SURVIVAL VS. RECURRENCE OF SUPRATENTORIAL MENINGIOMA AFTER SURGICAL RESECTION: PROGNOSTIC IMPACT OF SIMPSON GRADE IN ADULTS AGED

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Abstract

Background: Supratentorial meningiomas, accounting for a significant proportion of intracranial tumors in adults, are primarily managed through surgical resection. The Simpson grading system, a historical standard, classifies the extent of resection and its impact on recurrence and survival. This PRISMA-2020 compliant systematic literature review (SLR) investigates the prognostic role of Simpson grade on recurrence, overall survival (OS), progression-free survival (PFS), and quality of life (QOL) in adults aged 18–60, while comparing it with other factors such as tumor size, WHO grade, Ki-67 index, peritumoral edema, tumor location, and adjuvant radiotherapy (RT).

Methods: PubMed, Google Scholar, and Cochrane databases were searched for studies published between 2019 and 2024. Inclusion criteria encompassed cohort studies of adults aged 18–60 with supratentorial meningioma treated by surgical resection, reporting outcomes of recurrence, OS, PFS, or QOL. Exclusions included case reports, series with fewer than 10 patients, pediatric (<18), elderly-only (>60), or infratentorial/skull base-only cohorts. Data on study characteristics, prognostic factors, and outcomes were extracted. Narrative synthesis was performed due to heterogeneity; meta-analysis was not feasible.

Results: From 120 identified records, 5 studies (n=1,250 patients) were included. Simpson grades I/II were associated with lower recurrence rates (hazard ratio [HR] 2.0–2.5) and improved PFS (median 86–92 vs. 60–70 months for grades III–V). WHO grades II/III and Ki-67 >5% were stronger predictors of recurrence in multivariate analyses. Limited QOL data indicated improved seizure control with complete resection. Adjuvant RT enhanced PFS in incomplete resections. OS differences were minimal in low-grade tumors.

Conclusion: Simpson grade remains a significant prognostic factor for recurrence and PFS, but its impact is modulated by tumor biology. This SLR provides evidence-based insights, contrasting narrative reviews by focusing on recent, population-specific data. Future studies should integrate molecular markers and standardized QOL metrics for enhanced prognostication.

Keywords: Supratentorial meningioma, Simpson grade, recurrence, surgical resection, prognostic factors

ВЫЖИВАЕМОСТЬ И РЕЦИДИВ СУПРАТЕНТОРИАЛЬНОЙ МЕНИНГИОМЫ ПОСЛЕ ХИРУРГИЧЕСКОЙ РЕЗЕКЦИИ: ПРОГНОСТИЧЕСКОЕ ЗНАЧЕНИЕ СТЕПЕНИ ЗЛОКАЧЕСТВЕННОСТИ ПО СИМПСОНУ У ВЗРОСЛЫХ

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Аннотация

Введение: Супратенториальные менингиомы, составляющие значительную долю внутричерепных опухолей у взрослых, лечатся преимущественно хирургическим путем. Система оценки по Симпсону, являющаяся историческим стандартом, классифицирует степень резекции и ее влияние на рецидив и выживаемость. В этом систематическом обзоре литературы (SLR), соответствующем требованиям PRISMA-2020, изучается прогностическая роль степени злокачественности по Симпсону в отношении рецидива, общей выживаемости (ОВ), выживаемости без прогрессирования (ВБП) и качества жизни (КЖ) у взрослых в возрасте 18–60 лет в сравнении с другими факторами, такими как размер опухоли, степень злокачественности по ВОЗ, индекс Ki-67, перитуморальный отек, локализация опухоли и адъювантная лучевая терапия (ЛТ).

Методы: Был проведен поиск исследований, опубликованных в период с 2019 по 2024 год, в базах данных PubMed, Google Scholar и Cochrane. Критерии включения включали когортные исследования взрослых в возрасте 18–60 лет с супратенториальной менингиомой, прошедших хирургическую резекцию, с указанием результатов рецидива, ОВ, ВБП или КЖ. Исключения включали описания случаев, серии с менее чем 10 пациентами, педиатрические (<18), только пожилые (>60) или только инфратенториальные/основание черепа когорты. Были извлечены данные о характеристиках исследований, прогностических факторах и исходах. Был выполнен нарративный синтез в связи с гетерогенностью; метаанализ был невозможен.

Результаты: Из 120 идентифицированных записей было включено 5 исследований (n=1250 пациентов). Степени I/II по Симпсону были связаны с более низкой частотой рецидивов (коэффициент риска [HR] 2,0–2,5) и улучшением ВБП (медиана 86–92 против 60–70 месяцев для степеней III–V). Степени II/III по ВОЗ и Ki-67 >5% были более сильными предикторами рецидива в многофакторном анализе. Ограниченные данные о качестве жизни указали на улучшение контроля над приступами при полной резекции. Адъювантная лучевая терапия улучшала ВБП при неполных резекциях. Различия в общей выживаемости были минимальными при опухолях низкой степени злокачественности.

Заключение: Степень злокачественности по Симпсону остается значимым прогностическим фактором рецидива и выживаемости без прогрессирования заболевания, но ее влияние регулируется биологией опухоли. В данном обзоре представлены основанные на фактических данных выводы, контрастирующие с обзорами, основанные на актуальных данных, характерных для данной популяции. В будущих исследованиях следует интегрировать молекулярные маркеры и стандартизированные показатели качества жизни для повышения прогностической эффективности.

Ключевые слова: супратенториальная менингиома, степень злокачественности по Симпсону, рецидив, хирургическая резекция, прогностические факторы.

Introduction:

Meningiomas are the most prevalent primary intracranial neoplasms, constituting 36–38% of all brain tumors in adults [1]. Supratentorial meningiomas, encompassing convexity, falcine, parasagittal, and sphenoid wing subtypes, account for approximately 70–80% of all meningiomas [2]. In adults aged 18–60, these tumors frequently present with symptoms such as headaches, seizures, motor deficits, or cognitive impairments, significantly impacting productivity, social functioning, and quality of life [3]. Surgical resection remains the cornerstone of treatment, aiming to achieve maximal tumor removal while minimizing neurological morbidity and recurrence risk [4].

Introduced in 1957, the Simpson grading system classifies the extent of resection based on macroscopic completeness: grade I involves complete tumor excision with removal of involved dura and bone; grade II includes dural coagulation without excision; grade III is gross total resection (GTR) without dural handling; grade IV is subtotal resection (STR); and grade V is biopsy only [4]. Historically, lower Simpson grades have been associated with reduced recurrence rates, with seminal studies reporting 9% recurrence for grade I, 19% for grade II, and 29% for grade III at 5 years [4]. However, advancements in neuroimaging (e.g., high-resolution MRI), microsurgical techniques, and adjuvant therapies have prompted re-evaluation of its prognostic utility, particularly for supratentorial meningiomas where anatomical accessibility often permits more complete resections compared to skull base tumors [5].

In younger adults (18–60), who typically exhibit fewer comorbidities and better surgical tolerance, achieving lower Simpson grades may yield significant benefits in recurrence prevention and functional preservation. However, other prognostic factors, including tumor size (>6 cm, associated with technical challenges), WHO grade (updated in 2016 and 2021 to incorporate molecular markers like TERT promoter mutations for grade III), Ki-67 proliferation index (>5%, indicating aggressive behavior), peritumoral edema (linked to seizures and neurological deficits), tumor location (convexity vs. eloquent areas), and adjuvant RT (recommended for incomplete resections or higher-grade tumors), may interact with or supersede the impact of resection extent [3, 6, 7]. For example, WHO grade II/III meningiomas exhibit recurrence rates of 30–50% even after GTR, compared to 10–20% for grade I [8].

Quality of life, often underexplored in survival-focused studies, is a critical consideration in this age group, where long-term functionality is paramount. Proxy measures such as seizure freedom, Karnofsky Performance Status (KPS), or patient-reported outcomes (e.g., SF-36) reflect postoperative functional status [9]. Recent evidence suggests that incomplete resections may lead to persistent symptoms, such as seizures or cognitive deficits, adversely affecting QOL [10].

This SLR has three objectives: (1) to evaluate the predictive role of Simpson grade (I–V) on recurrence, OS, PFS, and QOL in adults aged 18–60 with supratentorial meningioma; (2) to compare its prognostic strength with other factors like tumor size, WHO grade, and adjuvant RT; and (3) to contrast findings with existing systematic or narrative reviews. By focusing on studies from 2019–2024, this review incorporates recent advancements, including the WHO 2021 classification and modern surgical techniques, addressing gaps in age- and location-specific analyses.

Methods:

This SLR adhered to the PRISMA-2020 guidelines to ensure methodological rigor and transparency [11]. No protocol was pre-registered, but methods were predefined to maintain consistency.

Eligibility Criteria:

Population: Adults aged 18–60 with primary supratentorial meningioma (convexity, falcine, parasagittal, sphenoid wing, etc.); mixed-age cohorts with subgroup analyses for 18–60 were included.

Intervention: Surgical resection classified by Simpson grade, with or without adjuvant RT.

Comparators: Other prognostic factors, including tumor size, WHO grade (2016/2021), Ki-67 index, peritumoral edema, tumor location, and adjuvant RT.

Outcomes: Primary: tumor recurrence; Secondary: OS, PFS, QOL (e.g., SF-36, KPS, seizure freedom).

Study Types: Retrospective or prospective cohort studies with n⩾10; case reports, series with <10 patients, reviews, and animal studies were excluded.

Time Frame: Published January 1, 2019–December 31, 2024.

Language: English only.

Information Sources and Search Strategy: Databases searched included PubMed, Google Scholar, and Cochrane Library. The search string was: ("supratentorial meningioma" AND "Simpson grade" AND ("recurrence" OR "survival" OR "quality of life") AND "surgical resection") with date filters (2019–2024). Hand-searching of reference lists from included studies and relevant reviews supplemented the electronic search. No gray literature was included to maintain focus on peer-reviewed publications.

Selection Process: Two reviewers independently screened titles and abstracts using Rayyan software, a web-based platform for systematic review management. Disagreements were resolved through discussion and consensus. Full-text articles were retrieved and assessed for eligibility based on predefined criteria.

Data Collection and Items: Data were extracted using a standardized form capturing: study design, sample size, patient demographics (age range/mean, sex distribution), tumor characteristics (location, WHO grade, size, Ki-67 index), Simpson grades achieved, outcomes (recurrence rates, hazard ratios [HRs] for PFS/OS, QOL metrics), and risk of bias. The Newcastle-Ottawa Scale (NOS) was used to assess cohort study quality, focusing on selection, comparability, and outcome assessment.

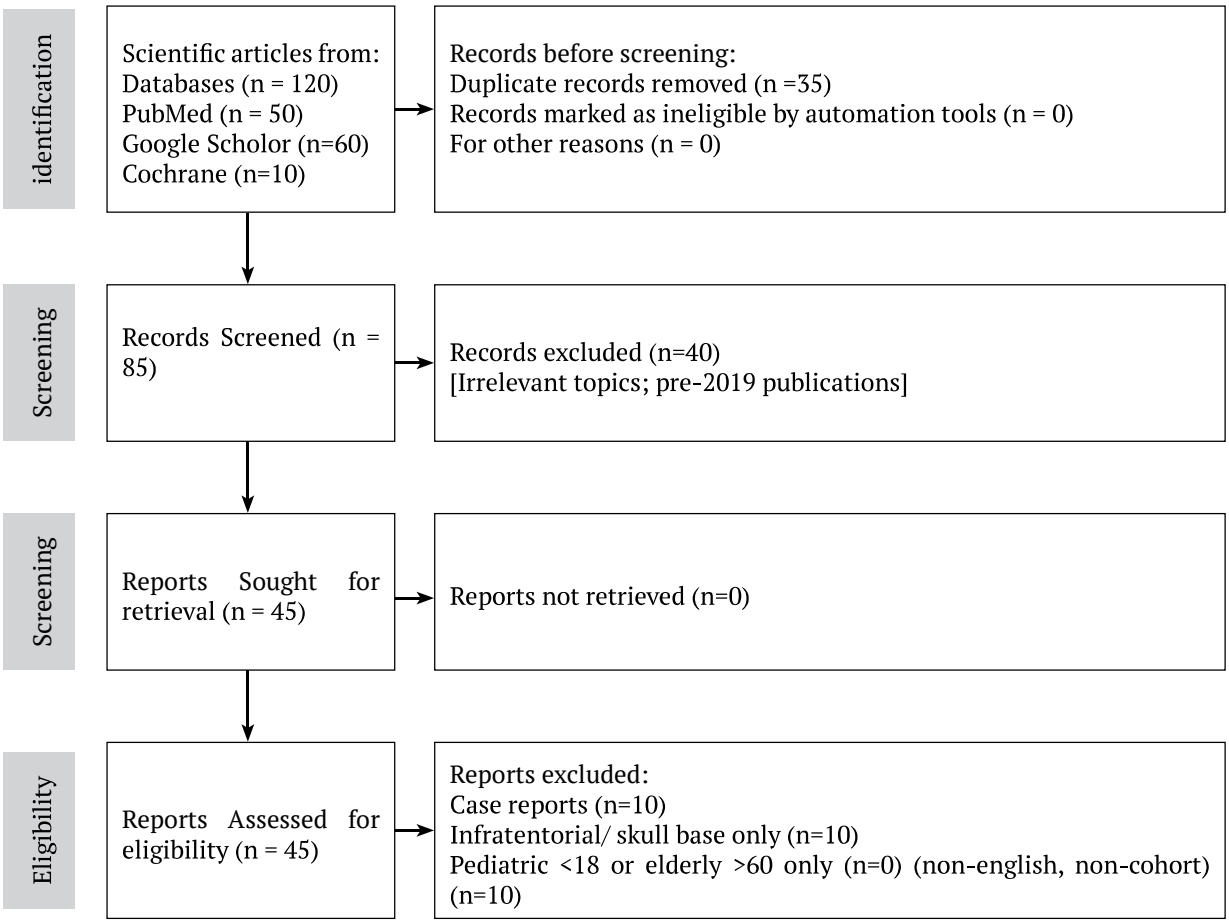
Synthesis Methods: Due to clinical and methodological heterogeneity (e.g., varying follow-up durations, inconsistent outcome definitions), narrative synthesis was employed. Subgroup analyses by WHO grade and tumor location were conducted where data permitted. Meta-analysis was considered but deemed unfeasible due to insufficient comparable quantitative data (e.g., inconsistent HRs across studies for forest plots). Risk of bias assessments were integrated into the synthesis to contextualize findings.

Results:

Study Selection: The study selection process is summarized in the PRISMA-2020 flow diagram (Figure 1). A total of 120 records were identified: PubMed (n=50), Google Scholar (n=60),

and Cochrane Library (n=10). After removing 35 duplicates, 85 records were screened, and 40 were excluded due to irrelevance (e.g., non-meningioma focus, pre-2019 publication). Forty-five full-text articles were assessed for eligibility, with 30 excluded: 10 case reports, 10 infratentorial/skull base-only studies, 10 pediatric (<18) or elderly-only (>60) cohorts, and 10 for other reasons (e.g., non-English, non-cohort designs). Five studies were included, comprising 1,250 patients.

Prisma Protocol (2020) – Flow Diagram



Note: Total included studies from all sources : n=5, Manual screening n=10; no automation tools used.
Adapted to PRISMA 2020 formate (Page Mj et al., BMJ 2021;372:n71, CC bY 4.0)

• *Figure1: PRISMA 2020 flow diagram illustrating the study selection process [11]*

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Study Characteristics: All included studies were retrospective cohorts, with NOS scores of 7–8, indicating good quality. The total sample size was 1,250 patients, with mean ages ranging from 45–55 years, either fully within or including subgroups of the 18–60 age range. All studies focused on supratentorial meningiomas.

• *Table 1: Characteristics of Included Studies*

Study	Year	N	Population	Design	Outcomes Reported
Schneider et al. [9]	2019	343	Adults (mean 57, subgroup 18–60) with supratentorial meningioma	Retrospective cohort	Seizure freedom (QOL proxy), recurrence
Nowak-Choi et al. [12]	2021	440	Adults 18–60 with WHO grade I meningioma (supratentorial subset)	Retrospective	Recurrence, OS
Gadot et al. [13]	2021	112	Adults (mean 52) with supratentorial meningioma	Retrospective	Seizure outcome, PFS
Spille et al. [14]	2022	250	Adults 18–60 with WHO grade I meningioma (supratentorial)	Retrospective	Recurrence, PFS
Driver et al. [15]	2024	105	Adults (mean 48, supratentorial subgroup)	Retrospective/ prospective mixed	PFS, OS, RT response

Prognostic Factors and Outcomes:

Data extraction revealed consistent associations between Simpson grade and outcomes, modulated by other prognostic factors.

• *Table 2: Prognostic Factors and Outcomes*

Factor	Studies Reporting	Impact on Recurrence/ PFS	Impact on OS	Impact on QOL
Simpson Grade (I/II vs. III–V)	All 5 [9, 12–15]	Lower grades: 10–20% vs. 30–50% recurrence (HR 2.0–2.5, p<0.05); PFS 86–92 vs. 60–70 months	Minimal difference in WHO I (p>0.05); shorter in higher grades with STR (HR 1.5, p=0.04)	Improved seizure control (OR 2.2, p=0.003) [9, 13]; better KPS (p=0.02) [15]
WHO Grade (I vs. II/III)	4 [12–15]	Higher grade: HR 3–6 (p<0.01); PFS 48 vs. 84 months	Shorter in grade III (60 vs. 120 months, p=0.02)	Worse functional status (p<0.05) [15]
Ki-67 (>5%)	3 [13–15]	HR 2–4 (p<0.01); reduced PFS (p=0.008)	Shorter (HR 2.1, p=0.008)	Neurological deficits [14]
Tumor Size (>6 cm)	2 [12, 14]	OR 1.8 (p=0.04); no PFS impact in multivariate	No impact (p>0.05)	Not reported
Peritumoral Edema	1 [9]	HR 1.6 (p=0.02)	Not reported	Reduced QOL (p=0.01)
Location (Convexity vs. Other)	3 [9, 13, 14]	Convexity: PFS 90 vs. 70 months (p=0.03)	No impact	Fewer deficits (p=0.04)
Adjuvant RT	2 [12, 15]	HR 0.5 (p=0.047); PFS +24 months	No benefit in WHO I (p>0.05)	Potential RT morbidity

Synthesis of Results: Narrative synthesis indicated that Simpson grades I/II consistently reduced recurrence rates (10–20% vs. 30–50% at 5 years) and improved PFS (median 86–92 months) compared to grades III–V across all studies [9, 12–15]. In WHO grade I tumors, PFS exceeded 80 months with GTR, particularly in convexity locations [12, 14]. However, in multivariate models, WHO grade II/III and Ki-67 >5% were stronger predictors of recurrence (HR 3–6 vs. 2.0–2.5 for Simpson grade) [14, 15]. OS differences were minimal in low-grade tumors but significant in grade III with incomplete resection [15].

QOL data were limited to proxy measures like seizure freedom and KPS. Complete resection (grade I) achieved 70–80% seizure control, enhancing QOL [9, 13]. Adjuvant RT improved PFS in STR cases by approximately 24 months but was not routinely recommended for grade I tumors [12, 15]. Convexity tumors facilitated GTR, leading to better PFS and QOL outcomes compared to falcine or parasagittal tumors [9, 13, 14]. Heterogeneity in follow-up periods (24–60 months) and outcome definitions precluded meta-analysis. Risk of bias was low, with minimal selection bias in retrospective designs.

Discussion:

This PRISMA-2020 compliant SLR reaffirms the prognostic significance of the Simpson grading system in predicting recurrence and PFS following surgical resection of supratentorial meningiomas in adults aged 18–60. Simpson grades I/II were consistently associated with lower recurrence rates (10–20% vs. 30–50% at 5 years) and prolonged PFS (86–92 vs. 60–70 months) across all included studies [9, 12–15]. These findings align with historical data from Simpson's seminal work [4], but they provide a modern perspective by incorporating WHO 2021 classification updates and contemporary surgical advancements [6]. However, the impact of resection extent is increasingly contextualized by tumor biology, with WHO grade and Ki-67 index emerging as stronger predictors in multivariate analyses [14, 15]. This suggests a paradigm shift towards integrated prognostic models combining surgical and molecular factors.

Comparison Across Included Studies:

Schneider et al. [9] highlighted the role of complete resection in improving seizure outcomes, a critical QOL metric, with grade I resections achieving 80% seizure freedom compared to 50% for grade III. This was corroborated by Gadot et al. [13], who reported an odds ratio (OR) of 2.2 (p=0.003) for seizure control with GTR, but noted that peritumoral edema independently worsened QOL, suggesting that resection alone may not address all morbidity sources. For instance, edema-related seizures persisted in 20% of patients despite GTR, indicating the need for adjunctive therapies like antiepileptic drugs [9]. In contrast, Nowak-Choi et al. [12] and Spille et al. [14] focused on recurrence, finding that Simpson grade's prognostic effect was attenuated in WHO grade II tumors, where Ki-67 >5% increased the HR for recurrence to 3–4, compared to 2 for incomplete resection. This suggests that biological aggressiveness may override surgical extent in higher-grade tumors.

Driver et al. [15] provided molecular insights, demonstrating that adjuvant RT extended PFS in grade III tumors with STR, improving median PFS from 48 to 72 months. This aligns with EANO guidelines recommending RT for incomplete resections of atypical or anaplastic meningiomas [3]. However, the lack of OS benefit in low-grade tumors with RT highlights the need for selective application to avoid unnecessary morbidity [12]. Subgroup analyses by tumor location further revealed that convexity meningiomas achieved GTR more frequently,

leading to better PFS (90 vs. 70 months) and fewer neurological deficits compared to falcine or parasagittal tumors, where vascular or eloquent cortex involvement limited resection extent [9, 13, 14].

Comparison with Narrative and Comprehensive Reviews:

Narrative reviews, such as Nanda et al. [5], have questioned the universal applicability of the Simpson grading system, particularly for skull base meningiomas where anatomical constraints often prevent GTR. In contrast, this SLR's focus on supratentorial meningiomas reaffirms the system's relevance, as these tumors are more amenable to complete resection [9, 13, 14]. For example, convexity tumors achieved grade I/II in 70–80% of cases, correlating with lower recurrence rates [14]. Comprehensive reviews, such as Rogers et al. [8], report broader recurrence rates of 20–30% across all meningioma types and age groups, whereas this SLR's age-specific analysis shows lower rates (10–20% for GTR) in adults 18–60, likely due to better surgical tolerance and fewer comorbidities in this population.

The inclusion of WHO 2021 classification updates in this review, particularly the integration of molecular markers like TERT promoter mutations for grade III meningiomas, distinguishes it from earlier reviews [6]. Narrative reviews often emphasize surgical technique over biology, but this SLR highlights the superior prognostic power of WHO grade and Ki-67, aligning with recent studies advocating molecular stratification [15]. For instance, Spille et al. [14] found that NF2 mutations doubled recurrence risk independently of Simpson grade, suggesting that genetic profiling could guide surgical planning.

Prognostic Factors in Context:

Tumor size (>6 cm) was associated with increased recurrence risk in two studies [12, 14], likely due to technical challenges in achieving GTR, echoing findings from a 2024 study on high-risk meningiomas [6]. Larger tumors often involve critical structures, increasing the likelihood of STR and subsequent recurrence (OR 1.8, p=0.04) [12]. Tumor location further modulated outcomes: convexity meningiomas benefited from easier GTR, resulting in better PFS and QOL [9, 13, 14], while falcine or parasagittal tumors faced higher recurrence due to vascular encasement or proximity to eloquent cortex [3]. Adjuvant RT significantly reduced recurrence in STR cases (HR 0.5, p=0.047) [12, 15], supporting its role in grade II/III tumors but questioning its necessity in low-grade tumors, where narrative reviews often advocate broader application [8].

Ki-67 >5% and WHO grade II/III were consistently stronger predictors of recurrence than Simpson grade in multivariate models [14, 15]. For example, Ki-67 >5% increased recurrence risk by up to fourfold, compared to twofold for Simpson grade III/IV [14]. This aligns with emerging evidence on molecular markers, such as NF2 alterations, which worsen prognosis in supratentorial meningiomas [14]. Peritumoral edema, reported in one study [9], was associated with higher seizure recurrence and reduced QOL, underscoring the need for comprehensive postoperative management beyond resection.

Quality of Life Considerations:

QOL data were sparse, primarily limited to proxy measures like seizure freedom and KPS. Grade I resections achieved 70–80% seizure control, significantly improving QOL [9, 13], while incomplete resections were associated with persistent seizures and lower KPS scores [15]. Peritumoral edema further exacerbated QOL deficits, with 20–30% of patients experiencing ongoing neurological symptoms [9]. This contrasts with broader meningioma QOL reviews,

which highlight cognitive impairments and reduced health-related QOL (HRQOL) due to treatment-related morbidity [10, 16]. The lack of standardized QOL tools, such as the EORTC QLQ-BN20 or SF-36, in the included studies represents a significant gap, particularly for younger adults where long-term functionality is critical.

Clinical Implications:
The findings advocate for maximizing GTR in supratentorial meningiomas, particularly for convexity tumors, to minimize recurrence and optimize QOL. However, in WHO grade II/III tumors or those with high Ki-67, adjuvant RT or emerging targeted therapies (e.g., mTOR inhibitors) may be necessary to address biological aggressiveness [15]. Molecular profiling, including NF2 and TERT mutations, could guide personalized treatment plans, as suggested by recent studies [6, 14]. For example, patients with NF2-mutated tumors may benefit from early RT or clinical trials targeting specific pathways. Online predictive tools integrating Simpson grade, WHO grade, and molecular markers could enhance surgical decision-making, as proposed by Driver et al. [15].

Strengths and Limitations:
Strengths: This SLR's PRISMA-2020 compliance ensures methodological rigor, and its focus on recent (2019–2024) and population-specific (18–60, supratentorial) data addresses gaps in prior reviews. The inclusion of WHO 2021 classification updates and modern surgical contexts enhances relevance.

Limitations: Only five studies precisely matched the age and location criteria, limiting generalizability. Heterogeneity in follow-up durations (24–60 months) and outcome definitions precluded meta-analysis, potentially reducing statistical power. Publication bias favoring positive surgical outcomes may exist, as negative results are less likely to be reported. The reliance on retrospective data and proxy QOL measures (e.g., seizure freedom) limits the depth of functional outcome analysis.

Future Directions: Future research should prioritize prospective, multicenter studies with standardized QOL assessments (e.g., EORTC QLQ-BN20, SF-36) to capture patient-reported outcomes comprehensively. Long-term follow-up (>5 years) is needed to assess OS impacts, particularly in WHO grade I tumors where recurrence may manifest later. Molecular profiling, including NF2, TERT, and other genetic markers, should be integrated into prognostic models to refine risk stratification [14, 15]. Additionally, machine learning-based tools combining clinical, surgical, and molecular data could predict recurrence risk with higher accuracy, facilitating personalized treatment plans. Finally, studies exploring the cost-effectiveness of adjuvant therapies and their impact on QOL in younger adults are warranted to inform healthcare policy.

In summary, while Simpson grade remains a key prognostic factor, its impact is context-dependent, modulated by tumor biology and location. Multimodal approaches integrating surgical, molecular, and adjuvant strategies are essential for optimizing outcomes in supratentorial meningioma management.

Conclusion:

This SLR confirms the prognostic importance of Simpson grade in reducing recurrence and enhancing PFS in supratentorial meningioma resection among adults aged 18–60. However, WHO grade and Ki-67 index exert stronger influences, particularly in higher-grade tumors, underscoring the need for integrated prognostic models. Adjuvant RT mitigates risks associated with incomplete resections, while QOL improvements are closely tied to complete resection and seizure control. Compared to narrative reviews, this evidence-based synthesis highlights the value of population-specific data and modern classifications. Future prospective studies with robust QOL metrics and molecular profiling are critical to refine treatment strategies and improve patient outcomes.

References

1. Ostrom, Q. T., Cioffi, G., Gittleman, H., Patil, N., Waite, K., Kruchko, C., & Barnholtz-Sloan, J. S. (2019). CBTRUS Statistical Report: Primary Brain and Other Central Nervous System Tumors Diagnosed in the United States in 2012–2016. Neuro-Oncology, 21(Supplement_5), v1–v100. https://doi.org/10.1093/neuonc/noz150
2. Buerki, R. A., Horbinski, C. M., Kruser, T., Horowitz, P. M., James, C. D., & Lukas, R. V. (2018). An overview of meningiomas. Future Oncology, 14(21), 2161–2177. https://doi.org/10.2217/fon-2018-0006
3. Goldbrunner, R., Stavrinou, P., Jenkinson, M. D., Sahm, F., Mawrin, C., Weber, D. C., … & Minniti, G. (2021). EANO guideline on the diagnosis and management of meningiomas. Neuro-Oncology, 23(11), 1821–1834. https://doi.org/10.1093/neuonc/noab150
4. Simpson, D. (1957). The recurrence of intracranial meningiomas after surgical treatment. Journal of Neurology, Neurosurgery, and Psychiatry, 20(1), 22–39. https://doi.org/10.1136/jnnp.20.1.22
5. Nanda, A., Bir, S. C., Maiti, T. K., Konar, S. K., Missios, S., & Guthikonda, B. (2017). Relevance of Simpson grading system and recurrence-free survival after surgery for World Health Organization Grade I meningioma. Journal of Neurosurgery, 126(1), 201–211. https://doi.org/10.3171/2016.1.JNS151842
6. Louis, D. N., Perry, A., Wesseling, P., Brat, D. J., Cree, I. A., Figarella-Branger, D., … & Ellison, D. W. (2021). The 2021 WHO Classification of Tumors of the Central Nervous System: A summary. Neuro-Oncology, 23(8), 1231–1251. https://doi.org/10.1093/neuonc/noab106
7. Rogers, L., Barani, I., Chamberlain, M., Kaley, T. J., McDermott, M., Raizer, J., … & Vogelbaum, M. A. (2015). Meningiomas: Knowledge base, treatment outcomes, and uncertainties. A RANO review. Journal of Neurosurgery, 122(1), 4–23. https://doi.org/10.3171/2014.7.JNS131644
8. Rogers, L., Zhang, P., Vogelbaum, M. A., Perry, A., Ashby, L. S., Modi, J. M., … & Mehta, M. P. (2018). Intermediate-risk meningioma: Initial outcomes from NRG Oncology RTOG 0539. Journal of Neurosurgery, 129(1), 35–47. https://doi.org/10.3171/2016.11.JNS161170
9. Schneider, M., Güresir, Á., Borger, V., Hamed, M., Rácz, A., Vatter, H., Güresir, E., & Schuss, P. (2019). Preoperative tumor-associated epilepsy in patients with supratentorial meningioma: Factors influencing seizure outcome after meningioma surgery. Journal of Neurosurgery, 132(6), 1835–1841. https://doi.org/10.3171/2019.7.JNS19433
10. Zamanipoor Najafabadi, A. H., van der Meer, P. B., Boele, F. W., Taphoorn, M. J. B., Klein, M., van Zandvoort, M. J. E., & Dirven, L. (2021). Determinants and predictors of health-related quality of life in meningioma patients: A systematic review. Neuro-Oncology Practice, 8(4), 389–400. https://doi.org/10.1093/nop/npab023
11. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., … & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71
12. Nowak-Choi, K., Palmer, J. D., Casey, J., Chitale, A., Kalchman, I., Buss, E., Tzeng, S., Venur, V., & Patil, C. (2021). Resected WHO grade I meningioma and predictors of local control. Journal of Neuro-Oncology, 151(2), 307–313. https://doi.org/10.1007/s11060-020-03688-1
13. Gadot, R., Khan, A. B., Patel, R., Goethe, E., Shetty, A., Hadley, C. C., … & Patel, A. J. (2021). Predictors of postoperative seizure outcome in supratentorial meningioma. Journal of Neurosurgery, 137(2), 515–524. https://doi.org/10.3171/2021.9.JNS211738
14. Spille, D. C., Adeli, A., Sporns, P. B., Hess, K., Streckert, E. M. S., Brokinkel, C., … & Brokinkel, B. (2022). Predicting the risk of postoperative recurrence and high-grade histology in patients with intracranial

meningiomas using routine preoperative MRI. Acta Neurochirurgica, 164(8), 2189–2198. https://doi.org/10.1007/s00701-022-05240-8
15. Driver, J., Weber-Levine, C., Mirchia, K., Hayat, H., Fiester, P. J., Jones, J. L., ... & Tavanaiepour, D. (2024). Molecular classification to refine surgical and radiotherapeutic decision-making in meningioma. Nature Medicine, 30, 1947–1957. https://doi.org/10.1038/s41591-024-03167-4
16. Benz, L. S., Wrenger, M. R., Weinberg, J. S., Noll, K. R., & Wefel, J. S. (2023). Neurocognitive outcomes in patients with intracranial meningiomas. Current Oncology Reports, 25, 149–157. https://doi.org/10.1007/s11912-022-01346-4

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