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Original Article

Association between Tumor Occupancy Ratio and Early Post-operative Motor Outcome in Treatment of Patients with Intradural Extramedullary Spinal Cord Tumor

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ABSTRACT

Background: Intradural extramedullary (IDEM) spinal tumors are typically benign lesions that are well visualized on contrast-enhanced magnetic resonance imaging (MRI). Previous studies suggest that greater spinal canal occupancy by the tumor is associated with poorer neurological outcomes; however, radiological predictors of postoperative neurological recovery remain inadequately explored. This study aimed to evaluate the association between tumor occupancy ratio and early postoperative motor outcome in patients with IDEM spinal tumors**. Methods & Materials**; This interventional study included 56 patients with cervical, thoracic, and lumbar IDEM tumors who underwent surgical treatment. Tumor occupancy ratio was calculated from MRI, and motor function was assessed preoperatively and, on the 14th, postoperative day using the MRC grading scale. Data were analyzed using SPSS to evaluate the association between tumor occupancy ratio and early postoperative motor outcome. **Results:** The majority of patients were aged 41–50 years (21.4%), with a mean age of 44.17 years. Schwannomas were the most common tumor type, predominantly located in the cervical and dorsal regions, followed by meningiomas, which were mainly dorsal. Most tumors were situated anterolaterally (82.1%). Postoperative assessment demonstrated significant improvement in muscle strength across all limbs. Although most patients achieved good early motor outcomes, no statistically significant association was found between tumor occupancy ratio and postoperative motor function. **Conclusion:** surgical resection of IDEM tumors leads to substantial improvement in early postoperative motor strength. While tumor occupancy ratio showed an observable relationship with outcome, it did not reach statistical significance. Tumor location remains an important factor in understanding disease behavior and prognosis in IDEM spinal tumors.

Keywords: *Intradural extramedullary tumors; Spinal cord tumors; Tumor occupancy ratio; Magnetic resonance imaging; Postoperative motor outcome; MRC grading scale; Neurological outcome; Spinal tumor surgery.*

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Introduction

Spinal tumors are broadly classified as extradural or intradural based on their anatomical relationship to the spinal dura mater. Intradural tumors are further subdivided into intramedullary spinal cord tumors and intradural extramedullary (IDEM) tumors, depending on whether they arise within or outside the spinal cord parenchyma [1]. IDEM tumors originate within the dural sac but external to the spinal cord and represent a distinct pathological and clinical entity. IDEM tumors are predominantly benign and account for approximately two-thirds of all primary spinal tumors [2]. The most common histological subtypes include schwannomas, meningiomas, and neurofibromas, while less frequent lesions include ependymomas, lipomas, hemangiomas, paragangliomas, metastatic lesions, and other rare vascular or nerve sheath tumors [3]. Although benign, these tumors can lead to significant neurological morbidity due to progressive compression of the spinal cord and nerve roots. Clinically, IDEM tumors present with axial or radicular pain and a variable combination of motor, sensory, and sphincter disturbances. Symptoms depend on tumor size, location, and degree of spinal cord compression, and any spinal level may be affected. Early diagnosis and timely surgical intervention are critical for preventing irreversible neurological deficits and improving functional outcomes [4]. Magnetic resonance imaging (MRI) is the diagnostic modality of choice for IDEM spinal tumors because of its superior soft-tissue contrast and multiplanar capability. MRI allows precise delineation of the tumor, spinal cord, cerebrospinal fluid, and subarachnoid space, facilitating accurate localization and surgical planning [5]. Typical MRI features of IDEM tumors include spinal cord compression and displacement, ipsilateral widening of the subarachnoid space, and contralateral narrowing. In addition, MRI avoids osseous artefacts and provides characteristic signal intensities and contrast enhancement patterns that aid qualitative diagnosis and prognostic evaluation [6]. Radiological parameters have increasingly been investigated as predictors of clinical presentation and surgical outcome. One such parameter is the tumor occupancy ratio

(TOR), which quantifies the proportion of the spinal canal occupied by the tumor at the level of maximal compression. The tumor occupancy ratio is calculated on axial MRI using the formula [{(a+b)/(A+B)} \times 100], where a and b represent the transverse and anteroposterior diameters of the tumor, andA and B represent the corresponding diameters of the intradural space [7].A higher tumor occupancy ratio reflects greater spinal cord compression and has been associated with more severe neurological deficits and poorer postoperative recovery. Previous studies have demonstrated that larger tumors and higher canal occupancy are linked to inferior functional outcomes following surgical resection [8]. Conversely, patients with lower tumor occupancy ratios tend to have better neurological recovery and improved surgical results [9]. Despite growing interest in radiological predictors, the methods used to quantify tumor size and spinal cord compression vary widely across studies, including canal occupancy percentage, cross-sectional area measurements, and volumetric estimation. Furthermore, heterogeneity in outcome assessment tools, such as the Frankel scale, Nurick grade, modified McCormick scale, and Medical Research Council (MRC) grading, limits direct comparison between studies [10]. Although advances in MRI technology, surgical instrumentation, and microsurgical techniques have significantly improved outcomes in IDEM spinal tumors, early diagnosis remains challenging due to insidious symptom onset. Delayed surgical intervention may result in permanent neurological deficits. Timely gross total resection remains the most important determinant of favorable functional recovery. Therefore, this study aims to evaluate the association between preoperative tumor occupancy ratio measured on MRI and postoperative motor outcome assessed using the Medical Research Council grading system.

Methods & Materials

This prospective interventional study was conducted in the Department of Neurosurgery, National Institute of Neurosciences & Hospital (NINS&H), Dhaka, Bangladesh, from July 2022 to December 2023. A total of 56 patients with intradural extramedullary (IDEM) spinal cord tumors from C1 to the upper border of L2, admitted for elective surgery, were enrolled in this study using purposive sampling technique. The sample size was calculated based on an expected outcome proportion of 80%, 95% confidence level, 80% power, and a 15% margin of error. Patients of all ages and both sexes with available preoperative MRI (T1-weighted with contrast and T2-weighted sequences within one month before surgery) who underwent standard gross total resection were included, while patients with multiple or recurrent tumors, prior spinal surgery, spinal instability, emergency neurological conditions, or significant comorbidities limiting surgery were excluded from this study. Tumor occupancy ratio was measured manually on axial MRI at the most compressed spinal cord segment using the formula [(a+b)/(A+B)]×100, where tumor and intradural canal diameters were assessed. Neurological evaluation, including motor power assessment was performed using the Medical Research Council (MRC) grading scale, preoperatively and repeated on the 14th postoperative day to assess early motor outcome. All surgeries were performed via a standard posterior approach under general anesthesia with the aim of gross total resection, and excised specimens were sent for histopathological examination. MRI was performed using a 1.5 Tesla scanner with standardized imaging protocols. Data were collected using a structured case record form (CRF). The collected data were analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics, chi-square test, ANOVA, and paired t-test were applied as appropriate, with a p-value <0.05 considered statistically significant. Ethical clearance for the study was obtained from the Institutional Review Board (IRB) of the National Institute of Neurosciences and Hospital, Dhaka, Bangladesh.

Results

A total of 56 patients with intradural extramedullary spinal cord tumors were included in the study.

Table I shows the age distribution of the 56 study participants. The majority of patients were middle-aged, with the highest proportion falling in the 41–50-year age group (21.4%), followed by those aged 61–70 years (19.6%). Patients aged 31–40 years constituted 17.9% of the study population, while the 21–30 and 51–60-year groups each accounted for 14.3%. Younger patients aged 20 years or below represented 10.7% of cases, whereas very elderly patients (71–80 years) were least represented (1.8%). The mean age of the participants was 44.17 ± 16.25 years, indicating a wide age range, with a median age of 45 years (range: 14–72 years). Overall, the data suggest that IDEM spinal tumors were more commonly observed in middle-aged and older adults in this study population.

Table I
Distribution of the study participants according to age (*n*=56).

Age (in years)	Frequency	Percentage (%)
20-Nov	6	10.7
21-30	8	14.3
31-40	10	17.9
41-50	12	21.4
51-60	8	14.3
61-70	11	19.6
71-80	1	1.8
Mean ±SD	44.17±16.25	
Median (Min-Max)	45 (14-72)	

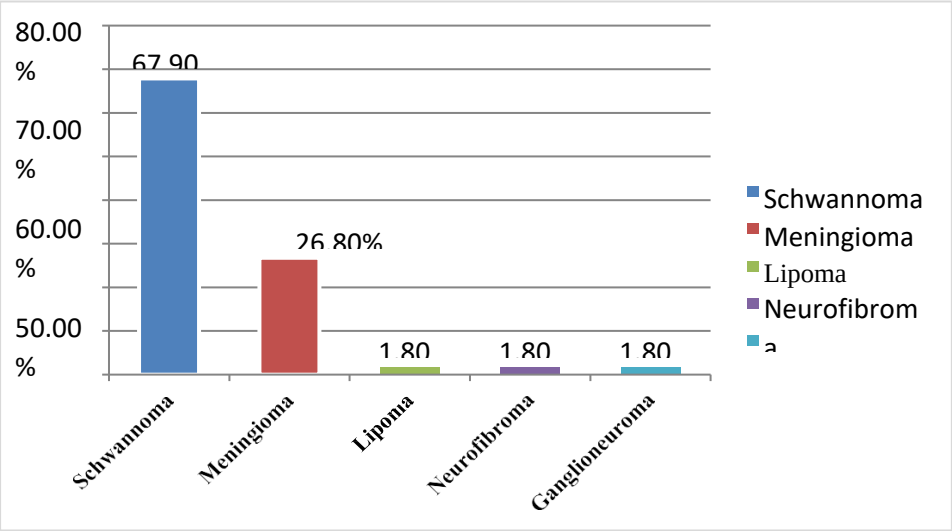

Figure 1 Histopathology of the tumors of study participants (*n*=56)

Figure 1 shows Histopathological analysis revealed that schwannoma was the most common tumor type, accounting for 38 cases (67.9%). Meningioma was the second most frequent, observed in 15 patients (26.8%). Less common tumor types included ganglioneuroma, lipoma, and neurofibroma, each occurring in 1 patient (1.8%).

Table II shows Most tumors were located in the dorsal (41.1%) and cervical (37.5%) regions. The anterolateral position was predominant (82.1%). The majority of tumors had an occupancy ratio ≤80 (75%), while 25% showed higher occupancy (>80).

Table II
Location and position of tumors in different locations (*n*=5).

Variables	Frequency	Percentage (%)
Location of Tumor		
Cervical	21	37.5
Dorsal	23	41.1
Dorso-Lumbar	5	8.9
Lumbar	7	12.5
Position of Tumor		
Anterior	4	7.1
Posterior	4	7.1
Lateral	2	3.6
Anterolateral	46	82.1
Tumor occupancy ratio		
≤80	42	75
>80	14	25

Table III presents tumor-related parameters across different tumor locations. The anteroposterior length and transverse diameter of tumors were significantly greater in cervical tumors compared to other locations, with statistically significant differences (p = 0.042 and p = 0.021, respectively). Similarly, the anteroposterior length and transverse diameter of the vertebral foramen were largest in the cervical region, showing highly significant variation among locations (p = 0.003 and p = 0.002). Tumor occupancy ratio also differed significantly by location (p = 0.01), being highest in cervical tumors and lowest in lumbar tumors. In contrast, the duration of symptoms did not vary significantly across tumor locations (p = 0.821).

Table III
Comparison of tumor related information in different location of tumors of the study participants (*n*=56).

Tumor related information	Tumor location				p- value
	Cervical (n=21)	Dorsal (n=23)	Lumbar (n=7)	Dorso-Lumbar (n=5)	
Anteroposterior length of tumor	2.46±0.68	2.01±0.47	2.13±0.23	1.96±0.43	0.042
Transverse diameter of tumor	2.00±0.74	1.54±0.43	1.44±0.10	1.52±0.36	0.021
Anteroposterior length of vertebral foramen	2.84±0.63	2.22±0.52	2.61±0.32	2.30±0.21	0.003
Transverse diameter of vertebral foramen	2.11±0.62	1.63±0.37	1.56±0.10	1.46±0.19	0.002
Tumor occupancy ratio	77.49±9.93	74.86±9.92	63.20±7.04	70.00±9.85	0.01
Duration of symptoms (months)	10.81±4.90	9.43±7.00	11.29±11.31	8.60±3.21	0.821

p-value obtained by ANOVA test, p<0.05 was considered as a level of significant

Table IV shows Schwannoma was the most common tumor type across all spinal locations, accounting for the majority of cases in the cervical (66.7%), dorsal (56.5%), lumbar (100%), and dorso-lumbar (80.0%) regions. Meningioma was the second most frequent tumor, predominantly seen in the dorsal region (43.5%) and less commonly in the cervical and dorso-lumbar regions, while no lumbar cases were observed. Other tumor types, including ganglioneuroma, lipoma, and neurofibroma, were rare and confined mainly to the cervical region. Overall, there was no statistically significant association between tumor incidence and tumor location (p = 0.492).

Table IV
Tumor incidence by anatomic location (*n*=56).

Tumor incidence	Cervical (n=21)	Dorsal (n=23)	Lumbar (n=7)	Dorso-Lumbar (n=5)	p-value
Schwannoma	14(66.7%)	13(56.5%)	7(100.0%)	4(80.0%)	
Meningioma	4(19.0%)	10(43.5%)	0(0.0%)	1(20.0%)	
Ganglioneuroma	1(4.8%)	0(0.0%)	0(0.0%)	0(0.0%)	0.492
Lipoma	1(4.8%)	0(0.0%)	0(0.0%)	0(0.0%)	
Neurofibroma	1(4.8%)	0(0.0%)	0(0.0%)	0(0.0%)	
Total	21(100.0%)	23(100.0%)	7(100.0%)	5(100.0%)	

p-value obtained by Chi-square test, p<0.05 was considered as a level of significant

Table V shows postoperative MRC scores improved across most tumor locations. Significant improvement was seen in cervical right upper limb and both lower limbs (p = 0.004–0.016), dorsal lower limbs (p < 0.001), lumbar left lower limb (p = 0.008), and dorso-lumbar left lower limb (p = 0.016). Other changes were not statistically significant (p > 0.05).

Table V
Association of pre and postoperative MRC scores of limbs (*n*=56).

Variables	Preoperative MRC score Mean±SD	Postoperative MRC scoe Mean±SD	p-value
Cervical	(n=21)	(n=21)	
Right upper limb	3.71±0.85	4.14±0.85	0.004
Left upper limb	3.76±0.70	4.00±0.84	0.171
Right lower limb	3.62±1.32	4.10±1.22	0.002
Left lower limb	3.57±1.33	4.00±1.05	0.016
Dorsal	(n=23)	(n=23)	
Right lower limb	3.22±0.85	3.87±0.81	<0.001
Left lower limb	3.09±0.95	3.83±0.58	<0.001
Lumber	(n=7)	(n=7)	
Right lower limb	4.29±0.76	4.86±0.38	0.103
=Left lower limb	3.86±0.90	4.57±0.53	0.008
Dorso-lumbar	(n=5)	(n=5)	
Right lower limb	3.80±0.84	4.40±0.55	0.071
Left lower limb	3.60±0.55	4.40±0.55	0.016

P-value is obtained by paired t test.

Table VI presents postoperative outcomes were mostly good, with 43 patients (76.8%) achieving a good outcome, 8 patients (14.3%) showing significant improvement, and 5 patients (8.9%) having poor outcomes. By tumor location, good outcomes were most frequent in dorsal tumors (39.5%) and cervical tumors (34.9%). Poor outcomes were highest in cervical tumors (60% of the poor outcome group). However, there was no statistically significant association between tumor location and outcome (p = 0.791), indicating that tumor location did not significantly affect postoperative recovery.

Table VI
Postoperative outcome of the study participants according to MRC grading (*n*=56).

Outcome	Good (n=43)	Significant (n=8)	Poor (n=5)	p-value
Cervical	15(34.9%)	3(37.5%)	3(60.0%)	
Dorsal	17(39.5%)	4(50.0%)	2(40.0%)	
Lumbar	6(14.0%)	1(12.5%)	0(0.0%)	0.791
Dorso-lumbar	5(11.6%)	0(0.0%)	0(0.0%)	
Total	43(100.0%)	8(100.0%)	5(100.0%)	

p-value is obtained by Chi-square t test.

Table VII shows postoperative outcomes did not differ significantly based on tumor occupancy ratio (p = 0.629). Among tumors with ≤80% occupancy, 73.8% had a good outcome, 16.7% showed significant improvement, and 9.5% had poor outcomes. For tumors with >80% occupancy, 85.7% had a good outcome, 7.1% showed significant improvement, and 7.1% had poor outcomes. This suggests that tumor occupancy ratio did not have a significant impact on postoperative recovery.

Table VII
Association of tumor occupancy ratio with postoperative outcome (*n*=56).

Outcome	Tumor occupancy ratio		p-value
	≤80	>80	
	Frequency (%)	Frequency (%)	
Good	31 (73.8)	12 (85.7)	0.629
Significant	7 (16.7)	1 (7.1)	
Poor	4 (9.5)	1 (7.1)	

p-value is obtained by Chi-square t test.

Discussion

In this study of 56 patients with intradural extramedullary spinal cord tumors, the mean age was 44.17 ± 16.25 years, with the highest frequency in the 41–50-year age group (21.4%). This age distribution is consistent with previous reports indicating peak incidence in middle adulthood, reflecting the slow-growing nature of IDEM tumors [11]. Regarding anatomical distribution, dorsal (41.1%) and cervical (37.5%) regions were most commonly affected. Similar patterns have been reported in earlier studies, where dorsal and cervical levels predominated among IDEM tumors [12, 13]. The marked predominance of anterolateral tumor positioning (82.1%) observed in our cohort is clinically important, as non-posteriorly located tumors are known to cause greater neurological compromise due to asymmetric spinal cord compression [14]. Morphometric analysis demonstrated significant regional differences in tumor and vertebral canal dimensions. Cervical tumors exhibited the greatest mean anteroposterior tumor length (2.46 ± 0.68 cm) and transverse diameter (2.00 ± 0.74 cm), as well as the largest vertebral foraminal dimensions. Consequently, the tumor occupancy ratio was highest in the cervical region (77.49 ± 9.93%) and lowest in the lumbar region (63.20 ± 7.04%), with a statistically significant difference across locations (p = 0.010). These findings correspond with anatomical observations by Ko et al., who demonstrated that the cervical spinal canal has the greatest diameter, permitting larger tumors before severe neurological symptoms develop [15]. Despite these anatomical variations, the duration of symptoms did not differ significantly among tumor locations, suggesting that symptom onset is multifactorial. Histopathological evaluation showed schwannoma as the most common tumor type (67.9%), followed by meningioma (26.8%). This distribution aligns with large contemporary series that identified schwannomas and meningiomas as the predominant IDEM tumors [16, 17]. Although schwannomas were more frequent in cervical and dorsal regions and meningiomas were predominantly dorsal, no statistically significant association between tumor type and anatomical location was found, indicating that tumor level alone does not reliably predict histology. Postoperative motor function assessment revealed significant improvement in most limb groups, particularly in the lower limbs. In cervical tumors, significant improvement was observed in three of four limbs, while dorsal tumors showed bilateral lower-limb improvement. These findings are consistent with reports demonstrating favorable neurological recovery following adequate surgical decompression of IDEM tumors [18]. The comparatively less consistent improvement in upper limbs may be related to chronic cord compression or more severe preoperative deficits. Overall, 76.8% of patients achieved good postoperative outcomes. Tumor location was not significantly associated with postoperative outcome (p = 0.791). While another study suggested poorer outcomes for tumors located in the upper thoracic spine or ventral compartment due to limited surgical corridors and vascular vulnerability [19], such an association was not demonstrated in our cohort, possibly due to the small number of ventral tumors. Finally, tumor occupancy ratio did not show a statistically significant association with early postoperative outcome. Although patients with occupancy ratios >80% demonstrated a high proportion of good outcomes (85.7%), this was not significantly different from those with ratios ≤80% (p = 0.629). While higher tumor occupancy ratios have been associated with worse functional disability was found in other study [20]. The findings of the present study, in line with previous report [21], suggest that early postoperative recovery may depend more on the adequacy of surgical decompression and preoperative neurological status than on tumor occupancy ratio alone.

Conclusion

The study highlighted that surgery was associated with significant improvements in muscle strength postoperatively suggesting the efficacy of surgical intervention in managing spinal tumors. While association between tumor occupancy ratio and early post-operative motor outcome was observed, it was not statistically significant. The location of the tumor was crucial to understanding the nature and progression of the disease in IDEM tumors.

Limitations

This study has several limitations that should be acknowledged. The sample size was relatively small, which may limit the generalizability of the findings. Additionally, long-term follow-up data were not available, preventing assessment of sustained functional recovery or tumor recurrence. Factors such as patient comorbidities, variations in surgical technique, and differences in postoperative rehabilitation protocols were not fully controlled, and these may have influenced the observed outcomes. Future studies with larger cohorts, extended follow-up, and more comprehensive control of confounding variables are warranted to validate these findings.

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