefore, long-term antiplatelet therapy is not mandatory after treatment. Owing to these properties, the WEB is suitable for a broad range of aneurysms, including wide-necked, bifurcation, and ruptured aneurysms.[2 5]

Although introduction of the WEB is relatively recent, experience with this device is rapidly increasing.[5–7] In the available studies, the WEB is predominantly used for wide-necked and bifurcation aneurysms, which are typically challenging to treat by conventional endovascular means.

Stent-assisted coiling (SAC) is an established technique for endovascular aneurysm therapy that has been explored for many years.[8 9] Intracranial stents act as a scaffold for coils and improve the neck coverage, allowing for a dense aneurysm packing. Typically, stents are used for wide-necked aneurysms with an unfavourable dome-to-neck ratio to prevent coil protrusion into the parent artery.[9] Previous research has shown that SAC is associated with more durable aneurysm obliteration than stand-alone coiling[9 10]; however, complication and morbidity rates may be slightly increased with SAC.[11] The need for long-term antiplatelet therapy is a further limitation of this technique.[12]

Although the safety and efficacy of WEB and SAC have been evaluated in numerous studies, a comparative analysis of these two techniques has yet to be published.

We present the results of a matched case–control study comparing WEB and SAC in a similar subset of ruptured and unruptured intracranial aneurysms, describing complication rates, clinical outcomes, angiographic results, and net material costs. To avoid a potential selection bias, we performed an inverse probability of treatment weighting (IPTW) approach using propensity scores.

METHODS

This is a retrospective analysis of consecutive patients treated with the WEB or SAC at three German high-volume neurovascular centers within a 7-year period (January 2011 to February 2018). According to the institutional guidelines, no ethics committee approval was required for this retrospective study.

Inclusion and exclusion criteria

Inclusion criteria were as follows: (1) successful aneurysm treatment by WEB or SAC; (2) aneurysm size 3–11 mm (3) location at the anterior communicating artery (AcomA), middle cerebral artery (MCA), internal carotid artery (ICA), or

basilar artery (BA); (4) patient age >18 years; (5) unruptured or ruptured aneurysm status; and (6) at least one available angiographic follow-up. Patients with (1) partially thrombosed aneurysms; (2) fusiform aneurysms (3) dissecting aneurysms; (4) multiple aneurysms treated during one session; and (5) combined treatment by WEB and stent implantation were excluded from the analysis.

At our institutions, we identified a total of 122 aneurysms treated with the WEB and 265 treated with SAC during the study period. Sixty-six aneurysms treated with the WEB met the inclusion criteria and were included in the analysis. Blinded to outcome and using coded data, these patients were matched in a 1:1 fashion with 66 SAC patients on the basis of aneurysm location and unruptured/ruptured aneurysm status.

Procedure

All treatment indications were made within an interdisciplinary team consisting of neurointerventionalists and neurosurgeons and after discussion with the patient. At our institutions, the WEB was predominantly used for wide-necked and bifurcation aneurysms with an unfavourable configuration for conventional coiling as an alternative for stent-assisted approaches or surgery. The decision to use WEB treatment was left to the neurointerventionalist's discretion and also depended on patient preference.

All procedures were performed through a transfemoral approach with the patient under general anesthesia in a biplane angiosuite (Philips, Best, the Netherlands and Siemens, Erlangen, Germany). The WEB was delivered through a dedicated VIA microcatheter (Sequent Medical, Aliso Viejo, California, USA) in the majority of cases.

The appropriate WEB size was selected according to the aneurysm width and height as measured on two-dimensional DSA images. Implant sizes were chosen to be slightly larger than the aneurysm equator diameter as recommended in the instructions for use. Adjunctive coiling was used in selected cases to provide optimal aneurysm occlusion.

Stents were deployed through a convenient microcatheter (Headway 17, Microvention, Tustin, California, USA or Prowler Select Plus, Raynham, Massachusetts, USA) using a triaxial guide-catheter system. The number of stents, stent type, and adjunctive use of coils was left to the operator's discretion. For SAC, two different techniques were applied. The standard approach consisted of deployment of a microstent across the aneurysm neck, followed by probing the aneurysm sac with a microcatheter through the stent interstices, and final coil embolization. Furthermore, the microcatheter jailing technique was used, in which the stent is deployed after microcatheterization of the aneurysm sac by an additional microcatheter and before coil deployment. Bifurcation aneurysms were treated either with a single stent, which is placed across the branching vessels, or with two stents using the Y-stent technique.

Antiaggregation therapy

In scheduled cases of unruptured aneurysm treatment, a bolus of heparin (5000 IU) was administered after groin puncture, followed by aliquots of 1000 IU/hour. Heparin was discontinued at the end of the procedure. Activated clotting time measurements were not performed routinely.

Patients undergoing elective WEB treatment received acetylsalicylic acid (ASA) 100 mg/day starting 5–7 days before the procedure and ASA monotherapy was continued for a minimum of 4–6 weeks. In SAC, a daily dual antiplatelet regimen with ASA 100 mg and clopidogrel 75 mg was initiated 5–7 days before treatment and continued for at least 4 months after the procedure. Thereafter, ASA monotherapy was continued life-long.

In patients with ruptured aneurysms treated with SAC, tirofiban (Aggrastat, Merck, New York, USA) was administered according to the manufacturer`s guidelines, starting promptly before stent placement and continued for 16–24 hours after the procedure, followed by a loading dose of ASA (500 mg) and clopidogrel (300 mg). Maintenance antiplatelet therapy was continued as described above for unruptured aneurysms. In patients with ruptured aneurysms treated with WEB only, no antiplatelets were administered.

In scheduled cases, platelet inhibition was tested with ASA and additionally, P2Y12 assays where required (VerifyNow, Accumetric, San Diego, California, USA). A platelet inhibition level between 350 and 550 ASA response units and 30–90% for clopidogrel was requested. An insufficient response to either drug was counteracted by dose escalation (eg, clopidogrel 150 mg/day) or substitution with prasugrel (60 mg bolus, 10 mg/day).

Data collection

Medical charts were retrospectively reviewed to determine patient demographics, aneurysm characteristics, and procedural specifics. The World Federation of Neurosurgical Societies grading scale and the Fisher scale were used to evaluate the extent of subarachnoid haemorrhage.

Baseline aneurysm characteristics were further evaluated by conventional four-vessel DSA. Aneurysm size, neck width, dome-to-neck ratio, and aspect ratio were determined for all aneurysms. Aneurysms with a neck width ≥4 mm and/or a dome-to-neck ratio ≤2 were considered as wide-necked.

All procedure-related complications were recorded. We report both symptomatic and asymptomatic complications. If the patient had transient or permanent neurological deficits after the procedure, the complication was categorized as neurological complication. Functional outcome was evaluated by the modified Rankin scale (mRS) at the 6-month follow-up. Unfavourable outcome was defined as mRS score >2.

For cost analysis, we determined the approximate material net costs of the implanted devices (WEB, stent, and coils) as provided by the manufacturers. For coiling procedures, the median cost of bare platinum detachable coils (€265 per coil in 2018) was used. Other costs were expected not to be significantly different between the two treatment groups. All net prices were adjusted to 2017/2018 and apply to a German university hospital buying syndicate.

Angiographic control and re-treatment

Angiographic follow-up was scheduled at 6 months after the procedure using DSA in the majority of cases or magnetic resonance angiography or CT angiography in the minority.

Aneurysm occlusion was evaluated according to the Raymond-Roy occlusion classification (1, complete occlusion, 2, neck remnant, 3, aneurysm remnant). Complete occlusion and neck remnants were defined as adequate occlusion. Neck remnants were subjected to re-treatment, if a relevant risk of rupture due to a large size and/or complex shape of the aneurysm was estimated and if re-treatment was expected to be associated with low morbidity.

Statistical analysis

Data are presented as means and SD for continuous variables and as numbers and percentages for categorical variables. The Shapiro-Wilk test was used to test normal distribution of

Table 1 Baseline patient and aneurysm characteristics

Characteristics	WEB (n=66)	SAC (n=66)	P values
Patient age (years)	57.5±13.1	55.0±12.1	0.3
Female sex	45 (68.2%)	51 (77.3%)	0.2
Ruptured aneurysms	24 (36.4%)	24 (36.4%)	1.0
WFNS ≤3	15 (22.7%)	9 (13.6%)	0.2
WFNS ≥4	9 (13.6%)	12 (18.2%)	
Missing data	0 (0%)	3 (4.5%)	
Fisher ≤3	11 (16.7%)	9 (13.6%)	0.9
Fisher 4	13 (19.7%)	10 (15.2%)	
Missing data	0 (0%)	5 (7.6%)	
Aneurysm location			1.0
AcomA	16 (24.2%)	16 (24.2%)	
MCA	9 (13.6%)	9 (13.6%)	
ICA			
Paraophthalmic	6 (9.1%)	10 (15.2%)	
PcomA	4 (6.1%)	3 (4.5%)	
Terminus	3 (4.5%)	0 (0%)	
BA	28 (42.4%)	28 (42.4%)	
Aneurysm size (mm)	7.3±2.0	7.2±3.7	0.8
<7 mm	30 (45.5%)	37 (56.1%)	0.2
>7 mm	36 (54.5%)	29 (43.9%)	
Aneurysm width (mm)	6.5±1.9	6.4±3.7	0.9
Aneurysm height (mm)	6.8±2.1	6.4±3.0	0.4
Neck width (mm)	4.3±1.2	4.2±2.0	0.9
D/N ratio	1.6±0.5	1.6±0.7	0.8
Aspect ratio	1.7±0.7	1.6±0.7	0.5
Wide neck	58 (87.9%)	60 (90.9%)	0.6

AcomA, anterior communicating artery; BA, basilar artery; D/N ratio, dome-to-neck ratio; ICA, internal carotid artery; MCA, middle cerebral artery; PcomA, posterior communicating artery, SAC, stent-assisted coiling; WEB, Woven Endobridge; WFNS, World Federation of Neurosurgical Societies grading scale.

continuous variables. Groups were compared using the unpaired t-test, Mann-Whitney U test, χ^2 test, and Fisher exact test, when appropriate. To avoid a potential selection bias, we used an IPTW approach based on the propensity score model. Propensity scores were calculated using a multivariate logistic regression model with treatment as the response and the following covariates: patient age, sex, ruptured/unruptured status, aneurysm location, aneurysm size, and neck width. Statistical analysis was performed using SPSS software (IBM SPSS Statistics for Windows, version 25.0, Armonk, New York, USA). A p value <0.05 was considered as statistically significant.

RESULTS

Patient and aneurysm characteristics

Baseline patient and aneurysm characteristics are presented in table 1. Sixty-six patients treated with WEB were included and matched with 66 patients treated by SAC on the basis of aneurysm location and ruptured/unruptured aneurysm status. In both groups, 24 aneurysms were initially ruptured, 16 were located at the AcomA, nine at the MCA, 13 at the ICA, and 28 at the BA, respectively. There were no significant differences among baseline patient and aneurysm characteristics between the two groups (table 1).

Table 2 Procedure-related complications

	WEB (n=66)	SAC (n=66)	P values
Complications	8 (12.1%)	14 (21.2%)	0.16
Thromboembolic complications	8 (12.1%)	12 (18.2%)	0.3
Hemorrhagic complications	0 (0%)	2 (3.0%)	0.5
Neurological complications	1 (1.5%)	5 (7.6%)	0.2
Ischemic stroke	1 (1.5%)	4 (6.1%)	0.4

SAC, stent-assisted coiling; WEB, Woven Endobridge.

Aneurysm treatment

Of 66 patients in the WEB group, 65 were treated by WEB only (98.5%). Adjunctive coils were used in one case (1.5%) to achieve complete aneurysm obliteration.

Immediate complete occlusion after WEB implantation was obtained in 39 aneurysms (59.1%), neck remnants in 9 (13.6%), and aneurysm remnants in 18 (27.3%).

In the SAC group, a single stent was used in 53 patients (80.3%) and two stents in 13 (19.7%), in which the Y-stenting technique was used in nine bifurcation aneurysms (13.6%). At the end of the procedure, 61 aneurysms showed complete aneurysm occlusion (92.4%) and five had neck remnants (7.6%). There were no aneurysm remnants.

The average treatment duration of SAC procedures (186±70 min) was significantly longer than that of WEB procedures (109±69 min, p<0.01). The net material costs for WEB procedures (€10 506±39) were significantly higher than for SAC (€4410±1717, p<0.01).

Complications

Procedural complications are listed in table 2. In the WEB group, complications occurred in eight patients (12.1%), all of them thromboembolic events—five in elective cases and three in patients with subarachnoid hemorrhage (SAH). Complications were symptomatic in one patient (one ischemic stroke). In the SAC group, 14 procedure-related complications (21.2%) occurred, including 12 thromboembolic events (18.2%) and two hemorrhagic events (3.0%). Five complications (7.6%) were associated with neurological deficits (four ischemic strokes, one aneurysm perforation). Of the 12 thromboembolic events in the SAC group, five occurred in scheduled, elective cases of patients with unruptured aneurysms who responded to ASA and clopidogrel and the remaining seven occurred in emergency cases that were conducted under antiaggregation with tirofiban. No procedure-related mortality was seen in either group. In the unweighted analysis, the overall and neurological complication rates were not significantly different between the two treatment groups (p=0.16 and p=0.2, respectively).

After IPTW adjustment, SAC was associated with a higher risk for both overall (OR=2.2, 95% CI 1.08 to 4.4, p=0.03) and neurological complications (OR=5.4, 95% CI 1.2 to 25.2, p=0.02) in comparison with WEB treatment.

Clinical outcome

Functional outcome at the 6-month follow-up is shown in table 3. The same percentage of patients attained favourable outcome in the WEB group (57/66, 86.4%) and the SAC group (57/66, 86.4%, p=1.0). All patients with unfavourable outcome were treated for a ruptured aneurysm within the acute phase of SAH. All patients treated electively for an unruptured aneurysm achieved a favourable outcome.

Table 3 Clinical outcome at the 6-month follow-up

	Overall			Unruptured aneurysms			Ruptured aneurysms		
	WEB (n=66)	SAC (n=66)	P values	WEB (n=42)	SAC (n=42)	P values	WEB (n=24)	SAC (n=24)	P values
mRS score			0.1			0.2			0.1
0	45	41		37	32		8	9	
1	5	13		3	7		2	6	
2	7	3		2	3		5	0	
3	2	0		0	0		2	0	
4	1	3		0	0		1	3	
5	5	5		0	0		5	5	
6	1	1		0	0		1	1	

mRS, modified Rankin scale; SAC, stent-assisted coiling; WEB, Woven Endobridge.

In the weighted analysis, a favourable outcome was achieved by a similar portion in both groups (OR=1.3, 95% CI 0.7 to 2.5, p=0.5).

Angiographic outcome

Angiographic results are summarized in table 4. At mid-term follow-up, in the WEB group, complete occlusion was obtained in 55 patients (83.3%), neck remnants in 7 (10.6%), and aneurysm remnants in 4 (6.1%). After SAC, complete occlusion was achieved in 56 patients (84.8%), neck remnants in 6 (9.1%), and aneurysm remnants in 4 (6.1%). Adequate occlusion rates were the same in the WEB group (62/66, 93.9%) and the SAC group (62/66, 93.9%, p=1.0). A similar percentage of patients were re-treated after WEB embolization (7/66, 10.6%) and SAC (8/66, 12.1%, p=1.0).

In the weighted analysis, adequate occlusion rates (OR=1.1, 95% CI 0.4 to 3.2, p=0.8) and re-treatment rates (OR=0.9, 95% CI 0.4 to 1.8, p=0.7) were not significantly different between the two groups.

DISCUSSION

Since its introduction in 2011, the WEB has emerged as important tool for endovascular treatment of wide-necked bifurcation aneurysms, which are typically difficult to treat by conventional endovascular means. The safety and efficacy of the WEB has been confirmed in several multicenter and good clinical practice studies. In the cumulative population of the three prospective studies WEBCAST (WEB Clinical Assessment of Intrasaccular Aneurysm), WEBCAST-2, and French Observatory, complete and adequate occlusion at the 1-year follow-up was seen in 52.9% and 79%, respectively, and re-treatment was performed in 6.9%.[6] In a large single-center cohort of 100 ruptured aneurysms, van Rooij *et al* reported complete occlusion in 73% and neck remnants in 23% after a follow-up period of 3 months, and re-treatment was performed in 6.8%.[13] In our study, the rates of complete and adequate occlusion after WEB treatment were 83.3% and 93.9%, respectively, and the re-treatment rate was 10.6%.

Table 4 Angiographic results

	WEB (n=66)	SAC (n=66)	P values
Follow-up period (months)	5.7±5.0	6.0±5.6	0.6
Complete occlusion (RROC 1)	55 (83.3%)	56 (84.8%)	1.0
Neck remnant (RROC 2)	7 (10.6%)	6 (9.1%)	
Aneurysm remnant (RROC 3)	4 (6.1%)	4 (6.1%)	
Adequate occlusion	62 (93.9%)	62 (93.9%)	1.0
Re-treatment	7 (10.6%)	8 (12.1%)	1.0

RROC, Raymond-Roy occlusion classification; SAC, stent-assisted coiling; WEB, Woven Endobridge.

A potential limitation of our study is that we report only mid-term occlusion rates. Since the introduction of the WEB is relatively recent, few studies have evaluated long-term angiographic results after WEB implantation. Mine *et al* reported mid-term and long-term outcome in 48 patients and concluded that aneurysm occlusion is stable at the long-term follow-up.[14] Although the available results of WEB treatment are promising, studies comparing the WEB with conventional endovascular strategies are needed. To the best of our knowledge, no such study has been published. To deal with this shortcoming, we compared the WEB device with SAC, which is a long-standing established endovascular method for treatment of wide-necked aneurysms. In order to produce reliable results, we performed a matched case–control study according to aneurysm location and ruptured/unruptured aneurysm status. To avoid a potential selection bias, we further performed a separate IPTW analysis using propensity scores. We included only aneurysms that were located at the AcomA, MCA bifurcation, ICA, and BA, because experience with use of the WEB for other locations is limited.[6 15] Moreover, we excluded aneurysms ≥11 mm, since these aneurysms exceed the diameter of the largest available WEB and are hence not suitable for WEB embolization according to the device's instructions for use.

Like the WEB, SAC is predominantly performed for the embolization of wide-necked aneurysms and to prevent protrusion of the coils into the parent artery. Numerous studies have shown that SAC provides more durable aneurysm occlusion than stand-alone coiling.[9 10 16 17] In a large series of 888 aneurysms by Piotin *et al*, aneurysm recurrence occurred in 14.9% after SAC compared with 33.5% after coiling alone.[9] Likewise, Jahshan *et al* reported complete aneurysm occlusion in 64.6% after SAC and 49.7% after coiling alone in a series of 489 aneurysms.[16] Our study produced comparable results, achieving complete occlusion in 84.8% and adequate occlusion in 93.9%. Hence, our study provides evidence that treatment of wide-necked and bifurcation aneurysms with the WEB achieves similar occlusion rates to those of SAC, at least among the subset of aneurysms that met the inclusion criteria of this study.

Moreover, re-treatment rates were similar between the WEB group (10.6%) and the SAC group (12.1%). Recently, Kabbasch *et al* evaluated 15 patients who underwent re-treatment after WEB placement.[18] Re-treatment consisted predominantly of stand-alone coiling (n=4) and stent-assisted coiling (n=7) and could be performed without any procedural complications, achieving adequate occlusion in all cases. The authors concluded that re-treatment after WEB implantation is feasible and safe.

The occurrence of thromboembolic complications is the most dreaded problem of SAC.[19] In our study, thromboembolic complications occurred in 18.2% after SAC, including four symptomatic ischemic strokes (6.1%). To reduce thrombus formation at the metal-covered surface, long-term antiplatelet medication is mandatory for stent-assisted procedures. Nevertheless, some studies reported increased rates of ischemic stroke after SAC when compared with coiling alone. For instance, Hetts *et al* reported 1-year ischemic stroke rates of 8.8% among 137 patients treated by SAC, compared with only 2.2% among 224 coiled patients.[10] Likewise, Piotin *et al* reported higher mortality in the SAC group (4.6%) than in the coil group (1.2%) in a cohort of 1137 patients.[9] Other studies found no significant

differences in thromboembolic complication and morbidity rates between SAC and stand-alone coiling.[20]

Similar to SAC, thromboembolism is considered as the most prevalent event related to WEB implantation.[21] In our study, thromboembolic complications occurred in eight patients (12.1%), which is within the range of similar studies.[21 22]

In the comparative analysis, the procedural complication rate in the SAC group (21.2%) was higher than in the WEB group (12.1%). Moreover, a higher percentage of patients treated by SAC developed neurological deficits (7.6% vs 1.5%), which could be mainly attributed to the occurrence of symptomatic ischemic stroke. After IPTW adjustment, these differences were statistically significant both for overall and neurologic complications.

Our findings corroborate the 30-day safety results from the WEB Intrasaccular Therapy (WEB-IT) study. Among 150 patients, the authors reported one primary safety event (one delayed parenchymal haemorrhage) and no incidence of major ischemic stroke. This is in contrast to the 8.8% ischemic stroke rate reported by Hetts *et al*.[10]

Besides the thrombogenic potential of intraluminal devices, current antiplatelet regimens are associated with an increased risk of haemorrhagic events, which can have serious consequences for the patient.[12 23] The influence of dual antiplatelet medication on the prevalence of hemorrhagic events has also been documented in patients treated with flow diverters.[24] Furthermore, the need for antiaggregant therapy limits the use of stents in the treatment of ruptured aneurysms, where double antiplatelet medication might increase the risk of rebleeding and can complicate intracranial surgical procedures which might be necessary during the acute phase of SAH.[25 26]

Since the WEB is placed within the aneurysm cavity and leaves the parent artery unaffected, the risk of delayed thromboembolic complications is estimated to be low, and long-term antiplatelet medication is not necessarily required. Therefore, the WEB can be used for both unruptured and ruptured aneurysms with an acceptable risk of complications and morbidity.[5 13] In contrast, in the SAC group, we observed the majority of complications among patients with SAH.

For the economic aspects, average net material costs of WEB procedures (€10,506±39) were significantly higher than those of SAC (€4410±1717). However, this is at least partially compensated for by a significantly shorter treatment duration in the WEB group, which was on average 80 min shorter than that in the SAC group.

Taken together, WEB treatment of wide-necked bifurcation aneurysms might be potentially associated with lower rates of thromboembolic complications than SAC, with similar occlusion rates at mid-term follow-up. Hence, the WEB may combine the advantages of conventional coiling (low complication rate, no obligatory permanent antiplatelet medication) and stent-assisted procedures (treatment of wide-necked and bifurcation aneurysms, durable aneurysm occlusion), at least in aneurysms with a suitable configuration for WEB implantation.

Limitations

The limitations of this study are mainly related to its retrospective design and the moderate number of included patients. Although the matched study design enhances the validity of our results, we cannot exclude a potential selection bias, since the SAC group may contain patients with aneurysms with unsuitable configuration for WEB treatment. As we report only mid-term occlusion rates, a comparative analysis of long-term angiographic outcome is yet to be done. A further limitation is that aneurysm occlusion was not determined by a core laboratory which might bias the interpretation of the angiographic results.[27] To reduce this potential bias at least in part, all angiographic images were assessed blinded and independently by three experienced consultant neurointerventionalists (CK, FD, ES). Discrepancies were resolved by consensus.

Finally, as the introduction of the WEB is relatively recent and WEBs might have been initially slightly undersized in a portion of cases, increased operator experience might have favored the SAC group for complication rates and angiographic outcome.

Despite these limitations, our study provides the first comparative analysis of WEB and SAC for the treatment of wide-necked bifurcation aneurysms.

CONCLUSIONS

In this study, we compared the clinical and angiographic outcomes using WEB and SAC in a similar subset of complex aneurysms. We found that WEB and SAC provide similar aneurysm occlusion rates, with a comparable re-treatment rate. Importantly, WEB was associated with favorable ischemic complication rates and mid-term clinical outcome. Since the WEB does not require long-term antiplatelet medication, our findings suggest that the WEB might be a viable alternative endovascular treatment for wide-necked bifurcation aneurysms—at least for aneurysms with suitable configuration for WEB implantation.

Contributors CK, LG, ES, MH, JB, BK, PS, and FD acquired the data. CK, LG, and TL developed the project, analyzed the data, and drafted the manuscript. All authors revised the paper critically for important intellectual content and provided final approval of the version published. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. CK and LG contributed equally as first authors.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests CK and FD serve as consultants for Acandis GmbH (Pforzheim, Germany). TL serves as proctor for MicroVention Inc/Sequent Medical (Aliso Viejo, California, USA).

Patient consent Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement All data will be made available upon request in an anonymized manner.

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