Biomechanics of the Anterolateral Structures of the Knee

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KEYWORDS

• Anterolateral • Tenodesis • Ligament • Iliotibial tract • Rotatory instability • Pivot-shift

KEY POINTS

- The primary soft tissue restraint to tibial internal rotation has been found to be the deep layer of the iliotibial tract, connecting from Kaplan fibers on the femur to Gerdy's tubercle on the tibia.
- The anterolateral ligament has been found to be relatively weak and poorly aligned to resist tibial internal rotation, but damage here does increase laxity and may be a sign of other structures being damaged.
- Although lateral tenodeses are not anatomic, they are effective in controlling tibial internal rotation.

BACKGROUND

Previously, the term anterolateral rotatory instability (ALRI) was synonymous for the instability caused by an isolated anterior cruciate ligament (ACL) injury. Hughston and colleagues[1] were the first to popularize the idea that only a concomitant anterolateral capsular injury can induce this excessive anterior subluxation of the lateral tibial

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plateau. With the introduction of arthroscopic ACL surgery, these peripheral injuries fell out of focus. Although intra-articular reconstruction of the ACL restored knee kinematics in the anterior/posterior direction, it failed to completely abolish the pivot-shift phenomenon in some knees.[2] This led to a more anatomic approach of intra-articular ACL reconstruction, reproducing its oblique course to the posterior aspect of the femur by using the medial portal technique.[3] However, despite many efforts to improve tunnel positioning, graft tensioning, and after-care protocols, rotational laxity still has not been completely abolished.[4]

This residual rotational laxity after ACL reconstruction may come from additional injury of the peripheral structures, which gained broad interest after anatomic description of the anterolateral ligament (ALL) in 2013.[5] Since then, many studies regarding anatomy, biomechanics, and possible reconstructions have been conducted.[6–10] However, there is still a lack of evidence on how to diagnose these injuries and more importantly which patients will benefit from an additional lateral extra-articular procedure.

Although this work has given promising biomechanical and clinical results, these questions must be clarified by level I studies. Similar to the medial side, anterolateral capsular structures may have a high healing potential, when the primary restraint to anterior tibial translation is reconstructed, so routine use of anterolateral procedures may place the patient at unnecessary risk of an additional extra-articular procedure. Conversely, undiagnosed anterolateral structure injuries may "stretch-out" over time in chronic cases and impose abnormal loads on the ACL graft, preventing it from healing in the bone tunnel.[11] The purpose of this review was to provide a biomechanical rationale regarding the anterolateral structures of the knee.

ANATOMY OF THE ANTEROLATERAL STRUCTURES

The anatomy on the anterolateral side of the knee can best be described in a layer-by-layer fashion. The first relevant layer is the iliotibial tract (ITT), which inserts onto the tibia at the Gerdy's tubercle and extents proximally as the fascia lata, merging into the gluteus maximus, gluteus medius, and tensor fascia lata muscles. The second layer is formed by the posterior fiber region of the superficial tract, which merges with the deep and capsulo-osseous structures of the ITT (**Fig. 1**).[12]

The deep layer of the ITT becomes visible approximately 60 mm proximal to the lateral femoral epicondyle.[12] A triangular area at the distal termination of the lateral intermuscular septum is formed by strong fibers (Kaplan fibers) connecting the superficial ITT layer to the femur. The capsulo-osseous layer was described as the deepest layer of the ITT and provides a lateral capsular strengthening.[13] This layer is also known as the retrograde tract insertion[14] and attaches at the lateral femoral supracondylar region and passes distal, where it inserts slightly posterior to the Gerdy's tubercle. This ligament-like unit is composed of the deep and capsulo-osseous layers of the ITT, and forms a sling around the posterolateral aspect of the femur, inserting posterior to the Gerdy's tubercle and was described as "acting as an anterolateral ligament" by Terry and colleagues[12,15] (**Fig. 2**).

The next layer is formed by the mid-third lateral capsular ligament, which can be divided into a meniscotibial portion and a meniscofemoral portion.[1] On the tibia, it attaches between the anteroinferior popliteomeniscal fascicle (popliteus hiatus) and the posterior border of the Gerdy's tubercle approximately 6 to 9 mm distal from the joint line.[16–20] The femoral attachment site was defined in the region of the lateral femoral epicondyle[17,19] with several other attachments on the posterior aspect of the popliteus attachment and at the lateral gastrocnemius tendon attachment.[21]