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ORIGINAL ARTICLE

A study on diffusion- weighted Magnetic Resonance imaging in Spinal Tuberculosis Patients

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Abstract

Introduction: Many studies have been performed till now and the role of DW-MRI in metastatic spinal involvement has been established. In this study we tried to establish ADC values in cases of spine TB.

Methods: This Retrospective Analytical study involved data of 100 of the randomly selected patients (candidates / study subjects) . The study was performed in two parts. The first part included all patients of known tuberculosis and patients with classical features of tuberculosis. The second part included patients with spinal pathology of indeterminate etiology. All the patients underwent a routine MRI examination along with diffusion sequences. The apparent diffusion coefficient (ADC) values were calculated from all the involved vertebral bodies.

Results: In total there were 46 vertebrae with high ADC values and 54 vertebrae with low ADC values. Based on all the results obtained we finally calculated that the mean ADC value of 1.4 ± 0.23 × 10-3 mm2 /s had a sensitivity of 63.8% and specificity of 74.5% for predicting spinal tuberculosis. The positive predictive value was 74.5%. Using Fisher's exact test, the p value was calculated and found to be significant. ($p < 0.0001$). Conclusion: DW-MRI and ADC values may help in the differentiation of spinal tuberculosis from other lesions of similar appearance . Diffusion MRI and ADC coefficient values are always best interpreted along with routine MRI sequences and a detailed clinical history and examination.

Keywords: USG , Thyroid Nodules , Malignant , Benign , Single Nodule

1 | INTRODUCTION

Spinal tuberculosis (TB), also called Pott's spine, was and now too quite common in India. It can be confidently diagnosed on MRI if there is involvement of contiguous vertebrae and intervening discs, with extensive adjacent soft tissue involvement and abscess formation. It can sometimes be difficult to diagnose this condition with confidence in the very early stages, especially when there is isolated vertebral body involvement without any soft tissue component, adjacent disc involvement, or abscess formation. In this retrospective study, we aim to quantify and evaluate the role of diffusion MRI and apparent diffusion coefficient (ADC) values in tuberculous vertebrae. Diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) have recently appeared as a new method of screening in characterizing lesions without necessitating contrast material and in evaluating the vertebrae quantitatively.[1-3] Diffusion-weighted MRI is now used extensively and has an established role in brain imaging. It is based on the principle of Fick's law of concentration gradients and Brownian movement of molecules within a given tissue. ADC values are a measure of the diffusion ability of molecules in the given tissue and give an idea of the composition of the given tissue.[1-2] A high ADC value means increased Brownian movement of molecules (which means no restriction), thereby suggesting less compactness of the given tissue microstructure. ADC is a quantitative parameter calculated from DWI that combines the effects of capillary perfusion and water diffusion.[4] Previous studies have been able to differentiate acute benign compression fractures from malignant compression fractures according to ADC values. [1-5] In a comparatively small number of surveys, ADC values have been studied in discriminating the infectious lesions from the malignant lesions[1-6]

Many studies have been performed till now and the role of DW- MRI in metastatic spinal involvement has been established. In this study we tried to establish ADC values in cases of spine TB. [1-6]

2 | METHEDOLOGY

This Retrospective Analytical study involved Prior Consent from Hospital Authorities / Medical Superintendents of the Local Randomly selected Secondary & Tertiary care Radio-diagnostic Centres / hospitals to see the records of the patients from their Medical Records Departments (MRD). The study was conducted within ethical standards. The Patients who were attending or admitted in randomly selected Diagnostic centres / hospitals in past 10 years were chosen for study . Randomization was done using computer tables in selecting data. All Patients underwent standard clinical examinations, routine biochemical and haematological investigations MRI. Medical record numbers were used to generate the data for analysis.

For the purpose of the present study, data of 100 of the randomly selected patients (candidates / study subjects) who seek care for care were retrospectively identified with age ranging from 15 to 80 years.

This study was conducted in two parts. In the first part, 50 patients with 130 abnormal vertebrae, either known to have tuberculosis or with classic tuberculous findings were imaged with DW-MRI. In the second part (50 patients), the ADC value that was arrived from the first part was used to predict its usefulness in diagnosing tuberculosis in 100 vertebrae with indeterminate pathology.

There were 76 males and 34 female patients, with the ages ranging from 15 to 80 years. Informed consent was obtained from all the patients. Detailed clinical history of all patients was taken before the start of the examination. Inclusion and exclusion criteria were as follows:

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Inclusion criteria

1. Known cases of spinal tuberculosis and those with classical features . This subset included 130 vertebrae.
2. Patients with spinal involvement but who were not proven cases of tuberculosis and who did not have the classical appearance of either tuberculosis or metastasis, irrespective of the ADC values. (This subset of patients was followed up till a diagnosis was established. They did not have any significant past history of trauma, osteoporosis, or malignancy) . This subset included 100 vertebrae.

Exclusion criteria

1. Patients with spine involvement due to trauma, osteoporotic collapse, metastasis, or any known disease other than tuberculosis.
2.Patients without any follow-up or those lost to follow- up.

It was made sure and observed that all patients underwent a routine plain MRI of the spine. DW-MRI was also performed in the same sitting. MRI of the spine, along with DW-MRI, was performed on a 1.5-T Siemens Avanto machine. The MRI protocol included T1 sagittal (TR – 430 ms, TE – 60 ms); T2 sagittal and axial (TR – 4200 ms, TE – 120 ms); and STIR coronal and sagittal (TR – 4000 ms, TE – 70 ms). Slice thickness was 3 mm. Field of view (FOV) was 32–37 cm.

ADC values were automatically computed after placing the ROI cursor entirely within the area of abnormal vertebral body signal intensity. Care was taken to place ROIs of same size and to see that there was no overlap with the adjacent disc or soft tissues. The smallest available ROI of 0.03 cm2 was used. The scanner software provides the mean value within the ROI, which equals the ADC value (multiplied by 10−3). Two normal-appearing vertebral bodies adjacent to the affected vertebrae were also sampled and the ADC values recorded. The final mean ADC value in all the proven cases of tuberculosis was calculated.

3 | RESULTS

In the first part of the study, of the 130 vertebral bodies, 11 were in the cervical spine, 58 were in the dorsal spine [Figures 1A–E, 2A–E], and the remaining 61 were in the lumbar spine [Figure 3A–C]. had solitary vertebral body involvement, while the rest had involvement of multiple vertebrae. 39% of patients had pre and paravertebral soft tissue involvement of varying degrees. Psoas abscesses were noted in 27% of patients. Four patients had involvement of posterior elements [Figure 4A–F]. All the involved vertebrae showed T1 hypointense signals [Figure 5A, B] with STIR hyperintensity. The T2 appearance was variable, ranging from hypointense to hyperintense signals. The vertebrae with T2 hyperintense signals revealed high ADC values and appeared brighter on the ADC images, while the vertebrae with T2 hypo/isointense signals revealed relatively lower ADC values and appeared less bright/dark on ADC images. The mean ADC value was 1.4 ± 0.23 × 10-3 mm2 /s. This ADC value was then applied to determine its ability to predict tuberculosis in the second part of the study in 100 vertebrae. Out of the 100 vertebrae in the second part of the study, 46 were finally proven to be cases of metastatic involvement and the remaining 54 were proven to be of tuberculous etiology . In total there were 46 vertebrae with high ADC values and 54 vertebrae with low ADC values. Based on all the results obtained we finally calculated that the mean ADC value of 1.4 ± 0.23 × 10-3 mm2 /s had a sensitivity of 63.8% and specificity of 74.5% for predicting spinal tuberculosis. The positive predictive value was 74.5%. Using Fisher's exact test, the p value was calculated and found to be significant. ($p < 0.0001$).

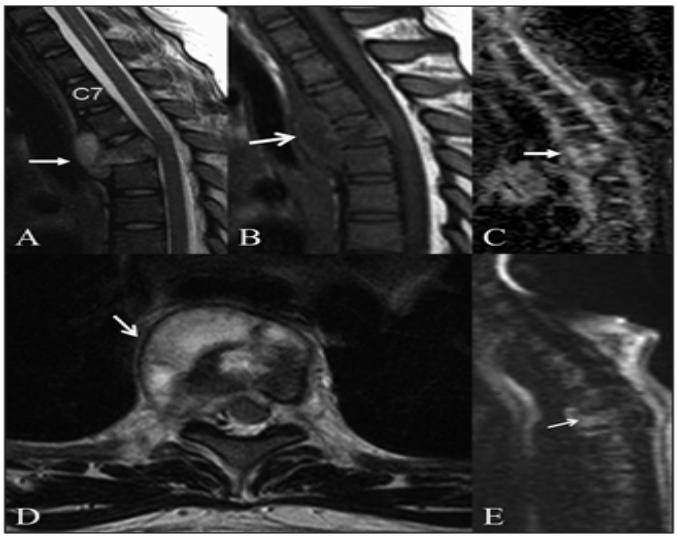

Figure 1 (A–E): *Tuberculosis of the spine. T2W (A), T1W (B) axial MRI images in a patient with upper dorsal spine tuberculosis show a small prevertebral abscess (arrow). Wedging of the D2 vertebral body is seen with marrow involvement. Sagittal ADC map (C) sagittal and T2W (D) and diffusion (E) images show increased diffusion (arrow) in the involved vertebra*

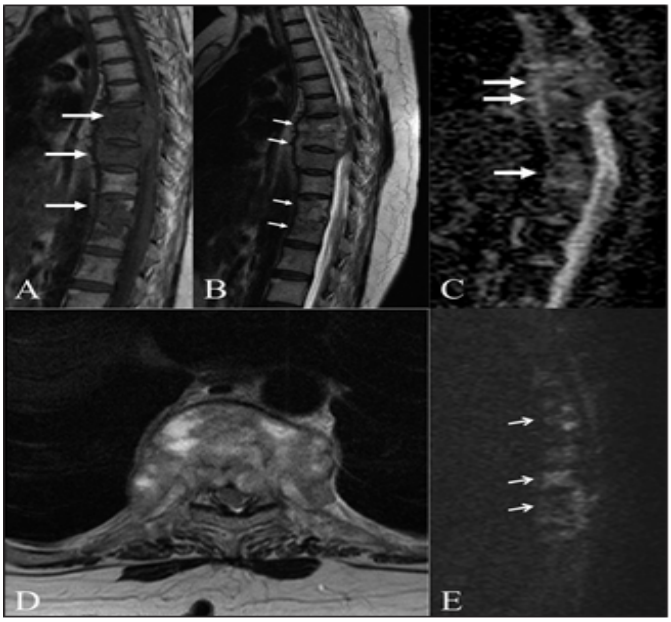

Figure 2 (A–E): *Tuberculosis of the spine. Sagittal T1W (A) and T2W (B) images in a patient with tuberculosis show multifocal dorsal vertebral body involvement (arrows) with an epidural soft tissue component. Sagittal ADC map (C) and axial T2W (D) and diffusion (E) images show increased diffusion (arrows) in the involved vertebrae.*

Figure 3 (A–C): *Tuberculosis of spine. Sagittal T1W (A) and T2W (B) images in a patient with spinal tuberculosis show a well-defined rounded lesion (arrow) with T1 hypointensity and T2 iso-hypointensity, which was difficult to characterize on routine MRI imaging. Sagittal ADC map (C) reveals increased diffusion in the lesion*

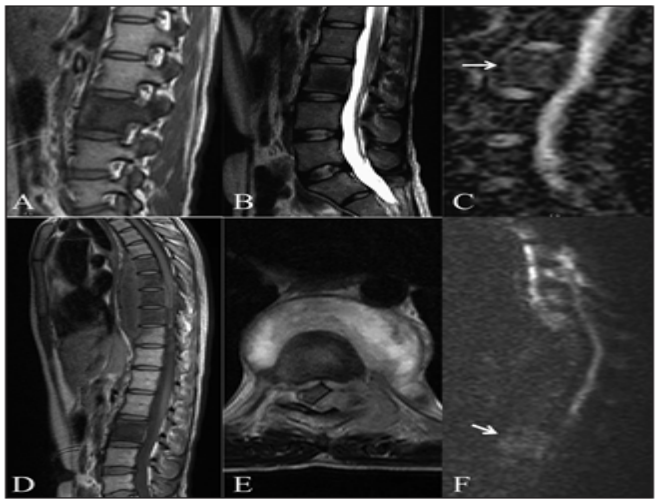

Figure 4 (A–F): *Tuberculosis initially misdiagnosed as metastasis. Parasagittal T1W (A) and sagittal T2W (B) images show a lesion with T1 and T2 hypointensity in the L1 vertebra and pedicle. Sagittal ADC map (C) reveals mild restriction of diffusion Sagittal T1W (D) and axial T2W (E) images after 6 months reveal multifocal lesions with T1 hypointensity, from D5 to D8, with a prevertebral abscess and an epidural soft tissue component. Sagittal diffusion image (F) at this time, reveals mildly bright signals in the involved dorsal vertebrae. The previously effected L1 vertebra (arrow in F) shows no significant change.*

Figure 5 (A, B): *Tuberculosis of the spine. Sagittal T1W image of a patient shows multiple vertebral body lesions (arrows) and wedging of L1, with no significant soft tissue component. It was not possible to differentiate between tuberculosis and metastases. Sagittal ADC map (B) reveals increased diffusion in the lesions, suggesting that metastatic involvement was probably less likely.*

In conclusion, Based on the result of this study, thyroid nodule size must not be considered as a criterion for malignancy and thyroid nodules of any size must be suspected as malignant. Important criteria for malignancy include irregular edges, being Solid hypoechogenicity and being a single nodule respectively. However, the presence of calcifications in the nodule by US indicates a higher risk of malignancy and should prompt the clinician to evaluate the nodule further with repeat FNA.

3. | DISCUSSION

DW-MRI has been extensively studied and used in the imaging of brain. It provides information about the composition of tissues, physical properties, and the microstructure of the tissues.[1] DW-MRI performed at high b value (1000) is a sensitive predictor of water mobility within the tissues and reduces the phenomenon of T2 shine-through. Many studies have been performed in different parts of the world to evaluate the efficacy of DW-MRI in differentiating between malignant and benign vertebral body involvement; in these studies the benign lesions included infections and traumatic osteoporotic vertebral body involvement. [2-4] All these studies have found that the ADC values of metastatic vertebral bodies are significantly different than those of benign lesions. [2-4] The presence of pre/paravertebral abscess and the involvement of contiguous vertebrae and intervening discs make the diagnosis of spine TB quite obvious. In cases where these classical features of spine TB are not present, there may be some difficulty in differentiating tuberculous lesions from malignant infiltration. In such cases, DW-MRI can prove to be a useful tool to arrive at the correct diagnosis. There is more free water content in the marrow in benign vertebral body involvement as compared to malignant infiltration.[2] In malignant infiltration, there is dense compact tumor infiltration, which inhibits free movement of water molecules, thereby causing diffusion restriction.[2] The areas of restricted diffusion appear bright on DW-MRI and dark on ADC mapping. The initial studies on DW-MRI of vertebral bodies were conducted by Beaur et al. [3] and Spuenturp et al. [4] Both the studies showed promising results. However, their studies were conducted on a small patient population (30 patients in the study by Beaur et al. and 34 patients in the one by Spuenturp et al.) and the b values were also lower (b = 165 s/mm2 in the Boeur et al. study and b = 598 s/mm2 in the Spuenturp et al. study). The study by Maeda et al. included 64 patients;
the b value in their study was 1000 cm/mm2 . [5] In their study, there was an overlap between the ADC values of benign and malignant vertebral body disease; however, the ADC values of benign lesions were significantly higher than those of malignant lesions. The mean ADC in benign vertebral body compression fractures was 1.21 ± 0.17 × 10-3 mm2 /s and in malignant vertebral compression fractures it was 0.92 ± 0.20 × 10-3 mm2 /s.[5] In the study conducted by Bhugaloo et al.[6] on 35 patients with 68 vertebral compression fractures, the positive and negative predictive values of diffusion MRI for detecting malignant vertebral body involvement were both 90%. In the study conducted by Herneth et al.[7] on 22 patients, the ADC value of vertebral metastases was 0.69 × 10–3 mm2 /s, which is lower than that in other studies. All the involved vertebrae in both parts of the study showed T1 hypointense and STIR hyperintense signals. All the involved vertebrae in both parts of the study revealed variable degrees of STIR hyperintensities.

4. | CONCLUSION

Diffusion-weighted magnetic resonance imaging may prove to be a relatively useful adjunct to conventional MRI in differentiating

tuberculous vertebral body involvement from metastatic lesions. False negative results can be obtained when there is dense solid caseation within the vertebrae, and in this situation overlap with ADC values of malignant lesions may be noted. Therefore, diffusion MRI and ADC coefficient values are always best interpreted along with routine MRI sequences and a detailed clinical history and examination.

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Ethical standards: Yes

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