ORIGINAL ARTICLE

PRIMARY SPINAL CORD TUMORS : A REVIEW OF DEMOGRAPHIC CHARACTERISTICS IN A PAKISTANI POPULATION AT A TERTIARY CARE CENTER

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ABSTRACT

OBJECTIVE: To evaluate the demographic characteristics, clinical presentation, and magnetic resonance imaging (MRI) features of patients with primary spinal cord tumors in a tertiary care center in Pakistan. **METHODOLOGY:** This retrospective observational study was done in the Department of Radiology, Punjab Institute of Neurosciences, Lahore, from January 2021 to December 2024. A total of 200 patients identified with primary spinal cord malignancies based on clinical and MRI findings were included. Demographic data, presenting complaints, tumor location, compartment type, and MRI signal characteristics were analyzed using descriptive statistics. **RESULTS:** Of the 200 patients, 102 (51%) were female and 98 (49%) were male, with a mean age of 43.6 ± 15.2 years (range 7–78). The highest incidence occurred in patients older than 50 years (22.5%). The most common presenting symptom was backache (60%), followed by lower limb weakness (25%) and neck pain (28%). The thoracic spine was most commonly involved (39.5%), followed by cervical (33%) and lumbar (27.5%) regions. Intradural extramedullary and intramedullary tumors were nearly equal in prevalence (49.0% and 49.5%, respectively). On MRI, 74.5% of lesions were T1 hypointense, 72.5% were T2 hyperintense, and 75% demonstrated post-contrast enhancement. Neural compression was present in 12% of cases. **CONCLUSION:** Primary spinal cord tumors are uncommon but clinically significant lesions, often presenting with nonspecific symptoms leading to delayed diagnosis. MRI remains the cornerstone for lesion detection, anatomical localization, and preoperative evaluation. Recognition of characteristic demographic and imaging patterns may facilitate earlier diagnosis and tailored management.

Keywords: Magnetic resonance imaging (MRI), spinal cord tumors, demographics, intramedullary, intradural extramedullary.

Introduction

Primary spinal cord tumors represent a relatively rare group of central nervous system neoplasms, accounting for approximately 5% of all spinal lesions and 10-15% of all central nervous system tumors.[1] Despite their low incidence, they carry significant morbidity due to their potential to cause progressive neurological impairment. The clinical presentation is often subtle and nonspecific manifesting as backache, sensory changes, or limb weakness resulting in delayed diagnosis and management.

Anatomically, spinal tumors are classified based on their compartmental location into extradural, intradural extramedullary, and intramedullary lesions. The majority of extradural tumors are metastatic in nature, whereas

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intradural extramedullary tumors are most frequently benign and include schwannomas and meningiomas. Intramedullary tumors are typically ependymomas and astrocytomas, with ependymomas showing a higher incidence among adults and astrocytomas being more common in the pediatric population. The histological diversity and overlapping imaging appearances of these lesions often make early and accurate diagnosis challenging.

The gold standard for evaluating spinal cord tumors is now magnetic resonance imaging (MRI). Precise localization, tumor margin delineation, and preoperative planning are made possible by MRI's superior soft-tissue contrast resolution, multiplanar capabilities, and capacity to characterize tumor enhancement.[2] By revealing details regarding tumor grade, fiber tract integrity, and vascularity, advanced MRI methods including diffusion tensor imaging (DTI) and perfusion-weighted imaging (PWI) significantly improve diagnostic specificity. However, such advanced techniques are still underutilized in many developing regions due to limited accessibility and resource constraints.[3]

In Pakistan and other low- to middle-income countries, the demographic and radiologic patterns of primary spinal cord tumors remain underreported. Most available data are derived from histopathological case series, with minimal focus on MRI-based demographic trends.[4] The lack of comprehensive, region-specific imaging data hinders the ability to formulate tailored diagnostic and management strategies. Recognizing local demographic tendencies and radiologic features can facilitate early suspicion, improve diagnostic accuracy, and guide treatment planning in resource-limited settings.

Therefore, this study was designed to analyze the demographic characteristics, clinical presentations, and MRI findings of patients with primary spinal cord tumors at a tertiary care neuroscience institute. By establishing a local reference pattern, we aim to contribute to a better understanding of disease distribution, support early imaging-based diagnosis, and assist in optimizing imaging protocols for preoperative assessment and follow-up.

Methodology

From January 2021 to December 2024, the Department of Radiology at the Punjab Institute of Neurosciences (PINS), Lahore, undertook this retrospective observational study. The study was carried out in compliance with the Declaration of Helsinki and approved by the institutional Ethical Review Board (Reference No: 2030 IRB/PINS). Before imaging, all patients or their legal guardians gave their informed consent.

Study Population

A total of 200 patients diagnosed with primary spinal cord tumors based on magnetic resonance imaging (MRI) and clinical findings were included. Data were collected from the institutional radiology database and medical records.

Inclusion Criteria

- Patients of all age groups and both genders.
- Preoperative patients with MRI findings consistent with primary spinal cord tumors.
- Patients with complete clinical and imaging data available for review.

Exclusion Criteria

- Postoperative or previously treated spinal tumor patients.
- Patients with non-neoplastic spinal lesions (e.g., infections, vascular malformations, demyelination).
- Incomplete or poor-quality MRI studies.

MRI Protocol

All MRI examinations were performed on a 3.0 Tesla Siemens MRI scanner using a dedicated spine array coil. The following sequences were acquired in sagittal and axial planes:

- T1-weighted images (T1WI)
- T2-weighted images (T2WI)
- Short Tau Inversion Recovery (STIR) for edema detection
- Post-contrast T1-weighted images, following intravenous administration of a gadolinium-based contrast agent (0.1 mmol/kg body weight).

Slice thickness was maintained at 3-4 mm with an interslice gap of 0.5 mm. Field of view (FOV), matrix size, and repetition time (TR)/echo time (TE) parameters were adjusted according to patient anatomy and region of interest.

Data Collection

Demographic data (age, gender), clinical presentation

(symptom type and duration), and imaging parameters (tumor location, compartment type, MRI signal characteristics, and enhancement pattern) were recorded for each patient. Tumor size was measured in anteroposterior, transverse, and craniocaudal dimensions.

Tumors were categorized by their anatomic compartment as:
- Extradural
- Intradural extramedullary
- Intramedullary lesions

Data Analysis

The Statistical Package for the Social Sciences (SPSS), version 28 (IBM Corp., Armonk, NY, USA), was used to analyze all of the data. The data was summarized using descriptive statistics. Age, tumor size, and symptom duration are examples of continuous variables that were reported as mean ± standard deviation (SD). Frequencies and percentages were used to display categorical characteristics (such as gender, tumor kind, and spinal level). When relevant, a p-value of less than 0.05 was regarded as statistically significant.

Result

The most common presenting complaint was backache, reported in 60% (n=120) of patients. Other frequent symptoms included neck pain (28%), lower limb weakness or paraparesis (25%), urinary incontinence (18%), and quadriparesis (12%). The duration of symptoms prior to diagnosis ranged from 1 to 80 months, with a mean of 16.4 ± 10.2 months, reflecting the chronic and insidious nature of these lesions. Clinical presentations are detailed in (Tab.2).

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	98	49.0
	Female	102	51.0
Age group (years)	1 - 10	8	4.0
	11 - 20	29	14.5
	21 - 30	43	21.5
	31 - 40	42	21.0
	41 - 50	33	16.5
	> 50	45	22.5
Mean ± SD (years)	—	43.6 ± 15.2	—

Table 1: Baseline demographic characteristics of patients (n=200)

Clinical Feature	Frequency (n)	Percentage (%)
Backache	120	60.0
Neck pain	56	28.0
Lower limb weakness / Paraparesis	50	25.0
Urinary incontinence	36	18.0
Quadriparesis	24	12.0
Sensory disturbances / Hypesthesia	22	11.0
Mean duration of symptoms (months)	—	16.4 ± 10.2

Table 2: Presenting complaints and duration of symptoms

Tumor Location and MRI Findings

The thoracic spine was the most frequently involved region (39.5%; n=79), followed by the cervical spine (33%; n=66) and lumbar region (27.5%; n=55). The majority of lesions were located intradural extramedullary (49.0%; n=98) or intramedullary (49.5%; n=99), while a small proportion were extradural (1.5%; n=3).

MRI analysis revealed that T1-weighted images (T1WI) showed hypointense signal intensity in 74.5% (n=149) of cases, while T2-weighted images (T2WI) demonstrated hyperintense signals in 72.5% (n=145). Post-contrast enhancement was observed in 75% (n=150) of the tumors, with homogeneous enhancement in low-grade lesions and heterogeneous enhancement in high-grade tumors. Associated neural compression was detected in 12% (n=24) of cases as described in (Tab.3). Tumor dimensions averaged 10 mm anteroposterior, 13 mm transverse, and 18 mm in craniocaudal dimension. Low-grade lesions frequently displayed cystic components and syringomyelia, while high-grade tumors exhibited leptomeningeal spread and irregular margins.

Anatomic Compartment	Frequency (n)	Percentage (%)
Extradural	3	1.5
Intradural extramedullary	98	49.0
Intramedullary	99	49.5

Table 3: Distribution of tumors by anatomic compartment (n = 200)

- Female predominance (51%) with highest incidence in >50 years.
- Thoracic spine was most common tumor site (39.5%).

Parameter	Category	Frequency (n)	Percentage (%)
Spinal Level	Cervical	66	33.0
	Thoracic	79	39.5
	Lumbar	55	27.5
T1-weighted Signal	Hypointense	149	74.5
T2-weighted Signal	Hyperintense	145	72.5
Post-contrast Enhancement	Present	150	75.0
	Absent	50	25.0
Neural Compression	Present	24	12.0

Table 4: Distribution of tumors by location and MRI characteristics (n = 200)

• Intramedullary and intradural extramedullary tumors had nearly equal prevalence.
• Neural compression and syringomyelia were more frequent in long-standing cases.
MRI typically showed T1 hypointensity, T2 hyperintensity, and post-contrast enhancement in 72-74% of cases as shown in the following figures.

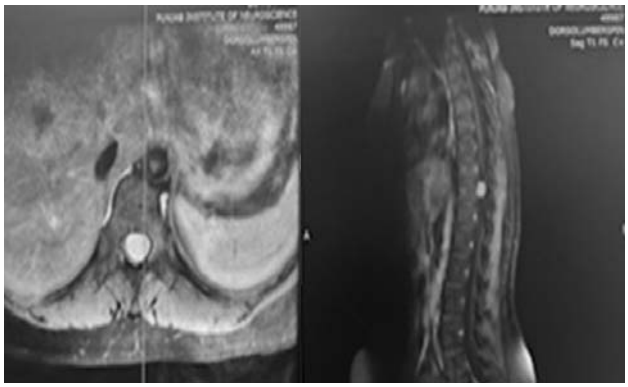

Figure 1: Sagittal & axial T1W1 post contrast images showing enhancing intradural extramedullary tumor at D12 causing compression on spinal cord.

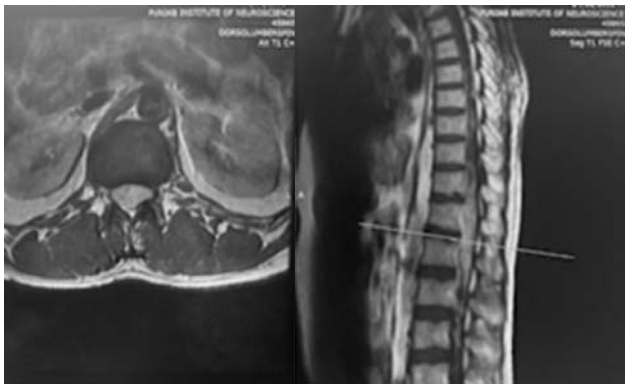

Figure 2: Sagittal & axial T1W1 post contrast images showing enhancing intramedullary tumor extending from D6 to D8 level causing expansion of spinal cord

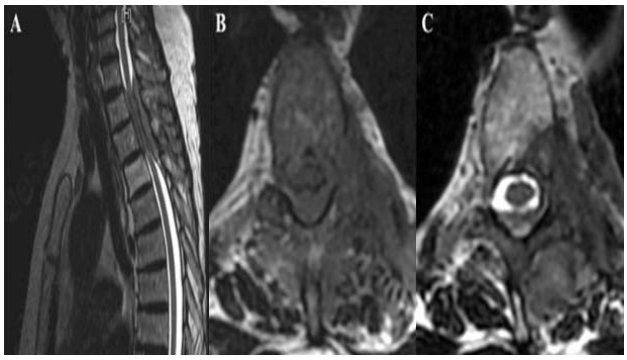

Figure 3: Extradural tumor . Sagittal T2-weighted MRI showing the dorsal epidural lesion with cord compression. B) Axial T2-weighted MRI showing circumferential epidural compression of the spinal cord by the tumor mass with, C) tumor extension through the intervertebral foramen with lateral extension into the paraspinal tissues

Discussion

One uncommon but clinically relevant category of neoplasms of the central nervous system is primary spinal cord tumors. Neurological impairment and delays in diagnosis are frequently caused by their subtle appearance and inconsistent imaging findings. In this study, we examined the clinical features, MRI results, and demographics of 200 patients at a tertiary neuroimaging facility in Pakistan who had been diagnosed with primary spinal cord tumors. The results highlight several demographic and radiologic trends consistent with global literature while providing new insights into region-specific disease patterns.
The mean patient age in our cohort was 43.6 ± 15.2 years, with the highest incidence occurring in those over 50 years of age. Females represented 51% of the study population, reflecting a slight female predominance. This gender trend has been reported in several recent series, particularly among cases of spinal meningioma, which are known to be hormonally influenced and more prevalent in females in their fifth and sixth decades.[5] Intramedullary astrocytomas and ependymomas have shown a slight male predominance in younger patients, suggesting possible genetic or environmental differences.[6] These observations merit further investigation through multicenter molecular and genetic studies.
The thoracic spine was the most frequently affected region, followed by cervical and lumbar levels. These findings are consistent with contemporary epidemio-

logical reports that identify the thoracic cord as the most common site of spinal meningiomas and intradural extramedullary tumors.[7]

Intradural extramedullary and intramedullary tumors were nearly equal in distribution (49% and 49.5%, respectively). This differs slightly from historical data where intradural extramedullary tumors predominated.[8] Intramedullary tumors primarily include ependymomas and astrocytomas, which can be challenging to differentiate radiologically. Recent studies have reported an increasing relative frequency of intramedullary tumors in high-resolution MRI series, supporting our findings.[9]

Clinically, the majority of patients presented with backache (60%), followed by lower limb weakness (25%) and neck pain (28%). The mean duration of symptoms before diagnosis was 16.4 months, reflecting the slow-growing nature of these tumors and the tendency for delayed imaging referral.[10] Similar trends have been reported in both regional and international studies, emphasizing that prolonged symptom duration before diagnosis correlates with poorer neurological recovery after treatment.[11] Persistent pain without neurological signs often leads to misdiagnosis as degenerative spinal disease, delaying MRI examination. This finding underscores the need for clinician awareness to initiate spinal MRI earlier in patients with atypical or progressive spinal symptoms.

MRI remains the modality of choice for diagnosis, classification, and surgical planning in spinal cord tumors because of its superior soft-tissue contrast, multiplanar capability, and ability to delineate cord compression. In our study, 74.5% of lesions were hypointense on T1-weighted images, 72.5% were hyperintense on T2-weighted images, and 75% demonstrated post-contrast enhancement.[12] These imaging characteristics are well-established markers for intradural and intramedullary lesions.[13] Low-grade tumors, such as ependymomas and schwannomas, often exhibit cystic changes or syringomyelia, whereas high-grade lesions tend to show heterogeneous enhancement and irregular borders.[14] Post-contrast imaging remains essential for differentiating tumor types and assessing extent, especially in lesions with subtle cord expansion.[15]

The role of advanced MRI techniques continues to evolve. Diffusion tensor imaging (DTI) and perfusion-weighted imaging (PWI) provide additional functional data regarding tumor cellularity, vascularity, and fiber tract involvement. These modalities assist in preoperative planning and prognostication, particularly for intramedullary lesions.[16] Recent work has demonstrated that DTI-based fiber tracking improves surgical safety by identifying functional white matter tracts displaced by tumors, minimizing postoperative deficits.[17] Although resource constraints limited the inclusion of these advanced techniques in our current study, their integration into future local protocols is strongly recommended to enhance diagnostic confidence and facilitate resectability assessment.[18]

Comparative analysis of our data with other regional studies reveals both parallels and contrasts. The almost equal distribution of intradural extramedullary and intramedullary tumors differs from previous Pakistani and Bangladeshi series where intradural extramedullary lesions predominated.[19] This difference could be attributed to improved MRI-based detection, tertiary referral bias, or inclusion of a wider age range in our study population. Furthermore, the thoracic predilection seen in our patients is similar to international series, reinforcing the established anatomical trend .The longer symptom duration observed in our patients (up to 80 months) also highlights socioeconomic and healthcare access factors that contribute to diagnostic delays in developing countries.

The findings of this study support the established imaging principles that MRI signal intensity patterns and enhancement characteristics can guide differential diagnosis even without histopathological confirmation. Our results demonstrate that standard MRI sequences remain highly effective for identifying the tumor compartment and assessing neural compression, even in the absence of advanced imaging. With ongoing technological advancement and broader MRI access in the region, early diagnosis and improved surgical outcomes can be expected.[20]

Future studies should focus on prospective multicenter data collection, inclusion of histopathological and molecular correlations, and incorporation of advanced MRI sequences. Artificial intelligence - based image analysis and quantitative radiomics may further refine tumor grading, volumetry, and prediction of surgical outcomes.[21,22]

Regional collaboration between radiologists, neurosurgeons, and pathologists will be essential for developing standardized imaging and reporting protocols for primary spinal cord tumors.

LIMITATIONS

Our study contains a number of limitations. Because only patients with verified MRI results were included, the retrospective design may create selection bias. Histopathological correlation was not available for all cases, which limits precise subtype confirmation. Additionally, postoperative outcomes and tumor recurrence rates were not analyzed, preventing evaluation of prognostic factors. Despite these constraints, this study provides valuable local epidemiologic and imaging data, filling a major gap in spinal oncology research from Pakistan.

Conclusion

In conclusion, this study demonstrates that primary spinal cord tumors in our population exhibit demographic and imaging features largely comparable to international findings. Female predominance and thoracic involvement were common, while MRI patterns showed consistent signal and enhancement characteristics. MRI remains indispensable for diagnosis, localization, and treatment planning. Strengthening imaging infrastructure and promoting early MRI referral can reduce diagnostic delays and improve neurological outcomes. As MRI technology and clinical collaboration advances, future research integrating functional and molecular imaging will further enhance the understanding and management of spinal cord tumors.

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