e-ISSN: 0975-5160, p-ISSN: 2820-2651

Available online on www.ijtpr.com

International Journal of Toxicological and Pharmacological Research 2023; 13(8); 108-118

Original Research Article

Spinal Cord Compressive Myelopathy: Radiological Evaluation Using Magnetic Resonance Imaging in a Tertiary Care Center

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Received: 15-04-2023 / Revised: 21-06-2023 / Accepted: 26-07-2023
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Conflict of interest: Nil

Abstract:

Background: Compressive myelopathy is the term used to describe spinal cord compression from different causes. This can be caused by etiologies either from outside or within the cord. The aim of the study is to determine the various causes of compressive myelopathy and their MRI characteristics.

Methods: A prospective hospital-based study was conducted. Total of 30 cases were analysed over a period of from January 2020 to January 2022 and were investigated with MRI.

Results: MRI is the modality of choice to image spine and spinal cord pathologies because of its ability to delineate soft tissue anatomy in multiple planes without ionizing radiation and non –invasiveness. Most common cause for compressive myelopathy in our study was spinal trauma (46.6%)> Metastasis (20%) > Infection/TB (16.7%) = Primary neoplasm (16.7%). Most of spinal injuries (most common), infections and secondary neoplasms involve extradural compartment while most of primary neoplasm involves intradural compartment. The common site involved is the cervical (50%) followed by thoracic (37.5%) Regions in cases of spinal injury.

Conclusions: MRI is a very definitive, sensitive, accurate, specific, and non-invasive modality for evaluation of spinal cord myelopathy.

Keywords: Magnetic resonance imaging, Spine, Spinal cord compression, Myelopathy.

Introduction

Compressive myelopathy is the term used to describe spinal cord compression from different causes. This can be caused by etiologies either from outside or within the cord. Compression may be due to traumatic etiology, neoplasms or due to infective causes.[1] Plain radiographs have a low sensitivity for identifying traumatic or neoplastic spinal lesions.[2] CT scan is better than MRI in giving bony details but has low sensitivity for delineating soft tissue elements. MRI is best in evaluating the soft tissue details like cord, soft tissue edema, disc bulge, hemorrhages, and neoplasms which makes MRI, the definitive modality in assessing spinal soft tissue injuries, infections, and neoplasms. [3,4]

MRI has a great role in distinguishing compressive from non-compressive causes of myelopathy and its prognostic evaluation.[5] The aim of this study is to determine the various causes of compressive myelopathy and their MRI characteristics, classify lesions based on their location such as intradural or extradural and to evaluate the degree of spinal cord compression based on MRI characteristics and its prognostic significance.

Materials and Methods

Study design

Type of study: Prospective study.

Site and duration of study: This study was conducted in the Department of Radiodiagnosis, Medical Trust Hospital, Cochin, Kerala, INDIA, and Department of Radiodiagnosis, Malankara orthodox Syrian church medical college, Kolenchery, Kerala, INDIA.

This study was conducted using data collected from January 2020 to January 2022 for a period of two years. Institutional Ethical approval was obtained for the study. Written consent was obtained from all the participants of the study.

Reference population: The patients selected for the study were referred from Neurosurgery/Neurology OPD or Emergency department at our hospital, who are referred for radiological evaluation for suspicion of compressive myelopathy. The patients were presented with various symptoms like motor symptoms, sensory symptoms and urinary bladder symptoms of either gradual or acute onset.

The study group will include a sample size of 30 patients selected by a purposive sampling. The data will be analyzed by a descriptive analysis.

Inclusion criteria: All patients with clinical features suggestive of compressive myelopathy who are referred for radiological evaluation irrespective age and sex.

Exclusion criteria: Patient presenting with degenerative disc prolapse, hypertrophy of ligamentum flavum, ossified posterior longitudinal ligament, degenerative facet arthropathy and intracranial pathologies are excluded. Patients with contraindications for MRI such as cardiac pacemaker, cochlear implants, aneurysmal clips, and conditions producing non-compressive myelopathy such as myelitis are also excluded from the study.

Imaging Methods:

Patient preparation: The procedure was briefly explained to the patient and consent was taken. Detailed history for contraindication of MRI was specifically taken. They were provided with ear plugs to minimize the noise within the MRI room.

Equipment: 1.5 Tesla (Siemens Espree). Standard surface coils and body coils, were used for cervical, thoracic and Lumbar spine for acquisition of images.

Table 1: Sequences

Sequences	TR	TE
SE T1	760	12
T2	3000-4000	80
GRE T2*	560- 700	18
STIR	2500	40
T1 fat sat	1110	13

FOV: Sagittal: 30cm, Axial: 18cm

Matrix size: Sagittal and coronal: 320 x320, axial 260 x260

Slice thickness: 3mm - 5mm Contrast Contrast agent used was Magnevist (Dimeglumine Gadopentetate) in dose of 0.1 to 0.2mmol/kg, intravenously using T1 weighted fat suppressed sequences.

Technique:

Patients were examined with MRI scan in the supine position with proper positioning and immobilization of the body. Standard surface coils were used for acquisition of images. In cases where sedation is required, an anesthetist accompanied the patient.

Pre contrast scanning was done using: Sagittal T1WI, T2Wl, STIR, Gradient sequences, Axial T1W, T2W, Gradient T2* in case of cervical spine sequences, Coronal STIR sequences. Post contrast fat suppressed T1WI sag, axial and coronal images were obtained with use of contrast agent Magnevist (Dimeglumine Gadopentetate) in dose of 0.1 to 0.2 mmol/kg, intravenously in cases of neoplasms and infections. For spinal trauma contrast was not done. Whenever required, thinner sections were obtained in the region of interest.

Image Interpretation: All images are interpreted on synapse PACS and MRI console monitor with adequate gray-scale center level and window width settings. All cases were reported by experienced radiologists. The MRI images were analyzed based on location (cervical, thoracic lumbar), segment of the spinal cord involvement and severity of injury. In cases of trauma, site and level of injury, vertebral fracture, ligamentous injury, presence /absence of hematoma to classify into spinal subdural / extradural hematoma were noted. Neoplasms were classified based on appearance into benign /malignant, based on location into extradural, intradural (extramedullary).

Follow up: Whenever possible patients were followed up for histopathological diagnosis in cases of neoplasms and outcome in cases of spinal trauma.

Results and Observations

The majority of patients of spinal injury (57.14%) and primary neoplasm (60%) are in the middle age group (30-50 years). While Majority of patients of spinal infection (60%) are young adults and secondary neoplasm (83.33%) are in older age group (>50 years).

Most of the Spinal injury (71.43%) and infection/TB (80%) occur in male population and spinal primary neoplasm (60%) and secondary/ metastasis (60%) are more common in female population while primary neoplasms shared equal proportions among males and females(Table 2).

Table 2: Age, Gender, and Compartmental Distribution in Various Diagnosis

Variables	MR diagnosis				P value
	Traumatic (n=14)	Infection (n=5)	Primary Neoplasm (n=5)	Secondary /Neoplasm metastases(n=6)	
Age in years					
10-30	3(21.43%)	3(60%)	0(0%)	0(0%)	
31-50	8(57.14%)	1(20%)	3(60%)	1(16.67%)	
>50	3(21.43%)	1(20%)	2(40%)	5(83.33%)	0.015*
Gender					
Male	10(71.43%)	4(80%)	2(40%)	3(50%)	
Female	4(28.57%)	1(20%)	3(60%)	3(50%)	0.050*
Compartment					
Extradural	14(100%)	5(100%)	1(20%)	6(100%)	
Intradural	0(0%)	0(0%)	4(80%)	0(0%)	0.001*

Most common cause for compressive myelopathy in our study was spinal trauma (46.6%) > Metastasis (20%) > Infection/TB (16.7%) = Primary neoplasm (16.7%). Extradural compressive lesions (86.6%) are the most common cause for compressive myelopathy.

Table 3: Causes according to various compartment

Causes	Number of patients (n=30)	Extradural (n=26)	Intradural – Extramedullary (n=4)
Traumatic myelopathy	14	14(100%)	0(0%)
Infective/TB	5	5(100%)	0(0%)
Primary neoplasms	5	1(20%)	4(80%)
Secondary neoplasms/metastasis	6	6(100%)	0(0%)

Most of spinal injuries (most common), infections and secondary neoplasms involve extradural compartment while most of primary neoplasm involves intradural compartment. The common site involved is the cervical (50%) followed by thoracic (37.5%) regions in cases of spinal injury.

Table 4: Cord changes in spinal injury

Cord Changesin spinal injury		Number ofpatients(14)	%
Yes	**Total cord changes**	**11**	**78.57%**
	Only cord edema	**6(54.56%)**	
	Cord hemorrhage	**3(27.27%)**	
	Cord transaction	**2(18.18%)**	
No		**3**	**21.43%**

Cord changes are seen in the majority (78.57%) of spinal injury patients. Among them cord edema is the most common finding (Table 4). The pattern of signal intensity changes has prognostic value. Cases associated with edema /non-hemorrhagic contusion (42.2%) have favorable outcome as compared to cord hemorrhage (21.42%) which has poor prognosis (Table 5).

Table 5: Correlation of spinal cord changes with prognostic outcome incases of spinal injury

	No of Patients	Prognostic outcome		
		Recovery	Poor Recovery	Expired
No cord changes	3	3	0	0
Cord changes	11			
Cord Edema	6	5	0	1
Cord Hemorrhage	3	0	1	2
Cord transection	2	0	0	2

MRI depicts not only the spinal cord changes but also the relationship of subluxed/dislocated vertebral bodies to the cord, posterior elements fracture, ligamentous disruption, soft tissue injuries which all have prognostic implication and can be used to classify injury into stable / unstable (Table 6).

Table 6: Characterization of spinal injuries by MRI

MRI finding	No. of patients	%
1.Stable fractures	6	42.86
2.Unstable fractures	7	50%
3.Posterior elements fracture	7	50%
4.Ligamentous injury	7	50%
5.Cord changes	1	78.57
6.Epidural hematoma/ soft tissue component	6	42.86
7.Pre and paravertebral collection	7	50%

The thoracic region is the most common site for spinal metastases. The Multiplicity of the lesions is strong evidence for a metastatic disease.

Table 7: primary lesions

Primary neoplasms	No. of patients
Neurofibroma	2(40%)
Meningioma	1(20%)
Arachnoid cyst	1(20%)
Myxopapillary ependymoma	1(20%)
Total	5

All primary neoplasms except arachnoid cyst are located in the intradural compartment.

Table 8: Location of the primary neoplasms

Diagnosis	Cervical	Thoracic	Lumbar
Meningioma	0	1	0
Neurofibroma	0	1	1
Myxopapillary ependymoma	0	0	1
Arachnoid cyst	0	1	0

The majority (60%) of primary neoplasms are located in thoracic region (Table 8).

Table 9: Histopathological correlation of cases causing compressive myelopathy

MR diagnosis	No. of cases	Histopathologicalexamination	% correlation
Traumatic Myelopathy	14	-	
Infection/TB	5	4	80%
Metastases	6	4	66.67%
Myxopapillary ependymoma	1	1	100%
Neurofibroma	2	1	50%
Meningioma	1	1	100%
Arachnoid cyst	1	-	

Two cases MR diagnosis of metastasis lost follow up and unable to correlate with histopathological examination. One of the Neurofibroma of MR diagnoses was given a second differential diagnosis of schwannoma which was proven to be schwannoma on histopathological examination on follow up. MRI is very sensitive as well as specific in detecting extradural lesions such as metastases, epidural abscess, infective spondylitis with epidural soft tissue component and also intradural primary neoplasms.

Discussion

MRI is the modality of choice to image spine and spinal cord pathologies because of its ability to delineate soft tissue anatomy in multiple planes without ionizing radiation and non –invasiveness.

All the MRI scans in this study were performed using 1.5 T MRI scanner (Seimens Espree). The study comprised 63.33% males and 36.66% females. The age group of the patients studied ranged from 12 years to 72 years. In our study of 30 cases of compressive myelopathy we found various causes for compression. Among these are trauma (14), infectious causes (05), primary neoplasms (05) and secondary neoplasm (06).

Trauma

Out of 30 cases of compressive myelopathy, we had 14 (46.6%) cases of spinal trauma. Among 14 patients the mode of injury was RTA (71.5%) and fall from height (28.5%). In a study conducted by Kulkarni et al [6] , most common mode of injury to the spinal cord was road traffic accidents followed by the the fall. The similar finding of the mode of injury is found in our study conducted. In our study the level of injuries among the 14 patients was cervical (50%), thoracic (37.5%), and lumbar (12.5%). This is comparable to the study conducted by Parizel PM et al. [7]

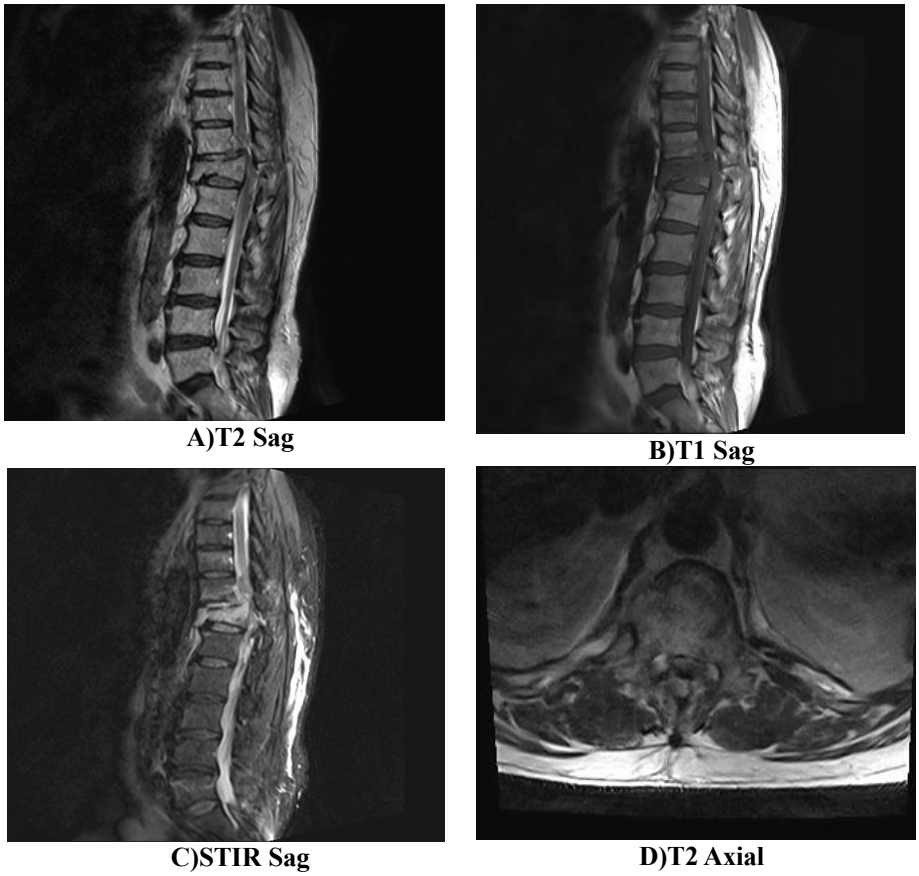


Figure 1: Traumatic myelopathy

Figure 1: A case of spinal injury with history of road traffic accident, shows comminuted fracture of D12 vertebral body and fracture of posterior inferior aspect of D11 with traumatic anterolisthesis of D11 over D12 causing significant compression of conus with near complete transection at D11-D12 level.

The spinal cord abnormalities demonstrated by MR imaging were cord compression and abnormal signal intensities within the spinal cord. Spinal cord compression was observed in all the 14 cases of spinal injury.

The causes of spinal cord compression included subluxation of vertebral body in 12 patients, impingement by fractured fragments in 3 patients and epidural hematoma in 6 patients.

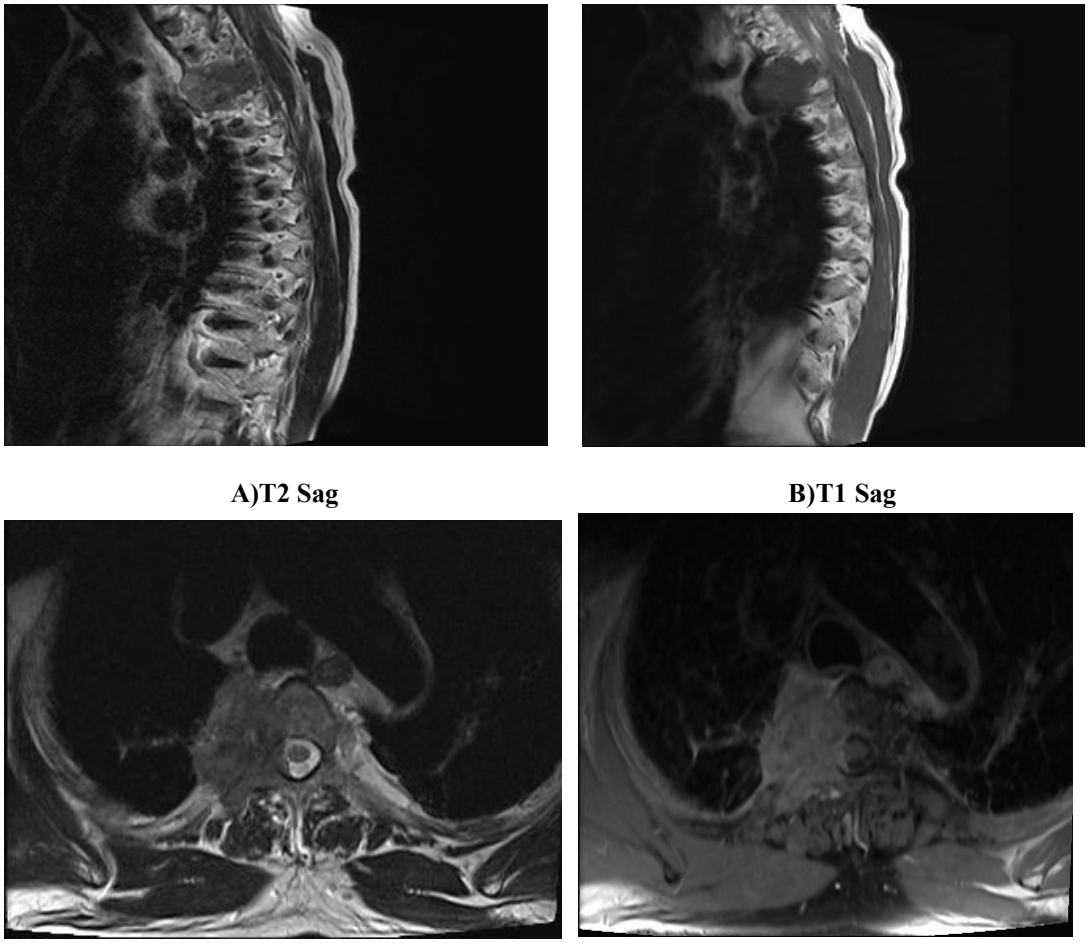
Abnormal signal intensities from the spinal cord were observed in 11 of 14 patients and 3 patients had no cord changes. Among eleven patients who showed cord changes there 6 patients who showed hypointensity on T1WI and hyperintensity on T2WI and FLAIR images within the spinal cord suggestive of cord edema / non-hemorrhagic contusion. Three patients showed heterogenous signal/ hyperintense on T1W images and corresponding hypointense signal on T2W images within spinal cord suggestive of cord hemorrhage. These signal changes are in consistent with studies done previously by Hackney et al.[8] and Ramon et al.[9] The cord signal intensity has the prognostic implication where patient with cord edema (9) recovered completely / partially.

While patients with cord hemorrhage (3) showed poor prognosis. This has also been shown by studies done by Flanders et al.[10] Of the 8 cervical injury patients, 5 patients expired during the period of hospitalization. This may be attributed to severity of cord compression and few of them showed complete transection of spinal cord. MRI depicted not only the spinal cord changes in our patients but also the relationship of subluxed/dislocated vertebral bodies to the cord (13 patients – 6 are stable fractures and 7 are unstable fractures), posterior elements fracture (7 patients), ligamentous disruption (7 patients), soft tissues injuries (7 patients) and epidural hematomas (6 patients). The advantage of MRI in demonstrating all these changes is shown by many studies done by Yamashita et al.[11]

Secondary neoplasms: In our study of 30 cases, 6 (20%) are of metastatic disease of the spine as a cause of compressive myelopathy.

These metastatic lesions causing cord compression were extended from an abnormal part of a vertebra and extradural in location in all six patients (Figure 2).

This is substantiated by a study conducted by Lien et al [12] in which 90% showed extradural masses extended from an abnormal part of a vertebra.



A)T2 Sag **B)T1 Sag**

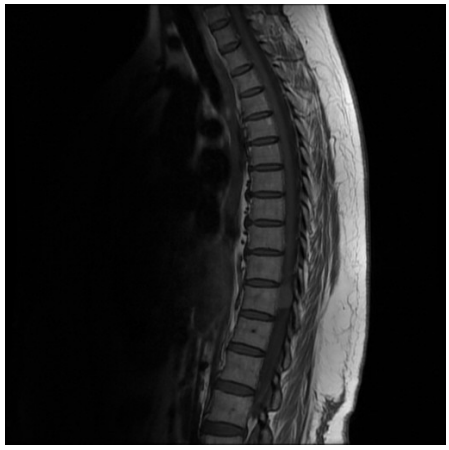
C)T2 Axial **D)T1 Post cont Axial**

Figure 2: Metastasis

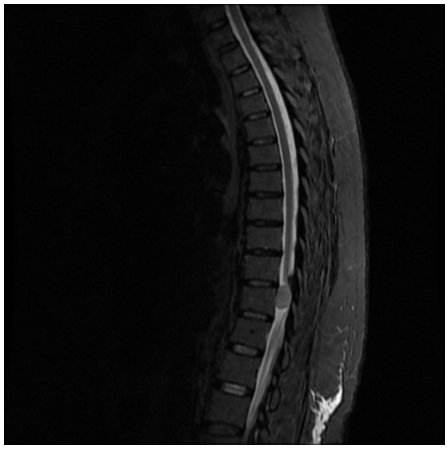
Figure 2: Altered destructive enhancing lesion noted involving the right half of body and pedicle of D3 vertebra with significant associated soft tissue, predominantly involving the right lateral extra pleural space with maximum thickness 2 cm. Enhancing epidural component noted at this level causing moderate narrowing of spinal canal with spinal cord compression.

Out of 6 patients, 4 (67%) showed more than one lesions. This is in comparison to study done by Lien et al[12] in which 78% had more the one lesions which include vertebral metastases in addition to those compressing the cord. In our study five out of six patients showed thoracic spine involvement. This is in comparison to the study done by Livingston et al [13] were site of epidural tumor in thoracic spine was 68%. The three most common primary tumors with metastases to the spine and extradural space was lung carcinoma (15%), breast (carcinoma 14%) and lymphoma (11%). In our study we had 2 patients with lung carcinoma, 1 carcinoma prostate, and 1 patient with myeloma and 2 patients were lost to follow up. We used T1WI, T2WI and STIR sequence and post contrast to image spinal metastases. T1WI was useful in the detection of bone marrow metastases and STIR helped in picking up more marrow lesions. IV Gd-DTPA was used in all six patients which showed mild homo-to- heterogeneous enhancement.

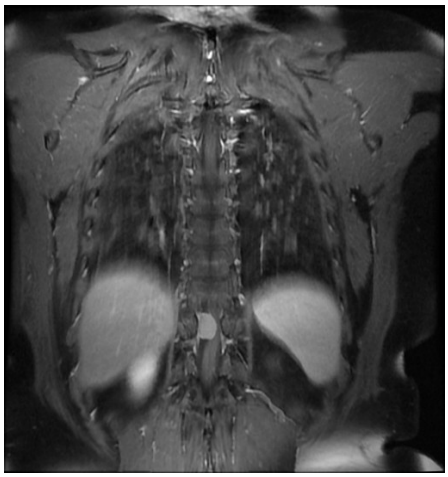
Primary neoplasms: We had 5 cases of primary neoplasms, among which 4 are intradural extramedullary and one was extradural in location. Out of 4 intradural extramedullary lesions, 2 were neurofibroma, 1 was meningioma and 1 was myxopapillary ependymoma.



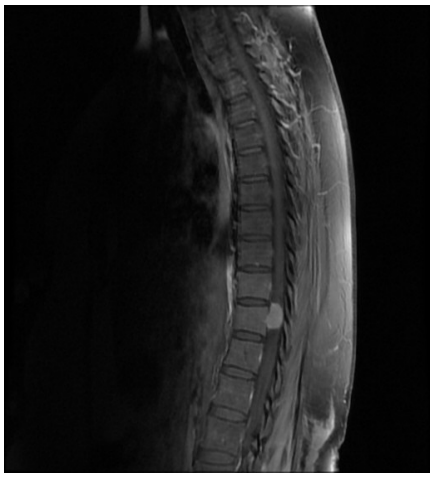
A)T1 Sag



B)STIR Sag



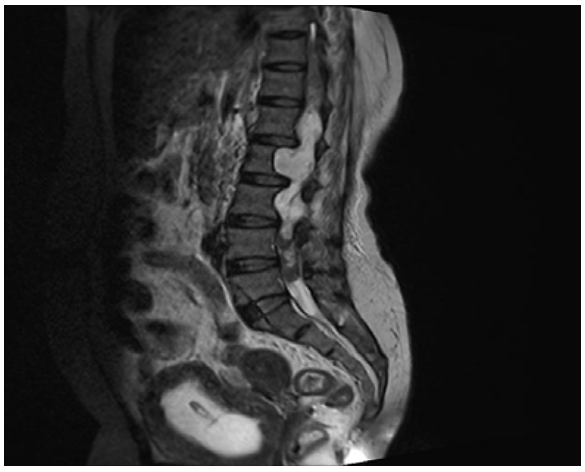
C)T1 Post cont Coronal



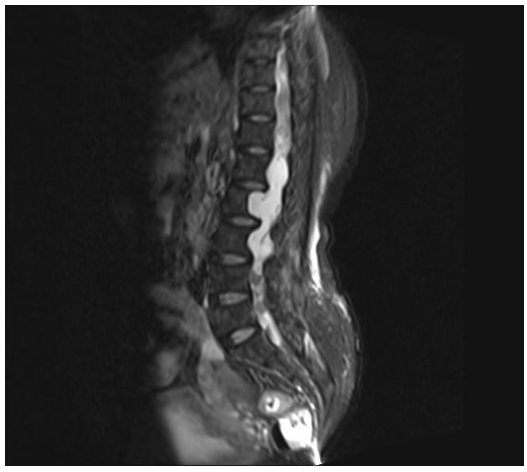
D)T1 Post cont Sag

Figure 3: Meningioma

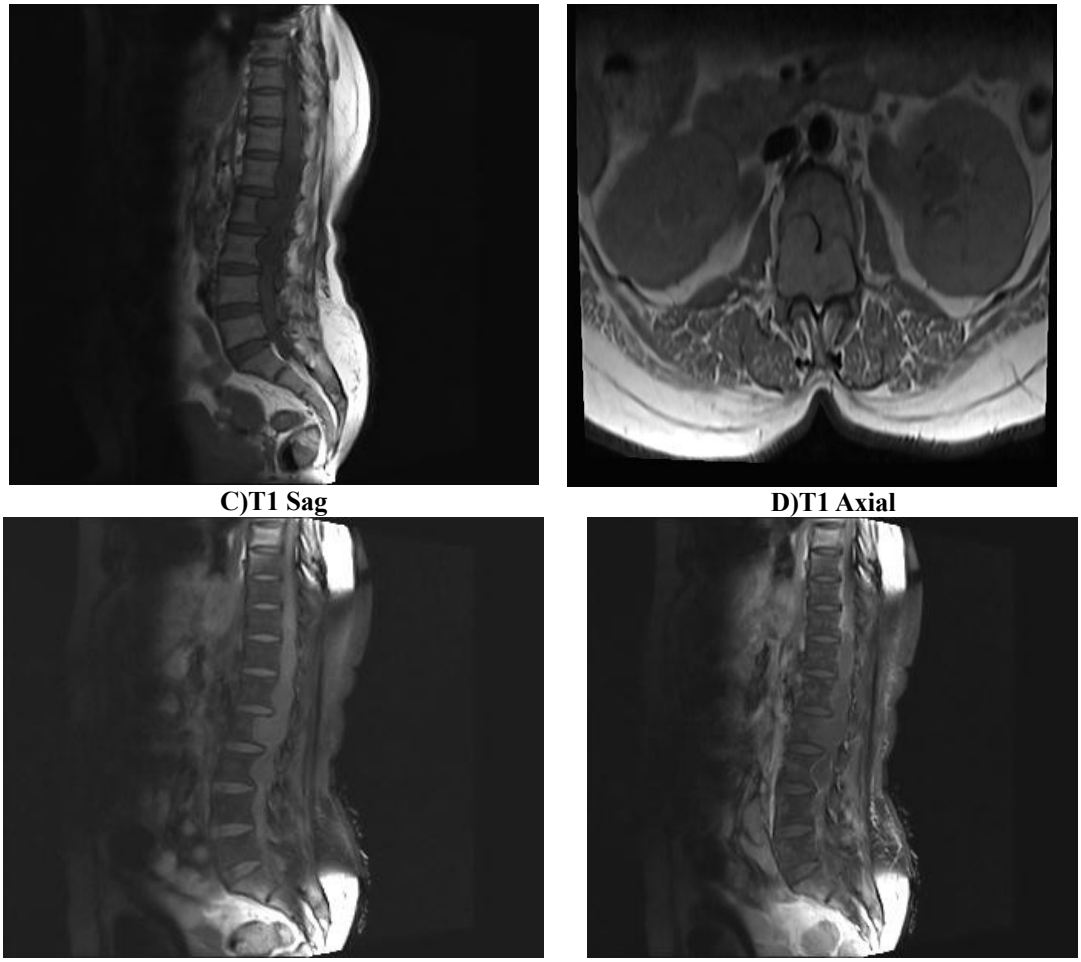
Figure 3: A well defined, isointense on T1, isointense to slightly hyperintense on T2, showing moderate homogeneous enhancement with broad-based dural attachment 'dural tail sign' noted at level of D9 located intradural extramedullary compartment causing severe compression of spinal cord, features suggestive of intradural meningioma.



A)T2 Sag



B)STIR Sag



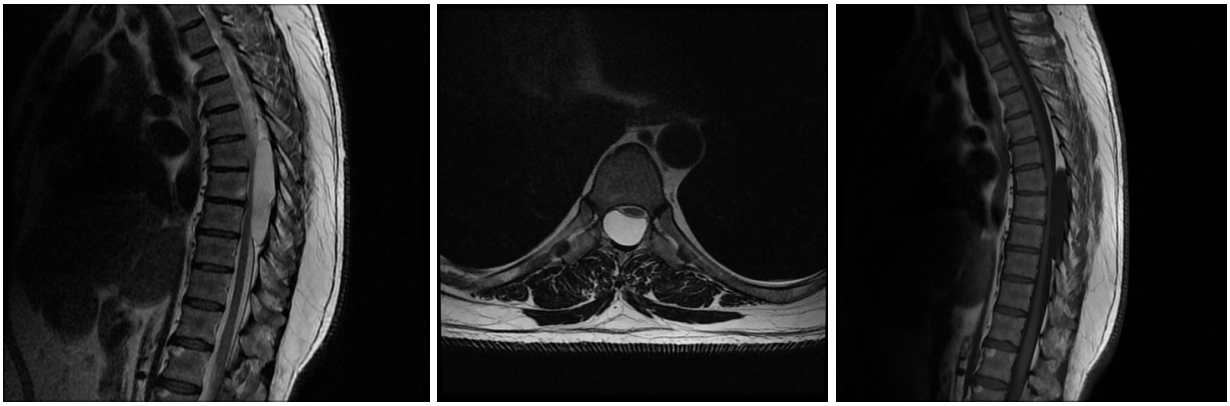
C)T1 Sag D)T1 Axial

E)T1 Fat sat F)T1 Post cont Sag

Figure 4: Myxopapillary ependymoma

Figure 4: Heterogenous intensity with irregular and inhomogenous lesion involving the long segment of spinal cord, from D11 till L5 level which is heterogeneously bright on T2 image with multiple intra lesional T2 hypointensities with hypointense layering at the inferior pole of lesion. On contrast study, lesion shows heterogeneous and minimal enhancement with predominantly involving peripheral region, Lesion fills the entire spinal canal with widening of the same. Involved vertebra shows posterior scalloping maximum at L2 and L3.

One extradural lesion was an arachnoid cyst (Figure 5).



A)T2 Sag B)T2 Axial C)T1 Sag

Figure 5: Arachnoid cyst

Figure 5: Well defined lesion homogenous low signal in T1W and bright signal in T2W images consistent with CSF signal extending from D3 to D5 in posterior epidural space causing significant compression of spinal cord. Features suggestive of extradural arachnoid cyst (type IA meningeal cyst).

All the 6 cases showed spinal cord compression. Out of the 2 cases diagnosed as neurofibroma on MR one case came as consistent with schwannoma on histopathological examination. Neurofibromas were iso- to- hypointense on T1WI and hyperintense on T2WI and showed intense enhancement on post contrast. One case showed extension into the neural foramina. Studies done by Dorsi et al [14] and Matsumoto et al [15] showed that on T1WI the signal varied from hypo to isointense to the cord and on T2WI they are hyperintense in signal and also may show decreased signal in the central portion consistent with necrosis.

Neurofibromas showed marked enhancement which was heterogeneous. Of the 4 intradural extramedullary neoplasms, one was meningioma. On MRI it was given as meningioma. It showed iso intensity on T1 & T2WI and showed moderate homogeneous enhancement with characteristic 'dural tail' on post contrast. Several studies by Matsumoto et al [15], Gezen et al [16] and Soweidane et al [17] showed signal characteristic of meningioma as iso intense to the cord on T1 and T2WI with intense homogenous enhancement on post contrast.

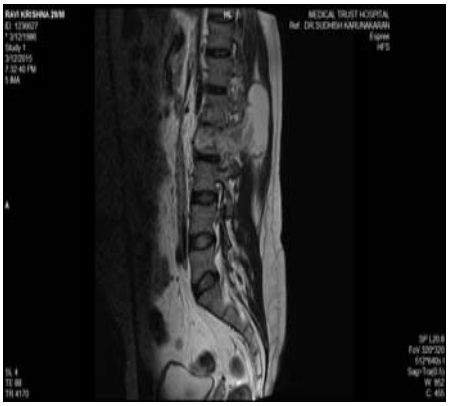
We had one case of extradural arachnoid cyst located at thoracic level compressing the spinal cord which appears hypointense on T1 and hyperintense on T2. Intraspinal meningeal cysts are a heterogenous entity which can be classified by CT-myelography or MRI combined with histological and intraoperative findings using the Nabor's classification.18 Extradural arachnoid cyst is a type Ia cyst as per Nabor et al classification [18]. The etiology and pathogenesis of extradural arachnoid cysts have been discussed controversially in the available literature. Rohrer et al [19] proposed a herniation of the arachnoid layer through a hereditary or inflammatory/traumatically induced dural weak spot.

Infective spondylitis

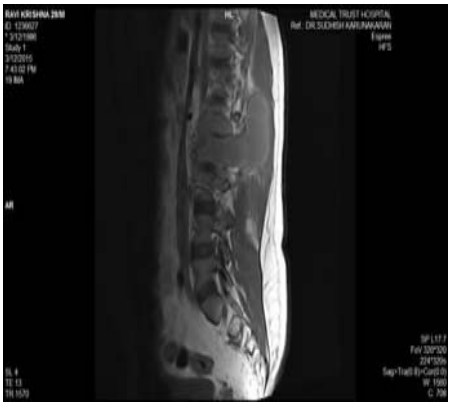
In our study, 5 cases of infective spondylitis were associated with compressive myelopathy. Three cases were in the thoracic region, 2 in the lumbar region and one in cervical region. X-ray showed some abnormality in all the 5 cases. Epidural soft tissue component compressing the cord was seen in four cases which was hypointense on T1WI, hyperintense on T2WI and STIR images. MRI showed vertebral body destruction with pre and para vertebral collection along with epidural component in 2 cases. Cord edema was also seen in these 2 cases.

On post contrast study these collections and epidural component showed peripheral rim enhancement in both cases which is consistent with abscess formation. Our study showed signal intensities of the abscess as comparable to the study conducted by Numaguchi et al. [20] Study by Roos DEA et al [21] showed thoraco – lumbar regions as the most common affected site as in our cases. They showed rim enhancement around the intra – osseous and paraspinal soft tissues abscess. One out of five cases showed complete collapse of L5 vertebra with retropulsion causing indentation on thecal sac.

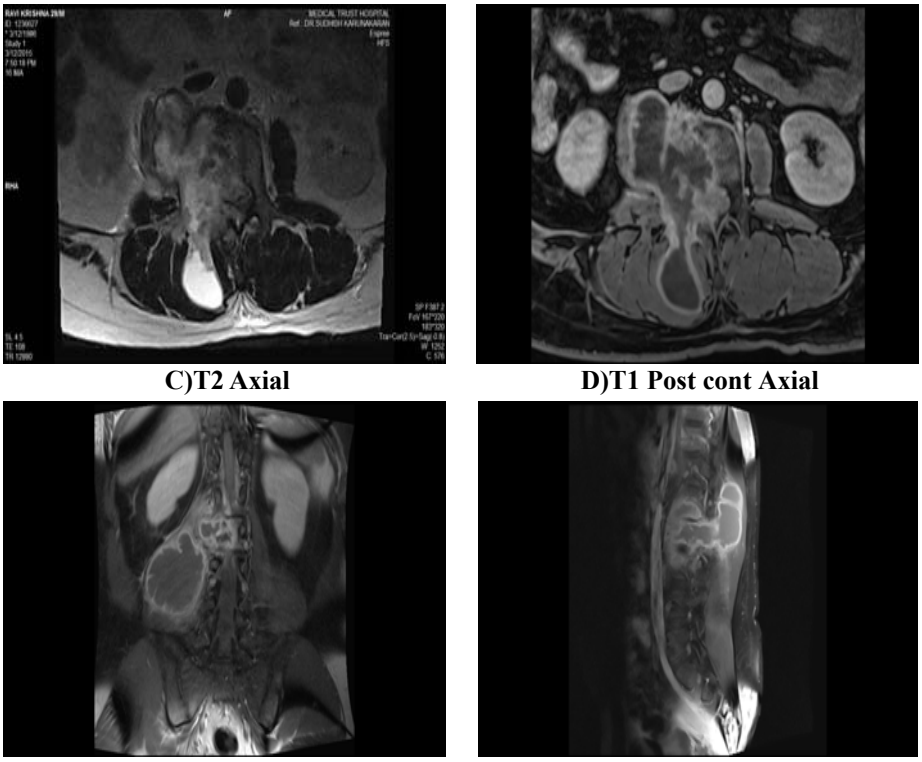
There was intense enhancement of the collapsed vertebra in post contrast studies. End plates and adjacent intervertebral discs showed no significant changes. Possibility of granulomatous pathology such as Eosinophilic granuloma or Tuberculosis was raised. After image guided biopsy histopathological examination was consistent with eosinophilic granuloma.



A) T2 Sag



B)T1 Sag



C)T2 Axial D)T1 Post cont Axial

E) T1 Post cont Coronal F)T1 Post cont Sag

Figure 6: Pyogenic Abscess

Figure 6: Altered destructive enhancing signals affecting L2 vertebra and inferior end plate of L1 vertebra with partial affection of L1 – L2 intervertebral disc. There is large associated peripherally enhancing soft tissue collection along the right psoas and the epidural space. Posteriorly it involves the right paraspinal muscles. Theca with the conus at this level appears significantly compressed and displaced towards left.

Limitations of the study

The study is done in a small population, so we are unable to generalize for the whole population. Also, we have lost follow up in a few patients and final histopathological diagnosis was not available with these cases.

Conclusion

MRI is the definitive modality to evaluate spinal cord, integrity of the intervertebral discs and ligaments. With the help of MRI, we can characterize the spinal tumor based on location into Extradural / Intradural and assess the integrity of spinal cord, intervertebral discs and ligament after acute spinal trauma.

MRI is a very definitive, sensitive, accurate, specific and non- invasive modality for evaluation of spinal cord myelopathy.

Acknowledgements

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References

1. Choi KH, Lee KS, Chung SO, et al. Idiopathic transverse myelitis: MR characteristics. AJNR Am J Neuroradiol. 1996; 17(6):1151-1160.
2. Chen CJ, Lyu RK, Lee ST, et al. Intramedullary high signal intensity on T2-weighted MR images in cervical spondylotic myelopathy: prediction of prognosis with type of intensity. Radiology. 2001; 221(3):789-794.
3. Fernandez de Rota JJ, Meschian S, Fernandez de Rota A, et al. Cervical spondylotic myelopathy due to chronic compression: the role of signal intensity changes in magnetic resonance images. J Neurosurg Spine. 2007; 6(1):17-22.
4. deSeze J, Lanctin C, Lebrun C, et al. Idiopathic acute transverse myelitis: application of the recent diagnostic criteria. Neurology. 2005; 65(12):1950-1953.
5. Kumar N. Pearls: myelopathy. Semin Neurol. 2010; 30(1):38-43.
6. Kulkarni MV, McArdle CB, Kopanicky D,

Miner M, Cotler HB, Lee KF, et al. Acute spinal cord injury: MR imaging at 1.5 T. Radiology.1987;164:837–43.
7. Parizel PM, Gielen JL, Vanhoenacker FM. The spine in sports injuries: the cervical spine. In: Vanhoenacker FM, Maes M, Gielen JL (eds) Imaging of orthopedic sports injuries. Springer, Berlin, 2007; 377–390.
8. Hackney D. B., Asato R., Joseph P. M., Carvlin M. J., McGrath J. T., Grossman R. I., et al. Hemorrhage and edema in acute spinalcord compression: demonstration by MR imaging. Radiology. 1986; 161:387– 390
9. Ramon S, Domínguez R, Ramírez L, Paraira M, Olona M, Castelló T et al. Clinical and magnetic resonance imaging correlation in acute spinal cord injury. Spinal Cord. 1997; 35: 664–673.
10. Flanders FD. Enhanced MR Imaging of hypertrophic pachymeningitis: AmJ Roentgenol. 1997; 169: 1425-1428.
11. Yamashita Y, Takahashi M, Matsuno Y, Kojima R, Sakamoto Y, OguniT, etal. Acute Spinal cord Injury. Magnetic resonance Imaging correlated with myelopahty: The British Journal of Radiology. 1991; 64:201-209.
12. Lien HH, Blomlie V, Heimdal K. Magnetic Resource Imaging of malignant extradural tumors with acute spinal cord compression: Acta Radiologica. 1990; 31:187-190.
13. Livingston KE, Perrin RG. The Neurosurgical management of spinal metastases causing cord and cauda equine compression: J. Neurosurg. 1978; 49: 590- 594.
14. Dorsi MJ, Belzberg AJ. Paraspinalnerve Shealth tumors: Neurosurg Clin NAm. 2004; 15: 217-222.
15. Matsumoto S, Hasuo K, Uchino A, Mizushima A, Kawa TF, Matsuura Y, etal. MRI of Intradural Extramedullary Spinal neurinomas and meningiomas: Clinical Imaging. 1993; 17:46-52
16. Gezen F, Kahraman S, Canakci Z, Beduk A Review of 36 cases of Spinalcord Meningioma: Spine. 2000; 25: 727-731.
17. Souweidane MM, Benjamin V. Spinal Cord Meningiomas: Neurosurgery Clinics of North America. 1994; 5: 283-291.
18. Nabors MW et al. Updated assessment and current classification of spinalmeningeal cysts. J Neurosurg. 1988; 68: 366–377.
19. Rohrer DC, Burchiel KJ, Gruber DP. Intraspinal extradural meningeal cyst demonstrating ball-valve mechanism of formation. J Neurosurg. 1993; 78: 122–125
20. Numaguchi Y, Rigamonti D, Rothman MI. Spinal epidural abscess. Evaluation with Gd enhanced MR Imaging: Radiographics. 1993; 13:545.
21. Roos DEA, Persijn V, Meerten EL, Bloem JI. MRI of Tubercular spondylitis: AJR. 1986; 146: 79-82.