The Concept of Anatomic Anterior Cruciate Ligament Reconstruction

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Growing interest in double-bundle anterior cruciate ligament (ACL) reconstruction has sparked tremendous research, yielding a better understanding of normal ACL anatomy, kinematics, and function. Recent studies have more accurately defined the size and orientation of the femoral and tibial insertion sites of the anteromedial and posterolateral bundles. At our institution, we have identified specific osseous landmarks to better guide tunnel placement. The goal of anatomic ACL is to use these discoveries, refine technique, and reconstruct the ACL in a manner that most closely mimics normal anatomy. Logically, we believe that anatomic ACL reconstruction will lead to more favorable kinematics and, in turn, improved patient outcomes. This article summarizes our experiences and details our systematic approach to anatomic ACL reconstruction. Finally, we highlight multiple issues with conventional ACL reconstruction to better illustrate the concept of anatomic ACL reconstruction.

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The anterior cruciate ligament (ACL) is 1 of 4 major ligaments in the knee, along with the posterior cruciate ligament, medial collateral ligament, and lateral collateral ligament. The ACL connects the distal femur to the proximal tibia, preventing excessive anterior translation and rotation of the tibia. Structurally, the ACL comprises 2 separate functional bundles named for their tibial insertion sites: the anteromedial (AM) and the posterolateral (PL) bundle (Fig. 1).1,2 Both bundles are evident during fetal development and persist throughout life.3,4 Throughout a functional range of motion, the ACL acts primarily as a restraint to excessive anterior tibial translation. More recent studies have also shown that the ACL, specifically the PL bundle, plays an important role in resistance to rotational forces.5,6

Understanding ACL injury mechanisms is a complex task. The typical injury occurs during a noncontact twisting mechanism or as the result of a valgus-directed blow to the knee. Noncontact mechanisms, which comprise more than 70% of acute ACL injuries, are seen in cutting sports during sudden, violent deceleration and change of direction with the knee close to full extension. Contact ACL injuries occur more often as a result of valgus collapse of the knee.7 Complete tears of the ligament produce a predictable pattern of mechanical instability and a variable degree of functional instability.8

After ACL disruption, ligament reconstruction is generally accepted as the most reliable method of re-establishing knee stability. The goal of ACL reconstruction is to return the patient to a previous level of function while preventing later degeneration of the knee. The best method to achieve such goals is through restoration of normal knee kinematics. Although single-bundle reconstruction is widely used for ACL reconstruction, recent publications have shown that reconstruction of both bundles (AM and PL) may better re-establish the normal kinematics of the knee.9-12 In addition, a recent meta-analysis showed that no more than 60% of the patients would attain full recovery after single-bundle ACL reconstruction.13 Another study with midterm follow-up also demonstrates significantly high occurrence rates of osteoarthritis after single-bundle ACL reconstruction.14 Thus, there is still room for continued improvement in ACL reconstruction.

The Concept of Anatomic ACL Reconstruction

Anatomy is the basis of orthopaedic surgery. Our approach to ACL reconstruction surgery is governed by this concept and,
thus, strives to closely reproduce the native anatomy of the ACL. There are 4 fundamental principles in anatomic ACL reconstruction. The first is to restore the 2 functional bundles of the ACL. Second, we aim to restore the native insertion sites of the ACL by placing the tunnels in the true anatomic positions. Tunnel and graft size are tailored to match the size of the native ACL insertion sites. The third principle is correct tensioning pattern of each bundle. The AM bundle is taut throughout knee range of motion, reaching a maximum between 45° and 60°, whereas the PL bundle is tight primarily in extension (Fig. 2). Therefore, we independently tension the AM and PL bundles accordingly to restore their native tensioning behaviors.

The fourth and final principle is individualized surgery for each patient. Tunnel diameter and graft size are dictated by native insertion sites. In addition, single-bundle ACL reconstruction is considered in patients with small native insertion sites (less than 14 mm in length), open growth plates, severe bone bruising, narrow intercondylar notch width, and multiligamentous knee injuries. The concept of anatomic reconstruction can also be extended to the revision ACL surgery setting. Single-bundle (AM or PL) augmentation surgery is routinely performed when only 1 of the 2 bundles is torn. We firmly believe that only when native anatomy is closely restored can superior outcomes be achieved.

To further demonstrate the concept of anatomic reconstruction, a few pitfalls of ACL surgery are discussed here:

The Clock Face Reference

Although the “clock face” reference has been widely accepted in the literature to describe femoral tunnel positioning during ACL reconstruction, it has generated more confusion than clarification in helping surgeons to locate the anatomic footprint of the ACL. The clock face reference is based on radiographs of the knee in extension, but ACL surgery is typically performed at or near 90° of knee flexion. Therefore, the orientation of clock face is wrong as the femoral AM and PL...