IV Knee – Anatomy

I. THE OSSEOUS STRUCTURES

A. Three components: the patella, the distal femoral condyles, and the proximal tibia plateaus. The knee is described as a hinge joint but actually it is more complicated than a hinge joint because, aside from flexion and extension, it also has a rotatory component to its motion. The joint may really be considered three joints in one with a joint between the patella and the femur and between each tibial condyle and a femoral condyle.

B. Femoral condyles. The femoral condyles are two rounded prominences, eccentrically curved with the anterior portion being part of an oval and the posterior option a section of a sphere. Thus, the condyles are more curved anteriorly than posteriorly. Anteriorly the condyles are somewhat flattened and this provides a greater surface area for contact and weight transmission. The condyles project very little in front of the femoral shaft but markedly so behind. The groove anteriorly between the condyles is the patellofemoral groove, or trochlea, which accepts the patella. Posteriorly the condyles are separated by the intercondylar notch. The articular surface of the medial condyle is longer than the lateral condyle, but the lateral condyle is wider. The long axis of the lateral condyle is oriented essentially along the sagittal plane while the medial condyle is usually at about a 22-degree angle to the sagittal plane.

C. Tibial plateau. The expanded proximal end of the tibia is formed by two rather flat surfaces, or condyles, which articulate with the femoral condyles. They are separated in the midline by the intercondylar eminence with its medial and lateral intercondylar tubercles. Anterior and posterior to the intercondylar eminence are the intercondylar areas, which serve as attachment sites for the cruciate ligaments and menisci. The posterior lip of the lateral tibial condyle is rounded off where the lateral meniscus slides posteriorly in flexion of the knee.
D. Patella. The patella is a somewhat triangular shaped sesamoid bone, being wider at the proximal pole than it is at the distal pole. The articular surface of the patella is divided by a vertical ridge creating a small medial and a larger lateral articular facet, or surface. Wiberg describes four patellar configurations. A Type I patella has equal medial and lateral articular surfaces, which are slightly concave. A Type II patella has a small medial surface and a large lateral surface with both being slightly concave. The Type III is similar to the Type II, but the medial surface is convex rather than concave. A Type II-III is one in which the medial surface is flattened rather than being either concave or convex. The Type II patella is the most common variety. With the knee in extension, the patella actually rides above the superior articular margin of the femoral groove. In extension, the distal portion of the lateral patellar facet articulates with the lateral femoral condyle, but the medial patellar face barely articulates with the medial femoral condyle until complete flexion is approached. At 45 degrees of flexion, contact moves proximally to the mid-portion of the articular surfaces. In complete flexion, the proximal portions of both facets are in contact with the femur and during flexion and extension, the patella moves some seven to eight centimeters in relation to the femoral condyles. With complete flexion, more pressure is applied to the medial facet.

E. Quadriceps. The quadriceps tendon inserts into the proximal pole of the patella. The four components of the quadriceps mechanism form a trilaminar quadriceps tendon to insert into the patella. The tendon of the rectus femoris flattens immediately above the patella and becomes the anterior lamina, which inserts at the anterior edge of the proximal pole. The tendon of the vastus intermedius continues downward as the deepest lamina of the quadriceps tendon and inserts into the posterior edge of the proximal pole. The middle lamina is formed by the confluent edges of the vastus lateralis and vastus medialis. The fibers of the medial retinaculum formed from the aponeurosis of the vastus medialis obliquus inserts directly into the side of the patella to help prevent lateral displacement of the patella during flexion. The patellar tendon takes origin from the apex, or distal pole of the patella and inserts distally into the tibial tubercle.
II. MECHANICS

A. If the shaft of the femur is held vertically, the medial condyle projects more distally than the lateral; however, in a normal upright posture, this is not true. This is because the mechanical axis and anatomic axis of the femur do not coincide. The anatomic axis passes through the center of the knee joint and along the femoral shaft, inclining laterally. The mechanical axis, on the other hand, passes from the center of the knee joint through the center of the hip joint and is more vertical. The angle between the mechanical axis and anatomical axis is approximately 6 degrees.

B. Because of disparity between the lengths of the articular surface of the femoral condyles and the tibial condyles, two types of motion during flexion and extension are noted in relation to the tibial and femoral condyles. The first is a rocking motion in which points equidistant on the tibia come into contact with points, which are equidistant on the femoral condyles. The second type of motion is a gliding motion in which a constant point on the tibia comes into contact with ever changing points on the femur. It is felt by many that the first 20 degrees of flexion of the knee consist of a pure rocking motion; however, Lindahl has disputed this and states that during the first 20 to 30 degrees of flexion there is a combined rocking and gliding motion rather than pure rocking motion. Due to the eccentricity of the femoral condyles, the transverse axis of rotation constantly changes position (instant center of rotation) as the knee progresses from extension into flexion.

C. The vertical axis for rotation is described as passing medial to the medial tubercle of the intercondylar eminence. As will be described later, the medial side of the knee joint is more securely anchored than the lateral so that inflexion the lateral tibial condyle can sweep through a greater arc of rotation than does the medial condyle. If the medial ligaments are disrupted, the axis of rotation shifts laterally. The knee has little or not rotation when it is in complete extension, but rotation is increased in flexion. The amount of rotation available has been studied by a number of investigators with varying opinions. One of the problems, of course, is in finding a neutral position from which to measure internal and external rotation of the tibial on the femur.
III. MEDIAL ASPECT OF THE KNEE.

A. The major structures on the medial aspect of the knee are the medial retinaculum and tibiocollateral ligament, and the pes anserinus, which consists of the tendinous expansions of the sartorius, gracilis, and semitendinosus.

B. Tibiocollateral ligament. The tibiocollateral ligament consists of a superficial and deep capsular portion. The superficial portion is a rather well delineated band-like structure inserting proximally into the medial femoral condyle and distally about a hands breadth below the joint line onto the medial aspect of the tibia. It glides forward in extension and posteriorly with flexion. Deep to the superficial portion is the capsular ligament divided into a meniscotibial and meniscofemoral portion. The superficial and deep capsular layers are separated anteriorly by a bursa but blend together posteriorly to form a triangular element, which in turn blends with the posterior capsule to form a sling about the medial femoral condyle. The medial meniscus is securely attached to the deep capsular portion.

C. Medial retinaculum. The medial retinaculum is a distal expansion of the vastus medialis obliquus aponeurosis. It attaches along the medial border of the patella and patellar ligament and distally inserts into the tibia. Its function is primarily to guide the patella medially.

D. Pes Anserinus. The conjoined tendons of the sartorius, gracilis and semitendinosus form the pes anserinus, inserting along the proximal medial aspect of the tibia. These muscles help protect the knee against rotary and valgus stress. They are primarily flexors of the knee and secondarily internal rotators of the tibia.
IV. POSTERIOR ASPECT OF THE KNEE.

A. Important structures:
   1. Posterior capsule
   2. Ramifications of semimembranosus tendon
   3. Oblique popliteal ligament (expansion of semimembranosus)
   4. Arcuate ligament
   5. Popliteus muscle
   6. Ligaments of Wrisberg and Humphrey.

B. Semimembranosus expansion – Five.
   1. Oblique popliteal ligament – from insertion of semimembranosus on posterior medial aspect of tibia, obliquely and laterally toward insertion of lateral gastroc head.
      a. Important stabilizing structure of posterior aspect of knee.
      b. If pulled medially and forward in surgical posterior-medial repair, helps tighten posterior capsule of knee.
   2. Attachments to posterior capsule and posterior horn of medial meniscus.
      a. Functionally helps tighten posterior capsule and pull medial meniscus posteriorly with knee flexion.
   3. Anterior or medial tendon – continues medially along tibial condyle and inserts beneath superficial tibiocollateral ligament just distal to joint.
   4. Direct head attaches to infraglenoid tubercle on posterior aspect of medial tuberosity of tibia just below joint line.
      a. Good firm point to anchor sutures in posterior-medial capsule repair.
   5. Distal ramification of tendon continues distally to form fibrous expansion of popliteus and fuses into the periosteum of medial tibia.
   6. Functionally semimembranosus.
      a. Flexor and internal rotator of tibia
      b. Retracts posterior rim of medial meniscus posteriorly in flexion
      c. Oblique popliteal ligament tenses posterior capsule as knee flexes.
      d. All branches act as major stabilizing element for posterior medial aspect of knee.

   1. Three tendinous origins
      a. Lateral femoral condyle
      b. Posterior fibular head
      c. Posterior horn of lateral meniscus
      These linkages by capsule and meniscal origin are called arcuate ligament.
2. Insertion into posterior aspect of posterior tibia.

3. Function
   a. Prime medial rotator of the tibia on femur
   b. Pulls posterior horn of lateral meniscus posteriorly.
   c. Provides rotary stability by preventing forward dislocation of tibia on femur during knee flexion.

   (1). Stability provided through attachments of posterior horn of lateral meniscus through ligaments of Wrisberg and Humphrey to posterior cruciate ligament.

D. Ligaments of Wrisberg and Humphrey.
   1. Location
      a. Ligament of Wrisberg – behind posterior cruciate and runs from posterior aspect of lateral meniscus to medial femoral condyle.
      b. Ligament of Humphrey – lies in front of posterior cruciate and attaches to posterior horn of lateral meniscus and to inner side of femoral condyle

   2. Function
      a. Both function to draw posterior arch of lateral meniscus in a medial direction as internal rotation of tibial occurs with flexion of knee with simultaneous contraction of popliteus.
      b. Provides stability to tibia (See III-C).

E. Posterior Capsule
   1. In extension posterior capsule pulled tightly around femoral condyles and stabilizes the knee.
      a. With intact posterior capsule, knee will be stable to valgus stress in extension, even with all other stabilizing structures cut.
      b. With knee in flexion, posterior capsule relases and loss of integrity of cut medial structures can be demonstrated.
V. LATERAL ASPECT OF THE KNEE

A. Important stabilizing structures.
   1. Iliotibial tract
   2. Lateral (fibular) collateral ligament
   3. Short collateral ligament (fabello-fibular ligament)
   4. Biceps tendon
   5. Popliteus tendon
   6. Extension of vastus lateralis

B. Iliotibial tract.
   1. Inserts proximally into lateral epicondyles tubercle of femur and distally into lateral tibial tubercle.
      a. Forms an additional ligament connected anteriorly to vastus lateralis and posterior to biceps.
      b. Moves forward in extension and backward in flexion but tense in both positions.
   2. With flexion, iliotibial tract, popliteus tendon and lateral collateral ligament cross each other thus enhancing lateral stability.
      a. Iliotibial tract and biceps tendon remain parallel to each other in flexion and extension.

C. Lateral (fibular) collateral ligament.
   1. Separated from the lateral meniscus unlike deep medial collateral ligament, which is intimately associated with the medial meniscus.
      a. Inserted into lateral femoral condyle and fibular head.
      b. In coronal plane, located more posteriorly than the deep medial collateral ligament (mid portion of medial capsular ligament).
   2. Provides stability to lateral side of knee in extension.
      a. Relaxes in flexion to permit rotation.

D. Short collateral ligament.
   1. Lies deep to lateral (fibular collateral ligament).
   2. Insertion – when fabella present attaches to it and called fabello-fibular ligament. Runs parallel to lateral collateral ligament and attaches to fibular head posterior to tendon of biceps.
   3. Reinforces posterior capsule and also contributes toward lateral stability.

E. Biceps tendon
   1. Inserts into fibular head lateral to insertions of lateral and short collateral ligaments.
   2. Strong flexor of knee with simultaneous strong external rotation of tibia.

F. Popliteus tendon (see posterior aspect of knee “III”)
1. Located between lateral collateral ligament and femoral condyle.
2. Functions as stabilizer in flexion.

G. Extension of vastus lateralis.
   1. Attaches to iliotibial tract and helps to tense this as knee extends and iliotibial tract moves forward.
   2. Functions not only in extension of the knee but also contributes toward lateral stability.

H. Quadruple complex (Kaplan)
   1. Consists of
      a. Iliotibial tract
      b. Lateral collateral ligament
      c. Popliteus tendon
      d. Biceps muscle.
   2. Stability and nearly normal function is maintained with loss of any two of the above four structures, according to Kaplan.
      a. In extension, lateral collateral ligament is chief stabilizer
      b. In flexion, biceps muscle, iliotibial tract, and popliteus tendon are chief stabilizers.
VI. INTERNAL KNEE ANATOMY

A. Menisci
   1. Functions
      a. Nutrition
      b. Shock absorption
      c. Stability (deepen joint).
      d. Weight bearing (conflicting opinions)
      e. Control motion
      f. Increase contact area
      g. Lubrication
   2. Motion
      a. Displaced forward with knee extension by action of patellomeniscal ligaments (expansion of extensor retinaculum) and by rolling action of the femoral condyle.
      b. With flexion, menisci move posteriorly due to muscular action of popliteus on lateral meniscus and semimembranosus on medial meniscus as well as rolling action of femoral condyles.
      c. Lateral meniscus is more mobile. Medial meniscus has more firm peripheral attachments.
      d. Motion with flexion and extension occur between menisci and femur. Rotary motion of the knee occurs between the menisci and tibia.

B. Cruciate Ligaments
   1. Function in both A-P and rotary stability.
      a. With external rotation of tibia on femur, cruciates unwind. 
         (1) With continued external rotation, anterior cruciate is wrapped around medial side of lateral femoral condyle and limits further external rotation.
      b. With internal rotation, cruciate ligaments twist on each other and limit internal rotation.
   2. Due to oblique insertions on the femoral condyles, a torsional effect is placed on the cruciates with flexion and extension. This arrangement maintains some fibers of the cruciate taut at all times.