Secondary Stabilizers of Tibial Rotation in the Intact and Anterior Cruciate Ligament–Deficient Knee

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KEYWORDS

• Anterior cruciate ligament • Iliotibial band • Anterolateral capsule • Lateral meniscus • Anterolateral ligament

KEY POINTS

- The anterior cruciate ligament is the primary stabilizer to tibial rotation.
- The iliotibial band is the main secondary stabilizer to tibial rotation, particularly at higher flexion angles at which the anterior cruciate ligament plays less of a role.
- The anterolateral complex is an important stabilizer for tibial rotation, but its exact anatomic definition remains ambiguous, as does its biomechanical function.
- The lateral meniscus also functions as a secondary stabilizer of tibial rotation.

INTRODUCTION

The controversy regarding the existence and possible function of the anterolateral ligament (ALL) has reinvigorated interest in rotational control of the knee joint. This is particularly true of internal rotation (IR), and anterolateral rotary instability. With anterior cruciate ligament (ACL) reconstruction failure rates ranging from 0% to 14%, many in the sports medicine community are pointing toward compromised anterolateral restraints as the underlying culprit.[1,2] The anterolateral complex includes the iliotibial band (ITB), the anterolateral capsule (ALC), lateral meniscus (LM), and lateral collateral ligament (LCL). This article provides breakdown of these structures, their functions, biomechanical properties, and clinical importance, based on a thorough review of available literature.

WHAT IS THE PRIMARY STABILIZER OF TIBIAL ROTATION?

The primary stabilizer of tibial rotation must first be defined before any secondary stabilizers can be named. In 1980, Butler and colleagues,[3] introduced the concept of the

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primary restraint. Primary restraint was conceptually explained by Andersen and Dyhre-Poulsen[4] as follows, “cutting a primary restraint results in an increase in joint motion, whereas cutting a secondary restraint will result in an increase of joint motion only in the absence of the primary restraint.” This notion was used as the foundation for future biomechanical studies looking to establish the significance of various restraints.

Early research posited the ACL as the primary restraint to tibial IR—particularly at low flexion angles. In 1981, Lipke and colleagues[5] found that isolated transection of the ACL resulted in significantly increased tibial IR, which increased even more so with subsequent sectioning of the ALC and LCL. Transection the lateral structures first and leaving the ACL intact, however, resulted in no significant difference to internal rotation. Also using cadaveric specimens, one study testing the biomechanical properties of intra-articular and extra-articular ACL reconstructions and a second study investigating the efficacy of a pivot shift testing mechanism[6] both found cutting the ACL alone led to significantly increased internal rotation—although the latter group did not find this to be true at 90° of knee flexion.[6,7] Several studies that examined the differences and importance of the 2 bundles of the ACL, confirm the previous findings that isolated transection of the ACL results in significantly increased IR of the tibia.[8–10] Biomechanically, tibial torque is believed to cause winding of the ACL fibers around each other, which results in loading of the ligament and resistance to rotation.[9]

An increasing body of evidence, however, suggests that the ACL is not, in fact, critical for IR stability. Andersen and Dyhre-Poulsen,[4] in a study of cadaver knees found that at the time of transection of the ACL, IR increased significantly when compared with normal knees at 10° and 30° of flexion, but not at 50°, 70°, or 90°. The group concluded the ACL was a primary stabilizer at low flexion angles. A classic study by Lane and colleagues,[11] found transection of the ACL did not result in any significant increase in IR; however, with only 14 cadaver specimens, this study may have been underpowered. Kittl and colleagues,[12] compared the percentage contribution to IR resistance of the ACL and several anterolateral structures and found the ACL was the chief restraint to IR only at full extension. Similarly, Kanamori and colleagues,[13] found no significant differences between ACL-intact and ACL-deficient knees, reporting a less than 3° difference between groups at all flexion angles during isolated tibial loading and during a simulated pivot shift test. At 15° of flexion, Oh and colleagues,[14] found transection of the ACL led to a significant, but small (.7°) change compared with intact knees. Several other studies found slightly larger degree differences between ACL-intact and ACL-deficient knees in response to IR. However, because of sample sizes and type of statistical testing, these still relatively minor IR increases were not found to be significant.[15–20] The ACL is likely the primary stabilizer of tibial internal rotation, particularly from 0° to 30° of flexion. At flexion angles greater than 30°, the ACL is still likely the chief restraint to internal tibial rotation, but the contribution of the anterolateral complex increases with increased flexion.

SECONDARY STABILIZERS

Iliotibial Band

The importance of the ITB was first elucidated by Kaplan[21] in 1958. He defined the ITB as a stabilizing ligament attached to the lateral femoral condyle at a fixed point and attached to Gerdy tubercle where it moves forward in extension and backward in flexion.[21] The ITB is a thickening of deep fascia, intimately connected with the tensor fasciae latae anteriorly and gluteus maximus posteriorly. It extends laterally from the iliac crest to the tibia, with connecting fibers to the femur along its length.[21] At the