

Role of MRI in the Evaluation of Compressive Myelopathy: Assessment of the Degree of Spinal Cord Compression and Its Clinical Correlation

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ABSTRACT

Background: Compressive myelopathy refers to spinal cord compression from intrinsic or extrinsic causes and is a major contributor to quadriplegia and disability. MRI is the preferred modality for definitive evaluation. **Objective:** To identify causes of compressive myelopathy, assess MRI findings (degree of compression, stenosis grades, compression ratio, signal changes), and correlate them with clinical severity using the Modified Japanese Orthopaedic Association (mJOA) score. **Methods:** Clinically suspected cases underwent MRI after clinical history and mJOA grading. Patients with MRI contraindications were excluded. **Results:** Degenerative disc disease was the most common cause, followed by trauma. Elderly males formed the majority (60%). A negative correlation was observed between mJOA scores and MRI findings ($r = -0.03846$ for stenosis, -0.21678 for compression), indicating that higher mJOA scores reflect milder disease and better prognosis. **Conclusion:** MRI accurately identifies the cause and extent of compressive myelopathy. The mJOA score correlates well with MRI findings and can aid in clinical diagnosis and management.

Keywords: MRI, Compressive Myelopathy, mJOA Score, Metastasis

INTRODUCTION

Spinal cord compression due to various causes which can be from the intrinsic cord compression or from the outside is defined as Compressive Myelopathy. Various aetiologies like trauma, haemorrhage, neoplasm, abscess etc can lead to cord compression and comes under compressive myelopathy.¹

Spinal cord compression is the major cause of quadriplegia and disability. Plain radiographs have a low sensitivity for identification of spinal cord lesions although dynamic views, flexion and extension have been shown to demonstrate unstable spinal cord lesions, successful evaluation requires an adequate range of motion, which can be limited in the acute setting. Therefore, patients presenting with clinical suspicion of compressive myelopathy should undergo MR for a more definitive evaluation of the spine. MRI is the modality of choice in assessment of vertebral column, especially in the evaluation of spinal cord, intervertebral discs and ligaments.²

In case of spinal cord trauma, MRI demonstrates the relationship of fractured vertebral bodies to the cord and help to highlight the degree of compression. The signal abnormalities within the cord can be identified, helping to localize and define the degree of trauma.

MRI is considered the procedure of choice for the work-up of all suspected spinal tumours which may be easily categorized as extradural & intradural (extramedullary, or intramedullary) in location.

Role of MRI: MRI can help detect and exclude compressive causes distinctly.⁵ Other causes of myelopathy which are due to various aetiologies like primarily vascular, inflammatory and infectious aetiologies are then be ruled out and come under intrinsic cord pathologies.³ MRI is used for non-invasive detailed anatomic evaluation of the spine without radiation exposure and is considered the imaging modality of choice for detection of an objective cause of radicular symptoms versus normal age-related changes.

MRI helps in detection of the type and extent of spinal cord injury, which affects patient management. MRI is used for exclusion of spinal cord lesions, ligamentous or other soft tissue injuries. MRI is the most appropriate imaging modality for spine, however CT/CT myelograms should be reserved for patients with contraindications for MRI.³

Application of different pulse sequences allows for image acquisition to exploit tissue composition for example: T1-weighted sequences provide optimal contrast between bright epidural fat and the internal components of the spinal canal & T2 weighted images have greater contrast differentiation compared to T1-weighted images.⁴

MRI can detect compression due to neoplasm and can serve as excellent method for imaging tumour involving spinal canal. MRI has the most impact in detecting posterior column involvement, suspected neoplasms with subtle symptoms and is considered as procedure of choice for all spinal tumours, early screening and workup.⁴

Spinal tumours often are categorized as intramedullary, intradural extramedullary and extradural in location from inside out. The first step in evaluation of any spinal mass whether neoplastic or inflammatory is to determine the compartment of origin. Though this classification system is used widely, certain setbacks (like neurofibromatosis) can occur simultaneously in two compartments and can also present as multiple lesions simultaneously in different compartments.

Note that epidural is extradural in location. Bone tumours can commonly occur in extradural space, however tumours like haemangioma and hemangioblastoma tend to occur superficially. Intramedullary metastasis is rare compared to primary intramedullary tumors.⁵

Intradural extramedullary lesions are located within the dura but outside the spinal cord, and can project into the subarachnoid space involving the nerve roots and impinging upon the meninges and can show compression of the spinal cord which can be identified by CSF cleft between the lesion and the cord.⁵

Neuromas and schwannomas which are nerve sheath tumours and meningiomas comprise of 90% of these tumours. Most common tumour in the cauda equina region is the myxopapillary ependymoma. Leptomeningeal metastases and spinal paragangliomas are less common as compared to meningiomas. However certain increase in the leptomeningeal metastasis is either due to increased diagnosis, increased incidence & certain ancillary complications.⁵ Finally intramedullary lesions are those which are located within the substance of cord deep to the pia matter and are the most common site for primary tumours. Most common sign for intramedullary lesions is that the neoplasms expand the spinal cord whereas non-neoplastic inflammatory lesions are more commonly shows non expansile signal changes.

Astrocytoma and ependymoma together constitute 90% of intramedullary tumors.⁵

Most of the spinal cord diseases are amenable if detected at early stage. The efficient and early use of diagnostic procedures, guided by a proper understanding of the anatomy and the clinical features of common spinal cord diseases correlating with the clinical examination findings, is required for a successful diagnosis.

NORMAL MRI ANATOMY

The spinal cord is a structure exhibiting intermediate signal intensity surrounded by an area of low signal intensity emanating from the CSF, thecal sac, posterior longitudinal ligaments and vertebral cortical bone. The conus medullaris is seen near the thoracolumbar junction at L1-L2 level along the posterior aspect of the thecal sac in the supine position. However, below the conus medullaris the filum terminale and nerve fibres are not clearly identified on MRI.⁶

Normally the anterior mass of the Atlas shows high signal intensity area with the low signal intensity cortical rim due to compact trabecular pattern on T2 weighted images. In contrast the odontoid process and dens shows low to intermediate signal intensity, less than that of the body on T2W images. Rest of the vertebral bodies, shows intermediate to high signal intensity and appears bright, surrounded by the very low signal intensities of compact cortical bone on T2W images. The anterior and posterior longitudinal ligaments are seen as areas of decreased signal intensity vertically & cannot be separated from the adjoining vertebral bodies.⁶ The intervertebral disc is composed of Central nucleus pulposus and peripheral annulus fibrosus, thereby showing high signal intensity in the centre and low signal intensity circumferentially in the periphery on T2W images. The signal intensity of the central nucleus pulposus is increased on fat saturation sequences like STIR which can also shows increased sharpness of the anterior aspect of annulus fibrosus and can clearly shows annular tears.⁶

The pedicles and neural foramina are visualized on sagittal images. The exiting nerve roots are visualised as bulk of nerve roots and patent neural foramina, individual nerve roots are seldom identified. Posterior arch elements, thecal sac, neural foramina, lateral recesses, traversing nerve roots, spinal cord are best to be seen on axial images. Extradural fat pad is most commonly seen in the lower thoracic or lumbar region between ligamentum flavum and thecal sac however it is absent in the cervical region. Epidural fat pad being brighter than the spinal cord it is always smaller in size than the cord.⁷ The coronal images are best for noting the curvature of the spinal cord, any levoscoliosis or dextroscoliosis, however evaluation of the spinal cord in coronal images is difficult and is not done in a single image plane. For good quality images in the sagittal plane the patient should be positioned parallel to the long axis of Z coil.⁷

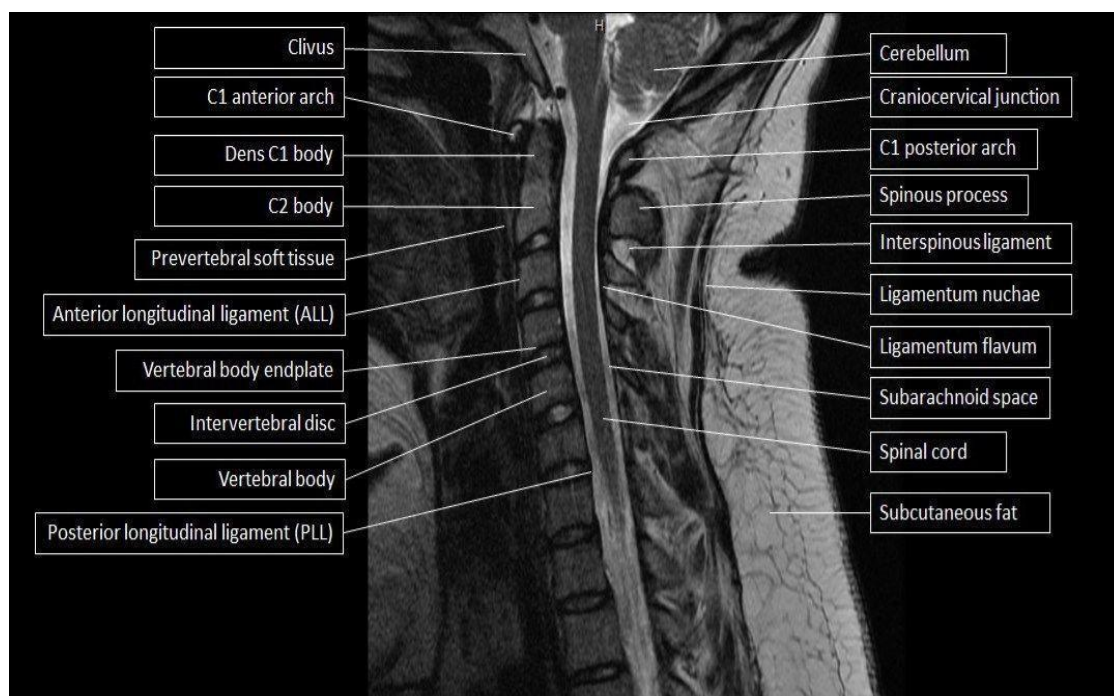


Image from Learning neurology

Normal imaging anatomy on Sagittal T2 weighted images of cervical spine on MRI

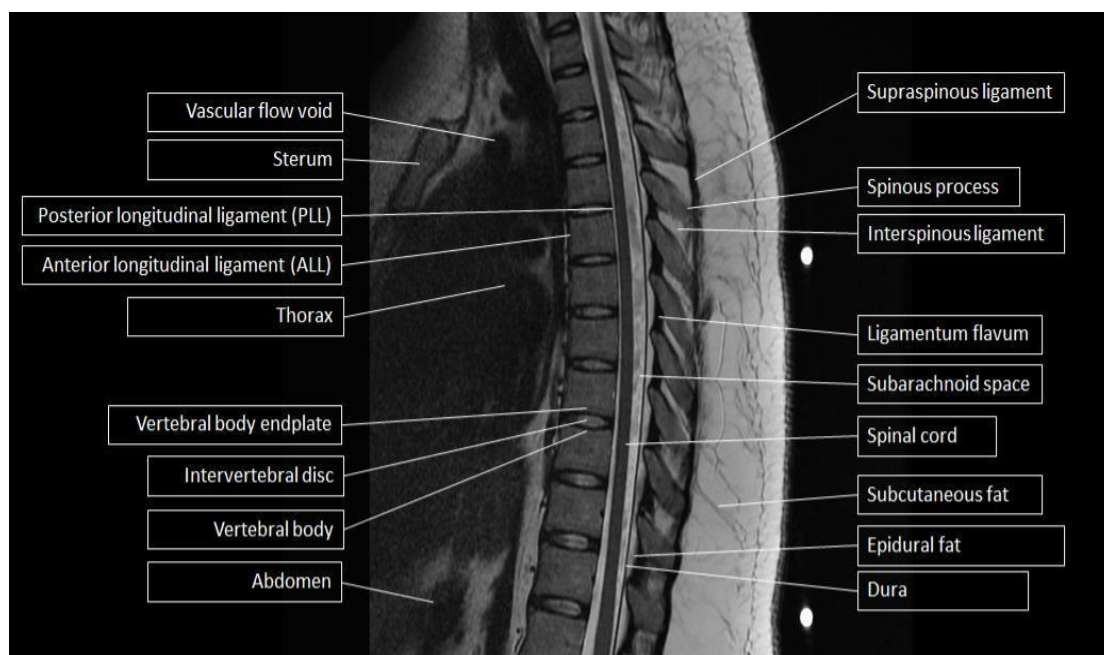


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Normal imaging anatomy on Sagittal T2 weighted images of dorsal spine on MRI

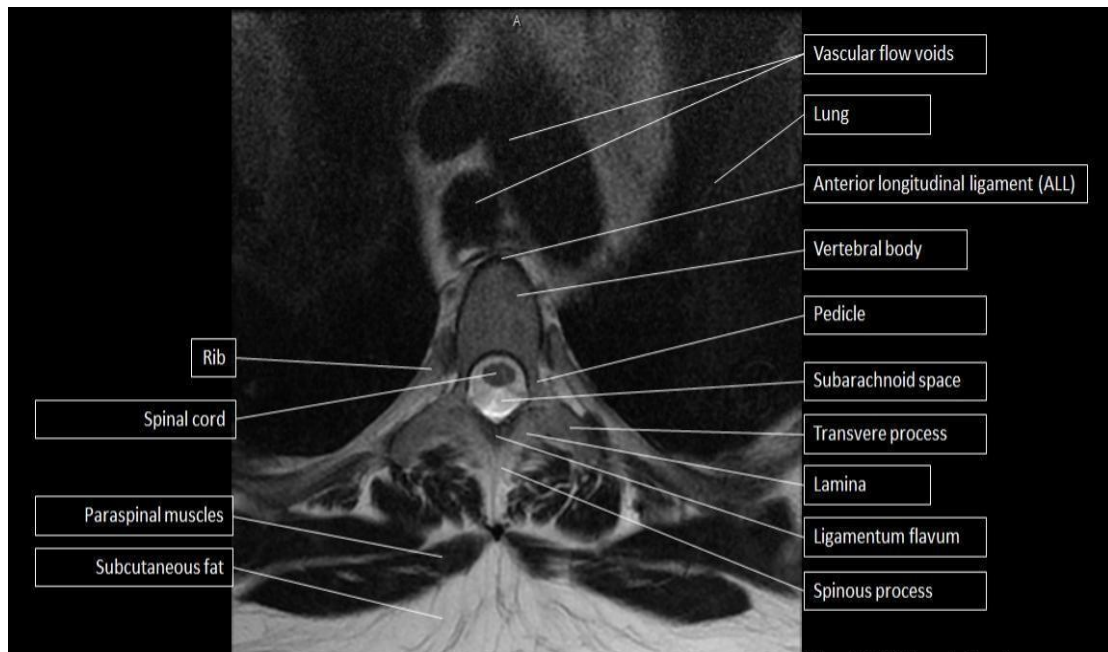


Image from Learning neurology
Normal imaging anatomy on Axial T2 weighted images of dorsal spine on MRI

Causes of compressive Myelopathy are classified as

1. Spinal Neoplasms:

A. Extradural Neoplasms:

- i. Benign tumours and cysts and tumour like masses
 1. Osteochondroma
 2. Aneurysmal Bone cysts
 3. Angiolipoma
 4. Neurofibroma
 5. Epidural Lipomatosis
 6. Vertebral body tumours
 - Haemangioma
 - Giant cell tumour
 - Osteoclastoma
 - Osteoblastoma
 7. Synovial cysts
- ii. Malignant tumours
 1. Lymphoma
 2. Metastases
 3. Sarcoma
 4. Myeloma
 5. Chordoma

B. Intradural / Extradural Neoplasms, Cysts and tumour like masses

- i. Meningioma
- ii. Schwannoma
- iii. Ganglioneuroma
- iv. Neurofibroma
- v. Paraganglioma
- vi. Dermoid / Epidermoid
- vii. Arachnoid cyst
- viii. Lipoma
- ix. Metastases

x. Ependymoma.

C. Intramedullary Tumours, Cysts and Tumour like masses

- i. Ependymoma
- ii. Astrocytoma
- iii. Hemangioblastoma
- iv. Glioblastoma
- v. Metastases
- vi. Hydro syringomyelia
- vii. Developmental tumours

1. Epidural abscess
2. Cervical Spondylosis
3. Epidural haemorrhage
4. Herniated discs
5. Post – traumatic compression by fractured / displaced vertebra or haematoma.

Spinal Cord tumours and tumour like Masses

These are traditionally classified by location into three categories.

- Extradural lesions (lesions of osseous spine, epidural space, and paraspinal soft tissues). Intradural extradural lesions (lesions that are inside the dura but outside the medullary cavity of the spinal cord).
- Intramedullary lesions (spinal cord tumours and cysts).

Extradural Tumours, Cysts and Tumour like masses

Extradural mass lesion because of its origin from the extradural space can cause focal displacement of the thecal sac and can show draping over the spinal cord without actual involvement or invasion of the

intramedullary spinal contents. This can be clearly seen on the MRI spine scans. Displaced epidural fat can be seen by the extradural mass lesion forming a Crescent shape area. In some cases, a crescent of displaced epidural fat can be seen capping the lesion.

Duffau H et al (2000) reported that as for the pattern of contrast enhancement, neurinomas tend to exhibit ring-like enhancement.

Gezen F et al (2000) mentioned that after Neurofibromas, meningiomas are the second most common intradural spinal tumour, accounting for one fourth of all primary spinal tumours. Intradural Intramedullary (1%) and Intradural Extradural in 83%. Meningiomas appear isointense to cord on T1 and T2WI with intense homogeneous post contrast enhancement.

Atlas SW et al (2002) found that hematologic dissemination occurs in skeletal tuberculosis.

Osborn AG et al (2003) classified Spinal Cord tumours and tumour like Masses by location into three categories. The most common benign extradural masses are degenerative and traumatic lesions such as disc herniations, osteophytes and fractures.²³

Spinal leptomeningeal metastases and non-Hodgkin lymphoma are the most common malignant extradural intradural tumours. It can spread from ependymoma and medulloblastoma and is typically seen in children. Epidermoid Cyst is uncommon intraspinal tumours in children. Lumbar spine is the most common site. It has variable imaging appears but mainly resemble fat.

Dorsi MJ et al (2004) reported that approximately one third of the intraspinal tumours are Schwannomas and neurofibromas. In this study 50 cases of pure intramedullary Schwannomas have been reported. Dumbbell tumours accounts for 6% to 14% of spinal neoplasms.

Cavaliere R et al (2004) stated that immediate attention should be given to Epidural spinal cord compression as it is a neurologic emergency. The most important aspect of treatment is the establishment of the diagnosis. Emergency MRI scan can be done in cases of severe cord compression. Post-myelography computed tomography can be done as an alternative.

Ahmed N et al (2004) reported that Neoplastic cord compression, infective spondylitis and non-compressive myelopathies were the main causes of paraparesis while spondylotic myelopathy was the main cause of tetra paresis resulting in more occurrence of Paraparesis in comparison to tetra paresis. Non-traumatic paraparesis or tetra paresis can be subcategorized into spondylosis, infective or neoplastic cord compression and non-compressive myelopathies.

Duhem-Tonnelle V et al (2005) stated that spinal cord compression can be caused by neuroblastic tumours either by arising primarily in the spinal canal or invading through the radicular foramen.

Neuroblastomas being common are generally treated with chemotherapy, while mature neuroblastic tumours (MNT), which include intermixed ganglioneuroblastomas (iGNB) and ganglioneuromas (GN), are less common and are treated surgically.

Mut M et al (2005) reported that Prostate, breast and lung cancer are the most common cause of Spinal cord epidural metastasis. Metastasis is more common in posterior aspect of vertebral body with invasion of epidural space in later stages. Vascular insufficiency is more important than spinal cord compression. The most common complaint is pain with two thirds of patients have motor signs at initial diagnosis. Currently MRI is the most sensitive diagnostic tool.

Greiner Perth R et al (2007) reported that hyperintense signal on both T1 and T2 sequences suggest the possibility of subdural hematoma although it can be mistaken for tumour like cystic lesion of the cord. Rapid surgical drainage of the subdural hematoma shows best prognosis especially in the cervical, thoracic, and thoraco-lumbar junctions of the spinal cord.

Kawasaki M et al (2007) has divided spondylolisthesis into mild, moderate and severe based upon the distance of displacement >3.5 mm as severe, 2.0-3.4 mm moderate, and 2 mm displacement as mild spondylolisthesis group. Anterolisthesis is more common in patients with severe spondylolisthesis. Degenerative spondylolisthesis at C3/4 or C4/5 and greater cervical mobility are seen more commonly in patients with severe spondylolisthesis. The anterolisthesis group had a significantly wider spinal canal than retrolisthesis group. Severe cord compression seen on T1-weighted images and high-intensity spinal cord signals seen on T2-weighted images corresponded to cord oedema.

Venkitaraman R et al (2007) reported cord compression due to skeletal metastasis from prostate cancer. The prognosis depends on early detection of Spinal Cord Compression is essential as the neurological status before treatment. The aim of this study is to determine the role of magnetic resonance imaging of the spine in detecting SCC or occult SCC in patients with metastatic prostate cancer with no functional neurological deficit (FND).

Gupta V et al (2007) reported that in cases of craniovertebral junction anomalies dynamic MRI is best to detect spinal cord compression, narrowing, any cord compression or any signal abnormality. It is extremely useful in detecting the cord abnormalities and also helps in early detection and to decide for decompression and surgery.

Cho YE et al (2011) found that intramedullary SI change is a poor prognostic factor and the intramedullary contrast (Gd-DTPA) enhancement on preoperative MRI should be viewed as the worst predictor of surgical outcomes in cervical myelopathy. Contrast (Gd-DTPA) enhancement and postoperative

MRI are useful for identifying the prognosis of patients with poor neurological recovery.

Horovitz DD et al (2011) reported that Spinal cord compression (SCC) is a known complication of mucopolysaccharidosis type VI (MPS VI) secondary to atlantoaxial subluxation, craniovertebral stenosis, posterior longitudinal ligament hypertrophy, or Dural thickening. SCC is expected to occur in the natural history of the disease,

regardless of enzyme replacement therapy (ERT), as intravenous enzyme does not cross the blood-brain barrier. We describe six MPS VI children with SCC, all diagnosed before 7 years of age. Within this group, four of the children were diagnosed with SCC after the introduction of ERT. We hypothesize that these patients may illustrate the previously undetected risk of increased joint mobility caused by ERT which may have contributed to increased cervical instability by loosening the 26 neck joint, thus leading to or unmasking SCC. We reinforce the need for close follow-up of SCC, periodic neurological assessment, spine imaging, and neurophysiology in all MPS VI patients before and during ERT. Neurophysiological abnormalities may precede changes in MRI images (as shown in patients 4 and 5 from this sample) and should, therefore, be accessed in MPS VI patient evaluations, allowing for timely intervention and better prognosis.

Toledano M et al (2013) reported that the differential of cervical spondylosis myelopathy (CSM) is broad and includes multiple conditions that can cause and mimic myelopathy. In adults older than 55 years of age, CSM is the most common cause of myelopathy. This article summarizes the pathophysiology, clinical presentation, differential diagnosis, diagnostic evaluation, and natural history of CSM.

Hrabálek L et al (2014) reported that Functional MRI of the brain revealed significant activation especially in primary and secondary motor cortex and sensory areas in patients with CSM. After surgical decompression of the spinal cord, cortical activations and maximum Z-score decreased in the majority of areas. We proved decreased cortical activation on functional MRI of the brain after surgery in patients with CSM (evaluated according to MRI of cervical spine), even at an initial stage of the disease.

Kato S et al (2015) reported that The Japanese Orthopaedic Association (JOA) score is widely used to assess the severity of clinical symptoms in patients with cervical compressive myelopathy, particularly in East Asian countries. In contrast, modified versions of the JOA score are currently accepted as the standard tool for assessment in Western countries. The JOA score and the mJOA score showed good correlation with each other in terms of their total scores and recovery rates.²⁷ Fehlings MG et al (2017)⁶⁶ reported that magnetic resonance imaging is helpful in clinical decision making and outcome prediction; and the type

& timing of rehabilitation in patients with Spinal cord injury.

Heary RF et al (2018) reported that Cervical myelopathy occurs as a result of compression of the cervical spinal cord. Symptomatology includes, but is not limited to, pain, weakness, paraesthesias, or gait/balance difficulties. Surgical decompression, if necessary, may be achieved from an anterior, posterior, or a combined anteriorposterior (AP) approach. Several aetiologies may lead to cord compression and cervical myelopathy. The best vector of approach with regard to anterior versus posterior surgical intervention is still under investigation. Regardless, management via surgical decompression has been demonstrated repeatedly to improve the Compressive myelopathy patient's quality of life

MATERIALS AND METHODS

Study Design and Setting

A descriptive study conducted in the Department of Radiodiagnosis, RIMT Medical College and Hospital, Mandi Gobindgarh, Punjab.

The study was conducted over a period of 18 months, from July 2020 to December 2021.

Sample and Case Selection

A total of 40 clinically suspected cases of compressive myelopathy, referred for MRI from OPD/IPD, were included using purposive sampling. Detailed clinical history with emphasis on motor and sensory symptoms was taken, and mJOA grading was done prior to imaging.

Inclusion Criteria

- All clinically suspected cases of compressive myelopathy referred for MRI. Patients of all age groups and both sexes.

Exclusion Criteria

- Patients with general contraindications to MRI.
- Cases of non-compressive myelopathy.

Patient Preparation

Informed consent was obtained. Contraindications for MRI were ruled out. Patients were provided with headphones to reduce acoustic noise during the scan.

Imaging Protocol

MRI scans were performed using a Philips 1.5 Tesla Achieva system with standard surface and body coils. Patients were scanned in a supine position with appropriate immobilization. The following sequences were used:

Pre-contrast: SE T1WI, FSE T1WI, T2WI, GRE T2*, FLAIR, STIR (sagittal and axial planes)

Post-contrast: (where indicated): T1WI (sagittal, axial, coronal) Contrast agent: Gadodiamide (Omniscan) at 0.1 mmol/kg body weight (used for

suspected neoplastic and infectious lesions; not used in trauma).

Technical Parameters

Field of View (FOV): Sagittal 30 cm, Axial 18 cm
Matrix size: 256 × 256 Slice thickness: 4.5 mm with 5 mm spacing
TR/TE/Flip angle: As per sequence (e.g., TR 500–8500 ms, TE 14–120 ms, Flip angle 30°–90°)

Image Analysis

MRI findings were evaluated for: Location (cervical, thoracic, lumbar) Spinal cord segment involved Severity and pattern of injury In trauma: site/level of injury, vertebral fracture, ligamentous injury, presence/type of hematoma In neoplasms: location (extradural/intradural), type (benign/malignant) based on imaging features.

RESULTS

This descriptive study was conducted over 18 months at Maharishi Markandeshwar Medical College, involving 40 patients with clinically suspected compressive myelopathy. Males comprised 60% of the sample.
A total of 40 patients with clinically suspected compressive myelopathy were evaluated. The most common etiology was degenerative disc disease and vertebral defects (66%), followed by trauma (10%), metastasis (7%), and infection including tuberculosis (5%). Less frequent causes included epidural soft

tissue compression and intrinsic cord pathology (5% each), and epidural hematoma (2%).
The cervical spine was the most frequently involved region (51%), followed by the thoracic spine (44%), with predominant involvement of the lower thoracic region (32%). Thoracolumbar involvement was seen in 5%. Multilevel involvement was present in 70% of cases.
There was a male predominance (60% males, 40% females). Severe spinal cord compression or cord atrophy was observed in 50% of patients, while mild compression was seen in 28% and minimal compression in 17%. No thecal sac compression was noted in 5%, attributed to intrinsic cord abnormalities. Grade 3 spinal canal stenosis with T2 hyperintensity was present in 50% of patients, followed by Grade 2 (28%) and Grade 1 (17%) stenosis. Cord signal changes were predominantly T1 hypointense and T2/STIR hyperintense, consistent with cord oedema. Fractures were present in 63% of cases, including 40% stable and 23% unstable fractures. Epidural soft tissue involvement was seen in 60%, and pre/paravertebral soft tissue involvement in 62% of patients.
Based on the modified Japanese Orthopaedic Association (mJOA) score, 55% of patients had moderate neurological impairment (6–11), 22% had severe impairment (0–5), and 23% had mild impairment (12–18). Lower mJOA scores correlated with higher grades of spinal canal stenosis and greater degrees of spinal cord compression.

Clinical and Radiological Analysis of Compressive Myelopathy (n=40)

1. Causes and Demographic Distribution of Compressive Myelopathy

Table 1: Causes of compressive myelopathy

MR Diagnosis	Number of Patients (n=40)	Percentage (%)
Vertebral defects / disc bulge	27	66%
Traumatic myelopathy	4	10%
Metastasis	3	7%
Infection / Tuberculosis	2	5%
Compression by epidural soft tissue	2	5%
Myelopathy due to intrinsic cord changes	2	5%
Epidural hematoma	1	2%

**Note: One case in the sample presented with dual pathology simultaneously (Epidural hematoma and disc bulge).*
As demonstrated, the most common etiology for compressive myelopathy in our study cohort is vertebral defects and disc bulges (66%), followed by traumatic myelopathy (10%), spinal metastasis (7%), and infection/TB (5%).

Table 4: Sex Distribution

Sex	Number of Patients (n=40)	Percentage (%)
Male	24	60%
Female	16	40%
Total	40	100%

Male patients comprised 60% of the study group compared to 40% female patients. This male predominance is predominantly attributed to the higher incidence of trauma-related spinal injuries among males.

2. Anatomical Level and Multiplicity of Spinal Lesions

Table 2: Level of Spinal Injury

Level of Lesion	Number of Patients (n=40)	Percentage (%)
Cervical (C)	22	51%
Thoracic (T) - Total	19	44%
• Upper Thoracic (UT)	5	12%
• Lower Thoracic (LT)	14	32%
Thoraco-Lumbar (TL)	2	5%

The cervical spine was the most frequent site of involvement (51%), followed by the lower thoracic region (32%). The increased vulnerability of the cervical spine is linked to its higher mobility and lack of rigid rib cage support.

Table 3: Multiplicity of Lesions

Multiplicity Status	Number of Patients	Percentage (%)
Multiplicity Present	28	70%
Multiplicity Absent	12	30%
Total	40	100%

Multilevel vertebral involvement was observed in 70% of cases (28 patients), particularly in conditions such as degenerative disc disease, spinal metastasis, tuberculosis, and traumatic myelopathy.

3. Severity of Cord Compression and Canal Stenosis

Table 5: Degree of Spinal Cord Compression

Degree Level	Description	Number of Patients	%
Grade 0	No thecal sac compression	2	5%
Grade 1	Minimal subarachnoid space compression	7	17%
Grade 2	Mild spinal cord compression	11	28%
Grade 3	Severe compression or cord atrophy	20	50%
Total		40	100%

Exactly 50% of the cohort exhibited severe cord compression or cord atrophy (Grade 3). Interestingly, 2 patients with clinical features of compressive myelopathy showed no physical thecal sac compression, later confirmed as intrinsic cord conditions (e.g., transverse myelitis).

Table 6: Grades of Spinal Canal Stenosis

Grade	Diagnostic Criteria	MRI	Number of Patients	%
Grade 0	Normal canal / No stenosis		3	7%
Grade 1	Obliteration of >50% subarachnoid space w/o cord deformity		5	13%
Grade 2	Central canal stenosis with spinal cord deformity (no T2 signal change)		12	30%
Grade 3	Increased signal intensity (SI) of spinal cord near compressed level on T2WI		20	50%
Total			40	100%

4. MRI Signal Characteristics and Associated Structural Findings

Signal alterations in the spinal cord were systematically evaluated across standard sequence modalities (T1WI, T2WI, and STIR). Approximately 37 patients (92.5%) exhibited T1-hypointense and T2/STIR-hyperintense signal alterations, representing cord edema or myelomalacia.

Associated Traumatic, Soft Tissue, and Paravertebral Features

Fracture Classification: Vertebral fractures were identified in 63% of patients (40% stable, 23% unstable based on Denis three-column criteria).

Epidural Soft Tissue: Present in 60% of cases causing direct compressive effect.

Intrinsic Cord Signal Changes: Observed in 82% of patients.

Pre/Paravertebral Extension: Soft tissue extension (edema, abscess, or collection) was present in 62% of patients (25 cases).

5. Clinical Assessment (mJOA Score) and Radiological Correlation

Table 7: Modified Japanese Orthopaedic Association (mJOA) Scoring System

Category / Subscore	Score	Clinical Description
Upper Extremity Motor Subscore (/5)	0 1 2 3 4 5	Unable to move hands Unable to eat with spoon but can move hands Unable to button shirt but can eat with spoon Able to button shirt with great difficulty Able to button shirt with mild difficulty / fine motor dysfunction Normal hand coordination
Lower Extremity Subscore (/7)	0 1 2	Complete loss of movement and sensation Complete loss of movement,

Category / Subscore	Score	Clinical Description
	3 4 5 6 7	some sensation present Inability to walk but some movement Able to walk on flat ground with walking aid Able to walk without aid, but must hold handrail on stairs Moderate to severe walking imbalance but can perform stairs w/o rail Mild imbalance when standing or walking Normal walking
Upper Extremity Sensory Subscore (/3)	0 1 2 3	Complete loss of hand sensation Severe loss of hand sensation OR pain Mild loss of hand sensation Normal hand sensation
Urinary Function Subscore (/3)	0 1 2 3	Inability to urinate voluntarily (requires catheterization) Frequent urinary incontinence (>1/month) Urinary urgency OR occasional stress incontinence (<1/month) Normal urinary function

Clinical severity assessed via mJOA demonstrated that 55% of patients had moderate dysfunction (score 6–11), 23% had severe symptoms (score 0–5), and 22% presented with mild impairment (score 12–18).

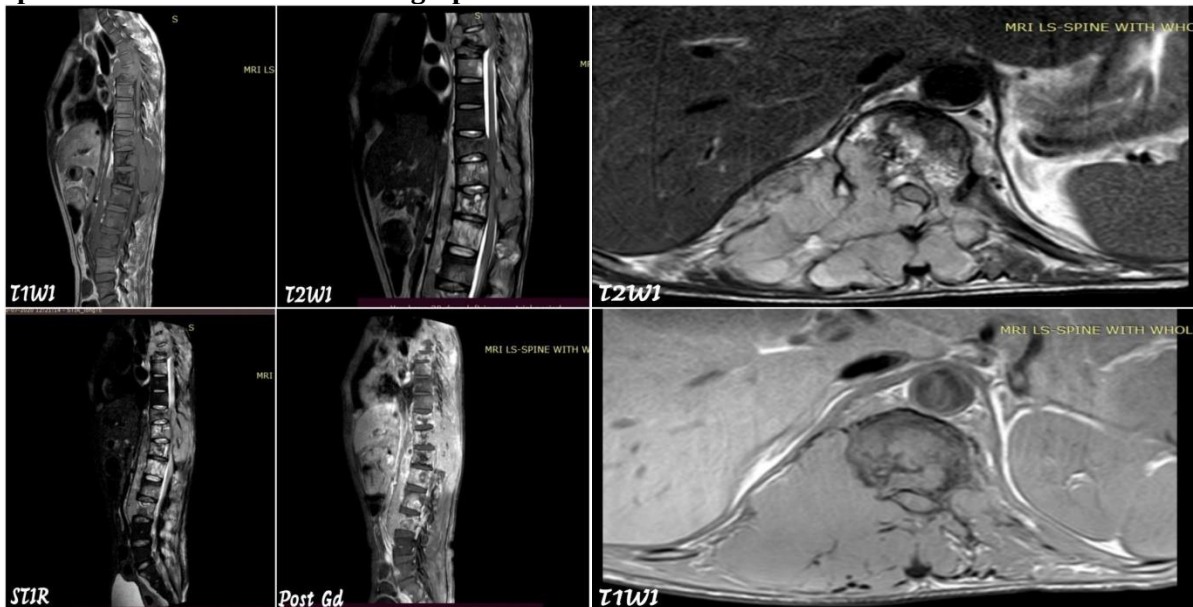
6. Illustrative Clinical Case Studies

Case 1: Transverse Myelitis with Spinal Cord Atrophy



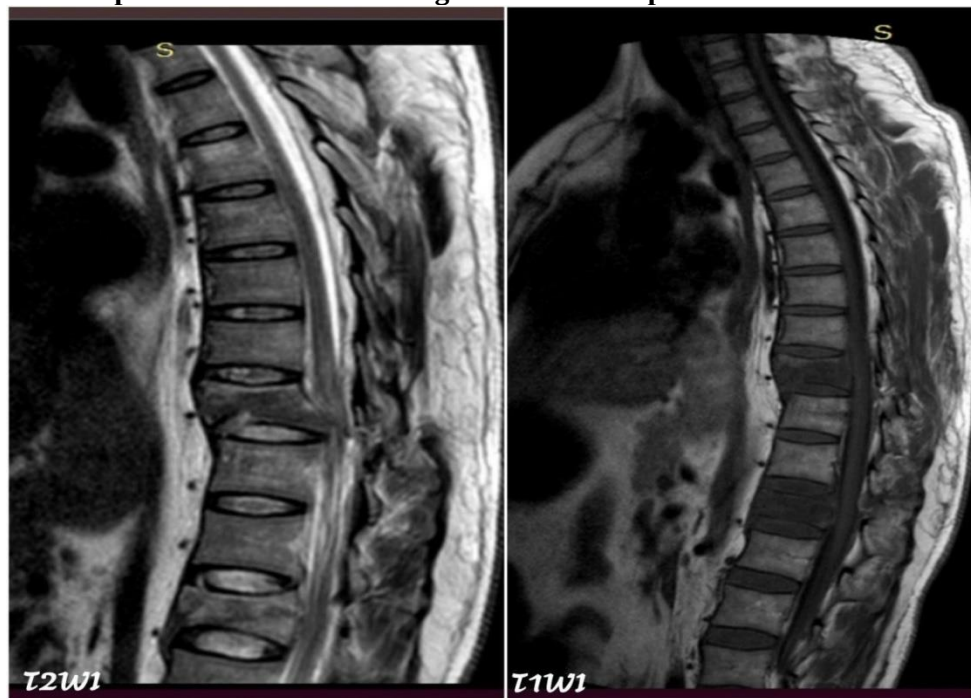
Detailed Analysis: A patient presenting with clinical signs of compressive myelopathy without external thecal sac compression [cite: 2]. MRI demonstrates intrinsic spinal cord signal alterations on sagittal T2WI and STIR sequences, with corresponding 3D Myelography depicting localized cervical spinal cord atrophy [cite: 2].

Case 2: Spinal Metastasis with Enhancing Epidural Soft Tissue Mass



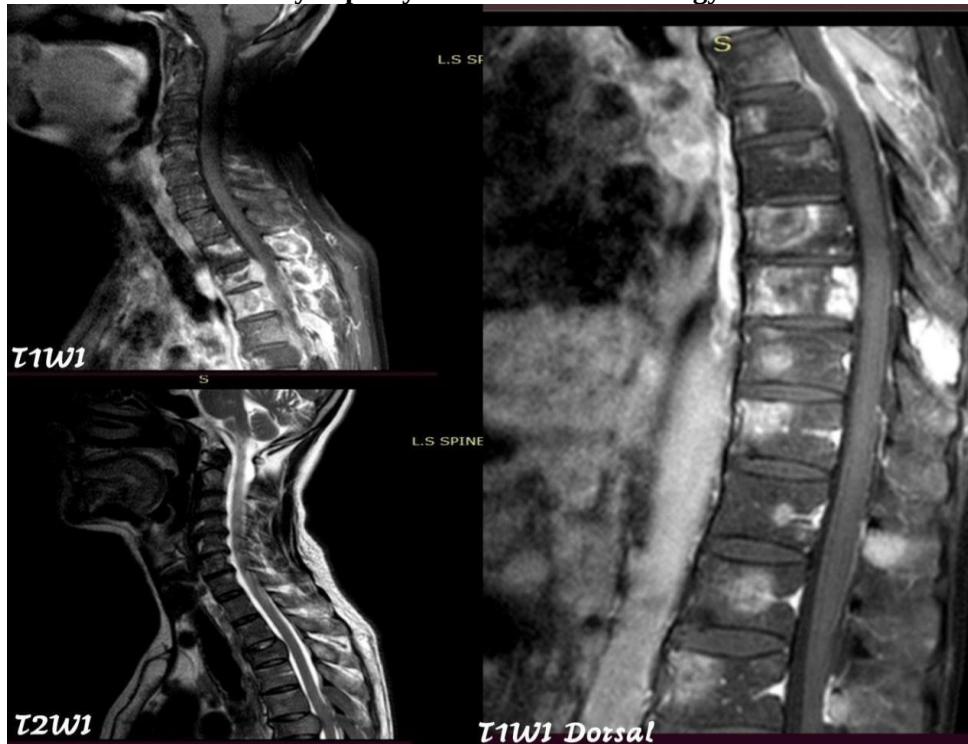
Detailed Analysis (Sagittal & Axial Evaluation): Sagittal T1WI, T2WI, STIR, and Post-contrast T1WI along with axial T1WI and T2WI demonstrate diffuse pathological vertebral body marrow involvement with a prominent soft tissue mass extending into the epidural space, causing significant anterior and posterior thecal sac compression and spinal cord deformity [cite: 2].

Case 3: Acute Burst Compression Fracture with Ligamentous Disruption



Detailed Analysis: Sagittal T2WI and T1WI views showing an acute traumatic burst fracture of the mid-thoracic vertebral body with posterior element retropulsion into the spinal canal, disruption of the posterior ligamentous complex, and focal severe spinal cord compression [cite: 2].

Case 4: Spondylosis of Cervical Cord Myelopathy with Infective Aetiology



Detailed Analysis: Sagittal T1WI, T2WI, and T1WI Dorsal sections revealing multi-level cervical spondylosis combined with extensive infective/inflammatory involvement of dorsal vertebral segments and adjacent soft tissues [cite: 2].

Case 5: Spondylosis of Cervical Cord Myelopathy with Severe Cord Compression & Atrophy



Detailed Analysis: Multi-segmental degenerative spondylotic changes on cervical T2WI and STIR sequences producing severe focal spinal cord narrowing, cord deformity, and localized myelomalacic/atrophic cord changes [cite: 2].

Case 6: Burst Compression Fracture with Bone Marrow Oedema of D11 Vertebral Body



Detailed Analysis: Sagittal T2WI and STIR MR images depicting an acute D11 burst compression fracture accompanied by extensive bone marrow edema (hyperintense on STIR) and posterior cortical retropulsion compressing the spinal cord [cite: 2].

Case 7: Osteophyte-Disc Complex Causing Moderate Spinal Canal Stenosis



Detailed Analysis: Mid-cervical degenerative disc disease with posterior osteophyte-disc complexes causing moderate central canal stenosis and early cord compression on sagittal T2WI and STIR sequences [cite: 2].

Case 8: Burst Compression Fracture of D12 Vertebral Body with Spinal Cord Compression & Oedema



Detailed Analysis: Traumatic burst fracture at the thoracolumbar junction (D12 level) with retropulsed bone fragments, severe local cord edema (high signal on STIR), and canal compromise [cite: 2].

Case 9: Congenital C7, D1 & D2 Vertebral Bodies Angulation



Detailed Analysis: Congenital segmentation/formation defects involving C7, D1, and D2 vertebral bodies leading to significant posterior angulation (kyphosis), secondary spinal canal narrowing, and compressive myelopathy [cite: 2].

Case 10: Soft Tissue Mass with Destruction of Posterior Arch Elements & Metastases



Detailed Analysis: Pre- and post-contrast T1WI sagittal views illustrating a large aggressive posterior soft tissue mass with extensive osseous erosion of the dorsal posterior arch elements, epidural extension causing cord compression, and associated bilateral pulmonary metastatic soft tissue nodules [cite: 2].

DISCUSSION

MRI is the preferred imaging modality for spinal pathologies due to its superior soft tissue resolution and lack of radiation. This study, involving 40 patients (mostly male, aged above 50), primarily included degenerative, infectious, and metastatic spinal conditions often due to falls and motor vehicle accidents. Cervical spine involvement was most common, followed by the thoracic region.

Compressive myelopathy was most frequently caused by disc bulges and trauma. Severe cord compression and associated signal changes, especially spinal cord oedema, were common. Multi-level involvement was seen in 70% of cases. Fractures were evaluated using the Denis classification, with 40% stable and 23% unstable. Posterior element involvement and intrinsic cord changes were frequent. Metastases were slightly more prevalent than infections like tuberculosis, attributed to improved TB management.

MRI findings were correlated with the modified Japanese Orthopaedic Association (mJOA) scoring system. Most patients (55%) had moderate scores (6–11), and lower scores correlated with more severe MRI findings. Statistical analysis showed a negative correlation between mJOA scores and both stenosis grade and cord compression, supporting MRI's diagnostic value.

Limitations included inter-observer variability in clinical scoring, small sample size, short study

duration, lack of follow-up, and absence of surgical or histopathological correlation.

STRENGTHS OF THE STUDY

The major strength of this study is the systematic evaluation of patients with clinically suspected compressive myelopathy using magnetic resonance imaging (MRI), with assessment of the underlying pathology, level of involvement, degree of spinal cord compression, spinal canal stenosis, and associated spinal cord signal abnormalities. The study also incorporates the modified Japanese Orthopaedic Association (mJOA) score, allowing clinical severity to be compared with MRI findings. The use of standardized MRI sequences and assessment of both degenerative and non-degenerative causes provides a comprehensive radiological evaluation of compressive myelopathy in the study population.

LIMITATIONS OF THE STUDY

This study has several limitations. First, the sample size was relatively small, with only 40 patients, which may limit the generalizability of the findings. Second, the study was conducted at a single institution and used purposive sampling, which may have introduced selection bias. Third, interobserver variability in the assessment of MRI findings and grading of spinal cord compression could not be completely excluded. Fourth, the study did not include long-term clinical or radiological follow-up to assess changes after

treatment. Fifth, surgical, histopathological, or other independent reference-standard correlation was not available for all cases. Finally, the study primarily evaluated the association between MRI findings and clinical severity and therefore does not establish a causal relationship or determine treatment outcomes.

FUTURE SCOPE

Future studies should include larger, multicentric patient populations with prospective study designs to improve the generalizability of the findings. Further research should evaluate the reproducibility of MRI grading systems using multiple independent radiologists and standardized quantitative measurements of spinal cord compression. Correlation of MRI findings with surgical, histopathological, and long-term clinical outcomes may further establish the prognostic value of MRI. Advanced MRI techniques, including diffusion tensor imaging, magnetization transfer imaging, and quantitative assessment of spinal cord signal changes, may also be explored for earlier detection of cord injury and improved prediction of neurological recovery.

CONCLUSION

MRI is a highly accurate, sensitive, and radiation-free modality for evaluating spinal and spinal cord abnormalities, including oedema, contusions, ligament integrity, disc herniation, tumors, and infections. It remains the only direct imaging tool for the spinal cord. This study demonstrates that the modified Japanese Orthopaedic Association (mJOA) score correlates well with MRI findings, higher mJOA scores indicate milder symptoms, fewer MRI abnormalities, and a better prognosis.

DECLARATIONS

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee of Maharishi Markandeshwar Medical College and Hospital Kumarhatti Solan before commencement of the study (Approval No.: MMMCH/IEC/20/313). Written informed consent was obtained from all participants prior to their inclusion in the study.

Consent for Publication

Written informed consent was obtained from the participants for publication of the study findings and any accompanying anonymized images, where applicable.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request, subject to institutional and ethical restrictions.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

Dr. Gaurav Singla: Study conception, methodology, data collection, MRI evaluation, data analysis, manuscript drafting, and final approval of the manuscript.

Dr. Neha Aggarwal: Literature review, data interpretation, manuscript review, and final approval of the manuscript.

Dr. Tanya Kathuria: Data collection, MRI assessment, literature review, manuscript review, and final approval of the manuscript.

All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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