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# Parasagittal Meningioma: A Comprehensive Case Series and Systematic Review

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**ABSTRACT**

**Introduction:** This case series included seven patients diagnosed with parasagittal meningioma, presenting their clinical histories, management, and outcomes. In parallel, a systematic review synthesized the existing literature on parasagittal meningioma. This comprehensive analysis combined the findings from both the case series and the systematic review to provide a holistic understanding of these tumors. This case series included seven patients diagnosed with parasagittal meningioma, presenting their clinical histories, management, and outcomes. In parallel, a systematic review synthesized the existing literature on parasagittal meningioma. This comprehensive analysis combined findings from both the case series and the systematic review to provide a holistic understanding of these tumors.

**Results:** This case series highlights the clinical heterogeneity of parasagittal meningiomas and presents cases with various clinical presentations, treatment approaches, and outcomes. The systematic review consolidates existing knowledge and reveals gaps in the understanding of optimal management for these tumors. The combination of case series and systematic reviews provides valuable insights into the clinical behavior, treatment strategies, and prognostic factors associated with parasagittal meningioma.

**Conclusions:** Parasagittal meningioma presents unique diagnostic and therapeutic challenges. This comprehensive study offers a multifaceted perspective on these tumors, enhancing our understanding of their clinical characteristics and management options. These findings can guide clinicians in making informed decisions and improving patient outcomes in the field of neuro-oncology.

## Introduction

Parasagittal meningioma represents a subset of intracranial tumors that arise in proximity to the sagittal sinus. These tumors, characterized by their location along the cerebral falx, present a unique challenge in both diagnosis and treatment due to their anatomical intricacies and potential for complex clinical manifestations. As meningiomas are among the most common primary brain tumors, understanding the distinct features and management strategies for parasagittal variants is of paramount importance. This

comprehensive case series and systematic review aim to provide a thorough exploration of parasagittal meningiomas by synthesizing available data from clinical cases and existing literature, offering insights into their clinical characteristics, diagnostic methods, treatment modalities, and outcomes (Mathiesen, 2020).

Parasagittal meningioma is a rare subtype of brain tumors that originates in the meninges and protective layers surrounding the brain and spinal cord. They typically arise along the parasagittal region, which is the area adjacent to the superior sagittal sinus. These tumors account for approximately 10.0-15.0% of all meningiomas. Despite their relatively low incidence, parasagittal meningiomas present unique challenges due to their proximity to critical structures and the potential for neurological deficits (Ricci et al., 2017).

Meningiomas, which account for approximately 30.0% of all primary brain tumors, have been extensively studied; however, parasagittal meningiomas have received relatively less attention in the literature compared to their intracranial counterparts. This challenge arises from their unique anatomical location adjacent to the sagittal sinus and the potential involvement of critical neurovascular structures. Accurate diagnosis and appropriate management of parasagittal meningiomas are essential to achieving favorable patient outcomes. Therefore, this study aims to consolidate and analyze the existing knowledge on these tumors to improve our understanding of their clinical behavior and therapeutic options (Ricci et al., 2017).

The management of parasagittal meningiomas requires a multidisciplinary approach involving neurosurgeons, neurologists, radiologists, and radiation oncologists. Treatment options include surgical resection, radiation therapy, and observation, depending on the tumor size, location, and clinical condition of the patient. However, the optimal management strategy remains a subject of debate, and the decision-making process often relies on individual case reports and small case series (Ricci et al., 2017).

To address the gaps in knowledge and provide a comprehensive understanding of parasagittal meningiomas, this study aimed to present a case series and a systematic review. By analyzing a larger cohort of patients and synthesizing the existing literature, we aimed to elucidate the clinical characteristics, treatment outcomes, and potential prognostic factors associated with parasagittal meningioma. This comprehensive analysis will contribute to a better understanding of these tumors and guide clinicians in making evidence-based

decisions regarding their management (Antunes & Winter, 2023).

The findings of this study have several clinical and research implications. Clinically, a comprehensive analysis of parasagittal meningiomas will shed light on optimal treatment strategies, including surgical techniques, adjuvant therapy options, and long-term follow-up protocols. Additionally, the identification of potential prognostic factors can aid in risk stratification and individualized treatment planning. From a research standpoint, this study consolidates the existing literature on parasagittal meningioma, highlighting gaps in knowledge and areas for future investigation. Ultimately, the aim is to improve patient outcomes and contribute to ongoing advancements in the field of neuro-oncology.

## *Case Series*

### *Clinical Profiles and Demographics*

In this case series, we present seven diverse cases of parasagittal meningioma, each with unique clinical characteristics and management challenges. Medical records were used as the source of the clinical data. Only adult patients (⩾ 18 years) were included. Parasagittal meningiomas were confirmed by histopathology performed by an experienced neuropathologist. We included all patients with parasagittal meningioma who underwent surgery at our center between 2019 and 2024. None of our patients were diagnosed with genetically inherited syndromes such as Neurofibromatosis Type 2.

**Table 1.** Patients included for case series

| Case Age Sex | CNS WHO Grade | TTM (Years) | Primary Location | Further Details | Initial Management | After Surgery Conditions |
|---|---|---|---|---|---|---|
| 45, Female | 2 | 2 years | 1/3 medial right parasagittal | Weakness in left leg, intermittent headaches, nausea, vomiting, and decreased consciousness | Craniotomy for tumor removal | Improved motor function, no significant deficits |
| 52, Female | 2 | 1 year | 1/3 medial left parasagittal | Seizures, right-sided limb weakness, speech difficulties | Craniotomy for tumor removal | Improved seizures and motor function. Still have speech difficulties |
| 68, Female | 1 | 5 months | 1/3 medial right parasagittal | Weakness in left arm and leg, worsening condition over time | Craniotomy for tumor removal | Improved motor function. |
| 47, Female | 1 | 4 months | 1/3 anterior left parasagittal | Recurrent headaches, worsening condition with seizure | Craniotomy for tumor removal | Improved seizure. No headaches. |
| 39, Female | 1 | 2 months | 1/3 anterior right parasagittal | Severe headaches, vomiting, weakness in left arm and leg | Craniotomy for tumor removal | Improved headache, no change in left body weakness |
| 61, Female | 1 | 3 months | 1/3 medial right parasagittal | Headaches, left hemiparesis | Craniotomy for tumor removal | Improved headache and motor function |
| 45, Female | 1 | 5 months | 1/3 anterior left parasagittal | Recurrent headaches, dysphagia | Craniotomy for tumor removal | Improved headache. Still have dysphagia |

*Descriptive analysis*

The descriptive analysis in this study encompassed a detailed examination of the present case series of parasagittal meningiomas. This case series provides comprehensive clinical histories, management details, and outcomes for seven patients diagnosed with parasagittal meningioma. These cases illustrate the diverse clinical presentations, treatment approaches, and outcomes associated with parasagittal meningiomas, emphasizing their clinical heterogeneity. The case series will then be further analyzed with the results from a systematic review to offer a holistic perspective on parasagittal meningiomas, providing insights into their clinical complexities, diagnostic challenges, and therapeutic options.

***Systematic review***

*Literature search*

The systematic review conducted in this study followed a rigorous methodology to synthesize and analyze the existing literature on parasagittal meningiomas. The process began with a comprehensive search of relevant medical databases, including PubMed, Web of Science, and the Cochrane Library, covering the period from January 1, 2014, to April 30, 2024. Specific search terms and MeSH descriptors, such as 'parasagittal meningioma,' 'clinical characteristics,' 'treatment modalities,' and 'outcomes,' were used to ensure targeted and comprehensive retrieval of relevant studies. To enhance the thoroughness of our search, we examined the reference lists of the included studies to identify additional relevant studies. Two authors independently screened the abstracts and assessed the full-text articles for eligibility, ensuring an unbiased selection and evaluation. This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, guaranteeing a transparent and standardized approach (Moher et al., 2009).

*Inclusion and Exclusion Criteria*

After retrieving the initial pool of articles, a systematic screening process was used to assess their eligibility. Studies were included if they met the following criteria: written in English, published within the last decade, conducted on human populations, focused primarily on parasagittal meningiomas, and discussed clinical characteristics, treatment modalities, and patient outcomes. To maintain a high level of evidence, the exclusion criteria included review articles, case reports, case series, and conference abstracts.

*Study selection*

Two independent reviewers meticulously evaluated the titles and abstracts of each article based on the predetermined inclusion and exclusion criteria. Following this initial screening, the full texts of potentially eligible studies were retrieved and reassessed to ensure that they met the inclusion criteria. Discussions were held to reach a consensus in cases of disagreement between the reviewers. If consensus could not be reached, a third reviewer was consulted to make a final decision, ensuring the integrity and impartiality of the selection process.

*Data extraction*

The selected studies underwent data extraction, which involved the collection of information on patient demographics, clinical presentations, treatment strategies, and outcomes. The data were systematically organized into a comprehensive database for further analysis. Subsequently, qualitative synthesis was performed, highlighting the key findings and trends across the selected studies. The clinical heterogeneity of parasagittal meningiomas, as well as variations in treatment approaches and outcomes, were thoroughly examined. This systematic review also aimed to identify gaps in the existing literature and pinpoint areas where further research is needed to improve the understanding and management of these tumors.

*Assessment of study quality*

The articles included in the systematic review underwent quality assessment using the Newcastle-Ottawa Scale (Lo et al., 2014). This process was independently performed by two reviewers.

*Synthesis with case series*

The findings of the systematic review were then integrated with those of the case series presented in this study, providing a holistic view of parasagittal meningiomas. By combining the systematic review results with detailed patient cases, this study offers a multifaceted perspective on rare intracranial tumors. The integration of broad literature insights with specific patient experiences enriched the analysis, highlighting both common trends and unique challenges in managing these tumors. This comprehensive approach enhances the understanding of clinical characteristics, treatment options, and prognostic factors, ultimately contributing valuable insights into the field of neuro-oncology.

The systematic review methodology involved a systematic search, rigorous screening, data extraction, and qualitative synthesis of relevant studies to complement the case series used in this study. This

approach facilitated a comprehensive analysis of parasagittal meningiomas, emphasizing their clinical heterogeneity and the importance of tailored treatment strategies and interdisciplinary collaboration for optimal patient care.

## Results

### *Case 1*

A 45-year-old female underwent craniotomy for removal of a right-sided WHO grade I meningioma. Postoperatively, she experienced leg weakness and intermittent headaches but showed significant improvement over time. The symptoms escalated a year prior to the current assessment, with severe headaches and decreased consciousness. Re-evaluation confirmed the initial diagnosis of the meningioma and indicated successful surgical outcomes, as demonstrated by improved motor functions and no significant neurological deficits. This case emphasizes the benefits of precise surgical intervention and the importance of ongoing monitoring and supportive care in meningioma management.

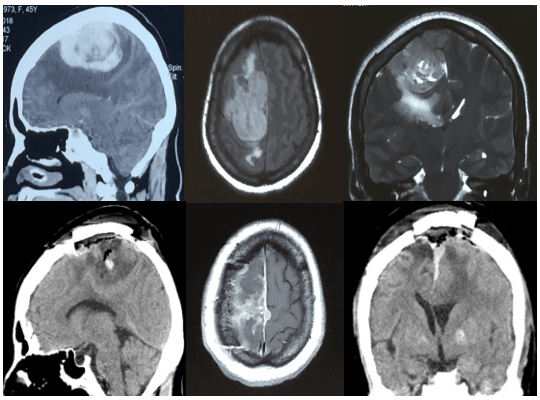

**Figure 1.** Pre-Op and post-op imaging comparison in sagittal, axial, and coronal views of case 1

### *Case 2*

A 52-year-old patient with a parasagittal meningioma underwent craniotomy followed by radiotherapy. During the initial surgery, the tumor was removed from the medial left falx. The patient later experienced seizures, limb weakness, speech difficulties, and radicular pain, which led to the diagnosis of L4/5 disc herniation, although she declined further surgery. The development of a new tumor necessitated re-craniotomy. The current symptoms include speech difficulties, seizures, visual disturbances, and motor deficits. MRI findings suggested malignant transformation, adding complexity to the patient's condition. When scheduled for the removal of another tumor, the patient underscores the importance of continuous personalized care in managing recurrent meningiomas.

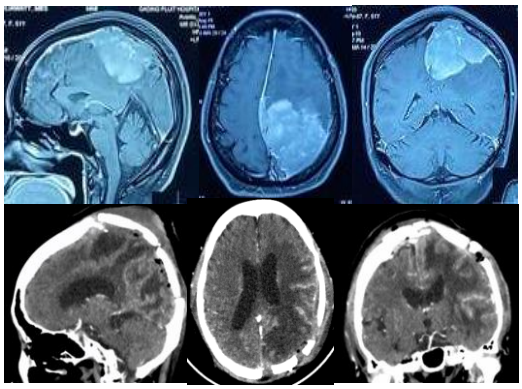

**Figure 2.** Comparison of pre-operative (contrast MRI) and post-operative (non-contrast CT) imaging in sagittal, axial, and coronal views for case 2

***Case 3***

A 68-year-old patient presented with left hemiparesis and was diagnosed with a right medial parasagittal meningioma with significant perifocal edema and midline shift. The patient underwent successful surgery for tumor removal. Postoperative outcomes included intensive care management, highlighting effective treatment and recovery from a substantial meningioma. This case emphasizes the need for clear documentation of patient outcomes, particularly for complex surgical recoveries.

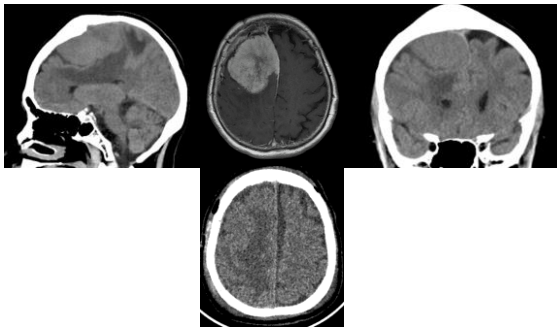

**Figure 3.** Pre-operative and post-operative imaging comparison in sagittal, axial, and coronal views for case 3. The pre-operative axial view was obtained using contrast MRI, while the remaining images were acquired using non-contrast CT scans.

***Case 4***

A 47-year-old patient with a left frontal parasagittal meningioma underwent successful craniotomy. Before the surgery, the patient experienced seizures and was managed with phenytoin, along with persistent headaches. Imaging revealed a midline shift with calcification, necessitating detailed surgical planning. The operation, which lasted 4 hours with an expected blood loss of 500 cc, was well prepared with the necessary blood products. Postoperatively, the patient was closely monitored in the ICU to manage complications, diabetes, and hypertension, which led to a successful recovery. This case highlights the importance of meticulous preoperative planning and careful postoperative care.

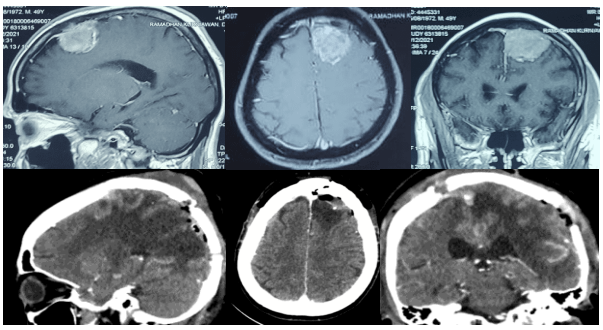

**Figure 4.** Comparison of pre-operative (MRI) and post-operative (non-contrast CT) imaging in sagittal, axial, and coronal views for case 4.

***Case 5***

A 39-year-old patient presented with severe headaches that began three days prior to evaluation. Initial contrast-enhanced magnetic resonance imaging (MRI) indicated a tumor, leading to craniotomy. Despite the surgical history, documentation discrepancies were noted, which were clarified postoperatively. Postoperatively, the patient experienced severe headaches that escalated in intensity; however, postoperative imaging showed promising results with significant headache relief, reducing the VAS score to 1-2. Persistent left-sided weakness was also observed. This case highlights the effectiveness of surgical treatment for parasagittal tumors and emphasizes the need for precise medical documentation.

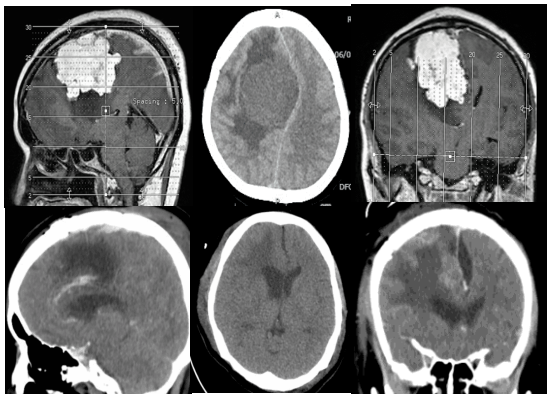

**Figure 5.** Pre-operative and post-operative imaging comparison in sagittal, axial, and coronal views for case 5.

***Case 6***

A 61-year-old patient presented with worsening left-sided body weakness and intermittent headaches of increasing intensity over 15 months. Symptoms initially appeared 25 months ago and escalated to difficulty walking and handling objects. A computed tomography (CT) scan identified a tumor, leading to further assessment and a contrast magnetic resonance imaging (MRI) brain scan, which confirmed a right parasagittal meningioma. The patient underwent successful craniotomy for tumor removal. Postoperatively, there was a significant improvement in strength and a reduction in headache intensity. Recovery includes physical therapy and medication, enhancing quality of life and managing residual symptoms.

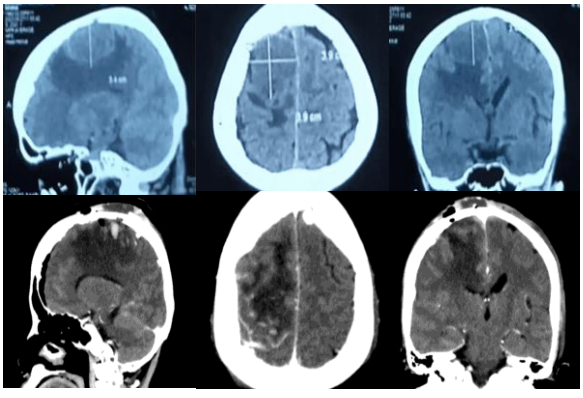

**Figure 6.** Pre-operative and post-operative non-contrast CT imaging comparison in sagittal, axial, and coronal views for case 6

***Case 7***

A 45-year-old patient experienced intermittent headaches and difficulty swallowing seven months prior to diagnosis. Computed tomography revealed a frontal sinus tumor, which was initially managed with Mestinon for swallowing issues. Contrast-enhanced magnetic resonance imaging confirmed a parasagittal meningioma. Despite treatment for dysphagia, the symptoms persisted with medication adjustments, leading to a decision to perform craniotomy. Postoperatively, the patient showed a marked improvement in swallowing and headache management. Ongoing medication effectively controlled the symptoms, demonstrating a successful response to the combined treatment.

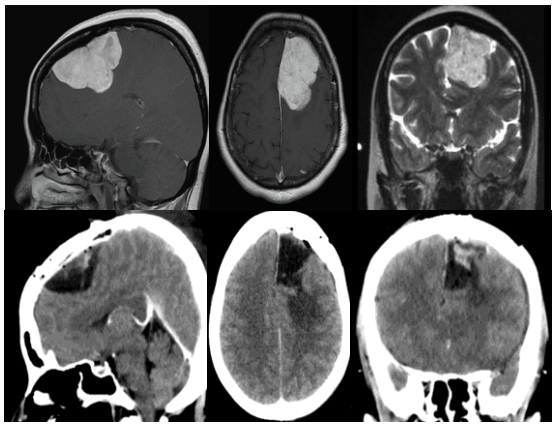

**Figure 7.** Pre-operative and post-operative imaging comparison in sagittal, axial, and coronal views for case 7

The case series presented here highlights the diversity of clinical presentations and management challenges posed by parasagittal meningiomas. Case 1 underscores the diagnostic complexity, as the patient initially presented with vague symptoms that were mistaken for migraines. This case emphasizes the importance of considering brain tumors in the differential diagnosis of severe headaches, even in the absence of typical neurological deficits. Case 2 exemplifies the challenges of managing recurrent parasagittal meningiomas, including their potential for malignant transformation. The patient's history of treatment adds complexity to current management. Case 3 illustrates the rapid progression of symptoms in some patients with parasagittal meningioma, necessitating timely surgical intervention. Case 4 emphasizes the need to consider comorbidities, such as diabetes and hypertension, when planning the management of these tumors. Case 5 highlights the diagnostic and therapeutic considerations for a patient with a parasagittal meningioma and a history of contraceptive use. Case 6 discusses the treatment and recovery from a right

parasagittal meningioma, which resulted in improved strength and reduced headaches after craniotomy. Finally, case 7 focuses on the management of dysphagia and a frontal sinus tumor, leading to improved symptoms following surgery and medication for suspected myasthenia gravis.

***Systematic review***

*Results of search strategy*

Figure 3 outlines the article selection process. The search identified 821 records, of which 440 were screened after duplicates were removed. Of the screened records, 381 were excluded from the study. Twenty-nine titles and abstracts of the screened articles were excluded. Of the full texts, 22 were also excluded. Seven studies met the predefined criteria and were included in the review, totaling 1,005 patients with parasagittal meningioma.

*Characteristics of eligible studies*

This systematic review consists of seven eligible studies, including five retrospective cohort studies and two comprehensive literature reviews (Figure 2). The five retrospective cohort studies discussed the outcomes of surgical resection for the treatment of parasagittal meningiomas. Some studies provided valuable insights into the integration of various advanced techniques such as intraoperative neuronavigation and conformal radiation therapy, which have been employed alongside surgical resection to enhance treatment efficacy and precision. All included cohort studies were deemed "good" in quality based on NOS scoring for observational studies.

*Clinical characteristics*

Each surgical intervention described in these cohort studies was meticulously guided using the Sindou classification system. This system categorizes parasagittal meningiomas based on the extent of SSS invasion. Sindou Class I tumors have minimal invasion, as they only attach to the outer surface of the sinus wall. In contrast, Sindou Classes V and VI indicate severe invasion, leading to significant narrowing or complete occlusion of the sinus. Furthermore, the extent of tumor removal was evaluated and categorized using the Simpson grading (SG) system, a widely recognized framework that correlates the completeness of tumor resection with the likelihood of recurrence. In this grading system, SG I represents total resection of the tumor along with its dural attachment and any involved bone, aiming for the highest likelihood of cure and the lowest risk of recurrence. On the other end of the spectrum, SG V indicates more limited resections, where the primary goal might be to decompress pressure caused by the tumor and alleviate

symptoms without achieving complete removal, often due to the high surgical risks associated with extensive resection (Sindou & Alvernia, 2006).

The integration of advanced techniques, such as intraoperative neuronavigation, provides real-time, precise guidance during surgery, enabling surgeons to navigate complex brain structures and achieve more accurate resections. Conformal radiation therapy is often used postoperatively to target residual tumor cells, thereby enhancing the overall treatment outcome and reducing the risk of recurrence (Sindou & Alvernia, 2006).

On the other hand, one literature review explored the promising potential of stereotactic radiotherapy and radiosurgery as alternative treatments to conventional surgical methods. This review highlights notable improvements in patient outcomes and reduced toxicity reported in several studies, suggesting that these advanced techniques could offer significant benefits. Intriguingly, this review also posits that radiotherapy could potentially serve as an exclusive treatment, eliminating the need for surgery in certain cases. This literature review provides a comprehensive and detailed examination of the current standards and practices in the management of parasagittal meningiomas, including surgery and radiotherapy.

The systematic review conducted in this study complements this case series by synthesizing existing literature on parasagittal meningiomas. This review revealed the clinical heterogeneity of these tumors, as reported in various studies, as well as variations in treatment approaches and outcomes. It also identified gaps in the literature, indicating the need for further research to optimize the management of parasagittal meningiomas.

The integration of case series and systematic review findings provides a comprehensive understanding of parasagittal meningiomas. Clinically, this study offers insights into optimal diagnostic and treatment strategies for these tumors. It emphasizes the importance of interdisciplinary collaboration, individualized patient management, and the consideration of comorbidities in decision-making. From a research perspective, this study highlights the need for large-scale studies and standardized approaches to improve evidence-based management of parasagittal meningiomas.

*Treatment options and outcomes*

Each surgical intervention described in these cohort studies was meticulously guided by the Sindou classification system. This system categorizes parasagittal meningiomas based on the extent of their invasion of the SSS. Sindou Class I tumors

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Furthermore, the extent of tumor removal was evaluated and categorized using the SG system, which is a widely recognized framework that correlates the completeness of tumor resection with the likelihood of recurrence. In this grading system, SG I represents total resection of the tumor along with its dural attachment and any involved bone, aiming for the highest likelihood of cure and the lowest risk of recurrence. On the other end of the spectrum, SG V indicates more limited resections, where the primary goal might be to decompress pressure caused by the tumor and alleviate symptoms without achieving complete removal, often due to the high surgical risks associated with extensive resection (Cho et al., 2000).

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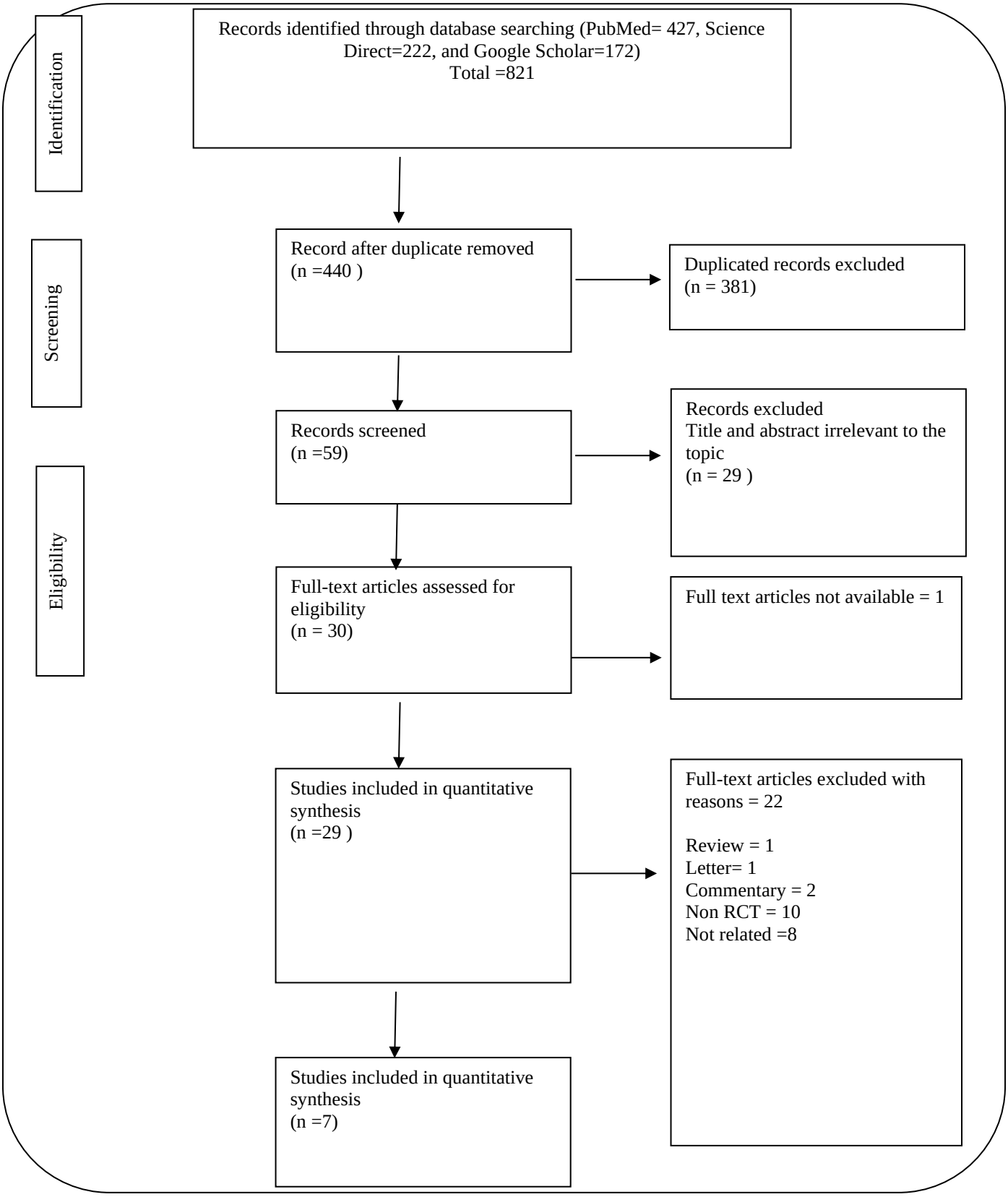
Identification
Records identified through database searching (PubMed= 427, Science Direct=222, and Google Scholar=172)
Total =821
Screening
Record after duplicate removed
(n =440 )
Duplicated records excluded
(n = 381)
Records screened
(n =59)
Records excluded
Title and abstract irrelevant to the topic
(n = 29 )
Eligibility
Full-text articles assessed for eligibility
(n = 30)
Full text articles not available = 1
Studies included in quantitative synthesis
(n =29 )
Full-text articles excluded with reasons = 22
Review = 1
Letter= 1
Commentary = 2
Non RCT = 10
Not related =8
Studies included in quantitative synthesis
(n =7)

Table 2. Study characteristics of included studies

| Characteristics | Pinzi (2019)[12] | Ricci (2017)[2] | Wang (2021)[13] |
|---|---|---|---|
| Number of Patients | 388 PSM patients | 75 PSM patients | 165 PSM patients |
| Study Design | Literature review | Retrospective cohort | Retrospective cohort |
| Intervention | Combination of SRT and single-session radiosurgery | Radical resection with SSS reconstruction, aided with ICGV | Surgical resection with various techniques |
| Clinical Characteristics | NA | Anterior-third SSS: mental disorder and personality changes;<br>Middle-third: hemiparesis, akinesia, brain swelling, venous infarction, CSF leak; and<br>Posterior third: septicaemia | Headache, upper or lower limbs weakness, seizure, dizzy, sensation disturbances, hyposmia, somnolence |
| Treatment Options | SRT<br>Radiosurgery | Total surgical resection (SG I-II)<br>ICGV | Surgical resection |
| Study Conclusion | Combination of SRT and single-session radiosurgery serve as an alternative to conventional surgery, as it shows improvement in outcomes and reduced toxicity (e.g. edema, motor weakness, headache) | Preservation of cortical veins and anterior-third of the SSS (to avoid changes in personality or mental disorders) are the key factors to successful surgery | Surgery is the key treatment for PSM, with aggressive resection leading to higher KPS score |

*PSM* parasagittal meningioma, *SRT* stereotactic radiotherapy, SSS superior sagittal meningioma, ICGV indocyanine green video-angiography, *NA* not available, *CSF* cerebrospinal fluid, *SG* Simpson grading, *KPS* Karnofsky performance scale

Table 2. Continued

| Characteristics | Aguiar (2022)[9] | Chen (2023)[10] | Kalfas (2019)[11] | Mathiesen (2020)[1] |
|---|---|---|---|---|
| Number of Patients | 65 PSM patients with the invasion of SSS | 212 PSM patients | 100 PSM/FM patients with >2.0 cm in the largest diameter | NA |
| Study Design | Retrospective cohort | Retrospective cohort | Retrospective cohort | Literature review |
| Intervention | Total surgical resection using SG I technique or surgical resection with preservation of the SSS wall (SG II) | Maximal safe resection.<br>Sindou I-II: radical resection<br>Sindou III-IV: GTR<br>Sindou V-VI: STR | Advanced microsurgical technique using image guidance and conformal radiation treatments | Surgical resection using SG and adjuvant radiosurgery |
| Clinical Characteristics | Headache, neurological deficit, intracranial hypertension, seizures, no symptoms | NA | Headache, seizure, ataxia, unilateral weakness, lower extremity weakness, psychosis, palpable mass, asymptomatic | Focal neurological deficit, epilepsy, increased ICP |
| Treatment Options | Surgical resection | Surgical resection | Surgical resection<br>Intraoperative neuronavigation<br>Radiosurgery | Surgical resection<br>Radiosurgery |
| Study Conclusion | SG II resection is better for PSM with invasion of SSS, as it diminishes vascular risks, lowering the frequency of severe postoperative deficit, and reduces mortality | The main predictors of increased perioperative complications were Sindou invasion classes V-VI and peritumoral edema ≥ 1cm<br><br>Sindou invasion classes III-IV and V-VI were the independent predictors for tumor recurrence | Advanced microsurgical technique using image guidance and conformal radiation treatments can optimize outcomes with minimal complication and mortality | Surgery is the main therapy for PSM and techniques have improved over the years, however tumor recurrence is not uncommon. Adjuvant radiosurgery and long-term follow-up are important to be considered |

*PSM* parasagittal meningioma, *SSS* superior sagittal meningioma, *FM* falcine meningioma, *NA* not available, *SG* Simpson grading, GTR gross total resection, *STR* subtotal resection, ICP intracranial pressure

Table 3. Newcastle-Ottawa Scale quality appraisal for retrospective cohort studies

| | | | **Selection** | | | **Comparability** | **Outcome** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **No.** | **Author** | **Year** | **Representativeness of the exposed cohort** | **Selection of the nonexposed cohort** | **Ascertainment of exposure** | **Incident disease** | **Comparability of cohorts based on the design or analysis** | **Outcome assessment** | **Follow up long enough for outcomes to occur** | **Adequacy of follow-up for cohort** | **Result quality** |
| 1 | Aguiar[9] | 2022 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | Good |
| 2 | Chen[10] | 2023 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | Good |
| 3 | Kalfas[11] | 2019 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | Good |
| 4 | Pinzi[12] | 2019 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | Good |
| 5 | Ricci[2] | 2017 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | Good |

Result quality: Good: 3 or 4 in selection, and 1 or 2 in comparability, and 2 or 3 in outcome; Fair: 2 in selection, and 1 or 2 in comparability, and 2 or 3 in outcome; Poor: 0 or 1 in selection, or 0 in comparability, or 0 and 1 in outcome.

**Table 2.** Study characteristics of included studies

| Characteristics | Aguiar et al. (2022) | Chen et al. (2023) | Kalfas & Scudieri (2019) | Mathiesen (2020) |
|---|---|---|---|---|
| Number of Patients | 65 PSM patients with the invasion of SSS | 212 PSM patients | 100 PSM/FM patients with >2.0 cm in the largest diameter | NA |
| Study Design | Retrospective cohort | Retrospective cohort | Retrospective cohort | Literature review |
| Intervention | Total surgical resection using SG I technique or surgical resection with preservation of the SSS wall (SG II) | Maximal safe resection.<br>Sindou I-II: radical resection<br>Sindou III-IV: GTR<br>Sindou V-VI: STR | Advanced microsurgical technique using image guidance and conformal radiation treatments | Surgical resection using SG and adjuvant radiosurgery |
| Clinical Characteristics | Headache, neurological deficit, intracranial hypertension, seizures, no symptoms | NA | Headache, seizure, ataxia, unilateral weakness, lower extremity weakness, psychosis, palpable mass, asymptomatic | Focal neurological deficit, epilepsy, increased ICP |
| Treatment Options | Surgical resection | Surgical resection | Surgical resection<br>Intraoperative neuronavigation<br>Radiosurgery | Surgical resection<br>Radiosurgery |
| Study Conclusion | SG II resection is better for PSM with invasion of SSS, as it diminishes vascular risks, lowering the frequency of severe postoperative deficit, and reduces mortality | The main predictors of increased perioperative complications were Sindou invasion classes V-VI and peritumoral edema ≥ 1cm<br><br>Sindou invasion classes III-IV and V-VI were the independent predictors for tumor recurrence | Advanced microsurgical technique using image guidance and conformal radiation treatments can optimize outcomes with minimal complication and mortality | Surgery is the main therapy for PSM and techniques have improved over the years, however tumor recurrence is not uncommon. Adjuvant radiosurgery and long-term follow-up are important to be considered |

*PSM* parasagittal meningioma, *SSS* superior sagittal meningioma, *FM* falcine meningioma, *NA* not available, *SG* Simpson grading, GTR gross total resection, *STR* subtotal resection, ICP intracranial pressure

| Characteristics | Pinzi et al. (2019) | Ricci et al. (2017) | Wang et al. (2022) |
|---|---|---|---|
| Number of Patients | 388 PSM patients | 75 PSM patients | 165 PSM patients |
| Study Design | Literature review | Retrospective cohort | Retrospective cohort |
| Intervention | Combination of SRT and single-session radiosurgery | Radical resection with SSS reconstruction, aided with ICGV | Surgical resection with various techniques |
| Clinical Characteristics | NA | Anterior-third SSS: mental disorder and personality changes;<br>Middle-third: hemiparesis, akinesia, brain swelling, venous infarction, CSF leak; and<br>Posterior third: septicaemia | Headache, upper or lower limbs weakness, seizure, dizzy, sensation disturbances, hyposmia, somnolence |
| Treatment Options | SRT<br>Radiosurgery | Total surgical resection (SG I-II)<br>ICGV | Surgical resection |
| Study Conclusion | Combination of SRT and single-session radiosurgery serve as an alternative to conventional surgery, as it shows improvement in outcomes and reduced toxicity (e.g. edema, motor weakness, headache) | Preservation of cortical veins and anterior-third of the SSS (to avoid changes in personality or mental disorders) are the key factors to successful surgery | Surgery is the key treatment for PSM, with aggressive resection leading to higher KPS score |

*PSM* parasagittal meningioma, *SRT* stereotactic radiotherapy, SSS superior sagittal meningioma, ICGV indocyanine green video-angiography, *NA* not available, *CSF* cerebrospinal fluid, *SG* Simpson grading, *KPS* Karnofsky performance scale

## Discussion

Each surgical intervention in these cohort studies followed the Sindou classification system, categorizing parasagittal meningiomas by their invasion of the SSS. Sindou Class I tumors attach minimally to the sinus wall, while Classes V and VI show severe invasion, causing significant narrowing or complete occlusion of the sinus. Tumor removal extent was assessed using the SG system, which correlates resection completeness with recurrence likelihood. SG I involves total resection, including dural attachment and any affected bone, aiming for high cure rates and low recurrence risk. Conversely, SG V entails limited resections to decompress tumor pressure and alleviate symptoms, often due to high surgical risks (Sindou & Alvernia, 2006).

The incorporation of intraoperative neuronavigation offers real-time, precise surgical guidance, allowing for accurate navigation of complex brain structures and improved resection accuracy. Postoperative conformal radiation therapy targets residual tumor cells, enhancing treatment outcomes and reducing recurrence risk (Cho et al., 2000). Conversely, a literature review examined the potential of stereotactic radiotherapy and radiosurgery as alternatives to conventional surgery, noting improved patient outcomes and reduced toxicity in several studies. The review also suggested that radiotherapy could potentially replace surgery in certain cases (Pinzi et al., 2019). This comprehensive review details current standards and practices in the management of parasagittal meningiomas, encompassing both surgical and radiotherapy approaches.

This systematic review complements the case series by synthesizing existing literature on parasagittal meningiomas, revealing clinical heterogeneity and variations in treatment and outcomes. It identifies gaps in the literature, indicating a need for further research to optimize management strategies. Integrating the case series and review findings offers a comprehensive understanding of parasagittal meningiomas, providing insights into optimal diagnostic and treatment strategies. This underscores the importance of interdisciplinary collaboration, individualized patient management, and consideration of comorbidities in decision-making. It also highlights the necessity for larger-scale studies and standardized approaches to enhance evidence-based management.

### *Clinical heterogeneity and diagnostic challenges*

Parasagittal meningioma, a rare intracranial tumor originating from the

meninges, presents a complex clinical landscape. This case series illustrates the extensive clinical heterogeneity of these tumors, showing patients with a diverse array of symptoms and diagnostic challenges. Symptoms range from severe headaches and limb weakness to recurrent seizures, speech difficulties, and neurological deficits, complicating timely and accurate diagnosis due to their overlap with other neurological conditions (Kondziolka et al., n.d.).

The diagnostic complexity is further underscored in this study. Case 1 highlights the challenge of recognizing parasagittal meningiomas when initial symptoms, like intermittent headaches, are misattributed to common conditions such as migraines. In Case 2, the recurrence and malignant transformation of the tumor added diagnostic complexity, necessitating a nuanced management approach. These cases exemplify the intricate interplay between symptoms and the diagnostic hurdles encountered by clinicians.

A critical aspect of this study is the importance of considering brain tumors, including parasagittal meningiomas, in the differential diagnosis of severe headaches, even without overt neurological deficits. Delayed diagnosis can significantly impact treatment outcomes. Therefore, healthcare providers must maintain a high index of suspicion and pursue comprehensive evaluations when confronted with severe headaches, leading to earlier detection and more effective management of parasagittal meningiomas.

In conclusion, the clinical heterogeneity and diagnostic challenges associated with parasagittal meningiomas emphasize the need for a multifaceted approach to their recognition and treatment, improving the prospects of patients affected by these rare intracranial tumors (Zheng et al., 2022).

*Treatment approaches and outcomes*

This study outlines various treatment approaches, including surgical resection, radiation therapy, and observation, depending on factors such as tumor size, location, and patient condition. This comprehensive approach ensures that each patient receives personalized care tailored to their specific situation. Surgical resection aims to remove the tumor entirely, while radiation therapy can be used when complete surgical removal is challenging or risky. Observation may be suitable for small asymptomatic tumors that do not pose an immediate threat to patient health. Considering these treatment options, clinicians can make informed decisions to optimize patient outcomes.

*Surgical Technique of Parasagittal Meningioma*

Resection of parasagittal meningiomas presents unique challenges owing to their proximity to the sagittal sinus, a major venous structure in the brain. Craniotomy involving the sagittal sinus requires meticulous planning and execution to minimize the risk of venous damage, which can lead to significant complications such as brain swelling, hemorrhage, or even fatal outcomes.

The surgical technique begins with a precise craniotomy that allows optimal exposure of the tumor while preserving critical vascular structures. Neurosurgeons often use neuronavigation systems to enhance the accuracy of tumor localization and delineate the boundaries between the tumor and the sinus. The surgical approach may vary depending on the degree of sinus encasement. For tumors that partially encase the sinus, careful debulking is performed to reduce tumor volume and relieve pressure on the sinus. Advanced microsurgical instruments and techniques are employed to meticulously dissect the tumor from the sinus wall, preserving venous integrity as much as possible (Zabolotny et al., 2019).

When the tumor involves the sagittal sinus, surgeons may need to decide between partial resection and sinus reconstruction. In cases where the sinus is extensively encased, partial resection is often performed to avoid compromising venous outflow. If the tumor infiltrates a segment of the sinus that can be safely removed, techniques such as direct suturing, patch grafting, or venous bypass may be employed to reconstruct the sinus and restore venous circulation (Zabolotny et al., 2019).

One of the critical considerations during surgery is the extent to which the tumor encases the sagittal sinus. When the tumor involves the sinus, complete resection becomes more complex and riskier. Surgeons must balance the goal of maximal tumor removal with the preservation of venous outflow. This often results in a higher rate of incomplete resections, as removing the entire tumor might necessitate sacrificing portions of the sinus, thereby increasing the risk of serious complications. In such cases, adjuvant therapies, such as radiation, may be employed postoperatively to manage residual tumor tissue, ensuring comprehensive treatment while mitigating surgical risks. Additionally, intraoperative monitoring of brain function and venous pressure can guide surgical decisions and help prevent complications (DeMonte et al., 2011; Sacko et al., 2007).

Furthermore, the importance of a multidisciplinary approach involving neurosurgeons, neurologists, radiologists,

and radiation oncologists in the management of parasagittal meningiomas cannot be overstated. These tumors are complex and often require a combination of surgical and non-surgical interventions. Neurosurgeons play a central role in tumor resection, whereas neurologists are essential in managing neurological symptoms and comorbidities. Radiologists provide crucial imaging expertise for diagnosis and treatment planning, while radiation oncologists offer expertise in delivering radiation therapy when necessary. Collaborative decision-making and ongoing communication among these specialists are vital for providing the best possible care to patients with parasagittal meningiomas (Chen et al., 2023).

This study highlights the need for individualized treatment plans, considering factors such as comorbidities and history of previous treatments, as demonstrated in the case series. Each patient's unique clinical presentation and medical history should guide treatment decisions. For example, comorbidities such as diabetes and hypertension may influence the choice of treatment and perioperative management. Additionally, patients with recurrent tumors, as seen in Case 2, may require different approaches than those with newly diagnosed tumors. By tailoring treatment plans for individual patients, healthcare providers can optimize outcomes and improve the overall quality of care for individuals with parasagittal meningiomas.

*Gaps in existing literature and research implications*

This study, which includes a series of cases and a systematic review of parasagittal meningiomas, reveals deficiencies in the current literature on this condition and emphasizes crucial areas for future research. The systematic review points out significant gaps in understanding the clinical characteristics, treatment strategies, and patient outcomes of parasagittal meningiomas. Future research should focus on addressing these gaps with large-scale studies and standardized management approaches. Additionally, the study stresses the need to investigate novel diagnostic techniques, assess the role of additional therapies like radiation or targeted therapy, and identify predictive factors for treatment response and prognosis. By exploring these areas, future research can significantly advance our knowledge of rare intracranial tumors and improve patient outcomes, thereby impacting both clinical practice and advancements in neuro-oncology.

## Conclusion

Parasagittal meningiomas present a distinct challenge in neuro-oncology. This study provides critical insights into their clinical characteristics, diagnostic challenges, treatment strategies, and outcomes. The heterogeneity and diagnostic complexities of these tumors necessitate a multifaceted approach for effective recognition and management. It underscores the importance of personalized treatment plans developed by a multidisciplinary team, considering factors such as comorbidities and previous treatments. Additionally, the study identifies gaps in the current literature, highlighting the need for further research to optimize management and improve patient outcomes. This research enhances our understanding of these rare intracranial tumors, guiding clinicians in making informed decisions to advance patient care in neuro-oncology.

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