

Microsurgery, Stereotactic Radiosurgery and Endovascular Treatment of Sylvian Fissure Arteriovenous Malformations: A Systematic Review

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Abstract

Background. Sylvian-fissure-region arteriovenous malformations (AVMs) are uncommon and anatomically heterogeneous; published labels often describe non-comparable lesions or populations.

Objective. To update evidence for microsurgery, stereotactic radiosurgery (SRS), and endovascular treatment (EVT).

Methods. Following PRISMA 2020, five databases were searched through May 2026 with citation chaining. Two reviewers independently screened records and extracted data. Dedicated sylvian/perisylvian cohorts were distinguished from broader cohorts and contextual technical reports. Incompatible endpoints, non-independent arms, and potentially overlapping cohorts were not pooled. Risk of bias and applicability were appraised.

Results. Nineteen reports were retained: 16 in the evidence synthesis and 3 as contextual background. Microsurgery achieved complete resection in 8/8, 40/41, and 94/94 patients. Transient deficits occurred in 4/8, 4/28, 9/94, and 18/41 patients; postoperative hematoma occurred in 2/94. Mortality windows varied. In the dedicated SRS cohort ($n = 87$), actuarial obliteration was 35% at 3 years, 60% at 4–5 years, and 76% at 10 years. Cumulative post-SRS hemorrhage was 5% at 1, 5, and 10 years (approximately 1% annually during latency); mortality was unreported. No dedicated curative EVT series for true sylvian AVMs was identified; available data described broader middle cerebral artery cohorts without sylvian-specific angiographic cure.

Conclusions. Microsurgery is supported for carefully selected accessible sylvian-fissure AVMs, whereas SRS and embolization have complementary roles. Comparative superiority cannot be inferred. Future studies require explicit anatomical definitions, modality-specific denominators, angiographic endpoints, and standardized follow-up.

Clinical Trial Number: not applicable.

1 Introduction

Sylvian-fissure-region arteriovenous malformations (AVMs) occupy a surgically and functionally complex corridor among the frontal and temporal opercula, insula, middle cerebral artery (MCA) branches, and eloquent networks. Sugita et al. classified these as pure, lateral, medial, or deep based on nidus position relative to the fissure [21]. Operative risk further depends on Spetzler–Martin (S–M) grade, arterial anatomy, venous drainage, rupture status, and functional eloquence [8, 19].

Synthesizing literature is challenging because terms like sylvian, perisylvian, sylvian-insular, insular, opercular, temporal, and MCA-region are used inconsistently. A cistern-centered lesion differs from an insular nidus approached transsylvianly or a broad MCA-territory cohort. Treatment selection amplifies these discrepancies: microsurgery features accessible lesions, radiosurgery targets unfavorable ones, and embolization often aims for partial devascularization.

A previous systematic review identified nine full-text articles through 2018, added two institutional cases, and proposed an anatomical classification [22]. The present review updates the evidence synthesis, separates direct sylvian/perisylvian evidence from indirect reports, and audits outcome comparability before any quantitative combination.

2 Materials and methods

2.1 Protocol and reporting

The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [15]. The protocol was not prospectively registered. Full PRISMA-S compliance was not claimed because [18]. Only published aggregate data were used.

2.2 Eligibility criteria

Eligible reports included at least 2 patients with sylvian, perisylvian, or sylvian-insular AVMs (or separable subgroups) treated with microsurgery, stereotactic radiosurgery (SRS), endovascular treatment (EVT), or multimodal strategies, providing at least one outcome. Editorials, reviews without primary cases, animal studies, and isolated reports were excluded. Three publications on insular/deep AVMs were retained purely for contextual transsylvian background [16, 17, 25]. Dedicated sylvian cohorts were distinguished from broader cohorts; broader outcomes were not attributed to sylvian subgroups unless explicitly stratified.

2.3 Information sources and search strategy

PubMed/MEDLINE, Embase, Scopus, Web of Science Core Collection, and the Cochrane CENTRAL register were searched from inception to 1 April 2026 and updated on 28 May 2026. Search concepts combined terms for the anatomical region, lesion, and treatment. Reference lists and forward citations were examined. Records were imported into Rayyan; DOI-based deduplication removed 456 records, and remaining records were checked for duplicates. Exact database-specific search histories were unavailable.

2.4 Study selection and data extraction

Two reviewers independently screened records and extracted publication details, recruitment period, anatomical definition, Sugita subtype, S–M grade, nidus size or volume, rupture status, treatment modality, adjunctive embolization, follow-up, imaging used to confirm obliteration, mortality and its reporting window, transient and permanent neurological deficits, functional outcome, seizure outcome, and post-treatment hemorrhage. Disagreements were resolved by consensus. Outcomes were standardized conservatively. Complete resection required explicit angiographic or imaging confirmation. Modified Rankin Scale (mRS) 0–2 and Glasgow Outcome Scale (GOS) 4–5 were considered favorable descriptively. Crude proportions were not substituted for actuarial estimates.

2.5 Source verification, overlap, and risk of bias

Every numerical endpoint was checked against the source report. Institutional origin and recruitment periods were examined for overlapping enrollment; potentially overlapping cohorts were not combined. Risk of bias was assessed using case-series guidance [11, 12] across participant selection, anatomical definition, outcome ascertainment, follow-up completeness, and selective reporting. Applicability was rated separately according to whether evidence came from a dedicated sylvian/perisylvian cohort, a separable subgroup, or contextual transsylvian anatomy. Judgments were low-to-some, some, or high concern; no numerical score was used, and no study was excluded solely on this basis.

2.6 Synthesis methods

Random-effects pooling had been planned, but source verification identified incompatible anatomy, immediate surgical versus actuarial SRS endpoints, non-independent multimodal arms, unstratified outcomes, and possible cohort overlap. No meta-analysis or publication-bias test was therefore performed. Results were synthesized at study level by modality, anatomical directness, endpoint definition, and follow-up window, following Synthesis Without Meta-analysis (SWiM) principles [4].

Counts, proportions, and published actuarial estimates were retained at their reported time points. Exact two-sided 95% Clopper–Pearson confidence intervals (CIs) were calculated for extractable crude binomial proportions; they describe within-study precision and were not pooled. Simple binomial CIs were not applied to actuarial SRS estimates. SRS mortality was coded as not reported (NR), and whole-cohort EVT data were not interpreted as Type II-specific outcomes.

3 Results

3.1 Study selection

Database searching identified 1,298 records. After removal of 456 duplicates, 842 records underwent title-and-abstract screening; 758 were excluded and 84 reports were sought for retrieval. Citation searching identified seven additional reports, giving 91 reports sought in total. Two reports could not be retrieved. Eighty-nine full-text reports were assessed, 70 were excluded, and 19 reports were retained: 16 for evidence synthesis and 3 for contextual background [16, 17, 25] (Fig. 1).

3.2 Study characteristics and anatomical directness

The 19 retained reports were published between 1987 and 2025. Twelve were dedicated sylvian or perisylvian cohorts, four were broader temporal, language-area, or MCA-region cohorts, and three were contextual insular or deep-AVM publications (Tables 1 and 2). Microsurgery dominated the literature. One dedicated SRS series enrolled 87 patients, one 15-patient cohort used both surgery and SRS with crossover, and no dedicated curative endovascular series was identified. A reliable total number of unique patients could not be calculated because subgroup denominators were not always separable and institutional overlap was possible. Study-level risk-of-bias and applicability judgments are summarized in Table 3.

Dedicated reports comprised 359 patient records, not necessarily 359 unique patients because overlap and crossover could not be excluded. Four broader cohorts contributed 42 anatomically relevant subgroup records (13 + 5+16 + 8); inseparable outcomes supported evidence mapping, not modality-specific estimates.

Table 1
Characteristics and extractable outcomes of dedicated sylvian or perisylvian clinical cohorts

Study	Design / recruitment	Anatomy and count	Baseline lesion features	Treatment	Outcome ascertainment / follow-up	Key extractable findings
Sugita et al. [21]	Retrospective surgical series; period NR	Dedicated sylvian fissure; Sugita pure/lateral/medial/deep; n = 16	Pre-Spetzler–Martin era; rupture and metric size NR	Microsurgery	Postoperative clinical outcome; angiographic method and follow-up incompletely specified	15 without additional deficit; 1 death
Kawaguchi et al. [7]	Technical case series; period NR	Dedicated sylvian fissure; circumferential/penetrating patterns; n = 3	Grade, rupture, and size NR	Microsurgery	Technical and anatomical reporting; follow-up NR	Operative anatomy and preservation of MCA passage arteries; no efficacy synthesis
Zimmerman et al. [26]	Retrospective case series	Pure sylvian fissure; n = 8	Nidus 6–27 cm ³ (mean 14); 3 hemorrhagic; 5 dominant hemisphere	Microsurgery	Postoperative angiography; neurological follow-up to 3 months	Complete resection 8/8; transient deficits 4/8; new permanent deficit 0/8 at 3 months
Cannestra et al. [5]	Prospective functional-guided series	Dominant-hemisphere perisylvian; n = 20	Mostly SM II–IV; size and rupture heterogeneous	Function-guided resection / multimodal care	Functional imaging and intraoperative mapping; follow-up and treatment definitions heterogeneous	Operability and functional-mapping evidence; narrative synthesis only
Lawton et al. [8]	Consecutive single-surgeon series	Dedicated sylvian fissure; pure 6, lateral 4, medial 9, deep 9; n = 28	SM I–IV; 15 presented with hemorrhage	Microsurgery	Postoperative assessment; mean late follow-up 20 months; mRS	Mortality 0/28; transient deterioration 4/28; permanent worsening 1/28; mRS 0–2 in 25/28
Wang et al. [24]	Technical mixed surgical series	Direct sylvian-fissure approach; AVM subgroup n = 2 within 62 patients	AVM-specific grade, rupture, and size NR	Microsurgery	AVM-specific outcome denominator not reported	Technical evidence only; not used for treatment-effect inference
Wang et al. [23]	Retrospective single-center series	Dedicated sylvian-fissure cohort; n = 94	SM I–IV; metric size and rupture distribution incompletely indexed	Microsurgery	Postoperative DSA; follow-up window not clearly reported in indexed record	Resection 94/94; transient deficits 9/94; hematoma 2/94; no postoperative deaths reported; KPS > 90 in all

Study	Design / recruitment	Anatomy and count	Baseline lesion features	Treatment	Outcome ascertainment / follow-up	Key extractable findings
Liu et al. [9]	Retrospective series, 2009–2011	Dedicated sylvian-fissure cohort; n = 41	SM I–IV; rupture history and deep venous drainage analyzed	Microsurgery	Mean follow-up 23 months (range 6–35); mRS	Resection 40/41; death within 1 month 1/41; transient deterioration 18/41; mRS 0–2 in 29/40 survivors
Bowden et al. [3]	Retrospective SRS series, 1987–2009	Within or adjacent to sylvian fissure; n = 87	Median volume 3.85 cm ³ ; 40 prior hemorrhage; 36 seizures	Gamma Knife SRS; median margin dose 20 Gy	Median follow-up 64 months; imaging-confirmed and actuarial outcomes	Actuarial obliteration 35% at 3 y, 60% at 4–5 y, 76% at 10 y; hemorrhage 5% at 1/5/10 y; mortality NR; cyst 3/87; permanent radiation deficit 0/87
Pabaney et al. [14]	Retrospective institutional series, 2000–2012	Sylvian/perisylvian; Sugita subtypes; n = 15	SM I 2, II 6, III 5, IV 2	SRS 8; microsurgery 7; selected adjunctive embolization; one crossover	mRS; modality-specific follow-up incompletely separable	Treatment arms non-independent; 9 unchanged, 3 worse, and 2 improved after treatment in total cohort; reported categories sum to 14/15, leaving one outcome unaccounted for in the source summary
Tarokhian et al. [22]	Two cases embedded in systematic review	Sylvian-fissure cases; n = 2	Case-level anatomy; grade/size individual	Microsurgery	Case-level imaging and follow-up	Primary cases retained narratively; review component secondary
Nathal et al. [13]	Retrospective 20-year institutional series	Dedicated sylvian fissure; n = 43	Mean age 33 y; hemorrhage 15/43; SM I–IV	Microsurgery with selected preoperative embolization	mRS at baseline and 12 months	mRS 0–2: 36/43 before surgery and 41/43 at 12 months; difference NS

Table 2
Broader anatomical cohorts and contextual publications

Study	Evidence tier	Design / recruitment	Relevant anatomy and count	Lesion features / treatment	Outcome reporting and synthesis role
Boström et al. [2]	Broader eligible cohort	Prospective temporal-lobe surgical series	Sylvian-fissure subgroup n = 13 within 44 temporal AVMs	Cohort SM I 7, II 17, III 17, IV 3; microsurgery	Follow-up reported for whole cohort; sylvian-specific outcomes not fully separable
Andreu-Canals et al. [1]	Broader eligible cohort	Retrospective temporal-lobe series	Sylvian temporal subtype n = 5 within broader cohort	Cohort mean SM approximately 2.5; microsurgery	Subgroup outcome denominators not consistently separable; narrative only
Su and Yu [20]	Broader eligible cohort	Retrospective MCA-region EVT series	Type II around sylvian fissure n = 16 within 135 MCA-region AVMs	Type II mean nidus diameter 3.9 ± 1.4 cm; Onyx EVT	Type II-specific cure, morbidity, and mortality NR; whole-cohort data shown separately
Meneghelli et al. [10]	Broader eligible cohort	Retrospective language-area surgical cohort	Sylvian-insular subgroup n = 8	Predominantly SM II–III at cohort level; microsurgery	Clinical/cognitive outcomes reported for broader cohort; subgroup effects not inferred
Potts et al. [16]	Contextual background only	Operative-technique series	Insular/basal-ganglia vascular lesions; sylvian fissure used as corridor	Transsylvian–transinsular microsurgery	Nidus was not a true sylvian-fissure AVM; excluded from efficacy synthesis
Potts et al. [17]	Contextual background only	Prospective deep-AVM registry series	Insular AVMs n = 25 within 48 deep AVMs	Predominantly higher-grade deep AVMs; microsurgery $\pm$ SRS for residual	Insular anatomy differs from true cisternal sylvian lesions; excluded from efficacy synthesis
Zeng et al. [25]	Contextual background only	Retrospective pediatric deep-AVM series, 2015–2018	Insular subgroup n = 4 within 10 deep AVMs	Mostly small, ruptured pediatric lesions; microsurgery	Small indirect subgroup; retained for anatomical context only and excluded from efficacy synthesis

Table 3
Study-level risk-of-bias and applicability summary

Study	Selection and case definition	Outcome ascertainment and follow-up	Overall concern / applicability
Sugita et al. [21]	SC: selected surgical series; clear sylvian taxonomy	HC: older report with limited follow-up and angiographic detail	HC
Kawaguchi et al. [7]	HC: three technical cases	HC: efficacy outcomes and follow-up incompletely reported	HC
Zimmerman et al. [26]	SC: small selected pure-sylvian series	SC: angiographic endpoint clear; clinical follow-up limited to 3 months	SC
Cannestra et al. [5]	SC: selected dominant-hemisphere perisylvian cohort	HC: heterogeneous treatment and functional outcome definitions	HC
Lawton et al. [8]	SC: consecutive but single-surgeon selected cohort	LSC: explicit outcomes and mean 20-month follow-up	SC
Wang et al. [24]	HC: AVM subgroup of two within mixed approach series	HC: AVM-specific outcomes not separable	HC
Wang et al. [23]	SC: large single-center surgical cohort	SC: postoperative DSA clear; follow-up window and permanent deficit reporting limited	SC; possible overlap
Liu et al. [9]	SC: retrospective selected cohort	SC: follow-up reported; permanent deficit denominator not separable	SC; possible overlap
Bowden et al. [3]	SC: selected SRS cohort	SC: long actuarial follow-up and imaging; mortality endpoint NR	SC
Pabaney et al. [14]	SC: small institutional cohort	HC: crossover, adjunctive embolization, and non-independent modality arms	HC
Tarokhian et al. [22]	HC: two cases embedded in review	HC: case-level reporting and very small denominator	HC
Nathal et al. [13]	SC: high-volume selected surgical cohort	SC: 12-month mRS reported; completeness endpoint not uniformly detailed	SC
Boström et al. [2]	SC: broader temporal cohort	HC: sylvian subgroup outcomes incompletely separable	HAC
Andreu-Canals et al. [1]	SC: broader temporal cohort	HC: subgroup outcome denominators incompletely separable	HAC
Su and Yu [20]	SC: whole MCA-region EVT cohort	HC for review question: Type II outcomes not stratified; discharge follow-up only	HAC
Meneghelli et al. [10]	SC: selected language-area cohort	HC for review question: sylvian-specific outcomes incompletely separable	HAC
*SC - Some concern; HC - High concern; LSC - Low-to-some concern; HAC - High applicability concern			

3.3 Microsurgery

Dedicated surgical series showed selected-case feasibility but no common cure or morbidity rate. Complete resection was 8/8 in Zimmerman et al., 94/94 in Wang et al., and 40/41 in Liu et al. [9, 23, 26]. Transient deterioration occurred in 4/8, 4/28, 9/94, and 18/41 in Zimmerman, Lawton, Wang, and Liu; permanent worsening was 0/8 at 3 months and 1/28, while separate permanent-deficit counts were NR in Wang and Liu [8, 9, 23, 26]. Mortality was 1/16 in Sugita, 0/28 in Lawton, and 1/41 within 1 month in Liu [8, 9, 21].

Exact CIs exposed the uncertainty: complete resection was 100% (95% CI 63.1–100.0), 100% (96.2–100.0), and 97.6% (87.1–99.9), respectively; transient-deficit estimates ranged from 9.6% (4.5–17.4) to 50.0% (15.7–84.3). Zero permanent deficits after eight operations retained an upper 95% bound of 36.9%. Functional outcome was mRS 0–2 in 25/28 at 20 months and 29/40 at 23 months; Nathal et al. reported 41/43 at 12 months [8, 9, 13].

Definitions and reporting windows differed, and duplicate enrollment between Wang and Liu could not be excluded; study estimates were therefore displayed separately (Figs. 2a, 3a, and 4a).

3.4 Stereotactic radiosurgery

The only dedicated SRS cohort included 87 patients (median target volume 3.85 cm³, margin dose 20 Gy, follow-up 64 months) [3]. Imaging-confirmed obliteration occurred in 43 patients; actuarial total obliteration was 35% at 3 years, 60% at 4–5 years, and 76% at 10 years. Cumulative post-SRS hemorrhage was 5% at 1, 5, and 10 years (approximately 1% annually during latency), with no event after confirmed obliteration. Engel I outcome was 19/36 (52.8%; 95% CI 35.5–69.6), delayed cyst formation 3/87 (3.4%; 0.7–9.7), and permanent radiation deficit 0/87 (upper 95% bound 4.2%). Mortality was NR, and actuarial endpoints were not converted to crude proportions.

Pabaney's eight-patient SRS arm was non-independent because outcomes covered the full 15-patient mixed cohort and one patient crossed over to surgery [14]. Total-cohort outcomes were unchanged in 9, worse in 3, and improved in 2 patients, accounting for 14/15; the remaining outcome was not imputed. No pooled SRS estimate was calculated (Figs. 2b, 3b, and 4b).

3.5 Endovascular treatment

No dedicated series of curative embolization for true sylvian-fissure AVMs was identified. Su and Yu reported 135 MCA-region AVMs, including 16 Type II lesions around the fissure [20]. Type II outcomes were not separable. In the whole cohort, less than one third, one third to two thirds, and more than two thirds of the nidus were embolized in 22/135, 64/135, and 49/135 patients, respectively; 4/16 Type II lesions were in the last category. Intraprocedural bleeding occurred in 4/135 (3.0%; 95% CI 0.8–7.4), discharge GOS 4–5 in 131/135 (97.0%; 92.6–99.2), and discharge mortality in 0/135 (upper 95% bound 2.7%). These whole-cohort, short-term estimates cannot be transferred to Type II lesions as durable treatment effects.

In the mixed perisylvian cohort, embolization was adjunctive [14]. Current guidance supports such use while considering evidence for primary curative embolization uncertain [6]. Endpoints are summarized in Figs. 2c, 3c, and 4c.

3.6 Anatomical classification and risk-of-bias appraisal

The Sugita scheme remains the most reproducible location-based classification in the dedicated surgical literature [8, 14, 21]. It clarifies the relationship of the nidus to the fissure, insula, and MCA branches, but has not been validated as an independent predictor of outcome. S–M grade, rupture status, compactness, deep venous drainage, arterial passage vessels, and functional eloquence remain essential descriptors [8, 9, 19].

All treatment reports were non-randomized and mainly retrospective. Recurrent concerns were selected cases, inconsistent anatomical boundaries, confounding by indication, incompletely separated adjunctive treatments, variable angiographic confirmation and follow-up, possible overlap, and selective outcome reporting. Applicability was considered separately: broader cohorts could have coherent methods yet remain indirect when sylvian outcomes were inseparable, whereas dedicated series could be directly applicable but internally biased. No numerical score or formal certainty grade was assigned.

4 Discussion

4.1 Principal findings

The evidence base remains small, anatomically heterogeneous, and dominated by selected microsurgical series. Pooling was invalid because surgical outcomes were immediate, SRS efficacy was time-dependent, multimodal cohorts contained crossover, and EVT lacked subtype-specific outcomes. This update extends the earlier review [22] by incorporating dedicated SRS and later MCA-region EVT data, separating direct from contextual anatomy, and adding study-level uncertainty without unsupported comparisons.

Exact intervals reinforce restraint: 100% resection in eight patients remains compatible with a true value as low as 63.1%, while 0/8 permanent deficits permits a risk up to 36.9%. Larger cohorts are more precise but remain affected by selection, inconsistent endpoints, and possible overlap. The modalities answer different questions—immediate surgical removal, delayed actuarial SRS obliteration, and whole-cohort EVT procedural outcomes—so they cannot be ranked.

4.2 Interpretation of microsurgical evidence

Microsurgery offers immediate angiographic cure and avoids the latency inherent to SRS. Favorable outcomes are reported in experienced centers [8, 13, 21, 26], but referral patterns, surgeon experience, lesion grade, rupture status, and the dissection plane limit

generalizability. A low complication rate in a selected cohort does not estimate risk in unselected patients.

Recurring technical principles are wide fissure opening, early identification of MCA arteries of passage, circumferential disconnection of true feeders, preservation of draining veins until nidus isolation, and avoidance of unnecessary parenchymal transgression [8, 13, 21, 26]. Functional mapping and tract-based planning are especially relevant in dominant-hemisphere lesions [5, 10]. These observations remain procedural, not comparative evidence.

4.3 Interpretation of SRS and endovascular evidence

SRS is supported principally by one institutional cohort. Its actuarial curve shows why a single crude proportion is misleading: obliteration increased with follow-up [3]. SRS may suit small, compact lesions with unfavorable surgical anatomy, but latency hemorrhage and prolonged imaging surveillance remain. The report did not provide mortality; 0/87 permanent radiation deficits still allowed an upper 95% bound of 4.2%. Future series should report numbers at risk and uncertainty around prespecified time points.

EVT evidence supports a role within multidisciplinary treatment, not a location-specific claim of stand-alone cure. Targeted embolization may address high-risk angioarchitectural features or facilitate surgery, but these objectives must be distinguished from complete and durable obliteration [6, 14, 20]. Whole-MCA discharge outcomes neither establish Type II efficacy nor describe late hemorrhage. Subtype-specific denominators and long-term follow-up are required.

4.4 Clinical interpretation

Treatment should be individualized by a multidisciplinary cerebrovascular team. A compact, accessible, low-grade nidus with a favorable plane presents a different decision from a small eloquent lesion without a safe corridor, or a ruptured lesion with a flow-related aneurysm that may require targeted embolization. Microsurgery may provide immediate cure in the first setting; SRS may offer delayed obliteration in the second. Embolization should be labeled as targeted, adjunctive, staged, palliative, or curative and judged against that purpose. Available data support this framework but do not compare its pathways.

4.5 Strengths and limitations

Strengths include the multi-database search, explicit anatomical stratification, source-level verification, separation of crude and actuarial endpoints, structured SWiM synthesis, exact study-level CIs, and distinct assessment of internal validity and anatomical applicability. Outcomes were retained in their original time horizons rather than forced into a cross-modality summary.

Limitations include absent prospective registration and unavailable database-specific search histories, which precluded full PRISMA-S reproducibility. Two reports could not be retrieved; older non-English reports had limited metadata; and broader cohorts often lacked separable sylvian outcomes. Aggregate data prevented adjustment for age, rupture, grade, compactness, venous drainage, eloquence, treatment era, or center volume. Outcome windows ranged from discharge to actuarial 10-year follow-up, and Pabaney's categories accounted for 14/15 patients. Exact CIs address sampling uncertainty but not selection bias, confounding, missing outcomes, non-independent arms, or overlap. Without patient-level data or a common estimand, meta-regression and formal modality or subtype comparisons were not defensible.

5 Conclusions

Microsurgery is an effective option for carefully selected, accessible sylvian-fissure AVMs in experienced centers; SRS provides progressive obliteration with latency risk. Dedicated evidence does not support a location-specific claim of curative stand-alone embolization, and observational data cannot rank modalities. Prospective multicenter registries should use uniform anatomy, provide subtype and treatment-specific denominators, report obliteration angiographically, and standardize neurological and functional follow-up. Patient-level data, prespecified time windows, and independent reporting of each treatment component are more informative than a pooled percentage from the present series.

Abbreviations

1. AVM
Arteriovenous malformation
2. DSA
Digital subtraction angiography

- 3. EVT
Endovascular treatment
- 4. GOS
Glasgow Outcome Scale
- 5. HAC
High applicability concern
- 6. HC
High concern
- 7. KPS
Karnofsky Performance Status
- 8. LGB
Lateral geniculate body
- 9. LSC
Low-to-some concern
- 10. MCA
Middle cerebral artery
- 11. mRS
Modified Rankin Scale
- 12. NR
Not reported
- 13. NS
Not significant
- 14. SC
Some concern

Declarations

Competing interests:

The authors declare no competing interests.

Ethics approval:

Not applicable. This systematic review used published aggregate data and did not involve new research with human participants or animals.

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Author Contribution

All authors contributed to the conception of the review, interpretation of the evidence, and critical revision of the manuscript. A.N. Konovalov coordinated the work and prepared the initial manuscript draft. All authors read and approved the final manuscript.

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Data availability:

The study-level data used in the figures and tables are provided in the article. Source publications are identified in the reference list. Exact database-specific electronic search histories were not available for this update.

Code availability:

Not applicable.

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Figures

PRISMA 2020 flow diagram

Sylvian-fissure-region AVMs: systematic review and critical evidence synthesis

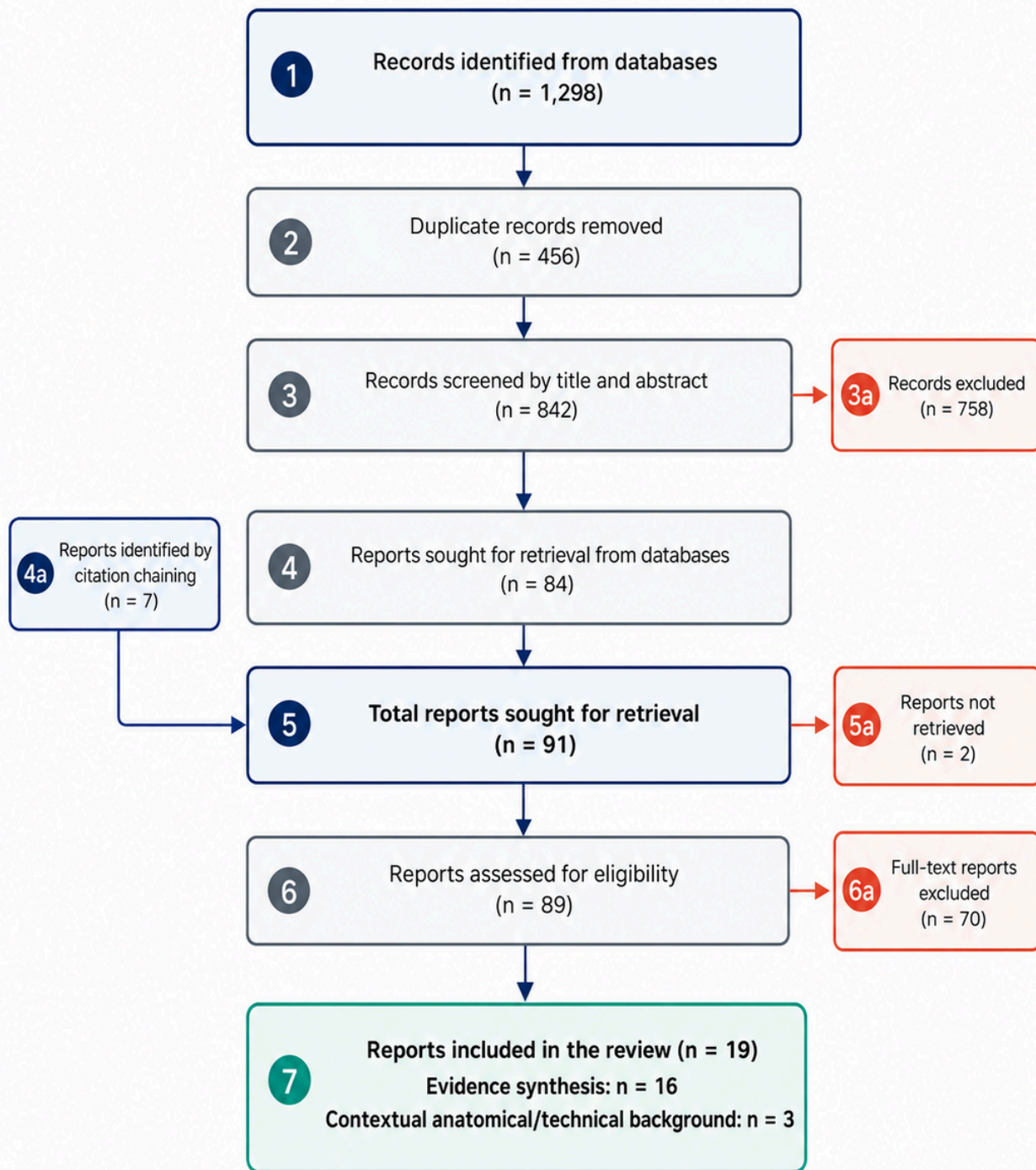


Figure 1

PRISMA 2020 flow diagram

Completeness-of-treatment endpoints reported for each modality

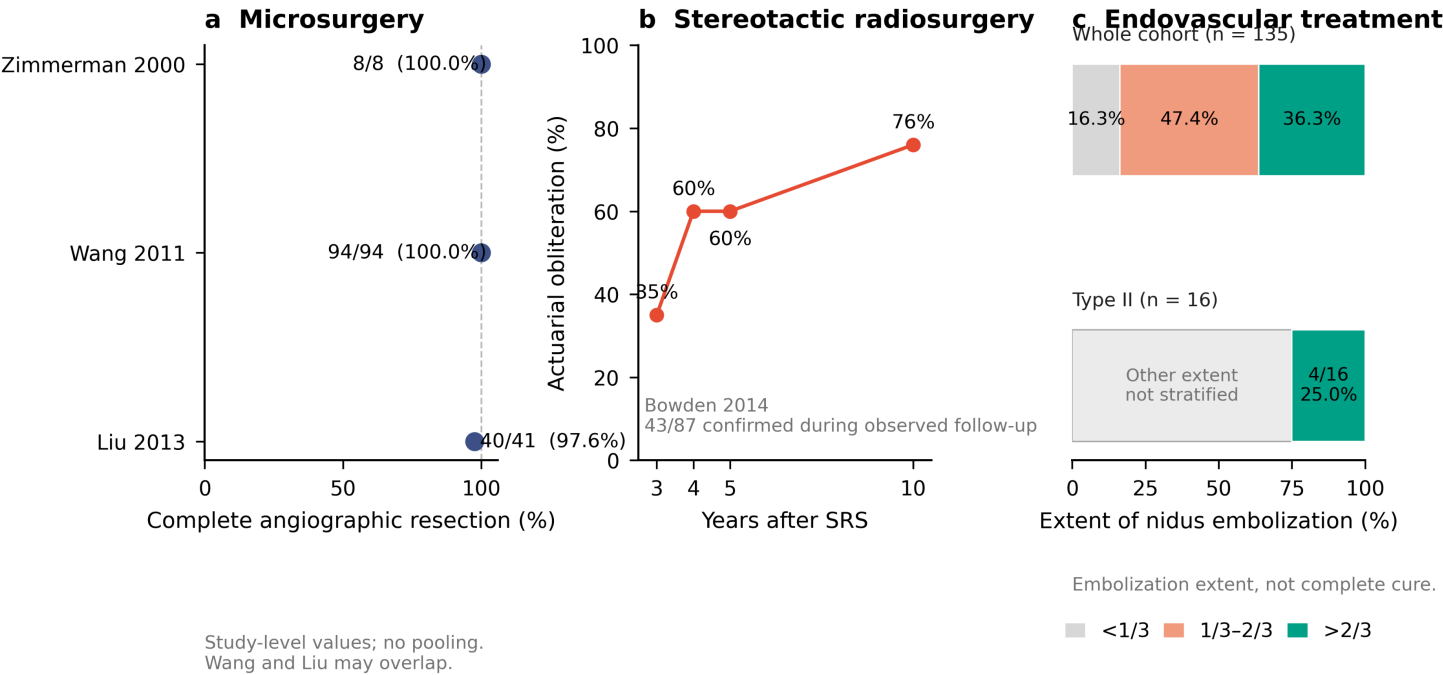


Figure 2

Completeness-of-treatment endpoints by modality. a Microsurgery: complete angiographic resection in Zimmerman et al. (8/8), Wang et al. (94/94), and Liu et al. (40/41); Wang and Liu may include overlapping patients and were not pooled. b SRS: actuarial total obliteration in Bowden et al. at 3, 4, 5, and 10 years; 43/87 patients had imaging-confirmed obliteration during observed follow-up. c EVT: extent of nidus embolization in the whole MCA-region cohort and the proportion of Type II lesions in which more than two thirds of the nidus was embolized in Su and Yu. Endovascular values describe embolization extent, not complete angiographic cure. The panels are descriptive and are not a direct comparison

Mortality endpoints: study-level data and explicit non-reporting

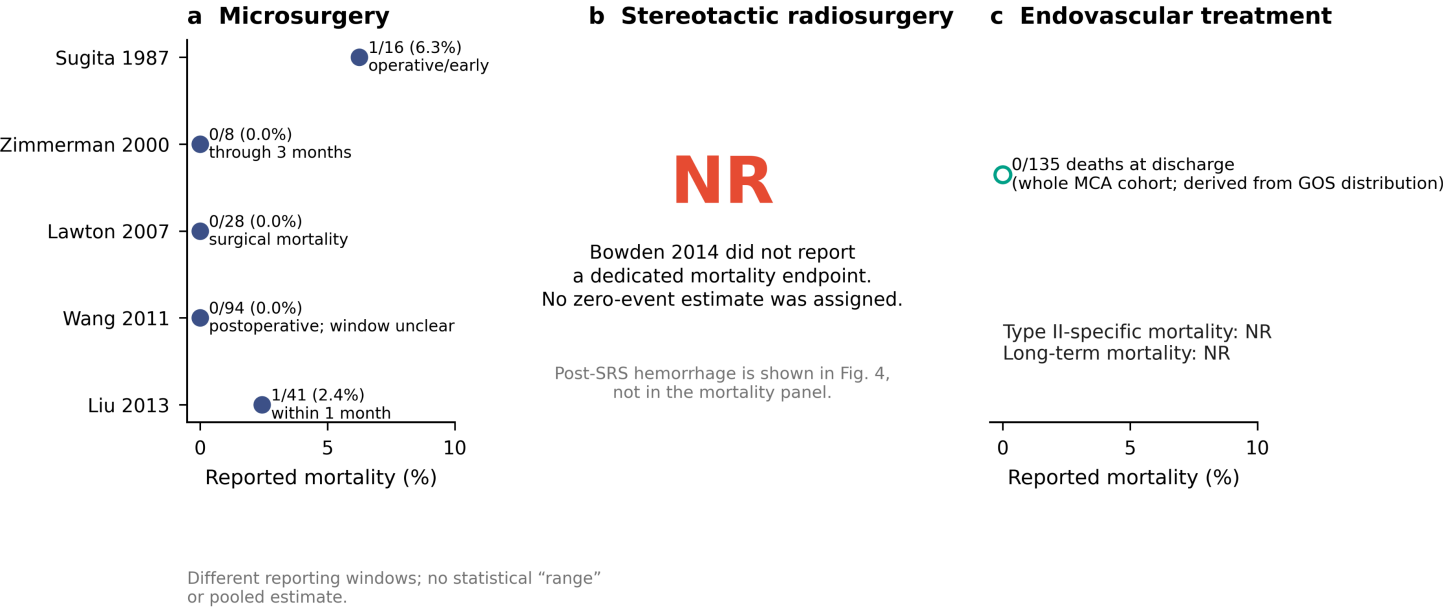


Figure 3

Mortality endpoints by modality. a Microsurgery: study-level mortality counts are shown with the reporting window used by each source; no statistical range or pooled estimate was calculated. b SRS: mortality was not reported in Bowden et al. and is displayed only as NR, without a zero-event point. Post-SRS hemorrhage is not a mortality endpoint and is shown in Fig. 4. c EVT: the full discharge GOS distribution in the Su and Yu whole MCA-region cohort contained no GOS 1 outcome, corresponding to 0/135 deaths at discharge; Type II-specific and long-term mortality were NR

Reported complications and adverse outcomes

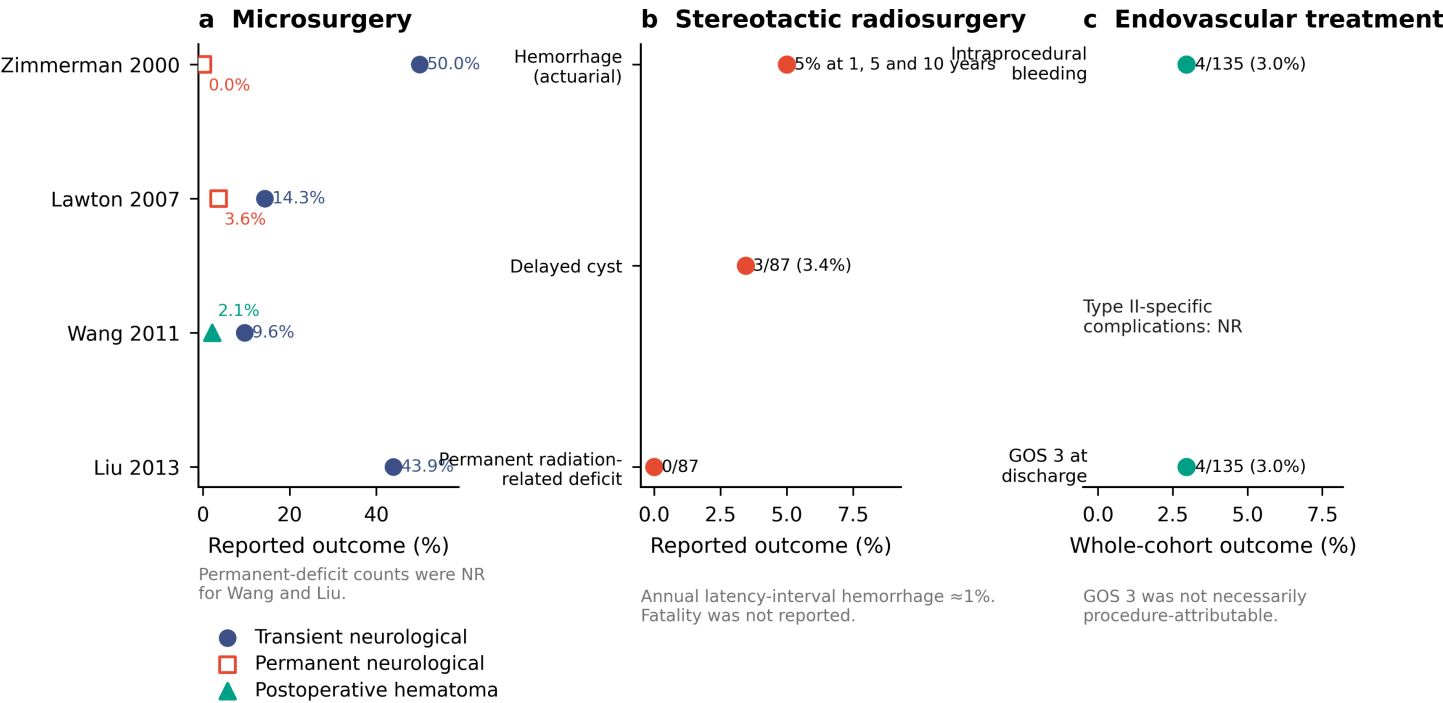


Figure 4

Reported complications and adverse outcomes. a Microsurgery: transient neurological outcomes were reported in 4/8 patients in Zimmerman et al., 4/28 in Lawton et al., 9/94 in Wang et al., and 18/41 in Liu et al.; permanent neurological outcomes were 0/8 at 3 months in Zimmerman et al. and 1/28 in Lawton et al., while separate permanent-deficit counts were NR in Wang and Liu. Wang et al. also reported postoperative hematoma in 2/94. b SRS: cumulative actuarial post-SRS hemorrhage was 5% at 1, 5, and 10 years, delayed cyst formation occurred in 3/87, and permanent radiation-related neurological deficit was 0/87; the annual latency-interval hemorrhage rate was approximately 1%, and hemorrhage fatality was NR. c EVT: intraprocedural bleeding and GOS 3 at discharge each occurred in 4/135 patients in the whole Su and Yu cohort; Type II-specific complication counts were NR, and GOS 3 was not necessarily procedure-attributable

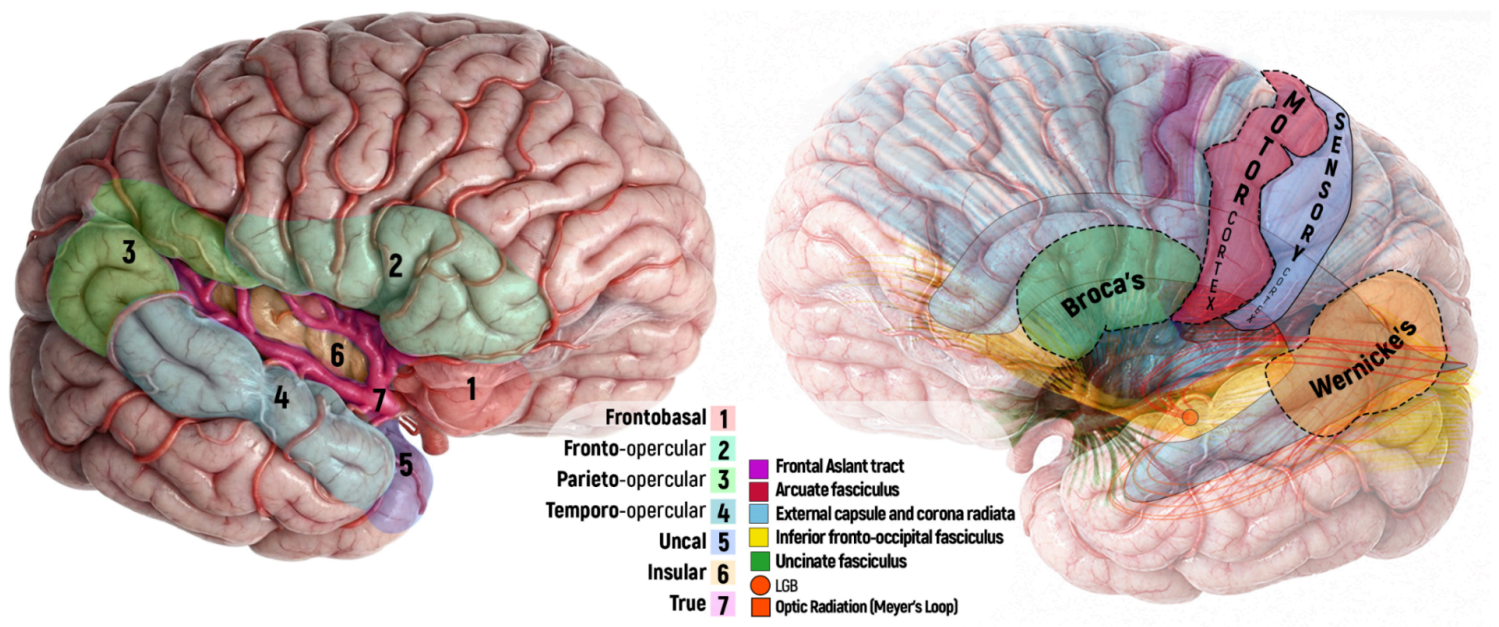


Figure 5

Topographic and functional anatomy of the sylvian and perisylvian region. Left, representative anatomical subregions relevant to lesion description: frontobasal (1), fronto-opercular (2), parieto-opercular (3), temporo-opercular (4), uncal (5), insular (6), and true sylvian-fissure (7). Right, schematic relationship of the sylvian region to the motor and sensory cortices, Broca and Wernicke language areas, and major subcortical pathways potentially at risk during treatment: the frontal aslant tract, arcuate fasciculus, external capsule and corona radiata, inferior fronto-occipital fasciculus, uncinate fasciculus, lateral geniculate body, and optic radiation (Meyer loop). The schematic illustration and descriptive labels do not represent patient-specific anatomy or constitute a validated prognostic grading system