OPEN ACCESS

Original research

New Artisse intrasaccular device for intracranial aneurysm treatment: short term clinical and angiographic result from the prospective registry INSPIRE-A

Sophia Hohenstatt ,[1] Vincent Costalat,[2] Cyril Dargazanli ,[3] Monika Killer-Oberpfalzer ,[4] Barbara Schreiber,[5] Riitta Rautio,[6] Matias Sinisalo,[6] Saleh Lamin,[7] Han Seng Chew ,[8] Laurent Spelle ,[9,10] Alejandro Tomasello,[11,12] Tufail Patankar,[13] Mariangela Piano,[14] Jens Fiehler,[15] Markus A Möhlenbruch[1]

For numbered affiliations see end of article.

Correspondence to
Dr Markus A Möhlenbruch; markus.moehlenbruch@med.uni-heidelberg.de

Received 2 October 2024
Accepted 13 January 2025

To cite: Hohenstatt S, Costalat V, Dargazanli C, *et al*. *J NeuroIntervent Surg* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/jnis-2024-022576

ABSTRACT

Background Intrasaccular devices have broadened treatment options for wide necked aneurysms. This study presents the preliminary experience with the Artisse 2.0 device.

Methods Innovative NeurovaScular Product Surveillance REgistry (INSPIRE) is a non-randomized, multicenter, real world clinical study with treatment arms for aneurysms (INSPIRE-A) and acute ischemic stroke (INSPIRE-S). This interim analysis included 87 patients enrolled from November 2022 to April 2024 in the INSPIRE-A Artisse cohort across 16 Europoean centers. Procedures followed standard clinical care, with 6 months of follow-up. Safety and efficacy endpoints included major stroke, neurological death, serious adverse events (SAEs), aneurysm occlusion, and retreatment rates. An independent core laboratory assessed imaging, and all SAEs were reviewed by a clinical events committee. The Artisse steering committee provided independent oversight of the data.

Results The Artisse device achieved an overall successful implantation rate of 96.6% (84/87), with satisfactory placement rates of 98.7% (74/75) for unruptured and 88.9% (8/9) for ruptured aneurysms. Following the procedure, 46.2% of unruptured aneurysm patients were receiving antiplatelet therapy (APT), predominantly aspirin monotherapy, while no ruptured aneurysm patients received APT. Device related SAE rate was 1.3% (1/87), and the overall stroke rate was 2.3% (2/87), including both ruptured and unruptured aneurysms. At 6 months, 80.0% (28/35) of patients with unruptured aneurysms showed complete obliteration, with no recurrences or retreatments.

Conclusions Preliminary experience with the Artisse 2.0 device demonstrated high technical success, favorable safety, and efficacy in aneurysm obliteration at 6 months. Larger studies with longer follow-up periods are needed to confirm these findings.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Intrasaccular devices (ISDs) have expanded treatment options for wide necked intracranial aneurysms.

⇒ Previous generations of ISDs, such as the Artisse 1.0, faced challenges with thromboembolic events and suboptimal occlusion rates, indicating a need for improved devices.

WHAT THIS STUDY ADDS

⇒ Preliminary experience with the Artisse 2.0 device is presented, demonstrating high technical success and favorable safety outcomes for both unruptured and ruptured aneurysms.

⇒ At 6 months, 80% of unruptured aneurysms achieved complete obliteration without recurrence or retreatment, showing promising efficacy compared with earlier devices.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE, OR POLICY

⇒ The favorable short term outcomes suggested that the Artisse 2.0 device could be a valuable addition to the treatment arsenal for intracranial aneurysms, potentially influencing treatment protocols and encouraging further research into its long term effectiveness.

INTRODUCTION

In recent years, intrasaccular devices (ISDs) have significantly broadened the treatment options available to neurointerventionalists, particularly for unruptured and ruptured wide necked aneurysms located at bifurcations.[1] Although coiling remains an excellent treatment option, it is associated with high recurrence rates, especially with wide necked aneurysms.[2] Stent coiling is another excellent option for unruptured bifurcation aneurysms, but its application in ruptured aneurysms is limited due to the mandatory requirement for dual antiplatelet therapy (APT).[1] The concept of intra-aneurysmal flow disruption has therefore emerged as a novel approach, with self-expanding ISDs designed to be placed completely within the aneurysm, providing a mesh of metal across the neck of the aneurysm that isolates it from the parent artery blood flow. This provokes blood stasis and progressive thrombosis of the

sac, ultimately combining the benefits of flow diversion and disruption as well as mechanical occlusion, while reducing the potential risks of dual APT.[3]

Among the ISDs meant as a standalone therapy currently in clinical use are the Woven Endobridge (WEB, Microvention, Aliso Viejo, California, USA) and the Contour (Stryker Neurovascular, Kalamazoo, USA).[4] The latest innovation in this field is the new Artisse 2.0 model of the Artisse, which is an enhanced version of the formerly known LUNA AES and the previous Artisse 1.0 device (Medtronic, Irvine, California, USA).[5 6] We report preliminary experience with this new device. LUNA AES and Artisse 1.0 are commercially not available.

METHODS

Study design

We report our preliminary experience with the new Artisse device, using data from the Innovative NeurovaScular Product SurveIllance REgistry (INSPIRE). INSPIRE is a non-randomized, post-market, multicenter, real world clinical registry platform[7] that collects data on multiple market approved Medtronic neurovascular devices from more than 85 centers worldwide, enrolling patients treated according to routine clinical practice. INSPIRE-Aneurysm (INSPIRE-A) is currently collecting real world data on the safety and effectiveness of the Artisse device for the treatment of intracranial aneurysms. While the study includes 5 year standard of care follow-up for all patients enrolled in the Artisse cohort, the current interim analysis is focused on the procedural and short term safety and effectiveness of the device. Patients with aneurysms in the anterior and posterior intracranial circulations were enrolled, regardless of the rupture or pretreatment status of the aneurysm. Follow-up evaluations could not be mandated but were conducted according to the standard of care at each site. The collected data were assessed for procedural safety and effectiveness under independent oversight and adjudication. A steering committee oversaw the study, with safety events adjudicated by the clinical events committee (CEC) and imaging assessments handled by an independent core laboratory. The remaining data were provided by the treating centers. The study received ethical approval from all participating institutions, and informed consent was obtained from all patients in accordance with regulatory and institutional guidelines.

Artisse device

The primary differences between the new Artisse 2.0 devices and the preceding Artisse 1.0 devices are their shapes and available size ranges. The Artisse 2.0 devices are offered in a single shape, 'flared', with varying widths (4.5–8 mm) and heights (3–5 mm). In contrast, the Artisse 1.0 devices included two shapes, 'spherical' and 'flared', maintaining the same width range but differing in height (5.4–10 mm).[5] Both models are constructed from NiTi DFT wires connected to a delivery wire, enabling electrolytic detachment and compatibility with a 0.021 inch inner diameter microcatheter.[5] The main differences between the LUNA AES and Artisse 2.0 devices include shape, braid wire configuration, detachment mechanism, and compatible microcatheter.[6] The improvements in the new Artisse 2.0 devices include: an atraumatic distal tip to protect the aneurysm dome during deployment; proximal and distal marker bands for improved visibility; a dual layer mesh basket that balances radial force and conformability for a secure fit; and a flared shape that enhances apposition against the aneurysm wall and coverage of the neck.

Procedure

In each participating institution, the treatment decision and its technique were decided on a case-by-case basis by a local multidisciplinary team. Selection of aneurysms treated with the Artisse device was performed independently by the interventional neuroradiologists in each center, with no involvement from the study sponsor.

All procedures were performed under general anesthesia and full anticoagulation with heparin. Access site varied (femoral, radial, or ulnar), according to the standard practice of the respective enrollment center. Procedures were conducted with guiding catheters and/or intermediate catheters positioned in the internal carotid artery or vertebral artery. Microcatheters with an internal lumen of 0.021 inches were used for device delivery, including Rebar 18 (Medtronic) in 73.6% of cases, Headway 21 (Microvention) in 12.6% of cases, and Phenom 21 (Medtronic) in 8% of cases.

Three-dimensional rotational angiography was acquired to plan the treatment and determine the most appropriate device size. Sizing was performed using the manufacturer provided sizing chart, which specifies eligible aneurysms as those with a maximum average width of 3.4–6 mm, measured in two orthogonal planes and averaged. Based on this measurement, the sizing chart provides two to three recommended device options. The final device selection is made by considering the expected device height after implantation, which is also provided in the sizing chart. If the measured aneurysm width falls between the listed widths on the chart, a larger size group is recommended, taking into account aneurysm height. The sizing chart inherently accounts for oversizing.

After positioning of the device, an angiogram was obtained to check the position of the Artisse in the aneurysm and to evaluate flow stagnation. Treatment with other devices (balloon, coils, or stents) was performed if deemed necessary by the treating physician.

All technical issues encountered during the procedure, as well as any adverse events or complications during or after embolization, were documented in the case report forms and adverse event report forms.

Data collection, follow-up, and antiplatelet therapy

Baseline demographic and clinical data were collected for all patients. Additionally, characteristics of the aneurysm (location, size, and neck size) and procedure information, including date, size of device used, access catheters used, perioperative medications, occurrence of complications, and use of additional devices during the procedure, were prospectively collected. To account for potential differences in outcomes, we reported the results separately for patients with ruptured and unruptured aneurysms, recognizing these as distinct study populations. Management of post-procedural APT was left to the physician's discretion.

Follow-up evaluations were according to the standard of care of each participating center, typically occurring about 6 months post-procedure, including clinical assessments, modified Rankin Scale (mRS) scores to assess disability, and imaging studies (imaging per standard of care) to assess aneurysm occlusion and device status. Follow-up visits for all enrolled patients are ongoing.

Endpoints

The primary endpoint was the occurrence of major stroke in the treated vascular area or neurological death. Stroke was defined as a focal neurological deficit of presumed vascular origin

Table 1 Baseline patient and aneurysm characteristics

Characteristics	Artisse ITT population: unruptured aneurysm patients and target aneurysm (n=78)	Artisse ITT population: ruptured aneurysm patients and target aneurysm (n=9)
Age (years)	61.3±11.8 (78) (63.0) (31, 83)	56.0±13.8 (9) (64.0) (28, 67)
Women	57.7 (45/78)	77.8 (7/9)
Risk factor		
Family history of stroke/TIA	9.0 (7/78)	11.1 (1/9)
Cigarette smoking	50.0 (39/78)	33.3 (3/9)
Hypertension	56.4 (44/78)	33.3 (3/9)
Diabetes	11.5 (9/78)	0.0 (0/9)
Hyperlipidemia	25.6 (20/78)	0.0 (0/9)
Atrial fibrillation	5.1 (4/78)	0.0 (0/9)
Coronary heart disease	9.0 (7/78)	0.0 (0/9)
Cardiac failure	1.3 (1/78)	0.0 (0/9)
Peripheral artery disease	2.6 (2/78)	0.0 (0/9)
Obesity	5.1 (4/78)	11.1 (1/9)
Subarachnoid hemorrhage (excluding rupture of target aneurysm)	5.1 (4/78)	0.0 (0/9)
Baseline mRS*	0.4±0.7 (77) (0) (0, 3)	0±0.0 (7) (0) (0, 0)
≤2	98.7 (76/77)	100.0 (7/7)
0	76.6 (59/77)	100.0 (7/7)
1	13.0 (10/77)	0.0 (0/7)
2	9.1 (7/77)	0.0 (0/7)
3	1.3 (1/77)	0.0 (0/7)
Aneurysm location		
Internal carotid artery	16.7 (13/78)	0.0 (0/9)
Anterior cerebral artery	1.3 (1/78)	0.0 (0/9)
Anterior communicating artery	33.3 (26/78)	100.0 (9/9)
Basilar artery	9.0 (7/78)	0.0 (0/9)
Carotid terminus	1.3 (1/78)	0.0 (0/9)
Middle cerebral artery	37.2 (29/78)	0.0 (0/9)
Pericallosal artery (A3–A5)	1.3 (1/78)	0.0 (0/9)
Location of aneurysm in vessel		
Terminus	3.8 (3/78)	0.0 (0/9)
Sidewall	7.7 (6/78)	0.0 (0/9)
Bifurcation	84.6 (66/78)	100.0 (9/9)
Side branch	3.8 (3/78)	0.0 (0/9)
Aneurysm morphology		
Saccular	100.0 (78/78)	100.0 (9/9)
Fusiform	0.0 (0/78)	0.0 (0/9)
Aneurysm configuration		
Spherical	84.6 (66/78)	44.4 (4/9)
Bi-lobar	6.4 (5/78)	11.1 (1/9)
Irregular	9.0 (7/78)	44.4 (4/9)
Aneurysm dome height (mm)†	5.5±1.7 (78) (5.0) (3.0, 10.0)	5.1±1.7 (9) (4.7) (1.9, 7.7)
Aneurysm dome width (mm)†	4.9±1.1 (78) (5.0) (2.1, 7.0)	4.6±1.0 (9) (4.5) (3.1, 6.0)
Aneurysm neck width (mm)†	3.5±0.9 (78) (3.5) (1.3, 5.4)	3.3±1.1 (9) (3.1) (1.9, 5.0)
Aneurysm size†		
Small (<7 mm)	97.4 (76/78)	100.0 (9/9)
Medium (7 to <13 mm)	2.6 (2/78)	0.0 (0/9)
Parent artery		
Parent artery diameter distal to aneurysm	2.9±0.8 (78) (3.0) (1.1, 5.2)	2.6±0.7 (9) (2.4) (2.0, 4.0)
Parent artery diameter proximal to aneurysm	3.1±0.9 (78) (3.1) (1.1, 6.1)	2.7±0.6 (9) (2.6) (1.6, 3.4)
Angulation between aneurysms axis and parental artery axis	76.8±60.8 (78) (53.0) (0.0, 218.0)	72.6±63.0 (9) (71.0) (0.0, 165.0)

Continued

Table 1 Continued

Characteristics	Artisse ITT population: unruptured aneurysm patients and target aneurysm (n=78)	Artisse ITT population: ruptured aneurysm patients and target aneurysm (n=9)
Previously treated	2.6 (2/78)	0.0 (0/9)
Surgical clipping	50.0 (1/2)	0.0 (0/9)
Coil embolization	50.0 (1/2)	0.0 (0/9)

Categorical values: % (n/N).
Continuous values: mean±SD (N) (median) (min, max).
*Three individulas had missing baseline mRS values (one in the unruptured cohort and two in the ruptured cohort).
†Site reported.
ITT, intention-to-treat; mRS, modified Rankin Scale; TIA, transient ischemic attack.

persisting for more than 24 hours, with neuroimaging or other diagnostic studies ruling out alternative etiologies. Major stroke was defined as a stroke persisting for 24 hours or more, resulting in an increase in the National Institutes of Health Stroke Scale score of >4, and occurring at any time post-procedure during the planned 5 year follow-up period of INSPIRE-A.

Secondary safety endpoints included the rate of procedure related serious adverse events (SAEs) and device related SAEs, and mRS scores at discharge and after 6 months of follow-up. Secondary efficacy endpoints were the rate of stasis within the aneurysm at the end of the index procedure, aneurysm occlusion rates at the 6 month follow-up, assessed with the Raymond–Roy occlusion classification scale (RROC), the rate of aneurysm reoccurrence, and the need for retreatment.

Aneurysm reoccurrence refers to the recanalization and regrowth of a previously occluded aneurysm, while residual aneurysm, on the other hand, describes any remaining aneurysmal filling observed immediately after the initial treatment, indicating incomplete occlusion.

Cumulative fluoroscopy time, total deployment time, and total procedure time were also secondary endpoints. Total deployment time was defined as the time from first study device introduction into the microcatheter to the time of last study device detachment. Total procedure time was defined as the time from guide catheter introduction to removal.

Statistical analysis

All statistical analyses were performed using Statistical Analysis System (SAS) for Windows (V.9.4 or higher, SAS Institute, Cary, North Carolina, USA). Descriptive statistics were used to present the data and to summarize the results. Discrete variables are presented with frequency distributions and cross tabulations. Continuous variables are summarized by presenting the number of observations (N), mean, SD, median, minimum, and maximum values. For adverse event reporting, the analysis was based on individual counts (eg, the number and percentage of individuals with an event among the total number of individuals). Data are presented in the format p% (x/N) [e], with p and x being the percentage and number of individuals with events, respectively, N is the sample size of the analysis population, and e is the total number of events that occurred in the x individuals. The intention-to-treat (ITT) population was defined as all participants who consented and in whom implant of an Artisse device was attempted, independent of the procedure being completed successfully. The per protocol (PP) population was defined as all participants who consented and in whom implant of an Artisse device was completed successfully (subset of ITT population). The key objectives related to safety were analyzed using the ITT population and those related to effectiveness were analyzed using the PP population. Because this was a post-market study focused exclusively on safety and efficacy, no control group was enrolled.

RESULTS

Study populations

Between November 2022 and April 2024, 87 patients (78 with unruptured and 9 with ruptured aneurysms) who underwent at least one treatment attempt with an Artisse device were enrolled from 16 European high volume neurointerventional centers and formed the ITT population. The PP population consisted of 84 patients (75 with unruptured and 9 with ruptured aneurysms) in whom an Artisse device was ultimately implanted, resulting in a successful implantation rate of 96.6% (84/87).

Demographics and medical history

Mean age was 61.3 (SD±11.8) years and 57.7% of participants were women in the unruptured aneurysm group. In patients treated due to acutely ruptured aneurysms, mean age was slightly younger (56.0±13.8 years) and the proportion of women was higher (77.8%). Four participants had a history of subarachnoid hemorrhage, excluding the rupture of the target aneurysm. Key risk factors included hypertension (56.4% and 33.3%, for unruptured and ruptured aneurysms) and cigarette smoking (50.0% and 33.3%, respectively). In the unruptured aneurysm group, the baseline mRS score was 0.4±0.7, with 98.7% of participants having an mRS score of ≤2 and one participant with mRS 3. All patients with acutely ruptured aneurysms had a baseline premorbid mRS score of 0. The main patient characteristics and risk factors for the occurrence and rupture of cerebral aneurysms are summarized in table 1.

Aneurysm characteristics

Of the 78 unruptured aneurysms, most were located in the middle cerebral artery (37.2%) and the anterior communicating artery (33.3%), whereas ruptured aneurysms were all located in the anterior communicating artery (100%). Most unruptured aneurysms were located at bifurcation (84.6%). Most aneurysms were small (<7 mm; 97.4% and 100%, in the unruptured and acutely ruptured populations, respectively). Aneurysm dome height averaged 5.5±1.7 mm, dome width 4.9±1.1 mm, and neck width 3.5±0.9 mm for unruptured aneurysms and dome height averaged 5.1±1.7 mm, dome width 4.6±1.0 mm, and neck width 3.3±1.1 mm for ruptured aneurysms. Two unruptured aneurysms (2.6%) had been previously treated; one was surgically clipped and one was previously coiled. None of the ruptured aneurysms had been previously treated. The main aneurysm characteristics are summarized in table 1.

Table 2 Procedural data and early angiographic outcomes

	Artisse ITT population: unruptured target aneurysm (n=78)	Artisse ITT population: ruptured target aneurysm (n=9)
No of Artisse device attempted per individual	1.1±0.3 (78) (1.0) (1, 2)	1.0±0.0 (9) (1.0) (1, 1)
0	0.0 (0/78)	0.0 (0/9)
1	89.7 (70/78)	100.0 (9/9)
2	10.3 (8/78)	0.0 (0/9)
No of Artisse devices implanted per individual	1.0±0.2 (78) (1.0) (0, 1)	1.0±0.0 (9) (1.0) (1, 1)
0	3.8 (3/78)	0.0 (0/9)
1	96.2 (75/78)	100.0 (9/9)
No of resheathings per device*	0.7±0.7 (75) (1.0) (0, 3)	0.4±0.7 (9) (0) (0, 2)
0	45.3 (34/75)	66.7 (6/9)
1	46.7 (35/75)	22.2 (2/9)
2	4.0 (3/75)	11.1 (1/9)
3	4.0 (3/75)	0.0 (0/9)
No of detachment attempts per device*	1.2±0.5 (75) (1.0) (1, 3)	1.4±0.7 (9) (1.0) (1, 3)
1	89.3 (67/75)	66.7 (6/9)
2	4.0 (3/75)	22.2 (2/9)
3	5.3 (4/75)	0.0 (0/9)
>3	1.3 (1/75)	11.1 (1/9)
Time of first study device introduction into microcatheter to the time of last study device removal or microcatheter removal (min)	16.0±12.9 (77) (15.0) (1, 69)	16.6±22.0 (9) (5.0) (0, 68)
Time from guide catheter introduction to removal (min)	63.8±28.2 (78) (58.0) (20, 145)	55.7±29.6 (9) (54.0) (18, 100)
Cumulative fluoro time (min)	24.3±14.3 (78) (20.0) (8, 71)	21.7±6.1 (9) (23.0) (9, 29)
Final access via		
Femoral	66.7 (52/78)	88.9 (8/9)
Radial	32.1 (25/78)	11.1 (1/9)
Ulnar	1.3 (1/78)	0.0 (0/9)
Adjunctive devices used to treat the aneurysm?		
No	94.9 (74/78)	88.9 (8/9)
Yes	5.1 (4/78)	11.1 (1/9)
Coil	50.0 (2/4)	0.0 (0/1)
Stent	50.0 (2/4)	100.0 (1/1)
Device implant success (patient level)	96.2 (75/78)	100.0 (9/9)
Satisfactory device placement*	98.7 (74/75)	88.9 (8/9)
Distal marker helpful for visualization*	90.7 (68/75)	100.0 (9/9)
Adequate conformability to aneurysm shape*	96.0 (72/75)	100.0 (9/9)
Post-procedure stasis*		
Complete stasis	4.0 (3/75)	11.1 (1/9)
Significant stasis	69.3 (52/75)	66.7 (6/9)
No stasis	25.3 (19/75)	22.2 (2/9)
Post-procedural APT		
No	53.8 (42/78)	100.0 (9/9)
Mono APT	30.8 (24/78)	0.0 (0/9)
Aspirin	29.5 (23/78)	0.0 (0/9)
Ticagrelor	1.3 (1/78)	0.0 (0/9)
Duration of mono APT		
≤60 days post procedure	15.4 (12/78)	0.0 (0/9)
≤180 days post procedure	5.1 (4/78)	0.0 (0/9)
≤365 days post procedure	9.0 (7/78)	0.0 (0/9)
>365 days post procedure	1.3 (1/78)	0.0 (0/9)

Continued

Table 2 Continued

	Artisse ITT population: unruptured target aneurysm (n=78)	Artisse ITT population: ruptured target aneurysm (n=9)
Dual APT	14.1 (11/78)	0.0 (0/9)
Duration of dual APT		
≤60 days post procedure	11.5 (9/78)	0.0 (0/9)
≤180 days post procedure	1.3 (1/78)	0.0 (0/9)
≤365 days post procedure	1.3 (1/78)	0.0 (0/9)
>365 days post procedure	0.0 (0/78)	0.0 (0/9)
Triple therapy (three agents or more)	1.3 (1/78)	0.0 (0/9)

Categorical values: % (n/N).
Continuous values: mean±SD (N) (median) (min, max).
*Data corresponds to per protocol population (unruptured cohort, n=75; ruptured cohort, n=9).
APT, antiplatelet therapy; ITT, intention-to-treat.

Procedural data

The main procedural data are summarized in table 2. Deployment of the Artisse device in unruptured aneurysms was successfully achieved in 75 cases, giving a technical success rate of 96.2% (75/78). In one patient, the Artisse device was in the microcatheter when aneurysm rupture occurred so that the device was never deployed. Another patient was treated with coil embolization after two different Artisse sizes were attempted for the aneurysm (width 8 mm, height 16.6 mm, and neck width 5.3 mm). In ruptured aneurysms the technical success rate was 100% with 9/9 devices successfully implanted. Satisfactory device placement, as defined by the treating physician, was achieved in 98.7% (74/75) and 88.9% (8/9) of cases, and conformability to the aneurysm shape was reported in 96.0% (72/75) and 100.0% (9/9) of cases, respectively, for unruptured and ruptured aneurysms. The average number of Artisse devices implanted per patient was 1.0±0.2 and 1.0±0.0, respectively.

The mean number of resheathings per device was 0.7±0.7 and 0.4±0.7 for unruptured and ruptured aneurysms, respectively, while the mean number of detachment attempts per device was 1.2±0.5 and 1.4±0.7, respectively. In 13.1% of cases, more than one detachment attempt was required. The potential necessity for multiple detachment attempts is noted in the manufacturer's instructions for use and does not indicate device malfunction. Furthermore, INSPIRE-A captures specific reasons for multiple detachment attempts only when they exceed three attempts, which may reflect isolated procedural or technical factors. This occurred in two cases, with the following underlying reasons: in one unruptured case, detachment was challenging and required manual manipulation, likely due to the detachment needle being placed in the groin rather than the shoulder; and in one acutely ruptured case, failure to detach the device was attributed to an issue with the system cable.

Adjunctive devices were used in 5.7% (5/87) of procedures. Four of these cases involved unruptured aneurysms, and one involved a ruptured aneurysm. In the unruptured aneurysm cases, coils were used in two procedures and stents in the other two. In the ruptured aneurysm case, a stent was used. Specific coiling cases included one where coil addition was required to secure the aneurysm dome, and in another, mentioned above, the aneurysm ruptured during the procedure, necessitating coil treatment instead of Artisse implantation. Specific stent cases in unruptured aneurysms included one cases where a stent was placed across the aneurysm neck to address Artisse device protrusion in an aneurysm that was not suitable for the Artisse device based on its height (aneurysm measurements from site: height 3 mm, width 4.4 mm, neck 4 mm, and aneurysm diameter 4.4 mm), and one case where a stent was used temporarily to keep the microcatheter in position to deliver the Artisse device in a sidewall aneurysm. In the specific stent case of the ruptured aneurysm, a stent was placed across the aneurysm neck to address a slight bulging of the Artisse device and to stabilize its position.

Regarding the access site, femoral access was the most common, with 66.7% (52/78) and 88.9% (8/9) of procedures. Radial access was used in 32.1% (25/78) and 11.1% (1/9) of cases and ulnar access was used in 1.3% (1/78) of cases only in the unruptured aneurysm group.

For unruptured and ruptured aneurysms, mean total deployment time was 16.0±12.9 and 16.6±22.0 min, mean total procedure time was 63.8±28.2 and 55.7±29.6 min, and cumulative fluoroscopy time was 24.3±14.3 and 21.7±6.1 min, respectively.

Antiplatelet therapy

Following the procedure, 46.2% (36/78) of patients with unruptured aneurysms were receiving APT, while no patients with ruptured aneurysms were receiving APT. Among those with unruptured aneurysms receiving APT, 30.8% (24/78) were receiving monotherapy, predominantly aspirin (29.5%, 23/78), with only one patient receiving ticagrelor. Additionally, 14.1% (11/78) of patients were receiving dual APT, typically consisting of aspirin combined with another P2Y12 inhibitor. The duration of dual APT varied, with most patients receiving it for ≤60 days post-procedure (11.5%, 9/78), and no patients continuing dual APT for >1 year. Also, triple therapy was administered in 1.3% (1/78) of patients due to concurrent medical conditions. The decision to prescribe APT was at the discretion of the treating interventionalist. Key features of the adopted antiplatelet regimes are summarized in table 2.

Safety outcomes

For patients with unruptured aneurysms, the primary safety endpoint, which included major stroke in the treated vascular area or neurological death, was met at a rate of 1.3% (1/78). This was due to an aneurysm rupture during the procedure, leading to a major hemorrhagic stroke in the treated vascular territory. Per site assessment, the Artisse device was in the microcatheter when the aneurysm ruptured due to a slight forward movement of the microcatheter while pushing the Artisse, and as a result, the device was never deployed in this patient. This complication was judged to be procedure related and possibly device related by the CEC, leading to a device related SAE rate

of 1.3% (1/78). Procedure related SAEs in patients ultimately implanted with the Artisse device were reported in 9.0% (7/78) of patients, including vascular access site hemorrhage in 2.6% (2/78), vascular access site pseudoaneurysm in 1.3% (1/78), and aneurysm rupture in 1.3% (1/78), the latter being the case of the patient described above. For patients with ruptured aneurysms, no primary safety endpoint events were reported. Procedure related SAEs were also not reported in this group.

Overall, the study reported no deaths, neurological or otherwise, among the 87 patients. Stroke occurred in 1.3% (1/78) and 11.1% (1/9) of patients in the unruptured and ruptured populations, respectively. Both strokes were classified as major, disabling hemorrhagic strokes. One of these strokes occurred within the treated vascular territory, caused by the rupture mentioned previously, and the other occurred outside the treated vascular territory, associated with the rupture of a second, non-target aneurysm after successful embolization of the target aneurysm. Asymptomatic cerebral infarction was reported as an incidental finding from MRI imaging in one patient with an unruptured aneurysm. MRI was performed on postoperative day 2 for an event of 'visual disturbances', which was assessed by the CEC as wet age related macular degeneration. mRS scores at the 6 month follow-up indicated that 92.2% (35/36) of patients with unruptured aneurysms had an mRS score of ≤1. One patient had a pre-existing condition that accounted for their mRS score of 2.

Table 3 Imaging and clinical follow-up at 6 months of unruptured target aneurysms

	6 month follow-up of unruptured target aneurysm (n=35, n=36)*
Imaging modality	
DSA	74.3 (26/35)
MRA	25.7 (9/35)
Degree of occlusion (RROC)	
Class I: complete obliteration	80.0 (28/35)
Class II: residual neck	0.0 (0/35)
Class III: residual aneurysm	11.4 (4/35)
Cannot determine	8.6 (3/35)
Parent artery stenosis	
0–5%	71.4 (25/35)
>5–25%	2.9 (1/35)
>25–100%	0.0 (0/35)
Cannot determine	25.7 (9/35)
Artisse device movement	
0 - in place	65.7 (23/35)
1 - movement (tilted)	2.9 (1/35)
2 - movement (neck remnant)	0.0 (0/35)
3 - protrusion	0.0 (0/35)
4 - migration	0.0 (0/35)
Cannot determine†	31.4 (11/35)
Recurrence (core laboratory)	0.0 (0/35)
Retreatment	0.0 (0/35)
mRS score	0.3±0.50 (36) (0) (0, 2)
0	77.8 (28/36)
1	19.4 (7/36)
2	2.8 (1/36)

Categorical values: % (n/N).
Continuous values: mean±SD (N) (median) (min, max).
*Imaging follow-up was for 35 patients and mRS follow-up for 36 patients.
†Instances where the core laboratory deemed the imaging insufficient to reliably assess occlusion status.
MRA, MR angiography; mRS, modified Rankin Scale; RROC, Raymond–Roy occlusion classification scale.

Efficacy outcomes

Post-procedure, complete stasis of the aneurysm was observed in 4.0% (3/75) of cases with unruptured aneurysms and in 11.1% (1/9) of cases with ruptured aneurysms. Significant stasis was observed in 69.3% (52/75) of unruptured aneurysms and in 66.7% (6/9) of ruptured aneurysms. No stasis was observed in 25.3% (19/75) of unruptured aneurysms and in 22.2% (2/9) of ruptured aneurysms (table 2).

At 6 months, 33.3% of patients underwent DSA follow-up, while 11.5% underwent MR angiography (MRA) follow-up (table 2). The aneurysm occlusion status, as judged by the core laboratory, showed that 80.0% (28/35) of patients with unruptured aneurysms achieved complete obliteration (RROC I), 11.4% (4/35) had a residual aneurysm (RROC III), and 8.6% (3/35) had an undetermined occlusion status (table 3). The undetermined occlusion status cases were due to MRI follow-ups that the core laboratory deemed insufficient to reliably assess occlusion. No recurrences or retreatments, and no Artisse device shape modifications, were reported.

For patients with ruptured aneurysms, occlusion data from the core laboratory were not available at the 6 month follow-up. An illustrative example is provided in figure 1.

DISCUSSION

In this study, we explored preliminary experience with the newly developed Artisse 2.0 device for treating intracranial aneurysms. For patients with unruptured aneurysms, the primary safety endpoint was met at a rate of 1.3%, due to one major hemorrhagic stroke in the treated vascular area caused by microcatheter perforation of the target aneurysm. For patients with ruptured aneurysms, no primary safety endpoint events were reported. The Artisse device demonstrated a high technical success rate, with high rates of satisfactory device placement and conformability to the aneurysm shape. It also exhibited a high rate of satisfactory placement on the first attempt and featured a reliable detachment mechanism. At the 6 month follow-up, 80.0% (28/35) of patients with unruptured aneurysms achieved complete aneurysm obliteration, and no recurrences or retreatments were reported. Overall, the study underscores the potential of the Artisse device as an effective and safe treatment option for intracranial aneurysms, particularly for unruptured cases. While the preliminary results for ruptured aneurysms were equally promising, they were based on a limited number of cases. More conclusive data are needed as the INSPIRE-A registry continues to recruit patients, including those with ruptured aneurysms.

The Artisse 1.0 device encountered several significant issues that led to its removal from the market.[5] First, the device was associated with a high rate of (peri)procedural thromboembolic events (22.2%, 2/9). In our study, the new Artisse 2.0 device outperformed the old version with a low rate of ischemic events (1.3%, 1/78) in patients in the unruptured group, comprising a patient with a silent cerebral infarction with a positive MRI scan and no clinical symptoms. There were no records of symptomatic or major ischemic strokes. This is low compared with the thromboembolic complication rates observed with other ISDs, but the data available for the Artisse device to date are based on a limited number of patients, which limits the strength

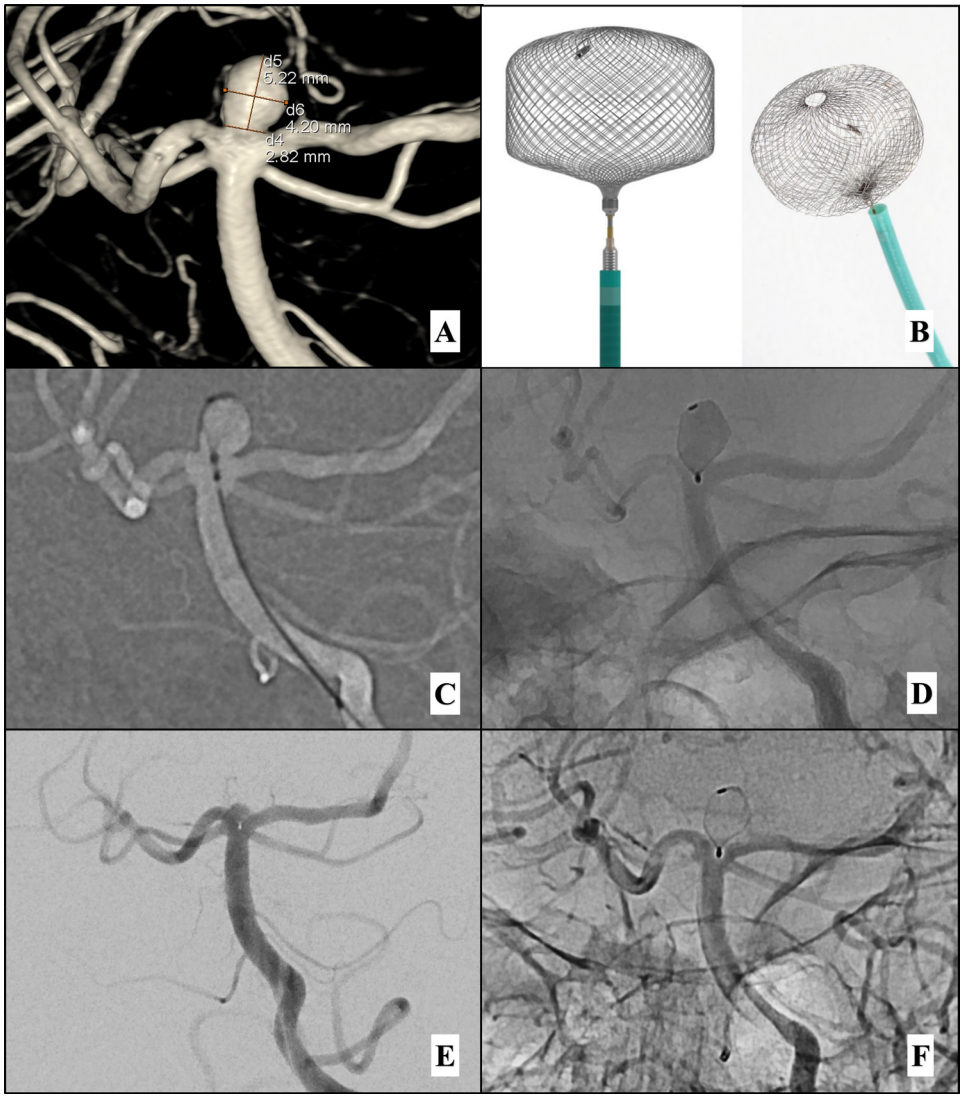

Figure 1 Illustrative case of a patient in his 60s with a history of arterial hypertension, coronary artery disease, and active smoking. The patient was treated for an unruptured basilar tip aneurysm measuring 5.2×4.2×4.6 mm, with a neck width of 2.8 mm (A). Artisse device (frontal and side profile view) 6.0×4.0 was chosen as the most appropriate device size (B). During deployment, the Artisse device demonstrated excellent visibility and wall apposition, conforming well to the aneurysm shape (C), as confirmed after detachment (D). The post-deployment angiographic run revealed a neck remnant with contrast inflow into the proximal part of the device (E). At the 6 month follow-up, the Artisse device remained well positioned with no signs of displacement or compaction, and complete aneurysm occlusion was observed (F).

of direct comparisons.[1 4] The rate of thromboembolic events for the WEB-SL/SLS in mainly unruptured, but also ruptured aneurysms, has been shown to vary between 6% and 15%.[8–12] Overall, when considering the previously used WEB generations and studies analyzing ruptured aneurysms, the thromboembolic event rates varied between 4.5% and 16.7%.[4] The Contour device had higher thromboembolic event rates, varying between 12.5% and 33.3% in different studies.[4]

In terms of efficacy, the angiographic outcomes of the Artisse 1.0 device were modest.[5] Post-deployment contrast stasis according to the O'Kelly–Marotta scale has been suggested as a good predictor of aneurysm occlusion, and immediately after implantation, only 33.3% of the treated aneurysms with the Artisse 1.0 device achieved complete occlusion.[5 13] This rate did not improve at the 6 month follow-up, and by the 36 month follow-up, the complete occlusion rate had declined to 28.6%. Frequently observed shape modification and subsequent retraction of the device into the aneurysm sac were thought to contribute to these recanalization and overall inadequate occlusion rates, with an 11.1% retreatment rate. No shape modifications with the Artisse 2.0 device leading to recurrences or retreatments have been reported to date, but it is important to note that the follow-up assessments reported here were limited to 6 months. Furthermore, our study showed complete or significant stasis within the aneurysm immediately after Artisse deployment of 73.3% and 77.8%, respectively, for unruptured and ruptured aneurysms. The rate of complete aneurysm occlusion at 6 months was 80% (28/35). Reported complete occlusion rates for the WEB and Contour devices are 39–62% and 55.6–73% at 12 months, respectively, which is slightly less than our reported 6 month outcomes.[4] A possible explanation for the higher occlusion rates observed with the Artisse device is that it is primarily used to treat smaller aneurysms, given the limited sizes available. Smaller aneurysms are generally known to heal and achieve occlusion more quickly than larger ones, which may contribute to the enhanced outcomes seen with the Artisse device. Additionally, some patients were evaluated with MRA follow-up, which is not suitable for detecting small intra-device

remnants, potentially leading to an artificial increase in total occlusion rates. INSPIRE-A continues to enroll patients and have more follow-up visits for already enrolled patients, serving as a source of long term occlusion rates and overall clinical data for the Artisse device.

The pre-ISD era treatment, and still a viable alternative for wide necked aneurysms, consists of balloon or stent assisted coiling, which comprised nearly 90% of this study population. A multicenter study evaluating wide necked bifurcation aneurysms treated primarily with stent assisted coiling showed a 1 year complete/near complete occlusion rate (RROC I and II) of 63% along with a treatment related complication rate of 11.2%, and morbidity and mortality of 5.8% and 1.7%, respectively.[14] While stent assisted coiling shows comparable occlusion rates, stents come with the downside of the need for dual APT. In our study, nearly 85% of patients with unruptured aneurysms were either not receiving APT or were receiving monotherapy, and none of the patients with ruptured aneurysms was receiving any APT. Among the 15.3% of patients on dual APT in the unruptured aneurysm group, >80% were receiving dual APT for <60 days.

Limitations

The INSPIRE-A study has several limitations that should be acknowledged. First, the sample size was relatively small, particularly for long term follow-up, which may limit the generalizability of the findings and the assessment of long term outcomes and device durability. However, the primary aim of this study was to report short term clinical and angiographic results. Second, the study design was observational and lacked a control group, which precludes direct comparisons with other treatment modalities or devices. Additionally, the treating interventional neuroradiologists made the selection of aneurysms and the decision to use the Artisse device autonomously, which could introduce selection bias. Also, currently the Artisse 2.0 device is available to treat aneurysms of a limited size range (maximum aneurysm width of up to 6 mm). Furthermore, heterogeneity in antiplatelet protocols and adjunctive device use could affect the consistency of the results. Lastly, some of the follow-up assessments were conducted with MRA, which has limitations in reliably evaluating occlusion status, device shape modifications, and intimal hyperplasia. As a result, the core laboratory classified some cases as 'undetermined'. The choice of follow-up modality reflects the standard of care at the respective centers, where MRA might be used for interim follow-up with DSA scheduled at a later stage.

CONCLUSIONS

The preliminary experience with the Artisse 2.0 device indicated a high technical success rate and a favorable safety profile, with good efficacy in achieving aneurysm obliteration at 6 months. These preliminary findings highlight the potential of the Artisse device as a safe and effective treatment option for wide necked aneurysms, both unruptured and ruptured. Further studies with larger sample sizes and longer follow-up are needed to confirm and fully assess the device's long term safety and efficacy.

Author affiliations
[1]Neuroradiology, University Hospital Heidelberg, Heidelberg, Germany
[2]Neuroradiology, Hôpital Gui de Chauliac, Montpellier, France
[3]Department of Neuroradiology, University Hospital Centre Montpellier, Montpellier, France
[4]Neurology/Research Institute of Neurointervention, Paracelsus Medical University, Salzburg, Austria
[5]Department of Anaesthesiology and Intensive Care, Paracelsus Medical University, Salzburg, Austria
[6]Department of Interventional Radiology, Turku University Hospital Polyclinic of Physical Medicine, Turku, Finland
[7]Interventional Neuroradiology. Radiology, Queen Elizabeth Hospital, Birmingham, UK
[8]Neuroradiology, Queen Elizabeth Hospital Birmingham, Birmingham, UK
[9]NEURI The Brain Vascular Centre, Bicetre Hospital Interventional Neuroradiology, Le Kremlin-Bicetre, France
[10]Paris-Saclay University Faculty of Medicine, Le Kremlin-Bicetre, France
[11]Interventional Neuroradiology Section, Department of Radiology, Vall d'Hebron University Hospital, Barcelona, Spain
[12]Vall d'Hebron Research Institute (VHIR), Vall d'Hebron University Hospital, Barcelona, Spain
[13]Leeds General Infirmary, Leeds, UK
[14]Neuroradiology, Ospedale Niguarda Ca Granda, Milano, Italy
[15]University Medical Center Hamburg-Eppendorf, Hamburg, Germany

X Saleh Lamin @salehlamin

Contributors All authors contributed significantly to this manuscript. SH and MAM conceived and designed the study. SH drafted the manuscript, and all authors contributed to the critical revision of the manuscript and approved the final version. SH is the guarantor for this study and accepts full responsibility for the work, ensuring that all aspects of the manuscript are accurate and complete.

Funding Innovative NeurovaScular Product SurveIllance REgistry (INSPIRE)-A is sponsored by Medtronic.

Competing interests VC is a consultant for Medronic and recipient of research grants from Medtronic. MK-O is a consultant for Medronic and part of the steering committee for Innovative NeurovaScular Product SurveIllance REgistry-Aneurysm (INSPIRE-A). RR has consulting agreements with Stryker, Balt, Medtronic, Microvention, and Acandis, and is part of the steering committee for INSPIRE-A . SL receives honoraria from Medtronic in relation to proctoring, speaking, and consulting, and is part of the steering committee for INSPIRE-A. LS is a consultant for Balt, Microvention, Medtronic, Stryker, and Cerenovus; receives research consultancy fees from Medtronic to attend steering committee meetings; and is part of the steering committee for INSPIRE-A. JF is part of the steering committee for INSPIRE-A and is consultant for Medtronic. MAM received research grants from Medtronic and Stryker, is part of the steering committee for INSPIRE-A, and is a consultant for Cerenovus and Siemens.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the following ethics committees or institutional boards: Ethikkommission für das Bundesland Salzburg 1092/2022; Varsinais-Suomen sairaanhoitopiirin kuntayhtymä Eettinen Toimikunta 45/1801/2017; Agence nationale de sécurité du médicament et des produits de santé (ANSM) - Bordereau d'enregistrement recherches et collections biologiques (RCB) 2017-A00053-50; Ethik-Kommission der Medizinischen Fakultät Heidelberg S311/2017; CET Lombardia 4 CET 66/23; Comité de ética de investigación con medicamentos (CEIm) del Hospital Universitari Vall d'Hebron PR(AG)194/2017; Comité de ética de investigación con medicamentos (CEIm) de Euskadi EPA2017038 (PS); Comité de ética de investigación con medicamentos (CEIm) del Principado de Asturias 117/17; and NHS Health Research Authority (HRA) 220323. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

ORCID iDs
Sophia Hohenstatt http://orcid.org/0000-0003-0951-3948
Cyril Dargazanli http://orcid.org/0000-0003-1891-9157
Monika Killer-Oberpfalzer http://orcid.org/0000-0001-5572-7694
Han Seng Chew http://orcid.org/0000-0002-1802-3935
Laurent Spelle http://orcid.org/0000-0002-6748-8528

REFERENCES

1 Bhogal P, Udani S, Cognard C, *et al*. Endosaccular flow disruption: where are we now? *J Neurointerv Surg* 2019;11:1024–5.
2 McDougall CG, Johnston SC, Gholkar A, *et al*. Bioactive versus bare platinum coils in the treatment of intracranial aneurysms: the MAPS (Matrix and Platinum Science) trial. *AJNR Am J Neuroradiol* 2014;35:935–42.

3 Ding YH, Lewis DA, Kadirvel R, *et al*. The Woven EndoBridge: A New Aneurysm Occlusion Device. *AJNR Am J Neuroradiol* 2011;32:607–11.
4 Hecker C, Broussalis E, Griessenauer CJ, *et al*. A mini-review of intrasaccular flow diverters. *J Neurointerv Surg* 2023;15:70–4.
5 Piotin M, Fahed R, Redjem H, *et al*. The ARTISSE intrasaccular device for intracranial aneurysm treatment: short-term, mid-term and long-term clinical and angiographic results. *J Neurointerv Surg* 2022;14:957–61.
6 Piotin M, Biondi A, Sourour N, *et al*. The LUNA aneurysm embolization system for intracranial aneurysm treatment: short-term, mid-term and long-term clinical and angiographic results. *J Neurointerv Surg* 2018;10:e34.
7 Szikora I, Holtmannspötter M, Martinez-Galdamez M, *et al*. The INSPIRE Registry: Entering a New Era of Medical Device Research in the Neurovascular Field. *Clin Neuroradiol* 2020;30:659–60.
8 Pierot L, Gubucz I, Buhk JH, *et al*. Safety and Efficacy of Aneurysm Treatment with the WEB: Results of the WEBCAST 2 Study. *AJNR Am J Neuroradiol* 2017;38:1151–5.
9 Fiorella D, Molyneux A, Coon A, *et al*. Demographic, procedural and 30-day safety results from the WEB Intra-saccular Therapy Study (WEB-IT). *J NeuroIntervent Surg* 2017;9:1191–6.
10 Arthur AS, Molyneux A, Coon AL, *et al*. The safety and effectiveness of the Woven EndoBridge (WEB) system for the treatment of wide-necked bifurcation aneurysms: final 12-month results of the pivotal WEB Intrasaccular Therapy (WEB-IT) Study. *J Neurointerv Surg* 2019;11:924–30.
11 Spelle L, Herbreteau D, Caroff J, *et al*. CLinical Assessment of WEB device in Ruptured aneurYSms (CLARYS): results of 1-month and 1-year assessment of rebleeding protection and clinical safety in a multicenter study. *J Neurointerv Surg* 2022;14:807–14.
12 Spelle L, Costalat V, Caroff J, *et al*. CLinical EValuation of WEB 17 device in intracranial aneuRysms (CLEVER): procedural, 30-day and 1-year safety results for ruptured and unruptured aneurysms. *J Neurointerv Surg* 2024;16:1299–306.
13 Al Saiegh F, Velagapudi L, Khanna O, *et al*. Predictors of aneurysm occlusion following treatment with the WEB device: systematic review and case series. *Neurosurg Rev* 2022;45:925–36.
14 De Leacy RA, Fargen KM, Mascitelli JR, *et al*. Wide-neck bifurcation aneurysms of the middle cerebral artery and basilar apex treated by endovascular techniques: a multicentre, core lab adjudicated study evaluating safety and durability of occlusion (BRANCH). *J NeuroIntervent Surg* 2019;11:31–6.