Original Article

DIAGNOSTIC ACCURACY OF MRI FOR SPINAL TUBERCULOSIS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Spinal tuberculosis (TB) is a serious form of extrapulmonary TB that can cause vertebral destruction, deformity, and neurological complications if diagnosis is delayed. MRI is widely used for its early detection and assessment of spinal and soft-tissue involvement; however, its findings may overlap with other spinal diseases such as pyogenic infection and metastatic disease. Histopathological examination remains the definitive diagnostic standard. This study therefore evaluated the diagnostic accuracy of MRI in detecting spinal tuberculosis using histopathology as the reference standard. To work out how accurate Magnetic Resonance Imaging (MRI) is at detecting spinal tuberculosis, benchmarked against histopathological examination as the definitive reference standard.

Materials and Methods: A Cross-sectional study at the Department of Radiology, Combined Military Hospital (CMH) Quetta, from January 2026 to April 2026 where 185 patients between 18 and 70 years of age with a clinical picture suggestive of spinal tuberculosis were enrolled via non-probability consecutive sampling. Every patient had a standardized spinal MRI, followed by CT-guided vertebral biopsy for histopathological confirmation. Radiologists reporting the MRI scans were kept blinded to the histopathology results so as to limit reporting bias. Diagnostic accuracy parameters — sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy — were worked out along with their 95% confidence intervals.

Results: Participants had a mean age of 39.8 ± 12.4 years, and males made up 60% (n=111) of the sample. Histopathology confirmed spinal tuberculosis in 130 patients (70.3%). MRI returned a sensitivity of 96.2% (95% CI: 91.2–98.8%), specificity of 72.7% (95% CI: 59.0–83.9%), PPV of 89.3% (95% CI: 82.4–93.9%), NPV of 88.9% (95% CI: 75.9–95.8%), and an overall diagnostic accuracy of 89.7% (95% CI: 84.4–93.7%). MRI findings were significantly associated with the histopathological diagnosis (Chi-square = 99.618; $p < 0.001$).

Conclusion: MRI offers high sensitivity and strong overall diagnostic accuracy for spinal tuberculosis in a high-prevalence clinical setting, making it a highly effective first-line imaging option. Even so, histopathological confirmation remains essential for a definitive diagnosis, given MRI's moderate specificity and the imaging overlap it shares with other spinal pathologies such as pyogenic spondylodiscitis and metastatic disease.

Keywords: Spinal tuberculosis; Magnetic resonance imaging; Diagnostic accuracy; Histopathology; Pott disease; Sensitivity and specificity.

INTRODUCTION

Tuberculosis (TB) remains one of the heaviest infectious disease burdens in the world today, striking populations in low- and middle-income countries hardest of all. The World Health Organization's Global Tuberculosis Report 2023 puts the number of new TB cases at roughly 10 million a year worldwide, with Pakistan sitting among the five countries carrying the largest share of that burden[1]. Pulmonary disease accounts for most cases, but extrapulmonary presentations still make up an estimated 15–20% of the total, a reminder of how far Mycobacterium tuberculosis infection can spread beyond the lungs[2].

Skeletal tuberculosis accounts for close to 10% of extrapulmonary cases, and of that group, the spine is involved more often than any other site — roughly half of all musculoskeletal tuberculosis[3]. Spinal

tuberculosis, better known historically as Pott disease after Sir Percivall Pott's 1779 description of the condition, mainly affects the thoracic and lumbar vertebrae. The disease process begins with hematogenous seeding of the vertebral body, usually from a pulmonary source, and progresses to destroy the intervertebral disc and neighbouring vertebrae. Left unchecked, this can end in vertebral collapse, kyphotic deformity, paraspinal abscess, and even paraplegia[4].

What makes spinal tuberculosis so hard to catch early is its quiet, non-specific presentation. Most patients turn up with weeks-to-months of chronic back pain, low-grade fever, unintended weight loss, and night sweats — a picture that overlaps with many other spinal conditions[5]. A smaller group present instead with progressive limb weakness or altered sensation, usually a sign that epidural disease is already advanced. Because the symptoms are so easily mistaken for something else, diagnosis is often delayed, and structural or neurological damage builds up before treatment ever begins.

Laboratory markers such as ESR and CRP can support suspicion but are not specific enough to confirm spinal tuberculosis by themselves. Plain radiographs are readily available but insensitive early on, since a large proportion of bone must be destroyed before changes become visible. CT is better at showing cortical destruction, abscess calcification, and canal compromise, but its soft-tissue contrast still falls short of MRI, and it does not reliably pick up early marrow change or cord signal abnormality[6].

MRI has therefore become the imaging test of choice once spinal tuberculosis is clinically suspected. It offers unmatched soft-tissue contrast, multiplanar views, and no ionizing radiation, letting it pick up vertebral marrow oedema — hypointense on T1, hyperintense on T2/STIR — well before any bony erosion shows up on plain films[7]. It also maps paravertebral and epidural collections, subligamentous spread, and cord involvement in detail, all of which matter for surgical planning and prognosis. International studies have reported MRI sensitivity for spinal tuberculosis of 91–100%, with specificity between 83% and 88%[8-10].

Even so, MRI has real limits here. Spinal TB, pyogenic spondylodiscitis, and spinal metastases can look remarkably similar on imaging, especially early in the disease course. Disc-sparing vertebral involvement, posterior element disease, and epidural soft-tissue collections can all be seen across these conditions, making it difficult to rule out alternatives on imaging alone[11]. This is exactly why histopathological examination of tissue obtained by CT-guided biopsy or open surgical sampling remains the definitive reference standard, since it can demonstrate caseating granulomas, Langhans giant cells, and acid-fast bacilli.

Disease prevalence, local epidemiology, and imaging practice all vary considerably between healthcare settings, so MRI's diagnostic performance for spinal tuberculosis may not match figures from the international literature exactly. Pakistani studies have shown encouraging results, but data from high-prevalence, resource-limited military hospital settings are still scarce. This study was designed to fill that gap — determining the diagnostic accuracy of MRI for spinal tuberculosis, using histopathology as the reference standard, in a high-prevalence population at a tertiary-level military institution.

MATERIALS AND METHODS:.

This cross-sectional study ran at the Department of Radiology, Combined Military Hospital (CMH) Quetta, over a three-month window from January 2026 to April 2026. A total of 185 patients were enrolled using non-probability consecutive sampling. The sample size was worked out on the basis of an anticipated MRI sensitivity of 94%, a 5% margin of error, and a 95% confidence level.

Patients of either gender aged 18 to 70 years with clinical features suggestive of spinal tuberculosis were eligible for inclusion. These features comprised chronic back pain lasting more than six weeks, a raised erythrocyte sedimentation rate (ESR), and constitutional symptoms such as fever, weight loss, or night sweats. Patients were excluded if they had already received anti-tuberculous therapy, had undergone prior spinal surgery, had documented spinal trauma, had a known primary malignancy with potential for spinal metastasis, or had any absolute or relative contraindication to MRI, such as an implanted metallic device or claustrophobia.

All enrolled patients had spinal MRI performed on a 1.5 Tesla scanner, following a standardized protocol of T1-weighted sagittal and axial images, T2-weighted sagittal and axial images, Short Tau

Inversion Recovery (STIR) sequences, and post-contrast T1-weighted fat-suppressed images obtained after intravenous gadolinium-based contrast. Scans were interpreted independently by radiologists with at least five years of subspecialty training in musculoskeletal and spine imaging, all of whom were kept blinded to the histopathological results at the time of reporting.

MRI findings were classified as positive for spinal tuberculosis when two or more of the following features were present: vertebral body hypointensity on T1-weighted images; hyperintensity on T2-weighted and STIR sequences; intervertebral disc involvement; paravertebral or psoas abscess formation; epidural extension of disease; subligamentous spread beneath the anterior or posterior longitudinal ligament; and abnormal post-contrast enhancement of the vertebrae or adjacent soft tissue.

CT-guided vertebral biopsy was carried out in every enrolled patient under strict aseptic conditions by an experienced interventional radiologist, with tissue specimens sent to the Pathology Department for formal histopathological examination. A diagnosis of tuberculosis was confirmed histopathologically through identification of caseating granulomas, Langhans giant cells, and acid-fast bacilli, and this served as the definitive reference standard against which MRI performance was assessed.

Data were entered and analyzed in SPSS version 23.0 (IBM Corporation, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. A Chi-square test was used to evaluate the association between MRI and histopathological findings, with a p-value of ≤0.05 taken as statistically significant. Diagnostic accuracy parameters — sensitivity, specificity, PPV, NPV, and overall accuracy — were calculated from a standard two-by-two contingency table, together with their 95% confidence intervals.

RESULTS

185 patients who met the eligibility criteria were enrolled and analyzed. Participants had a mean age of 39.8 ± 12.4 years, ranging from 18 to 70 years. Males made up 60% of the cohort (n=111), and females the remaining 40% (n=74). Table 1 summarizes these demographic characteristics.

Table 1: ***Demographic Characteristics of Study Participants (n=185)***

Variable	Value
Mean Age (years)	39.8 ± 12.4 (range: 18–70)
Male	111 (60.0%)
Female	74 (40.0%)

Histopathology confirmed spinal tuberculosis in 130 patients (70.3%), which formed the true-positive disease prevalence for this cohort. MRI correctly picked up 125 of these 130 histopathologically positive cases as true positives, while 5 were recorded as false negatives, where MRI did not show the classical features of spinal tuberculosis despite histopathological confirmation. Among the 55 patients in whom histopathology ruled out tuberculosis, MRI correctly classified 40 as true negatives, while the remaining 15 were categorized as false positives on account of MRI findings mistakenly attributed to tuberculosis. Table 2 sets out the full cross-tabulation of MRI results against histopathological findings.

Table 2: ***Cross-Tabulation of MRI Findings Against Histopathology (n=185)***

MRI Result	TB Positive (Histopathology)	TB Negative (Histopathology)	Total
Positive	125 (TP)	15 (FP)	140
Negative	5 (FN)	40 (TN)	45
Total	130	55	185

The diagnostic accuracy parameters calculated for MRI in detecting spinal tuberculosis are set out in Table 3. MRI findings showed a statistically significant association with histopathological diagnosis (Chi-square = 99.618; $p < 0.001$), confirming that the correspondence between the two diagnostic modalities was not due to chance.

Table 3: ***Diagnostic Accuracy Parameters of MRI for Spinal Tuberculosis (n=185)***

Parameter	Value	95% Confidence Interval
Sensitivity	96.2%	91.2–98.8%
Specificity	72.7%	59.0–83.9%
Positive Predictive Value (PPV)	89.3%	82.4–93.9%
Negative Predictive Value (NPV)	88.9%	75.9–95.8%
Overall Accuracy	89.7%	84.4–93.7%

DISCUSSION

Spinal tuberculosis is still a major cause of morbidity and preventable disability in endemic regions, and Pakistan carries a disproportionate share of the global tuberculosis burden. Diagnosing spinal TB calls for a high index of clinical suspicion, backed up by appropriate imaging and ultimately confirmed through tissue examination. Against this backdrop, the present findings reinforce MRI's central role as the first-line imaging investigation for patients with clinically suspected spinal tuberculosis.

MRI in this study returned a sensitivity of 96.2% (95% CI: 91.2–98.8%), sitting at the upper end of what has been reported in the published literature. Earlier work has put MRI sensitivity for spinal tuberculosis anywhere between 91% and 100%[19,21]. The exceptionally high sensitivity seen here reflects MRI's ability to catch early marrow signal changes, subtle disc involvement, and paraspinal soft-tissue abnormality well before bony destruction becomes apparent on plain radiographs or CT. The five false-negative cases in this cohort were most likely early-stage disease with minimal, non-classical marrow signal change — a recognized blind spot for MRI in the detection of nascent tuberculous involvement[19,22].

Specificity in this study came out at 72.7% (95% CI: 59.0–83.9%), somewhat lower than the 83–88% range quoted in certain international series[8-10]. This can largely be put down to the well-known imaging overlap between spinal tuberculosis and other spinal pathologies, in particular pyogenic spondylodiscitis and malignant spinal disease. Pyogenic spondylodiscitis, usually caused by organisms such as Staphylococcus aureus or Gram-negative bacteria, can produce MRI appearances that closely mimic spinal TB, including vertebral body signal abnormality, disc involvement, and paraspinal collections. Metastatic spinal disease, though it often spares the disc, can likewise show marrow replacement, epidural extension, and pathological fracture that simulate tuberculous spondylitis on MRI[3,22]. The 15 false-positive cases in this series most likely reflect exactly these diagnostic pitfalls, which are difficult to avoid in cross-sectional spinal imaging within a clinically heterogeneous population.

The high disease prevalence in this cohort (70.3%) needs to be kept in mind when interpreting the predictive values. The positive predictive value of 89.3% (95% CI: 82.4–93.9%) is shaped substantially by the elevated pretest probability of tuberculosis in this population, given that patients were drawn from a military hospital in Quetta, a high-endemicity region. The PPV would likely be lower were this MRI protocol applied to a population with lower disease prevalence, which underlines the importance of reading diagnostic accuracy figures in light of the specific epidemiological setting they come from.

The high negative predictive value of 88.9% (95% CI: 75.9–95.8%) recorded here carries real practical weight. A negative MRI meaningfully lowers the probability of spinal tuberculosis and can help guide the decision on whether CT-guided biopsy is truly necessary, sparing some patients an invasive procedure where appropriate. That said, given the only moderate specificity demonstrated, a positive MRI result should not on its own be taken as sufficient grounds to start a prolonged course of anti-tuberculous therapy. The lengthy duration of anti-TB treatment, and its potential for hepatotoxicity, peripheral neuropathy, and ocular toxicity, mean microbiological or histopathological confirmation is still required before treatment begins[18,23].

Recent literature backs up these findings. Fayisa et al.[14] and Qi et al.[15] both highlight the diagnostic value of conventional MRI in spinal tuberculosis, particularly for catching disease early, while also flagging novel biomarkers such as serum mannose-binding lectin as a way to build diagnostic confidence. Dahal and Parajuli[16] put together a detailed pictorial review of MRI findings in central nervous system tuberculosis, drawing out the imaging features that help separate tuberculous from non-tuberculous pathology. More advanced MRI techniques — diffusion-weighted imaging (DWI) and MR spectroscopy — have also been proposed to sharpen specificity, as shown by Meier[17] and Liu et al.,[21] who described how perfusion-weighted MRI could support earlier diagnosis of spinal TB.

Kanna et al.[23] validated the high diagnostic accuracy of whole-spine MRI through systematic correlation with histopathology, arriving at findings broadly in line with the present study. Similarly, Khokhar et al.[20] reported comparable MRI

diagnostic accuracy parameters in a Pakistani cohort, lending some regional weight to our results. The overall accuracy of 89.7% (95% CI: 84.4–93.7%) recorded here positions MRI as a highly reliable first-line diagnostic tool for spinal tuberculosis in high-prevalence settings. Its non-invasive nature, freedom from ionizing radiation, and ability to map the full anatomical extent of disease make it especially valuable wherever surgical planning and assessment of neurological risk are required.

This study has a number of limitations worth flagging. First, its single-centre design may limit how well the findings generalize to other institutions with different patient demographics, disease prevalence, or MRI scanner specifications. Second, the high disease prevalence (70.3%) in this cohort may inflate the PPV compared with what would be seen in community-based or lower-prevalence settings. Third, interobserver variability in MRI interpretation was not formally assessed, which is an inherent source of uncertainty in radiological studies of this kind. Finally, advanced MRI techniques such as diffusion-weighted imaging, MR spectroscopy, and dynamic contrast enhancement were not systematically built into the imaging protocol, which may have limited sensitivity for atypical or early-stage cases. Future multicentre, prospective studies incorporating advanced imaging modalities, larger sample sizes, and blinded independent radiological review would help refine these diagnostic performance estimates further for MRI in spinal tuberculosis.

CONCLUSION

MRI shows high sensitivity and strong overall diagnostic accuracy for detecting spinal tuberculosis in a high-prevalence clinical population, establishing its place as the preferred first-line imaging investigation for patients with clinically suspected Pott disease. Its capacity to detect early marrow change, characterize soft-tissue extension, and map the anatomical extent of disease makes it indispensable in both the diagnostic workup and preoperative assessment of spinal tuberculosis. Even so, MRI's moderate specificity and its inability to reliably tell spinal tuberculosis apart from other inflammatory and neoplastic spinal conditions mean histopathological confirmation is still needed before starting definitive anti-tuberculous therapy. Bringing MRI findings together with clinical, laboratory, and microbiological data remains the most robust diagnostic strategy for this patient population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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