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*Review Article*

# Efficacy of endovascular embolization versus microsurgical clamping in the treatment of intracranial aneurysms: a meta-analysis

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**Abstract:** Intracranial aneurysms (IA) can induce increased intracranial pressure, headache, and the development of nausea and vomiting if not treated in time, and failure to receive timely diagnosis and treatment can lead to disability or death. However, the efficacy and prognostic value of craniotomy and endovascular embolization in patients with IA remains a controversial topic. This meta-analysis systematically evaluated the efficacy of endovascular coiling versus cranial aneurysm clamping on the immediate postoperative outcome and prognosis of patients with IA. PubMed, EMBASE, and the Cochrane Library databases were searched for retrieval of relevant references. Literature was screened according to pre-defined inclusion and exclusion criteria, and data were extracted and assessed for quality. A total of 10 studies, including 2,654 cases, were included in the analysis. Among them, 1,313 cases underwent craniotomy clipping surgery (clip group), and 1,341 cases underwent endovascular coiling (coil group). The quality of the studies in 8 articles evaluated using the Newcastle-Ottawa Scale (NOS) was ≥6. Meta-analysis was conducted using Rev Man 5.3 and Stata 17 software. The results of meta-analysis showed that no significant difference in complete occlusion rate [$OR$=1.76, 95% $CI$ (0.78, 3.96), $P$=0.17] when comparing the clip and coil group. Compared to the clip group, the coil group had a better clinical short-term outcome [$OR$=1.55, 95% $CI$ (1.05, 2.27), $P$=0.03], but an increased rate of postoperative residual or recurrence [$OR$=0.40, 95% $CI$ (0.17, 0.91), $P$=0.03]. In addition, there were no significance differences identified in terms of complications, including the rates of postoperative rebleeding [$OR$=1.60, 95% $CI$ (0.97, 2.63), $P$=0.07], ischemic stroke [$OR$=1.12, 95% $CI$ (0.45, 2.79), $P$=0.81], and cerebral vasospasm [$OR$=0.90, 95% $CI$ (0.13, 6.03), $P$=0.91]. Subsequently, we conducted experimental sequence analysis for each indicator, and the results were consistent with the results of meta-analysis. According to the recent clinical prognosis, a funnel plot was constructed, showing significant asymmetry on both sides, indicating some publication bias. However, the results of Begg's test with $P$=0.734 and Egger's test with P=0.633 suggest no significant publication bias. In general, endovascular coiling and microsurgical clipping appear to be equally effective in achieving vascular occlusion. Endovascular coiling may be more effective in improving the short-term clinical outcomes for patients. However, this approach may increase the rate of postoperative residual issue or recurrence.

**Keywords:** Endovascular coiling, craniotomy clamp surgery, complete occlusion rate, clinical near-term prognosis

## Introduction

Intracranial aneurysm (IA) refers to a local abnormal bulging and pathological dilation caused by a reduction in the structural integrity of the arterial wall [1]. In fact, IA is not a tumor but a cerebrovascular disease. It typically occurs in vulnerable areas of the arteries for cerebral blood supply, where these areas gradually expand under the pressure of blood flow, forming a sac-like structure resembling a berry. Another cause is related to arteriosclerosis, trauma, and infection. It is akin to a "time bomb" inside the brain, which could "explode" at any time. Once it "explodes", the arterial blood pressure will immediately surge into the

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cranial cavity, causing subarachnoid hemorrhage, which can lead to severe disability or death [2]. Therefore, timely prevention and treatment are crucial to avoid the "explosion" of this "bomb".

Craniotomy for clipping of IA, a long-standing surgical method, has always held a place in the field of aneurysm treatment. By directly removing and clipping the aneurysm, it achieves thorough treatment of the lesion, ensuring the completeness of the treatment [3]. However, a significant drawback of this surgical approach is its substantial trauma [3, 4]. This trauma may not only delay the patient's recovery process but also may be mentally challenging for patients due to the invasiveness. In contrast, endovascular coiling, as a relatively new treatment modality, employs precise catheter techniques to achieve embolization by filling the aneurysm with coils, thereby blocking blood flow and preventing aneurysm rupture [5]. The advantage of this method lies in its minimally invasive nature, which not only reduces direct damage to the patient's cerebral vasculature but also causes relatively less damage to surrounding tissues. This smaller trauma helps reduce the risk of postoperative complications, such as cerebral hemorrhage and brain edema, thereby creating favorable conditions for rapid recovery [6].

The implementation of endovascular interventional coiling in patients with IA is theoretically suitable for clinical promotion and implementation. However, the debate on the efficacy and prognostic value of craniotomy clipping versus endovascular coiling remains unresolved. This study aims to evaluate the impact of endovascular coiling on short-term outcomes and prognosis in patients with IA, a topic that continues to be a subject of discussion in the field of neurosurgery. The novelty of this study lies in its ability to synthesize a large body of evidence to provide clearer guidance for clinical practice. Unlike previous studies that may have been limited by smaller sample sizes (106) or less rigorous methodology [7], this meta-analysis leverages a large dataset and high-quality studies to draw more definitive conclusions about the relative benefits and risks associated with endovascular coiling versus craniotomy clipping.

## Methods

### *Eligibility criteria*

We conducted a search using the terms "Intracranial Aneurysm", "endovascular coiling", and "craniotomy clipping" with a strategy of combining subject terms and free-text words in databases (such as the Cochrane Library, EMBASE, and PubMed). The search was set to cover the period from the inception of the databases up to January 2024, collecting studies published to date on endovascular coiling and craniotomy clipping for the treatment of IA. The language limit is English, and with complete clinical data. Manual retrieval of relevant references supplemented the search.

In pursuit of high-quality research outcomes, the PICOS principle is often followed to complete the research design and to clarify the search questions and information needs. This study adheres to the PICOS principle and has set strict requirements for the research subjects and treatment measures when establishing inclusion and exclusion criteria.

The studies included met the following criteria: (1) the study population consists of patients with a confirmed diagnosis of IA; (2) the study results are reported with detailed and clear data; (3) use of endovascular embolization to treat aneurysms; (4) the language of the study is English. Literature that meets the following criteria was excluded: (1) reviews, guidelines, conference proceedings, letters, and consensus documents; (2) case reports, traumatic aneurysms, iatrogenic aneurysms; (3) studies with overlapping research subjects and populations; (4) incomplete literature data or inability to obtain raw data; (5) the observed indicators in the literature do not match the observed indicators studied in this paper.

### *Literature screening*

Initially, a preliminary review of the titles and abstracts of the literature was conducted to exclude articles that were clearly not relevant to the research topic by two evaluators. Subsequently, a thorough reading of the remaining abstracts and full texts was carried out to ensure that only highly relevant articles were included. After the screening process was completed, a cross-checking step was performed, and in case of any discrepancies, consensus was reached through discussion and negotiation with a third party.

*Data collection*

Data were collected from the included studies, including general information (author, year, country), study characteristics (baseline data of study subjects, sample size, grouping), and outcomes (embolization rate/complete occlusion rate, short-term prognosis, postoperative residual or recurrence rate, and related complications).

*Outcome measures*

Primary outcomes include occlusion rate/complete closure rate and short-term prognosis.

Secondary outcomes comprise postoperative residual or recurrence rate and associated complications (postoperative rebleeding rate, postoperative ischemic stroke incidence, postoperative cerebral vasospasm occurrence rate).

*Literature quality evaluation*

Two evaluators used the Newcastle-Ottawa Scale (NOS) to evaluate the quality of the included literature. The NOS consists of three main modules: study population selection, comparability, and exposure/outcome, and a total of 8 entries. Each entry is rated on a star system where the comparability component is awarded a maximum of two stars, and each other is awarded a maximum of one star for an overall maximum of nine stars. A total score of ≥6 was considered to be high-quality literature. When using NOS for quality evaluation, two authors independently performed the scoring and cross-checked after completion. Any disagreements in the scoring were resolved through third-party negotiation.

*Statistical analysis*

Meta-analysis was conducted using Rev Man 5.3 and Stata 17 software. The odds ratio (*OR*) and 95% confidence interval (*CI*) were used as the representation method for count data. $I^2$ test was employed to assess heterogeneity. If the $I^2$ value was ≥50% or the *P* value was ≤0.10, heterogeneity was considered, and a random-effects model was used for analysis. If the $I^2$ value was <50% or the *P* value was >0.10, no heterogeneity was assumed, and fixed-effects model was applied. In cases of significant heterogeneity, sensitivity analyses were conducted by changing the analysis model or using exclusion criteria. Funnel plots were used to test for potential publication bias. In addition, trial sequential analysis (TSA) is used for sample size estimation in meta-analysis. When the number of cases included in the meta-analysis does not reach a sufficient sample size, TSA was applied to minimize false positive results due to random error [8]. A *P* value of <0.05 was considered statistically significant.

## Results

*Literature search results*

After excluding the non-randomized controlled trials, non-observational studies and replicated studies, we obtained 248 studies in the preliminary screening. After further reading the abstract and full text, we then excluded 213 reviews, guidelines, conferences, case reports, and 25 studies that did not meet the criteria for inclusion of patients or with incomplete data. Ultimately, 10 eligible studies were incorporated into the analysis [7, 9-17]. The procedure for sifting through the literature is depicted in **Figure 1**.

*Characteristics of studies*

Among the 10 studies included, the cumulative sample size was 2,654 cases, including 1,313 and 1,341 cases in the coil and clip group, respectively (**Table 1**). The quality of studies were assessed by NOS, with 7 studies scoring ≥6 points and 3 studies scoring 5 points (**Table 2**).

*Meta-analysis results*

(1) Complete occlusion rate: 3 studies [12, 14, 17] with a total of 228 patients reported the complete occlusion rate, and the study data were not statistically heterogeneous ($I^2$=0%,

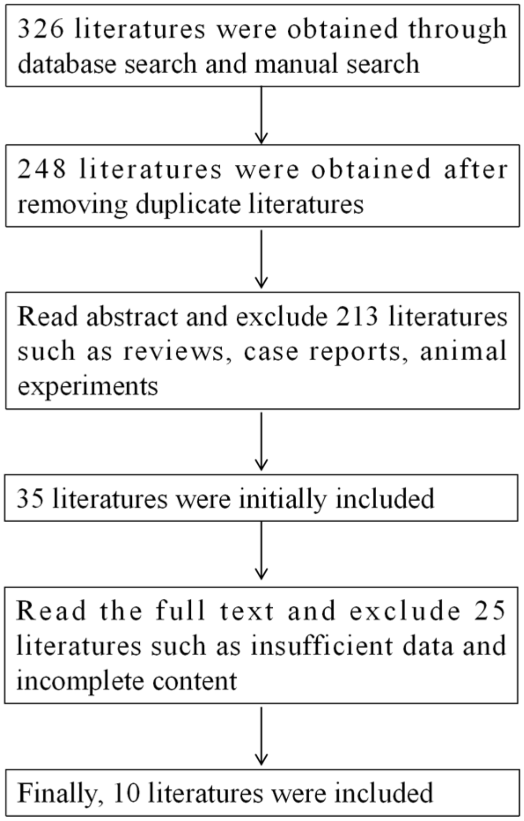


**Figure 1.** The procedure for sifting through the literature.

*P*=0.62), so a fixed-effects model was used. No significant difference was found in the complete occlusion rate when comparing the clip and coil groups [*OR*=1.76, 95% *CI* (0.78, 3.96), *P*=0.17] (**Figure 2**). TSA results showed that the accumulated Z value neither crossed the traditional threshold nor the TSA threshold, and the accumulated information did not reach the expected information, so there may be no statistical difference between the efficacy of the two groups (**Figure 3**).

(2) Short-term clinical prognosis: 9 studies [7, 9, 11-17] with a total of 2,251 patients reported short-term clinical prognosis, and the study data were statistically heterogeneous ($I^2$=67%, *P*=0.002), so we used random-effects model. No significant difference was found in the short-term clinical prognosis when comparing the clip and coil groups [*OR*=1.09, 95% *CI* (0.67, 1.80), *P*=0.72] (**Figure 4**).

We used itemized exclusion method to exclude studies one by one and found the study of Li et al. [7] was the source of the heterogeneity. After exclusion of their study, endovascular coiling for cerebral aneurysms demonstrated a better clinical near-term prognosis compared with cranial clamping [*OR*=1.55, 95% *CI* (1.05, 2.27), *P*=0.03] (**Figure 5**). The TSA results showed that the cumulative Z-value crossed the conventional boundary, as well as the TSA boundary and the required information size, indicating a positive conclusion that endovascular coiling treatment for brain aneurysms has a better clinical short-term prognosis (**Figure 6**).

(3) Postoperative residual or recurrence rate: 8 studies [9, 11-17], which included a total of 1,860 patients, showed statistical heterogeneity in the data ($I^2$=61%, *P*=0.01), so a random-effects model was used. Compared to microsurgical clipping, endovascular coiling increased the rate of postoperative residual or recurrence [*OR*=0.40, 95% *CI* (0.17, 0.91), *P*=0.03] (**Figure 7**).

We used itemized exclusion method to exclude studies one by one and found the study of Luo et al. [16] was the source of its heterogeneity. After exclusion of this study, the result did not change [*OR*=0.30, 95% *CI* (0.15, 0.59), *P*=0.0005] (**Figure 8**). The results of TSA showed that the cumulative Z-value crossed the conventional boundary, as well as the TSA boundary, indicating that the initial analysis suggests that endovascular coiling treatment increases the postoperative residual or recurrence rates (**Figure 9**).

(4) Postoperative rebleeding rate: 7 studies [9-11, 13, 15-17] with a total of 2,453 patients reported postoperative rebleeding rate, and the study data were not statistically heterogeneous ($I^2$=26%, *P*=0.23), so we used fixed-effects model. The postoperative rebleeding rate did not show a difference between the clip group and the coil group [*OR*=1.60, 95% *CI* (0.97, 2.63), *P*=0.07] (**Figure 10**). Further TSA results revealed that while the cumulative *Z*-curve crossed the traditional significance boundary, it did not cross the TSA-defined boundary (**Figure 11**).

(5) Incidence of postoperative ischemic stroke: 7 studies [7, 9, 11-14, 17], which included a total of 1,705 patients, reported incidence of

**Table 1.** Characteristics of studies

| Author | Year | Country | Coil group | | | Clip group | | | Outcome |
|---|---|---|---|---|---|---|---|---|---|
| | | | Age | Sample size | Gender (Male/female) | Age | Sample size | Gender (Male/Female) | |
| Li G et al. [7] | 2023 | China | 59.52±10.18 | 55 | 19/36 | 58.07±10.34 | 51 | 24/27 | ① ⑤ ⑥ |
| Chen C et al. [9] | 2023 | China | 56.9±10.5 | 405 | 137/268 | 58.4±10.3 | 362 | 115/247 | ① ③ ④ ⑤ |
| Qureshi AI et al. [10] | 2014 | America | 70.9±5.1 | 398 | 318/80 | 70.0±3.9 | 290 | 223/67 | ④ |
| Zhang L et al. [11] | 2019 | China | 54±11 | 225 | 98/127 | 55±10 | 257 | 114/143 | ① ③ ④ ⑤ |
| Song Z et al. [12] | 2018 | China | 58.3±9.3 | 20 | 9/11 | 57.5±8.9 | 25 | 10/15 | ② ③ ⑤ |
| Schwartz C et al. [13] | 2018 | Austria | 52 (25.0-71.0) | 38 | 11/27 | 54 (36.0-79.0) | 54 | 16/38 | ① ③ ④ ⑤ ⑥ |
| Ghorbani M et al. [14] | 2020 | Iran | 58 | 38 | 13/25 | 58.6 | 42 | 18/24 | ② ③ ⑤ |
| Darsaut TE et al. [15] | 2021 | Canada | NA | 81 | 23/57 | NA | 80 | 20/61 | ① ③ ④ |
| Luo J et al. [16] | 2022 | China | 48.93±8.91 | 65 | 9/46 | 48.89±8.45 | 65 | 8/47 | ③ ④ ⑥ |
| Dammann P et al. [17] | 2014 | Germany | 54 (27-78) | 16 | 6/10 | 53.7 (29-73) | 87 | 22/65 | ② ③ ④ ⑤ |

Note: ① Short-term clinical prognosis, ② Complete occlusion rate, ③ Postoperative residual or recurrence rate, ④ Postoperative rebleeding rate, ⑤ Incidence of postoperative ischemic stroke, ⑥ Incidence of postoperative cerebral vasospasm.

**Table 2.** Risk assessment of bias in NOS cohort studies

| Study | Selection | Comparability | Exposure/Outcome | Scores |
|---|---|---|---|---|
| Li G et al. [7] | ☆☆☆ | ☆☆ | ☆☆ | 7 |
| Chen C et al. [9] | ☆☆☆ | ☆ | ☆☆☆ | 7 |
| Qureshi AI et al. [10] | ☆☆ | ☆ | ☆☆ | 5 |
| Zhang L et al. [11] | ☆☆☆ | ☆ | ☆☆ | 5 |
| Song Z et al. [12] | ☆☆☆ | ☆☆ | ☆☆☆ | 8 |
| Schwartz C et al. [13] | ☆☆☆☆ | ☆ | ☆☆☆ | 8 |
| Ghorbani M et al. [14] | ☆☆☆ | ☆ | ☆☆☆ | 7 |
| Darsaut TE et al. [15] | ☆☆ | ☆ | ☆☆ | 5 |
| Luo J et al. [16] | ☆☆☆☆ | ☆ | ☆☆☆ | 8 |
| Dammann P et al. [17] | ☆☆☆☆ | ☆☆ | ☆☆ | 8 |

Note: NOS means the Newcastle-Ottawa Scale.

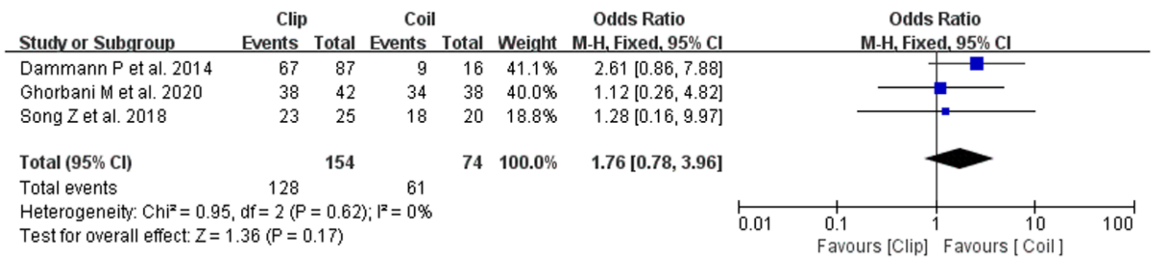


**Figure 2.** Forest chart of complete occlusion rate of cerebral aneurysm treated by endovascular coiling.

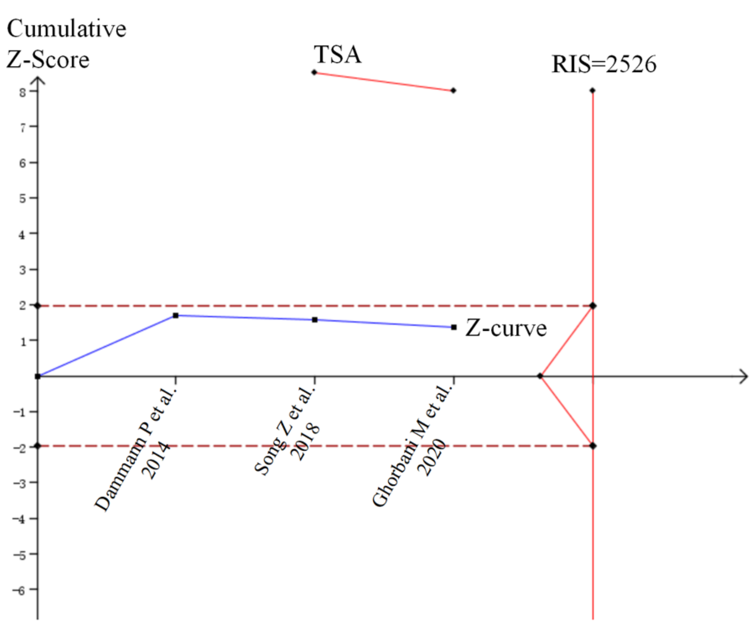


**Figure 3.** Trial Sequential Analysis (TSA) results (complete occlusion rate). Note: TSA means alpha-spending boundaries, RIS means Required Information Size.

postoperative ischemic stroke and showed statistical heterogeneity in the data ($I^2$=65%, *P*=0.009), so a random-effects model was used. The incidence of postoperative ischemic stroke did not show a difference when comparing the clip and coil groups [*OR*=1.12, 95% *CI* (0.45, 2.79), *P*=0.81] (**Figure 12**).

We used itemized exclusion method to exclude studies one by one and found that the study of Chen et al. [9] was the source of the heterogeneity. After exclusion of this study, the result did not change [*OR*=0.79, 95% *CI* (0.40, 1.56), *P*=0.50] (**Figure 13**). The TSA analysis results showed that the cumulative Z-curve did not cross the conventional boundary or the TSA boundary, and the cumulative information size did not reach the required information size. Therefore, the difference in the incidence of ischemic stroke between the

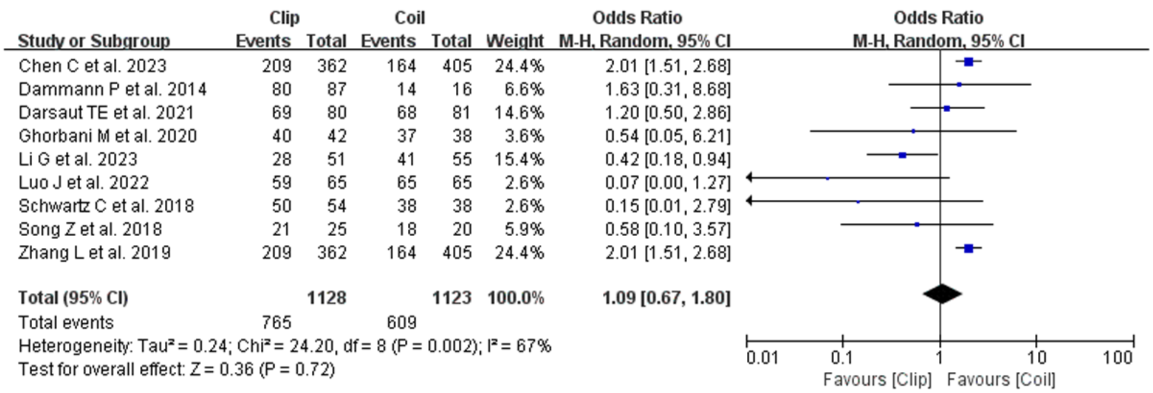


**Figure 4.** Forest map of short-term clinical prognosis of cerebral aneurysm treated with endovascular coiling.

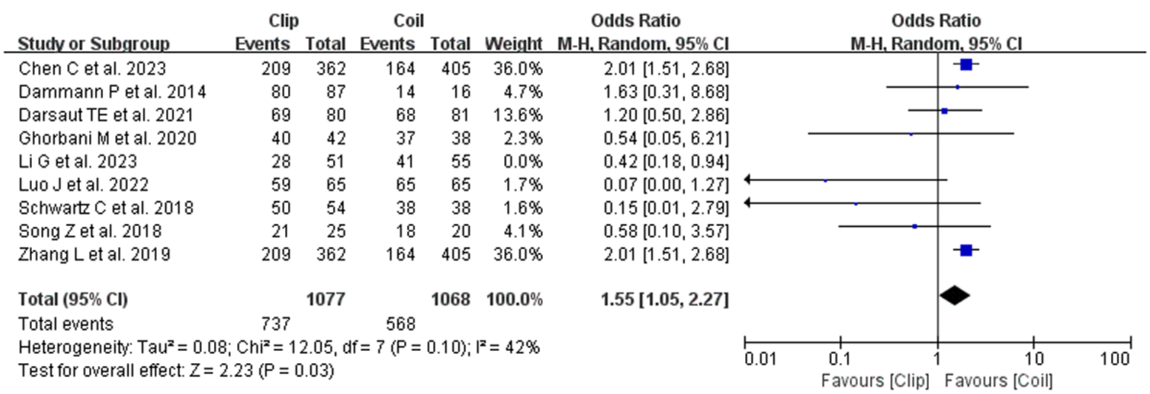


**Figure 5.** Forest map of short-term clinical prognosis of cerebral aneurysms treated with endovascular coiling (excluding heterogeneity).

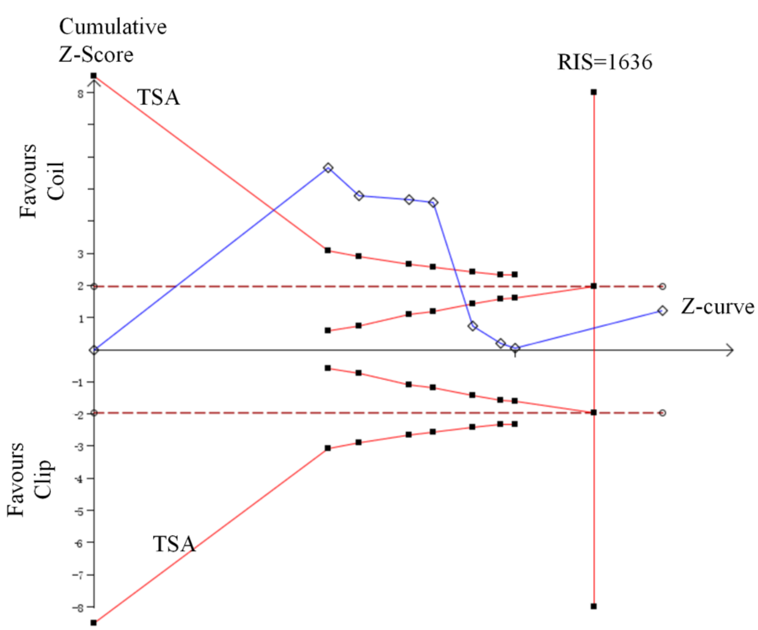


**Figure 6.** TSA results (short-term clinical prognosis).

two groups may not be statistically significant, and further trials are needed to confirm this (**Figure 14**).

(6) Incidence of postoperative cerebral vasospasm: 3 studies [7, 13, 16] involving a total of 328 patients were included in the analysis. There was statistical heterogeneity in the study data ($I^2$=68%, $P$=0.04), so we used random-effects model. The incidence of postoperative cerebral vasospasm did not show a difference when comparing the clip and coil groups [*OR*=0.90, 95% *CI* (0.13, 6.03), *P*=0.91] (**Figure 15**).

Using a sequential exclusion method to exclude studies one

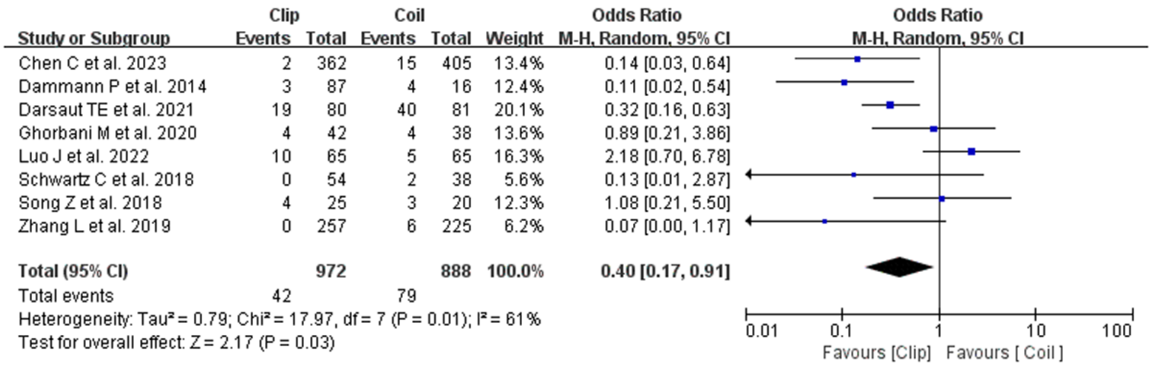


**Figure 7.** Forest plot of residual or recurrence rates after endovascular coiling for cerebral aneurysm.

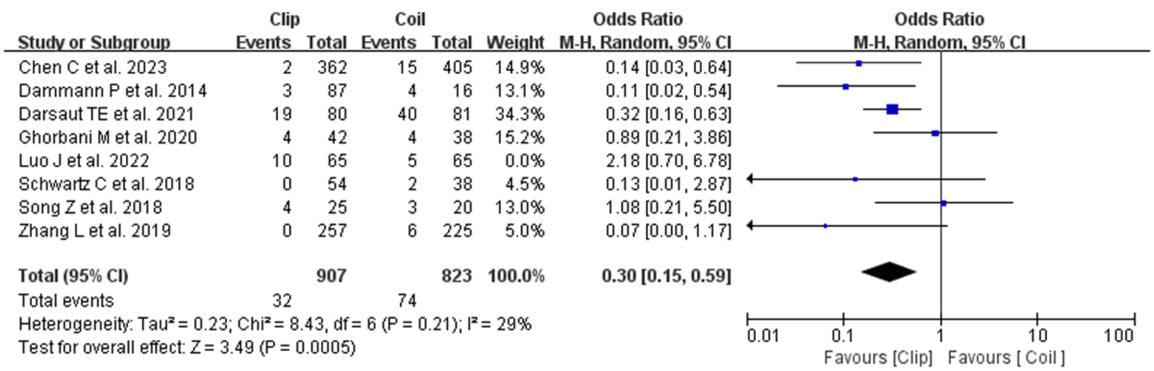


**Figure 8.** Forest plot of residual or recurrence rates after endovascular coiling for cerebral aneurysm (excluding heterogeneity).

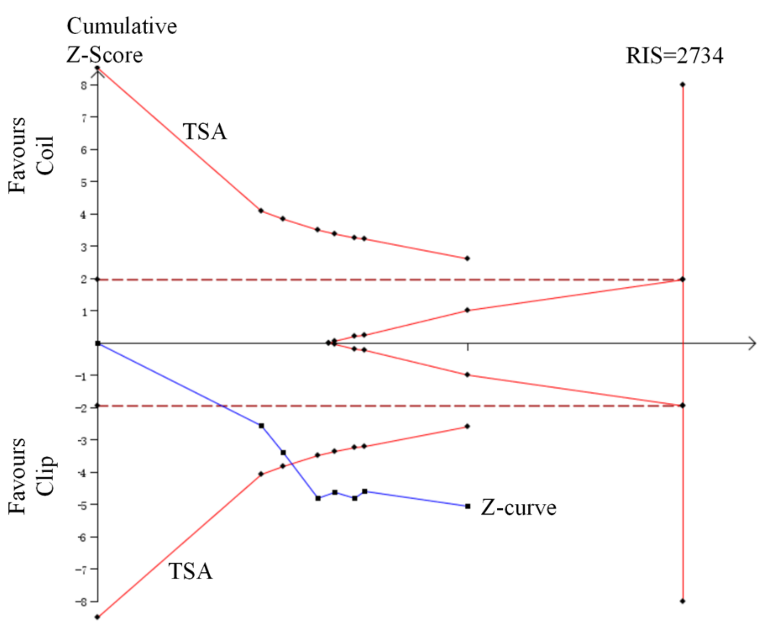


**Figure 9.** TSA results (postoperative residual or recurrence rate).

by one, it was found that the study of Schwartz et al. [13] was the source of heterogeneity. After excluding this study, the direction of the meta-analysis results remained unchanged [*OR*=1.92, 95% *CI* (0.67, 5.50), *P*=0.22]. The TSA analysis results showed that the cumulative Z-curve did not cross the conventional boundary or the TSA boundary, and the cumulative information size did not reach the required information size. Therefore, the difference in the incidence of postoperative cerebral vasospasm between the two groups may not be statistically significant, and more trials are needed to confirm this (**Figure 16**).

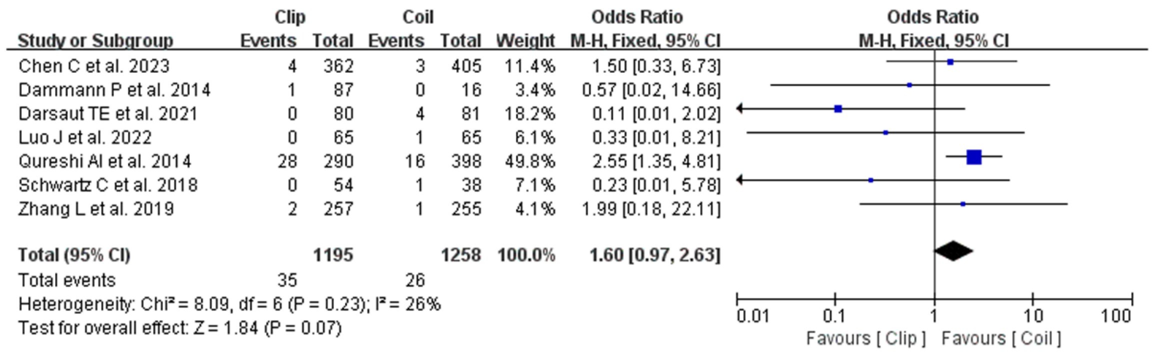


**Figure 10.** Forest chart of rebleeding rate after endovascular coiling for cerebral aneurysm.

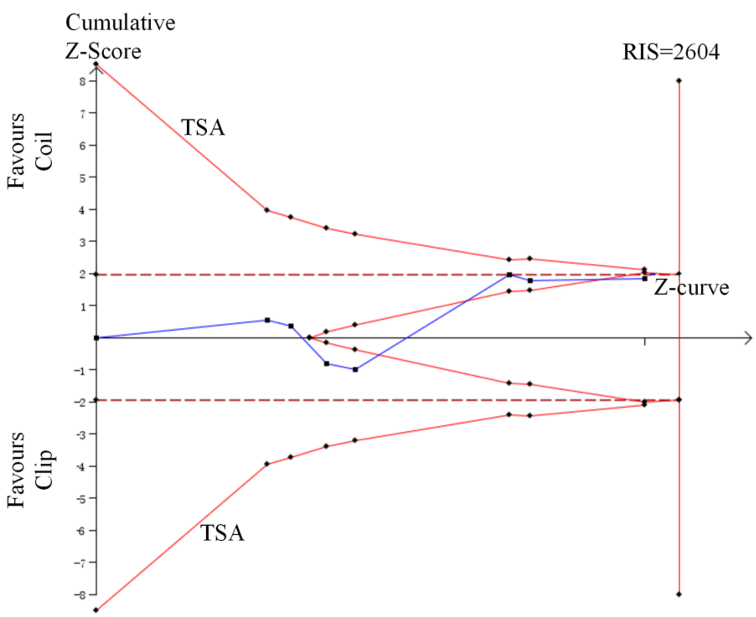


**Figure 11.** TSA results (postoperative rebleeding rate).

*Funnel plot*

A funnel plot was depicted based on the recent clinical prognosis (**Figure 17**). The literature scatter is distributed to the left and right of the null line, but the left and right sides are obviously asymmetric, with some publication bias. However, the results of Begg's test $P$=0.734 and Egger's test $P$=0.633 suggest no significant publication bias. This may be related to the limited quality, small sample size, and the heterogeneity of some studies.

**Discussion**

The global prevalence of IA in adults (average age 50) is approximately 3.2% [18]. Follow-up data from 312 patients (864 aneurysms) by van der Kamp et al. [19] showed an IA rupture rate of 7.6%, of which 2.9%, 4.3% and 6.0% were found at 6 months, 1 year and 2 years, respectively. Although the risk of IA rupture is relatively low, the overall mortality rate once ruptured ranges from 25% to 50%, and another 50% of survivors exhibit varying degrees of neurologic functional impairment and disability [20]. Currently, with the rise of minimally invasive surgery, endovascular coiling has become increasingly popular due to its minimal invasiveness and relatively low risk of complications. Despite the advocacy for interventional treatment due to its minimal invasiveness and rapid recovery [5, 6], whether it can completely replace traditional craniotomy surgery is still a matter of debate.

Our study shows that the two treatment methods have similar effects in achieving vascular occlusion. This is consistent with the findings reported by Ruan et al. [21]. This suggests that from a technical perspective, both occluding the aneurysm directly through surgical intervention and using endovascular coiling to block the aneurysm from within the blood vessel, can effectively halt blood flow within the aneurysm and reduce the risk of rupture. With advancements in medical technology, the materials and techniques used in endovascular embolization procedures (such as coils, flow-diverting devic-

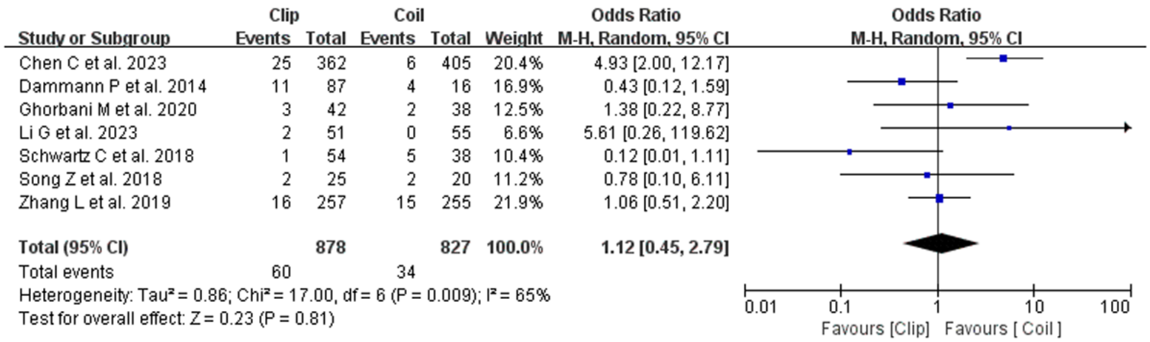


**Figure 12.** Forest chart of incidence of ischemic stroke after cerebral aneurysm treated by endovascular coiling.

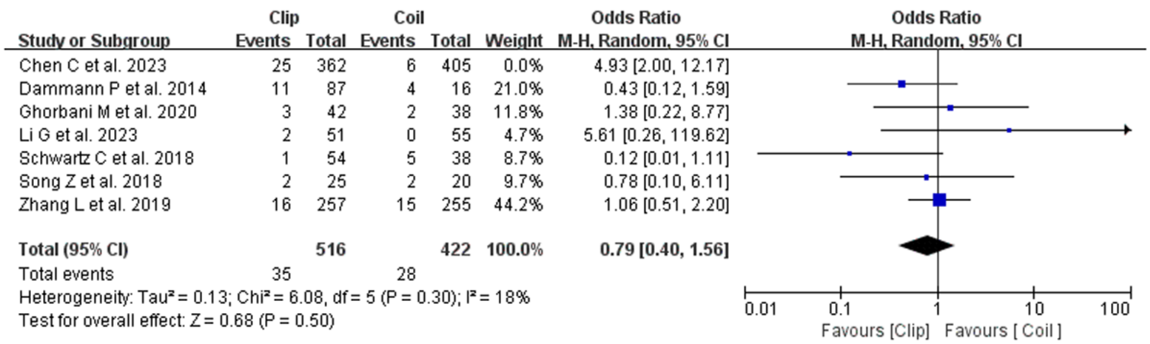


**Figure 13.** Forest chart of incidence of ischemic stroke after cerebral aneurysm treated by endovascular coiling (excluding heterogeneity).

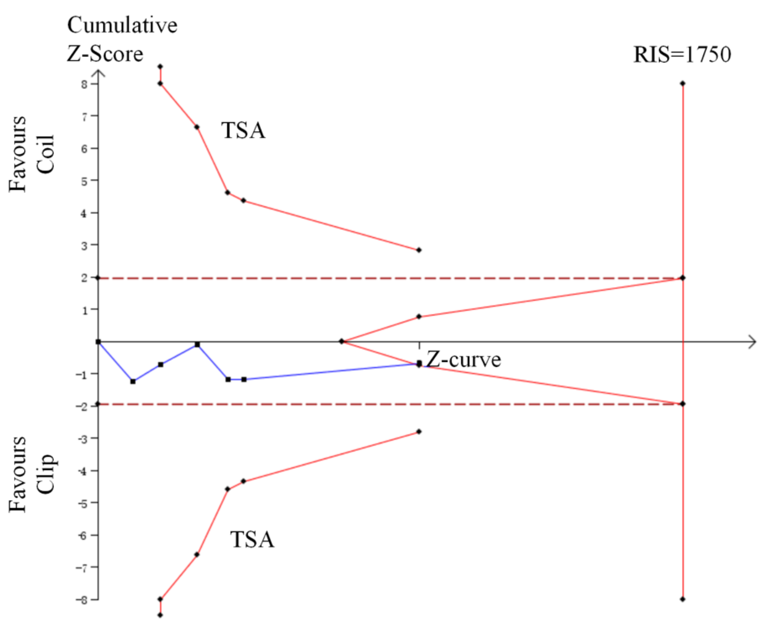


**Figure 14.** TSA results (incidence of postoperative ischemic stroke).

es, 3D rotational angiography, and stent assistance) have significantly improved. Even complex aneurysms can be more reliably and durably treated through endovascular coiling. Doctors can select the most suitable embolization materials and strategies based on the specific characteristics of the aneurysm (such as size, shape, and location) to achieve occlusion effects similar to open surgery. In a meta-analysis, although endovascular treatment has been continuously improving in terms of efficacy and safety, microsurgical clipping has a higher rate of complete occlusion (97.9% vs. 94.2%) [22]. Another retrospective study also supports that microsurgical clipping has a higher rate of complete occlusion (89.2% vs. 75.9%) [23]. Therefore, further research is needed to validate the complete occlusion rates.

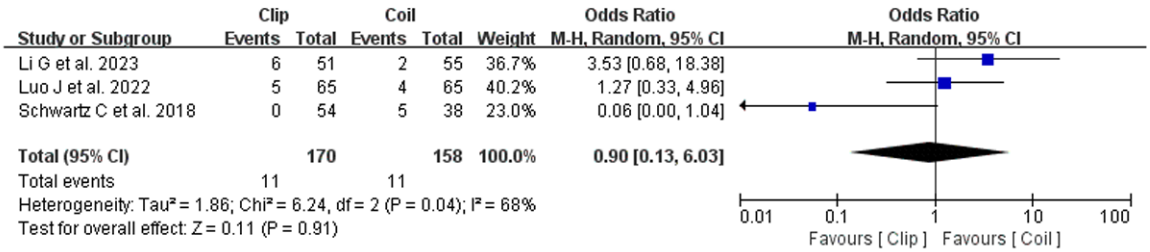


**Figure 15.** Forest map of incidence of cerebral vasospasm after endovascular coiling for cerebral aneurysm.

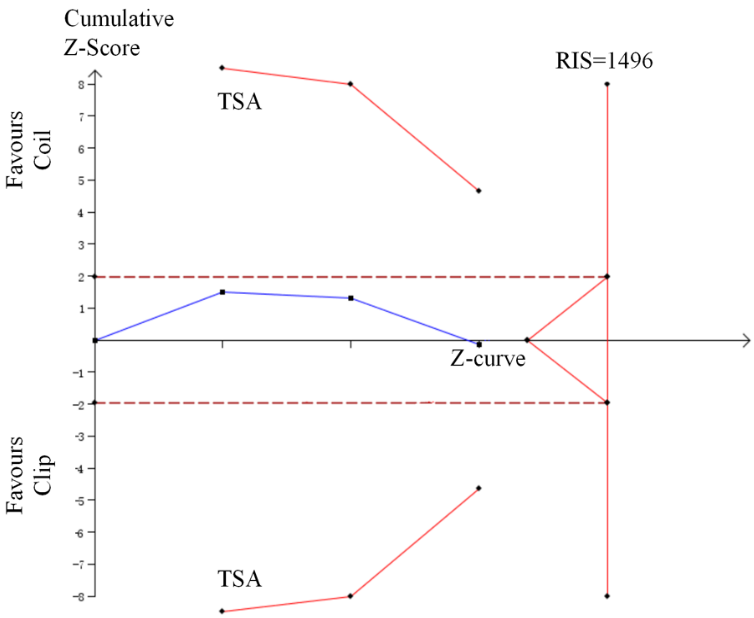


**Figure 16.** TSA results (Incidence of postoperative cerebral vasospasm).

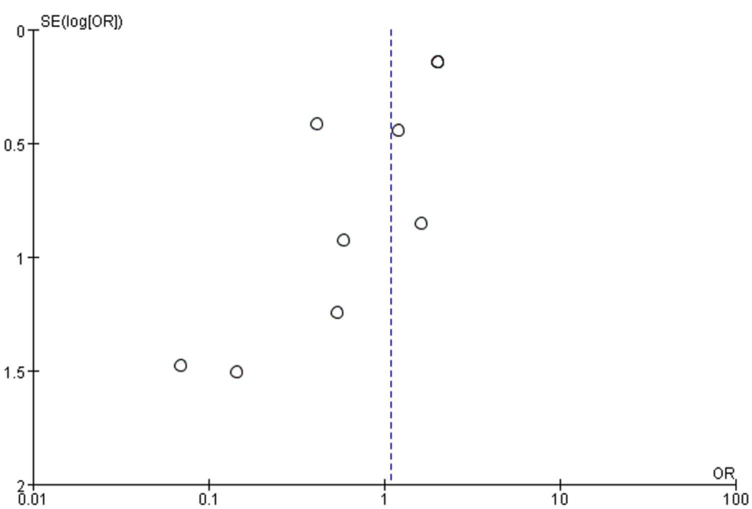


**Figure 17.** Funnel chart of clinical short-term prognosis.

Our study also revealed that endovascular coiling had a better short-term clinical outcome, but increased rate of residual issue or recurrence after surgery. This supports the results of another meta-analysis [24]. Interventional surgery, due to its minimally invasive nature, typically allows for a quicker recovery and better short-term outcomes for patients. However, over time, endovascular coiling may lead to a higher risk of aneurysm reperfusion, recurrence, or rebleeding due to technical limitations. Studies have reported that the recurrence rate after coiling for unruptured IA could be as high as 28.8% [25]. This higher recurrence rate may increase the risk of long-term adverse outcomes for patients. In contrast, although craniotomy surgery is a more invasive procedure requiring a longer recovery period, patients' neurologic function tends to improve over time, and the risk of long-term adverse outcomes gradually decreases. Additionally, there are clinical cases where endovascular coiling fails and craniotomy clipping is performed for IA [26]. Study of Krag et al. [27] found that the rate of retreatment for unruptured IA was higher in patients who underwent endovascular coiling alone compared to those who had microsurgical clipping (*IRR*=1.70, 95% *CI*: 1.50-1.93). Endovascular coiling involves placing coils into the aneurysm sac, which induces thrombus formation to fill and seal the aneurysm. However, the thrombus induced by the coils may sometimes naturally dissolve, leading to a higher risk of aneurysm reperfusion or recurrence after treatment [11]. In this study, we evaluated the postoperative residual or recurrence rates of brain aneurysms treated with endovascular coiling or surgical clipping through TSA. The results of TSA showed that the cumulative Z-curve crossed the significance boundary before reaching the predetermined information size, suggesting that endovascular coiling treatment increases the postoperative residual or recurrence rates. However, these results should be interpreted with caution. The finding of heterogeneity suggests that there may be important clinical or methodological differences between different studies. Additionally, our sample size is small and did not reach the required information size, so this conclusion may not be robust. Future studies should consider conducting larger-scale multicenter trials and using standardized outcome measurement methods to enhance the universality and comparability of results.

In addition, the rate of postoperative rebleeding is slightly higher in microsurgical clipping, although this rise did not show statistical significance. Further TSA results revealed that the meta-analysis may have yielded a false-positive conclusion. In other words, to confirm the therapeutic effect, more trial data are needed to support this conclusion. Therefore, the current evidence is insufficient to prove the significance of the treatment effect, and future research should continue to accumulate data for a more accurate assessment of efficacy. The incidence of complications (ischemic stroke and cerebral vasospasm) did not show a difference. The slightly higher risk of postoperative rebleeding in microsurgical clipping may be due to the complexity of the surgical procedure or the challenging anatomical location. The lack of significant differences in the incidence of ischemic stroke and cerebral vasospasm between the two treatment methods may indicate that these complications are not strongly related to the choice of treatment method, or they may be influenced by patient's baseline health condition, surgical techniques, postoperative management, etc.

While the meta-analysis of endovascular embolization for the treatment of IA provides valuable insights, there are several limitations within the study that may challenge the interpretation of the results. Firstly, the included studies were primarily retrospective, which means they may be subject to a higher risk of bias, potentially affecting the accuracy of the outcomes. Secondly, the variability between studies due to differences in the operators' skills, nursing care protocols, and methods of internal fixation could impact the results. Additionally, the use of different scoring systems, such as the Modified Rankin Scale and the Glasgow Outcome Scale, to assess patients' short-term outcomes may lead to inconsistent evaluation standards. Lastly, the meta-analysis may be affected by publication bias, where studies with negative results may not have been included in the analysis. Therefore, we should approach the conclusions of these studies with caution.

In summary, endovascular coiling for cerebral aneurysms has the advantages of minimal invasiveness and rapid recovery, and is ideal in achieving complete occlusion and improving the immediate clinical prognosis. However, endovascular coiling also has some risks, among which postoperative aneurysm remnants or recurrence is a major problem. Due to the diversity and complexity of aneurysms, as well as considerations of individual patient differences, the choice of therapeutic options still needs to be considered on a case-by-case basis.

### Disclosure of conflict of interest

None.

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