CLINICAL AND RADIOLOGICAL CORRELATION OF SPINAL TUBERCULOSIS

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Abstract

Introduction: Spinal tuberculosis (TB) is an extreme kind of extrapulmonary TB, which includes the destruction of the vertebrae and neurological problems, especially in endemic areas such as Pakistan. Clinical and radiological correlation is essential in accurate diagnosis, which is important in effective management.

Objective: To assess the clinical appearance, radiographic evidence, and histopathological correlation of the patients of spinal TB to debilitate accurate manifestation and administration.

Materials and Method: All patients who participated in the cross-sectional study were recruited between April, 2024 and July 2024 at Hayatabad Medical Complex Peshawar, Pakistan. In the study, 72 patients between their 18th and 65th birthday were included with signs and symptoms that showed they were suspected of having spinal TB. MRI/CT imaging, CT-guided biopsies, and clinical assessments were done, and data was analyzed concerning clinical-radiological-histopathological correlation.

Results: The average age was 38.6 years, where 61.1 percent were males. Prevalence was high in back pain (94.4%), paravertebral abscesses (68%), and communis thoracolumbara (58.3%). Histopathological confirmation was realized in 90.3%, and there exists a good correlation between clinical-radiological findings in 81.9% ($p<0.05$).

Conclusion: A combination of clinical, radiological, and histopathological results helps in better diagnosis of the condition in order to intervene early and avoid complications of spinal TB.

Keywords: Spinal tuberculosis, clinico-radiological correlation, Pott's disease, MRI, histopathology, Pakistan.

INTRODUCTION

Spinal tuberculosis (TB) is colloquially referred to as part of Pott's disease or disease, as it has the potential to result in disastrous neurologic and structural complications. Despite the diagnostic facilities and curative methods have improved, the disease still represents a serious challenge, particularly in developing nations, including Pakistan, where tuberculosis has become a form of endemic (1). Spinal TB most commonly targets the anterior regions of the vertebral bodies and can result in a vertebral collapse, kyphotic deformity, and even damage to the nerve systems in case of untimely diagnosis and treatment (2). Although the clinical presentation of the disease is well-documented, with constitutional symptoms such as fever, night sweats, weight loss, and back pain (localized), diagnosis of this disease may be challenging because of its indolent nature as well as indistinct signs and symptoms (3). Therefore, effective management of the disease remains inconceivable without timely and proper diagnosis by means of clinical examination and radiological imaging.

Radiological tests including X-rays, CT scans, and MRI are critical in the diagnosis of spinal TB, particularly in the aspect of matching the clinical presentation with the level of spinal destruction as well as the level of compression of the spinal cord (4). The development of imaging techniques, such as computer-aided diagnostic schemes and deep learning algorithms, improves the accuracy of the diagnosis and reveals even minor alterations, pointing to the presence of tuberculous spondylitis (5). However, there still are difficulties associated with making an ultimate diagnosis, and clinicians tend to use a mixture of imaging, histological confirmation obtained via biopsy, and microbiological cultures to make an adequate diagnosis (1). Histologically, the confirmation with the help of image-guided biopsies is crucial in most situations, especially those with limited resources (1).

Spinal TB treatment involves pharmacological and surgical options of treatment. Antituberculous therapy constitutes the primary treatment, whereas surgery is provided only to patients who have acquired neurological deficits, spine instabilities, or massive deformations (6). Some of the biomarkers and molecular indicators are also now under investigation to increase diagnostic yield and monitor therapeutic response. An example is the immune markers MMP9 and STAT1, which have demonstrated promise of recognizing immune events in response to anti-tuberculosis treatment and can help diagnose the existence of active versus healing disease (7). Moreover, molecular analyses have proved that non-coding RNA like lncRNA NEAT1 is involved in the development of the disease process in spinal TB, suggesting opportunities for diagnostic and treatment investigations (8).

The other important predictor of the progression and outcome of spinal tuberculosis is nutritional status. Poor nutrition/deficiencies, especially in those micronutrients, including vitamin D, are reported to have contributed to the greater risk of tuberculosis infection and worse clinical consequences (9). Preoperative nutritional scores predispose postoperative recovery as well as long-term outcomes, such as the Prognostic Nutritional Index (PNI) and Controlling Nutritional Status (CONUT) scores, which are related to surgical wound healing and overall patient recovery (10). In a country like Pakistan, where socioeconomic inequalities lead to poor access to healthcare and malnutrition, measuring these parameters can be essential in obtaining crucial information on patient prognosis and even customizing an individualized approach to managing a patient.

Biomechanical instability tends to happen frequently in the case of spinal TB because of the loss of vertebral components and the alteration of the spinal structure. The proper definition and identification of instability play an important part in determining surgical intervention (11). There have been encouraging results in the biomechanics of reconstruction, such as anterior column reconstruction with either PEEK or titanium cages (12). However, the selection of an implant material may have implications on such factors as fusion rates or cage subsidence in patients with poor bone quality (12). Serum indicators such as levels of pre-albumin are predictive of wound healing problems in such cases and should be considered before surgery (13).

Spinal pathology evaluations have been highly promoted by the radiological evolution. Bone marrow imaging has specifically been found to be helpful in distinguishing between infectious lesions and neoplastic conditions, thereby aiding in diagnostic clarification (14). Despite the limitations of conventional radiography in detecting early disease, it remains a valuable tool for evaluating

alignment and structural changes in cases of chronic diseases (15). In age-related degenerative and deformity-related disorders of the spine, such as TB, a comprehensive radiographic evaluation of the spine, pelvis, and hips yields important data on surgical planning and surgical outcomes (16). In situations where a traditional diagnostic procedure is unable to provide the final product, metagenomic next-generation sequencing (mNGS) has been known to help detect Mycobacterium tuberculosis DNA in clinical specimens, facilitating its diagnosis when the standard test is unproductive (17).

The determinants in the reconstruction of the spine are bone mineral density and vertebral bone quality. Parameters predicting bone strength, such as Hounsfield units (HU) and dual-energy X-ray absorptiometry (DEXA) scores, are becoming popular in predicting complications, including cage subsidence, that occur after interbody fusion procedures (18). This becomes important, particularly in patients who have undergone long-segment spinal fusion to correct the deformity against tuberculosis (19). In addition to that, the proper range of fusion and fixation is also debatable amongst spine surgeons. According to retrospective clinical studies, the individualized surgical strategy based on the magnitude of vertebral involvement and deformity ought to be recommended as a key to optimal clinical and radiological outcomes (19).

Spinal tuberculosis can be complicated by the multiple clinical manifestations, the problem with its diagnosis, and the ability to have serious complications. It is important to have a clear picture of the disease involving both clinical analysis and radiological and pathological examination that is necessary to effectively diagnose and treat the disease at an appropriate time. In a scenario such as Pakistan, where there is still a high prevalence of TB and health resources are not adequate, it is even more valuable to relate clinical findings with the methods of imaging and histopathology findings to avoid delays in treatment and unavoidable complications. Due to the advent of new diagnostic methods, molecular markers, and refined surgery approaches, it is now easier to treat this troublesome disease, achieve successful patient outcomes, and decrease the disability burden in patients with spinal tuberculosis.

Objective: To assess the radiology and clinical presentation in patients with spinal tuberculosis and the association of clinical presentation, radiology, and histopathological correlation in making clinical and radiological diagnosis and patient management.

MATERIALS AND METHODS
Design: Descriptive cross-sectional study.
Study setting: This was carried out at Hayatabad Medical Complex Peshawar, Pakistan.
Duration: The study was conducted over a six-month period from April, 2024 and July 2024.

Inclusion Criteria: All patients of both genders were included who were aged between 18 and 65 years and presented with clinical or radiological evidence indicating spinal tuberculosis, supported by radiological evidence in the form of MRI findings or a CT scan of the region depicting evidence of tuberculous spondylitis. The study also included patients who gave informed consent and received a second-time confirmation through biopsy or histopathology.

Exclusion Criteria: Patients who had spinal trauma, malignancy or had previously undergone spine surgery, incomplete medical and imaging data, or were known to have immunodeficiency disorders were excluded.

Methods
Clinical examination was done thoroughly in all the patients who matched the inclusion criteria to include examination of symptoms like back pain, neurological deficits, fever, and constitutional signs. Imaging with X-rays, either through MRI or CT scan, was taken to evaluate the involvement of vertebrae, narrowing, and abscess formation in the intervertebral area and compression of the spinal cord. Standardized imaging protocols that followed and interpreted images by independent radiologists to reduce observer bias were done. In cases where radiological findings strongly suggested spinal tuberculosis, a CT-guided or C-arm-assisted biopsy was performed for

histopathological confirmation. Laboratory investigations, including ESR, CRP, and complete blood count, were also documented. Data on radiological features were compared with clinical and pathological findings to evaluate the correlation. Ethical approval was obtained from the institutional review board of JPMC, and informed consent was taken from all patients. All collected data were entered into a structured database and analyzed statistically to assess the strength of the correlation between clinical, radiological, and histological findings.

RESULTS

A total of 72 patients were enrolled in this study. The mean age of the participants was 38.6 ± 12.7 years, with the age range between 18 and 65 years. The majority of patients were male (n=44, 61.1%), and the remaining were female (n=28, 38.9%). Most patients presented with a primary complaint of back pain (n=68, 94.4%), followed by constitutional symptoms such as fever (n=42, 58.3%) and weight loss (n=35, 48.6%). Neurological deficits were observed in 27 patients (37.5%).

Table 1: Demographic and Clinical Characteristics of Patients (n=72)

Variable	Frequency (%)
Age (mean ± SD)	38.6 ± 12.7 years
Gender	
- Male	44 (61.1%)
- Female	28 (38.9%)
Presenting Symptoms	
- Back Pain	68 (94.4%)
- Fever	42 (58.3%)
- Weight Loss	35 (48.6%)
- Neurological Deficits	27 (37.5%)

Radiological findings revealed that the most commonly involved spinal region was the thoracolumbar junction (T10–L2), accounting for 42 cases (58.3%), followed by lumbar (n=16, 22.2%), thoracic (n=10, 13.9%), and cervical regions (n=4, 5.6%). Paravertebral abscesses were seen in 49 cases (68%), while vertebral collapse was evident in 32 cases (44.4%). Epidural extension was present in 39 patients (54.2%).

Table 2: Radiological Findings in Spinal TB (n=72)

Radiological Feature	Frequency (%)
Involved Region	
- Cervical	4 (5.6%)
- Thoracic	10 (13.9%)
- Thoracolumbar Junction	42 (58.3%)
- Lumbar	16 (22.2%)
Paravertebral Abscess	49 (68%)
Vertebral Collapse	32 (44.4%)
Epidural Involvement	39 (54.2%)

Histopathological confirmation was achieved in 65 out of 72 patients (90.3%) who underwent biopsy. The remaining 7 patients showed strong radiological and clinical suspicion but could not be confirmed due to inadequate sample or refusal for biopsy. A strong clinical-radiological correlation was found in 59 cases (81.9%), while moderate correlation was seen in 9 cases (12.5%), and poor correlation in 4 cases (5.6%).

### Table 3: Clinical-Radiological-Histopathological Correlation (n=72)

Correlation Strength	Frequency (%)
Strong	59 (81.9%)
Moderate	9 (12.5%)
Poor	4 (5.6%)

The mean ESR was elevated at 62.4 mm/hr, and CRP was positive in 66 cases (91.7%). These markers showed significant association with radiological severity, especially in patients with epidural extension and vertebral collapse.

Table 4: Laboratory Markers in Relation to Radiological Severity

Radiological Severity	Mean ESR (mm/hr)	CRP Positive (%)
With Epidural Extension	72.8	38 (97.4%)
Without Epidural Extension	48.3	28 (82.3%)
With Vertebral Collapse	76.2	30 (93.7%)
Without Vertebral Collapse	51.7	36 (88.2%)

The correlation between clinical presentation, radiological evidence, and histopathological confirmation was statistically significant ($p < 0.05$), suggesting high diagnostic accuracy when combining clinical and imaging parameters.

Graph 1: Distribution of Spinal Involvement by Region
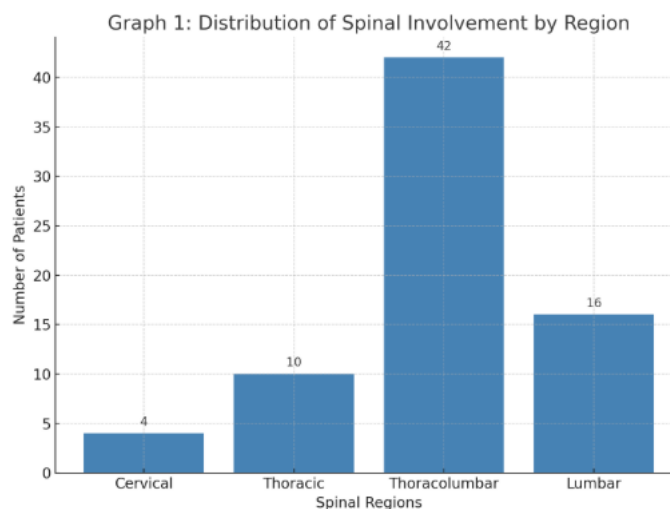
This analysis emphasizes that the thoracolumbar region is the most affected area in spinal tuberculosis and that radiological features like abscess formation and vertebral collapse strongly correlate with clinical severity. The combination of imaging with clinical and laboratory diagnosis guarantees the improvement of diagnostic accuracy and prompt treatment.

DISCUSSION

Pott disease, or spinal tuberculosis, continues to be a serious health problem to society in third-world countries such as Pakistan, where tuberculosis is an epidemic. The aim of the study was to analyze the clinical, radiological, and histopathological aspects of the patients who were found to have spinal TB in one of the tertiary care hospitals in Pakistan. The results of this study add to a better comprehension of the manifestation of this disease and emphasize the significance of compound diagnostic criteria. The average age of the patients within the study was 38.6 years, matching the

available literature on this topic, according to which spinal TB is a phenomenon that occurs in young to middle-aged adults at the stage of their most economically active years.

The prevalence of males (61.1%) observed in the study is also analogous with multiple reports that there can be a gender-based variation in exposure, occupation, and health-seeking behavior. The most harmful presenting symptom was back pain, occurring in 94.4 percent of the patients. This is in line with the described insidious progression of TB of the spine, in which pain is usually localized and gradual. Constitutional symptoms were also prevalent in the form of fever and weight loss, which are the consequences of the systemic inflammatory response to TB infections. One-third of all the patients had neurological deficits, depicting the level of spinal involvement and the possibility of developing long-term morbidity in the absence of early therapy. This rate can be compared to those conducted in similar resource-poor environments where late diagnosis frequently leads to subsequent neurological issues.

Radiologically, the thoracolumbar junction (T10–L2) was the most commonly affected region in our study, followed by the lumbar and thoracic areas. This finding is supported by various studies that suggest this junction is particularly vulnerable due to the mechanical stress and anatomical transition between the thoracic and lumbar spine. The cervical spine was least affected, which is in line with the global data showing lower incidence of TB in this region. Paravertebral abscess formation, seen in 68% of patients, is a hallmark of spinal TB and serves as a key radiological indicator. The presence of vertebral collapse in nearly half of the patients (44.4%) and epidural involvement in more than half (54.2%) further emphasizes the destructive potential of the disease when diagnosis is delayed. These findings correlate with studies from India and Bangladesh, where similar imaging characteristics are used for early suspicion and diagnosis.

Histopathological confirmation was achieved in 90.3% of patients, indicating that tissue diagnosis remains a reliable tool when samples are adequate. The presence of caseating granulomas with Langhans giant cells was the most definitive diagnostic feature. However, in a small percentage of cases (9.7%), diagnosis was based solely on clinical and radiological suspicion due to poor biopsy yield or patient refusal. This draws attention to the necessity of non-invasive but sensitive diagnostic modalities, especially in resource-deficient situations. In more than 80 percent of the cases, this correlation was strong with regard to clinical-radiological correlation. This observation is supportive of the increased use of MRI to diagnose spinal TB. MRI can especially find early marrow edema, disc involvement, and soft tissue extension, which cannot be clearly seen in plain radiographs or even CT scans.

Moreover, MRI is used in helping to distinguish TB spinal pathology from the other two potential spinal etiologies presenting different clinical presentations but requiring a completely different management approach, including metastatic tumor or pyogenic spondylitis. In most patients, there were increased levels of inflammatory indicators like ESR and CRP that were significantly related to the radiological severity. Epidural involvement and vertebral collapse of patients were also distinguished by significantly increased levels of ESR and, more frequently, with positive CRP. This reaffirms the utility of these markers as well as being used in the process of diagnosis, disease progression, and response to therapy. The paper also features the issue of early diagnosis in low-income environments. Patients arrive late in the disease, and they have often received several weeks or months of symptomatic treatment of back pain.

Their delay in the diagnosis is multifactorial, including the absence of awareness, insufficient access to diagnostic centers, and the ability of TB to simulate the effects of other diseases of the spine. Such delay makes it an enormous risk of complications, including spinal deformity and permanent neurologic loss. In addition, the integration of histopathology, radiology, and clinical data leads to increased accuracy of diagnosis. The multidisciplinary approach ought to be promoted in the clinical practice. Despite the fact that biopsy is the gold standard, it is generally restricted due to availability or constraints on resources. Consequently, the combination of characteristic imaging findings and clinical presentation can be indicative of starting empirical anti-tubercular therapy (ATT), particularly in endemic areas where tissue diagnosis is not possible.

This study was able to validate much of the already available body of knowledge, reassuring that spinal TB in Pakistan conforms to the patterns of the world with respect to clinical presentation and the radiological manifestation of the disease. Nevertheless, certain disparities might occur because of socioeconomic factors, access to health care, and health education. This is because the study had a high rate of histopathological confirmation, which may or may not be reproducible within rural or periphery health institutions where biopsy is not easily accessible. A shortcoming of this study is that it was carried out in one facility, which can limit the applicability of the results to the total population. Besides, no conclusions may be drawn regarding treatment outcomes or recurrence rates due to the absence of long-term follow-up data. Nonetheless, the data presents a lot of useful information that can inform research and other policies on TB spine management in Pakistan in the future.

CONCLUSION
The paper identifies clinical, radiological, and histopathologic features of spinal tuberculosis in patients of a tertiary care hospital in Pakistan. The results confirm again that spinal TB is usually seen in young to middle-aged adults, with back pain as the most common symptom. The radiological investigations, especially MRI, were very useful in determining the typical clinical manifestations of paravertebral abscesses, the collapse of vertebrae, and the epidural area. The biopsy histopathological confirmation had a very great rate of diagnostic accuracy, which is only important in definitive diagnosis. The very close linkage among clinical, radiological, and histopathological findings favors the application of a multidisciplinary approach in early and accurate diagnosis. It is always important to have early detection, which will help avoid neurological complications and future disability. In the resource-limited context, further contribution of increased awareness, access to sophisticated imaging, and laboratory backup are essential because of diagnostic difficulties. The research also determines the necessity of early assessment and thorough review to enhance patient outcomes and limit the load of spinal TB in endemic areas.

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