An analysis of compressive and non compressive vertebral lesions using diffusion weighted MRI

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Purpose

The study objectives were:

• To evaluate the utility of diffusion weighted MRI in differentiating benign and malignant vertebral lesions in conjunction with routine MRI sequences.
• To evaluate the role of apparent diffusion coefficient (ADC) in differentiating benign and malignant compressive and non-compressive vertebral lesions.

Methods and Materials

Methods and Materials:

A cohort of 74 patients aged 38-87 years comprising of 46 males and 28 females were included in the study.

• Prospective analysis of traumatic and non-traumatic vertebral lesions in these patients was done in a 1.5T MRI scanner at Advanced Medicare and Research Institute (AMRI Hospital), Kolkata, India. Dense sclerotic vertebrae were excluded from the study module.

• After routine MRI sequences (T1, T2, STIR and T1 with Gadolinium), all patients underwent DWMRI (SE-EPI sequence) with b value of 1000, slice thickness 5mm, data taken in sagittal acquisition. The analysis was qualitative (using variation in signal intensities) as well as quantitative (using ADC measurement) and possible benign or malignant etiology was suggested. The imaging diagnosis was confirmed with histopathological correlation in cases of pathological fractures.

MRI sequence protocol:-

MR imaging was performed in a 1.5T system with a spine-array surface coil.

<table>
<thead>
<tr>
<th>Sequences</th>
<th>TR/TE (msec)</th>
<th>Section Thickness</th>
<th>Matrix</th>
<th>FOV (mm)</th>
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<td>Thickness / Interspace</td>
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Results:

- Qualitative analysis using signal intensity variations of diseased or collapsed vertebrae did not show any significant difference between benign and malignant lesions. Significant overlap of benign and malignant entities was noted with similar grades of hyperintense marrow signal in few cases.

- Quantitative analysis using ADC measurements revealed significant variation in ADC values between benign and malignant vertebral lesions.

- A summary of results is tabulated in table-A & displayed in a pie chart.

- In the benign group, restriction was found to be more in cases of tubercular spondylitis, than in traumatic and osteoporotic vertebral collapse. Statistical study showed a significant difference (p < 0.05). For an ADC threshold value of 0.000537 (malignant lesion ADC < 0.000537), ROC curve showed a specificity of 83% and a sensitivity of 85.7%.

Results of the study using conventional MRI sequences (detailed above) followed by DWI with ADC measurements are depicted in a pie chart (Image-B).

A. Benign Vertebral Collapse (Fig-I):

i). Traumatic vertebral collapse:

- 15 patients presented with history of trauma, 6 of them presenting with history of road traffic accidents and 9 patients presenting with history of fall from height.
• Acute traumatic collapse: Hypointense marrow in T1WI, hyperintense in T2WI & STIR sequences representing marrow edema.

• Compression fractures older than 4-12wks showed marrow appearing iso to hyperintense to normal due to restoration of marrow fat in these cases [1].

ii). Osteoporotic collapse:

• Osteoporosis was seen in 12 out of 74 cases. All cases with osteoporosis presented with vertebral collapse following known or unknown trauma. The cases presenting with known history of trauma were followed up clinically without biopsy correlation, and most cases reported resolution of back pain with conservative treatment. Five cases were treated with percutaneous vertebroplasty for back pain. These cases showed normal clinical parameters and resolution of pain by 8-12 weeks.

• The evaluation of conventional sequences was key to the prediction of benign vertebral collapse coupled with DWI sequences and ADC values.

Review of MR imaging features of benign vertebral collapse is as follows.

• Fluid and edema replacing the fatty marrow in acute osteoporotic collapse appears hypointense in T1, iso to hyperintense in T2WI and hyperintense in STIR sequences.

• The signal abnormality may be complete, incomplete or band shaped[2,3,4]. The area of signal abnormality is well defined in 71% of cases and illdefined in 29% cases. [5].

• Fatty marrow appearing hyperintense in T1WI opposite to the fractured end plate with a hypointense band adjoining it, are features specific for benign osteoporotic collapse [4,6,7].

• Diffusely hypointense marrow signal in T1WI without any fat sparing is not common in benign collapse. Follow-up MRI within twelve weeks usually shows restoration of fatty marrow in cases of benign collapse. However, in cases with healing bone with sclerosis or fibrosis, persistent hypointensity may be seen in T1WI. DWI with ADC values helps excluding malignant collapse in these cases.

• Signal change from hyperintense to isointense in T2WI is a strong evidence of benign collapse [1,2].
• Majority of benign vertebral collapse show normal posterior concave contour and intact pedicles except in 2-19% cases showing bulged posterior cortex of vertebral bodies, a common feature of malignant collapse [4,8].

• Bone fragmentation with dorsal angulation or retropulsion of bone fragments of bone fragment is common feature of benign collapse [4,9,10].

• Signal changes in one or both pedicles involving only a portion of the pedicle is seen in 6-29% of benign cases [4,5,8].

• Fluid sign described by Dupuy et al. [11]. is seen in 12-50% of osteoporotic collapse and 5-6% of pathological collapse () [4,12,13]. Common morphology of fluid sign is linear signal subjacent to the anterior part of superior end plate, however triangular and focal signal abnormalities were also seen in some cases [14].

• Bone fragmentation is seen in 10% of benign cases but not seen in malignant collapse. This is possibly due to the increased energy required to fracture normal and osteoporotic vertebrae than infiltrated vertebrae [3].

• Paraspinal mass is seen rarely in benign osteoporotic collapse, however a study by Shih et al. showed a thin rim shaped paraspinal soft tissue mass in 100% of cases [5].

• Hematomas associated with acute traumatic collapse may mimic paraspinal soft tissue swelling.

• Involvement of intervertebral disc is rare, however it may rarely be seen in cases of osteoporotic or traumatic collapse.

• Acute osteoporotic collapse may show intense post gadolineum enhancement while subacute and chronic cases show mild enhancement [4,5,6]. Enhancement of vertebrae are homogenous (62%) or heterogenous (38%) [5].

• Restricted diffusion in osteoporotic and acute traumatic collapse has no reasonable explanation, however different patterns of marrow edema has been cited as the etiology [15].
B. Tubercular & Infective Spondylitis (Fig-II, Fig-III & Fig-IV):

Vertebral osteomyelitis and consequent collapse is commonly seen in immunocompromised patients. Infective collapse seen in cancer patients often leads to diagnostic dilemma in imaging.

MR imaging provides high sensitivity & specificity in diagnosing vertebral osteomyelitis.

**MR imaging features are detailed below.**

- Contiguous involvement of two vertebral bodies with end-plate and sub-endplate regions appearing hypointense in T1, hyperintense in T2 & STIR sequences and post gadolinium enhancement are common features of Pott's disease [16,17].

- Post gadolinium enhancement of paraspinal or epidural soft tissue mass or abscess, enhancement of discs with hyperintense discs seen in T2WI and disruption of the cartilaginous end plate in T2 are common features. Disc involvement may be absent in 10% of vertebral osteomyelitis [18].

- Paraspinal, epidural and subligamentous spread of infection is more common in tubercular spondylitis in comparison with other granulomatous infections [19].

- Posterior arch elements are rarely involved in infective spondylitis. However tubercular spondylitis may involve posterior arch as well as the vertebral ends of ribs.

- Skip lesions are rarely seen in tubercular spondylitis [17].

- Qualitative evaluation of DWI images reveal hyperintense marrow signal of involved vertebrae representing restricted diffusion. Our experience reveals that DWI and ADC values when coupled with T1, T2, STIR & post gadolinium T1WI helps in differentiating infective spondylitis and malignant collapse. In cases with epidural or paravertebral abscesses DWI shows hypointense signal in the ADC maps suggesting presence of abscesses. The high ADC values seen in infective spondylitis especially tubercular spondylitis may be assigned to the presence of increased necrotic tissue and possibly increased vascularity of the granulomatous tissue.
Though the ADC values show narrow margin of differentiation between benign and malignant collapse, our study shows that detailed evaluation of conventional sequences helps differentiating the two entities.

However no single pathognomonic imaging sign is specific for diagnosis of tubercular spondylitis in MRI.

Sometimes increase in marrow edema may also alter the calculation of ADC appearing higher than normal.

C. Malignant infiltration of vertebrae and collapse (Fig-V, Fig-VI & Fig-VII):

Pathological collapse of vertebra may be solitary or multiple.

Vertebral collapse may be the presenting feature in a case of occult malignancy or benign vertebral collapse may simulate a pathological collapse in a known case of malignancy. Hence radiological diagnosis indicating the necessity of fine needle aspiration cytology or biopsy stands paramount in such situations. Common causes of malignant collapse are metastasis, myeloma, plasmacytoma, lymphoma, and rarely sarcoma. Common malignancies causing vertebral metastasis are breast, bronchus, prostate and renal carcinomas [4,6].

Common MR imaging features of malignant infiltration are as follows:

- Signal characteristics of vertebrae in T1 & T2WI seen in malignant collapse is similar to their benign counterparts.

- Malignant infiltration usually causes complete marrow replacement. Hence hypointense T1 signal & hyperintense T2 signal or heterogenous signal usually involves the entire collapsed vertebra in two third of cases. However one third of cases may show incomplete marrow replacement and hence simulate benign osteoporotic collapse. The preserved marrow shows round or focal morphology, rarely showing incomplete or band like patterns.

- Follow up MRI in cases of malignant infiltration do not show any evidence of restoration of fatty marrow, rather the signal remains unchanged or increase in the infiltration is seen.

- Infiltration causing destruction of bony trabeculae results in vertebral collapse.
• Multiple vertebral involvement is seen in 63-88% of cases [3,4,6,9].

• Secondary deposits in vertebral bodies are usually well defined and rounded lesions. Anterior or posterior margins of vertebral bodies show bulged contours in 33-70% of malignant collapse [8,20]. Pedicle involvement is common in metastasis and is seen involving one or both pedicles in 69-88% of cases. Pedicles are completely involved in 75% of cases and 55% cases show pedicular expansion which is specific for malignancy [5].

• Paraspinal or epidural soft tissue masses are seen in 47-100% cases with malignant collapse [6,7].

• Disc involvement is seen in primary vertebral malignant lesions and not in cases of secondaries where hematogenous spread prevents it from extending to avascular structures.

• Post gadolineum enhancement is an important criteria in characterising malignant collapse. Enhancement is heterogenous in most cases possibly due to heterogeneity in vascular supply or tumour necrosis [5].

• Myelomatous infiltration of vertebra usually cause incomplete marrow replacement and in newly diagnosed cases; 20% show normal marrow and 50% show multiple vertebral collapse [21]. Lecouvet et al. in their series observed that 67% of cases of multiple myeloma showed benign characteristics in MRI. Sclerotic variety of myeloma showed loss of signal in T1 & T2WI and no enhancement in post contrast sequences [22].

• Diffusion weighted MRI traces the micromolecular motion of water in the intracellular as well as intercellular spaces. Apparent diffusion coefficient (ADC) is the quantitative measure of the motion of water molecules across membranes [31].

• In case of malignant infiltration interstitial space is compromised due to increase in cellularity and hence decreased extracellular free water contributes to reduction in ADC. Though low b values have been used to differentiate benign and malignant infiltrations [32,33], our experience with higher b values showed significantly good SNR.
Conclusion

Conclusion:

• DWMRI using ADC of vertebral lesions provides vital diagnostic information in differentiating benign and malignant vertebral lesions.

• Coupled with routine MRI sequences DWI can be a potent imaging weapon to clinch diagnosis of benign and malignant spinal lesions particularly in cases lying within the clinician's gray zone described below.

*Known malignancies with collapse.

*Occult malignancies with collapse.

*Osteoporosis with trivial trauma & collapse.

*Infective spondylitis under treatment with new collapse.

• DWMRI with ADC values of vertebral lesions provide useful data to increase the radiological confidence in non-invasive diagnosis of vertebral compression and infiltrating lesions thus restricting the recurrent use of invasive procedures for diagnosis.

References

References:-


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