Systematic review

Safety and efficacy of the Contour Neurovascular System for treating intracranial aneurysms: a systematic review and meta-analysis

Ahmet Günkan ,[1] Luca Scarcia ,[2] Marcio Yuri Ferreira ,[3] Marina Vilardo ,[4] Luis Flavio Fabrini Paleare,[5] Jhon E Bocanegra-Becerra ,[6] Mohamed E M Fouad ,[7] Henrique Garcia Maia ,[8] Gabriel Semione,[9] Andrea Maria Alexandre ,[10] Leonardo Vilardo,[11] Frédéric Clarençon,[12,13] Yafell Serulle,[3] Pascal Jabbour [14]

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/jnis-2024-022461).

For numbered affiliations see end of article.

Correspondence to
Dr Ahmet Günkan; gunkanahmet@gmail.com

Received 3 September 2024
Accepted 3 November 2024

ABSTRACT

Background The Contour Neurovascular System (CNS, Stryker, Kalamazoo, MI) has a unique design that allows it to address various aneurysm morphologies, including wide-necked, irregular, and shallow-shaped lesions. However, evidence of its safety and efficacy remains limited. This systematic review and meta-analysis synthesizes the current data on CNS performance.

Methods A comprehensive search guided by the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) standards was performed across PubMed, Embase, and Web of Science, including studies with ≥5 patients reporting on CNS use. Efficacy outcomes included immediate and last follow-up adequate aneurysm occlusion and technical success. Safety outcomes included good functional outcome (modified Rankin Scale (mRS) score of 0–2 at last follow-up), procedure-related morbidity (permanent neurological deficits), procedure-related mortality, intraoperative and postoperative complications. Pooled analyses with 95% confidence intervals (CI) were conducted, with heterogeneity assessed using I^2 statistics, and a random-effects model was applied.

Results Nine studies, including 483 patients (58.8% female; mean age: 59.3±15.6 years) with 484 aneurysms, were analyzed. Of the 467 patients in whom rupture status was reported, 81.8% presented with unruptured aneurysms and 18.2% with ruptured aneurysms. Immediate adequate aneurysm occlusion rate was 53% (95% CI: 1% to 100%), with follow-up adequate occlusion at 93% (95% CI: 88% to 97%) and technical success at 98% (95% CI: 95% to 100%). Intraoperative and postoperative complication rates were 3% (95% CI: 0% to 7%) and 7% (95% CI: 3% to 12%), respectively. Procedure-related morbidity was 2% (95% CI: 0% to 3%), with no procedure-related mortality.

Conclusion The CNS is a safe and effective novel intrasaccular device for treating intracranial aneurysms.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The Contour Neurovascular System (CNS), a novel intrasaccular device, has been shown to be safe and effective for the treatment of intracranial aneurysms in multiple observational studies.

WHAT THIS STUDY ADDS

⇒ This systematic review and meta-analysis of 483 cases, including both bifurcation and sidewall aneurysms, found that the CNS is an effective and safe option for treating intracranial aneurysms. It demonstrates a high rate of technical success, significant aneurysm occlusion rates, and a favorable safety profile with minimal procedure-related complications.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE, OR POLICY

⇒ The findings of this study support further research, particularly in the form of prospective studies and direct comparisons with other treatment modalities, including clipping, intrasaccular devices, and stent-assisted coiling, to fully establish the CNS's role in the management of intracranial aneurysms.

INTRODUCTION

Intracranial aneurysms remain challenging neurovascular lesions with their catastrophic rupture risk and, consequently, significant morbidity and mortality.[1] Over the preceding decades, multiple microsurgical and endovascular approaches were introduced and evolved dramatically, particularly endovascular techniques such as coiling, flow diversion, and intrasaccular flow disruption.[2] However, until now, there has yet to be a definite consensus as to the best treatment option, considering the diversity of aneurysmal anatomical, morphological, and rupture status.[2] Thus, the development of new modalities is an ongoing process that aims to achieve the best clinical outcomes and the lowest complication rate.

In this context, the Contour Neurovascular System (CNS, Stryker, Kalamazoo, MI) is a novel emerging device due to its promising advantages in treating large-necked bifurcation aneurysms with a lower likelihood of commonly seen thromboembolic or hemorrhagic complications.[3–5] The CNS is

Check for updates

© Author(s) (or their employer(s)) 2024. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Günkan A, Scarcia L, Ferreira MY, *et al*. *J NeuroIntervent Surg* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/jnis-2024-022461

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.

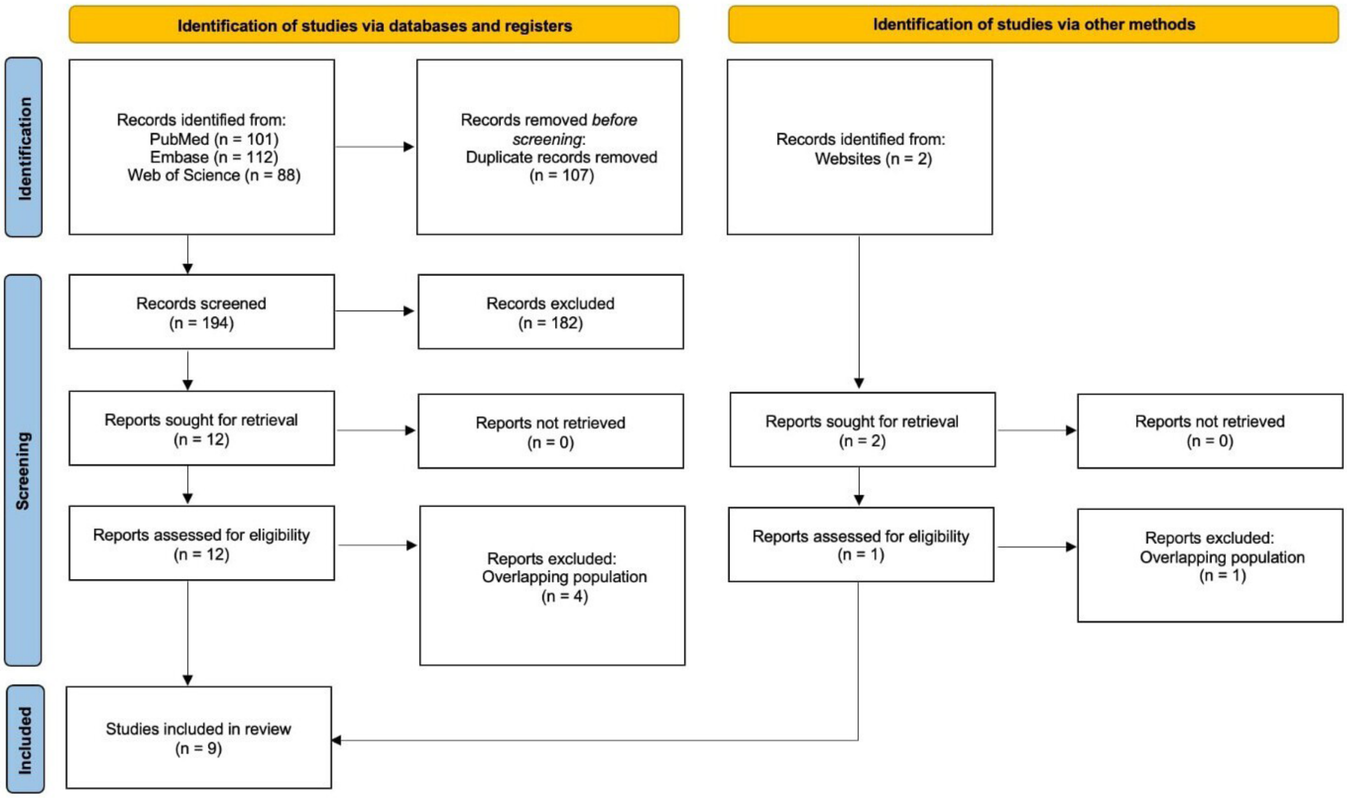

Figure 1 PRISMA flow diagram.

a versatile, cup-shaped device designed to treat aneurysms with diverse morphologies, including wide-necked, irregular, and shallow-shaped aneurysms.[6 7] The CNS not only disrupts and diverts blood flow within the aneurysm, facilitating progressive occlusion, but also reduces the need for dual antiplatelet therapy.[8 9] In addition, the CNS adapts to the aneurysm neck in a semi-2D manner, allowing for easy sizing based on the neck's width and 2D diameter without the need for a volumetric approach.[10] Nevertheless, there is still a dearth of evidence in the literature for the safety and efficacy of CNS, with a notable lack of randomized controlled trials and comprehensive meta-analyses on the subject.

We present a comprehensive systematic review and meta-analysis of the available literature on the safety and efficacy of the CNS for treating intracranial aneurysms. This study aims to synthesize the current evidence and critically analyze the outcomes, thereby addressing existing gaps and providing valuable insights to inform clinical decision-making regarding the adoption of this novel therapeutic approach.

METHODS

This systematic review and single-arm meta-analysis followed the recommendations of the Cochrane Collaboration Handbook for Systematic Review of Interventions[11] and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 statement guidelines.[12]

Eligibility criteria

The included studies met the following criteria: (1) they were either case series, prospective or retrospective cohorts, or randomized controlled trials; (2) they reported data on the applicability, safety, or efficacy of the use of CNS for treating intracranial aneurysms; (3) they included a cohort of at least five patients; and (4) they were written in English.

Search strategy, data extraction, and quality assessment

A comprehensive search was conducted on PubMed, Embase, and Web of Science, from inception to June 3, 2024, with the following search strategy: ("Contour" OR "Contour Neurovascular System") AND (aneurysm OR aneurysms) AND (intracranial OR brain OR cerebral). The database search was supplemented with a comprehensive forward and backward review of the references in the included studies. The Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) tool was adopted to evaluate the risk of bias in the included studies.[13] Two authors (MV and GS) independently assessed the data extraction and quality assessment, and any conflict was resolved by a third author (AG).

Endpoints definition and outcomes

Efficacy outcomes

The efficacy outcomes following embolization were: (1) immediate adequate aneurysm occlusion, (2) adequate aneurysm occlusion at the last follow-up, (3) technical success, defined as successful deployment of CNS.

Adequate occlusion was defined as total aneurysm obliteration, cases with residual neck filling, or those classified as Raymond-Roy grade[14] 1 or 2 in the study.

Safety outcomes

The safety outcomes were (1) good functional outcome, defined as a modified Rankin Scale (mRS) score of 0–2 at the last follow-up; (2) procedure-related morbidity, defined as procedure-related complications that resulted in permanent

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.

Table 1 Patient demographics, aneurysm features, and procedural description

Variable	N (%)
Sex	
Male	199 (41.2)
Female	284 (58.8)
Age (mean±SD)	59.3±15.6
Clinical status at presentation	
mRS 0	256 (77.6)
mRS 1	48 (9.5)
mRS 2	6 (1.2)
mRS 3	7 (2.1)
mRS 4	7 (2.1)
mRS 5	9 (2.7)
NR	150
Aneurysm rupture status at presentation	
Unruptured	383 (81.8)
Ruptured	85 (18.2)
NR	16
Aneurysm Location	
Anterior Circulation	353 (73.5)
Posterior Circulation	127 (26.5)
NR	4
Procedural fashion	
Elective	405 (86.2)
Emergent	65 (13.8)
NR	14

mRS, modified Rankins scale; NR, not reported; SD, standard deviation.

neurological deficits; (3) procedure-related mortality, defined as death due to procedure-related complications; (4) intraoperative complications; (5) postoperative complications.

Additionally, a subanalysis was conducted on the available stratified safety and efficacy outcomes for ruptured cases.

Statistical analysis

The statistical analysis was performed using R software version 4.3.0 (R Core Team, 2023) using the *meta* package, employing the inverse variance and the restricted maximum likelihood methods.[15] We computed single proportion analyses of the pooled prevalence (%) with 95% confidence intervals (CI) under a random-effects model. We assessed heterogeneity with I^2 statistics, and $I^2 > 40\%$ was considered significant for heterogeneity.[11] Due to the limited number of included studies, fewer than 10 per analysis, it was not feasible to conduct Egger's regression test to assess publication bias or perform a meta-regression.[11]

RESULTS

Study selection

A total of 301 articles were identified from PubMed (101), Embase (112), and Web of Science (88). After title and abstract screening, 12 articles underwent full-text review. Four studies were excluded because they had overlapping populations. An additional search of websites (detailed in online supplemental appendix) on expert suggestion yielded the inclusion of one study. Ultimately, nine articles[7 9 16–22] satisfied the inclusion criteria (all were retrospective, and three were multicentric studies). The search is illustrated in figure 1.

Baseline patient and study characteristics

A total of 483 patients (58.8% female; mean age: 59.3±15.6 years) were included. Most patients presented with a pre-treatment mRS score of 0–2 (64.2%) (table 1). The total number of aneurysms was 484 (81.8% unruptured at presentation and 72.9% located in the anterior circulation); further aneurysm characteristics are available in table 2. An elective procedural fashion was predominantly reported (83.7%) for the CNS placement. Further details on the procedure, follow-up, and individual descriptions of the studies are presented in table 2.

Pre- and post-procedural antiplatelet regimens were reported in six of nine studies, demonstrating considerable variability. For elective cases, pre-procedural antiplatelet therapy included single antiplatelet therapy, dual antiplatelet therapy, or no therapy.[7 9 17 20 22] For ruptured aneurysms, pre-procedural antiplatelet therapy was avoided in three studies[17 20 22], initiated as single antiplatelet therapy for 71% of patients from one study[9], and as dual antiplatelet therapy (ticagrelor 180 mg and aspirin 300 mg) for all patients in one study.[19] Post-procedural antiplatelet therapy was reported by six studies[7 9 16 19 20 22] as single antiplatelet therapy (aspirin 75 mg or 100 mg). The duration varied across studies, with a median of 6 weeks, ranging from 4 to 8 weeks. None of the studies described the use of platelet aggregation testing. Online supplemental table S1 summarizes the antiplatelet protocols across studies.

Efficacy outcomes

Regarding immediate adequate aneurysm occlusion, data from five studies were included with 75 lesions, yielding a rate of 53% (95% CI: 1% to 100%; I^2=99%). Concerning follow-up adequate occlusion, eight studies were included, presenting a rate of 93% (95% CI: 88% to 97%; I^2=34%, figure 2), with 303 out of 335 patients reporting adequate obliteration (follow-up ranged from 3 to 24 months).

In the evaluation of technical success, data from nine studies were included in the analysis, reporting a rate of 98% (95% CI: 95% to 100%; I^2=46%), with 472 out of 488 procedures successfully performed.

Safety outcomes

Regarding good functional outcomes at the last follow-up, data from eight studies were included, yielding a rate of 98% (95% CI: 95% to 100%; I^2=16%), with 363 out of 378 patients considered as having a good outcome. Eight studies concerning procedure-related morbidity were included, presenting a rate of 2% (95% CI: 0% to 3%; I^2=0%) with 9 out of 375 events.

Nine studies were included for procedure-related mortality, presenting a rate of 0%. Concerning the intraoperative complications rate, nine studies were included, presenting a rate of 3% (95% CI: 0% to 7%; I^2=70%), with 29 out of 483 events. For postoperative complications rate, eight studies were included, presenting a rate of 7% (95% CI: 3% to 12%; I^2=31%), with 38 out of 435 events. The results of the safety and efficacy outcomes, along with the subanalysis for ruptured cases, are summarized in table 3, and all corresponding forest plots are available in the online supplemental appendix.

Quality assessment

online supplemental file 1 S12 and S13 depict the risk of bias assessment conducted using the ROBINS-I tool. The majority

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.

Table 2 Description of individual study regarding patient demographics, aneurysm features, and procedure details

Study characteristics			Patients characteristics				Aneurysm features							Intervention	
Study, year	Country	Design	Sample size	Sex (M/F)	Mean age (years)	Baseline clinical status (No.)	UR/R	Location (No.)	Mean aneurysm height (mm)	Mean aneurysm width (mm)	Mean aneurysm neck width (mm)	Dome-to- neck ratio		Contour sizes (No.)	Follow-up (No. of patients)
Akhunbay-Fudge 2020[7]	UK	RO SC	11	0/11	65.0±6.4	GCS 15 (11) mRS 0 (11)	11/0	Basilar tip (4) MCA bifurcation (3) ICA terminus (2) ACOM (1) SCA (1)	7.6±2.7 (4.3–13)	6±2.14 (3.5–10.2)	3.7±0.89 (2.4–5.4)	1.7±0.4 (1.0–2.2)		7 mm (3) 9 mm (3) 11 mm (5)	**Clinical** 6 weeks(11)**Radiological** six mos(11)12 mos(9)24 mos(6)
Chung 2022[18]	UK	RO SC	5	4/1	60 (44–71)	NR	5/0	AC (2) PC (3)	NR	NR	4.22 (3.3–5)	NR		NR	**Clinical and Radiological** six mos(3/5)
Dange 2022[19]	India	RO MC	13	6/7	52.2±12.2	mRS 0 (1) mRS 1 (7) mRS 2 (2) mRS 3 (2) mRS 4 (1) Hunt–Hess score I (10) II (2) III (1)	1/13	MCA bifurcation (6) ACOM (6) Basilar tip (1) Distal ACA (1)	NR	5.2 (1.8–10.9)	*4.8 (2–7.6)	*1.1 (0.9–1.8)		5 mm (2) 7 mm (5) 9 mm (5) 11 mm (2)	**Clinical and Radiological** *three mos (IQR 3–4.5)(13)
Diana 2022[17]	Spain	RO SC	5	2/3	*59 (50-75)	mRS 0 (1) mRS 2 (2) mRS 5 (2) Hunt–Hess score II (1) III (1) V (1)	2/3	ACOM (2) ICA (1) Basilar tip (2)	*5.4 (5-8)	*6 (3.5–7.5)	*3.5 (2.4–5)	NR		5 mm (2) 7 mm (2) 9 mm (1)	**Clinical** three mos(5)**Radiological** *three mos (0.03–7)(5)
Gallo-Pineda 2024[20]	Spain	RO MC	25	5/20	*64 (IQR 28–88)	mRS 0 (24) mRS 2 (1)	22/3	ACOM (9) PCOM (1) MCA bifurcation (6) Basilar top (2) Carotid T (1) Pericallosal (2) Other locations (4)	NR	*7.5 (IQR 4.6–8.8)	*4 (IQR 3–5)	NR		7 mm (9) 9 mm (10) 11 mm (3) 14 mm (3)	**Clinical** 3 mos (24) **Radiological** 6–12 mos (24)
Gärtner 2023[21]	Germany	RO SC	48	36/12	58±12.5 (31–88)	NR	33/15	AC (39) PC (9)	NR	NR (2–10.5)	NR (2-10)	NR		5 mm (NR) 7 mm (NR) 9 mm (NR) 11 mm (NR) 14 mm (NR)	NR
Griessenauer 2024[9]	Germa, Austria, Denmar, France, UK, Spain	RO MC	279	106/173	*60 (IQR 52–68)	mRS 0 (219) mRS 1 (39) mRS 2 (3) mRS 3 (5) mRS 4 (6) mRS 5 7	232/31	MCA (74) ACOM (73) Basilar tip (65) ICA terminus(27) ICA sidewall (15) PCOM (16) PICA (3) Pericallosal artery (3) SCA (3)	*5.7 (IQR 4.3–7.8)	*5.20 (IQR 4.20–7.00)	*3.90 (IQR 3.00–5.00)	*1.34 (IQR 1.13–1.68)		5 mm (48) 7 mm (103) 9 mm (66) 11 mm (45) 14 mm (2)	**Radiological** *12 (IQR 6–12) mos(212)
Mostafa 2023[16]	Germany	RO SC	21	14/7	57 (31–74)	NR	11/10	AC (17) PC (4)	NR	NR	NR	≥ 1.6		NR	**Radiological** 9.0 (6-18) mos(13)
Radomi 2024[22]	Germany	RO SC	76	26/50	58.9 ± 12.4	NR	66/10	ICA (15) ACOM (22) Pericallosal (4) MCA bifurcation (5) Basilar tip (25) SCA (4) PICA (1)	5.7±3.2 (2.0–18.0)	5.6±2.5 (1.8–17.3)	4.0±1.6 (1.6–9.0)	1.5±0.4 (0.9–2.9)		5 mm (16) 7 mm (33) 9 mm (18) 11 mm (10)	**Clinical** NR **Radiological** Mean 12.2±9.3 mos Last FU(56)

*median (range).
AC, anterior circulation; ACA, anterior cerebral artery; ACOM, anterior communicating artery; GCS, Glasgow coma scale; ICA, internal carotid artery; IQR, interquartile range; MC, multicenter; MCA, middle cerebral artery; Mo, months; mRS, modified Rankin scale; NR, not reported; PC, posterior circulation; PCOM, posterior communicating artery; PICA, posterior inferior cerebellar artery); R, ruptured; RO, retrospective; SC, single center; SCA, superior cerebellar artery; UR, unruptured.

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.

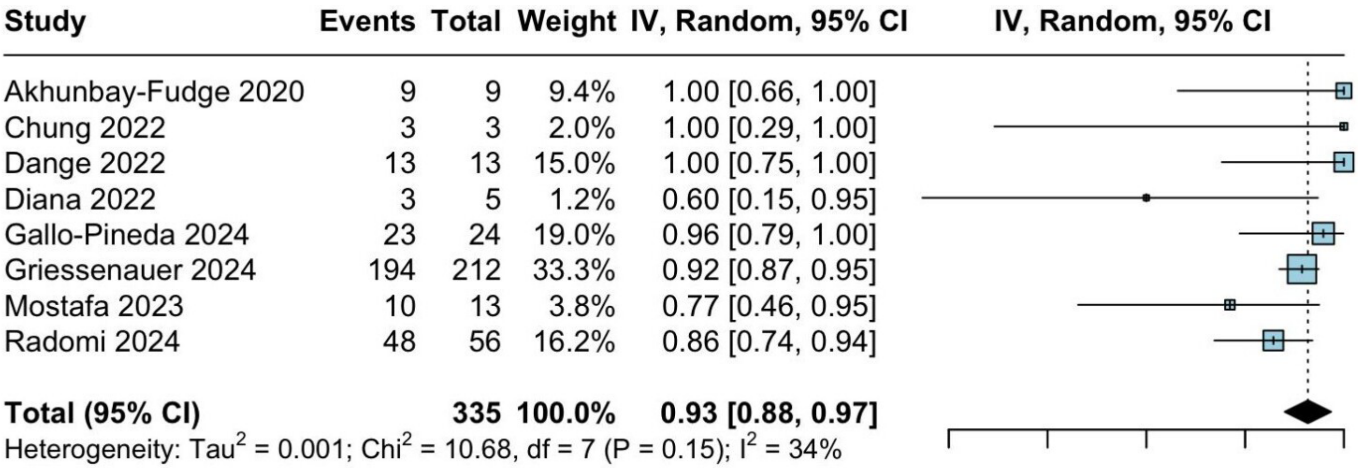

Figure 2 Forest plot of follow-up adequate aneurysm occlusion.

of studies were found to have a moderate risk of bias, predominantly influenced by issues in the classification of interventions, the measurement of outcomes, and the selection of reported results. Most outcomes, including follow-up aneurysm occlusion, procedure-related morbidity and mortality, and good clinical outcomes, showed no heterogeneity across the included studies (table 3).

DISCUSSION

Our systematic review and meta-analysis, encompassing 484 aneurysms treated with the CNS, yielded significant findings that have important implications for the treatment of intracranial aneurysms. The CNS, a novel device designed to adapt to the aneurysm's shape and provide both flow disruption and diversion, has shown promising short- and mid-term safety and efficacy outcomes (up to 24 months follow-up), with a very low rate of commonly encountered complications such as vasospasm, thrombosis, and bleeding.

The technical success of CNS deployment in our meta-analysis was remarkably high at 98%, underscoring the feasibility and reliability of the system in diverse clinical settings. The high rate of technical success further reinforces the adaptability and utility of the CNS across a variety of aneurysm morphologies and locations. Despite the majority of aneurysms in our analysis being located at bifurcations, our study was not limited to bifurcation aneurysms; it included all cerebral aneurysms treated with the CNS, better reflecting real-world experience and expanding the understanding of CNS applications beyond bifurcation locations. Information on immediate occlusion was available in only 75 out of 483 patients (15.5% of cases), with a 53% adequate occlusion rate in this subset. Information on follow-up occlusion outcomes was available in 335 of 483 patients (69.4% of cases), with an

Table 3 Summary of meta-analysis findings

Overall				
Outcomes	**Proportion (95% CI)**	**I^2 (%)**	**No. of studies**	**Events/ Total**
Efficacy				
Immediate adequate aneurysm occlusion rate	53% (1-100)	99	5	42/75
Adequate aneurysm occlusion rate at last follow-up	93% (88-97)	34	8	303/335
Technical success	98% (95-100)	46	9	472/488
Safety				
Good functional outcome	98% (95-100)	16	8	363/378
Procedure-related morbidity	2% (0 to 3)	0	8	9/375
Procedure-related mortality	0% (0 to 0)	0	9	0/483
Intraoperative complications	3% (0 to 7)	70	9	29/483
Postoperative complications	7% (3-12)	31	8	38/435
Subanalysis for ruptured aneurysms				
Outcomes	**Proportion (95% CI)**	**I^2 (%)**	**No. of studies**	**Events/ Total**
Efficacy				
Adequate aneurysm occlusion at last follow-up	95% (86-100)	16	5	41/45
Technical success	100% (96-100)	0	5	59/60
Safety				
Intraoperative complications	9% (0 to 20)	41	5	8/60
Postoperative complications	3% (0 to 8)	0	5	2/60

No., Number.;

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.

adequate occlusion rate of 93% at the last follow-up, suggesting that the CNS provides a progressive rate of occlusion over time. This progressive occlusion is likely attributable to the flow-diversion properties of the CNS, which promote thrombosis within the aneurysm sac, gradually leading to complete occlusion.[10] Despite being based on a small number of cases (60 of 483, 12.4%), the subanalysis of ruptured cases treated with CNS yielded similar technical success rates and follow-up occlusion outcomes to the overall analysis results (table 3). Compared with other endovascular treatment options, especially with the Woven Endobridge (WEB, Microvention) the CNS shows promising follow-up occlusion rates. Five-year follow-up studies reported adequate occlusion rates of 77.9% to 87.2% for the WEB.[23 24] A recent meta-analysis found an 89% complete occlusion rate for wide-neck bifurcation aneurysms treated with Y-stent-assisted coiling.[25]

In terms of safety, our analysis revealed a very favorable profile for the CNS. The procedure-related mortality rate was 0%, and the procedure-related morbidity was 2%. This low incidence of severe complications indicates that the CNS may offer a safer alternative to more traditional endovascular treatments, which are often associated with higher morbidity and mortality rates. For example, previous studies on other endovascular methods, including X or Y stenting, stent/balloon-assisted coiling, and neck bridging devices, have reported procedure-related morbidity rates ranging from 7% to 10% and mortality rates from 1.0% to 5.4%.[3 5 26 27] The CNS's ability to achieve high rates of good functional outcomes — 98% of patients had an mRS score of 0–2 at the last follow-up — highlights its potential for a safe treatment. Compared with the WEB-IT trial, which reported a procedure-related mortality of 0.7% and morbidity of 1.3%, the CNS demonstrates a promising safety profile.[23]

The CNS also showed a relatively low rate of intraoperative (3%) and postoperative (7%) complications (table 4). These findings are particularly notable when compared with the complication rates associated with other techniques such as flow diversion or stent-assisted coiling, where complication rates can be higher. For instance, flow diverters for bifurcation aneurysms are associated with a 22% complication rate and a 7% rate of procedure-related morbidity.[28] The reduced need for aggressive antiplatelet therapy with the CNS likely contributes to its safer profile, which is a significant advantage, especially for patients with comorbidities or those who are at higher risk for bleeding complications.[6 8 9] This feature not only simplifies post-operative care but may also lower the overall risk of long-term complications, contributing to better patient outcomes. Additionally, the CNS's cup-like configuration allows for more stable and precise placement within the aneurysm sac, as it conforms to the bottom of the aneurysm on deployment, reducing the likelihood of device displacement, as reflected by its high technical success rates.[21 29] The non-volumetric simplified sizing approach allows for device selection based on the equatorial dome diameter of the aneurysm and the diameter of the neck (figure 3). Furthermore, the significantly shorter median deployment times compared with the WEB device further underscore the ease of use and safety profile of the CNS.[29]

However, despite the promising results, this study is not without its limitations. Most of the included studies were retrospective and conducted in single-center settings, which could introduce biases in patient selection and outcome reporting. The radiologic and clinical outcomes were self-adjudicated, and the radiologic follow-up was short, ranging from 3 to 24 months. Additionally, there was considerable variability in how complications were defined and reported across the studies, which may affect the generalizability of our findings. The lack of a standardized protocol for assessing and categorizing complications also introduces potential observer bias, which we attempted to mitigate by providing detailed descriptions of all reported complications and their outcomes. Lastly, 57.6% of the included aneurysms were reported by Griessenauer *et al*,[9] which may suggest that the results of this study could disproportionately influence the meta-analysis outcomes. However, it is important to note that this was a 10-center retrospective cohort study, and we excluded multiple studies to prevent potential population

Table 4 Summary of procedure-related complications

Study	Intraoperative complications (No. of events)	Postoperative complications (No. of events)	Management (No. of events)	Final outcome (No. of events)
Akhunbay-Fudge 2020[7]	None	Headache (1) Thromboembolic (2)	Discharged on 6 weeks of ASA and 3 months of clopidogrel (1) IV Abciximab 5mg; discharged on 2 months of ASA and clopidogrel (1)	No clinical repercussion
Chung 2022[18]	None	None	NA	No clinical repercussion
Dange 2022[19]	None	None	NA	No clinical repercussion
Diana 2022[17]	None	None	NA	No clinical repercussion
Gallo-Pineda 2024[20]	Embolism (2) Device displacement (3)	Minor stroke (1) Device displacement (5)	IV Tirofiban (2) Retreatment with other embolization techniques (3)	No clinical repercussion
Gärtner 2023[21]	NR	None	NR	NR
Griessenauer 2024[9]	Premature detachment (4) Other device-related (17)	Hemorrhagic (1) Thromboembolic (19)	NR	mRS 3 (3), mRS 4 (2), mRS 5 (1)
Mostafa 2023[16]	Device-related (1) Thromboembolic (1) Aneurysm rupture (1)	Severe vasospasm (1)	NR	No clinical repercussion (2) Severe neurological impairment (2)
Radomi 2024[22]	None	Transient visual disturbances (3) Inguinal hematoma (1) Asymptomatic hemorrhagic event (1) Thromboembolic (3)	IV ASA and Tirofiban (1) No specific treatment (7)	No clinical repercussion (7) Major ischemic stroke that resulted in morbidity (1)

ASA, aspirin; NA, not applicable; NR, not reported; IV, intravenous; mRS, modified Rankin scale

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.

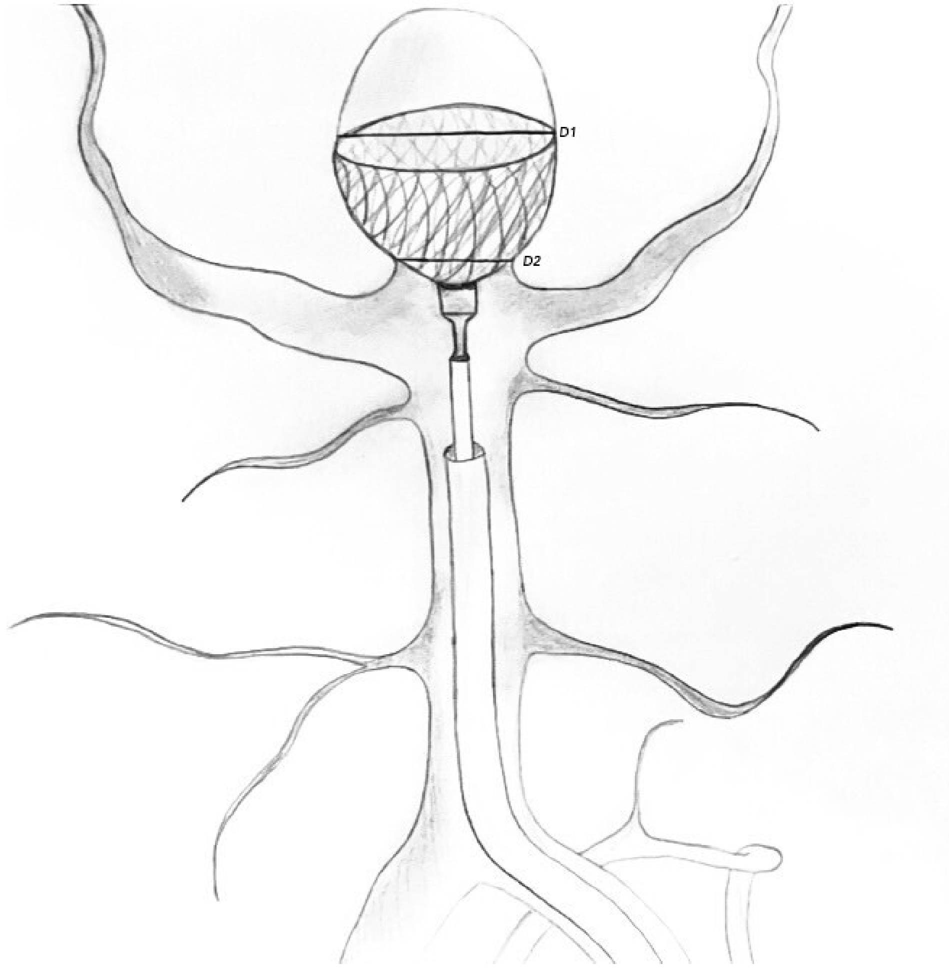

Figure 3 The hand-drawn illustration depicts the endovascular treatment of a saccular basilar tip aneurysm using the Contour Neurovascular System (Stryker). D1 and D2 represent the equatorial dome diameter of the aneurysm and the neck diameter, on which the sizing process is based.

overlap where individual institutions had previously published their experiences.

Furthermore, while the CNS appears to be highly effective for a wide range of aneurysms, it is important to note that our analysis did not include a direct comparison with other established treatment modalities. Future studies should aim to conduct randomized controlled trials comparing the CNS directly with other treatment options, such as clipping, flow diverters, intrasaccular devices, and stent-assisted coiling, to further validate its efficacy and safety.

In conclusion, our systematic review and meta-analysis suggests that the CNS is a highly effective and safe option for the treatment of intracranial aneurysms. It offers a high rate of technical success, significant rates of aneurysm occlusion, and a favorable safety profile, with minimal procedure-related complications. These findings support the CNS as a viable alternative to more traditional endovascular techniques, particularly in complex cases where other devices may be less effective or pose higher risks. However, further research, particularly in the form of prospective studies and direct comparisons with other treatment modalities, is warranted to fully establish the CNS's role in the management of intracranial aneurysms.

Author affiliations
[1]Department of Radiology, Fatih Sultan Mehmet Training and Research Hospital, Istanbul, Turkey
[2]Diagnostic and Interventional Neuroradiology, Hospital Foch, Créteil, France
[3]Department of Neurosurgery, Lenox Hill Hospital, New York, New York, USA
[4]Faculty of Medicine, Catholic University of Brasilia, Brasilia, DF, Brazil
[5]School of Medicine, Pontifical Catholic University of Paraná, Parana, Brazil
[6]Academic Department of Surgery, School of Medicine, Universidad Peruana Cayetano Heredia, Lima, Peru
[7]Département de Radiologie et Imagerie Médicale, Centre Hospitalier Universitaire Dijon (Hospital Center University François Mitterrand), Dijon, France
[8]Faculty of Medicine, Universidade Estácio de Sá, Rio De Janeiro, Rio de Janeiro, Brazil
[9]University of West Santa Catarina, Joaçaba, Santa Catarina, Brazil
[10]UOSA Neuroradiologia Interventistica, Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Roma, Italy
[11]Civil engineering, University College London, London, UK
[12]Sorbonne Université, Paris, France
[13]Neuroradiology, Pitié-Salpêtrière Hospital, Paris, France
[14]Neurological surgery, Thomas Jefferson University, Philadelphia, Pennsylvania, USA

X Ahmet Günkan @doctorgunkan, Marina Vilardo @MVilardo, Jhon E Bocanegra-Becerra @JhonBocanegraB1 and Pascal Jabbour @PascalJabbourMD

Acknowledgements We would like to express our sincere thanks to Mrs. Luiza Rangel Agostinho for her thoughtful work in drawing Figure 3.

Contributors AG conceptualized and designed the study, contributed to manuscript writing, and served as the guarantor. LS, MYF, and MV contributed to data acquisition and analysis. LFFP and JEBB participated in drafting the manuscript. MEMF, HGM, GS, and AMA contributed to the critical revision of the manuscript for important intellectual content. LV conducted the statistical analysis. FC, YS, and PJ, as senior authors, reviewed and edited the manuscript. All authors approved the final version of the manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests FC reports conflicts of interest with Medtronic and Balt

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.

Extrusion (consultant), ClinSearch (core lab), Penumbra and Stryker (payment for reading), and Artedrone (Board). PJ is a consultant for Medtronic and Microvention. The remaining authors report no competing interests.

Patient consent for publication Not applicable.

Ethics approval As this study is a systematic review and meta-analysis of previously published literature, which does not involve any new human or animal subjects or the use of confidential data, ethics approval was not required

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iDs
Ahmet Günkan http://orcid.org/0000-0002-6236-5633
Luca Scarcia http://orcid.org/0000-0002-1316-0383
Marcio Yuri Ferreira http://orcid.org/0000-0001-9924-474X
Marina Vilardo http://orcid.org/0009-0001-9487-1119
Jhon E Bocanegra-Becerra http://orcid.org/0000-0003-3661-7195
Mohamed E M Fouad http://orcid.org/0009-0004-1871-4244
Henrique Garcia Maia http://orcid.org/0009-0002-7719-5910
Andrea Maria Alexandre http://orcid.org/0000-0002-8080-3916
Pascal Jabbour http://orcid.org/0000-0002-1544-4910

REFERENCES

1 Tjoumakaris SI, Hanel R, Mocco J, *et al*. ARISE I Consensus Review on the Management of Intracranial Aneurysms. *Stroke* 2024;55:1428–37.
2 Deshmukh AS, Priola SM, Katsanos AH, *et al*. The Management of Intracranial Aneurysms: Current Trends and Future Directions. *Neurol Int* 2024;16:74–94.
3 Gunkan A, Onal Y, Ramazanoglu L, *et al*. Stent plus balloon-assisted coiling with low-profile braided stents in the treatment of complex wide-necked intracranial bifurcation aneurysms. *Neuroradiol J* 2024;37:603–10.
4 Pierot L, Costalat V, Moret J, *et al*. Safety and efficacy of aneurysm treatment with WEB: results of the WEBCAST study. *J Neurosurg* 2016;124:1250–6.
5 Bartolini B, Blanc R, Pistocchi S, *et al*. "Y" and "X" stent-assisted coiling of complex and wide-neck intracranial bifurcation aneurysms. *AJNR Am J Neuroradiol* 2014;35:2153–8.
6 Biondi A, Primikiris P, Di Caterino F, *et al*. How to use the Contour intrasaccular device: two illustrative cases. *J Neurointerv Surg* 2024;16:225.
7 Akhunbay-Fudge CY, Deniz K, Tyagi AK, *et al*. Endovascular treatment of wide-necked intracranial aneurysms using the novel Contour Neurovascular System: a single-center safety and feasibility study. *J Neurointerv Surg* 2020;12:987–92.
8 Biondi A, Primikiris P, Vitale G, *et al*. Endosaccular flow disruption with the Contour Neurovascular System: angiographic and clinical results in a single-center study of 60 unruptured intracranial aneurysms. *J Neurointerv Surg* 2023;15:838–43.
9 Griessenauer CJ, Ghozy S, Biondi A, *et al*. Contour Neurovascular System for endovascular embolization of cerebral aneurysms: a multicenter cohort study of 10 European neurovascular centers. *J Neurointerv Surg* 2024.
10 Liebig T, Killer-Oberpfalzer M, Gal G, *et al*. The Safety and Effectiveness of the Contour Neurovascular System (Contour) for the Treatment of Bifurcation Aneurysms: The CERUS Study. *Neurosurgery* 2022;90:270–7.
11 Higgins J, Welch V. *Cochrane handbook for systematic reviews of interventions*.Available: https://training.cochrane.org/handbook
12 Page MJ, McKenzie JE, Bossuyt PM, *et al*. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71.
13 Sterne JA, Hernán MA, Reeves BC, *et al*. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016;355:i4919.
14 Roy D, Milot G, Raymond J. Endovascular treatment of unruptured aneurysms. *Stroke* 2001;32:1998–2004.
15 Balduzzi S, Rücker G, Schwarzer G. How to perform a meta-analysis with R: a practical tutorial. *Evid Based Ment Health* 2019;22:153–60.
16 Mostafa K, Bueno Neves F, Gärtner F, *et al*. Contour device implantation versus coil embolization for treatment of narrow neck intracranial aneurysms. *Sci Rep* 2023;13:4904.
17 Diana F, de Dios Lascuevas M, Peschillo S, *et al*. Intrasaccular Flow Disruptor-Assisted Coiling of Intracranial Aneurysms Using the Novel Contour Neurovascular Systems and NEQSTENT: A Single-Center Safety and Feasibility Study. *Brain Sci* 2022;12:991.
18 Chung R-E, Jadun CK, Nayak S, *et al*. P03 Early experience of a novel intrasaccular flow disrupter for the treatment of intracranial aneurysms – the contour device. 14th Congress of the European Society of Minimally Invasive Neurological Therapy 2022 Meeting Abstracts; BMA House, Tavistock Square, London, WC1H 9JR: BMJ Publishing Group Ltd, 2022
19 Dange NN, Roy JM. Initial Experience with the Contour Device in the Treatment of Ruptured Intracranial Wide-necked Bifurcation Aneurysms: A Single-operator, Multicenter Study. *Neurol India* 2022;70:2059–64.
20 Gallo-Pineda F, Fernández-Gómez M, Domínguez-Rodríguez C, *et al*. Evaluating Efficacy and Complications of Contour Intrasaccular Device in Cerebral Aneurysm Management: A Multicenter Analysis. *World Neurosurg* 2024;183:e738–46.
21 Gärtner F, Klintz T, Peters S, *et al*. Intra-cranial aneurysm treatment with contour or WEB - a single center comparison of intervention times and learning curves. *Interv Neuroradiol* 2023;15910199231179512.
22 Radomi A, Goertz L, Forbrig R, *et al*. Safety and efficacy of the Contour Neurovascular System for intracranial aneurysm treatment: a retrospective analysis of 76 patients. *J Neurosurg* 2024;1–9.
23 Fiorella D, Molyneux A, Coon A, *et al*. Safety and effectiveness of the Woven EndoBridge (WEB) system for the treatment of wide necked bifurcation aneurysms: final 5 year results of the pivotal WEB Intra-saccular Therapy study (WEB-IT). *J Neurointerv Surg* 2023;15:1175–80.
24 Pierot L, Szikora I, Barreau X, *et al*. Aneurysm treatment with the Woven EndoBridge (WEB) device in the combined population of two prospective, multicenter series: 5-year follow-up. *J NeuroIntervent Surg* 2023;15:552–7.
25 Gunkan A, Ferreira MY, Batista S, *et al*. Efficacy and safety of low profile stents in Y-stent assisted coil embolization of wide-necked bifurcation aneurysms: a systematic review and meta-analysis. *Neurosurg Rev* 2024;47:123.
26 De Vries J, Boogaarts HD, Sørensen L, *et al*. eCLIPs bifurcation remodeling system for treatment of wide neck bifurcation aneurysms with extremely low dome-to-neck and aspect ratios: a multicenter experience. *J Neurointerv Surg* 2021;13:438–42.
27 Sorenson TJ, Iacobucci M, Murad MH, *et al*. The pCONUS bifurcation aneurysm implants for endovascular treatment of adults with intracranial aneurysms: A systematic review and meta-analysis. *Surg Neurol Int* 2019;10:24.
28 Kashkoush A, El-Abtah ME, Petitt JC, *et al*. Flow diversion for the treatment of intracranial bifurcation aneurysms: a systematic review and meta-analysis. *J Neurointerv Surg* 2024;16:921–7.
29 Hecker C, Broussalis E, Pfaff JAR, *et al*. Comparison of the Contour Neurovascular System and Woven EndoBridge device for treatment of wide-necked cerebral aneurysms at a bifurcation or sidewall. *J Neurosurg* 2023;139:563–72.

J NeuroIntervent Surg: first published as 10.1136/jnis-2024-022461 on 21 November 2024. Downloaded from http://jnis.bmj.com/ on November 22, 2024 at Stryker Neurovascular. Protected by copyright.