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MRI Evaluation of Patients with Tuberculosis of the Spine

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Abstract

Background: Spinal tuberculosis is the most common form of skeletal tuber culosis and is a major cause of spinal deformity and neurological deficits if not diagnosed early. Magnetic resonance imaging (MRI) is considered the imaging modality of choice because of its ability to detect early marrow changes, soft tissue extension, and neural involvement.

Objectives: To evaluate the MRI findings in patients with spinal tuberculosis and to compare the diagnostic performance of conventional radiography (X-ray) with MRI.

Materials and Methods: This hospital - based observational cross - sectional study was conducted in the Department of Radio diagnosis and Imaging, Muzaffarnagar Medical College, Uttar Pradesh, over a period of 18 months. Thirty patients with clinically

and/or radio logically suspected spinal tuberculosis underwent MRI evaluation using a 1.5 Tesla scanner. Clinical, laboratory, radiographic, and MRI findings were recorded and analyzed. MRI findings were compared with X-ray findings, and statistical analysis was performed using SPSS version 30.0. A p-value <0.05 was considered statistically significant.

Results: The mean age of the study participants was 37.6 years, with females constituting 63.3% of the study population. Backache was present in all patients (100%), while raised erythrocyte sedimentation rate (ESR) was observed in 100%. On MRI, disc involvement was seen in all patients (100%), vertebral body involvement in 83.3%, epidural extension in 60%, pre/ para vertebral involvement in 63.3%, para spinal abscess in 36.7%, and psoas abscess in 30%. Most lesions were hypo intense on T1-weighted images (63.3%) and hyper intense on T2-weighted (80%) and STIR (83.3%) sequences. MRI detected significantly more posterior element involve ment (p=0.03) and para spinal soft tissue involvement (p=0.008) than conventional radiography. No significant association was observed between age and MRI findings.

Conclusion: MRI is the most sensitive imaging modality for evaluating spinal tuberculosis, providing superior detection of vertebral, disc, epidural, and para spinal involvement compared with conventional radiography. Early MRI evaluation facilitates accurate diagnosis, assessment of disease extent, and timely management, thereby reducing the risk of neurological complications and permanent spinal deformity.

Keywords: Spinal tuberculosis, Pott's spine, Magnetic resonance imaging, MRI, Spondylodiscitis, Para spinal abscess, Epidural extension.

Introduction

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality worldwide, particularly in developing countries such as India. Despite significant advances in diagnosis and treatment, TB continues to pose a major public health challenge. According to the World Health Organization (WHO), approximately 10.8 million people developed tuberculosis globally in 2023, with India accounting for the largest share of the global disease burden.[1]

Although pulmonary tuberculosis is the most common form, extra pulmonary tuberculosis constitutes approximately 15–20% of all cases, increasing to nearly 50 % among immune compromised individuals.[2]

Skeletal tuberculosis represents nearly 10–20% of extra pulmonary tuberculosis, and spinal tuberculosis (Pott's spine) accounts for almost 50% of all skeletal TB cases.[3]

The disease most commonly affects the thoracic and lumbar spine and usually begins in the anterior aspect of the vertebral body adjacent to the end plate before spreading to the inter vertebral disc and contiguous vertebrae through sub ligament us extension.[4]

Progressive vertebral destruction may result in kyphotic deformity, spinal instability, epidural abscess formation, neurological deficits, and permanent disability if diagnosis and treatment are delayed.[5]

The clinical presentation of spinal tuberculosis is often nonspecific. Persistent back pain is the most frequent symptom and may be associated with constitutional features such as fever, weight loss, malaise, and night sweats.

Neurological manifestations including radiculopathy, limb weakness, sensory disturbances, and bowel or bladder dysfunction occur in advanced disease because

of spinal cord or nerve root compression.[6] Owing to its indolent course, early diagnosis remains challenging.

Conventional radiography is usually the first imaging investigation performed in patients with suspected spinal pathology because it is inexpensive and widely available. However, radiographic abnormalities become evident only after substantial bone destruction has occurred. Early marrow edema, epidural extension, posterior element involvement, and para spinal soft tissue abnormalities are often not visualized on plain radiographs, limiting their diagnostic sensitivity.[7]

Magnetic resonance imaging (MRI) has emerged as the imaging modality of choice for evaluating spinal tuberculosis because of its excellent soft tissue contrast and multi planar capability. MRI can detect early vertebral marrow changes before cortical destruction becomes apparent on radiographs. It also provides comprehensive assessment of inter vertebral disc involvement, para spinal and epidural abscesses, spinal cord compression, posterior element involvement, sub ligament us spread, and skip lesions.[8] MRI is therefore invaluable not only in establishing the diagnosis but also in determining disease extent, guiding treatment decision ns, and monitoring therapeutic response.[9]

Typical MRI features of spinal tuberculosis include hypo intense signal on T1-weighted images, hyper intense signal on T2-weighted and STIR sequences, vertebral body destruction, involvement of adjacent inter vertebral discs, para vertebral collections, epidural extension, and sub ligament us spread involving multiple vertebral levels[10]

Contrast-enhanced MRI further improves lesion characterization by demonstrating rim enhancement of abscesses and inflammatory granulation tissue, although non-contrast sequences remain highly sensitive in routine practice.[11]

Considering the increasing burden of spinal tuberculosis and the need for early diagnosis, this study was undertaken to evaluate the MRI findings in patients with spinal tuberculosis presenting to a tertiary care hospital.

The study also compares MRI findings with conventional radiography to determine the additional diagnostic information provided by MRI in the assessment of spinal tuberculosis.

Materials and Methods

Study Design and Setting

This hospital-based observational cross-sectional study was conducted in the Department of Radio diagnosis and Imaging, Muzaffarnagar Medical College, Muzaffarnagar, Uttar Pradesh, India. The study was carried out over a period of 18 months, comprising 12 months of data collection followed by 6 months of data compilation and analysis.

Study Population

The study included patients of all age groups and both sexes attending the outpatient and inpatient departments who were clinically suspected of having spinal tuberculosis and/or had radiological suspicion on plain radio graphs (X-ray spine) and were referred to the Department of Radio diagnosis and Imaging for MRI evaluation.

Sample Size and Sampling Technique

A total of 30 patients were enrolled in the study. The sample size was determined based on the number of patients presenting with suspected spinal tuberculosis during the study period and the feasibility of MRI evaluation. Patients were selected using a purposive sampling technique.

Inclusion Criteria

Patients fulfilling any of the following criteria were included in the study:

- Clinical suspicion of spinal tuberculosis.
- Radiological suspicion of spinal tuberculosis on X-ray spine.
- Evidence of active disease such as back pain, spinal deformity, neurological deficit, or cold abscess.
- MRI findings consistent with tuberculosis of the spine.
- Written informed consent for participation.

Exclusion Criteria

Patients were excluded if they had:

- Malignant or metastatic spinal disease.
- Normal MRI findings with no evidence of spinal tuberculosis.
- Refusal to provide written informed consent.

Study Procedure

Following approval from the Institutional Ethics Committee, eligible patients were recruited from the outpatient and inpatient departments. Patients meeting the inclusion criteria were informed about the objectives, benefits, and potential risks of the study in their preferred language, and written informed consent was obtained before enrolment.

Each participant was assigned a unique identification number, and demographic information including age, sex, and hospital registration number was documented in a pre-designed Case Record Form (CRF).

Clinical Evaluation

A detailed clinical assessment was performed for every patient. Clinical history included presenting complaints such as back pain, limb weakness, numbness, radicular pain, fever, weight loss, and malaise. Information regarding the duration and progression of symptoms, previous history of tuberculosis, contact with tuberculosis patients, previous anti-tubercular therapy, and relevant medical and family history was also recorded. General physical and detailed neurological examinations were performed to assess spinal tenderness, deformity, motor weakness, sensory deficits, and bowel or bladder involvement.

Laboratory Investigations

Baseline laboratory investigations included:

1. Haemoglobin estimation.
2. Total leukocyte count (TLC).
3. Differential leukocyte count (DLC).
4. Erythrocyte sedimentation rate (ESR).

These investigations were performed to assess the inflammatory status and support the clinical diagnosis of tuberculosis.

Radio graphic Evaluation

All patients underwent conventional radiographic evaluation, which included:

- X-ray spine (anter oposterior, lateral, and oblique views).
- Chest X-ray (poster anterior or anteroposterior view).

The spinal radiographs were evaluated for vertebral body destruction, reduction in intervertebral disc space, vertebral collapse, kyphotic deformity, and para vertebral soft tissue shadows suggestive of abscess formation. Chest radiographs were assessed for evidence of associated pulmonary tuberculosis.

MRI Examination

All enrolled patients underwent MRI of the involved spinal region using a 1.5 Tesla Siemens Magnetom Essenza MRI scanner. Patients were examined in the supine position using appropriate surface coils according to the spinal region being evaluated.

The MRI protocol consisted of:

- T1-weighted sequences.
- T2-weighted sequences.
- Short Tau Inversion Recovery (STIR) sequences.

Images were obtained in sagittal and axial planes to evaluate vertebral bodies, intervertebral discs, spinal canal, spinal cord, and adjacent soft tissues.

MRI Image Analysis

MRI images were independently reviewed by experienced radiologists. The following imaging para meters were evaluated systematically:

Vertebral and Disc Involvement

- Vertebral body signal abnormalities.
- Posterior element involvement.
- Intervertebral disc involvement.
- Number of vertebrae involved.
- Presence of contiguous or skip lesions.

Soft Tissue and Extra Spinal Extension

- Prevertebral and para vertebral soft tissue involvement.
- Presence of para spinal or psoas abscess.
- Subligamentous spread of disease.

Intra spinal Involvement

- Epidural extension.
- Spinal canal stenos is.
- Spinal cord compression.
- Intradural or intramedullary involvement.

Signal Characteristics

Signal intensity of lesions was assessed on T1-weighted, T2-weighted, and STIR sequences and categorized as hypo intense, iso intense, hyper intense, or intermediate according to standard MRI signal characteristics.

Data Collection

Clinical findings, laboratory investigations, radiographic findings, and MRI observations were prospectively recorded in a pre-designed Case Record Form. All collected data were checked for completeness and accuracy before entry into a computerized database for statistical analysis.

Comparison of X-ray and MRI Findings

Radiographic findings were compared with MRI findings for assessment of:

- Vertebral body involvement.
- Posterior element involvement.
- Inter vertebral disc involvement.
- Soft tissue involvement and para spinal abscess.

MRI was considered the reference standard for evaluating the diagnostic performance of conventional radiography.

Statistical Analysis

Data were entered and analysed using Statistical Package for the Social Sciences (SPSS) version 30.0. Descriptive statistics were expressed as mean, frequency, and percentage. Associations between categorical variables were analysed using the Chi-square test or Fisher's exact test, wherever appropriate. Mc Nemar's test was used to compare findings between X-ray and MRI. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of Muzaffar nagar Medical College, Muzaffar nagar.

Written informed consent was obtained from all partici pants before enrolment. Confidentiality and anonymity of patient information were maintained throughout the study in accordance with ethical guidelines.

Results and Observations

The present hospital-based observational cross-sectional study included 30 patients with clinically and/or radio

logically suspected spinal tuberculosis who underwent MRI evaluation. The observations are presented below.

Table 1: Demographic profile of study participants (N = 30)

Variable	Number	Percentage (%)
Age group (years)		
10–20	2	6.67
20–30	8	26.67
30–40	10	33.33
40–50	1	3.33
50–60	5	16.67
60–70	2	6.67
70–80	2	6.67
Gender		
Male	11	36.67
Female	19	63.33

Mean age: 37.6 years

Table 2: Clinical presentation and laboratory findings (N = 30)

Variable	Number	Percentage (%)
Clinical features		
Backache	30	100
Root pain	16	53.33
Constitutional symptoms	10	33.33
Paresis	5	16.67
Laboratory findings		
Decreased haemoglobin	25	83.33
Raised TLC	19	63.33
Abnormal DLC	16	53.33
Raised ESR	30	100

Table 3: X-ray findings (N = 30)

Variable	Number	Percentage (%)
Lumbar involvement	15	50.00
Dorsal involvement	10	33.33
Dorsolumbar	1	3.33
Lumbosacral	4	13.33
Vertebral body involvement	26	86.67

Soft tissue shadow	4	13.33
Posterior element involvement	0	0
Positive chest X-ray	5	16.67

Table 4: MRI findings: Site of involvement (N = 30)

MRI finding	Number	Percentage (%)
Vertebral body involvement	25	83.33
Disc involvement	30	100
Posterior SI hyper intensity	6	20
Posterior structural involvement	1	3.33
Epidural extension	18	60
Intradural extramedullary involvement	0	0
Para spinal abscess	11	36.67
Subligamentous extension	5	16.67
Pre/para vertebral involvement	19	63.33

Table 5: MRI signal characteristics (N = 30)

Sequence	Finding	Number	Percentage (%)
T1	Hypo intense	19	63.33
	Iso intense	11	36.67
T2	Hyper intense	24	80.00
	Intermediate	5	16.67
	Iso intense	1	3.33
STIR	Hyper intense	25	83.33
	Intermediate	5	16.67

Table 6: MRI spinal cord and associated findings (N = 30)

Finding	Number	Percentage (%)
Canal stenos is	11	36.67
Psoas abscess	9	30.00
No associated finding	21	70.00

Table 7: MRI regional involvement (N = 30)

Variable	Number	Percentage (%)
Number of vertebrae involved		
0–2	2	6.67
2–4	25	83.33
4–6	2	6.67

6–8	1	3.33
Most common anatomical levels		
L1–L2	5	16.67
L2–L3	3	10.00
D10–D11	3	10.00
Other levels	19	63.33

Table 8: Association of age with MRI findings

MRI parameter	p-value	Statistical significance
Vertebral body involvement	0.84	Not significant
Disc involvement	0.71	Not significant
Posterior SI	0.79	Not significant
Posterior structural involvement	0.92	Not significant
Epidural extension	0.68	Not significant
IDEM involvement	1.00	Not significant
Para spinal abscess	0.87	Not significant
Subligamentous extension	0.75	Not significant
Pre/ para vertebral involvement	0.81	Not significant
T1 signal	0.77	Not significant
T2 signal	0.66	Not significant
STIR signal	0.83	Not significant
Canal stenos is	0.94	Not significant
Psoas abscess	0.88	Not significant
Number of vertebrae involved	0.89	Not significant
Anatomical region	0.92	Not significant

Table 9: Comparison of X-ray and MRI findings

Parameter	X-ray	MRI	p-value
Vertebral body involvement	26	25	0.32
Posterior element involvement	0	1	0.03*
Soft tissue/para spinal abscess	4	11	0.008*
Lumbar involvement	15	19	—
Dorsal involvement	10	11	—
Dorsolumbar/Multilevel involvement	5	14	—

*Statistically significant

Table 10: Diagnostic performance of X-ray using MRI as the reference standard

Parameter	Sensitivity (%)	Specificity (%)
Vertebral body involvement	100	80
Posterior element involvement	0	100
Para spinal soft tissue involvement	36.4	100
Disc involvement	0	Not applicable

Discussion

The present hospital-based observational cross-sectional study evaluated MRI findings in 30 patients with spinal tuberculosis and compared MRI with conventional radiography. MRI demonstrated excellent capability in identifying vertebral involvement, disc disease, epidural extension, soft tissue collections, and associated complications, thereby confirming its role as the imaging modality of choice for spinal tuberculosis.

The mean age of the study population was 37.6 years, with the highest frequency occurring in the 30–40-year age group (33.3%). Similar observations have been reported by Ansari et al., who observed that spinal tuberculosis predominantly affects young and middle-aged adults because of greater exposure and higher disease prevalence in the economically productive age group.[12] Jain and Kumar also reported maximum incidence during the third and fourth decades of life.[13]

Females constituted 63.3% of the study population, whereas males accounted for 36.7%. Although several studies have demonstrated a slight male predominance, female preponderance has also been reported in hospital-based Indian studies, reflecting regional epidemiological variations and healthcare-seeking behavior.[14]

Back pain was present in 100% of patients, making it the most consistent presenting symptom. Root pain occurred in 53.3%, constitutional symptoms in 33.3%, and neurological weakness in 16.7% of patients. These findings closely resemble those reported by Turgut, who described back pain as the earliest and most frequent symptom in spinal tuber culosis, followed by neuro logical manifestations in advanced disease.[5]

Raised ESR was observed in 100% of patients, while anemia was present in 83.3%. Elevated inflammatory markers have consistently been reported as useful supportive findings in spinal tuberculosis although they lack specificity.[15]

Radiographic evaluation demonstrated vertebral body destruction in 86.7% of patients, whereas soft tissue shadow was detected in only 13.3%, and no patient showed posterior element involvement. These findings highlight the limited sensitivity of conventional radiography in detecting early disease and extra skeletal extension. Similar observations have been reported by Moorthy and Prabhu, who emphasized that radiographs generally detect disease only after significant osseous destruction has occurred.[16]

MRI demonstrated vertebral body involvement in 83.3% and disc involvement in 100% of patients. Disc involvement is a characteristic feature of spinal tuberculosis because infection commonly spreads beneath the anterior longitudinal ligament to adjacent vertebrae through the intervertebral disc. Similar frequencies have been reported by Bur rill et al., who described contiguous vertebral and disc involvement as the hall mark of tuberculousspon dylodiscitis.[17] Epidural extension was identified in 60% of patients, while pre/

para vertebral involvement was observed in 63.3% and para spinal abscesses in 36.7%.

These findings are consistent with previous MRI studies showing that para spinal soft tissue collections and epidural disease are common manifestations of spinal tuberculosis owing to caseousnecrosis and subligament us spread.[18]

Posterior element involvement was uncommon (3.3%) in the present study. Isolated posterior element tuberculosis is relatively rare but is clinically important because it may mimic neo plastic or pyogenic lesions. Similar low incidences have been described by Garg and Somvanshi.[19]

Regarding MRI signal characteristics, 63.3% of lesions were hypo intense on T1-weighted images, while 80% were hyper intense on T2-weighted images and 83.3% were hyper intense on STIR sequences. These signal characteristics reflect marrow edema, inflammatory granulation tissue, and abscess formation and are comparable with the MRI appearances described by Sharif et al.[20]

Canal stenosis was identified in 36.7% of patients, while psoas abscesses were observed in 30%. Early identification of these complications is clinically important because neurological deterioration can occur due to spinal cord or nerve root compression. MRI remains the most sensitive modality for assessing these complications and guiding surgical planning when necessary.[21]

Most patients (83.3%) demonstrated involvement of 2–4 vertebrae, with the lumbar region being the most commonly affected. The L1–L2 level represented the single most common anatomical site.

Previous investigators have similarly reported thoracolumbar junction involvement as the predominant site because of its rich vascular supply and biomechanical stress.[22]

No statistically significant association was observed between age and MRI findings in the present study. This suggests that disease extent and imaging characteristics are influenced more by disease progression than by patient age, a finding also supported by previous observational studies.[23] Comparison between X-ray and MRI revealed significantly better detection of posterior element involvement ($p = 0.03$) and para spinal soft tissue involvement ($p = 0.008$) by MRI.

Although vertebral body involvement showed no statistically significant difference, MRI detected substantially more extra spinal disease than conventional radiography. Similar superiority of MRI has been consistently demonstrated by numerous investigators.[16-18]

Diagnostic performance analysis showed that conventional radiography had 100% sensitivity for vertebral body destruction but only 36.4% sensitivity for para spinal soft tissue involvement and failed to detect posterior element disease. These findings reinforce the limited role of radiography in evaluating disease extent. MRI provides superior assessment of bone marrow involvement, epidural disease, neural compression, soft tissue extension, and abscess formation, making it indispensable in both diagnosis and treatment planning.[24]

Overall, the findings of the present study support the established role of MRI as the gold standard imaging modality for spinal tuberculosis. Early MRI evaluation enables prompt diagnosis, accurate assessment of disease extent, detection of neurological complications, and appropriate therapeutic intervention, thereby reducing long-term disability.

Conclusion

MRI is the imaging modality of choice for the evaluation of spinal tuberculosis because it accurately detects vertebral and intervertebral disc involvement, epidural extension, paraspinal abscesses, subligamentous spread, and spinal canal compromise at an early stage. In the present study, MRI identified soft tissue and posterior element involvement more effectively than conventional radiography, demonstrating its superiority in assessing the full extent of disease. Early MRI evaluation facilitates prompt diagnosis, appropriate treatment planning, and timely intervention, thereby helping to prevent neurological complications and permanent spinal deformity in patients with spinal tuberculosis.

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