Editorial Commentary: Tibial Attachment of the Anterior Cruciate Ligament: Just 1 Piece to the Complex Puzzle of Individualized, Anatomic Anterior Cruciate Ligament Reconstruction

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Abstract: The anterior cruciate ligament (ACL) is a complex, biologic structure that continues to be explored in the literature. Given the individual uniqueness of the ACL, variation exists, and studies continue to attempt to tease out what is truly important for ACL reconstruction. Although individual components of the ACL structure provide function, the ACL works as a dynamic structure, in unison with the surrounding bony morphology, to produce normal knee kinematics. Ultimately, in ACL reconstruction, the surgeon is tasked with restoring the native dimensions, collagen orientation, and insertion sites according to the individual anatomy.

See related article on page 2101

Our knowledge of the anatomic, morphological, and biomechanical aspects of the anterior cruciate ligament (ACL) continues to grow and evolve. Anatomically and functionally, the ACL consists of 2 bundles, anteromedial and posterolateral. The 2 bundles are distinct in the fetal ACL and are divided by a well-defined septum of vascularized connective tissue.[1] Variations naturally exist given the uniqueness of the surrounding bony morphology and the complex nature of the form and function of the knee as a whole.[2] A ribbon-like appearance of the ACL has been described more recently[3]; however, it is important to recognize that physiological aging and dissection of the synovial covering, which is essential to biologic viability of the ACL, can contribute to the differences seen in specimens.

In the study, "The Role of Fibers Within the Tibial Attachment of the Anterior Cruciate Ligament in Restraining Tibial Displacement," Lord, El-Daou, Zdanovicz, Smigielski, and Amis continue their fine work on the biomechanical functions of the fibers of the ACL.[4] This laboratory previously published a cadaveric, biomechanical study of the load-bearing function of the fibers of the femoral attachment.[5] The central, proximal attachment fibers, which correspond more toward the anteromedial bundle, provided the majority of resistance to anterior tibial translation. The current study investigated the tibial attachment fibers. The authors found the anterior and medial attachment fibers provided the greatest restraint to anterior tibial translation, internal rotation, and a simulated pivot shift test. This correlated with a reported distinct anteromedial C-shaped dense fiber attachment area.

The authors acknowledge the limitation that the age of their specimens, mean 55 years, is problematic given that ACL rupture and reconstruction is an issue of the younger population (i.e., younger than age 25 years). As with all human tissue, physiological aging is a natural process, and there is evidence of posterolateral ACL fiber degeneration in the literature. In a recent study of 100 patients, mean age 26 years, undergoing ACL reconstruction, the tibial insertion was elliptical in 51 knees, triangular in 33 knees, and C-shaped in 16 knees.[6] Posterolateral fatty degeneration was observed in 26 knees. Given the smaller number of C-shaped insertion sites in this younger age group, fatty degeneration with aging may explain the C-shaped appearance of some specimens.

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The authors report the following potential conflicts of interest or sources of funding: V.M. reports personal fees from Smith & Nephew and Springer, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

0749-8063/19503/$36.00

https://doi.org/10.1016/j.arthro.2019.04.017

This study presents excellent anatomic and biomechanical work from an excellent laboratory that continues to progress our knowledge of the ACL; however, this remains as just 1 piece of the puzzle. The ACL is a complex tissue that functions as part of the living organ that is the knee. The collagen fibers and their load bearing contribute only 1 part to this issue of providing rotatory knee stability. Decades of research have led to the consensus that "the ACL is a dynamic structure, rich in neurovascular supply and comprised of distinct bundles, which function synergistically to facilitate normal knee kinematics in concert with bony morphology. Characterized by individual uniqueness, the ACL is inherently subject to both anatomic and morphological variations, as well as physiologic aging."[7] Ultimately, the goal of this plethora of research is an individualized, anatomic ACL reconstruction functionally restoring the ACL to its native dimensions, collagen orientation, and insertion sites according to the individual anatomy.[8]

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