**Safety and Efficacy of Aneurysm Treatment with WEB in the cumulative population of 3 prospective, multicenter series**

**Running Title:** Safety and efficacy of WEB aneurysm treatment

**Key words*:*** Aneurysms; Endovascular treatment; Flow Disruption; WEB device

**Abstract**

**Background and Purpose:** Flow Disruption with the WEB is an innovative endovascular approach for treatment of wide-neck bifurcation aneurysms. Initial studies have shown a low complication rate with good efficacy.The purpose of this study is to report clinical and anatomical results of the WEB treatment in the cumulative population of 3 Good Clinical Practice Studies: WEBCAST (WEB Clinical Assessment of Intrasaccular Aneurysm), French Observatory, and WEBCAST-2.

**Methods:** WEBCAST, French Observatory, and WEBCAST-2 are single-arm, prospective, multicenter, GCP (Good Clinical Practice) studies dedicated to the evaluation of WEB treatment. Clinical data were independently evaluated. Post-operative and 1-year aneurysm occlusion was independently evaluated using the 3-grade scale: complete occlusion, neck remnant, and aneurysm remnant.

**Results:** The cumulative population was 168 patients with 169 aneurysms, including 112 females (66.7%). Age was between 27 and 77 years (mean: 55.5 +/- 10.2 years). Aneurysm locations were middle cerebral artery in 86/169 aneurysms (50.9%), anterior communicating artery in 36/169 (21.3%), basilar artery in 30/169 (17.8%), and internal carotid artery terminus in 17/169 (10.1%). The aneurysm was ruptured in 14/169 (8.3%), There was no mortality at one month and procedure/device-related morbidity was 1.2% (2/168). At one-year, complete aneurysm occlusion was observed in 81/153 aneurysms (52.9%), neck remnant in 40/153 aneurysms (26.1%), and aneurysm remnant in 32/153 aneurysm (20.9%). Retreatment was performed in 6.9%.

**Conclusions**: This series is at the moment the largest prospective, multicenter, GCP series of patients treated with aneurysms treated with WEB. It shows the high safety and good mid-term efficacy of this treatment.

**Clinical Trial Registration:** URL: <http://www.clinicaltrials.gov>.

French Observatory: Unique identifier: NCT18069.

WEBCAST and WEBCAST-2: Unique identifier: NCT01778322

**Introduction**

As wide-neck aneurysms are sometimes untreatable or difficult to treat with standard coiling, alternatives techniques have been developed including flow disruption.1-4 Flow Disruption involves the placement of an intrasaccular cage that will disrupt the blood flow at the level of the neck and induce aneurysmal thrombosis. Two devices are currently available (Artisse: Medtronic, Minneapolis, MN and WEB: Sequent Medical, Aliso Viejo, CA). While limited clinical evaluation data of the Artisse device are currently available, the WEB device has been evaluated in several retrospective and prospective series.5-10 Moreover Good Clinical Practice studies, including 2 European (WEBCAST, WEBCAST-2), 1 US (WEB-IT), and 1 French (French Observatory) have been conducted since the introduction of this new device in Europe in 2010.11-15

The present paper reports the clinical and anatomical results, including mid-term (1 year) follow-up, of WEB aneurysm treatment in the accumulated population of the WEBCAST, French Observatory, and WEBCAST-2 series, which is, as of now, the largest prospective and multicenter group of patients treated with WEB.

**Materials and Methods**

The WEBCAST, WEBCAST-2, and French Observatory, are single-arm, prospective, consecutive, multicenter studies dedicated to the evaluation of WEB treatment for bifurcation aneurysms, conducted in Europe and France, respectively.

The 3 studies received national regulatory authorization, including in France CCTIRS (Consultative Committee of Information Processing in Healthcare Research program) approval, Reims Institutional Review Board approval, and CNIL (National Commission for Data Processing and Freedom) approval. For WEBCAST and WEBCAST-2 centers outside France, national or institutional approval was obtained according to each country’s regulations. Written informed consent was obtained for all patients.

**WEB devices**

The WEB is a self-expanding, retrievable, electrothermally detachable, nitinol braided device, which is placed within the aneurysm sac. There were several WEB device iterations available over the course of the 3 studies.

The WEB DL was initially used and contains a second nitinol braid. From November 2013, WEB DL was no longer used, replaced by WEB SL and WEB SLS. WEB SL has a barrel shape and WEB SLS, a spherical shape.

The most recent evolution of the device has been enhanced visualization, WEB EV that incorporates composite wire strands made from nitinol and platinum.

In parallel to this evolution, the microcatheters used to deliver these devices have changed. Initially, the WEB DL was delivered using Rebar-27 (Covidien, Irvine, California), Headway 27 (Microvention, Tustin, California ) or DAC 038 (Stryker, Fremont, California) according to the size of the device. Sequent Medical developed specific microcatheters for WEB treatment including the VIA 27 and VIA 33 (Sequent Medical, Aliso Viejo, CA). Recently, the VIA 21 and 17 (Sequent Medical, Aliso Viejo, CA) was introduced for WEB sizes between 4-7 mm.

**Trial design and procedural modalities**

Trial design and procedural modalities have been described in previous publications.17-20 **Inclusion and exclusion criteria are presented in Table 1.** Inclusion criteria for the 3 studies were: ruptured (Hunt & Hess I, II, or III) and unruptured aneurysms located in the basilar apex (BA), middle cerebral artery (MCA) bifurcation, internal carotid artery terminus (ICAt) or anterior communicating artery complex (ACom). In each center, EVT was selected, **for the patients treated in the studies**, as the first-line treatment by a local multidisciplinary team that included neurosurgeons and neuroradiologists. The selection of aneurysms treated with the WEB device was performed autonomously in each center by the interventional neuroradiologists based upon aneurysm characteristics.

Pre-, intra, and post-operative antiplatelet therapy was managed in each center as indicated for typical endovascular treatment with coils or stents and coils. Antiplatelet activity testing was not required in the study protocols. Triaxial access was recommended. Appropriate device sizing was determined based on 2D and 3D digital subtraction angiography (DSA). Depending on the size of the WEB device to be used, different microcatheters were used to catheterize the aneurysm (see above). Treatment with ancillary devices (balloon, coils and stents) could be performed in the French Observatory, if deemed necessary by the treating physician. In WEBCAST and WEBCAST-2 use of ancillary devices was authorized as a rescue treatment, not as an initial planned treatment strategy.

**Data collection**

Each center completed a patient file with the following data:

* Demographic: patient’s age and gender,
* Aneurysm: rupture status, location, size, and neck size,
* Procedure: date, type of device used (DL or SL/SLS), perioperative antiplatelet medications, occurrence of complications during or after the procedure, and use of additional devices during the procedure (coils, remodeling balloons, stents, or flow diverters).

Preoperative Hunt and Hess grade was collected in the case of ruptured aneurysms. Modified Rankin Scale score (mRS) was collected before treatment (unruptured/recanalized aneurysms), at 30 days (+/- 7 days), and 12 months (+/- 3 months). Last mid-term (before 15 months) vascular imaging was collected. Retreatments were collected.

**Data analysis**

The databases of the 3 studies were pooled after introduction of the more recent data regarding follow-up. In the 3 studies, clinical data were independently monitored and analyzed by the same medical monitor (AM), including all adverse events. All adverse events were collected in this GCP series even if no specific treatment was needed and if no clinical worsening was associated with them. Thromboembolic events were diagnosed intraoperatively by angiography regardless of type (clotting near the neck of the aneurysm, clotting in the distal branches, and parent vessel occlusion). Postoperative thromboembolic events were diagnosed by MRI and/or digital subtraction angiogram performed in cases of sudden neurological compromise. Intraoperative rupture was diagnosed by the exit of the tip of the coil or the microcatheter outside the limit of the aneurysmal sac and/or extravasation of contrast media. Morbidity was defined as mRS > 2 when preoperative mRS was ≤ 2 (or in case of ruptured aneurysm) and as increase of 1 point when preoperative mRS was > 2.

In the 3 studies, an expert interventional neuroradiologist (JB) independently evaluated aneurysm location on initial angiogram and aneurysm occlusion at last angiographic follow-up using the previously validated 3-grade scale: complete occlusion, neck remnant, and aneurysm remnant. According to a previous publication, opacification of the proximal recess of the WEB device was considered as complete occlusion.9 **Evolution of aneurysm occlusion between post-operative DSA and mid-term follow-up was also evaluated by the core lab: using a 3 grades scale: improved, stable, worse.**

**Statistical analysis**

Continuous variables were described as mean ± standard deviation (SD). Categorical data were described numerically as a categorical total and as a percentage of the analyzed population. Binomial data were described as a ratio of the true value and the analyzed population (x/n). Confidence Intervals for binomial data were calculated by the Clopper-Pearson method, and p-values were calculated by the Fisher Exact Test. Analyses were conducted using SPSS statistical software and ExactX Software for Confidence Intervals and p-values.

**Results**

**Patient and aneurysm population**

The cumulative population was 168 patients (WEBCAST: 51; French Observatory: 62; WEBCAST-2: 55) including 112 females (66.7%). Age was between 27 and 77 years (mean: 55.5 +/- 10.2 years). All but one patient had 1 aneurysm, leading to a total number of aneurysms of 169. Aneurysm status was ruptured in 14/169 (8.3%), unruptured in 150/169 (88.8%), and recanalized in 5/169 (3.0%). In the 5 recanalized aneurysms, the initial aneurysm treatment was coiling. Aneurysm locations per core lab analysis were middle cerebral artery (MCA) in 86/169 aneurysms (50.9%), anterior communicating artery (Acom) in 36/169 (21.3%), basilar artery (BA) in 30/169 (17.8%), and internal carotid artery (ICA) terminus in 17/169 (10.1%).

Aneurysm size was between 2.8 and 17.0 mm (mean: 7.6 +/-2.5 mm).

Aneurysm neck size was between 2.4 and 13.8 mm (mean: 5.2 +/- 1.6 mm). The neck was wide (≥4 mm) in 144/169 aneurysms (85.2%).

**Antiplatelet treatment before and during the procedure is reported in Table 2. Antiplatelet activity testing was not performed in all participating centers and was not analyzed.**

**Treatment feasibility, adjunctive treatments, and adverse events**

Treatment was successfully performed in 163/169 aneurysms (96.4%). Causes for failure were protrusion and subsequent retrieval of the device in 2 aneurysms, lack of appropriate device sizing in 3 aneurysms, and inability to deploy the WEB in 1 aneurysm.

Among aneurysms treated with WEB devices, adjunctive devices were used in 12/163 aneurysms treated with WEB (7.4%): coils alone in 7 aneurysms (4.3%) and stents or flow diverters in 5 aneurysms (3.1%). A WEB DL was implanted in 78/163 aneurysms (47.9%) and WEB SL/SLS in 85/163 aneurysms (52.1%).

Adverse events are reported in Table 3. Intraoperative rupture (2/167 patient, 1.2%) and intracranial hemorrhage (related to antiplatelet treatment, 1/167 patients, 0.6%) were asymptomatic.

**Mortality / Morbidity at 1 month (Table 2)**

Clinical evaluation at one month was conducted in 167/168 patients (99.4%) (Fig. 1).

There was no mortality at one month. Global morbidity was observed in 5/167 patients (3.0%); related to a TE event in 2 patients (mRS 3) with device protrusion in 1 patient, to initial aneurysm rupture in 2 patients (mRS 3 and 4), and to worsening of pre-existing aneurysm mass effect in 1 patient (mRS 3). Morbidity was related to the device in 1 patient (0.6%), to the procedure in 1 patient (0.6%) and to the disease in 3 patients (1.8%).

**Mortality / Morbidity at 1 year**

At the 12-month follow-up (mean 12.1 months+/- 1.7), 153 of the 168 patients (91.1%) enrolled in the study were clinically evaluated with mRS scoring (Fig. 1).

Five (5) out of 153 patients (3.3%) died between 1 month and 1 year follow-up: 3 unrelated to aneurysm disease or treatment (cancer: 2 and cirrhosis: 1), 1 from worsening of pre-existing mass effect described previously (this patient was mRS 3 at 1 month), and 1 as the consequence and complication of a retroperitoneal hematoma during the index procedure. At 1-year all-cause, neuro-related, and procedure-related mortality are respectively, 5/153 (3.3%), 1/153 (0.7%), and 1/153 (0.7%).

Among the 5 patients who had mRS>2 at 1 month related to the procedure, 1 died between 1 month and 1 year (progressive brainstem compression), 3 were improved at one year (1 patient was mRS 1 and 2 patients were mRS 2), and 1 was unchanged (mRS 3 due to a thromboembolic event). Another patient was mRS 3 due to a thromboembolic event that occurred during a retreatment with a flow diverter (see below). All-cause, neuro-related, and procedure-related morbidity are respectively, 2/153 (1.3%), 0/153 (0.0%), and 2/153 (1.3%).

**Anatomical results at mid-term follow-up**

Anatomical results at 1 year (mean: 12.1 +/- 1.7 months) were evaluated in 152/168 patients (90.5%) with 153/169 aneurysms (90.5%) (Fig. 1).

For patients retreated before or at one-year follow-up, aneurysm occlusion was evaluated on the DSA performed at the beginning of the retreatment. Vascular imaging technique was digital subtraction angiography (DSA) in 134/153 (87.6%) aneurysms, CTA in 4/153 aneurysms (2.6%), and MRA in 15/153 aneurysms (9.8%).

**Aneurysm occlusion at mid-term and evolution of occlusion from immediate post-operative DSA to mid-term follow-up imaging is presented in Table 4 for the global population and patients treated with DL and SL/SLS.** At mid-term, complete occlusion (Fig. 2) was observed in 81/153 aneurysms (52.9%), neck remnant (Fig. 3) in 40/153 aneurysms (26.1%), and aneurysm remnant (Fig. 4) in 32/153 aneurysms (20.9%). Adequate occlusion (complete occlusion or neck remnant) was observed in 121/153 aneurysms (79.1%).

**Importantly no neck or aneurysm remnant was associated with bleeding/rebleeding during the follow-up period.**

**Retreatment**

The retreatment rate was evaluated in 160 aneurysms. Excluded from this analysis were the 6 aneurysms that were not treated with WEB, the aneurysms of the 2 patients who withdrew their consent, and 1 aneurysm in a patient lost to follow-up. Eleven (11) aneurysms were retreated (6.9%). Retreatment was performed with stent and coils in 4 aneurysms, flow diverter in 4, stent in 1 patient, WEB and stent in 1 patient and WEB in 1 patient. One (1) patient retreated with a flow diverter 14 months after the initial procedure had a delayed parent artery occlusion with clinical worsening (mRS 3). One (1) patient had attempted retreatment with flow diverter, but it was not possible to properly place it due to anatomical reasons (coverage of perforators).

**Discussion**

The cumulative population of the 3 European and French GCP studies is currently the largest prospective and multicenter cohort of patients with aneurysms treated with WEB with a completely independent evaluation of clinical and anatomical results.

**Feasibility and safety of WEB aneurysm treatment**

The treatment with WEB was highly feasible (96.4%) knowing that 3 out of 6 failures were related to the lack of appropriate size availability. Adjunctive devices were used in a relatively limited percentage of cases (7.4%). In 4.3%, coils were used in addition to the WEB device on a planned or unplanned basis. For some aneurysms, their shape or size made it clear that treatment with the WEB alone was potentially difficult and adjunctive use of coils was foreseen at the beginning of the procedure. In other cases, the adjunctive placement of coils was decided after WEB detachment if the device was not properly deployed against the aneurysm wall or was not occluding the neck. This situation was mostly encountered at the beginning of the WEB experience, when the device was not oversized as a routine. Stents and flow diverters were added in 3.1% of aneurysms in cases of WEB protrusion or when the neck was so wide that it was not possible to manage it without an intravascular device.

Thromboembolic events, including the asymptomatic appearance of thrombus during the procedure, were observed in 14.4% of patients, but permanent deficit was encountered in only 3.0% of patients. This rate of thromboembolic events is slightly higher to what was reported in large coiling series (7.1% in ATENA/unruptured aneurysms and 13.3% in CLARITY/ruptured aneurysms).1-2 Importantly these series were dealing with all kinds of aneurysms, whereas the present series is dealing with wide-neck bifurcation aneurysms, associated with a higher risk of thromboembolic events.16

Intraoperative rupture was reported in 2 patients (1.2%). This rate is lower compared to what was reported in ATENA (2.0%) and CLARITY (3.7%).Moreover both ruptureswere asymptomatic. Finally one delayed (48h) intracranial bleeding was observed (0.6%) with no clinical worsening.

Global morbidity and mortality at one month were respectively 3.0% and 0.0%. Treatment-related morbidity and mortality were respectively 1.2% and 0.0% and are comparable or better than the rates reported in coiling series like ATENA (morbidity: 1.7%; mortality: 1.4%) or CLARITY (morbidity: 3.7%; mortality: 1.5%). These numbers are confirming the high degree of safety of the treatment, considering that WEB treatment was used in difficult aneurysms and the studied population was partially included at the beginning of the clinical experience with WEB (learning curve).

A comparison with surgical series is more difficult. Looking at morbidity/mortality, in the largest meta-analysis dealing with unruptured aneurysms treated by clipping, the rate of death after surgery (1.7%) was higher compared to the present series (0.0%) and the rate of unfavorable outcomes at 1 year was 6.7% compared to 4.6% in the present series (with procedure –related unfavorable outcomes of 2.0%).17**Similarly, in the International Study of Unruptured Intracranial Aneurysms (ISUIA), in a very large prospective group of patients treated by surgery, the rate of surgery-related death was 1.8% and morbidity (mRS 3-5) 3.0%.18 At 1 year, surgery-related death was 2.7% and morbidity 1.4%. In a recent single-center series, dealing with ruptured and unruptured MCA aneurysms (the most frequent indication for WEB in the studied population), surgical mortality was 5.3% and at late follow-up permanent neurological morbidity was 4.6%.19 In patients with unruptured MCA aneurysms, poor outcomes were observed in 6.1%.**

**Efficacy of WEB aneurysm treatment**

Complete aneurysm occlusion was observed in 52.9% of aneurysms with adequate occlusion (complete occlusion or neck remnant) in 79.1% of aneurysms. These results are very similar to results reported in a retrospective European series, with complete and adequate occlusion, respectively, of 69.0% and 89.7%, at mid-term follow-up (median: 13 months), and respectively, of 68.4% and 84.2%, at long-term follow-up (median: 27 months).9-10

Anatomical results observed in this cumulative population are difficult to compare with previous series dealing with other endovascular approaches, as WEB treatment is used in a relatively specific group of aneurysms (wide-neck bifurcation aneurysms that are prone to recurrence).20 In Matrix and Platinum Science (MAPS) Trial, a subgroup analysis was conducted showing that in unruptured aneurysms with wide-neck (not necessarily bifurcation), the rate of complete and adequate occlusion (at 12 months) was, respectively, 27.1% and 57.6% with coils.21 With stenting and coiling, higher rates of complete and adequate occlusion (respectively, 45.7% and 62.8%) were obtained, albeit at the price of a higher rate of complications. Finally, it is very difficult to compare WEB treatment and clipping efficacy as surgical series reporting one-year or long-term anatomical results evaluated with DSA by an independent core lab are lacking.17, 19

Retreatment was performed in a limited percentage of aneurysms treated with the WEB (6.3%). It is difficult to compare retreatment rates from one study to another, as indications for retreatment are not well established and are quite variable from one center to another.22 However, the very low retreatment rate observed with WEB is absolutely comparable to the lowest rate of retreatment reported in the largest coiling series: HELPS trial, 3.0% with both bare and hydrogel coils; CLARITY study, 3.3% for aneurysms treated with bare coils, but 9.5% in the Matrix group; Cerecyte Coil Trial, 3.5% in the bare coils group and 7.7% in the Cerecyte coils group; MAPS wide-neck aneurysm subset, 13.7% for coils alone and 14.1% for stent and coils.20-21, 23-24

**Place of the WEB device in the EVT armamentarium**

In the 3 GCP series, the WEB device was used in typical indications: wide neck bifurcation aneurysms. Recent publications suggest that indications for WEB aneurysm treatment will potentially enlarge in the future. In a recent, single-center series, WEB treatment was used in 49% of aneurysms treated with EVT.25 In another multicenter series, WEB was used in “atypical” locations.26

**Limitations**

This study has 2 main limitations. First, it is not a randomized study, and comparison with other techniques is difficult. However, it is to date the largest GCP series of patients with aneurysms treated with WEB and demonstrates the good safety and efficacy (at mid-term follow-up) of this treatment. Second, long-term follow-up is needed to precisely evaluate the place of this treatment in the management of intracranial aneurysms. Follow-up at 3 and 5 years is foreseen in French Observatory, WEBCAST, and WEBCAST-2.

**Conclusion**

This analysis of the cumulative population of 3 GCP studies dealing with wide-neck bifurcation aneurysm treatment with the WEB device (WEBCAST, French Observatory, and WEBCAST-2) confirmed the high safety of this treatment with no mortality and low morbidity at one-month. This treatment is associated with a good efficacy at one-year with a complete and adequate occlusion rate of respectively 52.9% and 79.1%.

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**Competing Interests Statement:**

**Contributorship Statement:**

All authors have:

* Provided a substantial contribution to the conception and design of the studies and/or the acquisition and/or the analysis of the data and/or the interpretation of the data;
* Drafted the work or revised it for significant intellectual content;
* Approved the final version of the manuscript;
* Agree to be accountable for all aspects of the work, including its accuracy and integrity.

**Data Sharing:** NA.

**References**

1. Cognard C, Pierot L, Anxionnat R, Ricolfi F, the Clarity Study group. Results of embolization used as the first treatment choice in a consecutive nonselected population of ruptured aneurysms: clinical results of the Clarity GDC study. Neurosurgery. 2011;69:837-841.
2. Pierot L, Spelle L, Vitry F, for the ATENA investigators. Clinical outcome of patients harbouring unruptured intracranial aneurysms treated by endovascular approach: results of the ATENA trial. Stroke. 2008;39:2497-2504.
3. Pierot L, Wakhloo AK. Endovascular treatment of intracranial aneurysms: current status. Stroke. 2013;44:2046-2054.
4. Pierot L, Biondi A. Endovascular techniques for the management of wide-neck bifurcation aneurysms: a critical review of the literature. Journal of Neuroradiology. 2016;43:167-175.
5. PierotL, LiebigT, SychraV, Kadziolka K, Dorn F, Strasilla C, et al. Intrasaccular Flow Disruption: a new endovascular approach for the treatment of intracranial aneurysms. Results of a preliminary clinical evaluation in a multicenter series. AJNR Am J Neuroradiol. 2012;33:1232-1238.
6. PierotL, KlischJ, CognardC, Szikora I, Mine B, Kadziolka K, et al. Endovascular WEB flow disruption in middle cerebral artery aneurysms: Preliminary feasibility, clinical, and anatomical results in a multicenter study. Neurosurgery. 2013;73:27-35.
7. Papagiannaki C, SpelleL, JanuelAC, Benaissa A, Gauvrit JY, Costalat V, et al. Flow Disruption with WEB device: report of a prospective, multicenter series of 83 patients with 85 aneurysms. AJNR Am J Neuroradiol. 2014;35:2006-2011.
8. Mine B, Pierot L, Lubicz B. Intrasaccular flow-diversion for treatment of intracranial aneurysms: the Woven EndoBridge. Expert Rev Med Devices. 2014;11:315-325.
9. Lubicz B, Klisch J,Gauvrit JY, Szikora I, Leonardi M, Liebig T, et al. Short-term and mid-term follow-ups in patients with wide-neck bifurcation aneurysms treated with the WEB device: a retrospective European study. AJNR Am J Neuroradiol. 2014;35:432-438.
10. Pierot L, Klisch J, Liebig T, Gauvrit JY, Leonardi M, Nuzzi NP, et al. WEB-DL endovascular treatment of wide-neck bifurcation aneurysms: long-term results in a European series. AJNR Am J Neuroradiol. 2015;36:2314-2319.
11. Fiorella D, Molyneux A, Coon A, Szikora I, Saatci I, Baltacioglu F, et al. Demographic, procedural and 30-day safety results from the WEB Intra-saccular Therapy Study (WEB-IT). [published online ahead of print January 17, 2017].J Neurointerv Surg. 2017. pii: neurintsurg-2016-012841. doi: 10.1136/neurintsurg-2016-012841. Accessed March 17, 2017.
12. Pierot L, Moret J, Turjman F, Herbreteau D, Raoult H, Barreau X, et al. WEB® treatment of intracranial aneurysms: Indications, Feasibility, Complications, and One-month Safety Results with WEB-DL and WEB-SL/SLS in the French Observatory. AJNR Am J Neuroradiol. 2015;36:922-927.
13. Pierot L, Costalat V, Moret J, Szikora I, Klisch J, Herbreteau D, et al. Safety and Efficacy of Aneurysm Treatment with WEB®: Results of WEBCAST Study. J Neurosurg. 2016;124:1250-1256.
14. Pierot L, Moret J, Turjman F, Herbreteau D, Raoult H, Barreau X, et al. WEB treatment of intracranial aneurysms: Clinical and Anatomical results in the French Observatory. AJNR Am J Neuroradiol. 2016;37:655-659.
15. Pierot L, Gubucz I,Buhk JH, Holmannspötter M, Herbreteau D, Spelle L, et al. Safety and Efficacy of Aneurysm Treatment with WEB®: Results of WEBCAST 2 Study. AJNR Am J Neuroradiol (in press)
16. Pierot L, Cognard C, Anxionnat R, Ricolfi F, and CLARITY investigators. Ruptured intracranial aneurysms: Factors affecting the rate and outcome of endovascular treatment complications in a series of 782 patients (CLARITY). Radiology. 2010;256:916-923.
17. Kotowski M, Naggara O, Darsaut TE, Nolet S, Gevry G, Kouznetsov E, et al. Safety and occlusion rates of surgical treatment of unruptured intracranial aneurysms: a systematic review and meta-analysis of the literature from 1990 to 2011. *J Neurol Neurosurg Psychiatry.* 2013;84:42-48.
18. International Study of Unruptured Intracranial Aneurysms Investigators. Unruptured intracranial aneurysms : natural history, clinical outcome, and risks of surgical and endovascular treatment. Lancet. 2003;362:103-10.
19. Rodriguez-Hernandez A, Sughrue ME, Akhavan S, Habdank-Kolaczkowski J, Lawton MT. Current management of middle cerebral artery aneurysms: surgical results with a « clip first » policy. Neurosurgery. 2013; 72:415-27.
20. Pierot L, Cognard C, Anxionnat R, Ricolfi F, CLARITY investigators. Endovascular Treatment of Ruptured Intracranial Aneurysms: Factors Affecting Midterm Quality Anatomic Results: Analysis in a Prospective, Multicenter Series of Patients (CLARITY). AJNR Am J Neuroradiol. 2012;33:1475-1480.
21. Hetts SW, Turk A, English JD, Dowd CF, Mocco J, Prestigiacomo C, et al. Stent-Assisted Coiling versus Coiling Alone in Unruptured Intracranial Aneurysms in the Matrix and Platinum Science Trial: Safety, Efficacy, and Mid-Term Outcomes. AJNR Am J Neuroradiol. 2014;35:698-705.
22. Pierot L, Fiehler J, White P. TAR: a useful index to follow-up coiled intracranial aneurysms?

AJNR Am J Neuroradiol. 2015;36:2-4.

1. White PM, Lewis SC, Gholkar A, Sellar RJ, Nahser H, Cognard C, et al. Hydrogel-coated coils ver- sus bare platinum coils for the endovascular treatment of intra- cranial aneurysms (HELPS): a randomised controlled trial. Lancet. 2011;377:1655– 62.
2. Molyneux AJ, Clarke A, Sneade M, Mehta Z, Coley S, Roy D, et al. Cerecyte Coil Trial. Angiographic Outcomes of a Prospective Randomized Trial Comparing Endovascular Coiling of Cerebral Aneurysms With Either Cerecyte or Bare Platinum Coils. Stroke. 2012;43:2544-2550.
3. Van Rooij WJ, Peluso JP, Bechan RS, Sluzewski M. WEB Treatment of Ruptured Intracranial Aneurysms. AJNR Am J Neuroradiol. 2016 ;37 :1679-1683.
4. Pierot L, Biondi A, Narata AP, Mihalea C, Januel AC, Metaxas G, et al. Should indications for WEB aneurysm treatment be enlarged ? Report of a series of 20 patients with aneurysms in « atypical » locations for WEB treatment. J Neuroradiol. (in press)

Table 1: Inclusion and exclusion criteria for French Observatory, WEBCAST, and WEBCAST 2.

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Fr Obs** | **WEBCAST/WEBCAST2** |
| **Inclusion** | **Similar criteria** | |
|  | * Age ≥ 18 years * Ruptured/Unruptured aneurysms * Location : BA, MCA, ICAt, Acom/ACA * Diameter suitable for WEB use * DN ratio ≥ 1 * Ruptured aneurysm : H&H>III | |
| **Inclusion** | **Distinctive criteria** | |
|  | * Recanalized aneurysms | * Neck size ≥ 4mm * No additional implant |
| **Exclusion** | **Similar criteria** | |
|  | * Age > 75 years * More than one aneurysm to be treated within 30 days * Microcather could not reach target aneurysm * Tumor or AVM | |
| **Exclusion** | **Distinctive criteria** | |
|  | None | * Unruptured aneurysm: SAH/ICH within 3 months prior treatment |

Table 2: Antiplatelet treatment before, during, and after WEB procedure.

|  |  |  |  |
| --- | --- | --- | --- |
| Antiplatelet  Treatment | Before  (n=168) | During  (n=168) | After (1Month FU)  (n=167\*) |
| 0 | 70 (42.0%) | 30 (17,9%) | 37 (22.2%) |
| 1 | 47 (28.0%) | 62 (36.9%) | 91 (54.5%) |
| 2 | 51 (30.0%) | 76 (45.2%) | 39 (23.4%) |

\* one patient withdraw his consent after the procedure.

Table 3: Adverse events, morbidity, and mortality at 1 month.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Event Type** | **All**  **(n=167)** | **DL**  **(n=80)** | **SL/SLS**  **(n=87)** | **p** |
| Thromboembolic Events (TE) | 24 (14.4%) | 15 (18.8%) | 9 (10.3%) | 0.130 |
| Asymptomatic | 11 (6.6%) | 9 (11.2%) | 2 (2.3%) | 0.027 |
| Symptomatic without Sequelae | 8 (4.8%) | 4 (5.0%) | 4 (4.6%) | 1.000 |
| Symptomatic with Sequelae | 5 (3.0%) | 2 (2.5%) | 3 (3.4%) | 1.000 |
| Intraprocedural Rupture | 2 (1.2%) | 1 (1.3%) | 1 (1.1%) | 1.000 |
| Intracranial Hemorrhage | 1 (0.6%) | 1 (1.3%) | 0 (0.0%) | 0.479 |
| Morbidity\*\* | 5 (3.0%) | 3 (3.8%) | 2 (2.3%) | 0.671 |
| Mortality | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | NA |

\*One patient withdraw his consent between the procedure and the one-month follow-up.

\*\* mRS > 2 if baseline ≤ 2. mRS +1 or more if baseline >2. mRS >2 and ruptured at baseline.

Table 4: Aneurysm occlusion at mid-term follow-up and evolution of aneurysm occlusion between post-operative DSA and mid-term follow-up imaging.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Aneurysm occlusion at mid-term follow-up** | | | | |
|  | All  (n=153) | WEB DL  (n=72) | WEB SL/SLS  (n=81) | p |
| Complete occlusion | 81 (52.9%) | 38 (52.8%) | 43 (53.1%) | 1.000 |
| Neck remnant | 40 (26.1%) | 19 (26.4%) | 21 (25.9%) |
| Aneurysm remnant | 32 (20.9%) | 15 (20.8%) | 17 (21.0%) |
| Evolution of aneurysm occlusion between postoperative DSA and mid-term FU imaging | | | | |
|  | All  (n=152) | WEB DL  (n=72) | WEB SL/SLS\*  (n=80) | p |
| Improved | 94 (61.8%) | 46 (63.9%) | 48 (60.0%) | 0.911 |
| Stable | 53 (34.9%) | 24 (33.3%) | 29 (36.3%) |
| Worsened | 5 (3.3%) | 2 (2.8%) | 3 (3.8%) |

\*In 1 patient/1 aneurysm, postoperative aneurysm occlusion was not evaluable.

**Figure captions**

Figure 1: Flow chart of the population included in the 3 studies for safety and efficacy.

Figure 2: Unruptured left middle cerebral artery aneurysm.

A/ DSA, working view, and B/ 3D-DSA show the aneurysm (transverse diameter: 6.3mm; height: 5.3mm ; neck: 5.4mm).

C/ and D/ DSA at the end of the procedure (unsubtracted and subtracted view) show the detached WEB device (WEB SL 7x3mm) and residual flow in the aneurysm and the device.

E/ and F/ 6 months DSA (unsubtracted and subtracted views) show the WEB device and complete aneurysm occlusion

G/ and H/ 12 months DSA (unsubtracted and subtracted views) shows the WEB device and stable complete aneurysm occlusion.

Figure 3: Unruptured left middle cerebral artery aneurysm.

A/ 3D-DSA shows the aneurysm (transverse diameter: 3.8mm ; height: 4.2mm; neck: 2.4mm).

B/ One-year DSA (unsubtracted view) shows the WEB device.

C/ One year 3D-DSA shows a neck remnant.

Figure 4: Unruptured anterior communicating artery aneurysm.

A/ DSA, working view, and B/ 3D-DSA show the aneurysm (transverse diameter: 6.2mm ; height: 4.3mm; neck: 4.6mm).

C/ and D/ DSA (unsubtracted and subtracted views) show the detached WEB device (WEB-SL 7x3mm) and slow flow in the aneurysm and the device.

E/ and F/ 12 months 3D-DSA (with and without device subtraction) show a small aneurysm remnant.