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Assessment Of Mr (Magnetic Resonance) Imaging Characteristics In Intramedullary Spinal Cord Tumors

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Abstract
Introduction:
Intramedullary Spinal Cord Tumors present a diagnostic challenge due to their varied etiologies and overlapping clinical manifestations. Magnetic Resonance Imaging (MRI) serves as a pivotal tool in their evaluation, providing valuable insights into their morphological and pathological features.
Objective:
- *To assess the MRI characteristics of Intramedullary spinal cord tumors, encompassing a wide spectrum of neoplastic, lesions.*
- *The assessment of Magnetic Resonance Imaging (MRI) characteristics and tissue composition in Intramedullary spinal cord tumors , Determine Lesion Location , Extension and Mass Effect.*
- *To evaluate Enhancement Patterns and Recognize Cystic and Necrotic Components, Assess Diffusion Characteristics, Evaluate Perilesional Edema to Facilitate Treatment Planning.*

Material and Methods:
- *Retrospective observational study was carried out on 50 patients referred for MRI scan at department of Radiology, Dr. M.K SHAH Medical college and Research centre Ahmedabad from Dec'21- March 23. MRI examinations performed on 1.5 Tesla MRI scanners.*

Results:
- *Comparison of the MRI characteristics observed in this study with those reported on characteristics in Intramedullary spinal cord tumors, Clinical Implications and Conclusion.*

Conclusion:
- *The indispensable role of MRI in the assessment of Intramedullary spinal cord tumors, offering a comprehensive understanding of their imaging characteristics essential for precise diagnosis and optimal patient management.*

Keywords: *Intramedullary spinal cord tumors, Astrocytoma, ependymoma, Lesion Characterization, Tumor Assessment.*

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I. Introduction

Magnetic Resonance Imaging (MRI) has emerged as a cornerstone in the diagnostic evaluation of Intramedullary spinal cord tumors within the spinal cord. Intramedullary spinal cord tumors represent a diverse array of pathological entities ranging from benign tumors to malignant neoplasms, inflammatory processes, and vascular malformations. Understanding the imaging characteristics of these lesions is paramount for accurate diagnosis, treatment planning, and prognostication [1].

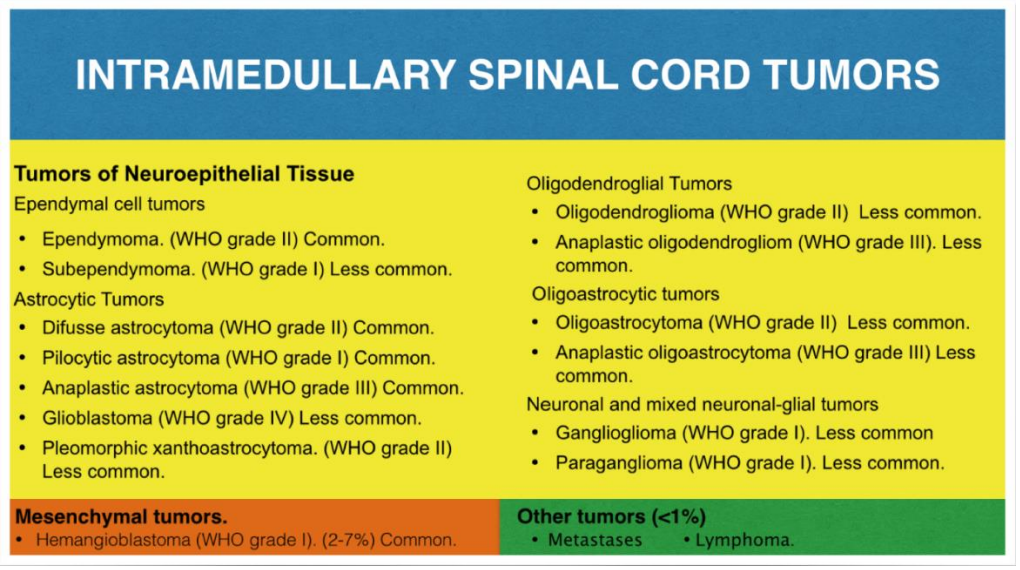
MRI offers unparalleled soft tissue contrast and multiplanar imaging capabilities, making it an indispensable tool in the evaluation of Intramedullary spinal cord tumors. By utilizing various pulse sequences such as T1-weighted, T2-weighted, and gadolinium-enhanced sequences, MRI can provide detailed anatomical information along with crucial tissue characterization [2].

In this assessment, we aim to elucidate the diverse MRI characteristics encountered in Intramedullary spinal cord tumors. We will explore key imaging features such as signal intensity, enhancement patterns, mass effect, and associated findings, which play a pivotal role in differential diagnosis and management decisions [3].

Furthermore, we will discuss the importance of incorporating clinical history, patient demographics, and ancillary imaging findings into the interpretation of MRI studies. The integration of these factors is essential for formulating a comprehensive differential diagnosis and guiding subsequent therapeutic strategies [4].

Ultimately, a nuanced understanding of the MRI characteristics of Intramedullary spinal cord tumors is essential for radiologists, neurosurgeons, and other healthcare professionals involved in the care of patients with spinal cord pathology. By leveraging the capabilities of MRI and integrating clinical and imaging data, we can enhance diagnostic accuracy, optimize patient care, and improve clinical outcomes [5].

- Assessment of MRI characteristics including:
- Location, size, and extension of the masses.
- Signal intensities on T1-weighted and T2-weighted images.
- Presence of cystic changes, hemorrhage, and spinal cord edema.
- Enhancement patterns following gadolinium administration.
- Additional findings such as spinal canal compression and involvement of adjacent structures.



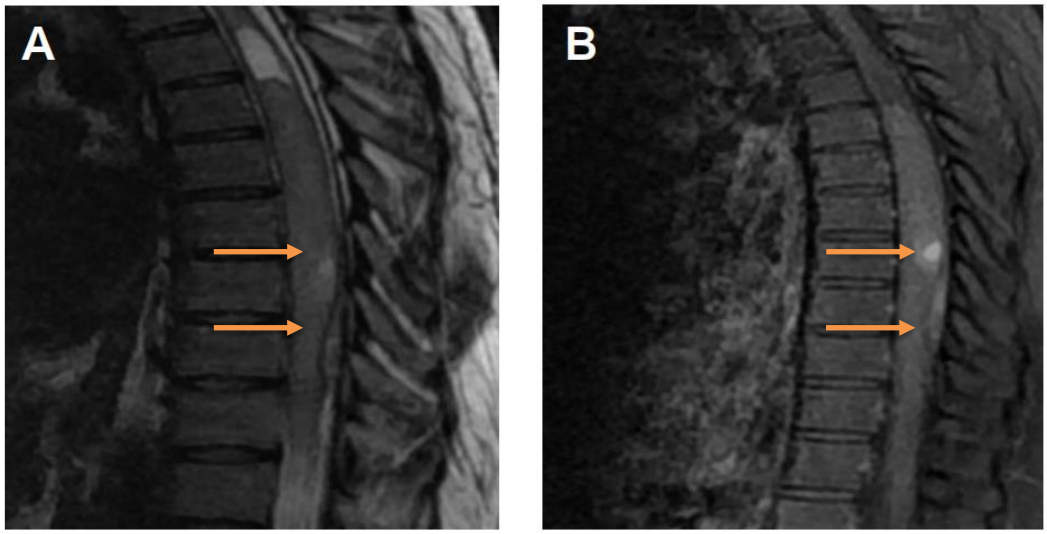
(Figure 1) References: Department of Radiology, Clinical University Hospital Virgen de la Arrixaca, Murcia/Spain 2015.

EPENDYMAL TUMORS

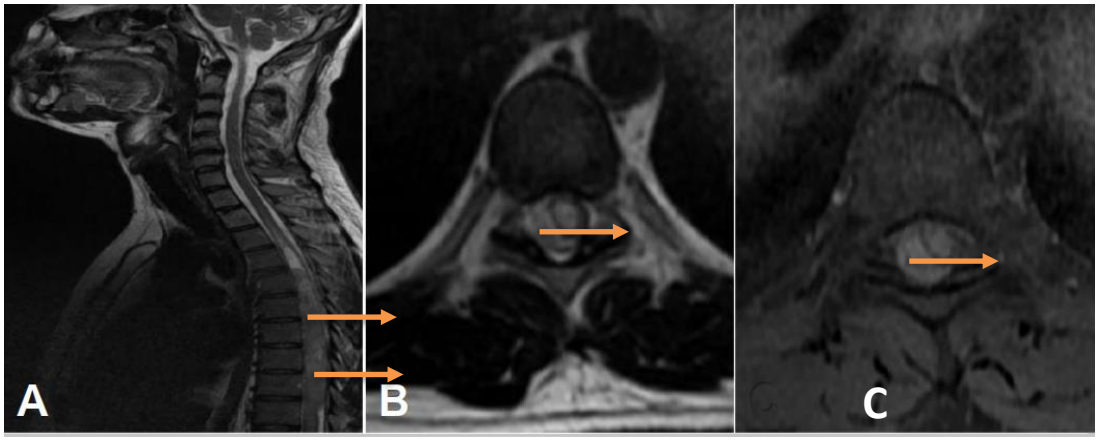
Ependymal tumors are a type of glial tumor that arise from ependymal cells lining the ventricles of the brain or the central canal of the spinal cord.

Ependymal tumor includes: Ependymoma, Subependymoma.

Ependymal tumors typically appear as well-defined lesions, arise from the spinal cord and present as intramedullary masses. Ependymal tumors typically appear isointense to hypointense on T1 and hyperintense on T2-weighted images. On contrast studies , it enhances strongly, mostly in-homogenously. Some ependymal tumors may contain cystic components, which appears as fluid-filled spaces within the tumor mass. These cystic areas may show variable signal intensity on MRI depending on the composition of the fluid. It can cause peritumoral edema. It widens the spinal cord and tends to occupy the central portion of the spinal cord causing symmetrical cord expansion [6,8,19,20]. (Figure 2 & 3)



(Figure 2) Intramedullary spinal cord ependymoma. A, sagittal T2WI image shows a well demarcated intramedullary hyperintense lesion centered at the D4-D9 vertebral level. B, sagittal post-contrast T1WI demonstrates lesion showing heterogenous post-contrast enhancement of the solid component. It is surrounded by dilated cystic spaces which are not surrounded by enhancing tissue and may represent a tumor syrinx.



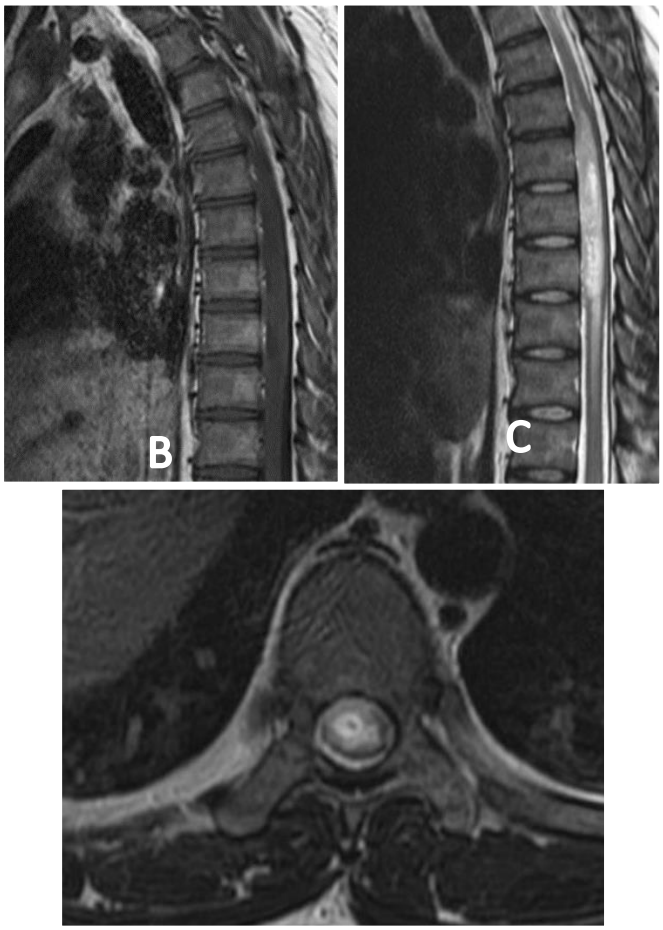
(Figure 3) Intramedullary spinal cord ependymoma. A, sagittal T2WI image shows hyperintense intramedullary cystic lesion cranially surrounding the lesion with capping of CSF at D4 level suggestive of syringomyelia. B, axial T2WI image shows hyperintense centrally located mass with circumscribed well-defined margins. C, axial T1WI shows homogenous enhancement of the lesion.

Astrocytic tumors

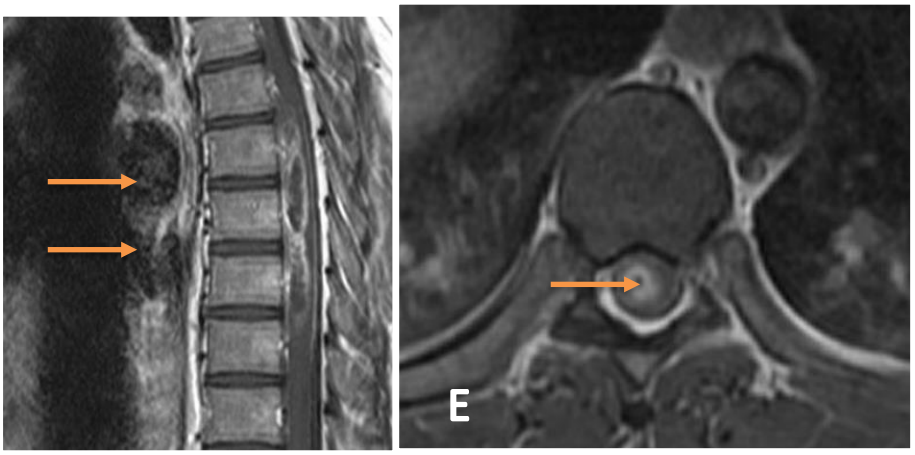
Astrocytic tumors are originating from astrocytes, which are a type of glial cell in the brain.

Astrocytic tumor includes: Diffuse astrocytoma, Glioblastoma, pilocytic astrocytoma, anaplastic astrocytoma, Pleomorphic xenthoastrocytoma.

Astrocytic tumors typically present as hypo- to isointense masses on T1-weighted MRI, with central heterogeneous signals due to necrosis or intratumoral hemorrhage. On T2-weighted and FLAIR images, these tumors appear hyperintense with surrounding vasogenic edema and lack the "mismatch" sign. Contrast enhancement is variable but often peripheral, irregular, and nodular, typically surrounding areas of necrosis. These tumors are frequently associated with peritumoral edema. High-grade astrocytic tumors, such as glioblastoma multiforme, may show intratumoral hemorrhage, appearing hypointense on T2-weighted and hyperintense on T1-weighted images. Calcifications can be present, especially in lower-grade lesions like pilocytic astrocytomas. High-grade astrocytic tumors often exhibit restricted diffusion on diffusion-weighted imaging (DWI) due to increased cellularity and cellular crowding [8,9,10,21]. (Figure 4 & 5)



(Figure 4) Spinal cord Astrocytoma. A, sagittal T1WI image shows hypointense lesion centered at the D5-D8 vertebral level. B & C, sagittal & axial T2WI demonstrates well demarcated hyperintense lesion between D4-D11 vertebral level. The lesion causes cord displaced posteriorly and to the left.

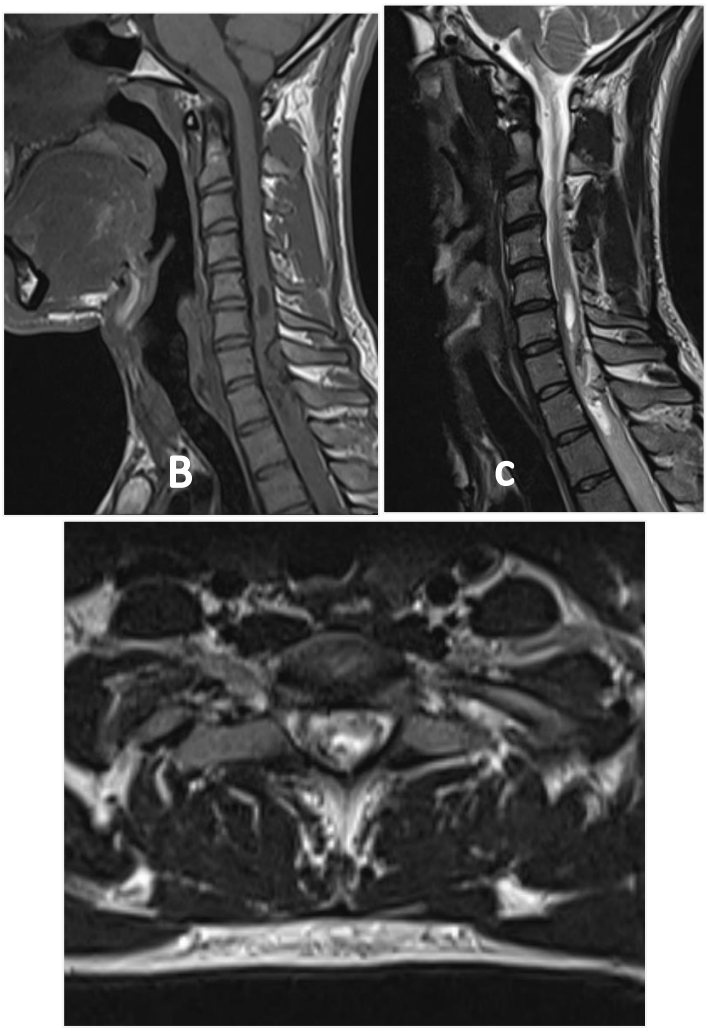


(Figure 5) Spinal cord Astrocytoma. D & E, sagittal & axial post-contrast T1WI demonstrates heterogeneous contrast enhancement of the lesion with patchy irregular peripheral enhancement of this lesion, and central hypointensity.

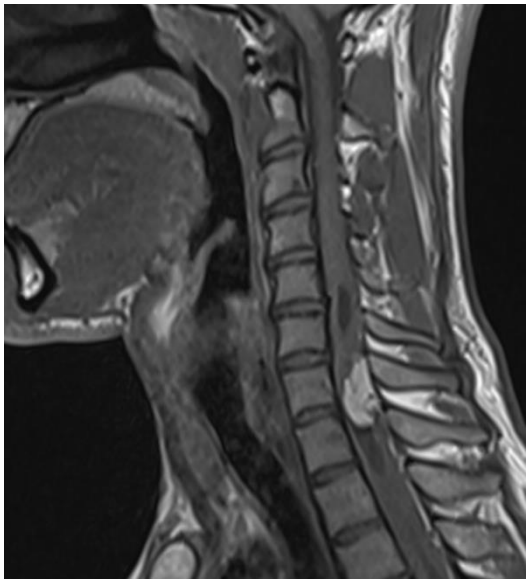
Hemangioblastoma

Hemangioblastomas are the third most common intramedullary spinal neoplasm, typically benign tumors.

On T1-weighted MRI, hemangioblastomas typically manifest as sharply outlined, solid lesions with signal intensity similar to or slightly lower than normal brain tissue. On T2-weighted imaging, they present as bright areas. Contrast-enhanced MRI reveals pronounced enhancement. Hemangioblastomas often exhibit cysts, adjacent edema, and calcifications. Their robust vascular characteristics may result in a flow void effect [11,12]. (Figure 6 & 7)



(Figure 6) Spinal cord Hemangioblastoma. A, sagittal T1WI image shows mild hypointense lesion centered at the C7-D1 vertebral level. B & C, sagittal & axial T2WI demonstrates well demarcated isointense lesion. The lesion indents the cord with anterior displacement. Cord syrinx is noted extending from C5 to D5 vertebral levels.

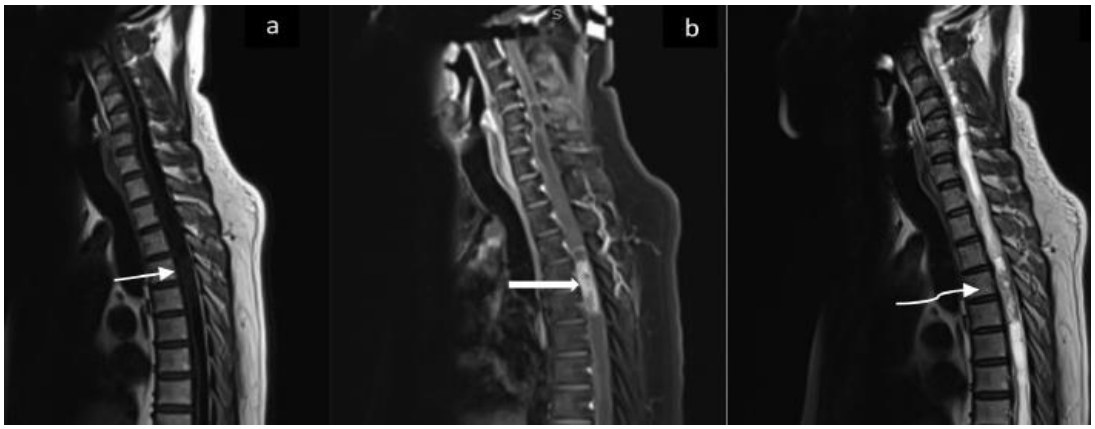


(Figure 7) Spinal cord Hemangioblastoma. D, sagittal post contrast T1WI image shows that tumor nidus enhances avidly.

Oligodendrogliomas

Oligodendrogliomas arises from oligodendrocytes, a type of glial cell.

Oligodendrogliomas usually present as hypointense lesions on T1-weighted MRI and hyperintense on T2-weighted and FLAIR images. Enhancement is often variable and typically heterogeneous. Calcifications, when present, may show "blooming" on GRE/SWI images. These tumors often have well-defined margins, helping to distinguish them from more infiltrative tumors like glioblastomas. Oligodendrogliomas typically do not show restricted diffusion on DWI sequences. On MR perfusion (PWI) images, they exhibit increased vascularity with a "chicken wire" network appearance, resulting in elevated relative cerebral blood volume [13,14]. (Figure 8)



(Figure 8) Spinal cord Oligodendrogliomas. A, sagittal T1WI image shows iso-to-hypointense lesion centered at the D4-D5 vertebral level. B, sagittal postcontrast T1WI demonstrates heterogenous enhancement. C, sagittal T2WI appears hyperintense with extensive syringomyelia.

Anaplastic oligoastrocytoma

Anaplastic oligoastrocytoma not otherwise specified (NOS) contains both oligodendroglial and astrocytic components and is characterized by high-grade features.

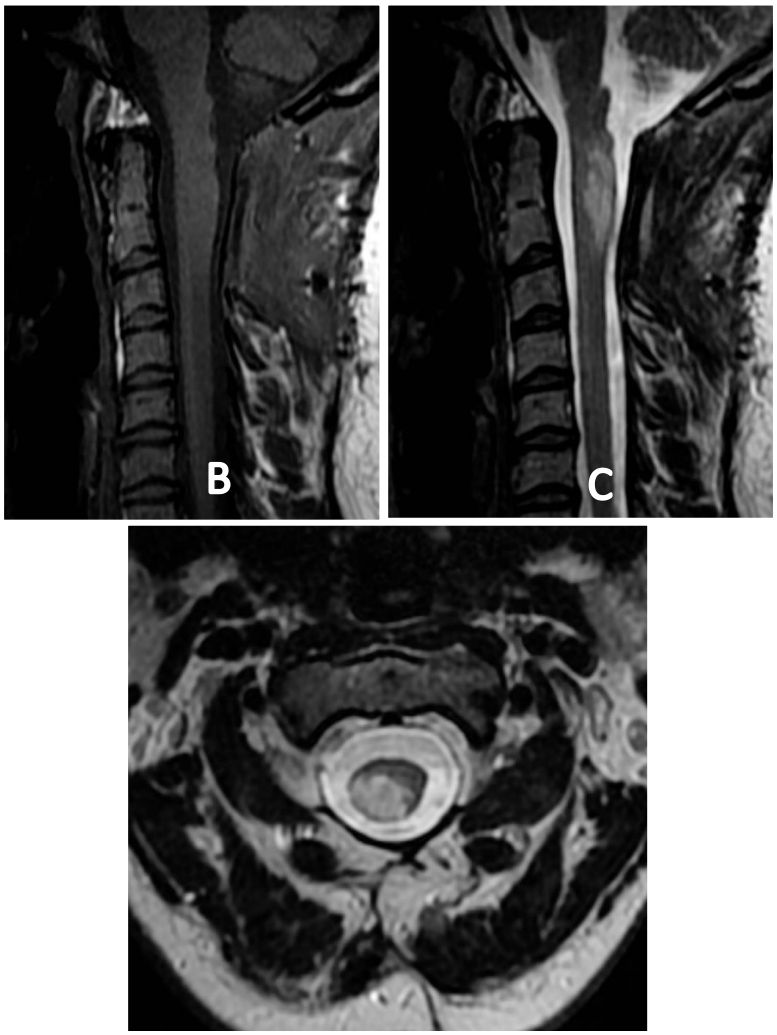
Anaplastic oligoastrocytomas often cause significant peritumoral edema and have infiltrative margins, making complete surgical resection challenging. On MRI, this infiltrative nature appears as ill-defined borders between the tumor and surrounding structures. These tumors may demonstrate calcifications, cystic changes, and areas of necrosis. Restricted diffusion may be observed on DWI sequences, indicating high cellularity or necrosis. Increased blood vessel density in anaplastic oligoastrocytomas can sometimes be appreciated on MRI as regions of abnormal vascularity or as foci of susceptibility artifacts on gradient echo sequences [15,16].

Neuronal and mixed neuronal-glial tumors

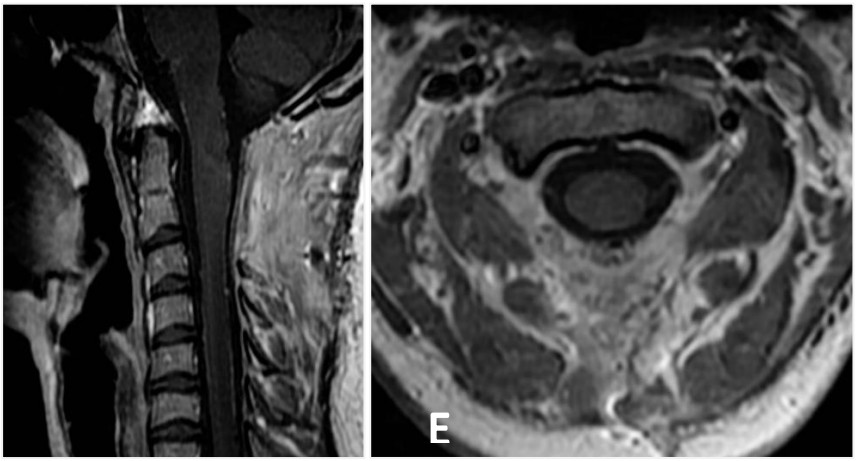
Neuronal and mixed neuronal-glial tumors can present with various MRI findings depending on their type, location, size, and other factors.

Neuronal and mixed neuronal-glial tumors includes: gangliоglioma, paraganglioma.

These tumors typically exhibit a solid component that is iso- to hypointense on T1-weighted images and hyperintense on T2-weighted images. They show a heterogeneous enhancement pattern with solid nodules upon contrast administration. Surrounding edema is often present, especially in larger or more aggressive tumors. Calcified areas appear with blooming signal loss on GRE/SWI images [17,18]. (Figure 9 & 10)



(Figure 9) Spinal cord Ganglioglioma. A, sagittal T1WI shows isointense lesion centered at the C1-C2 vertebral level. B & C, sagittal & axial T2WI demonstrates lesion show well demarcated hyperintense lesion. The lesion causes cord expansion.



(Figure 10) Spinal cord Ganglioglioma. D & E, sagittal & axial post-contrast T1WI demonstrates no contrast enhancement and no evidence of hemorrhage.

Objective:

1. **Identify Intramedullary Mass Origins:** Differentiate between various causes of intramedullary masses, such as neoplastic, inflammatory, vascular, and infectious conditions, based on their distinct MRI features.
2. **Analyze Tissue Composition:** Evaluate MRI signal intensities of intramedullary masses across T1-weighted, T2-weighted, and specialized sequences to discern tissue composition and aid in differential diagnosis.

3. **Interpret Enhancement Patterns:** Evaluate contrast enhancement patterns on post-contrast MRI sequences to distinguish enhancing and non-enhancing components of intramedullary masses, informing lesion characterization and treatment decisions.
4. **Locate and Assess Lesion Extension:** Precisely localize intramedullary lesions within the spinal cord and assess their extension along the neuraxis using multiplanar MRI imaging, facilitating accurate diagnosis and guiding management.
5. **Evaluate Diffusion Characteristics:** Use Diffusion-Weighted Imaging (DWI) and Apparent Diffusion Coefficient (ADC) mapping to assess diffusion characteristics of intramedullary lesions, aiding in subtype differentiation and assessment of tumor aggressiveness.
6. **Guide Treatment Strategies:** Utilize MRI findings to plan treatments such as surgical resection, radiation therapy, or medical management tailored to the specific characteristics and extent of intramedullary lesions.

Achieving these objectives enhances diagnostic accuracy, optimizes treatment approaches, and improves outcomes for patients undergoing MRI evaluation for intramedullary masses.

II. Materials And Methods

MR images obtained with proved Intramedullary spinal cord tumors was retrospectively reviewed. T1- and T2-weighted images were obtained. Gadolinium diethylenetriamine penta-acetic acid (Gd-DTPA) was intravenously administered ; enhanced sagittal and axial T1-weighted spin echo images were reviewed.

Imaging Protocol:
- MRI examinations performed on 1.5 Tesla MRI scanners.
- Standard imaging sequences included T1-weighted, T2-weighted, and gadolinium-enhanced sequences.

Image Analysis:
- Blinded review of MRI images by experienced radiologists or neuroradiologists.

Data Collection:
- Demographic data including age, gender, and clinical presentation.
- Imaging findings recorded using a standardized data collection form.

Study Design:
- Retrospective observational study was carried out on 40 referred for MRI scan at department of Radiology, Dr. M.K SHAH Medical college and Research centre Ahmedabad from Dec'21- March 23.
- MRI examinations performed on 1.5 Tesla MRI scanners.
- Inclusion of patients diagnosed with Intramedullary spinal cord tumors confirmed through histopathology.

Inclusion Criteria:
- Patients with histo-pathologically confirmed Intramedullary spinal cord tumors.
- Patient above 10 years and below 80 years of age.
- MRI studies conducted as part of diagnostic workup or preoperative evaluation.

Exclusion Criteria
- Patients who refuse to give consent for Magnetic resonance imaging for spinal pathology.
- Patients who refuse to participate in the study.
- Patients with pace makers, metal implants in their bodies and those having claustrophobia.
- Patient below 10 years and above 80 years of age.
- Lost to follow up.
- Patients who are pregnant.
- Patients in which contrast study is contraindicated.

Ethical Clearance
- Compliance with ethical guidelines for human research.
- Informed consent obtained from patients for prospective studies.
- Protection of patient confidentiality and privacy throughout the study.

III. Results And Discussion

Demographic Characteristics

- Overview of the demographic data of the study population, including age, gender distribution, and any relevant medical history.

Imaging Findings

- Description of MRI characteristics of Intramedullary spinal cord tumors, including:
- Tumor location within the spinal cord (e.g., cervical, thoracic, lumbar).
- Size and morphology of the tumor.
- Signal intensity on different MRI sequences (T1-weighted, T2-weighted, FLAIR, etc.).
- Presence of cystic or solid components within the tumor.
- Enhancement pattern following administration of contrast agent.

Discussion

Comparison with Previous Studies

- Comparison of the MRI characteristics observed in this study with those reported in previous literature on Intramedullary spinal cord tumors.

Clinical Implications

- Discussion of the clinical significance of the observed MRI features in terms of diagnosis, prognosis, and treatment planning for patients with Intramedullary spinal cord tumors.

Limitation

- The study acknowledges potential issues such as sample size, selection bias, or technical factors affecting MRI image quality.
- *Overlapping Imaging Features:* Some imaging characteristics of intramedullary spinal cord tumors may resemble those of other spinal cord tumors or non-neoplastic lesions, complicating definitive diagnosis based solely on imaging.
- *Artifacts:* MR images can be distorted by motion artifact, susceptibility artifact, or other technical challenges, particularly in spinal regions prone to respiratory or cardiac motion.
- *Location-Specific Challenges:* Intramedullary spinal cord tumors manifest in various spinal cord locations—intramedullary, intradural-extramedullary, or extradural—each presenting distinct difficulties in imaging interpretation.
- *Size and Clarity:* Detecting or characterizing small lesions or those with subtle imaging features can be difficult, especially with suboptimal imaging resolution.
- *Interpretation Variability:* Interpretation of MR imaging findings may vary subjectively among radiologists, potentially leading to discrepancies in diagnosis or characterization.

Intramedullary Spinal Tumors	Number of Cases
Ependymoma	12
Astrocytic tumors	10
Hemagioblastoma	7
Oligodendrogliomas	5
Anaplastic oligoastrocytoma	3
Neuronal and mixed neuronal-glial tumors	3
Total	40

Table 1: Incidence of different types of intramedullary spinal tumors.

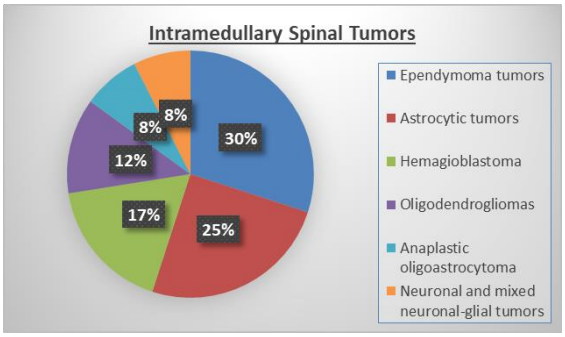


Chart 1: Incidence of different types of intramedullary spinal tumors.

Age (in years)	Number of Cases
10 to 20	9
21 to 30	3
31 to 40	3
40 to 50	4
50 to 60	10
60 to 70	12
Total	**40**

Table 2: Age wise distribution of intramedullary spinal tumors.

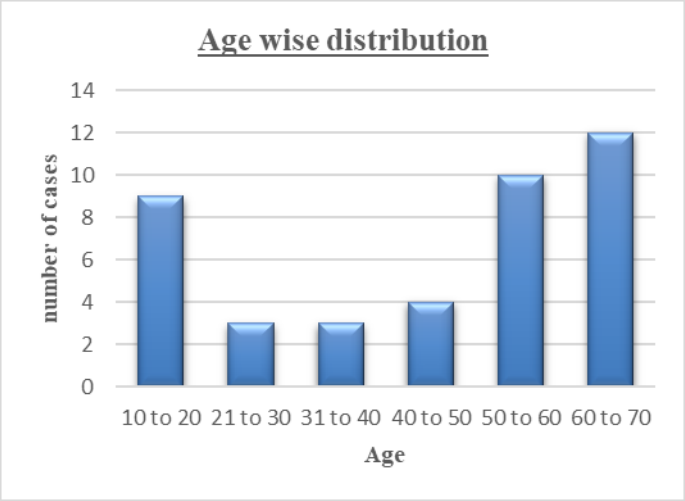


Chart 2: Incidence of different types of intramedullary spinal tumors.

IV. Conclusion

The comprehensive assessment of MRI characteristics in intramedullary spinal cord tumors is crucial for accurate diagnosis, effective treatment planning, and prognostic evaluation. Recent advancements in imaging techniques have significantly enhanced our ability to evaluate these tumors in detail. Key imaging modalities include:

1. **T1-weighted and T2-weighted Imaging**: These fundamental MRI sequences help determine the basic anatomical and structural features of the tumor. T1-weighted images typically provide information about the solid and cystic components of the tumor, while T2-weighted images highlight the tumor's relation to surrounding spinal cord tissue and any associated edema.
2. **Diffusion-weighted Imaging (DWI)**: DWI assesses the movement of water molecules within tissue and can provide information about tumor cellularity. Restricted diffusion often indicates high cellularity, which can be seen in malignant tumors.
3. **Dynamic Contrast-Enhanced MRI (DCE-MRI)**: This technique involves the administration of contrast material to evaluate tumor vascularity. It helps in identifying areas of neovascularization, which are common in high-grade tumors. The pattern of contrast enhancement can also aid in differentiating between tumor types.

By employing a combination of these methods, healthcare professionals can gather comprehensive information about the tumor's morphology, vascularity, cellularity, and metabolic activity. This detailed evaluation aids in distinguishing between various pathological entities such as tumors, infections, or inflammatory conditions, leading to more precise diagnoses and tailored treatment strategies.

Standardized imaging protocols and criteria are essential for ensuring consistency in reporting findings and facilitating effective communication among healthcare providers, including radiologists, neurosurgeons, and oncologists. This collaborative approach is vital for optimizing patient care and outcomes.

Ongoing research and technological innovations continue to enhance MRI's ability to characterize intramedullary spinal cord tumors. These advancements promise further improvements in diagnostic accuracy and patient outcomes, offering hope for better management and prognosis of these complex conditions.

In summary, the thorough assessment of MRI characteristics in intramedullary spinal cord tumors plays a pivotal role in clinical decision-making and patient management. By integrating advanced imaging techniques and methodologies, healthcare professionals can achieve more accurate diagnoses, guide treatment planning, monitor treatment response, and ultimately improve the overall care and outcomes for patients with intramedullary spinal cord tumors.

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