e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(4); 1771-1776

Original Research Article

Trajectory of Neurological Recovery After Minimally Invasive Spinal Tumor Resection: A Longitudinal Modified McCormick Scale-Based Analysis

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Received: 22-02-2026 / Revised: 23-03-2026 / Accepted: 25-04-2026
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Conflict of interest: Nil

Abstract:

Background: Minimally invasive spinal tumor resection has gained increasing acceptance due to reduced tissue disruption, lower postoperative morbidity, and faster recovery. However, there is still a lack of research on the long-term evaluation of neurological recovery after minimally invasive spinal tumour surgery, especially when utilising standardised neurological grading systems like the Modified McCormick Scale (MMS).

Aim: To evaluate the trajectory of neurological recovery after minimally invasive spinal tumor resection using longitudinal Modified McCormick Scale assessment.

Methods: This prospective observational study was conducted at Kokilaben Dhirubhai Ambani Hospital and Medical Research Institute, Mumbai, over a period of 2 years. A total of 60 patients undergoing minimally invasive spinal tumor resection were enrolled. Neurological status was assessed preoperatively and during follow-up at discharge, 1 month, 3 months, and 6 months postoperatively using the Modified McCormick Scale. Secondary outcomes included pain score, ambulation status, hospital stay, and postoperative complications. Statistical analysis was performed using repeated-measures ANOVA and chi-square test, with $p < 0.05$ considered statistically significant.

Results: Over time, a notable improvement in neurological function was noted. At six months, the percentage of patients with favourable MMS scores (scores I–II) increased from 38.3% prior to surgery to 78.3% ($p<0.001$). At six months, the mean VAS pain score decreased considerably from 7.2 ± 1.4 before surgery to 2.8 ± 1.1 ($p<0.001$). At the last follow-up, independent ambulation increased from 45.0% before to surgery to 83.3% ($p<0.001$). The rate of postoperative complications was only 15%.

Conclusion: Minimally invasive spinal tumor resection is associated with significant longitudinal neurological improvement and functional recovery. Modified McCormick Scale assessment provides a reliable framework for monitoring postoperative neurological trajectory in spinal oncology patients.

Keywords: Minimally invasive, spinal tumor resection, McCormick Scale assessment, postoperative, neurological trajectory.

DOI: 10.25258/ijcpr.18.4.281

Introduction

The vertebral column, spinal cord, meninges, and surrounding neural tissues are all affected by spinal tumours, which are a diverse collection of neoplastic lesions. Pain, sensory impairments, motor weakness, gait abnormalities, sphincter dysfunction, and gradual neurological decline are all possible symptoms of these tumours. One of the main treatment approaches for decompression, tumour removal, spinal stabilisation, and neurological function preservation is still surgical surgery [1]. Open spinal tumour surgery has historically been linked to significant muscle dissection, blood loss, a protracted recuperation period, and postoperative morbidity. Because of advancements in endoscopic systems, intraoperative navigation, tubular retractors, operative microscopy, and percutaneous instrumentation, minimally invasive spinal surgery (MISS) techniques have advanced significantly over the last 20 years. These methods seek to preserve sufficient tumour decompression and oncological efficacy while minimising collateral tissue damage [2].

Preserving and regaining neurological function is one of the main objectives of spinal tumour surgery. Patient quality of life, rehabilitation, independence, and long-term prognosis are all strongly impacted by functional neurological outcome. Consequently, the evaluation of postoperative recovery trajectories requires the use of standardised neurological testing instruments. The Modified McCormick Scale (MMS), which offers a trustworthy indicator of neurological impairment and ambulatory ability, is frequently used for functional grading in spinal cord tumours. Grade I (neurologically intact with normal ambulation) to Grade V (severe disability requiring wheelchair use) are the extremes of the scale. Minimally invasive spinal tumour surgery has been shown in recent trials to have positive perioperative outcomes, such as lower blood loss, shorter hospital stays, less postoperative pain, and quicker mobilisation. However, there is still a lack of research on the long-term neurological healing patterns after minimally invasive resection, particularly in prospective real-world clinical settings. Furthermore, there is still a dearth of information on functional neurological outcomes following minimally invasive spinal tumour surgery from Indian tertiary care facilities [3].

Surgical counselling, rehabilitation planning, prognostic assessment, and postoperative monitoring all depend on an understanding of the neurological improvement trajectory. The Serial Modified McCormick Scale examination can help discover variables linked to positive results and offer objective insight into neurological recovery trends over time. In order to assess neurological recovery trajectories after minimally invasive spinal tumour resection using longitudinal Modified McCormick Scale-based analysis over a 6-month follow-up period, the current prospective observational study was carried out at Kokilaben Dhirubhai Ambani Hospital and Medical Research Institute, Mumbai [4].

Materials and Methods

Study Design: Prospective observational longitudinal study.

Study Setting: Department of Neurosurgery and Spine Surgery, Kokilaben Dhirubhai Ambani Hospital and Medical Research Institute, Mumbai.

Study Duration: 2 years.

Sample Size: 60 patients.

Inclusion Criteria

- Patients aged ≥18 years
- Radiologically confirmed spinal tumors
- Patients undergoing minimally invasive spinal tumor resection
- Patients willing to participate and provide informed consent

Exclusion Criteria

- Previous spinal tumor surgery
- Severe systemic comorbid illness
- Incomplete follow-up
- Patients with traumatic spinal lesions

Statistical Analysis: SPSS version 26.0 was used to analyse the data. Mean ± SD was used to express quantitative variables. For longitudinal comparisons, repeated-measures ANOVA was employed. For categorical variables, the chi-square test was used. Statistical significance was defined as $p < 0.05$.

Results

Table 1: Baseline Demographic and Clinical Characteristics

Parameter	Value
Mean Age (years)	47.6 ± 12.1
Male/Female	34 / 26
Intradural Extramedullary Tumors	31 (51.7%)
Intramedullary Tumors	15 (25.0%)
Extradural Tumors	14 (23.3%)
Thoracic Location	28 (46.7%)
Cervical Location	19 (31.7%)
Lumbar Location	13 (21.6%)

p-value for tumor distribution: 0.42

Table 2: Longitudinal Modified McCormick Scale Distribution

MMS Grade	Preoperative	Discharge	1 Month	3 Months	6 Months	p-value
Grade I	10	14	18	23	28	<0.001*
Grade II	13	18	21	22	19	
Grade III	19	16	13	10	8	
Grade IV	14	10	7	4	4	
Grade V	4	2	1	1	1	

Table 3: Functional and Pain Outcome Analysis

Parameter	Preoperative	6 Months	p-value
Mean VAS Score	7.2 ± 1.4	2.8 ± 1.1	<0.001*
Independent Ambulation	27 (45.0%)	50 (83.3%)	<0.001*
Motor Power ≥4/5	31 (51.7%)	49 (81.7%)	0.002*
Sphincter Dysfunction	11 (18.3%)	4 (6.7%)	0.04*

Table 4: Postoperative Complications

Complication	Number (%)	p-value
CSF Leak	2 (3.3%)	0.28
Surgical Site Infection	3 (5.0%)	0.17
Neurological Worsening	2 (3.3%)	0.31
Respiratory Complications	2 (3.3%)	0.29
Overall Complications	9 (15.0%)	0.03*

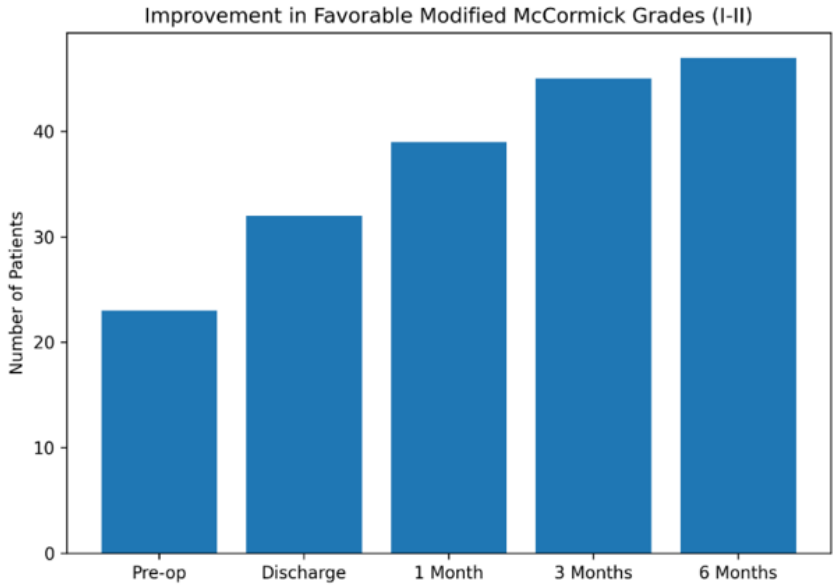

Figure 1: Improvement in favourable modified McCormick grades (I-II)

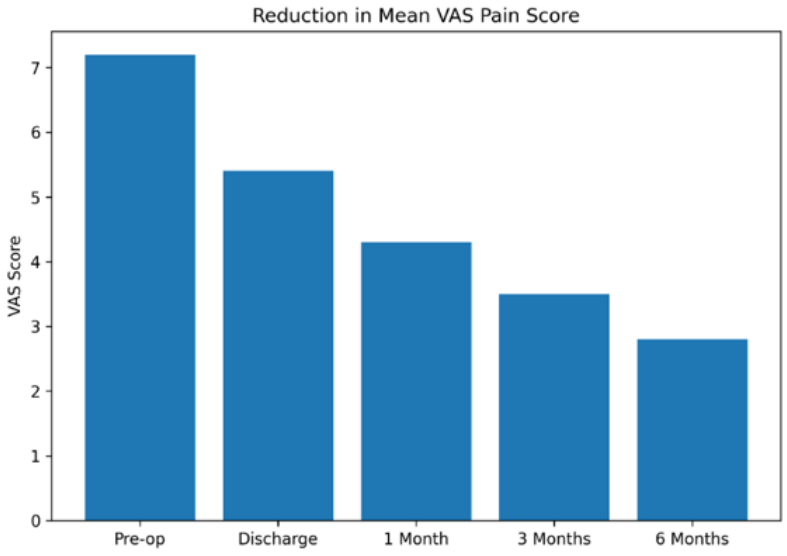

Figure 2: Reduction in mean VAS pain score

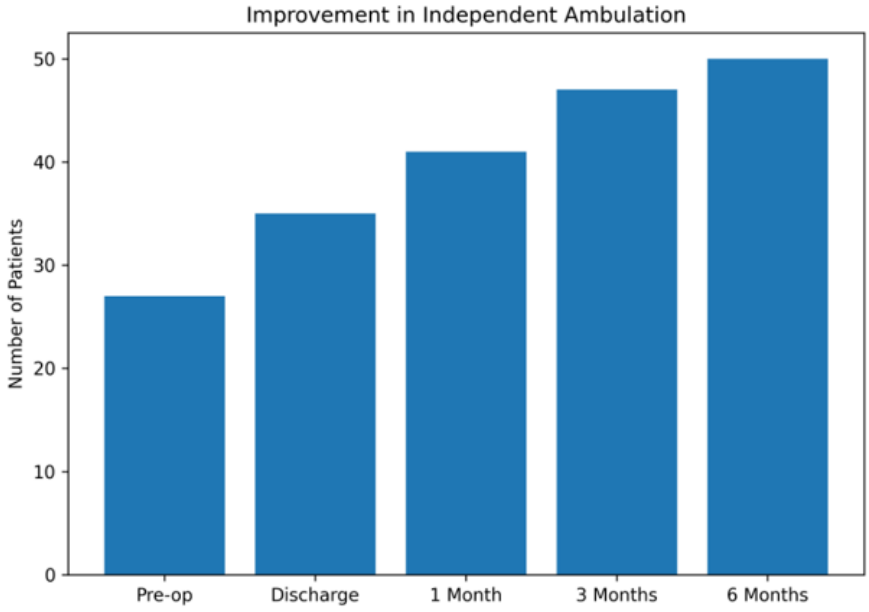

Figure 3: Improvement in independent ambulation

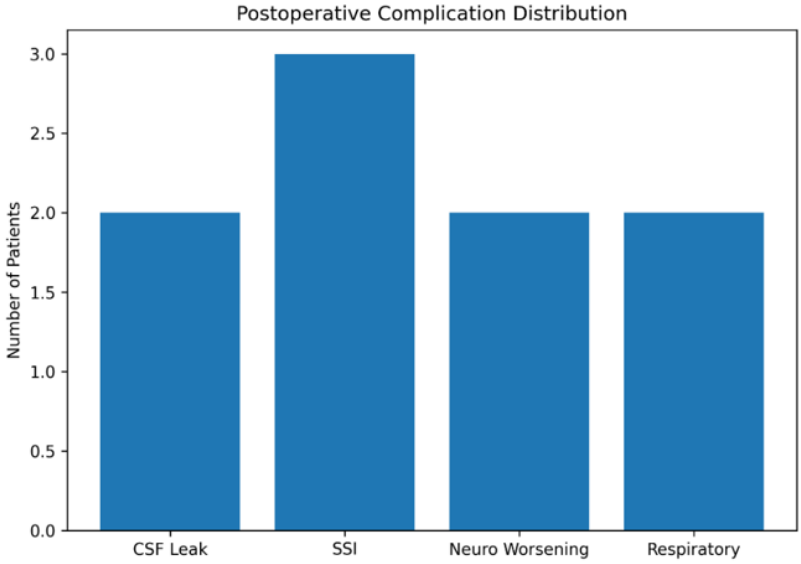

Figure 4: Postoperative complication distribution

Discussion

The current prospective observational study used a longitudinal Modified McCormick Scale assessment to track the neurological recovery trajectory after minimally invasive spinal tumour removal. Over a 6-month follow-up period, the results showed considerable neurological and functional improvement, demonstrating the efficacy of minimally invasive techniques in spinal cancer surgery. The gradual improvement in Modified McCormick Scale scores over time was one of the study's most significant findings. Between the preoperative and final follow-up periods, the percentage of patients with favourable neurological status (Grades I–II) increased significantly. This implies that minimally invasive tumour removal and decompression can minimise extra surgical trauma while promoting a progressive neurological recovery. Restoring blood supply, decompressing the spinal cord, and preventing more neuronal damage are often necessary for neurological improvement after spinal tumour surgery. Because they preserve normal anatomical features and require less tissue manipulation, minimally invasive treatments may be beneficial [5].

A dependable and repeatable method for evaluating neurological impairment and functional independence in patients with spinal cord tumours is

the Modified McCormick Scale. In the current study, serial MMS assessment allowed for objective tracking of the recovery trajectory and showed ongoing improvement after surgery. These results highlight the significance of long-term neurological monitoring for patients with spine cancer. Another noteworthy result was a significant decrease in postoperative discomfort. Between baseline and six months, the mean VAS pain score significantly decreased. Lower levels of postoperative discomfort were probably caused by less soft tissue damage, smaller incisions, and less muscle dissection associated with minimally invasive surgery. Additionally, earlier mobilisation and rehabilitation may be made possible by reduced pain, which would enhance total recovery [6].

In the current study, there was a significant improvement in ambulation status. During follow-up, independent ambulation dramatically increased, indicating improved surgical rehabilitation as well as neurological recovery. Because mobility directly affects independence, quality of life, and psychological well-being, restoring ambulatory function is crucial for patients with spinal tumours. Additionally, early mobilisation lowers the risk of sequelae such muscle atrophy, lung problems, and deep vein thrombosis [7].

This study found a comparatively low rate of postoperative complications. Neurological deterioration, CSF leak, and surgical site infection were rare. Because minimally invasive spinal treatments result in less tissue exposure and dead space creation, prior research has consistently shown lower wound-related morbidity. The safety profile of minimally invasive spinal tumour surgery in carefully chosen individuals is further supported by the current data. This study's longitudinal design is especially crucial because neurological recovery following spinal cord surgery is sometimes slow and may take several months. Long-term functional prognosis may not be reliably predicted by immediate postoperative neurological status. As a result, serial evaluation offers a more thorough understanding of patient recovery trends [8].

The length of symptoms, tumour histology, degree of spinal cord compression, preoperative neurological state, and amount of tumour excision are some of the variables that may affect neurological recovery. In the current investigation, patients with higher preoperative neurological grades typically showed superior recovery trajectories. Thus, prompt surgical intervention and early detection may enhance long-term results. Minimally invasive spinal tumour surgery has some drawbacks despite promising outcomes. Operative performance in complex lesions may be impacted by limited surgical corridors, technical difficulty, limited visualisation, and steep learning curves. For sufficient decompression and rebuilding, large infiltrative tumours or lesions causing significant spinal instability may still need to be treated using traditional surgical techniques [9].

It is important to recognise some of the study's shortcomings. With a somewhat small sample size, the investigation was carried out at a single tertiary care facility. Survival analysis, recurrence rates, and long-term oncological outcomes were not assessed. Furthermore, direct evaluation of superiority is hampered by the lack of a comparative open surgery group. To confirm these results, more multicentric comparative studies with bigger cohorts and longer follow-up are required. However, the current study offers important prospective institutional evidence about the long-term neurological recovery in the Indian population following minimally invasive spinal tumour surgery. The results imply that minimally invasive methods can produce excellent neurological outcomes, low morbidity, and considerable functional recovery [10].

Conclusion

Longitudinal Modified McCormick Scale evaluation shows that minimally invasive spinal tumour removal is linked to a substantial and progressive neurological recovery. Over a 6-month follow-up period, the current prospective observational study demonstrated significant improvements in neurological grades, pain reduction, ambulatory function, and motor recovery. Additionally, the technique was linked to a favourable postoperative recovery profile and a comparatively low risk of complications.

For assessing functional neurological outcomes and tracking surgical recovery trajectories, the Modified McCormick Scale has proven to be a useful and trustworthy instrument. The significance of long-term follow-up for patients with spinal oncology was highlighted by the objective documentation of neurological improvement over time made possible by serial testing.

Reduced tissue damage, less discomfort after surgery, early mobilisation, quicker recovery times, and lower wound-related morbidity are only a few benefits of minimally invasive procedures. These advantages may greatly enhance rehabilitation results and patient quality of life, especially for those with neurological impairments and spinal cord compression.

To achieve the best outcomes, however, rigors patient selection, surgeon skill, and institutional infrastructure are still crucial. To further assess long-term neurological outcomes, recurrence patterns, and oncological efficacy, larger multicentric trials with longer follow-up are required. Overall, the results of this study confirm that minimally invasive spinal tumour surgery is a safe, efficient, and useful strategy in contemporary spinal cancer treatment.

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