Review article:
Magnetic resonance imaging and computed tomography in the diagnosis of occult proximal femur fractures

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ABSTRACT
Electronic databases of MEDLINE, EMBASE, CINAHL, and the Cochrane Library as well as the Google Scholar search engine were used. Studies written in the English language highlighting the use of magnetic resonance imaging (MRI) and computed tomography in diagnosing occult proximal femoral fractures despite negative or equivocal plain radiographs were included. Two reviewers independently extracted data from each article. Raw frequencies for each of the details investigated were calculated. 15 prospective and 7 retrospective studies from 1989 to 2009 were included in this systematic review. A total of 996 patients (mean age, 75 years; standard deviation, 5 years) with suspected occult proximal femur fractures underwent MRI for further assessment. 350 (35%) of the patients tested positive for proximal femoral fractures, of whom 295 (84%) underwent further treatment/surgical interventions. MRI also detected other fractures and soft-tissue injuries. MRI was superior to other imaging modalities in diagnosing occult proximal femoral fractures and should be performed within 24 hours of injury. Early diagnosis and management may avoid substantial displacement and complications, and improve overall mortality and morbidity.

Key words: hip fractures; magnetic resonance imaging; radiography; review; tomography, X-ray computed

INTRODUCTION
Proximal femoral fractures represent a major component of health care costs.1–3 Their incidence has increased in elderly people, as a result of osteoporosis and longer life spans.4 Insufficiency fractures secondary to falls are also increasingly common. Of 310 000 patients presenting with fractures in the United Kingdom each year,5 a quarter are hip fractures, which typically occur in elderly persons after a fall. In the United Kingdom, the rate of hip fractures has increased by 2% per year from 1999 to

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and the number is projected to rise from 70,000 in 2007 to 91,500 in 2015 and 101,000 in 2020. Clinical assessment and radiography are the primary diagnostic tools, but 10 to 15% of the diagnosis was missed or delayed when based on radiographs. Approximately 15% of proximal femoral fractures are undisplaced, so no shortening or external rotation of the limb ensues. Hip movements and even walking may be possible, despite pain. In patients with osteoporosis, the use of plain radiographs to diagnose minimally displaced proximal femoral fractures can be challenging. Repeat radiography days later or a bone scan at 72 hours may be needed for confirmation. If these fractures remain undiagnosed, the risk of morbidity, mortality and prolonged hospitalisation increases. A delay of 2 days in surgical treatment for an acute hip fracture doubles the mortality. A missed undisplaced fracture may displace, and the risk of surgery is much higher, and rehabilitation is prolonged. In contrast, early diagnosis enables prompt treatment, shorter hospital stay, and is more cost-effective. Magnetic resonance imaging (MRI) and computed tomography (CT) are therefore used to diagnose occult proximal femur fractures. We therefore conducted a systematic review of the literature to determine the role of MRI and CT in diagnosing occult proximal femoral fractures.

MATERIALS AND METHODS

Electronic databases of MEDLINE, EMBASE, CINAHL, and the Cochrane Library were used. The Google Scholar search engine was also used to avoid missing studies that remain unpublished. Two separate searches were performed on 31 October 2009 using Medical Subject Heading terms: occult fracture, hip, fracture, femur, proximal femur, MRI, magnetic resonance imaging, MR, magnetic resonance, CT scan, and computerized tomography.

Studies were included if they met following criteria: (1) plain radiographs were negative or equivocal but there was a high clinical suspicion of fracture; (2) further investigation had entailed MRI, CT, both, or MRI and bone scan; (3) the case series (prospective or retrospective) that were written in English. However, single case reports were excluded, as were studies involving bone scans without MRI.

Two reviewers independently extracted the following data from each article: authors, year published, total number of patients, number of patients with positive MRI for proximal femoral fractures, age group, number of patients needing operative treatment, and any other injuries found. If the results differed, the 2 reviewers resolved disagreements by consensus. Raw frequencies for each of the details investigated were calculated.

RESULTS

196 and 13 articles related to MRI and CT were identified, respectively. The full texts of 47 articles were screened, and 19 fulfilled the inclusion criteria. Three more papers were identified from the reference lists of the screened articles. In total, 15 prospective and 7 retrospective studies from 1989 to 2009 were included in this systematic review (Table).

A total of 996 patients (mean age, 75 years; standard deviation, 5 years) with suspected occult proximal femur fractures underwent MRI for further assessment, as the plain radiographs failed to demonstrate the fractures. Some also underwent examination using other imaging modalities. 350 (35%) of the patients tested positive for proximal femoral fractures, of whom 295 (84%) underwent further treatment/surgical intervention. MRI also detected other injuries such as pubic rami fracture, isolated greater trochanteric fracture, acetabular fracture, pelvic ring fracture, sacral fracture, synovitis, and a large haematoma. Bilateral occult fractures were identified in 3 patients. In no study was CT performed without MRI. One study compared MRI with CT, and 3 compared MRI with bone scans. It was concluded that MRI was as an investigation of choice for occult proximal femoral fractures.

DISCUSSION

British Orthopaedic Association guidelines on good care for proximal femoral fractures suggest prompt, comprehensive assessment, and early surgical intervention to prevent morbidity and mortality, especially in elderly patients. Indeed, surgical intervention within 24 to 48 hours is recommended. Radiolucency and breaches in the cortical continuity are the main characteristics to identify fractures on radiographs, but in elderly patients with osteoporotic bones, impacted or minimally displaced fractures can be difficult to identify. Further diagnostic tools are required to identify them with higher accuracy and clinical confidence, and should be readily available, easy to perform, and confer minimal risks.
In a study comparing the efficacy of MRI and CT in the early diagnosis of proximal femoral fractures, MRI enabled a definitive early diagnosis in patients with painful hips, whereas CT was less reliable. Nonetheless, a small sample size and selection bias limited the utility of these results. In another study, MRI was more sensitive than CT (99% vs 53%) in detecting insufficiency fractures. The number of missed femoral head fractures on CT was higher, suggesting MRI was more likely to provide an accurate diagnosis. Similarly, incomplete inter-trochanteric fractures can be diagnosed with certainty using only MRI.

The sensitivity and specificity of bone scans in occult proximal femoral fractures has been reported to be 93 and 95%, respectively. However, bone scans may produce false positive and false negative results, and should not serve as a sole indicator of fracture. MRI was superior to bone scans in terms of sensitivity (100% vs. 91%) and accuracy (100% vs. 95%), and similar in terms of specificity (100% vs. 100%). In addition, MRI is non-invasive, quick to perform, and cost-effective for the diagnosis of occult proximal femoral fractures.

MRI focusing only on the hip region takes only ≤15 minutes and is well tolerated by patients. Regardless of the time involved, the diagnosis is reached much quicker with MRI than with other imaging techniques. T1-weighted images were sufficient for diagnosis of hip fractures within 4 hours of injury. There were no false-negative results in patients who underwent MRI within 24 hours. Senior radiologists achieved 100% accurate results when the MRI was performed within 48 hours. MRI should be performed within 24 hours of injury so as to achieve an early diagnosis and short hospital stay.

Not only does MRI facilitate the diagnosis of undisplaced occult proximal femur fractures, it also assists diagnosis of other injuries. Limited MRI protocols with T1-weighted coronal images are sufficient to detect proximal femoral fractures. T2-weighted images facilitate recognition of oedema and soft-tissue injuries. In a study, 13 of 33 patients sustained soft-tissue injury that could mimic fractures, including muscle oedema, osseous contusion, and bursitis. In another study, out of 103 soft-tissue lesions, 102 (99%) were detected by MRI, whereas only 13 (13%) were detected by CT. MRI can also be used in suspected osteonecrosis, haematoma, metastasis,
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