Normal Anatomy and Biomechanics of the Knee

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Abstract: Functionally, the knee comprises 2 articulations—the patellofemoral and tibiofemoral. Stability of the joint is governed by a combination of static ligaments, dynamic muscular forces, meniscocapsular aponeurosis, bony topography, and joint load. The surgeon is ill equipped to undertake surgical treatment of a dislocated knee without a sound footing in the anatomic complexities of this joint. We review the normal anatomy of the knee, emphasizing connective tissue structures and common injury patterns.

Key Words: knee anatomy, capsular ligaments, cruciate ligaments, knee stability, biomechanics

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The knee can be conceptualized as 2 joints—a tibiofemoral and a patellofemoral joint. The tibiofemoral joint allows transmission of body weight from the femur to the tibia while providing hinge-like, sagittal plane joint rotation along with a small degree of tibial axial rotation. Functionally, the quadriceps muscle group and patellofemoral articulation—along with the tibialis anterior and ankle joint—act to dissipate forward momentum as the body enters the stance phase of the gait cycle.[1]

The purpose of this study is to outline important aspects of functional, injury, and surgical anatomy of the knee. Our institution has published extensively on the subject of knee anatomy, and the reader is urged to explore more in-depth anatomic descriptions in selected references for a more comprehensive understanding of this complex topic.[2–18]

PATELLOFEMORAL ARTICULATION

The patellofemoral articulation is commonly referred to as the extensor mechanism. Although true that the concentric action of this motor unit is extension of the knee, functionally, the quadriceps acts eccentrically during gait, running, or jumping. Although it is thought of less as a focus of treatment, the extensor mechanism may be involved in instances of knee dislocation, such as the buttonholing of the lateral femoral condyle through the lateral retinaculum that occurs in a posterolateral dislocation or in the tears of the vastus medialis obliquus and vastus medialis that can occur with capsular ligament injury.[19] Further, a knowledge of the response of the plica or fat pad to injury helps to prepare the surgeon to deal with secondary sequelae of a knee dislocation.

OSSEOUS ANATOMY

The patella is the largest sesamoid bone in the body. Described in more detail in the section that follows, the patella is invested in the retinacular layer of the extensor mechanism receiving direct insertion of the deeper layer of the patellar tendon distally and the vastus intermedius proximally. Concave on its superficial surface, the articular surface of the patella contains a vertical central ridge that separates a broader lateral facet from a medial facet and a smaller, more medial odd facet. The patella articulates with the femoral sulcus or anterior articular surface of the distal femur, which is a coalescence of the medial and lateral femoral condyles. Matching the patella, the lateral portion of the femoral sulcus is relatively broader and contains a higher lateral ridge than the medial portion. This topography ascribes some bony stability to the joint when the patella is engaged in the sulcus at an angle of approximately 45 degrees of knee flexion.

CAPSULAR LIGAMENTS

The capsular ligaments, functionally, can be divided into thirds (Figs. 1A, B). The anterior-third capsular ligaments are, in fact, the medial and lateral retinacular ligaments of the extensor mechanism. They attach distally to the tibia and to the anterior horns of the menisci, but as aponeurosis of the quadriceps femoris muscle group, they have no organized femoral attachments.

The extensor mechanism tendinous and capsular structures are organized into 3 layers (Fig. 2A). Most superficial, the arciform layer is a thin peritendinous membrane continuing from the sartorial fascia medially and the biceps fascia laterally and arching to blend anteriorly across the patella and patellar tendon. The thin arching fibers extending from the dual joint spanning hamstrings suggests a proprioceptive role for this tissue and any peritendinous synovial or vascular supply functions it may perform. The intermediate layer, or retinacular layer, is made up of the anterior-third capsule, or retinaculum, and its condensations, and the iliopatellar ligament laterally, lying superficial to the retinaculum on the anterolateral aspect of the knee (Fig. 2B). The iliopatellar ligament is that condensations of the retinaculum have been described; 2 currently have surgical significance in patellar stabilizing procedures. Patellofemoral ligaments course from medial or lateral isometric points to corresponding superior poles of the patella (Fig. 2C). They course along the distal and deep border of the vastus medialis obliquus and vastus lateralis obliquus and serve to anchor the distal femoral origin of these muscles. Their association with these muscles implies a dynamic action of the muscle on the ligament. The lateral patellofemoral ligament courses from the proximal lateral epicondyle to the vastus lateralis tendon insertion on the patella. The medial patellofemoral ligament, a topic of much recent interest,[20–25] courses from the adductor tubercle to the vastus medialis obliquus insertion on the patella. On the tibial side, the corresponding condensations of the retinaculum have no direct muscular input and are more purely static. The medial patellotibial ligament extends from the

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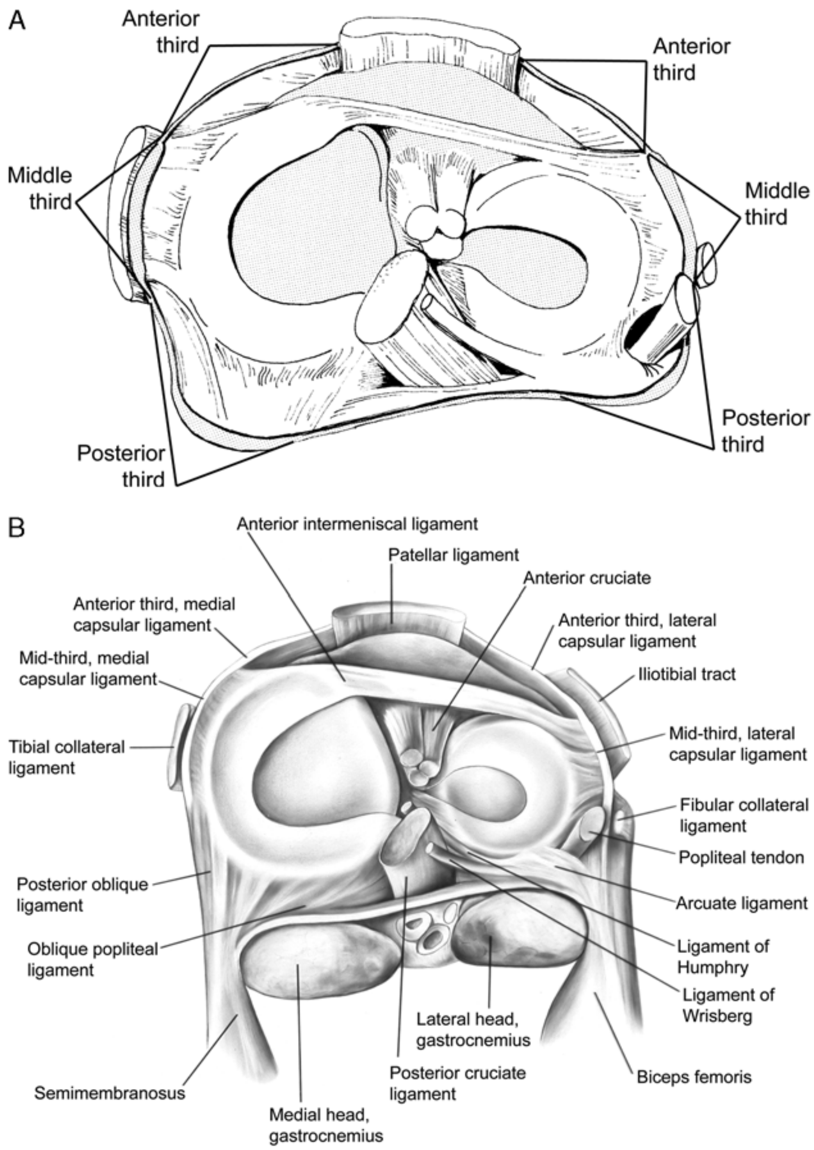

FIGURE 1. Capsular ligaments of the knee. A, The capsule can be roughly divided into thirds on the medial and lateral side. The anterior thirds are a component of the extensor mechanism or patellofemoral articulation, and the posterior two-thirds are components of the tibiofemoral articulation. B, The major structures involved in meniscoligamentous stability.

inferomedial patella to the anteromedial physeal scar of the proximal tibia. Its primary clinical significance is in distal extensor mechanism reconstruction in juvenile patients with excessive Q angles and an open proximal tibial physis. The lateral patellotibial ligament courses from the inferolateral patella to the lateral tibial tubercle deep to the iliopatellar ligament. Its dysfunction has been identified as a cause of medial subluxation after a lateral release; its reconstruction used to correct this problem has been described.[26]

QUADRICEPS

The quadriceps muscle group, consisted of 7 discrete heads, forms the primary motor unit of the extensor mechanism. The deepest of these heads; the articularis genu (Fig. 3A), is the only muscle belly that does not insert directly into the patella; it terminates in the superior synovial plica elevating and protecting it from impingement by the patella and femoral sulcus. The vastus intermedius originates broadly on the anterior surface of, and parallels, the femoral shaft. Its distal tendon, separated from the more superficial rectus tendon by a discrete bursa, comprises the deep layer of the aponeurosis in this area and inserts directly into the superior pole of the patella. The rectus femoris parallels the vastus intermedius but runs in the retinacular layer. It originates on the anteroinferior iliac spine of the pelvis and blends into the central tendon of the quadriceps. As noted above, the rectus femoris tendon is discretely separated from the deeper vastus intermedius tendon by a significant bursa until it reaches its most distal extent. The rectus femoris, along with the vastus medialis obliquus, vastus medialis, vastus lateralis, and vastus lateralis obliquus, terminates in an aponeurosis that merges into the

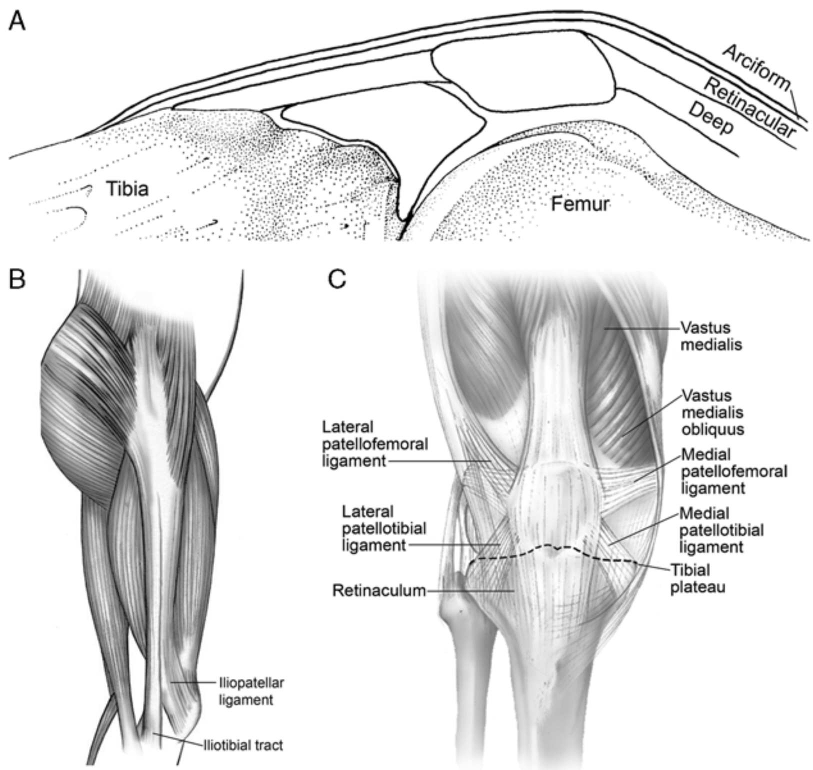

FIGURE 2. Extensor mechanism anatomy. A, Connective tissue of this aponeurosis is organized into 3 layers: the superficial arciform layer, the middle retinacular layer, and the deep layer. B, The iliotibial tract receives dynamic input from the tensor fascia lata and gluteus maximus muscles. It is functionally divided into the iliopatellar ligament, a component of the extensor mechanism, and the iliotibial tract, a component of the tibiofemoral joint. C, Ligaments of the retinacular layer. The medial patellofemoral and lateral patellotibial ligaments are currently the focus of some patellar stabilizing procedures.

anterior-third joint capsule, which is in essence the retinacular layer. This layer courses over and is adherent to the superficial surface of the patella and continues distally investing and comprising the superficial portion of the patellar tendon ultimately becoming contiguous with tibial periosteum. The remaining muscles of the quadriceps insert at an angle to the axis of the femur (Fig. 3B). The vastus lateralis makes up approximately 50% of the bulk of the

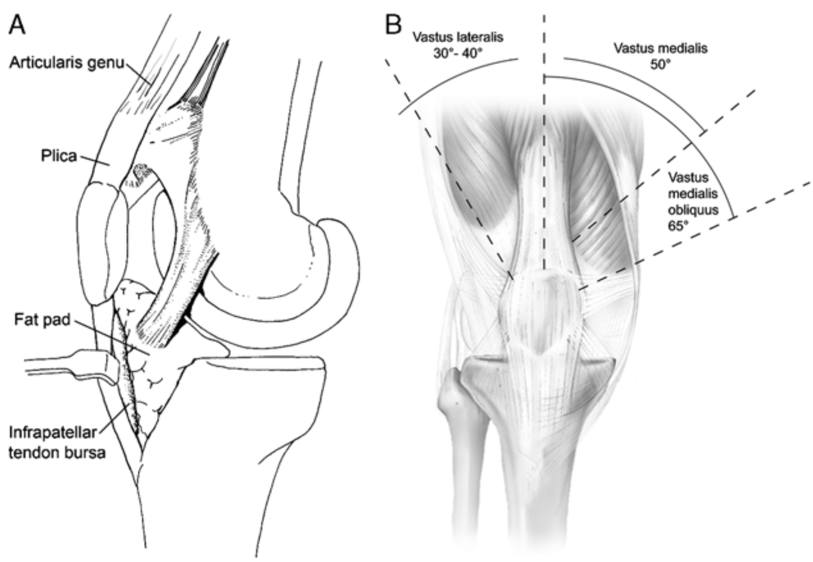

FIGURE 3. A, The relation of the articularis genu to the synovial plica and infrapatellar fat pad is shown here. The infrapatellar tendon bursa and fat pad isolate the tendon from the articular rim of the underlying tibia to its insertion on the tibial tubercle. B, The major heads of the quadriceps muscle group. A balance of muscle mass and geometric angle of insertion (to the anatomic axis of the femur) exert an influence on patellar stability.

entire quadriceps muscle group. It originates from the anterolateral aspect of the femur and lateral intermuscular septum beginning proximally at the level of the greater trochanter. Its angle of insertion is approximately 30 to 40 degrees laterally off the axis of the femur. The vastus lateralis courses in association with the lateral patellofemoral ligament, which has been described earlier. The vastus medialis originates from the anteromedial aspect of the femur and medial intermuscular septum medially approximately 50 degrees off the axis of the femur. The vastus medialis obliquus originates from the abductor tubercle and distal medial intermuscular septum at an angle of approximately 65 degrees medially off the axis of the femur.

PATELLAR TENDON

The patellar tendon extends from the inferior pole of the patella and inserts on the tibial tubercle. Proximal to the tubercle it is separated from the underlying tibia by the infrapatellar tendon bursa (Fig. 3A). The patellar tendon comprises a superficial layer, which is contiguous with the retinacular layer, and a deeper layer, which is again the deep layer of the extensor mechanism. In the substance of the patellar tendon, these layers are largely adherent, much as the subscapularis tendon is to the anterior capsule of the shoulder joint.

SYNOVIAL STRUCTURES

Plica

A remnant of embryologic development, the synovial plica (Fig. 3A) is variably developed in different individuals. Its form can range from a complete septation of the suprapatellar pouch from the more inferior joint, to a band extending from the medial fat pad through the medial gutter and across the suprapatellar pouch flaring out in the lateral gutter, to a remnant or to no structure at all. In its normal state, it is tissue-paper thin but can become thickened, scarred, and contracted as a consequence of injury and causes ankylosis and painful tethering of the quadriceps tendon.

Fat Pad

The infrapatellar fat pad (Fig. 3A) is normally consisted of primarily adipose tissue and a small vascular arcade that arises from convergence of the inferior medial and inferior lateral geniculate arteries and provides the primary vascular supply to the anterior cruciate ligament (ACL). It is suspended from the superior intercondylar notch by a thin synovial fold, the ligamentum mucosum. As a consequence of injury, the structure may fibrose causing ankylosis, painful extension block, and infrapatellar contracture of both the patella and patellar tendon.[27]

TIBIOFEMORAL ARTICULATION

It is important to remember, in any such discussion, that the stability of the tibiofemoral joint results from an interplay of many static and dynamic elements. Dynamic stability involves muscles acting on or across the knee joint. The quadriceps, in addition to being the primary eccentric decelerator of the knee, acts as a dynamic antagonist to an intact ACL and can reduce posterior subluxation in the event of posterior cruciate ligament (PCL) injury. The hamstring group functions medially and laterally as antagonists to an intact PCL directly reducing anterior subluxation, but they can also tense the ligaments through their insertion into the medial and lateral capsular ligaments. This action eliminates any laxity that is present and increases the articular surface load, as well. In this manner, muscles also augment the static mechanism of stability. Similarly, the iliotibial band and gastrocnemius heads augment the stability derived from capsular ligaments. Static stability is derived from a combination of tibiofemoral ligaments, the menisci, the topography of the articular surfaces, and the loads placed on these articular surfaces.[9,28] To attribute all stability of the knee to tibiofemoral ligaments is naive. However, the ligaments and menisci are most amenable to surgical reconstruction; therefore, it is important to be able to recognize and categorize patterns of ligamentous injury so that treatment algorithms can be created, tested, and applied to clinical practice.

OSSEOUS ANATOMY

If an analogy can be made to the elbow, the lateral compartment of the knee is analogous to the radiocapitellar joint, whereas the medial compartment is analogous to the olecranon-trochlear articulation. Thus, the medial femoral condyle and medial tibial plateau are more elongated, or ovoid, than in the lateral compartment. The articular surface of the medial tibial plateau is concave, whereas the lateral plateau has an anteroposterior convexity (Figs. 4A and B). This topography accounts for the so-called screw-home mechanism, or internal rotation, of the femur on the fixed tibia as the knee approaches extension. Weight bearing occurs not only centrally on the medial and lateral tibial plateaus but also on the cephalad-sloping medial and lateral tibial eminences (Fig. 4C), much as a horseback rider bears weight in a saddle.

MENISCI

The menisci, by their complex anatomy, serve a variety of biomechanical functions, such as load bearing, constituting a contact area, guiding rotation, and stabilizing translation. The medial meniscus is broader than the lateral meniscus, although its body is slightly thinner. It opens more widely to the intercondylar notch and has a relatively flat undersurface. It is anchored in the central posterior region of the intercondylar spine near the fovea centralis and anterior to the anterior intermeniscal ligament that courses across to become confluent with the lateral mid-third capsular ligament. Around its periphery, it anchors through the meniscotibial segment of the capsular ligaments to the tibial articular rim approximately 5 mm distal to the articular margin (Fig. 5A).

The lateral meniscus is more saucer-shaped and, owing to the convex topography of the lateral tibial plateau, is more triangular-shaped in cross section than the wedge-shaped medial meniscus. This shape gives rise to the so-called bowtie appearance of the lateral meniscus as seen in sagittal sections of magnetic resonance imaging scans. Its anterocentral attachment merges with the insertion of the ACL. Posteriorly, it anchors both on the lateral tibial eminence band and also through the ligaments of Wrisberg and Humphry. Its peripheral attachment parallels that of the medial meniscus; however, at the junction of the anterior two-thirds and posterior third, the peripheral attachment is interrupted by the popliteal hiatus.

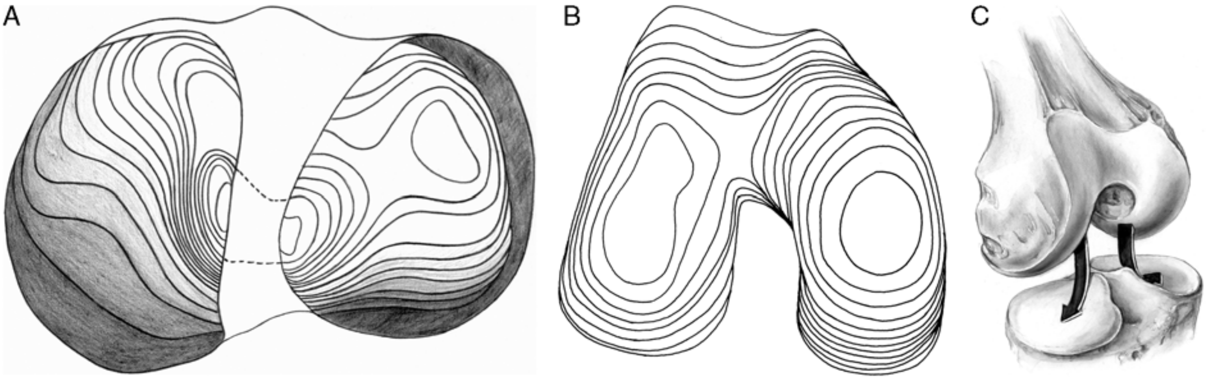

FIGURE 4. Bony topography of (A) the tibial plateau and (B) the femoral condyle provide some stability to the tibiofemoral articulation and guide the screw-home mechanism. C, Weight bearing occurs on the tibial eminences, and on the central plateaus.

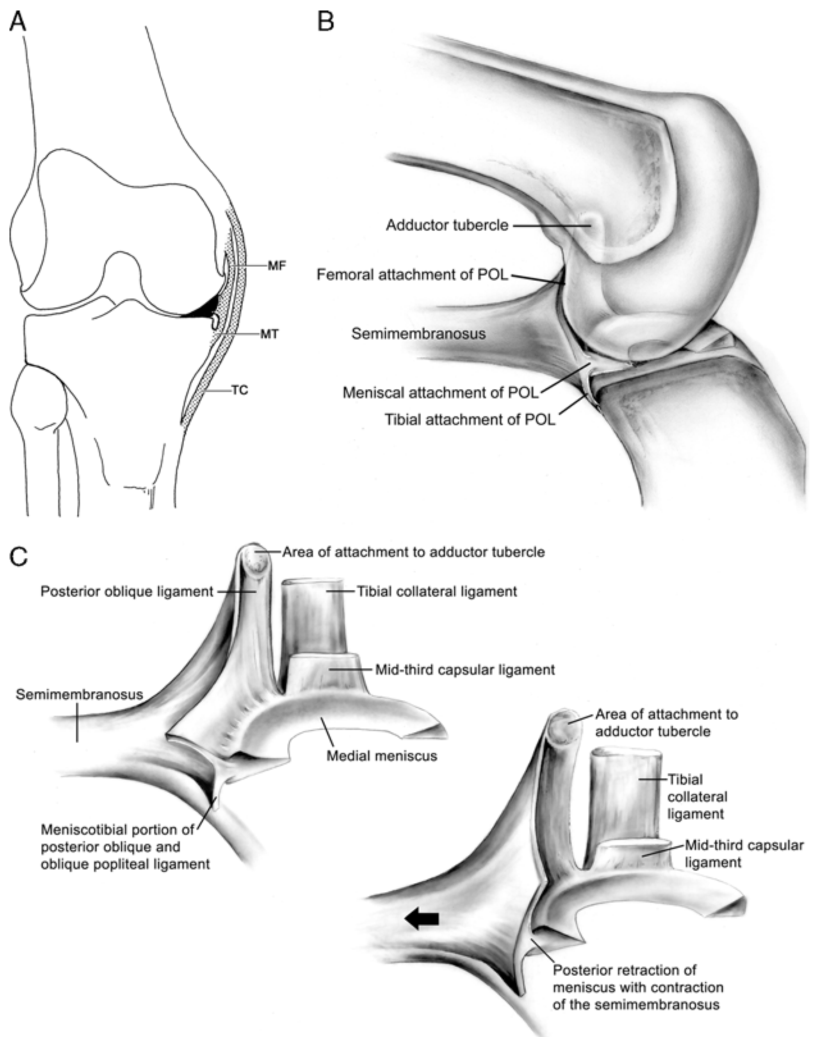

FIGURE 5. Relationship of the capsular ligaments (medial side) and menisci. A, The mid-third capsular ligament is divided into a proximal longer meniscofemoral (MF) segment in a span from the medial epicondyle to the meniscus and a distal shorter meniscotibial (MT) segment. TC=tibial collateral ligament. Function of the meniscocapsular expansion of the posteromedial corner coupled with the semimembranosus. B, Femur in place. POL=posterior oblique ligament. C, Femur removed to show the relaxed state. Contraction of the semimembranosus (arrow) retracts the posterior horn of the medial meniscus and bowstrings the capsule increasing joint contact pressure.

CAPSULAR LIGAMENTS

The medial and lateral mid-third and posterior-third capsular ligaments compose the static tibiofemoral ligaments and are the capsular ligaments involved in tibiofemoral stability. Functionally, the posteromedial or posterolateral corner of the knee acts as a large aponeurotic expansion of the medial or lateral hamstring, respectively. This expansion spans from the muscle belly to (and including) the meniscus (Figs. 5B, C). This broad expansion wraps around the entire posteromedial or posterolateral corner and becomes confluent with the contralateral posterior capsule and distal mid-third capsular ligaments. Together, these structures cup and buttress the posterior aspect of the femoral condyles accommodating their increasing volume in knee extension and decreasing volume in knee flexion. As such, these aponeurotic pouches are able to prevent any posterior subluxation of the femoral condyles on the tibial plateaus, which of necessity accompanies anterior translation of the tibia on the femur. The term meniscocapsular ligament-musculotendinous unit complex, coined by Terry and Hughston[18] most appropriately describes their functional anatomy.

Medial Side

The sartorial fascia on the medial side of the knee is the most superficial layer. This fascia is an aponeurotic extension of the sartorius tendon and merges imperceptibly into the fascia of the vastus medialis obliquus and the anterior medial retinaculum, continuing across the anterior aspect of the knee as the arciform layer of the extensor mechanism (Fig. 6A). In the mid-third of the layer, is the tibial collateral ligament. The tibial collateral ligament takes its origin from the medial epicondyle and extends distally to insert on the tibia deep to the anterior border of the sartorius and deep to the pes anserinus (Fig. 6B). A series of partially confluent bursae, originally described by Brantigan and Voshell,[29] separates the tibial collateral ligament from the deeper medial mid-third capsular

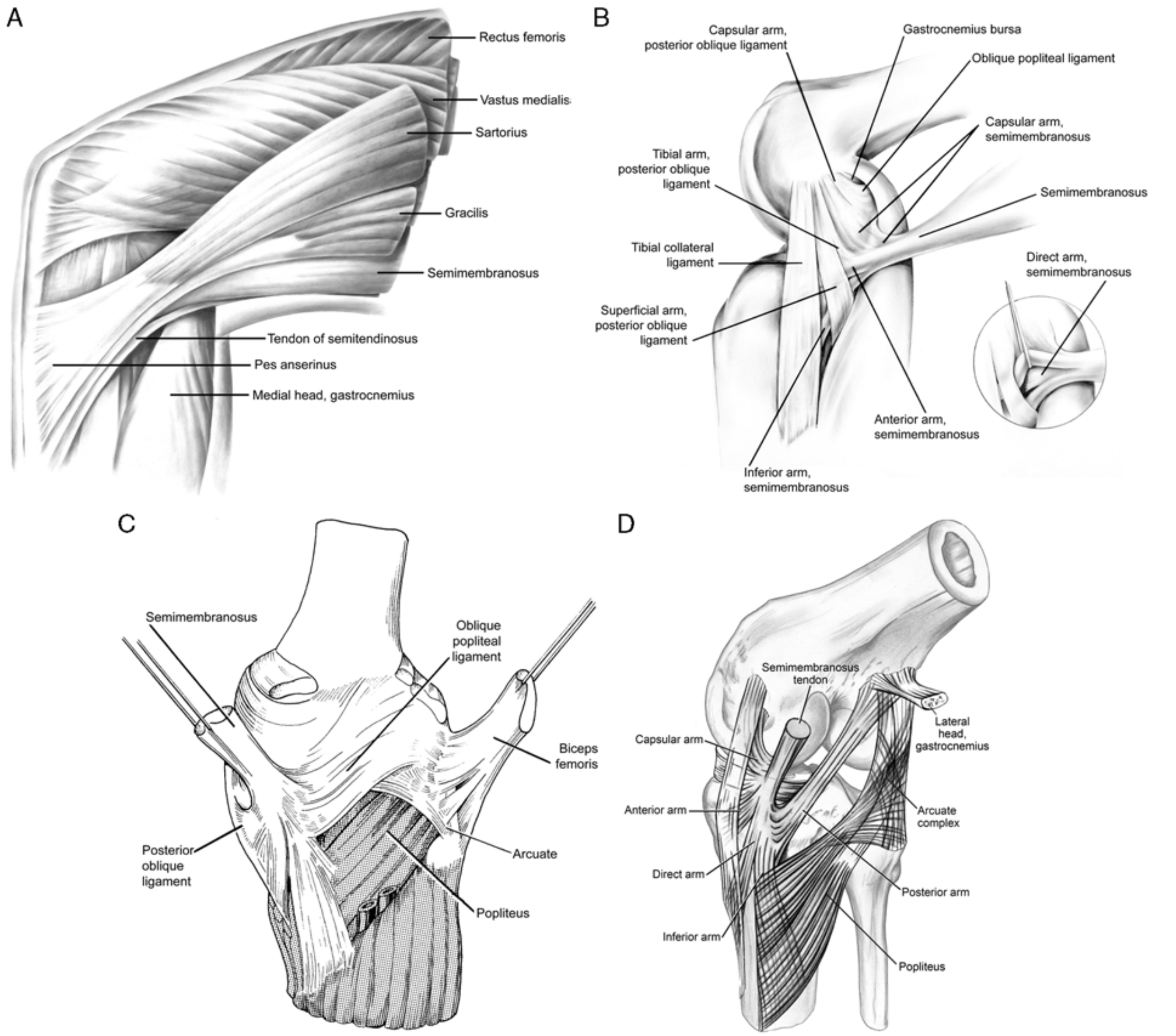

FIGURE 6. Anatomy of the medial capsule and related structures. A, Superficial anatomy. B, Capsular structures deep to the sartorial fascia (the medial mid-third capsular ligament is deep to the tibial collateral ligament and is not shown here). C, Relationship of the posteromedial capsular structures and semimembranosus to the posterior capsule. D, The 5 arms of insertion of the semimembranosus.

ligament and, as such, could actually be considered at least partially extracapsular. The medial mid-third capsular ligament also takes its origin from the medial epicondyle, but deep to the tibial collateral ligament and provides a capsular attachment for the middle third of the medial meniscus. It inserts just distal to the articular margin. The meniscofemoral segment of capsular ligaments extends from its bony origin to the meniscus and the meniscotibial segment extends from the meniscus to the tibial insertion (Fig. 5A). The meniscotibial segment is only approximately 5 mm in length at the mid-third portion of the capsule, or, in surgical terms, it presents a space from meniscus to ligament insertion that is just sufficient to accommodate the volume of the tip of a mosquito hemostat. If a greater void is present, a tear of the tibial insertion is assumed. The term medial collateral ligament does not describe a specific ligament and, in fact, is not a recognized term in *Nomina Anatomica*. Unfortunately, this term is used commonly to collectively describe all the capsular ligaments in the posteromedial corner. On account of its anatomic imprecision, we discourage use of the term.

On the medial side, the posterior-third capsule contains 2 capsular ligaments that originate from the adductor tubercle (Fig. 6C). The oblique popliteal ligament courses obliquely and posteriorly across the popliteal surface of the posterior capsule and becomes confluent with the medial

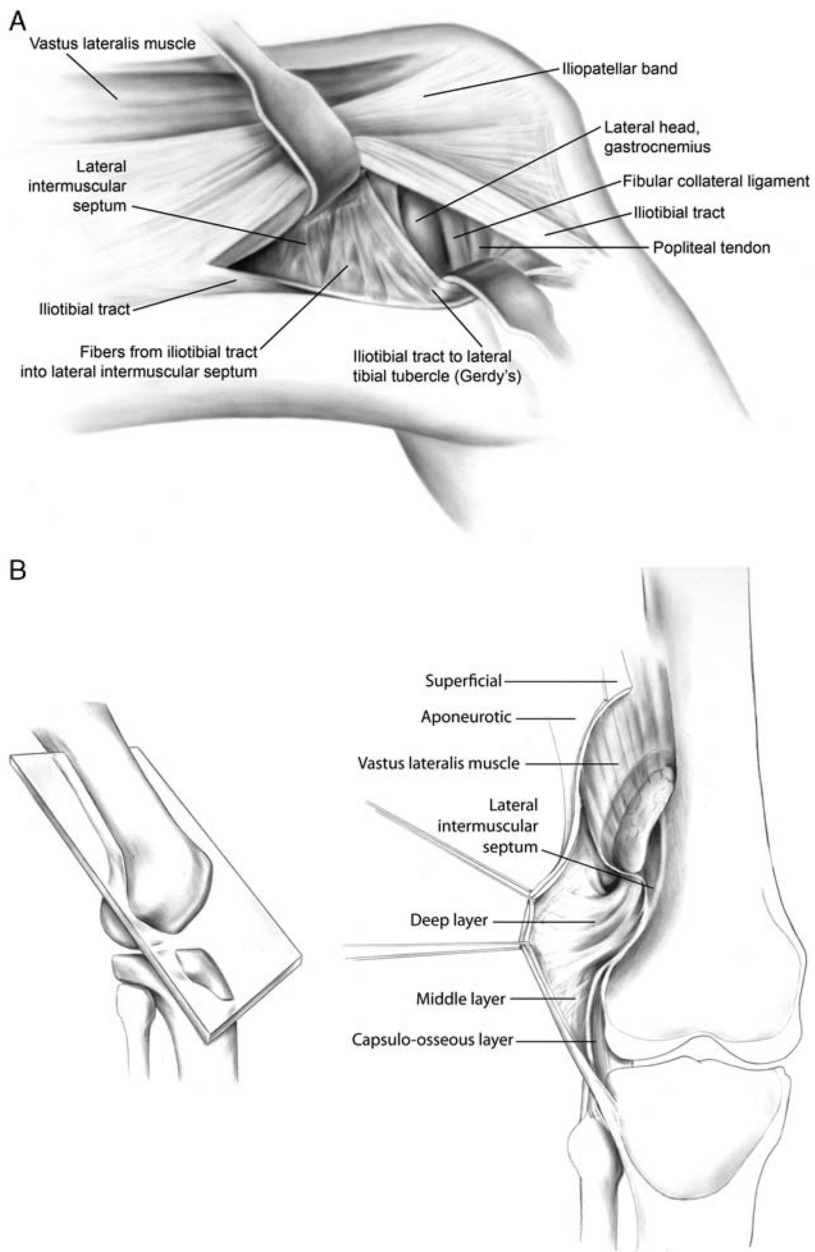

FIGURE 7. A and B, Deeper layers of the iliotibial tract. Rupture of these layers deep to the superficial layer allow anterolateral rotatory subluxation of the lateral tibial plateau on the fibula. They must be ruptured for the pivot shift to occur.

aponeurotic extensions of the posterior arcuate ligament. In addition, taking origin from the adductor tubercle, the posterior oblique ligament originates just anterior to the oblique popliteal ligament and extends distally along its border with the medial mid-third capsular ligament. The posterior oblique ligament also provides the capsular attachment for the posterior horn of the medial meniscus. The insertion of the posterior oblique ligament, like that of the medial mid-third capsular ligament, is on the tibia just distal to the articular margin. Hughston and Eilers[2] studied the anatomy and function of the posterior oblique ligament and determined that immobilizing the knee in 60 degrees of flexion is the ideal position for optimal healing. Thus, for conservative treatment of medial ligament injuries, a 60-degree bent-knee immobilizer allows the ligaments to heal without placing excessive tension on them. Excessive tension could cause them to heal stretched and become lax. Hughston and Eilers[2] and Hughston[6] also described 3 discrete arms of the posterior oblique ligament: the capsular, tibial, and superficial arms.

The semimembranosus is the dynamic motor for the posteromedial corner (Fig. 6D). Its insertion comprises 5 arms: (1) the anterior arm, the tibial arm or pars reflexa, which courses distally and anteriorly to insert on the tibial condyle at the tibial collateral ligament insertion; (2) the direct arm, which inserts into the posterior tibial tubercle; (3) the posterior arm, which forms the inferior border of the oblique popliteal ligament; (4) the capsular arm, which becomes confluent with the posterior oblique ligament and the proximal border of the oblique popliteal ligament forming a border of the medial gastrocnemius bursa; and (5) the inferior arm, which courses more directly distally and forms a broad distal attachment along the posteromedial corner of the proximal tibia blending with the popliteal fascia.

Anterolateral Side

The most superficial layer on the lateral aspect of the knee contains the iliotibial band and more posteriorly the biceps fascia. The iliotibial band receives dynamic muscular input proximally from the tensor fascia lata muscle and has 2 functional divisions: the iliopatellar ligament, which is a functional component of the extensor mechanism, and the iliotibial tract, which is a functional component of the tibiofemoral joint (Fig. 2B). This functional division occurs at or near the intermuscular septum with the iliotibial tract usually encompassing the posterior 2 cm of the iliotibial band (Fig. 7A). Distally, the iliotibial tract has deep aponeurotic expansions—the middle, deep, and capsulo-osseous layers (Fig. 7B). The capsulo-osseous layer is partially confluent with the fabellofibular ligament and derives an origin from the distal linea aspera, or insertion of the intermuscular septum. It wraps anteriorly and distally to insert on the lateral tibial (Gerdy) tubercle. It is a rupture of these fibers that is responsible for the rotatory component of the pivot shift, or "jerk" test.

More distally on the anterolateral side are the aponeurotic insertions of the biceps femoris muscle. The biceps femoris muscle has 2 heads (Fig. 8A). A long head originates from the pelvis and a short head originates from the posterior aspects of the distal femur and distal intermuscular septum. The short head of the biceps femoris muscle terminates in 6 arms, 3 of which are clinically significant (Fig. 8B). The capsular arm has a broad attachment to the posterolateral capsule, fabella, and lateral gastrocnemius complex. The direct arm has a fibular attachment just lateral to the fibular styloid and medial to the long head attachment. The anterior arm inserts on the tibia just at or lateral to the lateral tibial (Gerdy) tubercle and is responsible for the lateral avulsion fracture (the Segond sign,[30] or lateral capsular sign). The long head of the biceps femoris has 2 arms—a direct arm inserting on the fibula just anterior to the insertion of the short head of the biceps and an anterior arm inserting on the lateral tibia again just distal to the short head of the biceps insertion (Fig. 8C). A small bursa separates the distal biceps tendon from the underlying fibular collateral ligament as it courses toward its insertion on the fibula.

Posterolateral Side

The mid-third lateral capsular ligament lies deep to the iliotibial tract and iliopatellar ligament in the mid-third section of the lateral capsule. It takes its origin from the lateral epicondyle and provides an attachment for the lateral meniscus in this area. It inserts just distal to the articular margin on the lateral tibia (Fig. 9A).

The popliteal tendon and fibular collateral ligament lie deep to the lateral mid-third capsular ligament and take their origins and insertions from the lateral epicondyle. The

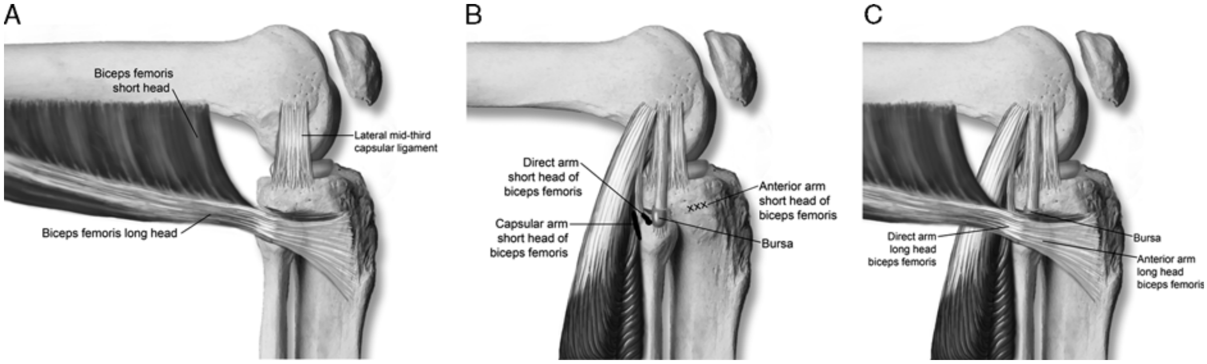

FIGURE 8. A, The biceps femoris muscle has 2 heads, the long head originating from the pelvis and the short head originating from the posterior aspects of the distal femur and distal intermuscular septum. B, The short head has 3 clinically significant arms: the direct arm, the anterior arm, and the capsular arm. C, The long head of the biceps femoris has 2 arms: a direct arm and an anterior arm. A small bursa separates the distal biceps tendon from the underlying fibular collateral ligament as it courses toward its insertion on the fibula.

popliteal tendon inserts slightly anterior to the fibular collateral ligament; it courses posteriorly and distally deep to the fibular collateral ligament and passes through the popliteal hiatus of the lateral meniscus to blend into the muscle belly of the popliteal muscle. The fibular collateral ligament courses distally to insert just anterior to the lateral aspect of the fibular head. The popliteal muscle belly takes its origin from the proximal posterior fibula coursing obliquely and proximally toward its insertion (described earlier) (Fig. 9B). It gains attachment to the lateral meniscus through anteroinferior, posterosuperior, and posteroinferior popliteal meniscal fascicles.

The popliteal fibular ligament originates at the popliteal-musculotendinous junction and courses distally to attach to the medial aspect of the fibular styloid (Fig. 9C). The fabellofibular ligament originates from the lateral

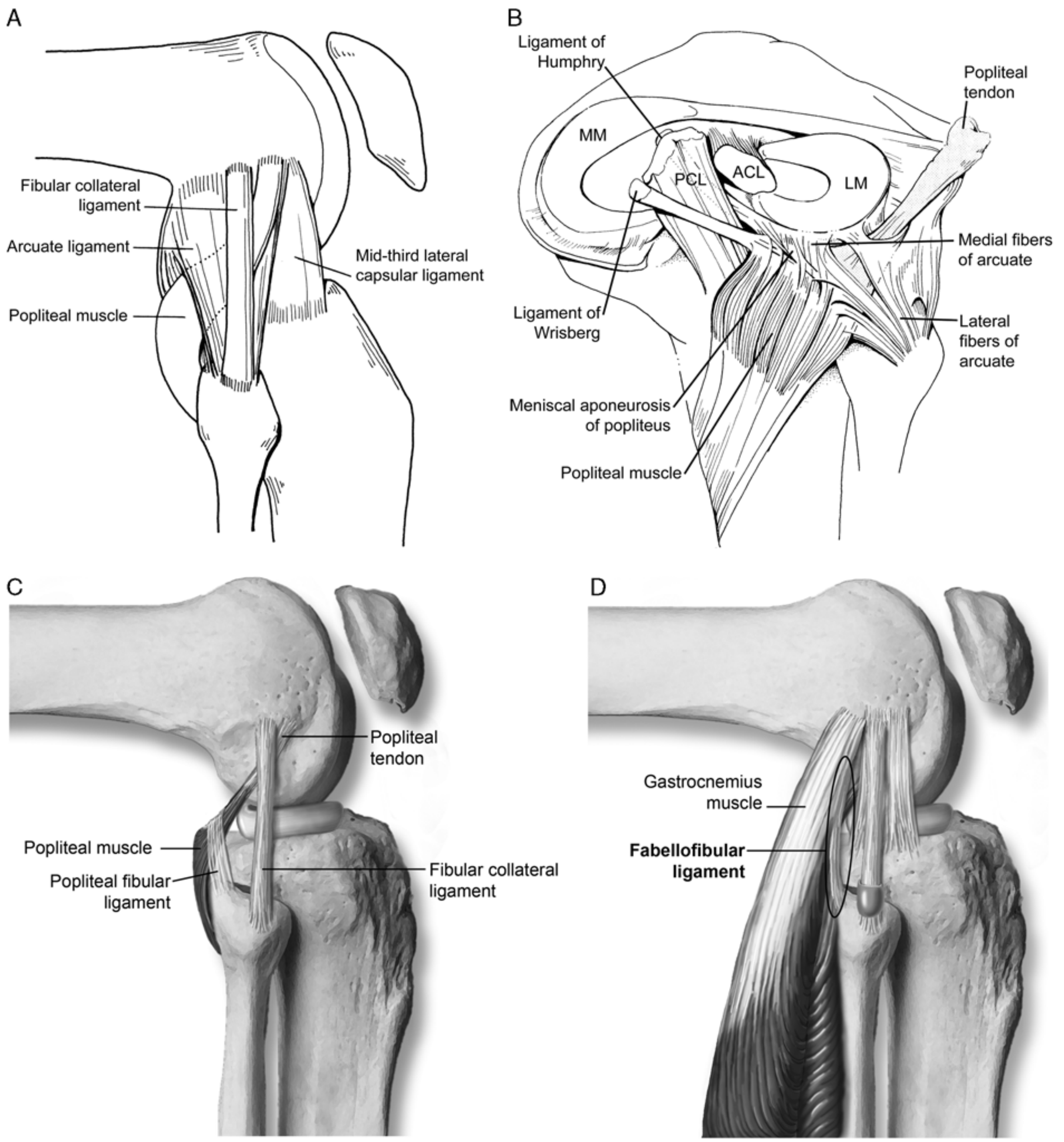

FIGURE 9. Lateral capsular structures. A, The major mid-third lateral capsular ligaments. B, Relationship of the popliteus, arcuate ligament, lateral meniscus, and lateral meniscofemoral ligaments of Wrisberg and Humphry. ACL, anterior cruciate ligament; MM, medial meniscus; PCL, posterior cruciate ligament, lateral meniscus. C, The fabellofibular ligament takes its origin from the lateral aspect of the bony or cartilaginous fabella and inserts lateral to the tip of the fibular styloid just lateral and perhaps distal to the insertion of the popliteal fibular ligament. D, The popliteal fibular ligament takes its origin at the popliteal musculotendinous junction and courses distally to attach to the medial aspect of the fibular styloid.

aspect of the bony or cartilaginous fabella and inserts lateral to the tip of the fibular styloid just lateral and perhaps distal to the insertion of the popliteal fibular ligament (Fig. 9D).

The arcuate ligament straddles the posterolateral corner with a function and morphology analogous to the posterior oblique and oblique popliteal ligaments of the medial side. Its lateral, or fibular, portion borders the lateral mid-third capsular ligament; its medial, or tibial, portion lies deep to the lateral gastrocnemius head; and its posterior component, which is partially confluent with the lateral head of the gastrocnemius muscle, arcs across the popliteal surface of the capsule to merge with the oblique popliteal ligament (Fig. 9B).

The fibular collateral ligament, popliteus, lateral head of the gastrocnemius muscle, and arcuate ligament can be referred to collectively as the arcuate complex.

CRUCIATE LIGAMENTS

Much has been written with regard to anatomy and treatment of the anterior and PCL s over the last 3 decades, making it impossible to summarize the topic in a few paragraphs. Subsequent articles in this publication will address these structures more fully.

ACL

The ACL originates within the posterolateral surface of the intercondylar notch and courses distally and anteriorly to insert on the intercondylar eminence. There is general agreement that it contains 2 bundles—an anteromedial and a posterolateral bundle—although some controversy exists as to whether an intermediate bundle is present, as well. There are varying degrees of tension in these bundles based on flexion angle, with the anteromedial bundle being tighter in extension and the posterolateral bundle being tighter in flexion. Further, the bundles spiral from lateral to medial, thus wrapping upon themselves and increasing tension as the tibia internally rotates. In full extension, the anterior surface of the ACL lies against the intercondylar shelf assisting the ligament in preventing hyperextension. In addition to this function, the ACL is most commonly thought of as primarily resisting anterior translation, although it is biomechanically best postured to do so at approximately 20 degrees of flexion. In addition, the ACL guides rotation of the tibia during the screw-home mechanism as the knee extends. It also couples translation to tibial axial rotation. The blood supply to the ACL comes through anastomosis of the medial and lateral inferior geniculate arteries through the fat pad and the middle geniculate artery branching off the posterior capsule. In any substance tear of the ACL, the blood supply is usually permanently disrupted, which explains why the healing potential after repair of mop end tears of the ACL is poor, and reconstruction rather than repair is the preferred surgical tactic.

PCL

The PCL originates on the medial surface of the intercondylar notch extending distally to insert on the proximal tibia in the fovea centralis. As such, its insertion is anterior to the posterior extent of the femoral and tibial condyles and in line with the posterior cortex of the femur and tibia. Its proximal origin is also in line with the epicondylar axis of the femur and, for practical purposes, represents the center of axial rotation of the knee. The PCL has 2 bundles—a posteromedial and an anterolateral bundle. The posteromedial bundle is more taut in extension, and the anterolateral bundle is more taut in flexion. Again, internal rotation of the tibia will not only wrap these bundles upon themselves, as occurs in 90-degree anteroposterior drawer tests in internal rotation as a test of PCL competency, but as also results in the ACL and PCL ligaments wrapping upon themselves. The ligaments of Wrisberg and Humphry, originating from the posterior capsular attachments of the lateral meniscus, course forward to attach posteriorly and anteriorly, respectively, with the PCL on the femur. In full extension, the PCL is the primary restraint to any translation or coronal plane rotation (abduction or adduction stress). Unlike the ACL, because of its association with the posterior capsule, blood supply is not permanently lost with a substance tear of the PCL. Thus, primary repair of these injuries is possible.

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