Indian Journal of
Applied Radiology

Open Science Publications

Volume 10, Issue 1 - 2024

www.opensciencepublications.com

The Role of Magnetic Resonance Imaging in the Evaluation of Tubercular Spondylitis

Research Article

Ahmad F[1], Kataria B*[2] and Anil Taneja[3]

[1]*Department of Radio diagnosis, Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Manohar Lohia Hospital, New Delhi, India.*

[2]*Senior Resident, Department of Radio diagnosis, Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Manohar Lohia Hospital, New Delhi, India.*

[3]*Department of Radio diagnosis, Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Manohar Lohia Hospital, New Delhi, India*

***Corresponding author:** Bhavya Kataria, Department of Radio diagnosis, Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Manohar Lohia Hospital, New Delhi, India. Email Id: nono_5333@yahoo.co.in

Article Information: **Submission: 08/08/2024; Accepted: 26/09/2024; Published: 30/09/2024**

Abstract

Background: Tuberculous spondylitis [TS], also known as Pott disease, affects the spine and can cause severe damage if not diagnosed early. In countries like India, TS is a major health concern due to its high prevalence.

Purpose: The study aimed to determine the role of Magnetic Resonance Imaging [MRI] in evaluating TS and compare the diagnosis with X-ray for evaluating the TS manifestations.

Materials and Methods: A cross-sectional observational study was conducted at Department of Radio Diagnosis at ABVIMS and Dr. RML Hospital, New Delhi, enrolling 106 subjects who presented TS. The subjects were clinically and biochemically evaluated for TS, followed by radiological and MRI assessments.

Results: The most common symptom was insidious onset backache, observed in >90% of cases. Elevated ESR and CRP levels were found in about ~74% of subjects and a positive Mantoux test in 67.9%. Reduced vertebral body height was seen in >85% of cases, irrespective of their gender. Para-vertebral calcification and loss of Psoas shadow were observed in only 12% and 16% of subjects, respectively. Epidural collection was more common in females than males [29.3% vs. 64.6%], and intra-medullary collections were rare [1.9%]. X-ray imaging was highly sensitive [100%] and specific [100%] in identifying the reduction in vertebral body height, vertebral body collapse, and para vertebral calcification to MRI.

Conclusion: Although MRI is the preferred method for accurate diagnosis and management of TS, X-ray can serve as a cost-effective alternative for early detection in developing countries such as India.

Keywords: Magnetic resonance imaging; X-ray; tuberculosis; Spondylitis; India; Back Pain

ISSN: 2581-3919

Introduction

Tuberculous spondylitis, also referred to as Pott disease, is a type of tuberculosis that predominantly impacts the spinal column. Tuberculosis (TB) is caused by Mycobacterium tuberculosis and primarily affects the lungs. However, it can also spread to other parts of the body, such as the spine [1]. Globally the incidence of extra pulmonary tuberculosis has been reported to be 3%, of which skeletal tuberculosis accounts for~10% cases. Incidentally, being the most common, TS cases constitute 50% alone of all skeletal cases [2-4]. Of late, owing to the 'global migration phenomenon' and the emergence of multidrug-resistant strains of *Mycobacteriumtuberculosis,* TS has seen a gradual increase in its pervasiveness in the developed countries posing a significant global health challenge. Based on world health organization reports, the Southeast Asian region contributed nearly 50% of tuberculosis cases and India alone contributes about 23% of the global burden of the disease [3, 5, 6].

While *Mycobacteriumtuberculosis* primarily affects the lungs, spinal infection is always secondary and is caused by hematogenous spread from the primary site[7]. There are several clinical manifestations of spinal TS, and the disease progresses very slowly [8, 9]. The severity of TS is modulated by its location, duration, and the existence of sequelae such as abscesses, sinuses, deformity, and neurological issues. Moreover, from the onset of symptoms, the diagnostic window can last anywhere between two weeks and many years [1, 10, 11]. TS symptoms can exhibit a range of variations, typically encompassing back pain, stiffness, and a progressive decline in spinal mobility. As the disease advances, it may result in spinal deformities, including kyphosis. In more severe instances, compression of the spinal cord or nerve roots can occur, leading to the manifestation of neurological impairments like weakness, numbness, or paralysis. The presence of granulomatous inflammation, accompanied by lymphocytic infiltration and the appearance of epithelioid cells, is a defining feature of tuberculosis. This can result in the development of Langhans-type giant cells, the formation of caseating necrosis in affected tissues, and the occurrence of cold abscesses. [10, 12].

The diagnosis of TS involves a combination and correlations of clinical evaluation, laboratory tests, and imaging studies. A physical examination might help assess neurological deficits, spinal deformities, or tenderness. While as spinal X-rays can reveal recognizable alterations such as vertebral body collapse or disintegration, the creation of bone debris, and spinal abnormalities in the later stages of the disease. However, plain radiographs are poor in the early diagnosis of TS but are useful in assessing coronal and sagittal alignment [3]. Given its ability to detect the earliest alterations, MRI has become the imaging approach of choice for detecting TS [13]. MRI scans of the spine produce precise pictures that make it possible to assess the afflicted vertebral bodies, spinal cord, and encircling tissues [14]. It can be useful in determining the disease's severity, the compression of the spinal cord, and the existence of abscesses.

India is a diverse country that contributed significantly to the global tuberculosis burden [15]. The TS is one of the significant contributors to the resurgence of TB in India. The access to high throughput diagnostic tests like CT MRI to a significant proportion of the population is limited [16]. Moreover, there is a paucity of studies related to MRI evaluation of TS. Therefore, the current study aimed to determine the role of MRI in the evaluation of TS and compared the diagnostic efficacy of MRI and X-ray in evaluating the manifestations associated with TS.

Methods

This cross-sectional observational study was conducted at ABVIMS and Dr. RML Hospital in New Delhi from January 2021 to May 2022. The study included all patients who were referred for MRI evaluation due to clinical suspicion of TS, based on their clinical, laboratory, or X-ray findings. Nevertheless, individuals who had certain conditions or circumstances that made them unsuitable candidates for MRI were not included in the study. These included individuals with cardiac pacemakers, cochlear implants, orthopaedic metallic implants, metal dental implants, magnetic foreign bodies, claustrophobia, or those who declined to participate. Each patient underwent imaging procedures to capture detailed images of the involved spine. This included anterior to posterior and lateral radiographs, as well as MR images using conventional MR sequences. The MR images were taken at 3.0 T MRI and included T1 weighed, T2 weighed, and STIR sagittal sequences, as well as T1/T2 axial sequences. Additionally, post-contrast T1 fat suppressed sagittal and axial sequences were obtained. These imaging procedures were performed by trained radiographers/technicians at the institute. The imaging findings were compared to the results of clinical and laboratory investigations, such as the erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), Mantoux test, and X-ray findings. Prior to their participation in the study, all patients provided informed written consent. The study underwent a thorough review and received approval from the institutional ethics committee. The X-ray and MR imaging procedures were conducted using the Siemens MULTIX Intact fixed X-Ray Machine and Siemens 3T Magnetom Skyra, both of which are manufactured in India.

Statistical analysis

The data were entered in Microsoft Excel and then analyzed and statistically evaluated using GraphPad Prism [version 8.0.0 for Windows, CA, USA]. Continuous data were expressed by mean and standard deviation while categorical data was presented in percentage. The sensitivity and specificity of radiological findings in detecting the manifestations of TS were estimated while taking MRI as a reference. A two-tailed p-value of the magnitude of <0.05 was considered statistically significant.

Results

A total of 106 subjects who presented TS were recruited in the current study. The mean age ±SD of all the subjects was 29.9±15.1 years. The demographic, clinical, and biochemical profiles of the subjects recruited in the current study are presented in [Table 1].

We observed a marginal overrepresentation of females over males [ratio: 1.2:1] who presented TS in our cohort with the majority of them working as labourers [27.1%]. The disease was more pervasive among students as well [37%]. More number of cases were in the age group of 19-60 years in both genders. The insidious onset and backache were

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Table 1: Demographic, clinical, and biochemical profile of the subjects with tuberculous spondylitis recruited in the current study stratified by gender

Feature N=016	Frequency Total N (%)	Frequency N (%)	
		Males	Females
Gender	106 (100)	48 (45.3)	58 (54.7)
Age category (in years)			
≤18	28 (26.4)	14 (29.2)	14 (24.1)
19 – 30	37 (34.1)	15 (31.2)	22 (37.9)
31 – 60	36 (33.9)	15 (31.2)	21 (36.2)
≥61	5 (4.7)	4 (8.3)	1 (1.7)
Occupation			
Labourer	17 (16.0)	13 (27.1)	4 (6.9)
Students	39 (36.8)	16 (33.3)	23 (39.7)
Shopkeeper	8 (7.5)	8 (16.70	0 (0)
Housewife	29 (27.4)	0 (0)	29 (50.0)
Healthcare personnel	6 (5.7)	5 (10.42)	1 (1.7)
Unemployed	7 (6.6)	6 (12.5)	1 (1.7)
Clinical profile			
Insidious onset	96 (90.6)	42 (87.5)	54 (93.1)
Fever	78 (73.6)	35 (72.9)	43 (74.1)
Backache	102 (96.2)	46 (95.8)	56 (96.6)
Weight loss	83 (78.3)	36 (75.0)	47 (81.0)
Bladder and bowel involvement	56 (52.8)	28 (58.3)	28 (48.3)
Neurological complaints(other than bladder, bowel)	65 (61.3)	27 (56.3)	38 (65.5)
ESR			
Normal	28 (26.4)	13 (27.1)	15 (25.9)
Raised	78 (73.6)	35 (72.9)	43 (74.1)
CRP			
Normal	28 (26.4)	13 (27.1)	15 (25.9)
Raised	78 (73.6)	35 (72.9)	43 (74.1)
Mantoux			
Negative	34 (32.1)	15 (31.2)	19 (32.8)
Positive	72 (67.9)	33 (68.8)	39 (67.2)
Disease			
Pulmonary tuberculosis	14 (13.2)	4 (8.3)	10 (17.2)
Intracranial involvement	7 (6.6)	3 (6.3)	4 (6.9)

the most common symptom in nearly all the subjects [>90%] while as bladder and bowel involvement was reported by 52.8% of subjects. The ESR and CRP were raised in 73.6% of subjects and the elevation was independent of the gender. A positive Mantoux tuberculin test was reported by 67.9% of subjects while pulmonary tuberculosis and inter-cranial involvement was reported in 13% and 75% of subjects respectively. Upon radiological assessment, reduced vertebral body height was seen in most of the patients [>85%] irrespective of their gender. The para-vertebral calcification and loss of Pso as shadow were seen in only 12% and 16% of subjects respectively. Unlike cranio vertebral junction [CVJ] [5.7%], the dorsal [61.3%] and lumber vertebrae [51.9%] were common sites involved. Most of the subjects were found to have 2-4 vertebrae involved while 22% of subjects had more than 6 vertebrae involved with TS [Table 1]. When the patients were subjected to MRI, a reduction in the height of the vertebral body was more than 85% of subjects in both genders, followed by pre/para vertebral collection [84%] and Spinal Cord/ nerve root compression[82%]. While epidural collection was more common in females than males [29.3% vs. 64.6%], intra-medullary collection was the least common finding [1.9%] seen in our cohort [Table 2].

Table 2: X-ray and MRI findings of the subjects with tuberculous spondylitis stratified by gender

Findings N=106	Frequency Total n (%)	Frequency n (%)	
		Males (n=48)	Females (n=58)
X-ray radiograph findings			
Reduced vertebral body height	91 (85.8)	41 (85.4)	50 (86.2)
I.V. disc Space Reduction	49 (46.2)	20 (41.7)	29 (50.0)
Vertebral body collapse	65 (61.3)	27 (56.3)	38 (65.5)
Para-vertebral Calcification	13 (12.3)	6 (12.6)	7 (12.1)
Bulging of para spinallines	68 (64.2)	35 (72.9)	33 (56.9)
Loss of Psoas shadow	17 (16.0)	6 (12.5)	11 (18.9)
Site Involved			
Cervical	26 (24.5)	11 (22.9)	15 (25.9)
Dorsal	65 (61.3)	31 (64.6)	34 (58.6)
Lumbar	55 (51.9)	29 (60.4)	26 (44.8)
Sacral	15 (14.2)	5 (10.4)	10 (17.2)
CVJ	6 (5.7)	2 (4.2)	4 (6.9)
Number of vertebrae involved			
1	7 (6.6)	3 (6.3)	4 (6.9)
2	33 (31.1)	15 (31.5)	18 (31.0)
3	21 (19.8)	7 (14.6)	14 (24.1)
4	14 (13.2)	10 (20.8)	4 (6.9)
5	9 (8.5)	3 (6.3)	10 (6.3)
≥6	22 (20.7)	10 (20.8)	12 (20.7)
FindingsonMRI			
Reduction in height of the vertebral body	91 (85.8)	41 (85.4)	50 (86.2)
Contiguous involvement of>2 vertebrae	76 (71.7)	38 (79.2)	38 (65.5)
Intra-osseous collection invertebrae	29 (27.4)	11 (22.9)	18 (31.0)
Intervertebral disc involvement	65 (61.3)	30 (62.5)	35 (60.3)
Wedge collapse/Destruction of the vertebral body	65 (61.3)	27 (56.3)	38 (65.5)
Posteriorelements involvement	58 (54.7)	30 (62.5)	28 (48.3)
Pre&para vertebral collection	90 (84.9)	43 (89.6)	47 (81.0)
Epidural collection	48 (45.3)	31 (64.6)	17 (29.3)
Intra-dural collection	2 (1.9)	0 (0.0)	2 (3.4)
Intra-medullary collection	2 (1.9)	1 (2.1)	1 (1.7)
Sub ligamentous Extension	64 (60.4)	30 (62.5)	34 (58.6)
Spinal Cord/nerver root compression	87 (82.1)	39 (81.2)	48 (82.8)
Kyphosis	56 (52.8)	23 (47.9)	33 (56.9)

The representative X-ray radiographs and MR images depicting various manifestations of TS are presented in (Figure 1), (Figure 2) and (Figure 3).

Upon assessing the sensitivity and specificity of the X-ray *vs.* MRI in determining various manifestations associated with TS, we observed that both approaches were highly sensitive and specific in identifying the reduction in vertebral body height and vertebral body collapse. Nonetheless, we observed that X-ray imaging was specific enough to identify inter-vertebral space reduction, [sensitivity: 75%; specificity 100%], disc involvement vertebral body collapse [sensitivity: 74%; specificity 100%] and loss of Psoas shadow [Table 3]. Both positive and negative predictive values were high for all the parameters evaluated.

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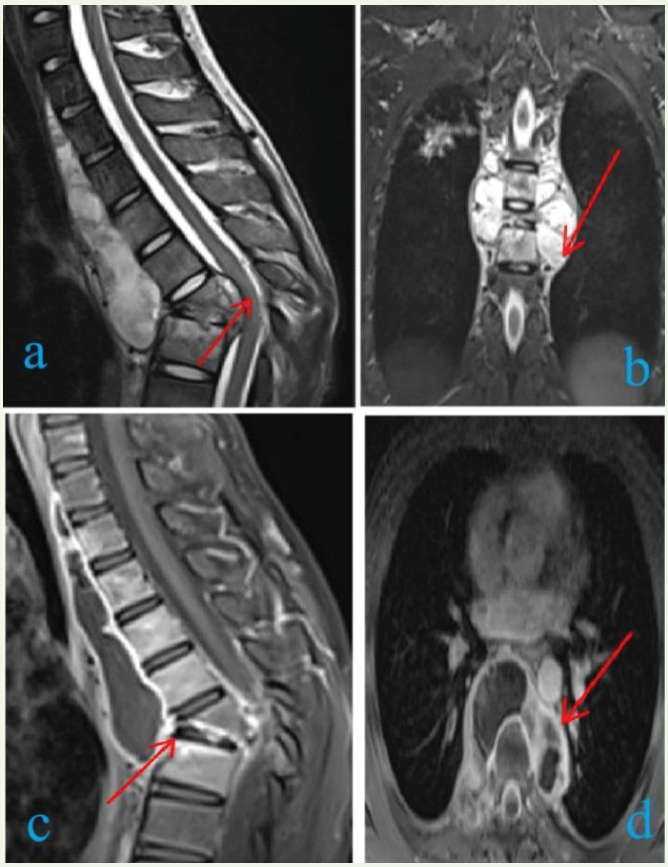

Figure 1: [a-d].Spinal tuberculosis with pulmonary involvement, [a]: MR sagittal T2WI, [b]: coronal T2W TIRM:turbo inversion recovery [c]: sagittal T1W FS post contrast, and [d] axial T1W FS post contrast images show T2/TIRM hyperintense pre and paravertebral collections showing subligamentous spread extending from D1 to D7 vertebrae with contiguous involvement of vertebral bodies. Angular kyphosis is noted at D5- D7 vertebral level with anterior wedge collapse of D6 vertebral body with compressive myelopathy at this level. Tuberculous infiltrate in the right upper lobe is identified.

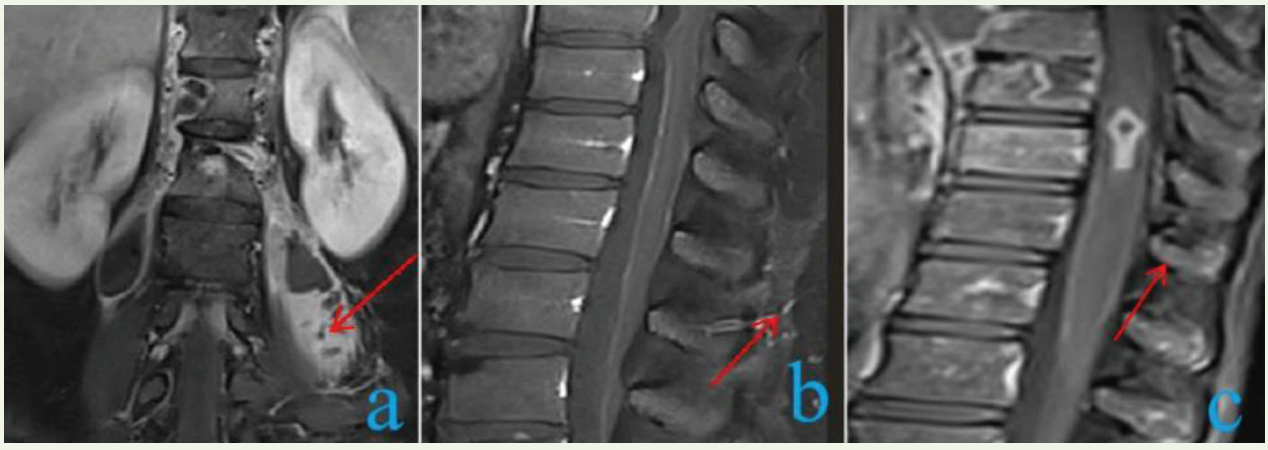

Figure 2: [a-c] MR Images of patients with spinal tuberculosis. [a]: MR coronal T1W FS post gadolinium image shows peripherally enhancing bilateral psoas muscle abscesses with heterogeneous enhancement of visualized vertebral bodies in a patient of tuberculous spondylitis. [b]: In a patient of tuberculous spondylitis, MR sagittal T1W FS post contrast image shows leptomeningeal enhancement of the spinal cord. [c]: MR Sagittal T1W FS post contrast shows intramedullary ring enhancing lesion within the central cord at D9-D10 intervertebral disc level with enhancement of the vertebral bodies and associated pre and paravertebral collections.

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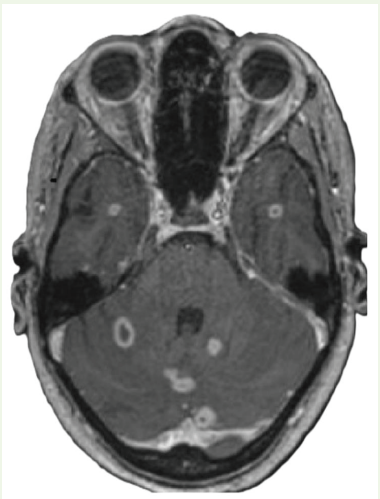

Figure 3: Brain Axial T1W FS post contrast image shows multiple, discrete as well as conglomerated ring enhancing lesions in cerebral and cerebellar parenchyma suggestive of tuberculomas.

Table 3: Sensitivity and specificity of the X-ray and MRI in determining various manifestations associated with tuberculous spondylitis.

Radiological findings	Plain Radiography Findings N (%)	MRI Findings N (%)	Sensitivity (%) Specificity (%) PPV (%) NPV (%) with 95% CI
Reduced vertebralbodyheight	91(85.8%)	91(85.8%)	100 (96.0 – 100) 100 (96.0 – 100) 100 (96.0 – 100) -
I.V. disc Spacereduction/ Discinvolvement	49 (46.2%)	65(61.3%)	75.4 (63.1 – 85.2) 100 (91.4 – 100) 100 (92.7 – 100) 71.9 (58.5 – 83.0)
Vertebral bodycollapse	65 (61.3%)	65(61.3%)	100 (94.4 – 100) 100 (91.5 – 100) 100 (94.4 – 100) 100 (91.5 – 100)
Para-vertebralCalcification	13 (12.3%)	---	-
Bulging ofparaspinallines	68 (64.2%)	90(84.9%)	75.6 (65.4 – 84.0) 100 (79.4 – 100) 100 (94.7 – 100) 42.1 (26.3 – 59.2)
Loss of Psoas shadow	17(16.0%)	23(21.7%)	73.9 (51.6 – 89.8) 100 (95.6 – 100) 100 (80.5 – 100) 93.3 (85.9 – 97.9)

Discussion

In this study, a group of 106 individuals with TS were selected to examine the effectiveness of MRI in assessing TS. It is evident that MRI is the preferred diagnostic tool for evaluating patients with TS due to its numerous benefits in accurately assessing the extent and seriousness of the condition. Nevertheless, despite some limitations, X-Ray remains a cost-effective diagnostic tool that is readily accessible to patients who lack access to more advanced imaging techniques such as MRI, particularly in developing nations like India.

The studies evaluating the pervasiveness of TS among men and women have shown mixed results. Some studies have seen men to be more susceptible to TS [17, 18], while others have observed females to be more vulnerable to TS [19]. However, some reports did not find any significant predilection for any of the genders towards TS [20-22]. In the current study, we also observed a marginal overrepresentation of females presenting TS. Similar to our results a large recent study also observed that although men are more susceptible to tuberculosis in general, women are more affected with TS [23]. However, the role of gender in determining TS susceptibility is not clear yet and warrants further investigation.

The mean age of the patients in our cohort was 30 years, suggesting that TS can affect young subjects as well. An earlier study from India reported a mean age in their cohort to be 40 years [24]. However, this earlier study was based on a smaller sample size than ours, suggesting more replicative studies should be carried out to have a conclusive understanding on the issue. Besides, in our study, we observed that most of the patients were in the age group of 19-60 years in both genders. Earlier studies have also reported a similar trend in the age of their patient cohorts [24, 25]. Shi *et al* and Yuan *et al* in their recent large study also found a higher representation of this age group with TS [26, 27]. However, reports show older patients are more susceptible to TS [28]. Given this heterogeneity in results, it is likely that TS can affect all age groups. Moreover, in our study, we found that students, housewives, and labourers were the most affected groups with TS, suggesting that the country's economically productive age group can also be vulnerable. Besides the pervasiveness of TS among students in our cohort is an uncommon finding and needs to be replicated and evaluated in future studies.

Unlike pulmonary tuberculosis, the progression of TS is slow and insidious with the former often accompanied by sputum, fever, or night sweating and is often non-specific. But the most common symptom of TS is back pain, typically localized to the site of involvement and usually in the thoracic region [29], leading to misdiagnosis till a later stage of the disease. Similar to earlier reports the clinical pattern of the disease onset and symptoms reported in this study is not an uncommon finding [25, 26, 29].

In TS, a relatively early and subtle sign, reduction in vertebral height is often observed along with the irregularity of the antero superior endplate. Moreover, a classical appearance with TS,some irregularity of the anterior vertebral margin is also noticed due to the sub ligamentous extension. In line with several other studies, we also observed the involvement of the intervertebral disc in most of the cases both on MRI and X-ray investigations [30].Upon radiological examination, we observed the presence of paraspinal abscesses in a sizable portion of subjects while the frequency was higher upon MRI. Given the lack of proteolytic enzymes in M. *tuberculosis* [29], calcification,a diagnostic indicator of TS, is also seen in vertebral regions [8]. Of a smaller subset of subjects in our study presented para vertebral calcification. These observations are not uncommon findings and have been reported earlier as well [8].

The TS initially appears in the anterior inferior portion of the vertebral body followed by its spread into the central part of the body or disk [29]. Similar to earlier reports, in our study we observed that

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the involvement of dorsal vertebrae was maximum and CVJ was least involved [31]. However, Batirel *et al* [**17**] found the lumbar region as the most affected region in their study [32]. Moreover, we observed that 2 vertebrae were involved in more subjects than a single vertebral involvement, an atypical presentation of the TS, was seen in few patients. The likely plausible explanation for the latter is that all these cases were subjected to an early MRI examination and that infection had not spread sub ligamentously to the neighboring vertebrae.

Given its advantages, MRI reveals key manifestations associated with TS such as epidural collection, arachnoiditis, spinal cord compression/canal stenosis, and cord edema that are crucial for determining the therapeutic intervention and prognosis in the future. In our patients,MRI revealed disc involvement, paravertebral abscess and its extent, and psoas involvement in a significant number of patients with a better contrast than on an X-ray radiograph. Our results for these observations are in agreement with the published literature [30, 33]. Moreover, like earlier reports, in the current study,we did not observe any isolated involvement of posterior elements in any of the cases [34].

On evaluating the sensitivity and specificity of X-ray vs. MRI, we observed that the former has reasonable sensitivity and specificity for detecting various manifestations of TS. Our results show a reasonably high sensitivity and specificity that reported by Bansal *et al* [24]. In contrast to our study, the previous research was conducted with a smaller sample size. Without a doubt, the benefits of MRI in visualizing bone involvement and related complications such as nerve root compression, cord edema, pre- and paravertebral, and epidural abscesses, make it the preferred imaging technique. Nevertheless, India is a country of great diversity, with a significant portion of its population living in rural areas where access to modern healthcare facilities is limited. In addition, India plays a significant role in the global burden of tuberculosis. Based on our research findings, it is recommended to utilize X-ray radiography as the primary method for early detection in individuals with TS. In addition, the effectiveness of anti-tubercular therapy [the radiographic findings post ATT] on these patients can be assessed by examining X-ray results. If necessary, patients can be referred to tertiary care hospitals for optimal disease management. However, MRI plays a vital role in evaluating the effectiveness of a treatment by analyzing the results of previous post-contrast studies and assessing factors such as the resolution of abscesses and the decrease in enhancement of vertebral body and inter vertebral discs.

The primary imaging modality utilized for diagnosing the condition remains a conventional X-ray radiograph. This investigation is both cost-effective and easily accessible. Calcification is a critical diagnostic characteristic of the disease and plays a significant role in plain X-ray radiographs. Nevertheless, plain radiography does have some limitations, such as its inability to detect certain early-stage diseases and conditions like cord edema, small prevertebral and paravertebral collections, and arachnoiditis.

Conclusion

The study findings indicate that MRI is the recommended and cost-effective method for accurately diagnosing and treating TS. However, in developing countries such as India, X-ray can also be a reliable and accurate method for early detection of TS. Further research is needed to validate our findings through additional studies with a larger sample size.

Limitations

The study was conducted at a tertiary referral center, suggesting that patients with advanced stages of the disease may have been more prominent than those with early presentations. However, this is not expected to have influenced the study's findings. In addition, the study may also raise concerns about the smaller sample size.

Ethics Approval Statement

The present cross-sectional observational study was conducted between January 2021 to May 2022 at the Department of Radio Diagnosis at ABVIMS and RML Hospital, New Delhi. Informed written consent was taken from all the patients before being enrolled in the study. The study was reviewed and approved by the institutional ethics committee.

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Citation: Ahmad F, Kataria B, Taneja A. The Role of Magnetic Resonance Imaging in the Evaluation of Tubercular Spondylitis. Indian J Appl Radiol. 2024;10(1): 201.