The Role of the Anterolateral Structures and the ACL in Controlling Laxity of the Intact and ACL-Deficient Knee: Letter to the Editor
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What is This?
The Role of the Anterolateral Structures and the ACL in Controlling Laxity of the Intact and ACL-Deficient Knee: Letter to the Editor

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Dear Editor:

We read with significant interest the article by Kittl et al10 on the role of the anterolateral structures in controlling laxity of the intact and anterior cruciate ligament (ACL)-deficient knee. We congratulate the authors on this interesting study, which contributes further to our understanding of the role of these anatomic structures.

However, we would like to bring up some important questions and remarks related to this paper. First, has the dissection technique utilized in this study been previously validated? How did the authors confirm that they were isolating the deep iliotibial band (ITB) from the superficial ITB? Similarly, the isolation of the anterolateral ligament (ALL) performed in this study has never, to our knowledge, been performed in this way. How did the authors ensure that the deep capsulo-osseous layer and the ALL were completely separated in their entirety? Was histologic analysis subsequently performed to ensure that each structure tested was as described?

The ALL described in the article and illustrated in Figure 3 is visually quite different from the structure described in previous publications.1-5,19 The ALL depicted in Figure 3 of this article appears significantly smaller, with an attachment that appears to be adjacent to the joint line of the tibia, above the tibial landmarks previously described. Furthermore, the anatomic depiction lacks the fanlike insertion on the tibia that has been widely published.1-5,19 In addition, Figure 2B of the Kittl et al19 article demonstrates the knee after resection of the capsule-osseous layer of the ITB, prior to isolation of the ALL, yet there does not appear to be any distinguishable structure remaining, certainly not the presence of a robust ALL.

We know that the dissection technique utilized contributes significantly to the interpretation of the characteristics of these anterolateral structures, specifically the ALL,1-5,6 and that this interpretation also alters the biomechanical characteristics of these structures.9,14 A review of articles by Kaplan2,8 and Terry et al17,18 reveals the historical challenge in defining these structures. It is interesting, however, that Terry et al17 describe the capsule-osseous layer of the deep ITB as a structure “whose proximal origin is continuous with fascia covering the plantaris and lateral gastrocnemius and whose tibial insertion is just posterior to the Gerdy tubercle.” Furthermore, Terry et al17 describe this structure as acting as if it is “an anterolateral ligament of the knee” (Figure 118). We postulate that perhaps the “deep capsulo-osseous layer of the ITB” referenced by Terry et al17 and the ALL of the knee are generally the same structure, just dissected with different techniques.

Current literature clearly demonstrates that directly underneath the “superficial” ITB lies the ALL, as demonstrated not only by the dissection technique from Daggett et al12 but also by magnetic resonance imaging studies showing that the ALL runs inferior to the ITB with no other distinguishable structure between them.6,11 Additionally, we know that this structure is histologically an extracapsular ligament4,19 and is involved in rotational control of the knee.13,15,16 The correlation between the ALL and the “capsulo-osseous layer of the ITB” as described by Terry et al17 is further supported by biomechanical findings. When the findings of this study by Kittl et al10 are compared with those of other studies examining the role of the ALL in internal rotation control of the tibia,13,15,16 the results are quite similar if one considers the structures to be the same. Regardless of name, we are now all in agreement that an anatomic structure, deep to the superficial ITB that inserts posterior to the Gerdy tubercle, plays a significant role in controlling internal rotation of the knee.

Furthermore, while the authors found a significant contribution of the “superficial” ITB to stability of the knee, we believe that these laboratory findings do not translate clinically. In the setting of acute ACL tear, one rarely encounters an injury to the ITB. Additionally, although the authors found the different structures contributing to rotation at varying degrees of flexion, physiologic motion of the knee in its entirety is what is important, and this motion is limited internal rotation toward knee extension (ie, 15°) with significantly more physiologic rotation in deeper degrees of knee flexion (ie, 90°).12

Figure 1. The capsulo-osseous layer of the iliotibial band as described by Terry et al17 demonstrates significant similarity to the anterolateral ligament as described by Claes et al.1 (Reprinted with permission from Terry et al17 ©1986, American Orthopaedic Society for Sports Medicine.)
In conclusion, we believe that the findings in this study could be biased because of the dissection technique chosen, thus preventing a reasonable conclusion from being reached. We agree with the comment by Terry et al that “the functional anatomy of the iliotibial tract is complex.” Regardless of nomenclature, we do agree with the authors that the anterolateral structures play a significant role in rotational control of the knee, and they should remain a focus of study to improve our clinical and functional results after pivot shift–type injuries.

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The Role of the Anterolateral Structures and the ACL in Controlling Laxity of the Intact and ACL-Deficient Knee: Response

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Authors’ Response:

We thank Daggett and colleagues for their insightful comments and their interest in our article regarding the role of the anterolateral structures in controlling knee laxity. In light of the recent anatomic development, we are most grateful to have the opportunity to clarify a number of points from our work.

Before answering the concerns raised regarding our dissection routine, we feel that it is very important to elucidate our anatomic point of view. In an examination of some recent publications of the anterolateral ligament (ALL), it seems as though other important anatomic structures have not received sufficient attention. It was not only Terry et al11 who described the deep fibers of the iliotibial tract (ITT) to be important in controlling the anterior subluxation of the lateral tibial plateau but also Müller,9 Lobenhoffer et al,7 and Hassler and Jakob.4
Terry et al11,13 were the first to associate the deep ITT fibers (namely, the capsulo-osseous layer) with the term...
anterolateral ligament, followed by Vieira et al\textsuperscript{14} in 2007. Confusion may have arisen from the use of different names in the literature: Müller, ligamentum femorotibiale anterius; Lobenhoffer, retrograde fiber bundle; and Hassler and Jakob, ligamentum tractotibiale. These terms have all been applied to what may be described as the femoral attachment of fibrous structures, which are effectively a distal prolongation of the lateral intermuscular septum and which include the Kaplan fibers. All the cited studies found a femoral insertion site at the linea aspera around the distal termination of the intermuscular septum and a tibial insertion site either posterior to the Gerdy tubercle or directly at it. Conversely, the description of the femoral insertion site of the ALL varies widely among authors. Originally, it was reported to be anterior and distal to the lateral femoral epicondyle, and a conjunction to the lateral meniscus was described. These characteristics certainly do not match the descriptions of the capsulo-osseous layer of the ITT. Thus, in accordance with Claes et al,\textsuperscript{1} we believe that the original ALL “is clearly distinct from the ITB, and both its deep layer and its capsulo-osseous layer should not be confused with the ALL.”

Some later descriptions of the ALL,\textsuperscript{2,3,6} however, postulate different insertion sites related to the lateral femoral epicondyle, and it remains unclear whether this “ligamentous” structure is a capsular thickening or an extracapsular structure. Based on the pictures in recent anatomic and biomechanical publications,\textsuperscript{2,6,10} it may be possible that the anterolateral knee capsule (which has a connection to the lateral meniscus) and fibers of the capsulo-osseous ITT layer have been collectively described as this “robust” ALL, having a fanlike tibial insertion site posterior to the Gerdy tubercle (Figure 1). This, of course, raises an important question: why the original terms (capsulo-osseous layer, midthird capsular ligament) have been neither maintained nor adopted. Thus, it seems that the orthopaedic community is lacking a consistent terminology for the anterolateral side of the knee. Some studies may also have been affected by the use of embalmed cadaver specimens.\textsuperscript{1,2} This preservation method has been shown to be unsuitable for the specific layer-by-layer dissection of the lateral side of the knee (Terry et al\textsuperscript{11}; P. Lobenhoffer, personal communication, 2015). Therefore, one should be cautious when interpreting anatomic studies using this embalming technique.

The present study, however, addressed these layered anatomic structures using fresh-frozen cadaver specimens. At least 15 cadaver knee specimens were dissected prior to this study, and the anatomic structures and their insertion sites were evaluated. It was easy to separate the superficial layer of the ITT from the deep/capsulo-osseous layer, as they have completely different insertion sites. All fibers of the superficial layer of the ITT inserting at the Gerdy tubercle were resected, and when these fibers were followed proximally, there was no insertion site at the metaphysis of the femur. As such, they could be completely removed. The superficial layer, which was covering the capsulo-osseous layer, was then peeled off, leaving the more-posterior fibers in place. The next step included resection of the biceps femoris, with all its arms inserting at different locations. Terry and LaPrade\textsuperscript{12} described an anatomic structure called the biceps femoris capsulo-osseous confluens, which connects the biceps femoris tendon with the capsulo-osseous layer. This resection confirmed the presence of the capsulo-osseous layer without any superficial fibers left on it. This dissection technique was adopted and slightly modified from that of Müller\textsuperscript{5}.

The capsulo-osseous layer of the ITT was then resected, to identify the proximal attachments at the linea aspera, and followed distally. Once freed from its proximal attachment, this structure was not adherent with its underlying structures and could be easily followed to its distal insertion site at the area posterior to the Gerdy tubercle. Thus, this structure formed a direct link from the linea aspera of the femur to the tibia, just posterior to the Gerdy tubercle. There was absolutely no doubt that the capsulo-osseous layer was completely separated from its underlying structures. Once these 2 layers had been removed, a large drop in torque was observed in all 16 knees, implying a potent role of the ITT in controlling internal tibial rotation.

Owing to the aforementioned inconsistencies in the descriptions of the ALL, it was necessary to divide the next step into 2 separate cuts. A 4-N m internal rotational torque was applied to identify the tense fibers running obliquely over the lateral collateral ligament (LCL). These were cut representing all ALLs described running superficial to the LCL. The remaining structure, named the mid-third capsular ligament in the early 1970s, was then cut.\textsuperscript{5} This last cut exposed the surface of the lateral femoral condyle, lateral meniscus, and rim of the tibial plateau as far as they have completely different insertion sites. Therefore, the ITT was divided into layers, namely the superficial ITT layer (also described as the biceps femoris capsulo-osseous confluens), the capsulo-osseous layer, and the deep ITT layer (also described as the anterolateral ligament complex) in accordance with the working model introduced by Claes and Jakob.\textsuperscript{7}

Figure 1. The lateral aspect of a left knee: distal to the left, proximal to the right. The anterolateral ligament complex (ALL) is grasped by the forceps close to the femoral attachment, which is 6 to 10 mm proximal and posterior to the lateral epicondyle. The ALL complex passes over the lateral (fibular) collateral ligament and fans out to wrap over the anterolateral rim of the tibial plateau. This exposure followed a longitudinal incision of the posterior edge of the iliotibial tract and anterior reflection of the resulting flap (in upper forceps), with sharp dissection posterior to the Gerdy tubercle, exposing/clarifying the ALL and the lateral collateral ligament.
posteriorly as the LCL, so no fibers could have been left intact across the area identified as being the ALL in all studies that we had seen. These 2 structures directly deep to the ITT, whatever one may consider the ALL, had no significant contribution in controlling internal tibial rotation in this robotic setup. A histologic analysis of the resected structures was not necessary, because every structure could be identified macroscopically.

By a fortunate coincidence, the senior signatory of the letter from Daggett et al, Bertrand Sonnery-Cottet, had arranged to visit our laboratory, and so we took the opportunity to dissect some knees together. We found that we were largely in agreement about the anatomy of the ALL: its course—passing over the LCL; its attachments—posterior/proximal to the lateral epicondyle and midway between the Gerdy tubercle and the head of the fibula; and how it was tightened by tibial internal rotation (see Figure 1). We also saw that the internal rotation laxity increased when the ALL had been transected.

How, then, to explain our difference of opinion regarding the importance of the ALL as a restraint of tibial internal rotation laxity? We believe that this difference has arisen because of our differing methods of study, both anatomic and biomechanical. Anatomically, the structure defined as the ALL complex in Figure 1 is bulkier than the relatively flimsy ALL that had been described at the time when our cutting study started,1,3 which had no connection to the ITT. Some fibers seen here would have been defined as belonging to the deep capsulo-osseous layer of the ITT in our study—which dissected them from the underlying ALL by separating the layers proximal to distal—whereas the preparation in the picture was dissected posterior to the ITT and left the distal attachment around the rim of the tibia. Most biomechanical studies have been based on observations of changes of laxity when the ALL was cut, whereas our study moved the tibia by a fixed amount and measured the reduction of force and/or torque needed after a structure was cut. While changes of laxity are observed during clinical examination and are familiar to surgeons, it is the measurement of changes of load needed to displace the tibia that is necessary to discover the primary and secondary restraints. Use of that method found that the ITT resisted much more of the tibial internal rotation torque than the ALL.

CONCLUSION

The confusion surrounding the anatomy of the anterolateral side of the knee suggests an urgent need for a consistent terminology for these structures, including older descriptions of the deep fibers of the ITT and the joint capsule. It seems that some interpretations of the ALL may describe a structure complex that includes fibers from different anatomic structures. The ALL complex may be found crossing the anterolateral aspect of the knee just proximal/posterior to the lateral epicondyle, over the LCL, and down to the rim of the tibia posterior to the Gerdy tubercle and anterior to the head of the fibula.

Finally, there is no doubt that it is best to study the anatomy by dissecting knees together! We all learned a lot from each other when Bertrand visited us in London, and we have formed a friendly partnership now and are planning to do some experiments on lateral extra-articular soft tissue reconstructions together—une vraie entente cordiale!

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