Chondrolysis of the Tibial Plateau Caused by Articular Aspergillosis After ACL Autograft Reconstruction: Management with a Fresh Osteochondral Allograft

A Case Report

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Arthroscopically assisted reconstruction of the anterior cruciate ligament (ACL) is a common and effective method for treatment of anterior knee instability following ACL injury. Annually, an estimated 250,000 ACL injuries are diagnosed and approximately 100,000 ACL reconstructions are performed in the United States[1-3]. Chondrolysis is an extremely rare but devastating complication following ACL reconstruction. It is characterized by complete destruction of the articular cartilage and a profound inflammatory response consisting of pain, swelling, and loss of joint motion. The differential diagnosis includes osteonecrosis, direct trauma related to the injury or to the surgical procedure, infection, an adverse reaction to pharmacological agents (including local anesthetic infusions), and unknown causes.

Infection after arthroscopic ACL reconstruction is rare: its incidence has been reported as 0.14% to 1.7%[2,4-7]. The most common causative organisms are *Staphylococcus aureus, Staphylococcus epidermidis,* and *Staphylococcus haemolyticus*[2,4-6]. When tissue allografts have been used for ACL reconstruction, other organisms such as Peptostreptococcus, Klebsiella, Enterobacter, and Clostridium species as well as gram-negative bacilli have been implicated[6,8]. Although infrequent, infection can be a devastating complication that leads to septic arthritis, chondrolysis, osteomyelitis, osteochondral destruction, and, in rare cases, death[2,5,8,9].

We describe a case of medial tibial plateau osteochondral destruction secondary to an *Aspergillus flavus* fungal infection in an immunocompetent thirteen-year-old girl who had undergone elective ACL reconstruction. The patient and her parents were informed that data concerning the case would be submitted for publication, and they provided their consent.

To the best of our knowledge, a case of Aspergillus fungal arthritis following ACL reconstruction has not been previously reported. Furthermore, salvage options outlined in the literature have been limited to primary arthrodesis, prosthetic reconstruction, use of allograft-prosthesis composites, and use of nonarticular allograft void fillers[9-11]. We describe a salvage technique in which the medial tibial plateau, the associated articular cartilage, and the medial meniscus were successfully replaced with a fresh osteochondral/meniscus allograft.

Case Report

A thirteen-year-old otherwise healthy female athlete sustained an acute ACL injury while playing soccer. Approximately three months after the injury, she underwent arthroscopically assisted ACL reconstruction with use of a quadruple hamstring autograft at a local outpatient surgery center. Radiographs made prior to the reconstruction revealed closure of the distal femoral and proximal tibial physes, and physeal sparing techniques were not employed for the reconstruction. The graft was fixed on the femoral side with use of the EndoButton (Smith & Nephew, Andover, Massachusetts) and distally with a large-fragment cortical screw and soft-tissue washer (Synthes, Paoli, Pennsylvania). The procedure was reported to be uneventful, and routine evaluation of the articular anatomy revealed healthy cartilage throughout the knee.

Postoperatively, the patient did not receive any type of local anesthetic-infusion device or pain pump. Although the immediate postoperative course was reported to be routine, the patient continued to have substantial medial-sided knee pain over the next two months. Rehabilitation was slow, and knee motion remained limited despite active physical therapy. On

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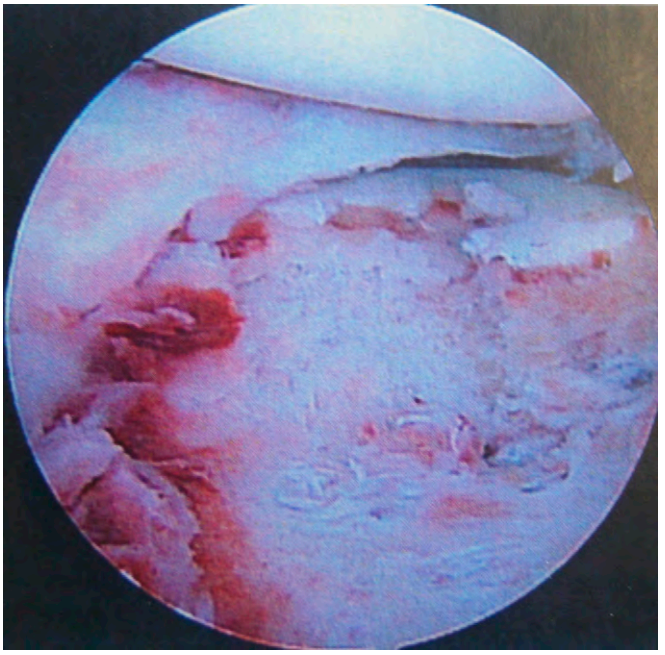

Fig. 1

Arthroscopic photograph three months after ACL reconstruction, demonstrating chondrolysis of the medial tibial plateau with exposed cancellous bone and severe damage to the posterior horn of the medial meniscus.

follow-up examination, the surgical incisions were seen to be healing well and there were no local or systemic signs of infection. Because of the persistent pain and poor knee motion, which was attributed to arthrofibrosis, a second-look arthroscopy was performed at the same surgery center three months after the initial reconstruction. During this procedure, substantial destruction of the medial tibial articular cartilage with associated damage to the medial meniscus was noted (Fig. 1). The remaining areas of the knee, including the lateral compartment and the patellofemoral compartment, were normal. No intraoperative culture specimens were obtained at that time. The underlying cause of the chondrolysis was undetermined, and the patient was referred to our institution for additional treatment.

In our clinic, the patient continued to complain of medial-sided joint pain. The incisions were well healed. Knee motion was 10° to 105°. All ligaments, including the ACL, were clinically intact. There was a small joint effusion but no substantial joint-line tenderness or erythema. Review of the arthroscopic and magnetic resonance images (MRI) confirmed degeneration of the medial proximal tibial articular cartilage with meniscal injury as well as bone edema in the medial tibial plateau (Fig. 2). The patient had remained afebrile without constitutional symptoms. The peripheral white blood-cell count was 6200/mm^3. The differential diagnosis at that point included osteonecrosis of the tibial plateau, delayed degeneration of the articular cartilage due to the initial injury or surgery, and idiopathic chondrolysis. Infection was not considered strongly as part of the initial differential diagnosis. The initial impression was that the findings most likely represented a vascular insult to the medial tibial plateau in an aseptic environment. A fresh osteochondral hemi-tibial plateau/meniscus allograft was obtained

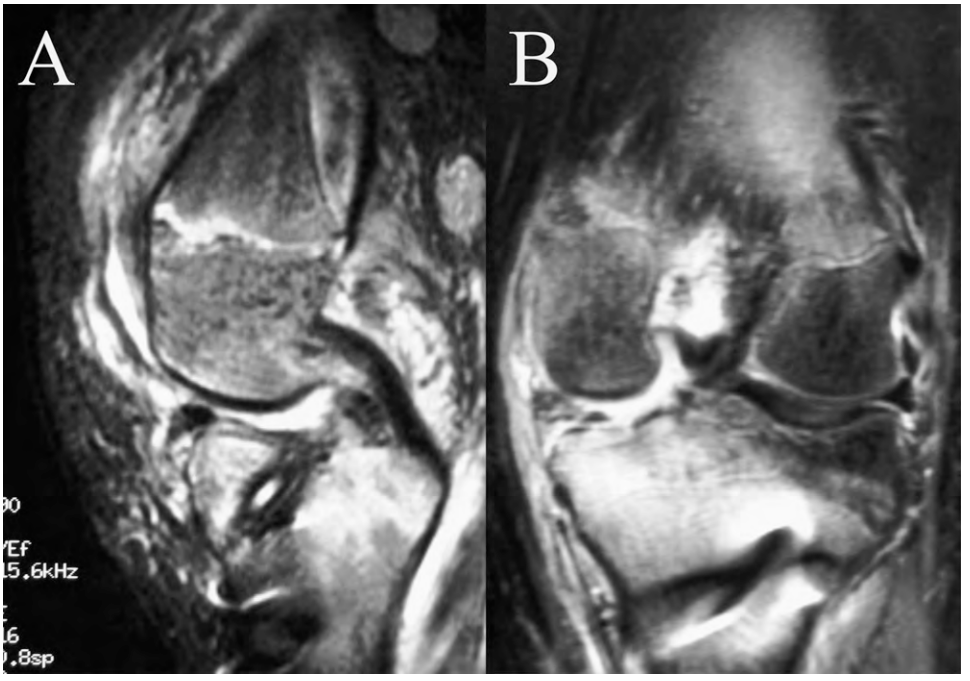

Fig. 2

Sagittal (**Fig. 2-A**) and coronal (**Fig. 2-B**) T2-weighted MRIs images obtained approximately two months after the ACL reconstruction. There is substantial degeneration of the medial tibial articular cartilage with associated subchondral osteonecrosis.

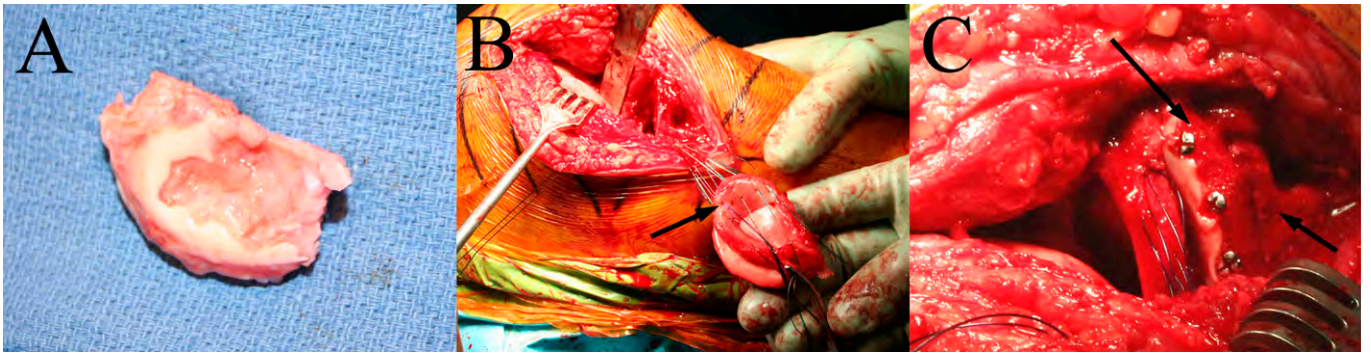

Fig. 3

Figs. 3-A, 3-B, and 3-C Intraoperative photographs. **Fig. 3-A** Resected medial tibial specimen with nearly complete degeneration of the articular cartilage. **Fig. 3-B** Preparation of the osteochondral allograft with sutures in place through the posterior horn (arrow) of the medial meniscus. **Fig. 3-C** Final position of the osteochondral allograft (long arrow) with anterior and anteromedial 3.0-mm cancellous screws in place. The short arrow indicates the adjacent tibia.

to be used in an effort to restore the articular cartilage surface and medial meniscus.

A limited medial parapatellar approach revealed complete delamination of the medial tibial articular cartilage (Fig. 3-A) and degeneration of the medial meniscus. The autograft used in the ACL reconstruction appeared relatively intact, although it was degenerated within the tibial canal. The ACL autograft was removed to accommodate the hemi-tibial plateau allograft and was sent for culture and histological examination. The cortical screw and washer were removed from the proximal part of the tibia. Specimens were obtained from the joint and tibial tunnel for routine culture. No purulence was noted. At this point, the recipient site for the osteochondral allograft was prepared with use of unicompartmental knee-replacement cutting guides. The remaining native medial meniscus was resected. The fresh osteochondral allograft consisting of metaphyseal bone, articular cartilage, and the allograft meniscus was sutured to the knee capsule with standard suturing techniques (Fig. 3-B). The graft was secured anteriorly and anteromedially with use of four cancellous 3.0-mm cannulated screws (Synthes) (Fig. 3-C).

Postoperatively, within a four-day period, *Aspergillus flavus* grew in one of two cultures of specimens from the tibial canal (Fig. 4-A). To help interpret the importance of the positive culture, the direct-tissue Gram stain was restained for fungi (Calcofluor White stain), and rare fungal hyphae were identified (Fig. 4-B). On the basis of the rapid fungal growth in the culture and the findings of the Gram stain, this was considered to be a true fungal infection rather than specimen contamination. The pediatric infectious disease consultant recommended a combination therapy of intravenous (IV) voriconazole, 250 mg every twelve hours, and IV caspofungin, 100 mg every twenty-four hours, for two weeks, followed by twelve months of oral voriconazole, 200 mg twice a day. In addition, the patient returned to the operating room for irrigation and debridement of the wound as well as of the tibial canal. The tibial tunnel was thoroughly

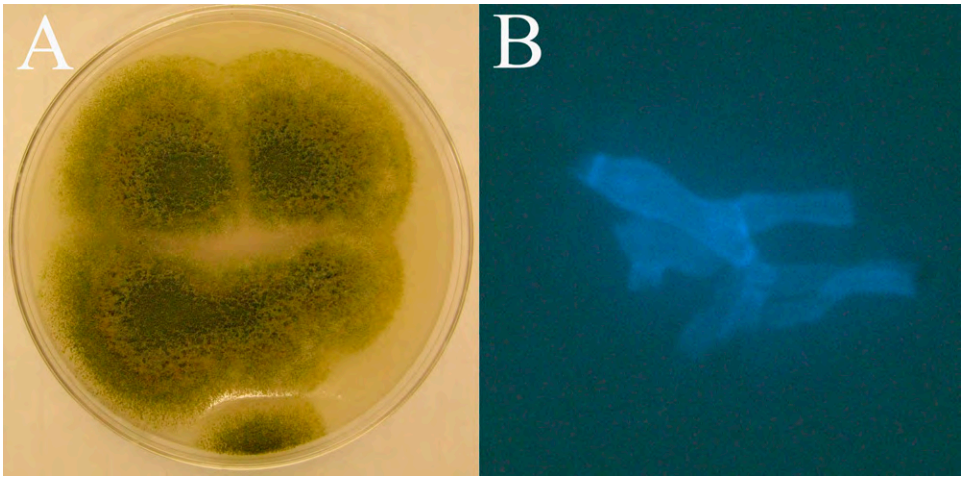

Fig. 4

Fig. 4-A Fungal culture of a specimen from the tibia demonstrating growth of *Aspergillus flavus* on potato dextrose agar. **Fig. 4-B** High-magnification photomicrograph of the tibial canal tissue showing narrow, septate hyphae with acute-angle branching consistent with immunofluorescent staining demonstrating the branching hyphae of *Aspergillus flavus* (Calcofluor White, 100×).

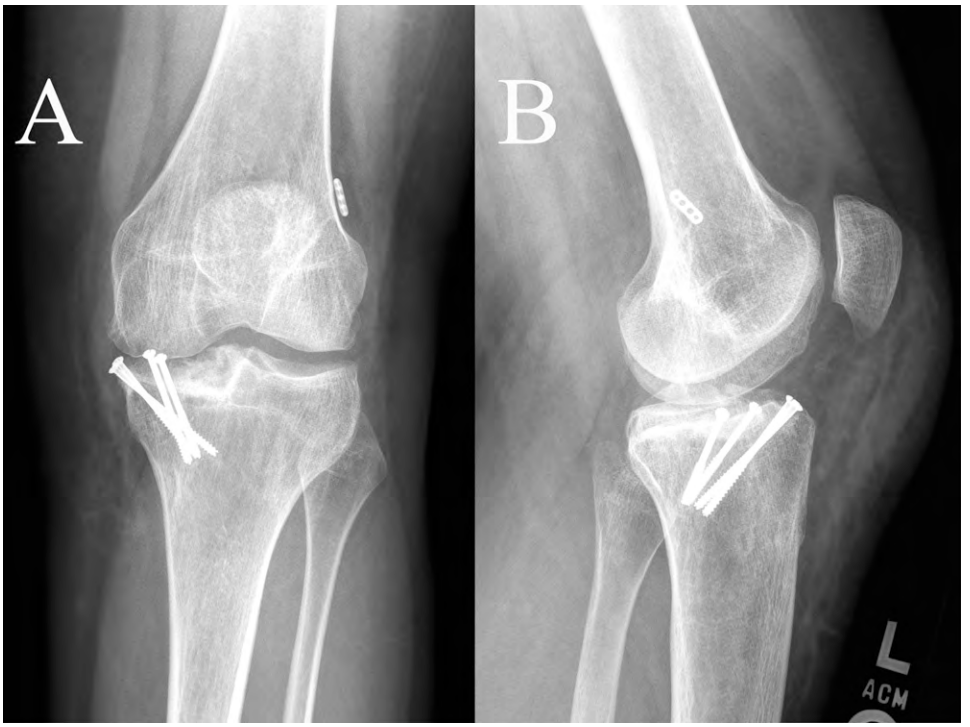

Fig. 5

Twenty-eight-month postoperative anteroposterior (**Fig. 5-A**) and lateral (**Fig. 5-B**) radiographs of the right knee.

debrided, and a voriconazole-impregnated calcium-sulfate paste was introduced into the tunnel[12]. Two additional cultures of specimens from the second procedure were positive for *Aspergillus flavus*. Additionally, histological examination of the tibial tissue revealed polymorphonuclear neutrophils (PMNs) adjacent to bone fragments as well as a lake of PMNs between trabeculae. The postoperative rehabilitation protocol consisted of non-weight-bearing for twelve weeks. A hinged knee brace was placed and was locked in full extension for the first two weeks, followed by six weeks in which the knee brace was locked between 0° and 90°. Subsequently, and up to the three-month mark, the brace was unlocked with no restriction on flexion. During physical therapy, passive flexion was limited to 90° for the first six weeks.

At the twenty-eight-month follow-up visit, the patient demonstrated excellent, pain-free knee motion from full extension to 140° of flexion. She had been off all antifungal medications for over a year. She had returned to playing softball and was able to run without pain. Despite the ACL deficiency, examination showed a negative Lachman test, a negative pivot-shift test, a negative posterior-drawer test, and no joint-line opening with varus or valgus stress. Radiographs revealed osseous integration of the allograft with no evidence of osteolysis, periosteal reaction, or osteoarthritis (Fig. 5). The patient had no symptomatic knee instability but had not returned to cutting or pivoting sports. Her parents reported that she now ran slower than preoperatively. We counseled the patient and her family that she was at increased risk of developing osteoarthritis in the future. If the knee does develop instability, a revision ACL reconstruction could be considered, even with the medial tibial osteochondral allograft.

Discussion

Reconstruction of the ACL is a common and generally successful procedure, with over 100,000 cases performed annually in the United States[13]. Although relatively rare, chondrolysis following ACL reconstruction can be a devastating complication. The differential diagnosis for chondrolysis includes osteonecrosis, infection, and direct trauma, as well as chondrocyte destruction from local anesthetic infusions.

Infection rates following ACL reconstruction vary considerably throughout the orthopaedic literature. In 2002, Indelli et al.[2] reported an infection rate of 0.14% following 3500 ACL reconstructions. In 2003, a similar review of 575 cases by Schollin-Borg et al.[7] revealed a rate of 1.7%. The sequelae of intra-articular infection can be quite variable. Early diagnosis and prompt treatment of infections involving antibiotic-sensitive organisms can be successful, even with retention of the ACL graft[2,4-6,14,15]. The primary goal of treatment should be preservation of articular cartilage and graft retention whenever possible[5,14,16]. Although eradication of infection is possible, long-term sequelae, including limited postoperative activity levels, have been reported[7].

Infections following ACL reconstruction usually are caused by bacteria and only rarely by fungi. A review of the literature revealed eight reported cases of fungal infection following ACL reconstruction[10,17,18]. In each reported case, the

fungal infection led to devastating osteomyelitis with substantial bone loss. Compared with pyogenic bacterial infections, fungal infections produced fewer tissue reactions and often had a more indolent course, leading to substantial osseous destruction over time[10,11,17,19]. To the best of our knowledge, Burke and Zych[10] described the first case of fungal infection following ACL reconstruction, in a thirty-four-year-old otherwise healthy woman who had undergone ACL reconstruction with a bone-patellar tendon-bone autograft. Shortly after surgery, the patient fell in the shower and sustained a partial wound dehiscence that ultimately led to a large cavitary abscess within the proximal part of the tibia, which was treated with debridement of an extensive area of tibial osteomyelitis with associated osseous and articular cartilage necrosis. Histological analysis of the tissue identified fungal structures consistent with a phycomycosis of the fungal order Mucorales. Treatment consisted of extensive metaphyseal debridement and excision of the medial articular cartilage. The infection healed with a substantial bone void, which led to genu varum and painful knee motion of only 5° to 30°.

Muscolo et al.[11] recently reported six cases of fungal infection following ACL reconstruction, performed with autograft hamstring tendons (five cases) or bone-patellar tendon-bone autograft (one case). There was substantial bone loss in each case. In five cases, cultures were positive for Rhizopus species; in one case, cultures were positive for *Candida albicans*. All six patients were immunocompetent. The mean bone loss reported was 12.8 cm, with a range from 9.5 to 19.0 cm. Radical debridement was performed in all six cases. In two patients, both the femoral and the tibial articular surfaces were preserved, and reconstruction was performed with use of fragmented bone allograft (to fill the metaphyseal void) and a hemicylindrical intercalary structural cortical allograft. In the four remaining cases, only one articular surface, either the tibial or the femoral, could be preserved. One patient underwent arthrodesis secondary to articular destruction and loss of the extensor mechanism. The remaining three patients were treated with staged allograft-prosthesis composites.

In our case, much like the cases presented by Musculo et al.[11], the knee had substantial osteochondral destruction as a result of the fungal infection. To our knowledge, this is the first reported case of *Aspergillus flavus* osteomyelitis following ACL reconstruction. Aspergillus species are ubiquitous molds that produce abundant conidia that are 2 to 4 μm in diameter. The small size of these fungal spores facilitates their dispersion in air currents and the subsequent deposition into wounds[20,21]. Despite the prevalence of these spores, Aspergillus species remain an uncommon cause of osteomyelitis and most often lead to infections in immunocompromised patients[21-27]. In a review of the surgical literature by Pasqualotto and Denning[21], 500 cases of postoperative aspergillosis were identified; forty-two of these were orthopaedic surgery cases. Of these forty-two cases, twenty-seven occurred following arthroplasty procedures; Aspergillus was also cultivated from the air in the operating room[20,21].

In their review of the treatment of aspergillosis, Walsh et al.[28] stated that antifungal therapy should be initiated early for patients with suspected invasive aspergillosis. Voriconazole or combination therapies that include voriconazole are considered the contemporary treatment of choice for these infections[28]. The optimal duration of antifungal treatment for aspergillosis bone infections has not been identified. In a worldwide review of twenty cases of invasive bone aspergillosis treated with voriconazole therapy, Mouas et al.[29] reported that patients who had a satisfactory response to treatment had received voriconazole therapy for a median duration of 180 days, compared with just fourteen days of therapy for those with poor responses.

Although relatively rare, fungal infection due to operative or postoperative contamination should be considered when more common causes of pain or joint destruction following ACL reconstruction are excluded. In such cases, a high index of suspicion is necessary to ensure appropriate specimen collection since the definitive diagnosis of fungal osteomyelitis requires successful culture of the organism or histological identification from tissue samples. It should be noted that positive bacterial cultures do not exclude the possibility of coexisting fungal infection. Once identified, fungal infections should be treated with aggressive surgical debridement and appropriate antifungal therapy. Definitive treatment may require multiple debridements and, in some cases, amputation may be necessary to control proliferation[30]. Reconstructive options are limited for patients with substantial loss of articular cartilage and metaphyseal bone following infection. Fresh osteochondral allografts have a long history of clinical use for treatment of chondral and osteochondral defects and localized osteoarthritis. An allograft acts as a foreign body in the early time period after implantation although the cancellous bone can theoretically remodel and revascularize. As such, there is a definite risk of secondary colonization and infection. In our case, the allograft was placed prior to the diagnosis of a fungal infection. Once the diagnosis had been made, we entertained two options: remove the allograft and place an antibiotic-impregnated cement spacer, or perform a surgical debridement and prescribe a long-term course of antifungal treatment. The first would have undoubtedly led to degeneration of the apposing femoral surface and, most probably, the entire knee. Because of the patient's young age, our recommendation was to attempt to salvage the allograft with aggressive debridement and antifungal medical management. In addition to the previously described salvage options, including prosthetic implantation, use of an allograft-prosthesis composite, and primary arthrodesis, surgeons faced with this reconstructive challenge may also consider reconstruction with a fresh osteochondral allograft in conjunction with appropriate medical management. ■

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