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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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HISTOPATHOLOGICAL PREDICTORS AND FUNCTIONAL RECOVERY IN PATIENTS WITH INTRACRANIAL MENINGIOMAS

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Abstract.

Introduction: The aim of this study was to investigate the clinical, morphological, and functional predictors of rehabilitation potential (RP) in patients following the removal of intracranial meningiomas. The primary objective was to assess the prognostic significance of tumor biomarkers (Ki-67, CD34), the depth of brain invasion, and the extent of surgical intervention in relation to functional recovery and the likelihood of recurrence. Meningiomas exhibit a wide biological spectrum that affects recurrence risk, neurological outcomes, and rehabilitation potential. In this context, a key aspect of the study was the correlation between the tumor's morphological characteristics and clinical outcomes, including changes in functional independence scales (ΔKPS, ΔFIM) and long-term recovery metrics. The data obtained are intended to optimize individualized prognosis, improve surgical planning, and enhance the post-operative rehabilitation strategy for patients with central nervous system tumors.

Methods: The study included 124 patients (mean age 49.1 ± 7.6 years, range 32-68 years) who underwent surgical treatment for meningiomas during the period 2017-2024. The extent of resection, histological subtype, Ki-67 proliferation index, microvessel density (CD34), and postoperative clinical-functional parameters were evaluated. Functional status was assessed preoperatively and three months postoperatively using the Karnofsky Performance Scale (KPS) and the Functional Independence Measure (FIM).

Results: Grade I tumors demonstrated significantly lower Ki-67 (2.0–2.5%) and CD34 (6–10 vessels/HPF) values compared to Grade II (7.4%) and Grade III (17.9%) tumors ($p < 0.001$). Brain invasion ≥3 mm independently increased the risk of early recurrence (OR = 3.8; $p < 0.001$). Ki-67 >8% and CD34 >15 vessels/HPF were identified as independent predictors of recurrence (Cox regression). A high rehabilitation potential (ΔKPS ≥15 and ΔFIM ≥20) was achieved in 73% of patients with Grade I tumors versus 10% with Grade III tumors ($p < 0.001$).

Conclusion: Low Ki-67 and CD34 values, combined with the absence of brain invasion, reliably predict favorable recovery and a low risk of recurrence. Aggressive morphological features necessitate early adjuvant therapy and more intensive rehabilitation interventions.

Key words. Meningioma, Ki-67, CD34, brain invasion, recurrence, functional outcomes, rehabilitation potential.

Introduction.

According to current epidemiological data, meningiomas account for approximately 30–35% of all primary intracranial tumors in adults, ranking first among benign brain neoplasms [1-4]. Despite their generally favorable course, about 20–25% of meningiomas exhibit atypical or anaplastic features, characterized by increased mitotic activity, brain parenchymal invasion, and a high risk of recurrence [4-7]. The most common clinical manifestations include neurological deficits, seizure syndromes, and symptoms of intracranial hypertension. However, the severity of these symptoms does not always correlate with tumor size, underscoring the importance of histological characteristics as key prognostic markers [8,9].

In recent years, there has been growing interest in identifying biological and histopathological factors that influence not only the risk of recurrence but also the pace of functional recovery after surgical resection of meningiomas. In this context, particular attention has been paid to the tumor's proliferative activity (e.g., Ki-67 index), angiogenesis (CD34), the degree of brain tissue invasion, and the extent of resection according to Simpson classification [10-12]. Specifically, a low Ki-67 index (<4%) is associated with slower tumor growth and better postoperative outcomes [13], while limited vascular invasion (CD34 < 12 vessels/HPF) and absence of diffuse brain infiltration predict reduced neuronal damage and higher recovery rates [14].

Modern neurosurgical and rehabilitation approaches increasingly require personalized prognostic assessment, including the consideration of tumor morphological features. Postoperative functional status is traditionally evaluated using the Karnofsky Performance Status (KPS) and the Functional Independence Measure (FIM), which provide a quantitative description of recovery level and patient dependency [15-17]. However, to date, the impact of specific histopathological predictors on KPS, FIM scores, and overall rehabilitation potential (RP) remains insufficiently studied.

Thus, meningiomas demonstrate a broad biological spectrum that significantly affects recurrence risk, neurological outcomes, and recovery potential. Determining the relationship between tumor histopathology and functional treatment outcomes is therefore crucial for optimizing postoperative patient management. Understanding the influence of the tumor's biological properties on recovery and recurrence risk is essential for personalized therapy and rehabilitation strategies [18-35].

The aim of this study was to assess the impact of histopathological predictors (Ki-67, CD34, brain invasion, and extent of resection) on functional recovery and rehabilitation potential in patients with intracranial meningiomas.

Materials and Methods.

The study employed a mixed design: retrospective enrollment based on archival data was conducted in 2017-2018, while

prospective observation was carried out during 2019-2024 at the Neurosurgery Department of the Multidisciplinary Clinic of Samarkand State Medical University. Prior to initiation, the study received official approval from the Local Ethics Committee (Protocol No. 12 dated April 5, 2017). Patient enrollment was performed exclusively after obtaining written informed consent for participation in the study and processing of medical data.

The aim was to identify prognostic factors associated with functional recovery and rehabilitation potential in patients with intracranial meningiomas following surgical intervention. A total of 124 patients with histologically confirmed intracranial meningiomas who were hospitalized and underwent surgery between 2017 and 2024 were included in the study. The mean age was 49.1 ± 7.6 years (range: 32-68), with 78 women (62.9%) and 46 men (37.1%), consistent with literature reports on the predominance of women among meningioma patients [Louis et al., 2021; Wiemels et al., 2010].

Histological verification was performed according to the 2021 WHO Classification of Tumors of the Central Nervous System [Louis et al., 2021]: **Grade I (benign meningiomas):** 82 patients (66.1%); **Grade II (atypical):** 32 patients (25.8%); **Grade III (malignant/anaplastic):** 10 patients (8.1%).

Inclusion criteria: Age between 32-68 years; Presence of a single intracranial meningioma confirmed by MRI and histology; Undergoing surgical resection of the tumor; Written informed consent for participation. **Exclusion criteria:** Prior neurosurgical operations or radiotherapy to the CNS; Multiple CNS tumors or systemic malignancies; Severe comorbid somatic or neuropsychiatric conditions (e.g., stroke, dementia, autoimmune disorders); Coagulopathies or active infections.

Tumor Characteristic Assessment:

The extent of resection according to the Simpson classification was determined based on the operative report and confirmed by control MRI performed 72 hours after surgery.

Following surgical removal, tumor classification and assessment included: **Proliferation Index (Ki-67, %):** determined via immunohistochemistry according to the protocol by Baay et al. (2018); **Angiogenesis (CD34):** measured as the average number of microvessels per high-power field (HPF) [Ribalta et al., 2004]; **Brain Invasion:** assessed histologically in millimeters and by visual morphologist evaluation; invasion ≥3 mm was considered significant.

Functional Recovery Assessment: Karnofsky Performance Status (KPS): evaluated before and 3 months after surgery [Mor et al., 1984]; Functional Independence Measure (FIM): standardized assessment scale ranging from 18 (complete dependence) to 126 (complete independence) [Keith et al., 1987]; Rehabilitation Potential (RP): defined by improvements in KPS and FIM scores and return to independent living; KPS (Karnofsky Performance Status): Quantifies physical activity and self-care ability, ranging from 0 to 100: 100 = fully active, no restrictions; 70–80 = self-sufficient with activity limitations; 40–50 or below = significant dependence on external assistance. ΔKPS (Delta KPS): Difference in KPS score before and 3 months after surgery, reflecting the trajectory of functional recovery. *Example: Pre-op KPS = 65; post-op KPS = 80 → ΔKPS = +15 points.*

FIM (Functional Independence Measure): Assesses the patient's ability to perform self-care, mobility, communication, and social interaction. Scores range from 18 (full dependence) to 126 (full independence). **ΔFIM (Delta FIM):** Change in FIM score, indicating rehabilitation progress. *Example: Pre-op FIM = 80; post-op FIM = 105 ⟶ ΔFIM = +25 points.*

The study was conducted in full accordance with the principles of the Declaration of Helsinki (WMA, 2013) and approved by the institution's Local Ethics Committee (Protocol No. 12, dated 05.04.2018). All participants provided written informed consent for participation, processing of personal and medical data, histological and immunohistochemical analysis, and postoperative clinical and functional assessment. Confidentiality and the right to withdraw at any stage without affecting the quality or scope of medical care were ensured.

Statistical Analysis: Data analysis was performed using SPSS version 13.0.

Statistical methods included: Shapiro-Wilk test for normality. ANOVA with Tukey's post hoc test for quantitative variables. Chi-square and Mann–Whitney U tests for qualitative variables. Multiple logistic regression analysis to identify independent predictors of high rehabilitation potential (odds ratio, 95% CI, $p < 0.05$).

Results.

Tumor Characteristics and Resection Outcomes:

Simpson I-II resection was achieved in 86% of Grade I tumors, 69% of Grade II, and 40% of Grade III tumors ($p < 0.001$). Tumor localization was as follows: convexity (41%), parasagittal (26%), skull base (22%), and posterior cranial fossa (11%).

One of the key factors determining the success of surgical treatment for meningiomas is the extent of tumor resection. In the present study, Simpson Grade I–II resection was achieved in 86% of patients with Grade I meningiomas, 69% of those with Grade II, and only 40% of patients with Grade III tumors. The differences between malignancy grade groups were statistically significant ($\chi^2 = 17.8$; $p < 0.001$), highlighting the increasing difficulty of achieving radical resection as tumor aggressiveness increases. This trend suggests that Grade III tumors are generally more invasive, exhibit greater vascularization, and often adhere tightly to critical anatomical structures, which limits the feasibility of complete resection without significant risk to neurological function. In contrast, Grade I meningiomas typically have well-defined margins and are located in more surgically accessible regions, allowing for higher rates of radical resection.

The results presented in Figure 1 clearly demonstrate the dependence of surgical radicality on the histological grade of meningiomas. In patients with benign tumors (Grade I), complete or subtotal resection according to Simpson I-II was achieved in the vast majority of cases (86%), reflecting their well-defined growth boundaries, lower vascularization, and relatively accessible locations.

In Grade II meningiomas, the proportion of radical resections decreased to 69%, which can be explained by their increased

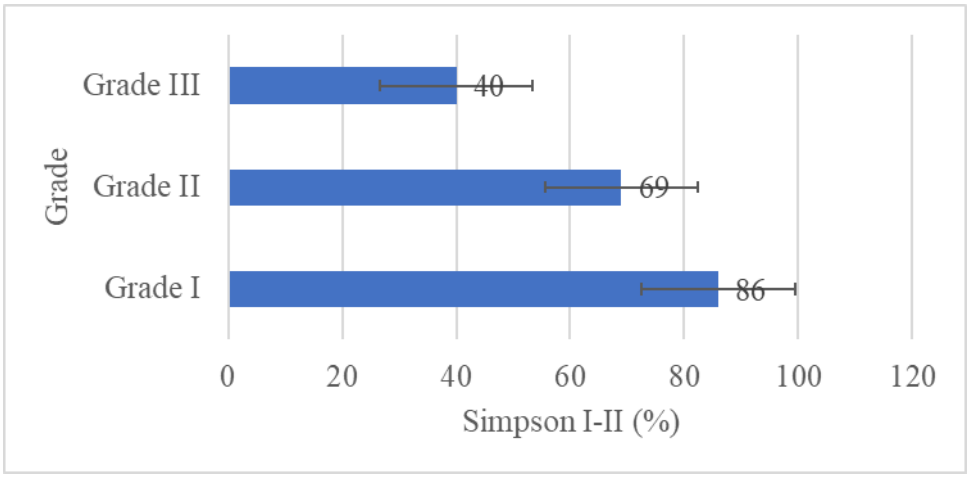

Figure 1. *Frequency of Simpson I-II resections in patients with meningiomas of different histological grades (Grade I-III).*
Note: *The diagram illustrates the proportion of radical resections (Simpson I-II) within each group. The highest rate of radical removal was observed in Grade I tumors, whereas the lowest was recorded in Grade III.*

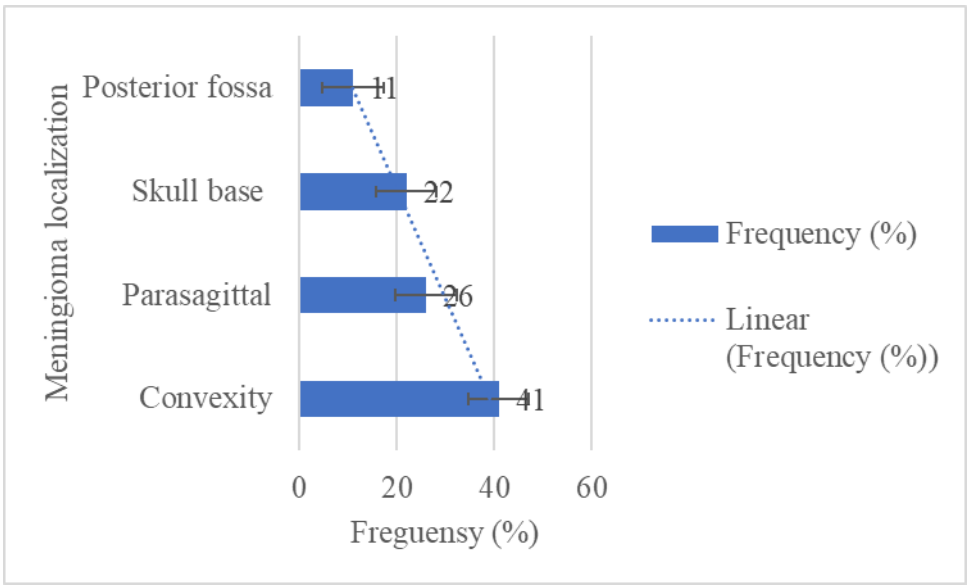

Figure 2. *Distribution of intracranial meningiomas by anatomical localization.*
Note: *The figure illustrates the proportion of meningiomas located at the convexity, parasagittal region, skull base, and posterior cranial fossa. Convexity meningiomas were the most frequent.*

biological aggressiveness and closer interaction with surrounding tissues. The most pronounced limitations in surgical radicality were observed in Grade III meningiomas, where Simpson I-II resection was achieved in only 40% of cases. This is attributable to deep invasion into brain tissue, marked angiogenesis, and frequent occurrence in surgically challenging locations, where the risk of damaging critical neurovascular structures restricts the possibility of complete removal.

Thus, the data confirm that the histological grade of a meningioma is one of the key factors determining both the surgical strategy and its outcomes. While radical resection can be achieved in the majority of Grade I cases, patients with Grade III tumors require additional strategies, including combined approaches, early initiation of adjuvant therapy, and more intensive rehabilitation.

The distribution of tumors by anatomical localization also has important clinical and surgical implications (Figure 2). The most common tumor localization in the study was convexity meningiomas (41%), followed by parasagittal (26%), skull base (22%), and posterior fossa meningiomas (11%). This pattern aligns with established data in the literature, where the predominance of supratentorial meningiomas is attributed to larger surface area and specific vascular anatomy. Notably, skull base and posterior fossa meningiomas, although less frequent, are often associated with greater technical complexity during resection and a higher risk of postoperative complications. This partially explains the lower rates of radical resections observed in Grade II and III groups, where such challenging localizations are more prevalent than in typical convexity-based Grade I tumors.

Thus, these findings emphasize the importance of considering both histological grade and anatomical localization when predicting the feasibility of radical meningioma resection and assessing postoperative risk.

Histological Subtypes and Proliferative Activity:

The findings presented in Table 1 clearly demonstrate a strong association between the histological subtype of meningioma, the level of proliferative activity (Ki-67), and angiogenesis (CD34). A statistically significant increase in both markers was observed from Grade I to Grade III tumors ($p < 0.001$), highlighting the progressive biological aggressiveness associated with higher tumor grades.

Proliferative Activity (Ki-67): The lowest Ki-67 levels were found in meningothelial (1.82 ± 0.12%) and psammomatous (2.15 ± 0.21%) meningiomas, consistent with their favorable biological behavior. The fibrous subtype showed a mean value of 2.65 ± 0.22%, while atypical (Grade II) meningiomas demonstrated a significantly higher index of 7.65 ± 0.40%. The highest Ki-67 value was recorded in malignant meningiomas (Grade III), averaging 18.73 ± 1.37% ($p < 0.001$ vs. Grade I and II), reflecting a high mitotic potential. The wide range within this group [13.36–25.54%] also indicates considerable heterogeneity among Grade III tumors.

Angiogenesis (CD34): Microvascular density also progressively increased with tumor grade, from 6.41 ± 0.57 vessels/HPF in psammomatous tumors to 21.55 ± 2.11 vessels/HPF in Grade III meningiomas ($p < 0.001$ compared to Grade I and II). These results are consistent with the understanding that angiogenesis plays a crucial role in the growth and invasiveness of high-grade meningiomas.

Correlation Between Ki-67 and CD34: Correlation analysis confirmed a statistically significant relationship between the level of proliferative activity, as measured by Ki-67, and the degree of angiogenesis, assessed via CD34 expression. Pearson's correlation coefficient was $r = 0.72$, indicating a strong positive correlation; the p-value was < 0.001, confirming high statistical reliability. This means that an increase in the proportion of actively dividing cells (high Ki-67) is associated with increased microvascular density (high CD34). This pattern was consistently observed with progression from benign (Grade I) to atypical (Grade II) and malignant (Grade III) meningiomas, with a synchronous rise in both markers: Grade II (atypical): Ki-67 = 7.65%, CD34 = 16.02 vessels/HPF; Grade III (malignant): Ki-67 = 18.73%, CD34 = 21.55 vessels/HPF This correlation has important biological and clinical implications. A high proliferative index combined with marked angiogenesis may indicate a potentially more aggressive tumor course and an elevated risk of recurrence.

Thus, the correlation analysis confirmed a close relationship between Ki-67 and CD34 levels ($r = 0.72$; $p < 0.001$), suggesting that tumors with higher proliferative activity are also more vascularized, facilitating invasive growth and recurrence risk. Therefore, Ki-67 and CD34 can serve not only as morphological indicators of tumor malignancy but also as valuable markers for prognosis and guiding follow-up strategies.

Brain Invasion and Recurrence:

Invasion depth increased with tumor grade (Figure 3): Grade I - 0.92 ± 0.07 mm, Grade II - 2.50 ± 0.14 mm, and Grade III – 4.51 ± 0.18 mm (ANOVA, $p < 0.001$). Invasion ≥ 3 mm was observed in 4% of Grade I, 47% of Grade II, and 80% of Grade

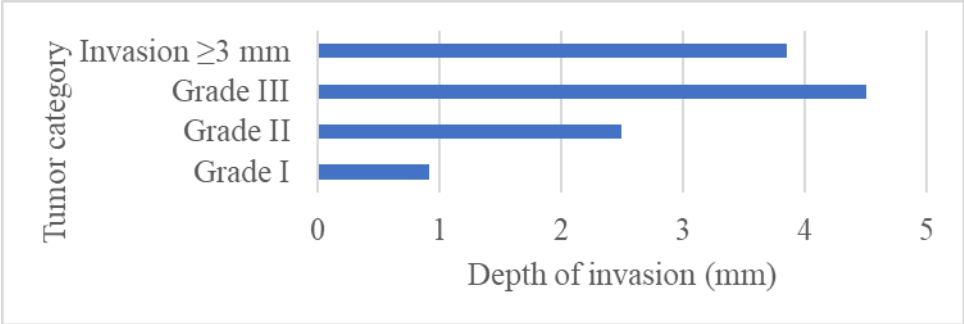

Figure 3. *Depth of tumor invasion into the brain (mm) across Grade I-III groups, indicating the category "invasion ≥ 3 mm. Invasion depth (mm) reflects the mean depth of tumor infiltration into brain tissue across groups. Tumor category indicates classification by malignancy grade and the invasion threshold of ≥3 mm.*

Table 1. *Proliferative and Angiogenic Activity Across Meningioma Subtypes.*

Histological Subtype	Ki-67 (%)			CD34 (vessels/HPF)		
	(M±m)	[25%;75%]	[Min;Max]	(M±m)	[25%;75%]	[Min;Max]
Meningothelial	1.82 ± 0.12	[1.31; 2.30]	[0.24; 3.67]	8.06 ± 0.31	[6.90; 9.62]	[2.07; 11.70]
Fibrous	2.65 ± 0.22	[2.12; 3.15]	[0.20; 5.46]	9.60 ± 0.47	[7.46; 11.12]	[5.22; 15.00]
Psammomatous	2.15 ± 0.21	[1.87; 2.51]	[0.97; 3.13]	6.41 ± 0.57	[5.26; 6.88]	[4.31; 11.17]
Atypical (Grade II)	7.65 ± 0.40	[5.53; 8.64]	[4.07; 15.88]	16.02 ± 0.68	[13.43; 18.59]	[8.30; 24.80]
Malignant (Grade III)	18.73 ± 1.37	[15.71; 21.51]	[13.36; 25.54]	21.55 ± 2.11	[19.20; 26.05]	[7.55; 30.99]

"" – Statistically significant difference compared to Grade I and II ($p < 0.001$).*

Ki-67 is a proliferative index expressed as a percentage (%) and reflects the proportion of tumor cells actively undergoing division. For example, Ki-67 = 7.4% indicates that 7.4% of the cells are in the mitotic phase.

CD34 is an immunohistochemical marker of angiogenesis, measured as the number of vessels per high-power field (vessels/HPF) under a microscope. CD34 = 16 vessels/HPF means that, on average, 16 microvessels are observed within one high-power field at 400× magnification.

A significant increase in both Ki-67 and CD34 values was observed from Grade I to Grade III meningiomas ($p < 0.001$).

III patients ($p < 0.001$) and was associated with an increased risk of early recurrence (OR = 3.8; $p < 0.001$).

The five-year recurrence risk was 9.8% for Grade I, 28.1% for Grade II, and 60% for Grade III ($p < 0.001$), confirming the prognostic significance of invasion depth in meningiomas.

The data presented in Table 2 confirm the presence of significant differences in tumor invasiveness and recurrence rates depending on the histological grade of malignancy. Brain tissue invasion was detected in only 4% of patients with Grade I meningiomas, whereas this figure increased to 47% in Grade II and reached 80% in Grade III cases ($p < 0.001$), indicating a progressive disruption of the tumor-brain interface with increasing tumor aggressiveness.

Invasion depth also played a significant role: in patients with tumor infiltration ≥3 mm, the risk of early recurrence was 3.8 times higher compared to other cases (OR = 3.8; $p < 0.001$). This underscores the clinical importance of morphologically assessing invasion depth as an independent prognostic factor. The five-year recurrence rate increased progressively with tumor grade: 9.8% for Grade I, 28.1% for Grade II, 60% for Grade III ($p < 0.001$). These statistically significant differences highlight the need for more intensive postoperative surveillance and possible adjuvant therapy in patients with high-grade and invasive meningiomas.

Thus, the presence and depth of brain invasion should be considered key factors when planning follow-up treatment and assessing recurrence risk in meningioma patients.

Functional Recovery (FR) and Rehabilitation Potential (RP):

The results presented in Table 3 demonstrate a significant improvement in patients' functional status following surgical treatment of meningiomas. The average preoperative Karnofsky Performance Scale (KPS) score was 68.4 ± 1.5 (interquartile range [65; 70], range [60; 75]). Three months after surgery, this score significantly increased to 79.5 ± 1.4 ([75; 85], range [65; 90]; $p < 0.001$). This improvement confirms the effectiveness of surgical intervention in restoring daily functional activity and reducing neurological deficits. The average difference between pre- and postoperative scores was +11.1 points, reflecting a positive trajectory and successful recovery in most cases. Importantly, statistically significant improvement was also observed in patients with Grade II and Grade III tumors, underscoring the relevance of surgical intervention even in more aggressive tumor forms-provided that appropriate postoperative monitoring and rehabilitation measures are implemented. The graphical comparison of ΔKPS and ΔFIM alongside the rate of high rehabilitation potential (Figure 4) underscores significant differences in patient recovery capacity according to the meningioma's malignancy grade.

The indicators of functional recovery (Table 4), including ΔKPS and ΔFIM, as well as rehabilitation potential (RP), demonstrated a clear dependence on the malignancy grade of the meningiomas. The greatest increase in Karnofsky Performance Scale scores (ΔKPS) was observed in patients with Grade I tumors, averaging 18.2 ± 1.1 points, compared to 11.4 ± 1.3 points in Grade II and only 4.1 ± 0.9 points in Grade III. The differences between Grade I/II and Grade III groups were statistically significant ($p < 0.001$). Similarly, recovery as measured by the Functional Independence Measure (FIM) showed the following improvements: 25.1 ± 1.2 points for Grade I, 14.2 ± 1.6 for Grade II, and 6.3 ± 1.1 for Grade III, with statistically significant differences observed when compared to Grade III ($p < 0.001$). These findings indicate a notably higher recovery potential among patients with benign meningiomas. The proportion of patients classified as having a high rehabilitation potential (High RP)-defined as those achieving substantial functional improvement-was also the highest in the Grade I group (73.2%), followed by Grade II (34.5%), and significantly lower in Grade III (10.1%) ($p < 0.001$). These results emphasize that patients with well-differentiated tumors not only achieve better clinical outcomes but also have a markedly higher likelihood of successful postoperative rehabilitation.

Thus, the KPS scale serves as a reliable and sensitive tool for assessing functional status, providing an objective measure of recovery quality following the resection of intracranial

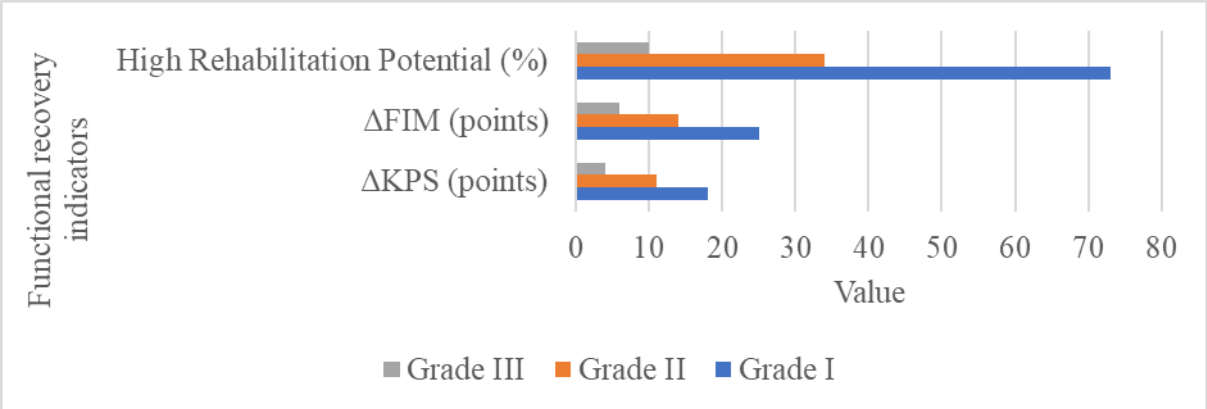

Figure 4. *Comparison of Functional Recovery and Rehabilitation Potential by Meningioma Grade.*

Note: *FR - Functional Recovery. ΔKPS (Delta Karnofsky Performance Status) - the change (increase or decrease) in Karnofsky score, which assesses a patient's functional status on a scale from 0 to 100 (where 100 indicates full activity). For example, ΔKPS = +18 means the patient's functional status improved by 18 points following treatment or surgery. ΔFIM (Delta Functional Independence Measure) - the change in FIM score, which evaluates a patient's ability to perform daily activities independently. The FIM covers both cognitive and motor functions. ΔFIM = +25 indicates a 25-point improvement in the patient's level of independence after rehabilitation.*

Table 2. *Comparative Characteristics of Tumor Invasion Depth by WHO Grade.*

Grade	M±m (мм)	IQR [25%;75%], мм	Range [Min;Max], мм
Grade I	0.92 ± 0.07	[0.76; 1.14]	[0.23; 1.63]
Grade II	2.50 ± 0.14	[2.03; 3.04]	[1.03; 4.08]
Grade III	4.51 ± 0.18 *	[3.99; 5.24]	[1.88; 6.06]
Invasion ≥3 mm	3.85 ± 0.21 *	[3.10; 4.50]	[3.00; 6.10]

"" – Statistically significant difference compared to Grade I and II (based on one-way ANOVA with Tukey's post hoc test, p < 0.001). Brain invasion was observed in 4% of Grade I, 47% of Grade II, and 80% of Grade III meningiomas (p < 0.001). Invasion ≥3 mm significantly increased the risk of early recurrence (OR = 3.8, p < 0.001).*

Table 3. *Assessment of Karnofsky Performance Scale (KPS) Before and After Surgery.*

Group	Preoperative KPS (points)	KPS at 3 Months Postoperative (points)
Grade I	67.2 ± 1.5	85.4 ± 1.2*
Grade II	59.3 ± 1.8	70.7 ± 1.5*
Grade III	*48.4 ± 2.1*	*52.5 ± 1.7*

* – Statistically significant improvement compared to preoperative level (p < 0.001). Data are presented as mean ± standard error (M ± m). Statistical analysis was performed using the paired t-test.

Table 4. *Functional Recovery and Rehabilitation Potential According to Tumor Grade.*

Grade	ΔKPS			ΔFIM			RP		
	points	[25%;75%]	[Min;Max]	points	[25%;75%]	[Мин;Макс]	High RP (%)	[25%;75%]	[Min;Max]
Grade I	18,2 ± 1,1 *	[15; 21]	[10; 25]	25,1 ± 1,2 *	[20; 29]	[15; 35]	73,2 *	[68; 78]	[60; 84]
Grade II	11,4 ± 1,3 *	[9; 14]	[5; 20]	14,2 ± 1,6 *	[11; 17]	[7; 22]	34,5 *	[29; 39]	[21; 45]
Grade III	4,1 ± 0,9	[3; 6]	[2; 8]	6,3 ± 1,1	[4; 8]	[3; 10]	10,1	[7; 12]	[5; 15]

Note: *Values are presented as mean ± standard error (M±m), interquartile range [25%; 75%], and range [Min; Max]. High RP = High Rehabilitation Potential. "*" - indicates statistically significant difference compared to Grade III (p < 0.001). Statistical analysis was performed using ANOVA followed by Tukey's post-hoc test.*

Table 5. *Independent Predictors of High Rehabilitation Potential.*

Predictor	OR	CI	p	Definition and Association with Rehabilitation Potential (RP)
Ki-67 < 4%	4.6	2.0-10.5	0.001	Low proliferative index; increases the likelihood of high RP more than fourfold.
CD34 < 12 vessels/HPF	2.9	1.3-6.4	0.008	Reduced tumor angiogenic activity; associated with favorable recovery outcomes.
Simpson Grade I–II Resection	2.5	1.1-5.6	0.027	Radical tumor removal; significantly increases the probability of successful rehabilitation.
Absence of Diffuse Invasion	3.2	1.4-7.2	0.005	No deep brain invasion; lowers the risk of neuronal damage and facilitates recovery.

Note: *Statistical analysis was performed using multivariate logistic regression. The significance threshold was set at p < 0.05. OR - Odds Ratio; 95% CI – 95% Confidence Interval.*

meningiomas. The malignancy grade of the meningioma has a direct impact on the depth of functional recovery and rehabilitation prospects, which should be carefully considered when developing an individualized patient management plan.

Predictive Model.

The regression analysis (Table 5) identified a number of independent factors significantly associated with high rehabilitation potential (RP) in patients following meningioma resection. The most significant biological marker was a low proliferative index: Ki-67 levels below 4% increased the likelihood of high RP by more than fourfold (OR = 4.6; p = 0.001). This finding reinforces the importance of low mitotic activity as a predictor of favorable recovery. Another important predictor was angiogenic activity as measured by CD34 expression. A microvessel density of less than 12 vessels/HPF was significantly associated with improved rehabilitation outcomes (OR = 2.9; p = 0.008), highlighting the role of reduced vascular invasion in achieving better recovery. Additionally, the extent of tumor resection showed a statistically significant impact: complete or subtotal resections (Simpson Grade I-II) increased the probability of high RP by 2.5 times (OR = 2.5; p = 0.027), underscoring the importance of surgical radicality in the rehabilitation process.

Finally, the absence of diffuse tumor invasion into brain tissue also emerged as a reliable predictor of favorable functional recovery (OR = 3.2; p = 0.005). This is likely related to less neuronal damage and more favorable conditions for neuroplasticity in the postoperative period. Taken together,

these factors may serve as the foundation for a prognostic model aimed at evaluating rehabilitation potential and guiding personalized planning of postoperative recovery strategies.

Discussion.

The conducted study provided a comprehensive assessment of the clinicopathological features of meningiomas of varying WHO grades, with a particular focus on proliferative activity (Ki-67), angiogenesis (CD34), invasiveness, functional outcomes, and rehabilitation potential. The results underscore the complex interrelationship between the biological behavior of the tumor and the clinical outcomes in affected patients. It should be noted that the small number of patients with Grade II and Grade III tumors reduces the statistical power of the analysis in these subgroups, which may have led to an underestimation of differences or to wider confidence intervals.

Ki-67 Proliferative Activity as a Marker of Tumor Aggressiveness and Prognosis:

The Ki-67 proliferative index showed a significant increase from Grade I to Grade III (mean 1.82% in Grade I vs. 18.73% in Grade III; $p < 0.001$), reflecting enhanced mitotic activity in high-grade meningiomas. This trend is consistent with several international studies. For instance, Sahamie et al. (2015) reported that Ki-67 levels above 4% significantly increase the risk of tumor recurrence. In our study, Ki-67 < 4% was found to be an independent predictor of high rehabilitation potential (OR = 4.6; $p = 0.001$), highlighting its clinical relevance not only in oncologic prognosis but also in assessing functional recovery prospects.

Angiogenesis (CD34) and Its Role in Evaluating Tumor Biology:

CD34, indicating microvascular density within the tumor, also showed a progressive increase from Grade I (mean 8.06 vessels/HPF) to Grade III (21.55 vessels/HPF; $p < 0.001$). In our analysis, CD34 levels below 12 vessels/HPF were significantly associated with high rehabilitation potential (OR = 2.9; $p = 0.008$). These findings are consistent with those of Zheng et al. (2020), who emphasized the role of vascularization in tumor aggressiveness. High vascular density correlates with accelerated growth, invasiveness, and recurrence risk, while moderate angiogenesis is linked to more favorable postoperative outcomes.

Brain Invasion and Its Prognostic Significance:

Tumor invasion into brain tissue was observed in 80% of patients with Grade III meningiomas, compared to only 4% in Grade I ($p < 0.001$). A depth of invasion ≥3 mm was found to increase the risk of early recurrence by 3.8 times ($p < 0.001$), whereas the absence of diffuse brain invasion was an independent predictor of favorable functional recovery (OR = 3.2; $p = 0.005$). These findings are in line with the conclusions of Marosi et al. (2008), who noted that microscopic invasion is a hallmark of aggressive tumor behavior. From a neurophysiological perspective, deep invasion compromises neuronal connectivity, limiting plasticity and reducing the brain's capacity for functional restoration.

Extent of Resection and Its Impact on Outcome:

Complete or subtotal resection (Simpson Grade I-II) was identified as a significant independent predictor of high rehabilitation potential (OR = 2.5; $p = 0.027$). This is consistent with findings from Sandow et al. (2014), which emphasized the importance of radical surgical removal in reducing recurrence risk and enhancing rehabilitation outcomes. This factor is especially critical in patients with Grade II meningiomas, where aggressive resection may help offset the tumor's less favorable biological characteristics.

Overall, the integration of morphological, biological, and surgical variables offers a more nuanced understanding of recovery prospects and can inform personalized strategies for postoperative care and rehabilitation in patients with intracranial meningiomas.

Functional Recovery and Rehabilitation Potential:

Patients with Grade I meningiomas demonstrated the most favorable recovery outcomes: $\Delta KPS = +18$, $\Delta FIM = +25$, and high rehabilitation potential (HRP) in 73.2% of cases ($p < 0.001$). In contrast, Grade III patients showed significantly poorer outcomes: $\Delta KPS = +4$, $\Delta FIM = +6$, with HRP achieved in only 10.1% of cases. These findings confirm that a biologically favorable tumor profile-low Ki-67, moderate angiogenesis, absence of brain invasion, and complete resection-is associated with better quality of recovery.

Prognostic Model: Practical Significance:

The combination of four factors (Ki-67 < 4%, CD34 < 12 vessels/HPF, Simpson Grade I-II resection, and absence of diffuse invasion) enabled the construction of a predictive model for assessing the likelihood of high rehabilitation potential. This model has potential clinical utility in guiding surgical decision-making and forecasting postoperative outcomes, including the need for rehabilitation strategies. The study confirms the prognostic value of Ki-67, CD34, and brain invasion in meningiomas. Grade I tumors demonstrate superior functional recovery due to low proliferative activity and limited angiogenesis. In contrast, more aggressive tumor forms are associated with complications, delayed recovery, and higher recurrence rates. Histopathological characteristics-including Ki-67 expression, CD34 expression, and depth of brain invasion ≥3 mm-are significant prognostic indicators of recurrence risk and functional outcome. These parameters can be incorporated into routine pathological evaluation of meningiomas to improve patient risk stratification. Based on these findings, individualized follow-up protocols, decisions on adjuvant therapy, and timing of neurorehabilitation can be formulated-especially for patients with Grade II–III tumors or evidence of invasive growth.

Future Research Directions.

Further studies on meningiomas should focus on the following areas:

- Integration of molecular-genetic profiling, including mutations in TERT, NF2, TRAF7, and others, to enhance molecular classification and predict aggressive behavior.
- Development of predictive models using machine learning, incorporating multiparametric data (CT/MRI, histology, clinical parameters) for automated recurrence risk estimation.
- In-depth exploration of tumor–microenvironment interactions, particularly the roles of immune cells, angiogenesis, and fibrosis in meningioma progression.

· Creation of universal morphometric invasion scoring systems suitable for routine pathological use and highly reproducible across centers.

Limitations and Potential Sources of Bias.

Despite meaningful results, the study has several methodological limitations:

· The retrospective nature of the analysis limits control over confounding variables and complicates causal inference.
· Underrepresentation of Grade II and III subgroups, reducing the statistical power of comparative analyses.
· Variability in immunohistochemical procedures and interpretation of Ki-67 and CD34 expression across laboratories.
· Limited follow-up duration, which may hinder the assessment of delayed recurrences, especially in the Grade I group.
· Lack of detailed evaluation of surgical quality (e.g., Simpson grade documentation), which may influence the interpretation of prognostic markers.

Conclusion.

Morphological markers such as Ki-67 < 4%, low CD34 expression, and absence of brain invasion define a subgroup of patients with a favorable prognosis and high recovery potential. These parameters should be considered essential tools in planning postoperative follow-up and rehabilitation strategies.

Conflict of interest.

Authors declare about not having financial and personal interests.

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Гистопатологические предикторы и функциональное восстановление у пациентов с внутричерепными менингиомами

Аннотация

Введение: Целью данного исследования было изучить клинико-морфологические и функциональные предикторы реабилитационного потенциала (РП) у пациентов после удаления внутричерепных менингиом. Основной задачей являлась оценка прогностической значимости биомаркеров опухоли (Ki-67, CD34), глубины инвазии в мозг и объёма хирургического вмешательства в отношении функционального восстановления и вероятности рецидива. Менингиомы демонстрируют широкий биологический спектр, влияющий на риск рецидива, неврологические исходы и потенциал реабилитации. Учитывая это, важным аспектом исследования стало сопоставление морфологических характеристик опухоли с клиническими исходами, включая изменения в шкалах функциональной независимости (ΔKPS, ΔFIM) и долгосрочные показатели восстановления. Полученные данные направлены на оптимизацию индивидуального прогноза, улучшение планирования хирургического лечения и последующей реабилитации пациентов с опухолями ЦНС.

Методы: В исследование включены 124 пациента (средний возраст 56 ± 12 лет; 61 % женщины), перенёсшие хирургическое лечение менингиом в период 2019-2024 гг. Оценивались объём резекции, гистологический подтип, индекс пролиферации Ki-67, плотность микрососудов (CD34), а также послеоперационные клинико-функциональные показатели. Функциональный статус оценивался до и через 3 месяца после операции с использованием шкалы Карновского (KPS) и шкалы функциональной независимости (FIM).

Результаты: Опухоли Grade I имели значительно более низкие значения Ki-67 (2,0-2,5 %) и CD34 (6-10 сосудов/HPF) по сравнению с Grade II (7,4 %) и Grade III (17,9 %) ($p < 0,001$). Инвазия ≥3 мм независимо увеличивала риск раннего рецидива (ОР = 3,8; $p < 0,001$). Ki-67 >8 % и CD34 >15 сосудов/HPF являлись независимыми предикторами рецидива (Cox-регрессия). Высокий реабилитационный потенциал (ΔKPS ≥15 и ΔFIM ≥20) был достигнут у 73 % пациентов с Grade I против 10 % с Grade III ($p < 0,001$).

Заключение: Низкие значения Ki-67 и CD34 в сочетании с отсутствием инвазии в мозговую ткань достоверно предсказывают благоприятное восстановление и низкий риск рецидива. Агрессивные морфологические характеристики требуют ранней адъювантной терапии и расширенного реабилитационного вмешательства.