

Novel magnetic resonance imaging scoring system for diagnosis of spinal tuberculosis: A preliminary report

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ABSTRACT

Background: There exists a lot of ambiguity in the preoperative diagnosis of the various vertebral lesions. Mostly in these patients tuberculosis of spine (TB) is suspected due to endemicity of the disease in the Indian subcontinent. However, no definite guidelines are available to diagnose tuberculous (TB) vertebral lesions in the current literature. **Study Design:** This prospective study was conducted in the Department of Neurosurgery, Nizam's Institute of Medical Sciences, from August 2009 to March 2012. **Aim of the Study:** To formulate non invasive methods to diagnose tuberculous vertebral lesions confidently so that the dependency on histopathologic diagnosis can be reduced. **Material and Methods:** Spinal MRI images of 45 patients suspected of having tuberculosis aetiology were included in the study prospectively. **Results:** A total of 64 patients were analysed and 19 patients were excluded due to lack of regular follow up or histological proof. The patients were divided into two groups; those with TB of the spine and those with some other condition affecting the spine (non TB spine) based on the final diagnosis. Of the 45 patients males were 30 (66.6%) and females were 15 (33.3%). There was no significant difference in the mean age of presentation. For TB patients this was 41 ± 15.56 years and in Non TB was 43 ± 18.27 years. All patients presented with backache in either group. There was epiphyseal involvement (100%), disc height reduction (71.42%) and pedicle destruction (42.82%) in plain X-rays in the TB group. Lumbar spine was the most common affected region in our study (26.31% in non TB and 34.6% in TB group of patients). Significant *P* value and the Odds Ratio was found for T1 hypo intensity, T2 hyper intensity, epiphyseal involvement, disc involvement, pedicle involvement, anterior subligamentous extension, paraspinal extension and no spinous process involvement (eight parameters). The eight parameters were tested among both the groups and it was noted that scores ≥ 6 favored a tuberculous pathology whereas ≤ 4 were suggestive of non tuberculous etiology. **Conclusions:** The eight point MRI criteria of the vertebral lesions are likely to enhance the diagnostic ability of tuberculous and non tuberculous pathologies thereby reducing the dependency on histopathologic diagnosis or invasive method for early initiation of therapy.

Key words: Diagnostic criteria, magnetic resonance imaging, scoring system, spinal tuberculosis

Introduction

In the practice of dealing with spinal diseases, clinicians have faced the problem of diagnosis despite advanced imageological studies, subjecting patients to invasive procedures for final diagnosis. Tuberculosis of the spine is one of the most common vertebral lesion encountered daily in the neurosurgical practice in an endemic

country like India which has a very high incidence of pulmonary tuberculosis and around 1.7% of patients with pulmonary tuberculosis have spinal tuberculosis.^[1,2]

The insidious onset, with absence of constitutional signs, delayed reporting/attending a physician are additionally responsible for delay in the diagnosis coupled to the dilemma of the physician and lack of single diagnostic test for diagnosing tuberculosis. A plethora of investigations are ordered to add to the raising cost and confusion. The long treatment, side effects of antitubercular drugs, noncompliance to anti-tubercular treatment (ATT), delayed response coupled with vasculitic phenomenon (*encasing granulomatous arachnoiditis, vasculitis of spinal cord vessels*) blunts the confidence of the physician who looks for a more definitive/strong armamentarium for diagnosis. Differentiating tuberculous spine from its closest

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differentials like bacterial spondylitis, brucellosis, fungal involvement, malignancy (both primary and secondary) at the earliest, in a cost effective manner is the need of the day.

Tuberculosis of spine is potentially curable; diagnosis should be made promptly since any delay in starting antituberculous drugs is associated with increased morbidity. Treatment options following the diagnosis have been outlined in various studies.^[3,4] This study is proposed to scientifically evaluate the clinicoimageological profile of the patients to establish diagnostic criteria which would help avoiding invasive procedures for the diagnosis of the spinal lesions.

Materials and Methods

Inclusion criteria

- Patients presenting with chronic back pain who are not responding to the conventional symptomatic management.
- Patients having vertebral lesions detected on X-ray, Computed Tomography (CT), MRI.

Exclusion criteria

- Traumatic fractures not accounting to osteoporosis were excluded.
- Patients with inadequate follow up and those without histological diagnosis.

Diagnostic criteria of TB spine

- Histopathologic (HPE) proof suggestive of tuberculosis (Surgical/CT guided biopsy).
- Short of histological proof patients treated empirically based on the opinion of expert Radiologist and Senior Neurosurgeon with a follow up scan showing resolution.
- Short of histological proof patients treated empirically based on the opinion of expert Radiologist and Senior Neurosurgeon without follow scan ($n = 6$, on back pain presentation the patient with the MRI score of 6 on ATT improving in the main symptom in 2- 6 months. Definite proof by follow up MRI or histopathologic proof is not available in these patients).

Evaluation

All patients included in the study were evaluated by detailed clinical, radiological, histopathological evaluation to prove or disprove the provisional diagnosis. Imageological studies included MRI spine T1, T2, STIR and contrast whenever possible. Other investigations included erythrocyte sedimentation rate (ESR), Total Leukocyte Count (TLC), chest X- ray, CT scan, Bone scan.

Follow up

The patients were assessed at one, three, six months and one and two years.

Statistical analysis

Data was analysed using *SPSS software, version 13.0 (SPSS, Inc., Chicago, IL)*. Means and standard deviations were computed for continuous variables and marginal distributions for categorical variations. Comparison of categorical variables between the two variables was performed using *Chi- square test* and a *P* value of <0.05 was considered significant. Logistic regression was used when multivariate analysis was required.

Results

A total of 64 patients were analysed and 19 patients were excluded for want of regular follow up. The patients were divided into two groups TB spine and non TB spine based on the final diagnosis. Of the 45 patients males were 30 (66.6%) and females were 15 (33.3%). There was no significant difference in the age of presentation with the Mean age of presentation for TB patients was 41 ± 15.56 and in Non TB was 43 ± 18.27 years. All patients presented with backache in either group.

Magnetic resonance imaging features

Vertebral body lesions were found most commonly in the lumbar region ($n = 14$; non TB = 5 (26.31%); TB = 9 (34.6%)) followed by dorsal ($n = 12$; non TB = 6 (31.5%); TB = 6 (23.07%)) and cervical region ($n = 5$; non TB = 1 (5.3%); TB = 4 (15.4%)). We had two patients of purely sacral involvement in the non TB group but none in the TB group. Multilevel involvement (cervical, dorsal, lumbar, sacral) was seen in seven patients (non TB = 3; TB = 4). There was no significant difference in the site preference in the either group. Single vertebral involvement was more common in the non TB group ($n = 10$, (52.63%)) whereas two (contiguous) or more vertebral involvement was common in the TB group ($n = 20$; (76.9%)). Signal intensities were evaluated and compared among the groups. The lesions were hypo intense on T1 and unrestricted hyper intense on T2 W and STIR images in the TB group whereas in the non TB group, they varied from hypo to hyper. Epiphyseal margin involvement, body involvement, anterior subligamentous extension and paraspinous extension was noted in all 26 patients of the TB group. Epiphyseal involvement and disc involvement was not noted in the non TB group. Disc height reduction and dehydration was not noted also in two patients in the TB group. Body involvement was seen in all patients of the non TB group. None of the patients in the TB group had involvement of the spinous process or the facet

involvement while three patients had involvement of these anatomical locations in the non TB group. Epidural extension of the lesion was seen in 12 patients of non TB group whereas the same was noted in 23 patients of the TB group ($P = 0.084$). Posterior subligamentous extension was seen in 11 patients of the non TB group and 20 patients of the TB group ($P = 0.213$) [Table 1].

Odds ratio

Odds ratio was calculated which showed epiphyseal margin involvement, anterior subligamentous extension, disc involvement (height reduction and dehydration) and paraspinal extension, epidural extension, posterior subligamentous extension on MRI as significant findings [Table 2].

We have retrospectively applied the significant and independent variables to formulate the scoring system to objectivise the diagnosis. Each of the variables were given 1 point when present and zero when absent.

MRI features having a significant P value and Odds ratio in the study suggestive of TB spine are

- T1 hypo intense
- T2 hyper intense
- Disc involvement
- Epiphyseal involvement
- Pedicle involvement
- Anterior subligamentous extension
- Paraspinal extension
- No involvement of spinous process

Eight point score

Eight above mentioned parameters were tested among the tuberculosis of spine patients ($n = 26$) and the non tuberculosis of spine patients ($n = 19$). The score in the non tubercular patients is ranging from one to a maximum of four [Figures 1-3]. The score in tubercular patients is ranging from six to seven [Figures 4 and 5]. The spinous process was not involved in any of the patients in the TB group in our series.

Table 1: Magnetic resonance imaging findings

Findings	Non TB ($n=19$) (%)	TB ($n=26$) (%)	P value
Cervical ($n=5$)	1 (5.3)	4 (15.4)	
Dorsal ($n=12$)	6 (31.5)	6 (23.07)	
Lumbar ($n=14$)	5 (26.31)	9 (34.61)	
Sacral ($n=2$)	2 (10.52)	0	
Combined (cervicodorsal or dorsolumbar) ($n=5$)	2 (10.52)	3 (11.53)	
Multilevel ($n=7$)	3 (15.78)	4 (15.4)	
Single vertebrae (16)	10 (52.63)	6 (23.07)	
Two vertebrae (12)	1 (5.26)	11 (42.30)	
Multiple vertebrae involvement (17)	8 (42.10)	9 (34.61)	
T1 weighted images	Hypo intense=12 (66.66) Iso intense=3 (16.66) Mixed intensity=3 (16.66)	Hypo intense=26 (100)	
T2 weighted images	Hypo intense=1 (5.55) Iso intense=1 (5.55) Hyper intense=7 (38.88) Mixed intensity=9 (50)	Hyper intense=26 (100)	
STIR images	Hypo intense=1 (5.55) Iso intense=2 (11.11) Hyper intense=9 (50) Mixed intensity=6 (33.33)	Hyper intense=26 (100)	
Epiphyseal margin involved		26 (100)	0.000
Disc hydration decreased		24 (92.3)	0.000
Disc height		24 (92.3)	0.000
Body involvement	19 (100)	26 (100)	
Pedicles involvement	14 (73.68)	10 (38.46)	0.000
Spinous process	3 (16.7)		0.062
Facets	3 (16.7)		0.062
Epidural extension	12 (66.7)	23 (88.5)	0.084
Anterior subligamentous extension	4 (21.05)	26 (100)	0.000
Posterior subligamentous extension	11 (57.9)	20 (76.9)	0.213
Paraspinal extension	7 (36.82)	26 (100)	0.000

Table 2: The odds ratio of the parameters used in the present study in the descending order of significance

Parameters	Odds ratio
Epiphyseal margin involvement on MRI	1800
Disc involvement on MRI	925
Epiphyseal involvement on X-ray	273
Anterior subligamentous extension on MRI	272
Disc height reduction on X-ray	32
Paraspinal extension on MRI	13.33
Epidural extension on MRI	4.472
Fever	3.273
ESR elevated	2.9
Gender	2.443
Posterior subligamentous extension on MRI	2.424
Radicular pain	1.482
Autonomic disturbances	0.970
Osteoporosis on X-ray	0.95
Chest X-ray abnormal	0.786
Spinous process involvement on MRI	0.74
Bowel bladder disturbances	0.696
TLC elevated	0.667
Weakness	0.632
Disability	0.509
Pedicle destruction on X-ray	0.115
Pedicle involvement on MRI	0.189
Weight loss	0.1
Appetite loss	0.1

TLC-Total leukocyte count, ESR-Erythrocyte sedimentation rate

Discussion

Tuberculosis spine (TB spine), the most common and most serious form of osteoarticular tuberculosis, accounts for up to one half of the cases of extra pulmonary TB and 5-10% of total TB cases.^[5] The lungs are the main targets for this disease but lymph nodes, genitourinary systems, bones, and joints are some of the commonly involved regions.^[6] Although the true incidence is not certain, it has been estimated that tuberculous spondylitis occurs in 1.7% of all cases with TB.^[1,2]

Bone destruction, deformity, and neurologic deficits associated with spinal TB warrant early diagnosis and treatment.^[7-12] Various Medical Research Council trials Cochrane reviews have concluded that uncomplicated spinal tuberculosis is indeed a medical problem,^[13,14] recommending multidrug chemotherapy for at least six months duration.^[15] It is therefore vital to maintain a high degree of clinical suspicion in countries where the incidence is still high.^[16-18]

A previous history of TB and contact with TB-infected patients are thought to be valuable clues for the diagnosis of extra pulmonary TB. Pertuiset *et al.*, reported frequencies of 18.1% for past history of TB.^[7,19,20] Therefore, spinal tuberculosis may be considered

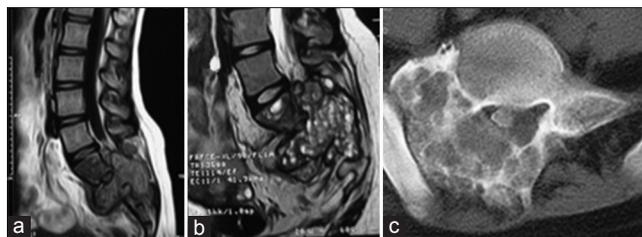


Figure 1: A case of aneurysmal bone cyst showing a lesion involving the sacral spine, iso on T1, speckled hyper on T2, pedicular and spinous process involvement (Score=3)

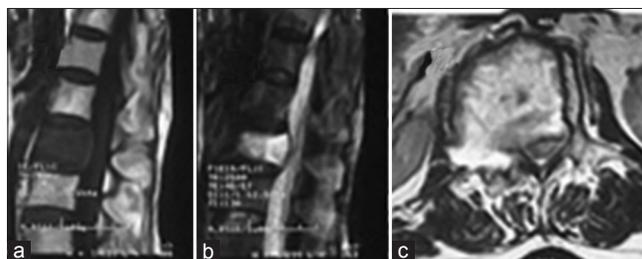


Figure 2: A case of follicular carcinoma of thyroid with metastasis with hypo on T1, variable hyper on T2, pedicular involvement and anterior and paraspinal involvement (Score=4)



Figure 3: A case of multiple myeloma showing lesions involving multiple vertebral bodies mixed intensities on T1 and T2 W images with no discal or epiphyseal involvement. There is no evidence of any anterior or paraspinal extension. Pedicular involvement is noted (Score=1)

in the patients who had pulmonary tuberculosis^[21] and therefore the patient's past medical history is an important guide for diagnosis.^[22-25] However in this study only backache was considered as an important and reliable history for further workup.

Spinal tuberculosis is common in the first three decades of life.^[11,21] The mean age of spinal tuberculous infections is reported to be 40 to 45 years.^[7,16,26-28] In our study the mean age for involvement of spine was 41 years (7-66 years).

Back pain non responsive to non steroidal anti inflammatory drugs (NSAIDs) and localized spinal tenderness, when present, are important findings which lead to diagnosis.^[7,14,27,29-32]

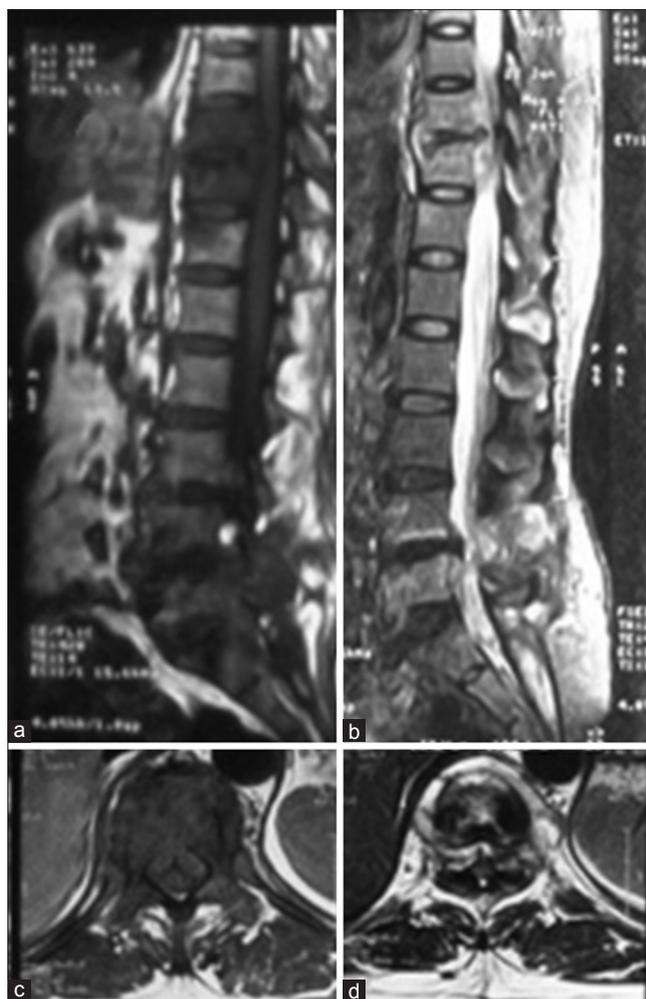


Figure 4: MRI of spinal tuberculosis: (a, c-sagittal; b, d- axial) images showing vertebral lesion hypo on T1 and hyper on T2W images, epiphyseal and discal involvement with anterior and paraspinous extension. No pedicular or spinous process involvement (Score=6)

MRI is the most sensitive (93-96%) and specific (92.5-97%) modality for early detection of spinal infections.^[33-36] Although in more than 50% of cases the typical features of spinal infections are apparent by MRI in the first two weeks, a further 20% of positive findings will be revealed in the following two weeks. For this reason, a repeat MRI is recommended after at least two weeks if an early scan detects no abnormalities, but a clinical suspicion of infection exists.^[37]

Few authors have recommended plain radiographs as the first imaging study in all patients suffering from backache.^[11,32,38-40] Early lesions are usually missed on plain radiography because at least 30 to 40% mineral density should be lost before changes appear on radiographs.^[41] The sensitivity (82%) and specificity (57%) of plain radiography is very low, especially in the early stages.^[42] Back pain with initial normal X-rays is one of the common presentations.^[20,28,30,38] Abnormalities

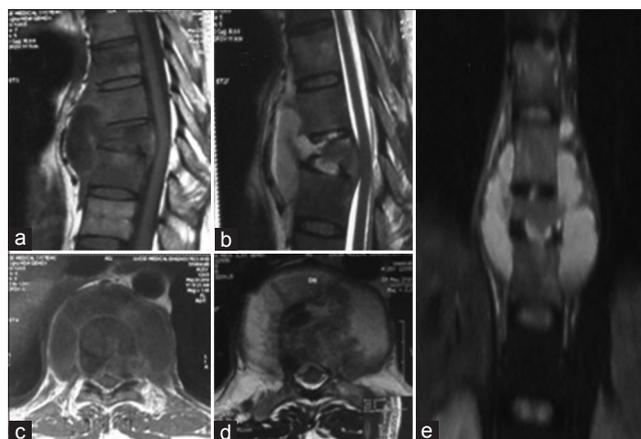


Figure 5: MRI of spinal tuberculosis: (a, c-sagittal; b, d- axial; e-coronal) images showing vertebral lesion hypo on T1 and hyper on T2W images, epiphyseal and discal involvement with anterior and paraspinous extension. No pedicular or spinous process involvement (Score=6)

on spine plain radiography, such as decreased height of the intervertebral disc and irregularity of vertebral endplates, are usually not present until two to eight weeks after the onset of backache (due to infection).^[43-47]

The presence of large paravertebral abscesses, involvement of two contiguous vertebrae and intervertebral disc are well known radiologic features of spinal tuberculosis.^[35,43,48] Paravertebral extension was present in all the cases of TB group as compared to 36% in non TB group and hence is not an independent variable. Involvement of two contiguous bodies was seen in 42% cases and hence can be missed on early presentation.

The thoracic spine is the major site for tuberculosis of spine. However, different studies report involvement of different regions of the spine.^[31,49,50]

Lumbar spine was the most common affected region in our study 26.31% in non TB and 34.6% in TB group.

Differentiation between degenerative and infectious endplate abnormalities is occasionally difficult.^[51] Intervertebral disc space infections give rise to vertebral marrow edema, demonstrating as areas of low signal intensity on TIWI and high signal intensity on T2WI, mimicking type 1 Modic changes.^[52,53] All patients in the TB group had T1W hypo and unrestricted hyper intensity on T2W but in non TB group 66% of the patients had hypo intensity on T1 and 38% hyper intensity on T2. Changes other than hypo on T1 and hyper on T2 should be evaluated for non TB pathologies. Tuberculosis of the spine begins in the anterior part of the body behind the anterior longitudinal ligament affecting adjacent segments and the intervening disc.^[32] This explains

early involvement of the epiphysis, disc involvement and anterior subligamentous extension gradual involvement of the body and paraspinal extension and epidural extension follows the initial insult. Pedicles were involved in the 10 patients in the present study with tuberculosis as a part of advanced disease with collapse of the body.

Mycobacterium tuberculosis culture is the gold standard for diagnosis.^[4,5] In several studies, the frequencies of bacteriological proof in patients with tuberculous spondylitis who were not on ATT have been reported as 47 to 84%.^[7,20,27,43,54,55]

Drug sensitivity test are essential for proper clinical management of TB. Therefore bacteriologic confirmation and sensitivity should be obtained in nearly all adult cases of TB.^[56] However, rates of isolating the causative organism are less than 50% in TB spondylitis and 60 to 80% for pyogenic spondylitis.^[23,34,57-61] In our series ($n = 16$ of 26) cultures were negative for the growth of Mycobacterium tuberculosis probably because all were already on ATT prior to sending the culture. The patients in the TB group were treated based on HPE showing granulomatous inflammation with caseation.

In 10 of 26 cases (38.4%) of TB spine diagnosis is not backed up with histopathological analysis or culture. We have considered them as tuberculous because of on clinicoimageological improvement with anti-tubercular treatment. However, it is not possible to conclude on the final nature of the lesion as tuberculous in these cases because some non tuberculous lesions like spinal brucellosis can also improve on ATT. However, even then the presumption of them having TB spine are high as spinal brucellosis in the low sporadic zone of the present series cases is extremely rare.

Conclusions

The eight point MRI criteria of the vertebral lesions are likely to enhance the diagnostic ability of tuberculous and non tuberculous pathologies thereby reducing the dependency on histopathologic diagnosis or invasive method for early initiation of therapy. This MRI scoring system should be further evaluated with clinical picture, less costly and readily available laboratory investigations (TLC, ESR, C-reactive protein (CRP), and Serum ferritin), digital X-rays and CT scan, various newer MR sequences especially diffusion sequences of spine for early and confident diagnosis of tuberculosis.

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