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Surgical Management of Giant Intracranial Meningiomas: Key Considerations and Postoperative Results

Dev İntrakraniyal Menenjiyomların Cerrahi Tedavisi: Temel Hususlar ve Ameliyat Sonrası Sonuçlar

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Abstract

Objective: Giant intracranial meningiomas (GIM) present significant surgical challenges due to their size and involvement with critical neurovascular structures. This study aims to evaluate key surgical considerations and postoperative outcomes for patients undergoing resection of GIM and to highlight factors influencing recurrence-free survival and patient prognosis.

Methods: A retrospective review was conducted of 8 patients with GIM (>5 cm in diameter) who underwent surgical resection between 2021 and 2023. Demographic data, tumor characteristics, surgical techniques, and postoperative outcomes were analyzed. Tumor size, extent of resection, and recurrence were assessed through imaging and clinical follow-up.

Results: The cohort included 3 males (37.5%) and 5 females (62.5%) with a mean age of 56.4 years. The most common tumor location was the olfactory groove (37.5%). The mean tumor volume was 107.6 cm^3, and the mean follow-up duration was 9.6 months. Gross total resection (Simpson grade 2) was achieved in 75% of cases, while subtotal resection (Simpson grade 4) was achieved in 25% of cases. Two patients with World Health Organization grade 2 pathology received postoperative radiotherapy. No major postoperative complications were observed, and the mean duration of hospitalization was 11 days.

Conclusion: Surgical resection of GIM remains a challenging but essential approach to managing these complex tumors. While gross total resection is the preferred goal, subtotal resection may be necessary to preserve neurological function. Postoperative radiotherapy may be required in higher-grade tumors. Tumor location, vascularity, and advanced intraoperative techniques significantly influence surgical outcomes and recurrence-free survival.

Keywords: Giant intracranial meningioma, recurrence-free survival, surgical outcome, meningioma

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Öz

Amaç: Dev intrakraniyal menenjiyomlar (GİM), boyutları ve kritik nörovasküler yapılarla ilişkileri nedeniyle önemli cerrahi zorluklar oluşturur. Bu çalışmanın amacı, GİM rezeksiyonu uygulanan hastalarda temel cerrahi faktörleri ve postoperatif sonuçları değerlendirmek, nüksüz sağkalım ve hasta prognozunu etkileyen faktörleri ortaya koymaktır.

Yöntem: 2021-2023 yılları arasında cerrahi rezeksiyon uygulanan, çapı 5 cm'den büyük 8 GİM hastasının geriye dönük incelemesi yapıldı. Demografik veriler, tümör özellikleri, cerrahi teknikler ve postoperatif sonuçlar analiz edildi. Tümör boyutu, rezeksiyon derecesi ve nüks, görüntüleme ve klinik takipler aracılığıyla değerlendirildi.

Bulgular: Kohortta 3 erkek (%37,5) ve 5 kadın (%62,5) hasta yer aldı; ortalama yaş 56,4 idi. En sık görülen tümör yerleşimi olfaktör oluk (%37,5) idi. Ortalama tümör hacmi 107,6 cm^3, ortalama takip süresi ise 9,6 ay olarak bulundu. Olguların %75'inde total rezeksiyon (Simpson evre 2), %25'inde subtotal rezeksiyon (Simpson evre 4) gerçekleştirildi. Dünya Sağlık Örgütü evre 2 patolojiye sahip iki hastaya postoperatif radyoterapi uygulandı. Majör postoperatif komplikasyon gözlenmedi ve ortalama hastanede yatış süresi 11 gündü.

Sonuç: GİM'lerin cerrahi rezeksiyonu, bu karmaşık tümörlerin tedavisinde zorlu ancak vazgeçilmez bir yaklaşımdır. Total rezeksiyon tercih edilen hedef olsa da, nörolojik fonksiyonun korunması amacıyla subtotal rezeksiyon gerekli olabilir. Yüksek dereceli tümörlerde postoperatif radyoterapi gerekebilir. Tümör yerleşimi, vaskülaritesi ve ileri intraoperatif tekniklerin kullanımı, cerrahi sonuçlar ve nüksüz sağkalımı önemli ölçüde etkilemektedir.

Anahtar Kelimeler: Dev intrakraniyal menenjiyom, nükssüz sağkalım, cerrahi sonuç, menenjiyom

Introduction

Meningiomas are the most frequently encountered benign tumors of the central nervous system and arise from arachnoid cap cells. They characteristically develop as extra-axial, slow-progressing lesions[1,2]. Among them, giant intracranial meningiomas (GIMs) constitute a clinically significant subgroup distinguished by their extensive size and tendency to involve adjacent neurovascular structures, which considerably increases surgical complexity[3,4]. Because of their indolent growth pattern, meningiomas often remain asymptomatic for prolonged periods. Clinical manifestations generally emerge as a consequence of mass effect, tumor location, or elevated intracranial pressure, and radiological identification frequently occurs only after substantial enlargement has taken place[5]. Size-based classification systems describe meningiomas larger than 3 cm as large, while lesions exceeding 5 cm at diagnosis are categorized as giant[6,7]. The management of giant meningiomas presents particular challenges. Their considerable volume contributes to raised intracranial pressure, and their intimate relationship with essential anatomical structures complicates operative planning and execution. Consequently, these tumors demand meticulous surgical strategy and advanced technical expertise[4,7]. Various treatment protocols are employed for meningiomas, ranging from simple observation and partial resection, through radiosurgery (as a primary or adjuvant therapy), to aggressive surgical resection[8-10]. Therapeutic approaches to meningiomas range from active surveillance to subtotal resection, stereotactic radiosurgery-either as a standalone modality or adjunctive therapy-and extensive microsurgical excision[6]. In cases involving large or giant lesions, operative treatment is often indicated due to significant mass effect and neurovascular compromise. Importantly, the objectives of surgical intervention extend beyond tumor removal, emphasizing not only overall survival but also preservation of postoperative functional status and quality of life[11].

Critical factors influencing the choice of surgical approach include the tumor's complex location, growth trajectory, involvement of adjacent structures, patient age, and the surgeon's experience[12]. Surgery for GIM poses unique challenges due to the tumor's large volume, increased vascularity, involvement of vital neurovascular structures, and severe cerebral edema, all of which complicate visualization and resection. Gross total resection is the primary goal in the surgical management of meningiomas. However, achieving this is not always feasible for giant meningiomas due to their size and frequent adherence to, or encasement of, critical neurovascular structures. These factors significantly increase the risk of postoperative complications, making the surgical approach more complex and requiring careful consideration of subtotal resection in some cases to preserve neurological function and patients' quality of life.

Materials and Methods

Permission for the study was obtained from the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (approval no: 2025-01-35, date: 24.10.2025).

A retrospective analysis was conducted of patients who underwent surgical treatment for intracranial tumors between 2021 and 2023 and who received a histopathological diagnosis of meningioma. Within this population, only cases with a maximum tumor diameter greater than 5 cm were included, consistent with the definition of GIM.

Demographic characteristics, clinical presentation, radiological findings, intraoperative use of neuronavigation, applied microsurgical techniques, and postoperative outcomes were systematically extracted from medical records, operative reports, imaging databases, and follow-up documentation.

Histopathological evaluation was performed in accordance with the World Health Organization classification criteria[13]. Tumor volume was estimated using the formula a×b×c/2 based on radiological measurements.

Early postoperative neuroimaging was obtained within 48 hours to assess the extent of tumor resection. During follow-up, magnetic resonance imaging was scheduled at six-month intervals throughout the first postoperative year and annually thereafter.

Recurrence was defined radiologically as either the reappearance of tumor tissue at the original site after gross total resection or a measurable enlargement of residual tumor tissue, regardless of the presence or absence of clinical symptoms.

Statistical Analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated.

Results

The demographic and clinical data of 8 patients who underwent surgical intervention between 2021 and 2023 were analyzed. The demographic, clinical, and histological characteristics of all patients with giant meningiomas are summarized in Table 1. The mean follow-up duration for the patients is 9.6 months (9.6±6.8 months). The cohort included 3 males (37.5%) and 5 females (62.5%), with a mean age of 56.4 years (56.4±10.4). Among the 8

Table 1. Demographic data of GIM patients along with clinical features

Patient	Age (years)/ gender	Location	Size of tumor (mm)	Symptom/sign	Operation duration (hour)	Intraoperative blood lose (cc)	Simpson grade	Pathology grade	Length of hospital stay (day)	Postoperative radiotherapy	Follow-up (month)
1	64/F	Tuberculum sella	81x64x70	Dizziness	24	1250	2	1	6	-	18
2	61/F	Olfactory groove	60x66x45	Anosmia, syncope, visual deficit	23	1200	2	1	21	-	18
3	32/M	Convexity	93x65x58	Seizure	10	1500	4	2	3	+	9
4	50/F	Sphenoid wing	67x51x60	Facial paralysis, headache	14	800	2	1	5	-	12
5	61/F	Falx	62x55x50	Headache	14	1000	4	2	4	+	3
6	55/M	Tentorial	40x40x60	Headache	10	1250	2	1	5	-	1
7	61/M	Olfactory groove	62x50x58	Anosmia, dizziness, gait disturbance, headache	16	1100	2	1	14	-	1
8	67/F	Olfactory groove	60x50x60	Dizziness, gait disturbance, headache, incontinence	13	800	2	1	30	-	15

F: Female, M: Male, mm: Millimeter, GIM: Giant intracranial meningiomas patients, the most common tumor location was the olfactory groove (3 cases; 37.5%), followed by tuberculum sella, convexity, sphenoid wing, falx, and tentorial locations, each representing 1 case (12.5%). The mean operation duration was 15.5 hours (15.5±5.2 hours). The mean bleeding amount was 1112.5 cc (1112.5±235.7 cc). Simpson grade 2 was observed in 75% of cases, and Simpson grade 4 was observed in 25% of cases. Pathology grade 1 was seen in 75% of cases, and pathology grade 2 was seen in 25% of cases. The mean hospitalization duration was 11 days (11.0±9.2 days). The mean tumor size is 107.6 cm^3 (107.6±43.4 cm^3). Two patients with grade 2 pathology received postoperative radiotherapy. No major postoperative complications were observed. The pre and post-resection status of cases in the study cohort are illustrated (Figure 1-8).

Discussion

This study reports the clinical results of eight patients treated surgically for GIMs. Particular emphasis was placed on the operative difficulties associated with these uncommon lesions, underscoring the necessity of comprehensive anatomical knowledge and the application of refined microsurgical strategies to optimize surgical outcomes. By doing so, we aimed to emphasize the complexity of these cases and the critical factors involved in achieving safe and effective resections.

GIM typically shows a female predominance and occurs around the age of 40[3,14]. In our series, giant meningiomas were more common in female patients (62.5%). Clinical symptoms vary according to tumor location, but headaches are the most common symptom in our series (62.5%). Chan and Thompson[15] demonstrated that parasagittal or falx meningiomas are the most common tumor localization. In our series, olfactory groove meningiomas were more frequently observed; however, the small number of cases is insufficient to support generalizations. Long operation durations and blood loss play a critical role in meningioma surgeries[16]. For tumors close to vascular structures, operative duration is longer. The outcome may vary depending on the surgeon's experience. Our series includes surgeries performed by a single surgeon. In our series, the mean intraoperative blood loss is 1112.5 cc (1112.5±224.65 cc). The mean operation duration is 15.5 hours (15.5±5 hours).

Irrespective of anatomical location, the surgical management of GIMs is technically demanding. Their considerable size, marked vascularity, associated peritumoral edema, and frequent encasement or displacement of critical neurovascular structures significantly increase operative complexity (Figure 9). Consequently, the choice of surgical strategy must be tailored to the tumor's anatomical position and vascular characteristics.

In this context, Attia et al.[17] described a skull base technique for the treatment of giant anterior clinoidal meningiomas that incorporated extradural optic canal unroofing, anterior clinoidectomy, and early decompression of the optic nerve. This method improved surgical exposure, enhanced tumor removal, and minimized the likelihood of injury to adjacent neurovascular structures. Surgical challenges in GIMs include safely identifying and preserving critical neurovascular structures, particularly in medial sphenoid wing and clinoidal meningiomas. Early optic nerve decompression and extradural clinoidectomy are key techniques in these cases, especially when visual impairment is present. For olfactory groove meningiomas, both the pterional and bifrontal approaches are commonly used. Visual impairment associated with olfactory groove meningiomas is generally less severe than that observed in clinoidal lesions and shows a more favorable recovery following a bifrontal surgical approach. Alternatively, the pterional-transsylvian corridor provides several operative advantages, including early identification and control of critical neurovascular structures, limited cortical manipulation, reduced perioperative morbidity and mortality, and relatively low recurrence rates.

In our series, two patients underwent adjuvant radiotherapy because their tumors were histopathologically classified as grade II. The mean duration of follow-up was 9.6 months, while the average length of hospitalization was 11 days. The calculated mean tumor volume was 107.6 cm^3.

Certain tumor characteristics were associated with less favorable outcomes. Invasion of the paranasal sinuses and encasement of the anterior cerebral artery were associated with higher rates of postoperative complications and of recurrence. Extensive peritumoral brain edema represents another major surgical challenge in GIM cases, particularly when accompanied by pronounced mass effect or midline shift.

To address elevated intracranial pressure and facilitate safer resection, several intraoperative strategies may be employed. Controlled cerebrospinal fluid drainage through multiple dural openings and staged internal decompression using neuronavigation guidance and a cavitron ultrasonic aspirator can be particularly beneficial. These techniques are especially useful for anterior skull-base tumors and giant medial sphenoid-wing meningiomas.

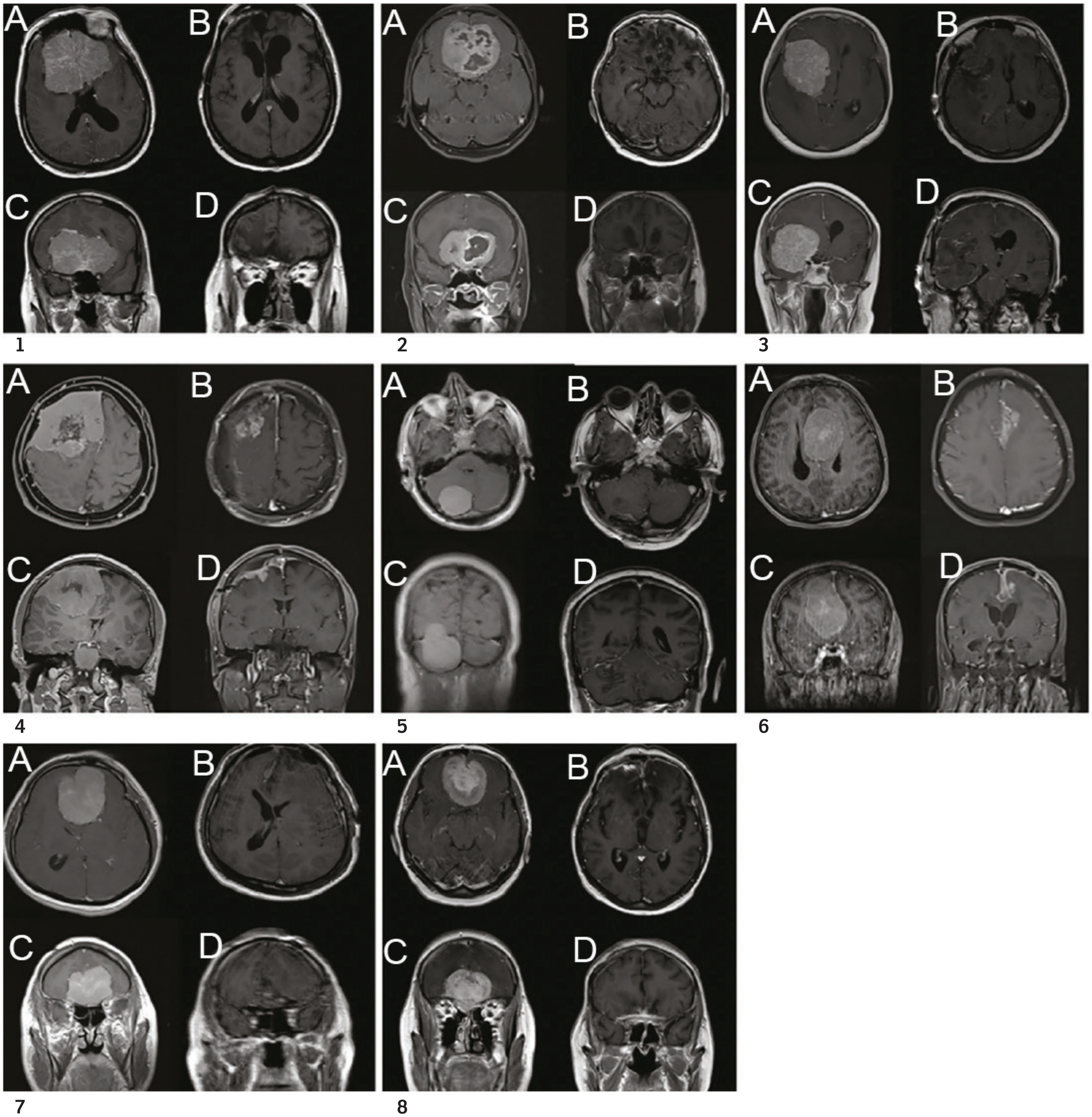

Figure 1-8. Pre- and post-operative contrast-enhanced MRI images of giant meningioma

A) Pre-operative axial images, B) Post-operative axial images, C) Pre-operative coronal images, D) Post-operative coronal images

MRI: Magnetic resonance imaging

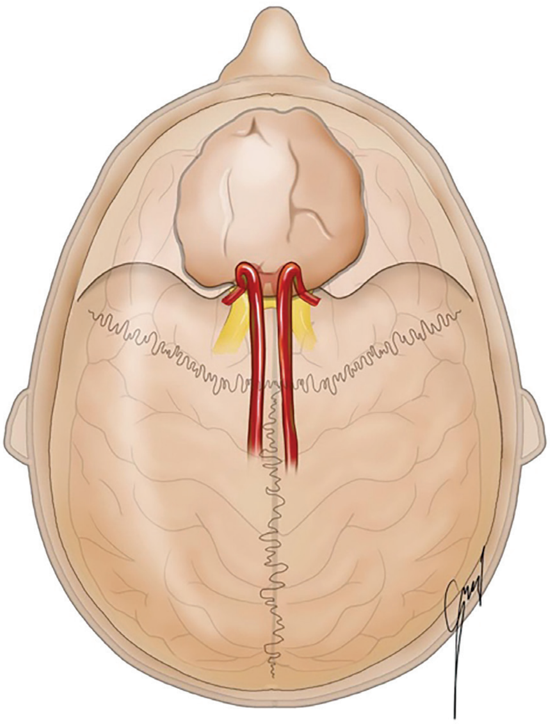

Figure 9. Illustration of a giant meningioma

Resection of giant petroclival meningiomas is demanding due to their size and the distortion of surrounding anatomical landmarks, paralleling the challenges encountered in clinoidal and olfactory groove lesions. For posterior fossa GIMs, Sanai described a modified far-lateral approach that enables gross total resection while maintaining low morbidity and mortality rates[18]. This technique provides several operative benefits, including enhanced tumor exposure, improved control of venous bleeding, and early entry into the spinal subarachnoid cisterns. Accurate identification of eloquent neural structures and major vascular elements, combined with meticulous manipulation of a tense and edematous brain, are critical to achieving maximal safe resection in cases of GIMs.

In their series, Chan and Thompson[15] reported that gross total resection was accomplished in 83% of patients, whereas subtotal removal was necessary in 17% of cases. Reported complication rates following surgical treatment of GIMs include postoperative neurological deterioration in 10.8% of patients, a perioperative mortality rate of 4%, and a tumor recurrence rate of 22%.

Excessive intraoperative hemorrhage remains a major operative challenge in GIM resections. The pronounced vascularity of these tumors may originate from multiple sources, including dural, pial, and transosseous arterial feeders, thereby increasing the risk of significant blood loss during dissection.

Preoperative endovascular embolization targeting the dominant arterial supply has been proposed as a strategy to mitigate intraoperative bleeding. Nevertheless, as emphasized by Bendszus et al.[19] effective reduction in blood loss is achieved only when embolization is complete, whereas partial devascularization offers limited benefit[20,21]. In our cohort, preoperative embolization was not performed, which likely contributed to the relatively elevated intraoperative blood loss. Giant meningiomas located at the olfactory groove or planum sphenoidale may derive their vascular supply from branches of the internal carotid artery, the middle meningeal artery, or the distal maxillary artery, thereby increasing the potential risk of visual compromise during surgical manipulation.

To mitigate this risk, Manjila et al.[22] described an extracranial approach involving open or endoscopic ligation of the ethmoidal arteries via transcaruncular or Lynch approaches prior to tumor resection. In our series, a comparable technique was used in patients with olfactory groove meningiomas.

Furthermore, the integration of advanced preoperative imaging modalities and intraoperative adjuncts-including cortical mapping, neuronavigation systems, and frameless stereotactic guidance-has substantially improved both operative safety and resection outcomes in the management of GIMs. Neuronavigation played a crucial role in achieving better resection outcomes, influencing overall survival. In this cohort, patients with skull base meningiomas had a better prognosis, likely due to their lower histological grade and improved resection status. In cases where the tumor involves critical regions, such as the petroclival area, selectively pursuing subtotal resection followed by radiotherapy may be a more reasonable approach than attempting gross total resection[10]. This is particularly true when gross resection poses significant risks to the patient's neurological function. The extent of tumor resection is typically assessed using the Simpson grading system, and in our series, we achieved gross total resection (Simpson grade 2) in six cases. Subtotal resection (Simpson grade 4) was performed in two patients because of the tumor's proximity to critical structures. Neuronavigation, in particular, allows surgeons to plan the shortest and safest route to the tumor and design an optimal craniotomy, thereby improving tumor resection rates and patient survival. Complications during GIM surgeries are uncommon, but can include tumor bed hematoma, cerebrospinal fluid collection or leak, and infection. Inadequate hemostasis at the tumor bed can predispose patients to postoperative hematoma formation and associated neurological complications, whereas incomplete dural closure increases the risk of cerebrospinal fluid accumulation or leakage. Notably, in our series, no instances of hematoma or cerebrospinal fluid fistula were observed. These outcomes highlight the importance of meticulous surgical planning and technique to minimize complications in giant meningioma surgery.

Several factors can influence recurrence-free survival (RFS) in GIM cases. Incomplete resection (Simpson grade 4) and poor histological grade negatively impacted RFS.

A meticulous preoperative evaluation, thorough understanding of risk factors, an effective surgical approach, and judicious use of intraoperative adjuncts (such as neuronavigation) are critical to optimizing surgical outcomes. These elements collectively play a pivotal role in ensuring both safety and efficacy in the resection of GIMs. Giant meningiomas are extremely rare and pose significant challenges to total resection. GIMs exert a significant mass effect on adjacent brain tissue, leading to increased intracranial pressure, compression-related hemodynamic changes, and disruption of normal neural function. Vasogenic edema in the surrounding parenchyma is observed in over half of cases and can often be mitigated preoperatively through corticosteroid therapy.

Surgical management of GIMs presents multiple challenges. Prolonged operative times increase the risk of intraoperative blood loss and often necessitate careful dissection of encased cerebral arteries and cranial nerves. Tumor exposure may be limited by bridging veins and surrounding vasculature, making preoperative identification of critical neurovascular structures essential for safe resection. Initial operative steps typically involve coagulation of feeding vessels, with particular attention to avoiding injury to tense or edematous brain tissue throughout the procedure.

For skull base GIMs, cerebrospinal fluid drainage via transsylvian dissection facilitates brain relaxation, allowing internal debulking of the tumor. Endoscopic techniques, particularly for anterior skull base lesions, enable early devascularization and mobilization of the mass. Additional operative strategies that are critical for optimizing outcomes include proper patient positioning to reduce venous hypertension, selection of the most appropriate surgical corridor to minimize parenchymal injury, maintenance of excellent visualization of the operative field, and early identification of vital neurovascular structures. Meticulous dissection, preservation of bridging veins and perforating vessels, maintenance of the arachnoid plane, and diligent hemostasis are pivotal in reducing complications and improving postoperative outcomes.

Surgical planning must account for tumor location, size, and growth pattern. Convexity meningiomas typically require craniotomies larger than the lesion itself to allow safe manipulation, whereas skull base tumors demand a tailored approach. Craniofacial approaches may be indicated for extensive anterior skull base lesions, while pterional, subfrontal, or endoscopic endonasal routes are employed for tumors arising from the anterior fossa or tuberculum sellae. Intraventricular lesions can be accessed via tubular retractors with endoscopic assistance or through an interhemispheric transcallosal corridor.

The overarching goal of surgery is to maximize tumor removal while preserving neurological function and quality of life. Factors influencing the choice of surgical strategy include tumor location, direction of growth, involvement of adjacent neurovascular structures, patient age, and the operating surgeon's experience. The substantial size of GIMs can limit the extent of resection and be associated with higher recurrence rates, increased perioperative morbidity and mortality, and variable overall survival. Prognostic outcomes depend on multiple parameters, including tumor size and location, completeness of resection, histopathological grade, and use of adjuvant therapies. Notably, extensive vasogenic edema involving the bifrontal white matter in anterior skull-base meningiomas may predict poorer postoperative recovery.

Study Limitations

This study is limited by its retrospective design, small sample size, and relatively short and variable follow-up period. The heterogeneity of tumor locations limits meaningful subgroup comparisons, while the absence of inferential statistical analysis precludes definitive conclusions regarding prognostic factors and RFS. In addition, tumor volume was estimated using a simplified radiological formula rather than segmentation-based volumetry, and functional outcomes were not assessed using standardized scales. All procedures were performed by a single surgeon, which limits the generalizability of the findings despite reducing inter-operator variability.

Conclusion

GIM are rare and technically challenging lesions that require meticulous preoperative planning and individualized surgical strategies. Their large size, extensive vascularity, peritumoral edema, and frequent involvement or displacement of critical neurovascular structures substantially increase the risk of intraoperative blood loss, prolonged operative time, neurological morbidity, and incomplete resection. In our series, gross total resection was achieved in most patients, whereas subtotal resection was selected when tumor involvement of critical neurovascular structures made complete removal unsafe. Tumor location, extent of resection, and histopathological grade appeared to be important determinants of postoperative outcome and RFS. The use of neuronavigation, appropriate skull base or cranial approaches, early identification and control of feeding vessels, internal tumor debulking, cerebrospinal fluid drainage, and meticulous preservation of neurovascular structures may facilitate maximal safe resection. Given the rarity of GIMs and the limited number of patients in the present series, larger multicenter studies with longer follow-up are warranted to better define prognostic factors and establish standardized surgical strategies.

Ethics

Ethics Committee Approval: Permission for the study was obtained from the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (approval no: 2025-01-35, date: 24.10.2025).

Informed Consent: Retrospective analysis.

Footnotes

Authorship Contributions

Concept: Y.D., M.E.G., E.G., Design: Y.D., M.E.G., Data Collection or Processing: Y.D., M.E.G., E.G., A.G.Ş., Literature Search: Y.D., M.E.G., E.G., Writing: Y.D., M.E.G., E.G., O.K.D., A.G.Ş., B.D., E.E., A.G.

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