Radiographic Features of Anterior Cruciate Ligament Reconstruction

Mark I. Burnstein
Burton I. Ellis
Robert A. Teitge
Martin L. Gross
Christopher K. Shier

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Anterior cruciate ligament disruption is a common injury that occurs in contact sports such as football. The treating orthopedic surgeon may elect any of a variety of therapeutic options. Surgical management may consist of primary repair of the torn ligament or replacement of the torn ligament with graft material, known as anterior cruciate ligament reconstruction (ACLR). Many physicians, including radiologists, are unfamiliar with the surgical procedure or the expected postoperative radiographic appearance of ACLR.

Assessment of radiographs following ACLR, as with many surgical procedures, requires understanding of the surgical procedure. We present our experience in assessing the postoperative radiographs of 24 patients who underwent ACLR. We describe the expected postoperative radiographic appearance, based on the particular type of ACLR performed, which allows the recognition of normal postoperative radiographic anatomy as well as sequelae or complications of the procedure. (Henry Ford Hosp Med J 1986;34:270-4)

Anterior cruciate ligament (ACL) disruption is a significant and common injury. For some patients the treating orthopedic surgeon seeks to surgically repair or replace the torn ACL in an attempt to reestablish normal anatomy and biomechanics and to allow the patient to return to the usual level of physical activity. Replacement of the torn ligament, anterior cruciate ligament reconstruction (ACLR), involves installation of a graft material, usually of the soft tissues, to function as the anterior cruciate ligament. Some surgical variations of the reconstruction include a bone as well as a soft tissue component to the graft. Because of the widespread use of this surgical option, the diagnostic radiologist as well as the orthopedic surgeon should be familiar with and recognize the normal postoperative radiographic appearance as well as sequelae or complications of ACLR.

Material and Methods
We reviewed the medical records and radiographs of patients undergoing anterior cruciate ligament reconstruction during 1983 and 1984. Of the 27 medical records reviewed, only 24 cases had postoperative radiographs available. These 24 cases form the basis of this study.

Because a variety of anterior cruciate ligament reconstructions can be employed, the medical records were reviewed to determine the type of ACLR performed. The postoperative radiographs were then analyzed to determine the characteristic features of the ACLR and to assess for sequelae or complications.

Results
Types of surgical reconstruction
A variety of anterior cruciate ligament reconstructions are performed at Henry Ford Hospital. The goal of ACLRs is to replace the torn cruciate ligament with graft material which attempts to reestablish the anatomy and function of the ACL. Three important surgical considerations, which are reflected on postoperative radiographs, include the type, placement, and fixation of the graft.

Type of graft—The graft may consist of tendon or soft tissue alone. However, in some cases a patellar tendon graft will include a block of patellar bone [Figs 1(A) and (B)]. The bone block may be rectangular or wedge-shaped. A tibial bone block may be harvested as well.

Placement of graft—The graft may be extraarticular or intraarticular in location. An intraarticular graft is associated with more distinctive radiographic features. The intraarticular grafts are fixed after passage through intraosseous tunnels whose intraarticular orifice is positioned to reproduce the fixation points of the ACL sagitally. Fixation may be sutured, intramedullary, or plate fixation.

Radiographic features
Standard anteroposterior and lateral views of the knee are taken postoperatively. Radiographs are obtained with the knee fully extended, and the foot should be placed in slight internal rotation. This alignment is used to reproduce the anatomic relationship of the patellar tendon and iliotibial band with the ilium as well as to reproduce the relationship of the patellar tendon and the patellar ligament with the patella. The knee should be extended to 0° flexion and to 30° flexion. In the 0° flexion position, the patellar ligament is absent and the patellar tendon is the only remaining bone-patellar ligament bone complex. The other view, obtained at 30° flexion, shows the chondral surfaces of the patella. The radiographs are then compared with preoperative radiographs and the results of the surgery are evaluated.

Fig 1 (recta)
of the ACL (Fig 2) or after passage over the top of the posterior-superior aspect of the lateral femoral condyle.

**Fixation of graft**—Sutures may be used to transfix the bone block to the bone, either the tibia or femur. The bone block may be sutured to orthopedic hardware fixed at the distal femur or proximal tibia. The bone block may be screwed into the bone; in the case of a wedge-shaped bone block, it is impacted into the intraosseous tunnel. Surgical staples, spiked ligament washers, or plates can be used to anchor a soft tissue graft to bone.

**Radiologic findings**
Radiographic evaluation reveals a variety of postoperative changes. The particular findings reflecting the specific ACLR performed include: 1) the intraosseous tunnels in the femur or tibia housing the graft (Fig 3); 2) the bone blocks in the femur or tibia anchoring the graft (Fig 4); 3) fixation hardware; and 4) patellar bone block, tibial bone block, and bone block donor site (Fig 5).

Sequelae or postoperative complications may be recognized. Three radiographic observations are of particular interest. First, postoperative fracture of the patella may occur, but in our experience this occurred only with wedge-shaped patellar bone grafts (Fig 6) (1). Second, calcified intraarticular loose bodies may develop. Clinically, limitation of knee extension may be evident (Fig 7). Third, delayed postoperative effusions may develop, which are of unknown clinical significance.

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*Fig 1(A)—Patellar tendon graft including patellar bone block (rectangular bone block).*

*Fig 1(B)—Patellar tendon graft including patellar bone block (wedge-shaped bone block).*
Fig 2—Tibial and femoral tunnels (arrows) may be constructed to house the graft, anatomically reproducing the intraarticular attachment sites of the ACL.

Fig 3—Intraosseous femoral and tibial tunnels. Note intraarticular orifices reproducing ACL attachment sites (arrows).

Fig 4—Intraosseous femoral and tibial tunnels with bone blocks.

Discussion

The treating orthopedic surgeon must decide which surgical approach is appropriate for an individual patient. Some patients have been managed with primary anterior cruciate ligament repair in an attempt to salvage the native ligament. Experience with this surgical procedure suggests that a nonanatomic result may lead to biomechanical sequelae, particularly degenerative joint disease. Biomechanical assessment of the knee has been performed using instant-center analysis, which is performed in the following manner. A series of lateral knee radiographs are obtained, in varying degrees of flexion, through normal range of motion. Two fixed anatomic reference points are obtained in the femur. Lines are drawn connecting these pairs of reference points, which change from one degree of flexion to the next. The intersection of the perpendicular bisectors of these reference lines represents the instant-center for that range of knee flexion. Over a range of normal knee flexion, a normal pattern of movement of the instant-center has been described. Throughout the full range of motion, it usually lies within the contours of the femoral condyles on the lateral radiographic projection. This implies parallel movement of the articulating joint surfaces. An abnormal instant-center reflects altered biomechanics and has been correlated with subsequent development of degenerative joint disease (2). Follow-up radiographic evaluation of patients with unsuccessful primary repair may confirm the development...
of osteoarthritis, which is manifested by a variety of radiographic changes (3).

There has been little critical evaluation of the postoperative radiographs in patients who have undergone ACLR. This lack of information was a principal stimulant to review the postoperative radiographic studies in these patients, allowing recognition of expected postoperative changes as well as sequelae or complications following ACLR. Our review demonstrates a variety of normal postoperative findings which may be observed on radiographs to help define the type of ACLR performed. In particular, an intraarticular reconstruction is easily recognized as the type of ACLR performed when intraosseous femoral and tibial tunnels are present on the radiograph. Although the intraarticular orifice of an intraosseous tunnel is created to reproduce the normal attachment site of the ACL, there has been no critical radiographic evaluation of the position or orientation of the tunnels. Standardized radiographic evaluation of the precise orientation and location of these tunnels might provide useful information regarding the precision of reproduction of ACL anatomy and thus may be of prognostic value in determining biomechanical sequelae. To our knowledge such detailed evaluation has not been undertaken, probably because of the difficulty of exact reproduction of patient positioning from one patient to another.

Postoperative sequelae were recognized in our patient population. Loose joint bodies may develop, as with any form of
trauma to the articular cartilage. Delayed effusions may be recognized radiographically. Such effusions are frequently sterile and of unknown clinical significance. It is clear, however, that the late development of radiographic evidence of effusion should not necessarily imply a significant complication, particularly infection.

Diagnostic radiologists, as well as other physicians who view imaging studies, are best equipped to evaluate radiographic examinations with in-depth background knowledge regarding the patient's clinical status, including any surgical procedures that may have been performed. Frequently, a radiographic examination may be viewed without full knowledge of the patient. Our retrospective review of the postoperative radiographs of patients undergoing ACLR allowed recognition of 1) the normal postoperative radiographic anatomy, 2) the specific type of reconstruction performed in most cases, and 3) postoperative sequelae or anatomic changes which might predispose to complications (such as patellar fracture).

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References