

# MRI evaluation of steroid- or alcohol-related osteonecrosis of the femoral condyle

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We reviewed 30 patients (46 knees) with steroid- or alcohol-related osteonecrosis of the femoral condyle. Their average age was 35 (14–61) years and the mean observation time was 7 (3–16) years. The medio-lateral extent and the anterior-posterior (AP) location of the necrotic lesion were evaluated on T1-weighted MRI and related to the collapse of the condyle. The size of the lesion was classified into three categories on the mid-coronal MRI of the femoral condyle: there were 44 small, 20 medium, and 9 large lesions. The condyle was divided into 3 zones: anterior, middle, and posterior. The location of the lesion was evaluated on the mid-sagittal image.

There were 7 anterior, 9 middle, 29 posterior, 14 middle and posterior and, in 14 cases, all 3 zones were involved. 44 small lesions did not collapse, while 6/20 medium lesions and 5/9 large lesions collapsed. No lesion involving only one zone collapsed, while 4/14 lesions involving the middle and posterior zones and 7/14 lesions involving all three zones progressed to collapse. 4/6 condyles with large necrotic lesions involving all three zones collapsed. We conclude that the extent of the necrotic lesion on both the mid-coronal and mid-sagittal planes is of importance for the prognosis of osteonecrosis of the femoral condyle.

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Since 2 patients were reported by Dubois and Cozen (1960) in a series of 400 cases of systemic lupus erythematosus, steroid- or alcohol-related osteonecrosis of the femoral condyle has been sporadically reported (Isono et al. 1987, Bohn et al. 1989, Havel et al. 1989, Kelman et al. 1990, Motohashi et al. 1991, Ochi et al. 1995). Condyles with minimum clinical symptoms may progress to collapse and generate osteocartilaginous fragments (Hall and Hume 1970, Ishkhanian and Ramsey 1977), needing surgical treatment. Therefore, it is important to be able to predict the collapse.

Extent and location of the lesion on radiographs have been reported to correlate with the prognosis in both spontaneous idiopathic necrosis (Roizing et al. 1980, Lotke et al. 1982, Aglietti et al. 1983) and steroid-related cases (Sasaki et al. 1986). However, it is difficult to evaluate the extent and location of the lesion accurately on radiographs. Anterior and posterior parts of the lesion project over each other on antero-posterior (AP) radiographs and medial and lateral condyles on lateral radiographs. MRI is better than radiographs for early detection of osteonecrosis and for evaluating the extent and location of lesions in the hip and knee (Pollack et al. 1987, Healy 1991, Chancelier et al. 1992, Sugano et al. 1994b). Our purpose

was to investigate the relationship between the prognosis of necrotic lesions and the extent and location of these lesions on MRI by reviewing patients with steroid- or alcohol-related osteonecrosis of the femoral condyle.

## Patients and methods

Between January 1975 and January 1994, 288 patients were diagnosed having non-traumatic osteonecrosis of the femoral head in our department. 34 patients (12%), also had necrosis of the distal femur (53 knees). Osteonecrosis of the knee only was found in 4 patients (7 knees). The diagnosis was based on radiographs and bone scintigraphy in the beginning of the series, but since 1986 we have used MRI, including 4 patients who had already been diagnosed radiographically. The following were excluded from this study: 2 patients (3 knees) were lost to follow-up within 3 years after diagnosis. 3 patients (5 knees) showed typical necrotic changes on radiographs and did not undergo MRI. MRI showed necrotic lesions in the metaphysis or diaphysis in only 3 patients (6 knees). Thus, the remaining 46 knees of 30 patients were included in this study.

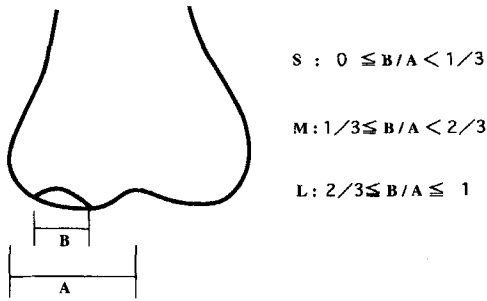


Figure 1. Size of the lesions on the mid-coronal plane.

There were 12 men and 18 women and the mean age at diagnosis was 35 (14–61) years. The mean observation time was 7 (3–16) years. 27 patients had been treated with corticosteroid therapy and 3 patients had a history of alcohol abuse, without any known trauma to the knee. The underlying diseases in steroid-related necrosis were systemic lupus erythematosus in 13, idiopathic thrombocytopenic purpura in 2 cases, Hashimoto's disease in 2 cases, and Harada's disease in 2 cases. 1 patient underwent bone marrow transplantation, and 1 renal transplantation. The reasons for steroid administration in the other 6 patients were nephrotic syndrome, allergic granulomatous angitis, sarcoidosis, hepatitis, optic neuritis, and cervical spinal cord injury. The mean total dose of prednisolone before diagnosis was 12 (0.3–40) g. The mean maximum daily dose of prednisolone was 50 (10–100) mg. The lateral condyle was affected in 20 knees, the medial condyle in 3 knees, and both condyles in 23 knees. 4 condyles had 2 lesions anteriorly and posteriorly; these were regarded as separate lesions.

### Clinical evaluation

43 knees (28 patients) showed clinical symptoms which were: pain during walking (41 knees) and climbing stairs (2 knees), swelling (4 knees), and mild limited range of motion (3 knees). All symptomatic patients were treated with non-steroidal anti-inflammatory drugs (NSAID) and physiotherapy. Clinical status at diagnosis and at the latest follow-up was evaluated, using the Hospital for Special Surgery Score (Ranawat et al. 1976).

### Radiographic staging

All patients were examined with AP and lateral radiographs. Serial radiographs were assessed according to the Association of Research Circulation Osseous International Staging System (ARCO staging system, Stulberg 1997). There were 24 stage I, 16 stage II, and 6 stage III knees at the initial examination.

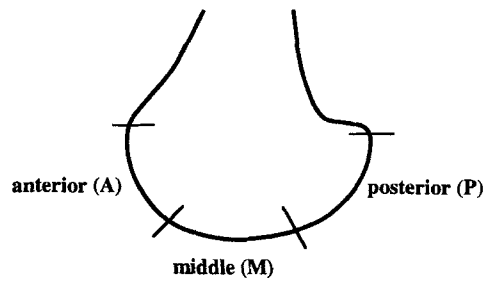


Figure 2. AP location of lesions on the mid-sagittal plane.

### MRI evaluation

There was a low-intensity area or a high-intensity area demarcated by a low-intensity band on T1-weighted MRI and a low-intensity area or a heterogeneous iso- and low-intensity area on T2-weighted MRI in all cases. There was no case of bone marrow edema. In the beginning, a 0.5 Tesla superconducting magnet (Vista MR HP; Picker, Cleveland, OH, USA) was mainly used and, after 1992, a 1.0 Tesla superconducting magnet (Magnetom Impact; Siemens, Germany) was used to generate image sections in the coronal and sagittal planes. T1-weighted spin-echo images were obtained with repetition times of 500–800 milliseconds and echo times of 15–43 msec, and T2-weighted spin-echo images were obtained with repetition times of 2000–4500 msec and echo times of 96–117 msec, in 5–10 mm thicknesses. The image matrix was 256 × 256 elements.

The sizes of the lesions on the mid-coronal T1-weighted images of the femoral condyle were classified into three categories: small (S)–involving less than one third of the condyle, medium (M)–involving more than one third and less than two thirds, large (L)–involving more than two thirds (Figure 1). To evaluate the AP location of the lesions, the medial or lateral condyle was divided into three zones: anterior (A), middle (M), and posterior (P) on the mid-sagittal plane of T1-weighted images (Figure 2).

## Results

### Clinical results

The mean pain score and total knee score improved from 23 (5–30) points to 27 (20–30) points and from 90 (48–100) points to 94 (72–100) points at the latest follow-up, respectively (Table 1). 19 knees were painless, 28 knees had walking pain, 2 knees pain at rest, and 5 knees a mild limited range of motion.

Table 1. Clinical evaluation

	At diagnosis	At latest follow-up
Pain score (range)	23 (5-30)	27 (20-30)
Total score (range)	90 (48-100)	94 (72-100)

Table 2. Radiographic staging

Number of knees at diagnosis		Number of knees at latest follow-up	
Stage I	24	Stage I	22
		Stage II	2
Stage II	16	Stage II	12
		Stage III	4
Stage III	6	Stage III	4
Stage IV	0	Stage IV	2

Table 3. Size and anterior-posterior location on T1-weighted MRI, number of collapsed condyles / number of total condyles

Extent on the mid-coronal image	AP location on the mid-sagittal image				
	A	M	P	MP	AMP
S	0/7	0/5	0/29	0/3	-
M	-	0/4	-	3/8	3/8
L	-	-	-	1/3	4/6

### Radiographic staging

22/24 knees in stage I did not progress, and the other 2 knees progressed to stage II 4 years after diagnosis. 4/16 knees in stage II progressed to stage III in 21 (18-24) months, and the other 12 did not progress during the follow-up period. 2/6 knees in stage III progressed to stage IV in 50 (45-55) months, but the other 4 did not progress during the follow-up period (Table 2). All alcohol-related cases (4 knees of 3 patients) remained in stage I.

### MRI evaluation, extent and location

73 condyles had a necrotic lesion on MRI, but 45 of them were not visible on radiographs (stage I). There were 44 small, 20 medium, and 9 large lesions. 36 lesions were located solely in the anterior or posterior condyle. These could not be detected on the mid-coronal plane and were classified as small. As for the AP location, 7 lesions involved only condylar zone A, 9 involved only zone M, 29 involved only zone P, 14 involved zones M and P, and 14 involved all three zones.

41/44 small lesions were located in a single AP zone only and the other 3 lesions in zones M and P. 6/20 medium lesions were located in zones M and P or in all three zones on the mid-sagittal images, and the other 4 lesions were located in zone M. All large lesions involved zones M and P or all 3 zones (Table 3).

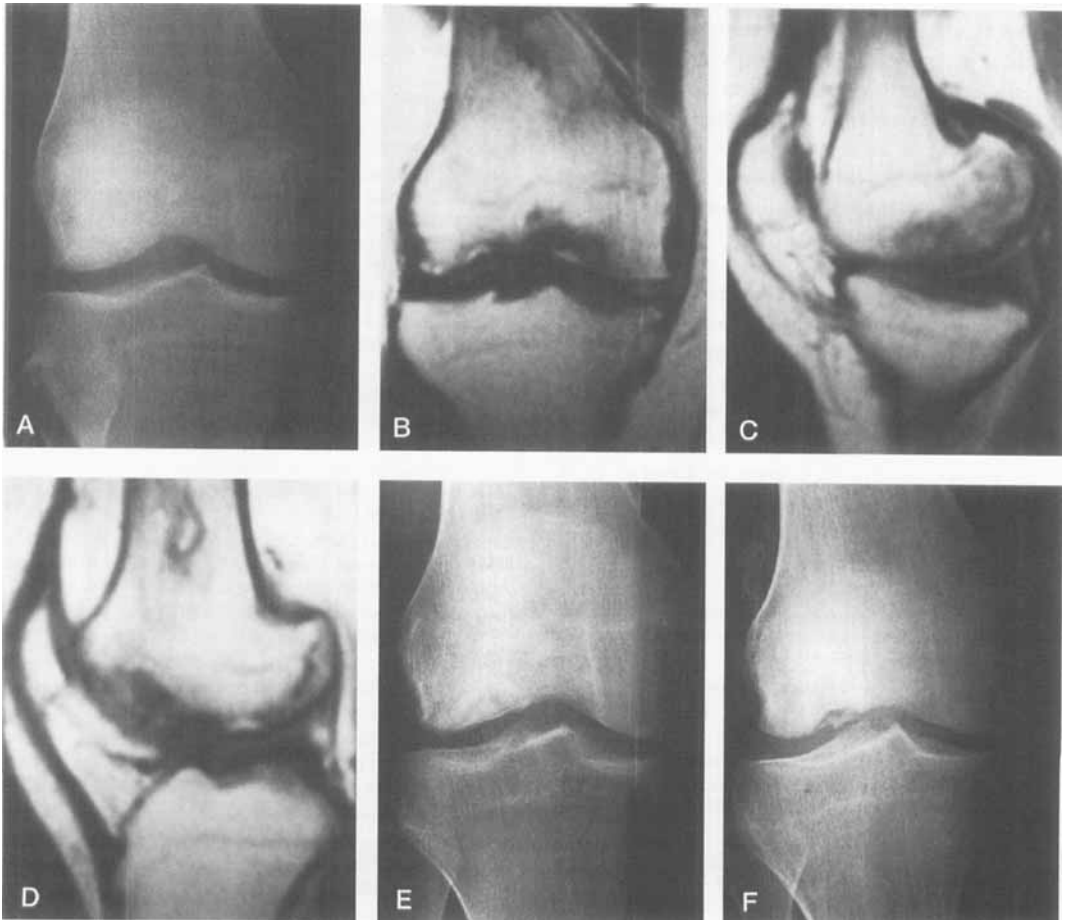
### Radiographic staging and MRI evaluation

38/44 condyles with small lesions at diagnosis remained in stage I, and 6 remained in stage II at the latest follow-up. No condyle with a small lesion collapsed. 6/20 condyles with medium lesions collapsed; 5 were in stage III and 1 was in stage IV at the latest follow-up. 6 condyles remained in stage I and 8 in stage II. 5/9 condyles with large lesions collapsed; 3 condyles were in stage III and 2 condyles in stage IV at the latest follow-up. The other 4 condyles were stage II. No condyle with a lesion located in a single zone only (A, M, P) collapsed. 4/14 condyles with a lesion located in zones M and P collapsed. 7/14 condyles with a lesion involving all three zones collapsed (Figure 3). 4/6 condyles with a large lesion involving all three zones collapsed (Table 3).

At the latest follow-up, of 26 medial condyle lesions, 19 were in stage 1, 4 in stage 2, 2 in stage 3, and 1 in stage 4. Among 47 lateral condyle lesions, 25 were in stage 1, 14 in stage 2, 6 in stage 3, and 2 in stage 4. The average age at diagnosis was 37 years in stage 1, 36 years in stage 2, 24 years in stage 3, and 27 years in stage 4. Although the patients were too few for statistical analysis, there was little difference in prognosis between medial and lateral lesions and there was a tendency that the average young age at diagnosis increased the risk of collapse.

### Discussion

There have been many case reports about steroid- or alcohol-related osteonecrosis of the femoral condyle (Dubois and Cozen 1960, Hall and Hume 1970, Ishkhanian and Ramsey 1977, Isono et al. 1987, Havel et al. 1989, Kelman et al. 1990, Healy 1991, Motohashi et al. 1991, Ochi et al. 1995), but the natural history and best treatment are still unknown. In our study, lateral condyles tended to be affected and both condyles were mainly involved, as Chancelier et al. (1992) claimed, in steroid-related osteonecrosis. All knees, except 5 which were debrided arthroscopically, were treated non-operatively and clinical symptoms were mild or moderate, with almost normal range of motion at the latest follow-up. The incidence of collapse was low, compared to osteonecrosis of the femoral



Figures 3. A 17-year-old girl with steroid-related osteonecrosis of both femoral condyles. The initial anteroposterior (AP) radiograph (3A) was normal (stage I), but T1-weighted MR images showed a high intensity area demarcated by a low-intensity area on the mid-coronal plane of the medial condyle (small size) and lateral condyle (medium size) (3B) and on the mid-sagittal plane of the medial condyle (middle zone) (3C) and the lateral condyle (anterior, middle, and posterior zones) (3D). After 5 months, an AP radiograph showed a stage II necrotic lesion on the lateral condyle (3E). After 2 years, an AP radiograph showed free osteochondral fragments (stage III) (3F).

head (77%) (Sugano et al. 1994a). Thus, the course of most cases of osteonecrosis of the femoral condyle may be benign.

The size and location of necrotic lesions are supposed to be important for predicting the fate of the femoral condyle (Rozing et al. 1980, Lotke et al. 1982, Aglietti et al. 1983, Sasaki et al. 1986). However, it is difficult to assess a necrotic lesion on plain radiographs. By definition, stage I cases cannot be evaluated. Therefore, one must use MRI. There is no previous report about prognostication of osteonecrosis of the femoral condyle, using MRI. We evaluated the lesions in the same way as in a previous investigation of osteonecrosis of the femoral head (Sugano et al. 1994b). The size of the necrotic lesion was measured on the mid-coronal images, because the necrotic lesions were mainly in the central weight-bearing

area. While the AP location is considered to be an important factor, because the condyles usually collapsed in the weight bearing area, the size of the lesion on the mid-sagittal image is more important for the prognosis. With combined evaluation of the medio-lateral and AP extent of the lesions, osteonecrosis of the femoral condyle, with little risk of collapse, was identified as a small lesion involving one zone only but, if more than one third of the condyle is involved on the mid-coronal image or the middle and posterior zones, the risk of collapse is great and more active treatment may be needed.

To distinguish osteonecrosis of the femoral condyle from bone marrow edema and other lesions, especially small ones, both T1-weighted and T2-weighted spin-echo images were necessary. In our study, those images showed a low-intensity area or a high-intensity

ty area, demarcated by a low-intensity band on T1-weighted images and a low-intensity area or a heterogeneous iso- and low-intensity area on T2-weighted images. Those images showed no homogeneous high-intensity area on T2 images, which indicated bone marrow edema. However, contours of necrotic lesions, especially small ones, on T2-weighted images were more difficult to see than on T1-weighted images. We could not determine the contour of the necrotic lesions or assess the size and location of the necrotic lesions on T2-weighted images. Therefore, to diagnose osteonecrosis of the femoral condyle, both T1- and T2-weighted spin-echo images were necessary, but to assess necrotic lesions, T1-weighted images were sufficient. The necrotic lesions on MRI correspond to the histological lesions, as Takatori et al. (1987) reported about osteonecrosis of the femoral head. This has not been shown in the knee.

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