

# CHARACTERIZATION AND PATHOLOGICAL CHARACTERISTICS OF SPONTANEOUS OSTEONECROSIS OF THE KNEE

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## ABSTRACT

**Objective:** Spontaneous osteonecrosis of the knee affects patients typically over the age of fifty-five years. Evidence exists that this process may not be true necrosis. The purpose of this study was to characterize the demographic, radiographic, and pathologic features of this condition.

**Materials and Methods:** Twenty-one patients (twenty-two knees) consecutively treated for spontaneous osteonecrosis of the knee were studied.

**Results:** Only one of twenty-two specimens demonstrated evidence of bone necrosis. No specimens showed fat necrosis, marrow necrosis, fibrous change or appositional bone repair. Fourteen of twenty-two specimens (64%) showed significant osteopenia and fifteen of twenty-two specimens (68%) showed evidence of osteoarthritis.

**Conclusions:** This study demonstrated that spontaneous osteonecrosis of the knee is not an osteonecrotic condition and has been misnamed. Osteopenia and osteoarthritis may play a role in the pathogenesis of this disease.

## INTRODUCTION

Spontaneous osteonecrosis of the knee (SPONK) is a condition that leads to knee pain in patients who are typically over 55 years of age. It usually affects one condyle of the knee and often leads to arthritic changes. Originally, it was proposed that this condition is caused by bone death or osteonecrosis.<sup>1,12</sup> However, patients have

a different history, clinical course, and bony involvement than those with true osteonecrosis. True osteonecrosis typically occurs in younger patients (often less than 40 years), affects multiple joints and condyles, and is associated with risk factors such as corticosteroids and alcohol abuse.<sup>12</sup> SPONK most typically affects the medial condyle of the knee, is unilateral, and occurs in older patients with no osteonecrosis risk factors.<sup>6</sup>

The histopathology of SPONK lesions was initially thought to show signs of cell death.<sup>3</sup> Recent work has shown that the cause of SPONK may be subchondral or stress fractures in osteopenic bone.<sup>15</sup> SPONK may then be a misnomer and not true osteonecrosis.

The purpose of this study was to characterize the various demographic and radiographic aspects of SPONK. Another primary purpose was to qualitatively and quantitatively assess the histopathology associated with this disease.

## MATERIALS AND METHODS

### Selection of Subjects

Patients with SPONK were selected from a database of one hundred and sixty patients (285 knees) who underwent surgical intervention for a preoperative diagnosis of osteonecrosis of the knee. Institutional Review Board approval was obtained for this study. Patients diagnosed with spontaneous osteonecrosis of the knee were then identified based on clinical history and imaging data. Subjects over the age of fifty-five years with unilateral disease that primarily affected the medial femoral condyle, had no other joint involvement, and no history of risk factors for osteonecrosis were included in the study group (sixteen patients, sixteen knees). Five more patients with clinical variants of SPONK were later added to the study group; two patients were under fifty-five years of age, two patients exhibited lateral femoral condylar disease only, and one patient had bilateral knee disease. Before inclusion in the study group, each diagnosis of SPONK was confirmed by an examination of plain radiographs and magnetic resonance images. The final study group included twenty-one patients and twenty-two knees. The mean age for the group of spontaneous osteonecrosis patients was sixty-seven years (range, forty-two to eighty-one years) and sixty-two percent were women (thirteen of twenty-one patients).

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### **Clinical Evaluation**

Patient hospital records were analyzed to obtain demographic data including age at time of presentation, gender, race, height, weight, corticosteroids, tobacco and alcohol use, comorbid diseases, symptom onset and duration, laterality of disease, and involvement of other joints. Alcohol and tobacco use were assessed qualitatively based on patient responses to a questionnaire. Corticosteroid use was assessed quantitatively. The total dosage was calculated by obtaining the duration of corticosteroid use, the average daily dose, and the maximum daily dose.

### **Radiographic Evaluation**

Plain radiographic films, bone scans, and magnetic resonance images were reviewed for all patients. Anterior-posterior and lateral plain radiographs were used to assess lesion stage. Although a unique staging system for spontaneous osteonecrosis of the knee was proposed by Aglietti and associates in 1982, a modified version of Ficat and Arlet's criteria for osteonecrosis of the hip was chosen for this study (Table 1).<sup>7-10</sup> According to this system, Stage I lesions have normal plain radiographs but can be identified by characteristic changes on magnetic resonance imaging and bone scintimetry. Stage II lesions demonstrate sclerotic or cystic change on plain radiographs, identified by radiodensities in the distal femur or proximal tibia. Stage III lesions exhibit subchondral collapse, as evidenced by the characteristic "crescent sign" on plain radiographs. Stage IV lesions reveal articular collapse, joint space narrowing, degeneration on both sides of the joint, and possible osteophyte formation. Stage IV disease is often indistinguishable from osteoarthritis on plain radiographs. When available, staging was conducted on two separate sets of radiographs, one obtained at the time of clinical presentation and the other obtained at the final visit before surgery.

### **Histological Examination**

Hematoxylin and eosin-stained paraffin sections of the total knee arthroplasty (n = 13) and core decompression (n = 9) specimens were obtained and evaluated microscopically by one of us (EFM) in a masked manner. The location of the lesions for examination was carefully performed on macroscopic specimens obtained after total knee arthroplasty. Core decompressions included biopsies that samples the area of involvement based on x-rays and magnetic resonance imaging evaluation.

The bone and marrow for each specimen were evaluated in the following systematic manner: initially, the bone was analyzed qualitatively for osteoporosis, evidenced by thinning and depletion of trabeculae. The

bone itself was then analyzed for evidence of death, revealed by a generalized loss of lacunar osteocytes. Bone that demonstrated viable repair surrounding a dead core was tabulated as dead bone. By comparing the amount of dead trabeculae and the total amount of bone specimen, an actual percentage of dead bone was determined and recorded for each sample. Trabecular bone was also examined for evidence of microfracturing on a qualitative basis only.

The amount of appositional bone repair was determined by examining dead trabeculae surrounded by viable bone. This type of repair exhibits a dark seam of osteoid between the dead bony core and the surrounding viable bone. The percentage of dead bone that exhibited evidence of a reparative process was recorded.

Marrow was examined for fat necrosis, granulation tissue, fibrous tissue, edema, calcifications, and lipid cysts. Of those areas where marrow necrosis was evident, the tissue was differentiated into fat necrosis, granulation tissue, or fibrous tissue. Fat necrosis was identified by a loss of lipocyte nuclei and cell membrane blurring. Fibrous tissue was identified by the presence of fibroblasts and obvious fibrous organization. The percentage of each of these three tissue types of the total abnormal The presence of edema in the marrow space, as evidenced by an eosinophilic fluid occupying the space between lipocytes, was recorded. The degree of marrow edema was qualitatively assessed on a scale of zero to three, with zero representing no edema and three signifying extensive edema. Calcifications of fat necrosis within the marrow were readily identified by distinct areas of increased staining. Lipid cysts were identified as large, circular, membrane-bound structures in areas of obvious fat necrosis. The presence of these histological entities was recorded qualitatively.

The presence of osteoarthritis was assessed, based on the observation of articular cartilage fraying and reactive bone changes directly beneath the articular surface. Cases of osteoarthritis exhibited subcortical bone thickening, active bone formation with osteoid seams, and some focal areas of necrotic bone. Areas of bone necrosis and active repair secondary to osteoarthritic change were not included in the above categories.

The osteonecrosis pathological stage for each specimen was determined based on the system of Arlet and Durroux for osteonecrosis of the hip.<sup>4</sup> Based on this classification system, Stage I lesions demonstrate a loss of normal hematopoetic marrow elements and evidence of edema only. Stage II lesions display obvious fat necrosis only. Stage III lesions reveal both marrow and bone necrosis. Stage IV lesions display necrosis, as well as marrow fibrosis and appositional repair.

**TABLE 1**

	<u>True Osteonecrosis</u>	<u>SPONK</u>	<u>Mean</u>	<u>Our Study</u>	
Age	< 45 yrs	> 55 yrs	67	20/22	> 55 92%
Gender	M > F alcohol F > M SLE	F > M		13/21	F > M 62%
Unilateral	< 20%	> 95%		21/22	95%
Affected Femoral Condyle(s)	Multiple	One		20/22	
Tibial Involvement	22%	Less common		3/22	
Location of Bone	Diaphysis, metaphysis, and Epiphysis	Epiphysis only		Epiphysis only	
Risk Factor	Alcohol, Steroids, 80%	Rare		1/22	
Other Joint Involvement	90%	Rare		0/22	

**RESULTS**

The mean duration of symptoms prior to surgical procedures was eleven months (range of three to thirty-six months) for the group of spontaneous osteonecrosis patients. None of the spontaneous osteonecrosis patients had other large joints involved with symptomatic disease.

The laterality of disease was equivalent (eleven left knees and eleven right knees). The majority demonstrated lesions primarily in the medial femoral condyle (nineteen of twenty-two knees). Four knees (eighteen percent) showed evidence of disease in the lateral femoral condyle.

None of the spontaneous osteonecrosis patients had corticosteroid exposure greater than 2 grams for the previous ten years before the diagnosis. Three of twenty-one patients reported a history of heavy alcohol use (400 ml of ethanol per week for greater than one year.<sup>12</sup> Comorbid disease in the patients included one patient each with diverticulitis, Parkinson’s disease, prostate cancer, hypothyroidism, polycystic kidney disease, lymphoma, polymyositis, chronic pancreatitis, hepatitis, and inflammatory bowel disease. There were no patients with systemic lupus erythematosus, sickle cell disease, diabetes, or documented coagulation disorders.

Three of twenty-two knees were graded as Stage I, eight (thirty-six percent) as Stage II, four as Stage III, and seven were judged to be Stage IV. One magnetic resonance image could not be located for examination, but a radiographic report was found that documented a visible lesion (Stage II). On magnetic resonance imaging, the presence and location of a low signal intensity

lesion as well as evidence of bone edema, subchondral fracture, and meniscal tearing were documented. Nine knees demonstrated characteristic low signal intensity lesions, and two knees exhibited signs of bone marrow edema in the affected condyle.

Nineteen of twenty-two specimens (eighty-six percent) were classified as normal bone with no evidence of bone marrow edema, marrow necrosis, or bone necrosis. Only two specimens (nine percent) in the group of specimens demonstrated evidence of bone marrow edema. None of the specimens demonstrated necrotic bone with repair. One specimen in the spontaneous osteonecrosis group showed evidence of necrotic bone. No marrow necrosis was observed in any specimens.

Twenty-one of twenty-two knees specimens (ninety-five percent) were categorized as Arlet and Durroux Stage 0. The one specimen that demonstrated necrotic bone was classified as Stage III because there was no repair noted. Fourteen of twenty-two specimens (sixty-four percent) demonstrated qualitative evidence of osteopenia and fifteen of twenty-two specimens (sixty-eight percent) demonstrated osteoarthritic changes. Figure 1 shows these common findings. No evidence of microfractures or subchondral fractures was seen.

**DISCUSSION**

While the clinical picture of spontaneous osteonecrosis of the knee has been well-characterized, the associated histopathology has received less scrutiny. The earliest report of spontaneous osteonecrosis provided only descriptive histologic data.<sup>2</sup> It was from this study

that the term “spontaneous osteonecrosis of the knee” originated. The present quantitative study of histology indicates that this term may not be entirely appropriate for this disease. Contrary to its classification as osteonecrosis, this disease does not seem to be associated with any appreciable amount of bone necrosis. Only one specimen from the twenty-two knees (four percent) demonstrated any evidence of bone death. In the present study, we characterized the clinical and radiographic data from twenty-two knees that were not dissimilar from previous studies. In this study, the greater majority of patients fell into typical categories for SPONK with only a few exceptions (2 patients <55, one with history of alcohol use, one bilateral knee). This has been what we have generally found; patterns that allow easy classification in most cases with occasional patients with one aberrant demographic variable (e.g., age less than 55 years, bilateral disease).

The results of this study further support the theory that SPONK is not caused by bone death but may be caused by osteoporosis and insufficiency fractures. This has been suggested by evaluation of magnetic resonance imaging scans<sup>11,13,14</sup> and by evaluation of histological specimens.<sup>5</sup> For example, Narvaez demonstrated three cases of insufficiency fracture of the medial femoral condyle and one of the medial tibial plateau in knees with SPONK. While our study revealed no histological evidence of fracture lines, osteopenia was evident in sixty-four percent of the specimens. A recent report has suggested that biochemical markers of bone turnover are elevated in SPONK.<sup>5</sup> They found these markers in twenty-two patients with SPONK and compared these to twenty patients with osteoarthritis of the knee. In both diseases, markers were elevated which were indicative of increased bone turnover with deposition of collagen Type I more pronounced in SPONK knees.

Yamamoto and Bullough studied fourteen knees in patients who had operative treatment for SPONK.<sup>5</sup> Their findings were similar to the present study in that osteonecrosis was not found to be the primary event. They only found localized evidence of osteonecrosis as a result of subchondral insufficiency fractures. Our study did not find any insufficiency fractures.

Our study had several limitations. This was a retrospective case series. The evaluation of histological specimens was also subject to sampling error. Assessments of osteopenia and osteoarthritis were not entirely ideal since only qualitative observations were made. However, any attempt to quantitate the degree of osteopenia in the specimens would be difficult because of the high prevalence of osteoarthritic changes. Nevertheless, despite these shortcomings, we can definitely conclude that necrotic bone is rarely, if ever, found in these lesions.

This study demonstrated that SPONK is not an osteonecrotic condition. Further work to more carefully evaluate the pathology of this condition and to determine the role of osteoporosis and insufficiency fracture in its etiology needs to be performed.

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