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ROLE OF MAGNETIC RESONANCE IMAGING IN DIFFERENTIATING BENIGN AND MALIGNANT CAUSES OF VERTEBRAL COLLAPSE

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Abstract

Introduction: Vertebral collapse is associated with breakdown of vertebra resulting in decrease in height of vertebral body. Magnetic Resonance Imaging is well known method to evaluate bone and bone marrow diseases, one of the reliable markers to differentiate between benign and malignant compressive fractures and certain characteristics which aids in early differentiation of benign and malignant vertebral collapse and also helps in diagnosis of etiological background of vertebral collapse.

Objectives: Primarily to differentiate benign and malignant vertebral collapse on Magnetic resonance imaging and subsequently differentiating vertebral collapse between osteoporotic, traumatic and infective etiology.

Materials and methods: The study was conducted in department of radiology and orthopedics. Study subjects were those who attended radiology and orthopedics department with complaints of back pain, lower limb weakness, generalized body ache, tingling and numbness .Detailed clinical history was taken and subjects were subjected to imaging statistical analysis was done.

Results: Study subjects were subjected for MRI in accordance of MRI findings of vertebral collapse was classified as benign and malignant, 76% and 24% respectively. Out of which 80% presented with multiple vertebral collapse in which 32.5% were osteoporotic in nature. Solitary vertebral collapse accounts for 20% out of which 50% traumatic etiology.

Conclusion: In present study, total 50 cases of vertebral collapse were studied. Out of these 12 cases were diagnosed as malignant, all of which were metastatic in nature, and 38 cases of benign etiology comprising of osteoporotic (n=15) , traumatic(n=12), and infective (n=11) causes were studied. Age of patients ranged from 3 to 74 years. Male: female ratio was 2:1.MRI is the reliable method to differentiate between benign and malignant compression fracture. Certain MRI characteristics which allow early differentiation of benign and malignant vertebral fractures were studied.

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INTRODUCTION

Magnetic Resonance Imaging is well known method to evaluate bone and bone marrow diseases .Magnetic Resonance Imaging also aids in differentiating benign and malignant compression fractures [2,3,5,6,8-17].Vertebral collapse is associated with increase in width of body with posterior bulging of posterior wall towards the spinal cord or nerve root compression in severe cases [1] .Vertebral collapse is also associated with breakdown of vertebra resulting in decrease in height of ve rtebral body .

It is extremely difficult for radiologist to differentiate between benign and malignant vertebral collapse. About 1/3rd of primary malignant patient with history of veterbral collapse are benign. Possibility of infection vertebral collapse should also be considered in primary cancer patient who are also immunocompromised [7]. Acute back pain syndrome which is clinically apparently secondary to spontaneous vertebral collapse which is one of the incidental finding in practice.

In acute cases it is difficult to distinguish between two causes because both display low signal due to tumor is neoplastic and marrow edema in non neoplastic conditions [6]. In chronic vertebral collapse ,on basis of signal intensities of MRI it can be easily differentiated between benign and malignant, where as osteoporotic vertebral collapse ,vertebral body shows similar signal intensity to normal vertebrae and lower signal intensity on short TR images [5].

As vertebral collapse is incidental finding but frequent in clinical radiological practice. Diagnosis of vertebral collapse on plain x-ray is difficult in differentiating between benign osteoporotic vertebral collapses from malignant replacement; where as evidence of osteoporosis is easily documented on plain films as multiple vertebral deformities leading to biconcave

appearance of vertebral discs and osseous demineralization [3].

In contrast to X-ray ,CT shows specific evidence of tumor replacement, absence of which diagnosis is difficult but still cannot be excluded, such as osseous lysis in cortical areas and excessive soft tissue along vertebral walls. MRI is well known for evaluating bone and bone marrow disease , one of the reliable marker to differentiate between benign and malignant compressive fractures and certain characteristics which aids in early differentiation of benign and malignant and also helps in diagnosis of etiological background of vertebral collapse .

The role of MRI in acute phase vertebral collapse is one of the clinical interested aspect which has been not fully described and no comprehensive study were conducted .hence, the present study aims to evaluate the vertebral collapse on MRI based on differentiating benign and malignant condition and their etiological background of vertebral collapse .

MATERIALS AND METHODS

The present study was conducted in the "Department Of Radiodiagnosis, Shri B M Patil Medical College Hospital & Research Centre, Bijapur". The study is basically a prospective observational study conducted from December 2014 to June 2016. The subjects were those who attended Department of Radiodiagnosis & orthopaedics with complaint of back pain, lower limb weakness & generalized body ache. A detailed clinical history was obtained from all patients. Detailed examination and findings were recorded. Imaging was done with 1.5 TESLA Magnetic Resonance Imaging equipment Philips Achieva.

Inclusion criteria:

Patients of all age groups, both sexes, referred for MRI, having vertebral collapse (whether solitary or multiple), from the Department of Radiodiagnosis and Department of Orthopedics, were included in this study.

Exclusion criteria: Patients with benign or malignant spinal involvement without associated collapse were excluded and also those who underwent previous spinal surgeries The normal bone marrow signal intensity of vertebral body on T1 and T2 weighted images were evaluated in detail. Signal intensity in the marrow of abnormal vertebral bodies was considered hypointense, isointense, hyperintense or mixed in comparison with the signal intensity of normal vertebrae in the same patient on T1- and T2-weighted images. The replacement of bone marrow is homogenous or heterogenous, was also evaluated in detail. In addition, the following findings were particularly examined; convex

posterior border of vertebral body, abnormal signal intensity of the pedicle or posterior element, paravertebral collection, destruction of bony cortex, retropulsion of a posterior bone fragment, fluid sign on T2-weight (classified as focal, linear and triangular shape), decreased disc height and multiple levels of compression fractures.

Our study was approved by institutional thesis board, which maintained that a formal consent should be acquired from the patient undergoing examination or from his/ her relatives.

EQUIPMENT: 1.5 TESLA MAGNETIC RESONANCE IMAGING equipment PHILIPS ACHIEVA.Body surface coil and Non ionic contrast medium, if and when required. Based on review of the literature and our own clinical experience was used to choose MRI characteristics to evaluate and differentiate between benign and malignant vertebral collapse are: pedicle or posterior element involvement, convex posterior border, Epidural or paravertebral soft tissue lesion or collection. Homogeneous or heterogenous marrow replacement and spared normal bone marrow

RESULTS:

The whole of the study group was divided in 8 age groups with age of patients ranging from 3 years to 80 years. There was a male predominance with 66% (33/50 cases) males and 34% (17/50 cases) being females. The Male: Female ratio was almost 2:1 .The mean age of presentation was 45.06 years. Maximum number of patients were in the age group of 31- 40(22%) followed by 51- 60 years (20%) and 61-70 years (20%).Majority of male patients were in the age group of 31 to 40 and 51 to 70 years and majority of female patients were in the age group of 21 to 40 years (Table I) Out of 50 cases, solitary vertebral collapse was seen in a total of 10 cases (20%) presenting with traumatic etiology in 6 cases (12%) and 2 cases each (4%) due to metastasis and osteoporosis. 40 cases (80%) presented with multiple vertebral collapses; 13 (32.5%) of them were osteoporotic in nature, 11 (27.5%) were due to infective causes, 10 (25%) were malignant and 6 (15%) were traumatic in nature. All infective cases had multiple vertebrae involvement. Multiple vertebrae involvement is not statistically significant for malignant collapse.($P>0.05$) (Table II) Involvement of pedicles and posterior elements is the diagnostic sign for malignant vertebral collapse on MRI & was seen in almost all the cases with malignant etiology in our study. Pedicle or posterior element was seen in 11 cases of malignant vertebral collapse, while 1 case of benign collapse cases also had

pedicle involvement. Thus, involvement of pedicle and posterior element was found to be statistically significant (P<0.001) for malignant collapse. (Table III) Along with involvement of posterior elements, convexity of posterior border with bone erosion was seen in majority of the cases of malignant collapse. Out of 12 malignant vertebral collapse cases, convex posterior border was found in 10 (83.3%) cases. 3 cases (7.89%) of benign vertebral collapse also showed convex posterior border. Convex posterior border was found to be statistically significant (P<0.001) for malignant cases. (Table IV) In table V compares the signal intensities of the lesions on T1and T2 weighted images of MRI. Signal intensities on T1 weighted images were mainly hypointense or mixed signal intensity. And signal intensities on T2 weighted images were hypointense, isointense, mixed and hyperintense. Hypointensity on T1 WI and hyperintensity on T2WI was noted in 10 cases (83.3%) of malignant collapse and 9 cases of benign collapse. Infective etiology mainly contributed to benign etiology with 6 cases (54.54%), followed by traumatic etiology with 2 cases and osteoporotic etiology with 1 case. Hypointense signal on T1 and T2 WI was noted in 7 cases of benign etiology but no malignant collapse case presented with it. Hypointense signal on T1 and isointense signal on T2 WI was noted in 17 cases (44.7%) of benign etiology and 1 case (8.3%) of malignant etiology. Traumatic etiology with 10 cases (83.3) and osteoporotic etiology with 6 cases (40%) contributed mainly to benign cases. Pre and paravertebral soft tissue collection was smooth and rim like and noted in 13 (34%) cases of benign vertebral collapse. Out of which, 10 cases (26.3%) were of infective etiology and 3 cases (7.89%) were of traumatic etiology. Malignant cases did not show any paravertebral collection. Presence of paravertebral collection was found to be statistically insignificant (P>0.05) for malignant cases. (Table VI) In homogenous bone marrow signal was seen in 15 cases with rest showing homogenous signal intensity. In homogenous signal intensity was noted in 7 cases of malignant and in 8 cases of benign vertebral collapse. Presence of in homogenous signal intensity was found to be statistically significant for malignant collapse. (P<0.05)(Table VII) Cord compression was seen in less than 1/3rd of the total cases of vertebral collapse. Amongst the positive cases, it was most commonly seen in 8(66.6%) out of 12 cases of malignancy, followed by infection as the second most common cause comprising of 5 cases(45.4%) and 2 cases(16.6%) of trauma. None of osteoporotic collapse cases had cord compression. (Table VIII)

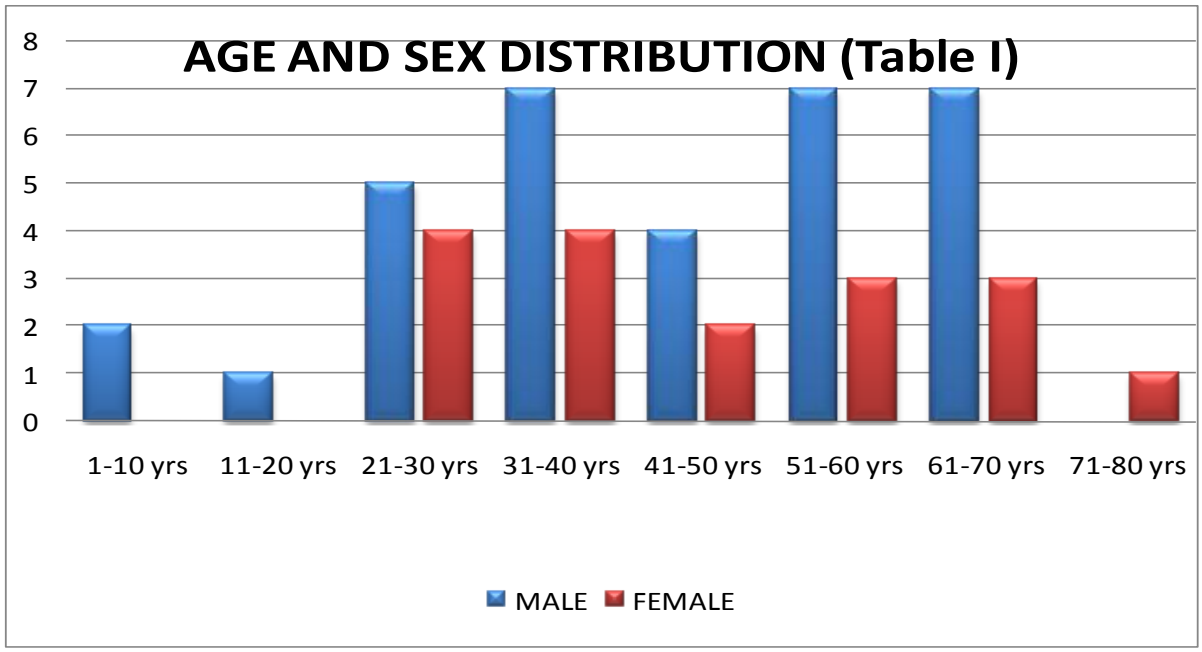

TABLE I: AGE AND SEX DISTRIBUTION (n =50)

Final Diagnosis	Number of Vertebrae Involved					
	Multiple		Solitary		Total	
	No.	%	No.	%	No.	%
Infective Collapse	11	100.00	0	0.00	11	100.00
Malignant Collapse	10	83.33	2	16.67	12	100.00
Osteoporotic Collapse	13	86.67	2	13.33	15	100.00
Traumatic Collapse	6	50.00	6	50.00	12	100.00
Total	40	80.00	10	20.00	50	100.00

Table IIA: Distribution of cases according to number of vertebrae involved and their related etiology. Multiple vertebrae involvement is not statistically significant for malignant collapse. (P>0.05)

Number of Vertebrae Involved	Final Diagnosis					
	Benign		Malignant		Total	
	No.	%	No.	%	No.	%
Multiple	30	78.95	10	83.33	40	80.00
Solitary	8	21.05	2	16.67	10	20.00
Total	38	100.00	12	100.00	50	100.00

Table IIB: Distribution of cases according to number of vertebrae involved and their related etiology. Multiple vertebrae involvement is not statistically significant for malignant collapse. (P>0.05)

Involement of Pedicle or Posterior element	Final Diagnosis		
	Benign	Malignant	Total
	No. (%)	No.(%)	No.(%)
Absent	37 (97.37)	1(8.33)	38(76)
Present	1(2.63)	11(91.67)	12(24)
Total	38(100)	12(100)	50(100)

TABLE III: DISTRIBUTION OF LESIONS ACCORDING TO INVOLVEMENT OF PEDICLE AND POSTERIOR ELEMENTS

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Convex Posterior Vertebral Border	Final Diagnosis		
	Benign	Malignant	Total
	No.(%)	No.(%)	No.(%)
Absent	35(92.11)	2(16.67)	37(74.00)
Present	3(7.89)	10(83.33)	13(26.00)
Total	38(100.00)	12(100.00)	50(100.00)

Table IV: DISTRIBUTION OF LESIONS ACCORDING TO CONVEX POSTERIOR VERTEBRAL BORDER

. T1 SIGNAL INTENSITY	T2 SIGNAL INTENSITY	FINAL DIAGNOSIS		
		Benign	Malignant	Total
Hypo	Hyper	9	10	19
	Hypo	7	0	7
	Iso	17	1	18
	Mixed	3	0	3
Mixed	Mixed	2	1	3
Total		38	12	50

TABLE V: DISTRIBUTION OF LESIONS ACCORDING TO SIGNAL INTENSITY ON T1WI AND T2WI

Pre and Paravertebral Soft Tissue Collection	Final Diagnosis		
	Benign	**Malignant**	**Total**
	No. (%)	**No. (%)**	**No. (%)**
Present	13 (34.21)	0(0.00)	13(26.00)
Absent	25(65.79)	12(100.00)	37(74.00)
Total	38(100.00)	12(100.00)	50(100.00)

TABLE VI: DISTRIBUTION OF LESIONS ACCORDING TO PRE AND PARAVERTEBRAL SOFT TISSUE COLLECTION

* Presence of paravertebral collection was found to be statistically insignificant (P>0.05) for malignant cases.

Replaced Marrow Signal	Final Diagnosis		
	Benign	**Malignant**	**Total**
	No.(%)	**No.(%)**	**No(%)**
Homogenous	30(78.95)	5(41.67)	35(70)
Inhomogenous	8(21.05)	7(58.33)	15(30)
Total	38(100.0)	12(100.0)	50(100)

TABLE VII: DISTRIBUTION OF LESIONS ACCORDING TO REPLACED BONE MARROW SIGNAL INTENSITY

*Presence of inhomogenous signal intensity was found to be statistically significant for malignant collapse. (P<0.05)

Cause	Number of cases of cord compression
Malignant collapse	8
Infective collapse	5
Traumatic collapse	2
Osteoporotic collapse	0
Total	15

TABLE VIII: VERTEBRAL COLLAPSE ASSOCIATED WITH CORD COMPRESSION

DISCUSSION

Vertebral collapse is one of the most common clinical problems encountered in the elderly [8]. Determining the etiology of vertebral collapse has always been a challenging aspect in cases of vertebral collapse with no significant history of trauma or infection, especially in the older population [2]. MRI is a well validated technique in evaluating disease of bone and bone marrow. Hence the present study was performed to evaluate the role of MRI in cases of vertebral collapse among Indian patients.

Attempts to differentiate between benign and malignant vertebral collapse present a major problem in elderly patients where the two entities may occur simultaneously. The limitations of other imaging modalities like radiographs, bone isotope scanning, myelography and computed tomography in the diagnosis of benign and malignant vertebral disease have been well documented[7,8,15]. Plain radiographs have a limited ability to display bone marrow changes, posterior element and pedicle involvement and associated soft tissue changes.

Tokuda O et al [18] compared MRI and SPECT for differentiating benign and malignant fractures and found that accuracy of MR images was significantly greater than that of other. Various studies have reported that both malignant and acute benign fractures may give rise to low signal intensity on T1 weighted images and high signal intensity on T2 weighted images [3,4,8,16]. This is attributed to increased focal water content resulting from hemorrhage and edema in post traumatic and infective etiologies. Similarly in present study, hypointensity on T1 WI and hyperintensity on T2WI was noted in 10 cases (83.3%) of malignant collapse and 9 cases of benign

collapse with 6 cases of infective etiology and 2 cases of traumatic etiology, thus making it a non specific finding to differentiate between these entities. Also, inflammatory edema may be seen in degenerative cases too, leading to the above mentioned signal changes in benign osteoporotic collapse [20,22]. In present study also, 1 case of osteoporotic etiology gave similar signal intensities on MRI. Hsu CY et al[9] also demonstrated the unusual MR imaging patterns of low signal intensity on T1 weighted images with mixed or high signal intensity on T2-weighted images in seven patients with infective vertebral collapse in their study. After the acute stage, hematoma and edema decrease, resulting in a low to intermediate signal intensity on T2-weighted images. In our study, hypointensity on T1 and T2 WI was noted mainly in benign vertebral collapse with 7 cases. However, in malignant fractures, the infiltrated abnormal tissues and associated reactive response continue to show the low T1 and high T2 signal patterns[8,12]. Hence follow up for atleast six months is advised to differentiate between the two entities. Pongpornsup et al[5] had reported that MR imaging features suggestive of malignant vertebral compression fracture were convex posterior border of the vertebral body, involvement of pedicle or posterior element, epidural or paraspinal mass and destruction of bony cortex. Among these, involvement of pedicle or posterior element was the most reliable finding for malignant collapse with sensitivity and specificity of 91.4% and 82.6% respectively. In our study, pedicle involvement was the most consistent finding with a high sensitivity and specificity of 91.6% and 97.3% respectively. It was followed by convex posterior border as the most reliable individual finding with sensitivity of 83.3% and specificity of 92.1%. This finding is possible because in most cases of malignant compression fractures, tumoral cell has already spread to the pedicles and neural arch before it collapses, whereas the reactive bone marrow changes usually spare the pedicles in osteoporotic compression fractures [5,10]. However, in our study one case of infective etiology also showed involvement of pedicles, making it difficult to differentiate between infective and malignant collapse. This case was later confirmed by histopathological examination to be vertebral osteomyelitis, of tubercular etiology. Though pedicle and posterior element involvement is highly predictive of malignant etiology, it can also be involved in spinal infections especially tuberculosis [21]. Cord compression was seen as an indicator for malignancy in several studies [2,8-10].In our study, out of a total of 15 cases with cord compression, only 8 were due

to malignant collapse with associated irregular nodular epidural soft tissue component causing pressure effect on thecal sac, spinal cord and exiting nerve roots. Seven cases with infective and post traumatic etiologies also presented with cord compression, making it a specific but not a sensitive tool for ascertaining malignant involvement. Abdel-Wanis et al[19] ,Tehranzadeh et al[16] and Fu TS et al [18] analysed various MRI based characteristic criteria to differentiate benign and malignant vertebral collapse. Jung HS [13] et al discriminated metastatic and acute osteoporotic compression fractures on the basis of MR imaging findings and computed the differences by using chi square test. They deduced that the following imaging findings are suggestive of acute osteoporotic compression fractures: a low signal intensity band on T1 and T2 weighted images, spared normal bone marrow signal intensity of the vertebral body, retropulsion of a posterior bone fragment, and multiple compression fractures. In our study, normal bone marrow signal intensity was seen in most of the cases i.e.13 cases out of 15 osteoporotic collapse cases , however linear intravertebral hyperintense signal on sagittal STIR sequences was seen only in 6 cases of 15 osteoporotic collapse. All these MRI based features help in differentiating causes of vertebral collapse into benign and malignant etiology, and correct diagnosis helps in deciding best management protocol for the patient. The formulation of a treatment plan for patients with injuries to spine also depends on the presence and extent of neurologic injury and deformity and an estimate concerning spinal stability. Both nonsurgical and surgical treatment options are available to achieve the goals of preservation of neurologic function and restoration of spinal stability.

Conclusion:

In present study, total 50 cases of vertebral collapse were studied. Out of these 12 cases were diagnosed as malignant, all of which were metastatic in nature, and 38 cases of benign etiology comprising of osteoporotic(n=15) , traumatic(n=12), and infective (n=11) causes were studied. Age of patients ranged from 3 to 74 years. Male : female ratio was 2:1. MRI is the reliable method to differentiate between benign and malignant compression fracture. Certain MRI characteristics which allow early differentiation of benign and malignant vertebral fractures were studied. In the present study various MR character involved are- Pedicle and Posterior element involvement, Convex posterior vertebral border enhancing paraspinal soft tissue mass, Compression of

cord, To replaced bone marrow signal intensity, according to signal intensity on T1WI and T2WI. Thus, it was concluded in our study that the diagnostic accuracy of pedicle involvement (96%), convex posterior border(90%) found to be high in cases of malignant vertebral collapse, which helps in accurately differentiating it from benign vertebral collapse.

Conflict of Interest Statement-There is no conflict of interest.

REERENCES:

1. Laredo JD, Lakhdari K, Bellaiche L, Hamze B, Janklewicz P, Tubiana JM. Acute vertebral collapse: CT findings in benign and malignant nontraumatic cases. Radiology 1995; 194(1):41-48.
2. Vaccaro AR, Shah SH, Schweitzer ME, Rosenfeld JF, Cotler JM. MRI description of vertebral osteomyelitis, neoplasm, and compression fracture. Orthopedics 1999; 22(1):67-73.
3. Old JL, Calvert M. Vertebral compression fractures in the elderly. Am Fam Physician 2004; 69(1):111-116.
4. Zhou XJ, Leeds NE, McKinnon GC, Kumar AJ. Characterization of benign and metastatic vertebral compression fractures with quantitative diffusion MR imaging. Am J Neuroradiol 2002; 23(1):165-170.
5. Pongpornsup S, Wajanawichakorn P, Danchaivijitr N. Benign versus malignant compression fracture: A diagnostic accuracy of magnetic resonance imaging. J Med Assoc Thai 2009; 92 (1): 64-72.
6. Falcone S. Diffusion-weighted imaging in the distinction of benign from metastatic vertebral compression fractures: is this a number game? Am J Neuroradiol 2002; 23(1):5-6.
7. Castillo M, Arbelaez A, Smith JK, Fisher LL. Diffusion weighted MR imaging offers no advantage over routine noncontrast MR imaging in the detection of vertebral metastases. Am J Neuroradiol 2000; 21(5):948-953.
8. Fu TS, Chen LH, Liao JC, Lai P L, Niu CC, Chen WJ. Magnetic Resonance Imaging characteristics of benign and malignant vertebral fractures. Chang Gung Med J 2004; 27(11):808-815.
9. Hsu CY, Yu CW, Wu MZ, Chen BB, Huang KM, Shih TT. Unusual manifestations of vertebral osteomyelitis: intraosseous lesions mimicking metastases. Am J Neuroradiol 2008; 29(6):1104-1110.
10. An HS, Andreshak TG, Nguyen C, Williams A, Daniels D. Can we distinguish between benign versus malignant compression fractures of the spine by magnetic resonance imaging? Spine 1995; 20(16):1776-1782.
11. Baker LL, Goodman SB, Perkash I, Lane B, Enzmann DR. Benign versus pathologic compression

fractures of vertebral bodies: assessment with conventional spin-echo, chemical-shift, and STIR MR imaging. Radiology 1990; 174(2):495-502.

12. Baur A, Stabler A, Arbogast S, Duerr HR, Bartl R, Reiser M. Acute osteoporotic and neoplastic vertebral compression fractures: fluid sign at MR imaging. Radiology 2002; 225(3):730-735.
13. Jung HS, Jee WH, McCauley TR, Ha KY, Choi KH. Discrimination of metastatic from acute osteoporotic compression spinal fractures with MR imaging. Radiographics 2003; 23(1):179-187.
14. Moulopoulos LA, Yoshimitsu K, Johnston DA, Leeds NE, Libshitz HI. MR prediction of benign and malignant vertebral compression fractures. J Magn Reso Imaging 1996; 6(4):667-674.
15. Cuenod CA, Laredo JD, Chevret S, Hamze B, Naouri JF, Chapaux X et al. Acute vertebral collapse due to osteoporosis or malignancy: appearance on unenhanced and gadolinium-enhanced MR images. Radiology 1996; 199(2): 541-549.
16. Tehranzadeh J, Tao C. Advances in MR imaging of vertebral collapse. Semin Ultrasound CT MR 2004; 25(6): 440-460.
17. Lolge S, Maheshwari M, Shah J, Patkar D, Chawla A. Isolated solitary vertebral body tuberculosis--study of seven cases. Clin Radiol 2003; 58(7):545-550.
18. Tokuda O, Harada Y, Ueda T, Ohishi Y, Matsunaga N. Malignant versus benign vertebral compression fractures: can we use bone SPECT as a substitute for MR imaging? Nucl Med Commun 2011; 32(3):192-198.
19. Rybak LP, Rosenthan DI. Radiological imaging for the diagnosis of bone metastasis. Q J Nucl Med 2001; 45(1):53-64.
20. Harvey CJ, Saifuddin A, Nordeen MH, Taylor BA. Sagittal vertebral body fractures: magnetic resonance imaging features. Br J Radiol 1997; 70(834):645-649.
21. Burrill J, Williams CJ, Bain G, Conder G, Hine AL, Misra RR. Tuberculosis: radiologic review. Radiographics 2007; 27(5):1255-1273.
22. Li KC, Poon PY. Sensitivity and specificity of MRI in detecting malignant spinal cord compression and in distinguishing malignant from benign compression fractures of vertebrae. Magn Reson Imaging 1988; 6(5):547-556.