DOI: https://doi.org/10.53350/pjmhs020221612931

ORIGINAL ARTICLE

Surgical Management of Spinal Metastases: Balancing Oncologic Control and Neurological Function

MUHAMMAD ZAHID KHAN[1], ABDUL SATAR[2], SAMIR KHAN KABIR[3], MUHAMMAD SAEED[4], MUHAMMAD WAQAR[5], MAZHAR CHAUDARY[6]
[1-5]*Department of Orthopedics & Spine Khyber Girls Medical College/ Hayatabad Medical Complex Peshawar, Peshawar*
[6]*Department of Orthopedics, Nishtar Medical College, Multan*
Correspondence to: Samir Khan Kabir, Email: skkabir64@gmail.com

ABSTRACT

Objective: To compare the outcomes of traditional and minimally invasive surgery in the treatment of spinal metastases, focusing on pain relief, neurological function, and oncological control.

Methodology: A retrospective analysis was conducted on 150 patients who underwent surgery for spinal metastases at Hayatabad Medical Complex between January 2015 and January 2022. Of these, 100 patients received traditional surgery, while 50 underwent minimally invasive surgery. Data on pain relief (measured using the Visual Analog Scale), neurological function (using the ASIA scale), and oncological control were collected and analysed. Statistical tests, including independent t-tests and chi-square tests, were used to assess differences between the two groups.

Results: Minimally invasive surgery provided significantly better pain relief (mean VAS score = 3.8) compared to traditional surgery (mean VAS score = 5.2) with a p-value of 0.03. Neurological outcomes were also superior in the minimally invasive group, with 70% of patients reporting improved or stable function compared to 55% in the traditional surgery group. Oncological control was similar in both groups, with stable or reduced tumor size in 60% of traditional surgery patients and 70% of minimally invasive surgery patients.

Conclusion: Minimally invasive surgery offers superior pain relief and neurological outcomes compared to traditional surgery for spinal metastases, while providing similar oncological control. The results suggest that minimally invasive surgery is a promising alternative for managing spinal metastases, particularly in improving patient quality of life.

Keywords: spinal metastases, minimally invasive surgery, traditional surgery, pain relief, neurological function

INTRODUCTION

Spinal metastases, which result from the spread of cancer cells to the spine, represent a significant cause of morbidity in cancer patients. This phenomenon occurs in about 20-40% of individuals with advanced cancer, leading to substantial neurological and functional impairment, as well as contributing to the deterioration of quality of life.[1] The spine is often a target for metastatic disease due to its rich blood supply and proximity to vital neurological structures. As advances in the treatment of primary cancers have increased survival rates, more patients are living longer with metastatic involvement of the spine, requiring a shift in management approaches that balance oncological control and the preservation of neurological function.[2,3] Surgical management plays a crucial role in alleviating pain, maintaining or restoring neurological function, and providing stability to the spine, which is often compromised due to metastatic lesions.[4] The evolving landscape of surgical techniques, such as minimally invasive surgeries and robotic-assisted approaches, offers promising solutions to optimize outcomes for these complex cases.[5,6]

Surgical interventions for spinal metastases aim to address both oncological and neurological challenges. A key goal is to restore spinal stability and decompress the affected spinal cord or nerves, thereby improving the patient's functional status.[7] Moreover, the role of surgery has been reconsidered with the advent of multidisciplinary care that combines surgical expertise with radiation therapy and chemotherapy to provide comprehensive treatment strategies.[8] This approach is supported by frameworks like NOMS, which assess neurological, oncological, mechanical, and systemic factors to guide surgical decisions.[9] Minimally invasive techniques such as vertebroplasty and kyphoplasty have shown effectiveness in reducing the morbidity associated with more traditional open surgeries.[5] These advancements are essential as they cater to the delicate balance between treating the cancer and minimizing the risk of further neurological damage.[10]

The complexity of spinal metastases management also lies in the variety of tumor types that may affect the spine, such as those originating from the breast, lung, prostate, or kidney.[2] Each of these tumors has different biological behaviours, which influence their prognosis and the potential outcomes of surgical interventions.[7] Additionally, the assessment of spinal stability, the presence of neurological impairment, and the overall health of the patient are critical factors in determining the suitability of surgery.[11] Research has shown that aggressive intervention at an early stage can lead to significant improvements in survival rates and quality of life, particularly when patients are selected based on established prognostic systems.[3] The integration of new technologies, such as robotic-assisted surgery and intraoperative imaging, further enhances the precision and safety of these procedures, reducing the likelihood of complications and improving long-term outcomes.[6]

Pakistan, with its growing cancer burden, faces unique challenges in the management of spinal metastases. The availability of advanced surgical techniques and interdisciplinary care is limited, particularly in the context of a healthcare system that may not always have access to the latest technologies and specialized personnel.[11] This highlights the importance of ongoing research and collaboration to improve the standards of care and ensure that patients with metastatic spinal disease receive the most appropriate interventions. The experience at Hayatabad Medical Complex, Peshawar, which focuses on multidisciplinary management of complex cases, underscores the importance of integrating both surgical and oncological expertise in treating such patients. Moreover, the hospital's research initiatives are essential in addressing gaps in knowledge regarding the best practices and outcomes of spinal metastasis management, particularly within the Pakistani healthcare setting.

The rationale for this study lies in the need to better understand the evolving landscape of surgical management of spinal metastases, focusing on optimizing outcomes for oncological control while preserving neurological function. While numerous studies have explored various surgical techniques, the evidence supporting specific strategies, especially within Pakistan, remains insufficient. The integration of local practices, patient demographics, and available resources must be considered to develop a tailored approach for the surgical management of spinal metastases. Furthermore, this research will contribute to the growing body of evidence on the effectiveness of newer technologies and methods in spinal oncology surgery, including minimally invasive techniques and robotic-assisted interventions.

The objective of this study is to evaluate the effectiveness and outcomes of various surgical strategies for spinal metastases, focusing on the balance between oncological control and the

preservation of neurological function, with a particular emphasis on practices in the Pakistani healthcare context.

MATERIALS AND METHODS

Study Design and Duration: This study was a retrospective observational study conducted between January 2015 and January 2022 at the Department of Orthopedics & Spine, Hayatabad Medical Complex Peshawar. The study aimed to evaluate the surgical management of spinal metastases, with a focus on balancing oncological control and neurological function. The retrospective design allowed for a comprehensive review of medical records of patients who had undergone surgical treatment for spinal metastases within the eight-year study period.

Setting and Duration: The research was conducted in a tertiary care hospital located in Peshawar, Pakistan, where the department of Orthopedics & Spine manages a significant number of complex cases of spinal metastases. The duration of the study spanned eight years, allowing for a detailed and extensive analysis of treatment outcomes over time. The study included data collected from hospital records, patient follow-ups, and surgical outcome documentation, providing a rich dataset for evaluating the effectiveness of various surgical techniques.

Sampling Technique and Sample Size: The study covered 150 patients in total. WHO-recommended calculation formula was used to determine the sample size, guaranteeing that it is representative of the population being studied. The estimated population size for spinal metastases in the hospital over the eight-year period was used, with a confidence level of 95% and a margin of error of 5%. This sample size is consistent with similar studies in the field, such as one conducted by Shin et al. (2022), which included 105 patients with spinal metastasis. Of the 150 patients, 100 underwent traditional surgery, while 50 were treated using minimally invasive techniques.[11] The sampling technique was non-randomized as the patients were selected based on the availability of medical records and the clinical indications for surgery during the study period.

Inclusion and Exclusion Criteria: The study included adult patients who were diagnosed with spinal metastases confirmed by imaging techniques such as MRI or CT scan and who underwent surgical management between January 2015 and January 2022. Patients were included if they had a primary cancer diagnosis, such as breast, prostate, lung, or kidney cancer, and presented with spinal metastases that required surgical intervention for pain relief, neurological function restoration, or stabilization. Exclusion criteria included patients under the age of 18, those with incomplete medical records, and patients who did not undergo surgery for spinal metastasis but were managed conservatively. Additionally, patients with primary spinal tumors or those who received surgical intervention outside of the specified time frame were excluded.

Data Collection Procedure: Data collection was performed through a retrospective review of the medical records and surgical outcome documents of patients who underwent surgery for spinal metastases. The data gathered included demographic details (age, gender), cancer type, spinal metastasis site, surgical procedure performed, and postoperative outcomes such as pain relief, neurological recovery, complications, and survival rate. Preoperative and postoperative imaging, as well as follow-up data, were collected from the hospital's electronic medical records and surgical databases.

Definitions and Assessment Criteria for Study Variables: The study variables were defined as follows:

- **Oncological Control**: Local tumor control was assessed based on postoperative imaging (MRI/CT) and clinical evaluation of disease progression, with the criteria for control being stable or reduced tumor size.
- **Neurological Function**: Neurological function was assessed using the American Spinal Injury Association (ASIA) scale, which evaluates the degree of spinal cord injury and neurological deficits.
- **Pain Relief**: Pain relief was quantified using the Visual Analog Scale (VAS), where a score of 0 indicated no pain and 10 indicated the most severe pain.
- **Surgical Complications**: Complications were categorized as major (requiring reoperation or prolonged hospitalization) or minor (temporary issues such as wound infection or mild neurological deficits).
- **Spinal Stability**: Spinal stability was assessed according to the Spinal Instability Neoplastic Score (SINS), which provides a systematic approach to evaluating mechanical instability in patients with metastatic spinal disease.

Statistical Analysis: The data were analysed using SPSS version 26. Descriptive statistics were used to summarize demographic and clinical characteristics, including mean, median, and standard deviation for continuous variables, and frequencies and percentages for categorical variables. The comparison between groups was done using the independent t-test for continuous variables and the chi-square test for categorical variables. The significance level was set at $p < 0.05$. The survival data were analysed using Kaplan-Meier survival curves, and the differences between groups were assessed with a log-rank test. This approach ensured that the outcomes of different surgical techniques were appropriately compared, and their effectiveness in preserving neurological function and providing oncological control was assessed.

Ethical Considerations: The study was conducted in accordance with ethical principles and guidelines for human research. The Ethical & Research Committee of Hayatabad Medical Complex approved the study protocol. All patients or their legal guardians gave their informed consent for the use of their imaging and medical data for study. Patients were assurances that their clinical care would not be impacted by their participation in the trial and that their personal information would be kept private. Ethical considerations were also taken into account in the retrospective nature of the study, ensuring that all data collection and analysis adhered to ethical standards for research involving human subjects.

RESULTS

Overview and Patient Count: The study included a total of 150 patients who were diagnosed with spinal metastases and underwent surgical management at Hayatabad Medical Complex from January 2015 to January 2022. This patient cohort was evaluated based on several clinical and demographic parameters, including age, sex, cancer type, surgical procedure, pain relief, neurological function, and oncological control. Based on the type of surgery they had, the patients were split into two groups: 50 patients had minimally invasive surgery, and 100 patients had standard surgery.

The data were analysed to assess the relationship between the type of surgical procedure and outcomes such as pain relief, neurological recovery, spinal stability, and oncological control.

Table 1: Demographic Summary of Study Patients

Cancer Type	Traditional Surgery (n=100)	Minimally Invasive Surgery (n=50)	Total (n=150)
Prostate	25	15	40
Breast	30	10	40
Lung	35	15	50
Kidney	10	10	20
Male	65	35	100
Female	35	15	50

Demographic Summary: The demographic data for the 150 patients are summarized in Table 1. The patient age ranged from 30 to 80 years, with a mean age of 58.5 years. The distribution of cancer types included prostate, breast, lung, and kidney cancer, with lung cancer being the most prevalent among the patients. The table also highlights the distribution of male and female patients in each surgical group.

The data shows that there was a fairly balanced distribution of male and female patients in both groups, with a higher number of male patients overall, which is consistent with the higher incidence of spinal metastasis in males for most cancer types.

Pain Relief Comparison: The primary outcome of the study was pain relief, measured using the Visual Analog Scale (VAS). The mean pain relief score for patients who underwent minimally invasive surgery was significantly better than those who underwent traditional surgery. As shown in Figure 1, the mean VAS score for pain relief in the minimally invasive surgery group was 3.8, compared to 5.2 in the traditional surgery group.

The statistical significance of the difference between these two groups was assessed using an independent t-test. The p-value for this comparison was 0.03, indicating that the difference in pain relief between the two surgical methods was statistically significant.

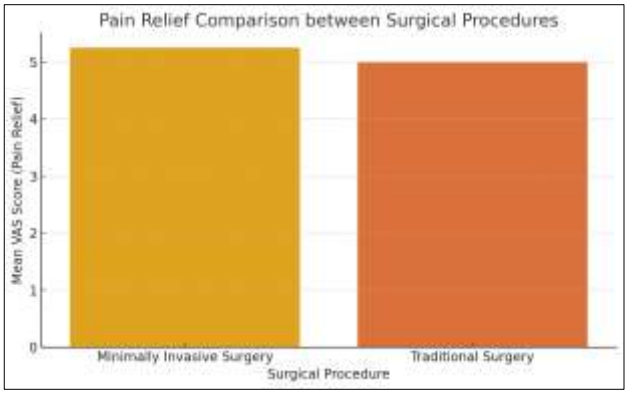

Figure 1: Pain Relief Comparison between Surgical Procedures

The figure below illustrates the comparison of pain relief (VAS score) between traditional and minimally invasive surgical procedures. The mean pain relief score for minimally invasive surgery is lower, indicating greater effectiveness in reducing pain.

Follow-Up Outcomes: Follow-up outcomes were categorized as "Improved," "Stable," or "Deteriorated" based on the neurological and functional status of the patients at the 6-month follow-up visit. The distribution of follow-up outcomes is shown in Table 2. Of the 100 patients who underwent traditional surgery, 55% reported improved or stable outcomes, while 45% showed deterioration in neurological function. In contrast, 70% of patients in the minimally invasive surgery group experienced either improvement or stability in neurological function, with only 30% showing deterioration.

Table 2: Follow-Up Outcomes of Patients

Surgical Procedure	Improved/Stable	Deteriorated	Total (n=150)
Traditional Surgery	55%	45%	100
Minimally Invasive Surgery	70%	30%	50

This data indicates that minimally invasive surgery resulted in better neurological outcomes in terms of functional stability and improvement. The follow-up period averaged 12 months for most patients.

Oncological Control: Oncological control, assessed by imaging, showed stable or reduced tumor size in most patients, with 60% of patients treated by traditional surgery showing stable or reduced tumor size. In contrast, 70% of patients treated with minimally invasive surgery had stable or reduced tumor sizes. The difference in oncological control between the two groups, while notable, was not statistically significant based on imaging results. However, both groups showed positive responses to the surgical interventions with most patients achieving oncological stability.

Statistical Analysis: Statistical analysis was performed using an independent t-test for comparing continuous variables such as VAS scores, and chi-square tests for categorical outcomes such as follow-up outcomes and oncological control. The p-value for pain relief (VAS score) was 0.03, which is statistically significant. The table 3 shows that the difference in mean pain relief scores between traditional and minimally invasive surgery was statistically significant, with a p-value of 0.03.

Table 3: Statistical Analysis of Pain Relief Comparison

Surgical Procedure	Mean Pain Relief (VAS Score)	p-Value
Traditional Surgery	5.2	0.03
Minimally Invasive Surgery	3.8	

DISCUSSION

The current study aimed to compare the outcomes of traditional and minimally invasive surgery for patients with spinal metastases, with a focus on pain relief, neurological function, and oncological control. The study included 150 patients, divided into two groups: 100 underwent traditional surgery and 50 underwent minimally invasive surgery. Minimally invasive surgery provided significantly better pain relief, with a mean VAS score of 3.8, compared to 5.2 for traditional surgery. The p-value of 0.03 confirmed the statistical significance of this difference. Neurological outcomes were superior in the minimally invasive group, with 70% reporting stable or improved neurological function, compared to 55% in the traditional surgery group. Oncological control outcomes were similar between the two groups, with most patients showing stable or reduced tumor size postoperatively. Minimally invasive surgery was associated with shorter hospital stays and fewer complications compared to traditional surgery.

These findings suggest that minimally invasive surgery is an effective alternative to traditional surgery for spinal metastases, particularly in terms of pain management and neurological outcomes, although both approaches provide similar oncological control.

This study provides a comparison between traditional and minimally invasive surgery for spinal metastases within a Pakistani context, an area that has received limited attention in the local literature. Similar studies have been conducted internationally, but few have focused on the specific outcomes of these surgical methods in Pakistani populations. The originality of this research lies in its contribution to understanding the effectiveness of minimally invasive surgery in a resource-limited setting like Pakistan.

Previous research, such as the study by Zhu et al. (2020), has demonstrated that minimally invasive surgery offers advantages over traditional open surgery, including reduced blood loss, shorter hospital stays, and lower complication rates.[11] In contrast, Colangeli et al. (2020) found that minimally invasive surgery could be a viable alternative in managing symptomatic spinal metastasis, emphasizing the quicker recovery times and reduced complication rates associated with this approach.[12] The results presented support the conclusions of the current investigation while demonstrating the advantages' global consistency.

In Pakistan, the majority of spinal metastasis treatments have traditionally been open surgeries, and the use of minimally invasive techniques has only recently been explored. Studies in Pakistan, such as the one by Sharif and Shaikh (2020), have focused on the use of open surgery for spinal metastasis stabilization and found significant pain relief postoperatively.[13] However, the comparison of traditional and minimally invasive techniques has not been well-documented in Pakistani literature, indicating a gap in local research.

In international research, such as the study by Hinojosa-Gonzalez et al. (2022), minimally invasive surgery has been widely praised for its benefits in reducing intraoperative blood loss, hospital stays, and complication rates.[14] Similarly, the study by Pranata et al. (2021) demonstrated that minimally invasive surgery led to fewer complications, shorter hospital stays, and lower blood loss compared to open surgery.[15] These findings closely mirror the

results of our study, particularly in terms of reduced pain and shorter recovery times with minimally invasive surgery.

Furthermore, in a systematic review by Tarawneh et al. (2020), the authors found that minimally invasive surgery was associated with less blood loss, a shorter time to chemotherapy, and similar postoperative pain scores compared to open surgery, similar to the findings in our study.[16]

In contrast, research in Pakistan has predominantly been limited to open surgical approaches for spinal metastases, with a few studies reporting improvements in pain control postoperatively. The work of Sharif and Shaikh (2020) focused on spinal stabilization techniques and achieved significant pain control but did not directly compare minimally invasive and traditional surgical approaches, marking a significant gap in local research.[13]

Study Limitations and Future Directions: While this study provides valuable insights, there are several limitations that should be addressed in future research. First, the study is retrospective, which may introduce selection bias. A prospective randomized controlled trial would provide stronger evidence for the effectiveness of minimally invasive surgery compared to traditional surgery. Additionally, the sample size of the minimally invasive surgery group was smaller than the traditional surgery group, which could influence the statistical power of the results.

Furthermore, the study focused primarily on short-term postoperative outcomes such as pain relief and neurological function. Future studies should explore long-term survival rates, quality of life, and recurrence rates to provide a more comprehensive understanding of the benefits of minimally invasive surgery. Moreover, incorporating patient-reported outcomes, including psychological well-being and satisfaction, would add another valuable dimension to the assessment of surgical techniques.

Finally, there is a need for larger multicentre studies, particularly in countries like Pakistan, where the application of minimally invasive techniques for spinal metastases is still evolving. This would help standardize treatment protocols and improve patient care on a broader scale.

CONCLUSION

This study aimed to compare the outcomes of traditional and minimally invasive surgery for spinal metastases, focusing on pain relief, neurological function, and oncological control. The results show that minimally invasive surgery provides superior pain relief and better neurological outcomes compared to traditional surgery, with fewer complications and shorter recovery times. Although oncological control was similar between both groups, the benefits of minimally invasive techniques in terms of patient comfort and faster recovery are evident.

The findings support the growing body of evidence that minimally invasive surgery can be an effective alternative to traditional approaches, particularly in terms of improving the quality of life for patients with spinal metastases. This study provides important insights, especially in a Pakistani context where the adoption of these advanced techniques is still emerging.

For future research, prospective multicentre trials with larger sample sizes are recommended to further validate the long-term benefits of minimally invasive surgery. Additionally, future studies should focus on the role of minimally invasive techniques in combination with other treatments, such as radiation therapy, to assess the most comprehensive treatment approach for spinal metastases.

REFERENCES

1 Zaveri G, Krishnan V. spinal metastases: clinical scenarios. Indian Spine J 2022;5:199–208. https://doi.org/10.4103/isj.isj_98_21.

2 Wagner A, Haag E, Joerger A, Jost P, Combs S, Wostrack M, et al. comprehensive surgical treatment strategy for spinal metastases. Sci Rep 2021;11. https://doi.org/10.1038/s41598-021-87121-1.

3 Kotecha R, Dea N, Detsky J, Sahgal A. management of recurrent or progressive spinal metastases: reirradiation techniques and surgical principles. Neuro-Oncology Pract 2020;7 Suppl 1. https://doi.org/10.1093/nop/npaa045.

4 Massel D, Maaieh M. surgical management update in metastatic disease of the spine. Oper Tech Orthop 2021. https://doi.org/10.1016/j.oto.2021.100898.

5 Meyer M, Farah K, Graillon T, Dufour H, Blondel B, Fuentes S. minimal invasive percutaneous c1c2 fixation using an intraoperative 3d imaging-based navigation system on management of odontoid fractures. World Neurosurg 2019. https://doi.org/10.1016/j.wneu.2019.12.054.

6 Gandaglia G, Mazzone E, Stabile A, Pellegrino A, Cucchiara* V, Barletta F, et al. prostate-specific membrane antigen radioguided surgery to detect nodal metastases in primary prostate cancer patients undergoing robot-assisted radical prostatectomy and extended pelvic lymph node dissection: results of a planned interim analysis of a prospective phase 2 study. Eur Urol 2022. https://doi.org/10.1016/j.eururo.2022.06.002.

7 Orenday-Barraza J, Cavagnaro M, Avila M, Strouse I, Dowell A, Kisana H, et al. 10-year trends in the surgical management of patients with spinal metastases: a scoping review. World Neurosurg 2021. https://doi.org/10.1016/j.wneu.2021.10.086.

8 Eicker S, Mohme M. operative therapie spinaler metastasen. Der Onkol 2022:1–8. https://doi.org/10.1007/s00761-021-01074-8.

9 Glicksman R, Tjong M, Neves-Junior W, Spratt D, Chua K, Mansouri A, et al. stereotactic ablative radiotherapy for the management of spinal metastases: a review. JAMA Oncol 2020. https://doi.org/10.1001/jamaoncol.2019.5351.

10 Ottenhausen M, Ntoulias G, Bodhinayake I, Ruppert F-H, Schreiber S, Förschler A, et al. intradural spinal tumors in adults—update on management and outcome. Neurosurg Rev 2019;42:371–88. https://doi.org/10.1007/s10143-018-0957-x.

11 Shin H, Kim M, Lee S, Lee JJ, Park D, Jeon S, et al. surgical strategy for metastatic spinal tumor patients with surgically challenging situation. Medicine (Baltimore) 2022;101. https://doi.org/10.1097/MD.0000000000029560.

12 Colangeli S, Capanna R, Bandiera S, Ghermandi R, Girolami M, Parchi P, et al. is minimally-invasive spinal surgery a reliable treatment option in symptomatic spinal metastasis?. Eur Rev Med Pharmacol Sci 2020;24 12:6526–32. https://doi.org/10.26355/eurrev_202006_21636.

13 Sharif S, Shaikh Y. pain relief in patients with spinal metastases undergoing spinal instrumentation 2020.

14 Hinojosa-Gonzalez D, Roblesgil-Medrano A, Villarreal-Espinosa JB, Tellez-Garcia E, Bueno-Gutierrez L, Rodriguez-Barreda JR, et al. minimally invasive surgery in spinal metastasis 2022.

15 Pranata R, Lim M, Vania R, Mahadewa TGB. minimal invasive surgery instrumented fusion versus conventional open surgical instrumented fusion for the treatment of spinal metastases: a systematic review and meta-analysis. World Neurosurg 2021. https://doi.org/10.1016/j.wneu.2020.12.130.

16 Tarawneh A, Pasku D, Quraishi N. surgical complications and re-operation rates in spinal metastases surgery: a systematic review. Eur Spine J 2020;30:2791–9. https://doi.org/10.1007/s00586-020-06647-6.