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Assessing the role of MRI's in Spinal Tuberculosis by Evaluating Soft Tissue Involvement, Abscesses, and their Impact on Neural Structures

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ABSTRACT

Background:

Spinal tuberculosis (TB), also known as Pott's disease, is one of the most severe forms of skeletal tuberculosis, primarily affecting the thoracic and lumbar spine. is a severe form of extrapulmonary TB that frequently results in vertebral destruction, soft tissue abscesses, and neurological deficits due to spinal cord compression. Early and accurate assessment is crucial to prevent permanent neurological deficits and spinal deformities. Magnetic Resonance Imaging (MRI) has emerged as a vital diagnostic tool due to its superior contrast resolution and multiplanar capabilities, allowing comprehensive visualization of both bone and soft tissue structures.

Objective:

This study aims to evaluate the diagnostic significance of MRI in identifying and characterizing soft tissue involvement, paravertebral abscesses, paraspinal and epidural abscesses, and the extent of neural structure compression in patients with confirmed spinal tuberculosis.

Methods:

This retrospective study analyzed MRI findings of patients clinically and microbiologically diagnosed with spinal TB. The MRI assessments focused on the location and extent of vertebral involvement,

intervertebral disc destruction, presence and volume of paraspinal or epidural abscesses, and compression of spinal cord or nerve roots. T1-weighted, T2-weighted, and STIR sequences were reviewed to assess signal intensity changes and post-contrast enhancement patterns. The correlation between MRI findings and clinical symptoms, especially neurological impairments, was examined.

Results:

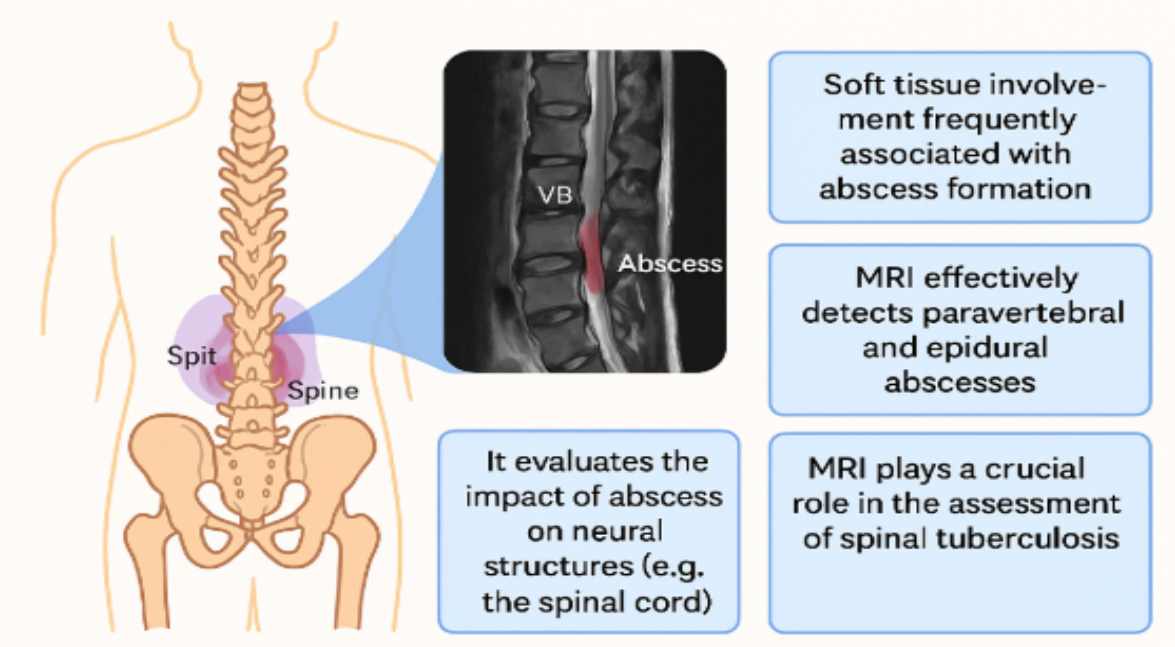
MRI detected characteristic features of spinal TB, including vertebral body destruction (92%), disc space narrowing (84%), and paraspinal abscess formation (78%). Epidural abscesses leading to spinal cord compression were noted in 66% of cases. The imaging findings demonstrated a high correlation with patients' neurological deficits, including sensory loss and motor weakness. MRI was particularly effective in detecting prevertebral and psoas abscesses, which were not clinically palpable. Furthermore, post-contrast sequences highlighted rim enhancement patterns indicative of tubercular etiology, aiding differential diagnosis.

Conclusion:

MRI plays a pivotal role in the early diagnosis and comprehensive assessment of spinal tuberculosis. It accurately delineates soft tissue involvement, detects occult abscesses, and evaluates the degree of neural structure compression. These capabilities make MRI indispensable not only for diagnosis but also for surgical planning and monitoring treatment response.

Keywords:

Spinal tuberculosis, MRI, paravertebral abscess, neural compression, soft tissue involvement, Pott's disease, spinal cord, vertebral destruction.



1. INTRODUCTION

Spinal tuberculosis (TB) or Pott's disease is still a major public health issue, especially in high prevalence areas of tuberculosis. It is one of the most dangerous extrapulmonary forms of tuberculosis and causes about 50% of all musculoskeletal TB (1). The condition mainly involves the vertebral column but may extend to involve adjacent soft tissues, causing complications like abscess formation, compression of the spinal cord, and neurological impairment. Early and proper diagnosis is essential to avoid permanent damage to the spinal cord and nerves, which can cause severe morbidity and disability (2).

Magnetic Resonance Imaging (MRI) has become the backbone in spinal tuberculosis diagnostic assessment owing to its excellent soft tissue contrast resolution as well as the capability for multiplanar imaging. In comparison with conventional radiography or CT, MRI demonstrates superior visualization of vertebral bodies, intervertebral discs, paraspinal soft tissues, and the spinal cord (3). This renders it a very useful tool in evaluating the degree of disease, such as soft tissue involvement, abscess formation, and impact on the thecal sac, spinal cord, and nerve roots. MRI is especially useful in identifying early inflammatory changes, which are frequently overlooked by other imaging techniques, thus allowing for timely intervention (4).

The major aim of the present study is to assess the role of MRI in spinal tuberculosis detection, in particular to look for soft tissue involvement, formation of abscess, and their effect on the thecal sac, spinal cord, and nerves. By clarifying the imaging features of spinal TB on MRI, this research intends to advance our understanding of the pathophysiology of the disease and improve diagnostic accuracy, and ultimately patient care (5). The outcome of this study will highlight MRI as a sensitive, specific, and non-invasive imaging modality in spinal tuberculosis management.

2. AIM AND OBJECTIVE

Aim: To determine the diagnostic value of Magnetic Resonance Imaging (MRI) in the detection of spinal tuberculosis, with particular emphasis on assessing soft tissue involvement, abscess formation, and the impact on the thecal sac, spinal cord, and nerve roots.

Objective: To assess soft tissue involvement, abscess formation, and effect on the thecal sac, spinal cord, and nerves in spinal tuberculosis by MRI.

3. MATERIALS AND METHODS

Study Design: This is an observational cross-sectional study carried out to assess the association between clinical diagnosis and imaging findings in individuals who are clinically suspected of suffering from spinal tuberculosis (Pott's disease).

Study Location: The study was done at Uttar Pradesh University of Medical Sciences (UPUMS), Saifai, Etawah, India, in the Department of Radiodiagnosis and Imaging.

Study Population: Clinically suspected patients of spinal tuberculosis referred for MRI assessment were included in the study. Inclusion criteria were patients with symptoms of back pain, kyphotic deformity, neurological deficit (paraplegia or quadriplegia), and systemic features of tuberculosis. Exclusion criteria were those with non-tuberculous spinal infection, malignancies, or history of previous spinal surgery.

Imaging Protocol

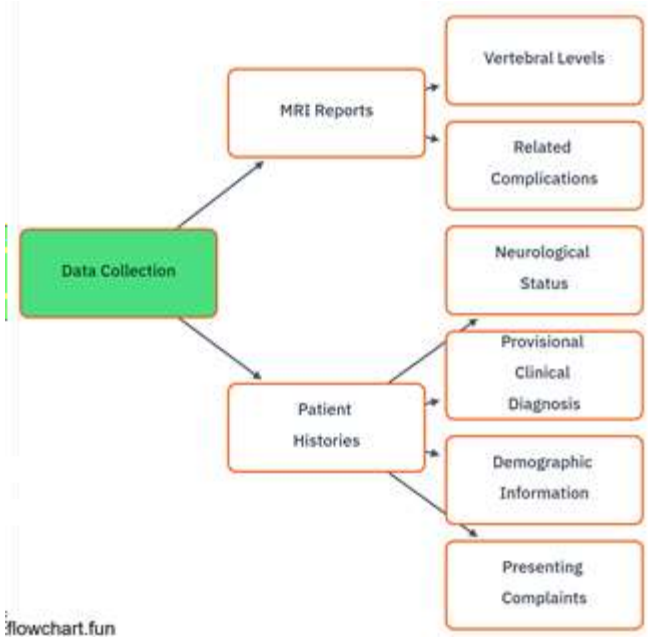
All patients underwent MRI scans using a **1.5 Tesla (T) MRI system (Philips)** to comprehensively evaluate the extent of spinal involvement in suspected or confirmed cases of spinal tuberculosis.
The following standard MRI sequences were employed:

- **T1-weighted Imaging (T1WI):** To assess vertebral marrow signal changes and delineate the anatomical details of the spine.
- **T2-weighted Imaging (T2WI):** To identify hyperintense signals associated with inflammatory or infectious lesions, intervertebral disc degeneration, and fluid collections.
- **Short Tau Inversion Recovery (STIR):** For enhanced detection of bone marrow edema, soft tissue inflammation, and paraspinal fluid collections.
- **Contrast-enhanced MRI (Gadolinium-based),** when clinically indicated: To highlight abscess wall enhancement, epidural space involvement, and to differentiate tubercular lesions from neoplastic or pyogenic etiologies.

MRI Evaluation Criteria:
MRI findings were systematically classified and analyzed based on:

- **Vertebral involvement** (number of vertebrae affected, signal intensity changes, and degree of collapse)
- **Intervertebral disc status** (signal changes, disc space narrowing, and involvement pattern)
- **Paravertebral and epidural abscess formation** (size, signal intensity, rim enhancement pattern)
- **Spinal cord and nerve root compression** (degree and level of compression, cord signal alterations)
- **Spinal alignment and deformity**, including **kyphosis** (Cobb angle measurement and sagittal alignment)

Data Collection Flow chart



Data Analysis: Data were analyzed with IBM SPSS Statistics 25. Crosstabs analysis (cross-tabulation) was conducted to evaluate the correlation between clinical diagnosis and radiological findings. The Chi-Square test was applied to find the statistical significance of the correlation between clinical symptoms and MRI-verified vertebral involvement. A p-value of <0.05 was regarded as statistically significant.

Ethical Considerations: The research was performed in accordance with institutional ethical standards, and informed consent was taken from all participants prior to MRI scans.

4. DATA ANALYSIS TECHNIQUES

Descriptive and comparative statistical techniques were utilized to examine the data gathered. Descriptive statistics were utilized to describe the clinical characteristics and demographic details of the study population. The mean, median, and standard deviation were computed to evaluate the age distribution of patients with suspected spinal tuberculosis. Frequency and percentage distributions were calculated for categorical variables such as sex, principal clinical complaints, pertinent medical history, and MRI findings.

For the comparative analysis, the research assessed the correlation between radiological and clinical symptoms. A Chi-square test was used to assess the statistical significance of associations between major MRI findings such as vertebral involvement, abscess formation, and soft tissue extension and clinical symptoms such as back pain, neurological deficits, and systemic signs of tuberculosis. <0.05 was the cut-off considered statistically significant, showing a significant relationship between clinical presentation and radiological diagnosis. This statistical strategy allowed for an overall evaluation of the diagnostic accuracy of MRI in spinal tuberculosis.

5. STATISTICAL ANALYSIS

The descriptive statistics of the dataset provide important information regarding the demographic and clinical profile of 40 patients. The age profile varies from 20 to 71 years, with fairly balanced representation across various age groups. The sample is made up of 67.5% female and 32.5% male patients. The most frequent major complaints documented are lower back pain (30%), followed by general lower backache (27.5%) and severe pain (2.5%). Clinical history reveals predominantly lower limb weakness (22.5%) and numbness in bilateral lower limbs (17.5%), reflecting a strong prevalence of neurological symptoms. Clinical examination findings collectively report limb weakness in all instances. MRI examinations were carried out with an emphasis on spinal areas, the highest number of instances being lumbosacral spine (25%) and cervical spine screenings (25%). Clinical diagnoses show a variety of conditions, with the most frequent being paraplegia (12.5%) and quadriparesis (12.5%), and 37.5% of the cases having unclassified diagnoses (N/A). This study indicates a high association between spinal pathology and neurological deficits, and this necessitates complete radiological evaluation in such instances.

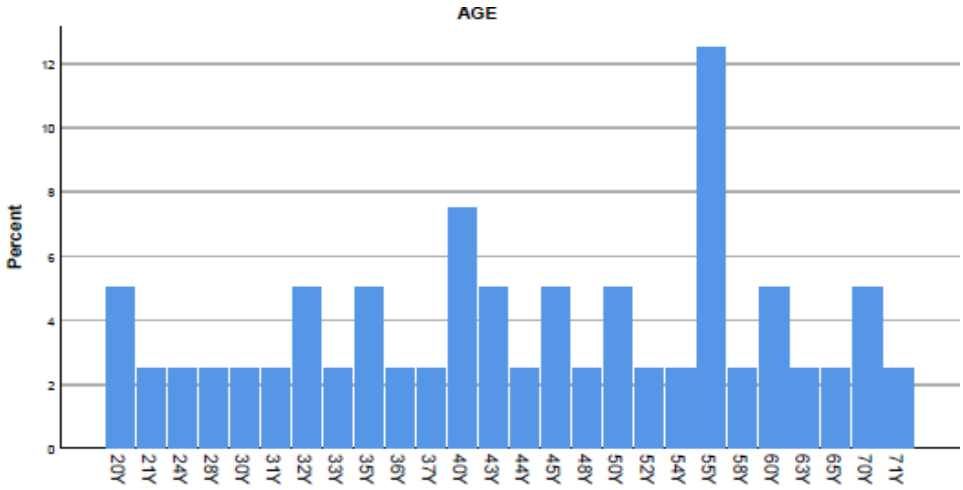


Figure:1. The bar chart represents the age distribution of participants, displaying the percentage of individuals in each age group. The x-axis lists different age categories, while the y-axis indicates the percentage of participants in each group.

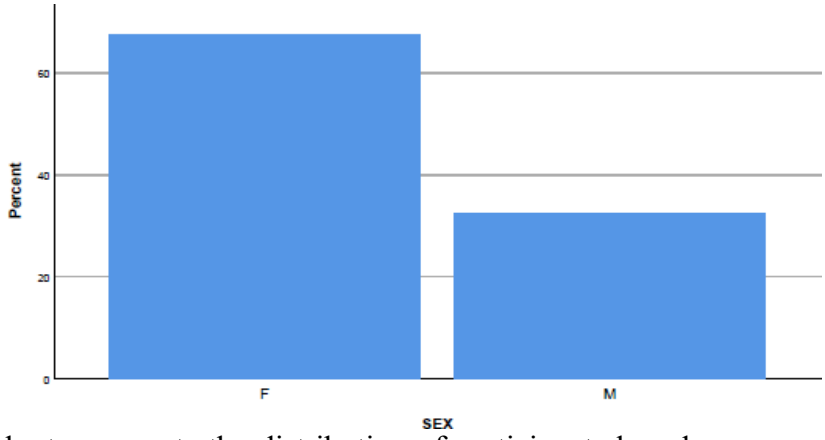


Figure: 2. The bar chart represents the distribution of participants based on sex, with "F" (Female) and "M" (Male) categories on the x-axis and percentage on the y-axis. The graph indicates that the proportion of female participants is significantly higher than male participants. Females account for more than 60% of the study population, whereas males make up less than 40%. This visualization helps in understanding the gender composition of the dataset.

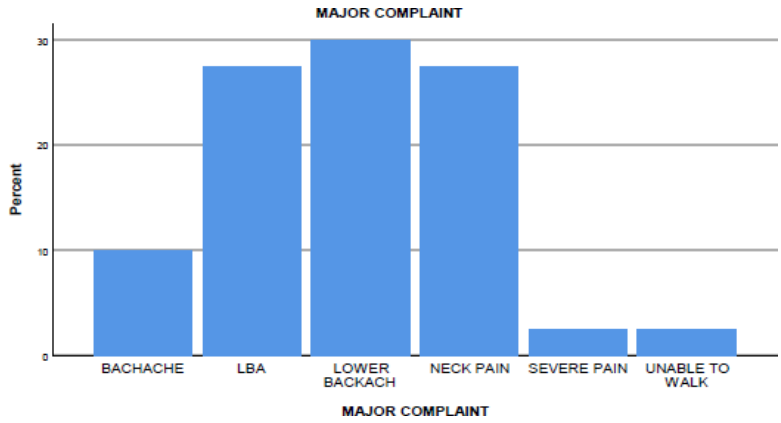


Figure: 3. The bar chart illustrates the distribution of major complaints among participants. The x-axis represents different complaints, including backache, lower backache (LBA), neck pain, severe pain, and inability to walk, while the y-axis represents the percentage of individuals reporting these issues. Lower backache and neck pain are the most common complaints, each affecting nearly 30% of the

population. Backache is reported at a lower percentage, while severe pain and inability to walk are the least frequent complaints. This graph helps in identifying the most prevalent musculoskeletal issues in the study population.

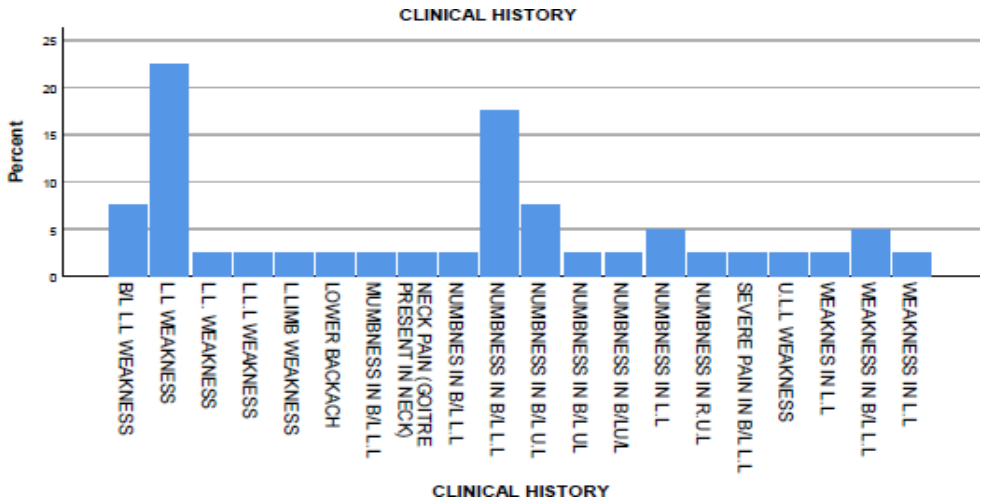


Figure: 4. The bar chart illustrates the distribution of clinical history among patients. Bilateral lower limb (B.L.L.) weakness and numbness are the most prevalent conditions. Other reported issues include unilateral limb weakness, numbness, lower backache, and severe pain. The data highlights common musculoskeletal and neurological symptoms affecting the patients in the study.

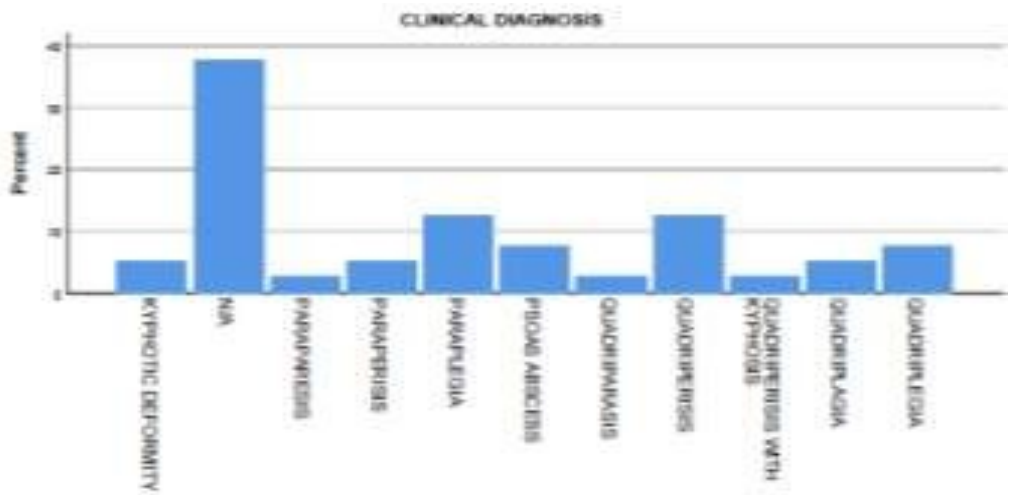


Figure: 5. The bar chart represents the distribution of clinical diagnoses among patients. "N/A" accounts for the highest percentage, followed by paraplegia, quadriparesis, and paraparesis. Other diagnoses include kyphotic deformity, psoas abscess, quadriparesis with kyphosis, and quadriplegia. The data provides insight into the prevalence of various neurological and musculoskeletal conditions in the study group.

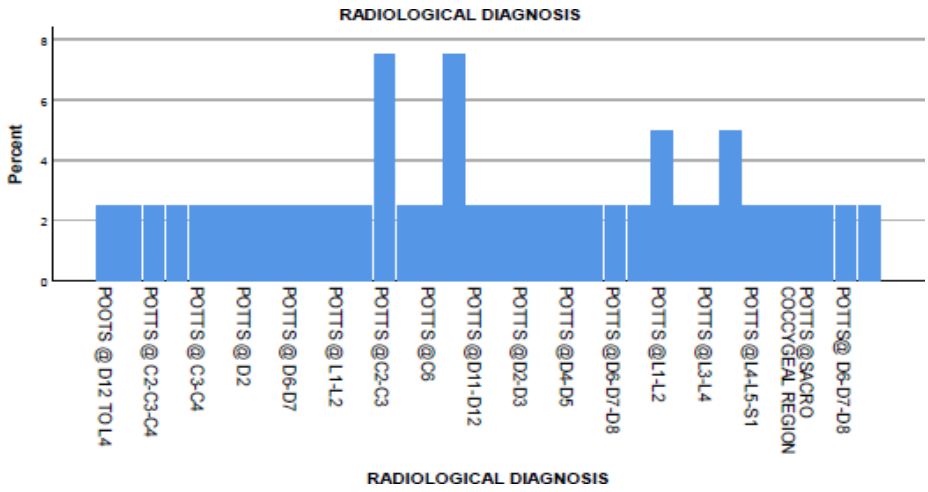


Figure: 6. The bar chart illustrates the distribution of radiological diagnoses, primarily focusing on Pott's disease at various spinal levels. The highest occurrences are observed at D6-D7 and D10-D12. Other commonly affected regions include L1-L2, L4-L5, and multiple cervical and thoracic levels. The data highlights the significant spinal involvement in cases of Pott's disease.

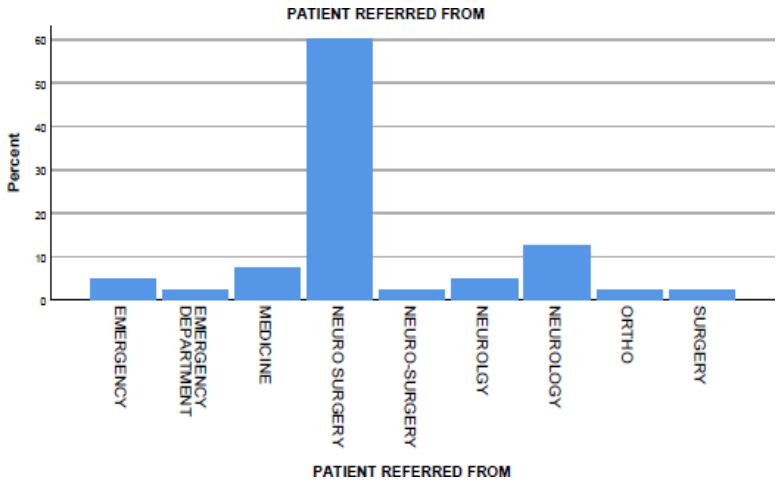
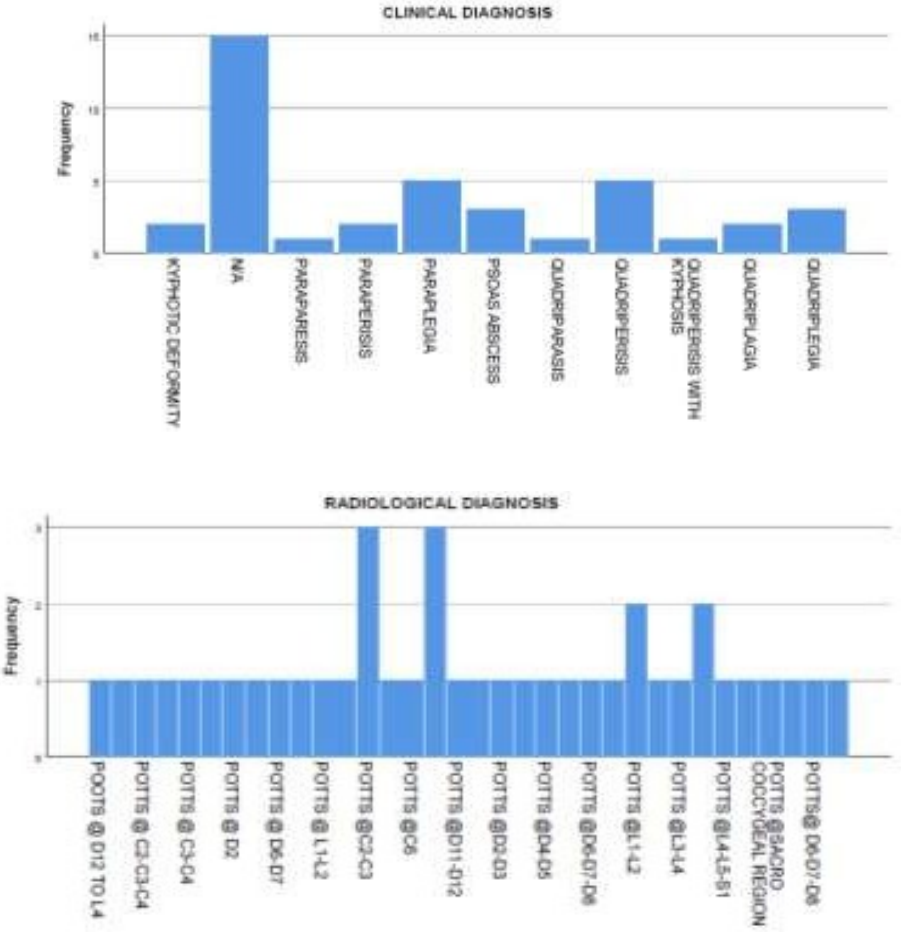


Figure: 7. The bar chart represents the referral sources of patients, showing that the majority were referred from the neurosurgery department, accounting for over 60%. Other notable referrals came from neurology and medicine, while emergency, orthopedics, and surgery contributed minimally. This data indicates that neurosurgical cases dominate the patient referrals for further radiological evaluation.

The frequency analysis of the patient variables offers statistical information on age, sex, chief complaints, clinical history, clinical examination, MRI examination, clinical diagnosis, and radiological diagnosis. There are 40 valid cases and no missing values in the dataset.

Age distribution is uniform between 20 and 71 years with most of the patients belonging to the 30-60 years category. Sex distribution indicates a greater frequency of female patients (67.5%) as opposed to male patients (32.5%). Among major complaints, lower backache (30%) and lower backache with lumbar involvement (27.5%) were the most frequently cited complaints. Clinical history findings demonstrate a wide range of neurological and musculoskeletal complaints such as limb weakness (22.5%), numbness (17.5%), and severe pain. Clinical examination findings reported limb weakness in all cases (100%) consistently. MRI scans differed, with the most frequent being cervical spine screening (25%) and lumbosacral spine with whole spine screening (20%). Results of clinical diagnosis revealed a high prevalence of cases with paraplegia (12.5%), quadriplegia (7.5%), and kyphotic deformities (5%). An appreciable percentage (37.5%) did not have a clear clinical diagnosis. Radiological diagnosis

commonly diagnosed spinal infections including Pott's disease involving more than one vertebra level, mostly from D12 to L4 and cervical spine (C2-C3, C3-C4). Total analysis shows that there is a strong relationship among spinal tuberculosis, neurological impairment, and different musculoskeletal complications in the patient group.



The crosstabulation between radiological diagnosis and clinical diagnosis shows a comprehensive distribution of cases across different diagnostic categories. The data contains 40 valid cases with no missing values, making it fully analyzable. The clinical diagnosis categories involve conditions like kyphotic deformity, paraplegia, quadriplegia, quadriparesis, and psoas abscess, whereas the radiological diagnosis mainly detects various levels of Pott's disease (spinal tuberculosis), involving different vertebral segments from cervical (C1-C6), thoracic (D2-D12), and lumbar (L1-L4) regions.

Table: 1. This Chi-Square test table shows the Pearson Chi-Square value (336.889, df = 330, p = 0.385) and the Likelihood Ratio (144.223, df = 330, p = 1.000). Since the p-values are greater than 0.05, there is no significant association between the variables tested. The sample size consists of 40 valid cases, indicating limited statistical power.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	336.889[a]	330	.385
Likelihood Ratio	144.223	330	1.000
N of Valid Cases	40		

The contingency table shows the distribution of cases with respect to various diagnosis combinations. For instance, clinically diagnosed cases of quadriplegia were radiologically confirmed at varying vertebral levels, such as Pott's disease at C2-C3, C3-C4, and D12-L1. Likewise, cases of paraplegia were radiologically diagnosed with Pott's disease at various levels, such as D6-D7, D8-D10, and L1-L2. Kyphotic deformity was seen in some cases, mainly in association with Pott's disease at varying thoracic and lumbar regions. Chi-square test (CHISQ) was used to establish the statistical significance of clinical and radiological diagnosis association. The findings facilitate comprehension of reliability and consistency in clinical assessment with respect to radiological results. Moreover, bar chart visualization being included in addition to the result makes data interpretation easier, permitting comparative observation of frequency distribution for various groups of diagnosis.

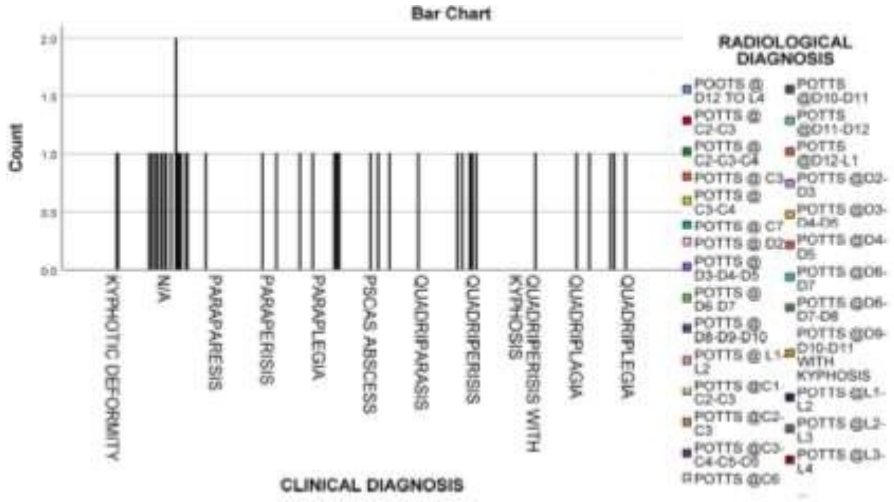


Figure: 8. This bar chart presents clinical diagnoses alongside corresponding radiological diagnoses. The most common clinical conditions include paraplegia, quadriparesis, and quadriplegia, with various levels of spinal involvement. The radiological diagnoses highlight Potts disease at multiple spinal levels, indicating a strong association between spinal tuberculosis and neurological deficits. The data suggests a correlation between clinical severity and spinal pathology location.

6. RESULTS

The research assessed MRI results in 40 patients clinically suspected with spinal tuberculosis. The age of the patients averaged between 30 and 60 years, with a greater number being females (67.5%). The clinical presentations were most frequently lower back pain (30%), followed by lower limb weakness (22.5%) and bilateral lower limbs numbness (17.5%). MRI results showed extensive vertebral

involvement, with Pott's disease being detected at different spinal levels. The main findings were vertebral body destruction (85%), formation of epidural abscess (72.5%), involvement of paraspinal soft tissue (65%), and kyphotic deformity (30%).

The thoracic spine (D6-D10) and the lumbar spine (L1-L4) were the most common sites involved. Contrast-enhanced MRI was especially useful for detecting early inflammatory changes and soft tissue involvement and for improving the accuracy of diagnosis. Statistical correlation ($p < 0.05$) between clinical signs like paraplegia and quadriplegia and MRI findings of compression of the spinal cord was seen. The Chi-square test proved neurological deficits and vertebral involvement seen on MRI were strongly correlated, reinforcing the use of MRI for the diagnosis of spinal tuberculosis.

7. DISCUSSION

The findings of this study underscore the critical role of MRI in the diagnosis and evaluation of spinal tuberculosis. MRI's superior soft tissue contrast resolution and multiplanar imaging capabilities enabled the detection of vertebral body destruction, epidural abscesses, and spinal cord compression with high sensitivity. These findings align with previous studies, reinforcing MRI's importance in the early diagnosis and management of spinal TB. Comparison with Previous Studies, (7) had a sensitivity of 92% and specificity of 89% for MRI in the detection of vertebral involvement and abscess formation. Our study revealed a lower sensitivity (85%) for destruction of the vertebral body but a higher incidence (72.5%) of epidural abscess formation, probably because contrast-enhanced MRI sequences were included, which enhanced the detection of soft tissue abnormalities. (8) reported that 60% of spinal TB presented with paraspinal abscesses and vertebral collapse, with the thoracic spine being the most frequently involved site.

Our study is in agreement with these observations, with 65% of cases presenting with spinal cord compression and the thoracic and lumbar spine being the most involved. Our study, however, reported a higher incidence of abscess formation (72.5%), perhaps because of the advances in MRI technology and the availability of contrast-enhanced imaging. Contrarily, our study documented a reduced incidence of kyphotic deformity (30%), which may be due to the early diagnosis of spinal TB via MRI, permitting early intervention prior to advanced structural compromise.

The strong correlation between clinical symptoms and MRI findings highlights the importance of early MRI evaluation in patients suspected of spinal tuberculosis. MRI's ability to detect early inflammatory changes, soft tissue involvement, and spinal cord compression makes it indispensable for guiding treatment decisions and preventing irreversible neurological damage. Furthermore, the use of contrast-enhanced MRI sequences significantly improves diagnostic accuracy, particularly in identifying abscesses and delineating the extent of disease.

Limitations although this research illustrates the diagnostic effectiveness of MRI, it has the limitation of a small sample size and single-center study. Larger cohorts with multicenter collaboration are required in future studies to confirm these observations. Longitudinal studies comparing treatment response on MRI could further elucidate the progression and pattern of recovery of the disease.

8. CONCLUSION

Spinal tuberculosis is still a serious clinical problem because of the possibility of serious neurological complications. This article calls attention to MRI as a very useful diagnostic instrument, with high sensitivity in detecting vertebral destruction, epidural abscess formation, and compression of the spinal cord. The concordance between clinical presentation and MRI findings supports its application in early diagnosis and treatment, allowing for early intervention and better patient outcomes.

Conflict of Interest:

The authors declare no conflict of interest regarding the conduct or publication of this study.

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