

HISTOLOGIC ANALYSIS OF ACETABULAR AND PROXIMAL FEMORAL BONE IN PATIENTS WITH OSTEONECROSIS OF THE FEMORAL HEAD

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Background: The purpose of this study was to investigate the hypothesis that osteonecrosis of the femoral head may also involve the acetabulum and the proximal part of the femur.

Methods: Twenty-five patients who underwent simultaneous bilateral total hip arthroplasty and thirty-eight patients who had a unilateral total hip arthroplasty for treatment of symptomatic osteonecrosis of the femoral head were included in the study. There were fifty-five men and eight women. The etiology of the osteonecrosis was idiopathic in forty patients (fifty-six hips, 64%), associated with ethanol abuse in eighteen patients (twenty-five hips, 28%), and associated with steroid use in five patients (seven hips, 8%). The mean age of the patients at the time of arthroplasty was 47.1 years. We performed cancellous bone biopsies in the acetabulum, the proximal part of the femur, and the femoral head intraoperatively and then examined the specimens histologically.

Results: Of the eighty-one hips with idiopathic or ethanol-associated osteonecrosis, seventy-six (94%) had normal or stage-1 bone in the acetabulum and the proximal part of the femur according to the system of Arlet and Ficat, and seventy-eight (97%) of the eighty-one had a grade of 0 or 1 according to the system of Humphreys et al. Of the seven hips with steroid-associated osteonecrosis, four had normal or stage-1 bone and a grade of 0 or 1 and three had stage-2 or 3 disease and a grade of 2 or 3. Therefore, the vast majority of hips with idiopathic or ethanol-associated osteonecrosis had normal or nearly normal bone in the acetabulum and the proximal part of the femur. Three of the seven hips with steroid-associated osteonecrosis had abnormal bone in the proximal part of the femur only.

Conclusions: One can expect to find normal or nearly normal cancellous bone in the acetabulum and the proximal part of the femur of patients with either idiopathic or ethanol-associated osteonecrosis of the hip. More extensive osteonecrosis may accompany steroid-associated osteonecrosis of the hip.

Long-term results of total hip arthroplasty have generally shown that a subset of patients with femoral head osteonecrosis have fared worse than their age-matched counterparts with other diagnoses^{1,2}. Premature loosening of implants in patients with osteonecrosis may be related to the presence of abnormal cancellous bone at the implant-bone and cement-bone interfaces³⁻⁵. In this study, we examined this hypothesis by performing bone biopsies intraoperatively followed by histologic analysis of specimens from the femoral head, acetabulum, and proximal part of the femur from young patients undergoing total hip arthroplasty for symptomatic osteonecrosis.

Materials and Methods

This prospective study included twenty-five patients treated with bilateral total hip arthroplasty and thirty-eight pa-

tients treated with unilateral total hip arthroplasty by one surgeon (Y.-H.K.). All patients had Ficat and Arlet stage-III or IV osteonecrosis of the femoral head⁶. The study was approved by our institutional review board, and all patients provided informed consent. No patient was lost to follow-up. Demographic data on the patients are summarized in Table I.

Surgical Technique

A posterolateral approach was utilized in all patients. The femoral head was removed and placed in 10% buffered formalin solution. Samples of cancellous bone (0.3 cm³) were taken from the following six areas: zone I' of the acetabulum, the femoral head, the base of the femoral neck, the greater trochanter, the lesser trochanter, and the medullary canal approximately 4 cm distal to the lesser trochanter (Fig. 1). All bone samples were harvested before reaming of the acetabular

TABLE I Demographic Data on the Patients

No. of patients	63
Gender (M/F) (no.)	55/8
Age* (yr)	47.1 (25-64)
Height* (cm)	169.2 (153-180)
Weight* (kg)	66.7 (41-90)
Diagnosis	
Idiopathic	40 patients (56 hips, 64%)
Ethanol abuse	18 patients (25 hips, 28%)
Steroid-associated	5 patients (7 hips, 8%)
Charnley class ¹⁵	
A	38 patients (60%)
B	25 patients (40%)
C	0 patient (0%)
Duration of follow-up* (yr)	4.85 (3-5)

*The values are given as the mean, with the range in parentheses.

TABLE II Histologic Stages Described by Arlet and Ficat⁸

Histologic Stage	Findings
1	Disappearance of the hematopoietic marrow, separation of the lipocytes by edema or hemorrhage, and presence of foam cells
2	Necrosis of the fatty marrow
3	Medullary and trabecular necrosis
4	Complete necrosis with dense medullary fibrosis and formation of new bone in apposition to the dead trabeculae

cavity and the femoral canal and were then stored in buffered formalin. All of the samples were individually coded to ensure that the histologic examination was carried out in a blinded manner by the pathologist.

Histologic Analysis

The femoral heads were sectioned in the coronal plane at 0.5-cm intervals. Undecalcified samples were embedded in resin and were stained with Goldner trichrome and toluidine blue. Decalcified samples were embedded in paraffin wax and stained with Mayer hematoxylin and eosin. The samples were then examined for evidence of osteonecrosis of the femoral head and were graded according to the histologic stages described by Arlet and Ficat⁸ (Table II).

The number of empty osteocyte lacunae was quantified according to the method of Humphreys et al.,⁹ by an examiner who was unaware of the underlying diagnosis of each specimen. Ten high-powered fields of each bone specimen were examined and each was graded, with Grade 0 indicating no empty osteocyte lacunae in ten high-powered fields; Grade 1, fewer than three of the ten high-powered fields with empty os-

teocyte lacunae; Grade 2, three to six high-powered fields with empty osteocyte lacunae; and Grade 3, more than six high-powered fields with evidence of empty osteocyte lacunae.

Results

Histologic Analysis

Preoperatively, all hips had stage-3 or 4⁶ osteonecrosis of the femoral head as seen on plain radiographs. Histologic examination of the femoral head confirmed stage-3 osteonecrosis in four hips (5%) and stage-4 osteonecrosis in eighty-four hips (95%) with use of the criteria of Arlet and Ficat⁸. No other metabolic bone disease was identified histologically in any patient.

Fifty-three (95%) of the fifty-six hips with idiopathic osteonecrosis, twenty-three (92%) of the twenty-five hips with ethanol-associated osteonecrosis, and four of the seven hips with steroid-associated osteonecrosis had normal or stage-1 bone in the acetabulum and the proximal part of the femur. The remaining three hips with steroid-associated osteonecrosis had stage-2 or 3 disease (Table III).

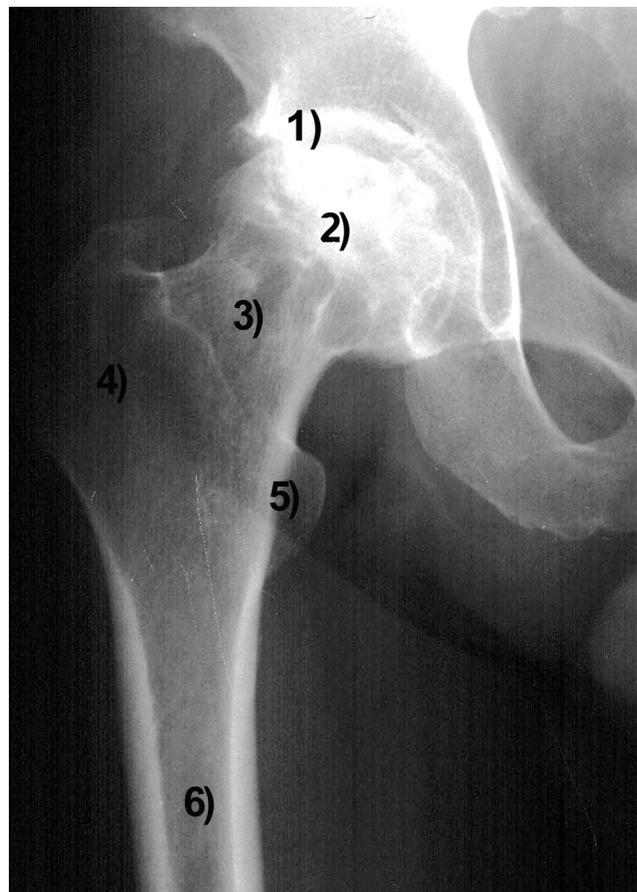


Fig. 1
Anteroposterior radiograph of the hip in a patient with advanced osteonecrosis of the femoral head (Ficat and Arlet stage IV⁶), showing the six regions of cancellous bone sampled from the acetabulum and the proximal part of the femur (see text).

TABLE III Results of Bone Biopsies According to the Histologic Stages described by Arlet and Ficat^{8*}

Stage	Acetabulum	Femoral Head	Base of Femoral Neck	Greater Trochanter	Lesser Trochanter	Medullary Canal
Normal	77 (87%)	0 (0%)	51 (58%)	53 (60%)	44 (50%)	41 (47%)
1	11 (13%)	0 (0%)	32 (36%)	32 (36%)	40 (46%)	45 (51%)
2	0 (0%)	0 (0%)	3 (3%)	1 (1%)	2 (2%)	1 (1%)
3	0 (0%)	4 (5%)	1 (1%)	2 (2%)	2 (2%)	1 (1%)
4	0 (0%)	84 (95%)	1 (1%)	0 (0%)	0 (0%)	0 (0%)

*The values are given as the number of hips, with the percentage in parentheses.

Fifty-five (98%) of the fifty-six hips with idiopathic osteonecrosis, twenty-three (92%) of the twenty-five hips with ethanol-associated osteonecrosis, and four of the seven with steroid-associated osteonecrosis had Grade-0 or 1 bone in the acetabulum and the proximal part of the femur, as assessed with the method of Humphreys et al.⁹ The remaining three hips with steroid-associated osteonecrosis had Grade-2 or 3 bone necrosis (Table IV and Fig. 2). Therefore, the majority of the hips with idiopathic or ethanol-associated osteonecrosis had normal or nearly normal bone in the acetabulum and the proximal part of the femur. In contrast, three of the seven hips with steroid-associated osteonecrosis had abnormal bone in the proximal part of the femur only.

Discussion

Adequate fixation of a femoral component depends on the establishment of an initial mechanical interlock with the adjacent bone of the femoral canal³. In a histologic study, Calder et al.⁵ found that patients with osteonecrosis of the femoral head involving proximal femoral zones 1, 2, 6, and 7 of Gruen et al.¹⁰ had evidence of extensive osteocyte death. Ten of the sixteen patients in their series had a diagnosis of sickle-cell disease or steroid-induced osteonecrosis. They proposed that osteonecrosis in these regions may reduce the remodeling capacity of bone at the implant-bone or implant-cement interface and thus impair osseointegration and adequate long-term fixation of the prosthesis. Pa-

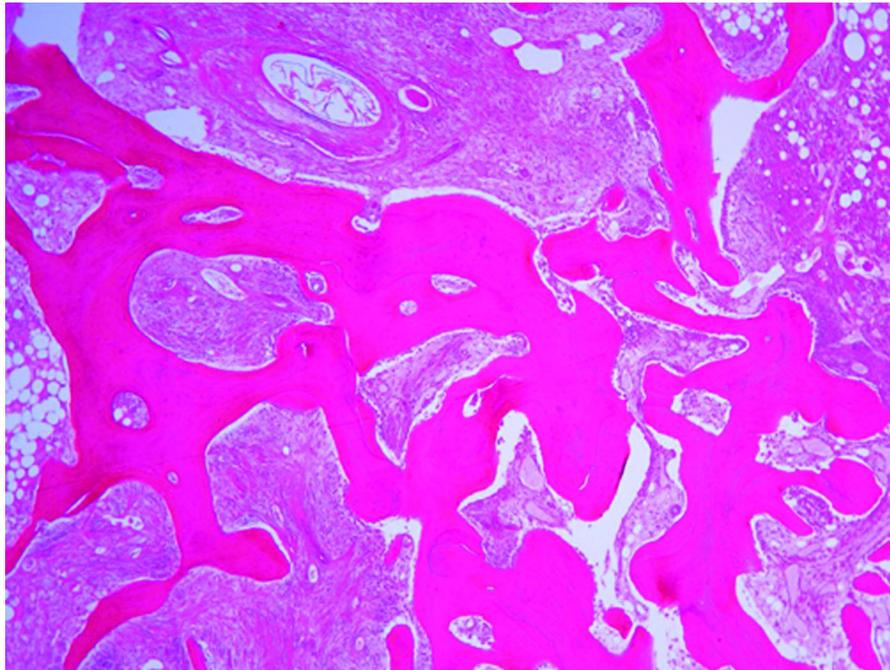


Fig. 2

Histologic appearance of a decalcified specimen of the femoral medullary canal obtained 4 cm distal to the lesser trochanter from a patient with osteonecrosis of the femoral head associated with steroid use. The grade was 3 (empty osteocyte lacunae found in more than six of ten high-powered fields) according to the method of Humphreys et al.⁹ (Mayer hematoxylin and eosin, $\times 200$.)

TABLE IV Scores for Bone Necrosis as Determined with the Method of Humphreys et al.⁹ and Calder et al.^{5*}

Grade	Acetabulum	Femoral Head	Base of Femoral Neck	Greater Trochanter	Lesser Trochanter	Medullary Canal
0	62 (70%)	0 (0%)	60 (68%)	61 (69%)	53 (60%)	50 (57%)
1	19 (22%)	1 (1%)	26 (30%)	25 (28%)	32 (36%)	36 (41%)
2	6 (7%)	2 (2%)	0 (0%)	1 (1%)	2 (2%)	1 (1%)
3	1 (1%)	85 (97%)	2 (2%)	1 (1%)	1 (1%)	1 (1%)

*The values are given as the number of hips, with the percentage in parentheses.

tients with osteonecrosis of the femoral head secondary to sickle-cell disease or steroid use have been found to have poor results of total hip arthroplasty when compared with age-matched controls¹¹⁻¹⁴.

In our series of sixty-three patients (eighty-eight hips), the majority of whom had idiopathic osteonecrosis or osteonecrosis secondary to ethanol abuse, we found normal or nearly normal bone in zone I of the acetabulum and in areas of the proximal part of the femur that are crucial for fixation of the implant. Importantly, none of our patients had sickle-cell disease and very few had steroid-associated osteonecrosis in our series. Absence of these subgroups could account for our findings that osteonecrosis was predominantly confined to the femoral heads.

The results of total hip arthroplasty are poor for patients with sickle-cell anemia and steroid-induced osteonecrosis^{5,11-14}. Since none of our patients had sickle-cell anemia and only five had steroid-associated osteonecrosis (two of whom had abnormal bone), future studies are necessary to examine the results of bone biopsies in patients with these diagnoses. In our

limited series, patients with idiopathic or ethanol-associated osteonecrosis seemed to have normal bone in key areas for prosthetic fixation.

To our knowledge, our observation that osteonecrosis is confined to the femoral head in certain patients with osteonecrosis has not been documented previously. ■

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