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Characterization of magnetic resonance (MR) findings of malignant and benign vertebral compression fractures

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Introduction : *Differentiation between benign and malignant causes of a vertebral compression fracture is a common clinical problem, particularly in elderly patients. Establishing the correct diagnosis is of great importance in determining its treatment and prognosis.*

Objective : *To examine and characterize MR findings of malignant and benign vertebral compression fractures.*

Setting : *BMA General Hospital*

Research design : *A retrospective study*

Patients : *Patients with MRI of thoraco-lumbar vertebral compression fractures from December 2007 to December 2008 were recruited into the study.*

Methods : *The data collected for examination were MRI conventional T1W, T2W echo sequences in the sagittal and axial orientations with 5mm thickness. Vertebral compression fractures were examined for abnormal bone marrow signal intensity, convex of posterior cortex, retropulsed bony fragment, signal intensity and enhancement of adjacent discs, involvement of posterior elements, presence or absence of paravertebral-epidural mass, endplate integrity and fluid sign in fracture endplate. The diagnoses were confirmed by surgical findings, follow up MR imaging, clinical follow ups, or unequivocal imaging findings.*

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Results : *Twenty-five malignant vertebral compression fractures (25 metastatic carcinoma) and 59 benign ones (21 osteoporosis, 4 post-trauma and 34 spondylitis) were identified. The features of metastatic vertebral compressions were abnormal bone marrow signal intensity (100.0%), convexity of posterior cortex (80.0%), involvement of the posterior elements and pedicles (68.0%) and epidural/paravertebral soft-tissue mass (52%). Spondylitis compression fracture showed abnormal bone marrow signal intensity (100.0%), epidural/paravertebral soft-tissue mass/abscess (88.2%), abnormal endplate disruption (67.6%), high T2 signal intensity and increased enhancement of intervertebral discs (61.8%,61.8%) and posterior elements involvement (58.8%). MR features of acute osteoporotic fracture were abnormal marrow signal intensity (75%), complete preservation of vertebral signal intensity (25%), retropulsed bony fragment (66.7%) and fluid sign beneath the fractured endplate (66.7%).*

Conclusion : *Convexity of the posterior vertebral cortex was determined to be suggestive of, but not specific for, a malignant origin. Three good to excellent features, considered typical for spinal infection are, namely: endplate disruption, high T2 signal intensity and increased enhancement of intervertebral discs. At least two adjacent vertebral lesions are also more typical for spondylitis than neoplasm. Preservation of signal intensity of the vertebra is suggestive of the benign nature of a collapse. A retropulsed bony fragment and fluid sign beneath a fractured endplate were considered typical for acute osteoporotic vertebral compression fracture. Age and sex were not useful in differentiating of malignant from benign vertebral compression fractures. MR imaging is therefore helpful in distinguishing a benign from malignant vertebral collapses. However, when MRI features are atypical or equivocal, correlation with other imaging techniques, a short internal follow-up of MRI examination and biopsy, may be needed to establish a correct diagnosis.*

Keywords : *MR, Vertebral compression fracture, Benign, Malignant.*

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จินตวรี ศรีสมบูรณ์. ลักษณะเฉพาะของภาพกระดูกสันหลังยุบตัวจากโรคมะเร็งและโรคอื่น ๆ ที่พบจากเครื่องตรวจด้วยคลื่นสะท้อนในสนามแม่เหล็ก. จุฬาลงกรณ์เวชสาร 2552 มี.ค. – เม.ย.; 53(2): 119 – 33

บทนำ : *การหาสาเหตุของภาวะการยุบตัวของกระดูกสันหลังจากโรคมะเร็งและโรค อื่น ๆ บางครั้ง อาจสรุปได้ไม่ชัดเจนโดยเฉพาะในผู้สูงอายุ การหาลักษณะเฉพาะของรอยโรคจะช่วยให้วินิจฉัยและรักษาโรคได้อย่างรวดเร็ว*

วัตถุประสงค์ : *เพื่อรวบรวมรอยโรคและหาลักษณะจำเพาะของโรคต่าง ๆ เหล่านี้ด้วยเครื่องตรวจด้วยคลื่นสะท้อนในสนามแม่เหล็ก (เอ็ม อาร์ ไอ)*

สถานที่ที่ทำการศึกษา : *โรงพยาบาลกลาง*

รูปแบบการวิจัย : *การศึกษาแบบย้อนหลัง*

ผู้ป่วยที่ได้ทำการศึกษา : *ผู้ป่วยภาวะกระดูกสันหลังยุบช่วง Thoraco-lumbar ที่ได้รับการตรวจด้วยเครื่องเอ็ม อาร์ ไอ ระหว่าง เดือนธันวาคมพ.ศ. 2550 ถึง เดือนธันวาคม พ.ศ.2551*

วิธีการศึกษา : *ข้อมูลทั้งหมดได้มาจากการตรวจด้วยเครื่องเอ็ม อาร์ ไอ ด้วยเทคนิค T1W และ T2W echo sequences ในระนาบตามขวาง และระนาบซ้ายขวา ด้วยความหนา 5 มิลลิเมตร การวินิจฉัยยืนยันด้วยผลชิ้นเนื้อผลตรวจจากห้องปฏิบัติการ การติดตามของอาการ และการติดตามการตรวจด้วยเครื่องตรวจเอ็ม อาร์ ไอ*

ผลการศึกษา : *ภาวะยุบตัวของกระดูกสันหลังจากโรคมะเร็งระยะแพร่กระจาย 25 รอยโรค และ รอยโรคจากสาเหตุอื่น 59 รอยโรค แบ่งเป็นภาวะกระดูกพรุน 21 รอยโรค, บาดเจ็บ 4 รอยโรคและการติดเชื้อ 34 รอยโรค ลักษณะที่พบจากกระดูกสันหลังยุบจากโรคมะเร็งระยะแพร่กระจายมีดังนี้ มีสัญญาณของมวลไขกระดูกสันหลังผิดปกติ (100%) มีความโป่งของกระดูกสันหลังทางด้านหลัง (80%) ปรากฏความเข้มของสัญญาณที่ผิดปกติที่กระดูกสันหลังส่วนหลัง (68%) ก้อนหรือฝีหนองที่บริเวณรอบกระดูกสันหลัง (52%) ลักษณะที่พบจากกระดูกสันหลังยุบจากโรคการติดเชื้อมีดังนี้ มีการสัญญาณของมวลไขกระดูกสันหลังผิดปกติ (100%) ก้อนหรือฝีหนองที่บริเวณรอบกระดูกสันหลัง (88.2%) มีการทำลายของแผ่นปลายประสาทเคลื่อนไหวของกระดูกสันหลัง(67.6%)*

วิจารณ์และสรุป : *ความเข้มของสัญญาณเพิ่มขึ้นในเทคนิค T2 และ หลังการฉีดสาร paramagnetic gadolinium-base contrast agents ที่หมอนรองกระดูก (61.8%) และปรากฏความเข้มของสัญญาณที่ผิดปกติที่กระดูกสันหลังส่วนหลัง (58.8%) ลักษณะที่พบจากกระดูกสันหลังยุบจากโรคภาวะกระดูกพรุนมีดังนี้ มีสัญญาณของมวลไขกระดูกสันหลังผิดปกติ (75%) มีเศษกระดูกที่แตกยื่นออกไปด้านหลัง (66.7%) และมีสัญญาณของเหลวใต้แผ่นปลายประสาทเคลื่อนไหวของกระดูกสันหลังที่แตก (66.7%) ลักษณะบ่งชี้ถึงภาวะยุบตัวของกระดูกสันหลังจากโรคมะเร็งระยะแพร่กระจายคือมีความโป่งของกระดูกสันหลังทางด้านหลัง ลักษณะเฉพาะของภาวะกระดูกสันหลังยุบจากโรคการติดเชื้อ คือมีการทำลายของแผ่นปลายประสาทเคลื่อนไหวของกระดูกสันหลัง มีความเข้มของสัญญาณที่เพิ่มขึ้นในเทคนิค T2 และ หลังการฉีดสารparamagnetic gadolinium-base contrast agents ที่หมอนรองกระดูก และลักษณะเฉพาะที่พบจากกระดูกสันหลังยุบจากโรคภาวะกระดูกพรุนคือ มีเศษกระดูกที่แตกยื่นออกไปด้านหลัง และมีสัญญาณของเหลวใต้แผ่นปลายประสาทเคลื่อนไหวของกระดูกสันหลังที่แตก*

การตรวจด้วยเครื่องเอ็ม อาร์ ไอ มีประโยชน์ในการช่วยวินิจฉัยและแยกภาวะการยุบตัวของกระดูกสันหลังจากโรคมะเร็งและโรคอื่น ๆ ได้ อย่างไรก็ตามในกรณีที่รอยโรคที่ได้จากภาพเครื่องตรวจเอ็ม อาร์ ไอ ไม่สามารถสรุปได้ชัดเจน การติดตามการตรวจด้วยเครื่องเอ็ม อาร์ ไอ ในระยะเวลาอันสั้นและการตรวจชิ้นเนื้อจะช่วยวินิจฉัยได้ถูกต้องยิ่งขึ้น

คำสำคัญ : *เครื่องตรวจด้วยคลื่นสะท้อนในสนามแม่เหล็ก, การยุบตัวของกระดูกสันหลัง, โรคมะเร็งและโรคอื่น ๆ ที่ไม่ใช่มะเร็ง*

Differentiation between benign and malignant causes of vertebral compression fracture is a common clinical problem, particularly in elderly patients. Osteoporosis is the most common cause of compression fractures in this age group. However, the spine is a common site of metastatic disease and accounts for up to 39% of all bone metastases. Such metastases may result in a pathological fracture. [1] Signs of neurological dysfunction may be nonspecific to both types of fracture, wherein back pain may be the only complaint of the patient.

The determination of the malignant and benign causes of vertebral compression fractures is challenging. A malignant fracture may represent the first manifestation of malignancy. On the other hand, osteoporosis is common, and vertebral fractures may occur even without trauma or after a minor injury. In addition to osteoporosis, causes of benign compression fractures include trauma, osteomyelitis, Langerhans cell histiocytosis, Paget's disease, hemangiomas, etc.

Spinal tuberculosis is the most common site of osseous involvement in tuberculosis. The disease prevalence will continue to rise as the number of immunocompromised patients increases. A malignant compression fracture can be either a metastasis or primary bone tumor such as multiple myeloma, lymphoma, leukemia, etc.

Establishing the correct diagnosis is of great importance in determining the treatment and prognosis. Conventional radiography, bone scintography and Computed Tomography (CT) have been used for the diagnostic work up of a patient with compression fracture. Magnetic resonance imaging (MRI) is currently a modality of choice for the evaluation of these fractures. Advantages of MR imaging include the capacity of multiplanar imaging, direct evaluation of the bone marrow and contemporary visualization of the neural structures.

The purpose of this study was to examine and characterize the MR imaging appearance of compression fractures whether they were benign or malignant processes in order to establish useful criteria for specific diagnosis.

Material and Method

MR images of patients with vertebral compression fractures (VCFs) of thoraco-lumbar spine from December 2007 to December 2008 were retrospectively reviewed without any knowledge of their clinical history and pathological results. There were 48 patients with 84 vertebral compression fractures (VCFs), 24 men and 24 women. Their mean age was 59 years; range, 39 – 86 years.

The reviewer evaluated vertebral compression fractures for abnormal bone marrow signal intensity, convex of posterior cortex, retropulsed bony fragment, abnormal signal intensity and enhancement of the adjacent intervertebral discs, involvement of posterior elements and pedicles, presence or absence of paravertebral-epidural mass, endplate integrity and fluid sign in fracture endplate. The diagnoses were confirmed with surgery, follow-up radiological imaging and clinical follow-up.

The patients with metastatic vertebral compression fracture, diagnosed based on the presence of histopathological evidence. The patients with tuberculous and pyogenic spondylitis, diagnosed based on the presence of histopathological or microbiological evidence. A diagnosis of traumatic

fracture was made when there was a history of trauma and improvement in the follow-up studies. The diagnoses of the patients with osteoporotic vertebral compression fracture were confirmed by follow-up radiological imaging and clinical follow-up. Follow-up radiological imaging was performed 4 - 13 months after the study MR imaging. The relief of pain and lack of vertebral destruction were used to confirm the benign nature of a fracture.

The patients without definite diagnosis from any evidence were excluded from this study.

MR Image Acquisition

MR imaging was performed with a 1.5-T imager (Symphony; Siemens, Erlangen, Germany). Data collected for examination included MRI conventional T1W, T2W echo sequences in sagittal and axial orientation with 5mm thickness.

Data Analysis

Univariate analysis with the X2 test was performed between MR imaging findings, age, sex and the dependent variable of metastatic or benign vertebral compression fractures.

Results

Fifty-nine benign vertebral compression fractures in 36 patients and 25 malignant vertebral compression fracture in 12 patients were analyzed in the study. There were 7 men and 5 women with metastatic compression fracture; their mean age, 57 years; range 47 -76 years old. There were 17 men and 19 women with benign compression fracture; their mean age, 60 years; range 39 - 86years.

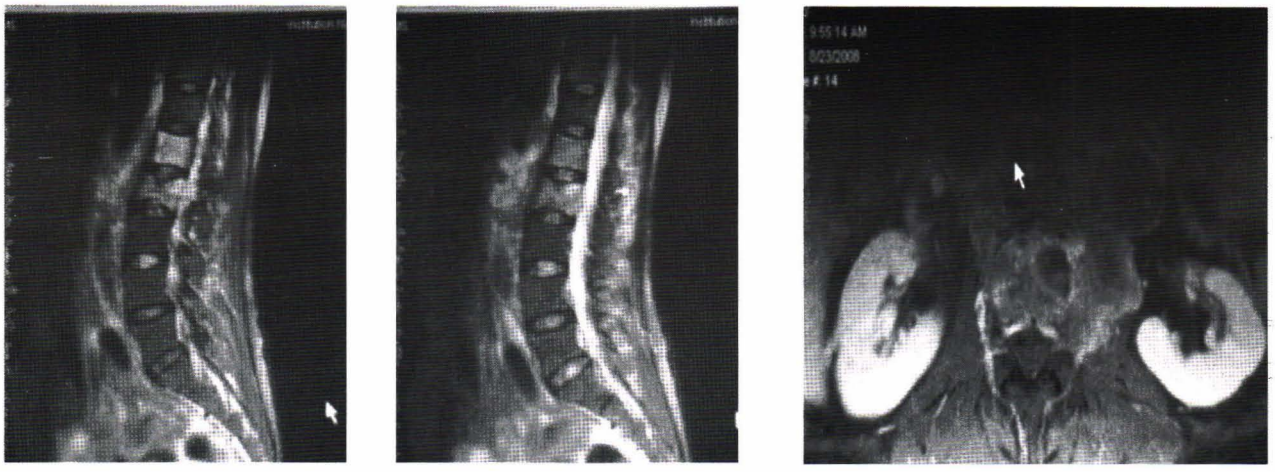
Of the 12 patients with malignant compression fracture, all had metastatic cancer: bronchogenic carcinoma (n = 4), colorectal carcinoma (n = 3), prostate carcinoma (n = 2), breast carcinoma (n = 1), cervical carcinoma (n = 1) and transitional cell carcinoma of the kidney (n = 1).

Of the 36 patients with benign compression fracture, 16 had osteoporosis (4 men and 12 women, mean age, 67years); 3 patients with post-trauma (3men, mean age, 51 years); and 17 patients with spondylitis (10 men and 7 women, mean age, 51 years). There were 9 vertebral compression fractures with chronic osteoporosis, 12 had acute osteoporosis; 4 trauma; 32TB spondylitis; and 2 pyogenic spondylitis.

Age and sex were not useful in differentiating of metastatic from osteoporotic and spondylitic vertebral compression fractures, p value > 0.001)

Malignant vertebral compression fractures

MRI features of metastatic vertebral compression fracture are abnormal marrow signal intensity, replacement with low signal intensity on T1WI and high signal intensity on T2WI (25/25,100%), convex posterior cortex of the vertebral body (20/25, 80.0%), involvement of the posterior elements and pedicles (17/25, 68.0%) and presence of heterogenous enhancing epidural/paravertebral soft-tissue mass (13/25, 52%). Uncommon findings include fluid sign in fractured endplate (figure5) and endplate disruption are about 2/25(8.0%) and 1/25 (4.0%). Multiple fractures that involved at least two adjacent vertebral bodies were 9/25 and 36 % (Table 1).



a. b. c.

Figure 1. Metastatic compression fracture at L2 vertebral body:
(a) Sagittal T2-weighted MR image shows compression fracture with a complete replacement of normal bone marrow of the L2 vertebral body. A convex posterior cortex is also noted.
(b) Sagittal fat-suppressed contrast material–enhanced T1-weighted MR image shows enhancement of the L1 and L2 vertebral bodies. **(c)** Axial fat-suppressed contrast-enhanced T1-weighted MR image shows heterogenous enhancing left paravertebral mass.

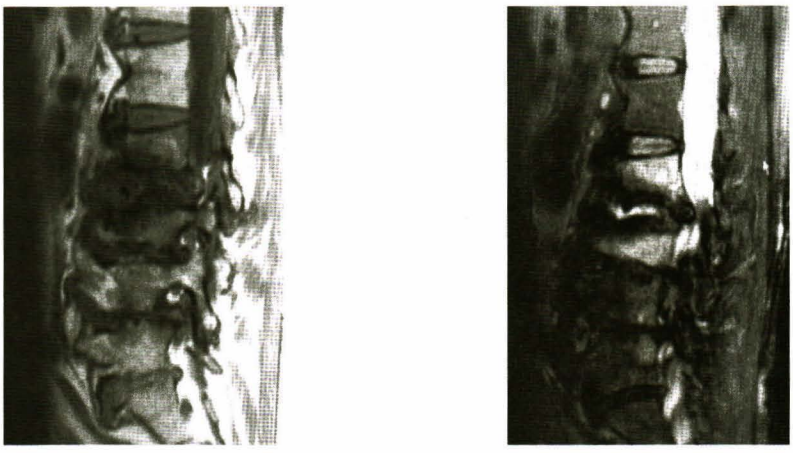
Benign vertebral compression fractures

MRI features of chronic osteoporotic fracture are complete preservation of the vertebral signal intensity (9/9,100%). MRI features of acute osteoporotic fracture are abnormal marrow signal intensity (9/12, 75%), complete preservation of vertebral signal intensity (3/12, 25%), retropulsed bony fragment (8/12, 66.7%) and fluid sign beneath the fractured endplate (8/12, 66.7%) (Figure2). On the other hand, the uncommon features are such as convexity of the posterior cortex, endplate disruption and abnormal signal intensity of the pedicle and posterior elements (1/12, 8.3%) (Figure 4).

MRI features of 4 trauma cases were marrow replacement with (4/4,100%), retropulsed bony fragment (2/4, 50%) and the uncommon features such as posterior element involvement were 1/4 (25%).

MRI features of spondylitis are abnormal bone marrow signal intensity (34/34,100.0%); presence of heterogenous enhancing epidural/paravertebral soft-tissue mass/abscess (30/34, 88.2%); mostly of large size, relative to other causes; abnormal endplate disruption (23/34, 67.6%); high signal intensity of intervertebral disc on T2WI (21/34, 61.8%); intervertebral disc enhancement (21/34, 61.8%) and posterior elements involvement (20/34, 58.8%) (Figure 3).

Multiple fractures that involved at least two adjacent vertebral bodies involvement were 29/34 and 85.3%.

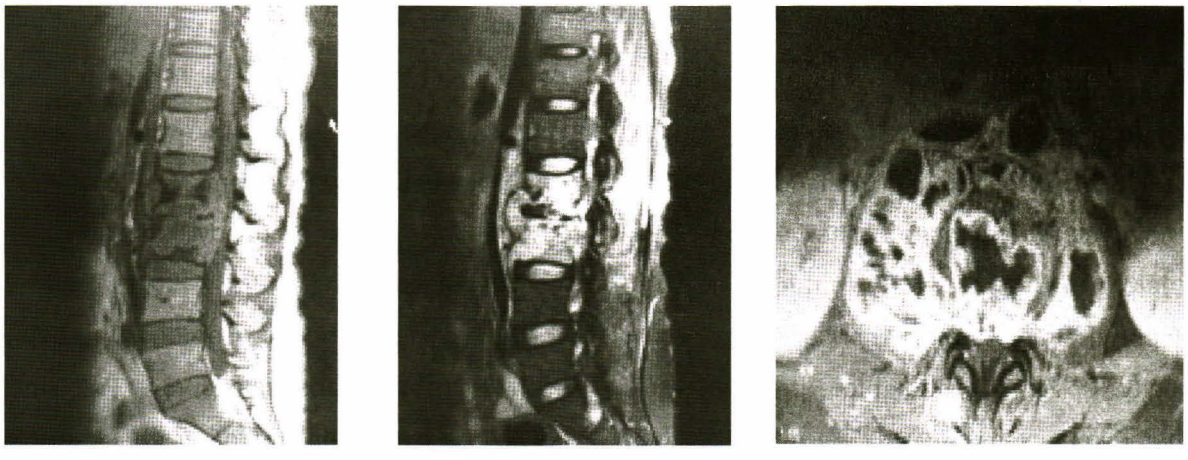


a. b.

Figure 2. Acute osteoporotic compression fracture at L2, L3:

(a) Sagittal T1-weighted MR image shows compression fracture of L2 and L3 with bone marrow edema;

(b) Sagittal T2WI shows linear fluid sign at fractured endplate and retropulsion of bone fragment at the posterior portions the vertebral body.



a. b. c.

Figure 3. Tuberculosis spondylitis of the two adjacent L2-3 vertebral bodies.

(a) Pre-GadoliniumT1-Weighted in sagittal plane shows marrow replacement at L2, L3 vertebrae;

(b) T2-weighted in sagittal plane shows increased signal intensity of the vertebrae and L2-3 intervening disc involvement;

(c) Post-gadolinium T1-weighted in axial plane shows paravertebral/epidural abscess. MRI features of pyogenic spondylitis were abnormal bone marrow signal intensity, heterogenous enhancing epidural/ paravertebral soft-tissue mass/abscess, abnormal endplate disruption, high signal intensity of intervertebral disc on T2WI, intervertebral disc enhancement and posterior elements involvement, which are not significantly different from TB spondylitis.

Table 1. MR Imaging Findings of Metastatic and Benign Vertebral Compression Fractures (VCFs).

MRI Findings	Percentage of Fractures with Findings			
	Metastasis (25VCFs)	Acute Osteoporosis (12VCFs)	Trauma (4VCFs)	Spondylitis (34VCFs)
Abnormal marrow signal intensity	100 (25/25)	75 (9/12)	100 (4/4)	100 (34/34)
Preservation of normal SI,T1WI	-	25 (3/12)	-	-
Convex of posterior cortex	80 (20/25)	8.3 (1/12)	-	-
Retropulsed bony fragment	-	66.7 (8/12)	50 (2/4)	-
Posterior element involvement	68 (17/25)	8.3 (1/12)	25 (1/4)	58.8 (20/34)
Fluid sign beneath fractured endplate	8 (2/25)	66.7 (8/12)	-	-
Abnormal endplate disruption	4 (1/25)	8.3 (1/12)	-	67.6 (23/34)
High SI of disc,T2W	-	-	-	61.8 (21/34)
Disc enhancement	-	-	-	61.8 (21/34)
Epidural-paravertebral soft-tissue mass	52 (13/25)	-	-	88.2 (30/34)
Multiple adjacent lesions	36 (9/25)	35 (4/12)		85.3 (29/34)

Discussion

The ability to differentiate malignant from benign vertebral compression fractures; acute osteoporotic and spondylytic vertebral compression fractures is of considerable clinical interest as conditions are common in elderly patients. Establishing the correct diagnosis is of great importance in determining treatment, surgical approach, and prognosis.

Malignant vertebral compression fracture

The most common cause of malignant collapse is metastatic disease, usually from breast carcinoma, bronchogenic carcinoma, prostatic carcinoma or renal carcinoma.[2,3] Multiple myeloma or solitary plasmacytoma and lymphoma are less common.[3]

Malignant vertebral compression fracture is associated marrow replacement with low signal intensity on T1-weighted image (100%). Marrow replacement from tumor infiltration is usually complete.[4,5] There is complete marrow replacement because the vast majority of vertebral metastases will not fracture until there is complete tumor infiltration, thus causing structural bone weakening from destruction of trabeculae, cortex or both. Yuh et al.[1] found that a complete loss of signal intensity in the bone marrow on T1-weighted images provides a high level of accuracy in diagnosis of malignant fractures. In study of Cuenod CA et al., in the two malignant vertebral collapses with areas of preserved signal intensity, low signal intensity within the vertebral body were round, which is different from the band-like arrangement of the areas of low signal intensity seen in osteoporotic vertebral collapses.

Complete preservation of bone marrow signal intensity of the vertebral body was highly excluded malignant cause.

A convex posterior cortex of the vertebral body was more frequent in metastatic compression fractures than acute osteoporotic compression fractures (80% of metastatic fractures (Figure 1) *vs* 8.3% of acute osteoporotic fractures, p value < 0.001, and Table 2). It determined to be suggestive of, but not specific for, a malignant origin; 6% of the osteoporotic vertebral collapses exhibited this finding. [3] Anterior and posterior vertebral bodu bulging or convexity can be seen in 33% to 70% of malignant collapse cases. [4] Two mechanisms may explain the presence of this finding in osteoporotic collapses, especially when the height of the vertebral body is greatly reduced: Fracture lines may extend into the posterior part of the vertebral body, which results in an apparent convexity of the posterior cortex. Bone marrow may also be pushed out the vertebral body during the collapse.

No evidence of retropulsed bony fragment into the spinal canal was detected on metastatic compression fracture in this study, the same with previous report. [3] This appearance could not be mistaken for the convex posterior bulge that involved the whole posterior cortex of the vertebral body.

The presence of other metastases, pedicle involvement, intact vertebral discs and the absence of vertebral body fragmentation are secondary findings suggestive of a fracture due to metastasis. [1]

Benign compression fracture

Osteoporosis

Chronic benign compression fractures can be easily detected due to its absence of abnormal signal intensity in a compressed vertebra. [2,4] Spared normal bone marrow signal intensity of the vertebral body was highly suggestive of benign nature.

In acute osteoporotic compression fractures, edema and fluid replace the fatty marrow within the vertebral body, appearing hypointense on T1-weighted images, which was difficult to differentiate from malignant cause. Acute osteoporotic vertebral compression fracture, T1-weighted images demonstrated preservation of normal marrow in at least some areas of the vertebral body. These areas of normal signal intensity are opposite to the fractured site and have a band-like arrangement. [4]

Table 2. MR Imaging Findings of Metastatic and Acute Osteoporotic Vertebral Compression Fractures (VCFs)

MRI Findings	Percentage of Fractures with Findings		
	Malignant (25VCFs)	Acute Osteoporosis (12VCFs)	*P* Value From X 2 Test
Abnormal marrow signal intensity	100 (25/25)	75 (9/12)	0.009
Convex of posterior cortex	80 (20/25)	8.3 (1/12)	< 0.001
Posterior element involvement	68 (17/25)	8.3 (1/12)	0.001
Fluid sign beneath fractured endplate	8 (2/25)	66.7 (8/12)	< 0.001
Abnormal endplate disruption	4 (1/25)	8.3 (1/12)	0.585
Multiple adjacent lesions	36 (9/25)	35 (4/12)	0.874

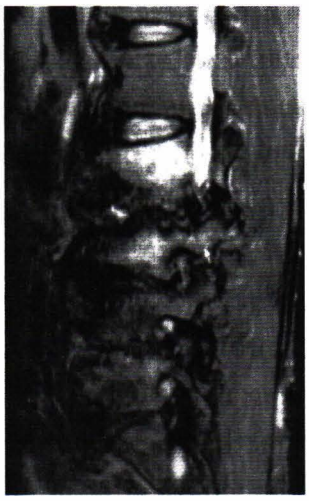


Figure 4. Unusual acute osteoporotic compression fracture with abnormal signal intensity of the pedicle.
Sagittal T2-weighted image shows abnormal increased signal intensity of the pedicle.

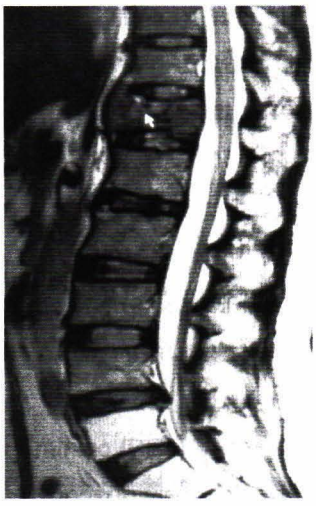


Figure 5. Unusual metastatic compression fracture with fluid sign.
Sagittal T2-weighted image shows triangular fluid sign at the fractured superior endplate.

Retropulsion of a posterior (often posterior-superior) bony fragment of the vertebral body into the spinal canal is determined to be specific for a benign fracture (Figure 2b). In a prior study, no malignant compression fracture showed retropulsed of a posterior bony fragment which is consistent with this study. [3] A vacuum cleft in collapsed vertebrae is indicative of a vascular necrosis and suggestive of a benign etiology.

The presence of high signal intensity (fluid sign) adjacent to vertebral endplate on T2WI is more frequent in acute osteoporotic compression fracture (Figure 2b) than metastatic compression fracture (67.7% *vs.* 8%, p value < 0.001 and Table 2). It is said to be fractures of acute and sub-acute osteoporosis fracture and is rarely seen in metastasis fractures. [5] Although this finding is significant, a tumor cannot be excluded because of this sign. Other morphologic features should be considered if the diagnostic decision is difficult. [5]

Increased signal intensity on T1weighted images was observed with some benign fracture with or without history of trauma but not malignancy. This phenomenon may be related to degenerative yellow fat replacement and/or compaction of residual bone marrow in the benign process, in contrast to bone marrow replacement by tumor cells.

Paraspinal and/or epidural soft tissue masses were not present in the benign osteoporotic vertebral compression fracture.

In summary, the preservation and configuration of normal-signal-intensity bone marrow may be useful findings for differentiation of benign from malignant compression fractures.

Spondylitis

Magnetic resonance imaging (MRI) is the investigation method of choice for the diagnosis of spondylodiscitis because it presents certain

advantages including high sensitivity in early stages, better definition of paravertebral and epidural extension and spinal cord involvement.[6-8] An increasing number of atypical forms characterized by spondylitis without disc involvement were reported and even claimed to be the most common pattern of spinal TB type in foreigners from industrialized countries. [6, 9]

In this study, the classical infective spondylitis features, which showed paraspinal soft tissue formation (88.2%), involvement of at least two adjacent vertebral bodies (85.3%), abnormal endplate disruption (67.6%) and abnormalities of the intervening disc (61.8%), are still the most common patterns of spinal TB. Its atypical form which characterizes in spondylitis without disc involvement [9] also presents 13/34 (38.2%).

Destruction of the endplates, high signal in disc on T2W and disc enhancement are considered typical for spinal infection. [10-13] They are also shown in this study (Table 1, 2). However, some authors reported intact endplates on both sides of an infected disc and lack of endplates involvement can therefore not be use as a reliable sign to exclude spinal infection. [14-16] Pseudo-sparing of the endplate due to chemical shift artifact can be avoided by means of selection of the phase-encoding plane in the craniocaudal direction. [17]

In the early state, infection usually originates at the anterior sub - chondral bone adjacent to the vertebral endplates. Then, it spreads underneath the longitudinal ligament, mostly anterior longitudinal ligament, followed by adjacent vertebra or multiple vertebral bodies and discs involvement. When both of the neighboring vertebral bodies are involved, the disc may lose its nutrition and is involved secondarily. [18]

High signal in disc on T2W and disc enhancement are considered typical for spinal infection but not specific for TB. [10, 11] It also can be seen in other conditions such as highly vascularized degenerative discs in erosive intervertebral osteochondritis. [19]

High sensitivity but low specificity signs in MRI include abnormal bone marrow replacement, posterior element involvement (68% of spondylitis compression fracture *vs.* 58.8% of metastatic compression fracture; p value = 0.687) and paravertebral soft-tissue formation (88.2% of spondylitis compression fracture *vs.* 52% of metastatic compression fracture; p value = 0.002, Table3). However the size of paravertebral mass/abscess in infective process is more predominate, comparing to metastasis. Other signs are less sensitive and less specific because other disease processes can also produce the same appearance.

The presence of intense enhancement of paraspinal and/or epidural soft tissue masses, especially ring-enhancement is indicative of an abscess; and, intense enhancement of the disk and adjacent vertebral endplate and body are particularly helpful in strengthening the diagnosis of vertebral osteomyelitis. [20, 21]

Differentiating spinal TB from pyogenic spondilitis is usually difficult, although there are many previous claims that there may be some features helpful. Clinically, TB infection generally affects adults in their forties and fifties whereas the peak incidence of pyogenic spondylitis is seen in the sixties or seventies. [18] The smooth margin of a cold abscess

from TB, which is sub-ligamental spread without destruction of the paraspinal ligament, contrasts with the irregular margin of pyogenic abscesses, which proteolytic enzyme can destroy the paraspinal ligament. [8] Posterior elements or multiple vertebral body involvement are less commonly encountered in pyogenic spondilitis. [10, 21-23] In addition, size of the paraspinal mass is larger in tuberculosis than in pyogenic infections. [22, 23] Collapse of the vertebral bodies is rarely seen in pyogenic spinal infection but common in spinal TB. [24] In this study there was only 1 patient with 2 levels of pyogenic spinal infection, showing no significant different from TB features.

Isolated involvement of the posterior elements with sparing of the vertebral body, a feature that are more typical of neoplasm than infective process, does occur in spinal TB especially in countries where TB is epidemic but not found in this study. Overall, the sensitivity and specificity of MRI for spinal tuberculosis were 100% and 88.2% respectively. [6] Multifocal spinal TB was reported to account for 1 - 36% of the cases. [6] At least two adjacent vertebral lesions are also more typical for spondylitis than neoplasm (85.3% of spondylitis compression fracture vis-ι-vis 36% of metastatic compression fracture; p value < 0.001, Table 3).

Conclusion

Convexity of the posterior vertebral cortex was determined to be suggestive of, but not specific for, a malignant origin. [3] Three good to excellent features that are considered typical for spinal infection were end-plate disruption, high T2 signal intensity and increased enhancement of the intervertebral discs. At least two adjacent vertebral lesions are also more typical for spondylitis than neoplasm.

Preservation of signal intensity of the vertebra suggests a benign nature of a collapse. Retropulsed bony fragment and fluid sign beneath fracture endplate are considered typical for acute osteoporotic vertebral compression fracture. It can be an additional sign of osteoporosis that rarely occurs in metastatic fractures. [3] Age and sex were not useful in differentiating of malignant from benign vertebral compression fractures.

Previous reports [1] and the results of this study demonstrate that MR imaging is helpful to distinguish a benign from malignant vertebral collapses when clinical, biologic, and conventional radiographic findings are not conclusive. Using conventional MR imaging, a diagnostic accuracy of up to 94% can be achieved even without clinical information. With the help of clinical information this accuracy level can achieve more than 90 %. [25]

Table 3. MR Imaging Findings of Metastatic and Spondylitic Vertebral Compression Fractures (VCFs).

MRI Findings	Percentage of Fractures with Findings		
	Malignant (25VCFs)	**Spondylitis (34VCFs)**	***P* Value From X 2 Test**
Posterior element involvement	68 (17/25)	58.8 (20/34)	0.687
Abnormal endplate disruption	4 (1/25)	67.6 (23/34)	< 0.001
Epidural-paravertebral soft-tissue mass	52 (13/25)	88.2 (30/34)	0.002
Multiple adjacent lesions	36 (9/25)	85.3 (29/34)	<0.001

However, when MRI features are atypical or equivocal, correlation with other imaging techniques, a short internal follow-up MRI examination and biopsy, may be needed to make correct diagnosis. In addition, it is possible for a metastasis to occur in a previously benign fracture and for a traumatic fracture to occur in a vertebra with a metastasis or osteoporosis.

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