The Anatomy of the Posterior Aspect of the Knee

An Anatomic Study

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Background: The orthopaedic literature contains relatively little quantitative information regarding the anatomy of the posterior aspect of the knee. The purpose of the present study was to provide a detailed description of, and to propose a standard nomenclature for, the anatomy of the posterior aspect of the knee.

Methods: Detailed dissection of twenty nonpaired, fresh-frozen knees was performed. Posterior knee structures were measured according to length, width, and/or distance to reproducible osseous landmarks.

Results: The semimembranosus tendon had eight attachments distal to the main common tendon. The main components were a lateral expansion to the oblique popliteal ligament; a direct arm, which attached to the tibia; and an anterior arm. The oblique popliteal ligament, the largest posterior knee structure, formed a broad fascial sheath over the posterior aspect of the knee and measured 48.0 mm in length and 9.5 mm wide at its medial origin and 16.4 mm wide at its lateral attachment. It had two lateral attachments, one to the meniscofemoral portion of the posterolateral joint capsule and one to the tibia, along the lateral border of the posterior cruciate ligament facet. The semimembranosus also had a distal tibial expansion, which formed a posterior fascial layer over the popliteus muscle. A thickening of the posterior joint capsule, the proximal popliteus capsular expansion, which in this study averaged 40.5 mm in length, connected the posteromedial knee capsule at its attachment at the intercondylar notch to the medial border of the popliteus musculotendinous junction. The plantaris muscle, popliteofibular ligament, fabellofibular ligament, and semimembranosus bursa were present in all specimens.

Conclusions: The anatomy of the posterior aspect of the knee is quite complex. This study provides information that can lead to further biomechanical, radiographic imaging, and clinical studies of the importance of these posterior knee structures.

In our referral sports medicine practices, we have treated a number of injuries involving the posterior structures of the knee that have been associated with pain and functional genu recurvatum instability. In an attempt to better understand these injuries, we found that the literature provides little quantitative information on posterior knee anatomy and no magnetic resonance imaging studies of these structures. After several dissections of fresh knee specimens revealed that the oblique popliteal ligament was attached to the lateral capsule rather than to the lateral femoral condyle as has been described in several articles[1-4], and after observing that sectioning of this structure caused an observable increase in genu recurvatum, we conducted a thorough literature review of this topic.

The anatomy of the posterior aspect of the knee is a complicated network of dynamic and static stabilizers. Central to its function and structure are the multiple attachments of the semimembranosus and popliteus muscles. Our literature review was complicated not only by competing vocabularies but also by descriptions that detailed a wide range of findings in both the number of structures and the location of their attachments[1,2,5-14]. Little attention was paid to the size of these structures, their relationships to surrounding anatomy, and their attachment sites.

It is critical to have an accurate description of these posterior knee structures not only to facilitate the analysis of their functional role through biomechanical studies but also to iden-

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TABLE I Quantitative Relationships of the Osseous and Soft-Tissue Posterior and Distal Attachments of the Semimembranosus Muscle at the Knee

Relationship	Measurement* *(mm)*
Main semimembranosus tendon	
Width at bifurcation	11.9 (9.0 to 15.0)
Width of lateral tendinous expansion contributing to oblique popliteal ligament	7.6 (6.0 to 10.0)
Direct arm	
Distance distal to posterior joint line	11.6 (5.0 to 16.0)
Width at tibial attachment	21.6 (17.0 to 26.0)
Proximal posterior capsular arm	
Distance between edge of proximal attachment to attachment of posterolateral meniscofemoral capsule on lateral femoral condyle	6.8 (1.0 to 15.0)
Distance from inferior border along perpendicular line to the lateral edge of the posterior cruciate ligament facet	15.2 (12.0 to 21.0)
Distal tibial expansion	
Length of medial division	107.5 (86.0 to 134.0)
Length of lateral division	107.3 (89.0 to 132.0)

*The values are given as the mean, with the range in parentheses.

tify normal and injured structures on magnetic resonance imaging scans in order to determine the etiology of functional problems in patients. Therefore, the present study was conducted to clarify these questions by providing a qualitative and quantitative analysis and to propose a standard nomenclature for the individual anatomic structures of the posterior aspect of the knee.

Materials and Methods

Twenty nonpaired, fresh-frozen cadaveric knees with no evidence of previous injury, surgery, or cachexia were utilized for the present study. The average age of the donors at the time of death had been 59.2 years (range, forty-three to seventy-six years). The dissections consisted of identification of the posterior structures of the knee that were located between the posterior borders of the posterior oblique ligament and the tibial course of the superficial medial collateral ligament medially and the medial border of the long head of the biceps femoris and fibula laterally. All structures anterior (deep) to the medial and lateral heads of the gastrocnemius were preserved and identified, except that the neurovascular bundle and the common peroneal nerve were removed. We chose to remove the neurovascular structures because we could not accurately identify and measure the relationships among the posterior knee structures with them still present.

The oblique popliteal ligament and the structures confluent with it were dissected first. The distal attachments of the semimembranosus were identified, and their dimensions were noted. The location of other individual structures and attachments were identified, and the distance from the major structures (measured to the nearest 0.5 mm) to selected osseous landmarks (the midportion and/or lateral border of the posterior cruciate ligament facet, the posterior articular surfaces of the tibial plateaus, and the attachment of the posterior capsule on the femur) was measured with a dial caliper with measurement accuracy to 0.01 mm (L.S. Starrett, Athol, Massachusetts).

Once the superficial posterior structures were measured, the deeper semimembranosus bursa was identified

TABLE II Quantitative Measurements of the Oblique Popliteal Ligament

Relationship	Distance* *(mm)*
Length from medial origin to proximal lateral attachment	48.0 (43.0 to 55.0)
Width at medial origin	9.5 (7.0 to 13.0)
Width along line perpendicular to midportion of posterior cruciate ligament facet on proximal posterior tibia	10.4 (7.0 to 14.0)
Width at lateral attachment	16.4 (14.0 to 20.0)
Distance from attachment of meniscofemoral posterolateral capsule on femur distally to the proximal lateral attachment of oblique popliteal ligament	19.0 (16.0 to 29.0)

*The values are given as the mean, with the range in parentheses.

and the distance between the tibial attachment of the direct arm of the semimembranosus and the proximal edge of the medial tibial plateau at the joint line was measured. The presence of a plantaris muscle, fabellofibular ligament, popliteofibular ligament, and a palpable fabella was also recorded. Deeper dissection (to include the functional bundles of the posterior cruciate ligament and the posterior meniscofemoral ligaments) was not performed.

Results

Individual posterior knee structures are described below and are grouped into complexes where appropriate. The measurements that are presented are the averages for all structures (Tables I, II, and III).

Posterior Semimembranosus Complex

Dissection of the posterior aspect of the knee revealed eight consistent posterior attachments of the semimembranosus muscle distal to the main common tendon at the knee: a direct arm, a lateral tendinous expansion off the main common tendon that contributed to the oblique popliteal ligament, an attachment to the coronary ligament of the medial meniscus, the oblique popliteal ligament, a proximal posterior capsular arm, a distal tibial expansion, an anterior arm, and the components (capsular, tibial, and superficial arms) of the posterior oblique ligament (Fig. 1 and Table I).

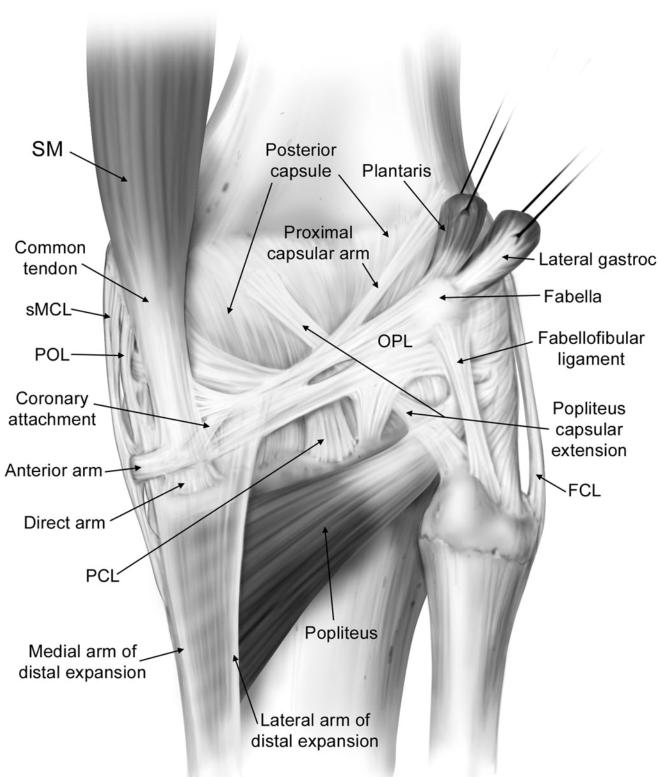

Fig. 1

Illustration of the posterior aspect of a right knee with medial and lateral gastrocnemius complexes and neurovascular structures removed. SM = semimembranosus muscle, sMCL = superficial medial collateral ligament, OPL = oblique popliteal ligament, FCL = fibular (lateral) collateral ligament, Lateral gastroc = lateral gastrocnemius, POL = posterior oblique ligament, and PCL = posterior cruciate ligament.

TABLE III Quantitative Relationships of the Proximal Popliteus Capsular Expansion

Relationship	Measurement* *(mm)*
Length (popliteus musculotendinous junction to posteromedial capsular attachment on femur)	40.5 (36.0 to 46.0)
Width at popliteus attachment	4.5 (3.0 to 6.0)
Width at posteromedial capsular attachment on femur	3.9 (3.0 to 6.0)

*The values are given as the mean, with the range in parentheses.

Two centimeters proximal to its bifurcation into the direct and anterior arms at the posterior aspect of the medial tibial plateau, the main common tendon of the semimembranosus was 11.9 mm wide (Fig. 2). Just prior to this bifurcation, a lateral tendinous expansion from the main common tendon continued on to form the oblique popliteal ligament. The main portion continued on to form the direct arm, which coursed distally and expanded to attach to an osseous prominence, the tuberculum tendinis, on the proximal part of the posteromedial aspect of the tibia, 11.6 mm distal to the joint line at the posterior medial tibial plateau. The direct arm fanned out at this point to form a broad U-shaped convex distal attachment on the proximal posteromedial tibia. Just prior to its tibial attachment, the direct arm attached to the posterior aspect of the coronary ligament (the meniscotibial portion of the posterior capsule) of the posterior horn of the medial meniscus.

The semimembranosus bursa formed just proximal to the attachment of the direct arm on the tibia and was present in all knees. Its lateral aspect was sandwiched between the direct arm attachment to the coronary ligament and the direct arm attachment to the tibia. The medial aspect of the semimembranosus bursa surrounded the anterior arm of the semimembranosus.

An anterior arm of the semimembranosus was noted in all specimens (Fig. 2). It was a thick anteromedial tendinous expansion off the bifurcation of the distal aspect of the main common tendon of the semimembranosus, which originated just proximal to the tibial attachment of the direct arm. Its origin was within the medial edge of the semimembranosus bursa, and it attached deep to the proximal tibial attachment site of the superficial medial collateral ligament.

The oblique popliteal ligament was formed at its medial aspect by a confluence of the lateral expansion off the semimembranosus common tendon (distally) and the capsular arm of the posterior oblique ligament (proximally)[8] (Fig. 3). It continued laterally as a broad fascial band over the posterior aspect of the knee. Two distinct lateral attachments of the oblique popliteal ligament were identified. The oblique popliteal

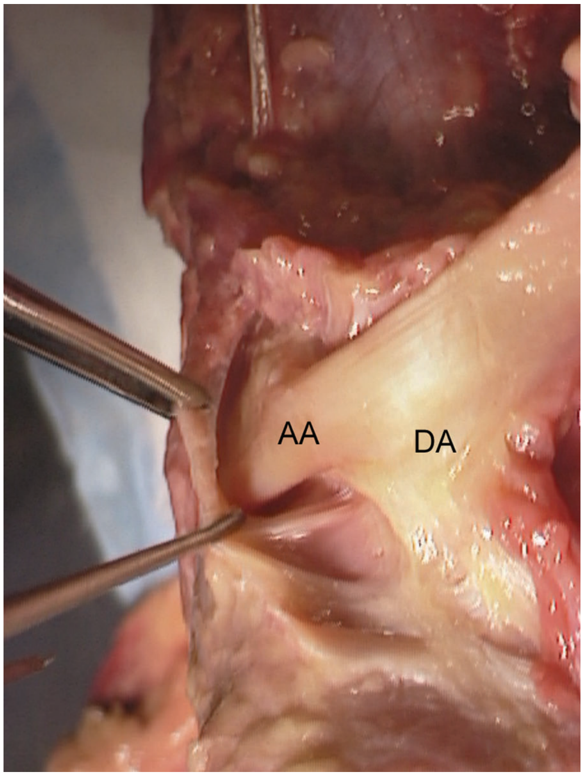

Fig. 2
Posteromedial view of the right knee. The main common tendon of the semimembranosus muscle bifurcates into the anterior arm (AA) and the direct arm (DA). The anterior arm, located medially within the semimembranosus bursa, courses anterolateral and deep to the superficial medial collateral ligament (retracted).

ligament measured 9.5 mm wide at its medial junction, 10.4 mm wide at the midportion of the posterior cruciate ligament facet on the posterior part of the tibia, and 16.4 mm wide at its proximal lateral attachment (Table II). The average length of the oblique popliteal ligament was 48.0 mm from its medial origin to its proximal lateral attachment.

The proximal lateral attachment of the oblique popliteal ligament was to an osseous or cartilaginous fabella (the fabella was palpable in all cases, but radiographs were not made to distinguish between the two types), the meniscofemoral portion of the posterolateral joint capsule, and a plantaris muscle in all twenty knees (Fig. 3). On the average, the proximal lateral attachment of the oblique popliteal ligament was 19.0 mm distal to the proximal attachment of the meniscofemoral portion of the posterolateral joint capsule on the posterior part of the femur. There was no direct attachment of the oblique popliteal ligament to the posterior aspect of the lateral femoral condyle in any knee. In addition to its proximal lateral attachment, the oblique popliteal ligament also had a fibrous distal lateral attachment to the lateral aspect of the posterior cruciate ligament facet on the posterior part of the tibia, which was just lateral to the posterior cruciate ligament and distal to the posterior root attachment of the lateral meniscus.

A proximal posterior capsular arm of the semimembranosus, a fine fascial aponeurosis that coursed along the superior border of the oblique popliteal ligament, blended laterally with the posterolateral joint capsule and the adipose and fine fascial tissues at the posterolateral aspect of the distal part of the femur (Fig. 4). It also extended to the posterior and medial portion of the short head of the biceps femoris. The lateral aspect of this proximal posterior capsular arm attached at an

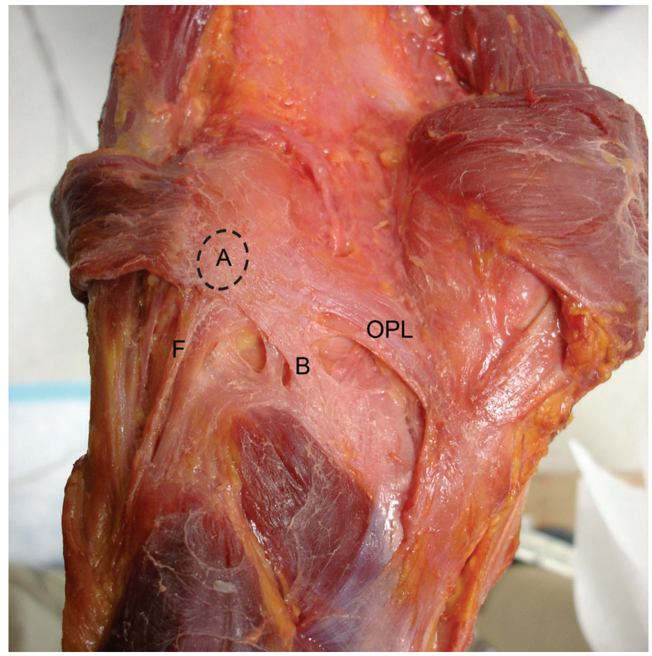

Fig. 3
Posterior view of the left knee, with the plantaris and gastrocnemius muscles removed. The oblique popliteal ligament (OPL) and its proximal lateral (A) and distal lateral (B) attachments are noted. The fabella (outlined by broken line) and the fabellofibular ligament (F) are also noted.

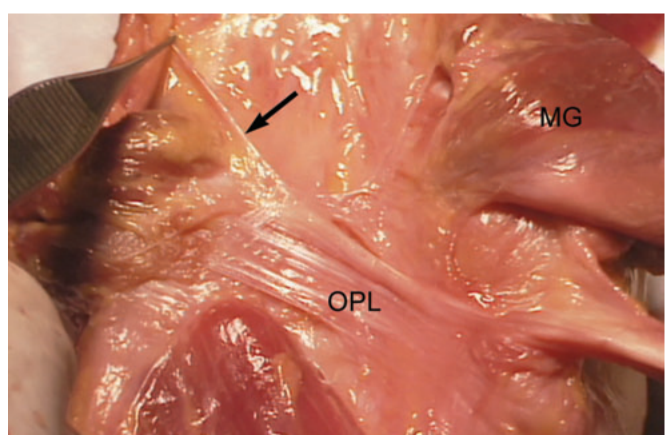

Fig. 4
Posterior view of the left knee. The proximal posterior capsular arm of the semimembranosus (arrow) is located proximal to the proximal edge of the oblique popliteal ligament (OPL). MG = medial head of the gastrocnemius muscle.

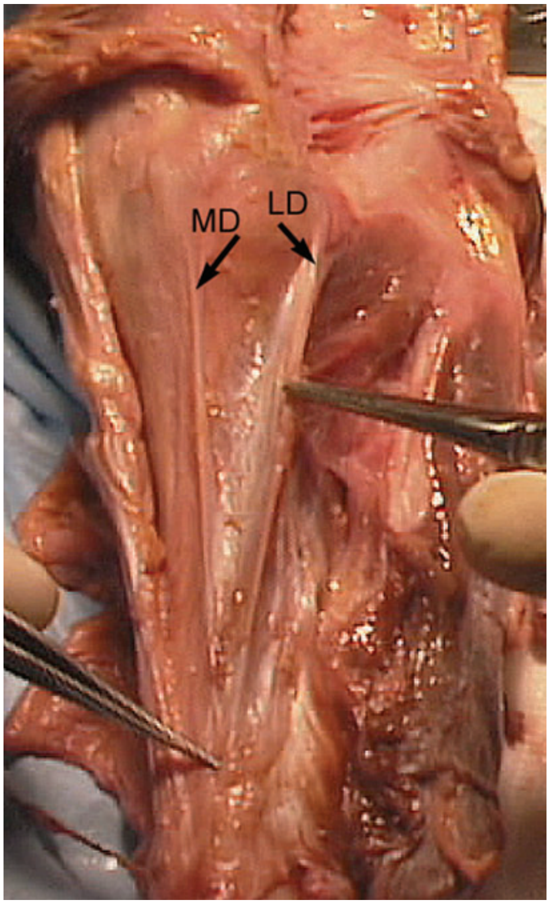

Fig. 5
Posterior view of the right knee. The medial (MD) and lateral (LD) divisions of the distal tibial expansion of the semimembranosus muscle are connected by a thin fibrous layer, which covers the popliteus muscle.

average of 6.8 mm proximal to the meniscofemoral lateral capsular attachment on the posterior part of the femur (Table I). This structure was thin and had multiple fine fascial attachments to the posterior joint capsule and the proximal border of the oblique popliteal ligament.

A distal tibial expansion of the semimembranosus muscle, comprising two connected but distinct medial and lateral divisions, was also present and formed a posterior fascial expansion over the popliteus muscle (Fig. 5). The proximal attachments of the medial and lateral divisions were to the coronary ligament, on either side of the direct arm of the semimembranosus, at the level of the posterior horn of the medial meniscus. The medial and lateral divisions of the distal tibial semimembranosus expansion coursed distally and joined together at the distal aspect of the popliteus muscle on the posteromedial border of the tibia. The medial division coursed just posterior to the posterior border of the tibial collateral ligament and was also connected to the distal aspect of the superficial arm of the posterior oblique ligament[8]. A thin fascial layer, which connected the medial and lateral divisions of the distal tibial semimembranosus expansion in a somewhat triangular shape, covered the posterior aspect of the popliteus muscle (Fig. 5).

Capsular Defect of the Posteromedial Joint Capsule

A variably sized capsular defect in the meniscofemoral portion of the posteromedial joint capsule, located proximal to the direct arm of the semimembranosus and distal to the medial head of the gastrocnemius attachment on the posteromedial capsule, was present in eighteen of the twenty knees (Fig. 6). The specific dimensions of this capsular defect were not measured because of its variable size and our dissection methods. In the other two knees, a visible translucent thinning of the capsule was present in this same area.

Posterior Popliteus Complex

A posterior capsular thickening that extended from the medial aspect of the popliteus musculotendinous junction to the posteromedial posterior joint capsule attachment at the posterior aspect of the intercondylar notch was noted in all knees (Fig. 7). We have termed this the proximal popliteus capsular expansion because it was a capsular thickening that extended proximally from the popliteus musculotendinous junction. The proximal popliteus capsular expansion was 40.5 mm long and passed anterior (deep) to the oblique popliteal ligament along its course (Table III). This expansion was in continuity with and parallel to the popliteofibular ligament attachment at the popliteus musculotendinous junction and qualitatively was noted to become tightened when the popliteofibular ligament was tensioned.

A fabellofibular ligament, which has been defined as the distal edge of the capsular arm of the short head of the biceps femoris[15-17], was identified in all twenty knees in the course of the superficial dissection (Fig. 3). Deep to the fabellofibular lig-

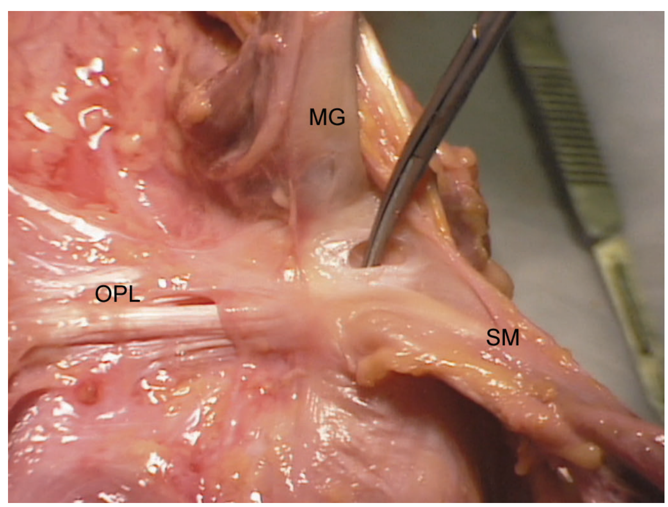

Fig. 6
Posterior view of the left knee. The posteromedial knee joint capsular defect (hemostat) can be located distal to the medial head of the gastrocnemius (MG) attachment on the posterior capsule and proximal to the direct arm attachment of the semimembranosus. OPL = oblique popliteal ligament, and SM = common tendon of semimembranosus (reflected distally).

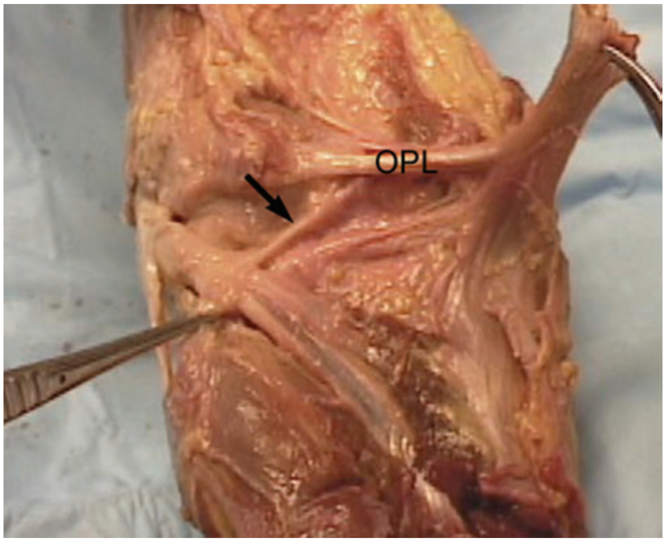

Fig. 7
Posterior view of the left knee. The proximal popliteus capsular expansion (arrow) is a capsular thickening between the medial aspect of the popliteus musculotendinous junction and the posteromedial joint capsule attachment at the posteromedial intercondylar notch. The popliteofibular ligament is held by the forceps. OPL = oblique popliteal ligament.

ament, a popliteofibular ligament[15,17] was also identified in all twenty knees. The popliteofibular ligament originated at the lateral edge of the popliteus musculotendinous junction and attached to the medial aspect of the fibular styloid[15,17]. A quantitative assessment of the anatomy of the popliteofibular ligament has already been performed[15] and was not repeated for the present study.

Discussion

To our knowledge, a detailed quantitative and qualitative assessment of the anatomy of the posterior aspect of the knee has not been performed previously. Most studies[1,5-11,14] have described various anatomical components but have not included a comprehensive analysis of the anatomy of the posterior aspect of the knee. Recently, a detailed anatomic study of the posterolateral corner of the knee was published[17]. The present anatomic study of the posterior knee is, in part, an extension of that work[15-18]. While we recognize that the majority of these structures course over the posteromedial aspect of the knee, it was not believed that a study limited to this area would have been sufficient to answer our clinical interests.

A lack of a common nomenclature for the main structures of the posterior part of the knee exists in the literature. At least six names can be found in the literature for the oblique popliteal ligament (oblique popliteal ligament, posticum Winslow, popliteal ligament of Winslow, popliteal oblique ligament, oblique tendon of Winslow, posterior oblique ligament of the semimembranosus)[1,6,9,16,19,20]. Similarly, at least five terms have been used to describe the anterior arm of the semimembranosus (anterior tendon, reflected tendon, pars reflexa, horizontal extension of the semimembranosus, reflected head tendon)[1,6,9,11,19].

We propose a common standard nomenclature for the posterior aspect of the knee that is anatomically based and that describes these specific structures. It is recommended that eponyms or nonanatomic descriptions not be utilized because they can be confusing and may not represent the actual anatomy present.

The complex anatomy of the posterior part of the knee has resulted in confusion about the number and locations of the distal and posterior attachments of the semimembranosus at the knee[1,5-11,14]. Both the reported number and the location of these attachments vary[1,5-11,14], and between three and seven attachments have been reported[1,5-11,14]. Of these seven, previous investigators have routinely agreed on three: the direct and anterior arms of the semimembranosus and the oblique popliteal ligament, which appear to have been first described by Poirier and Charpy[12]. In the present study, we found eight posterior and distal attachments of the semimembranosus muscle complex distal to the main common tendon at the knee (the eight structures included a direct arm, a lateral tendinous expansion off the main common tendon that contributed to the oblique popliteal ligament, an attachment to the coronary ligament of the medial meniscus, the oblique popliteal ligament, a proximal posterior capsular arm, a distal tibial expansion, an anterior arm, and the components of the posterior oblique ligament). While we did not specifically dissect out the three arms of the posterior oblique ligament of the semimembranosus[8], it is considered to be the other principal attachment of the semimembranosus at the knee.

The oblique popliteal ligament, an extension of the semimembranosus muscle formed by the confluence of the capsular arm of the posterior oblique ligament and an expansion of the main common tendon of the semimembranosus, was the largest structure over the posterior aspect of the knee. In the present study, we identified two lateral attachments of the oblique popliteal ligament. Its proximal lateral attachment site was not to the posterior aspect of the lateral femoral condyle, as suggested by some texts and illustrations[1-4], but was always to the meniscofemoral portion of the posterior capsule, at an average 19.0 mm distal to the lateral capsule attachment on the lateral femoral condyle. At its proximal lateral attachment site, it attached to an osseous or cartilaginous fabella and the plantaris muscle. Therefore, in this location, it would, in effect, have a common attachment with the fabellofibular ligament and the capsular arm of the short head of the biceps femoris[15-17]. In addition, to our knowledge, the distal lateral attachment of the oblique popliteal ligament to the tibia has not been described previously. This structure, which could easily be injured if it was not recognized during the surgical approach to a posterior cruciate ligament tibial inlay reconstruction[21], appeared to provide a stout anchor to the remaining proximal portion of the oblique popliteal ligament as it crossed the posterior aspect of the knee. At this point in time, the biomechanical and functional implications of these findings are not known, but we theorize that the tibial attachment of the popliteal ligament has a role in providing rotatory stability, and possibly preventing hyperextension, of the knee. We propose that future studies attempt to answer this question.

Our study does not support previous reports of semimembranosus attachments to the lateral meniscus[10]. The proximal posterior capsular arm of the semimembranosus, which we observed in all twenty knees, has not, to our knowledge, been described previously, although it is visible in previously published schematics and photographs[9,22]. The distal tibial expansion has been described in part before, but it either was not named[3,14] or was referred to as the tendinous extension to the popliteus muscle[1,9].

We also identified a thickening of the posterior capsule, which we have termed the proximal popliteus capsular expansion, which extended from its attachment at the medial aspect of the popliteus musculotendinous junction to the joint capsular attachment at the posteromedial aspect of the intercondylar notch. To our knowledge, this structure has not been previously described. We theorize that it provides a connection between the posterior aspect of the medial femoral condyle and the fibular styloid (through the popliteus musculotendinous junction and the popliteofibular ligament[17]) and may provide rotatory stability to the knee. Additional biomechanical studies are planned to investigate this possibility.

A posteromedial capsular defect between the direct arm of the semimembranosus and the medial head of the gastrocnemius was present in 90% of specimens. This defect was consistent with the area where a Baker cyst may form. The capsular defect may be the result of progressive degeneration as the two specimens without this defect showed translucent thinning of the capsule in the area where others had a defect. This observation may provide some support to previous contentions that the formation of a Baker cyst in many cases may be the result of progressive wear associated with aging[23]. It was impossible to determine in these specimens if the defect was congenital or developmental.

We propose that the posterior knee nomenclature presented here should be adopted so that clinicians and investigators can more confidently communicate about specific structures, their contributions to clinical problems, and the magnetic resonance imaging appearance of normal and injured structures of this region. Important clinical issues that are poorly understood because of a lack of understanding of the anatomy and biomechanics of the posterior aspect of knee are posteromedial rotatory instability of the knee[8,24] and also genu recurvatum due to injury when the cruciate and collateral ligaments are intact. Our future plans include both biomechanical studies to determine the functional importance to knee stability of these posterior knee structures and magnetic resonance imaging studies to help to identify which structures may contribute to these clinical instabilities. ■

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