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Operative Techniques in
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Future Perspectives of Anterior Cruciate Ligament Reconstruction

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Reconstruction of the anterior cruciate ligament (ACL) is a common procedure of orthopaedic surgery. The challenges of recreating normal knee function after an injury to the ACL have led to excessive research and continuous innovation of the surgical techniques for ACL reconstruction. Recently, focus has been turned toward the anatomical ACL reconstruction that is one of the most intriguing approaches regarding the surgical technique. Furthermore, exploration of basic anatomy of the knee has led to further insight in concepts of tunnel placement, graft options, and treatment strategies. The possibility of quantitative measurement of knee laxity has evolved and is presented as one future approach to individualized surgery. The vast amount of literature available on ACL reconstruction illustrates that evidence regarding many aspects is advancing. However, it also illustrates that some studies are not generalizable, and that there is a need for further high-quality research. This article presents an overview of the development of ACL reconstruction and existing evidence. It reviews important aspects that influence current and future perspectives on ACL reconstruction.
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Background

Injury to the anterior cruciate ligament (ACL) is common, and surgical reconstruction of the ACL is one of the most frequently performed orthopaedic procedures. The quest for a surgical technique that restores native function of the ligament and provides regained stability of the knee joint has been persistent. The vast amount of literature available on the subject might be the result of the high numbers of ACL ruptures worldwide, the variability of injury patterns, and the morbidity associated with an injury to the ACL. However, what ultimately drives orthopaedic surgeons toward research and continuous innovation in ACL reconstructive surgery is probably the challenge of restoring knee joint kinematics and anatomy. To understand future directions of this surgical profession, one must first understand how the techniques and knowledge have developed in the recent past. Moreover, one must understand that extensive knowledge in basic science such as anatomy and

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biomechanics is the foundation for the development of new treatment paradigms. The aim of this article is to present an overview of important aspects that influence current and future perspectives in ACL reconstruction.

Anatomy and Function

Native Insertion Sites

The ACL originates on the posteromedial portion of the lateral femoral condyle and inserts anteriorly on the medial tibia, medial to the anterior horn of the lateral meniscus. Identifying the native insertion sites is important during reconstructive surgery, and several anatomical landmarks aid the surgeon for this purpose. The anterior border of the femoral footprint is marked by a bony structure on the medial wall of the lateral femoral condyle known as the lateral intercondylar ridge, and no ACL fibers insert anterior-superior to this ridge. Perpendicular to this ridge appear another landmark—the lateral bifurcate ridge. This ridge divides the femoral footprint into 2, and on either side of the ridge with 1 of the 2 bundles composing the ACL inserts (Fig. 1). The area of the footprint is approximately 3.5 times larger than the cross-sectional area of the ACL midsubstance. Its shape has been described as a "crescent" or oval, measuring a mean length of 18 mm and a width of 11 mm.[1,2] However, the exact insertional anatomy of the ACL has yet to be conclusively established. The insertion site has been reported to be in direct continuity with the posterior femoral cortex with a flat insertion of the ACL along the intercondylar ridge.[3] Moreover, direct and indirect insertional anatomy of ACL fibers in the femoral footprint has recently been described.[4] Fibers that originate immediately posterior and parallel to the lateral intercondylar ridge are reported to form the direct insertion of the ACL. It is suggested that these fibers have a predominant role in load-bearing and therefore in providing stability. The fibers of the indirect insertion "fans out" over an area posterior to the direct insertion

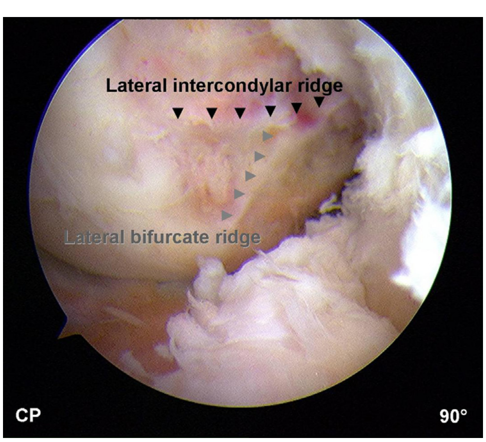

Figure 1 Arthroscopic picture of the right knee in 90° flexion. The anterior border of the femoral footprint is marked by the lateral intercondylar ridge. Located between the insertion sites of the 2 bundles is the lateral bifurcate ridge. (*Picture courtesy*: University of Pittsburgh Medical Center, USA.)

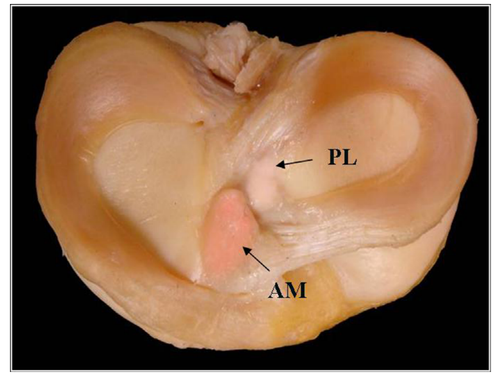

Figure 2 Picture showing the tibial insertion sites for the AM and the PL bundle. (*Picture courtesy*: University of Pittsburgh Medical Center, USA.)

but anterior to the posterior articular cartilage of the lateral femoral condyle.[4] Future understanding of the anatomy of the femoral insertion site is probably a key point for optimizing tunnel placement with ambition of restoring the native anatomy during ACL reconstruction.

The tibial insertion site is slightly larger than the femoral, approximately 120% larger in area.[1] Traditionally, the tibial insertion site has been described as oval to triangular in shape, located between the medial and lateral tibial spine (Fig. 2). Recent studies question this description though, and suggest that the tibial insertion site instead is flat and C-shaped, with the center of the C at the insertion site of the anterior horn of the lateral meniscus. This is proposed to be a result of a flat and "ribbon"-like configuration of the midsubstance of the ACL.[5]

Properties of the ACL Bundles

During the course through the knee, from the femoral insertion site to tibia, the ACL appears as a helical structure. This architecture is a result of a twisting of the ACL owing to the fact that fibers originating most anteriorly in the femoral footprint insert at the most posterior part of the tibia, and vice versa. Even though the ACL is a single ligament morphologically, this arrangement divides the ACL into 2 functionally distinct fiber bundles (Fig. 3). The existence of the bifurcate ridge, that divides the femoral insertion site into 2, further strengthens the idea of 2 bundles. The bundles are named after their respective insertion site on the tibia: the anteromedial bundle (AM), and the posterolateral bundle (PL). The tension pattern of the fibers within the ligament vary with range of motion, and by the synergistic interaction of 2 functional bundles, both antero-posterior and rotatory stability are provided. As the bundles originate from the posterior part of the femoral condyle, different degrees of knee flexion vary the position of the bundles. Because of this anatomy, the PL bundle is tight when the knee is extended whereas the AM bundle is quite lax in this position. During knee flexion, the tension of PL bundle loosens, and in contrast the AM bundle tightens. Thus, the PL bundle has greater effect on the stability when the knee is extended, and the opposite situation arise during knee flexion.