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Early magnetic resonance imaging of radiographically occult osteoporotic fractures of the femoral neck

早期應用磁共振成像診斷放射檢查無法偵測的骨質疏鬆性股骨頸骨折

Osteoporosis is associated with thinning of cortical and trabecular bone, which reduces bone strength and predisposes individuals to fracture development. Femoral neck fractures in patients with osteoporosis may not be apparent on radiographs. Magnetic resonance imaging is useful at detecting these radiographically occult fractures; yet, the practice has not been widely adopted in Hong Kong. In this article, we review our experience of early magnetic resonance imaging in this clinical context—that is, imaging performed within 48 hours of presentation to hospital. Twenty-eight patients (age range, 69-93 years) over a 3-year period were studied. Magnetic resonance imaging revealed radiographically occult neck fractures in 14 (50%) cases (equivalent to 4% of all femoral neck fractures). These fractures were treated surgically (64%) or conservatively (36%) with good bone healing and clinical outcome. When no femoral neck fracture was present, magnetic resonance imaging revealed an alternative cause for symptoms in all 14 cases. We strongly endorse the use of early magnetic resonance imaging for patients with osteoporosis who have a clinically suspected femoral neck fracture that is not visible radiographically.

骨質疏鬆與皮層骨和枝狀骨變薄有關，會減低骨幹的強度，容易造成骨折。在骨質疏鬆症的病人身上出現的股骨頸骨折不一定在放射線照片上清晰可見，此時採用磁共振成像術偵測放射檢查無法顯示的骨折會相當有用，然而，這種方法在香港還沒有得到廣泛應用。本文總結了在病人入院48小時內應用磁共振成像的經驗，有關研究以3年時間跟進了28位年齡由69至93歲的病人，其中14位（即50%）經磁共振成像檢查後，發現有放射檢查無法顯示的股骨頸骨折(相當於所有股骨頸骨折病例的4%），64%接受手術，36%以保守治療，所有病人骨幹癒合情況和臨床結果良好。沒有股骨頸骨折的其餘14位病人，亦經磁共振成像檢查發現造成表面症狀的成因。因此，我們認為，如果從臨床症狀推測患有骨質疏鬆的病人有放射檢查無法偵測到的股骨頸骨折，應當及早應用磁共振成像檢查來加以診斷。

Key words:
Aged;
Femoral neck fractures;
Magnetic resonance imaging;
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關鍵詞：
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Introduction

The proximal femur is a common site for fracture in elderly patients with osteoporosis. The majority of cases are displaced fractures and, as such, are readily diagnosed radiographically. In a minority of cases, however, patients present with a strong clinical suspicion of a proximal femoral fracture but their X-ray shows no identifiable fracture. Previously, treatment of these patients was either by immobilisation, repeated radiography, and monitoring of clinical progress at 7 to 10 days to confirm or refute the presence of a fracture, or by gentle mobilisation in the knowledge that a displaced fracture may or may not be detectable in the immediate future. Two recent studies revealed that magnetic resonance imaging (MRI) performed early during observation in hospital is useful in elderly patients with osteoporosis who have a clinically suspected femoral neck fracture but whose radiographs show no apparent fracture.[1,2] Yet, use of early MRI has not been widely adopted. In this article, we review our experience of early MRI in such a clinical setting.

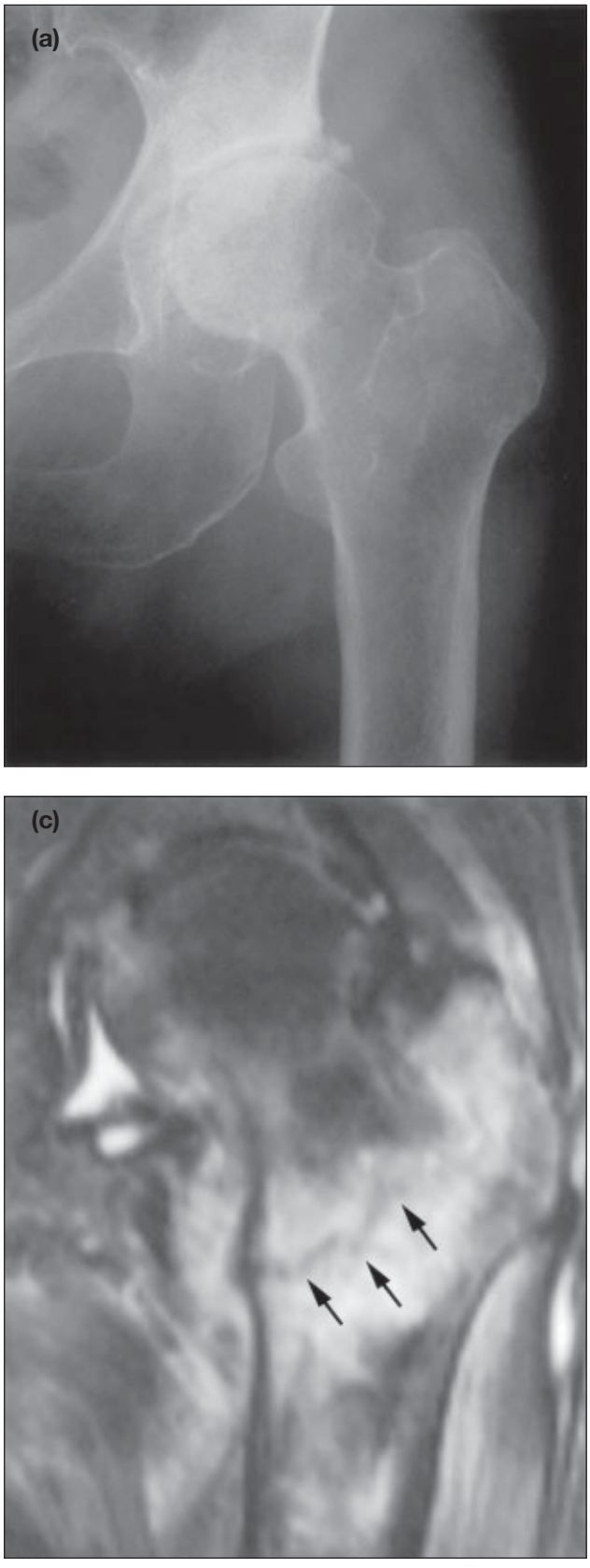

Fig 1. An 82-year-old woman with left hip pain following a fall 3 days previously

(a) Frontal radiograph, left hip. Moderate generalised osteopenia is present but no fracture is apparent; (b) T1-weighted and (c) T2-weighted oblique coronal images of the hip showing an intertrochanteric fracture. Both the incomplete fracture line (arrows) and the surrounding medullary oedema are apparent

Materials and methods

Medical and nursing case notes and imaging records were retrieved for 28 patients who had a clinically suspected traumatic femoral neck fracture although no fracture was visible by radiography. The patients had undergone an MRI examination at the Prince of Wales Hospital between January 2000 and December 2002. Trauma had resulted from a fall in all cases. The study group comprised three men and 25 women, whose mean age was 83 years (range, 69-93 years). Radiographic and MRI findings at presentation, treatment, and clinical outcome were reviewed. In addition, the total number of patients treated for fractured neck of the femur at the Prince of Wales Hospital during the study period was determined from hospital databases.

All patients were seen initially in the Accident and Emergency Department. Patients with a clinically suspected fracture in the neck of the femur whose radiographs revealed osteopenia but no evidence of a fracture were admitted to hospital for bed rest and observation. These patients were re-examined the following day by senior clinician staff, and if clinical suspicion of a fractured neck of femur remained, urgent MRI was performed following further review of the radiographs by an experienced radiologist.

Radiographic examination consisted of a standard antero-posterior projection of the pelvis, with coned antero-posterior (Fig 1a) and lateral projections of the symptomatic

Table 1. Fracture type and treatment of 14 radiographically occult proximal femoral neck fractures revealed by magnetic resonance imaging

	Fracture type				Treatment	
	Displaced	Non-displaced	Complete	Incomplete	Operative	Conservative
Subcapital (n=2)	0	2	0	2	2	0
Transcervical (n=1)	0	1	0	1	1	0
Intertrochanteric (n=11)	0	11	4	7	6	5

hip. A frog lateral projection of both hips was also obtained in some cases. Magnetic resonance imaging was performed on a 1.5-T Gyroscan machine (Philips, Best, Netherlands); T1-weighted (time-to-repetition [TR], 590; time-to-echo [TE], 20), and T2-weighted fat-suppressed short-tau inversion recovery (STIR) sequence (TR, 5170; TE, 56) in the oblique coronal plane were obtained using a standard surface coil. The slice thickness was 3 mm, the intersection gap was 0.3 mm, and the field of view was 150 mm with a 256 x 256 matrix. Magnetic resonance imaging was performed within 48 hours of presentation in all cases.

A fracture was defined on an MRI scan as a hypointense line transversing the medullary canal on T1-weighted images. Fractures were deemed to be complete if the fracture line involved both the superior and inferior cortex of the proximal femur; they were deemed incomplete if only one or none of the two cortices were visibly involved. A stress response was defined as diffuse marrow hyperintensity on fat-suppressed T2-weighted sequences without a corresponding discrete hypointense line on either T1-weighted or T2-weighted fat-suppressed sequences (Fig 1).

Results

Detection of fractures

Radiographs did not reveal a femoral neck fracture in any case. A minimally displaced greater trochanteric fracture was apparent in one case and a superior pubic ramus fracture in another. Osteopenia of varying severity was apparent in all cases as cortical thinning and loss of tensile trabeculae.

Magnetic resonance imaging revealed a femoral neck fracture in 14 (50%) of the 28 patients examined. All of these fractures were non-displaced. Of the 14 fractures, 11 (79%) were intertrochanteric, one (7%) was transcervical and two (14%) were subcapital. Four (28%) of the 14 femoral neck fractures were complete (all intertrochanteric) while the remaining 10 (72%) fractures were incomplete (Table 1).

During the same 3-year study period, a total of 330 patients were treated for proximal fractures of the neck of the femur at the Prince of Wales Hospital. All except 14 (2.1%) of these fractures were radiographically apparent. Hence, 4.2% of femoral neck fractures overall were radiographically occult.

Table 2. Additional injuries revealed by magnetic resonance imaging in 14 patients without proximal femoral fracture

Injury	No.*
Gluteal muscle haematoma or sprain	5
Obturator externus muscle sprain	1
Hip joint effusion	3
Degenerative change of hip joint	1
Avascular necrosis of femoral head	1
Bone marrow oedema (' stress response')	2
Greater trochanteric fracture	1
Pubic ramus fracture	1

* One patient had both proximal femoral bone marrow oedema without fracture and muscle sprain

Detection of other injuries

Magnetic resonance imaging revealed significant local injury or pre-existing disease in all of the 14 (50%) cases without a proximal femoral neck fracture (Table 2). The most common local injury was gluteal muscle oedema or haematoma (Fig 2). Other apparent abnormalities were hip effusions, degenerative change, and proximal femoral bone marrow oedema without fracture. Avascular necrosis was present in one case. All these additional diagnoses, except degenerative disease of the hip, were not apparent on radiographs. For the patients whose greater trochanteric fracture and superior pubic ramus fractures were evident on radiographs, MRI helped exclude the presence of a co-existent clinically suspected femoral neck fracture.

Treatment and clinical outcome

Nine of the femoral neck fractures were treated operatively. All of the three femoral neck fractures were treated with parallel 6.5-mm titanium hip screws insertion. Six of the 11 intertrochanteric fractures were treated with dynamic hip screw insertion; according to MRI findings, fractures had been complete in four cases and incomplete in two cases. All operated patients were ambulatory and able to perform full–weight-bearing walking exercises by postoperative day 4. Follow-up radiographs at 1 year showed satisfactory fracture healing in all cases.

The remaining five intertrochanteric fractures were managed conservatively. Premorbid ill health prompted non-surgical treatment in all cases. A prolonged non–weight-bearing walking exercise programme was implemented during the next few months. Subsequent radiographs in the weeks following MRI failed to reveal a fracture in any of these non-operated cases. Radiographs at 1 year showed satisfactory healing in all cases.

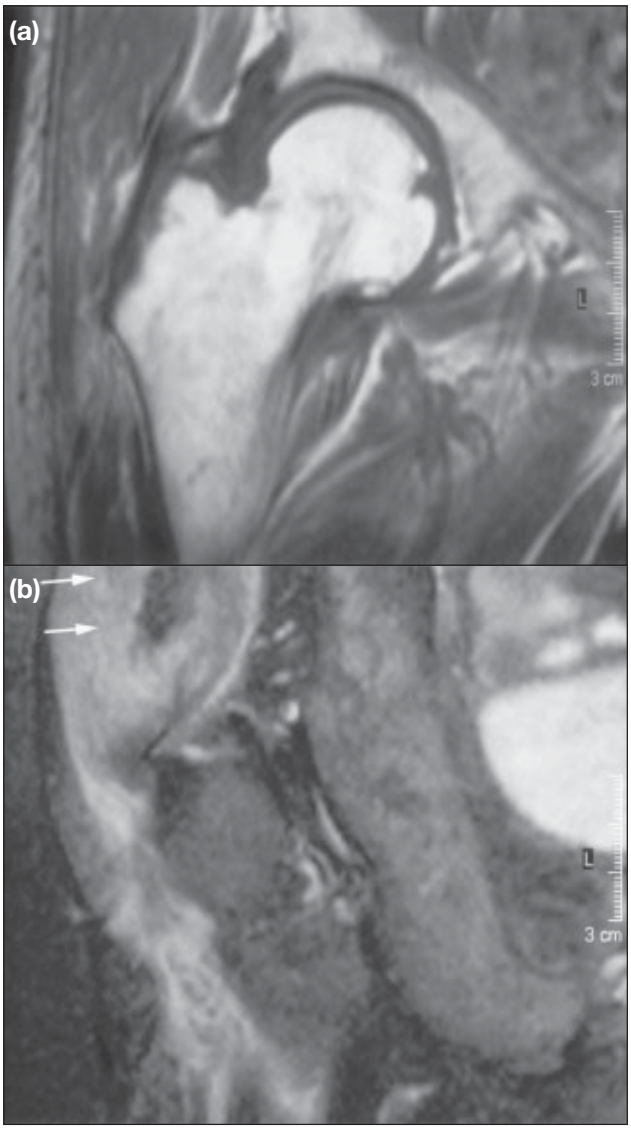

Fig 2. A 76-year-old woman with right hip pain having fallen from a chair 5 days previously
(a) T1-weighted oblique coronal images of the right hip; no proximal femoral fracture is present; (b) T2-weighted fat-suppressed oblique coronal image located posterior to the proximal femur shows a large gluteal muscle haematoma (arrows)

Patients with no femoral neck fracture on MRI scans were treated conservatively. No femoral neck fracture subsequently occurred in this subgroup—that is, no false-negative MRI results were encountered.

Discussion

Newer imaging modalities, such as MRI, computed tomography, and ultrasonography, have allowed a much better understanding of the limitations of radiographs in particular clinical settings. Undisplaced fractures of the proximal femur in patients with pre-existing osteoporosis is one such clinical setting in which radiographs may not reveal all fractures.

Bone cortex is normally much thicker on the femoral shaft than in the femoral neck. For the femoral shaft, most of the bone strength is provided by the femoral cortex. In the femoral neck, bone cortex is normally thinner. As a result, the relative contribution of cancellous or trabecular bone to bone strength of the proximal femur is greater in the shaft than in the neck. Radiographs are useful at revealing fractures of cortical bone, but not those of trabecular bone. In osteoporosis of the proximal femur, cortical bone becomes thinned to a relatively greater degree than trabecular bone.[3,4] This additional thinning of the cortex leads to undisplaced fractures in the osteoporotic proximal femur, which are difficult to appreciate on radiographs. On the other hand, MRI reveals injury to cortical and trabecular bone by demonstrating that the fracture line extends across the medullary canal, and by detecting any medullary canal oedema or bleeding surrounding the fracture line. In this respect, MRI is more sensitive and specific than computed tomography or isotope bone scanning.[5-7] As well as being accurate at detecting fractures, normal MRI findings have an extremely high negative predictive value.

The early confirmation or exclusion of radiographically occult femoral neck fractures helps guide treatment, encourages early ambulation, and minimises complications from immobilisation. Any likelihood of progression from undisplaced to displaced fracture is also minimised. Undisplaced proximal femoral neck (Garden's type I) fractures have a better prognosis than displaced (Garden's type III/IV) fractures. Anatomical alignment is maintained and the risk of avascular necrosis is lower for Garden's type I fractures, thereby allowing a more conservative surgical approach to be taken. The morbidity and mortality risks for parallel hip screw fixation (for Garden's type I/II fracture) are appreciably lower than those for hip hemiarthroplasty (for Garden's type III/IV fracture). The additional cost of MRI in this clinical context is more than offset by cost savings achieved through the reduced hospital stay and the avoidance of other investigations such as scintigraphy.[5-7]

Magnetic resonance imaging revealed radiographically occult fractures in 50% of 28 patients examined. This is comparable to the 37% to 66% detection rate reported in earlier similar studies of 23, 15, and 33 patients,[1,2,8] and higher than the 14% fracture detection rate reported in a later study.[9] This later study included all patients (osteoporotic as well as non-osteoporotic) with suspected proximal femoral fracture, whereas our study investigated only patients with radiographically apparent osteoporosis. Overall, radiographically occult proximal femoral neck fractures were not common—only 4.2% of all femoral neck fractures.

Despite its high yield in revealing fractures in patients with osteoporosis and clinically suspected femoral neck fractures that are not apparent on radiographs, early MRI has not been universally adopted in this clinical setting. Results of an informal survey of public hospital–based MRI

units in Hong Kong supports this impression (personal communication). Limited MRI for suspected femoral neck fracture is well tolerated by elderly patients and can be completed in 20 minutes with only two sequences being sufficient. All MRI examinations in this study were performed within 48 hours of presentation. The results are a testament to the tailored short MRI time needed, thereby facilitating inclusion of MRI for standby cases between booked elective cases.

If MRI reveals a fracture, it can be treated either operatively or, if the patient is not a suitable surgical candidate, conservatively with good outcome. Even in cases in which no fracture is present, MRI will usually reveal the likely cause of symptoms either in the hip joint or surrounding soft tissues, hence allowing physicians to proceed confidently with the appropriate management option.

In summary, early MRI is an extremely useful investigation in patients with osteoporosis and clinically suspected cases of femoral neck fracture that are not visible on radiographs. We would strongly encourage the general adoption of early MRI in this particular clinical setting.

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