

## RESEARCH LETTER

# International Study of Intracranial Aneurysm Treatment Using Woven EndoBridge: Results of the WorldWideWEB Consortium

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**E**ndovascular treatment of wide-neck bifurcation aneurysms is notoriously challenging, as wide necks predispose to coil herniation into the parent artery and the bifurcation location poses challenges to use of assist devices. While flow diversion has revolutionized the treatment of wide-necked sidewall aneurysms, tubular flow diverting stents for bifurcation aneurysms are often unable to cover the entire length of the aneurysm neck and preclude further attempts at coiling.

The Woven EndoBridge device (WEB) was designed specifically for wide-neck bifurcation aneurysms. This study aims to present multi-center data that can aid clinicians in decision-making and prognostication when considering the use of a WEB device.

## METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request. The primary Institutional Review Board approval was from the lead institution. Individual approval was obtained at all centers included in the consortium. A retrospective review of prospectively maintained databases at 22 academic institutions was performed to identify adult patients with intracranial aneurysms treated with the WEB device. Both ruptured and unruptured aneurysms in all intracranial locations (including bifurcation and sidewall aneurysms) were included. For more details, see Methods in the [Supplemental Material](#).

Angiographic outcome was assessed using digital subtraction angiography, magnetic resonance angiography, or computed tomography angiography. Aneurysm occlusion after treatment, both immediately and at last follow-up, were categorized using the validated WEB occlusion 3-point

**Key Words:** computed tomography angiography ■ intracranial aneurysm ■ magnetic resonance angiography ■ middle cerebral artery ■ ruptured aneurysms

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## Nonstandard Abbreviations and Acronyms

**WEB** Woven EndoBridge device

scale: complete occlusion, neck remnant, and aneurysm remnant. Adequate occlusion was defined as either complete occlusion or neck remnant with lack of aneurysm remnant. WEB device compaction refers to device shape modification and is defined as the percentage reduction in the distance between the 2 WEB markers (distal and proximal) between the initial procedure digital subtraction angiography and imaging at the last follow-up.

## RESULTS

The cumulative population comprised 671 patients (median age 61.4 years; 71.2% female) with 683 intracranial aneurysms. Middle cerebral artery bifurcation (30.2%) was the most common location. Previously ruptured aneurysms accounted for 26.2% of all aneurysms, of which 23.9% were acute (<2 weeks). At the last follow-up (median 11 months), adequate occlusion was documented in 85.7% of aneurysms and complete occlusion was at 57.8%. Retreatment was required in 7.8% of aneurysms. Thromboembolic complications were encountered in 7.5% of procedures, of which only 4.0% were symptomatic and 2.0% were permanent. Hemorrhagic complications were encountered in 3.0% of procedures. No patient experienced aneurysm re-rupture after treatment. Deployment issues were encountered in 1.8% of patients.

Minor compaction (adjusted odds ratio, 0.45 [95% CI, 0.24–0.86],  $P=0.015$ ) or major compaction (adjusted odds ratio, 0.25 [95% CI, 0.11–0.57],  $P=0.001$ ) as compared with no compaction were significantly associated with lower rates of adequate aneurysm occlusion. Furthermore, compared with those who had complete occlusion, immediate remnant aneurysm (adjusted odds ratio, 0.45 [95% CI, 0.18–1.00],  $P=0.065$ ) at the end of procedural digital subtraction angiography trended towards less adequate aneurysm occlusion on last follow-up.

## DISCUSSION

The WEB device, when evaluated in a large cohort of ruptured and unruptured aneurysms at any intracranial location, has an efficacy and safety profile that approximates currently available endovascular techniques.

Our results emphasizes the importance of achieving optimal aneurysm occlusion after the initial treatment. To this end, oversizing of WEB device to ensure neck bridging has been recommended.<sup>2</sup> Comparison of WEB versus other endovascular treatments are included in the [Supplemental Material](#).

Limitations of our study include the nonrandomized and retrospective nature of our study that predispose to selection and confirmation bias, the lack of a core laboratory, and the lack of uniformity in the radiological modalities used for follow-up imaging.

## ARTICLE INFORMATION

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### Disclosures

None.

### Supplemental Material

Supplemental Methods  
Tables S1–S7

### REFERENCES

1. Fiorella D, Arthur A, Byrne J, Pierot L, Molyneux A, Duckwiler G, McCarthy T, Strother C. Interobserver variability in the assessment of aneurysm occlusion with the WEB aneurysm embolization system. *J Neurointerv Surg*. 2015;7:591–595. doi: 10.1136/neurintsurg-2014-011251
2. Goyal N, Hoyt D, DiNitto J, Eljovich L, Fiorella D, Pierot L, Lamin S, Spelle L, Saatci I, Cekirge S, et al. How to WEB: a practical review of methodology for the use of the Woven EndoBridge. *J Neurointerv Surg*. 2020;12:512–520. doi: 10.1136/neurintsurg-2019-015506



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