The use of MRI to detect occult fractures of the proximal femur

A STUDY OF 102 CONSECUTIVE CASES OVER A TEN-YEAR PERIOD

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An MR scan was performed on all patients who presented to our hospital with a clinical diagnosis of a fracture of the proximal femur, but who had no abnormality on plain radiographs. This was a prospective study of 102 consecutive patients over a ten-year period. There were 98 patients who fulfilled our inclusion criteria, of whom 75 were scanned within 48 hours of admission, with an overall mean time between admission and scanning of 2.4 days (0 to 10). A total of 81 patients (83%) had abnormalities detected on MRI; 23 (23%) required operative management.

The use of MRI led to the early diagnosis and treatment of occult hip pathology. We recommend that incomplete intertrochanteric fractures are managed non-operatively with protected weight-bearing. The study illustrates the high incidence of fractures which are not apparent on plain radiographs, and shows that MRI is useful when diagnosing other pathology such as malignancy, which may not be apparent on plain films.

Insufficiency fractures from low-energy falls are an increasingly common problem in the UK. Patients who present with hip pain following a fall and who have no fracture detected on plain radiographs, are a particularly difficult subgroup to treat. To miss the diagnosis of an occult fracture of the femoral neck may lead to displacement of the fracture and otherwise unnecessary surgery. In contrast, early diagnosis allows prompt treatment, whether by early weight-bearing and rehabilitation, or surgery. With early diagnosis may come a shorter hospital stay, quicker access to a multidisciplinary team and reduced complications from prolonged immobilisation. During a typical year at our institution approximately 170 patients are treated for a fracture of the proximal femur.

MR imaging is readily accessible in most hospitals in the United Kingdom and, unlike other imaging modalities such as radioisotope bone scanning or CT, gives an immediate diagnosis of hip pathology with high sensitivity and specificity.1,2 Furthermore, it is descriptive regarding the nature and degree of displacement of a fracture, which in turn may influence treatment decisions.

We investigated the use of MRI in making an early diagnosis and formulating a management plan in patients with no visible fracture of the proximal femur on plain radiographs.

Patients and Methods

This was a prospective study of 102 consecutive patients treated at our hospital from March 1997 to November 2007. All patients presented after a fall and were unable to bear weight on the affected side. They were either admitted from A&E or were in-patients who had fallen on the ward.

The criteria for further imaging with MRI were the same as previously published by Chana et al:3 negative plain radiographs (anteroposterior pelvic and lateral hip views), and a high clinical suspicion of fracture (persistent hip pain after trauma, inability to bear weight, and pain on attempted straight leg raising, passive rotation or axial loading tests). Such patients underwent an urgent MR scan, within 48 hours where possible.

All plain radiographs were reviewed by a consultant panel of orthopaedic surgeons at the next weekday trauma meeting, and subsequently by two separate consultant musculoskeletal radiologists (JL, JH).

MRI was performed using a Siemens 1T system (Magnetom Impact, Siemens AG, Erlangen, Germany) between 1997 and 2002, and a 1.5T Siemens Symphony MR Scanner (Siemens Medical Solutions, Erlangen, Germany) from 2002 onwards. MRI sequences included coronal T1 (TR616, TE20, FOV 512 mm, matrix 512 × 512) and STIR (TR6000, TE70, TI 130 ms, TA 04.36, matrix 256 × 256,
FOU 380) images. The acquisition time of the separate sequences, including a planning scout image, was 5 minutes 23 seconds. The overall scan time was between ten and 15 minutes.

A hip fracture was diagnosed when there was evidence of trabecular oedema of intermediate signal and a low-intensity signal traversing the bone on the T1 sequence. In such circumstances there was a corresponding high signal traversing the bone on the STIR sequence.

**Results**

We entered 102 patients into the study over a ten-year period; four were excluded as they were unable to have an MRI. These patients were further investigated by different radiographic methods. One patient had a pacemaker and had a CT scan. Another patient did not tolerate an MRI but could tolerate a CT. The other two had no further imaging as they were too unwell and later died.

Of the remaining 98 patients these were 74 women and 24 men, with a mean age of 77 years (42 to 100). The mean time between admission and scanning for the whole group was 2.4 days (0 to 10); 75 patients were scanned within 48 hours of admission. There were 81 patients (83%) with an abnormality on MRI of whom 42 (43%) had a fracture of the proximal femur and 39 (40%) had evidence of other bony or soft-tissue pathology in the hip, pelvis or low lumbar region.

These were 19 patients under the age of 70 years, 17 of whom had an abnormality identified on MRI. This included eight proximal femoral fractures, four pelvic fractures, four patients with metastatic bone disease, and a 43-year-old woman with a subcapital fracture secondary to osteoporosis of pregnancy.

The results of the MR scans and the subsequent management of the patients are given in Table I.

<table>
<thead>
<tr>
<th>MRI results</th>
<th>Number of patients</th>
<th>Non-operative treatment</th>
<th>Operative treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic ring fracture</td>
<td>27</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>Intertrochanteric fracture</td>
<td>20</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Subcapital fracture</td>
<td>13</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Greater trochanteric fracture</td>
<td>7</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Metastatic disease (no fracture)</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Lesser trochanteric fracture</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Subtrochanteric fracture</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>No abnormality</td>
<td>17</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>75</td>
<td>23</td>
</tr>
</tbody>
</table>

We aim to treat all subcapital fractures operatively in our unit. However, three of the 13 subcapital fractures in this series were treated non-operatively because of the patient demonstrating a rapid clinical deterioration, making them unfit for surgery. There were eight subcapital fractures which were fixed with either AO cannulated screws (Synthes) or a two-hole DHS. One patient had their operation changed to a hemi-arthroplasty intra-operatively when the fracture was seen to have displaced significantly. One incomplete fracture secondary to a bony metastasis was treated with an intramedullary proximal femoral Gamma Nail (Stryker).

There were 27 patients with fractures of the pelvic ring. Of these, 15 had simple fractures of the pubic rami, one an isolated sacral fracture, and nine a combination of both. There were two acetabular fractures. These patients were

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**Fig. 1**

T1 coronal MR scan showing an example of a subcapital fracture of the right hip that was treated with AO cannulated screws.
In ten patients pain was secondary to bony metastatic disease. For one it was the first diagnosis of a malignancy. A second patient had a known primary tumour of the prostate, but this was the first diagnosis of bony metastases. The remaining eight patients had known metastatic disease. Of the ten patients who had a pathological fracture there were two subcapital, one intertrochanteric and one pubic ramus fracture. One of the two subcapital fractures was treated with a DHS and the other, and the intertrochanteric fractures, were managed by a proximal femoral intramedullary Gamma Nail (Stryker). Malignancies that were not associated with a pathological fracture were treated non-operatively and referred to the regional oncology service. No fracture required prophylactic stabilisation, as none fell into the high-risk category of possible fracture.4

Fig. 2a

a) A plain anteroposterior pelvic radiograph and b) T1 coronal MR scan showing an incomplete left intertrochanteric fracture which was treated non-operatively.
Of the remaining six patients with an abnormal MR scan, four had bony and soft-tissue bruising, and two a prolapsed lumbar intervertebral disc.

Discussion
In a study of over 1000 fractures of the femoral neck, Pathak, Parker and Pryor found that less than 1% could not be seen on plain radiographs. We therefore prospectively followed 102 patients with hip pain who required MR scanning on clinical grounds of suspicion of a fracture. The majority (81%) were aged over 70 years.

Of the 42 patients with fractures of the proximal femur, eight were under the age of 70 years. In general, these patients would be expected to have a higher bone mineral density and therefore be less likely to fracture as a result of low-energy forces. This group must not be overlooked in the presence of strong clinical signs.

The clinical findings used to select the patients requiring an MRI were similar to those employed by Hossain et al., who found that axial loading of the hip and loss of pre-fracture mobility had the highest positive predictive values when predicting a fracture. These findings were not as sensitive as further imaging studies, but did help in deciding which patients required an MR scan.

MRI has been shown to be superior to plain radiographs, and CT scanning and radioisotope bone scanning, as a diagnostic tool for occult fractures of the proximal femur and pelvis, having a reported specificity and sensitivity of 100%. MRI is also useful when assessing the extent of a fracture line. This is helpful in the presence of incomplete intertrochanteric fractures.

Radioisotope bone scanning has a reported specificity of 95% and sensitivity of 93%. However, it may take up to 72 hours for the scan to be positive following a fracture, especially in the elderly. This leads to unnecessary delays in diagnosis, with a consequent increased risk of morbidity. It also leads to longer in-patient stays compared with MRI, and hence, an increased financial burden on the health service.

The majority of MR scans in our study were performed within 48 hours of admission. All radiographs and scans were reported by consultant musculoskeletal radiologists. This has been shown to improve the accuracy of diagnosis compared with the trainees reporting. A total of 17 of the scans (17%) were negative for any abnormality. This is similar to the findings of Oka and Monu, who found that 20% of 76 scans performed were normal.

We found that nine patients had fractures of both the pubic ramus and the ala of the sacrum. There were, however, no patients with fractures of the femoral neck who had associated fractures of the pelvic ring. These findings agree with those of Lakshmanan et al., in that they seem to be mutually exclusive. Consequently, we do not recommend an MR scan in the presence of an acute fracture of the pubic ramus on plain radiographs.

In our series, nine of the 20 intertrochanteric fractures were incomplete. It is our policy to treat these non-operatively with protected weight-bearing and regular radiological and clinical follow-up. We treated eight of the fractures this way; none displaced. Alam et al. retrospectively reviewed patients diagnosed with incomplete intertrochanteric fractures on MRI, having treated five out of eight patients non-operatively. No patient required readmission for fracture progression and they recommended conservative management. The one remaining incomplete fracture in our series was treated operatively because of worries about displacement as a result of the inability of a patient with a high BMI to partially weight-bear.

A significant proportion (10%) of patients had a bony malignancy, two of whom were diagnosed with new metastatic disease. This emphasises the need for an MRI in a predominantly elderly population with a real risk of undiagnosed malignancy. Cabarrus et al. similarly found a high association of insufficiency fractures with malignant disease.

In conclusion, we feel that the use of MRI is appropriate for patients with a high suspicion of a fracture of the proximal femur. Our results show that there is a significant number of fractures that are not apparent on plain radiographs. MRI can lead to early diagnosis and initiation of definitive management, demonstrate the extent of a fracture, and identify other occult pathology of the hip and pelvis. We recommend stabilisation of fractures of the femoral neck and non-operative management of all incomplete intertrochanteric fractures unless a patient is unable to partially weight-bear. There must also be a high index of suspicion of undiagnosed malignancy.

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References


