ORIGINAL ARTICLE

Risk-adapted Surveillance Strategies for Intracranial Meningiomas: A Retrospective Analysis of Post-operative Imaging

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Abstract

Background: Epidemiological research shows that meningiomas occur at a rate of 6 cases per 100,000 people, with women twice as likely as men to develop them. These tumors, which originate from arachnoid membrane cells, represent 13–26% of all brain tumors. This retrospective single-center study evaluated the importance of short-term post-operative imaging in patients with intracranial meningiomas, considering the extent of surgical removal (Simpson grade) and histological classification (World Health Organization [WHO] grade). **Methods:** The medical records of 283 patients who underwent surgical removal of intracranial meningiomas between 2016 and 2024 were reviewed. Logistic regression analysis identified WHO grade and post-operative radiation therapy as the most significant predictors of recurrence. **Results:** The risk of recurrence increased with higher WHO grades, with odds ratios of 3.18 and 6.59 for Grade II and Grade III meningiomas, respectively, compared with Grade I. The extent of resection within Simpson Grades I and II did not significantly affect early recurrence rates. The WHO grade I meningiomas with complete or nearly complete resection have a very low recurrence risk, suggesting that routine high-frequency post-operative imaging may have limited value in the absence of new neurological symptoms. In contrast, WHO grade II and III meningiomas showed significantly higher recurrence risks, warranting closer post-operative monitoring, especially in the early post-surgery period. **Conclusion:** These findings support a risk-adapted surveillance strategy based on the WHO tumor grade and clinical presentation, which could optimize resource utilization while maintaining oncological safety of the patients. Further prospective multicenter studies are required to refine evidence-based follow-up protocols for patients with intracranial meningiomas.

Key words: Epidemiological, intracranial, meningiomas, retrospective, Simpson grade, WHO grade

INTRODUCTION

Epidemiological research shows that meningiomas occur at a rate of 6 cases per 100,000 people, with women twice as likely as men to develop them. These tumors, which originate from arachnoid membrane cells, represent 13–26% of all brain tumors. Autopsy studies have shown that the incidence of meningiomas is 1.4%, including asymptomatic cases. Intracranial meningiomas are commonly diagnosed in individuals between 40 and 60 years old, and multiple tumors occur in fewer than 10% of patients.[1-3]

Most meningiomas are benign and classified as Grade I by the World Health Organization (WHO) histopathological standards, with well-defined edges and slow growth. Atypical meningiomas (WHO grade II) comprise 5–7% of cases and show increased cell division or three or more specific traits: High cellularity, small cells with a high nuclear-to-cytoplasmic ratio, large nucleoli, a uniform growth pattern, and areas of necrosis. Anaplastic meningiomas (WHO grade III) exhibit significant malignant characteristics exceeding those of atypical types, including malignant cell structures similar to sarcomas or carcinomas and high mitotic activity. Their occurrence is 1–3%. The outlook for meningiomas is positive: Population-based cancer registries

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Received: 08-11-2025
Revised: 21-12-2025
Accepted: 27-12-2025

show relative 5-year survival rates over 80%, 10-year survival at 74–79%, and 15-year survival at approximately 70%.[4-6]

Grade I meningiomas are benign, with a low mitotic rate (<4/10 high-power field) and no brain invasion. Grade II meningiomas show a mitotic rate of 4–19/10 high-power field, brain invasion, or three of five histological features (necrosis, prominent nucleoli, high cellularity, small cells with a high nucleus-to-cytoplasm ratio, and sheet-like growth). Grade III meningiomas have mitotic rates exceeding 20/10 high-power field or a malignant appearance, with high recurrence and poor survival rates. The distribution of meningiomas is 80% Grade I, 18% Grade II, and 2% Grade III.[7-9]

Most of the individuals diagnosed with meningioma undergo surgery to remove the tumor and alleviate the neurological issues. Identifying a tumor through neuroimaging or observing an enlarged residual tumor node does not warrant surgery. Complete removal often results in a cure. Radiation therapy is mainly used for partially removed, recurrent, or malignant meningiomas.[10-12]

Despite advancements in neurosurgical technology, the ability to fully resect tumors remains constrained by the skull's intricate anatomical structures. The extent of surgical resection was assessed using the Simpson scale, which categorizes operations from Grade I to V. This system, introduced by Simpson in 1957, outlines the recurrence rate of intracranial meningiomas after surgery. Although conducted retrospectively and before the advent of microsurgical techniques, computed tomography (CT), and magnetic resonance imaging (MRI), later publications have validated its clinical relevance. The Simpson scale is widely accepted for evaluating the extent of resection.[13-15]

After surgery and/or radiation therapy, patients undergo regular CT or MRI follow-up examinations to identify tumor recurrence or progression of the remaining tissue. However, limited evidence supports this practice; a literature search of the Cochrane Library and Medline found no studies assessing the effectiveness of post-operative imaging in meningiomas. The frequency and timing of follow-up examinations are determined individually by physicians based on each patient's follow-up care arrangements.[16,17]

This study aimed to evaluate the importance of short-term post-operative imaging studies in patients with intracranial meningiomas, considering the varying degrees of surgical removal and histological classification according to the WHO.

MATERIALS AND METHODS

This was a single-center retrospective observational study. Medical records of all patients with intracranial meningiomas surgically removed at the Neurosurgical Clinic of the National Hospital, Ministry of Health of the Kyrgyz Republic, between 2016 and 2024 were reviewed. The collected data included patient age at surgery, extent of tumor resection (Simpson scale), tumor location, WHO histological classification, post-operative radiation therapy status, recurrence detection date, and dates of follow-up CT and MRI scans.

A search of the Cochrane and Medline databases from 1980 to the present using pertinent keywords found no studies examining post-operative imaging following meningioma resection.

When the Simpson grade of resection was not explicitly mentioned in the surgical protocols, it was retrospectively assigned based on the surgical procedure description, following the criteria of the classification. The analysis included 283 cases, with the only eligibility requirement being the confirmed surgical removal of intracranial meningiomas between 2016 and 2024. Recurrence was identified as the emergence of new changes or the progression of existing changes on CT or MRI, compared to previous studies, including an increase in remaining tumor tissue. Typically, initial post-operative imaging was not conducted according to a single standardized protocol, regardless of the WHO histological tumor grade or Simpson resection category. Treatment strategies for recurrence were based on the tumor location and histological features; in most instances, a combination of repeat surgery and radiation therapy was employed.

Statistical analysis was performed using Statistical Package for the Social Sciences version 21, including descriptive statistics of patient demographics, tumor characteristics, resection extent, and recurrence rates. Multivariable logistic regression identified recurrence predictors, with stepwise inclusion guided by the Akaike Information Criterion. Odds ratios quantified the associations between the predictors and recurrence. Graphical analyses were performed to determine the recurrence incidence, follow-up imaging timing, and recurrence detection at 6-month intervals. A $P < 0.05$ was considered statically significant.

The Bioethics Committee of I.K. Akhunbaev Kyrgyz State Medical Academy approved this study (Approval no. 01/24, dated September 01, 2024). Given the anonymized data and the absence of patient intervention, formal consent was not required.

RESULTS

This study included 118 male and 165 female participants, with a mean age of 59 years (range, 22–89 years) [Table 1]. Figure 1 illustrates the patient distribution according to the WHO histological grade (I, II, and III), while Figure 2 depicts the distribution based on the Simpson resection grade (I–IV).

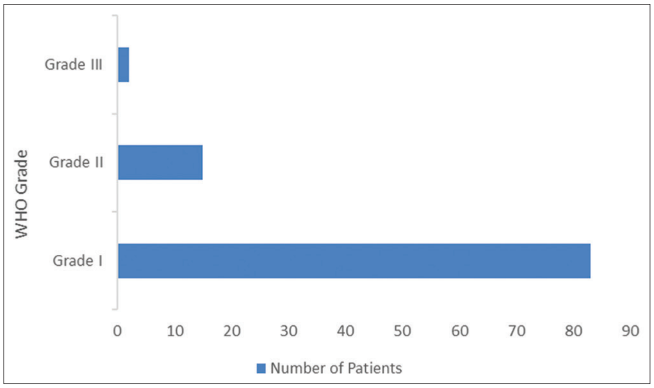

Figure 1: Distribution of patients according to World Health Organization classification of meningiomas

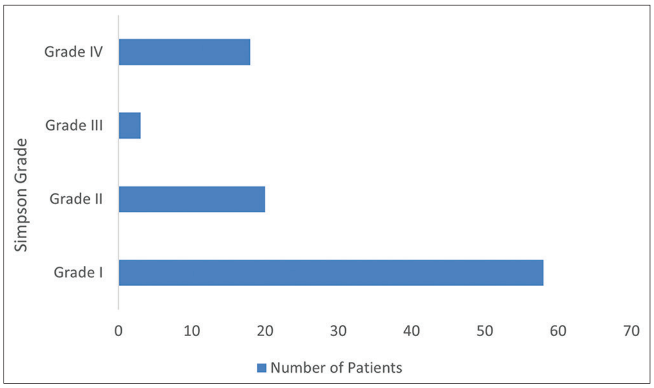

Figure 2: Distribution of patients due to Simpson grade of meningioma removal

Logistic regression analysis identified the WHO histological classification and post-operative radiation therapy as the most significant predictors of recurrence. The calculated coefficients suggest that the probability of recurrence increases with higher tumor grades; the odds ratio was 3.18 for WHO Grade II and 6.59 for Grade III meningiomas compared with Grade I. Importantly, the findings also showed a higher recurrence rate among patients who underwent radiation therapy [Table 2].

Meningiomas are among the most prevalent central nervous system tumors and are the most common benign central nervous system tumors. Surgical excision is typically curative, especially for WHO Grade I meningiomas, which are the most frequent histological variants. Although prognostic factors for meningioma recurrence have been studied, neither patient age nor sex has shown significant predictive value. The prognostic significance of these histological features remains debatable.

Owing to the lack of defined risk factors for recurrence, no established guidelines exist for the optimal frequency and timing of post-operative imaging in patients after meningioma removal. A literature review indicates that few published studies have assessed the effectiveness of follow-up imaging in this patient group. Our clinic does not have a standardized protocol for post-operative monitoring.

Table 1: Baseline demographic characteristics of the study population

Characteristic	*n* (%)
Total patients	283 (100%)
Age, mean (range), years	59 (22–89)
Sex, *n* (%)	
Male	118 (41.7%)
Female	165 (58.3%)

Data presented as *n* (%), n: Number of patients, %: Percentage of patients

Table 2: Logistic regression analysis of predictors of meningioma recurrence

Variable	OR	Interpretation
WHO Grade II versus I	3.18	Increased risk of recurrence
WHO Grade III versus I	6.59	Markedly increased risk of recurrence
Post-operative radiotherapy	1 recurrence observed	Shows high baseline tumor aggressiveness

WHO: World Health Organization, OR: Odds ratio

In practice, routine CT or MRI scans are commonly performed after surgery, regardless of the WHO meningioma grade or Simpson resection extent. New clinical symptoms indicating tumor recurrence necessitate imaging, regardless of the completeness of resection. However, in our sample, most post-operative scans were conducted without clinical symptoms, and recurrences were identified through imaging before the appearance of clinical signs. Discussions with neurosurgeons from other departments confirmed this widespread practice.

Figure 2 illustrates the patient distribution based on the degree of meningioma resection according to the Simpson classification.

Logistic regression analysis revealed that the histological grade of meningioma, as classified by the WHO, was the most significant indicator of recurrence. Descriptive analysis indicated that the current post-operative imaging frequency is largely unwarranted for most patients. WHO Grade I meningiomas that are completely or nearly completely resected (Simpson grades I or II) have a very low likelihood of recurrence.

Routine follow-up imaging in these patients seldom detects recurrence signs. The low recurrence rate in this group was associated with specific clinical factors. Two recurrences within 2 years after the removal of a WHO Grade I meningioma during a Simpson Grade I resection were found in the same patient who had previously undergone multiple surgeries for falx and parasagittal meningiomas. In such cases, more frequent monitoring is justified by clinical necessity.

Patients with WHO Grade II and III meningiomas comprised a smaller portion of the sample but showed a significantly higher relapse rate, aligning with the accepted notion of more aggressive progression of these tumors.

In many patients with radiologically detected recurrences, surgery or radiation therapy was not immediately performed; instead, monitoring with repeated imaging was performed. The decision for surgery and/or radiation therapy was based on the tumor location, histological features, progression rate, resectability, and patient preference.

The Simpson resection grade was determined from the surgeon's notes or reconstructed from the surgical procedure description. Data suggest that early post-operative imaging to verify the resection grade is unnecessary. No significant differences in early recurrence rates were observed between tumors resected at Simpson grades I and II. Therefore, early imaging frequency should not depend on whether the resection was Simpson Grade I or II. Analysis showed no instances of surgeons misdiagnosing the degree of macroscopic resection.

Repeated follow-up imaging involves considerable costs, including financial, time, and organizational resources, and may increase the stress of patients. The psychological aspects warrant investigation: Regular imaging might reduce anxiety by fostering a sense of control; however, frequent examinations can prolong stress from anticipating relapse. Financial costs are pertinent in rationalizing medical care, and cost-effectiveness is crucial for evaluating clinical approaches. A cost analysis at one center highlighted the high expense of existing post-operative imaging strategies. This calculation excludes additional economic consequences, such as lost work capacity and psychological costs incurred by patients undergoing regular examinations.

DISCUSSION

This retrospective single-institution study showed that the WHO histological grade of meningioma is the most reliable predictor of post-operative recurrence. The extent of resection within Simpson grades I and II did not affect early recurrence rates. These results suggest that tumor biology should guide post-operative monitoring strategies.

Our findings show that WHO Grade I meningiomas, when fully or nearly fully resected, have a low recurrence risk, aligning with population-based studies. Registry analyses have shown that WHO Grade I tumors have 5-year recurrence-free survival rates exceeding 90% after gross total resection, irrespective of patient age or sex.[18-20] This suggests that routine high-frequency imaging may have limited value unless new neurological symptoms arise.

WHO Grade II and III meningiomas showed significantly higher recurrence risks, with odds ratios increasing with histological grade. This aligns with data showing that atypical and anaplastic meningiomas have higher proliferative indices, greater invasive potential, and earlier recurrence, even after complete resection.[21-23] Recent WHO updates have highlighted the prognostic significance of histological and molecular characteristics over anatomical factors.[24]

The role of resection remains debatable. While historical studies have shown clear recurrence risk gradients across Simpson grades, modern studies suggest minimal differences between Simpson grades I and II resections, especially for WHO Grade I tumors.[25-27] Our findings support this view, as no significant difference in recurrence was observed between Simpson grades I and II, and post-operative imaging matched the surgical assessments of resection completeness. The link between post-operative radiotherapy and recurrence likely indicates confounding by indication, as radiation is used for aggressive tumors or incomplete resection. Studies have shown that while radiotherapy enhances local control in high-risk meningiomas, it is not an independent predictor of a positive prognosis.[28-30]

A key finding was the limited benefit of routine short-interval post-operative imaging in asymptomatic patients with low-risk tumors. Most recurrences were identified through imaging before the appearance of symptoms; however, significant findings in WHO Grade I patients after Simpson Grade I–II resection were very low. Recent studies have questioned the value of frequent imaging in patients with low-risk meningioma.[4,31,32]

The economic and psychological effects of intensive imaging surveillance warrant further consideration. Repeated scans increase healthcare costs and may cause stress to patients. Recent literature emphasizes the need to balance early recurrence detection with patient-centered outcomes and resource use, especially in resource-limited systems.[33]

These findings support a risk-based surveillance approach in which imaging frequency is determined by the WHO tumor grade and clinical status. For WHO Grade I meningiomas resected to Simpson grades I or II, longer imaging intervals seem justified. More frequent imaging is suitable for WHO Grade II and III tumors, especially in the early post-operative years, when the recurrence risk is highest.

CONCLUSION

This retrospective single-center study showed that the WHO histological tumor grade is the most reliable predictor of post-operative recurrence in intracranial meningiomas. The distinction between Simpson grades I and II resections does not significantly affect the early recurrence risk, highlighting the importance of tumor biology over minor differences in surgical extent.

The risk of recurrence is very low for WHO Grade I meningiomas with complete or nearly complete resection. Routine post-operative imaging at short intervals provides minimal clinical benefit and may be unnecessary in the absence of new neurological symptoms. Extending surveillance intervals or selectively discontinuing routine imaging after stable follow-up may be suitable for carefully selected patients.

Patients with WHO Grade II and III meningiomas have a higher recurrence risk, requiring closer post-operative monitoring in the initial post-surgery years. Surveillance should be individualized, with more frequent imaging and additional therapies based on tumorbehavior and patient factors.

These findings support a risk-adapted surveillance strategy based on histological grade and clinical presentation. This approach could reduce unnecessary imaging and patient burden and optimize resources while maintaining oncological safety. Multicenter prospective studies are required to refine evidence-based follow-up protocols across a broader patient population.

ACKNOWLEDGEMENT

None.

REFERENCES

1. Longstreth WT Jr., Dennis LK, McGuire VM, Drangsholt MT, Koepsell TD. Epidemiology of intracranial meningioma. Cancer 1993;72:639-48.
2. Claus EB, Bondy ML, Schildkraut JM, Wiemels JL, Wrensch M, Black PM. Epidemiology of intracranial meningioma. Neurosurgery 2005;57:1088-95.
3. Bondy M, Ligon BL. Epidemiology and etiology of intracranial meningiomas: A review. J Neurooncol 1996;29:197-205.
4. Halliday J, Fernandes H. Meningioma recurrence: The efficacy and cost-effectiveness of current screening. Br J Neurosurg 2010;24:55-61.
5. Huang H, Buhl R, Hugo HH, Mehdorn HM. Clinical and histological features of multiple meningiomas compared with solitary meningiomas. Neurol Res 2005;27:324-32.
6. Louis DN, Ohgaki H, Wiestler OD, Cavenee WK, Burger PC, Jouvet A, *et al.*The 2007 WHO classification of tumours of the central nervous system. Acta Neuropathol 2007;114:97-109.
7. Ostrom QT, Gittleman H, Liao P, Vecchione-Koval T, Wolinsky Y, Kruchko C, *et al.* CBTRUS Statistical Report: Primary brain and other central nervous system tumors diagnosed in the United States in 2010-2014. Neuro Oncol 2017;19:v1-88.
8. Hwang KL, Hwang WL, Bussière MR, Shih HA. The role of radiotherapy in the management of high-grade meningiomas. Chin Clin Oncol 2017;6:S5.
9. Louis DN, Perry A, Reifenberger G, von Deimling A, Figarella-Branger D, Cavenee WK, *et al.* The 2016 World Health Organization classification of tumors of the central nervous system: A summary. Acta Neuropathol 2016;131:803-20.
10. Yrysov KB, Arstanbekov NA, Mamytov MM, Akmataliev AA, Turganbaev BJ, Vityala Y. Postoperative complications in patients with intracranial meningiomas who underwent surgery. Biomedicine 2023;43:1023-6.
11. Simpson D. The recurrence of intracranial meningiomas after surgical treatment. J Neurol Neurosurg Psychiatry 1957;20:22-39.
12. Mirimanoff RO, Dosoretz DE, Linggood RM, Ojemann RG, Martuza RL. Meningioma: Analysis of recurrence and progression following neurosurgical resection. J Neurosurg 1985;62:18-24.
13. Stafford SL, Perry A, Suman VJ, Meyer FB, Scheithauer BW, Lohse CM, *et al.* Primarily resected meningiomas: outcome and prognostic factors in 581 Mayo Clinic patients, 1978 through 1988. Mayo Clin Proc 1998;73:936-42.
14. Whittle IR, Smith C, Collie D. Meningiomas. Lancet 2014;363:1535-43.
15. Naumann M, Meixensberger J. Factors influencing meningioma recurrence rate. Acta Neurochir (Wien) 2009;107:108-11.
16. Marks SM, Whitwell HL, Lye RH Recurrence of meningiomas after surgery. Surg Neurol 2016;25:436-40.
17. Adegbite AB, Khan MI, Paine KW The recurrence of intracranial meningiomas after surgical treatment. J Neurosurg 2013:58:51-6.
18. Ostrom QT, Price M, Neff C, Cioffi G, Waite KA, Kruchko C, *et al.*CBTRUS statistical report: Primary brain and other central nervous system tumors diagnosed in the United States in 2016-2020. Neuro Oncol 2023;25:iv1-99.
19. Rogers L, Barani I, Chamberlain M, Kaley TJ, McDermott M, Raizer J, *et al.* Meningiomas: Knowledge base, treatment outcomes, and uncertainties. A RANO review. J Neurosurg 2015;122:4-23.
20. Goldbrunner R, Stavrinou P, Jenkinson MD, Sahm F, Mawrin C, Weber DC, *et al.* EANO guideline on the diagnosis and management of meningiomas. Neuro Oncol 2021;23:1821-34.
21. Sahm F, Schrimpf D, Olar A, Koelsche C, Reuss D, Bissel J, *et al.* TERT promoter mutations and risk of recurrence in meningioma. J Natl Cancer Inst 2016;108:djv377.
22. Vasudevan HN, Braunstein SE, Phillips JJ, Pekmezci M, Tomlin BA, Wu A, *et al.* Comprehensive molecular profiling identifies FOXM1 as a key transcription factor for meningioma proliferation. Cell Rep 2018;22:3672-83.
23. Youngblood MW, Miyagishima DF, Jin L, Gupte T,

Li C, Duran D, *et al.* Associations of meningioma molecular subgroup and tumor recurrence. Neuro Oncol 2021;23:783-94.
24. Louis DN, Perry A, Wesseling P, Brat DJ, Cree IA, Figarella-Branger D, *et al.* The 2021 WHO classification of tumors of the central nervous system: A summary. Neuro Oncol 2021;23:1231-51.
25. Sughrue ME, Sanai N, Shangari G, Parsa AT, Berger MS, McDermott MW. Outcome and survival following primary and repeat surgery for World Health Organization Grade III meningiomas. J Neurosurg 2010;113:202-9.
26. Gousias K, Schramm J, Simon M. The Simpson grading revisited: Aggressive surgery and its place in modern meningioma management. J Neurosurg 2016;125:551-60.
27. Nanda A, Bir SC, Maiti TK, Konar SK, Missios S, Guthikonda B. Relevance of Simpson grading system and recurrence-free survival after surgery for World Health Organization Grade I meningioma. J Neurosurg 2017;126:201-11.
28. Rogers CL, Won M, Vogelbaum MA, Perry A, Ashby LS, Modi JM, *et al.* High-risk meningioma: Initial outcomes from NRG oncology/RTOG 0539. Int J Radiat Oncol Biol Phys 2020;106:790-9.
29. Aizer AA, Bi WL, Kandola MS, Lee EQ, Nayak L, Rinne ML, *et al.* Extent of resection and overall survival for patients with atypical and malignant meningioma. Cancer 2015;121:4376-81.
30. Hwang WL, Marciscano AE, Niemierko A, Kim DW, Stemmer-Rachamimov AO, Curry WT, *et al.* Imaging and extent of surgical resection predict risk of meningioma recurrence better than WHO histopathological grade. Neuro Oncol 2016;18:863-72.
31. Islim AI, Millward CP, Mills SJ, Fountain DM, Zakaria R, Pathmanaban ON, *et al.* The management of incidental meningioma: An unresolved clinical conundrum. Neurooncol Adv 2023;5:i26-34.
32. Nassiri F, Price B, Shehab A, Au K, Cusimano MD, Jenkinson MD, *et al.* Life after surgical resection of a meningioma: A prospective cross-sectional study evaluating health-related quality of life. Neuro Oncol 2019;21:i32-43.
33. Henriksson R, Asklund T, Poulsen HS. Impact of therapy on quality of life, neurocognitive function and their correlates in glioblastoma multiforme: A review. J Neurooncol 2011;104:639-46.

Source of Support: Nil. **Conflicts of Interest:** None declared.