

Complications of Anterior Cruciate Ligament Reconstruction With Bone–Patellar Tendon–Bone Constructs

Care and Prevention

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Rupture of the anterior cruciate ligament is a common injury. Correct diagnosis and patient selection, along with proper surgical technique, with careful attention to anatomic graft placement, followed by attention to proper rehabilitation, leads to predictably good to excellent results. This article reviews the recognition and avoidance of complications associated with bone–patellar tendon–bone constructs of anterior cruciate ligament reconstruction.

Keywords: anterior cruciate ligament; complications; knee instability; ligament reconstruction; fixation

Treatment of the anterior cruciate ligament (ACL)–deficient knee has evolved markedly over the few decades. More than 100 000 ACL reconstructions are performed annually in the United States,¹⁵ and the incidence of ACL injury continues to rise along with the growing numbers of competitive and recreational athletes. The orthopaedic literature is replete with series of successful reconstructions performed using varying grafts and graft-fixation devices. Perioperative care has evolved from inpatient hospital stays with immobilization to outpatient surgery with immediate range of motion. Recent studies have demonstrated predictably good and excellent patient objective and subjective outcomes with full expectation of return to sport and work.

Complications in ACL surgery can be disastrous, as the majority of reconstructions are often performed on young patients. While surgical treatment can predictably restore stability and improve function in 85% to 90% of patients,^{7,8,10,26,37,61,95,96,107,119} extrapolation of these results suggest a 10% to 15% failure rate. Although repeat injury and new trauma clearly play a role in failures, several authors cite technical errors as a contributing factor in up to 70% of failed ACL reconstructions.^{7,46} This area is of considerable interest and the AOSSM is currently organizing and funding a multicenter revision ACL reconstruction study with failure and outcome analysis.

The best way to avoid a primary ACL failure is to understand the technical pitfalls in ACL reconstruction and to

fully document and appropriately treat any concomitant injuries. Significant complications may be avoided by properly recognizing other pathologies (eg, posterolateral corner injuries) that, if left untreated, may contribute to failure. Vigilance is also necessary throughout the postoperative period, to ensure adherence to well-established rehabilitation protocols, with emphasis on avoiding early postoperative graft injury, while enhancing maximal functional recovery. Thus, there are many areas in primary ACL surgery where complications may occur—from the time the surgeon meets the patient, until well into the postoperative period. A key to minimizing this risk is understanding the common complications encountered during care of the ACL-deficient knee, while having sound strategies to deal with these issues should they occur.

When complications occur, recognition and adherence to sound principles can correct, minimize, or salvage difficult problems. The goal of this article is to present some of the common complications that arise during the care of the patient with an ACL-deficient knee when using a bone–patellar tendon–bone graft for reconstruction. Emphasis is placed on the complete care of this injury—from the first patient contact preoperatively, to the management of intraoperative complications, and how to deal with troublesome postoperative issues (Table 1).

MINIMIZING ACL COMPLICATIONS IN THE PREOPERATIVE PATIENT

Diagnosis

Preoperative evaluation of a suspected ACL-deficient knee is critical to the success of surgical reconstruction. The goals of this evaluation should be to confirm the presence

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TABLE 1
Complications of Primary Anterior Cruciate Ligament Surgery^a

Preoperative	Intraoperative	Postoperative
Improper diagnosis	Improper graft choice	Infection
Poor indications	Graft harvest errors	Loss of motion/stiffness
Improper preoperative range of motion	Inadequate notchplasty	Extensor mechanism failure
Improper surgical timing	Improper tunnel placement	Graft failure
	Femoral tunnel blowout	
Failure to prepare for concomitant procedures	Dropped graft	Patellar pain
Failure to note concurrent diagnoses	Graft laceration	Deep venous thrombosis/pulmonary embolus
	Graft-construct mismatch	
	Screw-tunnel divergence	
	Improper tensioning	
	Inadequate graft fixation	

^aVarious factors have been associated with failure after a primary anterior cruciate ligament surgery and are divided here into preoperative, intraoperative, and postoperative issues.

of an ACL tear and also identify any associated conditions that could decrease the likelihood of successful treatment. First and foremost, one must be able to accurately diagnose an ACL injury. While many patients are referred to orthopaedists after an injury with MRI diagnosis of an ACL tear, MRI is not necessary to make an accurate diagnosis and should never replace the findings of an appropriately performed history and physical examination. One should ascertain the mechanism of injury, as an ACL tear is more frequently a noncontact event with a deceleration or a change of direction maneuver, as opposed to a contact or direct blow injury. Patients may use the "2-fist" sign to characterize joint instability, placing 1 fist over the other and shifting them to try to visually reproduce their sense of instability. Up to 80% of patients report an audible "pop" or "tearing" sensation at the time of the index injury.⁷¹ The knee also typically develops a hemarthrosis within 3 hours, but there may be a gradual onset of swelling over 24 hours in a smaller subset of patients.

Two major physical examination tests assist the clinician in diagnosis: the Lachman⁶⁷ and the pivot-shift test.⁴⁵ The anterior drawer test, although commonly performed, is much less sensitive in the diagnosis of an acute ACL tear.¹¹¹ The pivot-shift phenomenon is considered pathognomonic of ACL deficiency.⁴² It may vary from a grinding or slipping sensation (grade 1), to audible or palpable slipping (grade 2), to transient locking (grade 3). With the knee in extension, the tibia subluxates anteriorly as gravity allows the femur to fall posteriorly relative to the tibia in the ACL-deficient knee. The iliotibial band then lies anterior to the anatomic center of rotation. As the examiner flexes the knee to 20° to 25°, the knee reduces and the pivot-shift phenomenon occurs. The magnitude of the pivot-shift phenomenon is affected by axial load, valgus force, and hip flexion and iliotibial band tension. The position of the hip and the rotation of the tibia have been shown to greatly influence the magnitude of the pivot-shift phenomenon, with an abducted hip and an externally rotated foot producing the greatest effect, likely due to the relaxation of the iliotibial band.¹² Although a variety of modifications have been described, the key principle is that the pivot shift represents the subluxation-reduction phenomenon that occurs with ACL instability. In the acutely injured patient, guarding can make it difficult to

TABLE 2
KT-1000 Arthrometer^a Findings¹¹

	Max Manual	Index	Side to Side
Normal	<10 mm	≤2	<3 mm
Anterior cruciate ligament injury	>10 mm	>2	>3 mm

^aThe KT-1000 arthrometer (MEDmetric, San Diego, Calif) is a reliable and reproducible objective measure of anterior tibial translation relative to the femur. It has been demonstrated that a manual maximum difference of >3 mm versus the contralateral limb or an absolute measure of 10 mm is highly suggestive of anterior cruciate ligament insufficiency.

assess the pivot shift, and at times a positive pivot may only be elicited with an examination under anesthesia. The Lachman test has been shown to be reliable in the acute injury phase and is the most sensitive test to assess ACL injury.⁶⁷ It should be noted that no significant differences have been noted between genders with regard to preoperative assessments of Lachman, anterior drawer, and pivot-shift grades.⁴¹

Arthrometric evaluation also plays a valuable role. The KT-1000 arthrometer (MEDmetric, San Diego, Calif) allows measurement of anterior translation of the tibia on the femur at 15 and 20 pounds of applied force and at maximum manual testing (approximately 30 pounds), with the knee in approximately 20° to 30° of flexion. The maximum manual side-to-side difference is the strongest predictor of an injury when comparing normal to the ACL-deficient knee, whereas the compliance index offers the strongest variable for differentiating between an acute and chronic ACL tear.¹¹ A maximum manual side-to-side difference of 3 mm and an absolute displacement greater than 10 mm on the affected knee have a sensitivity of 99% for a torn ACL¹ (Table 2). Proper technique is critical, with patient relaxation and neutral rotation of both legs essential to ensure accurate and precise measurements.

Recognition of associated injuries is crucial to avoid unanticipated intraoperative findings and to minimize the chances of a postoperative ACL reconstruction failure. Examination of the posterior cruciate ligament as well as varus-valgus testing at 0° and 30° of flexion is critical to diagnose associated

