Editorial Commentary: Knee Anterolateral Ligament Mechanoreceptors: The First Step From Peripheral to Central Nervous System

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Abstract: The mechanoreceptors around the knee are of interest, including those mechanoreceptors related to the anterolateral ligament. Histopathologic evaluations of mechanoreceptors are the first steps in understanding the exact sensorimotor system of the extremities. Many studies have shown these mechanoreceptors, but more electrophysiologic studies are needed to make sense of the reported phenomena.

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There is still debate by some researchers concerning the anterolateral ligament (ALL), but the results reported in the recent article "Study of the Nerve Endings and Mechanoreceptors of the Anterolateral Ligament of the Knee" by Ariel de Lima, Helito, Lacerda de Lima, Dias Leite, and Costa Cavalcante[1] constitute 1 step forward in the analysis of the mechanoreceptors in ALL. Type 1, Ruffini endings, and type 4, free nerve endings, were found in ALL, and the sensorimotor role of ALL was proved.[1]

The sensorimotor system of the knee is important but did not receive much attention until Schultz et al.[2] first described the mechanoreceptors in the human anterior cruciate ligament (ACL). In the past 5 decades, anatomic studies have mainly focused on origin and insertion points of ligaments and tendons around the knee, yet study of the close relation with sensorimotor system is relatively new. First, the sensorimotor function of central ligaments and their function in coordinating muscles around the knee were evaluated. Without organization of the agonist and antagonist muscles that cross the knee joint, even bipedal walking could be difficult. For example, the mean ultimate load of native ACLs is around 2160 N, but during squatting, anterior translation force could be up 5.5 times body weight, which corresponds to nearly twice this ultimate load.[3] Electrophysiologic studies have shown that there is an activating stimulus from the ACL to the quadriceps muscle and an inhibitory stimulus to the biceps femoris muscle. Similarly, the posterior cruciate ligament has an inhibitory effect on quadriceps and calf muscles but stimulate the biceps femoris muscle.[4] Via this coordination, the harmony of the walking process can be achieved; however, it is not only the cruciate ligaments that facilitate this process. The other ligaments, capsules, and tendons around the knee are also active parts of this system. Within this coordination, the muscle function could be achieved through peripheral impulses collected from mechanoreceptors transferred to the spinal cord via synaptic reflexes. Mechanoreceptors are the first step in this pathway. Mechanoreceptors were previously observed in many different joints from the thumb to lumbar discs,[5,6] yet De Lima et al.[1] are the first researchers to evaluate the ALL for mechanoreceptors.

Even though the ALL was first described by Segond[7] in the 1970s, the recent anatomic studies laid out the function of the ALL. Specifically, the ALL lies between the midpoint of the Gerdy tubercule and the fibular head on the tibial side and the lateral femoral condyle on the femoral side and may extend to the lateral meniscus. The ALL controls pivot shift and prevents anterolateral subluxation of the proximal tibia during flexion and internal rotation.[8] Caterine et al.[9] not only described the function of the ALL biomechanically but also demonstrated its role in proprioceptive function in

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rotational stability. This was one of the first studies about ALL to ever mention its proprioceptive function. De Lima and colleagues close the gap here with their study. They investigated the mechanoreceptors of ALL and found that these were type I and IV receptors according to Freeman and Wyke. Type I receptors, Ruffini endings, govern the control of joint position, are sensitive to axial and tensile loading, and have a role in regulating joint stiffness by controlling the muscles surrounding the joint.[10,11] They become active with tightening of the collagen bundles around them. The ALL tightens with internal rotation, and the mean length increases from 3.6 mm at 30° to 9.9 mm at 90° of flexion.[12] It did not surprise me that De Lima et al.[1] found Ruffini endings in the ALL. It is possible that internal rotation tightened the ALL and Ruffini endings activate to limit the rotation and translation. We need electrophysiologic studies to evaluate this function.

Another interesting finding of this study is that De Lima et al.[1] found ALL extensions to the anterior horn and body of the lateral meniscus. The lateral meniscus is more mobile than the medial meniscus, and therefore a control mechanism is needed to prevent lateral meniscus from impinging between the tibia and the femur. On the posterolateral side, the popliteus tendon is responsible for this function.[13] With extensions of the popliteus tendon to the lateral meniscus, the flexion is facilitated. Similarly, on the anterolateral side, the ALL could be responsible for this action via extensions to the anterolateral part of the lateral meniscus.

During an evaluation of mechanoreceptors, the type of histologic study is also important. Immunohistologic studies with S100, neurofilament protein, nerve growth factor (NGF), and protein gene product (PGP) 9.5 antibodies are common, but there is still no consensus on how the specimens would be evaluated. Repeatability of the process is important, but many factors could affect this. First, immunohistologic studies are expensive and the total cost is not affordable if more than 1 antibody is used. The second difficulty is the sectioning technique: although mechanoreceptors are frequently located near bony insertions, they could lie through the entire ligament, and, thus, the whole ligament has to be analyzed, which could alter the analysis. De Lima et al.[1] used confocal microscopy with the immunofluorescence method. This is a good way to analyze mechanoreceptors because it can help determine both quantitative values and morphology of mechanoreceptors. It is difficult to analyze the morphology in 3- to 4-μm-thick sections because the mechanoreceptors are much larger than the thickness of each section. For example, a Ruffini ending is nearly 50 μm in diameter and 150 μm in length. To solve this problem, serial sections could be needed to define the exact morphology of the mechanoreceptor, but in confocal immunofluorescence microscopy, section thickness is nearly 50 μm and a virtual 3-dimensional image could be obtained. This is one of the strong points in the methodology of the study by De Lima et al.[1]

I enjoyed reading their study because of their strong hypothesis and detailed methodology, and they provide valuable results that show the role of the ALL in the sensorimotor system. However, we have to work hard to map the exact sensorimotor pathways from mechanoreceptors, which are terminal branches of the peripheral nervous system to the central nervous system, by combining anatomic studies with electrophysiologic studies.

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