Review Article

OPEN ACCESS
Pak. J. Adv. Med. Med. Res.
2024, 02(2): Page-166-171

SURGICAL MANAGEMENT OF BRAIN MENINGIOM AS TECHNIQUES AND OUTCOMES A SYSTEMATIC REVIEW

Naeem Ul Haq[1], Syed Nasir Shah[2], Ikram Ullah[3]

[1,2,3-]*Department of Neurosurgery, Bacha Khan Medical College Mardan*

ABSTRACT

Background: Surgical treatment of brain meningioma's is challenging because of their various sites, sizes and effects on surrounding neural structures.

Objective: This review aims to integrate the current surgical techniques and results in managing brain meningioma's.

Study Design: A Systematic Review.

Setting and Duration of Study: The study was conducted at the Department of Neurosurgery, Bacha Khan Medical College Mardan, for six months, from 8th October 2023 to 8th April 2024.

Methods: A systematic literature search was undertaken to identify recent studies and clinical trials about surgical therapy for brain meningioma. It also highlights microsurgical techniques, endoscopic approaches, advancement in neuro-navigation and intraoperative monitoring.

Results: The inclusion criteria were met by 52 studies of 18 randomized control trials (RCT),24 observational studies and 10 meta-analyses. The total number of patients included in these studies was 8420 who underwent surgery for brain meningiomas. Gross total resection (GTR) rates ranged between 70% -95%. Recurrence after GTR varied from 5%-15 % over a five-year follow-up period.

Conclusions: Over time, the management of Brain Meningiomas has changed due to advancements in technology and technique. Although microsurgical excision remains vital in therapy, endoscopic approaches and modern intraoperative adjuncts have widened the neurosurgeons' armamentarium, improving patient outcomes.

Keywords: brain meningiomas, microsurgical resection, neuro-navigation.

How to Cited this Article : Haq NU, Shah SN, Ullah I. Surgical Management of Brain Meningiomas: A Review of Current Techniques and Outcomes. Pak J Adv Med Med Res. 2024;2(2):166–171. doi:10.69837/pjammr.v2i02.44.

Corresponding Author: Ikram Ullah
Department of Neurosurgery, Bacha Khan Medical College Mardan

Email: akranullah@hotmail.com

https://orcid.org/0000-0001-8428-3922

Cell No +92 333 9415678

Article History

Received:	February	19-2024
Revision:	March	15-2024
Accepted:	April	2 1 -2024
Published:	July	05- 2024

INTRODUCTION

Meningiomas of the brain are the most common primary brain tumours originating from meninges, the membranous layers surrounding the brain and spinal cord [1]. Meningiomas account for approximately 30% of all intracranial tumours. They are usually benign, slow-growing tumours, with a subset being atypical and malignant [2]. Despite changes in technology and surgical techniques, surgical management of meningiomas remains a traditional procedure in neurosurgery [3]. For brain meningiomas, the principal aim of surgery is to achieve total resection while preserving neurological function. This goal is complicated by several factors, including tumour location, size, vascularity and proximity to vital structures within the brain [4, 5].Additionally, accurate surgical planning and execution are essential for recurrence prevention. Hence, surgery will optimize tumour removal while minimizing residual disease [6]. Traditional microsurgical resection has long been advocated as the treatment for this condition. The technique involves delicate dissection and removing a tumour under high magnification, allowing direct vision and precise manipulation of surrounding tissues [7]. These approaches have often achieved gross total resection with favourable long-term outcomes [8]. Invasiveness, however, leads to significant postoperative morbidity, especially when dealing with skull base tumours that are technically challenging to expose surgically [9, 10].On the other hand, endoscopic approaches have emerged as alternatives to craniotomy over the past few years. Endoscopic surgery is performed through small incisions using specialized instruments, which, among other benefits, reduce surgical trauma, shorten recovery time and produce better cosmetic results [11]. It also significantly helps when managing skull base meningiomas, where a conventional approach may not be feasible [12]. Nevertheless, technical maturity must be obtained because these tumours may not be suitable for endoscopic surgery at all locations. Integrating advanced neuro-navigation systems and intraoperative imaging has increased precision in meningioma surgeries. Neuro-navigation entails real-time three-dimensional navigation for surgical planning and unmatched accuracy during resection execution [13, 14]. Intraoperative magnetic resonance imaging (MRI) adds to it by enabling assessment of tumour removal during surgery, thereby reducing residual tumour formation thus preventing recurrence scenarios later on [15]. Fluorescence-guided surgery is another breakthrough in this field. It is used To identify the margins of a tumour where fluorescent dyes selectively accumulate, making total resection easier [16]. Thus, it can enhance surgical outcomes, particularly when differentiating between a brain tumour and normal brain tissue becomes difficult.

METHODOLOGY

Study Design: The study is a systematic review and meta-analysis.

Setting and Duration of Study: The study was conducted at the Department of Neurosurgery Bacha Khan Medical College Mardan for six months, from 8th October 2023 to 8th April 2024.

MATERIALS AND METHODS

These searches included peer-reviewed journals, clinical trial databases, medical sources like PubMed and neurosurgical publications. Databases such as PubMed, MEDLINE, Scopus, and Cochrane Library were used to collect articles published between January 2000 and December 2023. Keywords employed in the search are "brain meningiomas," "surgical management," "microsurgical resection," "endoscopic surgery", "neuro-navigation", "intraoperative MRI" and fluorescence-guided surgery." Researches about surgical techniques for brain meningiomas. Articles report clinical results obtained from different ways of removing brain tumours. Articles published only in English: peer-reviewed journal articles, clinical trials and meta-analyses. Studies involving people above eighteen years old were considered for inclusion. Studies with a primary focus other than brain meningiomas were excluded from this review. Nonsurgical treatments such as radiation therapy and chemotherapy. Case reports with fewer than five patients. Abstract articles that did not exist in full-text form. Papers involving children and minors would be left out of this study.

DATA EXTRACTION

Two reviewers independently extracted data to ensure accuracy and minimize bias. The following information was taken from each study: Author(s) and publication year. Design of analysis and sample size. Type and localization of meningiomas. Methods employed for surgical treatment. Use advanced technologies (e.g., neuro-navigation, intraoperative MRI, fluorescence-guided surgery). Clinical outcomes: extent of resection, recurrence rates, Postoperative morbidity and mortality. Length of follow-up.

QUALITY ASSESSMENT

Standard tools suitable for the type of studies were used to assess the quality of articles included in this review. The Cochrane Risk of Bias Tool was used to evaluate Randomized Controlled Trials (RCTs), while the Newcastle-Ottawa Scale was applied for observational studies assessments. Elements such as study design, sample size, selection bias, and clarity in outcome reporting were some factors that determined the grade assigned.

DATA ANALYSIS

Collected Data were synthesized into a comprehensive summary of current surgical techniques and their outcomes. Descriptive statistics were conducted to summarize the characteristics and primary findings in the reviewed studies. When appropriate meta-analyses were carried out to measure the overall effect size for specific surgical techniques on clinical outcomes using statistical methods such as fixed and random effect model as well as their results reported through tables and forest plots, Meta-regression analysis will be performed where other factors are thought to influence heterogeneity Statistical heterogeneity among studies was assessed using I^2 statistic, and subgroup analyses done to explore potential sources of variability.

ETHICAL CONSIDERATIONS

Given that this is a literature review paper, no new patient data was involved; hence, there was no need for any ethical approval.**Ref (BKMC/744/04/22)** ethical consideration from included studies was carefully reviewed to ensure adherence to ethical standards in clinical research.

RESULTS

Fifty-two studies met the inclusion criteria, comprising 18 randomized controlled trials (RCTs), 24 observational studies, and 10 meta-analyses. Together, these studies involved 8,420 patients who had surgical treatment for brain meningiomas. As such, the studies differed in their designs, patient populations and follow-up periods, thereby giving a comprehensive view on how brain meningioma surgery is being done today. Accessible and symptomatic brain meningiomas are still best treated by microsurgical resection. Out of the 28 studies focused on microsurgical techniques; The rate for gross total resection (GTR) ranged from 70% to 95%. Over five years, the recurrence rates after GTR were between 5% and 15%. There was a postoperative morbidity ranging from 10% to 20%, with neurological deficits, as well as mortality ranging from approximately 1- 2%. Studies indicated that outcomes were influenced by tumour location. For example, convexity meningiomas had higher GTR rates and lower morbidity than skull base meningiomas. The review of 12 studies showed that endoscopic techniques in skull base meningiomas were good. The percentage of GTR in endoscopic approaches was lower than in microsurgical resection and ranged from 60% to 80%. Rates of recurrence were slightly higher, varying between 10% and 20%. Postoperative morbidity rates related to complications were significantly reduced as a consequence since they amounted to only about 5–10%, with no reported mortality in the reviewed studies. As more patients recover faster, their hospital stay is shorter if they undertake endoscopic surgery. Of the 15 studies that involved neuro-navigation, about 10% improvement in GTR rate was seen compared to surgeries without this technology. Intraoperative MRI studies (7 in all) showed a marked decrease in residual tumour volume and increased GTR rates from 75% to 90%. The use of these technological devices also resulted in a reduction in recurrence rates and postoperative neurological deficits. In recent decades, fluorescence-guided surgery has undergone massive studies under eight research papers. Correspondingly, Around 80-90% of the GTR rate for FGS was not different from that of traditional microsurgery. It enabled surgeons to determine tumour borders more easily, particularly in complicated cases. Several other studies showed a decreased remnant tumour and increased long-term disease control. Comparative analysis of the various surgical techniques revealed that while microsurgical.

Resection remains highly effective for GTR; endoscopic approaches give many advantages in reduced morbidity and quick healing. Neuro-navigation and intraoperative MRI fusion improve operations to a great extent, particularly Cases where total tumour removal is difficult. Again, it seems possible to improve tumour visualization and resection accuracy by using fluorescence-guided surgery.

Table 1: Summary of Included Studies

Study Type	Number of Studies	Sample SizeRange	Follow-up Duration
Randomized Controlled (RCTs)	18	50 – 300	1 - 10 years
Observational Stud	24	30 – 500	1 - 15 years
Meta-analyses	10	100 – 1500	Variable
Total	52	8 – 420	1 - 15 years

Table 2: Outcomes of Microsurgical Resection

Outcome Measure	Range	Notes
Gross Total Resection (GTR)	70% - 95%	Higher in convexity meningioma's
Recurrence Rate	5% - 15	Overa 5-year follow-up
Postoperative Morbidity	10% - 20%	Includesneurological deficits
Mortality Rate	1% -	

Table 3: Outcomes of Endoscopic Surgery

Outcome Measure	Range	Notes
Gross Total Resection	60% - 80%	Lower than micros resection
Recurrence Rate	10% - 20%	Slightly higher than microsurgical
Postoperative Morbidi	5% - 10%	Significantly reduce
Mortality Rate	0%	No reported mortal
Hospital Stay Duration	Reduced	Faster recovery time

Table 4: Impact of Neuro-navigation and Intraoperative MRI

Technology	Gross Total Resection Improvement	Recurrence Rate Reduction	Postoperative Morbidity Reduction
Neuro-navigation	+10%	Not specified	**Not specified**
Intraoperative	+15%	Reduced	**Not specified**
Overall Effect	**Increased pr and accuracy**	**Lowerresi tumour**	**Lowerneural deficits**

Table 5: Outcomes of Fluorescence-Guided Surgery

Outcome Measure	Range/Effect	Notes
Gross Total Resection	80% - 90%	Comparable to conventional microsurgery
Tumor Margin Visualization	Significantly Enhanced	Improved distinction of tumor margins
Residual Tumor	Reduced	Leads to better long-term control
Long-term Tumor Control	Improved	Lowerrecurrence rates over time

DISCUSSION

This review's findings agree with earlier ones and supplement them concerning the surgical management of brain meningiomas. Prior studies have determined that microsurgical resection is the gold standard in treating these tumours, with GTR rates historically reported between 70% and 90%. This review supports the above by showing GTR rates for microsurgical resection ranging from 70% to 95%. The slight improvement in GTR rates in more recent studies can be attributed to advancements in surgical techniques and intraoperative technologies [17]. The recurrence rates following microsurgical resection observed in this review (5% to 15%) align closely with earlier studies that reported 7% and 20% recurrence rates over similar follow-up periods. This consistency reinforces the effectiveness of microsurgical resection in the long-term control of brain meningiomas [18]. However, the postoperative morbidity rates reported in this review (10% to 20%) are slightly lower than the 15% to 25% range documented in older studies. This reduction in morbidity may be due to improved surgical techniques and better perioperative care [19]. Endoscopic surgery for brain meningiomas, particularly those located at the skull base, has gained traction due to its minimally invasive nature. The GTR rates for endoscopic approaches were similar (60%-80%) to what the literature supports, ranging between 55%-75% [20]. Slightly higher GTR levels observed recently could result from an upgraded endoscopic machine and surgeon expertise increase. Postoperative morbidity on endoscopy (5%-10%) is much less compared to earlier studies that had ranged between 10-15%, demonstrating benefits such as minimal surgery and speedy recovery times [21]. Neuro-navigation systems and operating-room MRI scanning have significantly enhanced outcomes following surgery for brain meningioma patients. Those technologies enhance accuracy in achieving complete tumour resection, as indicated in previous studies, whereby GTR rates have been shown to improve by about 10%-15% [22]

The findings of this review support these improvements, with GTR rates increasing by 10%–15% when such. Technologies are used. This further supports the value of these advancements through reduced residual tumour volume and postoperative neurological deficits. Fluorescence-guided surgery is a relatively new technique promising improved tumour margin visualization. According to this review, the GTR rates for fluorescence-guided surgery were approximately the same as those in conventional microsurgery (80%-90%), consistent with earlier reports. Similarly, the improved tumour margin visualization reported here concurs with previous studies demonstrating the promise of fluorescence-guided techniques in improving surgical precision and reducing residual tumours[23,24]

STUDY LIMITATIONS

This review identified several limitations associated with it. Heterogeneity among the included studies, differing follow-up durations, and variable outcome reporting make it difficult to draw conclusive results. Also, publication bias and inclusion of only English-language studies could affect the findings.

CONCLUSION

On this reivew I will showcase significant milestones in the surgical treatment of brain meningiomas, which indicate that patients have improved results with contemporary methods and equipment.

Although microsurgical resection is still the mainstay treatment, there are now endoscopic options, neuro-navigation techniques, intraoperative MRIs and fluorescence-guided surgery that a neurosurgeon can employ. These surgical interventions must continue to be updated based on the latest technology and best scientific practices to improve their efficacy and safety.

SUMMERY OF REVIEW.

This review comprehensively analyzes surgical techniques for brain meningiomas, evaluating 52 studies involving 8,420 patients. Microsurgical resection remains the gold standard, with GTR rates of 70-95%. Endoscopic approaches offer reduced morbidity and faster recovery but lower GTR rates. Neuro-navigation, intraoperative MRI, and fluorescence-guided surgery enhance resection accuracy, reducing recurrence and neurological deficits.

Disclaimer: Nil
Conflict of Interest: There is no conflict of interest.
Funding Disclosure: Nil

Authors Contribution

Concept & Design of the Study: Naeem Ul Haq
Drafting: Syed Nasir Shah
Data Analysis: Ikram Ullah
Critical Review: Syed Nasir Shah
Final Approval of version: All Mention Authors Approved the Final Version.

REFERENCE

1. Ali MS, Magill ST, McDermott MW. Petrous face meningiomas. Handbook of clinical neurology. 2020;170:157-65.

2. Benjamin C, Shah JK, Kondziolka D. Radiation-induced meningiomas. Handbook of clinical neurology. 2020;169:273-84.

3. Butterfield JT, Golzarian S, Johnson R, Fellows E, Dhawan S, Chen CC, et al. Racial disparities in recommendations for surgical resection of primary brain tumours: a registry-based cohort analysis. Lancet (London, England). 2022;400(10368):2063-73.

4. Carbone L, Somma T, Iorio GG, Vitulli F, Conforti A, Raffone A, et al. Meningioma during pregnancy: what can influence the management? A case series and review of the literature. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstet. 2022;35(25):8767-77.

5. Casali C, Del Bene M, DiMeco F. Falcine meningiomas. Handbook of clinical neurology. 2020;170:101-6.

6. Coy S, Rashid R, Stemmer-Rachamimov A, Santagata S. An update on the CNS manifestations of neurofibromatosis type 2. Acta neuropathologica. 2020;139(4):643-65.

7. Drive r J, Hoffman SE, Tavakol S, Woodward E, Maury EA, Bhave V, et al. A molecularly integrated grade for meningioma. Neuro-oncology. 2022;24(5):796-808.

8. Gambacciani C, Grimod G, Sameshima T, Santonocito OS. Surgical management of skull base meningiomas and vestibular schwannomas. Current opinion in oncology. 2022;34(6):713-22.

9. Giammattei L, Starnoni D, Cossu G, Bruneau M, Cavallo LM, Cappabianca P, et al. Surgical management of Tuberculum sellae Meningiomas: Myths, facts, and controversies. Acta neurochirurgica. 2020;162(3):631-40.

10. Goldbrunner R, Stavrinou P, Jenkinson MD, Sahm F, Mawrin C, Weber DC, et al. EANO guideline on the diagnosis and management of meningiomas. Neuro-oncology. 2021;23(11):1821-34.

11. Hachem LD, Nater A, Fehlings MG. Spinal Meningiomas. Advances in experimental medicine and biology. 2023;1416:69-78.

12. Jungwirth G, Hanemann CO, Dunn IF, Herold-Mende C. Preclinical Models of Meningioma. Advances in experimental medicine and biology. 2023;1416:199-211.

13. Liu P, Wang X, Liu Y, Cai J, Yang Z, Quan K, et al. Surgical Management of Falcotentorial Junction Tumors: A Case Series Report. Frontiers in oncology. 2022;12:866225.

14. Loomis E, Wakasa M. Rehabilitation from meningioma. Handbook of clinical neurology. 2020;170:323-31.

15. Lukas RV, Mrugala MM. Nonmalignant Brain Tumors. Continuum (Minneapolis, Minn). 2020;26(6):1495-522.

16. Magill ST, McDermott MW. Tuberculum sellae meningiomas. Handbook of clinical neurology. 2020;170:13-23.

17. Mathiesen T. Parasagittal meningiomas. Handbook of clinical neurology. 2020;170:93-100.

18. Oyemolade TA, Adeolu AA, Malomo AO, Shokunbi MT, Salami AA. Spinal meningioma: clinical profile and outcome of surgical management. The Pan African medical journal. 2022;43:44.

19. Qian K, Nie C, Zhu W, Zhao H, Zhang F, Wang H, et al. Surgical management of tuberculum sellae meningioma: Transcranial approach or endoscopic endonasal approach? Frontiers in surgery. 2022;9:979940.

20. Raheja A, Couldwell WT. Cavernous sinus meningioma. Handbook of clinical neurology. 2020;170:69-85.

21. Rahman M, Dutta P, Agarwala P, Ikram S, Ahsan E, Shourav MMI, et al. Clinical manifestation, management and prognosis of clear cell meningioma: an evidence-based review. The International journal of neuroscience. 2023;133(6):648-53.

22. Sankhla SK, Jayashankar N, Khan MA, Khan GM. Surgical Management of Tuberculum Sellae Meningioma: Our Experience and Review of the Literature. Neurology India. 2021;69(6):1592-600.

23. Somma T, Bove I, Vitulli F, Cappabianca P, Pessina F, Alviggi C, et al. Management and treatment of brain tumors during pregnancy: an Italian survey. Journal of neuro-oncology. 2023;161(1):13-22.

24. Yaşar S, Kırık A. Surgical Management of Giant Intracranial Meningiomas. The Eurasian journal of medicine. 2021;53(2):73-8.