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Review Article

Endovascular Treatment of Bifurcation Aneurysms with the Woven EndoBridge: Product Features and Selected Results of Off-Label Use

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Treatment for wide-neck bifurcation cerebral aneurysms (WNBAs) is widely performed by endovascular treatment as well as open surgical clipping. However, due to factors such as the shape and size of the aneurysms, as well as the anatomical features of surrounding branch vessels, there are some cases in which simple coiling or conventional adjunctive techniques, such as balloon-assisted or neck bridge stent-assisted coiling, are not sufficient to achieve a satisfactory cure. Against this backdrop, the device known as the Woven EndoBridge (WEB) (MicroVention, Aliso Viejo, CA, USA) was developed and can be deployed directly into the aneurysm for treatment. Over a decade has passed since its development, and it is now used in many countries worldwide. This review provides insights into the evolution of the WEB device from its development to the date of this writing, highlighting the unique features of the device and its treatment indications. Additionally, it discusses the posttreatment course, perspectives on recurrence and retreatment, imaging assessments, and potential off-label use based on numerous studies primarily conducted in Europe and the USA.

Keywords ▶ intracranial aneurysm, bifurcation, Woven EndoBridge, flow disruptor

Introduction

Endovascular treatment for ruptured and unruptured cerebral aneurysms has recently become performed worldwide in the past few years, with advanced treatment techniques and various devices now available. However, challenges persist due to factors, such as the shape, location, size of the aneurysm, and the branching vessels associated with the aneurysm neck. These factors can make the treatment of certain aneurysms difficult, and there still remain other various unresolved issues.

In a systematic review by Ferns et al., the recurrence rate after coil embolization was reported as 20.8% (follow-up, 4.7–38 months), with half of these cases requiring retreatment. The others were followed up normally. Specifically, posterior circulation localization and aneurysms ≥10 mm are identified as risk factors for recurrence.[1)] Furthermore, an analysis of endovascular treatment cases by Pierot et al., including coiling and balloon-assisted coiling, identified factors associated with posttreatment for recurrences, the relation of other factors such as the nonsmoking status, rupture at presentation, aneurysm size ≥10 mm, wide neck, and middle cerebral artery (MCA) location (based on the ARETA study).[2)]

A systematic review focusing on wide-neck bifurcation cerebral aneurysms (WNBAs) showed that complete occlusion (CO) rates remained at 39.8% for endovascular treatment compared to 52.5% for open surgical clipping.[3)] Additionally, endovascular treatment outcomes for unruptured cerebral aneurysms located in the MCA or the basilar artery (BA) tip, as shown in the Branch Study, resulted

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in a CO rate of 30.6%.[4] Against this backdrop, there has been a growing demand for new devices to treat complexly shaped and localized aneurysms. One of the solutions to address these challenges was the development of the Woven EndoBridge (WEB) device, which can be placed inside the aneurysm to disrupt blood flow and promote thrombosis without the need for additional interventions (e.g., flow disruptors).

Application and Product Features of the WEB

The principle of the WEB involves deploying it as an intrasaccular flow disruptor within an aneurysm to fill the cavity and obstruct blood flow within the aneurysm, thereby promoting thrombus formation. It consists of an implant and a delivery system (delivery pusher and introducer sheath). The implant is a self-expanding device constructed from a combination of a nickel-titanium alloy (nitinol) or platinum wire coated with nitinol and a nitinol drawn-filled tube, and its detachment mechanism at the deployment site is controlled electrically.

Currently, there are two shapes available: the cylindrical WEB SL (single layer) and the spherical WEB SLS (single layer sphere). X-ray-opaque markers are attached to the tip and proximal end of the device. When introducing it into the aneurysm, a VIA Microcatheter (MicroVention, Aliso Viejo, CA, USA) is used, and each is sized to properly fit the dimensions of the device. Three different sizes of catheters are available, corresponding to the implant outer diameters of 4–7 mm, 8–9 mm, and 10–11 mm, with the inner diameters of 0.021, 0.027, and 0.033 inches, respectively. (The smallest system is the WEB 17, which is compatible with a 0.017-inch microcatheter; however, it has not yet been approved for use in Japan.) The use of a distal access catheter (DAC), such as the SOFIASELECT (MicroVention), is recommended as a guiding catheter in Japan.

Application and Usage of the WEB Device

The WEB device is used for endovascular treatment of wide-neck intracranial aneurysms located in the anterior circulation (the MCA, the internal carotid artery [ICA] terminus, the anterior communicating artery [Acom]), and the posterior circulation (basilar tip). These aneurysms typically have a neck size of ≥4 mm and a dome-to-neck ratio of <2. The eligible aneurysm sizes range from 3 mm to 10 mm, and the WEB device can be used for both ruptured and unruptured aneurysms.

The selection of implant size is based on 2D measurements of the aneurysm (neck, width, and height) obtained from working angles and the down-the-barrel view. Supplementary measurements, such as 3D imaging, may also be taken (some reports suggest the use of volume measurements and 3D imaging for size selection).[5–8] The choice between the WEB SL and WEB SLS is determined based on the aneurysm diameter and neck diameter while also considering the aneurysm's shape and height. Preoperative antiplatelet therapy is not mandatory because the device does not remain in the parent vessel. However, for unruptured cases, consideration of antiplatelet therapy during the perioperative and postoperative periods may be necessary depending on the aneurysm's shape, location, and access.

After introducing the device into the VIA Microcatheter, the guiding and intermediate catheter positions are adjusted, and the tip position of the VIA Microcatheter within the aneurysm is confirmed before starting deployment. The state when the device's tip first begins to emerge from the catheter is referred to as the "seed," and further pushing with the delivery pusher causes the implant to expand to about 1/3 of its size, known as the "sprout." Further pushing expands it to about 2/3 of its size, and finally, it reaches 4/5 of the displayed device diameter, called the "flower." The tip of the implant is most rigid immediately after deployment begins, presenting a higher risk of intraoperative rupture. Subsequently, while adjusting the position of the delivery system, it is confirmed that the implant has been properly deployed within the aneurysm before detachment is done electrically.

For postoperative assessment of aneurysm occlusion status, the WOS scale (i.e., the Web Occlusion Scale), based on the modified Raymond Roy scale, is commonly used.[9] CO is categorized as WOS A/B, neck remnant as WOS C, and intrasaccular flow remnant as WOS D. For a more detailed evaluation of the risk of recurrence and/or early or late rebleeding, reports suggest the use of the Bicetre Occlusion Scale Score (BOSS), which utilizes cone beam computed tomography (CT) (Vaso CT; Philips Healthcare, Best, the Netherlands).[10] Cases with residual intrasaccular flow (BOSS 1) may require antiplatelet therapy or may be influenced by the size of the device.[11]

Follow-up imaging is typically performed with digital subtraction angiography in the first months and then up

to 6 months following the procedure. Further evaluations can also be effectively conducted using MRA or contrast-enhanced MRA.[12] Raoult et al. reported that follow-up evaluation at 1 year after treatment can be done using CT angiography.[13]

Device Evolution and Treatment Outcomes

The WEB device's development and treatment outcomes can be traced back to 2011 when Ding et al. began preclinical studies by deploying the flow disruptor, initially known as the WEB I, in a rabbit aneurysm model.[14] At that stage, it was a single-layer device made of nitinol mesh. The 1-year CO rate was 33%. Histological findings confirmed the formation of connective tissue covering the aneurysm neck ≤3 months. Similar findings were observed in humans where a dense fibrous tissue was seen filling the central marker recess, which indicates occlusion of the aneurysm. Thus, the recess is theoretically completely "extra-aneurysmal" and flow limited to this region has no access to the aneurysm fundus.[9,15] Subsequently, the WEB II was introduced which could cover the aneurysm neck with a dual-layer (DL) configuration. The WEB II device obtained the Conformité Européenne (CE) mark of approval in 2010 and was used successfully for unruptured MCA and basilar tip aneurysms, achieving CO within 8 weeks without complications.[16] The device size variations included widths of 5–8 mm (requiring catheter induction of ≥0.027 inches) and 9–11 mm (requiring induction of a ≥0.032-inch diameter catheter), both of which had a relatively large profile.[9,15]

Cases with residual aneurysmal flow were often seen in early follow-ups (≤1 year), with many undergoing additional treatments such as coiling or stent-assisted coiling.[15,17] This was attributed to the selection of an inappropriate device size for the aneurysm's shape and size.[18]

Treatment outcomes of the WEB DL were reported in various European countries and in the USA.[17,18] The WEB SL and WEB SLS, which differ in shape, were introduced in 2013, each obtaining the CE Mark of approval. Several GCP (Good Clinical Practice) studies, including WEBCAST, WEBCAST 2, and the FRENCH Observatory series, were conducted in Europe.[19,20] **Tables 1** and **2** summarize selected case series in Europe and the USA that were treated using the WEB DL/SL/SLS. **Table 1** shows the patient's age, gender, aneurysm size, unruptured/ruptured, and location of aneurysms. **Table 2** shows the types of the WEB, occlusion status, morbidity/mortality, and retreatment rate during the follow-up period.

The French Observatory study indicated that the WEB SL and WEB SLS were more commonly used for smaller aneurysms (<10 mm), Acom aneurysms, and ruptured aneurysms when comparing the WEB DL and WEB SL/SLS.[20] The 1-year CO rate in that study was 52.9% (with 79% AO).

Combining the results of these three studies, the rate of retreatment at 1 year was 6.9%, and between 1 and 2 years was 2.0%.[21,22] The 5-year follow-up data from WEBCAST and WEBCAST 2 showed an AO rate of 77.9%, with morbidity and mortality at 1.0% and 7.0%, respectively. Morbidity and mortality specifically related to the device were both 0%. Most retreatments occurred within the first 2 years after the initial treatment.[23–26] WEBCAST used WEB DL exclusively, while WEBCAST 2 exclusively used WEB SL/SLS. Regarding the location of the treated aneurysms, Acom aneurysms were more common in WEBCAST (7.8%) than those in WEBCAST 2 (29.1%), highlighting the preference for low-profile WEB SL/SLS in Acom aneurysms.[19,20]

In 2014, a nitinol–platinum composite wire was introduced to improve visibility (EV [enhanced visibility] technology). In 2015, even lower-profile devices suitable for the VIA 21 were launched. The WEB-IT study, a prospective observational study evaluating the effectiveness and safety of the WEB device, was conducted in 2015 at 27 centers worldwide (21 centers in the USA and 6 abroad).[27] Among 150 cases, the WEB device was used in 148. Aneurysm locations included the Acom complex (27%), the MCA (30%), the ICA terminus (4%), and the basilar apex (39%). The 1-year CO rate was 53.8% (and as high as 84.6% when including neck remnants as AO). There were no cases meeting the major safety endpoints (death or severe stroke ≤30 days postoperation or any stroke >30 days to 1-year postoperation).[27] At the 5-year follow-up, the AO rate was 87.2% (with 58.1% CO), comparable to the European data.[28]

WEB 17, reported by Rooij et al. in 2017, along with outcomes for 40 cases, demonstrated its effectiveness and safety.[29,30] When compared to the WEB 21 system, there was no significant difference in treatment outcomes; however, there was a report expounding its increased usage for ruptured aneurysms.[31]

In 2018, the WEB device received US FDA approval. In Japan, it was approved in December 2019 based on the

Table 1 Characteristics of patients and aneurysms in a select case series in Europe and the USA

Author (year)	Patient mean age (range)	Female, n (%)	Aneurysms' mean size mm (range)	Unruptured, n (%)/ Ruptured, n (%)	Aneurysm location, n (%)
Klisch et al. (2011)[16]	NA	NA	6.3 (5.5–7)	2 (100)/0	MCA 1 (50)/BA 1 (50)
Pierot (2012)[62]	58.7 (35–75)	16 (80)	6.5 (4.0–15.0)	20 (95.2)/1 (4.8)	Acom 5 (23.8)/MCA 8 (38.1)/ICA 4 (19.1)/BA 4 (19.1)
Lubicz et al. (2013)[17]	54 (35–71)	14 (73)	9 (6–18)	19 (100)/0	Acom 2 (10.5)/MCA 14 (73.6)/IC 1 (5.2)/BA 2 (10.5)/VA-PICA 1 (5.2)
Pierot et al. (2013)[18]	55.8 (35–77)	28 (84)	6.9 (4–11)	31 (94.0)/2 (6.0)	MCA 33 (100)
Papagiannaki (2014)[63]	83 (85)	57 (68)	7.4 (4.6–13.8)	79 (95.3)/4 (4.7)	Acom 11(12.9)/MCA 48 (56.5)/ICA 8 (9.4)/BA 18 (21.2)
Lubicz et al. (2014)[15]	56.3 (35–74)	34 (76)	<5 mm in 5/5–10 mm in 38, >10 mm in 2	42 (93.3)/3 (6.7)	Acom 5 (11.1)/MCA 26 (57.8)/IC 1 (2.2)/BA 11 (24.4)/PICA 2 (4.4)
Pierot et al. (2015, 2016)[19,20]	55.6 (33–71)	23 (76.7)	<10 mm in 21	29 (93.5)/2 (6.5)	Acom 4 (12.9)/MCA 19 (61.3)/BA 6 (19.4)/IC 2 (6.5)
	57.4 (33–74)	16 (50)	<10 mm in 31	27 (84.4)/5 (15.6)	Acom 12 (37.5)/MCA 13 (40.6)/BA 3 (9.4)/IC 4 (12.5)
Caroff (2015)[64]	55 (26–83)	60 (66.7)	8.9 (3.7–39)	65 (66)/35 (34)	Acom 21 (21.4)/MCA 38 (38.8)/BA 19 (19.4), IC 15 (15.3)
Gherasim (2015)[65]	59.3	4 (40)	6.2 (3.5–8.1)	10 (100)/0	Acom 10 (100)
Pierot et al. (2016)[23,24]	55.6 (33–74)	35 (68.6)	8.2	48 (94.1)/3 (5.9)	Acom 4 (7.8)/MCA 29 (56.9)/IC 6 (11.8)/BA 12 (23.5)
Clajus (2017)[66]	55.6 (26–85)	78 (72.2)	6.4 (3.0–13.0 height/ unruptured)/7.3 (2.4–19.6 height/ruptured	61(56.5)/47 (43.5)	Acom 27 (23.7)/ACA 7 (6.1)/MCA 39 (34.2)/IC 17 (14.9)/Pcom 7 (6.1)/BA 15 (13.2)/VA 1 (0.9)/PCA 1 (0.9)
Pierot (2017)[67]	54.4 (27–77)	38 (69.1)	6.7 (2.8–17.0)	51 (92.7)/4 (7.3)	Acom 16 (29.1)/MCA 25 (45.5)/IC 5 (9.1)/BA 9 (16.4)
Fiorella et al. (2017)[3]	59 (29–79)	110 (73.3)	6.4 (3.6–11.4)	141 (94.0)/9 (6.0)	Acom 40 (26.7)/MCA 45 (30)/IC 6 (4)/BA 59 (39.3)
Lawson (2018)[68]	56.5	75 (68.8)	8.2 (3.8–18.3)	91 (83.5)/18 (16.5)	Acom 8 (7.3)/ACA 4 (3.7)/MCA 39 (35.8)/IC 9 (8.2)/Pcom 4 (3.7)/ BA 44 (40.4)/PCA 1 (1)
Spelle et al. (2022)[35]	54.5 (26–78)	31 (51.6)	6.6	0/60 (100)	Acom 26 (43.3)/ACA 2 (3.3)/MCA (38.3)/IC 1 (1.7)/Pcom 1 (1.7)/ BA 7 (11.7)
Youssef et al. (2021)[37]	57.8	32 (66.7)	6.1	0/48 (100)	Acom 17 (35.4)/MCA 10 (20.8)/BA 8 (16.7)/other 13 (27.1)

ACA: anterior cerebral artery; Acom: anterior communicating artery; BA: basilar artery; IC: internal carotid; ICA: internal carotid artery; MCA: middle cerebral artery; NA: not available; PCA: posterior communicating artery; Pcom: posterior communicating artery; VA: vertebral artery, posterior inferior cerebellar artery

Table 2 Summary of treatment results in a select case series in Europe and the USA

Author (year)	Number of cases (An)	Type of WEB	Study/location (prospective/retrospective)	Occlusion status (%) CO/NR (adequate occlusion)	Morbidity and mortality rate (%) (procedure/device related)	Follow-up period	Retreatment rate (%)
Klisch et al. (2011)[16]	2	WEB II (DL)	Germany	100/0 (100)	0/0	8 m	NA
Pierot (2012)[62]	21	DL	3 European centers/retrospective	46.7/33.3 (80)	4.8/0	3–12 m	9.5
Lubicz et al. (2013)[17]	18 (19)	DL	2 centers/prospective	10.5/78.9 (89.4)	10.5/0	3–12 m	15.7
Pierot et al. (2013)[18]	33 (34)	DL	5 European centers/retrospective	26.7/56.7 (83.4)	3.1/0	2–12 m	NA
Papagiannaki (2014)[63]	83 (85)	DL	11 French centers (22 WEBCAST/24 French Observatory)	56.9/35.4 (92.3)	1.3/0	3–24 m	10.8
Lubicz et al. (2014)[15]	45	DL	12 European centers/prospective	69/20.7 (89.7)	6.7/0	9–28 m	8.9
Pierot et al. (2015, 2016)[19,20]	30 (31)	DL (31)	French Observatory (10 centers)/prospective	51.2/29.8 (81.0)	3.3 (DL)/0	24 m	NA
Pierot et al. (2015, 2016)[19,20]	32	SL/SLS (32)	French Observatory (10 centers)/prospective	51.2/29.8 (81.0)	3.1 (SL/SLS)/0	24 m	NA
Piertot et al. (2016)[23,24]			French Observatory (10 centers)/prospective	51.7/27.6 (79.3)		12 m	3.2
Caroff (2015)[64]	90 (98)	SL	10 European centers/retrospective	26/39 (65)	2.2/1.1	3.3 m	NA
Gherasim (2015)[65]	10	DL/SL	5 French centers	28.5 /57.2 (85.7)	0/0	3 m	NA
Pierot et al. (2016)[23,24]	51	DL	WEBCAST (10 centers) Prospective	56.1/29.3 (85.4)	2.0/0	6 m	5.8
Clajus (2017)[66]	108 (114)	DL 49/SL 44/SLS 17	Europe/retrospective	57.8/17.8 (75.6)	5.3/8.5	13.4 m	14.8
Pierot (2017)[67]	55	SL 47/SLS 6	WEBCAST 2 (10 centers)	54/26 (80)	3.9/2.0	12 m	8.0
Pierot et al. (2018)[21]			WEBCAST/WEBCAST 2/ French Observatory (cumulative population)	52.9/26.1 (79.0)	1.3/0.7	12 m	6.9
Pierot et al. (2020)[22]			WEBCAST/WEBCAST 2/ French Observatory (cumulative population)	51.2/29.8 (81.0)	1.4/0.7	24 m	2.0
Pierot et al. (2021)[25]			WEBCAST/WEBCAST 2 (cumulative population)	50.8/32.8 (83.6)	0/1.3	3 y	11.4
Pierot et al. (2023)[26]			WEBCAST/WEBCAST 2 (cumulative population)	51.6/26.3 (77.9)	0/1.0	5 y	11.6
Fiorella et al. (2017)[3]	150	DL 19/SL 107/SLS 22	WEB-IT (25 USA/6 international) prospective	NA	0.7/0	1 m	NA
Arthur et al. (2019)[27]			WEB-IT	53.8/30.8 (84.6)	0.7/0	6–12 m	5.6
Fiorella et al. (2023)[28]			WEB-IT	58.1/29.1 (87.2)	0/0	5 y	15.5
Lawson (2018)[68]	109	DL 57/SL 41/SLS 6	14 UK centers	NA	6.0/0	3 m	NA
Spelle et al. (2022)[35]	60	SL 45/SLS 11	CLARYS13 European centers	41.3/45.7 (87.0)	9.6/3.8	12 m	10.0
Youssef et al. (2021)[37]	48	NA	USA multi-centers	61.5/30.8 (92.3)	12.5/6.3	5.5 m	4.2

An: aneurysms; AR: aneurysm remnant; BF: body filling; CO: complete occlusion; DL: double layer; m: month; NA: not available; NR: neck remnant; SL: single layer; SLS: single layer sphere; WEB: Woven EndoBridge; y: year

reference from the WEB-IT study,[27] and became eligible for the Japanese national medical insurance coverage in December 2020, with sales having commenced in January 2020. In conjunction with the insurance coverage, the Japanese Society of Neurosurgery, the Japan Stroke Society, and the Japanese Society of Neuroendovascular Therapy jointly established treatment device implementation standards and appropriate usage guidelines, published in March 2020.

The RISE trial, a randomized controlled trial, was recently concluded, and the results are highly anticipated. The trial involved 10 facilities in Canada, France, and the USA and included 250 cases. It spanned 4 years from 2019 to 2023 and is expected to provide more insights into the long-term outcomes of the WEB treatment.[32]

In a systematic review of 15 articles covering 963 aneurysms in 2020, van Rooij et al. reported intraoperative rupture in 0.83% of the cases, thromboembolic complications in 5.61%, and morbidity and mortality in 2.85% and 0.93%, respectively.[33] Hassankhani et al. conducted a review in 2023 of 27 articles, in which they noted that beyond 2 years, there was an increase in recurrent cases and retreatments.[34] Device shape changes, specifically the introduction of WEB compression, were observed in 43% of the cases, recurrence in 19%, and retreatment increased to 7.2% after 1 year.[34]

WEB Treatment for Ruptured Aneurysms

The effectiveness and safety of the WEB treatment for ruptured aneurysms have been thoroughly demonstrated. In the CLARYS study,[35] which included 60 cases of ruptured cerebral aneurysms from 13 European facilities, the CO rate at the end of the first year of treatment was 41.3% (including neck remnants, which accounted for 45.7%, resulting in an AO rate of 87.0%). The retreatment rate was 10%. This treatment had an overall morbidity of 15% at 1 month and 9.6% at 1 year, with mortality rates of 1.7% and 3.8%, respectively. Notably, there were no reported cases of postoperative rebleeding.

In a retrospective study conducted in eight facilities in the USA[36] involving 91 cases of ruptured cerebral aneurysms, the CO rate was 48.0%, with an AO rate of 80.0%, including cases with neck remnants. The procedural-related morbidity was 3.3%, and there were no mortalities. These results were consistent with those from other reports. The Acom aneurysm locations were the most frequently observed, followed by MCA aneurysms.[35,36] Similarly, in a multicenter study in the USA with 48 cases conducted in 2021,[37] the final CO rate was 92.3%, with a retreatment rate of 4.2%. In two systematic reviews conducted in 2021,[38,39] the results indicated a rebleeding rate of 1.2%–2.5%, a procedural-related complication rate of 4.0%–17.0%, and a retreatment rate of 6.8%–16.0% for the WEB treatment. A score-matching report focusing on ruptured Acom aneurysms[40] suggested that the WEB treatment tended to achieve a higher AO rate compared to coiling. Analyzing ruptured and unruptured aneurysms revealed no instances of rebleeding in either group, nor were there any significant differences in complications.[41]

Off-Label Use and Sidewall Aneurysms

Currently, the approved indications for WEB treatment primarily involve bifurcation aneurysms. However, reports of treatments for peripheral and sidewall aneurysms have also emerged. Lee et al. conducted a review encompassing 27 cohorts and 1831 cases, revealing 86% of the aneurysm locations fell within four major locations (on-label use): the MCA (34%), the Acom (26%), the basilar tip (18%), and the ICA terminus (7%). The remaining 14% constituted off-label use cases.[42] The most common off-label use locations included the posterior communicating artery (Pcom) (8%), followed by the anterior cerebral artery (ACA) (including the pericallosal artery, 6%), and the posterior inferior cerebellar artery (PICA) (4%). Additionally, since 2015, there has been a trend of decreasing aneurysm sizes and neck diameters observed in cases treated with the WEB device.[30,43] For locations where there is a potential for recurrence, the WEB treatment is considered a viable alternative alongside traditional coiling.[42,44,45]

Rodriguez-Calienes et al. conducted a review encompassing studies from seven European and three USA facilities, focusing on 285 cases of 288 sidewall aneurysms, of which 35% were ruptured.[46] Their review assessed the safety and efficacy of the WEB treatment. The most common locations included the anterior circulation (80%), with the Pcom being the most frequent location at 20%, followed by the communicating segment of the ICA at 14%, and the paraophthalmic segment at 12%. The posterior circulation accounted for 20%, with the most frequent locations being the superior cerebellar artery (17%) and the PICA (17%). The final AO rate was 89%, with a mean follow-up duration of 10.4 months. Procedural complications were observed in 8% of the cases.

Reports on the off-label use of WEB 17 for various applications have also been documented, showing favorable outcomes with no procedural complications and no reported fatalities. Early results (≤12 months) demonstrated a CO rate of 63.9%, while late results (>12 months) showed a rate of 77.8%. The overall CO rate was 64%, with an AO rate of 89%. The retreatment rate was 9%. Composite safety outcomes accounted for 8%, with intraprocedural complications during the intervention amounting to 6%. The all-cause mortality rate was 2%. Particularly, for peripheral aneurysms such as the PICA, WEB 17 has been reported to be particularly suitable.[47] Adeeb et al. reported on the off-label use of WEB for sidewall aneurysms, noting no significant differences in complication rates between the sidewall group (2.2%) and the bifurcation group (6.6%) for thrombotic complications nor between the sidewall group (3.3%) and the bifurcation group (3.3%) for hemorrhagic complications.[48]

The Outlook for WNBA Treatment and the Role of the WEB Device

As one of the treatment options for branching artery aneurysms, WEB devices have demonstrated safety and efficacy in addition to conventional treatment methods. While there is currently no long-term assessment of outcomes in Japan, evaluations in other countries, such as European countries and the USA, have shown promise.

Since their introduction in 2010, WEB devices have seen continuous improvements and technological innovations, making them a potential option, expanding the choices for treating branching artery aneurysms in addition to traditional coiling. An advantage of the WEB treatment is its applicability to treat both ruptured and unruptured aneurysms. Furthermore, the device does not leave foreign materials in the parent vessel, and it is not dependent upon antiplatelet medication. The introduction of low-profile WEB devices has extended their use to small aneurysms, even with some case series reporting effective outcomes for aneurysms as small as 3–3.5 mm (71% CO, 90% AO).[43] Comparing the treatment of ruptured aneurysms with the WEB 17 and 21 (low-profile devices), a report suggested that the WEB 17 was more effective for peripheral aneurysms.[31]

Adeeb et al. presented treatment outcomes based on the location of the aneurysms. The most common locations for treatment were the MCA, Acom, and basilar tip, in that order. However, in terms of the CO rate, basilar tip aneurysms showed a significantly higher rate, followed by ICA bifurcation aneurysms.[49] Regarding posterior circulation, especially for BA tip aneurysms, the WEB treatment may offer advantages in terms of reduced procedural time and avoiding the use of stents.[50,51]

On the other hand, off-label use remains controversial, and careful consideration should be given, including the preservation of branching vessel blood flow and evaluating long-term outcomes, including clinical courses.[42] That is, it may be challenging to determine whether or not the WEB treatment should be selected for all cases. There are also cautious opinions regarding the use of the WEB device for partially thrombosed aneurysms.[52]

Gawlitza et al. reported on the effectiveness of the WEB treatment for 17 cases of recurrent aneurysms.[53] Regardless of the initial treatment strategies, the WEB treatment can be considered one of the possible options to treat recurrent aneurysms.

The assessment after the WEB treatment is crucial for determining recurrence and the appropriateness and necessity of retreatment. According to Srinivasan et al., among 342 cases treated with the WEB devices in 13 facilities, 30 cases (8.8%) required retreatment, 23 cases of which received endovascular retreatment (12 with stent-assisted coiling, 7 with flow diverter, 2 with coiling, 1 with PulseRider [Cerenovus, Irvine, CA, USA] assisted coiling, and 1 additional WEB placement), and 7 cases underwent open surgical clipping. The timing of retreatment varies in different reports but there is a tendency for relatively early retreatment in many cases.[54]

Regarding image evaluation, in addition to angiography, the use of the Vaso CT allows for a more detailed assessment of the posttreatment condition. Caroff et al. reported that the BOSS I phenomenon (residual flow within the device at the neck of the aneurysm) was observed in 9.1% of the cases,[55,56] but it did not lead to rupture or require retreatment. Janot et al. identified factors such as postoperative antiplatelet medication and under-sizing of the WEB device as related to BOSS I.[11]

Furthermore, after the WEB device placement, there can be a phenomenon called WEB WshM (shape modification), where the device shortens and causes a change in morphology along with thrombosis of the aneurysm. There are various opinions on the WEB WshM relationship with recurrence. The choice of device size during treatment is critical. Oversizing is generally recommended; however, it is important to note that achieving proper placement with the intended size of the WEB device may not always

provide adequate stability, and the difficulty in size selection may continue to be an issue in the future.[11,56–59)]

For aneurysms ≥10 mm, those with branches originating from the body of the aneurysm, or cases where there is significant misalignment between the parent vessel and the aneurysm's axis, the selection of WEB treatment can be challenging from both a size and technical perspective. In such cases, other treatment options may be more appropriate. Regarding the approach, the transradial access is a feasible option and may be advantageous in reducing procedural and fluoroscopy times.[60,61)]

Conclusion

Treatment using WEB devices for branching artery aneurysms is an effective method and consists of safe embolization material that complements traditional endovascular treatment methods. Careful consideration of treatment indications is essential, and accurate and appropriate deployment is mandatory. Long-term follow-up observation is crucial in off-label use.

Disclosure Statement

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