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Revision Anatomic Double-Bundle Anterior Cruciate Ligament Surgery

J. Christopher Shaver, MD, and Darren L. Johnson, MD

As the number of primary anterior cruciate ligament (ACL) reconstructions performed in the United States continues to increase, so will the need for revision surgery for "failed" primary surgery. These failed ACL surgeries are often the result of technical errors in the primary surgery. Current literature reports inferior functional and objective results of revision ACL surgery in comparison with primary surgery. This is often the result of unrecognized injury to the secondary stabilizers of the knee. The anatomic double-bundle ACL surgery has been shown to more accurately recreate the kinematics of the native knee in comparison with "classic" transtibial single-bundle ACL reconstructions. We believe that the use of the principals and techniques of anatomic double-bundle ACL reconstruction in the revision situation may be advantageous for many reasons. This is a technically demanding procedure that requires proper preoperative preparation. This article outlines our approach to these challenging situations.
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KEYWORDS double bundle, anterior cruciate ligament, revision, reconstruction, ACL

As the incidence of anterior cruciate ligament (ACL) reconstruction surgery has steadily increased across the world during the past few decades, it follows that the numbers of failed primary surgeries and the need for revision surgery will concomitantly increase. The reasons for these failures are varied, but the final goal with revision is the same, to provide a stable and functional ACL that most accurately reproduces the kinematics of the native knee. Recent research has provided further accuracy of the native ACL anatomy, including gross, insertion site, and arthroscopic anatomy.[1,2] Contributions include the appreciation that the ACL has 2 functional "bundles," the anteromedial bundle and the posterolateral bundle. The true anatomy of the origin of the ACL in relation to the medial wall of the lateral femoral condyle has been determined, as well as the topographical relationship to the lateral intercondylar and lateral bicruciate ridge.[3] Much of the focus of study dealing with revision ACL surgery is directed toward the recreation of this anatomy. This article outlines our strategy to most accurately accomplish this goal in the case of a failed primary ACL reconstruction with recurrent anterolateral instability.

Department of Orthopaedic Surgery, University of Kentucky School of Medicine, Lexington, KY.

Address reprint requests to Darren L. Johnson, MD, Department of Sports Medicine, K431 Kentucky Clinic 0284, 740 South Limestone St, Lexington, KY 40536. E-mail: dljohns@uky.edu

It is our belief that anatomic restoration of the ACL through use of the anatomic double-bundle technique is advantageous and the treatment of choice in the majority of revision cases. It has been shown to be superior to single-bundle reconstructions in restoration of the normal kinematics of the knee.[4] Additionally, and more importantly, it allows for a greater volume of tissue to counteract the effects of laxity within secondary restraints commonly seen in revision situations. However, there are certain situations that may not be indicated for this approach. These situations include individuals of small stature and size that will not allow enough surface area and volume of bone in the lateral femoral condyle required to perform double bundle anatomic reconstruction. We prefer to revise these patients to an anatomic single bundle. Additionally, double-bundle surgery remains a more technically challenging procedure with a much steeper learning curve as well as longer operative times, increased risk of posterior wall blowout, short tunnels, and graft-tunnel mismatch when using autogenous bone-patella tendon-bone autografts.

Etiology of Primary Reconstruction Failure Leading to Recurrent Instability

The success of the revision ACL surgery depends on the precise determination of the root cause of the primary sur-

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gery's failure. Without this knowledge, any revision surgery is not likely to succeed in the primary goal, provision of a stable and functional knee. The causes of dysfunction of a primary ACL reconstruction can be many, but all may lead to a failure to create or maintain the native mechanics of the ACL.[5,6]

Surgical Technique

Poor surgical technique often creates a situation in which the primary ACL is not anatomically positioned. Nonanatomic placement of the graft is the most commonly seen cause of failure of the primary ACL reconstruction.[6] It leads to either loss of motion in flexion and extension and eventual attrition of the graft by stretching, malfunction of the graft due to inadequate graft tension, or mechanical attrition of the graft as it impinges on the femur. Other causes of loss of motion include formation of a fibro-proliferate nodule that limits extension ("Cyclops Lesion")[7] and capsulitis from excessive healing responses of the native structures leading to eventual arthrofibrosis and global loss of motion.[8,9] Fortunately, this is seen very infrequently. If the patient initially presents with loss of motion as their primary complaint, it is often a difficult problem and dealt with before addressing any issues of instability.

Recent studies have evaluated the anatomy of the ACL in respect to its topographical insertion on both the tibia and femur. These results suggest that with endoscopic trans-tibial femoral tunnel establishment, it is unlikely or impossible to recreate the native anatomic femoral footprint of the ACL.[10,11] The most commonly noted mistakes in graft placement include providing a tibial exit point too posterior and central within the notch, leading to PCL impingement and poor tensioning in relation to normal kinematics, and a femoral site too high and/or anterior on the medial wall of the lateral femoral condyle, creating a "vertical" graft (Figs. 1 and 2).[12] This combination results, at best, in a graft that provides some anteroposterior stability with little rotational stability. Possibly worse is a graft that not only provides little to no inherent stability, but also limits range of motion of the knee. The knee may have actually been made worse after surgery in this situation. These technical points must be addressed and corrected in any revision ACL surgery to ensure the best outcome.

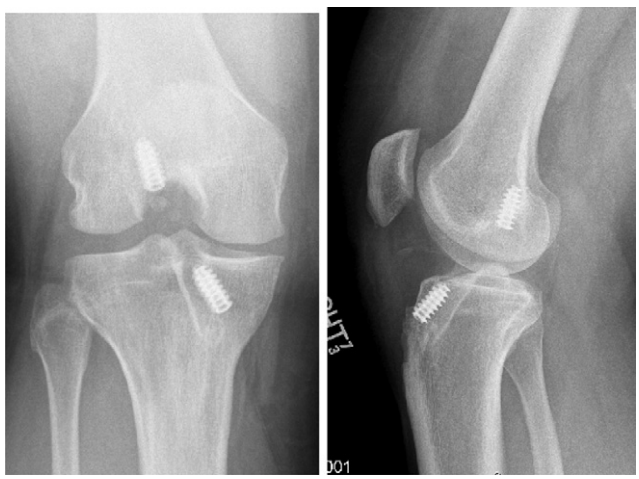

Figure 1 Anteroposterior and lateral radiograph of failed primary "vertical" graft.

The characteristics of the host and the primary graft must be considered and certain graft/host mismatches have been recognized. These include both soft tissue allo and autografts in young hyper lax females and high demand "level 1" athletes, and should be avoided to decrease the incidence of failure.[13-15] Failure to recognize the differences in the incorporation rates between bony versus. soft tissue autografts as well as various allografts may also lead to failure, especially if a "cookbook" standard rehabilitation protocol is used for all reconstructions.[16,17] These failures may often present in the case of a well positioned graft with no other obvious cause of recurrent instability. Adherence to biologic principles specific to each graft variety is essential to the success of the revision of the primary surgery.

Because the native ACL does not act in kinematic isolation within the knee, the reconstructed ACL functionally depends on secondary restraints to provide and maintain stability after reconstruction. Failure to recognize and address incompetent or lax secondary restraints causes excessive and unnatural forces on the primary graft, leading to eventual failure.[18-20] An anatomically placed graft will have a limited life span if secondary restraint absence places nonphysiologic forces on that graft. These secondary restraints include the menisci, medial collateral ligament, posterolateral corner, and the posteromedial complex (specifically the posterior oblique ligament). These may be injured in concert with the original ACL injury, or more commonly become insufficient because of repeated episodes of instability resulting from a lack of a functional ACL. Recognition and management of these deficiencies is vital to the success of revision surgery.

Preoperative Planning

As previously mentioned, the primary cause of failure of the index ACL surgery must be elucidated to devise a plan to perform a successful revision surgery. Evaluation of patient's current or, more importantly, desired level of activity must be considered, as well as communication of realistic goals and expectations of the patient and surgeon. Detailed knowledge of the primary injury and procedure, as well as their postoperative course, including complications, rehabilitation protocol, and subjective and objective results, must be taken into account. A baseline International Knee Documentation Committee score is often helpful to define the patient's current functional level. The patient's actual subjective complaints may vary widely along a spectrum from pain to instability. This may lead to an alteration of strategy in the revision situation. Thorough knowledge of the previous surgery is paramount to success. This will allow the surgeon to adequately plan for the expected course of events in revision, the equipment needed to perform the surgery, and the expected pitfalls that may be encountered. These include bone loss, hardware and fixation issues, and additional sources of insta-

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