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Endovascular Treatment and Microsurgical Clipping for the Management of Paraclinoid Intracranial Aneurysms: A Systematic Review and Meta-Analysis

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■ OBJECTIVE: **We aimed to compare the efficacy and safety of microsurgical clipping versus endovascular treatment (EVT) for paraclinoid aneurysms.**

■ METHODS: **A systematic search for studies including patients with paraclinoid aneurysms treated with a microsurgical or endovascular technique was conducted in 6 databases from inception to February 2022. Efficacy outcomes included complete angiographic occlusion at last follow-up, favorable functional outcome, and recurrence of the aneurysm. For safety, we assessed a composite of intraoperative and postoperative complications. Data were pooled using a random-effects model.**

■ RESULTS: **A total of 95 studies including 6711 patients, 3029 in the surgical group and 3682 in the EVT group were found. Pooled rates of complete occlusion were 94% (95% CI 91%–96%; I^2 = 0%) in the surgical group and 69% (95% CI 63%–74%; I^2 = 79%) in the EVT group, respectively. The favorable functional outcome rate was 86% (95% CI 76%–92%; I^2 = 72%) with surgical treatment and 95% (95% CI 92%–97%; I^2 = 61%) with EVT. The rate of aneurysm recurrence with surgical treatment was 1% (95% CI 0%–4%; I^2 = 0%) and 12% (95% CI 9%–16%; I^2 = 57%) with EVT. The composite safety outcome rate in the surgical group was 24% (95% CI 18%–30%; I^2 = 90%) and 10% (95% CI 8%–13%; I^2 = 71%) in the EVT group.**

■ CONCLUSIONS: **Our findings suggest that microsurgical clipping seems to have a higher efficacy than EVT in terms of angiographic occlusion and aneurysm recurrence; however, EVT seems to be safer in terms of intraoperative and postoperative complications. Considering the heterogeneity and low-level evidence of the data available, further prospective randomized studies are warranted to confirm our findings.**

INTRODUCTION

Paraclinoid aneurysms comprehend all intradural aneurysms arising from the segment of the internal carotid artery (ICA) lying between the exit of the cavernous sinus and the origin of the posterior communicating artery and account for 5%–15% of all intracranial aneurysms.[1] Paraclinoid aneurysms are a challenging pathology in neurosurgery due to the complex local anatomy, proximity to the optic nerve, anatomical variations of the vascular structures, difficulty in achieving proximal control of the ICA, and safe aneurysm exposure.[1-5] Furthermore,

Key words:
- Aneurysm
- Clipping
- Endovascular
- Paraclinoid

Abbreviations and Acronyms
CI: Confidence intervals
EVT: Endovascular treatment
FD: Flow diversion
ICA: Internal carotid artery
SAC: Stent-assisted coiling
TE: Thromboembolic

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paraclinoid aneurysms are associated with a potential risk of subarachnoid hemorrhage.[6] Nonetheless, an optimal treatment modality has yet to be completely defined.

In recent years, traditional clipping is becoming a less popular option for paraclinoid aneurysms, given the recent advances in endovascular treatment (EVT). Recent studies have shown that EVT has a safe and effective profile with shorter procedural duration, lower retreatment rates, excellent vascular accessibility, and steady development and evolution of current and novel technologies.[2,3,5,7,8] However, well-established microsurgical techniques are still considered for specific cases given their favorable clinical outcomes and acceptable risk profile.[2,3] Nevertheless, both approaches have potential risks and benefits that should be evaluated before the selection of the treatment plan. The risk for visual complications is considerable due to the anatomical complexity of these aneurysms.[9,10] According to a recent meta-analysis, visual worsening is higher following microsurgical interventions (10.8%) than EVT (2.0%).[10] Additionally, the overall rate of permanent morbidity with primary coiling is up to 8%, and 4%–7% of patients experience thromboembolic (TE) complications.[2] Nonetheless, EVT is associated with a higher rate of recurrence than surgical treatment.[2,3,8] Of significance, as the literature comparing microsurgical clipping with EVT is limited, the profile of the best treatment modality for paraclinoid aneurysms has not yet been established.

In order to determine the profile of these 2 treatment modalities, it is important to establish the complete occlusion rates, clinical outcomes as well as procedure-related complications of EVT and microsurgical clipping for paraclinoid aneurysms. Hence, we aimed to compare the efficacy and safety of EVT versus microsurgical clipping for paraclinoid aneurysms.

METHODS

Protocol and Guidance

This systematic review used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement to report the search results.[11]

Search Strategy and Eligibility Criteria

A systematic search was carried out in 6 databases: Medline, Scopus, Embase, Cochrane, Web of Science, and Scielo until February 03, 2022. We adapted the search algorithms to the requirements of each database and keywords such as "Aneurysm*" or "clinoidectomy." The final search strategy is available as **Supplementary Table 1**.

Articles were included in the analysis if they met the following criteria: 1) used a randomized (randomized controlled trial) or nonrandomized design (open-label trials, real-world or cohort observational studies, and case series) documenting angiographic outcomes; 2) included at least 10 cases of patients with ruptured or unruptured paraclinoid aneurysms undergoing treatment with a microsurgical or endovascular technique; and 3) was written in Spanish, Portuguese, Chinese, or English. Our definition of paraclinoid aneurysms included aneurysms arising in the clinoidal segment (C5) (anterolateral and medial variant) and the ophthalmic segment (C6) (ophthalmic artery, superior hypophyseal artery, and dorsal variant) of the ICA.[12,13] We excluded case reports, abstracts, posters, review articles, and studies in nonhumans.

Study Selection

The search strategy was applied individually to each database. Three reviewers (F.T., N.B., S.C.) independently screened all studies by titles and abstracts to identify potentially relevant articles. Finally, the same reviewers accessed the full-text versions and determined their eligibility. Any disagreements were resolved through an initial discussion among the 3 reviewers. A fourth reviewer (A.R.C.) was considered as arbitrator if no consensus was reached.

Data Collection Process

Three authors (F.T., N.B., S.C.) independently extracted the following data from each included article using a standardized form in a Microsoft Excel 2016 sheet. This form contains: author, year, study design, country, number of participants, number of aneurysms, aneurysm location, aneurysm morphology, intervention (surgery or EVT), and the prioritized outcomes. When studies with the same population were identified, only the most recent or complete publication was included. In case of disagreements, the final decision was made by a fourth researcher (A.R.C.).

Outcomes and Prioritization

The primary efficacy outcome was the proportion of complete angiographic occlusion at the last follow-up, defined as a Raymond-Roy scale of 1 in the EVT group and as angiographic complete exclusion of the aneurysms in the surgical group. The Raymond-Roy scale grades the angiographic occlusion as class I (complete obliteration), class II (residual neck), and class III (residual aneurysm).[14] Secondary efficacy outcomes included the modified Rankin Scale at the last follow-up (a favorable outcome was defined as modified Rankin Scale 0–2) and aneurysm recurrence.

The primary safety outcome was a composite of intraoperative and postoperative complications. Intraoperative complications included TE events (thrombus formation, complete vessel occlusion), hemorrhagic events, device deployment issues, and air embolism. Postoperative complications included ischemic and hemorrhagic events. Our secondary safety outcomes were visual outcome, defined in patients with or without a preoperative visual impairment concern based on perimetry assessment at the last follow-up visit and all-cause mortality.

Risk of Bias of Individual Studies

To assess the methodological quality of the studies included we used the risk of bias in nonrandomized studies of interventions for nonrandomized studies.[15] We used the classification of low, moderate, serious, and critical risk of bias for non-randomized studies of interventions following the instructions given in the Cochrane handbook for systematic reviews of interventions.[16]

Data Synthesis

A random-effects meta-analysis of proportions was performed using a generalized linear mixed-model to estimate pooled rates and 95% confidence intervals (CIs) for each prioritized outcome. Statistical heterogeneity across studies was assessed with the I^2

test (>50% suggests significant heterogeneity), while heterogeneity between subgroups was assessed with the Cochran Q test for heterogeneity. We planned further pre-specified sensitivity analyses for the endovascular techniques, including primary coiling, flow diversion (FD), and stent-assisted coiling (SAC). These analyses will also be stratified by the anatomical location of the aneurysm, whenever the data is available. In addition, we performed a sensitivity analysis restricted to all the EVT studies published after 2011 because this was the year where the first FD device was approved by the Food and Drug Administration.[17] The rationale of this was to validate our results focusing on the evolution of the EVT techniques for the aneurysms located in this region. Analyses and plots were generated using R statistical software (version 4, 1.3) and R Studio.

Meta-Biases

If more than 10 studies were available for each outcome, we assessed publication bias with the Egger's test.[18]

RESULTS

Study Selection

A flow diagram describing our literature search process is provided in **Supplementary Figure 1**. A total of 7007 articles were identified through the search strategy. After removing duplicates, we evaluated 4720 by title and abstract and 170 were included in the full-text phase. Finally, we included 95 clinical studies in the quantitative synthesis.

Study Characteristics

The main characteristics of the included studies are presented in **Table 1**. Our analysis included 6711 patients with a mean age of 52.6 years, predominance of female sex (63.4%) and a mean clinical follow-up of 23.7 months. Almost all studies were case series (81 retrospective; 2 prospective; 5 retrospective—prospective cases database) and there was 1 post hoc study of a non-randomized clinical trial. A total of 89 studies with 6703 aneurysms were included, with a mean follow-up imaging time of 22.2 months. Almost 18% of the total aneurysms were ruptured. Related to morphology, the mean maximum size, height, width, and neck were 10.2 mm, 7.7 mm, 6.9 mm, and 5.1 mm, respectively. Eighty-seven (97.7%) studies provided data on aneurysm location. Of the total of aneurysms, 294 (4.3%) were in the clinoidal segment of the ICA or C5; 1403 (20.9%) were in the ophthalmic segment of ICA; 156 (2.3%) were in the superior hypophyseal artery; and 456 (6.8%) were in the ophthalmic artery. We included 2445 aneurysms (36.5%) treated with surgery and

Table 1. Study Characteristics According to the Aneurysm Treatment Approach

	Total	Endovascular Treatment	Surgery
No. of studies	89	50	48
No. of patients	6711	3682	3029
No. of aneurysms	6703	3874	2829
Female, n (%)	4257	2561 (60.2)	1696 (39.8)
Mean age ± SD, years	52.6 ± 11.7	54 ± 12.1	51.3 ± 11.2
Ruptured aneurysms, n (%)	1186	651 (54.9)	535 (45.1)
Aneurysm location, n (%)			
Clinoidal segment of the ICA or C5	294	167 (56.8)	127 (43.2)
Ophthalmic segment of the ICA or C6	1403	720 (51.3)	683 (48.7)
Superior hypophyseal artery	156	56 (35.9)	100 (64.1)
Ophthalmic artery	456	230 (50.4)	226 (49.6)
Morphology, mean ± SD (mm)			
Maximum size	10.2 ± 4.4	10.2 ± 3.9	10.3 ± 5.0
Height	7.7 ± 3.7	6.9 ± 3.2	9.4 ± 4.4
Width	6.9 ± 2.8	7.2 ± 3.0	6.0 ± 2.0
Neck	5.1 ± 2.0	5.1 ± 2.0	-
Dome-to-neck ratio	6.9 ± 2.4	6.9 ± 2.6	0 ± 1.6
Aspect ratio	1.5 ± 0.7	1.5 ± 0.7	-
Follow-up, mean ± SD (months)			
Clinical	23.7 ± 16.1	22.2 ± 18.4	24.9 ± 2.2
Imaging	22.2 ± 17.1	18.9 ± 15.1	30.6 ± 23.3

ICA, internal carotid artery; SD, standard deviation.

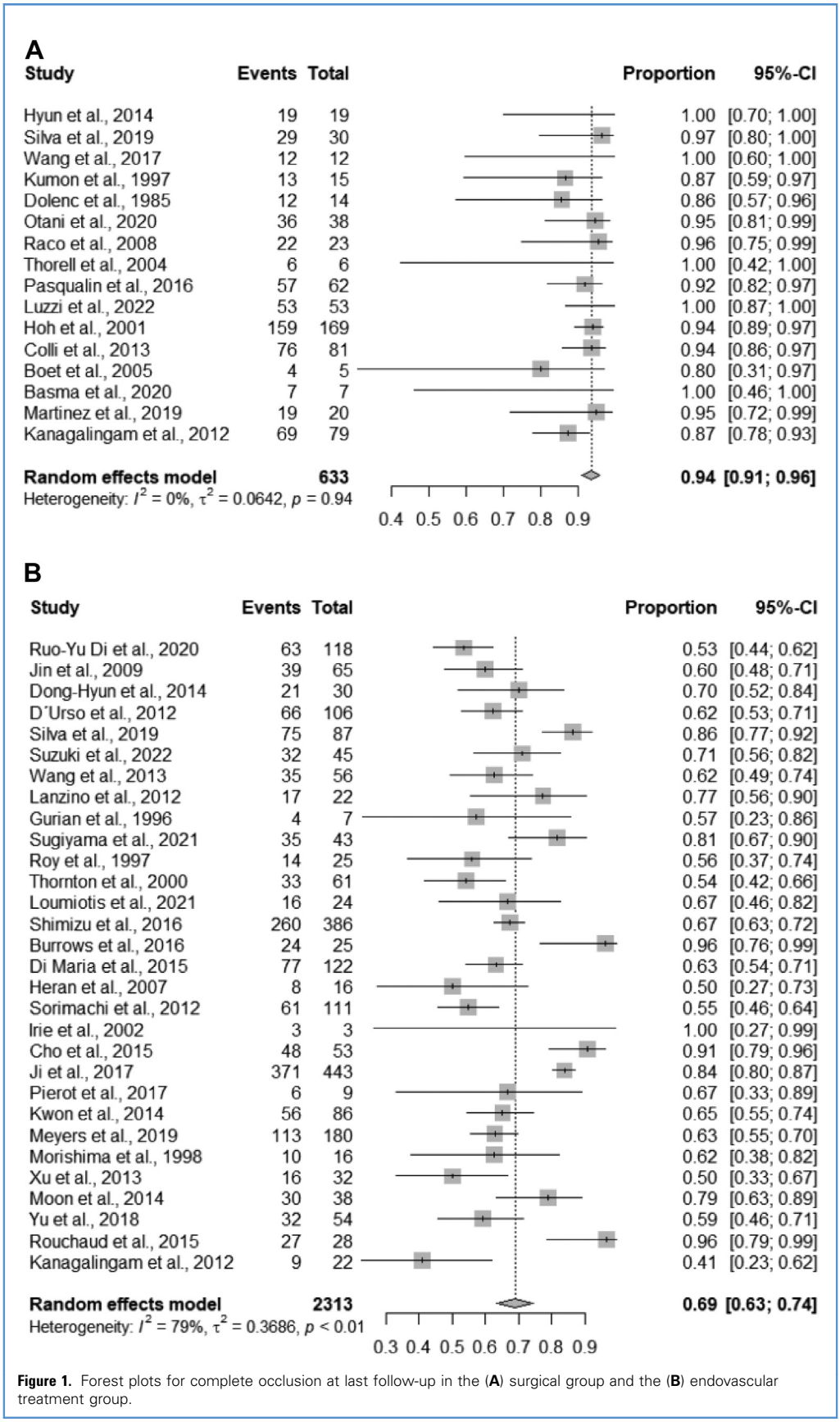


Figure 1. Forest plots for complete occlusion at last follow-up in the (**A**) surgical group and the (**B**) endovascular treatment group.

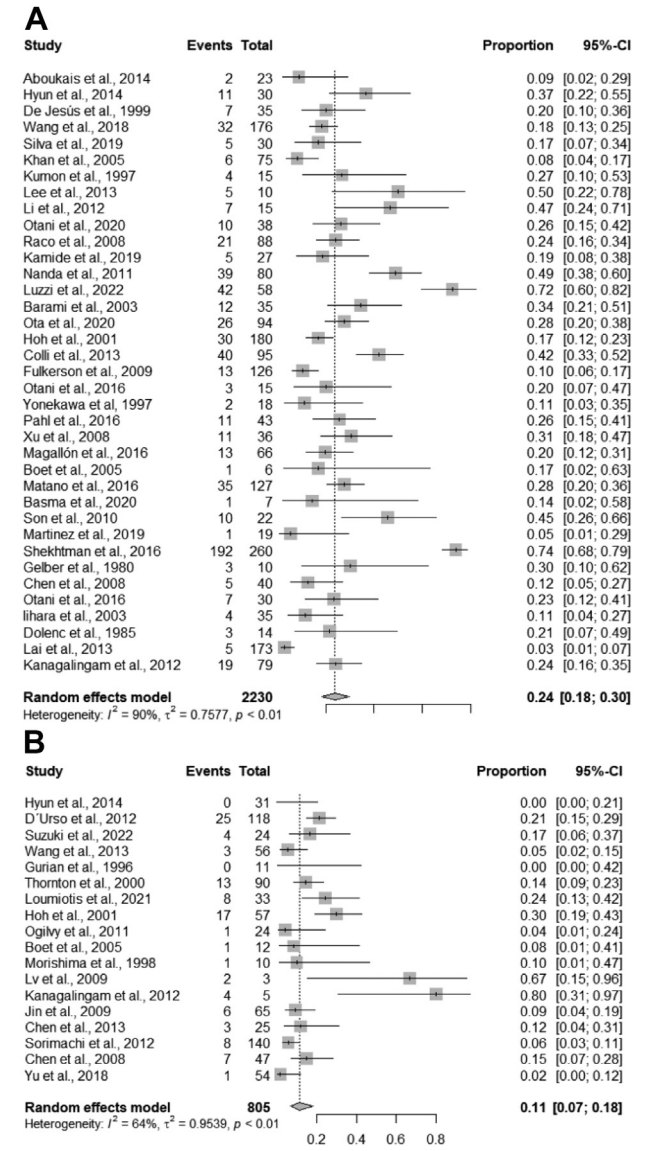


Figure 2. Forest plots for the composite safety outcome the (**A**) surgical group and the (**B**) endovascular treatment group.

3382 (50.5%) treated with EVT. Additional details about the included studies are presented in Supplementary Table 2.

Risk of Bias Among Studies

The overall risk of bias among the studies was serious in 49%, moderate in 26% and critical in 25% (Supplementary Figure 2). According to study design, most studies were retrospective, single center, and single arm (63%). In relation to the components of the risk of bias assessment instrument, 42% of the studies had serious bias due to confounding bias; 57% had moderate risk of bias in the selection of participants; 72% had moderate risk of bias in the classification of the interventions; 62% had low risk of bias in deviation from intended interventions; 75% had low risk of bias due to missing data; 100% had moderate risk of bias in outcome measurement; and 56% had low risk of bias in selection of the reported outcome.

The Eggers' test was suggestive of publication bias for favorable functional outcome, and intraoperative and postoperative complications in the EVT group (Supplementary Table 3).

Synthesis of Results

Efficacy. Overall, the pooled rate of complete occlusion at the last follow-up was 94% (95% CI 91%–96%; I^2 = 0%) in the surgical group and 69% (95% CI 63%–74%; I^2 = 79%) in the EVT group (Figure 1A and B, respectively). The favorable functional outcome rate at last follow-up was 86% (95% CI 76%–92%; I^2 = 72%) with surgical treatment and 95% (95% CI 92%–97%; I^2 = 61%) with EVT. The rate of aneurysm recurrence with surgical treatment was 1% (95% CI 0%–4%; I^2 = 0%) and 12% (95% CI 9%–16%; I^2 = 57%) with EVT.

Safety. The composite safety outcome rate in the surgical group was 24% (95% CI 18%–30%; I^2 = 90%), whereas in the EVT it was 10% (95% CI 8%–13%; I^2 = 71%) (Figure 2A and B). The pooled rate of intraoperative complications was 9% (95% CI 6%–14%; I^2 = 68%) with surgical treatment and 6% (95% CI 4%–8%; I^2 = 58%) with EVT. The rate of postoperative complications with surgical treatment was 21% (95% CI 17%–26%; I^2 = 86%) and 8% (95% CI 6%–11%; I^2 = 69%) with EVT.

Table 2 reports the visual outcomes of paraclinoid aneurysms according to preoperative visual impairment. In patients treated with EVT with preoperative visual impairment, the visual field test improved, was unchanged, or worsened in 17% (95% CI 4%–49%; I^2 = 79%), 13% (95% CI 5%–29%; I^2 = 75%), and 12% (95% CI 5–25%; I^2 = 45%) of cases, respectively. In patients treated with EVT, 6% (95% CI 3%–14%; I^2 = 82%) of patients with normal vision preoperatively presented de novo visual impairment. In patients with preoperative visual impairment in the surgical group, the visual field test improved, was unchanged, or worsened in 29% (95% CI 15%–50%; I^2 = 79%), 31% (95% CI 19%–45%; I^2 = 70%), and 12% (95% CI 7%–20%; I^2 = 50%) of cases, respectively. In patients treated with surgery, 14% (95% CI 9%–20%; I^2 = 71%) with normal preoperative vision presented de novo visual impairment. Finally, mortality rates were 4% (95% CI 3%–7%; I^2 = 57%) and 1% (95% CI 0–3%; I^2 = 0%) with surgical treatment and EVT, respectively.

Additional Analyses

The sensitivity analyses in the EVT group are shown in Table 3. Complete occlusion rates were 54%, 77%, and 52% for the primary coiling, FD, and SAC subgroups, respectively and the composite safety outcome rates were 6%, 11%, and 6%, respectively.

The analysis by aneurysm location is shown in Supplementary Table 4. For aneurysms in the ophthalmic segment (C6) of the ICA, complete occlusion rates were 86% (95% CI 82%–89%; I^2 = 0%) in the surgical group and 65% (95% CI 54%–76%; I^2 = 52%) in the EVT group. Among these aneurysms, complete

Table 2. Pooled Analysis for Visual Outcomes by Treatment Approach

Visual Outcome	Approach	No of Studies	No of Participants	Pooled Rates (95% CI)	I^2
Improved					
	EVT	5	229	17% (4%—49%)	79%
	Surgery	10	228	29% (15%—50%)	79%
Unchanged					
	EVT	7	346	13% (5%—29%)	75%
	Surgery	9	186	31% (19%—45%)	70%
Worsened					
	EVT	5	113	12% (5%—25%)	45%
	Surgery	11	271	12% (7%—20%)	50%
De novo					
	EVT	11	762	6% (3%—14%)	82%
	Surgery	15	1058	14% (9%—20%)	71%

CI, confidence interval; FD, flow diversion; SAC, stent-assisted coiling.

Table 3. Sensitivity Analyses by Endovascular Technique

Outcome	Subgroup	No of Studies	No of Participants	Pooled Rates (95% CI)	I^2
Complete occlusion at last follow-up	Primary coiling	18	759	54% (48%—59%)	50%
	FD	8	549	77% (54%—91%)	91%
	SAC	8	350	52% (39%—64%)	73%
Favorable functional outcome at last follow-up	Primary coiling	13	488	91% (80%—96%)	73%
	FD	3	276	72% (7%—99%)	98%
	SAC	5	303	97% (87%—99%)	77%
Recurrence	Primary coiling	8	362	32% (21%—46%)	85%
	FD	-	-	-	-
	SAC	5	314	6% (6%—13%)	64%
Safety composite	Primary coiling	14	636	6% (3%—11%)	63%
	FD	7	435	11% (7%—17%)	38%
	SAC	8	372	6% (2%—12%)	57%
Intraoperative complications	Primary coiling	12	655	7% (4%—14%)	63%
	FD	4	341	3% (1%—14%)	0%
	SAC	5	214	2% (0%—14%)	0%
Postoperative complications	Primary coiling	12	471	8% (4%—14%)	53%
	FD	6	413	8% (4%—15%)	73%
	SAC	6	241	6% (2%—17%)	32%
Mortality	Primary coiling	13	551	3% (1%—6%)	0%
	FD	3	299	3% (1%—9%)	39%
	SAC	5	210	0% (0%—46%)	0%

CI, confidence interval; EVT, endovascular treatment.

occlusion rates were 79%, 63%, and 53% for FD, SAC, and primary coiling, respectively.

Finally, the analysis restricted to EVT studies published after 2011 yielded a pooled rate of 71% (95% CI 65%–77%; $I^2 = 83\%$) for complete occlusion and 9% (95% CI 7%–12%; $I^2 = 72\%$) for the composite safety outcome. In addition, the analysis by EVT technique showed comparable pooled rates to the primary analysis (**Supplementary Table 5**).

DISCUSSION

This meta-analysis of paraclinoid aneurysms suggests that: 1) microsurgical clipping seems to have higher efficacy than EVT in terms of complete angiographic occlusion at last follow-up and aneurysm recurrence, although the rate of favorable functional outcomes was higher with EVT; 2) EVT seems to be safer than microsurgical clipping in terms of our composite of intraoperative and postoperative complications; 3) microsurgical clipping seems to achieve higher rates of visual field test improvement than EVT, although de novo visual field impairment was higher with microsurgical clipping; and 4) FD was the most efficient endovascular technique in terms of complete angiographic occlusion in comparison with primary coiling and SAC and the composite safety outcome was also higher with FD.

Treatment for paraclinoid aneurysms is recommended according to certain characteristics such as size, projection, presence of a bleb, visual loss, and rupture status.[19] Microsurgical clipping was the classical approach before the endovascular era.[3] Dissection of the cisterns, extra/intradural anterior clinoidectomy, opening of the optic nerve dura, distal dural ring, carotid oculomotor membrane and optic canal are key steps for aneurysm approaches and clipping techniques[10]; however, this implies mobilization of important neurovascular structures. Clip placement should be performed according to the projection and relationship of the aneurysm with the adjacent vascular branches.[20] Special consideration should be taken when using fenestrated clips to avoid kinking or inadvertently occluding side branches. On the other hand, EVT includes a wide range of technical options such as coiling, SAC, balloon-assisted coiling, and FD. Technical aspects that must be taken into account include the angle of the carotid siphon, the relationship between the ophthalmic artery and the aneurysm, the diameters of the parent vessel landing zones, and the collateral circulation between the ICA and the external carotid artery.[21,22] Currently, FD has shown better clinical and angiographic outcomes compared to other endovascular techniques at mid- and long-term follow-up.[23] On the other hand, large-volume coils have achieved high occlusion rates with good clinical outcomes in large paraclinoid aneurysms.[24]

We found a higher occlusion rate in the surgical compared to EVT cohort, which is consistent with several previous publications that reported long-term angiographic follow-ups. However, when flow diverters are used, occlusion rates are as high as 96% at 5-year angiographic follow-up for unruptured aneurysms.[23] These outcomes may be attributable to the FD effect and the withdrawal of dual antiplatelet therapy which may improve intrasaccular healing with clot formation. Better functional outcomes for EVT have been reported for both ruptured and unruptured aneurysms, similar to our results. The International Subarachnoid Aneurysm Trial[25] and The International Study of Unruptured Intracranial Aneurysms Investigators trial[26] reported better clinical outcomes and survival rates with EVT for ruptured and unruptured aneurysms, respectively. However, flow diverters were not evaluated in these 2 large studies. Indeed, primary coiling was mainly used for EVT, and a high rate of recurrence was reported. Recurrence is a drawback of EVT, especially for primary coiling and wide-neck aneurysms.[27,28] Nonetheless, SAC techniques and flow diverters have improved this limitation with acceptable recurrence rates, which are in accordance with our findings.[28,29]

We found a twofold rate of overall complications in the surgical (24%) compared to the EVT group (10%), which is high. In addition, intraoperative and postoperative complication rates were higher in the surgical cohort. Surgery involves the mobilization of neurovascular structures that may cause intraoperative ruptures of the sac, lesions to the optic apparatus, or thrombotic events. On the other hand, EVT of paraclinoid aneurysms using flow diverters has shown a favorable safety profile with a morbidity rate of 3.1%, including TE and hemorrhagic complications, according to a recent publication.[30]

Regarding visual outcomes, in cases without preoperative impairment, we found a twofold increase in de novo visual deficit. This finding is similar to a recent meta-analysis that reported a fivefold increase in the incidence of a new visual deficit following microsurgical intervention for unruptured paraclinoid aneurysms.[31] In general, visual impairments following surgery are attributed to heat, mechanical compression, retinal ischemia, and ophthalmic artery injury. However, in a study evaluating 94 patients treated surgically, Ota et al. found that excessive dissection of the carotid-oculomotor membrane may alter the venous drainage of the superior ophthalmic vein, which causes an imbalance of arterial and venous microcirculation, leading to delayed ischemia of the optic nerve sheath.[10] On the other hand, microemboli (especially when the ophthalmic artery arises from the aneurysm sac) and hemodynamic imbalance between ICA and external carotid artery blood flow may cause new visual deficits following implantation of conventional stents or flow diverters trapping the ophthalmic artery.[21,29] Nonetheless, fewer visual impairment complications have been reported when coils are used.

In cases with preoperative visual impairment, we found that visual recovery was higher in patients treated surgically, similar to the findings of previously published literature.[31] In this scenario, microsurgical clipping is recommended (especially in large or giant aneurysms) due to the decompression of the mass effect, which can be achieved by clip placement, suction decompression, or temporary clipping.[20] However, if FD is the selected approach, early treatment after symptom onset is suggested to optimize the possibility of achieving the best clinical outcomes.[32] Of note, patients with medially projecting aneurysms have a higher risk of developing a new visual deficit if treated surgically.[10] Based on our findings, microsurgery should be carefully indicated in patients without previous visual deficits and may be a valuable option to

consider for small, dorsally-located aneurysms, with previous visual compromise.[33]

Study Limitations

This study presents several limitations. First, almost all the studies included presented a serious risk of bias mainly due to their small sample size, observational design, uncontrolled confounders, and retrospective design. To address confounding factors and other biases, we performed sensitivity meta-analyses (**Table 3**) and qualitative methods (risk of bias in non-randomized studies of interventions tool [**Supplementary Figure 2**]) to address the methodological issues that could affect the validity of our results, as recommended when meta-analyzing non-randomized studies.[34] Second, there was important publication bias for some of the outcomes in the EVT group but not for the surgical group. Third, we observed methodological heterogeneity in the reporting of visual outcomes. Fourthly, our sensitivity analyses (by anatomical location of the aneurysm) were impacted by the limited number of studies and included patients, which prevented us from drawing definitive conclusions. Finally, the outcomes of additional EVT techniques (such as balloon-assisted coiling) were not available and, therefore, were not included in this meta-analysis.

CONCLUSION

Our findings suggest that microsurgical clipping seems to have higher efficacy than EVT in terms of complete angiographic occlusion at the last follow-up and aneurysm recurrence; however, EVT seems to be safer in terms of intraoperative and postoperative complications. Considering the heterogeneity and low-level evidence of the data available, further prospective trials are warranted to confirm our findings.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Aaron Rodriguez-Calienes: Conceptualization, Project administration, Formal analysis, Methodology, Writing — original draft. **Nagheli Fernanda Borjas-Calderón:** Data curation, Project administration, Writing — original draft. **Juan Vivanco-Suarez:** Data curation, Supervision, Validation, Writing — original draft. **J. Pierre Zila-Velasque:** Data curation, Writing — original draft. **Sandra S. Chavez-Malpartida:** Data curation, Writing — original draft. **Fernando Terry:** Data curation, Writing — original draft. **Pamela Grados-Espinoza:** Data curation, Writing — original draft. **Giancarlo Saal-Zapata:** Supervision, Validation, Writing — review & editing.

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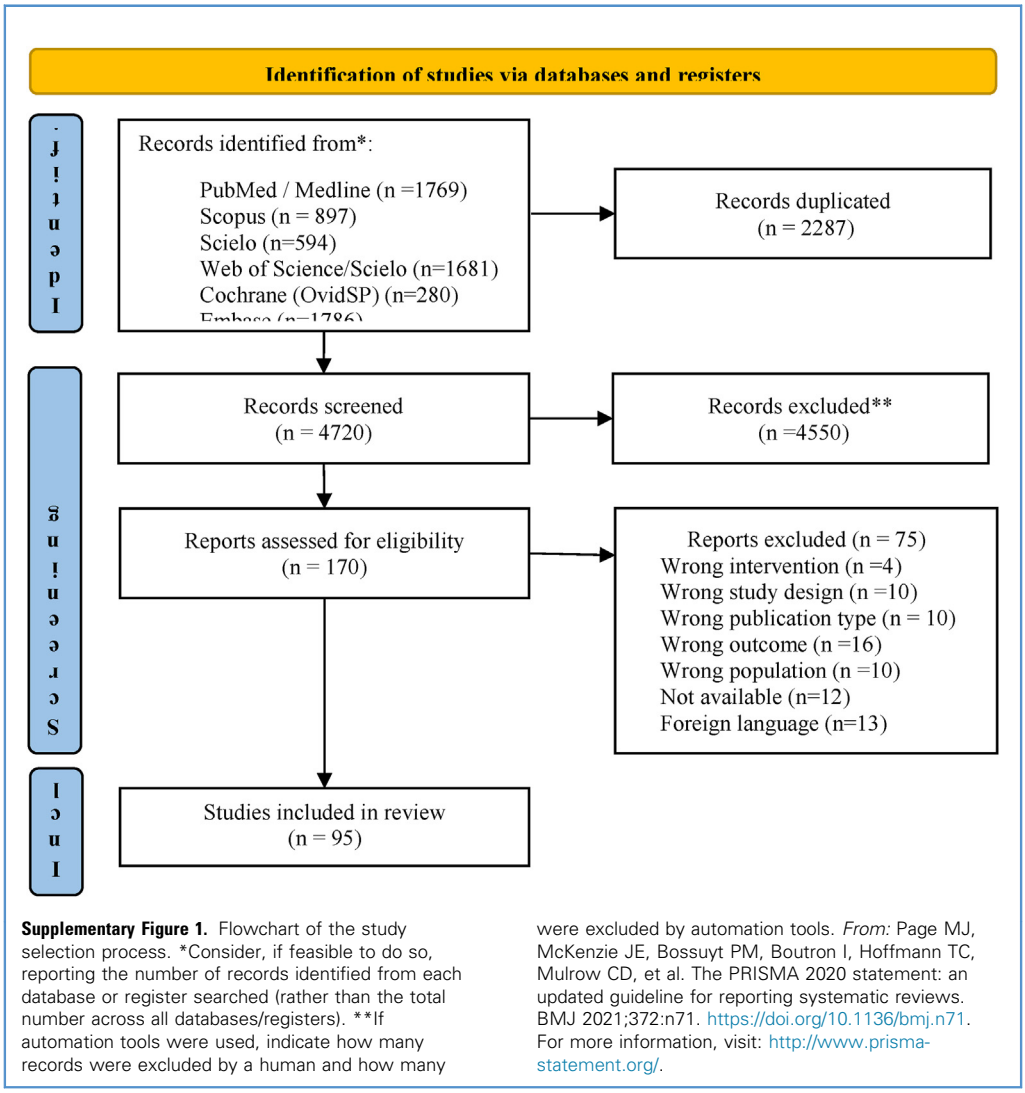
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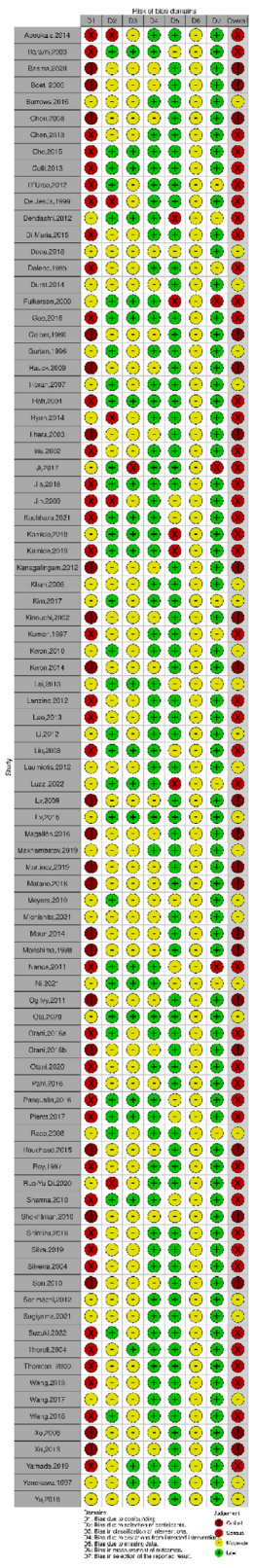
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SUPPLEMENTARY DATA



Supplementary Figure 1. Flowchart of the study selection process. *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). **If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools. *From:* Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. https://doi.org/10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/.



Supplementary Figure 2. Risk of bias assessment with the ROBINS I tool.

Supplementary Table 1. Search Strategy

Database	Search Strategy	Results
Pubmed/Medline	#1 (Aneurysm[mh] or aneurysm*[tiab]) OR ((dilatation[tiab]) AND (arter*[tiab])) #2 Paraclinoid[tiab] or "internal carotid"[ti] or "Carotid Artery, Internal"[mh] or ((carotid[tiab]) and (extracranial[tiab] or ophthalmic[tiab])) #3 ((treatment[ti] or management*[ti]) and (vascular[ti] or surgical[ti])) or (surgery[ti] and bypass[tiab]) or (suction[tiab] and decompression[tiab]) or (endovascular and techniques[tiab]) or "Anterior clinoidectomy"[tiab] or "Therapeutics"[Mh] #4 ((aneurysm*[tiab]) and (paraclinoid[tiab])) and (Treatment[ti] or management*[ti] or surgical[ti])	1769
Scopus	#1 (TITLE-ABS(Aneurysm*) or TITLE-ABS(dilatation w/2 arter*)) #2 TITLE-ABS-KEY(Paraclinoid) OR TITLE-ABS(carotid w/1 extracranial) OR TITLE-ABS(Carotid w/2 ophthalmic) #3 (TITLE-ABS-KEY(Treatment or management*) and TITLE-ABS(*vascular or surgical)) OR (bypass w/2 surgery) OR TITLE-ABS-KEY(Suction w/3 Decompression) OR TITLE-ABS-KEY(endovascular W/3 techniques) OR TITLE-ABS-KEY("Anterior clinoidectomy" OR "intradural clinoidectomy" OR embolization) #4 TITLE-ABS-KEY("internal carotid" and paraclinoid) and TITLE-abs-KEY(Treatment or management* or surgical)	897
Web Of Science/Scielo	#1 TS=(Aneurysm*) OR TS=(dilatation NEAR/2 arter*) OR (TS=(Paraclinoid) or (TS=(carotid) and ts=(ophthalmic or extracranial))) #2 TS=(Treatment or management* OR surgery or decompression or techniques or clinoidectomy or embolization) #3 TS=(paraclinoid) ((#1 AND #2) OR (#3 AND #2))	1681
Scielo	#1 TI=(Aneurysm*) OR TI=(dilatation NEAR/2 arter*) OR (TI=(Paraclinoid) or (TI=(carotid) and tI=(ophthalmic or extracranial))) #2 TS=(Treatment or management* OR surgery or decompression or techniques or clinoidectomy or embolization) #3 TS=(paraclinoid) (#1 AND #2) OR #3	594
Cochrane (OvidSP)	#1 Paraclinoid.ti,ot,sh,kw,ab. #2 carotid.ti,ot,sh,kw,ab. #3 (ophthalmic or extracranial).ti,ot,sh,kw,ab. #4 #2 AND #3 #5 #1 OR #4	280
Embase	#1'aneurysm'/exp OR 'aneurysm' OR aneurysm:ti,ab,kw OR ((dilatation NEXT/2 arter*):ti,ab,kw) #2 'paraclinoid aneurysm'/exp OR 'paraclinoid aneurysm' OR paraclinoid:ti,ab,kw OR ((carotid NEAR/3 (ophthalmic OR extracranial)):ti,ab,kw)	1786

Supplementary Table 2. Detailed Characteristics of the Included Studies

	Study	Study Design	Study Scale	Recruitment Period	Intervention	N pts	Age (years)	Female, n (%)	Ruptured, n/N	Aneurysm Location	An Max Size (mm)	An Neck Size (mm)	Follow-Up Imaging (months)
1	Ruo-Yu Di et al., 2020[1]	R	Single center study	2013—2017	EVT	101	56.9 ± 11.8	67 (66.3)	0/118	Paraclinoid: 118	6.3 ± 8.1	4.7 ± 2.1	Mean: 10
2	Aboukais et al., 2014[2]	R	Single center study	2000—2011	Surgery	23	Mean: 44.3	47 (90.4)	-	-	Mean: 7.9	Mean: 4.5	-
					EVT	29	Mean: 46.8		-	-			
3	Jin et al., 2009[3]	R	Single center study	1997—2007	EVT	65	Mean: 52.3	52 (80)	9/67	Paraclinoid: 67	-	-	Mean: 29.7
4	Dong-Hyun et al., 2014[4]	R	Single center study	2008—2012	Surgery	30	58.1 ± 10.6	24 (80)	11/30	Paraclinoid: 30	5.4 ± 2.5	-	-
					EVT	31	49.7 ± 10.8	28 (90.3)	1/31	Paraclinoid: 31	6.1 ± 5	-	-
5	De Jesús et al., 1999[5]	R	Multicenter study	1988—1996	Surgery	28	-	-	8/35	Paraclinoid: 35	-	-	-
6	D'Urso et al., 2012[6]	R	Single center study	1999—2010	EVT	118	55.1 ± 11.7	109 (92)	0/126	C5: 126	7.3 ± 3.6	-	31.9 ± 28.4
7	Wang et al., 2018[7]	R	Single center study	2010—2015	Surgery	176	-	121 (68.7)	-	Paraclinoid: 192	-	-	-
8	Silva et al., 2019[8]	R	Single center study	2011—2017	EVT	87	52 ± 13.3	77 (88.5)	-	Paraclinoid: 103	6.5 ± 5.2	-	-
					Surgery	30		27 (90)	-	Paraclinoid: 32			
9	Suzuki et al., 2022[9]	R	Single center study	2009—2019	EVT	45	-	34 (75.5)	-	Paraclinoid: 45	-	-	-
10	Wang et al., 2019[10]	R	Multicenter register	2011—2016	Surgery	12	Mean: 46.6	8 (66.6)	2/27	Paraclinoid: 27	Mean: 6.6	-	
11	Khan et al., 2005[11]	R	Single center study	1993—2003	Surgery	75	50.9 ± 10.9	60 (80)	44/81	C5: 81	-	-	-
12	Wang et al., 2013[12]	R	Single center study	2009—2010	EVT	56	52.1 ± 9.39	44 (78.5)	-	Paraclinoid: 64	-	6.9 ± 4.6	12.4 ± 3.7
13	Makhambetov et al., 2019[13]	R	Single center study	2008—2017	EVT	29	52 ± 7.6	21 (72.4)	2/29	Paraclinoid: 29	-	Mean: 10.6	-
14	Kumon et al., 1997[14]	R	Single center study	-	Surgery	15	53.8 ± 11	11 (73.3)	-	C6: 15	-	-	-
15	Dolenc, 1985[15]	R	Single center study	-	Surgery	14	42.8 ± 10	11 (78.5)	1/16	-	-	-	-
16	Lanzino et al., 2012[16]	R	Multicenter registry	-	EVT	21	51.0 ± 12.8	18 (85.7)	0/22	Paraclinoid: 22	-	-	9.7 ± 12
17	Gurian et al., 1996[17]	R	Single center study	1991—1995	EVT	11	Mean: 47.1	9 (81.8)	3/11	SHA: 11	-	-	Mean: 12.1

R, retrospective; P, prospective; EVT, endovascular treatment; SHA, superior hypophyseal artery; OA, ophthalmic artery.

Continues

Supplementary Table 2. Continued

	Study	Study Design	Study Scale	Recruitment Period	Intervention	N pts	Age (years)	Female, n (%)	Ruptured, n/N	Aneurysm Location	An Max Size (mm)	An Neck Size (mm)	Follow-Up Imaging (months)
18	Sugiyama et al., 2021[18]	R	Single center study	2003–2018	EVT	43	60.4 ± 12.1	39 (90.6)	0/43	Paraclinoid: 43	-	6.9 ± 4.6	25.9 ± 24.6
19	Roy et al., 1997[19]	R	Single center study	1992–1996	EVT	23	50.7 ± 11	20 (86.9)	8/25	Paraclinoid: 13; C6:12	-	Mean: 10.6	15.1 ± 7.8
20	Thornton et al., 2000[20]	R	Single center study	1994–1999	EVT	66	Mean: 50.1	56 (84.8)	13/71	Paraclinoid: 71	-	Mean: 3.8	Mean: 16
21	Loumiotis et al., 2012[21]	R	Multicenter study	1999–2010	EVT	33	52.9 ± 14.3	27 (81.8)	33/33	C5: 17; OA: 16	-	3.8 ± 1.8	29.3 ± 26.7
22	Shimizu et al., 2016[22]	R	Multicenter study	2006–2012	EVT	377	56.2 ± 11.2	330 (87.5)	0/400	Paraclinoid: 400	6.5 ± 2.8	-	32 ± 20
23	Chen et al., 2013[23]	R	Single center study	2008–2011	EVT	47	Mean: 46	26 (55.3)	19/51	Paraclinoid: 51	-	-	Mean: 18.6
24	Burrows et al., 2016[24]	R	Single center register	-	EVT	44	52 ± 14	41 (93.1)	0/46	C6: 46	-	-	-
25	Di Maria et al., 2015[25]	R	Multicenter register	2006–2013	EVT	138	-	111 (80.4)	0/162	C6: 162	Mean: 7.8	-	-
26	Lee et al., 2013[26]	R	Single center study	2001–2012	Surgery	10	Mean: 50.1	10 (100)	5/10	Paraclinoid: 10	Mean: 18.8	-	-
27	Li et al., 2012[27]	R	Single center study	2005–2010	Surgery	15	Mean: 50	10 (66.6)	8/15	Paraclinoid: 15	Mean: 21	-	-
28	Heran et al., 2007[28]	R	Single center register	1992–2006	EVT	17	-	16 (94.1)	0/17	Paraclinoid: 4; C6: 10; SHA: 3		5.9 + 1.6	-
29	Otani et al., 2020[29]	R	Multicenter study	2009–2018	Surgery	38	Mean: 56.5	33 (86.8)	0/40	Paraclinoid: 40	8.8 ± 5.4	-	3.8 ± 2.1
30	Raco et al., 2008[30]	R	Single center study	1973–2004	Surgery	104	Mean: 47.2	74 (71.1)	108/108	C6: 108	-	-	-
31	Sorimachi et al., 2012[31]	R	Single center study	1998–2010	EVT	138	-	-	-	Paraclinoid: 140	-	-	65.6 ± 37.2
32	Silveira et al., 2004[32]	R	Single center study	1990–2002	Surgery	51	Mean: 52	41 (80.4)	32/55	Paraclinoid: 55	-	-	-
33	Irie et al., 2002[33]	R	Single center study	-	EVT	4	Mean: 61	1 (25)	0/4	-	3.4 ± 0.8	-	-
34	Thorell et al., 2004[34]	R	Single center study	-	Surgery	6	-	-	0/6	OA: 6	-	-	-
35	Dehdashti et al., 2012[35]	R	Single center study	-	Surgery	21	50 ± 7	12 (57.1)	6/21	OA: 21	-	-	-

36	Jia et al., 2018[36]	R	Single center study	2016–2017	EVT	34	Mean: 55.9	25 (74)	0/34	C6: 34	Mean: 43	-	-
37	Kamide et al., 2018[37]	R	Single center study	1997–2016	Surgery	198	52 ± 14	164 (83)	23/208	OA: 208	-	-	Mean: 76.8
38	Kamide et al., 2020[38]	R	Single center study	1997–2016	Surgery	215	53.2 ± 13.4	206 (96)	0/231	Paraclinoid: 29 C5: 23 C6: 24 SHA: 27 OA: 128	8.8 ± 7.4	-	-
39	Gao et al., 2016[39]	R	Single center study	2012–2014	EVT	15	55.2 ± 15.3	11 (73.3)	-	Paraclinoid: 15	22.3 ± 7.8	-	-
40	Yamada et al., 2019[40]	R	Single center study	2014–2016	Surgery	33	Mean: 54.8	32 (97)	-	Paraclinoid: 33	Mean: 5.3	-	-
41	Cho et al., 2015[41]	R	Single center study	2012–2013	EVT	59	53.5 ± 9.3	50 (85)	0/59	Paraclinoid: 59	4.6 ± 1.2	-	10.9 ± 5.9
42	Nanda et al., 2011[42]	R	Single center study	1994–2009	Surgery	80	Mean: 52	67 (84)	30/86	C6: 86	-	-	-
43	Liu et al., 2008[43]	R	Single center study	2000–2005	Surgery	38	Mean: 53.3	32 (84.2)	28/40	Paraclinoid: 40	Mean: 11.37	-	-
44	Ni et al., 2021[44]	R	Single center study	2015–2019	EVT	110	58.5 ± 9.8	85 (77.2)	28/122	C5: 86 SHA: 36	6.1 ± 3.8	4.2 ± 1.9	8.9 ± 10.3
45	Kachhara et al., 2021[45]	R	Multicenter study	-	Surgery	35	-	26 (74.2)	27/36	Paraclinoid: 36	-	-	-
46	Lai et al., 2013[46]	R	Single center study	1992–2012	Surgery	169	50.6 ± 12.1	147 (87)	0/182	C6: 182	9 ± 6.9	-	Mean: 24.7
47	Pasqualin et al., 2016[47]	R	Multicenter study	1990–2014	Surgery	66	-	-	30/66	Paraclinoid: 66	-	-	-
48	Sharma et al., 2010[48]	R	Single center study	2001–2008	Surgery	78	Mean: 42	53 (67.9)	47/78	C6: 49; SHA: 29	-	-	-
49	Luzzi et al., 2022[49]	R	Multicenter study	1993–2021	Surgery	58	46.8 ± 17	31 (53.4)	26/58	Paraclinoid: 58	-	-	53.3 ± 38
50	Barami et al., 2003[50]	R	Single center study	1994–1999	Surgery	61	-	49 (80.3)	-	C5: 11; C6: 50	-	-	-
51	Lv et al., 2016[51]	R	Single center study	2013–2014	EVT	120	-	84 (70)	24/129	Paraclinoid: 129	-	-	Mean: 8.1
52	Ota et al., 2020[52]	R	Single center study	2015–2019	Surgery	94	54 ± 12.3	82 (87.2)	-	-	6.2 ± 3.3	-	Mean:16.9
53	Hoh et al., 2001[53]	R	Single center study	1991–1999	Surgery EVT	216	-	-	-	Paraclinoid: 180 Paraclinoid: 57	-	-	-

R, retrospective; P, prospective; EVT, endovascular treatment; SHA, superior hypophyseal artery; OA, ophthalmic artery.

Continues

Supplementary Table 2. Continued

	Study	Study Design	Study Scale	Recruitment Period	Intervention	N pts	Age (years)	Female, n (%)	Ruptured, n/N	Aneurysm Location	An Max Size (mm)	An Neck Size (mm)	Follow-Up Imaging (months)
54	Colli et al., 2013[54]	R	Single center study	1990—2010	Surgery	95	-	74 (77.9)	63/106	Paraclinoid: 106	-	-	64.4 ± 37.7
55	Fulkerson et al., 2009[55]	R	Single center study	1990—2005	Surgery	126	49.1 ± 11	-	34/126	Paraclinoid: 126	-	-	4.3 ± 4.1
					EVT	26	-		3/28	Paraclinoid: 28			1.4 ± 1.1
56	Otani et al., 2016[56]	R	Multicenter study	2004—2014	Surgery	15	66 ± 9.7	14 (93.3)	-	Paraclinoid: 15	15.4 ± 5.3	-	-
57	Ji et al., 2017[57]	R	Single center study	2014—2015	EVT	443	-	295 (66.6)	443/443	Paraclinoid: 443	-	-	-
58	Yonekawa et al., 1997[58]	R	Single center study	1993—1996	Surgery	30	50.4 ± 11	25 (83.3)	-	Paraclinoid: 18	-	-	-
59	Kwon et al., 2010[59]	R	Single center study	2005—2007	EVT	122	-	-	3/132	Paraclinoid: 132	5.3 ± 2.4	-	-
60	Pierot et al., 2017[60]	R	Single center study	-	EVT	9	50.9 ± 15.8	7 (77.8)	-	OA: 9	-	4.1 ± 0.9	8.2 ± 5.5
61	Kim et al., 2017[61]	R	Single center study	2005—2016	EVT	98	-	83 (84.7)	-	OA: 98	-	-	-
62	Ogilvy et al., 2011[62]	R	Single center study	2001—2008	EVT	91	-	81 (89.0)	8/94	Paraclinoid: 94	-	-	-
63	Hauck et al., 2009[63]	R	Single center study	2002—2006	EVT	15	57.6 ± 17.8	12 (75)	-	C6: 15	Mean: 27	-	27.3 ± 12.9
64	Pahl et al., 2016[64]	R	Single center study	2009—2014	Surgery	43	53.1 ± 8.2	37 (86)	-	Paraclinoid: 43	Mean: 12.3	-	Mean: 29.8
65	Xu et al., 2008[65]	R	Single center study	-	Surgery	36	Mean: 51.4	21 (58.3)	-	-	-	-	Mean: 10
66	Magallón-Barajas et al., 2016[66]	R	Single center study	2009—2015	Surgery	66	Mean: 49.55	61 (92.4)	46/66	Paraclinoid: 66	-	-	-
67	Daou et al., 2018[67]	R	Multicenter study	2010—2015	EVT	161	-	-	-	Paraclinoid: 61; C6: 100	-	-	17.4 ± 11.6
68	Boet et al., 2005[68]	R	Single center study	1995—2002	Surgery	6	49 ± 14.5	6 (100)	-	C6: 6	-	-	29 ± 34.7
					EVT	12	50.7 ± 12.1	7 (58.3)	-	C6: 13	-	-	29 ± 23.1
69	Kwon et al., 2014[69]	R	Single center study	2002—2012	EVT	113	Mean: 56.2	93 (82.3)	10/116	Paraclinoid: 116	Mean: 5.5	-	Mean: 20.4
70	Kinouchi et al., 2002[70]	R	Single center study	1993—2000	Surgery	7	58.4 ± 7.3	5 (71.4)	2/13	Paraclinoid: 13	-	-	-

71	Matano et al., 2016[71]	R	Single center study	2012—2014	Surgery	127	Mean: 56.8	108 (85)	-	Paraclinoid: 127	Mean: 6.9	-	-
72	Meyers et al., 2019[72]	P	Multicenter study	2012—2015	EVT	180	61 ± 9.9	165 (91.7)	-	Paraclinoid: 180	13.4 ± 5.7	6.7 ± 2.8	-
73	Basma et al., 2021[73]	R	Single center study	2013—2016	Surgery	7	53.7 ± 11.8	6 (85.7)	2/7	Paraclinoid: 7	7.5 ± 2.4	-	-
74	Son et al., 2010[74]	R	Single center study	2004—2008	Surgery	22	Mean: 53.5	17 (77.3)	9/24	Paraclinoid: 24	-	-	-
75	Morishima et al., 1998[75]	P	Single center study	-	EVT	16	57.5 ± 13.7	15 (93.8)	1/16	Paraclinoid: 16	-	-	Mean: 13.8
76	Martinez-Perez et al., 2020[76]	P	Single center study	2016—2018	Surgery	19	45 ± 8.2	17 (89.5)	3/20	Paraclinoid: 20	10.5 ± 5.4	-	-
77	Xu et al., 2013[77]	R	Single center study	2009—2012	EVT	31	58.4 ± 11.5	17 (54.8)	32/32	C5: 24; C6: 8	3.8 ± 0.9	3.8 ± 0.9	-
78	Shekhtman et al., 2016[78]	R	Single center study	2001—2015	Surgery	260	45.1 ± 9.7	185 (71.2)	164/260	-	-	-	-
79	Lv et al., 2009[79]	P	Single center study	2005—2008	EVT	9	46.3 ± 16.5	7 (77.8)	0/9	Paraclinoid: 9	-	-	Mean: 6.4
80	Gelber et al., 1980[80]	R	Single center study	1975—1978	Surgery	10	50.2 ± 16.4	7 (70)	1/11	Paraclinoid: 11	-	-	-
81	Moon et al., 2014[81]	R	Single center study	2011—2012	EVT	29	Mean: 55.5	29 (100)	-	Paraclinoid: 38	Mean: 6.8	-	Mean: 6.6
82	Chen et al., 2008[82]	R	Single center study	2005—2006	Surgery	40	-	67 (77)	4/40	Paraclinoid: 40	-	-	-
					EVT	47			1/47	Paraclinoid: 47			
83	Otani et al., 2016[83]	R	Multicenter study	2004—2015	Surgery	30	Mean: 62	28 (93.3)	7/30	Paraclinoid: 30	12.7 ± 5.3	-	-
84	Iihara et al., 2003[84]	R	Single center study	1997—2002	Surgery	35	52 ± 9	26 (74.3)	0/35	Paraclinoid: 35	-	-	-
					EVT	77	56 ± 9	61 (79.2)	0/77	Paraclinoid: 77			
85	Durst et al., 2014[85]	R	Single center study	2001—2009	EVT	65	56 ± 11.4	57 (87.7)	12/65	C6: 65	8.4 ± 4.6	3.2 ± 1.5	-
86	Yu et al., 2018[86]	R	Single center study	2010—2017	EVT	54	-	45 (83.3)	0/54	OA: 54	4.7 ± 1.7	-	Mean: 20.8
87	Michishita et al., 2021[87]	R	Single center study	2003—2018	EVT	173	Mean: 54.1	151 (87.3)	0/173	C6: 173	Mean: 6.8	-	-
88	Rouchaud et al., 2015[88]	P	Single center study	2009—2013	EVT	28	Mean: 52	19 (67.9)	-	OA: 28	Mean: 8	-	-
89	Kanagalingam et al., 2012[89]	R	Single center study	2004—2009	Surgery	79	-	-	-	C6: 79	-	-	Mean: 24
					EVT	22			-	C6: 22			Mean: 24

R, retrospective; P, prospective; EVT, endovascular treatment; SHA, superior hypophyseal artery; OA, ophthalmic artery.

Supplementary Table 3. Assessment of Publication Bias Using the Eggers' Test for Studies Included for Each Outcome

	P Value	
Outcome	**EVT**	**Surgery**
Complete occlusion at last follow-up	0.3290	0.1944
Favorable functional outcome	**0.0412**	0.4963
Recurrence	0.3296	*
Intraoperative complications	**0.0289**	0.9037
Postoperative complications	**0.0016**	0.4197

*Not calculated
EVT, Endovascular treatment.

Supplementary Table 4. Sensitivity Analysis by Anatomical Location of the Paraclinoid Aneurysm

			Complete Occlusion at Last Follow-Up				Composite Safety Outcome			
Location	**Approach**	**Specific Technique**	**No of Studies**	**No of Pts.**	**Pooled Rates (95% CI)**	**I^2**	**No of Studies**	**No of Pts.**	**Pooled Rates (95% CI)**	**I^2**
Clinoidal segment (C5) of ICA	Surgery		-	-	-	-	-	-	-	-
	EVT	Overall	4	261	59% (53–64%)	0%	3	182	20% (15–26%)	17%
Ophthalmic segment (C6) of ICA	Surgery		8	408	86% (82–89%)	0%	-	-	-	-
	EVT	Overall	10	480	65% (54–76%)	52%	7	451	9% (4–20%)	77%
		Coiling	4	154	53% (45–60%)	0%	-	-	-	-
		FD	4	433	79% (64–88%)	84%	3	319	4% (2–7%)	47%
		SAC	4	90	63% (46–77%)	61%	3	83	1% (0–8%)	0%

EVT, endovascular treatment; CI, confidence interval; FD, flow diversion; SAC, stent-assisted coiling.

Supplementary Table 5. Sensitivity Analysis by EVT Technique Restricted to Studies Published After 2011

Outcome	**Subgroup**	**No of Studies**	**No of Participants**	**Pooled rates (95% CI)**	**I^2**
Complete occlusion at last follow-up	Primary coiling	9	471	56% (46–65%)	64%
	FD	8	549	77% (54–91%)	91%
	SAC	6	269	53% (37–68%)	80%
Safety composite	Primary coiling	8	432	5% (2–11%)	63%
	FD	7	435	11% (7–17%)	38%
	SAC	6	233	4% (2–7%)	0%

CI, confidence interval; FD, flow diversion; SAC, Stent-assisted coiling.

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