# Osteonecrosis of the patella in patients with nontraumatic osteonecrosis of the femoral head

## MRI findings in 60 patients

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**ABSTRACT – We examined both knees in 60 patients with nontraumatic osteonecrosis of the femoral head with three-dimensional MRI. We found osteonecrosis of the patella in 9 patients (10 knees) and osteonecrosis of the femoral or tibial condyles/metaphyses in 35 patients (61 knees). In the patella, the necrosis was located in the proximal half and tended to develop in patients with other necrotic lesions in the knee.**

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Only 4 cases of nontraumatic osteonecrosis of the patella have been reported after steroid use (Yamaguchi et al. 1988, Oishi et al. 1991, Mizuta et al. 1993) (Table 1). We investigated the rate and the characteristics of osteonecrosis of the patella on three-dimensional MRI in patients with nontraumatic osteonecrosis of the femoral head.

## Patients and methods

Between August 1997 and August 1999, both knees in 60 patients (31 women) with osteonecrosis of the femoral head were examined with three-dimensional MRI. Their average age at diagnosis of the hip lesion was 42 (17–77) years. In 48 patients, the osteonecrosis was induced by corticosteroid therapy. The commonest steroid-treated disease (17 patients) was systemic lupus erythematosus. The mean maximum daily dose and cumulative dose of prednisone before diagnosis of the hip osteonecrosis were 50 (10–175) mg and 14 (1.2–44) g, respectively, and 21 patients had been given steroid pulse administration. 8 patients had alcohol abuse. 4 patients had no known etiologic factor for osteonecrosis.

Clinical knee symptoms were recorded when the hip osteonecrosis was diagnosed. All patients

**Table 1. Reported cases of steroid-induced osteonecrosis of the patella**

| A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|
| 1 [a] | 46 | M | steroid/bronchial asthma | 10 | R | pain | proximal | Xp, tomography, biopsy | – |
| 2 [a] | 32 | F | steroid/SLE [d] | 30 | L | pain | proximal | Xp, tomography, biopsy | – |
| 3 [b] | 54 | F | steroid/bronchial asthma | 10 | L | mild pain, effusion | proximal | Xp, tomography, MRI | + |
| 4 [c] | 45 | F | steroid/polymyositis | 25 | R | pain | proximal | Xp, tomography, scintigram | + |
| | | | | | L | pain | | | |

A Number
B Age, years
C Gender
D Related factor/basic disease
E Maximum daily steroid dose (prednisone, mg)
F Side of the patella
G Symptom
H Location on the patella (proximal/distal)
I Examination
J Treatment (arthroscopic debridement)

[a] Yamaguchi et al. [b] Oishi et al. [c] Mizuta et al. [d] Systemic lupus erythematosus

were examined with anteroposterior, lateral and skyline-view radiographs of the knee. The radiographic stage of osteonecrosis of the patella was evaluated with the ARCO (Association Research Circulation Osseous) International classification of osteonecrosis of the femoral head (Stulberg 1997).

The knees of all patients were imaged with a 1.0 Tesla superconducting magnet (Signa, General Electric, Milwaukee, Wisconsin), even when no symptom in the knee had been recorded. Cross-sectional images on the coronal plane were obtained with a 1.5-mm slice thickness, without interslice gap, a field view of 320 mm and one acquisition. The image matrix was 256 × 256 elements. T2WI (TR/TE = 3600/105 msec), spoiled gradient recalled echo pulse sequences (SPGR, TR/TE = 14/2.3 msec) and fat suppression SPGR (FS-SPGR) were obtained. The MRI data on the coronal plane were resliced for evaluation on the transverse and the sagittal planes on a Macintosh computer, using the NIH image ver. 1.61/ppc. To study the relationship between osteonecrosis of the patella and this condition elsewhere in the knee, we divided the knee into 7 sites: the medial and lateral femoral condyles, the distal femoral metaphysis, the medial and lateral tibial plateau, the proximal tibial metaphysis, and the patella. A normal fat intensity area, surrounded by a low-intensity band or diffuse low-intensity area on SPGR was judged a positive finding on MRI, according to MRI findings of osteonecrosis of the knee on T1 weighted images with spin echo sequence (Pollack et al. 1987, Healy 1991, Sakai et al. 1998).

The chi-square test was used for statistical analysis, and a p-value of less than 0.05 was considered significant.

## Results

Osteonecrosis of the knee was detected in 35 patients (61 knees) on MRI (Table 2). In 14 patients (21 knees), there were clinical symptoms consisting of mild pain when climbing stairs (9), moderate pain when walking (11), and severe pain when walking (1).

Osteonecrosis of the patella was found in 9 patients (10 knees) (Tables 2 and 3). There were 6 females and 3 males. In 7 patients, the necrosis was steroid-induced and in 2, alcohol-related. 5 patients had no symptoms. While 3 patients had mild anterior pain during walking, 1 patient (case 1) with bilateral lesions had moderate pain in the right and severe pain in the left knee (Table 3, Figure 1).

**Table 2. Location of osteonecrosis of the knee in 60 patients**

| Site | Number of knees | Number of patients |
|---|---|---|
| Total | 61 | 35 |
| Patella | 10 | 9 |
| Femoral condyle | 51 | 27 |
| Lateral | 47 | 24 |
| Medial | 39 | 22 |
| Distal femoral metaphysis | 24 | 15 |
| Proximal tibial metaphysis | 18 | 10 |
| Tibial plateau | 6 | 4 |
| Medial | 6 | 4 |
| Lateral | 4 | 3 |

There were 8 knees in stage 1, 1 in stage 2, and 1 in stage 4 (Table 3). All cases of osteonecrosis of the patella showed a diffuse low-intensity area on SPGR and T2WI, and a heteromogeneous high-intensity area on FS-SPGR. The lesion was located in the proximal and medial halves of the patella in 9 knees, while 1 lesion was observed in the proximal and lateral halves. In 8 knees, there were necrotic lesions in other areas, but 2 knees (cases 7 and 8) had necrotic lesions in the patella alone (Figure 2, Tables 3 and 4). There was a significant difference between the number of necrotic areas in knees with or without osteonecrosis of the patella ($p < 0.0001$) (Table 4).

## Discussion

Since three-dimensional MRI has the advantage that any reslicing of the reconstructed anatomy is possible, it resulted in a reliable diagnosis of necrotic lesions. Although SPGR imaging is not entirely the same as T1 weighted imaging with short TR/TE on spin echo sequence in some tissues (Elster 1993), there are few differences in the MRI findings of necrotic lesions in the femoral head

**Table 3. Patients with osteonecrosis of the patella (ONP)**

| A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 42 | F | steroid / SLE | 16.7 | 12 | + | R | moderate | 2 | condyles / metaphysis | plateau / metaphysis |
| | | | | | | | L | severe | 4 | condyles / metaphysis | plateau / metaphysis |
| 2 | 27 | F | steroid / SLE | 50 | 13 | + | L | mild | 1 | condyles / metaphysis | plateau / metaphysis |
| 3 | 35 | F | steroid / SLE | 175 | 32 | + | R | – | 1 | condyles | metaphysis |
| 4 | 33 | F | steroid / ITP | 30 | 11 | + | L | – | 1 | metaphysis | metaphysis |
| 5 | 21 | F | steroid / BMT | 30 | 20 | + | R | mild | 1 | condyles / metaphysis | plateau / metaphysis |
| 6 | 41 | F | steroid / BMT | 60 | 16 | + | L | mild | 1 | condyles / metaphysis | metaphysis |
| 7 | 54 | M | steroid / iritis | 25 | 1.2 | – | R | – | 1 | – | |
| 8 | 28 | M | alcohol | – | – | – | R | – | 1 | – | |
| 9 | 58 | M | alcohol | – | – | – | R | – | 1 | condyles | |

A Patient
B Age, years
C Gender
D Related factor/basic disease (see below)
E Maximum daily steroid dose (prednisone, mg)
F Total steroid dose (prednisone, g)
G Steroid pulse administration
H Side of the patella
I Pain
J Stage
K Location of femoral necrotic areas of the knee
L Location of tibial necrotic areas of the knee

SLE Systemic lupus erythematosus, ITP Idiopathic thrombocytopenic purpura, BMT Bone marrow transplantation for acute lymphatic leukemia (case 5) or acute monocytic leukemia (case 6)
ARCO (Association Research Circulation Osseous) International classification of osteonecrosis of the femoral head (ONFH). The location of the osteonecrosis was proximal-medial in all cases except in case 8 (proximal-lateral).

between SPGR imaging and T1 weighted imaging on spin echo sequence (Sakai et al. 2000). SPGR imaging with 1.5-mm slice thickness without an interslice gap may be a useful screening method for the knee. We did not compare MRI findings with histological findings. However, a similar MRI finding with histopathological proof of osteonecrosis has been seen in a patient with idiopathic osteonecrosis of the patella (Sanchis-Alfonso et al. 1997).

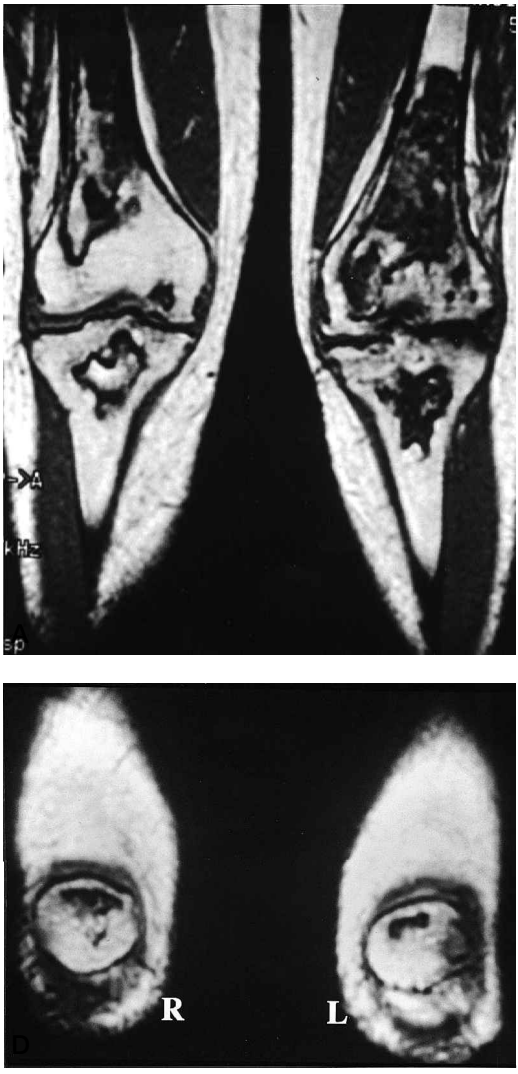
The necrotic lesions were all located in the proximal half of the patella as reported in previous studies (Yamaguchi et al. 1988, Oishi et al. 1991, Mizuta et al. 1993). The reason may be that this part of the patella is supplied by the mid-patellar artery alone, while the distal half of the patella is supplied by both the apical and the mid-patellar arteries (Björkström and Goldie 1980).

Osteonecrosis of the knee is often accompanied by nontraumatic osteonecrosis of the femoral head (LaPorte et al. 1998, Sakai et al. 1998, Mont et al. 1999). Osteonecrosis of the patella tended to develop in patients with other necrotic lesions of the knee (Table 4). The patella is surrounded by a vascular anastomotic ring derived from the 6 main joint arteries—that is, the supreme genicular ar-

**Table 4. Other necrotic lesions in the knees of patients with or without ONP [a]**

| Site | Knees with ONP [a] (n 10) | Knees without ONP [a] (n 110) |
|---|---|---|
| Femoral condyle | 7 | 44 |
| Lateral | 7 | 40 |
| Medial | 7 | 32 |
| Distal femoral metaphysis | 6 | 18 |
| Proximal tibial metaphysis | 7 | 11 |
| Tibial plateau | 4 | 2 |
| Medial | 4 | 2 |
| Lateral | 4 | 0 |
| None | 2 | 59 |
| Number of sites [b] | | |
| 6 | 4 | 0 |
| 5 | 0 | 1 |
| 4 | 1 | 7 |
| 3 | 1 | 3 |
| 2 | 2 | 21 |
| 1 | 0 | 19 |
| 0 | 2 | 59 |

[a] Osteonecrosis of the patella.
[b] Other necrotic sites: lateral and medial femoral condyles, distal femoral metaphysis, proximal tibial metaphysis, lateral and medial tibial plateaus.
Chi-square test $p < 0.0001$



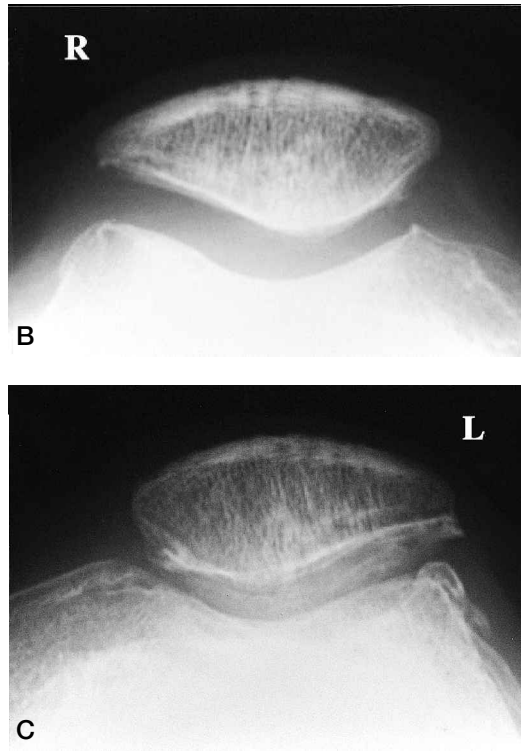




Figure 1. Steroid-related osteonecrosis of bilateral patellae in a 42-year-old female patient with systemic lupus erythematosus (case 1): A. Coronal MR images of bilateral knees on SPGR (TR / TE =14/2.3 msec), B. Skyline-view radiograph of the right patella, C. Skyline-view radiograph of the left patella, D. Coronal MR images of bilateral patellae on SPGR (TR/TE =14/2.3 msec). Osteonecrosis of both knees was detected in the distal femoral metaphysis, the medial femoral condyles, the proximal tibial metaphysis, and the patellae. Necrotic lesions of the patellae, seen as a diffuse low-intensity area on SPGR, were located in the proximal-medial half of the patellae.

tery, the medial and lateral superior genicular arteries, the medial and lateral inferior genicular arteries, and the anterior tibial recurrent arteries (Scapinelli 1967, Björkström and Goldie 1980). The femoral condyles and the distal femoral metaphysis are mainly supplied by the medial and lateral superior genicular arteries, while the tibial plateau and proximal tibial metaphysis are supplied by the medial and lateral inferior genicular arteries (Shim and Leung 1986). Thus the patella and distal femoral regions or the proximal tibial region have a shared blood supply. Therefore extensive vascular damage may lead to necrosis in many sites of the knee.

With awareness of this possibility, osteonecrosis of the patella should be diagnosed oftener in patients with hip osteonecrosis, if standard diagnostic procedures including MRI are used.

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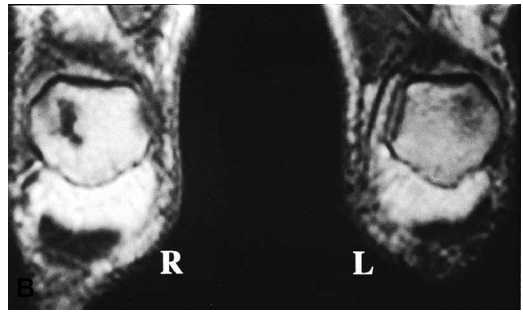
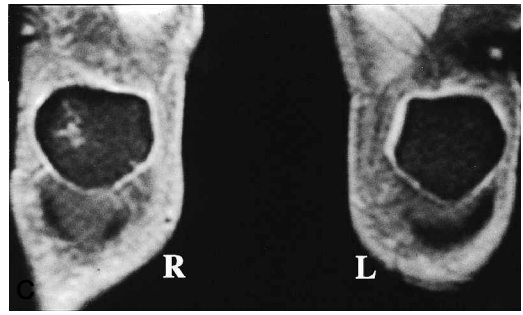
Björkström S, Goldie I F. A study of the arterial supply of the patella in the normal state, in chondromalacia patellae and in osteoarthrosis. Acta Orthop Scand 1980; 51: 63-70.

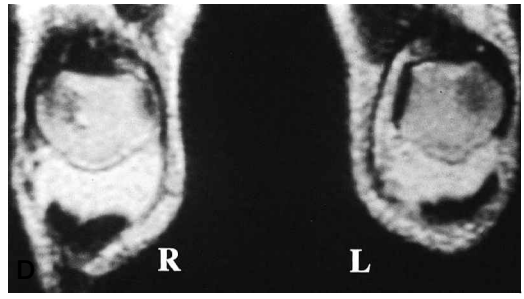




Figure 2. Alcohol-related osteonecrosis of the patella in a 28-year-old man (case 8). A. Coronal MR images of both knees on SPGR (TR/TE =14 / 2.3). B. Coronal MR image of right patella on SPGR (TR/TE =14/2.3 msec), C. FS-SPGR (TR/TE =14/2.3 msec), D. T2WI (TR/TE = 3600/105 msec). Osteonecrosis was detected in the right patella alone. Necrotic lesion of the patella was seen as a diffuse low-intensity on SPGR, heterogeneous high-intensity on FS-SPGR, and heterogeneous low-intensity on T2WI. The necrotic lesion was located in the proximal-lateral half of the patella.

Elster A D. Gradient echo imaging: technique and acronyms. Radiology 1993; 186: 1-8.

Healy W. Osteonecrosis of the knee detected only by magnetic resonance imaging: Case reports. Orthopaedics 1991; 14: 703-4.

LaPorte D M, Mont M A, Mohan V, Jones L C, Hungerford D S. Multifocal osteonecrosis. J Rheumatol 1998; 25: 1968-74.

Mizuta H, Kubota K, Shiraishi M, Kai K, Nakamura E, Takagi K: Case report.Steroid-related bilateral osteonecrosis of the patella. Arthroscopy 1993; 9: 114-6.

Mont M A, Jones L C, LaPorte D M (Collaborative osteonecrosis group). Symptomatic multifocal osteonecrosis. A multicenter study. Clin Orthop 1999; 369: 312-26.

Oishi Y, Yokota S, Nakagawa W, Tsunoda K, Ueda H, Takahashi Y, Sakuma M,Oshima T. Steroid-induced osteonecrosis of the patella.A case report. Acta Orthop Scand 1991; 62: 178-9.

Pollack M S, Dalinka M K, Kressel H Y, Lotke P A, Spritzer C E. Magnetic resonance imaging in the evaluation of suspected osteonecrosis of the knee. Skeletal Radiol 1987; 16: 121-7.

Sakai T, Sugano N, Ohzono K, Matsui M, Hiroshima K, Ochi T. MRI evaluation of steroid- or alcohol-related osteonecrosis of the femoral condyle. Acta Orthop Scand 1998; 69: 598-602.

Sakai T, Sugano N, Nishii T, Haraguchi K, Ochi T, Ohzono K. MR findings of the necrotic lesion and the extralesional area of osteonecrosis of the femoral head. Skeletal Radiol 2000; 29: 133-41.

Sanchis-Alfonso V, Rosello-Sastre E, Esquerdo J, Martinez-Sanjuan V. Occult localized osteonecrosis of the patella. Case report. Am J Knee Surg 1997; 10: 166-70.

Scapinelli R. Blood supply of the human patella. Its relation to ischemic necrosis after fracture. J Bone Joint Surg (Br) 1967;49: 563-70.

Shim S S, Leung G. Blood supply of the knee joint. A microangiographic study in children and adults. Clin Orthop 1986; 208: 119-25.

Stulberg B N. Editorial comment. Clin Orthop 1997; 334: 2-5.

Yamaguchi H, Masuda T, Sasaki T, Nojima T. Steroid-induced osteonecrosis of the patella. Clin Orthop 1988; 229: 201-4.