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Intracranial aneurysm treatment with intrasaccular flow disruption: comparison of WEB-21 and WEB-17 systems

Paolo Pagano, Laurentiu Paiusan, Sebastien Soize, Laurent Pierot

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Neuroradiology, Hopital Maison Blanche, Reims, Champagne-Ardenne, France

Correspondence to
Dr Laurent Pierot, Neuroradiology, Hopital Maison Blanche, Reims 51092, Champagne-Ardenne, France; lpierot@gmail.com

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ABSTRACT

Background New generations of Woven EndoBridge (WEB) devices (WEB-21 and WEB-17) are available to treat aneurysms with a width <6.5 mm. Limited comparisons between both systems exist in the literature, but mid-term efficacy has not been compared. Our study aimed to compare the indications, feasibility, and safety of both systems and to evaluate their efficacy at mid-term follow-up (12 months).

Methods Aneurysms treated with WEB-21 and WEB-17 were extracted from a prospective database. Patient and aneurysm characteristics, complications, and anatomical results were analyzed by an interventional neuroradiologist, independent of the procedures.

Results From June 2015 to November 2019, 87 patients with 92 aneurysms were treated with WEB-21 (38/92, 41.3%) and WEB-17 (54/92, 58.7%). WEB-21 and WEB-17 had high treatment feasibility (97.4% and 94.4%, respectively). A higher percentage of ruptured aneurysms were treated with WEB-17 (9.3%) than with WEB-21 (2.6%; p=0.03). Morbidity and mortality at 1 month were similar in both groups (no morbidity in either group, and mortality 2.7% in the WEB-21 group and 2.0% in the WEB-17 group). The rate of complete and adequate aneurysm occlusion was not significantly higher with the WEB-17 system (59.2% and 95.9%, respectively) compared with the WEB-21 (52.9% and 85.3%, respectively).

Conclusions This study showed the high feasibility of aneurysm treatment with both the WEB-21 and WEB-17 systems. Indications were relatively similar with both devices except for ruptured aneurysms, which were more frequently treated with the WEB-17 device. Efficacy at 12 months (complete and adequate occlusions) was slightly, but not significantly, better with the WEB-17 device.

INTRODUCTION

Endovascular treatment of wide neck aneurysms with coils has always been a challenge, and has led to the development of alternative techniques, such as balloon assisted coiling (BAC), stent assisted coiling, and flow diversion. The most recent endovascular technique for aneurysm treatment, intrasaccular flow disruption, was specifically developed for wide neck bifurcation aneurysms treatment.[1] Currently, the Woven EndoBridge (WEB) device is the only intrasaccular flow disruption device CE marked and approved by the US Food and Drug Administration.[2]

The WEB device is placed within the aneurysm sac to seal the neck and create intrasaccular blood flow stasis and subsequent thrombosis.[3] Moreover, the lack of device in the parent vessel implies that dual antiplatelet therapy is not required, unlike the flow diverter, and then the WEB can be used for the treatment of both unruptured and ruptured aneurysms.[2 4]

Since its introduction into European clinical practice in 2010, several iterations of the WEB device have been released, including the initial dual layer version (WEB-DL), two single layer versions (WEB-SL and WEB-SLS), and the EV (enhanced visualization) version of both single layer devices.[2 5] In parallel with this evolution, the profile of the devices was progressively improved, leading to a decrease in size of the microcatheters used for delivery of the WEB, with two systems successively launched, WEB-21 and WEB-17.[6]

The WEB has been extensively evaluated in single and multicenter retrospective and prospective series.[4 7–11] Several multicenter prospective studies, including two European trials (WEB Clinical Assessment of Intrasaccular Aneurysm Therapy (WEBCAST) and WEBCAST-2), one trial in the USA (WEB Intrasaccular Therapy (WEB-IT)), and one French trial (French Observatory), showed the high safety and efficacy in both the short and long term.[12–18] However, evaluation of WEB-21 and WEB-17 systems remains limited to a small number of retrospective single or multicenter series.[19–21] Both devices are being evaluated in two prospective multicenter studies currently under analysis: one dedicated to ruptured aneurysms (CLinical Assessment of WEB Device in Ruptured aneurYSms (CLARYS)) and one dedicated to the WEB-17 system (CLinical EValuation of WEB 0.017 Device in Intracranial AneuRysms (CLEVER)). To date, only limited series have compared the feasibility and safety of both the WEB-21 and WEB-17 devices, with efficacy evaluated only after short term follow-up.[6 22] Our single center retrospective study compared the indications, feasibility, and safety of the WEB-21 and WEB-17 systems, and evaluated their efficacy after mid-term follow-up (12 month).

MATERIALS AND METHODS

Study design

This was a retrospective, observational, single center study conducted at the Neuroradiology Department, University Hospital, Reims. All

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patients treated with WEB-21 and WEB-17 were identified and analyzed from our prospective database of all patients with intracranial aneurysms treated endovascularly since 2001. The 'Comité d'Ethique pour la Recherche en Imagerie Médicale' (CERIM) of Collège des Enseignants de Radiologie de France (CERF) approved this retrospective study and waived written informed consent due to the retrospective study design.

Web device

The WEB is a self-expanding, retrievable, electrothermally detachable nitinol braided device placed within the aneurysm sac. The WEB-21 was introduced in Europe in February 2015.[5] Its transverse diameter is between 4 and 7 mm and is compatible with 0.021 inch microcatheters (VIA-21, Microvention, Tustin, California, USA). According to the manufacturer's sizing table, aneurysms between 3.0 and 6.5 mm are suitable for treatment with the WEB-21 device.[6]

The fifth and latest generation of the WEB device is WEB-17. The WEB-17 has been available in Europe since December 2016.[23] It is compatible with a 0.017 inch microcatheter (VIA-17, Microvention) available in straight and pre-shaped versions. The WEB-17 has fewer total platinum cored nitinol wires than the WEB-21 (72–108 vs 144) but similar metal coverage at the neck (WEB-17 57–59%, WEB-21 59–62%).[19] The WEB-17 sizes are not completely similar to the WEB-21 sizes: (1) the smallest WEB-17 device is 3 mm in width, potentially permitting the treatment of smaller aneurysms (the manufacturer recommends WEB-17 treatment for aneurysms with a mean width of 2–6.5 mm); (2) there are shallow devices of 2 mm height for WEB-17 sizes between 3 and 5 mm in width; and (3) there are half sizes in width for the smallest WEB-17 sizes, including 3.5 and 4.5 mm in width.[6 24]

Interventional procedure and follow-up

Endovascular treatment was selected as the first line treatment by a local multidisciplinary team with neurosurgeons and neuroradiologists. For unruptured and recanalized aneurysms, DAPT with 75 mg aspirin and 180 mg ticagrelor per day was given 2 days prior to treatment; if no stent was placed, ticagrelor was discontinued after the intervention and aspirin was maintained for at least 1 month. For ruptured aneurysms, aspirin 250 mg intravenously was administered during the procedure followed by aspirin 75 mg for 1 month. Procedures were performed under general anesthesia (typically using a femoral access and triaxial approach) and accompanied by heparin treatment and intravenous aspirin. WEB size was selected according to measurements performed on three-dimensional DSA (no simulation tool was used). The WEB was usually oversized by approximately 1 mm in width and undersized in height by 1 mm.

Clinical follow-up was performed at 1, 6, and 12 months by neuroradiologists and/or neurosurgeons. Imaging follow-up was performed using DSA and MR angiography at 6 and 12 months.

Data collection

The following data were collected for each patient: age and sex; aneurysm number, location, status (ruptured/unruptured/recurrent), size (width/height), neck size, and angle between parent artery and main aneurysm axis; and type and dimension of WEB used, microcatheter used, additional device used (coils, remodeling balloons, stents, flow diverter), intraprocedural and postprocedural complications, retreatment of target aneurysm before 1 year of follow-up after the initial treatment, and latest available angiographic and clinical follow-up.

Data analysis

Data analysis was conducted by an interventional neuroradiologist (PP) independent of the procedures. Aneurysm location was classified in two groups according to initial WEB treatment indications:

- Typical locations: anterior communicating artery, middle cerebral artery (MCA) bifurcation, internal carotid artery (ICA) terminus (ICAt), and basilar artery tip;
- Atypical locations: other ICA locations (opthalmic, anterior choroidal, posterior communicating), MCA beyond bifurcation (M2 and M3 segments), anteroinferior cerebellar artery, and superior cerebellar artery).

Aneurysm size was dichotomized according to maximum width: ≤3 mm and >3 mm. Neck size was dichotomized as ≤4 mm and >4 mm. The angle between the parent artery and the neck-to-fundus axis was classified in two groups (<45° and ≥45°).

All complications were reviewed and classified into three categories: intraprocedural ischemic, intraprocedural hemorrhagic, and postoperative. For patients with ruptured aneurysms, the clinical status before rupture was retrospectively evaluated using the modified Rankin Scale (mRS) based on patient or caregiver reports of preoperative clinical status and activities. The Hunt and Hess grade before aneurysm treatment was collected. For patients with unruptured aneurysms, preoperative clinical status was evaluated during the preoperative medical visit using the mRS. Postoperative clinical status was evaluated with the mRS. Morbidity was defined as an mRS score of >2 when the preoperative mRS score was ≤2 and as an increase of 1 point when the preoperative mRS score was >2. Aneurysm occlusion was evaluated using a 3 point scale: complete aneurysm occlusion, neck remnant, and aneurysm remnant.

Statistical analyses

Distribution normality was assessed with the Shapiro–Wilk test. Continuous variables are described as mean±SD or median (IQR), and were compared using the Student's t test or Mann–Whitney U. Categorical variables are presented as counts and compared using the χ^2 or Fisher's exact test. A p value<0.05 was considered statistically significant. Analyses were performed using Medcalc software (release 18.2, Ostend, Belgium).

RESULTS

Patients and aneurysms

Detailed information is given in tables 1 and 2. From June 2011 to December 2019, 155 patients with 161 aneurysms were treated with the WEB. From June 2015 to November 2019, 87/155 (56.1%) patients with 92/161 (57.1%) aneurysms were treated with the WEB-21 device (38/92 aneurysms, 41.3%) and the WEB-17 device (54/92 aneurysms, 58.7%). Fifty-eight of 87 patients (66.7%) were women. Mean age was 55.2±10.4 years.

The percentage of ruptured aneurysms treated with the WEB-17 (5/54, 9.3%, Hunt and Hess grade 1 in one patient, grade 2 in three patients, and grade 5 in one patient) was slightly higher compared with the WEB-21 (1/38, 2.6%, Hunt and Hess grade 1; p=0.03). The percentage of aneurysms in atypical locations treated with the WEB-21 and WEB-17 devices were similar (21.1% and 20.4%, respectively; p=0.94). The percentage of aneurysm ≤3 mm treated with the WEB-21 and WEB-17 devices was also similar (10.5% and 12.9%, respectively; p=1).

Table 1 Aneurysm characteristics

	Total (n=92)	WEB-17 (n=54)	WEB-21 (n=38)	P value
Status (n (%))				0.03
Unruptured	82 (89.1)	49 (90.7)	33 (86.8)	
Ruptured	6 (6.5)	5 (9.3)	1 (2.6)	
Recurrent	4 (4.4)	0 (0)	4 (10.6)	
Location (n (%))				0.94
Typical	73 (79.3)	43 (79.6)	30 (78.9)	
ACom	20 (21.7)	14 (25.9)	6 (15.7)	
MCA bifurcation	39 (42.4)	21 (38.9)	18 (47.4)	
ICA terminus	9 (9.8)	7 (12.9)	2 (5.3)	
Basilar tip	5 (5.4)	1 (1.9)	4 (10.5)	
Atypical	19 (20.7)	11 (20.4)	8 (21.1)	
ICA ophthalmic	8 (8.7)	3 (5.5)	5 (13.2)	
ICA ACho	1 (1.1)	1 (1.9)	0 (0)	
ICA PCom	5 (5.4)	5 (9.2)	0 (0%)	
M2-M3	2 (2.2)	1 (1.9)	1 (2.6)	
AICA	1 (1.1)	1 (1.9)	0 (0)	
SCA	2 (2.2)	0 (0)	2 (5.3)	
Aneurysm size				
Sac maximum width (mm)	4.6 (3.8–5.5)	4.5 (3.7–5.7)	4.6 (3.9–5.5)	0.81
Sac height (mm)	4.5 (3.8–5.2)	4.5 (3.6–5.0)	4.6 (4.0–5.3)	0.52
Neck width (mm)	3.6 (3.0–4.5)	3.6 (3.0–4.5)	3.5 (3.1–4.5)	0.96
Dome to neck ratio	1.2 (1.1–1.5)	1.2 (1.1–1.4)	1.2 (1.0–1.5)	0.67
Sac maximum width (n (%))				1.00
≤3 mm	11 (11.9)	7 (12.9)	4 (10.5)	
>3 mm	81 (88.1)	47 (87.1)	34 (89.5)	
Sac neck (n (%))				
≤4 mm	59 (64.2)	35 (64.8)	24 (63.2)	
>4 mm	33 (35.8)	19 (35.2)	14 (36.8%)	
Angle aneurysm/artery ≥45° (n (%))	28 (30.4)	13 (24.1)	15 (39.5%)	0.12
Successful WEB implantation (n (%))	88 (95.6)	51 (94.4)	37 (97.4%)	0.64

Continuous variables are described as median (IQR) and categorical variables as number (%).
ACho, anterior choroidal artery; ACom, anterior communicating artery; AICA, anteroinferior cerebellar artery; ICA, internal carotid artery; MCA, middle cerebral artery; PCom, posterior communicating artery; SCA, superior cerebellar artery; WEB, Woven EndoBridge.

Table 2 Treatment modalities

	Total (n=88)	WEB-17 (n=51)	WEB-21 (n=37)	P value
				0.24
WEB alone (n (%))	71 (80.7)	39 (76.5)	32 (86.5)	
WEB +other device (n (%))	17 (19.3)	12 (23.5)	5 (13.5)	
WEB–balloon	5 (5.7)	4 (7.8)	1 (2.7)	
WEB–FD	1 (1.1)	1 (2.0)	0 (0)	
WEB–stent	6 (6.9)	4 (7.8)	2 (5.4)	
WEB–coils	1 (1.1)	0 (0)	1 (2.7)	
WEB–coils–stent	1 (1.1)	0 (0)	1 (2.7)	
WEB–RM–stent	2 (2.3)	2 (3.9)	0 (0)	
WEB–FD–coils	1 (1.1)	1 (2.0)	0 (0)	
WEB type (n (%))				0.69
WEB SL	81 (92.0)	46 (90.2)	35 (94.6)	
WEB SLS	7 (8.0)	5 (9.8)	2 (5.4)	

Categorical variables are described as number (percentage).
FD, flow diverter; RM, remodeling balloon; WEB, Woven EndoBridge; WEB SL, WEB single layer; WEB SLS, WEB single layer spherical.

Treatment feasibility

Treatment feasibility was similar (p=0.64) with both the WEB-21 (37/38; 97.4%) and WEB-17 (51/54; 94.4%). In one aneurysm treated with the WEB-21, the WEB size initially selected was not appropriate. During WEB withdrawal, the aneurysm ruptured and was rapidly treated with BAC (see complications). In two aneurysms, treatment with the WEB-17 was not feasible. In one patient treated for ICA–posterior communicating ruptured aneurysms, two WEB-SL (4×2 mm and 3×2 mm) devices were attempted; however, they were either too large or too small. As a 3.5×2 mm WEB-SL was unavailable, coiling was performed through VIA-17 with complete aneurysm occlusion. In a second patient with a ruptured irregular MCA-M2 aneurysm, treatment was attempted with two WEB-SL (4.5×2 mm and 5×2 mm) devices, which did not close the neck properly; thus, BAC was performed leading to complete aneurysm occlusion. In one aneurysm, treated with the WEB-17, the device migrated into the distal circulation after detachment (see complications). Adjunctive devices were used in 5/37 aneurysms (13.5%) in the WEB-21 group and in 12/51 (23.5%) in the WEB-17 group (p=0.24) (table 2).

Complications and morbimortality

Ischemic complications occurred in 3/87 (3.4%) patients, all three in the WEB-17 group (table 3). In one patient with a ruptured anterior communicating artery aneurysm treated by the WEB, coiling, and remodeling balloon, an asymptomatic embolus in a distal prefrontal branch was detected at the final DSA. No specific treatment was performed. No ischemic lesion was detected by MRI the day after the procedure, and the mRS score at discharge was 0. In a second patient, caudate ischemia was detected by MRI at 24 hours without clinical worsening (mRS score at discharge was 0). In a third patient with an MCA bifurcation aneurysm treated with the WEB and stent, intra-stent thrombosis occurred: treatment with intra-arterial administration of tirofiban led to full stent reopening and the patient had an mRS score of 0 at discharge.

Hemorrhagic complications occurred in 3/87 (3.4%) patients. In one patient treated with the WEB-21 for an unruptured MCA aneurysm, the distal tip of the microcatheter perforated the MCA artery leading to a large subarachnoid bleed treated with ballooning and MCA coiling: the patient died. In a second patient with two aneurysms (right MCA and left ICA–ophthalmic aneurysm in order of treatment) treated with the WEB-17, the WEB device placed in the ICA aneurysm migrated after detachment into the distal circulation. The device was removed from an M2 branch using a Solitaire (EV3, Irvine, California, USA) and aspiration catheter ACE 68 (Penumbra, Alameda, California, USA). Postoperatively, the patient worsened clinically and CT revealed a large left hemispheric hematoma resulting in the patient's death. In a third patient (WEB-17) treated for an unruptured MCA aneurysm, an aneurysm sac perforation occurred during microcatheterization: the WEB was rapidly deployed in the aneurysm

Table 3 Complications, and clinical and angiographic results

	Total	WEB-17	WEB-21	P value
Aneurysm occlusion (n=83) at 12 months* (n (%))	(n=83)	(n=49)	(n=34)	0.23
Complete occlusion	47 (56.7)	29 (59.2)	18 (52.9)	
Neck remnant	29 (34.9)	18 (36.7)	11 (32.4)	
Aneurysm remnant	7 (8.4)	2 (4.1)	5 (14.7)	
Adequate occlusion	76 (91.6)	47 (95.9)	29 (85.3)	0.12
Aneurysm retreated	2 (2.4)	0 (0)	2 (5.4)	0.17
mRS†	(n=87)	(n=51)	(n=36)	0.14
mRS preoperative (n (%))				
mRS ≤2	85 (97.7)	49 (96.1)	36 (100)	
mRS >2	2 (2.3)	2 (3.9)	0 (0)	
mRS at 12 months (n (%))				
mRS 0	77 (88.6)	44 (86.3)	33 (91.7)	
mRS 1	5 (5.7)	4 (7.8)	1 (2.7)	
mRS 4	2 (2.3)‡	2 (3.9)‡	0 (0)	
mRS 6	3 (3.4)§	1 (2.0)	2 (5.6)§	
Procedural related mortality	2 (2.3)	1 (2.0)	1 (2.7)	1.00
Complications (n (%))	9/87 (10.3)	7/51 (13.7)	2/36 (5.4)	0.14
Intraprocedural ischemic complications	3 (3.4)	3 (5.9)	0 (0)	0.51
Intraprocedural hemorrhagic complications	3 (3.4)	2 (3.9)	1 (2.7)	1.00
Postprocedural complications	3 (3.4)	2 (3.9)	1 (2.7)	0.26
Complication severity (n (%))				
Death	2 (2.3)	1 (1.9)	1 (2.7)	0.52
Transient deficit	7 (8.0)	6 (11.8)	1 (2.7)	

*Missing data for eight patients/9 aneurysms. Categorical variables are described as number (%).
†mRS 0=no symptoms; mRS 1=no significant disability despite symptoms; able to carry out all usual duties and activities; mRS 4=moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance; mRS 6=dead.
‡These 2 patients already had an mRS score of 4 before WEB treatment.
§2 patients died in relation to the WEB procedure (see complications). One more patient died 3 months after the procedure from an unrelated disease.
mRS, modified Rankin Scale.

sac and the bleeding stopped a few minutes later. Flat panel CT performed at the end of the procedure and MRI performed 24 hours postprocedure showed limited subarachnoid hemorrhage. mRS score was 0 at hospital discharge.

There were three postoperative complications in 87 patients (3.4%). In one patient (WEB-21 group) treated for an ICAt unruptured aneurysm, sudden and transient hemiparesis was reported 10 days postprocedure (aspirin was discontinued by the patient): diffusion weighted imaging–MRI showed a limited ischemic lesion. Aspirin was reintroduced and mRS score at 1 month was 0.

In one patient (WEB-17 group) treated for an MCA bifurcation aneurysm, transient hemiparesis and aphasia (approximately 1 hour) occurred 48 hours postprocedure. MRI depicted a small ischemic lesion in the pre-rolandic area. DAPT was continued for 6 months. At hospital discharge (3 days postprocedure), mRS score was 0. In another patient (WEB-17 group) treated for an MCA bifurcation aneurysm, transient aphasia and right sensitive deficit occurred 4 days postprocedure. MR angiography showed small ischemic spots on diffusion weighted imaging–MRI in the left MCA territory, leading to the decision to maintain DAPT for 6 months. Clinical outcome was mRS 0 at hospital discharge.

Of 87 patients, 1 (1.1%) died 3 months after the procedure from an unrelated disease. Nine of 87 patients (10.3%) had neurological complications during or postprocedure, including 2/36 patients (5.4%) in the WEB-21 group and 7/51 patients (13.7%) in the WEB-17 group (p=0.14). Mortality at 1 month was 1/36 (2.7%) in the WEB-21 group and 1/51 (2.0%) in the WEB-17 group. One month morbidity was 0% in both groups.

Angiographic results at 12 months and retreatment

Angiographic and clinical results are reported in table 3. Among the 87 patients/92 aneurysms, 79 patients (90.8%)/83 (90.2%) aneurysms had 12 month follow-up DSA. Three patients died (two in relation to the procedure and one 3 months after the procedure from an unrelated disease; see above); two patients had comorbidity precluding performance of DSA; and one patient refused follow-up DSA. Among the three dead patients, two had WEB aneurysm treatment failure including one who had two aneurysms treated in the same session, with WEB aneurysm treatment failure in one and successful WEB treatment in the other (this aneurysm was not evaluated at 12 months). Two additional patients who had failed WEB aneurysm treatment were not included in the analysis of 12 month WEB anatomical results.

In the WEB-21 group, 18/34 (52.9%), 11/34 (32.4%), and 5/34 (14.7%) aneurysms had complete occlusion, neck remnant, and aneurysm remnant, respectively. In the WEB-17 group, 29/49 (59.2%), 18/49 (36.7%), and 2/49 (4.1%) aneurysms had complete occlusion, neck remnant, and aneurysm remnant, respectively. Adequate occlusion (complete occlusion and neck remnant) was reported in 47/49 aneurysms (95.9%) in the WEB-17 group and in 29/34 (85.3%) in the WEB-21 group (p=0.12). There were 2/88 (2.4%) aneurysm retreatments before 1 year, both in the WEB-21 group (2/37; 5,4%; p=0.17). Aneurysm retreatment was performed by clipping in one aneurysm and coil in the other.

DISCUSSION

This comparative analysis of aneurysms treated with the WEB-21 and WEB-17 devices showed high feasibility of the treatment using both devices (97.4% and 94.4%, respectively). Indications were relatively similar with both devices. According to aneurysm location (dichotomized as typical and atypical locations), the percentage of atypical locations was similar in both groups (WEB-21 21.1% and WEB-17 20.4%). A significantly higher percentage of patients with ruptured aneurysms were treated with the WEB-17 (5/54, 9.3%) compared with the WEB-21 (1/38, 2.6%). Although the complication rate was slightly (but not significantly) higher with the WEB-17 (7/51, 13.7%) than with the WEB-21 (2/36, 5.4%), mortality was similar in both groups (WEB-17 1/51, 2.0% and WEB-21 1/37, 2.7%), and morbidity was 0% in both groups. Finally, anatomical results were slightly (but not significantly) better in the WEB-17 group (complete aneurysm occlusion 29/49, 59.2%; adequate occlusion 47/49, 95.9%) compared with the WEB-21 group (complete aneurysm occlusion 18/34, 52.9%; adequate occlusion: 29/34, 85.3%, respectively).

The initial version of the WEB device (WED-DL) was made of two layers and relatively difficult to navigate and deploy in the aneurysm sac.[12] Since its European introduction in 2010, the device has experienced a tremendous technical evolution, leading to the introduction of the WEB-21 (2015) and WEB-17

(2016) devices.[5 6] Two comparative studies have evaluated the performance of the WEB-21 and WEB-17.[6 22] Similar to what is reported in our study, these studies showed a high feasibility of WEB treatment. In the König *et al* series, feasibility was 95.2% with the WEB-21 and 98.5% with the WEB-17. Similarly, Goertz *et al* noted feasibility of 100% with the WEB-17 and 89.7% with predecessor WEB (pWEB) versions that are primarily WEB-21 (64/70, 91.4%).

Regarding the indications for WEB treatment, our series found a significantly higher proportion of ruptured aneurysms in the WEB-17 group (9.3%) than in the WEB-21 group (2.6%). Both König *et al* and Goertz *et al* observed the opposite, with a higher proportion of ruptured aneurysms treated with the WEB-21 or pWEB versions (34.9% and 34.3%, respectively) compared with the WEB-17 (22.3% and 26.3%, respectively). Our results also showed that a relatively small percentage of ruptured aneurysms were treated, regardless of the device used. Two factors likely influenced the low use of the WEB in ruptured aneurysm in our series: first, the inclusion of a relatively small number of ruptured aneurysms in the European and US studies (5.9% in WEBCAST and 11.1% in French Observatory); and second, the results of the CLARYS study (dedicated to the treatment of ruptured aneurysms with the WEB) were unknown. However, recent series also showed a higher percentage of ruptured aneurysms treated with the WEB-17 (22.8–54.3%).[6 19–22]

With regard to aneurysm location, the percentage with an atypical location was similar in the two groups (8/38, 21.1% in the WEB-21 group; 11/54, 20.4% in the WEB-17 group). A similar situation was observed in both the König *et al* series (9.5% with WEB-17 and 5.6% with WEB-21) and in the Goertz *et al* series (10.5% with WEB-17 and 7.1% with WEB-21).

In contrast with König *et al* (aneurysms ≤4.9 mm: 42.9% in the WEB-21 group and 64.6% in the WEB-17 group) and the Goertz *et al* series (mean aneurysm size in pWEB 5.6±1.4 mm; mean aneurysm size in WEB-17 group 4.9±1.5 mm), we did not observe differences in aneurysm size between the WEB-21 and WEB-17 groups (using a 3 mm cut-off).

Complication rates were slightly, but not significantly, higher in the WEB-17 group (13.7%) than in the WEB-21 group (5.4%). A similar rate was observed by both König *et al* (complications in WEB-21 group 6.3% and WEB-17 group 6.2%) and Goertz *et al* (cumulative rate of ischemic and hemorrhagic complications 15.7% in the pWEB group and 10.6% in the WEB-17 group). Morbidity rate was low in all series, with no morbidity in the WEB-21 and WEB-17 groups in our series; 3.2% and 2.5% in the WEB-21 and WEB-17 groups, respectively, in Koning *et al* series; and 2.6% in the WEB-17 group and 2.9% in the pWEB group in the Goertz *et al* series. Mortality was also very low in all studies: 0% in the WEB-17 group in König *et al* and Goertz *et al* series, and 2.0% in our series. These results are similar to what is reported with the WEB-21: 0% in Goertz *et al* series (pWEB), 1.6% in König *et al* series, and 2.7% in our series.

An important question to ask is whether the WEB-21 and WEB-17 systems have the same efficacy in terms of aneurysm occlusion. In the Goertz *et al* series, only immediate postoperative occlusion was reported, showing a similar rate of complete aneurysm occlusion in the pWEB (54.3%) and WEB-17 groups (57.9%, p=0.55). Adequate occlusion (complete occlusion and neck remnant) was slightly higher in WEB-17 (78.9%) than in the pWEB group (70.0%). König *et al* only reported short term follow-up (3 months) and did not include the global population: rates of complete aneurysm occlusion were 55.1% in the WEB-21 group and 65.5% in the WEB-17 group, whereas rates of adequate occlusion were 91.8% in the WEB-21 group and 86.9% in the WEB-17 group. Our series is the first to report comparative aneurysm occlusion at mid-term follow-up (12 months) showing that the WEB-17 was slightly more efficacious than the WEB-21, with complete aneurysm occlusion in 59.2% and 52.9%, and adequate occlusion in 95.9% and 85.3%, respectively. Several factors likely explain these better anatomical results with the WEB-17 system, including the learning curve with these two new generations of a recent devices, and the availability of more sizes for the WEB-17 system that can potentially lead to a more precise sizing of the WEB device according to aneurysm measurements. Rates of aneurysm retreatment were 5.4% in the WEB-21 group and 0% in WEB-17 group (p=0.17).

Limitations

The study had several limitations. First, our conclusions are not based on randomized controlled data, but rather retrospective analysis of a single center patient population. This limitation is partially mitigated by the fact that all patients treated with the WEB-21 or WEB-17 were prospectively included. A second limitation is the relatively small number of patients in each group (38 in the WEB-21 group and 54 in the WEB-17 group) making it difficult to conduct a matched pair analysis singularly regarding the safety and efficacy of both devices. Despite this limitation, our findings showed that mid-term efficacy (12 month aneurysm occlusion) was similar in both groups, a key finding which has not been demonstrated in previous studies. A third limitation is that the WEB sizes available with the 21 and 17 systems were different (see materials and methods). This difference would potentially have affected the indications for WEB treatment singularly regarding aneurysm size, which was not the case. Safety is not likely affected by the existence of more sizes with the WEB-17 system. Finally, we cannot exclude the fact that efficacy was affected by the higher number of WEB-17 sizes that allowed more precise sizing of the device according to aneurysm size. This last point needs to be analyzed in larger series.

CONCLUSION

The WEB-21 and WEB-17 devices provided similar safety and efficacy. Morbidity and mortality at 1 month were similar in both groups, with no morbidity in either group and mortality rates of 2.7% in the WEB-21 group and 2.0% in the WEB-17 group. The complete and adequate aneurysm occlusion rate was slightly, but not significantly, higher with the WEB-17 (59.2% and 95.9%, respectively) compared with the WEB-21 system (52.9% and 85.3%, respectively). In our series, a higher percentage of ruptured aneurysms (9.3%) were treated with the WEB-17 compared with the WEB-21 system.

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ORCID iDs
Paolo Pagano http://orcid.org/0000-0001-5821-2653
Laurent Pierot http://orcid.org/0000-0002-6893-661X

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