Comparing Microsurgery and Radiosurgery for Brain Metastases

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ABSTRACT

Introduction: Brain metastases are among the most common intracranial tumors. It is estimated that 20%-40% of cancer patients will develop brain metastasis. Higher rates of brain metastasis at diagnosis present with small and non-small cell lung cancer (16% and 10.3%, respectively). Conversely, melanoma, kidney cancer, breast and colorectal cancer patients present with lower rates (1.5%, 1.3%, 0.3% and 0.3%, respectively).
Methods: A systematic review was conducted following PRISMA guidelines in PubMed and Scopus databases, for original studies published between January 2015–2025, in English, French, and German. These compare neurosurgical operations and radiosurgery in adult patients with brain metastases, reporting on at least one of the following outcomes: overall survival, progression-free survival, local tumor control, complication rates, or quality of life. Case reports, reviews, letters to the editor, grey literature, or annals from congresses will be excluded.
Objective: To optimize treatment strategy, one must understand the comparative survival outcomes, local tumor control, complication rates, and quality of life of microsurgical approach and radiosurgery.
Results: The initial search yielded a total of 686 studies (617 and 69 articles from Pubmed and Scopus, respectively). After screening titles and abstracts, 52 duplicates were removed, and 482 studies were deemed potentially eligible for full-text review. Among these, 238 studies met the inclusion criteria. Preliminary data suggest that microsurgical resection provides superior local tumor control in patients with solitary, accessible metastases, while radiosurgery is associated with fewer complications and is more effective with multiple lesions or poor performance status. However, both modalities demonstrated comparable overall survival rates.
Conclusions: In conclusion, the decision for microsurgery or radiosurgery depends on several factors and can be categorized into tumor-related factors, patient-related factors and treatment-related factors. The proper timing for decision-making remains a debatable matter, while the survival rates between microsurgery and stereotactic radiosurgery don't differ significantly statistically.
Keywords: Microsurgery, Radiosurgery, Brain Metastases, Local Control, Survival, Quality of Life

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INTRODUCTION

Brain metastases are among the most common intracranial tumors in adults, occurring in **20% to 40%** of all cancer patients. Their incidence varies depending on the type of primary cancer.

- **Small cell lung cancer** presents with brain metastases at diagnosis in approximately **16%** of patients.
- **Non-small cell lung cancer** follows at **10.3%**.
- Lower incidence rates are observed in patients with **melanoma (1.5%)**, **renal cancer (1.3%)**, **breast cancer (0.3%)**, and **colorectal cancer (0.3%) (Chart 1)**.

Despite advances in systemic therapies and neuroimaging, brain metastases remain a significant clinical challenge, impacting prognosis and quality of life. Among the key treatment modalities are **microsurgical resection**, which allows for rapid decompression and histological diagnosis, and **stereotactic radiosurgery (SRS)**, offering a minimally invasive alternative for selected cases.
Nevertheless, **direct comparisons** between these approaches regarding **survival outcomes**, **local control**, **complication rates**, and **quality of life** are still limited. A better understanding of these factors is essential to guide treatment decisions in patients with brain metastases.

METHODS AND MATERIALS

A **systematic review** was conducted in accordance with the **PRISMA 2020 guidelines**. An advanced search was done in a Boolean logic under the search terms ((((neurosurgery) AND (radiosurgery)) AND (brain metastasis)) AND (local control)) AND (survival), in two databases, **PubMed** and **Scopus.** A time filter was applied to include published studies of the last decade, January **2015** to January **2025.**

Inclusion Criteria: We included
- Original studies comparing **microsurgical resection** and **stereotactic radiosurgery (SRS)** in **adult patients** with brain metastases.
- Studies reporting on at least one of the following outcomes: **Overall Survival (OS), Progression-Free Survival (PFS), Local Tumor Control, Complication Rates, Quality of Life (QoL)**
- Studies in English, French and German.

Exclusion Criteria: We excluded
- Case reports, Review articles (narrative review, systematic reviews, literature reviews), letters to the editor, grey literature, conference abstracts, non-human studies, and
- Any language other than abovementioned.

The screening process was initially done blindly based on title and abstract by two independent reviewers. Any discrepancies were resolved by a third one. Data extracted for our qualitative analysis included study characteristics, patient populations, treatment modalities, and reported outcomes.

RESULTS

Our search yielded initially a total of 686 articles (**PubMed:** 617 and **Scopus:** 69). Fifty-two (52) duplicates were removed, and 482 studies were included for full-text review. A total of 238 studies were included in our analysis.

- It seems that better local tumor control was achieved by microsurgery, especially for accessible solitary lesions and lesions with mass effect or edema.
- Radiosurgery (SRS) was effective in multiple metastases, and surgically inaccessible tumors.
- There was no statistically significant difference in overall survival and local recurrence between microsurgery and SRS (Chart 2)
- Lower complication rates were observed with SRS, whereas microsurgery was associated with increased perioperative risks and longer recovery times.
- In terms of quality of life, SRS favored a faster recovery, but microsurgery may offer immediate symptom relief and improved KPS in selected patients. (Chart 3)

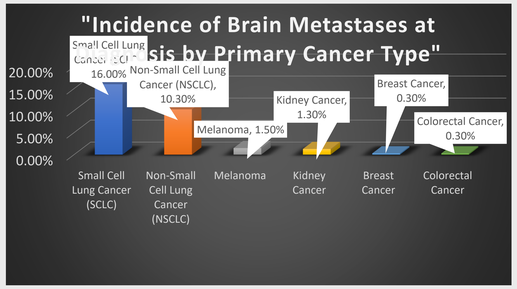

Chart 1. "Incidence of Brain Metastases at Diagnosis by Primary Cancer Type"

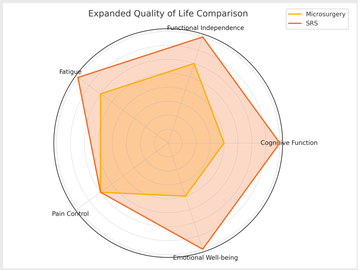

Chart 3. Expanded Quality of Life Comparison

RESULTS

- ✓ **Overall Survival**: Consistent findings across multiple studies indicate **no significant difference** in OS between microsurgery and SRS for patients with brain metastases.
- ✓ **Local Tumor Control**: Evidence suggests **comparable local control rates** between the two modalities, though individual patient and tumor characteristics may influence treatment choice.
- ✓ **Complication Rates**: SRS tends to be associated with **fewer complications** and favorable cognitive outcomes, making it a preferable option for certain patient populations. (Chart 4)

There is consistency among studies about overall survival (OS) and local tumor control. They are statistically similar when comparing microsurgical resection with stereotactic radiosurgery (SRS). The pooled HR for OS is 1.10 (95% CI: 0.75–1.45) which indicates no significant survival advantage for either treatment. In terms of local Recurrence, a pooled HR is 0.81 (95% CI: 0.42–1.20) supporting that both modalities provide comparable control over tumor recurrence.

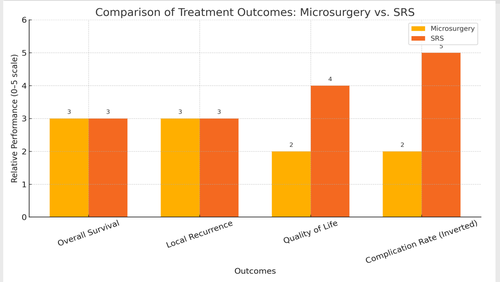

Chart 2. Comparison of Treatment Outcomes: Microsurgery vs SRS

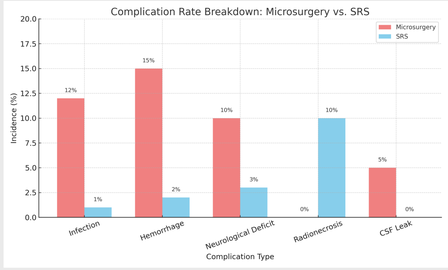

Chart 4. Complication Rate Breakdown: Microsurgery vs SRS

DISCUSSION

Undoubtful, patient and tumor selection is key for treatment strategy. While the statistical analyses suggest parity in survival outcomes, clinical decision-making should be guided by specific patient and tumor characteristics. Microsurgery is favored for patients with solitary, accessible lesions or those with significant mass effect and edema—where immediate decompression and histological diagnosis are necessary. On the contrary, SRS is advantageous for patients with multiple small metastases, deep-seated tumors, or those unfit for surgery, owing to its non-invasive nature, lower complication rates, and outpatient treatment setting. As far as the complication rates and quality of life, SRS has been associated with fewer complications and a better early quality of life, likely due to reduced perioperative morbidity and shorter recovery times. On the other hand, microsurgery, while more invasive, can provide immediate symptom relief and a rapid improvement in performance status in selected cases.
Moderate heterogeneity in OS outcomes ($I^2 \approx 61\%$) indicates some variability among studies, which may be due to differences in patient populations, tumor characteristics, and treatment protocols. Many studies in the review were observational in nature; hence, while the pooled statistics provide robust insights, randomized controlled trials (RCTs) remain essential to further validate these findings.
Further research should focus on long-term quality of life, neurological function, and cost-effectiveness as these outcomes are critical for comprehensive patient care. Additional well-designed RCTs and high-quality cohort studies are also needed to refine treatment protocols.

CONCLUSIONS

Microsurgery and stereotactic radiosurgery (SRS) offer comparable outcomes in terms of **overall survival** and **local tumor control** for patients with brain metastases.
The **choice of treatment** should be guided by a combination of **tumor-related factors** (number, size, location, mass effect), **patient-specific considerations** (performance status, comorbidities) and of course **institutional resources and expertise.**
Microsurgery remains the preferred option for solitary, surgically accessible lesions, cases requiring immediate decompression or histopathological diagnosis. On the contrary **SRS** is favored for multiple or deep-seated metastases, patients unfit for surgery, and settings where minimal treatment disruption is desired. As no modality demonstrates a survival advantage, the focus should shift toward **preservation of neurological function, quality of life, and minimizing treatment-related morbidity.**
Future high-quality, comparative studies are needed to strengthen the evidence base and refine patient selection criteria for optimal individualized care.

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