ABSTRACT

Purpose. To evaluate the sensitivity, specificity and accuracy of various magnetic resonance imaging (MRI) features in differentiating vertebral compression fractures caused by malignancy, osteoporosis, and infections.

Methods. 35 men and 45 women aged 40 to 78 (mean, 59) years underwent MRI to assess the underlying pathology of already diagnosed vertebral compression fractures (n=152). The interval from presentation to imaging ranged from 7 to 95 (mean, 62) days. MRI features of each vertebral compression fracture were assessed. The sensitivity, specificity, and accuracy for each of the MRI features were calculated. Association between each MRI feature and various underlying pathologies (malignancy, osteoporosis, and infections) of vertebral compression fractures was evaluated.

Results. Regarding these 80 patients, the MRI diagnosis was correct in 78 and inconclusive in 2 with malignancy. MRI features suggestive of malignant fractures were a convex posterior border of the vertebral body, pedicle involvement, posterior neural element involvement, an epidural mass, a paraspinal mass, and other spinal metastases. MRI features suggestive of osteoporotic fractures were retropulsion, low signal intensity band, spared normal marrow signal intensity, and the fluid sign. MRI features suggestive of infective fractures were contiguous vertebral involvement, end plate disruption, disc involvement, and paraspinal and epidural abscesses.

Conclusion. Combination of several MRI features can provide clues to differentiate between malignant, osteoporotic, and infective vertebral compression fractures.

Key words: fractures, compression; infection; magnetic resonance imaging; neoplasm metastasis; osteoporosis; osteoporotic fractures; spinal fractures

INTRODUCTION

Vertebral compression fractures are common,
especially in the elderly. Differentiating malignant from benign compression fractures based on clinical findings, radiography, bone scans, and computed tomography may not be sufficient, particularly for patients without a history of trauma or malignancy. Magnetic resonance imaging (MRI) features for differentiating benign and malignant spinal compression fractures have been reported. Most such studies only included osteoporotic fractures as the benign entity; few included infective vertebral fractures. Also, the relative importance, sensitivity, specificity, and accuracy of several MRI criteria are not fully established. We evaluated the sensitivity, specificity and accuracy of various MRI features in differentiating vertebral compression fractures caused by malignancy, osteoporosis, or infections.

MATERIALS AND METHODS

From May 2003 to May 2007, 35 men and 45 women aged 40 to 78 (mean, 59) years presented with back or neck pain and/or a neurological deficit after no or minor trauma (e.g. fall from standing height). They underwent MRI to assess the underlying pathology of the already diagnosed vertebral compression fractures (n=152). The interval from presentation to imaging ranged from 7 to 95 (mean, 62) days.

MRI was performed using a 1.5-tesla imager (Gyro ACS.NT synergy coil MR device-Philips) or a 0.2-tesla imager (Concerto Version syngo MR 2004A-Siemens). Gadolinium-diethylenetriamine pentacetatic acid (Gd-DTPA) of 0.2 ml/kg body weight was administered intravenously after conventional T1- and T2-weighted sequences are completed.

Various MRI features of each vertebral compression fracture were assessed. They included (1) bone marrow replacement; (i) complete replacement (no normal bone marrow signal in the compressed vertebra), (ii) incomplete replacement (some residual normal bone marrow signal), and (iii) complete preservation (only normal bone marrow signal); (2) convex posterior vertebral border; (3) pedicle involvement; (4) posterior element involvement; (5) other metastatic lesions (denoted by abnormal signal intensity in the bone marrow of other vertebrae); (6) retropulsion of a posterior bone fragment (often posterosuperior angle of the vertebral body into the spinal canal); (7) a low signal intensity band–like area on T1- and T2-weighted images corresponding to a fracture line or trabecular impaction; (8) a fluid sign: focal, linear or triangular areas of high signal intensity adjacent to the vertebral end plates on T2-weighted and short T1 inversion recovery images; (9) contiguous vertebral involvement; (10) vertebral end plate integrity; (11) vertebral disc involvement (manifest as an abnormal signal intensity pattern: hypointense on T1-weighted images and hyperintense on T2-weighted and post-contrast enhancement images) and reduced disc height; (12) epidural mass (anterior, posterior or encasing); (13) a paraspinal soft-tissue mass (anterior, posterior or both); (14) a paraspinal abscess; and (15) an epidural abscess. Both abscesses and soft-tissue masses exhibit low signal intensity on T1-weighted images and high signal intensity on T2-weighted images, but soft-tissue masses are enhanced by Gd-DTPA whereas abscesses show ring enhancement.

The sensitivity (true positive / [true positive + false negative] x 100), specificity (true negative / [true negative + false positive] x 100), and accuracy (number of correct MRI diagnosis / number of confirmed final diagnosis x100) for each MRI feature were calculated. Associations between each MRI feature and various underlying vertebral compression fracture pathologies were evaluated using the Chi squared test. A p value of <0.05 was considered statistically significant.

<table>
<thead>
<tr>
<th>Diagnostic result</th>
<th>Malignant fractures</th>
<th>Osteoporotic fractures</th>
<th>Infective fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>48 (96)</td>
<td>16 (100)</td>
<td>14 (100)</td>
</tr>
<tr>
<td>Inconclusive</td>
<td>2 (4)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Incorrect</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tumour origin</th>
<th>No. (%) of patients</th>
<th>No. (%) of fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>13 (26)</td>
<td>29 (34)</td>
</tr>
<tr>
<td>Myeloma</td>
<td>7 (14)</td>
<td>12 (14)</td>
</tr>
<tr>
<td>Liver</td>
<td>4 (8)</td>
<td>4 (5)</td>
</tr>
<tr>
<td>Lung</td>
<td>4 (8)</td>
<td>8 (9)</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>4 (8)</td>
<td>8 (9)</td>
</tr>
<tr>
<td>Prostate</td>
<td>4 (8)</td>
<td>4 (5)</td>
</tr>
<tr>
<td>Thyroid</td>
<td>3 (6)</td>
<td>5 (6)</td>
</tr>
<tr>
<td>Kidney</td>
<td>2 (4)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Colon</td>
<td>1 (2)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Uterus</td>
<td>1 (2)</td>
<td>3 (4)</td>
</tr>
<tr>
<td>Unknown</td>
<td>7 (14)</td>
<td>9 (11)</td>
</tr>
<tr>
<td>Total</td>
<td>50 (100)</td>
<td>85 (100)</td>
</tr>
</tbody>
</table>
Regarding these 80 patients, the MRI diagnosis was correct in 78 and inconclusive in 2 with malignancy (Table 1).

In 50 patients, the underlying pathology of 85 vertebral compression fractures was malignancy (Table 2). In 45 of them, the final diagnosis was confirmed histopathologically through open biopsy. In the remaining 5, it was based on progressive deterioration of the fractured vertebra and/or new development of spinal metastases evident with follow-up MRI. Indications for surgery were intertractable pain, neurological deficits, and a confirmed tissue diagnosis.

In 16 patients, the underlying pathology of 34 vertebral compression fractures was osteoporosis. In 14 of them, the final diagnosis was based on clinical and radiological follow-up over 6 to 12 months. In the remaining 2, it was confirmed histopathologically. Indication for surgery was neurological deficits.

In 14 patients, the underlying pathology of 33 vertebral compression fractures was infection. Their final diagnoses were confirmed histopathologically. The indications for surgery were intertractable pain, severe or progressive kyphosis, a large abscess, and spinal instability.

MRI features suggestive of malignant fractures were a convex posterior border of the vertebral body, pedicle involvement, posterior neural element involvement, an epidural mass, a paraspinal mass, and other spinal metastases (Table 3 and Fig. 1).

MRI features suggestive of osteoporotic fractures were retropulsion, a low signal intensity band, spared normal marrow signal intensity, and the fluid sign (Table 3 and Fig. 2). MRI features suggestive of infective fractures were contiguous vertebral involvement, end plate disruption, disc involvement, paraspinal abscesses, and epidural abscesses (Table 3 and Fig. 3).

**RESULTS**

Regarding these 80 patients, the MRI diagnosis was correct in 78 and inconclusive in 2 with malignancy (Table 1).

In 50 patients, the underlying pathology of 85 vertebral compression fractures was malignancy (Table 2). In 45 of them, the final diagnosis was confirmed histopathologically through open biopsy. In the remaining 5, it was based on progressive deterioration of the fractured vertebra and/or new development of spinal metastases evident with follow-up MRI. Indications for surgery were intertractable pain, neurological deficits, and a confirmed tissue diagnosis.

In 16 patients, the underlying pathology of 34 vertebral compression fractures was osteoporosis. In 14 of them, the final diagnosis was based on clinical and radiological follow-up over 6 to 12 months. In the remaining 2, it was confirmed histopathologically. Indication for surgery was neurological deficits.

In 14 patients, the underlying pathology of 33 vertebral compression fractures was infection. Their final diagnoses were confirmed histopathologically. The indications for surgery were intertractable pain, severe or progressive kyphosis, a large abscess, and spinal instability.

MRI features suggestive of malignant fractures were a convex posterior border of the vertebral body, pedicle involvement, posterior neural element involvement, an epidural mass, a paraspinal mass, and other spinal metastases (Table 3 and Fig. 1).

**DISCUSSION**

MRI is superior to other diagnostic tools in differentiating benign from malignant compression spinal fractures,1 based on several MRI features.2–9 However, only a few studies reported the sensitivity, specificity, and accuracy of each feature,1,3 which enable the surgeon to prioritise the MRI features in case of contradiction. For example in our study, the most accurate MRI feature for diagnosis of infective fractures was disc involvement. Its sensitivity, specificity and accuracy were 97%, 98% and 98%, respectively. If this feature is present, the addition of one or 2 other features suggestive of infection will be sufficient for diagnosis.

Combination of several MRI features strongly affirms the diagnosis of spinal compression fractures.1 Compared to a study in 2009,1 our study comprised a higher number of compression fractures (152 vs. 58), and the fractures were classified into 3 categories (malignancy, osteoporosis, and infection), rather than 2 (malignant vs. benign) categories, in
which the benign category (23 patients) included trauma and infection. In our study, the final diagnosis in 75% of patients was based on biopsy, compared to 22%.

Biopsy is the gold standard for final diagnosis of vertebral compression fractures. A study reported 3 patients who were provisionally diagnosed as having osteoporotic fracture, which was discovered by biopsy during vertebroplasty and kyphoplasty to be malignant fractures caused by lymphoma.11 In another study, the presumed aetiology in 18% of cases was not confirmed on pathological examination.12 In fact, a biopsy picture suggestive of chronic osteomyelitis was reported in 6 (11%) out of 66 patients diagnosed as having osteoporotic spinal fractures.13 Because the accuracy of percutaneous vertebral biopsy was reported to be 80 to 90%,14 our study should be considered accurate, as diagnoses of 75% of patients were made by open biopsy.

Our study may help develop an MRI score to differentiate compression fractures caused by

Figure 1  (a) Sagittal T1-weighted, (b) T2-weighted (c) short T1 inversion recovery, and (d) axial (L5) T2-weighted magnetic resonance images (MRI) of the lumbosacral spine in a 46-year-old woman: the compression fracture of the L5 vertebral body shows complete replacement of normal marrow signal intensity, convex posterior border (arrows), involvement of the pedicles and transverse processes (asterisk), and metastases affecting L3 and L4 vertebrae (arrowheads). The MRI diagnosis is metastases affecting L3, L4, and L5 vertebrae complicated with compression fracture of L5. The final diagnosis is metastatic compression fracture of L5 originating from breast cancer.

Figure 2  Sagittal (a) T1-weighted, (b) T2-weighted, (c) short T1 inversion recovery, and (d) axial (L2 and L3) T2-weighted magnetic resonance images (MRI) of the lumbosacral spine in a 60-year-old woman: compression fractures of L2 and L3 show anterior wedging of the L2 vertebral body, low signal fracture line at L2 and L3, fluid sign at L3, and incomplete replacement of normal marrow signal intensity. The MRI diagnosis is L2 and L3 acute osteoporotic compression fractures, which is also the final diagnosis.
REFERENCES