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Fig. 1 (a) Anteroposterior and (b) lateral radiographs of the right hip. (c) Coronal T1-W MR image of the right hip.

CASE PRESENTATION

A 84-year-old Chinese woman, an inmate of a nursing home for the aged, sustained a fall, and subsequently complained of right hip and thigh pain. She was previously ambulant, but was not able to weight-bear after the fall. She had no other known medical problem. Clinical examination revealed her right leg to be held in external rotation, with reduction in range of movement due to pain. No limb length shortening was noted when compared to the contralateral leg.

Initial radiographs of the right hip joint were obtained in the emergency department (Figs. 1a-b). What do these images show? In view of the severity of pain and inability to walk, she was admitted. Magnetic resonance (MR) imaging of the pelvis and right hip was done the next day (Fig. 1c). What does the MR image show? What is the diagnosis?

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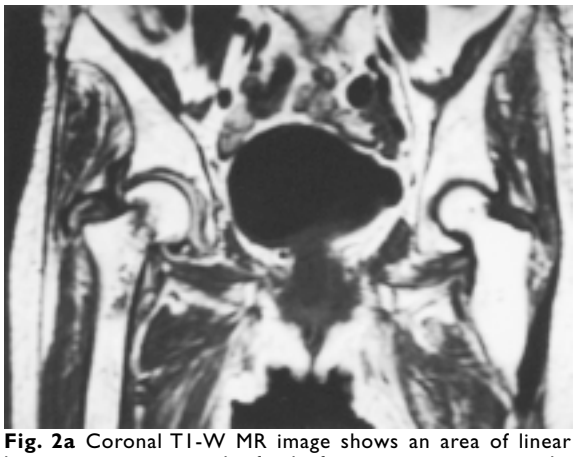

Fig. 2a Coronal T1-W MR image shows an area of linear hypointensity across neck of right femur, in comparison to the homogeneous high signal intensity of normal fatty bony marrow in the left hip.

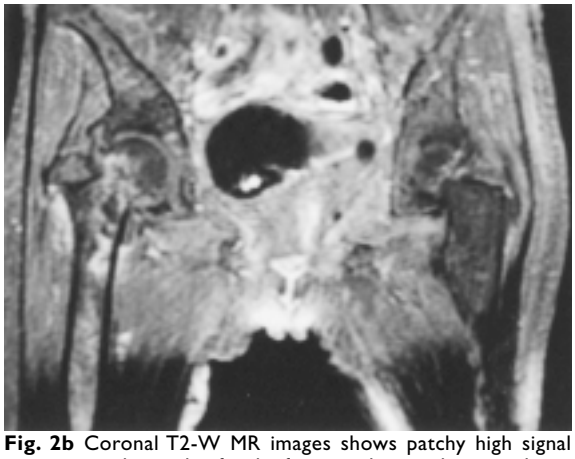

Fig. 2b Coronal T2-W MR images shows patchy high signal intensity in the neck of right femur, indicating bone oedema. Areas of patchy high signal intensity in the surrounding muscles represent muscle oedema.

Table 1. MR imaging diagnosis in patients presenting with post-traumatic hip pain and indeterminate radiographs. Local experience at Tan Tock Seng Hospital from July 1999 to July 2001.

Site of fracture	No. of cases
Pubic rami (superior / inferior / both)	20
Neck of femur	16
Sacrum	10
Trochanteric / intertrochanteric	10
Acetabulum	7
Iliac wing	3

IMAGE INTERPRETATION

The initial radiographs of the right hip joint and proximal femur (Figs. 1a-b) do not show any displaced fracture or cortical break. The configuration of the femoral head is preserved, and no dislocation of the right hip joint is seen. However, the positioning of the anteroposterior (AP) radiograph is suboptimal, as it is not taken in true neutral but in external rotation. This is shown by visualisation of more of the lesser trochanter than usual, and is likely to be related to limitation of movement by pain.

The T1-weighted MR image (Fig. 1c) shows an abnormal irregular line of low signal intensity extending across the neck of the right femur in an oblique direction. No displacement of the cortical margins is noted, and there are also ill-defined areas of abnormal low signal intensity adjacent to the irregular line and also in the proximal shaft, which represent bone marrow oedema pattern. MR images also showed a normal left hip and proximal femur. T2-weighted MR images were useful in confirming the presence of marrow oedema pattern adjacent to the right subcapital fracture, as well as surrounding muscle oedema.

DIAGNOSIS

Undisplaced occult subcapital fracture of the right femoral neck.

CLINICAL COURSE

The patient was placed on straight leg traction while in the ward. The decision was made to treat the fracture surgically, and a Moore's hemiarthroplasty was performed four days later. Her recovery from surgery was uneventful. She was subsequently able to ambulate with walking aids on the 5th post-operative day, and was discharged another five days later.

DISCUSSION

Trauma to the hip from a fall is a major cause of morbidity in any ageing society. Hip fracture incidence rates are shown to increase exponentially with age in both women and men[1]. This dramatic rise in fracture risk results from age-related decrease in bone mineral density in the proximal femur, poor vision, impaired balance, slower reflexes and various other reasons. This age-related increase in falls is responsible for at least 90% of all hip fractures[2]. Due to the rising health care costs, particularly in the acute care setting, early diagnosis is prudent[3]. First-line imaging for hip pain usually employ radiographs. These are easily available in all hospitals and emergency departments. Obvious fractures seen on the radiograph can be interpreted and the diagnosis is usually made by the emergency physician or orthopaedic surgeon. This allows appropriate treatment such as fracture reduction to be carried out immediately.

However, there are several factors that may make it difficult to interpret these pelvic and hip radiographs. When the radiograph is taken, positioning of the lower limb may not be optimal as movement may be limited by pain. This usually results in limitation of internal rotation, and the leg may be held in external rotation,

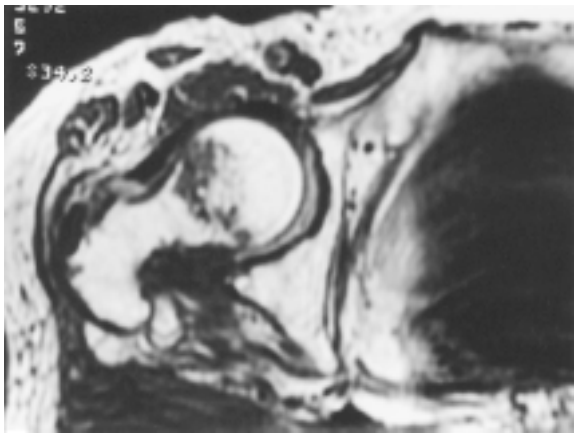

Fig. 3 Axial T1-W MR image of the right hip shows an area of linear hypointensity in the neck of femur, indicating an undisplaced fracture.

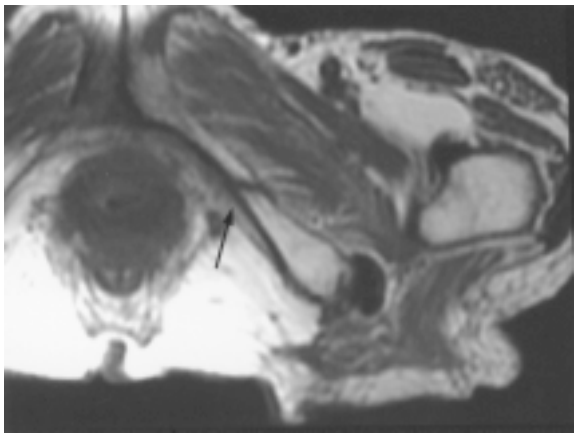

Fig.4a Axial T1-W MR image of the pelvis shows an area of linear hypointensity across the left superior pubic ramus, indicating a fracture (arrow).

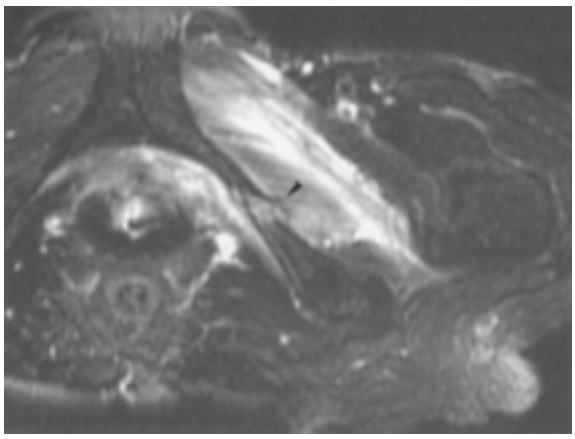

Fig. 4b Axial T2-W MR image shows an area of linear hyperintensity across the left superior pubic ramus, indicating bone oedema (arrowhead). The surrounding muscles also show streaky areas of hyperintensity, indicating muscle oedema.

such that the neck and intertrochancteric region may not be well visualised. Even if a pelvic radiograph is obtained, it also may not be easy to compare both sides, as both femurs may appear asymmetrical due to different degrees of rotation. Factors which also contribute to non-detection of subtle fractures include the presence of osteopaenia or degenerative changes of the hip joint with osteophyte formation. In other areas of the bony pelvis, the bowel gas shadows may overlap the sacrum and obscure subtle fractures.

In the local context, when patients are unable to weight-bear, they are often admitted to the hospital. If a fracture is diagnosed, appropriate treatment can be rendered. However, when no fracture is detected, patients will be mobilised and given physiotherapy. The problem then surfaces when there is an occult hip fracture. These may progress to complete and displaced fractures if the patient weight-bears inappropriately. To improve the speed and confidence in the diagnosis of occult hip fractures, we have begun to rely more on MR imaging, particularly when there is persistent pain but when no obvious fracture is demonstrated[4,5].

The routine MR imaging protocol for evaluation of the hip joint for trauma in our institution include coronal T1-weighted and short tau inversion recovery (STIR), and axial T1-weighted and T2-weighted sequences. The torso or pelvic coil is used to achieve a large field-of-view (34 to 38 cm), which includes both hip joints and the bony pelvis. The total scan duration is approximately 20 minutes. Intravenous gadolinium-chelate is not routinely administered in cases of trauma, and is given only when there is suspicion of other co-existing pathology, such as tumour, infection and occasionally, avascular necrosis.

On MR imaging, a fracture line appears as an irregular line of low signal intensity on both T1-weighted and T2-weighted sequences that occurs through the affected bone. This is associated with surrounding bone marrow oedema, which is most evident on the STIR sequence, and is seen as a prominent area of high signal intensity on the dark background of fat-suppressed marrow. There may also be associated soft tissue injury such as muscle strain or contusion, which also appears as areas of high signal intensity on STIR and fat-saturated T2-weighted sequences due to increased fluid content. Associated hip joint effusion can also be detected. In our experience, the commonest radiographically-occult fractures detected on MR imaging, in order of decreasing frequency, are: fractures of the pubic rami, neck of femur, trochanteric/intertrochanteric fractures, followed by fractures of the sacrum and iliac wing (Table I). About 10% of cases show soft tissue injury in the absence of a fracture.

Acute undisplaced neck of femur and trochanteric fractures show up as a discrete, low-signal intensity fracture line representing impacted bone trabeculae (Fig. 3). Detection or exclusion of a proximal femur fracture is essential, as treatment can be surgical. Weight-bearing can be instituted for those whom

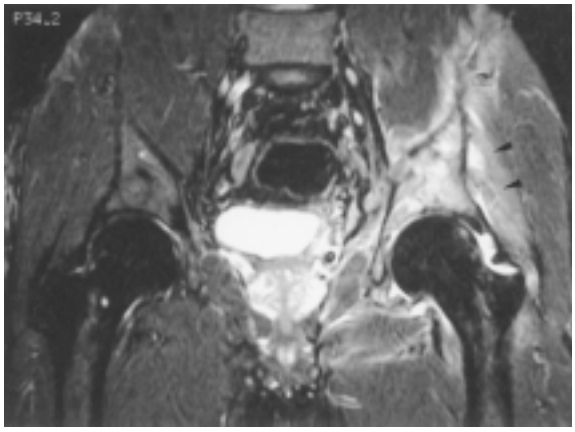

Fig. 5 Coronal T2-W MR image shows high signal within the muscles around the left hip joint, mainly involving the gluteal and adductor groups (arrowheads). There is no accompanying fracture.

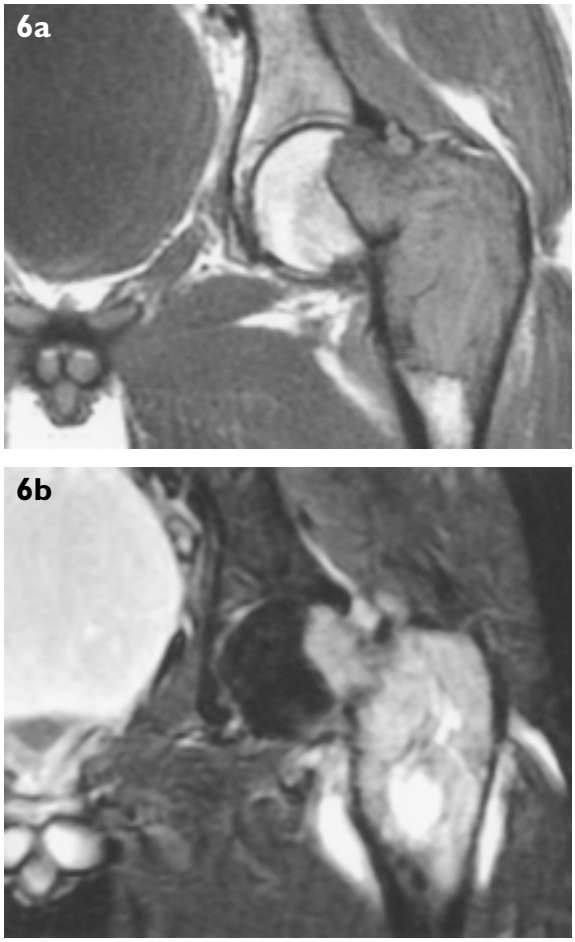

Fig. 6 Fibrous dysplasia. (a) Coronal T1-W MR image shows a large lesion involving the neck and trochanteric region of the left femur that is accompanied by expansion and deformity of the bone. There is no fracture. The lesion is isointense relative to muscles. (b) Coronal T2-W MR image shows the same lesion which is hyperintense. There is also an accompanying joint effusion.

fractures are excluded, and thus prevent complications such as pneumonia from prolonged rest in bed. Insufficiency fractures are relatively common in the sacrum, pubic rami and supra-acetabular regions of elderly women. They are characteristically located medial and parallel to the sacroiliac joint in the sacral ala, and when a transverse fracture is present, they are transversely-located across the midsacrum. Pubic rami fractures show focal marrow oedema that may extend through the cortex into adjacent tissue, indicating muscular injuries. These are most easily seen on T2-weighted or fat-suppressed images[6]. (Figs. 4a-b)

Muscle injuries are depicted as areas of high signal on T2-weighted sequences, which indicate oedema from strain or direct contusion. They may be seen in different muscle groups around the hip joint, depending on the mechanism of injury and site of trauma. They may or may not be associated with bony fractures. The common sites affected include the adductor, gluteal, obturator, iliacus, and iliopsoas muscle groups (Fig. 5). The presence of soft tissue injury may account for the patient's hip pain, and without an underlying bony fracture, this group of patients can be aggressively rehabilitated with faster mobilisation expected.

Occasionally, there may be unsuspected underlying pathology which may or may not be associated with fractures (Fig. 6). For example, a previously-undetected metastatic lesion may cause the unexplained pain in the hip. These are commonly seen in the proximal femur and iliac bone (Fig. 7). A pathological fracture through a benign or malignant bone lesion would also be detected on MR imaging. Another common cause of hip pain with a normal radiograph is avascular necrosis (AVN) or osteonecrosis. Causes of AVN include steroid ingestion, sickle cell disease, alcoholism, Gauchers's disease, and pancreatitis. There are four grades of AVN which are detected on MR imaging[7]. Early (grade 1) changes show focal low intensity in femoral head surrounded with high intensity margin or hyperaemic zones. Grade 2 changes show bone oedema with diffuse enhancement in the femoral head and neck. Combined findings from both grades 1 and 2 are considered as grade 3. In grade 4 disease, there is collapse and deformity of the femoral head, which is usually evident on radiographs.

It is no doubt that MR imaging is far superior compared to radiographs in diagnosis of hip pathology. However, the high cost of MR studies is prohibitive, thereby limiting its widespread use. This problem may be circumvented with the use of limited MR sequences which are sufficient to answer the clinical question of whether a significant fracture is present. The combination of sequences selected may vary. A single coronal T1-weighted MR series may be sufficient for detection of proximal femoral fractures. Soft tissue injuries would be better appreciated on fat-suppressed T2-weighted or inversion recovery sequences. Hence, a limited protocol comprising of coronal T1-weighted and coronal fat-suppressed T2-weighted

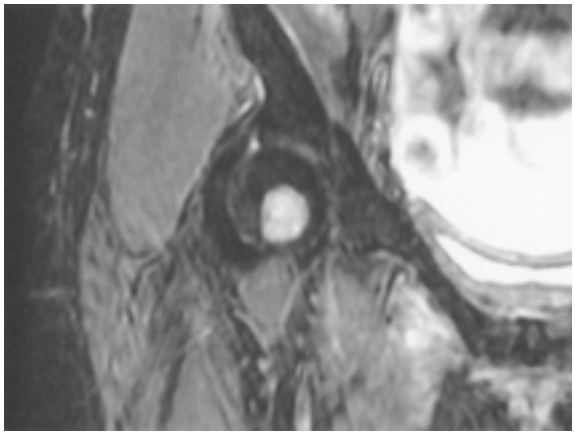

Fig. 7 Metastasis. Coronal T2-W MR image shows a round hyperintense area in the right femoral head. There is no fracture.

sequences would be sufficient in the evaluation of most hip injuries[8,9].

With a reduction in the number of sequences used, there is a corresponding decrease in the scan time, and this can be translated into reduced cost. The cost savings using such a limited protocol can be significant, where it may halve the cost of a complete MR scan[8]. The cost of this limited MR study is more than that of radiographs. However, if we factor in the number of days the patient has to stay in hospital with an undiagnosed fracture, resulting in prolonged stay due to inability to weight-bear, it would be more cost-effective to investigate initially with MR imaging, allowing early and accurate diagnosis. In our institution, inpatient requests for MR imaging are performed on the same day, with a provisional report issued immediately after the study is completed, so as any change in management plan can be rapidly adopted.

In an ageing society, the number of people who undergo hip arthroplasty is expected to progressively increase. We know that metallic prosthesis do cause considerable artifacts on MR imaging, and radiographs alone may not be sufficient for identifying subtle fractures in patients who have had hip arthroplasty. Other complications related to prostheses include fractures of the prostheses, dislocations, superficial and deep infections, and aseptic loosening[10]. There is a need to be able to accurately image these patients who have trauma or have post-hip arthroplasty pain. Recent developments with newer sequences[11,12] aim to reduce such artifacts. From the initial experiences of others, prosthetic complications such as periprosthetic fractures, loosening and osteolysis have been imaged and identified on MR imaging.

ABSTRACT

An 84-year-old woman, who sustained a fall in the nursing home, complained of right hip pain and inability to bear weight. Radiographs showed no fracture or cortical break. MR imaging showed an undisplaced subcapital fracture of the right femoral neck for which a hemiarthroplasty was performed. The patient was then discharged 10 days post-operation. Effectiveness of MR imaging for assessing occult hip fracture, a more superior imaging modality as compared to radiographs, is discussed. Early diagnosis can also expedite appropriate treatment and promote recovery, which can reduce the cost of prolonged or inpatient care. The role of MR imaging in detection of other causes of pain in the hip region is also discussed, drawing on examples in our local experience.

Keywords: hip fracture, hip pain, occult fracture, magnetic resonance (MR) imaging

Singapore Med J 2004 Vol 45(2):95-99

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