The Biceps Femoris Tendon and Its Functional Significance*

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Numerous clinical and experimental investigations on medial, anterior, and rotatory instability of the knee have been reported in recent years [1,2,4,9,11,12]. Lateral instability, however, has received less attention because of the lower frequency of injuries of the lateral structures. The stabilizing functions of the lateral collateral ligament, the iliotibial tract, the popliteal tendon, and the lateral joint capsule have been discussed in the literature [1,4-7,10]. The role of the biceps femoris tendon has not been well described nor is its detailed anatomy universally appreciated.

Sneath described the biceps femoris insertion as an extensive, laminated, fan-shaped tendon inserted into the head of the fibula, the lateral ligament of the knee, and the lateral tibial condyle with expansions to the crural fascia covering the anterior, lateral, and posterior compartments of the leg. However, he did not discuss the mechanical or functional role of the biceps in relation to other structures on the lateral aspect of the knee.

Kaplan [7] studied the comparative anatomy of the iliotibial tract and biceps femoris in lower animals and discussed the importance of its attachments in man. He found that, in most of the lower animals studied, the insertion of the biceps femoris formed a wide sheet over the entire lateral aspect of the knee and passed over the head of the fibula and lateral tibial tuberosity without attaching to either of these structures. With ascent of the evolutionary scale, the tendon receded in size and functional importance and had more proximal bone and ligamentous attachments. Kaplan therefore de-emphasized the role of the biceps tendon as a lateral stabilizer in man while stressing the importance of the iliotibial tract. Duchenne thought the biceps femoris was important as an external rotator of the knee and leg.

In recent studies Kennedy [8] thought that the major supports for lateral stability of the knee are the biceps and popliteal tendons, but their relative importance could not be determined. The capsule and the iliotibial band also contributed to lateral support. However, the clinical problem of lateral instability remains unexplained, partially because, in our opinion, the anatomy of the biceps femoris, its relationship to other structures, and its functional importance are inadequately portrayed in the cited studies. Therefore we tried to explore in detail the various components of the insertion of the biceps tendon and to correlate the anatomical findings with the functions of these components.

Materials and Methods

Twenty-one cadaver knees and ten fresh knees were dissected. The cadaver knees were obtained from the Department of Anatomy, Cornell University Medical

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College. The fresh knees were obtained from the Pathology Department of the New York Hospital-Cornell University Medical Center. There was neither soft-tissue nor bone involvement, or other lesions in or around the knee joint in any of the specimens. The knees were transected approximately twenty centimeters above and below the joint level, leaving the musculotendinous and ligamentous structures intact. After completion of the dissection, each knee was taken through various ranges of motion in an attempt to associate the functional relationships between the insertions and other structures.

Results

Our dissections revealed the following: The fleshy fibers of the long head of the biceps started to form a broad, flat tendon about seven to ten centimeters above the level of the knee joint. The short head of the biceps joined the tendon of the long head on its undersurface, remaining fleshy almost to the fibular head, at which point the two heads joined to form a short, thick common tendon. Beyond this point it was difficult to determine consistently from which head the various layers arose. This is in accord with the observations of Sneath.

The common biceps tendon passed downward and forward and, just before it reached the collateral ligament, the tendon split into three layers—superficial, middle, and deep. The superficial layer was lateral to the lateral collateral ligament, the middle surrounded it, and the deep layer was medial and deep to the lateral collateral ligament. These layers were always present but varied in thickness and extent in the individual knees.

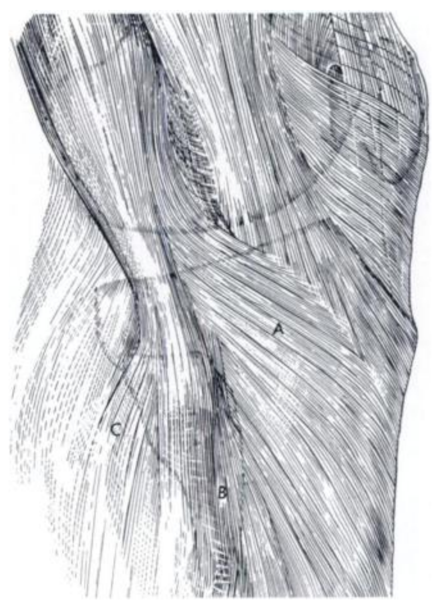

FIG. 1

Sketch of the superficial layer demonstrating the three expansions: anterior *(A)*, middle *(B)*, and posterior *(C)*. The deep anterior fibers to the tubercle of Gerdy cannot be seen. Note the size and distal extent of the anterior expansion.

The superficial layer formed three expansions: (1) anterior, (2) middle, and (3) posterior (Fig. 1). The anterior expansion was thin and sheetlike. It extended forward superficial to the lateral ligament of the knee and fanned out to blend with the anterior crural fascia (Fig. 2). This expansion was consistently very strong. Its direction was similar to that of the pes anserinus muscles medially. It passed down the leg

FIG. 2

FIG. 3

Fig. 2: Superficial layer of the common biceps tendon demonstrating the expansions: anterior *(A)*, middle *(B)*, and posterior *(C)*.

Fig. 3: The deep anterior fibers *(D)* of superficial layer beneath the tibialis anticus muscle *(E)* inserting into the tubercle of Gerdy. Knee in extension.

as far as fifteen centimeters in some cases. It also sent some fibers deep and anteriorly which reached the tubercle of Gerdy (Fig. 3) deep to the muscles of the leg. This portion could not be evaluated unless the anterior tibial muscle was stripped distally. In combination with the deep layer to the same site, it was most often stronger than the insertions into the fibula. The middle expansion of the superficial layer spread on the surface of the lowest part of the collateral ligament and the head of the fibula and blended with the fascia over the peroneal muscles of the leg (Figs. 1 and 2). Some of its deep fibers inserted into the lateral surface of the head of the fibula. The posterior expansion extended inferiorly and blended with the fascia over the calf muscles (Figs. 1 and 2).

The middle layer of the common biceps tendon was a thin, poorly defined layer which surrounded approximately the distal fourth of the collateral ligament like a sling (Figs. 5 and 6). As this layer split to surround the lateral ligament, it was separated from the ligament laterally, anteriorly, and medially by a bursa. In every case, there was a fibrous attachment into the posterior border of the lateral collateral ligament. This could always be separated by careful dissection and demonstrated different fiber direction from the lateral collateral ligament. The fibers at the lateral collateral ligament did not join into a common insertion, but the fibrous connection created a secure linear attachment.

The deep layer of the common biceps tendon bifurcated and had a fibular and tibial attachment. This bifurcation was cephalad to the head of the fibula. The distance of the bifurcation from the head of the fibula was variable. In eighteen knees the bifurcation was very low, just above the head of the fibula, twelve tendons bifurcated about two centimeters above the head of the fibula, and in one case the bifurca-

FIG. 4 FIG. 5

Fig. 4: Dissection of superficial layer with the knee flexed. Note the laxity of the fibular insertion *(D)*, the lateral collateral ligament *(A)*, and the direction, size, and tension of the tibial attachment of the tendon *(C)*.

Fig. 5: Dissection showing middle layer of the common biceps tendon *(B)* attaching to and surrounding the lateral collateral ligament *(A)*. Forceps are retracting the biceps tendon distally.

tion was high, about five centimeters above the head of the fibula. The tibial attachment was the tubercle of Gerdy. The fibular attachment was into the styloid process of the fibula and into the upper surface of the head deep to the distal attachment of the lateral collateral ligament (Figs. 7 and 8). An extension of this layer passed across the upper surface of the tibiofibular syndesmosis, strengthening its anterior capsule and inserting into the anterolateral aspect of the tibia. This extension, the tibial portion, and the portion from the superficial layer combined to form a well defined, strong, anterior attachment. In addition, one or more well developed extensions passed into the posterolateral aspect of the knee joint capsule. There was also a direct insertion into the posterior aspect of the tibia.

As the biceps tendon descended distally, it was readily distinguished from the iliotibial band. However, with progression distally and toward the joint, a fibrous attachment between the two became more prominent. At five to seven centimeters above the joint, a distinct, broad, fibrous band sweeping anteriorly could be distinguished.

As described for the insertions of the middle layer, the biceps tendon did not insert directly into the lateral collateral ligament. However, it was connected by a fibrous attachment posteriorly into the lateral collateral ligament. There was a loose, sling-like fascial connection around the ligament anteriorly, medially, and laterally separated from the lateral collateral ligament by a bursa for varying distances above the fibular head. The lateral collateral ligament was a single structure except in one case in which it bifurcated 1.5 to two centimeters above the fibula; two limbs inserting into the fibular head were separated by part of the superficial layer of the biceps tendon.

In knees in which there was a low bifurcation of the tibial attachment of the

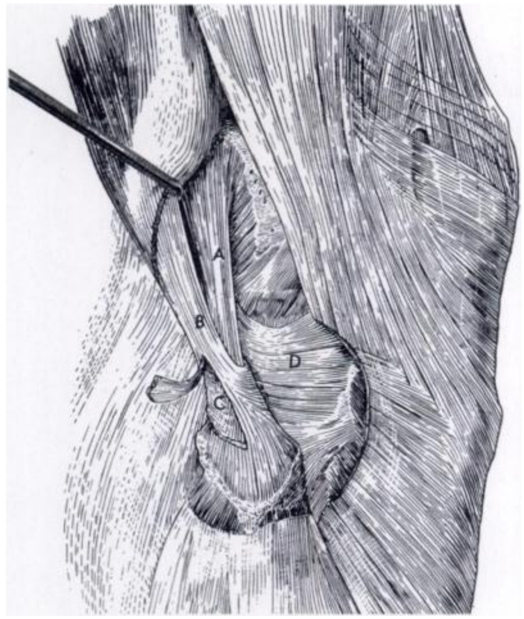

FIG. 6

Sketch of the middle layer *(B)* demonstrating the sleeve-like relation of the middle layer to the lateral collateral ligament *(A)*. Notice the fibrous attachment to the posterior aspect of the lateral ligament *(C)* and the deep layer *(D)*.

deep layer, it was difficult to distinguish the anterior tibiofibular ligament as a separate band because it was intimately fused with the biceps tendon (Fig. 8). In the case in which the biceps tendon bifurcation was quite high above the fibula, the attachment of the biceps tendon to the tibia was separated from the syndesmosis of the tibiofibular joint.

FIG. 7 FIG. 8

Fig. 7: Dissection showing the anterior attachment of the deep layer of the biceps femoris tendon to the tubercle of Gerdy *(B)* (arrows demonstrate extremes). Note that the extension is deep to the lateral ligament *(A)* of the knee.

Fig. 8: Sketch illustrating the relationship of the deep layer of the biceps femoris to the lateral ligament *(A)* of the knee. Note the anterior attachment of the tendon to the tubercle of Gerdy *(B)*.

Functional Relationship of the Biceps Femoris Tendon to Lateral Structures

The leg and thigh stumps were manipulated manually and observations were made on the various layers.

When the superficial layer was pulled, flexion, lateral rotation, and tension of the anterior expansions over the muscles of the leg were produced.

As the knee was flexed, the middle layer exerted backward pull on the lateral collateral ligament, bowing it posteriorly. This aided in keeping the lateral collateral ligament taut and it tended to slacken during flexion.

When the biceps tendon was pulled, flexion of the knee was produced and the tendon receded from the knee joint region. In doing so, it pulled on the knee joint capsule through its deep insertions, preventing impingement of the capsule between the tibia and femur. The tendon also became directly aligned with its anterior tibial attachment as the leg progressed posteriorly and the fibular attachment slackened (Fig. 4).

At the level of attachment of the biceps femoris tendon with the iliotibial band, pull on the biceps tendon, with the knee in flexion, caused the iliotibial tract to be pulled backward over the knee joint like a fan-shaped hood. It was interesting to note that the iliotibial tract was relatively taut in all positions; however, it was tightest at about 10 to 30 degrees of flexion.

The lateral collateral ligament was normally taut only in extension and became progressively slack as flexion progressed beyond 10 to 30 degrees. The posterior pull of the biceps on the ligament compensated somewhat for this slack, keeping some tension on the ligament but much less than in full extension. The collateral ligament and iliotibial band complemented each other; when the ligament was maximally taut the iliotibial band was somewhat slack, and when the iliotibial band was maximally taut the ligament was somewhat slack.

Discussion

In our studies we agree with both Kaplan [4,5,7] and Sneath regarding the lamination of the biceps femoris tendon. Kaplan [7] de-emphasized the functional role of the biceps expansions in man. We, on the other hand, are emphasizing the functional role of these expansions. Again, we do not agree with Sneath regarding the arrangement of the expansions and their origin from either the short or long head of the biceps femoris.

The superficial expansion in all but one specimen was extremely broad, long, and continuous down the lateral side of the leg. This expansion has been described before, but its strength and importance as a flexion lever and external rotator of the leg have been neglected. We believe that this attachment is the major force responsible for external rotation. Duchenne was the only author who described the biceps as an external rotator, and this expansion creates a plausible explanation. In contrast to Kaplan [7], we feel that the evolution of the biceps complex to its bone insertions have made it functionally more important.

The functional role of the strong fascial connection of the biceps to the lower iliotibial band may be to keep the lower portion of the iliotibial tract taut in various degrees of flexion; this portion of the band is fixed to the intermuscular septum above on the femur and the tibia below. In testing cadaver knees, Kennedy [8] noted that the iliotibial tract could be ruptured in 10 to 15 degrees of flexion and internal rotation. We found the biceps tendon aids in keeping the iliotibial tract tight during flexion of the knee. This is important if one considers that flexion is the functional position of the knee. In our studies, the iliotibial tract was tightest in 10 to 30 degrees of flexion; it may be most vulnerable to injury in this position. The biceps attachment to the iliotibial tract may actively furnish support via these connections.

The contribution of the biceps tendon to stability can also be demonstrated by its strong and complex tibial attachment. There has been very little attention directed at this most consistent and important part of the biceps insertion. The attachment becomes tight as the knee goes into flexion greater than 30 degrees. While Kennedy [9] noticed that the iliotibial band ruptures at 10 to 15 degrees, we have recently noticed several clinical cases of avulsion of the biceps tendon with intact iliotibial bands. It is interesting to note that these injuries occur during flexion of the knee. Therefore, it is reasonable to assume that the lack of predictibility with which structures rupture and their sequence of rupture may be related to the degree of flexion, contraction of the biceps, and tension exerted on the iliotibial band.

The middle layer is intimately connected with the lateral collateral ligament, but we did not find a direct insertion as described by Sneath, but a separable fibrous connection. However, an injury to either the lateral collateral ligament or the biceps tendon would invariably involve both structures. This connection may aid in keeping the lateral collateral ligament tight as the knee progresses in flexion, thereby contributing to knee stability.

The capsular attachment of the deep layer has not been emphasized in the literature. It did not seem to be a supporting structure but it contributed significantly to the posterior pull of the capsule as the knee was bent, preventing capsular impingement and thus keeping the capsule taut, allowing the capsule to contribute to stability as well. The deep layer also had a posterior tibial attachment much like that of the semimembranosus medially.

Summary

Thirty-one knees were dissected to determine the detailed anatomy of the biceps tendon. Findings regarding the expansions of the superficial, middle, and deep layers of the tendon, and the insertions, differed from previous descriptions. The possible functional contributions of the biceps tendon to lateral knee stability were determined. The most important is the support furnished by the direct tibial attachment of the superficial and deep layers as the knee progresses in flexion.

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