Retrospective review of radiographically occult femoral and pelvic fractures detected by MRI following low-energy trauma.

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Purpose

It has been suggested that as our population ages, the incidence of proximal femoral fractures following low energy trauma will significantly rise. Many patients suspected of having sustained such an injury have no detectable fracture on radiographs. In such patients, confident confirmation or exclusion of fracture remains essential for correct management.

MRI is an established method to identify radiographically occult proximal femoral fractures and has high sensitivity and specificity. It is also descriptive regarding the nature and extent of injury which in turn may influence management decisions.

In addition to femoral fractures, MRI commonly shows pelvic ring fractures (at sites such as sacrum, acetabulum and pubic ramus) or soft tissue injuries that account for symptoms but do not require operative treatment. However, the extent of co-existing pelvic and proximal femoral fractures in the same individual remains controversial.

The purpose of this retrospective study was to review the MRI examinations of a large group of low-energy trauma patients in whom pelvic MRI had detected radiographically occult fractures, in order to characterize prevailing fracture patterns and determine how often co-existing proximal femoral and pelvic fractures were observed.
Methods and Materials

We identified patients who underwent pelvic MRI between January 2010 and December 2014, using the regional Radiology Information system (RIS). Word-search software was used to select 558 MRI examination reports that contained the term "fracture". All these MRI examinations were reviewed and 257 cases with no fracture were discarded.

To ensure that MRI and radiographs were comparable in time, any case with an interval of more than 2 weeks between radiographs and MRI was excluded.

MRI requests for the remaining examinations were then reviewed and cases were excluded if

(i) There was no clear history of trauma or clearly expressed clinical suspicion of occult fracture

(ii) Trauma was likely to have involved high energy, such as a fall from a height or a motor vehicle accident

(iii) Patients had co-morbidities likely to hamper identification of discrete acute fractures, such as disseminated bone malignancy

Using these criteria cases 91 were excluded.

This yielded a study cohort of 210 cases with no confounding co-morbidity, a genuine history of low-energy trauma, contemporaneous radiographic and MRI examinations, and MRI that was performed due to clinical suspicion of an undiagnosed fracture.

All study cases had a standard trauma radiographic series at presentation, comprising an AP pelvis and shoot through lateral view of the symptomatic hip. In our centre, it is standard practice for radiographs to be reviewed prior to MRI scanning by a consultant Orthopaedic surgeon or consultant Radiologist, to confirm that they have not yielded a positive diagnosis.

All study MRI scans were performed on 1.5-T MRI scanners (Siemens, Erlangen, Germany). A standard exam comprised T1 and STIR coronal series covering the entire bony pelvis and proximal femora. In a small minority of cases, an additional sequence was requested by the radiologist supervising the examination.

Standard sequence parameters were:
(i) T1 TSE coronal: TE 25, TR 714, slice thickness 5mm, FOV 350mm, matrix 384x512, 1 excitation;

(ii) STIR coronal: TE 28, TR 8270, TI 130, slice thickness 5mm, FOV 400mm, matrix 256x320, 1 excitation.

The study cohort MRI examinations were reviewed by two radiologists who reached agreement by consensus. For each MRI scan, any fracture that had not been appreciated on radiographs was recorded. Femoral fractures were described by location and whether the fracture was complete or incomplete. An incomplete fracture was defined as one where a portion of femoral medulla retained normal signal. Pelvic fractures were described by location alone.
Results

The 210 study cases had a median age of 83 years and 128 (61.0%) were female. The median interval between pelvic radiographs and MRI was 2 days.

Of the 210 study cases, we found a total of 471 undiagnosed fractures. 110 (52.4%) of the study cases have more one undiagnosed fracture.

MRI showed 99 undiagnosed femoral fractures in 95 cases, 100 sacral fractures in 76 cases and 272 innominate bone (ilium, ischium, pubis and acetabulum) fractures in 106 cases.

The distribution of these fractures is presented in Table 1 and Figure 1.

Table 1: Fracture distribution in all patients.

<table>
<thead>
<tr>
<th>Femoral fracture distribution</th>
<th>N</th>
<th>Pelvic ring fracture distribution</th>
<th>N</th>
<th>Sacral fracture distribution</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete NOF</td>
<td>26</td>
<td>Acetabulum</td>
<td>17</td>
<td>Right</td>
<td>27</td>
</tr>
<tr>
<td>Partial NOF</td>
<td>18</td>
<td>Ilium</td>
<td>7</td>
<td>Left</td>
<td>25</td>
</tr>
<tr>
<td>Complete intertrochanter</td>
<td>16</td>
<td>Ischium</td>
<td>4</td>
<td>Bilateral</td>
<td>24</td>
</tr>
<tr>
<td>Partial intertrochanter</td>
<td>29</td>
<td>Body of the pubis</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localised greater trochanter</td>
<td>10</td>
<td>Junction of superior pubic ramus and acetabulum</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superior pubic ramus</td>
<td>58</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inferior pubic ramus</td>
<td>93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. 1: The distribution of common fractures identified (in %) Right sacral: 10.8%; Left sacral: 10.4%. Junction of the acetabulum and superior pubis ramus, Right: 6.2%; Left: 5.9%. Right superior pubic ramus: 6.4%; Left superior pubic ramus: 5.9%. Right inferior pubic ramus 10.2%; Left inferior pubic ramus: 9.6%. Right pubis: 3.2%; Left pubis: 4.5%. Right acetabulum: 1.9%; Left acetabulum: 1.7%. Right femoral neck: 5.5%; Left femoral neck: 3.8%. Right intertrochanteric: 5.7%; Left intertrochanteric 3.8%.

References: Clinical Radiology, Ninewells - Dundee/UK

In 11 cases (5.2%), with a median age of 80 years, MRI showed co-existing radiographically occult fractures of both proximal femur and pelvic ring. Of these 11 cases, 8 had fractures of the sacrum, 4 had fractures of the pubic bone, 2 had fractures of the ischium and one had an acetabular fracture. In 4/11 of these cases fractures had been sustained at three separate sites (proximal femur, pubic bone and sacrum).
In 8/11 (72.7%) cases with co-existing femoral and pelvic fractures, the femoral fracture was incomplete (partial neck of femur fracture in 3 cases, partial intertrochanteric in 5 cases).

In 4/11 cases with co-existing femoral and pelvic ring fractures, there had been previous surgery for a contralateral femoral fracture.

Illustrative examples of proximal femoral, pelvic bone and co-existing femoral and pelvic fractures are shown in Figure 2-6.
Fig. 3: T1 coronal MR image shows vertical bilateral sacral ala fractures (arrows).

References: Clinical Radiology, Ninewells - Dundee/UK
Fig. 4: STIR coronal MR image illustrates increased signal/fractures at the junction of acetabulum and superior pubic ramus on both sides (red arrows) and right superior pubic ramus (blue arrow).

References: Clinical Radiology, Ninewells - Dundee/UK
Fig. 5: T1 coronal MR image shows complete left neck of femur (blue arrow) and bilateral acetabular roof fractures (red arrows).

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**Fig. 6:** T1 coronal MR image shows partial left intertrochanteric femoral fracture (arrow) in a patient with a right total hip replacement. There is also co-existing left sacral insufficiency fracture (not shown)

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Fig. 2: T1 coronal MR image illustrates a partial left neck of femur fracture (arrow).

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Fig. 3: T1 coronal MR image shows vertical bilateral sacral ala fractures (arrows).

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Conclusion

MRI is an effective test to confirm or exclude a proximal femoral fracture following low energy trauma in patients with clinical suspicion despite normal radiographs. Many such fractures are incomplete.

Pelvic ring fractures are also common in this population and knowledge of their typical sites will assist detection. The tendency for these fractures to affect the sacrum and pubic bone suggests that for maximum sensitivity, the entire bony pelvis should be imaged but a two sequence coronal MRI exam is sufficient to confidently diagnose most fractures.

Proximal femoral and pelvic ring fractures may be arise simultaneously in the same patient. In such cases, pelvic fractures are often multiple and femoral fractures tend to be incomplete.
References


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