CHAPTER 7

Knee

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Essential Anatomy

The knee is a weightbearing, modified-hinge joint. Its motion is controlled and stabilized by muscles and ligaments, as well as the shape of the opposing bone surfaces and their associated meniscal cartilages. The knee is a highly efficient structure that can provide support for the body and meet the changing demands of multiple locomotor tasks. Because it is subject to high forces exerted along lengthy lever arms (tibia and femur), the knee is vulnerable to injury during the course of normal daily activities and during sports.

Knee motion is a complex function. Flexion and extension of the knee require rotation and some degree of abduction and adduction. The rotation effect can be demonstrated by placing the fingers over the tibial tubercle and noting that the tibia internally rotates as the leg goes into flexion and externally rotates as it goes into extension. This rotation depends on the relative size of the medial and lateral femoral condyles, the shape of the tibial condyles, and the effects of the controlling ligaments (Fig. 7.1). As the femoral condyles move through their rotational arc, they both roll and slide on the tibial condyles (Fig. 7.2). If the femoral condyles did not slide, the femur would simply roll off the tibia posteriorly at the extremes of flexion. In fact, the rolling motion is combined with a sliding motion, and it is this combination that allows for the full arc of stable flexion of the knee. Rolling and sliding varies between the medial and lateral sides of the knee. The lateral condyle rolls more and the medial condyle slides more, producing external rotation as the knee goes into full extension. The rolling and sliding mechanism is passively controlled by the anterior cruciate ligament as the knee flexes and by the posterior cruciate ligament as the knee extends.

X-RAY ANATOMY

Figure 7.3 shows radiographs of the knee with important elements labeled.

Skeletal and Articular Structure of the Knee

Femur (Fig. 7.4)

The shaft of the femur extends from the trochanters to the condyles and is triangular in cross section with its apex. The apex posterior with its ridges is called the linea aspera. The shaft is slightly bowed with anterior convexity and inclines from the trochanters to the condyles in slight adduction. Posteriorly, the linea aspera provides insertion for the adductors and extensors of the thigh, whereas the anterior surface of the midshaft and the trochanteric area provide origin for the extensors of the knee. As the shaft approaches the condyles, it broadens laterally and medially, and the ridges of the linea aspera merge with the supracondylar ridges. These ridges outline a triangle, called the popliteal surface, to which no muscles are attached.

The femoral condyles are the rounded ends of the femurs that articulate with the tibia. Anteriorly, the condyles merge to form the patella articular surface. The medial condyle is larger in surface area than the lateral condyle, which diverges from the medial. Although the lateral condyle is smaller in total area, it is longer in length than the medial (Fig. 7.4). The condyles of the tibia are the widened platforms that articulate with the condyles of the femur (Fig. 7.5). The medial side is concave and the lateral side convex from front-to-back. The medial and lateral tibial condyles are separated by the intercondylar eminence, whose medial and lateral spines articulate with the femur. The cruciate ligaments maintain contact between the spines and the femur. The actual center of rotation may vary but in static systems is considered to be near the medial spine.

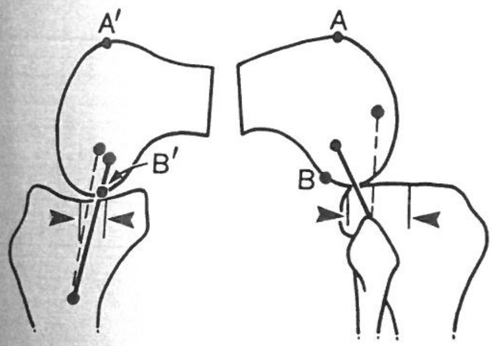


Figure 7.1. Unequal motion of the condyles is caused by the following: (1) The unequal length of the condyles. A to B is greater than A' to B' on the medial condyle. (2) The shape of the condyles. The medial tibial condyle is concave and the lateral is convex, allowing more posterior rolling. (3) The direction of the collateral ligament. The medial collateral is stretched faster and the lateral is more posterior, allowing the condyle to move farther back. (Adapted from Kapandji IA. The Physiology of the Joints. Edinburgh and London: E and S Livingstone, 1970:195,196.)

Anatomy of the lower extremities is such that the hips are wider apart than the ankles. Consequently, a physiologic valgus alignment is produced at the knee in order for the joint to remain parallel to the ground, biomechanically the most efficient orientation (Fig. 7.6).

Ossification Centers About the Knee

Three ossification centers are about the knee. The femoral condylar epiphysis is evident at birth and completes ossification by age 20. Ossification of the distal aspect of the femoral condyles can sometimes proceed in an irregular pattern, which must not be confused with osteochondritis (see "Nontraumatic Conditions of Childhood"). The tibial condylar epiphysis is usually evident at birth and completes ossification by age 20. This epiphysis includes the tibial tubercle as well as the tibial condyles. The patella ossifies from a single center that becomes radiologically evident by age 6. Ossification is completed during puberty.

Synovium of the Tibiofemoral Articulation

Figure 7.7 illustrates the three-dimensional form of the synovial space and the lines of attachment of the synovium to the articular borders of the femur and tibia. The menisci are included within the synovial space but the cruciate ligaments are excluded.

Within the synovium there can be shelves

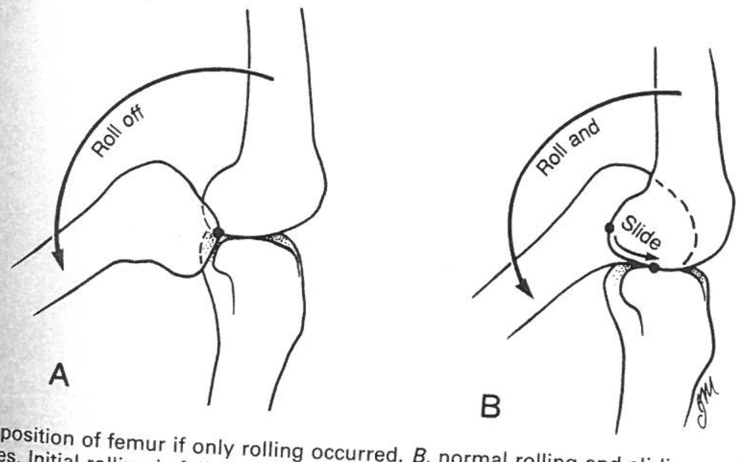


Figure 7.2. *A*, position of femur if only rolling occurred. *B*, normal rolling and sliding motion of the femoral condyles. Initial rolling is followed by sliding to maintain position on the tibial condyle.

Figure 7.3. Radiographic views of the normal knee. *A*, anteroposterior view; *1*, patella; *2*, tibial spines; *3*, medial joint space. *B*, lateral view; *1*, patella; *2*, patellar ligament. *C*, tunnel view; *1*, intercondylar notch. *D*, tangential view; *1*, patella; *2*, lateral patellar facet; *3*, trochlear groove.

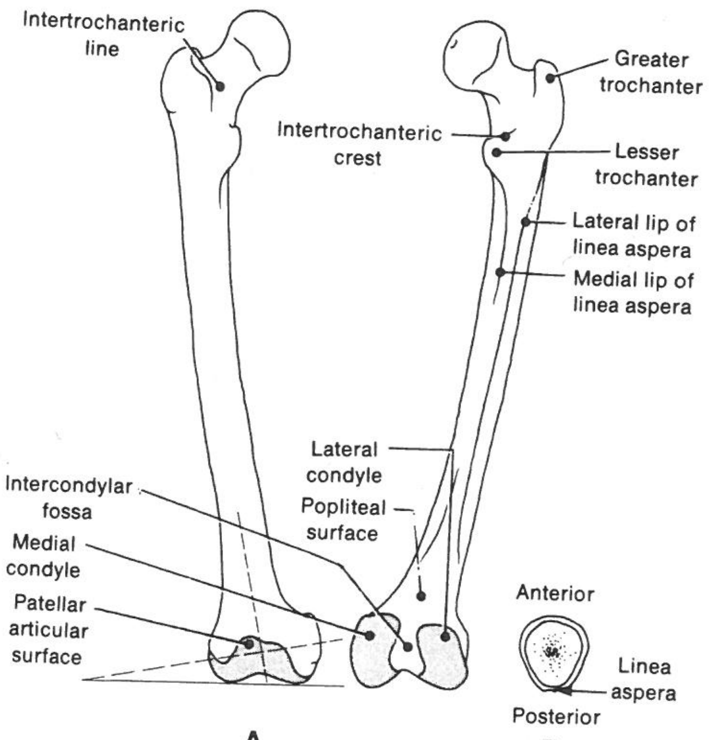
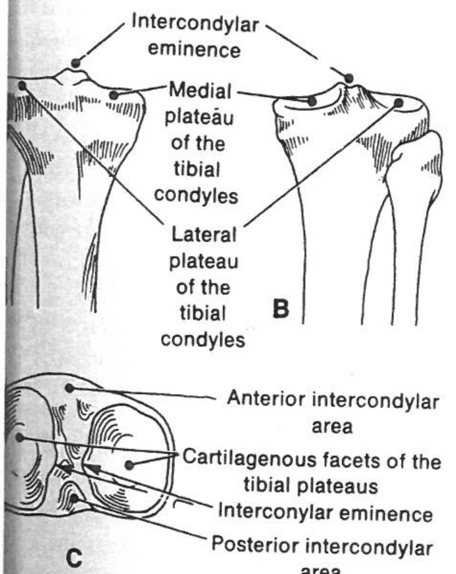


Figure 7.4. The femur. *A*, anterior and posterior views. *B*, cross section, midfemur.



e 7.5. The proximal condyles of the tibia. terior view. *B*, posterior view. *C*, superior

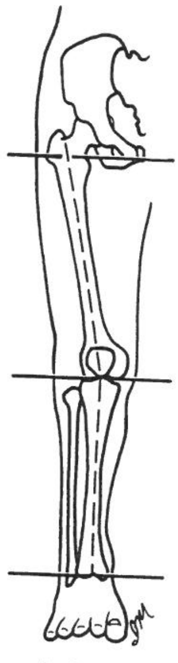


Figure 7.6. To keep the knee, pelvis, and ankle parallel to the ground, an angle is created by the wider pelvis and the knee.

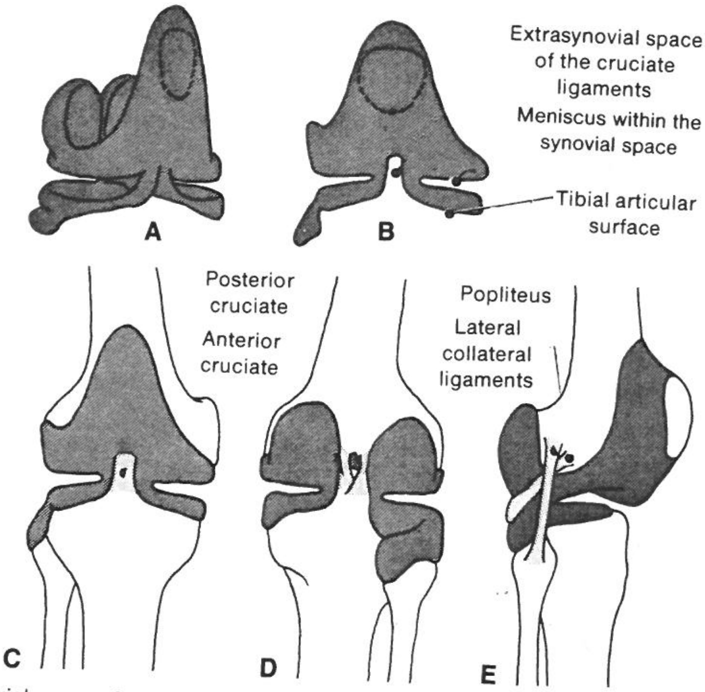


Figure 7.7. Synovial space of the knee. Diagrammatic cast of the synovial space. *A*, three-quarter anterior view. *B*, full-face anterior view. *C* through *E*, the cast of synovial space applied to the femur, patella, tibia, and fibula to indicate the margins of attachment of the synovial membrane to those bones.

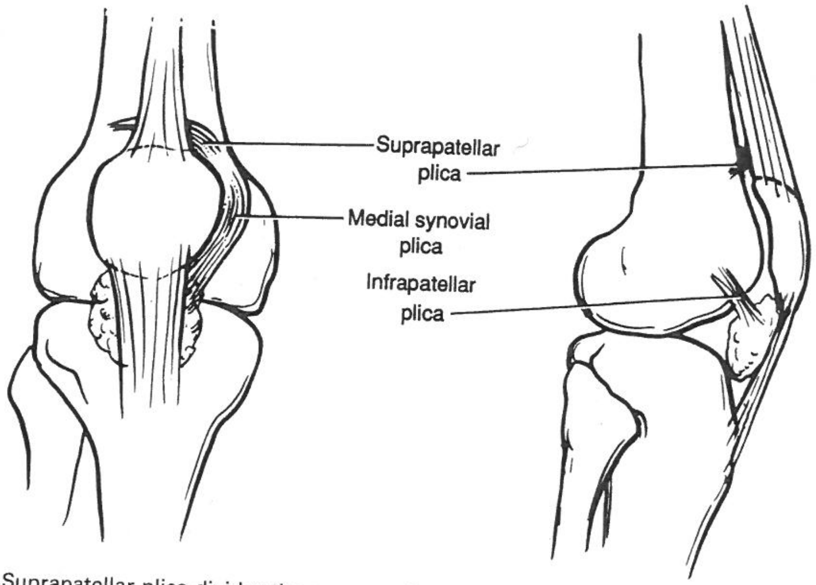


Figure 7.8. Suprapatellar plica divides the suprapatellar pouch and knee. Infrapatellar plica extends from the infrapatellar fat pad to the intercondylar notch. Medial plica extends from the fat pad to the suprapatellar plica.

or bands called plicae, which are the remnants of membranes that separated the compartments of the knee during embryonic development. There are three types of plicae, which vary in size (Fig. 7.8). The suprapatellar plica divides the suprapatellar pouch from the rest of the knee. The infrapatellar plica separates the medial and lateral compartments anterior to the cruciate ligaments. The medial plica originates from the medial synovium near the suprapatellar plica and extends to the infrapatellar fat pad. Also, the medial plica is the one band that often becomes symptomatic by being caught between the patella and medial femoral condyle or against the medial condyle alone, producing medial patellar pain. This will be discussed further in the section "Injury of the Patellofemoral Articulation."

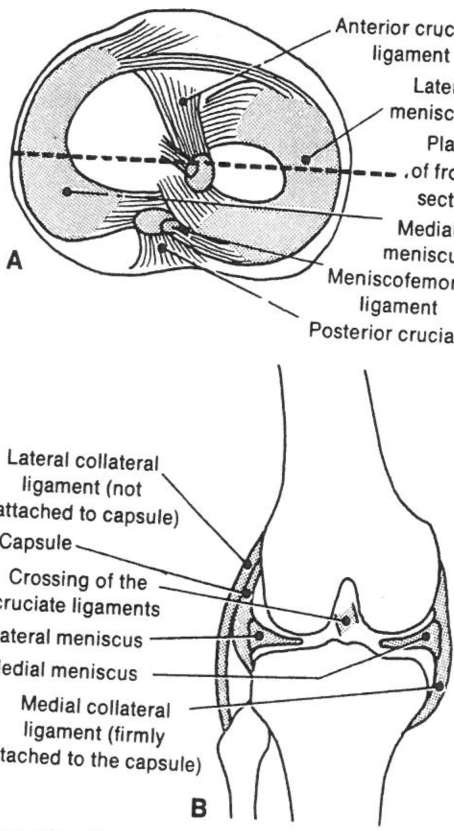


Figure 7.9. Relationship between the menisci, the capsule, and the ligaments of the knee. *A*, superior view of the menisci and cruciate ligaments. *B*, posterior view of a frontal section of the knee through the middle third.

Menisci

The two menisci are semilunar fibrocartilaginous wedges that rim and cushion each tibiofemoral articulation. The radius and circumference of the medial meniscus are larger than those of the lateral meniscus. Ends of the lateral meniscus attach to the intercondylar eminence, and ends of the medial meniscus attach to the intercondylar areas. Outer rims attach to the synovial membrane of the articular capsule (Fig. 7.9). The menisci sit on the tibial surfaces and assist in weight distribution through the knee. The medial meniscus shares half the load with the exposed weightbearing area of the tibial condyle. The lateral meniscus shares more of the weightbearing load than the exposed area of the lateral tibial condyle.

This weight distribution varies with activities (Fig. 7.10). The weightbearing area of the tibial condyle is posterior in flexion. The menisci become wedges that act as stabilizers in addition to accepting weight. In flexion the menisci are pushed back, and in extension they are pushed forward. In addition to these passive motions, the ligaments also affect the movement of the menisci. For example, the medial collateral ligament pulls the medial meniscus posteriorly during flexion and internal rotation of the tibia, and anteriorly during extension and external rotation of the tibia. On the lateral side, the popliteus muscle pulls the lateral meniscus posteriorly during flexion or during external rotation of the femur. The movement of the menisci is synchronous and obligatory. Consequently, abnormal stresses to the knee often produce meniscal tear. Because the lateral meniscus is less firmly attached to the capsule and more free to move about, it is injured less frequently than the medial meniscus.

Ligaments (Fig. 7.11)

The ligaments of the knee guide and check the movements of the articular surfaces. The lateral and medial patellar retinacula are continuations of the fascia lata and quadriceps tendon on their respective sides of the patella.

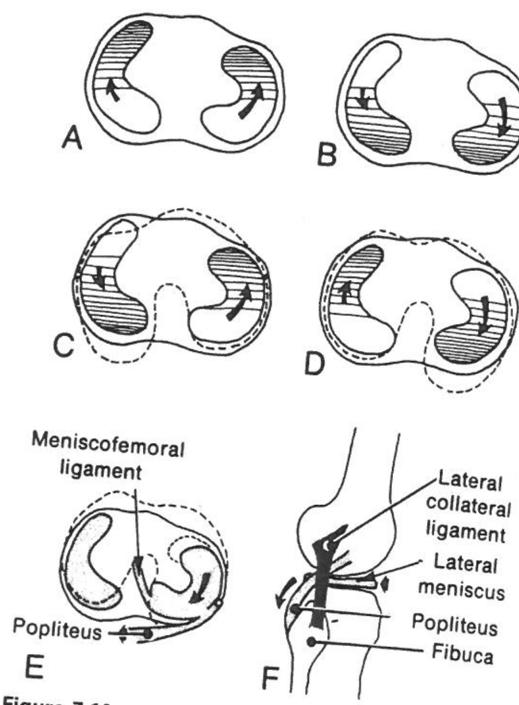


Figure 7.10. *A* through *D*, shifts in tibial weightbearing points and passive accommodations of the menisci during flexion-extension and rotation. *Shading* indicates weight distribution. *Arrows* indicate accommodative passive movements of the menisci. *Longer arrows* over the lateral meniscus symbolize its greater mobility. *A*, full extension. *B*, near full flexion. *C*, medial rotation of the femur. *D*, lateral rotation of the femur. *E* and *F*, active accommodations of the menisci during knee movement. During external rotation of the femur, the movement of the meniscofemoral ligament and the contraction of the popliteus muscle pull the lateral meniscus posteriorly and medially.

These retinacula merge with and reinforce the anterolateral and anteromedial aspects of the knee capsule. The retinacula limit the motions of the patella.

The medial collateral ligament extends in two layers from the medial femoral condyle to the medial tibial condyle. The superficial layer is a broad, triangular ligament with its apex extending posteriorly over the posterior aspect of the medial femoral condyle and joint line. The deep layer is a stout structure that blends intimately with the capsule and has an attachment to the medial meniscus. Located on the medial posterior corner is the posterior portion of the tibial collateral ligament or posterior oblique ligament.

The lateral collateral ligament is a cordlike structure with its main attachments extending from the lateral femoral condyle to the fibula; it does not blend with the capsule. Also part of the lateral stabilizing complex is the popliteus tendon, which runs beneath and attaches to the femur in front of the lateral collateral ligament. The arcuate ligament and short external collateral ligament are also on the lateral corner.

The anterior cruciate ligament extends from the anterior intercondylar area of the tibia to the medial aspect of the intercondylar area of the lateral femoral condyle. The posterior cruciate ligament extends from the posterior intercondylar area of the tibia anteromedially to the intercondylar surface of the medial femoral condyle.

Function

Because of the orientation of its fibers and the shape of the condyles, some portion of the medial collateral ligament is tight from extension through flexion. The posterior fibers are taut in extension and the anterior fibers are taut in flexion. The medial collateral ligament is the primary stabilizer to valgus stress at the knee. Acting as secondary stabilizers are the posteromedial capsule and anterior cruciate ligament. Consequently, a valgus force to the knee may first cause injury to the medial collateral ligament, but as this force continues, the anterior cruciate, posterior capsule, and posterior cruciate may be disrupted (Fig. 7.12).

The lateral collateral ligament is taut in extension and relaxed in flexion. The iliotibial tract assists in the range of 5 to 40° of flexion. The lateral collateral ligament is the primary stabilizer to varus stress. Secondary restraint is provided by the posterolateral complex, consisting of the popliteus tendon, short external collateral ligament, and arcuate ligament. A varus force will likely injure the lateral collateral ligament first, the posterolateral complex next, and if large enough, the posterior and anterior cruciate ligaments.

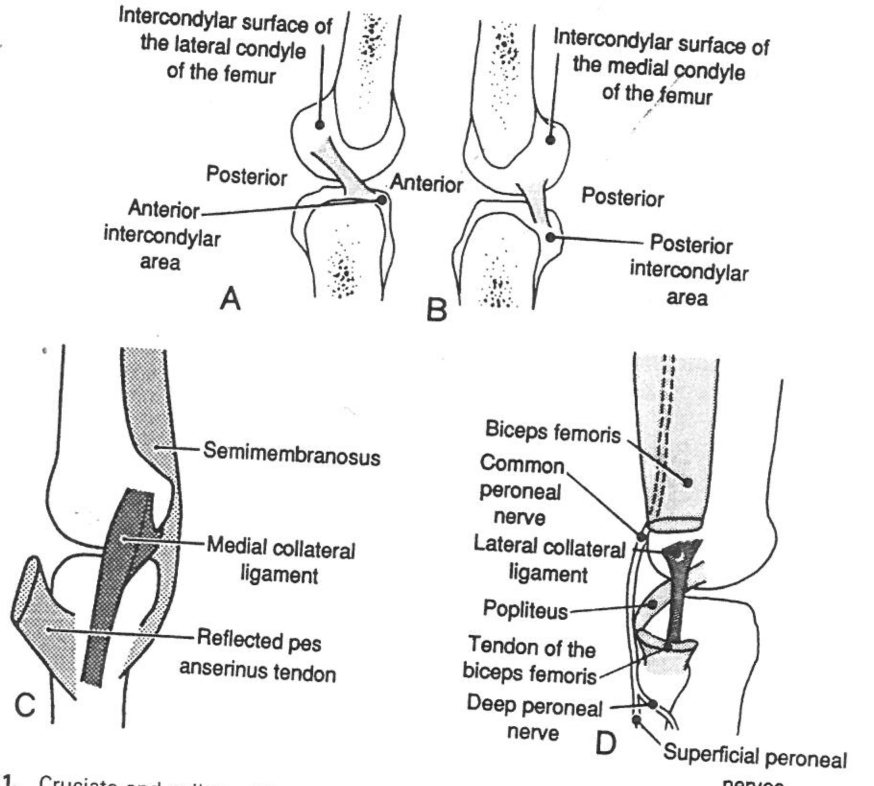


Figure 7.11. Cruciate and collateral ligaments. *A*, medial view of the anterior cruciate ligament. *B*, lateral view of the posterior cruciate ligament. *C*, medial view of the medial collateral ligament. *D*, lateral view of the lateral collateral ligament.

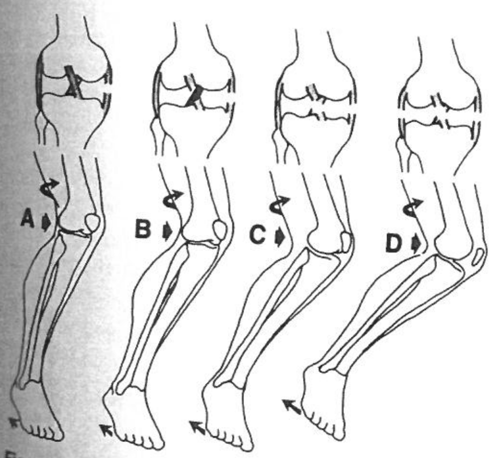


Figure 7.12. Order of vulnerability of ligaments of the knee to a valgus force. *A*, medial collateral ligament. *B*, medial collateral ligament and anterior cruciate. *C*, medial collateral ligament, anterior cruciate, and posterior cruciate. *D*, medial collateral ligament, anterior cruciate, posterior cruciate, and lateral collateral ligament.

The anterior cruciate ligament consists of two bands, the anteromedial and posterolateral. The anteromedial band tightens in flexion; this tightening, along with a twisting of the entire anterior cruciate ligament about the posterior cruciate ligament, controls anterior displacement of the tibia and compresses the joint surfaces. The posterolateral band of the anterior cruciate tightens in extension, maintaining contact. The anterior cruciate restricts anterior translation and resists internal rotation as well as hyperextension. As a secondary stabilizer to varus and valgus forces, the anterior cruciate may be injured as noted previously.

The posterior cruciate also demonstrates two bands: the anterolateral and posteromedial. The posteromedial band is tight in extension and, as the knee flexes, the entire ligament becomes tight. It is the main restraint to posterior displacement of the tibia. A force applied to the front of the tibia is resisted mainly by the posterior cruciate with little restraint from the posterior capsule. The posterior cruciate ligament can be injured in hyperflexion.

MUSCLES CONTROLLING THE KNEE

Extensors

The major extensor of the knee is the quadriceps muscle, which forms the anterior bulk of the thigh. The quadriceps muscle is made up of four parts: the rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius. Illustrated in Figure 7.13 are the origins and insertions.

The vastus medialis lies deep to the rectus femoris proximally and emerges distally to create the medial curve of the distal thigh. The vastus medialis has a special orientation at its distal end. The direction of its fibers applies a medial- and proximal-directed force to the patella during the last 15° of extension. This is important in maintaining patella stability and alignment. Both the vastus lateralis and medialis are in continuity with the knee capsule and can produce knee extension, even in the presence of patella fracture as long as there is not complete disruption of the anteromedial and anterolateral capsule (Fig. 7.14A).

All the extensors are innervated by branches of the femoral nerve, which is derived from the second through fourth lumbar roots.

Flexors

The main flexors of the knee are the gracilis, semitendinosus, semimembranosus, and biceps femoris muscles. Origins and insertions are illustrated in Figure 7.14. The gracilis and semitendinosus along with the sartorius insert into the medial aspect of the shaft of the tibia and anterior to the tibial collateral ligament, just inferior to the attachment of the patellar ligament to the tibial tubercle. This sweep of tendons over the tibial collateral ligament is known as the pes anserinus, or goose's foot.

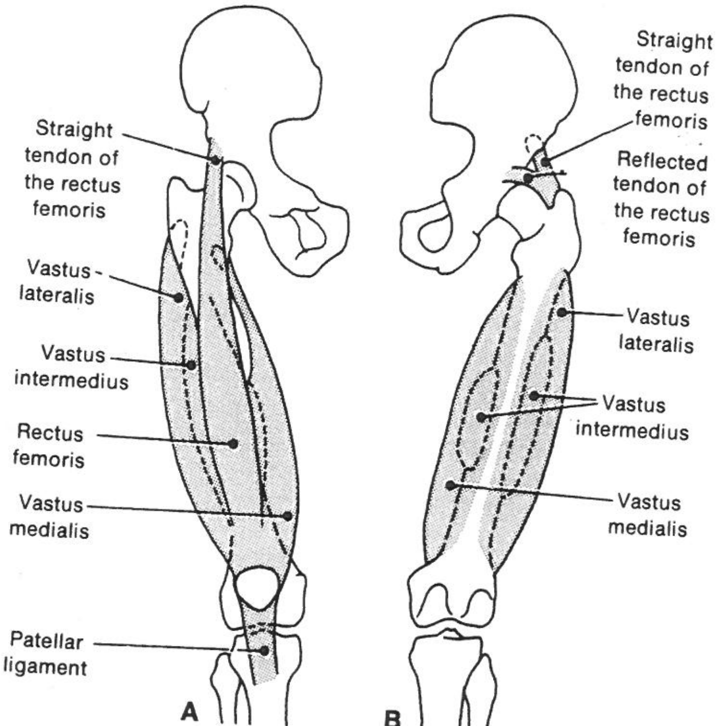


Figure 7.13. The quadriceps muscle. *A*, anterior view. *B*, posterior view.

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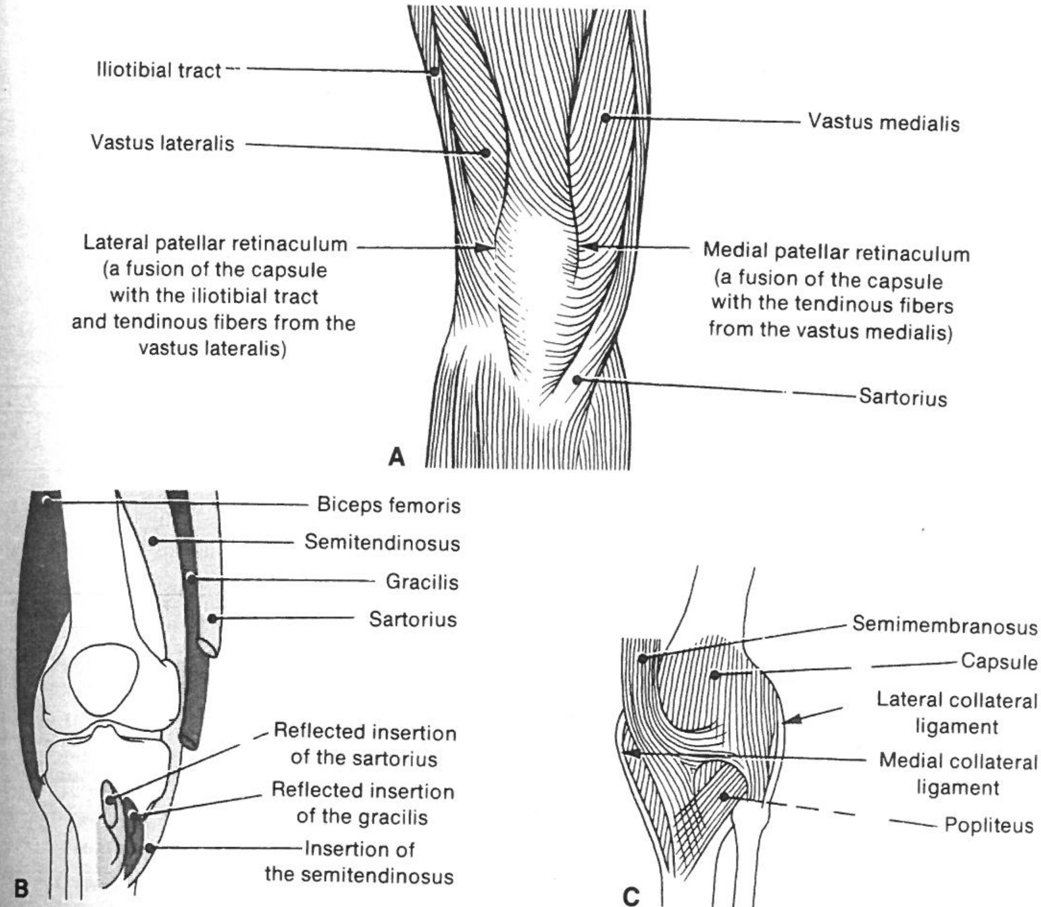

Figure 7.14. Tendinous expansions merging with capsule of the knee joint. *A*, anterior view showing the patellar retinacula. *B*, anterior view showing the tibial insertion of the sartorius, semitendinosus, and gracilis medially, and the fibular insertion of the biceps femoris laterally. *C*, posterior view showing the relationship of the semimembranosus to the capsule medially and posteriorly. The medial head of the gastrocnemius overlies posterior to the semimembranosus tendon (not illustrated).

A bursa is related to the pes anserinus, which is a common site of bursitis, particularly in patients with osteoarthritis of the knee.

The knee flexors have other actions in addition to flexing the knee. With the knee flexed, the flexors can serve as rotators of the leg in which the gracilis, semitendinosus, and semimembranosus internally rotate the leg and the biceps femoris externally rotates the leg. The internal rotators are slightly stronger than the external rotators of the leg.

The popliteus muscle arises on the posterior surface of the tibia. The tendon passes beneath the arcuate ligament and attaches to a depression on the anterior part of the groove of the lateral condyle of the femur. This muscle unlocks the knee, initiating flexion and rotation.

The sartorius, along with all the anterior muscles of the thigh, is innervated by branches of the femoral nerve. The gracilis, with all the adductors of the hip, is innervated by branches of the obturator nerve, with contribution from the third and fourth lumbar nerve roots. The other three flexors of the knee are innervated by branches of the sciatic nerve.

Fascia Lata

All the muscles of the thigh are enclosed within the fascia, a tough, unyielding covering. The fascia merges medially and laterally with the intermuscular septa. In combination with the fascia, the septa divide the thigh into anterior and posterior compartments. Because this fascial covering will not yield, extravasation of enough blood or edema into either of the two compartments of the thigh may produce a compartment syndrome.

INNERVATION AND BLOOD SUPPLY (FIG. 7.15)

The knee joint receives fibers from both the femoral and sciatic distributions. Because the femoral nerve also innervates the hip, patients with hip disorders may present with knee pain.

The femoral artery gives rise to the deep and superficial femoral arteries in the femoral triangle. The deep artery carries the major blood supply to the muscles of the thigh, and the superficial artery carries the major blood supply to the leg and foot. The deep artery penetrates deep to the adductors and eventually comes to lie between these muscles and the posterior surface of the femur. In this location, the artery and its accompanying veins are vulnerable to injury by the fragments of a fractured femoral shaft. In the distal third of the thigh, the artery passes posteriorly around the femur to lie directly on the popliteal surface of the femur, anterior to the sciatic nerve. In this area, the artery is vulnerable to injury with dislocation of the knee or juxta-articular fractures.

EVALUATION OF THE PATIENT WITH KNEE SYMPTOMS

EXAMINING FOR EFFUSION

Ambulatory patients should first be examined with both knees flexed 90°. Inspect the area on either side of the patellar ligament.

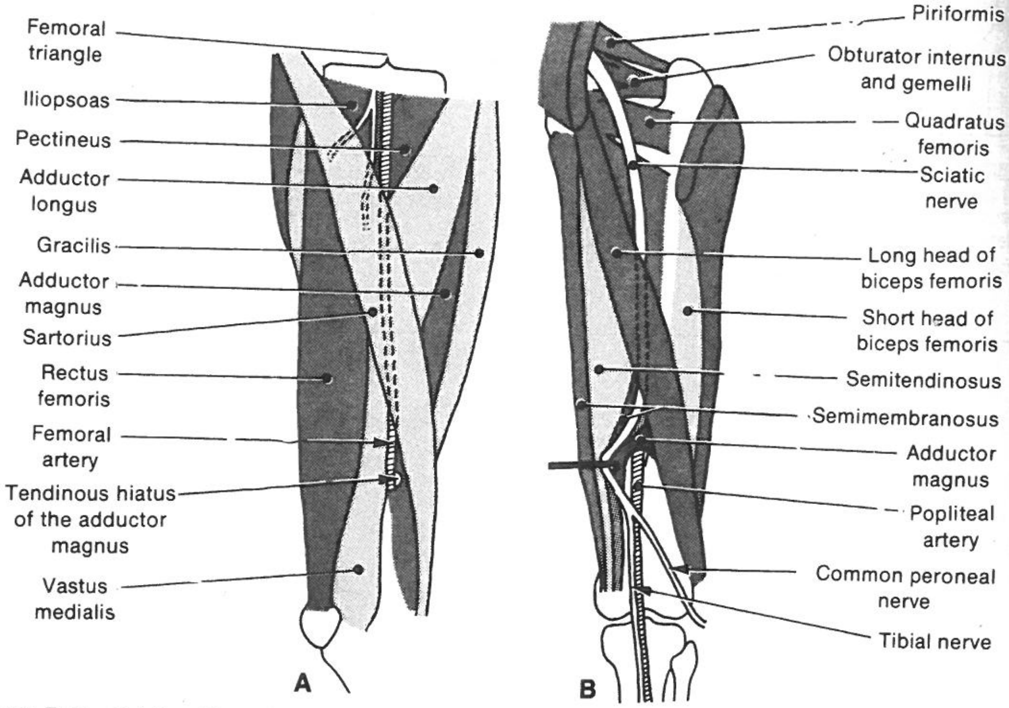

Figure 7.15. Relationships of the major vessels and nerves in the thigh. *A*, anteromedial view. *B*, posterior view.

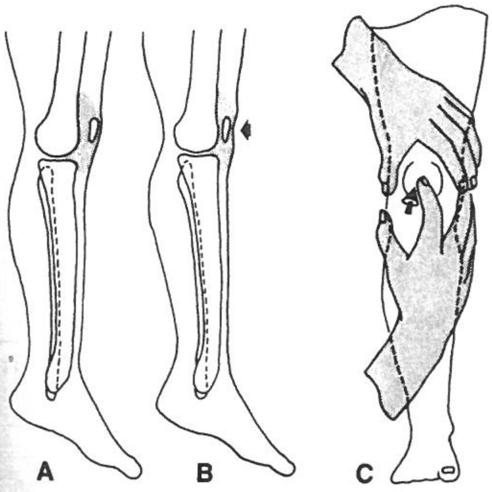

Figure 7.16. Examination for knee joint effusion. *A*, patella forced away from the femur by the effusion. *B*, patella forced downward onto the femur by ballottement maneuver. *C*, illustration of the ballottement maneuver.

Moderate effusions cause a bulging in these areas that is not present in the normal knee.

With the knee fully extended and the extensor apparatus relaxed, compress the knee above and on either side of the patella and attempt to subject the patella to ballottement with a finger. Sufficient effusion forces the patella away from the femur and allows ballottement (Fig. 7.16).

If neither of these observations suggests an effusion, attempt to flex the knee fully, unless a suspected injury to the extensor apparatus contraindicates this. An effusion can interfere with full flexion of the knee.

EXAMINATION OF THE EXTENSOR APPARATUS

Palpate the quadriceps tendon, the body of the patella, and the patellar ligament to look for defects and tenderness. Obtain x-rays if there is evidence of a defect over the quadriceps tendon or the patellar ligament, or if the body of the patella is tender or palpably fractured. A rupture of the extensor apparatus should be presumed if the x-ray reveals a fracture of the body of the patella or avulsion from the superior border or the inferior pole, or if the examination by palpation demonstrates an apparent defect in the quadriceps tendon or patellar ligament. Further examination should be discontinued and orthopaedic referral made.

When no evidence exists of rupture of the extensor apparatus, displace the patella laterally and medially to test for a retinacular tear or strain. Subluxation or dislocation of the patella should be suspected if this type of patella manipulation is associated with apprehension. Displace the patella proximally while forcing it posteriorly into its femoral articulation to test for pain and crepitus associated with chondromalacia patellae.

EXAMINATION OF THE COLLATERAL LIGAMENTS

Test the integrity of the medial and lateral ligaments by applying valgus and varus stress, attempting to open the joint line of the knee with the knee flexed to 30° (Fig. 7.17). If the knee opens in comparison to the opposite knee given the same stress and position, and there is local tenderness and a history of injury, a disruption of the ligament or ligament complex is present. Any opening indicates a complete or third-degree sprain. An opening of 1 to 5 mm is a grade I injury; an opening of 5 to 10 mm is a grade II injury; and an opening

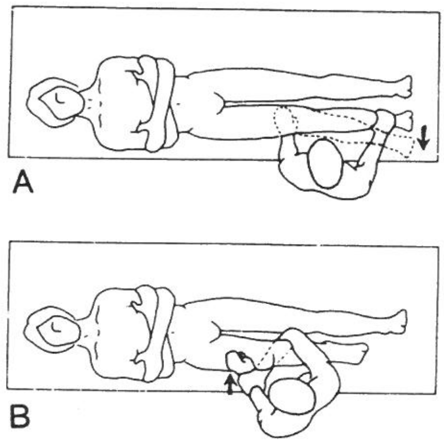

Figure 7.17. Examination for collateral ligament injuries. *A*, applying valgus stress. *B*, applying varus stress.

greater than 10 mm is a grade III injury. With higher grade injuries, the likelihood of injury to the secondary stabilizing ligaments increases. In addition to testing the ligaments with the knee flexed, stress testing should also be done with varus-valgus force with the knee extended. Instability in extension indicates more global ligamentous disruption.

EXAMINATION OF THE CRUCIATE LIGAMENTS

Anterior Cruciate

Perform the **anterior drawer test**. With the knee flexed to 90° and the hip flexed to 45°, the examiner sits on the patient's foot to keep it stabilized and uses both hands to grasp the tibia from behind. Keeping the hamstring relaxed, the pull is straight forward. If the foot is placed in external rotation, this maneuver tests the anterior cruciate ligament and also the secondary stabilizers in the posterior medial corner (Fig. 7.18). The movement of the injured knee is compared with the uninjured knee, as it is for all ligament stability testing.

Perform the **Lachman test** (Fig. 7.19). Place the patient supine and flex the knee to 20°. Stabilize the distal femur with one hand and the proximal tibia with the other. The tibia is moved forward on the femur and the degree of displacement noted. Compare the degree of displacement with the unaffected side.

Perform the **pivot-shift test** (Fig. 7.20). This is pathognomonic of a tear of the anterior cruciate ligament. The test can be performed in many ways, each producing anterior subluxation of the lateral tibial condyle and subsequent relocation, which produces the "pivot shift." One good method is for the examiner to place the patient's ankle beneath the examiner's arm with the patient's hip in abduction. The hands support the proximal tibia, exerting a valgus internal rotation and anterior translation force. With this combination of forces applied in relative extension, subluxation of the tibia occurs. As the knee is further flexed from this position, the tibia falls backward to anatomic position, producing a shifting sensation. This sensation reproduces the feeling of "giving way" that the patient experiences functionally. The pivot-shift test may be difficult to perform in both the acute and chronic stages. In the acute stage, the patient may be unable to extend the leg because of swelling and pain. In the chronic stage, the patient has learned to prevent subluxation by activating the quadriceps muscle because the shifting is uncomfortable.

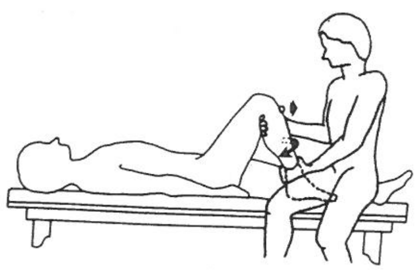

Figure 7.18. Examination for laxity of the anterior cruciate ligament.

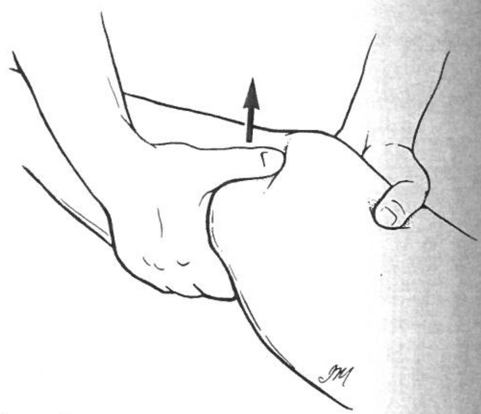

Figure 7.19. Lachman test. The knee is flexed 20°. The proximal tibia is grasped and moved forward while the femur is held with the other hand. (Adapted from Torg JS, Conrad W, Kalen V. Clinical diagnosis of anterior cruciate ligament instability in the athlete. Am J Sports Med 1976;4:84–93.)

Posterior Cruciate

Prepare to perform the **posterior drawer test** (Fig. 7.21). The patient's leg is positioned in a fashion similar to the anterior drawer test, with the knee flexed to 90° and the foot on the examining table. In this position, the in-

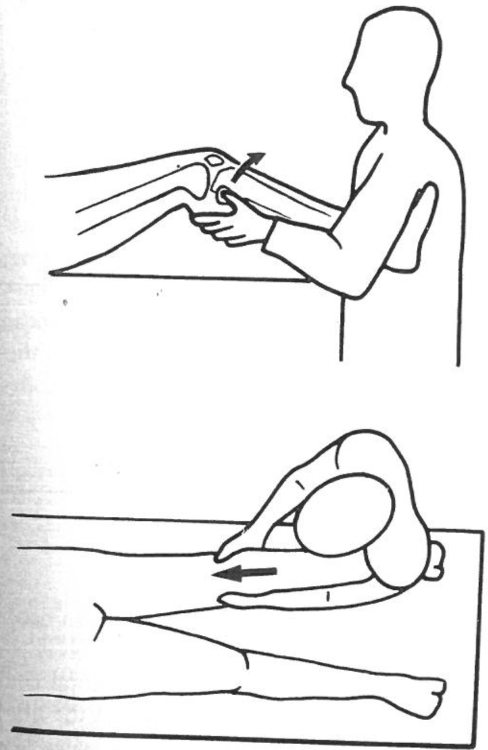

Figure 7.20. Pivot-shift test. The ankle and leg are held under the axilla. The leg is abducted and the knee extended. The hands are under the proximal tibia applying gentle anterior and internal rotation force. The tibia will subluxate forward and, as pressure is applied in line with the leg, the tibia will flex and reduce.

jured leg should be examined and compared with the opposite leg. A posterior "sag" of the injured tibia relative to the femur may occur. This is an important observation and is pathognomonic of posterior instability. Recognizing this also avoids misinterpreting "pseudo" anterior laxity of the knee in which the tibia begins from a posteriorly displaced position and, consequently, there is increased laxity on anterior drawer. In fact, this represents a posteriorly subluxed tibia.

After making the observation for posterior sag, a posterior force is placed against the proximal tibia. The degree of laxity is compared with the opposite side. A positive posterior drawer test or a sag that occurs with the knee flexed indicates posterior cruciate ligament injury. Laxity may be difficult to detect and quantify. In an isolated injury, an effusion may not occur and the pain may be manifest posteriorly. Ecchymosis present posteriorly should suggest posterior cruciate injury. The presence of varus or valgus laxity in full extension is also suggestive of posterior cruciate ligament injury.

EXAMINATION FOR MENISCUS INJURY

Palpate the joint lines. Shortly after an acute tear or displacement of a chronic tear,

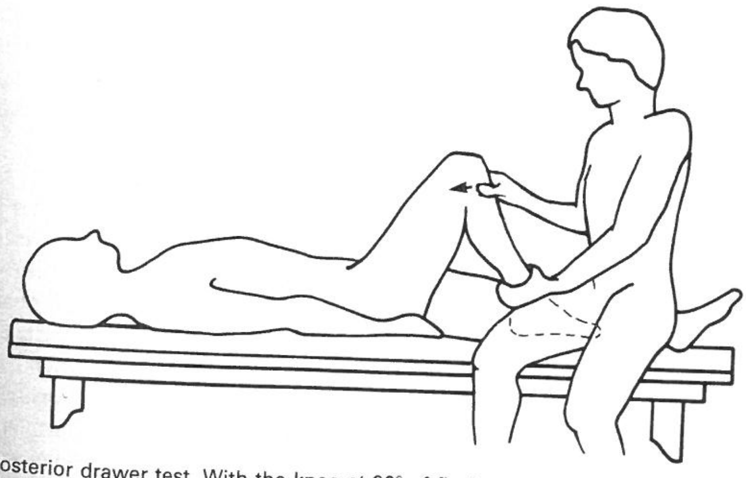

Figure 7.21. Posterior drawer test. With the knee at 90° of flexion, push back on the tibia to see whether there is increased motion or sag compared with the opposite leg.

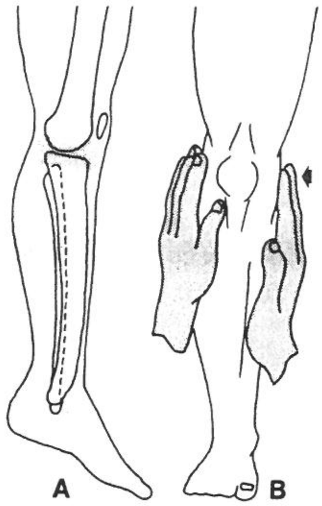

Figure 7.22. Examination for meniscus injury. *A*, area of tenderness. *B*, palpation for tenderness.

the associated joint line will be tender. Palpate the joint lines while rotating the leg back and forth. A torn meniscus may cause a palpable click during this maneuver (Fig. 7.22).

Perform **McMurray's maneuver** (Fig. 7.23). Flex the knee fully, with the leg externally rotated when testing for medial meniscus tear, and internally rotated when testing for lateral meniscus tear. While maintaining rotation, extend the knee with a firm controlled movement. A painful click in early or midextension is suggestive of a meniscus tear.

Perform **Apley's test** (Fig. 7.24). With the patient lying prone, flex the knee to 90°. While applying upward traction on the leg, rotate the leg internally and externally. Pain during this maneuver is more compatible with ligament injury than with meniscus tear. Repeat the rotation while bearing downward on the leg. Pain during this maneuver is more compatible with meniscus injury.

NONTRAUMATIC CONDITIONS IN ADULTHOOD

AVASCULAR NECROSIS

As in the hip, avascular necrosis can occur in the knee. It most commonly involves the medial compartment, with the femoral condyle more frequently involved than the tibial condyle. In some patients, an associated systemic factor will be noted, such as previous history of alcoholism, steroid therapy, or bone marrow disease. In most patients, avascular necrosis of the knee is idiopathic.

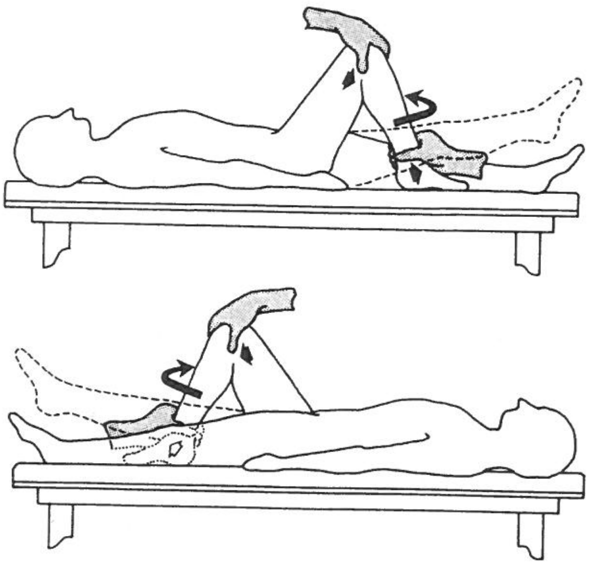

Figure 7.23. McMurray's maneuver.

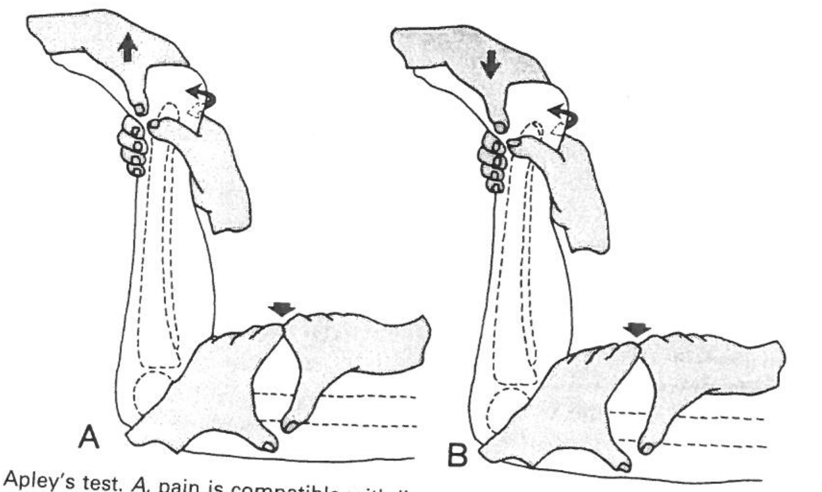

Figure 7.24. Apley's test. *A*, pain is compatible with ligament injury. *B*, pain is compatible with meniscus injury.

Clinical Characteristics

The patient usually presents with an acute onset of pain in the knee, most often on the medial side. Patients are usually over 50 years of age, and women are more commonly affected. A minority of patients have a more subacute onset of pain. The pain initially may be severe, but subsequently is more moderate. Patients often complain of stiffness and swelling, and an effusion is commonly noted.

X-rays taken early in the disease often are negative and the lesion can only be found by bone scan or magnetic resonance imaging. Later in the disease, x-rays become abnormal, usually showing a lucent region of the subchondral bone with surrounding sclerosis. Secondary degenerative changes may occur.

Treatment

The initial treatment of avascular necrosis should be conservative with restricted weight-bearing, anti-inflammatory medication, and analgesics. Many patients will improve with conservative management. For those who continue to have significant symptoms, orthopaedic referral is indicated for possible surgical intervention. Successful treatment usually requires osteotomy or knee replacement.

BURSITIS

Thirteen bursae have been described about the knee (Fig. 7.25). Of these, five are of particular importance to the primary clinician. They are the prepatellar bursa that lies between the patella and the skin; the superficial infrapatellar bursa that lies between the lower end of the patellar ligament and the skin; the deep infrapatellar bursa that lies between the lower end of the patellar ligament and the tibia; the anserine bursa that lies between the medial collateral ligament and the pes anserinus tendon; and the semimembranosus bursa that lies between the semimembranosus tendon and the medial head of the gastrocnemius. This bursa can communicate with the synovial cavity of the knee joint.

Prepatellar and Superficial Infrapatellar Bursitis

The prepatellar and superficial infrapatellar bursae are to the knee what the olecranon bursa is to the elbow. As such, they are exposed and vulnerable to trauma. The chronic form of prepatellar bursitis is classically referred to as "housemaid's knee." Thickening of the bursa is seen in patients whose occupations require kneeling, for example, carpet layers. The thickened bursa may not be symptomatic, but on occasion is sensitive. The bursal thick-

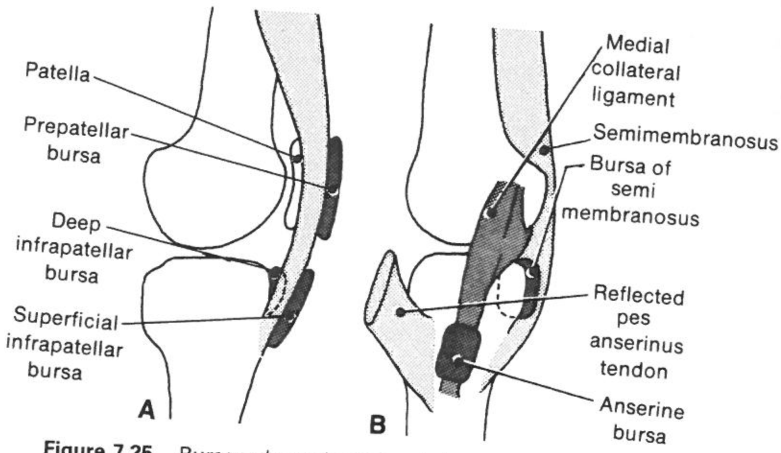

Figure 7.25. Bursae about the knee. *A*, lateral view. *B*, medial view.

enings may be small, firm, and mobile, giving the feeling of nodules or bone chips. Bursal swelling usually is localized to the prepatellar area and not to the surrounding tissue. Often bursal swelling is initiated by trauma, sometimes trivial. When trauma causes a laceration or abrasion over the bursa, differentiating between traumatic or septic bursitis is difficult.

Clinical Characteristics

The patient usually presents with localized pain and swelling in the bursa and tenderness may be present. No effusion of the knee itself is present. Patients with chronic bursitis may have mild swelling but little tenderness, and rarely experience extreme pain. An infected bursa presents with more severe pain, tenderness, and surrounding cellulitis.

Treatment

Chronic forms of bursitis are treated with anti-inflammatory medication. The patient should use padding to avoid repeated trauma. Chronic, recurrent, or persistent bursitis may require excision of the bursa. Acute bursitis is treated with rest, ice, and anti-inflammatory medication. If fluid is present, it can be aspirated. A purulent aspirate indicates a septic bursitis. Both acute and chronic bursitis may respond to cortisone injection, but infection must first be ruled out. Septic bursitis should be treated by incision, drainage, and antibiotics.

Anserine Bursitis

Individuals who are unaccustomed to lengthy, vigorous, weightbearing exercises may occasionally experience acute inflammation of the anserine bursa.

Clinical Characteristics

Patients usually complain of knee pain, which begins after some traumatic episode or unaccustomed weightbearing exercise. They experience an intense aching pain at rest that becomes worse when resisting extension or flexion. Swelling may be evident, and tenderness is elicited over the pes anserinus tendon or just superficial to its tibial attachment.

Pain and tenderness over the anserine bursa must be distinguished from several other conditions, including medial joint line tenderness associated with meniscal derangement or degenerative arthritis of the medial compartment. In the latter conditions, tenderness is localized to the joint line, whereas anserine bursitis causes tenderness below the joint line in the region of the bursa. Avascular necrosis of the tibial plateau or stress fracture of the tibia may be more difficult to distinguish because pain may be in the area of the anserine bursa. X-ray and bone scan are helpful in distinguishing these conditions. Stress fracture usually occurs in association with a history of recent increase in activity. Finally, patients with fibrositis syndrome may have pain in the anserine bursa area.

Treatment

Instruct the patient to minimize weight-bearing activities and avoid resisted extension (i.e., no climbing, jumping, running, squatting). The patient should apply ice packs over the inflamed bursa four times daily. Quadriceps-setting exercises can begin as soon as pain subsides. When pain and tenderness are fully remitted, range of motion and full quadriceps exercise can begin. Injecting a depository corticosteroid into the inflamed bursa can result in a dramatic remission. Oral anti-inflammatory agents may be prescribed, but these are less effective than local corticosteroid injection (see chapters 12 and 14).

Baker's Cyst

"Baker's cyst" is a term that is commonly applied to the formation of a swollen bursa posterior to the knee joint. This is most often caused by fluid distention of the bursa between the semimembranosus and medial gastrocnemius, but other posterior bursae can be associated with a Baker's cyst. Because these bursae can communicate with the synovial cavity of the knee joint, they often form because of inflammation and effusion in the knee secondary to intra-articular disorders. Because of this, the physician must rule out medial meniscal tear, degenerative joint disease, and rheumatoid or other arthritides.

Clinical Characteristics

Patients complain of a mass behind the knee that may or may not be slightly tender. If there is an underlying meniscal tear or arthritis, additional symptoms will be present. A fluctuant mass is palpable on the medial side of the popliteal fossa when the patient lies prone with the knee extended. Clear serous fluid is readily aspirated from the cyst, causing the cyst to collapse. X-rays may show evidence of degenerative arthritis.

Treatment

Aspiration not only confirms diagnosis, it removes the mass and usually relieves the patient's symptoms. Patients are often fearful that these masses are malignant tumors. To search for the cause of a chronic knee joint effusion, the examiner must obtain more detail about knee symptoms. Take note of range of motion, test patellar and tibiofemoral stability, examine for meniscus tear, and obtain x-rays for evidence of degenerative arthritis. The physician should perform a review of systems and a general orthopaedic examination, and obtain an erythrocyte sedimentation rate if any points of the history suggest an inflammatory arthritic disorder.

When the underlying disorder is obvious and its treatment is within the limits of primary practice, proceed appropriately. When no underlying disorder can be found or conservative treatment is ineffective, orthopaedic referral should be made.

TENDONITIS

Tendonitis is tendon degeneration without inflammation or with peritendinous inflammation, usually at the area of insertion or at the musculotendinous junction. This condition is probably related to microscopic tears that lead to pain. Repeated tearing results in tendon degeneration and scarring, and the scarred tendon is weaker and subject to rupture. Tendonitis is a common overuse syndrome in athletes.

Patellar Tendonitis

Patellar tendonitis, or "jumper's knee," is a common problem for athletes involved in sports that require jumping. Pain occurs during activity but often not enough to curtail the activity. Pain is also present after activity, usually after sitting for a long period. Tenderness is noted at the inferior pole of the patella.

Quadriceps Tendonitis

Quadriceps tendonitis involves the superior pole of the patella at the tendon junction. This type of tendonitis is common for athletes involved in sports that require running, jumping, and acceleration-deceleration activities. Pain and tenderness are noted over the superior pole of the patella.

Iliotibial Tract Tendonitis

The iliotibial tract is a condensation of some of the fibers of the fascia lata. It attaches to Gerdy's tubercle and overlies the lateral epicondyle and fibular collateral ligament. Pain develops from friction between the underlying structures and the iliotibial tract. This is most commonly seen in runners and in patients with an abnormally tight iliotibial tract. The examination reveals tenderness in the lateral epicondylar area that is amplified by pressure over the area as the knee goes through a range of motion.

Popliteus Tendonitis

The popliteus tendon attaches to the lateral aspect of the lateral femoral condyle and runs beneath the fibular collateral ligament. Tendonitis often develops with excessive downhill running, but also can occur with excessive squatting activities. Tenderness in this area must be differentiated from lateral joint line tenderness associated with lateral meniscus injury.

Treatment

Treatment of tendonitis is nonoperative and should begin with a period of rest. Ice after activity is helpful because it reduces inflammation, and anti-inflammatory medication is also helpful. After pain is relieved by the above methods, the patient should begin to gently stretch the scar tissue, then follow a graduated strengthening program. Cortisone injection into tendon sheaths to reduce inflammation is acceptable, but cortisone injection into the tendon causes tendon weakness and subsequent rupture.

TRAUMATIC DISORDERS OF THE KNEE

INJURIES TO THE EXTENSOR APPARATUS (FIG. 7.26)

The quadriceps muscle and tendon, patella, patellar ligament, and patellar retinacula constitute the extensor apparatus. Direct and indirect forces can disrupt the extensor apparatus at the knee.

Direct Impact Forces

These forces are typically generated in injuries that occur when an individual falls onto the knee or the knee is otherwise struck.

Direct blows to the quadriceps muscle result in varying degrees of injury. Some hemorrhage always occurs within the muscle. Tenderness and ecchymosis develop and associated knee effusion may occur. Tenderness is localized to the area of impact. Contusions of the quadriceps tendon at its insertion on the patella or at the site where it merges with the patellar retinacula are fairly uncommon because the area is not as exposed to

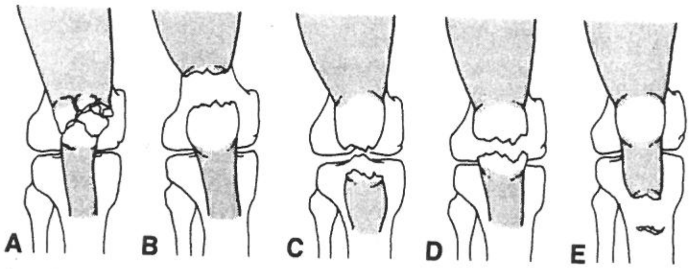

Figure 7.26. Injuries of the extensor apparatus. *A*, comminuted fracture of the patella. *B*, avulsion of the quadriceps tendon. *C*, avulsion of the patellar attachment of the patellar ligament. *D*, transverse fracture of the patella. *E*, avulsion of the tibial attachment of the patellar ligament.

impact. These injuries present with an indistinctly circumscribed swelling above the patella, which may be associated with fluctuation if bleeding into the suprapatellar bursa has occurred. Pain may inhibit active extension.

Direct blows to the patella can contuse the patellar cartilage or fracture the patella. Such fractures are usually comminuted and may or may not be displaced. The prepatellar bursa is always contused when these injuries occur, causing a hemorrhage into the bursa. Therefore, impact injuries to the patella present with circumscribed swelling over the patella and variable pain on lateral compression and manipulation of the patella. Pain may inhibit active extension.

Direct blows to the insertion of the patellar ligament contuse the superficial infrapatellar bursa and the patellar ligament at its attachment to the tibial tubercle. These injuries present with an indistinctly circumscribed swelling and tenderness over and just above the tibial tubercle. Pain may inhibit active extension.

Indirect Distracting Forces

When extension is applied with abrupt violence, as can occur when kicking or jumping, the resultant force may strain or rupture the extensor apparatus. Strain is suggested when tenderness is present over the quadriceps tendon or patellar ligament and the anatomy is palpably intact. Rupture is indicated by one of the following clinical pictures.

The quadriceps tendon may be avulsed from its patellar insertion and from its merger with the patellar retinacula. Such an injury is rare and presents with a depression just above the patella, a fluctuant mass about the depression reflecting hemorrhage into the suprapatellar bursa, and an inability to actively extend the knee without a significant extensor lag.

More commonly, the patella may be fractured. The inferior pole may be avulsed with the patellar ligament, or the patella may fracture into two fairly equal pieces. The injury presents with a fluctuant swelling, a palpable disruption of the patella, and an inability to actively extend the knee fully.

The patellar ligament may be avulsed from the inferior pole of the patella. This injury presents with a distinctly circumscribed swelling about the patellar ligament, an elevated patella, a palpable tendon defect when the knee is flexed to 90°, fluctuation above the tibial tubercle when hemorrhage has occurred into the deep infrapatellar bursa, and an inability to actively extend the knee fully.

Any complete disruption of the extensor mechanism, whether patella, ligament, or tendon, prevents full active extension of the knee. However, the patient may be able to lift the leg or have limited extension to −30° even with the rupture.

As soon as injury to the extensor apparatus is suspected, x-ray of the knee should be obtained to rule out fracture. This will prevent the examiner's converting an undisplaced fracture to a displaced fracture that may require operative treatment. A tangential view of the patella may show a vertical fracture line, often missed by standard AP and lateral views. However, a tangential view should not be requested if the injury is suspected to have occurred from distraction forces. This view requires that the knee be markedly flexed, which may complete the displacement partially produced by distraction forces.

Treatment

A simple contusion or strain may be treated symptomatically with rest, immobilization, and ice packs until active extension and range of motion are nearly painless. Quadriceps exercises (Fig. 7.27) and weightbearing exercises to the point of tolerable pain can then begin and progress as pain recedes. When the prepatellar bursa is swollen and fluctuant, the bursa should be aspirated.

An undisplaced fracture of the patella with injury to the patellar cartilage should be immobilized in a cylinder cast for 4 to 6 weeks. Weightbearing as tolerated is allowed while the extremity is immobilized. When the immobilization is removed, only partial weightbearing is allowed. The patient should be instructed in active quadriceps exercises, and active range of motion exercises are begun.

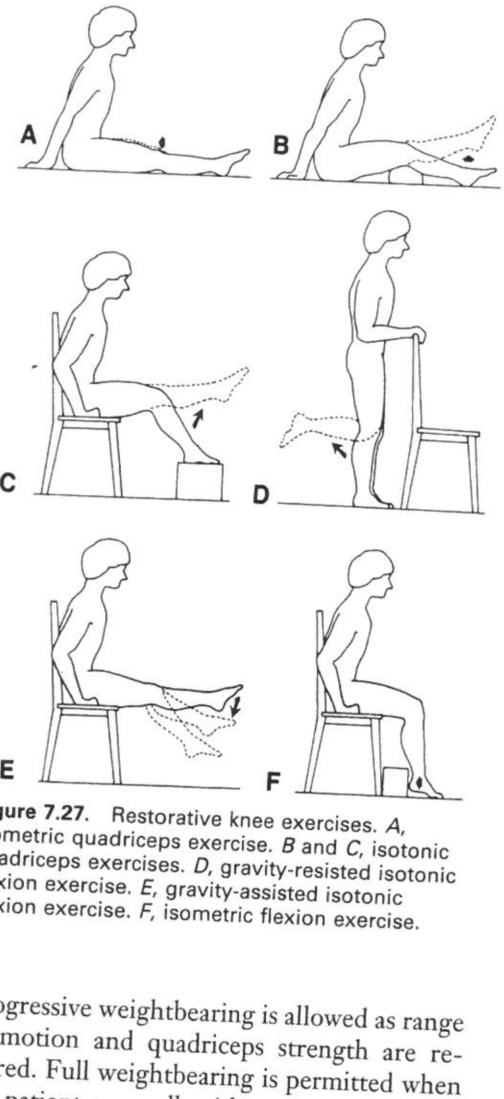

Figure 7.27. Restorative knee exercises. *A*, isometric quadriceps exercise. *B* and *C*, isotonic quadriceps exercises. *D*, gravity-resisted isotonic flexion exercise. *E*, gravity-assisted isotonic flexion exercise. *F*, isometric flexion exercise.

Progressive weightbearing is allowed as range of motion and quadriceps strength are restored. Full weightbearing is permitted when the patient can walk without pain or a limp.

When the extensor apparatus has been ruptured, either through the quadriceps tendon, through the patella, or by an avulsion of a patellar ligament from the inferior pole of the patella, the knee should be splinted in extension, and the patient should be referred to an orthopaedist for definitive treatment. Operative repair usually is required.

MENISCAL INJURY

Meniscal injury occurs when rotation of the femur on the tibia exceeds the normal physiologic range, when the normal synchronous internal rotation with flexion or external rotation with extension does not occur, or when excessive axial compressive loads exceed the meniscus strength. For example, consider the fall that occurs with the foot fixed in external rotation. As the individual falls, the knee flexes. Physiologically, this requires internal rotation, but the tibia is held in external rotation. The femoral condyle pushes the meniscus backward. The meniscus is held forward, however, by the medial collateral ligament. The meniscus is subjected to excessive stress and may be torn.

The medial meniscus is injured more frequently than the lateral meniscus because of its anatomy. The medial meniscus is trapped within the concavity of the medial tibial plateau and has more ligamentous tethers. The lateral meniscus is more mobile and can slide posteriorly more easily, thus avoiding the weightbearing of the condyle. The pattern of injury is also different for the medial and lateral menisci, with the medial more likely to sustain longitudinal tears and the lateral more likely to sustain radial tears (Fig. 7.28).

After the age of 40 years, a different type of injury occurs to the meniscus. A horizontal splitting occurs as a result of a lifetime of bending, squatting, turning, and twisting. The horizontal lesion is seen in a large percentage of people over the age of 55 years and is not necessarily symptomatic. This injury is more common in the medial meniscus and usually occurs at the junction of the mid and posterior one-third.

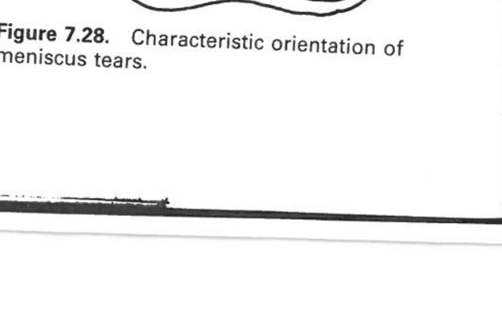

Figure 7.28. Characteristic orientation of meniscus tears.

Clinical Characteristics

Patients complain of pain at the time of injury that usually persists and interferes with weightbearing activity. Symptoms may subside initially, but recurrent episodes with minor stress are common. The pain is usually medial and often posteromedial in the case of the medial meniscus tear. Lateral meniscal pain is usually along the lateral joint line, but may be referred anteriorly or medially.

Effusion may develop, which may be minimal and noted as a feeling of tightness in the knee. If the joint communicates with one of several posterior bursae, swelling may be present in the back of the knee (see "Baker's Cyst"). Cystic swelling at the joint line with meniscal tear is more likely to develop on the lateral side because of the opening of the popliteus recess. Cystic swelling on the medial joint line is rare.

The patient often describes pain or inability to extend the knee fully, which is sometimes termed "locking." It is not true locking in the sense of not being able to move the knee at all, but is the lack of full extension. Because of the interposition of meniscus or the interference of the torn meniscus with normal rotation, there is no external rotation in extension. Therefore, the leg does not come into full extension and is considered "locked."

Many patients report a feeling of "giving way," describing a sense that the knee is going to collapse. Although this "giving way" feeling may occur as a result of a torn meniscus with interposition of meniscal tissue preventing normal rotation, it is a nonspecific symptom. This symptom can also result from pain or from various instabilities of the knee if the femorotibial or patellofemoral surfaces are moving abnormally.

In longstanding meniscal derangement, quadriceps atrophy is common because the pain and swelling inhibit motion of the quadriceps muscle.

Treatment

The knee should be immobilized if there is pain with motion. Painless knee motion does not require immobilization. Crutches should be used if there is swelling and weightbearing is painful. Quadriceps exercises may be initiated, and anti-inflammatory medication or analgesics should be provided. A tense effusion should be aspirated. If the knee is locked, manipulation may be attempted with adequate analgesia; rotation in flexion with a valgus stress may unlock the knee. However, it is not always necessary to attempt a manipulation. Spontaneous "unlocking" often occurs with immobilization and the use of analgesics.

Although most meniscal tears do not heal, a peripheral tear often does. The knee with a peripheral tear may be immobilized for 4 weeks by medial and lateral splints with the knee flexed at 15 to 20°, or a limited motion brace set to allow motion between 20 and 60°. If the knee remains locked or symptoms of pain, giving way, and swelling persist, orthopaedic referral should be made to consider surgical removal or repair. This can be accomplished arthroscopically. Meniscal injuries with symptoms that can be successfully eliminated by modifying activity and avoiding activities that produce effusion, catching, or giving way do not require surgery. Patients must accept limited activity because return to full activity may reactivate symptoms. If return to activity after symptoms have abated does not cause recurrence of symptoms, then patients may proceed with the activity.

LIGAMENT INJURY

The ligaments are subject to external forces as well as those generated by muscular force. Contact forces occur in sporting events, in vehicular accidents, and at work. The history of the injury and the exact mechanism involved are helpful in the evaluation.

Clinical Characteristics

The degree of injury depends on the amount of force and the circumstances of support by muscles. A first-degree sprain is a tear of the fibers of the ligament with no demonstrable instability or laxity. A second-degree sprain is a tear of ligamentous fibers with some loss of function but still no noticeable laxity.

A third-degree sprain is a gross disruption of the fibers with demonstrable laxity. Within this third-degree injury, there are grades I, II, and III laxity. In grade I third-degree sprain, there is a less than 5 mm opening of the joint surface with applied stress. In grade II, there is a less than 10 mm opening. In grade III, there is a greater than 10 mm opening.

All patients complain of pain at the time of injury. With first-degree, second-degree, and grade I third-degree injuries, patients are able to walk or even resume activities. The morning after injury, moderate stiffness is present. The physical examination will detect tenderness in the area of the ligament. Either the attachment site or the area along the line of the ligament is tender. Stressing the ligament will cause pain in all these injuries and slight laxity in the grade I third-degree injuries.

Patients with grade II third-degree injuries manifest more difficulties and are not likely to continue with their activities. They may have an effusion, which suggests that some of the capsule as well as some of the ligament has been stretched. Patients will have more laxity on ligament testing.

Grade III third-degree injuries have gross and easily detectable laxity, usually with accompanying effusion. The development of ecchymosis in the area of the ligaments suggests a moderate tear with gross laxity. In this case, one should suspect that more than one ligament is involved. Patients may have a knee dislocation if they have grossly unstable ligaments with multidirectional laxity and a history of violent injury. A large percentage of knee dislocations are accompanied by popliteal artery injuries; therefore, vascular consultation and angiography are recommended. X-rays will show no evidence of injury, but occasionally will show a small avulsion fragment from the site of ligament attachment.

Medial Collateral Ligament Injury

The medial collateral ligament usually is injured by a valgus force applied to the lateral aspect of the knee with the foot fixed. This ligament may also be injured by a twisting mechanism. Tenderness is present along the line of the ligament or at points of attachment, and grade I, II, or III laxity is present in the third-degree injuries. In the evaluation of a patient with medial or lateral collateral ligament injury, it is important to assess the presence of injury of the anterior or posterior cruciate ligaments. If cruciate ligament injury is suspected, orthopaedic referral should be obtained. It is also important to recognize that patients with medial (or lateral) instability in extension probably do not have an isolated ligament injury and these patients should also be referred for further evaluation and treatment.

Treatment

Isolated grade I and II injuries, without instability in extension, and without cruciate ligament injury, can be treated nonoperatively. The injured knee should be immobilized with commercially available immobilizers or medial-lateral plaster splints. This lessens pain and reduces strain on the ligament. Immobilization may continue for 7 to 14 days, depending on the degree of injury and pain. As pain subsides, the knee should be mobilized because mobilized ligaments heal with greater strength than continuously immobilized ligaments.

The patient should be placed on crutches with weightbearing as tolerated. Crutches are discontinued when there is no limp with ambulation. Aspiration may be required if a tense effusion is present. Ice should be used to reduce swelling and analgesics prescribed as necessary. When pain subsides and motion is full, whirlpool and bicycling are encouraged. Straight leg raising in the immobilizer is encouraged, followed by the use of weights when motion returns. The symptoms of a grade I injury may decrease rapidly and be at a point of strengthening in 2 weeks. A more severe injury will take at least 6 weeks before strength returns and the knee gains functional stability.

Grade III injuries can be treated nonoperatively; however, because it is often difficult to detect associated injury, an orthopaedic consultation is recommended to assess the need for surgical intervention for these injuries.

Lateral Collateral Ligament Injury

The lateral collateral ligament is injured by a varus force from the medial side of the knee. Because the peroneal nerve travels around the fibular head, any force applied to the inner aspect of the knee may cause stretch of the peroneal nerve. Therefore, with suspected lateral collateral ligament injuries, the function of the peroneal nerve should be assessed at the time of initial examination.

Treatment

Isolated grade I and II third-degree injuries can be treated nonoperatively. As in the case of the medial collateral ligament, however, a grade III injury is best handled by the orthopaedic surgeon. Treatment of grade I and II injuries is the same as for medial collateral ligament injury, with initial immobilization, crutches, and analgesics, followed by motion and weightbearing to a point of strengthening.

Anterior Cruciate Ligament Injury

The anterior cruciate ligament may be injured by either varus or valgus force that stretches the medial or lateral ligaments. An anterior cruciate ligament tear can result from a noncontact injury. The history will include a twisting injury accompanied by a pop or a tearing feeling and a subsequent effusion. With this history and the finding of a hemarthrosis, there is approximately a 70% chance of injury to the anterior cruciate ligament.

The anterior cruciate is the major restraint to anterior translation of the tibia on the femur. The quadriceps muscle antagonizes this restraint as the leg goes into extension. Strain is in the ligament in the last 20° of extension. A violent pull of the quadriceps, as in turning quickly or jumping, may rupture the anterior cruciate ligament. The ligament tightens in internal rotation; therefore, when the leg is forced into internal rotation strain is on the anterior cruciate. Strain is also in extreme valgus and external rotation, as occurs in skiing, and the anterior cruciate may be injured along with the medial collateral ligament. Hyperextension, as might occur when stepping in a hole, forces the anterior cruciate against the intercondylar notch, which may result in a tear.

Clinical Characteristics

The patient with an incompetent anterior cruciate ligament falls into one of three categories. The first group is made up of individuals who function satisfactorily without the ligament. This group, which includes some competitive athletes, is small, however, comprising less than 20% of the individuals.

Most individuals fall into a second category that requires modification of activities. High-risk activities that involve jumping are not usually possible. Volleyball and basketball are given up, but racquetball and tennis may be played. If the activities of tennis are difficult, the person may further limit activity to a level of bicycling, swimming, and jogging. Routine activities of daily living are done with little difficulty. The patient may have a giving way episode once or twice a year. With increased activity, there is a high likelihood of injuring a meniscus, and at some point a giving way episode may be followed by meniscal symptoms that require meniscal surgery. Some patients will be able to move up in the activity category by using a stabilizing brace.

In the last category are those individuals who cannot function well without the ligament. These patients are bothered by multiple giving way episodes in the course of daily activities and are significantly limited in sports. A brace may be tried, but does not provide adequate stability and is difficult to use for daily living activity.

After the initial injury, most people fall into one of these categories within 1 to 2 years.

Anterior Cruciate Ligament Examination (see also "Evaluation of the Patient with Knee Symptoms")

With a moderate degree of spasm and effusion, the detection of anterior cruciate ligament laxity can be difficult. The Lachman test is more sensitive than the anterior drawer test because the anterior drawer may be negated by the pull of the hamstrings or spasm about the knee. The pivot-shift test is difficult to elicit in the acutely injured, and even in follow-up examination if the patient learns to protect the knee and use the muscles to prevent subluxation of the tibia. X-rays usually do not provide evidence of injury; however, the finding of avulsion from the lateral tibial plateau (Segond fracture) is pathognomonic of an anterior cruciate ligament tear.

Treatment

Because of the difficulty in detecting anterior cruciate ligament injuries, in separating symptoms of instability from meniscal symptoms, and in determining need for reconstruction, the treatment of these injuries should be supervised by an orthopaedist. The treatment of acute anterior cruciate injury depends on the severity of injury. Patients with suspected injury or partial tear, i.e., hemarthrosis and consistent history but without significant demonstrable instability, may have a tense hemarthrosis requiring aspiration. The knee may be immobilized for comfort. Crutches should be used for nonweightbearing, or partial weightbearing if tolerated without pain. Follow-up examination should be at 5 to 7 days, and if laxity secondary to anterior cruciate ligament injury is not detected quadriceps exercises may be initiated and the knee and leg rehabilitated. For patients with demonstrable instability but without associated meniscal, collateral ligament, or posterior cruciate ligament injury, the knee should be immobilized for comfort and crutches provided for the patient. Because the torn anterior cruciate ligament is not likely to heal, quadriceps setting may be initiated. Patients with associated ligament injury or meniscal injury should be referred immediately to an orthopaedist because surgical intervention may be necessary.

To rehabilitate the leg with anterior cruciate injury, quadriceps exercises are initiated first. More vigorous exercises, with progressive strengthening of the quadriceps and hamstring muscles, are initiated when swelling subsides and range of motion returns. Recovery from an initial episode may take 6 to 8 weeks. If recovery is not sufficient in this time to allow the patient to ambulate, or if swelling is not reduced, the patient should be examined for meniscal injury. Meniscal symptoms may develop in the first 6 months after injury; meniscus injury will require treatment.

If a patient successfully rehabilitates with strength equal to or better than the uninjured leg, a brace may be applied. The patient is allowed to return to sports, and will then find the appropriate level of activity and make necessary modifications according to lifestyle.

The patient who continues to have difficulties in the activities of daily living and is not engaged in any sport activity, and the patient who has difficulties in the brace with absence of any meniscal disorder, become candidates for reconstruction of the ligament. Those persons who are professional or competitive athletes may not want to wait for 1 year to find the category into which they will fall, and should be considered for immediate reconstruction.

Posterior Cruciate Ligament Injury

The posterior cruciate ligament is often injured by a force that is applied to the anterior portion of the tibia, as in a dashboard injury. The ligament may also be injured from medial or lateral forces that injure other ligaments.

Treatment

The posterior cruciate is considered a prime stabilizer of the knee; early operation on gross instability of the posterior cruciate ligament, particularly if accompanied by medial or lateral collateral ligament injuries, yields better results than nonoperative management. Avulsion of the ligament with a bony fragment is best treated by open reduction and fixation. Isolated grade I and II third-degree injury is compatible with normal life activities and can usually be treated nonoperatively. Because of the significant instability, the knee should be evaluated by an orthopaedic surgeon.

It is important to rehabilitate all knee injuries, particularly those that will not require surgery, which may be meniscal or minor ligament injuries. Often, persistent symptoms are related to weakness as a result of the initial injury rather than to any significant intra-articular or extra-articular disorder. Patients will continue to have symptoms of aching and soreness in the knee. Extreme weakness may even result in swelling. The symptoms from weakness may increase the indications for surgery even though it may not be necessary. Improvement in muscle strength is an indication of a healing condition, whereas persistent weakness may indicate an operative condition.

Therapy may be accomplished either by the individual or under the care of a physical therapist. Motivation is a factor in successful rehabilitation and should be monitored either by the therapist or the physician.

FRACTURES

Fractures of the Shaft of the Femur

Fractures of the shaft of the femur are life-threatening injuries. They are typically accompanied by considerable bleeding into the thigh and hypovolemia. The violent forces required to produce them may impact directly on the surface of the thigh, or may apply torque or angulation to the thigh. Like hip dislocations, femur fractures occur most commonly in motor vehicle accidents. These fractures are nearly always complete and markedly displaced, with over-riding, angulation, and rotation of the distal segment on the proximal. Fractures may be transverse, oblique, spiral, or comminuted, and may be simple or compound.

Clinical Characteristics

Patients with fractures of the shaft of the femur often have other injuries. They may develop evidence of circulatory insufficiency shortly after injury. These patients do not move the extremity and, if conscious, complain of intense thigh pain that usually refers throughout the extremity. The thigh is swollen, and the portion of the extremity below the fracture site may be rotated and angulated. Tenderness, false motion, and crepitation are evident at the fracture site. Anteroposterior and lateral x-rays of the thigh will identify the fracture.

Treatment

The patient must be quickly assessed for other injuries. Hypovolemic circulatory failure must be treated (see Chapter 1). The fracture must be splinted, preferably with a "Thomas"-type splint (see Chapter 11). Traction improves alignment and stability. An orthopaedist should be responsible for definitive treatment of the fracture.

Fractures of the Tibial Condyles (Fig. 7.29)

The same forces that tear the collateral ligaments can fracture the contralateral tibial plateau, as well as tear the ipsilateral meniscus. The lateral tibial plateau is fractured more commonly than the medial. Until they tear, the stressed ligaments act as a tension band directing compressive forces onto the opposite tibial plateau. If the bone is less resilient than the ligaments, it will fracture before the ligaments tear. Osteoporotic individuals are more likely to suffer plateau fractures than torn ligaments, and commonly, they are women who fall from steps or ladders.

Clinical Characteristics

All patients with fractures of the tibial condyle complain of pain immediately at the time of injury. Pain persists and prevents weight-bearing. Within the first few hours after injury, the joint capsule becomes tense with a hemarthrosis. The fractured condyle is tender and any manipulation that compresses that side of the joint causes an increase in pain. Ligaments on the opposite side of the joint may or may not be tender. X-ray will reveal the plateau fracture. A neurovascular examination should be performed because fractures of the tibial plateau may be associated with neurovascular injury. The peroneal nerve is particularly vulnerable. This injury is often associated with a fracture of the proximal fibula accompanying a tibial plateau fracture.

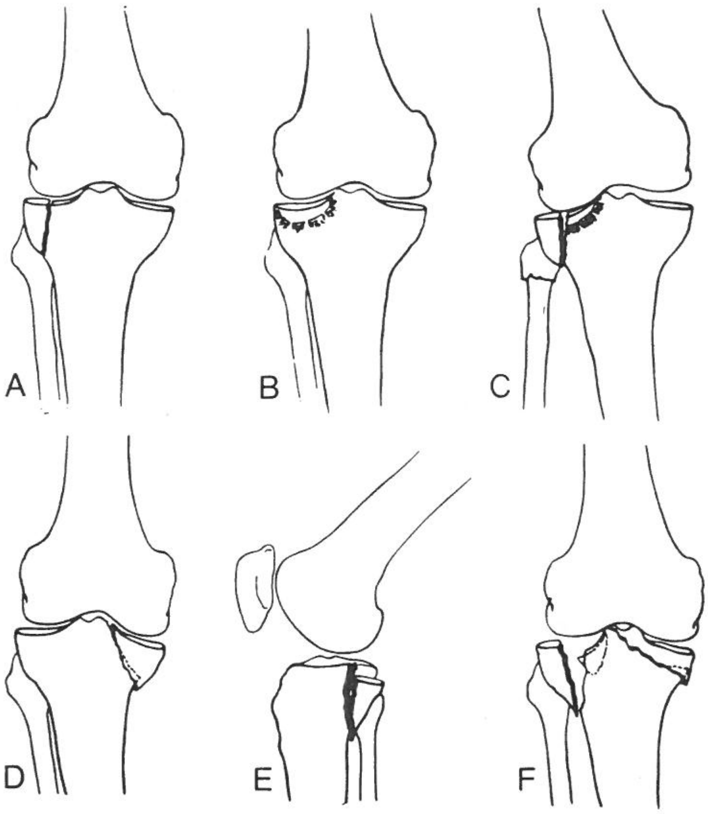

Figure 7.29. Hohl classification of fractures of the condylar end of the tibia. *A*, undisplaced. *B*, local compression. *C*, split compression. *D*, total condylar compression. *E*, split. *F*, comminuted. (Reprinted with permission from Hohl, M. Tibial condylar fractures. J Bone Joint Surg [Am] 1967;49A:1455–1467.)

Treatment

Initial treatment should include arthrocentesis if there is a tense hemarthrosis. Fractures should be splinted in full extension. If the patient is not comfortable in full extension, however, this position should not be forced. Orthopaedic referral is recommended for definitive evaluation and treatment of these intra-articular fractures.

If this is unavailable, minimally displaced fractures can be managed by the experienced primary practitioner. Nonoperative treatment can be considered if there is no significant depression of the joint surface, less than 3 mm of separation or depression at the fracture line, and no associated collateral or cruciate ligament rupture. A variety of treatment methods are appropriate for these minimally displaced fractures. In reliable patients, a long-leg splint can be applied in full extension. The patient is placed on crutches and continues nonweightbearing until healing is evident. Isometric exercise can be carried out in the splint, then at 10 to 14 days, the splint can be discontinued for active range of motion exercise. For less reliable patients, a long-leg or cylinder cast is applied for 3 weeks, then range of motion is begun. Another method is to apply a cast brace primarily. This protects the fracture from compressive force but allows range of motion to the knee. (See Chapter 11 for details of cast technique.) In these injuries, healing usually occurs in 8 to 12 weeks. Weightbearing should be delayed until that time.

If the fracture line is displaced or depressed more than 3 mm, orthopaedic referral should be obtained for definitive evaluation and treatment. These fractures often require open reduction. The goal of treatment is to restore an anatomical joint surface, repair ligament injuries, and progress with early range of motion. Successful accomplishment of these goals reduces the risk of posttraumatic arthritis.

The intimate anatomic relationship between the condylar ends of the femur and tibia and the sciatic nerve and popliteal vessels exposes these neurovascular structures to injury when there is juxta-articular fracture of the knee. In addition, these fractures superficially resemble any of the other causes of a hemarthrosis. Thus, the primary practitioner must consider this injury whenever evaluating a traumatic hemarthrosis because an unwary manipulation could result in displacement of an undisplaced fracture or neurovascular injury.

Fractures of the Condylar End of the Femur (Fig. 7.30)

These fractures usually result from an axial compression force with or without an angulatory force. The fractures in adults are of four kinds. Figures 7.30A and 7.30B show fractures of the medial or lateral femoral condyle. The axial compression force, when accompanied by an angulatory force, usually fractures the condyle on the side of the angulation. Figures 7.30C and 7.30D show T-shaped or Y-shaped intracondylar fractures of the femur. Straight axial compression forces may fracture both condyles at once, driving them proximally to each side of the femur. Figure 7.30E shows a comminuted fracture.

Clinical Characteristics

Except in the severely osteoporotic patient, the injuring forces are violent. Patients with these fractures complain of pain immediately at the moment of injury and are unable to bear weight. All patients with these injuries present with a tense hemarthrosis; some present with shortening or an angular deformity. The condylar end of the femur is severely tender. Firm palpation will often elicit bony crepitation. Evidence of neurovascular injury may be present. Anteroposterior and lateral x-rays of the knee will identify the fracture.

Treatment

The reduction must be precise. Any disturbance of the normal orientation of the condyles to one another will disrupt the joint mechanism, thus decreasing range of motion and increasing wear on the articular surfaces. Vascular injury requires immediate repair to avoid ischemic necrosis below the knee. An orthopaedist and perhaps a vascular surgeon must assume responsibility for treatment. The primary practitioner should facilitate the treatment goals as follows. Assume every hemarthrosis is a fracture of the condylar end of the femur (or tibia) until proven otherwise. Examine sciatic nerve and vascular function whenever the distal end of the femur is tender or crepitant. If a neurovascular injury is evi-

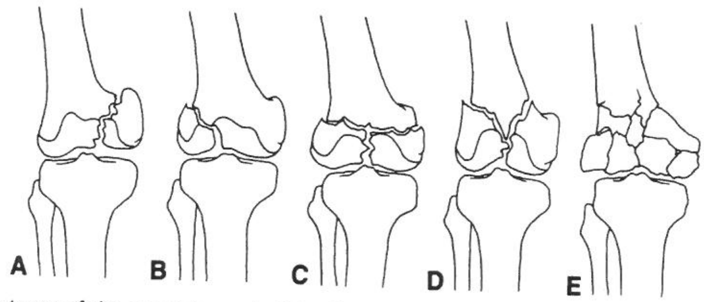

Figure 7.30. Fractures of the condylar end of the femur. *A*, fracture of the medial condyle. *B*, fracture of the lateral condyle. *C*, "T-shaped" intracondylar fracture. *D*, "Y-shaped" intracondylar fracture. *E*, comminuted fracture.

dent, notify a vascular surgeon or an orthopaedist at once, and begin preparations for surgery. When neurovascular function is intact, admit the patient to an orthopaedist and apply a long-leg splint (see Chapter 11). Ensure that neurovascular function is monitored until arrival of the orthopaedist.

Epiphyseal Fractures

Children and adolescents may sustain fractures of the distal femoral or proximal tibial epiphyses. These fractures may present as stable or unstable injuries. Injuries that produce ligament damage in the mature person may produce epiphyseal injury in the immature person. Fractures occur because the epiphysis is weaker than the ligament. Therefore, when stressing ligaments during an examination, be aware that opening may take place at the epiphyseal line and not as the result of ligament laxity. Stress x-ray will determine whether this is a ligamentous injury or a displacement through the epiphysis. Displaced fractures at either epiphysis may have accompanied popliteal artery injury. These injuries should be referred to an orthopaedist.

INJURY OF THE PATELLOFEMORAL ARTICULATION

To support body weight in the many activities of bipedal locomotion, tremendous force is exerted through the extensor mechanism of the knee. The patella is a sesamoid bone embedded in the quadriceps tendon. It enlarges the surface area of the tendon and increases the patella's efficiency by shifting the line of pull of the muscle anteriorly. This improves leverage of the quadriceps in extending the knee. The patella also provides a cartilage-on-cartilage low coefficient of friction for a smooth glide of the quadriceps and maintains the tendon in a centralized track.

The large force needed to attain upright stance produces a large reaction force between the patella and its femoral articulation (Fig. 7.31). The patellofemoral joint reaction force increases as the knee is flexed and is least at full extension. The force across the patellofemoral articulation in stair climbing may be three to five times body weight, and a tremendous force is generated in squat exercises with heavy weights on the shoulder. To meet these demands, the articular cartilage on the under-

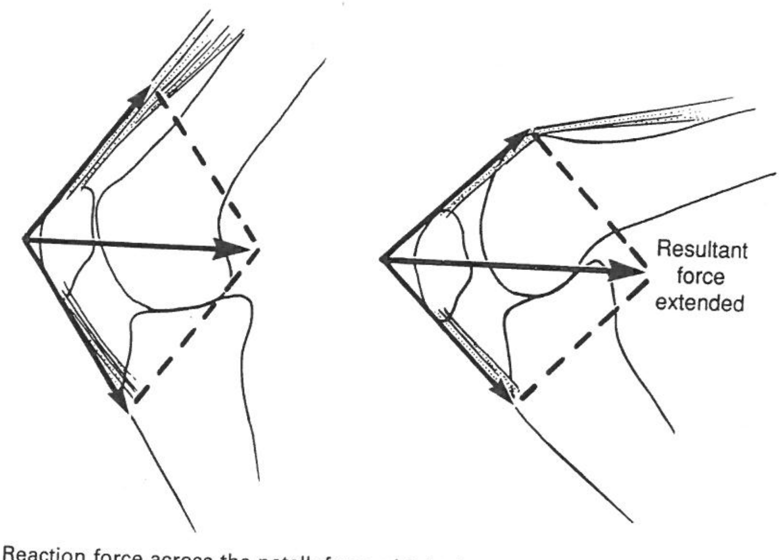

Figure 7.31. Reaction force across the patellofemoral joint increases with knee flexion. (Adapted from Ficat RP, Hungerford DS. Disorders of the Patello-Femoral Joint. Baltimore: Williams and Wilkins, 1977:24.)

surface of the patella is the thickest in the body.

The patella does not track in a straight line or have contact on the same surfaces throughout the range of motion. At full extension, the patella lies above the trochlea. Within 10 to 30° of flexion, the normal tibial internal rotation pulls the patella into the trochlea. By 60°, the midportion of the patella and midportion of the trochlea are in contact, and at 90°, the proximal portion of the patella and the distal portion of the trochlea are in contact (Fig. 7.32).

These dynamic relationships also accommodate the normal valgus vector of the extensor mechanism. Because of the position of the hips, upright stance requires a valgus position of the knee joint. As a result of this angulation, there is a valgus vector to the muscles. The force of the body tends to bow the knee outward and this is resisted by the lateral musculature and the architecture of the trochlea and patella: the vastus lateralis muscle is stronger than the medialis, and the lateral portion of the trochlea and the lateral segment of the patella are larger than the medial.

The common problems with the patellofemoral mechanism result when these normal relationships and biomechanics are disturbed (Fig. 7.33). These problems can be subdivided into problems of stability, in which there is muscle insufficiency or exaggeration of the normal valgus alignment with excessive lateral pull; problems in which there is excessive force across the patellofemoral joint; or a combination of the above.

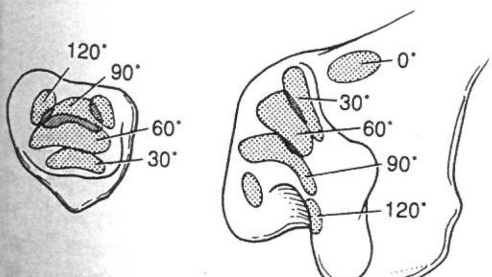

Figure 7.32. Contact areas from extension to flexion. (Adapted from Aglietti P, Insall JN, Walker PS, Trent P. A new patella prosthesis: design and application. Clin Orthop 1975;107(Mar–Apr):175–187.)

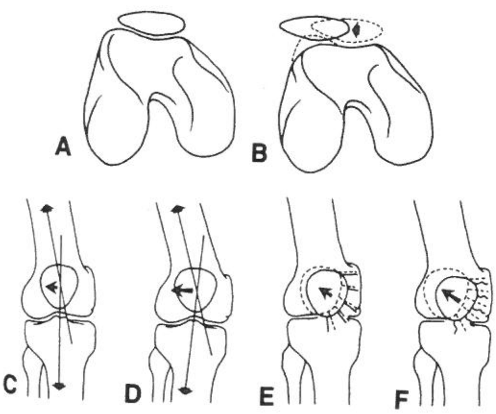

Figure 7.33. Anatomic peculiarities predisposing to recurrent patellar dislocation. *A*, normal, distal end of femur. *B*, flat anterior eminence of the lateral condyle. *C*, normal lateral vector during active extension. *D*, excessive lateral vector. *E*, normal medial retinaculum. *F*, lax medial retinaculum.

Examination of the Patellofemoral Articulation

When examining an injured patellofemoral articulation, it is important to differentiate the areas of pain. The pain associated with patellar problems usually is caused by peripatellar synovitis or synovial plica; this pain must be differentiated from medial joint line pain. Often, anterior swelling and inflammation extends to the anterior portion of the meniscus and may create symptoms mimicking meniscal derangement. This occurs when the swelling impinges on the anterior meniscus as the knee is extended. Lateral knee pain also may be present, which is caused by lateral synovitis, extension of the anterior swelling laterally, or hypertrophy of the lateral patellofemoral ligament. Palpable hypertrophy often is present at the lateral patellotibial ligament. This ligament may be tender or there may be tenderness at the insertion of the vastus lateralis at the superior patella. Some patients will have atrophy or actual dysplasia of the vastus medialis.

As noted previously, the alignment of the femur and the arrangement of the muscle at-

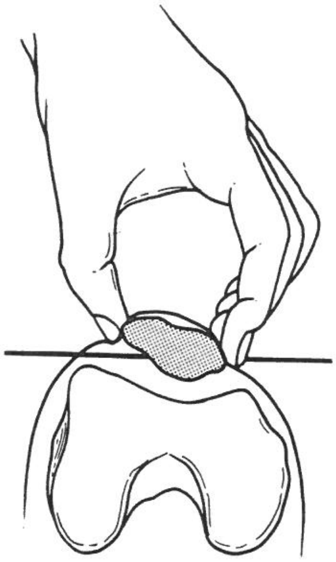

Figure 7.34. Testing for lateral tightness. (Adapted from Rosenberg TD, Kolowich PA. Complications of lateral retinacular release. In: Sprague NF III, ed. Complications in Arthroscopy. New York: Raven Press, Ltd., 1989:146.)

taching to the tibia through the patella have a valgus angle. This is the quadriceps angle (Q angle). The Q angle is determined by measuring the angle formed by a line through the center of the patella and femur and a line from the center of the patella through the tibial tubercle (Fig. 7.33). This angle does not exceed 15° in the normal individual.

Tightness in the lateral retinaculum can be demonstrated by attempting to lift the patella by the lateral edge. Inability to level the patella suggests tightness (Fig. 7.34). With the lateral structure held taut, palpate the lateral patellotibial and lateral patellofemoral ligaments (Fig. 7.35).

Observe the tracking of the patella from extension to flexion with the patient sitting. Normally, the patella is positioned laterally in extension and at 10° of flexion; by 30° of flexion the patella should have moved medially into the trochlear groove. A patella that stays lateral through flexion is abnormal. A patella that starts laterally, becomes medial, then goes back to lateral (a C-shaped route) also is abnormal. When the patella goes from flexion to extension, there is a gentle lateral excursion at the end; an abrupt lateral excursion suggests abnormality. Swelling may be evident in the peripatellar soft tissue, but effusion is rare except in dislocation. In patients with recurrent subluxation or dislocation, there is apprehension with patellar motion, especially if a lateral push is applied to the knee cap.

Confusion can result when differentiating patellar tendonitis and fat pad synovitis. Direct pressure over the tendon will also contact the fat pad. Isolating the tip of the patella is helpful by pressing on the superior patella and quadriceps tendon (Fig. 7.36), thereby lifting the inferior pole of the patella and palpating the patella at adjacent tendons rather than exerting pressure down on the fat pad.

X-rays in the lateral and skyline (tangential) projection are helpful in evaluating patellofemoral problems. On the lateral view, patella alta, a patellar tendon that is longer than the patella, can be determined by measuring the length of the patellar tendon and comparing this to the length of the patella. Any value over a 1.2 : 1 ratio may be considered patella alta (Fig. 7.37A). Skyline x-rays should be taken at 15°, 30°, 45°, and 60° to see the relationship between the patella and femur in varying degrees of flexion, because abnormal tracking may be missed on a single view (Fig. 7.37B). These views will demonstrate lateral subluxation or abnormal tilt of the patella and also dysplasia of the patella or trochlear groove. Various measurements are determined to demonstrate abnormal patella tilt or an incongruent articulation (Figs. 7.37 C and D).

Instability of the Patella

Instability of the patellofemoral mechanism usually is associated with excessive lateral pull. In the mildest forms, this excessive pull may produce occasional momentary subluxation of the patella. In its most severe form, chronic recurrent or persistent dislocation of the patella may be seen. There is another group of patients with a mild degree of pull in whom it is not possible to diagnose clear subluxation or malalignment, although many

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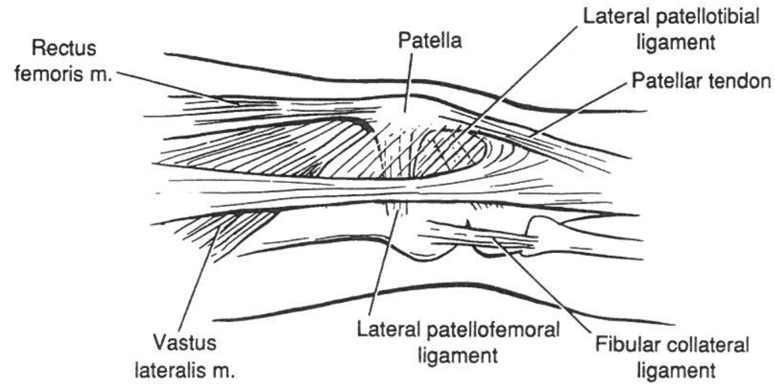

Figure 7.35. The lateral side of the knee. It is important to palpate the lateral patellotibial and patellofemoral ligament and the insertion of the vastus lateralis for their presence, tightness, and possible source of pain.

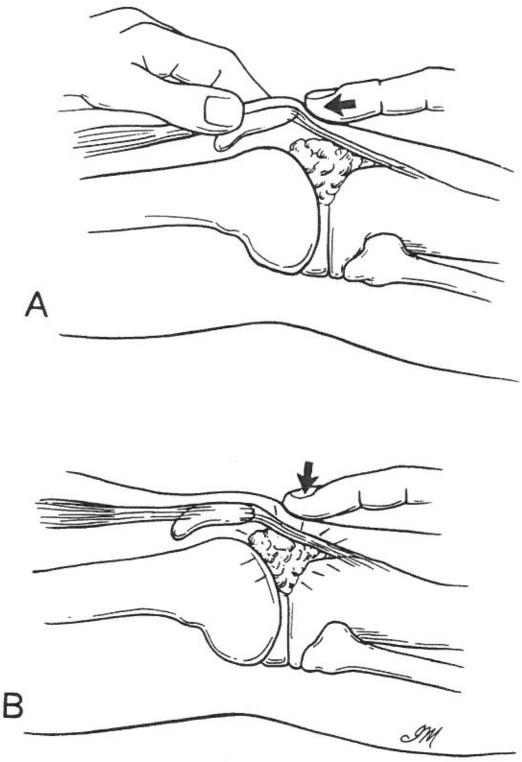

Figure 7.36. *A*, holding the patella and tilting it up isolates the patellar ligament and inferior pole of the patella from fat pad and synovium that may be tender. *B*, direct pressure over the ligament may elicit pain that is from the synovium and not the ligament.

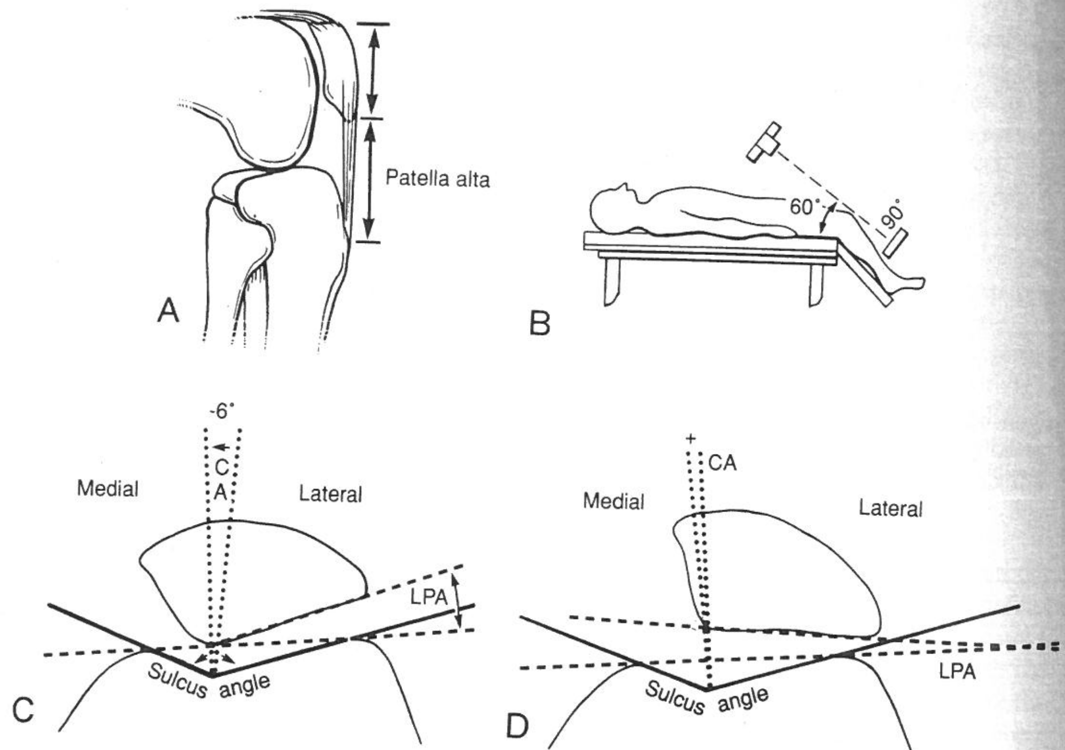

Figure 7.37. *A*, patella alta. *B*, X-ray beam directed across the top of the patella with varied angles to view the patella and trochlea. (Adapted from Carson WG Jr, James SL, Larson RL, Singer KM, Winternitz WW. Patellofemoral disorders: physical and radiographic evaluation. Part II. Radiographic examination. Clin Orthop 1984;185:178–186.) *C* and *D*. The lateral patellofemoral angle (LPA) is formed by a line on the femoral sulcus and a line on the lateral facet. An angle open laterally is normal (*C*) and a parallel or angle open medially suggests subluxation (*D*). The congruence angle (CA) is determined by a line bisecting the sulcus and a line drawn from the lowest point on the patella. The normal CA is $-6° \pm 11°$ (*C*). The sulcus angle is the angle of the trochlear surface measured from the highest point on the medial and lateral trochlea to the lowest midtrochlear point. The normal sulcus angle is 137° (*C*). (Adapted from Merchant AC, Mercer RL, Jacobsen RH, Cool CR. Roentgenographic analysis of patellofemoral congruence. J Bone Joint Surg [Am] 1974;56A:1391–1396; and Laurin CA, Levesque HP, Dussault R, Labelle H, Peides JP. The abnormal lateral patellofemoral angle: a diagnostic roentgenographic sign of recurrent patellar subluxation. J Bone Joint Surg [Am] 1978;60A:55–61.)

of these patients have other characteristic clinical signs that indicate their anterior knee pain is in fact secondary to functional instability of the patella.

Dislocation of the Patella

Some patients have dislocation of the patella as a result of a major acute injury, such as a direct impact on the patella, driving it laterally. These patients may have no underlying anatomic abnormalities. Many patients, however, have one or more anatomic abnormalities that predispose to patella dislocation.

Certain patients with patellar dislocation have Q angles in excess of 20°. Some individuals, however, have Q angles greater than 20° and an otherwise normal mechanism and alignment and may function well. The presence of a Q angle greater than 20° accompanied by excessive external rotation at the tibia and increased internal rotation at the hip is generally referred to as malicious malalignment, and patients with this condition more commonly have patellar dislocation. In patella alta, the increased length of the patellar tendon is inherently unstable because it allows the patella greater medial-lateral translation. It also allows the patella to ride high in the trochlea, where it is somewhat flatter, or even above the trochlea of the femur. Patients with a shallow trochlear groove or small, flat patella have substantially increased chance of dislocation. Finally, atrophy or dysplasia of the vastus medialis muscle also increases the relative strength of the lateral musculature, which can predispose to lateral subluxation.

Clinical Characteristics

Dislocation is manifested during a sudden motion, usually creating a valgus external rotation force. The patella slides over the lateral femoral condyle. Also, the patella may spontaneously reduce or may be reduced by gradual extension of the leg. Accompanying moderate hemarthrosis occurs. If the patient presents with a relocated patella and a moderate hemarthrosis, the history and appearance may suggest an anterior cruciate ligament injury, and medial tenderness may suggest medial collateral ligament injury. Tenderness that is localized to the medial or lateral patella and apprehension with lateral patella push should suggest patella dislocation. Anteroposterior and varus/valgus instability is absent. X-rays may show avulsion fractures from the medial patella, which usually do not require surgery. Lateral femoral condylar fractures also may be present and should be referred to an orthopaedic surgeon.

Treatment

A tense hemarthrosis should be aspirated and the leg immobilized. With dislocation, quadriceps atony is common; however, it is difficult to begin quadriceps setting and isometric exercise until 1 to 2 weeks after injury. Immobilization for 2 weeks allows for some early healing of the medial retinaculum. After 2 weeks, quadriceps setting can be initiated, and motion out of the immobilizer can be started if no pain occurs with motion. Patients will continue to need the immobilizer for support because the quadriceps usually will not gain sufficient strength for independent activity until 6 weeks. Thereafter, quadriceps development is important. An acute dislocation does not require surgery unless the patella cannot be maintained in an anatomic position or loose bodies are present that could cause derangement of the joint.

Subluxation of the Patella

Subluxations occur with the same mechanism as dislocations. They are accompanied by a pop and some swelling, but not as severe as with a dislocation. Symptoms are compatible with continued activities or at least with walking. Treatment is the same as with dislocations; however, rehabilitation is shorter, swelling subsides after 1 week, and quadriceps strength returns by 4 to 6 weeks.

Some patients with history of subluxation or dislocation and x-ray findings of patella dislocation may develop degeneration. This type of degeneration is called permanent subluxation. The patient experiences lateral knee pain when sitting and climbing stairs. Examination shows lateral patellar tenderness and tightness, and may show evidence of malalignment. X-ray will show degenerative changes in addition to changes of subluxation. Definitive treatment requires surgical intervention. In some patients, adequate symptomatic relief can be achieved with relief of aggravating activity and the use of anti-inflammatory medication.

Anterior Knee Pain Without Subluxation

The same valgus forces that produce subluxation may in some patients simply produce peripatellar knee pain. This has a more insidious onset and usually is related to athletic activities that involve turning, twisting, or running.

Clinical Characteristics

Pain usually occurs after the event or during the event, but allows the athlete to continue playing. The history may consist of the athlete having difficulties for long periods, but not enough to stop participation. An acute episode may occur in a quick turn. Often the symptoms are intermittent or only related to a certain sport. Effusion is uncommon, but the feeling of swelling medially in the patella and fat pad area may be present.

Pain with these episodes is related to the pull on the medial soft tissues by the lateral force, resulting in inflammation. In many instances, there is an associated synovial plica that is trapped between the patella and femur or against the medial femoral condyle. In other instances, the fat pad attached to the plica is pinched in the same area. The episode may not require medical treatment, but the condition may progress. The patient can continue to participate in sports after a brief period of rest.

Occasionally, symptoms are present with activities of daily living. Patients manifest difficulties in going up and down stairs, kneeling or squatting, and occasionally turning and twisting. They have crepitus in the knee and giving way. Crepitus in these instances usually comes from the swollen soft tissue. These patients may have some of the characteristics of dislocation. Also, they may have hypermobility, some degree of vastus medialis dysplasia or underdevelopment compared with the lateralis, or tightness in the lateral retinaculum.

In those patients whose anterior knee pain and soft tissue swelling are caused by a direct blow, as in a fall or dashboard injury, there may be no manifestation of malalignment or dysplasia.

Treatment

Ice should be used after athletic events, and anti-inflammatory medications may be used for moderate symptoms. A period of rest is advisable if the patient has difficulty participating in sports. Patients should avoid activities that cause irritation, such as bending, squatting, and stair climbing. They should initiate a period of stretching the hamstrings and quadriceps muscles, especially when the symptoms occur at the time of the adolescent growth spurt. Quadriceps muscle strengthening exercises are important for developing the medialis and maintaining a better muscular balance for the patella. This program is usually successful. Patellar bracing providing pressure to resist lateral subluxation may also be helpful. If after 6 months of nonoperative treatment or a long period of intermittent problems the patient still has pain with daily activity and is not able to participate in sports or exercise, evaluation by arthroscopy is indicated. Orthopaedic referral should be made.

Chondromalacia

As noted previously, there can be a large force across the patella in activities such as running or stair climbing. Cartilage that is subject to too much or too little force is likely to soften, producing the lesion known as chondromalacia. Chondromalacia can occur as the result of a direct blow, when a plica rubs against the medial inferior patella, or when high pressure is generated by doing squats with heavy weights. Chondromalacia can also occur in association with recurrent subluxation or dislocation or as a result of an isolated dislocation with damage to the cartilage surface. The softening may produce crepitus. The pain of chondromalacia is related to soft tissue inflammation and is usually peripatellar. Pain involving the patella itself does not become manifest until the cartilage is completely worn and bone-to-bone apposition occurs between the patella and trochlea.

Excessive Lateral Pressure Syndrome

People who do not have full excursion of the patella can develop a lateral tightness that holds the patella tightly in the trochlea. Degeneration develops laterally on the patella and trochlea with no evidence of subluxation. This syndrome is called excessive lateral pressure syndrome.

This condition is characterized by lateral knee pain when sitting and climbing stairs. Females are more commonly affected. Examination shows lateral patellar tenderness and tightness. X-ray changes will show lateral sclerosis and narrowing. As pain increases, the quadriceps weaken and degeneration extends into the medial and lateral compartments, resulting in complete degeneration.

Treatment of Chondromalacia and Excessive Lateral Pressure Syndrome

The problems occurring from chondromalacia or excessive lateral pressure syndrome may be alleviated by removing the source of pressure. This may be accomplished by discontinuing heavy weightlifting, or modifying the work environment to avoid climbing stairs and squatting. If symptoms persist despite force modification and use of anti-inflammatory medication, the patient should be referred to an orthopaedist.

ANTERIOR KNEE PAIN

Patients, especially young individuals, often complain of pain in the anterior portion of the knee. The problems related to patellar biomechanics have been described previously. However, there are other reasons for complaints in this area. The common term for anterior knee pain has been chondromalacia patellae. This is based on the finding that as a person ages, his or her patellar cartilage or articular surfaces become more irregular. The rough surfaces are equated with noise. With the advent of arthroscopy, there have been cases of crepitus that have been related to soft tissue swelling and not to the softening of the cartilage. Therefore, we cannot blame all pain or crepitus across the front of the knee on chondromalacia.

It is helpful to be specific about the area of pain. Several areas have to be considered (Fig. 7.38). First, the medial synovial plica can be related to patellar instability. The medial soft tissues may be pulled laterally by the patella and thereby injured by the mechanics of the patella. The patellar tendon must be evaluated as discussed previously. Laterally, the lateral patellar tibial ligament, the lateral retinaculum, and the area of the insertion of the vastus lateralis must be evaluated. The patella surface must evaluated for bursitis. Lastly, saphenous neuritis is a mimic that causes anterior knee pain that can confuse the evaluation.

Neuritis can be related to problems within the knee but can occur as a separate factor, making us believe that the knee is the cause

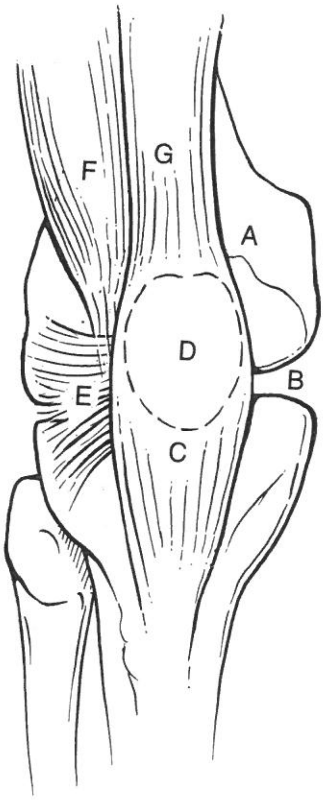

Figure 7.38. *A*, medial soft tissue—plica. *B*, anterior joint line—meniscus. *C*, patellar tendon. *D*, prepatellar bursitis. *E*, lateral retinaculum. *F*, insertion of lateralis vastus. *G*, quadriceps tendon.

of symptomatology. Table 7.1 reveals the numerous factors, both direct and indirect, that can produce saphenous neuritis.

Diagnosis of saphenous neuritis is made by the history and physical examination. Neuritis pain tends to be a steady pain and is not related

Table 7.1. Causes for Saphenous Neuritis

1. Direct
   - Direct blow
   - Cutting—by incision
   - Stretch—posterolateral instability
2. Indirect
   - RSD
   - Fibromyalgia
   - Lumbar disc disease
   - Degenerative joint disease
   - Medial meniscal pathology

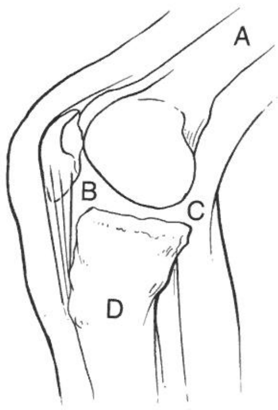

Figure 7.39. *A*, adductor canal. *B*, medial to patella and patellar ligament. *C*, posterior medial joint line. *D*, medial tibial plateau.

to any mechanical activities. The pain occurs even into the night. Often, patients can perform their daily activities. However, by evening when the patient returns home from work, the pain becomes intense, requiring medication. Heat may have a more beneficial effect than ice.

The physical aspects of neuritis are never noted specifically by the patient and must be elicited by the examination. This should be part of all examinations around the knee. The four-point saphenous sensitivity tests, as shown in Figure 7.39, places pressure on the four points. The first is approximately four finger breadths above the epicondyle at the adductor canal. The other points are medial patella and patella ligament, the posterior aspect of the medial joint line, and the medial tibial plateau. It is obvious that this is a mimic for meniscal pathology because point 3 makes the physician believe that the patellar ligaments or medial soft tissues are involved. Point 2 at the medial joint line suggests the diagnosis of meniscal injury. Indeed, medial meniscal injuries can produce the neuritis, thus providing a strong diagnostic challenge to differentiate between the two conditions. MRI is often helpful. If the MRI is negative, the medial meniscus is not the cause of the neuritis. Likewise, pressure over palpable pain of the medial tibial plateau can suggest pes anserine bursitis, when the pressure may be related to the neuritis. Four-point saphenous testing is an important part of the examination, because neuritis can be the cause of unnecessary or repeat surgery about the knee. If the saphenous test is positive and there is no mechanical cause such as posterolateral rotatory instability or meniscal injury, other causes for the neuritis should be considered (see Table 7.1).

Diagnostic block of the saphenous nerve at the adductor canal can help in the differential diagnosis. The block also may be therapeutic.

Suggested Readings

Ewing JW, ed. Articular Cartilage and Knee Joint Function: Basic Science and Arthroscopy. New York: Raven Press, 1988.
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Muller W. The Knee—Form, Function, and Ligament Reconstruction. Berlin: Springer-Verlag, 1982.