

Osteonecrosis of the Knee After Anterior Cruciate Ligament Reconstruction

A Report of 5 Cases

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Background: Anterior cruciate ligament (ACL) reconstruction is performed commonly, with a low risk of complication. Osteonecrosis of the knee is a potentially devastating condition and has been observed both spontaneously and after meniscectomy, although osteonecrosis has not been described as a complication after ACL reconstruction.

Purpose: To describe the development of osteonecrosis of the knee in 5 patients after arthroscopic ACL reconstruction.

Study Design: Case series; Level of evidence, 4.

Methods: This study involved 5 patients (mean age, 33.2 years) who developed osteonecrosis of the knee after ACL reconstruction. A retrospective chart review was performed to identify clinical characteristics and surgical factors present in each of the 5 cases.

Results: In 4 cases, the pathologic changes were present in both the medial and lateral femoral condyles, with isolated lateral condyle changes in the other case. The mean time to diagnosis was 11.6 months. These patients underwent an average of 1.8 additional surgical procedures after the diagnosis of osteonecrosis.

Conclusion: Osteonecrosis of the knee is a rare outcome after ACL reconstruction. We are unable to identify clear risk factors for the development of this complication, although we hope the presentation of these cases will help promote the identification of other cases in future studies.

Keywords: anterior cruciate ligament reconstruction; postoperative complications; osteonecrosis of the knee; knee arthroscopy

Osteonecrosis is a complex disease with incompletely defined causes, and the knee is the second most common location for this disease.¹³ Vascular insufficiency, metabolic changes, and subchondral insufficiency fractures have been implicated in the disease process and play a role in the pathophysiology.^{11,24} Osteonecrosis of the knee can be classified as either primary or secondary, with primary osteonecrosis encountered after treatment for a degenerative meniscal tear or without a known origin and secondary osteonecrosis occurring due to risk factors such as alcohol

or corticosteroid use.^{11,16,18} Ahlback et al¹ first described primary osteonecrosis, or spontaneous osteonecrosis of the knee, which is a condition often seen in elderly women.

Anterior cruciate ligament (ACL) reconstruction has evolved over time into a reliable procedure with low rates of complication. The morbidity of the procedure has been limited and benefited by advances in arthroscopic techniques. Common complications of ACL reconstruction include infection, arthrofibrosis, graft failure, hardware failure, venous thromboembolism, and cartilage injuries.^{5,6,14,20,23} While osteonecrosis after meniscectomy has been documented in the literature, isolated osteonecrosis of the lateral femoral condyle has previously been associated with ACL reconstruction in only 2 prior case reports.^{2,17}

As a tertiary referral center, we were referred 5 patients who developed osteonecrosis of the knee after ACL reconstruction. The purpose of this report was to describe the development of osteonecrosis of the knee after ACL reconstruction and to provide information regarding the demographics, clinical course, and outcome of this group. We hope that these details will prompt other clinicians to

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TABLE 1
Demographics for Patients With Osteonecrosis After ACL Reconstruction^a

Patient No.	Age, y	Sex	Race/Ethnicity	Primary or Revision	Graft Type	Tibial Fixation	Femoral Fixation	Sagittal ACL Graft Angle, deg	Additional Initial Procedures
1	30	Male	White	Revision	BTB allograft	Absorbable	Absorbable	66	None
2	23	Male	Hispanic	Primary	BTB autograft	Metallic	Metallic	60	None
3	40	Female	White	Primary	Soft tissue allograft	Absorbable	Suspensory	64	Meniscal debridement
4	46	Female	White	Primary	Soft tissue allograft	Absorbable	Absorbable	58	Partial medial meniscectomy
5	27	Female	White	Primary	Soft tissue allograft	Absorbable	Suspensory	62	Lateral meniscal repair

^aACL, anterior cruciate ligament; BTB, bone-tendon-bone.

recognize this entity early in its course and to provide other descriptions of similar cases to better delineate the cause of this devastating complication.

METHODS

This study was approved by our institutional review board. A retrospective chart review was conducted for 5 patients with a known history of osteonecrosis of the knee after ACL reconstruction. Inclusion criteria included a previous primary or revision ACL reconstruction with postoperative magnetic resonance imaging (MRI) of the knee that confirmed the diagnosis of osteonecrosis according to the early signs described by Lecouvet et al,⁸ including subchondral areas of low signal intensity on T2-weighted images and contour deformities. All imaging studies were reviewed, and data regarding the patients' clinical course were collected. The sagittal graft angle was measured on sagittal proton density-weighted MRIs according to previous descriptions.⁴

All patients were referred to our tertiary academic sports medicine practice for evaluation due to an atypical postoperative course after ACL reconstruction. As all the index procedures were not performed at our institution, limited information was available regarding the initial injury and preoperative treatment. Postoperative treatments and outcomes after ACL reconstructions were obtained from the referring physician and patient's description.

RESULTS

We have encountered 5 patients with osteonecrosis after single-bundle ACL reconstruction. Demographic information for these cases is summarized in Table 1. The mean age of this group of patients was 33.2 years (range, 23-46 years). Imaging from the time of the initial diagnosis of the ACL injury and prior to ACL reconstruction was available and reviewed for 2 patients, and these scans showed no evidence of osteonecrosis of the knee. The remaining patients also underwent MRI preoperatively and were not reported to have any osteonecrosis prior to surgery. Four patients had no known medical comorbidities prior to their ACL injury, and 1 patient had a history of acute myelogenous leukemia for which she received corticosteroids as part of her treatment and who was in remission for approximately

TABLE 2
Clinical Course After ACL Reconstruction^a

Patient No.	Time to Symptoms	Location Involved	Total Additional Operative Procedures	Time to Return to OR, mo
1	<1 wk	MFC, LFC, patella	1	9
2	6 mo	MFC, LFC	4	15
3	1 wk	MFC, LFC	1	8
4	21 mo	MFC, LFC	1	48
5	2 d	LFC	2	10

^aLFC, lateral femoral condyle; MFC, medial femoral condyle; OR, operating room.

20 years prior to her ACL reconstruction. No patient had a history of chronic corticosteroid use or alcohol abuse. The mean sagittal ACL graft angle was 62°.

All patients reported an abnormal postoperative course (Table 2), although the time course for the development of symptoms was variable. Four patients (patients 1, 2, 3, and 5) reported pain and swelling in the acute postoperative period (<6 months) that was deemed abnormal by the treating surgeon compared with routine recovery after ACL reconstruction. Only 1 patient (patient 4) developed pain and swelling more than 1 year after ACL reconstruction. Two patients (patients 1 and 5) required inpatient admission because of uncontrollable pain. Knee aspiration was performed in 2 patients with a large effusion (patients 1 and 3). Patient 1 was presumptively diagnosed with a postoperative infection and treated empirically with a 6-week course of intravenous vancomycin. However, no cultures were positive from the knee aspiration. A manipulation under anesthesia (2 months postoperatively) and intra-articular cortisone injection (6 months postoperatively) were attempted for patient 3 because of persistent limitations in range of motion.

The median time to diagnosis of osteonecrosis was 11.6 months (range, 6-30 months), and MRI images (Figures 1 and 2) were acquired in all cases to make this diagnosis. The medial and lateral femoral condyles were involved in 4 patients, and 1 patient had osteonecrosis isolated to the lateral femoral condyle. The patella was affected in 1

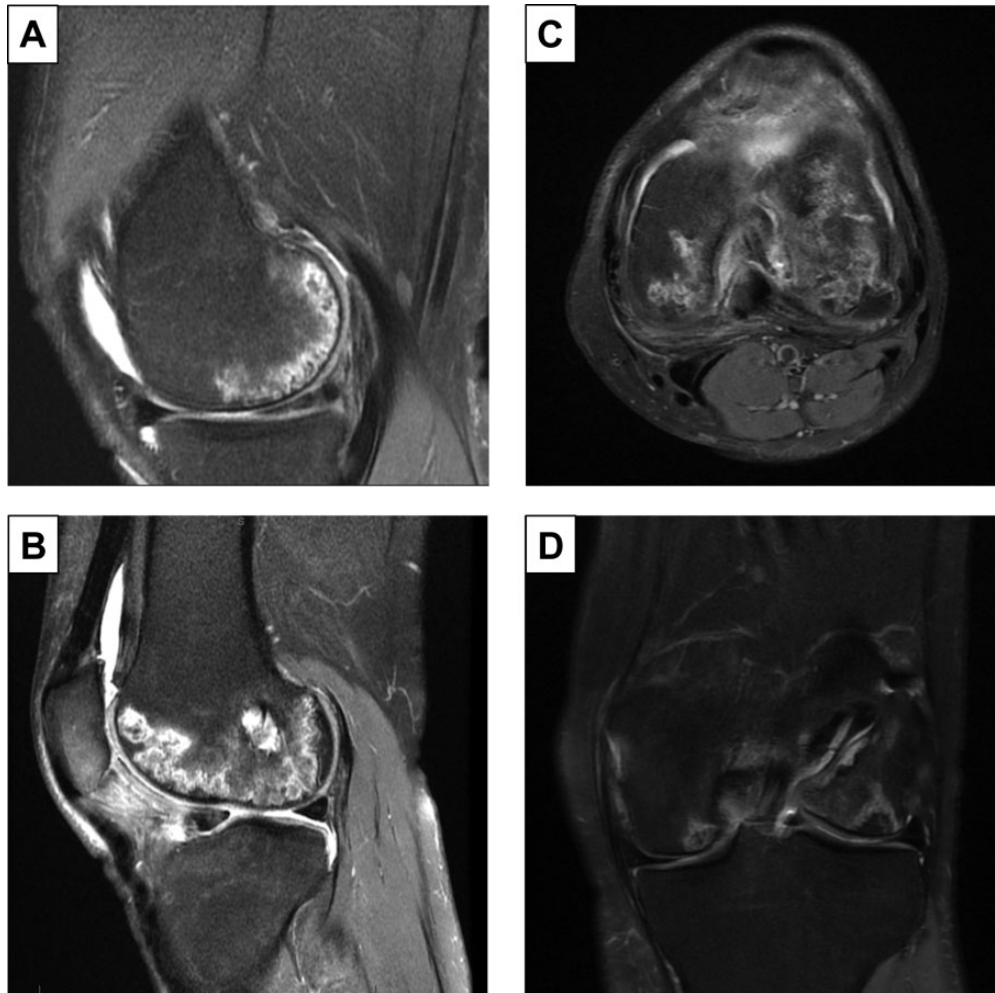


Figure 1. Fat-saturated, T2-weighted magnetic resonance images of the knee of patient 3: (A) sagittal image of the medial femoral condyle, (B) sagittal image of the lateral femoral condyle, (C) axial image of both femoral condyles and patella, and (D) coronal image of both femoral condyles and femoral tunnel.

patient. There was no evidence of osteonecrosis of the proximal tibia in any patient.

After the diagnosis of osteonecrosis, additional surgical procedures were performed for 4 of 5 patients. The mean time for return to the operating room was 18 months (range, 8-48 months), and the mean number of additional procedures was 1.8 (range, 1-4). The operative knee showed extensive damage in 4 patients, with cartilage injury and multiple intra-articular loose bodies. Representative images from follow-up arthroscopy are shown in Figure 3. A core decompression with iliac crest bone grafting was attempted for 1 patient, and an arthroscopic debridement was performed in the other cases. The ACL graft was removed in 2 patients. Tissue cultures were obtained for 2 patients, though bacterial, fungal, and acid-fast bacterial cultures showed no growth. One removed ACL graft was examined histologically, but there were no abnormalities. One patient underwent a total knee arthroplasty 4 years after ACL reconstruction.

DISCUSSION

Osteonecrosis is a rare but devastating outcome after ACL reconstruction. The etiology of osteonecrosis in general remains unclear, though it is likely the end result of insult to the vascular supply of the subchondral bone.¹⁵ Proposed pathophysiologic mechanisms for osteonecrosis after meniscectomy include microfractures of the subchondral bone, mechanical or loading changes in the knee, cartilage damage resulting in subchondral edema from the arthroscopy fluid, or iatrogenic surgical causes, including aggressive cautery usage.^{11,12,21,24} This series does not provide enough information to determine a cause of these pathologic findings, though there are several characteristics of this group of patients that are important to note in the context of prior reports of osteonecrosis after knee arthroscopy.

The mean patient age in this series of cases after ACL reconstruction is only 33.2 years and quite young relative to other reports of osteonecrosis after knee arthroscopy. Pape et al¹² provided a comprehensive review of previously

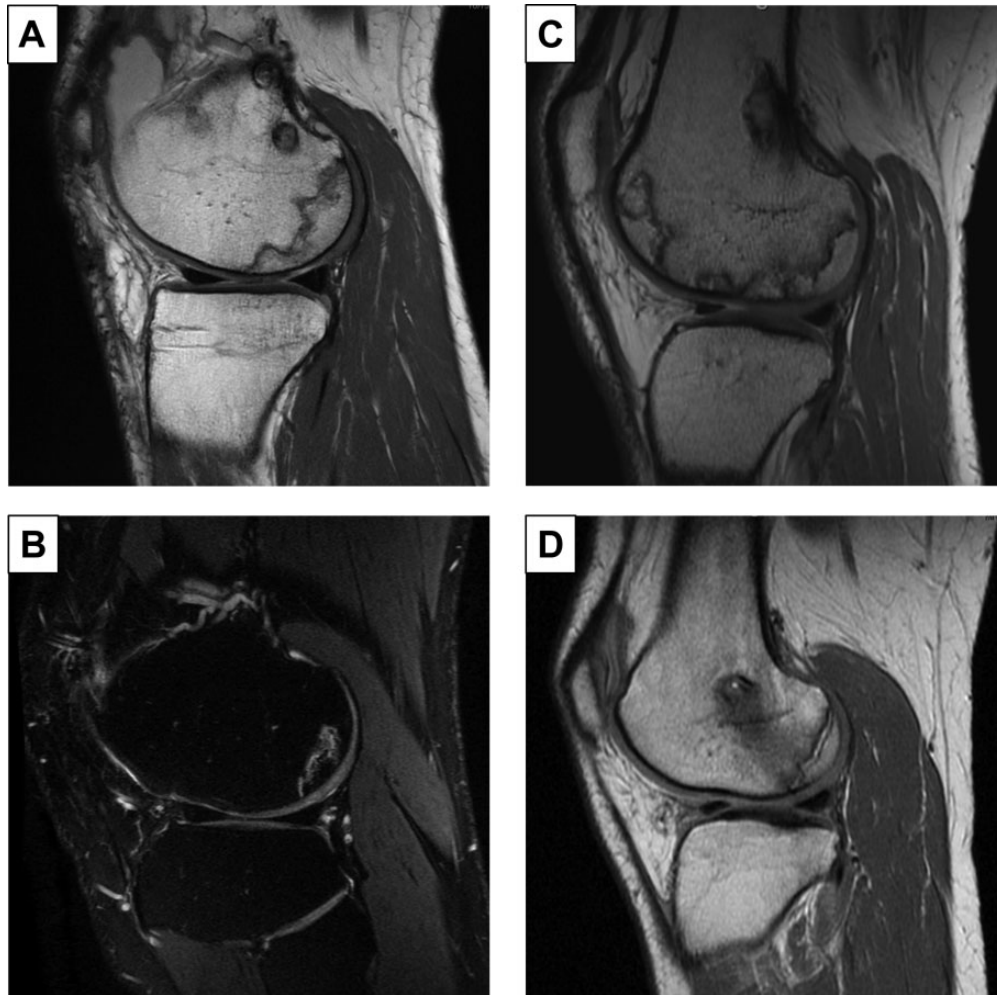


Figure 2. Magnetic resonance images demonstrating osteonecrosis of the lateral compartment of the knee for (A) proton density image of patient 1; (B) fat-saturated, T2-weighted fast spin echo image of patient 2; (C) proton density image of patient 4; and (D) proton density image of patient 5.

reported series of osteonecrosis in the postoperative knee. The mean age of patients in this review of 47 cases was 58 years.¹² Spontaneous osteonecrosis of the knee, first described by Ahlback et al,¹ is encountered primarily in patients over the age of 50 years. Narvaez et al¹¹ reported on distinguishing factors for patients with idiopathic or secondary osteonecrosis of the knee, with mean ages of 66 years and 49 years, respectively.

Treatment options for osteonecrosis of the knee remain limited. Core decompression has been shown to be efficacious, with failure rates of 8.2% to 27.5%.⁹ Cartilage restoration procedures, such as autologous chondrocyte implantation or osteochondral grafting, have been effective in small case series.^{9,22} Treatment with bisphosphonates and high-dose vitamin D supplementation produced excellent results in a series of 5 patients described by Breer et al.³ Arthroplasty or realignment procedures remain the final options for treatment of end-stage osteonecrosis, and 1 patient in our series progressed to a total knee arthroplasty 4 years after ACL reconstruction. This time frame

to knee arthroplasty is similar to what was observed in a series of patients with a mean age of 68 years who developed spontaneous osteonecrosis.⁷

The majority of our patients developed pathologic changes in both the medial and lateral femoral condyles, which is unusual when compared with prior reports of osteonecrosis of the knee. Two prior case reports of osteonecrosis after ACL reconstruction described isolated changes in the lateral femoral condyle.^{2,17} Shenoy et al¹⁷ described a patient with an abnormal pattern of bone marrow edema who developed osteonecrosis in this same location 2 years later. Athanasian et al² reported on 2 patients with osteonecrosis: 1 after posterior cruciate ligament reconstruction and the other after ACL reconstruction. The patient with osteonecrosis after an ACL reconstruction had isolated changes in the lateral compartment that were present 25 months after the index procedure.² For osteonecrosis in the postoperative knee, changes are noted primarily in the medial femoral condyle.¹² In reviewing reports of osteonecrosis after meniscectomy, the development of

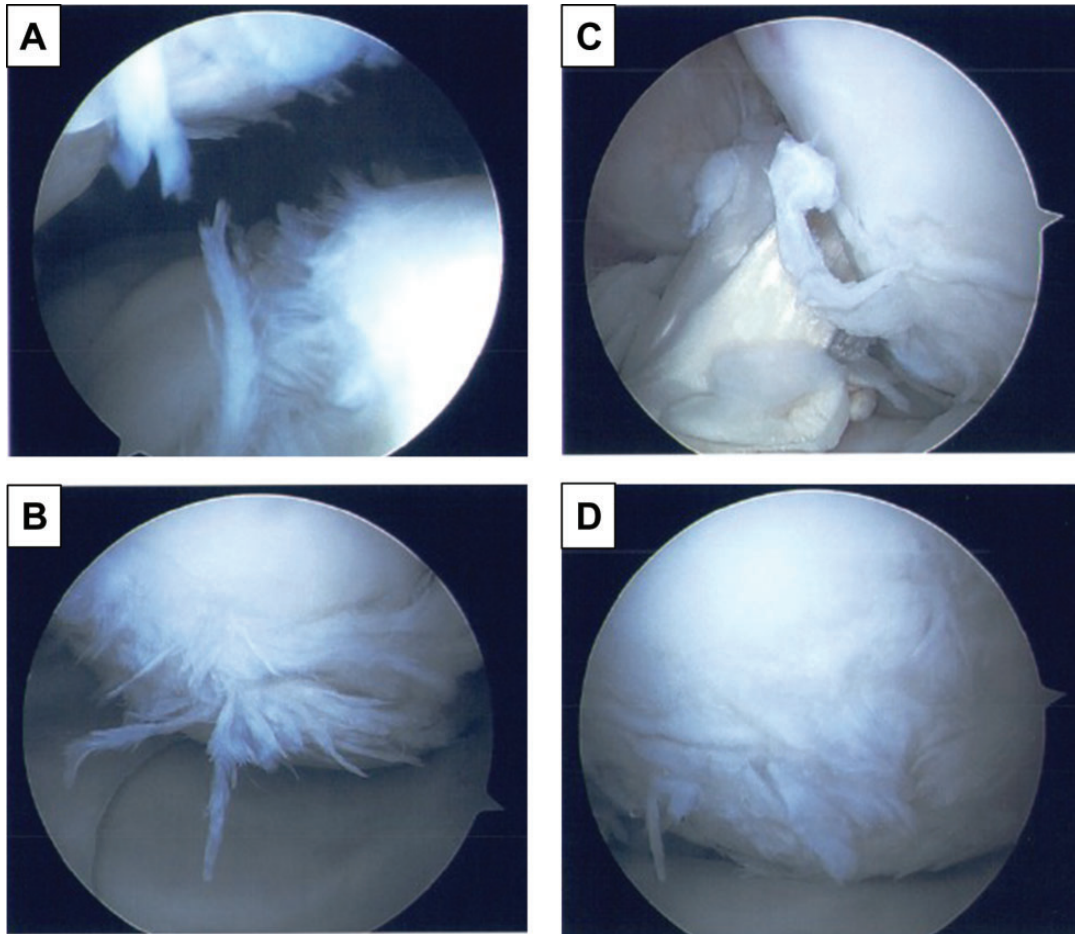


Figure 3. Arthroscopic images for patient 3 after the development of osteonecrosis with images of the (A) patellofemoral joint, (B) medial compartment, (C) anterior cruciate ligament and lateral femoral condyle, and (D) lateral compartment.

osteonecrosis only occurred in the compartment of preoperative pathology.¹² Spontaneous osteonecrosis of the knee is similarly described, affecting the medial femoral condyle almost exclusively.¹ The bicondylar pattern observed in most patients in this series is more commonly seen in individuals with risk factors for osteonecrosis, such as corticosteroid usage, alcoholism, or connective tissue disorders.¹⁰ Narvaez et al¹¹ found multifocal involvement in 88.2% of knees with secondary osteonecrosis compared with the involvement of a single femoral condyle or tibial plateau in 95.8% of cases with primary osteonecrosis. Global osteonecrosis was present in 4 of the 5 patients described in this series, which is more extensive than what has previously been described.

The postoperative course included persistent swelling and pain beyond that expected after an ACL reconstruction, but other more commonly described complications of ACL reconstruction were pursued, including infection and arthrofibrosis. The clinical course was similar to the symptoms in patients with infections after ACL reconstruction as described by Judd et al⁶ and Wang et al.²³ These studies demonstrated elevated inflammatory markers and synovial white blood cell counts in the acute postoperative period for

infected patients relative to controls. These markers may be useful also in differentiating infection from the development of osteonecrosis, though these data were not available for the patients in our series.

Four patients in this series developed abnormal symptoms in the postoperative knee early in the postoperative period, though the time to diagnosis of osteonecrosis was 11.6 months. The modified classification system of Soucacos et al¹⁹ describes 4 stages of osteonecrosis in the postoperative knee with a timeframe of progression over 1 year. Early changes may be reversible, while later, more severe changes are more likely to be permanent. Non-operative measures such as nonweightbearing, immobilization, or analgesics may provide benefit if initiated soon after the onset of osteonecrosis.

This series must be interpreted with knowledge of its limitations. We have identified a small group of patients, and all data were collected and reviewed retrospectively. There is insufficient information to allow for an estimate of the prevalence of this condition, and we lack extensive knowledge of the affected knees prior to the index ACL reconstruction. Causality or a clear risk factor for the development of osteonecrosis unfortunately cannot be

determined. However, we do want to point out this devastating complication, and hopefully, more clinical cases can be reported so that we can identify causes of this uncommon but severe complication of a common procedure.

CONCLUSION

We believe that this series of patients with osteonecrosis after ACL reconstruction should raise awareness of the possibility of this adverse outcome. There is nothing to suggest that this outcome was preventable in any case, though osteonecrosis should be considered for patients with abnormal pain or swelling after ACL reconstruction. The report of this series should prompt other investigators to note the presence of osteonecrosis after ACL reconstruction so that estimates of prevalence, risk factors, treatments, and outcomes may be better defined.

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