Innovation in neurosurgery: Evaluation of neurosurgical innovation, related ethics, and solutions

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Part 1: Evaluation of past neurosurgical innovation

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The Woven Endobridge Device for Treatment of Intracranial Aneurysms: A Systematic Review

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***Introduction**: The Woven Endobridge (WEB) device is an innovative endovascular device for treatment of intracranial aneurysms, especially bifurcation and wide-neck aneurysms. Although not approved by the U.S. Food and Drug Administration, it has been available in Europe since 2011. The aim of this review is to evaluate the outcomes of WEB device use for intracranial aneurysm treatment. **Methods**: A systematic review was conducted with MEDLINE search engines PubMed and Embase from 2011. The search strategy provided 6229 articles, and 19 articles were included. **Results**: A total of 19 papers were identified describing the use of WEB devices in 687 patients with 718 aneurysms. The 2 largest prospective multicenter studies (WEBCAST and the French Observatory Trial) reported successful treatment, defined as complete closure or a neck remnant, in 85% and 79% of aneurysms, respectively. The use of a WEB device in combination with coiling or stenting was described with varying results in multiple small series. Outcomes of WEB device use in ruptured aneurysms in 2 studies showed 94% and 80% adequate treatment. Thromboembolic events were described in 71 patients (10.3% of all patients) and infarctions in 8 patients (1.2% of all patients). **Conclusions**: Despite initial promising results, the WEB device should be used with caution given its potentially large learning curve and because it has primarily been investigated only in*

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wide-neck and bifurcation aneurysms. In addition, currently available prospective studies have short follow-up, and the device has not been directly compared with other treatment modalities.

Introduction

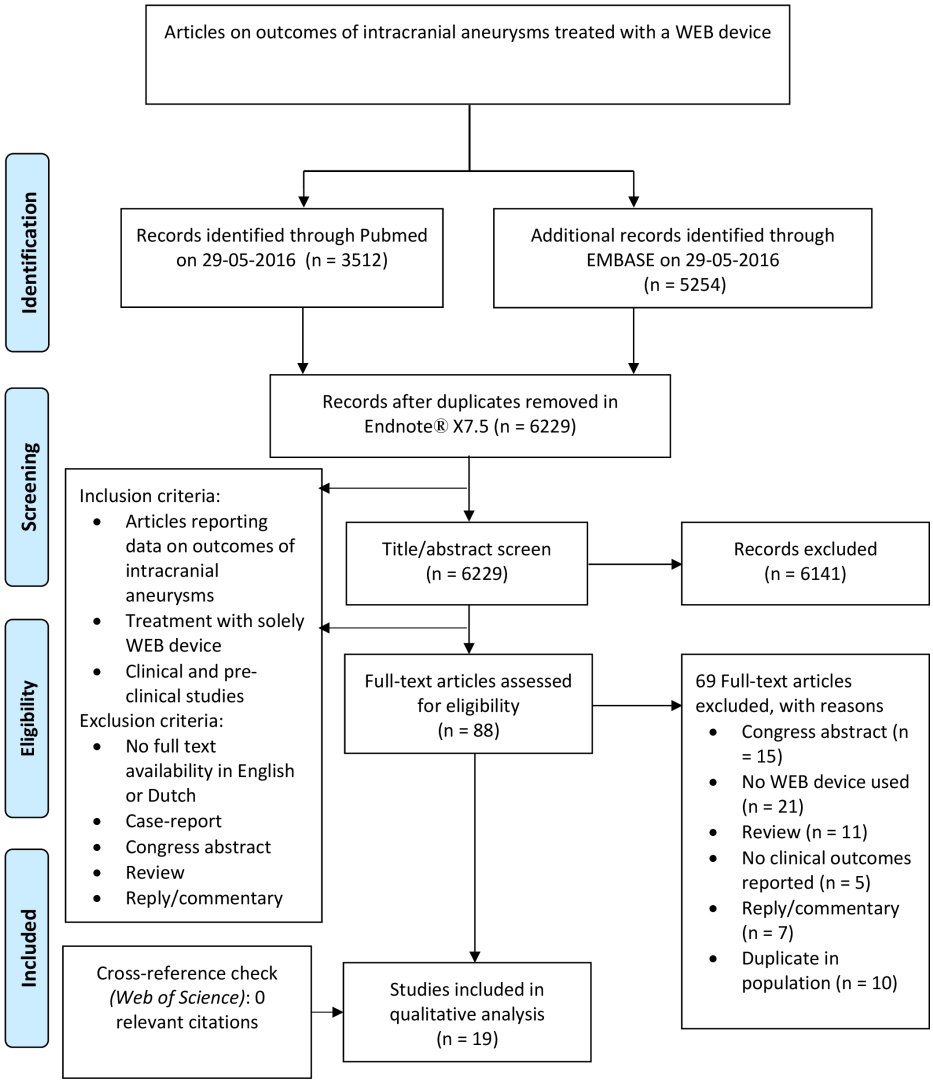
Wide-neck and bifurcation aneurysms, especially of the basilar artery, remain particularly difficult to exclude from the circulation.[1] Indeed, they still confer great morbidity and mortality despite advances in medical technology.[2] As a result, there have been a growing number of options to treat aneurysms using endovascular approaches (e.g. coiling or flow diverters) as opposed to traditional clipping.[3-5] A recently introduced innovative endovascular device, the Woven Endobridge (WEB) device (©Sequent Medical Inc., Aliso Viejo, California, USA), is a self-expanding mesh that can be introduced into intracranial aneurysms.[6] After deployment, the mesh covers the neck of the aneurysm, resulting in flow disruption in the sac of the aneurysm. This subsequently leads to exclusion of the aneurysm from the circulation.[6] This feature makes it ideal for treating wide-neck and bifurcation aneurysms, as it covers the neck of the aneurysm.[6] Since the introduction of the WEB device in 2011, it has become clinically available in Europe, but is currently not FDA (Food and Drug Administration) approved.[6] In this systematic review, the aim is to evaluate outcomes of aneurysms treated with a WEB device.

Methods

Search strategy and paper selection

A systematic review of the current literature was conducted to identify studies reporting on pre-clinical and clinical experience with WEB devices for intracranial aneurysms. To this aim, both PubMed and Embase databases were searched. As the WEB device was introduced in 2011, articles published before that time were excluded from the search.[6] For the search strategy the keywords "WEB device" and "endovascular therapy" with synonyms were used. The search strategy, which was made with help from a librarian, is described in **Supplementary Table 1.3**. The last search was conducted on 5-29-2016. This review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[7] The resulting flowchart is depicted in **Figure 1.1**. After the articles were imported into Endnote X7.5, duplicates were removed. Titles and abstracts were screened by two authors independently (IM and JS) for articles reporting on the use of the WEB device for intracranial aneurysms. For full text screening, articles reporting on outcome of aneurysms treated with a WEB device were included, both clinical and pre-clinical. Only literature in English and Dutch was reviewed. Case reports, congress abstracts, commentaries and reviews were excluded. If there were overlapping cohorts, only the largest cohort was included in the review. Web of Science was consulted for additional papers, and references of selected articles were checked for possible relevant studies.

Figure 1.1: Flowchart



Flowchart of study selection process for articles on the WEBdevice

Data extraction

The following variables were extracted from the full text of each study: study design, number of patients, number of aneurysms treated, aneurysm location, number of ruptured aneurysms, microcatheter size, successful WEB device placement, length of follow-up, complete aneurysm occlusion on angiogram, aneurysm neck remnant, aneurysm remnants, re-treatment, antithrombotic therapy, thromboembolic events, other complications, and re-rupture.

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Table 1.1: Study characteristics

Author (year of publication)	patients (N)	Number unruptured (%)	Trial design	Follow-up (month)	Sort of aneurysm	aneurysm location	anti thrombotic therapy protocol	microcatheter size used (inch)	Thromboembolic event	Other procedural complications reported
Ambrosi et al. (2015)	10	10 (100)	PCS	6	bifurcation	MCA (4), AcomA (5), Basilar Tip (1)	500mg aspirin preoperatively, 75 mg aspirin once daily for one month	0.027	0	
Behme et al. (2015)	52	41 (75)	RCS	3 (44 aneurysms)	Wide neck	MCA (19), AcomA (9), Basilar (10), Pcom (4), ICA (8), superior cerebellar artery (1), ACA (1)	100 mg aspirin and 75 mg Clopidogrel 5 days before treatment. aspirin was continued for 6 weeks post treatment	0.027	4	aneurysm rupture (1) P1 stenosis (1)
Caroff et al. (2014)	6	6 (100)	RCS	6	Wide neck	MCA (3), ACA(3)	none	0.027, 0.025	2	
Caroff et al. (2015)	90	65 (66)	RMCS	Mean 3.3 (54 aneurysms)	not specified	MCA (38), AcomA (21), BA(19) ICA (15)	Varied per hospital, all patient heparinized during the procedure	0.027, 0.033	6	aneurysm rupture (1), parenchymal hemorrhage (7)
Clajus et al. (2016)	108	67 (59)	RCS	mean: 13.4 (90 aneurysms)	87.5% wide neck	MCA (39), ACA (7), AcomA (27), ICA (17), Pcom (7), PCA (1), BA (15), VA (1)	Heparinized during procedure, aspirin 100mg, clopidogrel 75 mg one week prior and for 6 months post procedural	0.021, 0.027, 0.033, 0.038, 0.044	11	Re-bleed (2), infarction from WEB dislocation (2)
Colla et al. (2013)	4	2 (50)	RCS	7	basilar tip	BA (4)	not standardized	not standardized	NR	
Gherasim et al. (2015)	10	10 (100)	RCS	3 - 6	Wide neck	AcomA(10)	none	0.027, 0.038	1	WEB device protrusion with thromboembolic event (1)
Kabbasch et al. (2016)	8	7 (88)	RCS	3.5 - 38 months	large partially thrombosed	AcomA (5), Pcom (1), ICA (1) Basilar (1)	not standardized	NS	NR	
Klisch et al.	2	2	RCS	1.5	bifurcation	Basilar (1) , MCA (1)	heparinized during procedure and aspirin 100mg		0	

Table 1.1: Study characteristics (continued)

(2011)		(100)			and basilar tip		for 6 months postprocedural			
Lawson et al. (2016)	22	3 (14)	RCS	3	wide neck and bifurcation	MCA (5), ICA (3), AcomA (3), Basilar tip (11), Pcom (3)	heparinized during procedure	0.033	3	aneurysm rupture (1), Symptomatic ischemia (1)
Lescher et al. (2016)	22	22 (100)	RCS	mean: 7	NS	MCA (5), AcomA/ACA (4), ICA (I), BA (11), VA (1)	apririn 100 mg 3 months	0.021, 0.027, 0.033, 0.058, 0.072	0	
Liebig et al. (2015)	47	0 (0)	RMCS	Mean 4 (25 aneurysms)	Wide neck	MCA (7), Pcom (1)	not standardized	0.027, 0.033	4	aneurysm perforation (3), WEB device protrusion (4), infarction (2)
Lubicz et al. (2013)	19	19 (100)	PCS	mean: 6 month	Wide neck	MCA (14), AcomA (2), ICA (1), Basilar (2), VA (1)	none	0.027, 0.033	2	infraction (1), intraoperative aneurysm rupture (1)
Papagiannaki et al. (2014)	83	75 (88)	PMCS	Mean 5.3 (65 aneurysms)	NS	MCA (48), basilar (18), AcomA (11), ICA (8)	not standardized	≥ 0.027	9	aneurysm rupture (1)
Pierot et al. (2013)	33	29 (85)	RMCS	mean: 7.2 (30 aneurysm)	Wide neck	MCA (34)	not standardized	≥ 0.027	5	intraoperative rupture (1)
Pierot et al. (2015)	26	24 (92)	RMCS	mean: 27.9 (19 aneurysms)	Wide neck bifurcation	MCA (13), Basilar (8), PICA (1), AcomA (3), ICA (1)	NR	NR	3	
Pierot et al. (2016)	62	56 (89)	PMCS	12 (58 aneurysms)	Wide neck	MCA (32), AcomA(16), Basilar (9), ICA (6)	not standardized	0.027, 0.033	9	intraoperative rupture (1)
Pierot et al. (2016)	51	48 (94)	PMCS	6 months (41 aneurysms)	Wide neck	MCA (29), Basilar (12), ICA (6), AcomA(4)	not standardized	NS	9	
Van Rooij et al. (2016)	32	0 (0)	RCS	3 - 6 months (18 aneurysms)	Ruptured	AcomA(11), MCA (8), Pcom (7), pericallosal (3), superior cerebellar (1), BA (1), ophthalmic (1)	None	0.027, 0.033	3	

Legend: Abbreviations: RCS: retrospective case series, PCS: prospective case series RMCS: retrospective multicenter study, PMCS: prospective multicenter study, MCA: middle cerebral artery, ACA: anterior cerebral artery, AcomA: anterior communicating artery, Pcom: posterior communicating artery, ICA: internal carotid artery, Basilar artery: BA PCA: posterior cerebral artery, VA: vertebral artery, PICA: posterior inferior cerebellar artery, NS: Not specified

Results

After removing duplicates, 6229 articles were identified. After screening for title and abstract, 6141 articles were excluded and the full texts of 88 articles were reviewed. Afterwards, 19 studies were included in the review, with a total of 687 patients with 718 aneurysms.[6,8-25] Study characteristics are reported in **Table 1.1**.

Preclinical results

Two studies reported preclinical results of the WEB device.[26,27] The first study, performed in rabbits, reported complete occlusion of 19, incomplete occlusion of 2, and recanalization of 3 aneurysms at 12-month follow-up (n=24).[26] A different study in 80 rabbits found complete occlusion of 15, neck remnants in 11, proximal recess persistence in 11, and aneurysm remnants in 37 aneurysms based on histology.[27] In this study it was also noted that angiographic adequate occlusion had a sensitivity of 97.7% and a specificity of 64.9% compared to histology with an inter-observer weighted kappa coefficient of 0.76 (95% CI, 0.76 - 0.82).[27] Interestingly, this study was published when the WEB device was already used extensively in European clinics.[12,25]

Clinical results

In 2011, Klisch et al reported the first treatment of intracranial aneurysms using the WEB device.[6] They reported on two patients with unruptured wide-neck bifurcation

aneurysms that were treated successfully, with MRAs showing complete occlusion at eight weeks.[6]

Five studies reported on prospective outcomes. In the "WEB Clinical Assessment of Intrasaccular Aneurysm Therapy" (WEBCAST) European multi-center prospective trial for wide-neck aneurysms, 48 out of 51 (5.9% ruptured) aneurysms were considered treatable with a WEB device. At six-month follow-up with Digital Subtraction Angiography (DSA), complete occlusion was achieved in 23 (56.1%) patients, a neck-remnant was observed in 12 (29.3%), and an aneurysm remnant in 6 (14.6%), with 4 patients requiring additional endovascular intervention.[21] Another study also reports a patient with regrowth of a middle cerebral artery (MCA) aneurysm nine months after placement of a WEB device that was successfully recoiled, but no further follow-up was reported.[28]

In the prospective multi-center French Observatory study for WEB devices, 63 devices were placed in wide-neck bifurcation aneurysms in 62 patients. Of the 58 aneurysms with follow-up, 30 aneurysms were completely occluded, 16 (27.6%) had neck remnants and 12 (20.7%) showed aneurysm remnants at one-year follow-up. Among the aneurysms that showed a remnant, seven required additional endovascular intervention at time of WEB placement, and two required retreatment with a flow diverter.[24] Retreatment was unsuccessful for one of these two patients.[24] In the largest prospective multi-center study, 79 out of 85 WEB placement procedures were successful. Out of 65 aneurysms, there was complete occlusion in 37 (57.0%), neck-remnant in 23 (35.3%), and an aneurysm remnant in 5 (7.7%) at a mean follow-up of 5.3 months.[20]

In another prospective cohort study of 10 patients with bifurcation aneurysms, WEB placement was successful in 8 (80%) cases, with complete occlusion in 2 (25.0%), a neck remnant in 5 (62.5%), and an aneurysm remnant in 1 (12.5%) patient at 6-month follow-up.[8] Similar results were reported in a separate study of 20 wide-neck aneurysms, of which 19 were treated successfully. 19 Of the 14 aneurysms in this study with follow-up, 2 (14.2%) required retreatment, and there was complete occlusion in 0 (0%), neck-remnant in 13 (92.9%), and incomplete occlusion in 1 (7.1%) aneurysms.[19]

In the largest reported single-center experience, 114 aneurysms (41.2% of which were ruptured) were treated in 110 patients. Of the 90 aneurysms with follow-up, complete occlusion or occlusion with a neck remnant was achieved in 68, and 22 (24.4%) aneurysms showed residual filling.[12] A total of 15 (16.7%) aneurysms in this study were retreated with other endovascular procedures.[12] The second largest retrospective multi-center study reported success in 93(94.9%) out of 98 WEB device placement procedures for aneurysms (34% of which were ruptured). At a mean follow-up of 3.3 months, good outcomes were not further specified, although there were eight reported aneurysm remnants.11 Eight other retrospective case series with varying degrees of follow-up and occlusion had similar outcomes, and the results of these studies are depicted in **Table 1.2**.[9,10,13,15-18,22,23]

In terms of complications and adverse events associated with WEB device placement, procedural aneurysm rupture was reported in 10 patients.[9,11,16,18-20,22,24] Thromboembolic events associated with the procedure were reported more frequently with a total of 71 patients (10.3% of all cases) and infarction was seen in 8 cases (1.2% of all

cases).[9,12,14,16,18-23,25] Re-bleeds were only reported in five patients in two studies with mean follow-up of 3.3 and 14.4 months.[11,12]

Ruptured versus unruptured aneurysms

Specific outcomes for ruptured aneurysms were described in two retrospective studies.[18,25] The first study included 52 aneurysms, 20 of which had a mean follow-up of 4 months. Of these 20 aneurysms, 15 (75.0%) were completely occluded, 5 (25.0%) had a neck remnant, and 5 (25.0%) showed a remnant.[18] In the other study, 18 aneurysms of the initial 32 had at least 3 months of follow-up. Of these 18 aneurysms with adequate follow-up, 15 (83.3%) showed complete closure, 2 (11.1%) showed a neck remnant, and 1 (5.6%) showed a remnant.[25]

For unruptured aneurysms, 2 prospective studies reported the outcomes of 10 and 20 bifurcation aneurysms, respectively.[8,19] The first study reported 8 successful WEB device placements in 10 aneurysms. Of these 8 aneurysms with successful placement, 2 (25.0%) showed complete occlusion, 5 (62.5%) showed a neck remnant, and 1 (12.5%) showed an aneurysm remnant at follow-up.[8] In the second study, 14 of 20 aneurysms had follow-up, and of these 13 (92.9%) had a neck remnant and 1 (7.1%) showed an aneurysm remnant.[19] Three other retrospective studies for exclusively unruptured aneurysms also showed low numbers of aneurysm remnants as indicated in **Table 1.2**.[11,14,17]

In studies that reported exclusively ruptured or unruptured aneurysms, overall aneurysm remnant at follow-up was 6 out of 43 (14.0%) for ruptured aneurysms versus 8 out of 59 (13.6%) for unruptured aneurysms at follow-up.[8, 11,14,17-19,25] However, although these outcomes may appear similar, they cannot be adequately compared due to great variation in patient characteristics as indicated in **Table 1.1**.

WEB device in combination with other endovascular treatments

One study reported successful treatment of two patients with two aneurysms that were too big to treat with available WEB device sizes by using a combination of coiling and WEB device placement at the dome, with six months of follow-up in one patient.[29] Another study described eight complex large aneurysms, of which six were thrombosed, that were re-treated with a WEB device at the dome in combination with coiling of the sac of the aneurysm. Interestingly, all thrombosed aneurysms showed regrowth, all requiring additional endovascular treatment with stable occlusion in varying follow-up.[15] In another series of four patients with thrombosed aneurysms, two patients that were only treated with a WEB device suffered fatal rupture as opposed to the other two that were treated with a combination of WEB device placement and stenting.[30] There were 12 other studies describing patients that were primarily treated with a WEB device and another form of endovascular therapy varying from additional coiling to an additional WEB device to stenting, or a combination as depicted in **Table 1.1**.[11-13,17-25] In terms of re-treatment of aneurysm remnants, several studies reported on using either coiling, stenting, or again an additional WEB device, but outcomes were reported inconsistently (**Table 1.1**).[9,12,15-19,21,23,24]

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Table 1.2: Study Outcomes

Author (year of publication)	aneurysms treated (N)	successfull WEB. treatment with additional endovascula	Complete occlusion at placement	Neck remnant at placement	aneurysm remnant at placement	Timing of follow-up imaging	Complete occulsional follow-up	Neck remnant at	aneurysm remnant at follow-up	Re-treatment	successfull re-treATMENt	re-rupture
Ambrosi et al. (2015)	10	8	0	1	1	6	6 months	2	5	1	0	-	0
Behme et al. (2015)	55	51	NS	NR	NR	NR	99 days	15	14	15	15	50% (N = 10)	0
Caroff et al. (2014)	6	6	NS	NR	NR	NR	3 months	2	2	2	NR		0
Caroff et al. (2015)	98	93	12	27	2	67	mean 3.3 months	NS	NS	8	NR		3
Clajus et al. (2016)	114	110	13	87	10	12	mean 14.4	52	16	22	15	NR	2
Colla et al. (2013)	4	4	1	NR	NR	NR	minimal 7 months	NS	NS	NS	0		NR
Gherasim et al. (2015)	10	7	NS	2	4	1	3-7 months	3	3	1	NR		NR
Kabbasch et al. (2016)	8	8	8	4	3	1	3.5 to 38	2	2	4	5	NS	NR
Klisch et al. (2011)	2	2	0	NR	NR	NR	8 weeks	2	0	0	NR		0
Lawson et al. (2016)	25	22	0	4	5	13	3 months	8	5	8	2	NS	0
Lescher et al. (2016)	23	22	8	NR	NR	NR	median 7 months	12	7	3	1	NS	0
Liebig et al. (2015)	52	52	8	20	15	17	mean 4 months	15	5	5	4	NS	0
Lubicz et al. (2013)	20	19	4	1	13	5	6 months	0	13	1	2	2	0
Papagiannaki et al. (2014)	85	79	9	NR	NR	NR	mean 5.3	37	23	5	NR		0
Pierot et al. (2013)	34	33	4	NR	NR	NR	Mean 7.2	8	17	5	NR		0
Pierot et al. (2015)	26	NR	4	NR	NR	NR	mean 27.9	13	3	3	3	NS	0
Pierot et al. (2016)	63	62	7	NR	NR	NR	12 months	30	16	12	2	1	0
Pierot et al. (2016)	51	48	4	4	12	32	6 months	23	12	6	3	NR	0
Van Rooij et al. (2016)	32	31	2	NR	NR	NR	3 to 6 months	15	2	1	0		0

Legend: Abbreviations: NS: not specified, NR: not reported

Discussion

In this review, outcomes of WEB device use for treatment of intracranial aneurysms are described. We identified five prospective studies and fourteen retrospective studies.[6,8-28] Unfortunately, due to great variation of reporting it was not possible to conduct a meta-analysis.

In the two prospective multi-center trials, WEBCAST and French Observatory Trial, the WEB device completely occludes aneurysms in 56% to 52% of cases, respectively.[21,24] For coiling, adequate treatment is traditionally defined as either complete occlusion or a small neck remnant. If that standard is applied to these two prospective trials, the successful treatment rate which would increase to 85% and 79%, respectively.[5,21,24] Whether a neck remnant could be defined as adequate treatment for WEB devices, however, remains to be determined; first, because of a limited follow-up of the WEBCAST and French Observatory trial (6 and 12 months, respectively) and second because of incomplete follow-up (85% and 94% follow-up, respectively).[21,24] As indicated by Lawson et al. a more precise grading system of aneurysm occlusion would be valuable to assess outcome of various treatments, especially since neck remnants seem difficult to define and various types could have different clinical implications.[16] With prospective data, such a grading system, based for instance on aneurysm size and location, could potentially even provide a prediction model to aid clinical decision-making.

WEB device closure rates are lower compared to reported closure rates of endovascular coiling and clipping. ISAT (International Subarachnoid Aneurysm Trial) for instance reports complete occlusion or a neck remnant in 92% and 94% of aneurysms respectively at one year follow-up.[31,32] As wide-neck and bifurcation aneurysms are generally regarded as not suitable for coiling, however, a comparison with the ISAT trial cannot be made as it only included aneurysms treatable with coiling.[31,32] Furthermore, as these trials were for specific types of aneurysms, outcomes in other types of aneurysms may not be similar.[21,24]

Another problem with defining adequate aneurysm closure is the accuracy of DSA after placement of a WEB device. One study showed an accuracy of 82% at treatment and 82% at follow up compared to histology in rabbits.[27] We believe that this misjudging of aneurysm closure in approximately 20% of cases is considerable and could possibly have severe clinical consequences like re-rupture, which was reported in 5.6% and 2.2% of cases in two studies.[11,12] Two other studies also compared MRA to DSA for follow-up after WEB treatment, finding that MRA had low sensitivity (25% and 60%) for detecting an aneurysm remnant.[33,34] In the case of unsuccessful treatment, two studied reported that retreatment was necessary in 7.3% and 3.5% of cases with follow up.[21,24] The largest single-center retrospective study even reported retreatment in 16.7% of cases that were followed up.12 Furthermore, it was even reported that retreatment was only successful in 50% of cases in one study (n=10).[9] The Barrow Ruptured Aneurysm trial reports a similar necessity for retreatment in 10.6% of cases treated by coiling compared to 4.5% treated by clipping at one-year follow up.[35]

Few studies reported on the use of the WEB device for ruptured aneurysms. The WEBCAST and French Observatory Trial primarily investigated unruptured aneurysms, with 89% and 94% of the total aneurysms unruptured, respectively.[21,24]

Two other studies primarily examined WEB devices in ruptured aneurysms, reporting adequate occlusion in 94% (n=18) and 80% (n=20) of aneurysms with three to six month follow-up, respectively, and a mean follow-up of four months.[18,25] In the first study, 26 out of the 32 initial patients were treated on the day of the subarachnoid hemorrhage.[25] Overall, due to small numbers in these studies, more research is necessary to determine the therapeutic value of the WEB device in ruptured aneurysms. Furthermore, it has not been investigated whether ruptured aneurysms have similar outcomes to unruptured aneurysms. Due to the great heterogeneity in the studies (as indicated in **Table 1.1**), we were unable to make a direct comparison in this study.

There seems to be a lack of consensus about the necessity of antithrombotic medication. Even the WEBCAST and French Observatory Trial did not have specific protocols for anticoagulation, instead deferring this decision to the medical centers involved.[21,24] The authors of the WEBCAST trial suggested that no anticoagulation is necessary, as the WEB device is intrasaccular as opposed to intravascular devices such as stents. Furthermore, the authors found no significant relationship between the absence of anti-platelet prophylaxis and thromboembolic events when compared to patients on antiplatelet prophylaxis (p=0.6663).[21] In the other studies, there was also no consensus. While one study reported the use of antiplatelet prophylaxis for six months in ruptured aneurysm cases, another used no anticoagulation at all for all patients.[12,25] Similarly, a recent meta-analysis identified great variation in use of antiplatelet therapy in stent-assisted coiling.[36] The variation observed in this study might thus reflect variability in antiplatelet use for endovascular treatment of aneurysms in general.

Only one study examined the learning curve for WEB device deployment, showing that treatment was initially successful in approximately 40% of cases, which increased to approximately 80% in later cases.[9] In our opinion, this indicates a considerable learning curve and makes a practice model a necessity. Furthermore, outcomes could continue to improve with better deployment of the WEB device, but also through better case selection. Especially since every aneurysm is unique, and with the WEB device targeted at wide-neck and bifurcation aneurysms, outcomes could be improved with more specific guidelines.[6] For instance, thrombosed aneurysms seem to be associated with poor outcomes.[15] In terms of current clinical application, one center even reports that WEB device use has become the standard of care for all types of aneurysms despite the fact that follow up of reported prospective studies is short and only for specific aneurysms.[21,24,25]

Currently, two other trials are being conducted for the use of WEB devices for intracranial aneurysm treatment: the CLARYS (CLinical Assessment of WEB® Device in Ruptured aneurYSms, NCT02687607) trial, an observational, non-randomized, multi-center trial investigating outcomes of the WEB device in ruptured aneurysms, and the WEB-IT clinical study (NCT02191618), a multi-center single arm cohort including patients with wide-neck aneurysms. However, as the highest level of evidence of the (currently active) studies assessing WEB devices is 4 (Oxford Centre for Evidence-based Medicine- Levels of Evidence), due to a lack of a comparison group, this leaves much room for improvement. Improving the quality of these studies would contribute to better decision-making for treatment of a specific aneurysm.

We suggest that future research for aneurysm treatment should be conducted in accordance with a framework like the IDEAL (Idea, Development, Exploration, Assessment, Long-term Follow-up) framework for surgical innovation.[37] The IDEAL framework describes consecutive phases for innovative surgical research and procedures and requires that a new procedure is studied prospectively and randomized in comparison with the current practice (here, coiling or clipping) before implementation of a new procedure.[4,5,37-39] Also, involvement of the producer of the device, which was reported in 17 out 19 clinical studies, should be kept to a minimum to make sure results are reported without conflicts of interest.[6,9-12,14-25,28] Furthermore, we deem it essential that patients give informed consent for being treated with an unproven innovative device, which was only identified in six studies.[6,8,17,19,21,24] Overall, the WEB device has a potential role in the treatment of complex aneurysms, however, well-designed prospective trials should be performed before these devices should be routinely used in patients.

Conclusion

The WEB device is a promising innovative endovascular treatment for wide-neck and bifurcation aneurysms. For these aneurysms, which were previously not ideal for endovascular treatment, the WEB device has shown promising results in two multi-center prospective trials.[21,24] Complete aneurysm closure was found in 85% and 79% of cases, defined as complete closure or a small neck remnant. Multidisciplinary teams treating these aneurysms with a WEB device, however, should be cautious, as the WEB device is potentially associated with a considerable learning curve. Also, the WEB device currently has been investigated mainly in unruptured aneurysms with a wide neck, which make results difficult to extrapolate to other aneurysms. Furthermore, long-term results remain unknown, and no comparison has been made with currently available treatment options such as stent-assisted coiling or clipping. In the future, well-designed studies are necessary to determine the true added value of treating intracranial aneurysms with a WEB device.

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Table 1.3: Search syntax

Pubmed (29-05-2016)
(((((WEB[Title/Abstract]) OR Woven Endobridge[Title/Abstract])) OR ((((("Endovascular Procedures"[Majr:NoExp]) OR "Embolization, Therapeutic"[Majr:NoExp])) OR ((((endovascular[Title/Abstract]) OR intravascular[Title/Abstract])) AND (((((((technique*[Title/Abstract]) OR procedur*[Title/Abstract]) OR treatment[Title/Abstract]) OR surgery[Title/Abstract]) OR therapy[Title/Abstract]) OR flow disrupt*[Title/Abstract]) OR Embolization[Title/Abstract])))))) AND ((((((aneurism*[Title/Abstract]) OR aneurysm*[Title/Abstract])) AND (((((cerebral[Title/Abstract]) OR ruptured[Title/Abstract]) OR unruptured[Title/Abstract]) OR brain[Title/Abstract]) OR intracranial[Title/Abstract]))) OR intracranial aneurysm[MeSH Terms])
Embase (29-05-2016)
(('web':ab,ti OR 'woven endobridge':ab,ti) OR ((endovascular:ab,ti OR intravascular:ab,ti) AND (technique*:ab,ti OR procedur*:ab,ti OR treatment:ab,ti OR surgery:ab,ti OR therapy:ab,ti)) OR ('endovascular aneurysm repair'/exp OR 'neurovascular embolaization device'/exp OR 'device embolization'/exp OR 'artificial embolism'/exp)) ->8 AND (((aneurism*:ab,ti OR aneurysm*:ab,ti) AND (cerebral:ab,ti OR ruptured:ab,ti OR unruptured:ab,ti OR brain:ab,ti OR intracranial:ab,ti)) OR 'brain artery aneurysm'/exp OR 'intracranial aneurysm'/exp) AND [embase]/lim AND [2011-2016]/py