KNEE ANATOMY

Osseous Structures

The osseous structures of the knee include the femur, the tibia, and the patella (Table 13.1).

At the distal end of the femur lie the femoral condyles, which are responsible for the articulation with the patella and the tibial plateau (1). The femoral condyles are covered with articular cartilage, are convex in nature, and demonstrate two separate articulation points, one medial and one lateral (2). The superior division of the medial and lateral condyles within the femoral groove is primarily flat. The groove deepens distally toward the tibia (1). The angle and depth of the femoral groove has been associated with patellofemoral stability (3).

Table 13.1: General Information Regarding the Knee Complex.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bones</td>
<td>There are 3 bones in the knees: the tibia, the femur, and the patella</td>
</tr>
<tr>
<td>Number of dedicated joints</td>
<td>• 3 joints: the tibiofemoral joint is a bicondylar synovial joint, the superior tibiofibular joint is an arthrodial joint, and the patellofemoral joint is a pseudosaddle joint.</td>
</tr>
<tr>
<td>Patella</td>
<td>• Base is the superior aspect, apex is the inferior aspect</td>
</tr>
<tr>
<td></td>
<td>• With the knee extended, the apex is just proximal to the joint line</td>
</tr>
<tr>
<td></td>
<td>• Has thick articular cartilage</td>
</tr>
<tr>
<td></td>
<td>• 3 facets (4 in some cases)</td>
</tr>
<tr>
<td></td>
<td>Lateral—larger, slightly larger</td>
</tr>
<tr>
<td></td>
<td>Medial—smaller, varies in shape</td>
</tr>
<tr>
<td></td>
<td>Odd—on the extreme medial border</td>
</tr>
<tr>
<td>Menisci of the tibiofemoral joint</td>
<td>• Fibrocartilage, anchored in the intercondylar area by their anterior and posterior horns and along their exterior edges by the coronary ligaments. The slender transverse ligament attaches the menisci anteriorly</td>
</tr>
<tr>
<td></td>
<td>• The quadriceps and semi-membranosus attach to both menisci, and popliteus attaches to the lateral menisci. The muscles act to pull the respective menisci anterior or posterior</td>
</tr>
<tr>
<td></td>
<td>• Only the outer 1/3 has a blood supply</td>
</tr>
<tr>
<td></td>
<td>• Lateral menisci—more &quot;O&quot; shaped, making it more mobile than the medial menisci</td>
</tr>
<tr>
<td></td>
<td>• Medial meniscus—more &quot;C&quot; shaped</td>
</tr>
</tbody>
</table>
The tibia gives birth to the tibial plateau and contributes significantly to knee stability (1). The medial and lateral plateaus are concave, a tendency that is enhanced by the inclusion of the medial and lateral menisci (2). The lateral tibial plateau is larger, to account for the movement of the lateral femoral condyle. Between the two tibial plateaus is the pyramidal-shaped intercondylar eminence. This eminence serves as a pivot point for the femur and stabilizes the knee from excessive extension (1). This region also serves as an attachment site of the menisci.

Figure 13.2: The Proximal Articulation Components of the Tibia
The patella is a triangular-shaped sesamoid bone designed to improve the extensor mechanism of the knee. The inferior (posterior) surface of the patella has a medial and lateral facet but does exhibit three and occasionally four concave surfaces of articulation (2). The medial facet typically demonstrates the greatest anatomical variation (4). Generally, the medial facet is subdivided into two facets to more appropriately articulate with the condyle of the femurs (4). The lateral facet is longer and wider than the medial facet and is concave in both longitudinal and medial-lateral directions (4). Occasionally, a transverse ridge subdivides the lateral facet, creating a superior and inferior face for articulation.

![Figure 13.3: Posterior Surface of the Patella](image)

The inferior aspect of the patella articulates with the superior femoral groove during extension, and the superior aspect of the patella articulates with the inferior aspect of the femoral groove during flexion (4). The contact surface of the patella with the femur is greatest during flexion and least during full extension (2).

**Summary**

- The osseous structures of the knee include the femur, the patella, and the tibia.
- The femur provides for the articulation of the patellofemoral joint and the tibiofemoral joint.
- The posterior surface of the patella promotes movement and stability within the condyle of the femur.
- There are three joints at the knee, all of which are synovial.
- The outer 1/3 of the menisci have a blood supply.
- The patellofemoral joint has the thickest cartilage of any joint in the body.
Joints

The Tibiofemoral Joint

The tibiofemoral joint is the largest joint of the body. The femoral condyles are cam shaped and circular in structure. The medial condyle of the femur is larger than the lateral condyle (2) and encounters greater weight-bearing forces than the lateral aspect (5). Although the lateral condyle is smaller than the medial condyle, the lateral condyle projects anteriorly and acts as a stabilizer of the patella. The anterior part of the lateral condyle is flattened and provides a contact surface with the anterior horn and the anterior part of the tibial articular surface during full extension. Generally, the lateral component of the tibiofemoral joints allows greater mobility, less stability, and is more prone to laxity than the medial compartment.

![Figure 13.4: Anterior View of the Tibiofemoral Joint](image)

The femur articulates with the tibial plateau, which is inclined laterally and posteriorly and promotes stability during extension (Table 13.2). A number of capsular reinforcements also stabilize the knee complex. The medial and lateral menisci, both of which contribute to stability during various degrees of extension and flexion, significantly enhance this articulation. Both menisci absorb ground reaction forces across the knee and redistribute those forces to all aspects of the femoral condyle and tibial plateau (2).
Table 13.2: Theoretical Resting Position, Close Pack Position and Capsular Patterns of the Knee Joints.

<table>
<thead>
<tr>
<th>Joint</th>
<th>Theoretical Resting Position</th>
<th>Theoretical Close-Pack Position</th>
<th>Theoretical Capsular Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibiofemoral joint</td>
<td>Resting position = 25° flexion</td>
<td>Close-pack position = full extension, ER of the tibia</td>
<td>Capsular pattern = flexion, extension</td>
</tr>
<tr>
<td>Patellofemoral joint</td>
<td>Resting position = hyperextension to 5° of flexion</td>
<td>Close packed ~30–60° of knee flexion</td>
<td>Unknown</td>
</tr>
<tr>
<td>Superior tibiofemoral joint</td>
<td>Resting position = slight plantarflexion of the foot</td>
<td>Close packed = dorsiflexion of the foot</td>
<td>Pain when stressed</td>
</tr>
</tbody>
</table>

The Patellofemoral Joint

The patellofemoral joint is the articulation of the patella within the femoral groove (Table 13.3). During flexion and extension, the patella moves up to 7 or 8 centimeters in relation to the femoral condyles (1). The primary function of the patella is to improve the mechanical advantage of the quadriceps during movements of flexion and extension. The patella moves in a C-shaped pattern from extension to flexion and back. Additionally, the patella tilts medially from knee flexion to laterally during knee extension. This is most likely a mechanism associated with the concurrent rotation of the tibia and the shape and congruence of the femoral condyles.

Table 13.3: Capsular Reinforcements of the Knee Complex.

<table>
<thead>
<tr>
<th>Osteokinematics</th>
<th>Plane of Motion/Axis of Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Attachment sites include quad muscle, patellar retinacular fibers (which are extensions of connective tissue covering vastus lateralis, vastus medialis, and iliobibial tract)</td>
</tr>
<tr>
<td>Lateral</td>
<td>Attachment sites include lateral collateral ligament, lateral retinacular fibers, iliobibial tract, biceps femoris, tendon of popliteus, and lateral head of the gastrocnemius</td>
</tr>
<tr>
<td>Posterior</td>
<td>Attachment sites include oblique popliteal ligament (from semimembranosis tendon to lat fem condyle), arcuate popliteal ligament (from fibular head to posterior condyles), and popliteus, gastrocnemius, and hamstring muscles</td>
</tr>
</tbody>
</table>
Attachment sites include medial collateral ligament, medial patellar retinacular fibers, semimembranosus tendon, sartorius, gracilis and semitendinosus tendon (pes anserinus)

When dysfunction of the patella occurs, it may dislocate, sublux, fracture, degenerate, or develop a tracking problem (6). Pain associated with the patellofemoral joint is typically diffuse, generally involves crepitus and locking, and may lead to decreased functional activities (6). The tracking problem may result in a number of consequences including abnormal loading, abnormal pressures at the femur and patella, and pain (7).

**Summary**

- The tibiofemoral joint is the largest joint of the body.
- The medial aspect of the femur bears more weight than the lateral aspect.
- The extremely mobile patellofemoral joint moves up to 7 or 8 centimeters in relation to the femoral condyles.
- The theoretical resting position of the tibiofemoral joint is 25° of flexion.
- There are multiple capsular attachments to the knee, most of which articulate with tendons and muscles.

**Intra-articular Structures**

The most prominent nonligamentous intra-articular structures are the medial and lateral menisci. The menisci’s primary role is stabilization, shock absorption, proprioception, and improvement in lubrication and sequencing of the knee (5,8). The menisci actually absorb the majority of compressive force at the knee because the combined mass is greater than that of the surrounded articular cartilage (8). Like discs at other regions of the body, the knee menisci help to distribute contact forces over the articular surfaces by increasing the contact surface of the joint (5).

The medial meniscus attaches anterior to the articulating surface of the tibia, to the medial aspect of the capsule of the knee, and at the intercondylar tubercle. The medial meniscus also has an attachment posterior with the semimembranosus (1). The lateral meniscus connects (both the anterior and posterior horn) near a common attachment posterior to the intercondylar tubercle of the tibia and near the attachment of the posterior horn of the medial meniscus. The posterior aspect of
the lateral meniscus generally is attached to two meniscofemoral ligaments and is thought to be significantly altered biomechanically by the cooperative action of the popliteus and the meniscofemoral ligaments (9,10). Both the anterior aspects of the medial and lateral meniscus are attached via the ligamentum transversum, also known as the transverse meniscal ligament (1).

![Figure 13.5: The Tibial Attachments of the Medial and Lateral Menisci](image)

The medial meniscus is C shaped and the lateral meniscus is primarily circular shaped. Both menisci distort significantly (elongate in a sagittal plane) and move posteriorly during flexion and move anteriorly during extension. This distortion is greatest during higher loads (5). During rotation, such as during the screw home mechanism, the menisci follow the movements of the femur (2).

Actions such as weight bearing increase the mobility of the menisci. Of the two menisci, the medial meniscus encounters more forces during weight bearing than the lateral meniscus.

The menisci are damaged occasionally during weight-bearing activities and during normal processes of degeneration. Studies have shown that degeneration and tears often occur concurrently (8). Damage to the cartilage generally begins at the surface then extends through the thickness of the cartilage (5). Meniscal damage leads to cartilage thinning and subsequent loss of joint space (8).

The outer aspect of the menisci is innervated and is capable of producing pain when torn or degenerated (5). Historically, damage to the menisci involved removal of the menisci to avoid the painful consequences associated with knee locking. Nonetheless, when the menisci are removed,
forces along the femur and the tibia are significantly increased, specifically at the contact points of articulation (8). Furthermore, removal of the menisci commonly leads to articular surface breakdown of the femur and tibia within a few years (5,8,11). Articular breakdown may result in flattening of the femur at the compression site, fibrillation, sclerosis, and further narrowing of the joint space (12).

**Muscles**

Several muscles contribute to normal knee motion. The quadriceps femoris muscles include the rectus femoris, vastus lateralis, vastus medialis, and the vastus intermedius. Much of the efficiency of the knee extensor mechanism depends on the timing and position of the patella during muscular contraction. The maximal quadriceps contraction occurs at 60 degrees of knee flexion (2).

The knee flexors include the hamstrings, sartorius, gracilis, popliteus, and the gastrocnemius muscles. The popliteus muscle also contributes to knee flexion concurrently while initiating internal rotation.

<table>
<thead>
<tr>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The medial and lateral menisci’s primary role is stabilization, shock absorption, proprioception, and improvement in lubrication and sequencing of the knee.</td>
</tr>
<tr>
<td>• Both menisci distort significantly (elongate in a sagittal plane) and move posteriorly during flexion and move anteriorly during extension.</td>
</tr>
<tr>
<td>• The outer aspect of the menisci is innervated and is capable of being a pain generator.</td>
</tr>
<tr>
<td>• The collective output of the muscles in the knee work in concert to increase the stability during static and dynamic activities.</td>
</tr>
</tbody>
</table>

**Ligaments and Capsule of the Knee**

*The Capsule of the Knee*

The anterior, lateral, medial, and posterior capsular complexes of the knee integrate with muscle, ligaments, and surrounding tendon structures. Thus, the complex functions both passively and actively in its support of the knee (Table 13.4).
Table 13.4: The Patellofemoral Joint.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articular cartilage</td>
<td>Has the thickest articular cartilage of any joint—up to 7 mm thick</td>
</tr>
<tr>
<td>At 135° flexion</td>
<td>Patella contacts femur near the superior pole, the patella rests below the intercondylar groove bridging the intercondylar notch. The lateral facet and the odd facet contact the femur.</td>
</tr>
<tr>
<td>At 90° flexion</td>
<td>Contact area of the patella migrates inferiorly and between 90° and 60° flexion the patella occupies its greatest area of contact with the femur (but only ~30% of the total patella is in contact with the femur); therefore, there is a significant compression force per unit area (i.e., high joint compression force)</td>
</tr>
<tr>
<td>At 20–0° extension</td>
<td>Contact area is the inferior pole. In full extension the patella is completely above the intercondylar groove.</td>
</tr>
</tbody>
</table>

The Anterior Cruciate Ligament

The anterior cruciate ligament (ACL) is the primary structure responsible to counter anterior tibial transfer with respect to the femur (1). The ACL is a broad helical ligament that allows for appropriate tibia-to-femur rotation during movement but still supports the transfer of the tibia and side-to-side stabilization of the knee. The femoral attachment of the ACL is at the posterior aspect of the medial surface of the lateral femoral condyle (1). The tibial attachments are at the anterior aspect of the tibial spine (1).

Similar to other ligaments of the knee, the ACL is actually two distinct bands—an anterior-medial and a posterolateral band, based on the origins of the tibia. The anterior medial band is taut in flexion, and the posterolateral band is taut in extension (1). Subsequently, the bands change tension throughout movement of the knee from flexion to extension. Because the ligaments are relatively horizontal during flexion, the ligaments serve to stabilize tibial translation mostly at nearly 90 degrees. The ligament is also a secondary restraint to varus and valgus forces and internal rotation of the tibia.

The ligament is commonly injured when the tibia is driven anteriorly on the femur, but a large portion of ACL injuries are nontraumatic, occurring commonly in female athletes during cutting
or pivoting activities (13). Damage to the ACL may lead to increased risk of meniscus, chondral, and subchondral injury within 5 to 10 years (14).

**The Posterior Cruciate Ligament**

The posterior cruciate ligament (PCL) has a relatively compact tibial attachment, located posteriorly between the posterior horn of the medial and lateral menisci (15). The femoral attachment is extensive adjacent to the condylar cartilage and near the medial femoral condyle (15). Most researchers agree that the PCL is made of two separate systems of fibers that function separately, based on the forces provided to the knee joint (16). The PCL fibers run anterior and proximal and are designed to counter tibial posterior translation. It is projected that the PCL is strongest while one is younger, slowly weakening with age (15).

The PCL is the primary restraint of the tibia on the femur when the knee is flexed from 30 to 90 degrees (15). Isolated cutting of the PCL minimally affects posterior tibial translation while the knee is in extension (17). Structures other than the PCL are responsible for stability of the knee from 20 degrees of flexion to extension (15). The PCL is a secondary restraint to tibial internal and external rotation and valgus and varus forces (15).

The condition of the ACL affects the PCL as does the condition of the PCL affect the ACL. A stiffer ligament leads to increased force across both ligaments, and a more flexible or lax ligament leads to diminished forces along both ligaments (18). The ligaments function in concert to control anterior and posterior tibial translation.

**The Lateral Collateral Ligament**

The lateral collateral ligament is tightened during extension and is slackened during approximately 30 degrees of knee flexion (17). The popliteofibular ligament contributes to posterior-lateral stability during all angles of flexion and contributes as a deterrent to varus forces during extension and flexion (17).
The Medial Collateral Ligament Complex

The medial collateral ligament complex (MCL) consists primarily of three main structures: the longitudinal fibers of the superficial medial collateral ligament (sMCL), the deep medial collateral ligament (dMCL), and the posteromedial capsule (PMC) (19). At present, the true function of these fibers and whether the fibers function together or independently is unknown.

The MCL structures provide coronal shear stability and reduce the forces associated with valgus. In addition to the passive structures, the contribution of the muscles of the pes anserine aids in stabilizing the knee. Passively, the posteromedial capsule provides passive support during extension of the knee and provides some stability at extension. The MCL contributes more toward valgus stability of the knee during flexion.

The Meniscofemoral Ligaments

The meniscofemoral ligaments connect to the posterior horn of the lateral meniscus to the intercondylar area of the femur (20). Less common are meniscofemoral ligaments that attach to the anterior horn of the medial meniscus, which are present in approximately 90 percent of individuals.
MFLs are considered stabilizers of the knee, specifically stabilizers in rotation. The MFLs are responsible for moving the posterior horn of the meniscus during movement of the knee (21). The ligaments keep the meniscus moving consistently with the movement of the femur, thus preventing the meniscus from being ‘caught’ between the femur and the tibia.

Because the popliteus muscle also contributes to movement of the posterior horn of the meniscus, some have proposed that the MFLs function to counter the pull of the popliteus muscle (22). The anterior and posterior MLFs may serve to move the meniscus during extension and flexion movement, each being responsible for the movement of the menisci depending on the position of the femur relative to the tibia. Additionally, the MFLs are considered secondary restraints to a posterior drawer of the knee.

**The Posterolateral Knee Structures**

The posterolateral knee structures include the lateral collateral ligament, the arcuate ligament, the popliteofibular ligament, and variably the fibellofibular ligament (23). Isolated injuries to the posterolateral corner are rare (23) but may occur during contact to the anterior-medial aspect of the extended knee during weight bearing (27) or forced external rotation during a loaded and extended knee (24). When injured, patients report a sensation of knee instability during extension. Movements such as hyperextension are vague clinical findings during examination and may not be definitive of posterolateral knee instability (23). Posterolateral knee instability is rotational in nature and may involve displacement of the tibia posteriorly on the femur.

Because the PCL couples with external rotation of the tibia during posterior translation, the PCL ligament contributes poorly to the stability of the posterior lateral corner, specifically in extension. Isolated rupture of the posterior-lateral corner has a significant effect on the rotational and translatory stability of an extended knee (15). Because of this, posterior drawer tests performed in flexion are not sufficient to determine posterior-lateral instability. Generally, to determine posterior lateral corner instability, the clinician must examine tibial external rotation during 30 to 90 degrees of knee flexion (15,25).
Posterolateral instability may involve an injury to the popliteus tendon because this structure is considered an important restraint to tibial external rotation (25). The popliteus tendon originates on the posterolateral aspect of the femur and inserts on the anterior-lateral aspect of the fibular head, just distal to the lateral joint line. The tendon tightens during extension and external rotation.

**Posterior Ligaments and Structures**

The most important posterior stabilizing structures of the knee are the deep posterior capsule, the lateral condylar ligament, the oblique popliteal ligament, the semimembranosus muscle, and the arcuate ligament. The deep posterior capsule is tightened during knee extension and blends nicely with the tendinous insertions of the gastrocnemius muscles. The lateral condylar ligament, oblique popliteal ligament, and the arcuate ligament assist in stabilizing the structure of the posterolateral knee. The semimembranosus can contract and tighten the oblique popliteal ligament that is considered a continuation of the tendon.

![Figure 13.7: The Posterior Structures of the Knee](image)

**Summary**

- There are multiple ligamentous structures responsible for stability of the knee.
- Damage to one of the ligaments may negatively affect other ligaments.
- The most common outcome to damaged ligaments is instability.
KNEE BIOMECHANICS

Movement and Stability

Tibiofemoral Joint

In a normal knee, approximately 0 to 140 degrees of extension to flexion are present (2). Most individuals also exhibit some degree of knee hyperextension during passive weight bearing and non-weight bearing. In normal individuals, the combined contribution of the muscles, ligaments, and menisci serve to increase the stiffness and stability of the knee and allow the action of transmission of large loads throughout the joint (18).

Tibiofemoral translation is somewhat predictable during movements of extension to flexion. As a whole, during knee flexion, the tibia moves posteriorly on a fixed femur and the menisci move posteriorly as well. During knee extension, the tibia moves anteriorly on the fixed femur and the menisci move anteriorly. Movements in weight bearing initiate structures such as the cruciate ligaments and the menisci to balance the shear and compression forces at the tibiofemoral joint (26). Anterior forces are restrained primarily by the ACL, while posterior forces are restrained by the PCL.

Von Eisenhart-Rothe et al. (27) reported that the femur translates posteriorly on the tibia at 30 to 90 degrees of knee flexion during cocontraction of the extensors and flexors in a simulated loading response. However, isolated contraction on healthy subjects demonstrates anterior translation of the tibia with respect to the femur during extensor contraction and posterior translation of the tibia with respect to the femur during flexor contraction (28). Individuals with a damaged ACL demonstrate posterior translation of the femur during isolated extensor and flexor contractions. These findings are supported by others (29) that also found posterior migration of the femur on the tibia during flexion.

Although the lateral condyle is often considered to translate more so than the medial condyle, research results are mixed (27,28). Rolling is a fundamental movement of most articular surfaces, and the femur does roll significantly on the fixed tibia. During flexion, the femur rolls and slides posteriorly to the tibia to allow the distal and posterior aspects of the femoral condyle to
interface with the flattened tibial plateau. Much of this movement is guided by the posterior translation of the menisci and the control supplied by the cruciate ligaments and can be disrupted significantly during damage to these structures (27). The ACL pulls on the femur and encourages anterior slide during knee flexion while it rolls in a posterior direction. The PCL encourages the femoral condyle to slide posterior during active extension and roll in an anterior direction.

During extension and flexion, the knee exhibits coupled-knee internal and external rotation and sagittal motions (18). This concurrent action of coupled tibial rotation called the **screw home mechanism** occurs to enhance the stability of the knee. When the knee is flexed in a closed chain, the tibia moves internally, in some cases up to 6.5 to 36 degrees (30,31). During knee extension in a closed chain, the tibia moves into external rotation. Conversely, the femur appears to translate posteriorly, rotate laterally, and migrate proximally during flexion with respect to the tibia (18). To some extent, coupled varus and valgus motion occurs in conjunction with the sagittal and transverse plane movements. Nonetheless, these motions do not appear to be as compelling as rotations, flexion, and extension (18).

During flexion beyond 120 degrees, the femoral condyles lose congruency with the tibial plateau and have contact points at the posterior horn of the menisci (26). This is because the rolling of the femur outdistances the concurrent slide of the tibiofemoral complex. The external rotation that occurs at the femur increases the surface area for roll because it mimics the translatory aspect at the joint. Martelli and Pinskerova (32) advocate that the medial condyle is congruent and rounded and the lateral surface is flattened, allowing the lateral condyle to roll and slide at a greater quantity than the medial surface.

**Screw Home Mechanism**

The screw home mechanism appears to be guided by the location of the joint axis and by the passive action of the posterior and anterior cruciate ligaments (33). This mechanism is altered when damage is incurred to the anterior and posterior cruciate ligaments or when the stress-tension relationship of this ligament has someway been altered (33).
The popliteus plays a vital role in the screw home mechanism and initiates rotation of the tibia at 0 to 20 degrees of flexion. During this rotation, the menisci follow the movements of the femur (2). The popliteus is situated and well adapted to prevent tibial external rotation during knee flexion (18). During active extension, the popliteus functions actively to initiate knee flexion and retraction of the lateral meniscus (18).

**Summary**

- During an extension contraction, the tibia translates anteriorly.
- During a flexion contraction, the tibia translates posteriorly.
- During flexion, the tibia follows the convex-concave rule and rolls posteriorly. During extension, the tibia rolls anteriorly.
- The popliteus plays a vital role in the screw home mechanism and initiates rotation of the tibia at 0 to 20 degrees of flexion.
- During screw home rotation, the menisci follow the movements of the femur.

**Patellofemoral Joint**

Movement of the patellofemoral joint is a complex kinematic process. Numerous in-vitro studies have investigated patellofemoral movements and have reported significant variations of patterns (34,35). One study attempted to load the knee during 90 degrees of flexion to extension and found consistency of the patella during movement on the femur. During movement from flexion to extension, the patella starts in a medially tilted position, and then shifts to neutral, lastly shifting to a laterally tilted position while in extension (36).
Figure 13.8: Movement of the Patella during Extension to Flexion of the Knee

Recently, an *in vivo* study demonstrated variability in patellofemoral movements during extension to flexion movements. Laprade and Lee (37) reported that the patella typically moves distally during progressive extension to flexion, variably moves from anterior to posterior position (in many cases, the patella just moved posteriorly), and variably moves progressively laterally during knee flexion. In some cases, the kneecap moved medially first, then laterally as knee flexion progressed.

Abnormalities in patellofemoral biomechanics generally manifest at 0 to 30 degrees of flexion because of the deepening of the trochlear groove of the femur. Increases in knee flexion increase the compression of the patellofemoral joint (38). As the tibia continues to flexion, the iliotibial band pulls posteriorly on the patella, promoting posterior displacement against the femur (4). If the patella lies too far laterally during this motion, this process can cause abnormal lateral forces, tracking problems, and lateral dislocations. Powers (3) reported that the depth of the trochlear groove is highly correlated with abnormal patellar kinematics, with increased shallowness of the trochlear groove predictive of lateral patellar tilt and abnormal tracking.
Summary

• The articulation pattern of the patella may be variable during flexion and extension movements.
• The patella typically moves distally during progressive extension to flexion, variably moves from anterior to posterior movement (in many cases, the patella just moved posteriorly), and variably moves progressively laterally during knee flexion.
• Abnormalities in patellofemoral biomechanics generally manifest at 0 to 30 degrees of flexion because of the deepening of the trochlear groove of the femur.

Online References


