Anterior Cruciate Ligament Reconstruction Failure After Tibial Shaft Malunion

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abstract

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Anterior cruciate ligament (ACL) reconstruction is common, with >100,000 procedures performed each year in the United States. Several factors are associated with failure, including poor surgical technique, graft incorporation failure, overly aggressive rehabilitation, and trauma. Tibial shaft fracture is also common and frequently requires operative intervention. Failure to reestablish the anatomic alignment of the tibia may cause abnormal forces across adjacent joints, which can cause degenerative joint disease or attritional failure of the surrounding soft tissues.

This article describes a case of ACL reconstruction failure after a tibial fracture that resulted in malunion. Excessive force across the graft from lower-extremity malalignment and improper tunnel placement likely contributed to the attritional failure of the graft. This patient required a staged procedure for corrective tibial osteotomy followed by revision ACL reconstruction. This article describes ACL reconstruction failure, tibial shaft malunions, their respective treatments, the technical details of each procedure, and the technical aspects that must be considered when these procedures are done in a staged manner by 2 surgeons.

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A nterior cruciate ligament (ACL) reconstruction is common, with >100,000 procedures performed each year in the United States. When performed for the proper indications and with correct technique, ACL reconstruction has a 75% to 90% rate of good to excellent results. However, with the increasing number of procedures performed, an increasing number of ACL reconstruction failures occur that necessitate revision. The goal of revision surgery is similar to that of primary reconstruction: to eliminate symptomatic instability and minimize damage to the articular cartilage and menisci from episodes of instability.

When considering revision surgery, surgeons must determine the cause of failure of the primary reconstruction to assure that the problem is not repeated. When failure occurs early (first 6 months), it usually results from poor surgical technique, graft incorporation failure, or overly aggressive rehabilitation. Technical error is the most common cause of failure, and malposition of the bone tunnels is the most common surgical error. Failure after 1 year is usually the result of repetitive trauma or a single major reinjury.

Tibial shaft fractures are also common, occurring in 1 of 2000 people annually. Obtaining an acceptable alignment at healing by operative or nonoperative treatment is critical to minimize gait abnormalities and potential problems with adjacent joints. Angular malunion after tibial fractures is associated with a significant increase in ankle arthritis. Others have shown that ankle malalignment after tibial malunion causes poor clinical results. A varus malunion, particularly those close to the knee joint, may cause a varus thrust of the knee on initiation of weight bearing at heel strike. A varus thrust increases the contact stresses in the medial tibiofemoral compartment and causes opening of the lateral tibiofemoral compartment, increasing the tension on the lateral soft tissues of the knee. Attenuation of the lateral ligamentous structures may cause increased load across the ACL, with eventual ACL rupture in a varus knee. Thus, it is essential to evaluate the overall alignment of the extremity and the integrity of other soft tissue structures about the knee prior to ACL reconstruction.

This article describes a 2-staged reconstruction to treat knee instability after a tibial malunion and ACL reconstruction failure.

**Case Report**

A 35-year-old former college soccer player and coach presented with knee pain and instability. He had sustained a closed segmental tibia/fibula fracture 10 years previously that was managed nonoperatively and resulted in a malunion. He returned to playing soccer and sustained an ACL rupture, which was reconstructed using a bone–patellar tendon–bone autograft. He continued to coach soccer but began to experience instability and was unable to compete for several years.

On examination, he had slight anterior and valgus bowing of the lower leg with full knee range of motion (ROM). He had laxity with Lachman’s and anterior drawer testing but was stable to varus and valgus stress and posterior drawer testing. His pelvis was level while standing, and leg-length measurements showed that the involved leg was 4 mm longer than the contralateral leg.

Radiographs revealed a malunion of the midshaft tibia, with 15° of apex anterior angulation and valgus alignment with bayonet apposition of the fibula (Figure 1). The femoral tunnel appeared to be in a vertical position, and the tibial tunnel showed widening.

Due to the coexistent knee instability and tibial malunion, we treated the patient with a 2-stage reconstruction: corrective tibial osteotomy followed by revision ACL reconstruction.

First, he underwent a partial closing-wedge osteotomy of the tibia centered at the apex of the deformity (Figure 2). A bi-level fibula osteotomy was performed, and the tibia was reduced and stabilized with a reamed intramedullary nail (Figure 3). The tibial interference screw from his ACL reconstruction was removed at osteotomy, and the defect was grafted using bone removed from the closing wedge osteotomy. The proximal portion of the tibial nail was positioned approximately 3 cm distal to the level of the tibial plateau to preserve adequate room for a future tibial tunnel during ACL revision. The metaphyseal defect from nail insertion was also bone grafted.

The patient began bearing weight 5 weeks postoperatively. Radiographs revealed bridging bone at the tibial osteotomy 3 months postoperatively and healing by 7 months postoperatively (Figure 4). Despite adequate correction of the tibial deformity, he remained symptomatic, and revision ACL reconstruction was performed.

At revision ACL surgery, unstable medial and lateral meniscal tears, 2 loose
bodies, and chondral damage on the femoral trochlea, patella, and medial femoral condyle were observed and appropriately addressed. The tibial tunnel required placement in a slightly more medial position and at a slightly less oblique angle due to the position of the intramedullary nail. The previous femoral tunnel was in a nonanatomic vertical position in the notch and did not interfere with the new femoral tunnel placement. An Achilles tendon allograft was chosen for the ACL graft and was oriented with the bone plug in the femoral tunnel. This was secured with a metal interference screw in the femur and a bioabsorbable screw in the tibia after proper tensioning.

The patient began a standard rehabilitation program for ACL reconstruction. At 1 year postoperatively, his tibia and proximal fibula osteotomy were healed. The distal fibula osteotomy was incompletely healed but remained asymptomatic. He had not played soccer competitively in several years but was able to return to running on a hard surface with mild knee soreness during high-impact activity. This was markedly improved from his preoperative diffuse, unrelenting pain. He reported no instability and exhibited no laxity on Lachman’s test at final follow-up.

**DISCUSSION**

This article describes ACL reconstruction failure in a patient with significant tibial malunion. It is likely that abnormal forces across the knee contributed to this ACL reconstruction failure. Although little, if any, published literature exists regarding ACL insufficiency with posttraumatic tibial deformity, many articles regarding ACL insufficiency with nontraumatic genu varum have been published. Harner et al² reported that a varus knee or a lateral thrust during the stance phase of gait may cause ACL reconstruction failure due to chronic repetitive graft stretching. This is consistent with cadaveric studies, which show that an axial load applied through a varus knee resulted in significantly higher tension in the ACL than when applied through a normal knee.³

Although our case had a valgus alignment of the lower extremity rather than a varus alignment, the valgus knee was still subjected to abnormal forces due to the deformity. Chronic repetitive stressing of the ACL graft may cause late failure from attenuation.⁴ Therefore, revision ACL reconstruction seemed unlikely to have long-term success without correction of the tibial malalignment.

Osteotomies about the knee prior to ligamentous reconstruction have been well described. High tibial osteotomy and ACL reconstruction have been used in combination to successfully treat ACL-deficient knees with varus alignment.¹¹⁻¹³ Noyes et al¹¹ reported that high tibial osteotomy and delayed ACL reconstruction gave a 71% reduction in pain and 85% elimination of giving way in patients treated for ACL-deficient knees with varus alignment.

In some patients, correction of the malalignment with high tibial osteotomy may be sufficient to correct ACL instability symptoms.¹⁴ High tibial osteotomy can be used to decrease the posterior tibial slope to address the instability. Decreasing the tibial slope decreases the posterior vector of force of the distal femur with weight bearing and thus may be favorable after ACL reconstruction.¹⁰ The importance of the tibial slope must be considered when osteotomies are planned prior to ACL reconstruction, and care must be taken to avoid an increase in the tibial slope. The mechanical axis of the lower extremity
should be corrected prior to ACL reconstruction to prevent attenuation of the graft from increased stresses.

Wu et al\(^1\) reported a 100% union rate after a closing-wedge osteotomy of the tibia stabilized with a reamed intramedullary nail and fibulotomy, a 6% rate of deep infection, and a 3% rate of cortical perforation. Tibial osteotomy may be insufficient to allow significant angular correction of the leg. Therefore, fibula osteotomy is often performed. Preoperative calculation revealed that correction of the tibial malalignment would lengthen the fibula and potentially stretch the peroneal nerve >16 mm. Therefore, a 2-level fibula osteotomy was performed to distribute the stretch on the peroneal nerve between 2 locations and to avoid a bony prominence at the level of the fibula osteotomy.

Assessing the tunnel position is critical in revision ACL surgery. The ideal location of the femoral tunnel is at the 10 o’clock or 2 o’clock position on the femur for the right and left knee, respectively.\(^3\) Femoral tunnels placed too anteriorly result in excessive tension in the graft with knee flexion, which eventually causes attenuation of the graft and failure.\(^4\) A tunnel that is placed too vertically may result in impingement during extension and eventual failure. The tunnel malposition and the abnormal forces experienced by the graft due to tibial malunion are likely to have contributed to the ACL graft failure.

If the tunnels are in good position at revision ACL surgery, then the same tunnel may be reused during revision surgery. Widening of the bone tunnels may occur after ACL reconstruction failures. Although the cause of tunnel widening is not completely understood, assessment is critical because widening may compromise fixation of the graft at revision. A staged procedure with bone grafting is recommended to fill tunnels >15 mm wide.\(^2\)

In our patient, the position and quality of the bone tunnels was addressed during the tibial osteotomy. The interference screw in the tibia was removed at osteotomy, and its defect was filled with bone graft.

The functional results of revision ACL reconstruction are nearly equivalent to those of primary reconstruction, with good to excellent results obtained in 70% of patients.\(^4\) Ferretti et al\(^1\) reported laxity of 0 to 5 mm using the KT1000 arthrometer (MEDmetric, San Diego, California) in 26 of 28 patients who underwent revision ACL reconstruction with doubled semitendinosus and gracilis tendon in conjunction with a lateral extra-articular reconstruction. Despite this, patient satisfaction after revision reconstruction is inferior to patient satisfaction after primary reconstruction.\(^1\)

The degree of articular surface damage found at ACL revision correlated with decreased patient satisfaction after revision ACL surgery.

Mechanical alignment is an important factor in the success of ACL reconstruction. The repetitive stress on the ACL graft caused by the malunion deformity likely contributed to attenuation of the graft and eventual failure. Malalignment correction was performed with a partial closing wedge osteotomy of the tibia and bisevel osteotomies of the fibula.

Staged ACL reconstruction was performed 7 months after the osteotomy. Detailed planning of such a staged reconstruction is necessary to optimize results, especially when 2 surgeons will be involved in the procedures.

Care must be taken to avoid placing hardware for stabilization of the osteotomy in a position that would interfere with adequate tunnel position for ACL reconstruction. Placing the bone tunnels in the incorrect position is the most common cause of ACL reconstruction failure. In this case, the tibial nail was buried more than the usual amount, and bone grafting of the defect left at the nail insertion site was performed to allow for proper tunnel position and to optimize graft fixation. With proper planning and execution, an excellent result can be achieved.

**REFERENCES**


