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CASE REPORT

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Subchondral insufficiency fracture of the femoral head and medial femoral condyle

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Abstract This case report documents the clinical, radiographic, and histologic findings in a 69-year-old obese man, who had subchondral insufficiency fracture both in the femoral head and medial femoral condyle. On plain radiographs, both lesions underwent subchondral collapse. Magnetic resonance images of the left hip showed a bone marrow edema pattern with associated low-intensity band on T1-weighted images, which was convex to the articular surface. The histopathologic findings in the hip and knee were characterized by the presence of a subchondral fracture with associated callus and granulation tissue along both sides of a fracture line. There was no evidence of antecedent osteonecrosis. To our knowledge, this is the first case report to describe the multiple occurrence of collapsed subchondral insufficiency fracture.

Key words Subchondral insufficiency fracture · Femoral head · Medial femoral condyle · Osteonecrosis · MRI · X-ray

Introduction

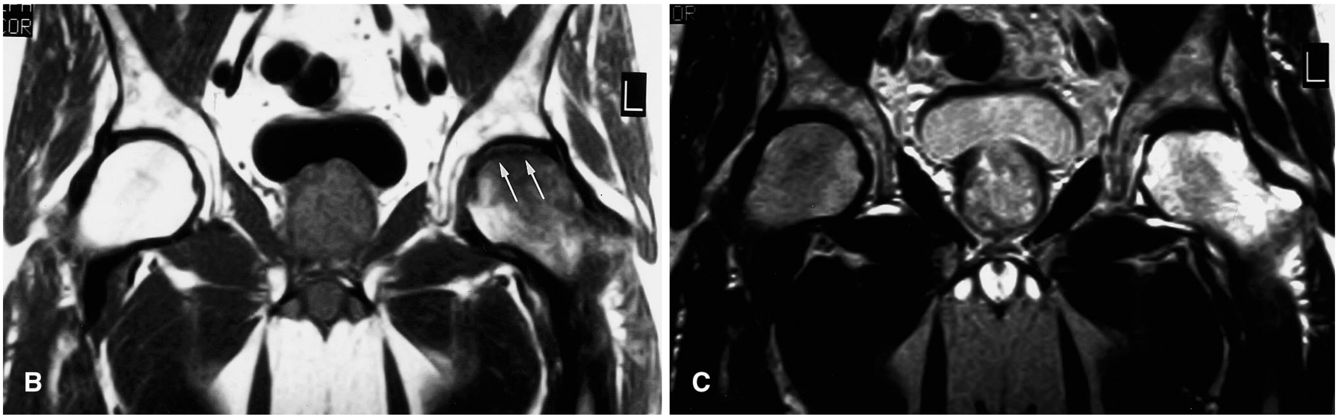
Subchondral insufficiency fracture has recently been described in both the femoral head and femoral condyle; mainly the patients have been osteoporotic and elderly or renal transplant recipients [1–7]. The mechanism of this fracture is considered to be insufficiency fracture, most often as a result of osteoporosis. The majority of the reported cases have resolved after conservative therapy without progressing to collapse [1–3]. However, recent reports have described patients who developed subchondral collapse and were treated surgically [4–7].

In this paper, we report on a 69-year-old man with subchondral insufficiency fracture in both the femoral head and subsequently, after a 2-year interval, in the medial femoral condyle. Both of these lesions underwent subchondral collapse and were treated surgically.

Case report

A 69-year-old man presented at our hospital with a 6-month history of left hip pain, which had been of sudden onset and was gradually getting worse. The pain was present at rest and kept him awake at night. He needed a cane to ambulate and could barely walk one city block. No history of corticosteroid intake, alcohol abuse, or antecedent trauma was elicited. The range of motion in the left hip at the time of admission was 100° of flexion, 40° abduction, 0° adduction, 20° external rotation, and 20° internal rotation. His height was 178 cm and body weight 115 kg. Body mass index (BMI), at 36.2, indicated obesity. (In the male, ideal BMI is around 23.3 and obese is over 28 [8].)

Radiographs of the left hip obtained 6 months after the onset of pain demonstrated a subchondral collapse of the femoral head. Around the fracture line, there were areas of decreased bone density (Fig. 1A). Joint space was preserved and sclerotic rim formation was not obvious. Magnetic resonance (MR) images obtained 1 month after the onset of



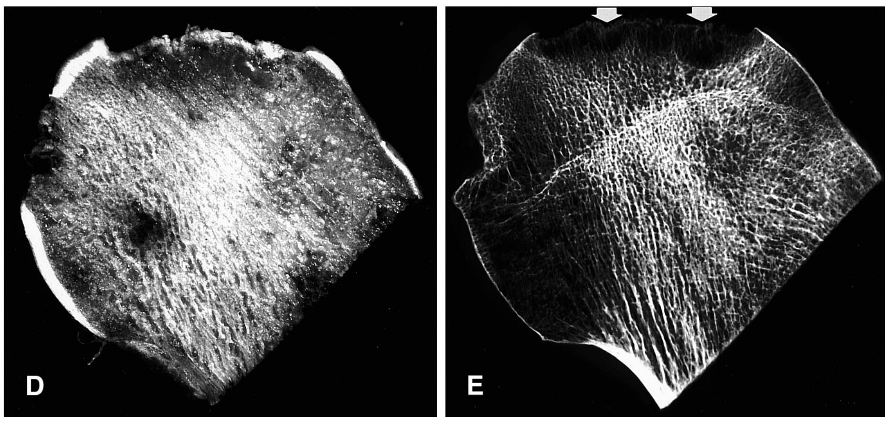


Fig. 1 **A** On the anteroposterior radiograph of the left hip, 6 months after the onset of pain, a subchondral fracture is observed at the superior portion of the femoral head. Around the fracture line, there are areas of decreased bone density. Joint space is preserved; a sclerotic rim formation is not obvious. **B,C** MR images obtained 1 month after the onset of pain show a bone marrow edema pattern with a diffuse low-intensity signal on T1-weighted (TR/TE: 600/25) images (**B**) and high-intensity signal on T2-weighted (TR/TE: 2000/90) images (**C**), extending from the femoral head to the intertrochanteric area. On T1-weighted images, a low-intensity band, convex to the articular surface, is observed, paralleling the subchondral bone endplate (*arrows*). This low-intensity band represented histopathologically the fracture line and associated repair tissue. **D** On a mid-coronal section, a notched linear-shaped zone of whitish gray tissue is observed at the superior surface of the femoral head. Note, there is no opaque yellow wedge-shaped osteonecrosis. **E** On the specimen radiograph, a subchondral fracture paralleling the articular surface is observed. Around the fracture line, there is a patchy osteosclerotic linear zone (*arrows*), which was microscopically confirmed as microcallus (**F,G**). This fracture line with associated repair tissue corresponds to the low-intensity band on T1-weighted images. Below the sclerotic zone, osteolytic areas are seen, where interruption of the trabecular pattern is noted. These lytic areas correspond to the whitish gray zone on the gross section in **D**. **F** Photomicrograph from the whitish gray area in **D** and from the area marked by *arrows* in **E** shows fracture callus (*), reactive cartilage, and granulation tissue. The surrounding bone tissue is focally resorbed by active osteoclasts and replaced by vascular granulation tissue (*arrows*), which corresponds to a lytic area on the radiograph. (hematoxylin and eosin, ×40). **G** Higher magnified view from the area (*) in **F** reveals fractured bone trabecula with associated fracture callus (*arrows*) and granulation tissue (hematoxylin and eosin, ×100)

pain showed a pattern of bone marrow edema with a diffuse low-intensity signal on T1- and high-intensity signal on T2-weighted images, extending from the femoral head to the intertrochanteric area (Fig. 1B,C). On some slices of T1-weighted images, a low intensity band, convex to the articular surface, was observed, paralleling the subchondral bone endplate. Bone scintigraphy was not performed. The patient underwent left total hip replacement.

The resected femoral head showed a flattened anterosuperior surface with a 5.5×4-cm flap of articular cartilage and attached subchondral bone. On a mid-coronal cut section, a notched linear-shaped zone of whitish gray tissue was observed under the cartilage flap paralleling the subchondral bone endplate (Fig. 1D). The specimen radiograph demonstrated a lytic zone paralleling the articular surface, and on the superficial aspect there was patchy osteosclerosis, which was microscopically confirmed as microcallus (Fig. 1E). Histologically the whitish gray regions consisted of fracture callus, including reactive cartilage, and granulation tissue (Fig. 1F,G). (The fracture line with associated repair tissue corresponded to the low-intensity band on T1-weighted MR images.) In the surrounding tissue there was focal bone resorption by active osteoclasts and replacement by vascular granulation tissue. This resorptive activity corresponded to the lytic region on the clinical and specimen

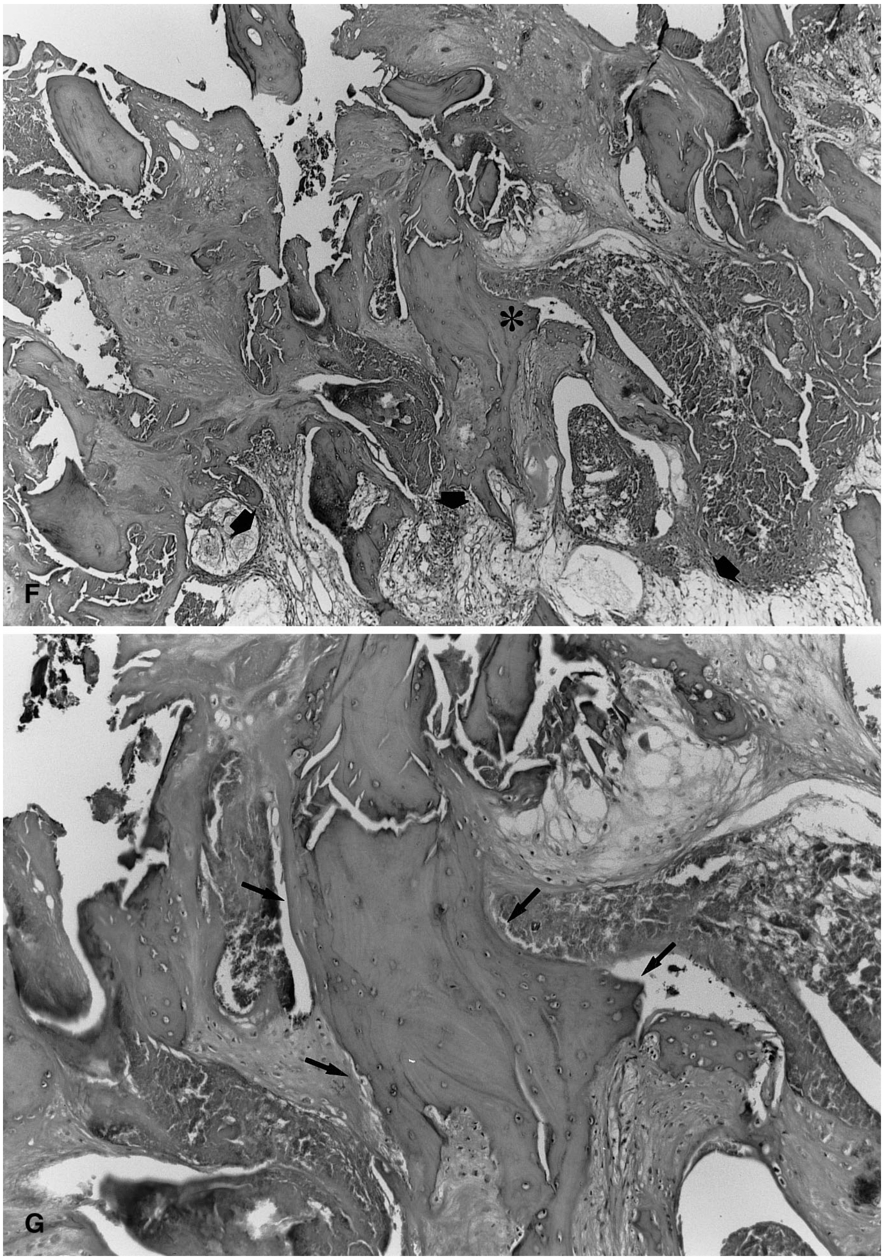


Fig. 1 Continued

radiographs. There was no evidence of antecedent osteonecrosis [6].

Two years later, this patient had sudden onset of left knee pain without recognizable antecedent trauma. When he was first seen at our institution 6 months after the onset of symptoms, the pain had become worse and stair climbing was especially difficult. On examination at the time of admission the range of motion was 0° to 140° of flexion. There was an effusion in the left knee joint and tenderness along the medial femoral condyle. Neither ligamentous instability nor localizing meniscal signs were noted.

The first radiographic examination was obtained 6 months after the onset of pain, which revealed a subchondral collapse in the medial femoral condyle, around which an osteolytic area was observed (Fig. 2A). Neither MRI nor scintigraphy was performed. The patient underwent arthroscopy and debridement. Intraoperative observation revealed a chondral flap, which included underlying subchondral tissue in the weight-bearing portion of the medial femoral condyle. This lesion was excised and submitted to pathology.

Microscopic examination of a section through the cartilage and thin layer of attached bone revealed a small area of necrosis between the fracture line and the articular surface, with fracture callus along the fracture line (Fig. 2B). No evidence of a well-demarcated wedge-shaped area of classic osteonecrosis was noted either grossly or microscopically. We therefore considered this necrotic region as a secondary phenomenon resulting from subchondral fracture, which was the initiating event [6, 9, 10].

Discussion

Since a subchondral collapse is commonly observed in symptomatic cases of osteonecrosis [11, 12] and a pattern of bone marrow edema is seen on MR in both osteonecrosis and transient osteoporosis of the hip [13–16], we believe it is important to discuss the differential diagnosis of subchondral insufficiency fracture from both of these conditions.

Based upon the previous reports and the case reported here, the clinical characteristics of subchondral insufficiency fracture may be considered as follows [1–7]. The patients are mostly elderly, and tend to be osteopenic and/or overweight. Shortly after the onset of pain, radiographic changes are unremarkable; the lack of change on the plain radiograph seems inappropriate to the reported severity of pain. MR imaging has been reported to show a pattern of bone marrow edema, which in most of the cases is associated with a focal low-intensity band on T1-weighted images. This low-intensity band,

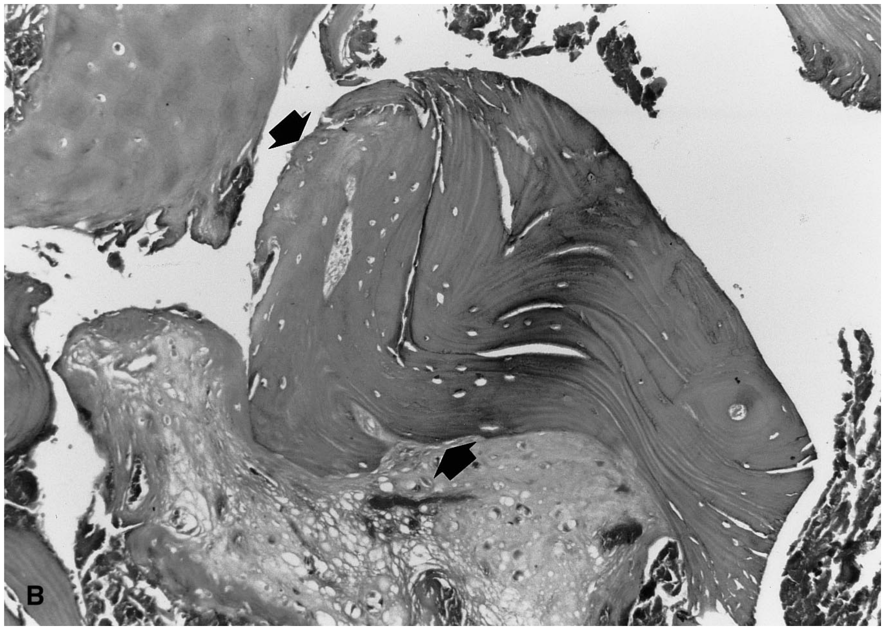


Fig. 2 **A** On the anteroposterior radiograph of the left knee, 6 months after the onset of pain, a subchondral collapse is observed in the medial femoral condyle, around which an osteolytic area is noted. **B** Fractured bone fragments with associated fracture callus (*arrows*) are observed along the fracture line (hematoxylin and eosin, ×200)

which reflects the fracture line and repair tissue histopathologically, has been reported to have a serpentine shape and lies parallel (i.e. convex) to the articular surface. On the other hand, in osteonecrosis, the shape of the low-intensity band is usually well delineated and concave to the articular surface [13–15].

The radiologic and histopathologic appearances of the knee lesion in this patient would very likely be considered by many to represent *spontaneous osteonecrosis of the knee*, which was first described by Ahlbäck et al. in 1968 [17]. In 1978, one of the authors of this paper, P.G.B., co-reported the histopathologic appearance of *spontaneous osteonecrosis of the knee*, where we noted that the necrosis was observed in only a small area of subchondral tissue between the fracture line and subchondral bone endplate [18]. We also noted that this appearance was different from most cases of osteonecrosis seen in the knee in association with treated rheumatoid arthritis, which were generally large and wedge-shaped.

At that time, we did not question the etiology of this disease. However, based upon our experience we now consider that the osteonecrotic region observed in *spontaneous osteonecrosis of the knee* is the result of subchondral insufficiency fracture of the medial femoral condyle rather than primary osteonecrosis. We base this opinion on the following findings. When a bone fractures, there is more or less tissue necrosis around the region of the fracture [9, 10]. This fracture-related necrosis should be differentiated from primary osteonecrosis. In the case we are reporting, although a small area of necrosis was recognized, it was seen only between the fracture line and articular surface. In addition, this necrotic focus was associated with extensive fracture callus formation and granulation tissue around the fracture line. Such reactive tissue is not seen in primary osteonecrosis [6, 9–12].

Based on the MR finding in the hip of a diffuse bone marrow edema pattern extending to the femoral neck or intertrochanteric region, the differentiation from transient osteoporosis of the hip is also important [16]. In transient osteoporosis of the hip, there is radiographic evidence of ill-defined focal bone loss as reported by Curtiss and Kincaid [19], and no subchondral collapse has been reported [20]. In addition, whereas transient osteoporosis of the hip is usually seen in pregnant women and middle aged men [19, 20], the age of patients with subchondral insufficiency fracture are considerably higher than the typical age group in transient osteoporosis as well as that of osteonecrosis.

Since the concept of subchondral insufficiency fracture is a recent one, the treatment options have not been established. The majority of patients with subchondral insufficiency fracture show no obvious change initially on radiographs in spite of the severe pain [1–7]. In general, the prognosis of the fracture may depend on a number of variables including the degree of osteopenia, activity, weight, the extent of fracture, and importantly the initial treatment. In this initial phase, aggressive conservative treatment of these fracture cases may lead to the remission of symptoms without surgery. The histopathologic evidence of callus formation and granulation tissue around the fractured area in our cases indicate at least the potential capacity for resolution of fracture. Even in cases that have undergone collapse requiring surgery, it is important to have outcome studies so that they can be compared with those of primary osteonecrosis.

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