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Role of Magnetic Resonance Imaging in Evaluation of Spinal Tuberculosis

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ABSTRACT

Introduction: To assess the diagnostic utility of Magnetic Resonance Imaging (MRI) in the evaluation of spinal tuberculosis and to determine its role in detecting disease extent, neural and paraspinal soft tissue involvement, and associated complications.
Materials and Methods: The study comprised of 50 patients referred to department of radio-diagnosis at tertiary care hospital in Ahmedabad, India between August 2024 to August 2025(12 months) with clinical suspicion of Pott's spine. Magnetic Resonance Imaging of the spine was performed.
Results: MRI effectively demonstrated early marrow edema, vertebral body destruction, and intervertebral disc involvement in patients with spinal tuberculosis. Characteristic findings included hypointense signals on T1-weighted images and hyperintense signals on T2-weighted and STIR sequences. Paravertebral and epidural abscesses, spinal canal compromise, and cord compression were accurately identified. MRI was superior to conventional radiography in detecting early disease and soft tissue involvement. MRI also enabled differentiation between active and healed disease based on signal characteristics and enhancement patterns.
Conclusion: MRI is a highly sensitive and specific imaging modality for the evaluation of spinal tuberculosis. It provides comprehensive information regarding disease activity, anatomical extent, and complications, making it indispensable in diagnosis, management planning, and follow-up of patients with Pott's spine.

Keywords*: Spinal tuberculosis, Tuberculous spondylitis, Pott's spine, Magnetic Resonance Imaging (MRI), Epidural extension, Paravertebral abscess, Vertebral body destruction, Disc involvement.*

INTRODUCTION

Spinal tuberculosis, also known as Pott's spine, is the most common manifestation of musculoskeletal tuberculosis and accounts for a significant proportion of extrapulmonary tuberculosis cases, particularly in developing countries. It remains a major cause of spinal deformity and neurological impairment if not diagnosed and treated at an early stage. The disease typically involves the vertebral bodies and intervertebral discs, with potential extension into paravertebral soft tissues and the epidural space, leading to spinal cord compression and neurological deficits.

Early diagnosis of spinal tuberculosis is often challenging due to its insidious onset and nonspecific clinical presentation. Conventional radiography may appear normal in the early stages of the disease, as radiographic changes become evident only after significant bone destruction has occurred. Computed tomography (CT) provides better delineation of osseous involvement but is limited in evaluating soft tissue extension, spinal cord involvement, and disease activity.

Magnetic Resonance Imaging (MRI) has emerged as the imaging modality of choice for the evaluation of spinal tuberculosis owing to its superior soft tissue contrast, multiplanar imaging capability, and high sensitivity in detecting early marrow changes. MRI enables accurate assessment of vertebral and disc involvement, paravertebral and epidural abscess

formation, spinal canal compromise, and neural compression. It also plays a crucial role in detecting skip lesions and posterior element involvement, which may be missed on conventional imaging.

In addition to its diagnostic role, MRI is valuable in differentiating spinal tuberculosis from other infective, inflammatory, and neoplastic conditions affecting the spine. Contrast-enhanced MRI further aids in evaluating disease activity, extent, and response to antitubercular therapy. Given these advantages, MRI is indispensable in the comprehensive evaluation, management planning, and follow-up of patients with spinal tuberculosis.

The present study aims to evaluate the role of MRI in the diagnosis and assessment of spinal tuberculosis, highlighting its significance in early detection, characterization of disease extent, and identification of complications from a radiodiagnostic perspective.

MATERIALS AND METHODS

1.Patient selection:

The study comprised of 50 patients referred to department of radiodiagnosis at a tertiary care hospital in Ahmedabad with clinical suspicion of Pott's spine over a period of 12 months. Patients with implanted electric and electronic devices, (heart pacemakers, especially older types), insulin pumps, implanted hearing aids, neurostimulators, intracranial metal clips, metallic bodies in eye, metallic hip replacements, sutures of foreign bodies were excluded from the study.

2.Image acquisition protocols:

Magnetic Resonance Imaging of Spine:

The patients were made to undergo a standard conventional contrast enhanced MRI spine on Siemens 1.5 T MRI using a spine / body coil with in plane spatial resolution 0.7 x 0.7 mm, field of view(FOV) 300-380 (sagittal/Coronal), 150—250 (axial), slice thickness (3 mm) with following protocols: T1-weighted fast spin echo (sagittal), T2-weighted fast spin echo(sagittal, axial), T2-weighted (fat-saturated- coronal, sagittal) sequences.

RESULTS:

1) SOCIODEMOGRAPHICS AND SYMPTOMATOLOGY:

- A total of 50 cases (Table 1) were included in the study in which the predominant age group involved was the 3rd decade (21-30 years) with a male to female ratio of 1.5:1.
- The mean age of our study population was 32.4 years, with a third of patients being infected in the third decade of life (21–30 years).
- Geriatric patients (age ≥65 years) accounted for 4 % of the study population.
- Most common clinical symptoms at presentation were back pain and axial pain at the site of involvement was almost universally present (95%); in comparison, constitutional symptoms such as fever (30%), weight loss (18%), and loss of appetite (16%) were present less frequently.

Table 1: Age Distribution of Patients with Spinal Tuberculosis (n = 50)

Age Group	Age-Range (Years)	Number of Patients(n)	Percentage (%)
Pediatric & Young adults	≤ 20	6	12%
Third decade	21-30	20	40%
Fourth decade	31-40	16	32%
Fifth & sixth decades	41-60	6	12%
Geriatric patients	>60	2	4%
Total	—	50	100%

Results (Age Distribution)

The study included 50 patients with spinal tuberculosis, with a mean age of 32.4 years. The most predominant age group was the third decade, accounting for 40% (n = 20) of cases, with a peak age of 33 ± 5 years. This was followed by patients in the fourth decade, who comprised 32% (n = 16) of the study population. Paediatric and young adult patients (≤ 20 years) constituted 12% (n = 6), while middle-aged adults (41–60 years) also accounted for 12% (n = 6). Geriatric patients (> 60 years) were least commonly affected, representing only 4% (n = 2) of cases.

- Descriptive statistics
- Mean age: 32.4 years
- Most predominant age group: Third decade
- Peak age: 33 ± 5 years
- Geriatric patients: 4% (n = 2)

Table 2. Sex Distribution of Patients with Spinal Tuberculosis (n = 50)

Sex	Number of Patients	Percentage (%)
Male	**30**	**60**
Female	**20**	**40**
Total	**50**	**100**

- Male : Female ratio = 1.5 : 1
- Results (Sex Distribution)
- Of the 50 patients with spinal tuberculosis, 30 (60%) were male and 20 (40%) were female, showing a male predominance with a male-to-female ratio of 1.5:1.

Table 3. Clinical Presentations of Patients with Spinal Tuberculosis (n = 50)

Clinical Symptom	Number of Patients (n)	Percentage (%)
Back pain	**48**	**95**
Fever	**15**	**30**
Weight loss	**9**	**18**
Loss of appetite	**8**	**16**

Results (Clinical Presentation)

- Among the 50 patients with spinal tuberculosis, back pain was the most common presenting symptom, observed in 48 patients (95%), which is in concordance with a study by Sajid Ansari et al.[1]
- Fever was present in 15 patients (30%), while weight loss and loss of appetite were reported in 9 (18%) and 8 (16%) patients, respectively. This highlights that localized spinal pain is the predominant symptom, with systemic manifestations being less frequent.

2) IMAGING FEATURES:

I) Location:

In our study, most common vertebra involved is Thoracolumbar junction(T11-L2) in 40% of case, followed by thoracic spine (Dorsal spine) in 30% of case, followed by Lumbo-sacral spine in 20% of case, least involved segment is cervical spine in 10 % of cases.

Table 4. Vertebral Level Involvement in Spinal Tuberculosis (n = 50)

Vertebral Level	Number of Patients	Percentage (%)
Thoraco-lumbar junction (T11–L2)	**20**	**40**
Dorsal spine (T1–T10)	**15**	**30**
Lumbosacral spine (L3–S1)	**10**	**20**
Cervical spine (C1–C7)	**5**	**10**
Total	**50**	**100**

Results (Vertebral Level Involvement)

In this study of 50 patients with spinal tuberculosis, the thoraco-lumbar junction (T11–L2) was the most commonly involved region, affecting 20 patients (40%), which is in accordance with study by Moorthy S, et al.[2].

The dorsal spine (T1–T10) was involved in 15 patients (30%), the lumbosacral region (L3–S1) in 10 patients (20%), and the cervical spine (C1–C7) in 5 patients (10%). This finding aligns with previous imaging studies that identify the thoraco-lumbar junction as the predominant site of TB involvement due to biomechanical stress and vascular supply patterns.

II) Pattern of involvement:

In our study, the most common pattern of involvement is para-discal type ; in 75% of cases involving the contiguous end plates of two adjacent vertebrae and the intervertebral disc, followed by central involvement in 10 % of case, followed by anterior subligamentous involvement in 8 % of case and least involved posterior elements in 7% of case.

Table 5. Pattern of Vertebral Involvement in Spinal Tuberculosis (n = 50)

Pattern of Involvement	Number of Patients (n)	Percentage (%)
Para-discal	**38**	**75**
Central	**5**	**10**
Anterior subligamentous	**4**	**8**
Posterior elements	**3**	**7**
Total	**50**	**100**

Results (Pattern of Vertebral Involvement)
Among the 50 patients with spinal tuberculosis, the para-discal pattern was the most common, observed in 38 patients (75%), which is similar to a study by Vijay Kubihal et al.[3]

The central type was seen in 5 patients (10%), anterior subligamentous involvement in 4 patients (8%), and posterior element involvement in 3 patients (7%).

III) Complication of pott's spine:
In our study most common complication found is pre-paravertebral abscess, soft tissue component in 77% of case, followed by para-spinal psoas abscess in 55% of case, epidural abscess in 47% of case, compressive myelopathy in 35% of case and gibbus deformity (kyphosis) in 21% of case.

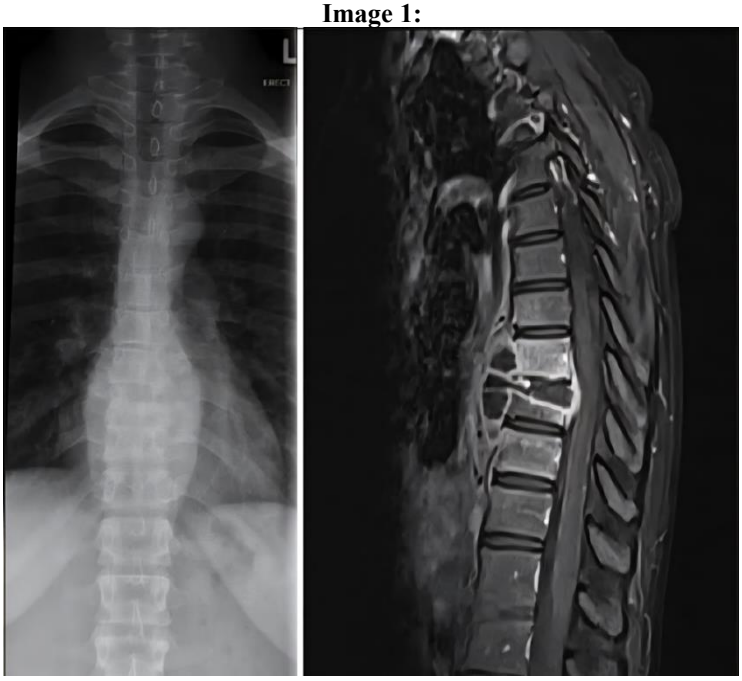
Table 6. Complications Observed in Spinal Tuberculosis on Imaging (n = 50)

Complication	Number of Patients (n)	Percentage (%)
Pre-/Paravertebral abscess	**39**	**77**
Paraspinal abscess	**28**	**55**
Epidural abscess	**24**	**47**
Compressive myelopathy	**18**	**35**
Gibbus deformity (kyphosis)	**11**	**21**

Results (Complications)
Imaging revealed pre-/paravertebral abscess formation as the most common complication, seen in 39 patients (77%), which is similar to study by Bhatnagar s. et. al.[4]

Paraspinal abscesses were identified in 28 patients (55%), while epidural abscesses were present in 24 patients (47%). Compressive myelopathy, secondary to epidural disease, vertebral collapse, or deformity, was observed in 18 patients (35%). Gibbus deformity (kyphosis) was noted in 11 patients (21%), representing a late structural complication of spinal tuberculosis.

Image 1:



Radiograph of the thoracic spine shows a T9 vertebral body fracture and widening of the paravertebral stripe extending from T8 to T12.

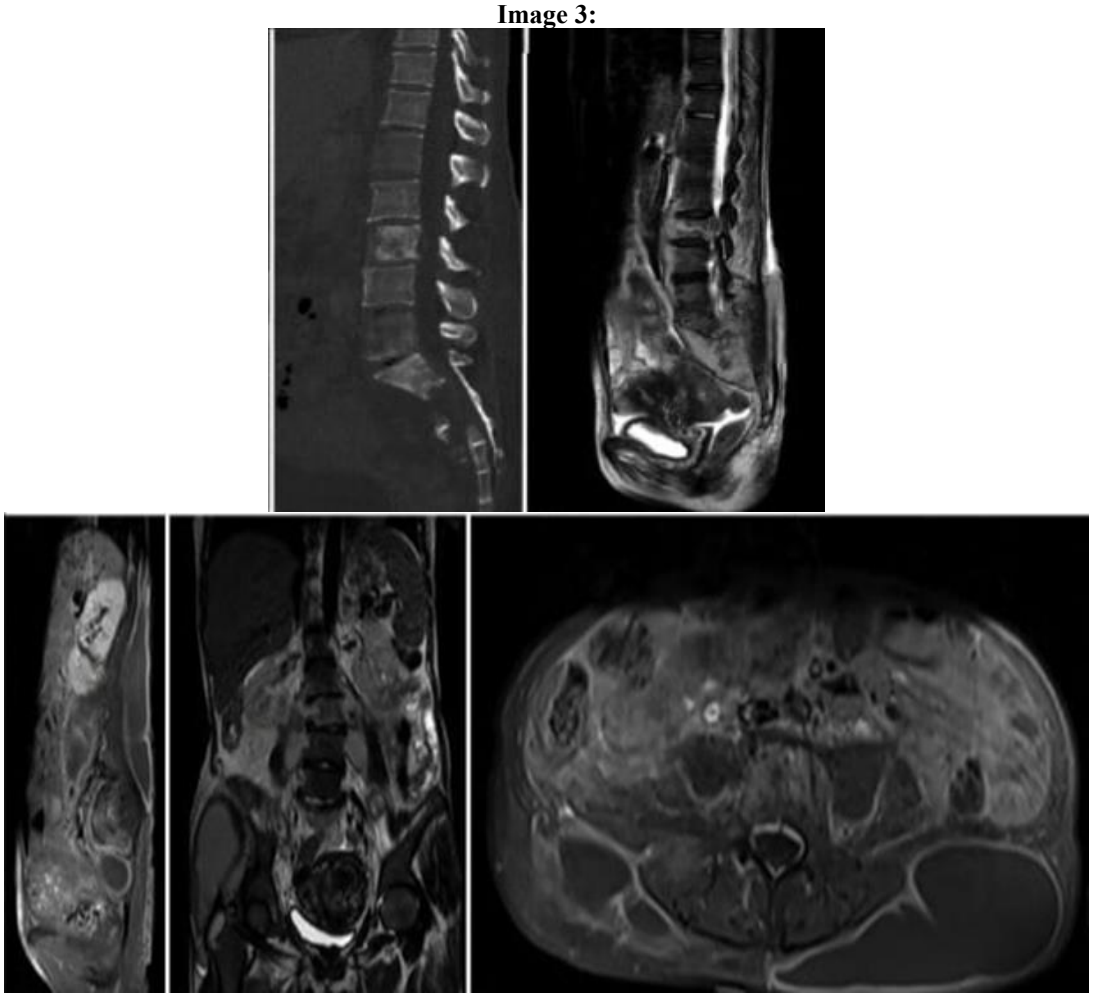
Post-contrast sagittal T1-W fat-saturated MR image of the thoracic spine shows a pathological T9 fracture with near-complete collapse. A prevertebral abscess with subligamentous spread from T8 to T10 and anterior scalloping of the vetebral bodies are also seen.

Image 2:

Sagittal T2W MR image of the thoracic spine shows skipped lesions with bone marrow oedema and bone destruction involving T5, T6 and T9 to T11 vertebral bodies. Retropulsion of a T10 pathological fracture results in thoracic cord compression and cord oedema.

Postcontrast sagittal T1-W fat-saturated MR image shows intraosseous abscesses in T5, T6, T9 and T10 vertebral bodies and rim-enhancing prevertebral and epidural collections from T9 to T11 .

Image 3:



Sagittal T2-W MR image of the thoracolumbar spine shows a pathological fracture of the L3 vertebral body with subligamentous spread of the prevertebral abscess to adjacent lumbar vertebrae and the sacrum. Bone destruction of the sacrum is also seen. Postcontrast sagittal T1-W fat-saturated MR image shows a large rim-enhancing subcutaneous collection in the posterior lumbar spine extending to the lower thoracic region. Presacral rim-enhancing collection is seen.

Coronal T2-W fat-saturated MR image shows collections in bilateral psoas muscles. Postcontrast axial T1-W MR image of the pelvis shows rim-enhancing paravertebral collections in bilateral psoas muscles and bilateral gluteal muscles.

3) Associated comorbidities:
In our study , preexisting comorbidities are present in roughly 52% of patients with diabetes is most common in 36% of patients, malnutrition low BMI(<18) in 11 % of patients, HIV in 2% of patients. In our study , 24% of patients have concomitant pulmonary TB.

DISCUSSION:
Comparison with Other Modalities
CT imaging, while helpful in delineating bony destruction and calcification, is limited in evaluating soft tissue and neural compromise. MRI remains superior in these aspects and shows higher diagnostic yield for disease extension, skip lesions, and soft tissue involvement.

Plain radiographs have limited utility in early disease and are mainly used as a preliminary screening tool.
Magnetic Resonance Imaging (MRI) has rapidly become the imaging modality of choice in the evaluation of spinal tuberculosis (Pott's spine) due to its high contrast resolution for bone marrow, soft tissues, spinal cord, and neural elements, outperforming conventional radiography and CT in diagnostic sensitivity and specificity. Early radiographic techniques often fail to detect early bone marrow changes, as plain radiographs typically show abnormalities only after substantial bone destruction has occurred. MRI, however, can identify marrow edema, soft tissue extension, and early osseous changes before gross structural damage is visible on X-rays or CT scans.

According to study by Sinan T, Al-Khawari H, Ismail M et al. [5] MRI offers excellent visualization of the bone and soft tissue components of spinal tuberculosis and helps to identify disease at distant asymptomatic sites. CT is useful in assessing bone destruction, but is less accurate in defining the epidural extension of the disease and therefore its effect on neural structures.

MRI Features and Disease Extent
Characteristic MRI features of spinal tuberculosis include contiguous vertebral body involvement, intervertebral disc destruction, bone marrow oedema, and formation of pre-, paravertebral and epidural "cold" abscesses with rim enhancement on post-contrast sequences. These features are attributable to the granulomatous nature of Mycobacterium tuberculosis and tend to be more extensive on MRI than appreciated on X-ray or CT imaging.

Vertebral body endplate involvement appears as heterogeneously enhancing endplate irregularity on post-contrast sequences.

Vertebral lesions appear hypo intense on T1W images, hyperintense on T2W images and shows heterogeneous or peripheral enhancement on postcontrast T1W images.

Marrow oedema appears as hyperintense areas on T2W and STIR images. Intervertebral disc involvement appears hypointense on T1W and hyperintense on T2W images and shows heterogeneous enhancement on post-contrast T1W images.

In present study of 50 cases, vertebral body oedema was seen in all the cases, disc involvement in the form of reduced disc height and enhancement on contrast scan was seen in 23 (92%) cases. Similar pattern of involvement was seen by Rivas et al [6] and Smith AS et al[7] in their study on spinal TB.

Prevertebral, paravertebral and psoas abscesses appear as heterogeneous lesions with peripheral enhancement and central non-enhancing hypointense areas on post-contrast T1W images. The level, extent and size of abscess can be well delineated on MRI. Granulation tissue appears heterogeneously enhancing soft tissue on post-contrast T1W images. The granulation tissues and epidural abscess can cause narrowing of thecal sac or compression of spinal cord causing neurological complications.

Studies demonstrate that MRI detects additional levels of involvement and skip lesions, improves identification of epidural component, and evaluates the degree of spinal canal compromise, thereby enabling early and accurate diagnosis and appropriate management planning.

Differentiation from Other Pathologies
MRI also aids in differentiating tuberculous spondylitis from pyogenic spondylitis, which is crucial since treatment regimens differ significantly.

According to study by Yeo JJY [8] and Jung NY et al [9], Typical MRI findings favouring tuberculous spondylitis include thin, smooth enhancement of abscess wall and well-defined paraspinal abscess walls, whereas pyogenic spondylitis often show thicker-, irregular enhancement of abscess wall and ill-defined paraspinal abnormal signal.

Similar pattern of thin, smooth enhancement of abscess wall observed in our study.
In TB endemic areas, this differentiation has clinical significance, helping to avoid inappropriate antibacterial therapy and guiding early antitubercular treatment.

More advanced MRI techniques and diagnostic models are even being developed to improve discrimination between tuberculous and pyogenic spondylitis.

Neurological Involvement and Complication Detection
MRI excels in evaluating spinal cord and neural involvement, a critical aspect in patients presenting with neurological signs. It demonstrates cord compression, myelomalacia, nerve root involvement, and epidural granuloma, information that directly influences surgical versus conservative treatment decisions.

Prevertebral, paravertebral and psoas abscesses appear as heterogeneous lesions with peripheral enhancement and central non-enhancing hypointense areas on post-contrast T1W images. The level, extent and size of abscess can be well delineated on MRI. Granulation tissue appears heterogeneously enhancing soft tissue on post-contrast T1W images. The granulation tissues and epidural abscess can cause narrowing of thecal sac or compression of spinal cord causing neurological complications.

Pre and paravertebral collection were seen in 39 patients, which means in 77 % of cases. Paraplegia and sometimes quadriplegia were serious complications of the tuberculous spine seen in approximately 10% of patients. Copious epidural pus and granulation tissue alone or in combination with vertebral collapse, subluxation, or dislocation produce cord compression. Rarely, the pus penetrates the dura resulting in severe meningomyelitis.

Epidural soft tissue formation was seen in 24 (47%) out of 50 cases. Cord compression due to epidural granulation tissue or vertebral compression/collapse was seen in 18(35%) cases in the present study.

Similar studies on MRI features in spinal TB have been done by, Zaidi H et al[10] and Andro Nikou S et al[11], and our study is consistent with findings of these observers.

Role in Treatment Monitoring
Beyond diagnosis, MRI is valuable in monitoring therapeutic response, enabling assessment of reduction in marrow edema, abscess regression, and evolution of healing changes, such as fatty replacement in bone marrow and resolution of contrast enhancement. This helps tailor antitubercular therapy duration and identify treatment failures early.

CONCLUSION:
MRI is a highly sensitive and specific imaging modality for the evaluation of spinal tuberculosis. It provides comprehensive information regarding disease activity, anatomical extent, and complications, making it indispensable in diagnosis, management planning, and follow-up of patients with Pott's spine. MRI is the imaging modality of choice for evaluating Pott's spine due to its ability to detect early disease, define extent, and assess neurological complications. It is essential for accurate diagnosis, treatment planning, and follow-up in patients with spinal tuberculosis.

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