Spontaneous Osteonecrosis of the Knee

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Abstract

Spontaneous osteonecrosis of the knee is a common cause of knee pain, principally seen in women over 60 years of age. This condition is distinguished from secondary conditions with known causes, such as corticosteroid-induced osteonecrosis. Although originally described and most common in the medial femoral condyle, it can also occur in the tibial plateaus and on the lateral side of the femur. The radionuclide bone scan will show focally increased uptake before the radiographs are abnormal. Magnetic resonance imaging can also be diagnostic, but the findings may be normal early in the course of the disease. The etiology remains unknown, but it is speculated that primary vascular ischemia or microfractures in osteoporotic bone are causative. Many patients have a benign course followed by resolution of symptoms. Therefore, conservative management is indicated initially. If progressive collapse accompanied by severe symptoms occurs, high tibial osteotomy, unicompartmental replacement, and total knee replacement are therapeutic alternatives. Recognition of this entity is important to avoid needless surgical intervention.

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Spontaneous osteonecrosis of the knee involving the medial femoral condyle was first described by Ahlback et al[1] in 1968. The condition can also occur in the lateral femoral condyle and in the tibial and lateral plateaus. It is called spontaneous, idiopathic, or primary osteonecrosis to distinguish it from secondary osteonecrosis, which is associated with corticosteroid therapy. Secondary osteonecrosis is associated with higher incidences of bilateral knee involvement, multiple joint involvement, and involvement of the lateral compartment of the knee than is primary osteonecrosis.

This article will discuss the clinical course, imaging findings, etiology, and treatment of spontaneous osteonecrosis of the knee in both the femoral condyles and the tibial plateaus.

Osteonecrosis of the Femoral Condyles

Clinical Presentation

Osteonecrosis of the knee is three times more common in women than in men, and most patients are more than 60 years old. The usual complaint is the sudden onset of pain on the medial aspect of the knee, which may have been precipitated by a specific activity or minor injury. The pain is frequently worse at night during the acute phase, which may last 6 to 8 weeks after the onset of symptoms. Depending on the size and stage of the lesion, the severe pain of the acute phase may either resolve gradually or become chronic.

Physical examination shows an area of well-localized tenderness over the affected condyle, which is most commonly medial. In one series,[2] the medial condyle was affected in 102 of 109 knees with primary osteonecrosis of the femoral condyle. Mild synovitis accompanied by a small effusion is common. A large effusion is unusual. Ligamentous stability is normal, and the range of motion is only minimally limited by the synovitis and pain.

Imaging Studies

Radionuclide Bone Scanning

The radionuclide bone scan is performed with technetium-99m and must be positive to make the diagnosis of osteonecrosis. Al-Rowaih et al[3] found that the pool phase of a three-phase study did not add useful diagnostic or prognostic information, but persistence of a high-flow phase and static uptake for 6 to 12 months correlated directly with a poor clinical and radiologic outcome. The static-phase image demonstrates a focally intense area of uptake over the affected condyle. It is usually easier to see on the lateral view that the increased uptake is only in the femoral condyle. Increased significant uptake in both

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the tibia and the femur is more indicative of osteoarthritis than osteonecrosis.

Radiography

We have divided the plain-radiographic presentation (Fig. 1) into five sequential stages.[4,5] The process can be arrested at any stage, and only the most severe cases reach stage 5.

In stage 1 the radiograph is normal. In some patients, the symptoms resolve spontaneously, and a radiographic lesion never develops.[6] Diagnosis in this stage depends on the radionuclide bone scan. In stage 2 (Fig. 1, A) there is subtle flattening of the weight-bearing portion of the affected condyle, which may easily be missed.

The typical lesion of osteonecrosis is seen in stage 3 (Fig. 1, B). It consists of a radiolucent area of variable size located in the subchondral bone and bordered proximally and laterally by a sclerotic halo. In stage 3, the extent of involvement is quantified by expressing the width of the lesion on the anteroposterior radiograph as a percentage of the width of the condyle. Lesions that involve more than 50% of the condyle have a poor prognosis and tend to deteriorate progressively.[7] More complicated methods that try to estimate volume of the lesion are no more accurate in describing the extent of the lesion or in predicting prognosis.[2]

In stage 4 (Fig. 1, C), the sclerotic halo thickens, and the subchondral bone begins to collapse. Stage 5 shows the osseous collapse of stage 4 accompanied by secondary degenerative changes in the femoral condyle (i.e., osteophyte formation, joint-space narrowing, and sclerosis). Secondary degenerative changes also occur on the corresponding tibial side of the joint. There is varus or valgus angulation, depending on which condyle is involved.

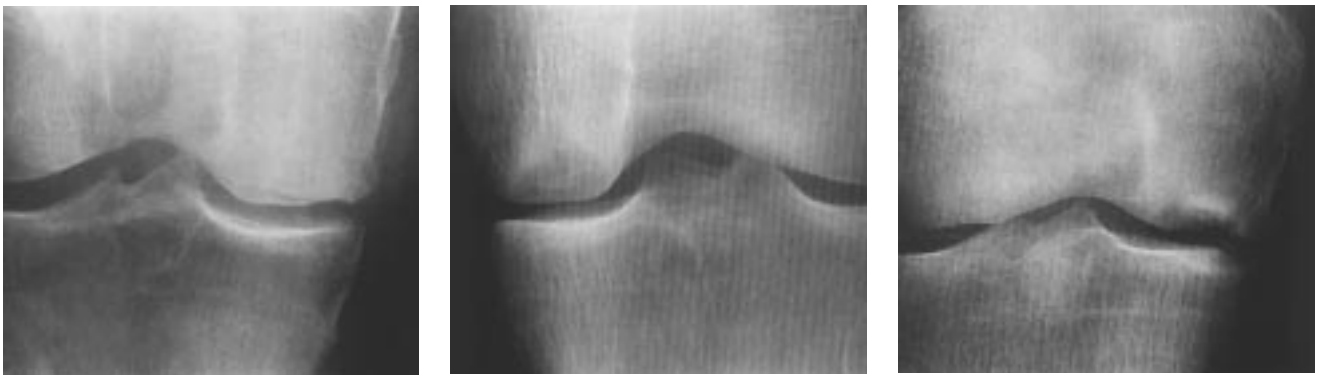
In a series of 40 patients followed up for 1 to 7 years, Al-Rowaih et al[8] found the typical lesion to have been present on the initial radiograph in 19 knees. In 14 of the remaining 21 knees, the typical radiographic lesion later developed at a mean of 28 weeks. Seven knees demonstrated changes only on the radionuclide bone scan, and the symptoms resolved.

Magnetic Resonance Imaging

Magnetic resonance (MR) imaging has shown the involvement of the condyle to be more extensive than can be appreciated on plain radiographs. The high-intensity signal on the T1-weighted image normally produced by the fat in the marrow is replaced by a discrete subchondral area of low signal intensity, sometimes surrounded by an area of intermediate signal intensity (Fig. 2). On the T2-weighted image, an area of low signal intensity is surrounded by a variable high-intensity signal, which is thought to be caused by edema surrounding the lesion.

Interestingly, Pollack et al[9] found that of 10 knees with classic symptoms of spontaneous osteonecrosis and a confirmatory radionuclide bone scan, only 2 appeared normal on MR imaging. They theorized that the initial small lesion might have been missed on the MR study due to the thickness of the section. Alternatively, the positive appearance might have been caused by a condition other than osteonecrosis.

There are other scattered reports in the literature of knees with normal initial MR imaging findings in which typical osteonecrosis eventually developed. For example, Brahme et al[10] reported seven cases in which



A B C

Fig. 1 Plain-radiographic appearance of stages of spontaneous osteonecrosis of the femoral condyle. **A,** Stage 2 lesion with flattening of the medial femoral condyle and subchondral lucency. **B,** Stage 3 lesion with radiolucency surrounded by slight sclerosis. **C,** Stage 4 lesion with collapse of the articular surface.

Fig. 2 T1-weighted MR image shows a large subchondral area of low signal intensity.

knees with no evidence of osteonecrosis on the initial MR images were treated by arthroscopic partial meniscectomy. Repeat MR imaging performed because of persistent or recurrent pain showed an area of low-intensity signal on the T1-weighted image. None of the patients had undergone radionuclide studies prior to the arthroscopy. The authors theorized that the diminished load-bearing capacity due to the injured meniscus might have resulted in microfractures and vascular insufficiency. They did not consider the possibility that the MR study might have been normal early in osteonecrosis or that the meniscal tears seen on the MR images might not have been causative of the presenting symptoms.

This alternative hypothesis is suggested by the findings of Bjorkengren et al[11] in a study of 16 patients with spontaneous osteonecrosis and a positive radionuclide study. Two patients had normal T1-weighted images. The MR imaging study showed buckling of the articular cartilage overlying the lesion in 12 patients and a tear of the medial meniscus in 9. Four of the knees appeared normal on T2-weighted images, which the authors related to a favorable clinical outcome.

Laboratory Studies

There are no specific abnormal laboratory findings related to spontaneous osteonecrosis.

Pathology

The gross appearance of the articular cartilage in the early stages is relatively normal, showing slight flattening and discoloration. With progression, a line of demarcation becomes evident, and a flap of articular cartilage develops, overlying an area of osseous necrosis. As secondary degenerative changes develop, the cartilage defect becomes filled with necrotic debris and fibrocartilage, and the surrounding joint develops the characteristic pathologic changes of osteoarthritis.

Microscopy shows a segment of dead bone in the weight-bearing portion of the femoral condyle associated with subchondral fracture and collapse.[12] The osteonecrotic center has dead bone with empty lacunae and fatty degeneration. The surrounding area shows reparative bone formation, osteoblastic activity, cartilage formation, and bands of fibrovascular granulation tissue.

Al-Rowaih et al [13] found that in five patients to whom technetium-99m was administered just prior to arthroplasty, the area of high uptake in the femur corresponded to the osteonecrotic center in the resected specimen. It might be suspected that earlier in the course of the process the center would have had low uptake surrounded by an area of high uptake.[13] It is possible that spontaneous osteonecrosis may be an unrecognized cause of many cases of severe osteoarthritis. However, since biopsy material is usually obtained only in cases of advanced disease, the original lesion may be obscured by the secondary and reparative changes.

Etiology

The etiology of spontaneous osteonecrosis is unknown, but either a vascular or a traumatic cause has been theorized. The vascular theory supposes interference with the microcirculation to the subchondral bone of unknown cause, producing edema in a nonexpandable compartment. The resultant increased pressure in the bone marrow further diminishes the circulation and results in osseous ischemia and the low signal intensity of the marrow seen on the MR study. If the dead bone collapses, the typical radiographic appearance develops. If revascularization occurs before collapse, the lesion may heal, and the symptoms may resolve.

The traumatic theory takes into account that most patients are elderly women, in whom osteoporosis is common and in whom, therefore, minor trauma might cause microfractures in the weaker subchondral bone. At this stage, the radionuclide study would be positive, but the MR imaging study could still be normal. It is postulated that fluid eventually enters the marrow space, increasing the pressure and causing ischemia. At this point, the MR image shows an area of low signal intensity. The lesion may then progress or resolve.

Unfortunately, there is no histologic evidence to support either of these theories.

Treatment

Spontaneous osteonecrosis should always be considered in the elderly patient with a painful knee that appears normal radiographically, so that inappropriate arthroscopy and meniscectomy can be avoided. This is particularly important because patients in this age group often have degenerative meniscal tears. Therefore, it is worthwhile to perform a radionuclide bone scan even if an MR imaging study was normal.

In stages 1 and 2, the treatment of osteonecrosis should be conservative until the size of the lesion and its progression have been defined,

which may take as long as 6 months. Management consists of analgesics and protected weight-bearing. Anti-inflammatory medications are often prescribed, but there is no evidence of an inflammatory component. Small lesions do well, although mildly symptomatic degenerative changes may slowly develop.

Surgical treatment options for the patient with larger lesions that progress to the more advanced stages of osteonecrosis include arthroscopic debridement, drilling or core decompression (with or without bone grafting), proximal tibial osteotomy, allografting, and prosthetic replacement. It does not appear that arthroscopic debridement alters the natural course of the process; the ultimate prognosis is more dependent on the size of the initial lesion.[14]

Jacobs et al[15] reported their experience with core decompression in 28 knees with avascular necrosis. Only 3 of the 28 knees had spontaneous osteonecrosis, however. The seven knees with Ficat stage I or II disease did well. Eleven of the 21 knees with stage III disease had good results initially, but 3 of the 11 had subsequent clinical deterioration. Interestingly, 50% of the knees had a normal baseline pressure, but 88% had a positive pressure-stress test. It is not clear that core decompression changed the ultimate prognosis. Drilling of the lesion has not been very successful.

Allografts are still experimental. Their use has been limited to the younger patient population; thus, this procedure is not appropriate for the usual older patient with symptoms of osteonecrosis.

For the patient with significant symptoms and a large lesion that has not responded to conservative management, the choices are high tibial osteotomy and prosthetic replacement. High tibial osteotomy is a consideration for younger, more active patients with medial femoral condylar involvement, but the majority of patients with osteonecrosis are not in this group. Osteotomy in the elderly is associated with more morbidity, complications, and failures than replacements are. Koshino[16] reported on 37 knees treated by proximal tibial osteotomy. Concomitant drilling or bone-grafting was performed in 23. The results were generally satisfactory and were best in knees with a varus deformity that had valgus angulation postoperatively. The necrotic lesion disappeared in 13 and improved radiographically in 17. Greater improvement was observed in those with concomitant bone grafting or drilling. After an average follow-up of 61 months, only one patient had subsequently undergone prosthetic replacement.

Prosthetic replacement should be considered for most patients with significant persistent symptoms. The choice between unicompartmental replacement and total knee replacement remains controversial.

Marmor [17] reported 89% good or excellent results in 34 knees treated with a unicompartmental prosthesis. Two of the four failures occurred because of the subsequent development of osteonecrosis of the lateral femoral condyle. Certainly, unicompartmental replacement can be considered for the patient with good bone stock and no degenerative changes in the lateral compartment or patellofemoral joint.

Bergman and Rand[18] achieved good or excellent results in 87% of 38 knees using a variety of total knee replacements. At 5 years, 85% had successful results when revision was used as an end point, but only 68% remained successful when moderate or severe pain was used as the end point.

Ritter et al[19] used Kaplan-Meier survival analysis to compare total knee replacement with use of a posterior-cruciate condylar prosthesis in osteonecrosis of the medial condyle with the same procedure in osteoarthritis. They found that when pain relief at 5 years was used as the end point, the survivorship was 82% for osteonecrosis and 90% for osteoarthritis. Although this was not a statistical difference, they noted that the statistical power, which is dependent on sample size, was not sufficient to illustrate a significant difference.

Osteonecrosis of the Tibial Plateau

Spontaneous osteonecrosis of the medial tibial plateau is less recognized than osteonecrosis of the medial femoral condyle, but it presents in a similar manner. It was first described in 1976 in the French- language literature by D'Anglejan et al and was later described in the English-language literature by Houpt et al.[20] As is the case with spontaneous osteonecrosis of the medial femoral condyle, most affected persons are women aged more than 60 years who have a sudden onset of pain on the medial side of the knee, often related to minor trauma or an increase in activity.

Physical examination reveals a well-localized area of tenderness over the medial aspect of the tibia, usually close to the joint line and on the posterior aspect of the plateau. The findings may be suggestive of a tear of the medial meniscus or bursitis of the pes anserinus. Recognition of this entity is necessary to avoid unnecessary arthroscopy and meniscectomy. Although the condition is more common on the medial side, we have encountered four patients with involvement of the lateral tibial plateau.[21]

Imaging Studies

The imaging findings are similar to those seen in the femoral condyle. The radionuclide bone scan shows a focal area of increased uptake localized within the tibial plateau. The plain radiographs may initially be normal, but in some cases the typical

subchondral lucency surrounded by sclerosis develops (Fig. 3). Later, collapse and secondary degenerative changes may occur. In some cases, the initial radiograph may show the minor preexisting degenerative changes common in elderly patients.

Magnetic resonance imaging may show more extensive involvement than plain radiographs, which may remain normal. The T1-weighted image typically shows areas of low signal intensity in the tibial plateau (Fig. 4). It should be expected that occasionally a patient will have a positive radionuclide scan but no evidence of osteonecrosis on MR imaging early in the course of the disease.

Etiology and Pathology

The etiology is unknown, but the possibilities include an ischemic event or an insufficiency syndrome with microfractures similar to that postulated for the femoral condyle. The pathologic findings in material obtained at arthroplasty are similar to those in femoral osteonecrosis.

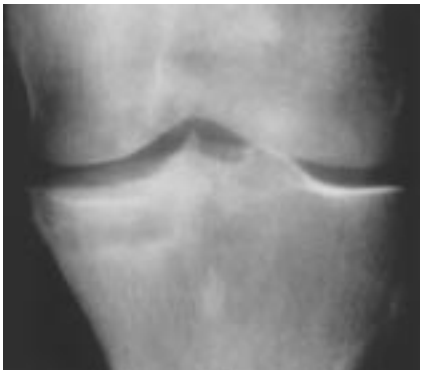


Fig. 3 Plain radiograph of the medial tibial plateau shows a subchondral area of lucency surrounded by sclerosis.

Fig. 4 T1-weighted MR image depicts a subchondral area of low signal intensity in the medial tibial plateau.

Clinical Course

The clinical course is proportional to the radiographic progression. In our series[21] of 36 patients whose initial radiographs were normal or showed minimal degenerative changes, only 3 developed a collapsing lesion. Two of the 3 required arthroplasty. The remaining 33 patients gradually became asymptomatic in 9 to 12 months, and the bone scan became inactive in 27 months. In our unpublished series of 16 knees in which plain- radiographic changes of osteonecrosis developed in the medial tibial plateau, only 2 stabilized and became asymptomatic. Eight were treated with total knee replacement, and 4 underwent unicompartmental replacement.

Treatment

Recognition of the syndrome is, of course, fundamental to appropriate treatment. Even when MR imaging shows a degenerative meniscal tear and no marrow changes, a radionuclide bone scan should be considered before proceeding with arthroscopic intervention. Without a specific lesion on the radiograph, conservative management consisting of nonsteroidal anti- inflammatory drugs and protected weight-bearing for a prolonged period will usually be successful.

If the radiologic lesion develops and symptoms persist, surgical intervention should be considered. We are unaware of any reports of the use of core decompression or arthroscopic debridement, but we doubt that those procedures would be efficacious. Tibial osteotomy might be considered, but in this age group we prefer prosthetic replacement. The choice of unicompartmental replacement or total knee replacement depends on the status of the rest of the joint and the surgeon's preference.

Summary

Spontaneous osteonecrosis can occur in both femoral condyles and both tibial plateaus. The typical patient is an elderly woman who experiences the sudden onset of pain on the medial aspect of the knee. Although the radiographs may initially be normal, the radionuclide bone scan shows a focal area of increased uptake on one side of the joint. The MR imaging study usually shows decreased signal intensity on the T1-weighted image but may be normal early in the course of the disease. The radiographic appearance may remain normal, or the typical finding of subchondral lucency surrounded by sclerosis may be depicted. Progression of symptoms is proportional to the size of the lesion. With progressive collapse and severe symptoms, prosthetic replacement produces the most predictable results.

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