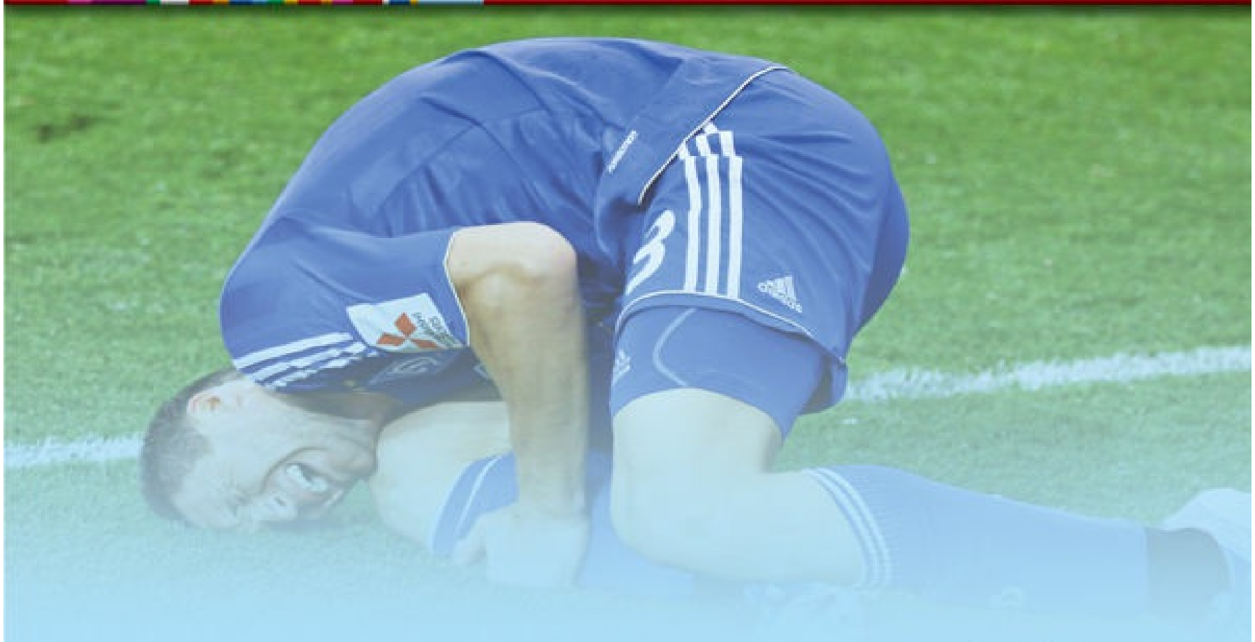
Basic Athletic Training
Course Pack B

For use in PES 385, Basic Athletic Training, SUNY Brockport.

CHAPTER

15

Knee Conditions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STUDENT OUTCOMES

1. Identify the major bony and soft-tissue structures of the knee region.
2. Identify the primary and secondary ligamentous restraints of the knee.
3. Describe the motions of the knee and identify the muscles that produce them.
4. Describe the forces that produce the loading patterns responsible for common injuries at the knee.
5. Explain the general principles used to prevent injuries to the knee.
6. Describe a thorough assessment of the knee and

patellofemoral joint.

7. Describe the common injuries to and conditions of the knee in physically active patients (including sprains, dislocations, contusions, strains, bursitis, meniscal tears, and by patellofemoral pain).
8. Explain the management strategies for common injuries and conditions of the knee.
9. List the various types of fractures that can occur at the knee and explain their management.
10. Explain the basic principles associated with rehabilitation of the knee.

INTRODUCTION

The knee is a complex joint that frequently is injured in physical activity. When walking and running, the knee moves through a considerable range of motion (ROM) while bearing loads equivalent to 3 to 4 times body weight. Because the knee is positioned between the two longest bones in the body (i.e., the femur and the tibia), the potential exists for creating large, injurious torques at the joint. These factors, coupled with minimal bony stability, make the knee susceptible to injury. Knee injuries comprise approximately 60% of all sport injuries, being the predominant site of injury among runners and one of the most frequently injured joints for all sport participants.[1–3]

This chapter begins with a review of the anatomy of the knee and a discussion of the associated kinematics and kinetics. General principles to prevent injuries are presented followed by a step-by-step injury assessment of the region. Discussion regarding common injuries to the knee complex and examples of rehabilitative exercises are then included.

ANATOMY OF THE KNEE

The knee is a large, synovial joint that includes three articulations within the joint capsule. The weight-bearing joints are the two condylar articulations of the tibiofemoral joint; the third articulation is the patellofemoral joint. The soft-tissue connections of the proximal tibiofibular joint also exert a minor influence on knee motion.

Bony Structure of the Knee

The proximal bone of the knee joint is the femur. The prominent posterior ridge of the femur, the linea aspera, serves as an attachment for many of the muscles that move the hip and knee. The distal portion of the femur broadens to form the medial and lateral epicondyles. The area between the epicondyles on the anterior surface of the femur is the femoral trochlea, through which the patella glides as the knee moves into flexion and extension (**Fig. 15.1**).

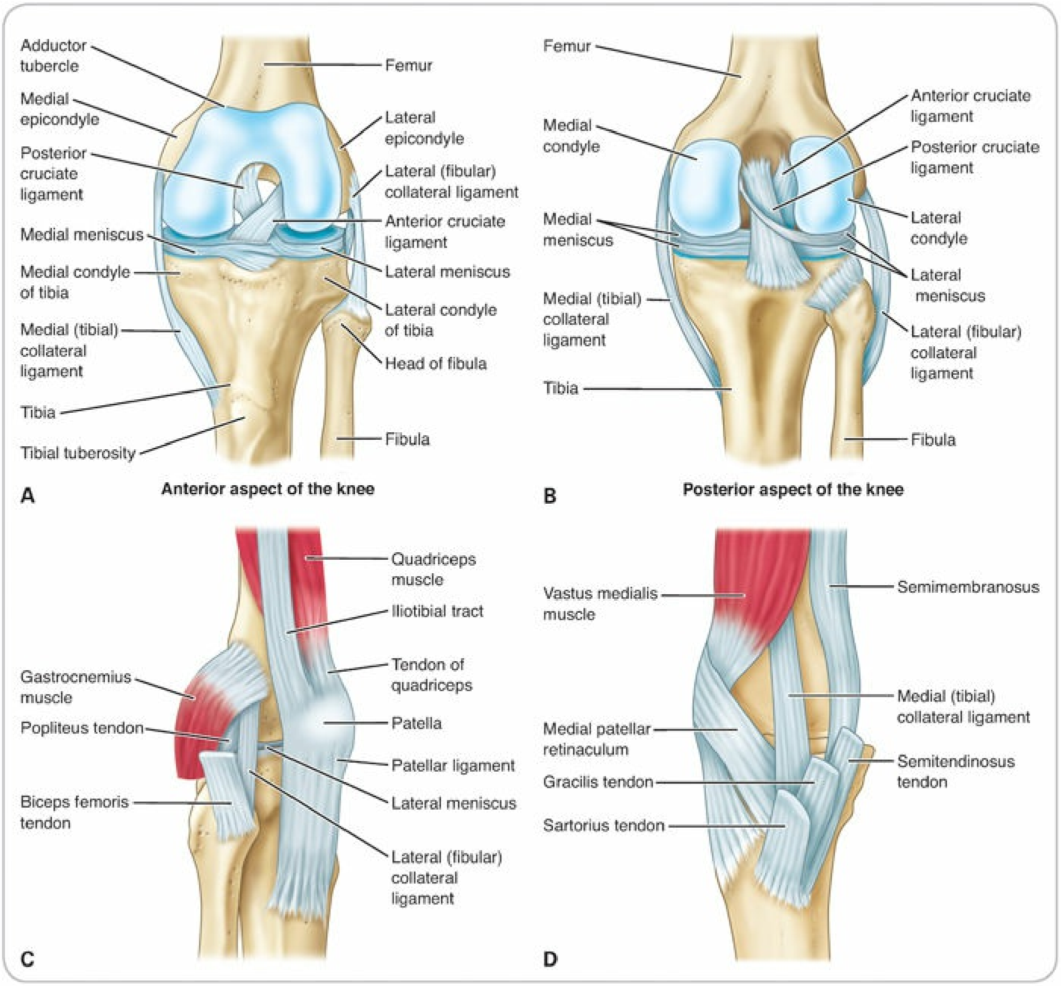

Figure 15.1. Structures of the knee. A, Anterior view. The joint is flexed, and the patella is removed. **B, Posterior view.** The knee is in extension. **C, Lateral view. D, Medial view.** *(continued)*

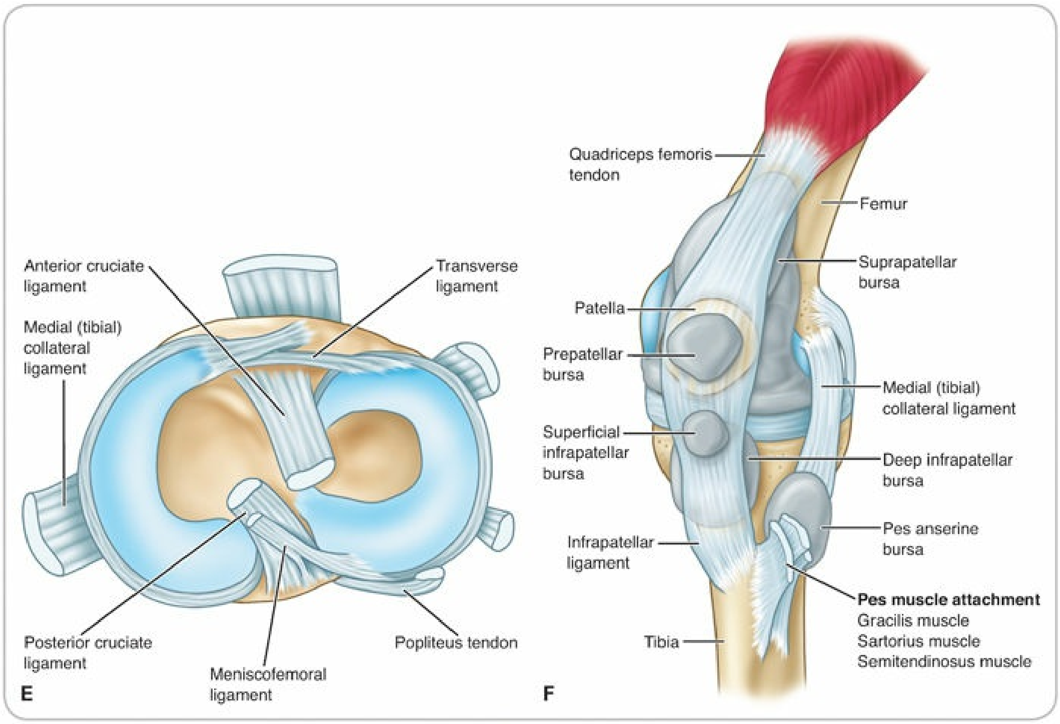

Figure 15.1. *(continued)* **E, Superior surface of the tibia. F, Bursae of the knee.**

The lateral epicondyle is wider than the medial epicondyle. Arising from the most superior crest of the medial epicondyle is the palpable adductor tubercle. Inferior to each epicondyle are the medial and lateral condyles, with the medial condyle being the longer. Sharing a common anterior surface, these condyles bifurcate posteriorly and are separated by the deep intercondylar notch.

Corresponding to the femoral condyles are the medial and lateral tibial plateaus with conformations that are complex and asymmetric.[4] To accommodate for the longer medial femoral condyle, the medial tibial plateau is 50% larger than the lateral tibial plateau. Separating the two tibial plateaus are the intercondylar eminences, which are raised areas that match the femur's intercondylar notch. The anterior aspect of the tibia includes the prominent tibial tubercle, which serves as the distal attachment of the infrapatellar ligament.

The patella is a sesamoid bone located in the quadriceps (patellar) tendon. It improves the biomechanical function of the extensor mechanism and protects the anterior portion of the knee. The fibula is not a direct part of the knee joint. The head of the fibula, however, does serve as a site for several soft-tissue attachments that support and stabilize the knee.

Tibiofemoral Joint

The distal femur and proximal tibia articulate to form two side-by-side condyloid joints that collectively are known as the tibiofemoral joint (see Fig. 15.1). These joints function together primarily as a modified hinge joint. Because of the restricting ligaments, some lateral and rotational motions are allowed at the knee. The medial and lateral condyles of the femur differ somewhat in size, shape, and orientation. As a result, the tibia rotates laterally on the femur during the last few degrees of extension to produce a "locking" of the knee. This phenomenon, known as the "screwing-home" mechanism, brings the knee into the close-packed position of full extension.

Menisci

The menisci, which also are known as semilunar cartilages because of their half-moon shapes, are disks of fibrocartilage firmly attached to the superior plateaus of the tibia by the coronary ligaments and joint capsule. They provide several functional advantages, including absorption and dissipation of force and significantly improved congruency of the joint surfaces to even the distribution of stress across the joint (Box 15.1).[5] In addition, because 74% of the total weight of the menisci is water, much of the fluid is squeezed out into the joint space when the knee undergoes compression during weight bearing, which provides lubrication to promote gliding of the joint structures.[6] The menisci also increase knee stability by serving as soft-tissue restraints that resist anterior tibial displacement.

BOX 15.1 Functions of the Menisci

- Deepen the articulation and fill the gaps that occur during knee motion.
- Aid in lubrication and nutrition of the joint.
- Reduce friction during movement.
- Increase area of contact between the condyles, thus improving weight

distribution.

- Provide shock absorption by dissipating stress over the articular cartilage, thus decreasing cartilage deterioration.
- Assist the ligaments and capsule in preventing hyperextension.
- Prevent the joint capsule from entering the joint during the locking mechanism by directing the movement of the femoral articular condyles.

When viewed in cross-section, the menisci are thicker along the lateral margin and thinner on the medial margin, serving to deepen the concavities of the tibial plateaus. When viewed from above, the medial meniscus is semicircular, whereas the lateral meniscus is somewhat more circular (see **Fig. 15.1**). The inner edges of both menisci are unattached to the bone, but the two ends of the menisci, known as the anterior and posterior horns, are attached to the intercondylar tubercles. The anterior horns of each meniscus are joined to each other by the transverse ligament and are connected to the infrapatellar tendon via the patellomeniscal ligaments.

The medial meniscus has an attachment to the deep medial collateral ligament (MCL) and fibers from the semimembranosus muscle. It is injured much more frequently than the lateral meniscus, in part because the medial meniscus is more securely attached to the tibia and, therefore, is less mobile.

In comparison, the lateral meniscus is a smaller and more freely movable structure. In addition to its attachments to the joint capsule, intercondylar tubercles, and transverse ligament, the lateral meniscus is attached to the posterior cruciate ligament through the meniscofemoral ligament (ligament of Wrisberg) and to the popliteus muscle via the joint capsule and coronary ligament. Contraction of the popliteus serves to retract the lateral meniscus. During flexion and extension of the knee, the medial and lateral menisci move posteriorly and anteriorly, respectively. The outer third of each meniscus is innervated and contains nociceptors that, when a meniscus is injured, send signals of pain to the brain.[7] The outer most portion of each meniscus is also the most vascularized portion of the structure, whereas the inner most portion of the structure is the least vascularized portion.[8] Injuries occurring to the vascularized portions of the menisci have a greater chance of healing than injuries occurring in the avascular region.

Joint Capsule and Bursae

The thin articular capsule at the knee is large and lax, encompassing both the tibiofemoral and patellofemoral joints. Anteriorly, it extends approximately 2.5 cm above the patella to attach along the edges of the superior patellar surface. The deep bursa formed by this capsule above the patella, known as the suprapatellar bursa, is the largest in the body (**Fig. 15.1F**). The suprapatellar bursa lies between the femur and quadriceps femoris tendon, and it functions to reduce friction between the two structures.

Posteriorly, two other bursae communicate with the joint capsule—namely, the subpopliteal and semimembranosus bursae. The subpopliteal bursa lies between the lateral condyle of the femur and the popliteal muscle. The semimembranosus bursa lies between the medial head of the gastrocnemius and the semimembranosus tendon.

During flexion and extension, synovial fluid moves throughout the bursal recesses to lubricate the articular surfaces. In extension, the gastrocnemius and subpopliteal bursae are compressed, driving the synovial fluid anteriorly. In flexion, the suprapatellar bursa is compressed, forcing the fluid posteriorly. When the knee is in a semiflexed or open-packed position, the synovial fluid is under the least amount of pressure; this position provides relief of pain caused by swelling in the joint capsule and surrounding bursae.

Four other key bursae are associated with the knee but not contained in the joint capsule—namely, the prepatellar, superficial infrapatellar, deep infrapatellar bursae, and pes anserine bursa. The prepatellar bursa is located between the skin and anterior surface of the patella, allowing free movement of the skin over the patella during flexion and extension. The superficial infrapatellar bursa is located between the skin and patellar tendon. Inflammation of this bursa caused by excessive kneeling sometimes is referred to as "housemaid's knee." The deep infrapatellar bursa is located between the tibial tubercle and the infrapatellar tendon, and it is separated from the joint cavity by the infrapatellar fat pad. This bursa reduces friction between the ligament and the bony tubercle. The pes anserine bursa is located between the MCL and the sartorius, gracilis, and semitendinosus tendons and distal to the joint line, in close proximity and posterior to the MCL. Images of knee bursa can be seen in **Figure 15.1F**.

Ligaments of the Knee

Because the shallow articular surfaces of the tibiofemoral joint contribute minimally to knee stability, the stabilizing role of the ligaments crossing the knee is of great significance. Two major ligaments of the knee are the anterior and posterior cruciate ligaments (see **Fig. 15.1**). The name cruciate is derived from the fact that the two ligaments cross each other, with anterior and posterior referring to their respective tibial attachments. These ligaments are termed intracapsular ligaments, because they are located within the articular capsule and extrasynovial ligaments because they lie outside the synovial cavity.

The anterior cruciate ligament (ACL) stretches from the anterior aspect of the intercondyloid fossa of the tibia just medial and posterior to the anterior tibial spine in a superoposterior direction to the posteromedial surface of the lateral condyle of the femur. The ACL is a critical stabilizer that prevents the following:

- Anterior translation (movement) of the tibia on a fixed femur
- Posterior translation of the femur on a fixed tibia
- Internal and external rotation of the tibia on the femur
- Hyperextension of the tibia

The ACL has two discrete bands—namely, an anteromedial and a posterolateral bundle. Occasionally, a third, intermediate band also is present. When the knee is fully extended, the femoral attachment of the anteromedial bundle is anterior to the attachment of the posterolateral bundle. When the knee is flexed, the positions are reversed, causing the ACL to wind on itself. The result of this action is that varying portions of the ACL are taut as the knee moves through a normal ROM. When the knee is fully extended, the posterolateral bundle is taut; when the knee is fully flexed, the anteromedial bundle is taut.[9] Generally, loads on the ACL correspond to anteriorly directed shear force at the knee.[10] During gait, this force is maximum in early stance and small in late stance. The ACL frequently is subject to deceleration injuries; internal tibial torque is the most dangerous loading mechanism, particularly when combined with an anterior tibial force.[11]

The shorter and stronger posterior cruciate ligament (PCL) runs from the posterior aspect of the tibial intercondyloid fossa in an anterosuperior direction to the lateral anteromedial condyle of the femur. It consists of a large anterolateral and a smaller posteromedial bundle. The PCL is considered the primary stabilizer of the knee, and it resists posterior displacement of the tibia on a fixed femur. The posterior fibers of the PCL are taut when the knee is fully extended, and the anterior fibers are taut when it is fully flexed.

The medial and lateral collateral ligaments also are referred to as the tibial and fibular collateral ligaments, respectively, after their distal attachments (see **Fig. 15.1**). Formed by two layers, the deep fibers of the MCL merge with the joint capsule and medial meniscus to connect the medial epicondyle of the femur to the medial tibia. The superficial layer originates from a broad band just below the adductor tubercle and is separated from the deep layer by a bursa. The two layers insert just below the pes anserinus, the common attachment of the semitendinosus, sartorius, and gracilis, thereby positioning the ligament to resist medially directed shear (i.e., valgus) and rotational forces acting on the knee. As a unit, the MCL is taut in complete extension. In midrange, its posterior fibers are the tautest; in complete flexion, the anterior fibers are the most taut.

The lateral collateral ligament (LCL) connects the lateral epicondyle of the femur to the head of the fibula, contributing to lateral stability of the knee. The ligament is separated from the lateral meniscus by a small fat pad. The LCL is the primary restraint against varus forces when the knee is between full extension and 30° of flexion, and it provides secondary restraint against external rotation of the tibia on the femur. The LCL is highly innervated and includes Ruffini endings, Golgi tendon organs, and free nerve endings, all of which can contribute to an indistinct pain when the knee is injured.[12]

Other Structures Stabilizing the Knee

Several other structures contribute to knee integrity. Posteriorly, the oblique popliteal ligament forms an extension of the semimembranosus tendon, and the arcuate popliteal ligament connects the lateral condyle of the femur to the head of the fibula. These two ligaments, which are called the arcuate–popliteal complex, provide support to the posterior joint capsule. The complex limits anterior displacement of the tibia relative to the femur as well as hyperextension and hyperflexion of the knee. It becomes taut during internal and external tibial rotation and during valgus and varus loading of the knee.

Although the knee is only partially surrounded by a joint capsule, the capsule is reinforced by several tendons, including the expanded tendons of the quadriceps, the tendon of the semimembranosus, and the iliotibial (IT) band. Laterally, the IT band is a broad, thickened band of fascia that extends from the tensor fasciae latae over the lateral epicondyle of the femur to the Gerdy tubercle on the lateral tibial plateau. The IT band is well supplied with free nerve endings that transmit signals for pain and proprioception to the brain, enhancing the structure's ability to promote lateral knee stability. The tissue under the IT band is a lateral extension and invagination of the knee joint capsule. Table 15.1 lists the structures providing stability to the knee, including primary and secondary restraints.

TABLE 15.1 Structures Contributing to the Stability of the Knee

TIBIAL MOTION	PRIMARY RESTRAINTS	SECONDARY RESTRAINTS
Anterior translation	ACL	MCL, LCL, middle third of the mediolateral capsule, IT band
Posterior translation	PCL	MCL, LCL, posterior third of the mediolateral capsule, popliteus tendon, anterior and posterior meniscofemoral ligaments
Valgus rotation	MCL	ACL, PCL, posterior capsule when the knee is fully extended
Varus rotation	LCL	ACL, PCL, posterior capsule when the knee is fully extended
Lateral rotation	MCL, LCL	Popliteus corner, ACL, PCL
Medial rotation	ACL, PCL	Anteroposterior meniscofemoral ligaments

Patellofemoral Joint

The patella (i.e., the kneecap) is a triangular bone that rests between the femoral condyles to form the patellofemoral joint (Fig. 15.2). The posterior surface of the patella is composed of three distinct facets, although the number, size, and shape of these facets vary from person to person.[13] A central, vertical ridge separates the medial and lateral regions, each having a superior, middle, and inferior articular surface. The odd facet, lying medial to the medial facet, has no articular subdivisions. The thickest articular cartilage in the body covers these facets, with the cartilage ranging up to 5 mm in thickness.[13]

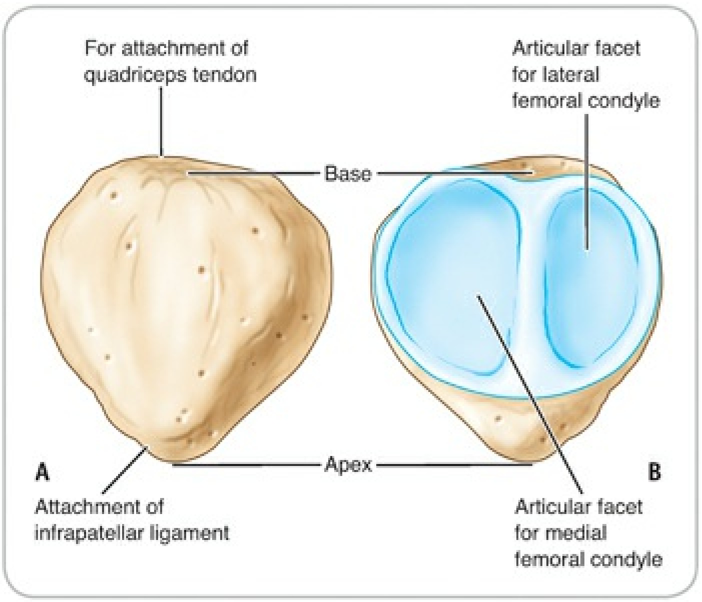

Figure 15.2. Patella. A, Anterior view. **B,** Posterior view.

In the sagittal plane, the patella serves to increase the angle of pull of the patellar tendon on the tibia, thereby improving the mechanical advantage of the quadriceps muscles to produce knee extension. Patellar positioning is both maintained and restrained by the patellar retinaculum. The lateral retinaculum originates from the vastus lateralis and the IT band and inserts on the patella's lateral border. The medial retinaculum originates from the distal portion of the vastus medialis and adductor magnus, and it inserts on the medial border of the patella. The superior portion of the knee's joint capsule thickens and inserts on the patella's superior border, forming the medial and lateral patellofemoral ligaments.

The Q-angle is defined as the angle between the line of resultant force produced by the quadriceps muscles and the line of the patellar tendon (Fig. 15.3A). One line is drawn from the middle of the patella to the anterior superior iliac spine of the ilium, and a second line is drawn from the tibial tubercle through the center of the patella. When the knee is fully extended during weight bearing, the normal Q-angle ranges from approximately 12° in males to approximately 22° in females.[14] A Q-angle of less than 12° or greater than 22° is considered to be abnormal and can predispose patients to patellar injuries or degeneration. adaver studies show that increasing the Q-angle increases lateral patellofemoral contact pressures and could promote lateral patellar dislocation, whereas decreasing the Q-angle could increase the medial tibiofemoral contact pressure.[15] Factors that contribute to an increased angle in women include a wider pelvis, increased femoral anteversion, increased knee valgus, external tibial torsion, increased ligamentous laxity, and hyperpronation of the foot.

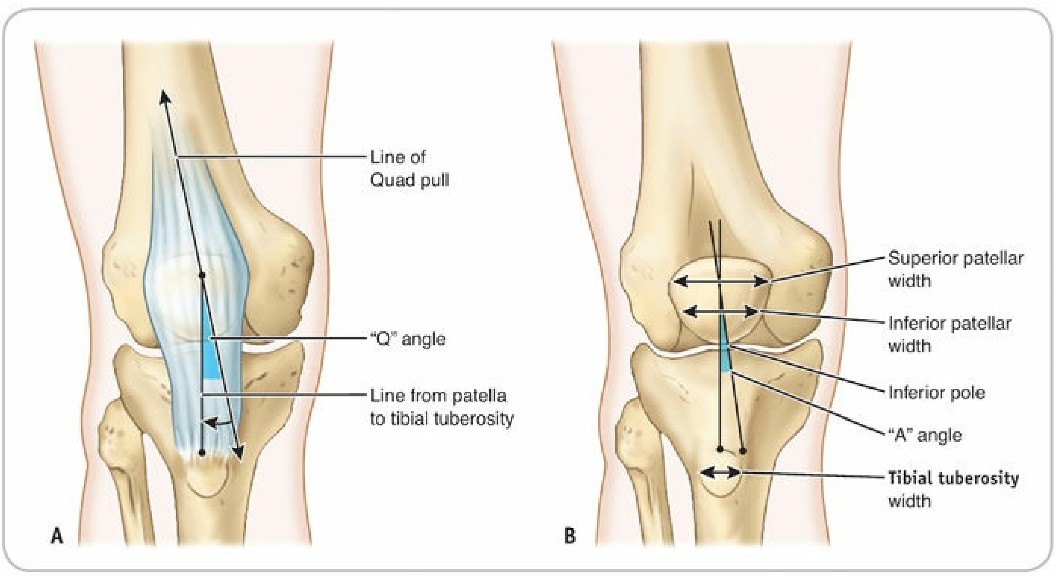

Figure 15.3. Angles at the knee. A, The Q-angle is formed between the line of quadriceps pull and the imaginary line connecting the center of the patella to the center of the tibial tubercle. **B,** The A-angle measures the relationship of the patella to the tibial tubercle.

Another measurement, similar to the Q-angle, is the A-angle, which measures the relationship of the patella to the tibial tubercle (Fig. 15.3B). This measurement consists of a vertical line that divides the patella in half. A second line is drawn from the tibial tubercle to the apex of the inferior pole of the patella. An A-angle of greater than 35° has been linked to increased patellofemoral pain, although some have questioned the reliability of this measurement because of the difficulty in consistently finding appropriate landmarks.

Muscles Crossing the Knee

The muscles of the knee develop tension to produce motion at the knee and contribute to the knee's stability.

See **Muscles Acting on the Knee**, available on the companion Web site at thePoint, for a summary of these muscles, including their attachments, primary actions, and innervation.

Nerves of the Knee

The tibial nerve (L4, L5, S1 to S3) is the largest and most medial continuation of the sciatic nerve. It innervates all the muscles in the hamstring group except for the short head of the biceps femoris, and it also supplies all muscles in the calf of the leg (**Fig. 15.4**).

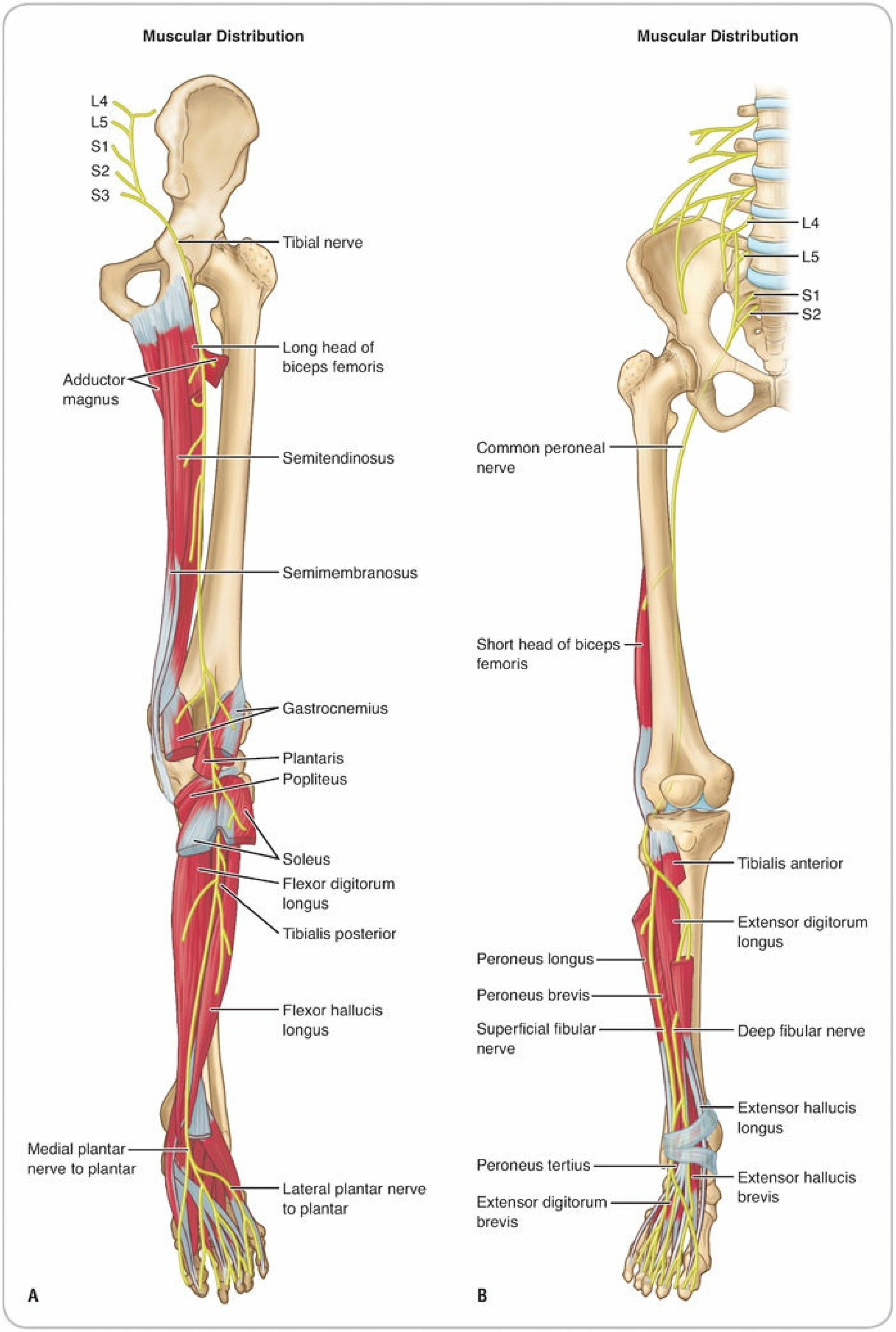

Figure 15.4. Innervation of the knee. A, Anterior view. **B,** Posterior view.

The common peroneal nerve (L4, L5, S1, S2) is the lateral branch of the sciatic nerve (see **Fig. 15.4**). It innervates the short head of the biceps femoris in the thigh and then circles around the Gerdy tubercle, or the lateral tubercle of the proximal tibia, with a radius of approximately 45 mm.[16] Proceeding inferiorly, it passes through the popliteal fossa to wind laterally along the subcutaneous surface to just below the proximal head of the fibula, where it can be easily damaged. As it passes between the fibula and the peroneus longus muscle, it subdivides into the superficial and deep peroneal nerves. An articular branch to the knee may arise either from the deep peroneal nerve or from both the deep and superficial peroneal nerves as a terminal branch of the common peroneal nerve.

The femoral nerve (L2 to L4) courses down the anterior aspect of the thigh adjacent to the femoral artery to supply the quadriceps group. The L2 and L3 branches of the femoral nerve also innervate the sartorius.

The Blood Vessels of the Knee

Just proximal to the knee, the main branch of the femoral artery becomes the popliteal artery. The popliteal artery courses through the popliteal fossa and then branches, forming the medial and lateral superior genicular, the middle genicular, and the medial and lateral inferior genicular arteries that supply the knee (**Fig. 15.5**). The superior and inferior genicular arteries intertwine with each other about the knee.

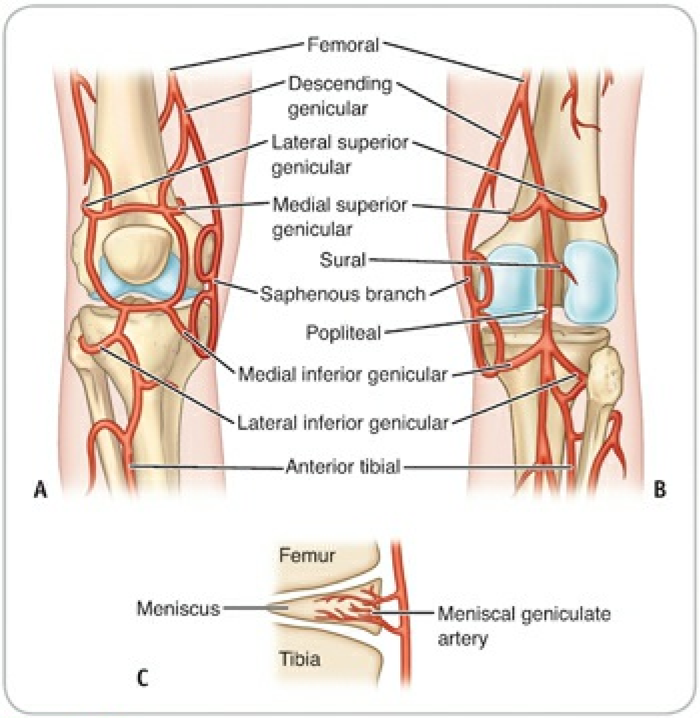

Figure 15.5. **Collateral circulation around the knee. A,** Anterior view. **B,** Posterior view. **C,** Circulation to meniscus.

KINEMATICS AND MAJOR MUSCLE ACTIONS OF THE KNEE

The knee functions primarily as a hinge joint. The different shapes of the femoral condyles, however, serve to complicate joint function.

Flexion and Extension

The primary motions permitted at the tibiofemoral joint are flexion and extension. Knee flexion is performed primarily by the hamstrings and is assisted by the popliteus, gastrocnemius, gracilis, and sartorius. In addition, the flexor musculature has a secondary responsibility of rotating the tibia. The flexors attaching on the tibia's medial side (i.e., semitendinosus, semimembranosus, gracilis, and sartorius) internally rotate the tibia, whereas those attaching on the lateral side (i.e., biceps femoris) externally rotate the tibia. Knee extension is carried out by the quadriceps femoris muscle group.

Although the name implies four muscles, most clinicians describe five—namely, the vastus lateralis, vastus intermedius, vastus medialis, vastus medialis oblique (VMO), and rectus femoris. The VMO is a discrete group of fibers arising from the medial femoral condyle and the fascia of the adductor magnus. Each muscle has a common attachment on the tibial tubercle via the patella and infrapatellar ligament.

In the terminal 20° of knee extension, the tibia externally rotates approximately 15° in what is called the "screw-home" mechanism. In full extension, the joint's close-packed position, maximal bony contact occurs between the femur and tibia, resulting in the joint being anatomically "locked." This rotation occurs because the articulating surface of the medial condyle of the femur is longer than that of the lateral condyle in this locked position, rendering motion almost completely impossible. Initiation of flexion from a position of full extension requires that the knee first be "unlocked." The role of "locksmith" in the closed kinetic chain is provided by the popliteus, which acts to externally rotate the femur with respect to the tibia and, in doing so, frees the joint for motion.

Once the knee is unlocked from full extension, bony contact is diminished, and motion in the transverse and frontal planes becomes freer. In an open kinetic chain, contraction of the popliteus causes internal rotation of the tibia on the femur. As the knee moves into flexion, the medial femoral condyle moves very little anteroposteriorly, but the lateral femoral condyle rolls back and the point of femorotibial contact shifts posteriorly, producing internal rotation of the tibia, with 120° of flexion accompanied by 20° of internal tibial rotation.[17] This motion is facilitated by the inferior sloping of the lateral compartment of the tibial plateau. The reverse occurs during extension as the lateral femoral condyle of the femur slides anteriorly on the tibia.

Rotation and Passive Abduction and Adduction

The rotational capability of the tibia with respect to the femur is maximal at approximately 90° of knee flexion. A few degrees of passive abduction and adduction are permitted when the joint is positioned in the vicinity of 30° of flexion.

Knee Motion During the Gait

During midstance of normal gait, the knee is flexed to approximately 20°, internally rotated approximately 5°, and slightly abducted. Knee motion during the swing phase includes approximately 70° of flexion, 15° of external rotation, and 5° of adduction. Gait is explained in more detail in Chapter 8.

Patellofemoral Joint Motion

During movements of knee flexion and extension, the patella glides in the trochlear groove, primarily in a vertical direction, with an excursion of as much as 8 cm. When the knee is fully extended, the inferior pole of the patella rests on the distal portion of the femoral shaft, just proximal to the femoral groove. During flexion, the patella makes initial contact with the groove at 10° to 20° of flexion, and it becomes seated within the groove as the knee approaches 20° to 30°. In this position, the lateral border of the trochlea is prominent, forming a barrier against lateral displacement of the patella. The inferior border of the patella tilts upward and medially during knee flexion, with the contact area increasingly shifted superiorly on the medial and lateral facets of the posterior patella.[18,19] The patella also undergoes medial and lateral displacement as the tibia is rotated laterally and medially, respectively, with the center of the patella following a circular path during knee flexion/extension.[20]

Tracking of the patella against the femur is dependent on the direction of the net force produced by the attached quadriceps. The vastus lateralis tends to pull the patella laterally in the direction of the muscle’s action line, parallel to the femoral shaft. The IT band and lateral extensor retinaculum also exert a lateral force on the patella, and IT band tightness can cause maltracking of the patella.[21] Although considerable debate exists regarding its role, the VMO seems to oppose the lateral pull of the vastus lateralis and, in doing so, keeps the patella centered in the patellofemoral groove. If the magnitude of the force produced by the vastus lateralis exceeds that produced by the VMO, the patella is pulled laterally out of its groove during tracking. Mistracking of the patella during knee flexion–extension can be extremely painful and lead to several chronic patellofemoral conditions.

KINETICS OF THE KNEE

Because the knee is positioned between the body's two longest bony levers (i.e., the femur and the tibia), the potential for torque and force development at the knee is significant. The key role played by the knee during weight bearing makes the knee subject to large forces during the gait cycle.

Forces at the Tibiofemoral Joints

Weight bearing and tension development in muscles crossing the knee are the predominant forces acting at the tibiofemoral joints, with both contributing to joint compression. The medial compartment sustains the majority of the load during stance, with compressive force at the joint reaching an estimated threefold body weight during the stance phase of gait, increasing to around three- to sixfold body weight during stair climbing.[22,23] Comparison of front and back squat exercises shows significantly higher knee compressive forces during the back squat as compared to the front squat, with shear forces at the knee during squat exercises being small and posteriorly directed.[24] During sport participation, knee forces undoubtedly are large, although quantitative estimates are lacking. Tension in the knee extensors also increases lateral stability of the knee, with tension in the knee flexors contributing to medial stability.

The menisci assist with force absorption at the knee, behaving as a rubberlike elastic material at high loading frequencies and as a more viscous force dissipator at lower loading frequencies.[25] The medial two-thirds of each meniscus have an internal structure that is particularly well suited to resisting compression. The menisci also serve to distribute force from the femur over a broader area and, in doing so, reduce the magnitude of joint stress. Tibiofemoral joint stress is an estimated threefold higher during weight bearing when the menisci have been removed. Because the menisci also serve to protect the articulating bone surfaces from wear, knees that have undergone complete or partial meniscectomies still may function adequately, but such knees are more likely to develop degenerative conditions.

Forces at the Patellofemoral Joint

Compressive force at the patellofemoral joint has been found to be half the body weight during normal walking gait, increasing up to eightfold body weight during stair climbing.[23] During stair climbing, there is an increase in patellofemoral pressure, lateral force distribution, and lateral patellar tilt.[26]

PREVENTION OF KNEE CONDITIONS

Because many of the muscles that move the knee also move the hip, prevention of knee injuries must focus on a well-rounded physical conditioning program. Although much debate continues as to the effectiveness of prophylactic knee braces (see Chapter 3), recent rule changes and improved shoe design have contributed significantly to a reduction of injuries at the knee.

Physical Conditioning

The development of a well-rounded physical conditioning program is the key to injury prevention. Exercises should include flexibility and muscular strength, endurance, and power as well as speed, agility, balance, and cardiovascular fitness. Lack of flexibility can predispose a patient to muscular strains. Exercises should focus on general flexibility and may be performed either alone or with a partner using proprioceptive neuromuscular facilitation stretching techniques. In particular, stretching exercises should focus on the quadriceps, hamstrings, gastrocnemius, IT band, and adductors. Because many of these muscles contribute to knee stability, strengthening programs also should focus on these muscle groups. Warm-up exercises (e.g., jogging, high-knee skipping, muscle activation, balance training with different jumping exercises, strength and core stability such as sit-ups) may reduce the incidence of knee injuries. When designing ACL injury prevention programs for females, specific attention needs to be focused on "core-based programs" that emphasize increasing hip abduction strength and muscle recruitment and overall neuromuscular training of the trunk muscles.[27] Specific exercises to prevent injury to the musculature that moves the knee are provided in Application Strategy 15.1. Additional exercises for muscles that cross the hip region are demonstrated in Application Strategy 16.1. Many of these exercises can be supplemented with tubing to add resistance to the exercise.

APPLICATION STRATEGY 15.1

Exercises to Prevent Injury at the Knee

Closed chain exercises involve all the joints in the lower extremity and engage both agonist and antagonist muscle groups.

1. **Body weight squats.** Starting position is with feet slightly wider than shoulder width apart, with toes pointed forward. Motion is initiated at the hips, and the body is lowered as if to sit on a chair. Knees should not extend beyond toes. In the ending position, body should be equally centered between hips, knees and hips flex to 90°, with torso upright. Hands may be held in front of body for balance. To return standing, extend hips and knees while keeping the chest upright.

2. Body weight squat progression. As the patient shows gains in strength and endurance and demonstrates improved proprioception, the patient can progress to performing squats on an unstable platform, with or without weights.

3. Body weight lunge. Patients will feel this exercise in their gluteal muscles, hamstrings, and quadriceps. Starting position is in standing with feet shoulder width apart. Hands may rest on hips or be held in front of body. One foot is kept stationary while the opposing limb is moved forward, as if stepping or lunging forward. Weight is transferred from back limb to front limb as patient begins to bend knee of back limb. The front knee should be directly over the ankle and should not extend beyond the foot. The back knee should not touch the ground, and weight is on the toes, not the foot. Attempt to maintain a 90° angle at the ankle, knee, and hip of both limbs. Torso should be balanced over hips and chest upright. To regain standing position, push off with front limb to step back into starting position. A basic lunge is performed on stationary platform. As the patient shows gains in strength and endurance and demonstrates improved proprioception, the patient can progress to lunging onto an unstable platform.

4. **Step-ups.** Make sure bench or box is secure and stand on both feet, facing step up box. Keeping torso upright, lift one limb onto box and extend hip and knee to raise body onto box. Body should be balanced over hips and lead knee should point in same direction as the lead foot,

keeping knee over foot. Bring trailing foot to rest beside lead foot on the top of the box.

5. **Step-up progression.** To increase difficulty and recruit additional muscle groups and movements, do not drop trailing leg to box but rather continue the motion and bring the trailing leg into 90° of flexion before returning to the floor.

6. **Roman deadlifts (RDLs).** RDLs are considered one of the best closed chain exercises for posterior chain muscles of the lower extremity. RDLs can be performed as a double-leg or single-leg exercise and standing on a flat or raised surface. Back should remain straight, shoulders should remain “down and back” (retracted position), core stable, hips and shoulders squared forward. Knee of standing leg should remain forward in line with toes, but knee should not be totally locked out (soft knee position).

Rule Changes

Rule changes in contact sports, particularly football, have significantly reduced injuries to the knee region. Specifically, modifications in acceptable techniques that prohibit blocking at or below the knee and blocking from behind have reduced traumatic injuries. Proper training methods on correct technique should continue throughout the season to ensure compliance with specific rules designed to prevent injury.

Shoe Design

Shoe design is discussed in Chapter 3. In field sports, shoes may have a flat-sole, long-cleat, short-cleat, or multicleated design. The cleats should be properly positioned under the major weight-bearing joints of the foot and should not be felt through the sole of the shoe. Although cleat pattern and type had previously been thought to predispose football athletes to knee injury, new research suggests that it is the interface between the turf and the stiffness of the upper portion of the shoe that is the greater risk factor to consider. Artificial turf and stiff uppers appear to have the greatest impact on rotational function.[28]

ASSESSING KNEE CONDITIONS

? A female high school basketball player is complaining of a deep, aching pain in the knee during activity. How should the assessment of this injury progress to determine the extent and severity of injury?

The lower extremity works as a unit to provide motion, and the knee plays a major role in supporting the body during dynamic and static activities. Biomechanical problems at the foot and hip can directly affect strain on the knee. As such, assessment of the knee complex must encompass an overview of the entire lower extremity. Refer to **Table 15.3** for a summary of the various knee instabilities, the tests used, and the injured structures as indicated by the various positive tests.

See **Special Tests for the Knee and Application Strategy: Knee Evaluation**, both available on the companion Web site at thePoint.

HISTORY

? The injury assessment of the female high school basketball player should begin with a history. What questions need to be asked to identify the cause and extent of this injury?

Conditions at the knee can be related to family history, age, congenital deformities, mechanical dysfunction, and recent changes in training programs, surfaces, or foot attire. Assessment should begin by gathering information on the mechanism of injury, associated symptoms, progression of the symptoms, any disabilities that may have resulted from the injury, and related medical history. Injuries seldom occur in an absolute frontal or sagittal plane; instead, most injuries involve a fixed, weight-bearing foot, with the patient trying to change directions or pivot. These acute, noncontact injuries most likely involve a rotational stress on the knee, which may injure several structures.

See **Application Strategy: Developing a History of the Injury**, available on the companion Web site at thePoint, for specific questions related to the knee.

Sprains of the collateral ligaments usually result in pain directly over the injury site, and the patient may describe medial/lateral instability. Injury to the ACL may be described as "deep in the knee" or "under the kneecap," whereas pain associated with a PCL tear is located in the posterior knee near the proximal attachment of the gastrocnemius. Unlike ACL injuries, PCL injuries usually do not cause incapacitating pain but, rather, produce vague symptoms, such as unsteadiness or insecurity of the knee. Patients with meniscal injuries frequently report knee pain after twisting their leg while the foot is bearing their full weight.

The patient also may describe an associated pop or snap or other unusual sensation at the time of injury. Hearing a "pop" is a classic sign of an ACL tear. Patients with an ACL tear may also describe a feeling of instability as if the lower leg is sliding out from under the thigh. Symptoms such as locking of the knee may indicate a meniscal tear; "giving way" may indicate a patellar subluxation or internal derangement of the knee. Pain following extended periods of sitting, the "moviegoer's" or "theater" sign, usually indicates prolonged pressure being placed on one of the patellar facets. Patients who have symptoms of patellar instability may have had a dislocation or recurrent subluxation.

The high school basketball player should be asked questions that address when, where, and how the injury occurred; intensity, location, and type of pain; when the pain begins (e.g., when you get out of bed, while sitting, while walking, during exercise, or at night); how long the condition been has present; how long the pain lasts; if the pain has changed or stayed the same; if the pain is worse before, during, or after activity; activities that aggravate or alleviate the symptoms; changes in training; changes in footwear; and previous injury, treatment, and medication. It is also important to allow the patient to describe sensations other than pain that she may be experiencing, such as catching, locking, snapping, or creaking. Check for episodes of instability and clarify what motions cause the instability, if any, to occur. Even though you will be assessing for presence of swelling, discoloration, fever, and areas of tenderness during the physical examination, check with the patient to see if these were present previously and, if so, when they resolved.

OBSERVATION AND INSPECTION

? The female high school basketball player indicates a deep, aching pain in the knee during activity that began 7 to 10 days ago. The patient cannot identify a specific mechanism of injury. She reports no episodes of instability; denies experiencing any popping, catching, or locking; and has not noticed any swelling in the area. She reports that practice has been taking place in two facilities. One gym has hardwood floors, and the other gym has composite flooring. She reports that there has been increased focus on cardiovascular conditioning during the past 2 weeks of practice. Explain the observation component in the ongoing assessment of the basketball player.

Both legs should be clearly visible to check symmetry, any congenital deformity, swelling, discoloration, hypertrophy, muscle atrophy, or previous surgical incisions. The patient should wear running shorts to allow a full view of the entire lower extremity. In addition, the patient should bring the shoes normally worn when pain is present so that they can be inspected for unusual wear, which could be indicative of a biomechanical abnormality.

The injured knee should be placed on a folded towel or pillow at 30° of flexion to relieve any strain on the joint structures. The injury site should be inspected for obvious deformities, discoloration, swelling, or scars that might indicate previous surgery. Swelling proximal to the patella may indicate suprapatellar bursitis or quadriceps involvement. Swelling distal to the patella may indicate patellar tendinitis, fat pad contusion, or internal derangement.

Posterior swelling may indicate a Baker cyst, gastrocnemius strain, or venous thrombosis. Medial swelling over the pes anserine may indicate bursitis or tendinitis. Girth measurements should be taken to determine the presence of swelling. One measurement should be at the joint line; subsequent measurements should be taken at 2-in increments (1-in for smaller patients) above the superior pole of the patella.

For patients seeking assistance with nonacute injuries, identifying the presence of faulty posture, malalignments, and other structural differences may assist the clinicians in discovering not only the injury but also factors they may predispose the patient to specific conditions as well as factors that may be the cause of the patient's pain. Faulty posture or congenital abnormalities can increase stress on any joint. In an ambulatory patient, observation should include a thorough postural examination. It is important to observe the alignment of the femur on the tibia. Normally, the angle between the femoral and tibial shafts ranges from 180° to 195°. An angle of less than 180° is called **genu valgum** (i.e., "knock knee"); an angle of greater than 195° is called **genu varum** (i.e., "bowlegs"). Hyperextension, or posterior bowing of the knee, is called **genu recurvatum**.

When evaluating a patient with a chronic condition, the clinician should observe patella alignment for any abnormalities (**Box 15.2**). A high-riding patella exposes the infrapatellar fat pad, leading to a double hump when viewed from the lateral side (i.e., "camel sign"). Although some misalignments may be observed during a postural examination, radiographs often are required to establish a definitive diagnosis.

BOX 15.2 Patellar Abnormalities

Patella alta	High-riding patella caused by a long patellar tendon
Patella baja	Low-riding patella caused by a short patellar tendon
Squinting patella	Medial-riding patella caused by hip anteversion

	(internal rotation of the femur) or internal tibial rotation
“Frog-eyed” patella	Lateral-riding patella caused by hip retroversion (external rotation of the femur) or external tibial rotation

Tibial torsion should be evaluated. Normally, the patella faces straight ahead while the foot faces slightly lateral (i.e., Fick angle). Medial torsion is associated with genu varum, in which the feet point toward each other, resulting in a “pigeon-toed” foot deformity. Genu valgum is associated with lateral tibial torsion, in which the feet point outward. When standing, most people exhibit a lateral tibial torsion. Femoral torsion, or anteversion (see Chapter 16), can impact the position of the patella relative to the femur and tibia.

While the patient is seated, the clinician should observe whether the tibial tubercles are directly below the patella or are displaced laterally by more than 10°, indicating an increased tubercle sulcus angle. Lateral displacement of the tubercle suggests bony patellofemoral malalignment and predisposition to lateral patellar tracking. The clinician should ask the patient to actively extend and flex the knee and should observe the dynamic tracking of the patella. The patella should be palpated for crepitus during the movement and compared with the contralateral knee. Although asymptomatic crepitus is common in certain patients, symptomatic crepitus in the injured knee may indicate articular cartilage damage on the patella or trochlea.

Following completion of a static examination, the clinician should observe the patient walking. This observation should include an anterior, posterior, and lateral view, with the clinician noting any abnormalities in gait, favoring of one limb, tibial torsion, increased Q-angle, or inability to perform a fluid motion.

See **Application Strategy: Postural Assessment of the Knee Region**, found on the companion Web site at thePoint.

Observation of the basketball player should include a full postural assessment and gait analysis. In particular, it is important to note the presence of pes planus, pes cavus, foot pronation, foot supination, genu varum, genu valgum, tibial torsion, patella alta, Q-angle, and leg length discrepancies. The specific injury site should be inspected for obvious deformities, discoloration, edema, scars that might indicate previous surgery, and the general condition of the skin.

PALPATION

Observation of the female basketball player reveals an increased Q-angle, genu valgum, and excessive foot pronation. Explain palpation specific to the injury sustained by the basketball player.

Bilateral palpation can determine temperature, swelling, point tenderness, crepitus, deformity, muscle spasm, and cutaneous sensation. Vascular pulses can be taken at the popliteal artery in the posterior knee, posterior tibial artery behind the medial malleolus, and dorsalis pedis artery in the dorsum of the foot.

Palpation should move proximal to distal, leaving the most painful area until last. The patient should be non–weight bearing, with a pillow placed under the knee to relax the limb. It may be necessary to change knee position to palpate certain structures more effectively. For example, meniscal lesions are best palpated at 45°; the joint line is more prominent at 90°. Externally rotating the knee exposes the anteromedial border of the medial meniscus; internally rotating the knee exposes the lateral meniscus.

Extreme pain or point tenderness during palpation of bony structures may indicate a fracture. Compression, distraction, and percussion also may be used to detect fracture. For example, compression at the distal tibia and fibula causes distraction at the proximal tibiofibular joint. Percussion or tapping on the malleoli, or use of a tuning fork, may produce positive signs at the fracture site as well.

Palpation should proceed proximal to distal, but the area anticipated to be the most painful should be left to last. The following structures should be palpated:

Anterior Palpation

1. Quadriceps muscles, adductor muscles, and sartorius
2. Patellar surface, edges, and retinaculum
3. Patellar tendon, fat pad, tibial tubercle, medial and lateral tibial plateaus, and bursa. When the knee is extended, the infrapatellar fat pad can be palpated on the medial and lateral sides of the patellar tendon.
4. Patella plica (medial to the patella, with the knee flexed at 45°)
5. Medial femoral condyle and epicondyle and MCL
6. Pes anserinus
7. IT band, lateral femoral condyle and epicondyle, LCL, and head of fibula. The LCL can be palpated further by having the patient place the foot of the affected limb on the knee of the unaffected leg while palpating the lateral joint line.
8. While the knee is flexed at 90°, the tibiofemoral joint line, medial and lateral tibial plateaus, medial and lateral femoral condyles, and adductor muscles should be palpated.

Posterior Palpation with Knee Slightly Flexed

1. Popliteal fossa for Baker cyst and popliteal artery
2. Popliteus muscle in posterolateral corner
3. Hamstring muscles and gastrocnemius

Palpation for Swelling

Two special tests are used to determine if the swelling is intra-articular or extra-articular. Intra-articular swelling feels heavy and mushy, because blood often is mixed with the synovial fluid. Extra-articular swelling is light and fluid and can easily be moved between the fingers from one side to the other.

Brush or Stroke Test (Milking) for Joint Swelling

This test differentiates between synovial thickening and joint effusion. With effusion, the knee assumes a resting position of 15° to 25° of flexion, which allows the synovial cavity maximum capacity for holding fluid. Beginning below the medial joint line, the clinician strokes two or three times toward the patient's hip, moving proximal to the suprapatellar pouch (Fig. 15.6A). Next, using the opposite hand, the clinician strokes down the lateral side of the patella (Fig. 15.6B). An effusion is present if a wave of fluid passes to the medial side of the joint and bulges just below the medial, distal portion of the patella.

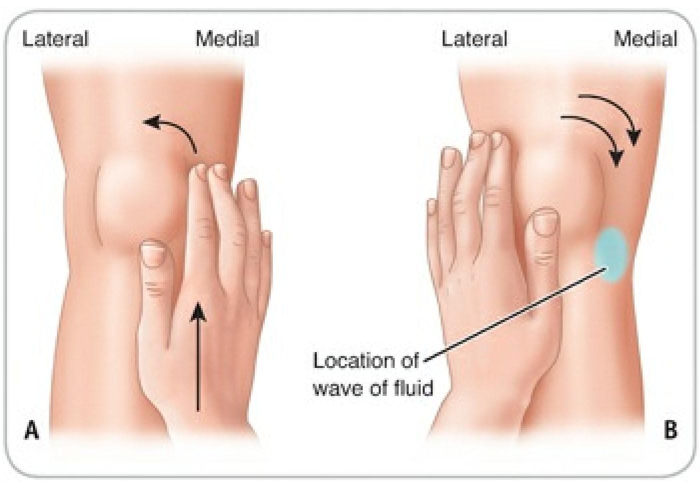

Figure 15.6. Assessment of joint swelling. A, To assess joint swelling, the clinician strokes the medial side of the knee several times, toward the hip. **B,** Using the opposite hand, the clinician strokes down the lateral side of the patella and notes any wave of fluid as it moves to the medial side of the joint.

Ballotable Patella Test

While the knee is relaxed, the clinician pushes the patella downward, into the patellofemoral groove (Fig. 15.7). If swelling is intra-articular, the fluid under the patella causes it to rebound, exhibiting the outlines of the floating patella. If the swelling is extra-articular, a click or definite stopping point is felt when the patella strikes the patellofemoral groove. The outline of the patella usually is obscured by extra-articular swelling, typically seen with a ruptured bursa.

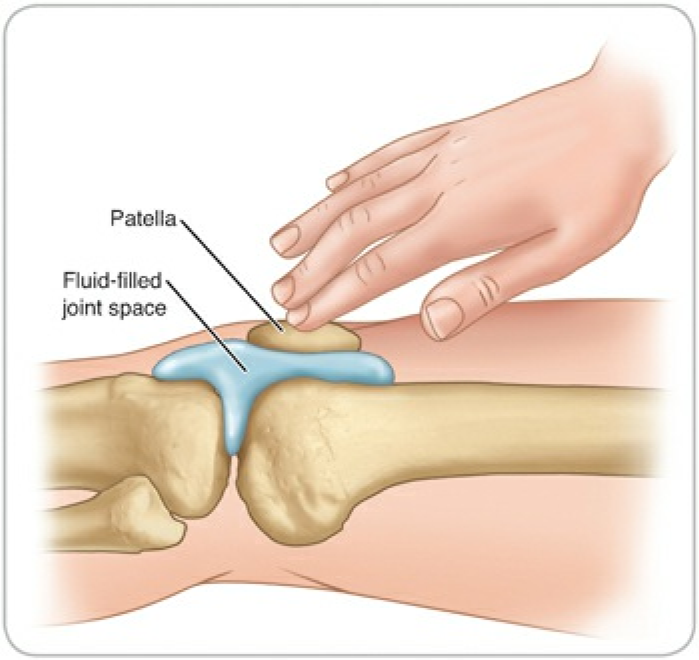

Figure 15.7. Ballotable patella test. The leg should be relaxed. The clinician gently pushes the patella downward into the groove. If joint effusion is present, the patella rebounds and floats back up.

Bilateral palpation of the basketball player's knee, with a particular focus on the patella, should include examining for presence of swelling, point tenderness, deformity, crepitus, temperature, other signs of trauma, and patellofemoral joint pain.

PHYSICAL EXAMINATION TESTS

? In palpating the basketball player's patella, point tenderness is elicited over the lateral facet. In addition, pain and crepitus are elicited when the patella is manually compressed into the patellofemoral groove. Explain the physical examination of the basketball player.

Physical examination tests are performed with the patient in a comfortable position, preferably supine. Pain and muscle spasm can restrict motion and cause an inaccurate result. The limb should not be forced through any sudden motions. It may be necessary to place a rolled towel under the knee to relieve strain on the joint structures.

Functional Tests

The clinician should determine the available ROM in knee flexion–extension and medial-lateral rotation of the tibia on the femur. Bilateral comparison with the noninjured knee is critical to determine normal or abnormal movement.

Active Movements

Active movements can first be performed while the patient is sitting, with the leg flexed over the end of the table, and then repeated in a prone or supine position. The thigh must be stabilized, and the most painful movements performed last to prevent painful symptoms from overflowing into the next movement. If assessing an acutely injured patient while still at the site where the injury occurred, the clinician may have to assess active ROM in the position in which the patient is most comfortable. The motions that should be assessed and the normal ROM for each are as follows:

- Knee flexion (0° to 135°)
- Knee extension (0° to 15°)
- Medial rotation of the tibia on the femur (20° to 30°) with the knee flexed at 90°
- Lateral rotation of the tibia on the femur (30° to 40°) with the knee flexed at 90°

Measuring ROM at the knee with a goniometer is not usually done during on-field or sideline assessment of injury but rather during follow-up evaluations and throughout the rehabilitation process. Measuring joint ROM with a goniometer is demonstrated in **Figure 15.8**.

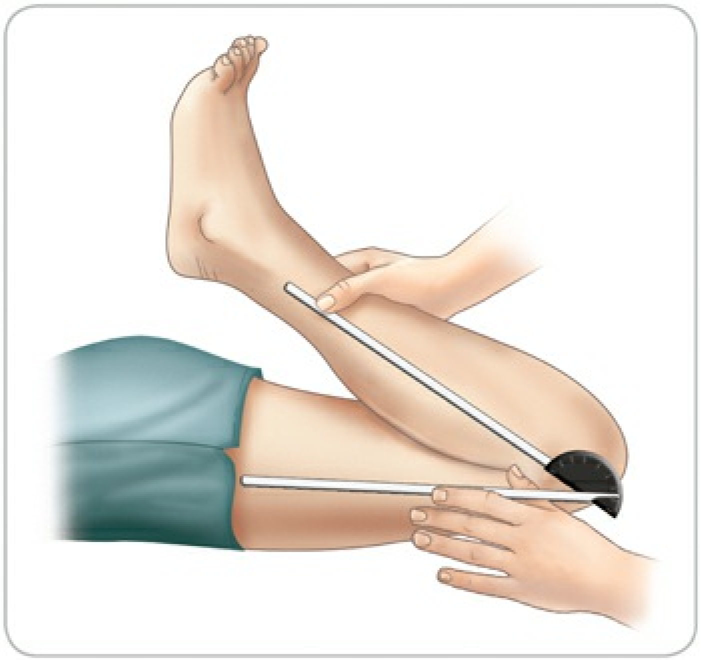

Figure 15.8. Goniometry measurement for knee flexion and extension. Center the fulcrum over the lateral epicondyle of the femur. Using the greater trochanter for reference, align the proximal arm along the femur. Align the distal arm in line with the lateral malleolus.

Passive Range of Motion

If the patient is able to perform full ROM during active movements, the clinician should apply gentle pressure at the extremes of motion to determine end feel. The end feel for flexion is tissue approximation. The end feel for extension is medial rotation, and that for lateral rotation is tissue stretch. Patellar motion should be performed passively, before palpation for point tenderness.

Resisted Muscle Testing

To assess resisted ROM testing, the clinician must stabilize the hip during testing to prevent muscle substitution. The assessment begins with the muscles on stretch, and resistance is applied throughout the full ROM. The clinician should note any muscle weakness when compared with the uninvolved limb. Potentially painful motions should be delayed until last.

The patient is in a seated position during testing of extension, internal, and external rotation of the tibiofemoral joint. During knee extension, any abnormal tibial movement or excessive pain from patellar compression should be noted. When assessing tibiofemoral flexion, the patient is a prone position. Figure 15.9 demonstrates motions that should be tested.

Figure 15.9. **Resisted range of motion testing. A,** Knee extension (L3). **B,** Ankle plantar flexion (S1). **C,** Ankle dorsiflexion (L4). **D,** Knee flexion (S1, S2). Myotomes are listed in parentheses.

Manual Muscle Testing

If pain or weakness is found during resisted ROM, the clinician may decide to perform a manual muscle test to determine which muscle is damaged. When performing manual muscle testing, class I and II muscles should be tested at end range with maximal shortening of the muscle.[29] One-joint muscles that concentrically contract through the ROM are considered class I muscles. Class I muscles are short and strong. In contrast, class II muscles are two-joint and multijoint muscles that actively shorten all joints crossed and are also strong at the end range. Several class I and II muscles are involved with lower leg, ankle, and foot motion. See Table 15.2 for manual muscle testing positioning.

TABLE 15.2 Manual Muscle Testing of Knee

MUSCLE	JOINT POSITIONING	APPLY PRESSURE
Semitendinosus/ semimembranosus	The knee should be flexed between 50° and 70° with the thigh in medial rotation and toes pointed toward the midline. Patient is in a prone position.	To the distal aspect of the leg in the direction of knee extension. With opposite hand, stabilize thigh.
Biceps femoris	With the patient prone, the knee should be placed in about 50° to 70° of flexion with the thigh in slight lateral flexion and the toes pointed away from the midline.	To the distal aspect of the leg in the direction of knee extension. With opposite hand, stabilize thigh.
Rectus femoris	Patient should be seated with knees lower legs handing off the table. Ask patient to fully extend testing limb.	To the anterior aspect of the distal leg, in the direction of flexion

Wong M. *Pocket Orthopaedics: Evidence-Based Survival Guide.* Sudbury, MA: Jones and Bartlett; 2010:318.

Stress Tests

From information gathered during the history, observation, inspection, and palpation, the clinician determines which tests will assess the condition most effectively. Only those tests deemed to be absolutely necessary should be performed. If ACL damage is suspected, tests for anterior cruciate instability should be performed as soon as possible, before swelling, joint effusion, and muscle spasm occludes the extent of instability. Possible structures injured with the various positive tests for unidirectional and multidirectional instability are listed in Table 15.3 and are not repeated in this section, except when necessary to explain the test.

TABLE 15.3 Classification of Knee Instability and Structures Injured		
INSTABILITY	**STRESS TEST**	**POSSIBLE STRUCTURES INJURED IF TEST IS POSITIVE**
Straight valgus (medial)	Abduction (valgus) stress with knee in full extension	1. MCL 2. Oblique popliteal ligament 3. Posteromedial capsule 4. ACL 5. PCL 6. Medial quadriceps expansion 7. Semimembranosus muscle
	Abduction (valgus) stress with knee slightly flexed (20°–30°)	1. MCL 2. Oblique popliteal ligament 3. PCL
Straight varus (lateral)	Adduction (varus) stress with knee in full extension	1. LCL 2. Posterolateral capsule 3. Arcuate–popliteus complex 4. Biceps femoris tendon 5. ACL 6. PCL 7. Lateral gastrocnemius muscle
	Adduction (varus) stress with knee slightly flexed (20°–30°) and tibia laterally rotated	1. LCL 2. Posterolateral capsule 3. Arcuate–popliteus complex 4. IT band 5. Biceps femoris tendon
Straight anterior	Anterior drawer test (90° knee flexion)	1. ACL (anteromedial bundle) 2. Posterolateral and posteromedial capsule 3. Deep MCL 4. IT band 5. Oblique popliteal ligament 6. Arcuate–popliteus complex
	Lachman test Modified Lachman test	1. ACL (anteromedial bundle) 2. Oblique popliteal ligament 3. Arcuate–popliteus complex
Straight posterior	Posterior sag (gravity) test Posterior drawer sign Reverse Lachman test	1. PCL (anterolateral bundle) 2. Arcuate–popliteus complex 3. Oblique popliteal ligament 4. ACL
Anteromedial rotary	Slocum drawer test (tibia externally rotated)	1. MCL 2. Oblique popliteal ligament 3. Anteromedial and posteromedial capsule 4. ACL
Anterolateral rotary	Slocum drawer test (tibia internally rotated) Lateral pivot shift test Jerk test Slocum ALRI Cross-over test Flexion-rotation drawer test	1. ACL 2. Anterolateral and posterolateral capsule 3. Arcuate–popliteus complex 4. LCL 5. IT band 6. Lateral meniscus

(continued)

TABLE 15.3 Classification of Knee Instability and Structures Injured *(continued)*		
Posteromedial rotary	Posteromedial drawer test Posteromedial pivot shift test	1. PCL 2. Oblique popliteal ligament 3. MCL 4. Semimembranosus muscle 5. Posteromedial capsule 6. ACL
Posterolateral rotary	Posterolateral drawer test External rotation recurvatum test	1. PCL 2. Arcuate–popliteus complex 3. LCL 4. Biceps femoris tendon 5. Posterolateral capsule 6. ACL

Straight Anterior Instability

Anterior Drawer Test

The patient is supine, with the hip flexed at 45° and the knee flexed at 90°. The clinician stabilizes the foot by placing it under the thigh to prevent any tibial rotation. In this position, the ACL is nearly parallel to the tibial plateau. The clinician places both thumbs on either side of the patellar tendon to palpate the anteromedial and anterolateral joint line and to determine anterior translation as the tibia is drawn forward on the femur. The fingers are placed in the popliteal fossa to ensure that the hamstrings are relaxed. A step-off at the medial tibial plateau should first be palpated to ensure the proper starting position (see "Posterior Drawer Test" section). While palpating the joint line, apply an alternating anterior (i.e., anterior drawer) and posterior (i.e., posterior drawer) displacement force on the proximal tibia (**Fig. 15.10A**). Stability can be visualized from a lateral view or palpated with the thumb at the joint line. The knee is tested with the foot in neutral rotation, external rotation, and finally, internal rotation. The amount of translation and the end point are compared with those for the contralateral knee. The sensitivity of the anterior drawer test has not been found to be consistently strong, with scores reported from .25 to .60.[30,31] However, the test appears to have higher specificity, with scores reported from .85 to .96.[30,31] The clinician should be aware that the anterior drawer test is not as effective as Lachman test for a variety of reasons (**Box 15.3**).

BOX 15.3 Limitations of the Anterior Drawer Test

- Gravity also has an effect.
- Guarding by the hamstrings group can mask anterior displacement of the tibia on the femur.
- The triangular shape of the meniscus can form a block against anterior movement of the tibia.
- A displaced "bucket-handle" meniscal tear can block anterior movement.

- Knee flexion at 90° may lead to anterior displacement of tibia, masking further displacement during the test.
- Increased pain is elicited in an acute injury at 90° of flexion, masking the true extent of injury.
- If the PCL is absent, anterior movement to the neutral position can be misread as abnormal anterior displacement.
- Because the knee is flexed at 90°, only the anteromedial bundle is tested.

Figure 15.10. Anterior cruciate ligament tests. A, Drawer test. The knee is flexed, and the clinician applies an anterior and posterior displacement force on the proximal tibia. **B, Lachman test.** Using one hand to stabilize the femur, the clinician applies firm pressure on the posterior proximal tibia in an attempt to move the tibia anteriorly.

Lachman Test

Lachman test isolates the posterolateral bundle of the ACL. The patient is supine, with the knee joint at 20° to 30° of flexion. When the knee is in slight flexion, the ACL is the primary restraining force that prevents anterior translation, because the secondary restraints are relaxed. The clinician stabilizes the femur with one hand while placing the other hand over the proximal tibia to displace the tibia anteriorly (**Fig. 15.10B**). If the patient has heavy, muscular legs, or the clinician is unable to appropriately manually support the patient's leg, a small support, such as a pillow or tightly rolled towel, can be placed under the femur. A positive sign results in a "mushy" or soft end feel when the tibia is moved anterior in relation to the femur. When the tibia is in slight internal rotation, anterior displacement indicates additional damage to the IT band and to the anterior and middle lateral capsule. When the tibia is in slight external rotation, anterior displacement indicates damage to the ACL, MCL, and medial meniscus. The Lachman test has a sensitivity of .87 and a specificity of .96, indicating that the Lachman test is a strong clinical tool to use for assessing the presence of ACL tears.[31]

Modified (Prone) Lachman Test

This test is used to differentiate abnormal tibiofemoral glide caused by tears of the ACL from glide caused by PCL deficiencies. It often is favored over the traditional Lachman position when the patient has large thighs or the clinician has small hands, because the weight of the femur is supported by the examination table and the tibia may be supported by the clinician's thigh or forearm.[32] The patient is in a prone position, and the knee is flexed at 30°. The clinician supports the tibia with one hand while palpating either side of the joint line. The other hand applies a downward pressure on the proximal portion of the posterior tibia (**Fig. 15.11**). The clinician notes any anterior tibial displacement. Positive anterior translation found with an anterior drawer, Lachman test, or modified Lachman test indicates a tear of the ACL. Positive anterior translation with the anterior drawer test or Lachman test and a negative modified Lachman test indicate a tear in the PCL.

Figure 15.11. Modified Lachman test. The clinician applies downward pressure on the proximal posterior tibia and notes any anterior translation.

Straight Posterior Instability

Posterior Sag (Gravity) Test

The true posterior sag test is performed in a supine position, feet resting on the table with the hips flexed at 45° and the knees at 90°. When viewed laterally, a loss of tibial tubercle prominence in a PCL-deficient knee is evident when the tibia falls back or sags on the femur because of gravitational forces. A variation of the posterior sag test is **Godfrey test**. To perform the Godfrey test, the patient is placed in 90° of hip and knee flexion. The clinician holds both relaxed legs distally to prevent manual reduction of the tibia and moves to the side of the patient, looking for the position of the tibia as it sags back on the femur (Fig. 15.12A) This maneuver is called Godfrey sign. Godfrey test is a very useful clinical tool, with strong sensitivity (.79 to 1.00) and strong specificity (1.00).[31] It is important to note the sag, because if the sag goes unnoticed, it may produce a false-positive Lachman test.

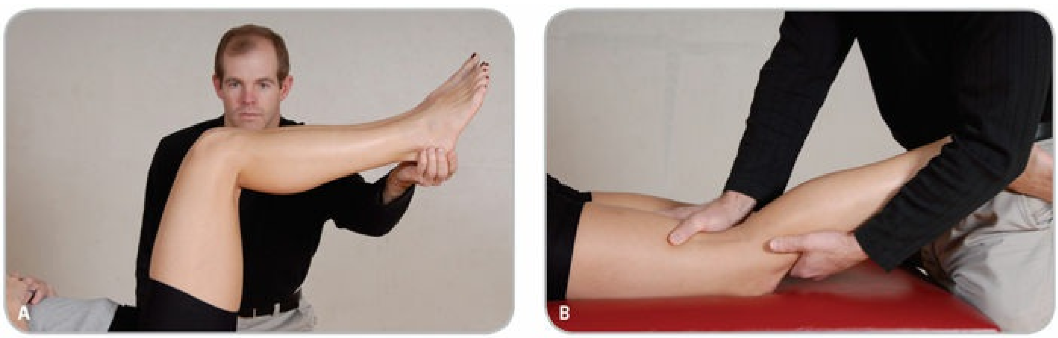

Figure 15.12. Posterior cruciate ligament tests. A, Posterior sag (gravity) test. The hips and knees are flexed, and the clinician looks from the side and compares the anterior contours of both legs. If one leg sags back and the prominence of the tibial tubercle is lost, the posterior cruciate may be damaged (Godfrey sign). **B, Reverse Lachman test.** The clinician stabilizes the femur with one hand while the other lifts the tibia up (superiorly). Any posterior translation and the quality of the end feel is noted.

Posterior Drawer Test

The evidence supports that the posterior drawer test is a clinical relevant test for assessing for the presence of PCL injury. Both the sensitivity and specificity scores are in the 90th percentile.[30] To perform the test, place the patient in the same pose as described for the anterior drawer test. The clinician initially observes the resting position of the tibial plateau in relation to the femoral condyles. When the knee is flexed to 90°, the medial tibial plateau normally lies approximately 1 cm anterior to the medial femoral condyle. This can be felt by running the thumb or index finger down the medial femoral condyle toward the tibia. In a PCL-deficient knee, this relationship is not present. The clinician then applies a posteriorly directed force to the tibia (see Fig. 15.10A). The knee is tested with the foot in neutral position, external rotation, and finally, internal rotation. Isolated PCL tears often produce only minimal posterior translation when the secondary restraints of the knee, particularly the posterior capsule and the posteromedial and posterolateral structures, are intact.

False-negative results can occur with a displaced bucket-handle meniscal tear, hamstring or quadriceps spasm, or hemarthrosis.

Reverse Lachman Test

Positioning of the patient is identical to that in the modified Lachman test. While the patient is prone and the knee flexed to between 20° and 30°, the clinician holds the distal femur to the table and grasps the proximal tibia (Fig. 15.12B). Using the hand on the femur to stabilize the thigh and ensure that the hamstrings are relaxed, the clinician lifts the proximal tibia posteriorly (up), noting the amount of translation and the quality of end point. A false-positive test may occur if the ACL is torn, allowing gravity to cause an anterior shift of the tibia. The test is not as sensitive for detecting a torn PCL, because the PCL functions more at 90° of knee flexion.

Straight Valgus Instability

Abduction (Valgus Stress) Test

Although the valgus stress test has been found to have poor specificity (.17), the test is highly sensitive, with scores ranging from .86 to 1.00.[29,30] To perform the test, the patient is placed supine, with the leg in full extension. The clinician places the heel of one hand on the lateral joint line, and the other hand stabilizes the distal lower leg. Next, a lateral or valgus force is applied at the joint line with the lower leg stabilized in slight lateral rotation (Fig. 15.13A). If positive, joint opening will occur (i.e., the tibia abducts) and indicates primary damage involving the structures of the medial joint capsule. The tibial collateral ligament or MCL is isolated by flexing the knee at 30° and repeating the valgus stress.

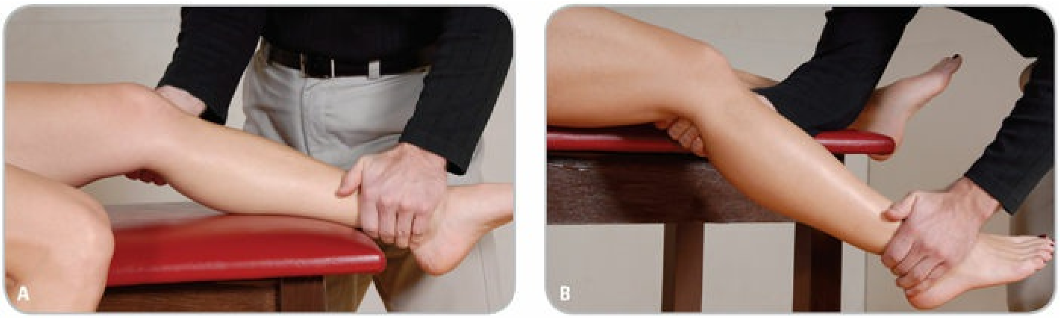

Figure 15.13. **Valgus and varus stress tests. A, Valgus stress test.** The knee is flexed at 30° to isolate the MCL. The clinician applies a gentle valgus stress at the knee joint while moving the lower leg laterally. The test is repeated with the knee fully extended. **B, Varus stress test.** The knee is flexed at 30° to isolate the LCL. The clinician applies a varus stress at the knee joint while moving the lower leg medially. The test is repeated with the knee fully extended.

Straight Varus Instability

Adduction (Varus Stress) Test

The knee is placed in the same position as for the abduction test, but a medial force (i.e., varus stress) is applied at the knee joint (Fig. 15.13B). Laxity in full extension indicates major instability and damage to the fibular collateral ligament, popliteus, and posterolateral capsule. When testing at 20° to 30° of flexion, which is the true test for one-plane lateral instability, a positive test indicates damage to the fibular collateral ligament. The varus stress test has been found to range in sensitivity from .25 to .75 yet has been found to be highly specific of .98.[30]

Anteromedial Rotary Instability

Slocum Drawer Test

Think of the Slocum drawer test as a spin-off of the anterior drawer test, with the focus being on assessing for anteromedial rotary instability (AMRI), instead of just liner anterior instability. The clinician should consider performing the Slocum drawer test when the history, inspection, and palpation point toward an ACL injury but the anterior drawer and Lachman tests are negative. This test is performed in the same position as the anterior drawer test, but with the tibia externally rotated (toes pointed outward) 15° (Fig. 15.14A). In this position, when an anterior drawer force is applied, the majority of anterior translation occurs on the medial side of the knee. If the amount of anterior translation is the same or increases, AMRI is present, indicating injury to the MCL, oblique popliteal ligament, posteromedial capsule, and ACL (posteromedial corner).

Figure 15.14. **Slocum drawer test. A,** An anterior drawer force is applied for AMRI with the tibia externally rotated 15°. **B,** Anterolateral rotary instability is tested with the tibia internally rotated 25° to 30°.

Anterolateral Rotary Instability

Slocum Drawer Test

This test also is performed in the same position as the anterior drawer test; with the tibia internally (toes pointing toward midline) rotated 25° to 30° (Fig. 15.14B). In this position, the majority of anterior translation occurs on the lateral side of the knee. If the anterior translation increases or does not decrease, anterolateral rotary instability (ALRI) is present.

Lateral Pivot Shift Test

This test duplicates the anterior subluxation/reduction phenomenon that occurs during functional activities in ACL-deficient knees. During the test, the tibia moves away from the femur on the lateral side (but rotates medially) and moves anteriorly in relation to the femur. While supine, the hip is flexed at 30° with no abduction. The clinician places one hand behind the head of the fibula, and the other hand holds the foot while internally rotating the lower leg approximately 20°. A valgus force is applied to the knee while maintaining the internal rotation; the knee is moved from extension into flexion (Fig. 15.15). If the ACL is torn, the femur displaces posteriorly when the knee is placed in 10° to 20° of flexion. As the knee continues to flex, the IT band changes its angle of pull from that of an extensor to that of a flexor. When the knee reaches 30° to

40° of flexion, the IT band causes the tibia to reduce or slide backward, resulting in a noticeable “clunk.” The pivot shift test has been found to have little clinical relevance in patients with osteoarthritis present within the knee[33] or when used on conscious patients.[34] The pivot shift test seems to be most appropriate to be used within nonarthritic patients under anesthesia.[33,34]

Figure 15.15. Lateral pivot shift test. While the hip is flexed and abducted 30° and is relaxed in slight medial rotation, the clinician places the heel of one hand behind the head of the fibula while the other hand grasps the distal tibia and 20° of internal tibial rotation is maintained. Next, the clinician applies a valgus force while the knee is slowly flexed. When the knee reaches 30° to 40° of flexion, the IT band causes the tibia to reduce or slide backward, giving a noticeable “clunk.”

Cross-Over Test

The patient is weight bearing on the involved limb and asked to step across and in front of the involved leg with the uninvolved leg, in essence rotating on the involved limb (Fig. 15.16). Because the foot of the weight-bearing leg remains fixed, the lateral femoral condyle is allowed to displace posteriorly relative to the tibia in the presence of laxity in the lateral capsular restraints. This motion will assess for presence of ALRI. Next, the patient is instructed to return to the starting position and then step behind and in back of the involved limb with the uninvolved leg. The foot of the involved limb should always remain in contact with the floor. Stepping behind assesses for the presence of AMRI. Pain, instability, or apprehension is a positive finding for this test.

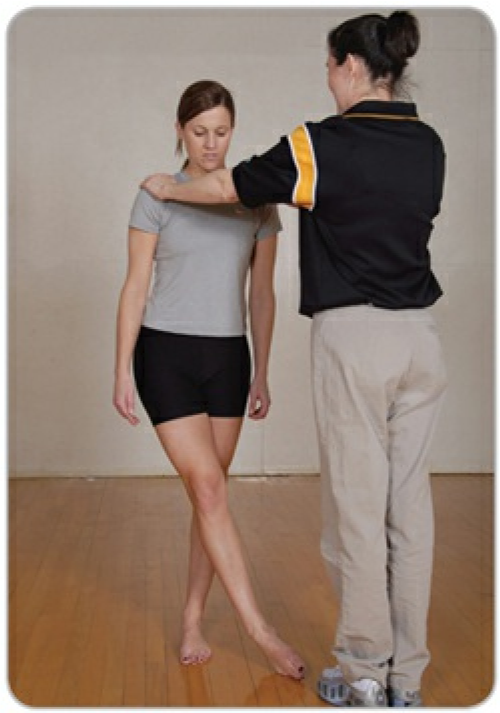

Figure 15.16. Cross-over test. Stepping across the injured leg determines ALRI. Stepping behind the injured leg can determine AMRI.

Posteromedial Rotary Instability

Hughston Posteromedial Drawer Test

This test combines what you already know about the *posterior drawer test* and *Slocum test*. The patient is supine with the knee flexed to 80° to 90° and the hip at 45°, which is similar to the position the patient is in for the posterior drawer test. The clinician medially rotates the patient's foot (toes pointed toward midline) and sits on the foot to stabilize it, which is similar to the Slocum test. Next, the clinician pushes the tibia posteriorly. If the tibia displaces or rotates posteriorly on the medial aspect by an excessive amount relative to the normal knee, the test is positive, indicating posteromedial rotary instability.

Posterolateral Rotary Instability

Hughston Posterolateral Drawer Test

The patient is in the same position as the Hughston posteromedial drawer test but with the foot laterally rotated or toes pointed away from the midline. The tibia is pushed posteriorly. If the tibia displaces or rotates posteriorly on the lateral aspect by an excessive amount relative to the normal knee, this indicates posterolateral rotary instability but only if the PCL is torn.

External Rotation Recurvatum Test

With the patient supine and the lower limbs relaxed, the clinician gently grasps the big toes of each foot and lifts both feet off the table (**Fig. 15.17**). The patient is told to keep the quadriceps relaxed. While elevating the legs, the clinician watches the tibial tubercles. If the test is positive, the affected knee goes into relative hyperextension on the lateral aspect, with the tibia and tibial tubercle rotating laterally. The affected knee appears to have genu varum, with damage to the PCL and LCL, arcuate ligament complex, posterolateral joint capsule, and biceps femoris.

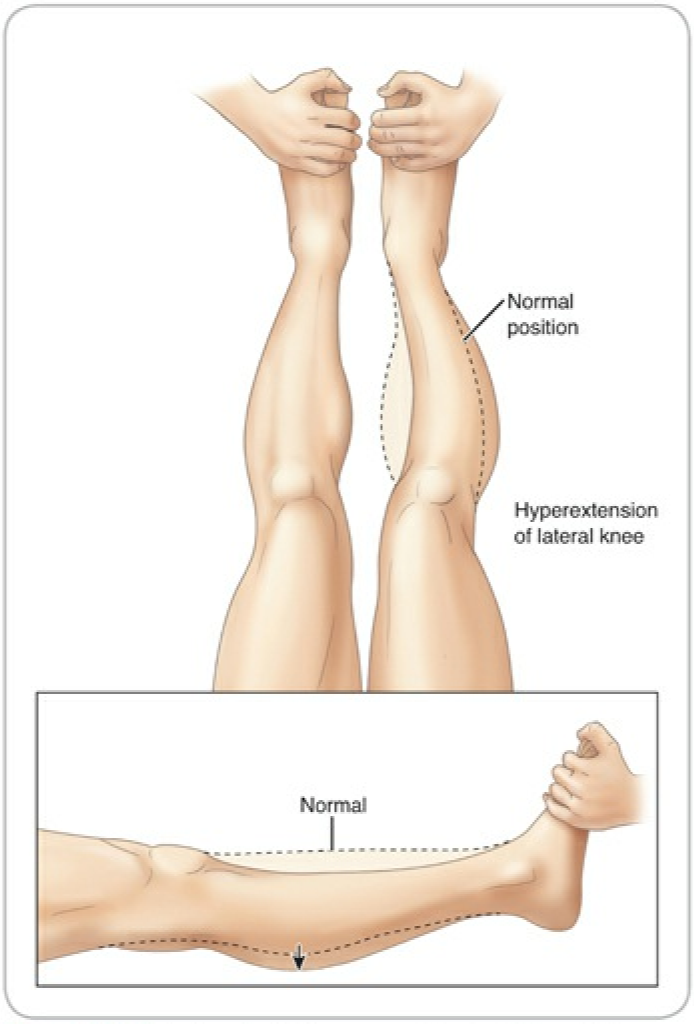

Figure 15.17. External rotation recurvatum test. The clinician grasps the big toes of each foot and then lifts both feet off the table. It is important that the patient keeps the quadriceps relaxed. In a positive test, the affected knee becomes hyperextended on the lateral aspect, with the tibia and tibial tubercle rotating laterally.

Special Tests

A variety of special tests can be used for detecting injury or related pathology involving the knee.

Tests for Meniscal Lesions

McMurray Test

While the patient is supine, the clinician flexes the knee and hip to about 90°.

The clinician should place the fingers of one hand along the medial and lateral joint line of the knee under examination, the opposite hand is used to grasp the distal aspect of the leg. The clinician then slowly moves the patient's knee and hip into increased flexion while externally rotating the tibia. Next, slowly extend the knee and hip while keeping hand contact with the joint line (**Fig. 15.18**). This action attempts to trap the displaced posterior horn of the medial meniscus in the joint and produce an audible and palpable click or thud. Next, the clinician returns the leg to the starting position while internally rotating and extending the knee and hip. This motion places stress on the posterior horn of the lateral meniscus. Each test is repeated several times. Sharp pain along the joint line and/or a palpable click in conjunction with pain is a positive finding. The McMurray test has moderate sensitivity (.49) and moderate to good specificity (.79).[31]

Figure 15.18. McMurray test. The hip and knee are flexed, and the clinician stabilizes the lower leg with one hand and laterally rotates the tibia. The other hand is placed over the anterior knee with the fingers on the joint line. The clinician slowly extends the leg. If a loose body is in the medial meniscus, this action causes a snap or click. Internally rotating the leg and repeating the test with the thumb over the lateral joint line tests for lateral meniscus damage.

Thessaly Test

To perform the Thessaly test, the patient is asked to stand flat-footed on the noninvolved leg and then flex the involved knee 5°. The clinician should grasp the outstretched hands of the patient in order to provide support and balance. The patient is then instructed to internally and externally rotate his or her torso three times while the knee remains flexed. The procedure is then again repeated with the knee flexed at 20°. Once that the patient is familiar with how to perform the test, the test is then repeated on the involved limb. A positive finding occurs when the patient complains of joint line pain or experiencing a locking or catching sensation. At 20° of flexion, the Thessaly test is reported to have a diagnostic accuracy of 94% in detecting medial meniscus injury and a 96% diagnostic accuracy of detecting lateral meniscal tears. The Thessaly test was also found to produce limited false-positive and false-negative findings.[35]

Tests for Tibiofibular Instability

Proximal Tibiofibular Syndesmosis Test

While the patient is supine and the knees are flexed at approximately 90° and feet resting on the table, the clinician stabilizes the tibia with one hand while the other hand grasps the proximal fibular head. In this position, the clinician attempts to displace the fibular head anteriorly and posteriorly. A positive test is indicated by any perceived movement of the fibula on the tibia. An anterior shift indicates damage to the proximal posterior tibiofibular ligament; posterior displacement indicates damage to the proximal anterior tibiofibular ligament.

Plica Tests

Mediopatellar Plica Test

While the patient is supine, the clinician flexes the affected knee to 30°. Next, the clinician moves the patella medially in an effort to cause pain, which would indicate a positive test. The pain is caused by pinching the edge of the plica between the medial femoral condyle and patella.

Plica "Stutter" Test

This is done with the patient seated on the edge of the examination table, with both knees flexed to 90°. The clinician places a finger over the patella and instructs the patient to extend the knee slowly. If the test is positive, the patella stutters or jumps between 45° and 60° of flexion (0° being full extension). The test is only effective if the patient has no joint swelling.

Tests for Patellofemoral Dysfunction

Because the cause of patellofemoral pain syndrome is so complex, multiple tests exist to examine this condition. However, no clear evidence has been found to establish the diagnostic accuracy of the majority of these tests due to the complex nature of patellofemoral dysfunction.[36] The tests included within this text are the ones most commonly used to assess patellofemoral dysfunction.

Patellar Mobility

When assessing a patient complaining of knee pain, patella mobility should be evaluated. While holding the patella in neutral position, the clinician should attempt to displace the patella first medially and then laterally. Medial glide of the patella stresses the lateral patellar retinaculum and the other soft-tissue restraints. Lateral glide stresses the medial patellar retinaculum, the VMO, and the knee's medial joint capsule. The patella should move half its width (one to two quadrants of the size of the patella) in both directions, with an end feel of tissue stretch (**Fig. 15.19**). Movement of one quadrant or less is called a hypomobile patella; movement of three quadrants or more is a hypermobile patella, indicating laxity of the restraints. The medial and lateral patellar glide test is moderately sensitive (.53).[31]

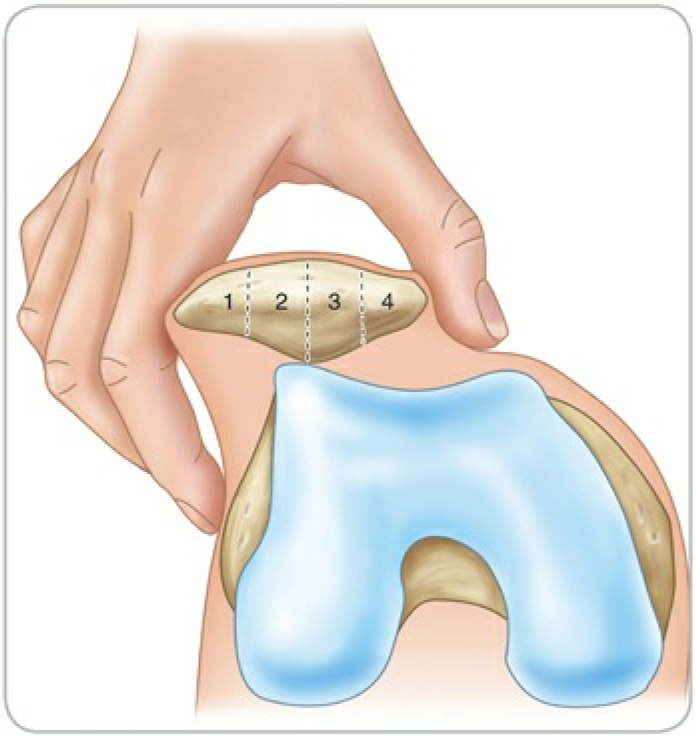

Figure 15.19. Patellar glide. Passive lateral glide of the patella demonstrating subluxation to its second quadrant. Hypomobility is manifested by less than one quadrant of displacement; hypermobility is manifested by three or more quadrants (greater than half of patellar width).

A hypermobile lateral glide may predispose the patient to a laterally subluxating or dislocating patella. If lateral displacement produces apprehension or reproduces symptoms of a subluxation (apprehension test), the test is considered to be positive, indicating patellar instability. The apprehension test for patellar instability has strong specificity (.86) but poor sensitivity (.35).[31] Comparing superior and inferior patellar glide sometimes can reveal side-to-side differences, especially in patients who have undergone surgery.

While the patient is supine, the patellar tilt test should be performed. The clinician grasps the patella, pushing down on the medial edge, and attempts to rotate the patella in the coronal plane to determine if the lateral patellar tilt can be corrected to "neutral" (i.e., when the patella's anterior surface comes parallel to the surface of the examination table). Normal tilt is between 0° and 15°. This test has poor to moderate reliability (.21 to .47) and may not be a clinically useful test.[31]

Patella Compression (Grind Test)

To assess articular pain resulting from irritation of subchondral bone, the clinician compresses the patella in the trochlea at various degrees of flexion. Normally, the patella enters the trochlea at 10° to 15° of knee flexion, so pressure applied in full extension does not directly produce articular compression between the patella and trochlea. As such, it is necessary to place a rolled towel under the knee, flexing the knee at approximately 20°. In this position, the clinician compresses the patella into the patellofemoral groove (Fig. 15.20A). The distal portion of the patella is articulating. Pain with compression in this range suggests a lesion in the distal patellar or proximal trochlear area. Conversely, as knee flexion increases, the patella is drawn distally in the trochlea, causing the area of articulation to be more proximal on the patella. Pain with compression in flexion suggests a more proximal patellar lesion. The test is considered to be positive if pain is felt or a grinding sound is heard, indicating pathology of the patellar articular cartilage.

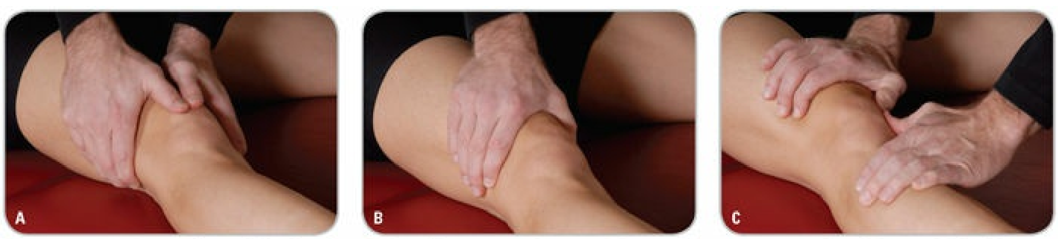

Figure 15.20. **Patellofemoral dysfunction. A, Patella compression or grind test.** Pain on compression of the patella indicates pathology of the patella articular cartilage. **B, Clarke sign.** Slight compression is applied just proximal to the superior pole of the patella while the patient contracts the quadriceps. The test is positive for chondromalacia patella if the patient has pain or is unable to hold the contraction. **C, Patellar apprehension test.** The clinician gently displaces the patella laterally. The test is positive for a subluxating patella if the patient shows apprehension.

Clarke Sign

Using the web of the hand, the clinician places the hand just proximal to the superior pole of the patella (Fig. 15.20B). The patient is instructed to contract the quadriceps while the clinician gently pushes downward. If the patient can hold the contraction without pain, the test is considered to be negative; if the patient has pain and is unable to hold the contraction, the test is considered to be positive for chondromalacia patellae. This test can elicit pain in any patient if the pressure is significant. Therefore, it is imperative to repeat the procedure several times with increasing pressure in full knee extension and at 30°, 60°, and 90° of knee flexion. However, the Clarke sign has been found to have very limited clinical usefulness due to the great variation in how the test is described and performed, resulting in poor reliability, sensitivity, and specificity.[37]

Waldron Test

The clinician palpates the patella while the patient does several slow, deep knee bends. Any crepitus, pain, “catching,” or improper tracking of the patella should be noted. If any of these signs or symptoms occurs simultaneously, the test is considered to be positive for chondromalacia patellae. The Waldron test has been found to have both low positive and negative likelihood ratios, suggesting the test may provide little relevant clinical information regarding the presence or absence of conditions relating to patellofemoral syndrome.[38]

Patellar Apprehension Test

While the knee is in a relaxed position, the clinician pushes the patella laterally (**Fig. 15.20C**). If the patient voluntarily or involuntarily shows apprehension, the test is considered to be positive for a subluxating patella.

Tests for Iliotibial Band Friction Syndrome

Noble Compression Test

The Noble compression test is used to assess for inflammation of the IT band fibers that cross the lateral femoral condyle or of the underlying bursa (**Fig. 15.21A**). The patient is supine on a table, with the hip and knee flexed at 45°. The clinician applies pressure with the thumb directly over, or 1 to 2 cm proximal to, the lateral epicondyle of the femur and passively lowers the leg and extends the knee. As the knee moves to 30° of knee flexion, a positive response is severe pain similar to that caused during activity.

Figure 15.21. **Tests for iliotibial band friction syndrome. A, Noble compression test.** The hip and knee are flexed at 90°. The clinician applies thumb pressure over the lateral epicondyle of the femur as the leg is extended. Pain at or near 30° of flexion indicates iliotibial band (ITB) syndrome. **B, Ober test.** The clinician passively abducts and slightly extends the hip. Then, the clinician slowly lowers the extended leg. If the ITB is tight, the leg remains in the abducted position.

Ober Test

Although the Ober test does not assess specifically for iliotibial band syndrome (ITBS), the test is used to assess for the presences of a tight or contracted IT band, which is thought to contribute to ITBS.[39] The patient lies on the side with the lower leg slightly flexed at the hip and knee for stability. The knee of the upper or affected limb is flexed to 90°. The clinician stabilizes the pelvis with one hand to prevent the pelvis from shifting posteriorly during the test. Next, the clinician passively abducts and slightly extends the hip of the upper or affected limb so that the IT band passes over the greater trochanter (Fig. 15.21B). Although the original Ober test called for the knee to be flexed at 90°, the IT band has a greater stretch if the knee is extended.[39] The clinician slowly lowers the upper leg. If the IT band is tight, the leg will remain in the abducted position.

Neurological Tests

Neurological integrity is assessed with isometric muscle testing of the myotomes, reflex testing, and sensation in the segmental dermatomes and peripheral nerve cutaneous patterns.

Myotomes

Isometric muscle testing should be performed in the following motions to test specific segmental myotomes:

- Hip flexion (L1, L2)
- Knee extension (L3)
- Ankle dorsiflexion (L4)
- Toe extension (L5)
- Ankle plantar flexion, foot eversion, or hip extension (S1)
- Knee flexion (S2)

Reflexes

Reflexes in the lower leg region include the patella (L3, L4) and Achilles tendon reflex (S1) (Fig. 15.22). The patellar reflex is tested with the patient seated on the end of a table so that the knee is flexed at 90°. The clinician strikes the tendon with the flat end of the reflex hammer using a crisp, wrist-flexion action. A normal reflex exhibits a slight, jerking motion in extension. In testing the Achilles tendon reflex, the clinician slightly dorsiflexes the ankle to place the tendon on stretch and taps the tendon with the flat end of the reflex hammer. An alternate position is to have the patient lie prone on a table or place the knee on a chair, with the foot extended beyond the edge. A normal reflex should elicit a slight plantar flexion jerk.

Figure 15.22. **Reflex testing. A,** The patellar reflex. **B,** The Achilles reflex. **C,** Alternate position for the Achilles reflex.

Cutaneous Patterns

The segmental nerve dermatome patterns for the pelvis, hip, and thigh are demonstrated in Figure 15.23. The peripheral nerve cutaneous patterns are demonstrated in Figure 15.24.

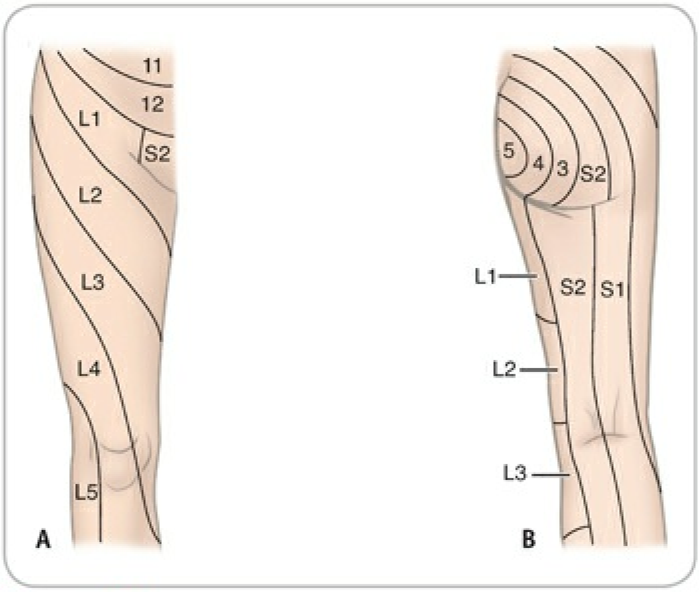

Figure 15.23. **Segmental nerve dermatome patterns. A,** Anterior view. **B,** Posterior view.

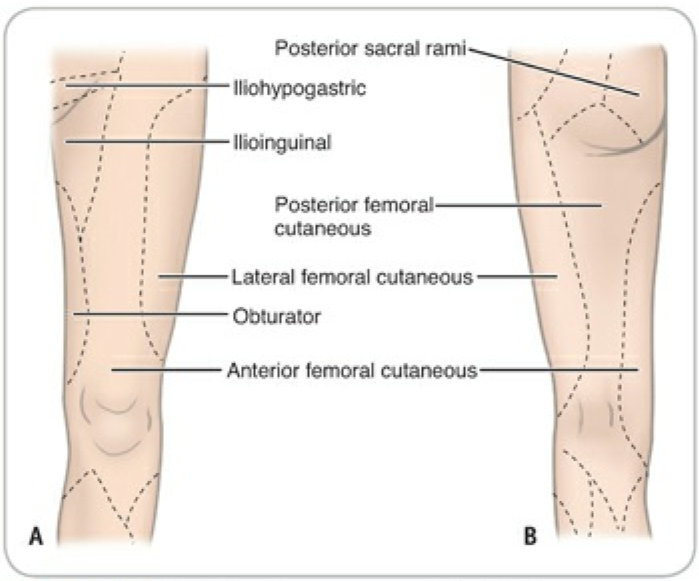

Figure 15.24. **Peripheral nerve sensory distribution patterns. A,** Anterior view. **B,** Posterior view.

Activity-Specific Functional Tests

Functional tests should be performed before clearing the patient for return to participation. These tests should be performed pain-free, without a limp or antalgic gait. Examples of functional tests include forward running, cross-over stepping, running figure eights or V-cuts, side-step running, and carioca running. When appropriate, functional braces or protective supportive devices should be used to prevent reinjury.

> The physical examination of the basketball player should include active ROM, passive ROM, and restricted ROM for knee flexion and extension and for internal and external tibial rotation. In addition, a battery of tests assessing for possible causes and presence of patellofemoral pain syndrome should be performed.

CONTUSIONS

> A volleyball player fell on the knee and felt an intense pain on the anterior of the joint. Pain is palpable on either side of the patellar tendon but not directly on the tendon. The patient reports a “catching” sensation. Extreme pain is felt with forced knee extension. What condition should be suspected, and how should the injury be managed?

Etiology

Contusions at the knee result from compressive forces (i.e., a kick or falling on the knee). The infrapatellar fat pad may become entrapped between the femur and tibia or inflamed during arthroscopy, leading to a tender, puffy, fat pad contusion. The common peroneal nerve leaves the popliteal space and winds around the fibular neck to supply motor and sensory function to the anterior and lateral compartments of the lower leg (see Fig. 15.4). A kick or blow to the posterolateral aspect of the knee can compress this nerve, leading to temporary or permanent paralysis. The nerve also may be injured by prolonged compression from a knee brace or elastic wrap, prolonged squatting (e.g., baseball or softball catcher), or traction caused by a varus stress or hyperextension at the knee.

Signs and Symptoms

General signs and symptoms of any contusion are localized tenderness, pain, swelling, and ecchymosis. With a fat pad contusion, locking, catching, giving way, palpable pain on either side of the patellar tendon, and extreme pain on forced extension may be present. In a mild acute injury to the peroneal nerve, an immediate “shocking” feeling of pain may radiate down the lateral aspect of the leg and foot. If the actual nerve is not damaged, tingling and numbness may persist for several minutes. In severe cases (i.e., when the nerve is crushed), initial pain is not immediately followed by tingling or numbness. Rather, as swelling increases within the nerve sheath, muscle weakness in dorsiflexion or eversion as well as loss of sensation on the dorsum of the foot, particularly between the great and second toes, may progressively occur days or weeks later.

Management

Following a full assessment to rule out fracture and major ligament damage, initial treatment includes ice, compression, elevation, rest, and nonsteroidal anti-inflammatory drugs (NSAIDs). Participation in sport and physical activity usually is not limited; however, the area should be protected to prevent further insult. If any signs of sensory changes or motor weakness become evident, the patient should be referred to a physician.

The volleyball player probably contused the infrapatellar fat pad during the fall onto the knee. Standard acute care (i.e., ice, compression, elevation, and protected rest) should be sufficient to address the injury.

BURSITIS

? As part of rehabilitation for a shoulder injury, a 30-year-old man is maintaining cardiovascular fitness by using a stationary bike. Following 1 week on the bike, the patient complains of pain on the proximal, medial tibia just distal to the knee joint. The pain is particularly evident after his workout. What structure may be inflamed, and are there any factors that may contribute to this condition?

Etiology

Bursitis can be caused by direct trauma, overuse, infections, metabolic abnormalities, rheumatic afflictions, and **neoplasms** (tumors). Compressive forces from a direct blow can be associated with a grossly distended, warm bursal sac filled with bloody effusion, called a hemabursa. Repeated insult can lead to the more common chronic bursitis, in which the bursal wall thickens and, when filled with fluid, appears to be distended. Inflammation of the pes anserine bursa typically develops from friction, but it also may occur in direct trauma. It often is seen in runners, cyclists, and swimmers who are subjected to excessive valgus stress at the knee or in patients who have tight hamstrings.

Signs and Symptoms

Common symptoms of bursitis include swelling and pain in the prepatellar region (i.e., **prepatellar bursitis**), in the distal patellar tendon region (i.e., deep **infrapatellar bursitis**), in the proximal medial tibia (i.e., **pes anserine bursitis**), or over the medial joint line (i.e., **tibial collateral ligament bursitis**).

Inflammation of the deep infrapatellar bursa due to overuse and subsequent friction between the patellar tendon and the structures behind it (i.e., fat pad and tibia) is often confused with Osgood-Schlatter disease in adolescents and with patellar tendinitis in older patients. In extension, the fat pad is squeezed between the patellar tendon and tibia and often extends beyond the sides of the tendon. Careful palpation over the distal patellar tendon and noting the specific area of tenderness will determine which condition is present. In flexion, bursitis is indicated by pain deep to the patellar tendon. In extension, pain palpated on either side of the patellar tendon indicates a fat pad contusion.

If the pes anserine bursa is inflamed, point tenderness, localized swelling, and crepitation may be palpated beneath the pes tendons (usually 2 cm below the medial joint line). When inflamed, contraction of the hamstring muscles, rotational movements of the tibia, and direct pressure over the bursa produce pain. Inflammation of this bursa is commonly seen in middle-aged or older, overweight women, many of whom also have osteoarthritis of the knee.[40] To avoid recurrence, the patient should begin an extensive flexibility program for the hamstrings and gastrocnemius–soleus complex.

The term **Baker cyst** identifies almost any synovial herniation of the posterior joint capsule or bursitis on the posterior aspect of the knee. With no posterior obstruction, internal derangement injuries (i.e., meniscal problems, cruciate ligament tears, or arthritis) commonly lead to joint effusion that expands into the bursal sac. The semimembranosus bursa most commonly is involved, because it often communicates with the joint capsule. A soft, tumorous mass can be palpated in the medial popliteal space and may or may not be painful. A Baker cyst does not pose a serious problem, although it may be bothersome during full flexion or extension of the knee.

Abrasions or penetrating injuries can lead to infected bursitis caused by bacteria entering broken skin. This condition differs from acute bursitis because of the localized and intense redness, increased pain, enlarged regional lymph nodes, spreading cellulitis, and subsequent fever and malaise. If infection is suspected, immediate referral to a physician is warranted for proper cleansing, irrigation, and closure (often with a drain). The infection can enter the lymph system, causing pyarthrosis, or suppurative arthritis, at the knee.

Management

Treatment consists of ice therapy, a compressive wrap, NSAIDs, avoiding activities that irritate the condition, or total rest until acute symptoms subside. A protective foam, or doughnut, pad may protect the area from further insult. A risk of infection exists if the skin is broken during the initial injury, in which case the patient should be referred to a physician immediately. The physician may culture any aspirated fluid to detect bacteria and subsequently prescribe medication.

Corticosteroid injections may be administered by the physician in cases of chronic or persistent bursitis when other means of treatment have been ineffective in decreasing inflammation.[40] Because these injections can weaken surrounding tendons or ligaments, they should not be injected close to these structures.

> The 30-year-old man using the stationary bike to maintain cardiovascular fitness could have pes anserine bursitis. Tight hamstrings and excessive valgus stress placed on the knee during the pedaling motion can predispose a patient to this injury. In addition to standard acute care, this patient should begin an extensive flexibility program for the hamstrings and gastrocnemius–soleus complex.

LIGAMENTOUS CONDITIONS

> ? A basketball player decelerated, set the left foot, and then forcefully pushed off the left leg to perform a right-handed layup shot. The player felt a sudden popping sensation and intense pain, and then the knee collapsed. Initial evaluation revealed point tenderness on the anteromedial joint line. The basketball player has swelling but no signs of deformity. What structures might be involved with this injury?

Knee joint stability depends on a static, passive system of support from its ligaments and capsular structures. The American Academy of Orthopaedic Surgeons (AAOS) classifies ligamentous injuries at the knee according to the functional disruption of a specific ligament, or amount of laxity (**Box 15.4**), and the direction of laxity. Clinicians often refer to minimal ligament failure as a grade I injury, partial ligament failure as a grade II injury, and complete disruption as grade III. The AAOS identifies four straight instabilities and four rotary instabilities (see **Table 15.3**). Knowing the knee position at impact and the direction the tibia displaces or rotates is beneficial in determining the damaged structures.

BOX 15.4 Signs and Symptoms of Ligament Failure

Minimal Ligament Failure (Distraction, < 5 mm)

- Less than one-third of the fibers are torn.
- Mild swelling and pain are localized over the injury site (with the MCL, pain is in the proximal 1–2 in).
- Active and passive ROM are normal, and muscular strength is normal or slightly decreased.
- No joint laxity is apparent during the stress test.
- Definite end feel is present.

Partial Ligament Failure (Distraction, 5–10 mm)

- One- to two-thirds of the ligament is damaged, with microtears present.
- Localized swelling and joint effusion may result from deep capsular tears, meniscal damage, or cruciate ligament damage.
- Pain is sharp and may be either transient or lasting.
- Patient may complain of instability and an inability to walk with the heel on the ground.
- ROM is decreased initially by pain and hamstring muscle spasm and later by soft-tissue swelling or effusion.
- Inability to fully extend the knee actively
- Visible translation of the tibia during stress tests

Complete Ligament Failure (Distraction, > 10 mm)

- More than two-thirds of the ligament is ruptured.
- Swelling is diffuse, indicating severe capsular tear and damage to intracapsular structures.
- Pain is initially sharp and often disappears within a minute.
- Patient is aware of the feeling of instability or the knee giving way.
- Significant loss of ROM

- Visible distraction of greater than 10 mm during stress testing may appear as a subluxation.

Unidirectional Instabilities

A straight plane (i.e., unidirectional) instability implies instability in one of the cardinal planes. Injury to the ACL or PCL produces instability in the sagittal plane, allowing equal anterior or posterior **translation** (i.e., shifting) of the medial and lateral tibial plateaus on the femur. Injury to the MCL and LCL leads to valgus or varus instability in the frontal plane. Although several structures may be damaged, the resulting instability involves a single plane.

Straight Medial Instability

Etiology

In straight medial instability, the MCL is damaged. This is known as a **valgus instability**. Lateral or valgus forces cause tension on the medial aspect of the knee, potentially damaging the MCL and posteromedial capsular ligaments as well as the PCL (**Fig. 15.25A**). Damage occurs more often when the valgus force is applied with the limb in a weight-bearing position or closed kinetic chain.

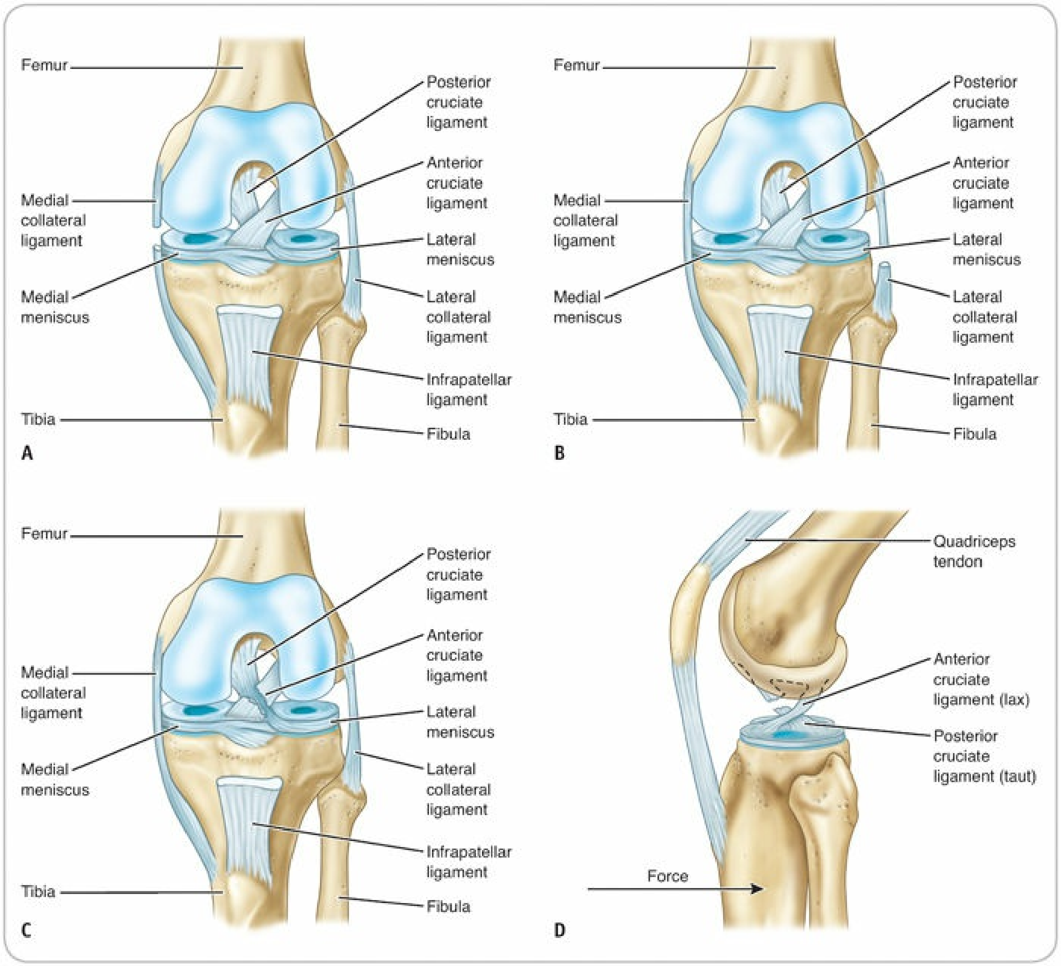

Figure 15.25. Knee instability. A, When a valgus force is applied to the knee, the MCL and medial capsular ligaments are damaged, leading to valgus laxity. **B,** An isolated varus force damages the LCL, leading to varus laxity. **C,** When changing directions during deceleration, the ACL can be damaged. **D,** During hyperextension of the knee or when the knee is flexed and the tibia is driven posterior, the PCL can be damaged.

Signs and Symptoms

A grade I sprain is characterized by mild point tenderness on the medial joint line and/or MCL, little or no joint effusion, full ROM that may include some discomfort, and a stable joint when doing the valgus stress test. A **positive valgus test in 30°** of flexion with a soft end feel indicates at least a grade II injury to the middle third of the capsular ligament and MCL. The patient may be unable to fully extend the leg and often walks on the ball of the foot, unable to keep the heel flat on the ground and will complain of tenderness over the MCL and joint line when palpated. A grade III MCL injury often has no significant intra-articular effusion, but if such effusion is found, injuries to the cruciate ligaments, patella, or meniscus should be assessed. A grade III injury has a positive valgus test with significant joint laxity, a soft or even absent end point because of a complete tear of the MCL, usually at the femoral attachment. **A positive valgus stress test in full extension** suggests MCL and medial joint capsule involvement.

Straight Lateral Instability

Etiology

Straight lateral instability, or **varus instability**, results from medial forces that produce tension on the lateral compartment, damaging the LCL, lateral capsular ligaments, PCL, and joint structures (**Fig. 15.25B**). This isolated injury is rare, because the biceps femoris, IT band, and popliteus provide a strong stabilizing effect. A potential mechanism for this injury can be seen in the sport of wrestling, in which an opponent often is between the patient's legs and is able to deliver an excessive varus force that can lead to injury.

Signs and Symptoms

Damage to the LCL has the same general signs and symptoms that are associated with an MCL sprain. The patient may experience lateral knee pain that is described as sharp. Swelling is minimal, because the ligament is not attached to the joint capsule. Instability is subtle, because other structures are intact. A positive varus test in 30° of flexion, however, should confirm damage to the ligament. A positive varus stress test in full extension may indicate damage to the lateral joint capsule and LCL. If tenderness is detected on the head of the fibula, an avulsion fracture or peroneal nerve injury may be present, although these injuries usually are associated with more severe knee injuries.

Straight Anterior Instability

Etiology

In a straight anterior instability, both tibial plateaus sublux anteriorly by an equal amount when an anterior drawer test is performed. This translation is resisted by the ACL. Isolated anterior instability is rare; instead, an anteromedial or anterolateral laxity usually occurs. Damage to the ACL commonly occurs during a cutting or turning maneuver, landing, or sudden deceleration (Fig. 15.25C).

The rate of ACL injuries is higher in women than in men, particularly for those women who are involved with jumping and pivoting sports.[41] Several theories have been put forth to explain this phenomenon, and recent research has begun to look at muscle strength imbalance between the hamstrings and quadriceps in both men and women. During a landing/deceleration maneuver, flexion movements are occurring at the hip and knee. Simultaneous eccentric contractions of the quadriceps to stabilize the knee and of the hamstrings to stabilize the hip decelerate the horizontal velocity of the body. The hamstrings also act to neutralize the tendency of the quadriceps to cause anterior tibial translation. If the muscles are unable to meet the demand of stabilization, inert internal tissues, such as ligaments, cartilage, and bone, are at risk for injury. Therefore, a deficit in eccentric hamstrings strength relative to eccentric quadriceps strength could predispose a patient to an ACL injury. Prophylactic bracing has not been shown to prevent ACL injuries.[40–42]

See **Possible Factors Influencing Increased Rate of Anterior Cruciate Ligament Injuries in Women**, available on the companion Web site at thePoint.

Signs and Symptoms

In approximately 80% of ACL injuries, patients experience a popping, snapping, or tearing sensation, and in a similar percentage of cases, patients note a rapid onset (i.e., usually within 3 hours) of swelling (hemarthrosis). Pain can range from minimal and transient to severe and lasting. It may be described as being deep in the knee but more often is felt anterior, on either side of the patellar tendon, or laterally, on the joint line. Weight bearing leads to a feeling of the knee giving way or as “the leg slipping out from under the knee.” The high incidence of damage to other internal structures necessitates immediate referral to a physician. Positive Lachman and/or anterior drawer tests suggest ACL damage.

Straight Posterior Instability

Etiology

In straight posterior instability, the medial and lateral tibial plateaus have equal translation posteriorly in a neutral position without rotation. The PCL, along with the arcuate complex and oblique popliteal ligament, provides nearly all resistance to prevent this motion. Hyperextension is the most common mechanism for injury. The PCL, however, also can be damaged during a fall on a flexed knee with the foot plantar flexed, resulting in a blow to the tibial tubercle that drives the tibia posteriorly (**Fig. 15.25D**).

Signs and Symptoms

In milder cases, intense pain and a sense of stretching are felt in the posterior aspect of the knee. In a total rupture, a characteristic pop or snap is felt and heard, and this may be followed by autonomic symptoms of dizziness, sweating, faintness, or slight nausea.[43] A large effusion and hemarthrosis usually occur within the first 2 hours after the acute injury. Knee extension is limited because of the effusion and stretching of the posterior capsule and gastrocnemius. A positive posterior sag (gravity) test or reverse Lachman test confirms damage to the PCL. When the PCL is torn, the extensor mechanism, including the patella and the patellar tendon, forcefully holds the tibia in a reduced position, which results in increased patellofemoral pressure. Increased patellofemoral loading also is caused by a vector change resulting from posterior tibial displacement. This concept may explain complaints of patellofemoral pain in patients with PCL-deficient knees.

Multidirectional Instabilities

Although unidirectional instability involves damage that results in instability to a single plane, multidirectional instability involves instability in more than one plane. This injury also is called a multiplane or rotary instability.

Anteromedial Rotary Instability

Etiology

AMRI results from anterior external rotation of the medial tibia condyle on the femur, leading to damage of the medial compartment ligaments and oblique popliteal ligament (Fig. 15.26). This instability can be accentuated by a tear of the medial meniscus and ACL. Although referred to as the “unhappy triad,” the MCL is the primary ligamentous restraint to this motion. In AMRI, valgus stress testing at 0° and 30° of flexion is positive. In addition, increased anterior translation of the medial tibial plateau is noted when a Slocum drawer test or Lachman test is performed with the tibia externally rotated. A more functional test for assessing rotary instability is the cross-over test.

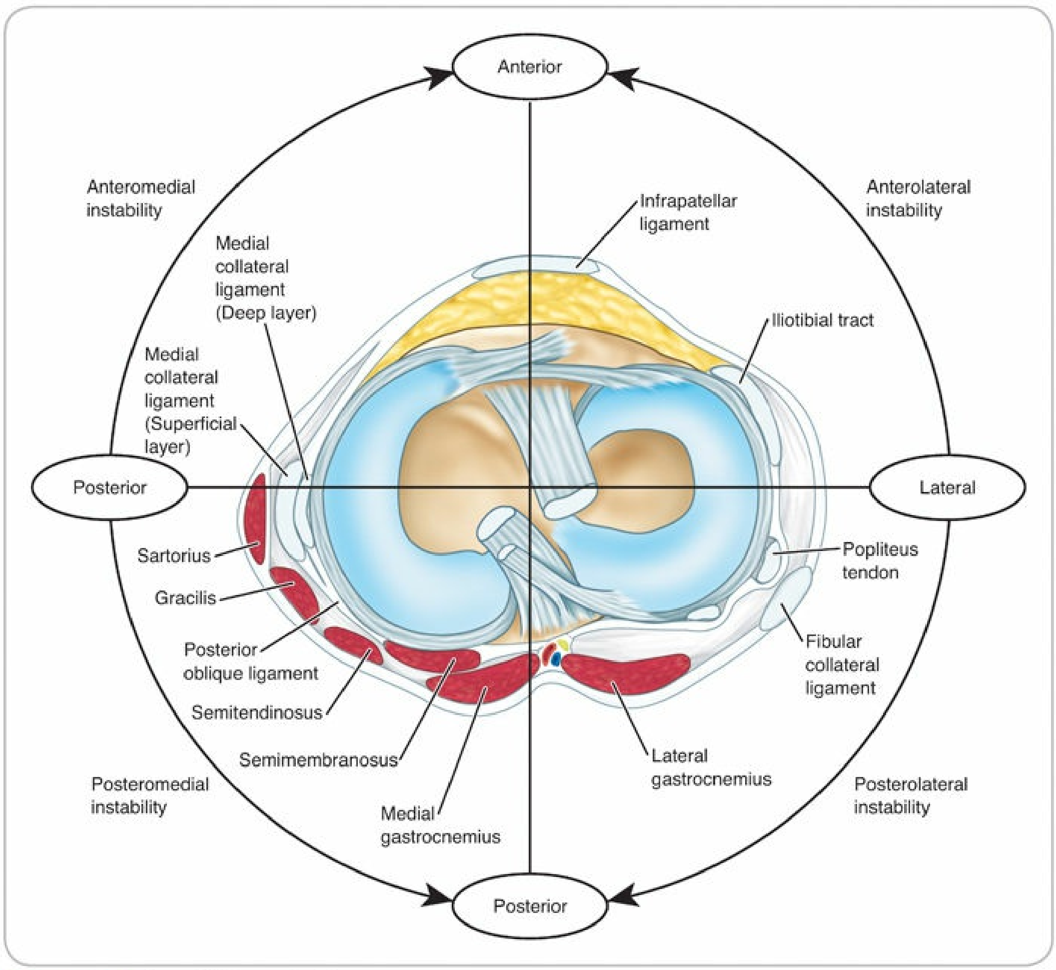

Figure 15.26. Instabilities at the knee.

Anterolateral Rotary Instability

Etiology

ALRI is a characteristic of an anterior internal subluxation of the lateral tibial condyle on the femur. The ACL is the primary structure damaged by this instability, but the IT band and lateral capsule ligaments also can be damaged. The injury typically is caused by a sudden deceleration and cutting maneuver, and it is the most frequent rotary instability at the knee. In anterolateral instability, the Slocum drawer test with the tibia internally rotated, Slocum ALRI test, and cross-over test show increased anterior translation of the lateral tibial plateau.

Posteromedial Rotary Instability

Etiology

In posteromedial rotary instability, the medial tibial plateau shifts posteriorly on the femur and opens medially. This is a severe injury and is indicative of damage to the superficial MCL, posteromedial capsule, oblique popliteal ligament, and both cruciate ligaments. Injury of the posteromedial capsule is suspected if joint space opening and a soft end point are apparent on valgus stress at 0°. The posteromedial drawer test and posteromedial pivot shift test are positive.

Posterolateral Rotary Instability

Etiology

In posterolateral rotary instability, a greater posterior translation of the lateral tibial plateau is noted, as compared to the medial tibial plateau, when a posterior drawer force is applied. This injury often is caused by a sudden anteromedial force that brings the knee joint from near-full extension into hyperextension. This mechanism, when combined with a varus moment, disrupts the posterolateral structures, which include the PCL, arcuate–popliteal complex, posterolateral capsule, and LCL. Other mechanisms may include a combined hyperextension and external rotation force, contact and noncontact hyperextension, severe varus bending moment, and severe tibial external rotation torque.[43] Injury of the posterolateral capsule is suspected if joint space opening and a soft end point are apparent on varus stress at 0° and 30°. In addition, the posterolateral drawer and external rotation recurvatum tests are positive.

Knee Dislocations

Etiology

Knee dislocations and less severe multiligament injuries make up approximately 20% of all grade III knee ligament injuries. Frequent two-ligament injuries include the ACL-MCL (most common), PCL-MCL, ACL-LCL, and ACL-PCL. Damage to only two ligaments does not result in enough translation of the joint to cause neurovascular injury. The exception, however, is injury to the LCL and a cruciate ligament that results in enough lateral opening to damage the peroneal nerve.

A minimum of three ligaments must be torn for the knee to dislocate. Most often, this involves the ACL, PCL, and one collateral ligament. Although dislocations may occur in any direction, the most common is in an anterior or posterior direction. As with any dislocation, additional damage can occur to other joint structures, including the ligaments, capsular structures, menisci, articular surfaces, tendons, and neurovascular structures. Associated injuries include vascular damage in 20% to 40% of knee dislocations and nerve damage in 20% to 30%. Posterior knee dislocations are associated with the highest incidence of damage to the popliteal artery; posterolateral rotary dislocations have the highest incidence of nerve injury.

Signs and Symptoms

The patient may describe a severe injury to the knee and hear a loud pop. Deformity of the knee may be present if the knee has dislocated and remained unreduced. Knee dislocations often reduce spontaneously, however, making identification difficult. Swelling occurs within the first few hours, but swelling may not be large because of an associated capsular injury and extravasation of the hemarthrosis. It is critical to identify the dislocated knee by the ligamentous structures that have been disrupted. If a vascular injury is left untreated or not repaired within 8 hours after injury, the amputation rate is 86%. If surgery is completed within 6 to 8 hours, however, the amputation rate drops to 11%. Associated nerve injury has a poor prognosis regardless of the treatment.

Management of Ligament Conditions

Injuries involving minimal ligament failure are managed conservatively, with ice application, compression, elevation, and protected rest until acute symptoms subside. A compression wrap, consisting of an inverted horseshoe around the patella secured by an elastic wrap, can be used with a knee immobilizer to reduce swelling. Cryotherapy and NSAIDs are used to reduce pain and inflammation. In suspected ACL injuries, radiographs should be obtained to rule out an associated intra-articular fracture. Avulsion fractures of the tibial eminence may occur, particularly in adults older than 35 years who have some associated osteopenia. Magnetic resonance imaging can clarify the diagnosis.

In consultation with a physician, a moderate injury with partial ligament failure is managed with ice, compression, elevation, and protected rest for 24 to 72 hours. Crutches are used until the patient walks without a limp. Progression to partial weight bearing with heel-to-toe gait can begin as tolerated. Rehabilitation should be initiated as soon as acute symptoms subside. ROM exercises should include assisted knee flexion and knee extension. Isometric exercises of the quadriceps and straight leg raises in all directions should progress to resisted exercises throughout the full ROM. Closed chain strengthening exercises and maintenance of ROM can be supplemented with cardiovascular exercises as tolerated.

The physician may determine that surgical repair is necessary for injuries in which isolated complete ligament failure has occurred or in which more than one major ligament is involved. Surgical reconstruction is based on the degree of laxity, activity-specific demands, hours per week of activity, intensity of activity, frequency of instability, and associated repairable meniscal tear. Reconstruction usually is delayed at least 3 weeks postinjury to allow swelling to decrease and ROM to increase. **Application Strategy 15.2**

describes the management and rehabilitation of a mild ACL injury.

APPLICATION STRATEGY 15.2

Management of an Anterior Cruciate Ligament Injury

Phase 1

1. Protect, restrict activity, ice, compression, elevation, and rest with a knee immobilizer to reduce swelling.
2. Use crutches if the patient cannot bear weight without pain.
3. ROM exercises within pain-free limits
   - Heel slides
   - Prone knee flexion, assisted with the opposite leg
   - Passive knee extension in a supine or seated position
4. Strengthening exercises
   - Bent leg raises in all directions
   - Multiangle isometric exercises for the quadriceps, hamstrings, and hip adductors
5. Cardiovascular fitness: upper body ergometer and unilateral leg cycling

Phase 2

1. ROM. Continue exercises to regain full ROM.
2. Unilateral balance activities. See Application Strategy 15.1 and progress as tolerated.
3. Strengthening exercises
   - Perform slow, controlled, eccentric closed chain exercises, such as two-legged squats to 60°, step-ups, step-downs, and lateral step-ups.
   - Calf raises (seated position) can progress to standing position when pain-free.
   - Perform straight leg raises in all directions, with tubing added as tolerated.

Phase 3

1. ROM. Maintain full ROM and flexibility in the lower extremity.

2. Strengthening
   - Hip leg press and squats
   - Toe raises with weights
   - Lunges
   - Isokinetic open and closed chain exercises
3. Cardiovascular fitness
   - Bilateral, minimal tension cycling if 110°–115° of knee flexion is present. Avoid full knee extension.
   - Pool running, swimming with a flutter kick, jogging in place on a trampoline, and power walking

Phase 4

1. Balance and proprioception. Continue exercises from the preceding.
2. Functional activities
   - Running drills, such as circles, figure eights, cross-over steps (cariocas), and jumping with double limb/single limb progressing from standing in place, front to back, to diagonals
   - Multidirectional, high-speed balance drills are added after the patient can run 2–3 miles.
   - Jumping, bounding, and skipping (plyometrics)
   - Slide board

The basketball player may have sustained an injury to the medial meniscus, the ACL, or the MCL. Additional assessment is necessary to confirm the involved structure.

MENISCAL CONDITIONS

? A 40-year-old golfer complains of mild swelling and tenderness on the medial joint line. Slight joint effusion is present, and pain can be elicited with rotation of the tibia on the femur and during extreme knee flexion. What injury may be present, and what is the management for this injury?

Etiology

Menisci, which become stiffer and less resilient with age, are injured in manners similar to the ligamentous structures. In addition to compression and tensile forces, shearing forces caused when the femur rotates on a fixed tibia trap the posterior horns of both menisci, leading to some tearing. Tears are classified according to age, location, or axis of orientation. Medial meniscus damage is more common than lateral meniscus damage because of the lower mobility of the structure.

Longitudinal tears result from a twisting motion when the foot is fixed and the knee is flexed (**Fig. 15.27A**). This action produces compression and torsion on the posterior peripheral attachment. The tear can be partial, affecting only the peripheral segment of the meniscus, or a complete tearing of the inner substance of the meniscus. A "**bucket-handle**" tear occurs when an entire longitudinal segment is displaced medially toward the center of the tibia (**Fig. 15.27B**). This tear can lead to locking of the knee at approximately 10° flexion; however, this only occurs in approximately 40% of complete meniscal tears.

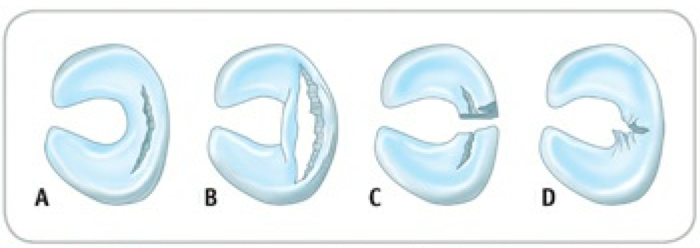

Figure 15.27. Meniscal tears. A, Longitudinal. **B,** Bucket-handle. **C,** Horizontal. **D,** Parrot-beak.

Horizontal cleavage tears result from degeneration and often affect the posteromedial portion of the meniscus (**Fig. 15.27C**). With age, shearing forces from rotational motions tear the inner substance of the meniscus. If detached, momentary locking, associated pain, and instability may occur. A parrot-beak tear is actually two tears that commonly occur in the middle segment of the lateral menisci, leading to the characteristic shape of a parrot's beak. It is seen more frequently in patients with a history of previous trauma or some cystic pathology that makes the meniscus more fixed at its periphery (**Fig. 15.27D**).

Signs and Symptoms

Meniscal injuries are difficult to assess, both because they are not innervated by nociceptors and because only 10% to 30% of the peripheral medial meniscus border and 10% to 25% of the lateral meniscus border receive direct blood supply. The patient may describe performing a cutting or rotational maneuver and experiencing sharp, stab-like pain in the joint line at the time of injury. Localized pain and joint-line tenderness near the collateral ligament probably are the most common findings. Anterior joint-line pain rarely reflects meniscal pathology unless a bucket-handle or ruptured bucket-handle tear is present. Because the meniscal periphery is attached to the synovial lining, tensile forces may cause synovial inflammation and slight joint effusion more than 12 hours after the initial injury. Pain occurs on rotation and extreme flexion of the knee. The patient may also describing episodes of instability, such as the knee "giving out" or locking. In the initial assessment, it is important to determine whether the knee lacked full extension from the time of injury (i.e., locked knee from displaced fragment) or lacked full extension the next day (i.e., pseudolocking from a hamstring spasm).

A chronic degenerative meniscal tear often results from multiple episodes of minimal trauma leading to almost no pain, disability, or swelling, although atrophy of the quadriceps may be present. Recurrent locking is typical. Chronic tears in the absence of degeneration have point tenderness only over the site of the lesion. The patient may experience a popping, grinding, or clicking sensation that can lead to the knee buckling or giving way. Special tests used to identify meniscal injuries that have been found to be clinically useful include Thessaly and McMurray tests.[44] However, if the patient has also sustained a concurrent ACL injury, diagnostic accuracy of the Thessaly test is diminished.[31]

Management

Initial treatment depends on the extent of damage. Mild cases with no ligamentous instability are managed with standard acute care, including ice, compression, elevation, protected rest, NSAIDs, and use of crutches as needed. Isometric strengthening exercises can be initiated when swelling has subsided. Application Strategy 15.3 summarizes the initial management and suggested rehabilitation exercises for a mild meniscal injury.

APPLICATION STRATEGY 15.3

Management of a Partial Meniscectomy

Phase 1

1. Protect, restrict activity, ice, compression, elevation, and bracing to reduce swelling. Use crutches if needed.
2. ROM exercises within pain-free limits
   - Heel slides
   - Supine wall slides
   - Prone knee flexion, assisted with the opposite leg
   - Passive knee extension in a supine or seated position

Phase 2

1. ROM. Continue exercises as tolerated.
2. Unilateral balance activities. See Application Strategy 15.1.
3. Strengthening exercises. Include the following:
   - Multiangle isometric exercises for the quadriceps, hamstrings, and hip adductors
   - Straight leg raises in all directions. Add tubing or ankle weights during later stages.
   - Short-arc quadriceps extension exercises. Place a pillow or bolster under the knee to support the knee at 45° of flexion. Extend the knee, and hold for 10 seconds. Add ankle weights to increase resistance.
   - Toe raises from a seated position can progress to standing position when pain-free.
   - Straight leg raises in all directions, with tubing added as tolerated
4. Cardiovascular fitness

- Use upper body ergometer and a stationary cycle with bilateral minimal tension if 115°–120° of knee flexion is present. Avoid full knee extension.

Phase 3

1. ROM. Maintain full ROM and flexibility in the lower extremity.
2. Strengthening
   - Hip leg press and squats
   - Toe raises with weights
   - Lunges
   - Isokinetic open and closed chain exercises
3. Cardiovascular fitness
   - Pool running, swimming with a flutter kick, jogging on a trampoline, and power walking

Phase 4 (Return to Activity)

1. Maintain ROM, flexibility, strength, and balance.
2. Functional activities. See Application Strategy 15.2.

If joint effusion is extensive, immediate referral to a physician is warranted. Immediate referral also is necessary if the knee is locked and cannot be spontaneously reduced.

Bucket-handle tear segments can be excised surgically without removing the total meniscus, although regeneration of the centrally displaced portion will not occur. Arthroscopic meniscectomy is performed as an outpatient procedure under local anesthesia, with return to function following partial meniscectomy within 2 to 6 weeks. Total meniscectomy increases rotary instability and can lead to arthritis.

The golfer has mild joint effusion and pain on the medial joint line that increases with rotation and extreme flexion of the knee. This suggests a possible chronic meniscal tear. This patient should be referred to a physician.

PATELLAR AND RELATED CONDITIONS

> ? A high school wrestler complains of an aching pain on the lateral side of the patella that increases during the workout. Slight effusion is present in the patellofemoral joint, and pain is elicited over the lateral patellar border. Intense pain is felt when the patella is pushed downward into the patellofemoral groove. What factors may contribute to this condition, and what long-term management should be considered after acute symptoms have subsided?

The patellofemoral joint is the region most commonly associated with anterior knee pain. Patellar tracking disorders and instability within the joint, along with obesity, direct trauma, and repetitive motions, all contribute to a variety of injuries. Patellofemoral pain may be classified into mechanical causes (e.g., patellar subluxation or dislocation), inflammatory causes (e.g., prepatellar bursitis or patellar tendinitis), and other causes (e.g., reflex sympathetic dystrophy or tumors). Other terms in the literature to describe anterior knee pain include patellofemoral arthralgia, patellar pain, patellar pain syndrome, and patellofemoral stress syndrome.

The main dynamic stabilizer is the quadriceps mechanism. More accurately called the **extensor mechanism**, it is made up of the vastus lateralis, vastus intermedius, vastus medialis, and rectus femoris, each of which is innervated by the femoral nerve. The vastus medialis has two heads, the superior longus head (vastus medialis longus) and the VMO. The VMO fibers approach the patella at a 55° angle. Although the VMO is incapable of producing knee extension, it provides a dynamic restraint to forces that would laterally displace the patella. Atrophy of this muscle nearly always is evident in patellofemoral dysfunction. The pes anserinus muscle group and the biceps femur influence patellar stability, because they control tibial internal and external rotation, which can significantly influence patellar tracking.

The static stabilizers include the anteriorly projected, lateral aspect of the femoral sulcus, the extensor retinaculum, IT band, quadriceps tendon, and patellar tendon. Oblique condensations of the retinacula produce the patellofemoral ligament and the medial and lateral patellotibial ligaments (Fig. 15.28). The structures that resist medial displacement of the patella (i.e., lateral retinaculum and IT band) are thicker and stronger than the soft-tissue structures that resist lateral displacement forces (i.e., medial retinaculum and lateral aspect of femoral sulcus). The patellar tendon resists superior displacement forces on the patella, whereas the quadriceps tendon resists inferior displacement of the patella. Both medial and lateral retinacula assist in knee extension even though the patellar tendon may be ruptured.

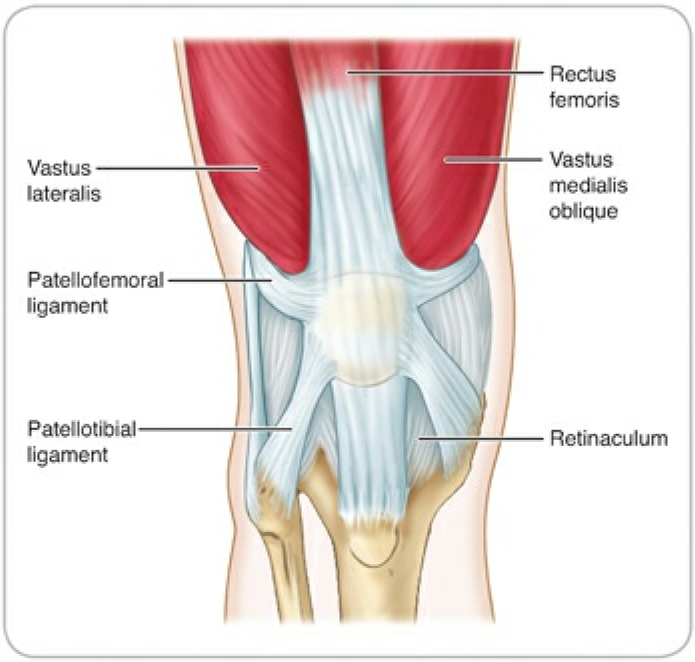

Figure 15.28. Extensor mechanism. The extensor mechanism is composed of dynamic and static stabilizers. Working together, they combine rolling and gliding motions to place the femur and patella in specific positions to effect the deceleration mechanism of the patellofemoral articulation and provide stability and function at the knee.

Deficiencies in stabilization of the extensor mechanism can be caused by several abnormalities of the patellofemoral region (Box 15.5), which can lead to anterior knee pain. Each condition can be counterbalanced in a healthy knee by the triangular shape of the patella, depth of the patellofemoral groove, and limiting action of the static ligamentous structures. Failure of medial structures to restrain the patella in a balanced position, or the presence of bony anomalies, can result in lateral tilting or lateral excursion of the patella, which in turn leads to patellofemoral **arthralgia**, or severe joint pain.

BOX 15.5 Causes of the Patellofemoral Pain

- Patellar instability caused by
  - Abnormally shaped medial patellar facet
  - Shallow patellofemoral (trochlear) groove
  - Variable length and width of the patellar tendon
  - Patella alta (high-riding patella)
- Weak VMO or VMO dysplasia
- Hypermobility of the patella caused by
  - Muscle atrophy after an injury
  - Tightness of the lateral retinaculum, IT band, and hamstrings
- Anatomical malalignment caused by
  - Shallow patellofemoral groove
  - Excessive femoral anteversion or external tibial rotation
  - Genu valgum or genu recurvatum
  - Increased Q-angle
  - Excessive foot pronation
- Plica syndromes and repetitive minor trauma

Patellofemoral Pain Syndrome

Etiology

Patellofemoral pain syndrome, also called lateral patellar compression syndrome, is pain in the patellofemoral joint without documented instability. The condition often occurs when either the VMO is weak or the lateral retinaculum that holds the patella firmly to the femoral condyle is excessively tight. Pain results when a tense lateral retinaculum passes over the trochlear groove or when increased patellofemoral stresses are transferred from the articular cartilage to pain fibers in the subchondral bone.

Signs and Symptoms

The patient may report a dull, aching pain in the anterior knee that is made worse by squatting, sitting in a tight space with the knee flexed, and descending stairs or slopes. Point tenderness can be located over the lateral facet of the patella, with intense pain and crepitus elicited when the patella is manually compressed into the patellofemoral groove. Synovial inflammation also may be present.

Management

Treatment involves standard acute care and NSAIDs. The entire lower extremity should be assessed for gait characteristics, flexibility, and strength of the proximal and distal portions. It is important to determine the presence of decreased rotation or strength in the lateral rotators of the hip as well as tightness in the hamstrings, quadriceps, and Achilles tendon. The McConnell taping technique uses passive taping of the patella to correct patellar position and tracking. The technique should be used in conjunction with corrective exercises to address the cause of the condition and is not intended to be used indefinitely. Patellofemoral support devices may be used to prevent lateral displacement of the patella, or orthotics may be employed to correct foot malalignment conditions.

Rehabilitation should focus on recruiting the VMO, normalizing patella mobility, and increasing flexibility and muscle control of the lower extremity. Closed chain exercises often are preferred because of the decrease in patellofemoral compression forces. Examples of closed kinetic chain exercises include knee flexion of 30° to 70° and lateral steps up of from 1 to 8 in to allow eccentric and concentric movements. Eccentric quadriceps strengthening is emphasized, because the quadriceps muscle is an important decelerator. Strengthening of the hip muscles to prevent adduction and internal rotation is critical to allow the progression of closed chain exercises. Restoring proprioception also is critical in reestablishing neuromuscular control. Weight-training programs that load the patellofemoral joint, such as bent-knee exercises, should be avoided. Resisted terminal knee extension exercises, straight leg raises in hip flexion and adduction, and quadriceps isometric, isotonic, and high-speed isokinetic exercises in a 60° to 90° arc may be performed. If the VMO is not monitored using biofeedback devices, proper recruitment is difficult to determine.

Chondromalacia Patellae

Etiology

Chondromalacia patellae is a true degeneration in the articular cartilage of the patella that results when compressive forces exceed the normal physical range or when alterations in patellar excursion produce abnormal shear forces that damage the articular surface. Because articular cartilage does not contain nerve endings, chondromalacia should not be considered as the true source of anterior knee pain. Chondromalacia is a surgical finding that represents areas of hyaline cartilage trauma or aberrant loading; it is not the cause of pain. The medial and lateral patellar facets are most commonly involved. The condition is confirmed when pain results from Clarke sign and Waldron test. Chondromalacia has four stages, which are detailed in **Figure 15.29**.

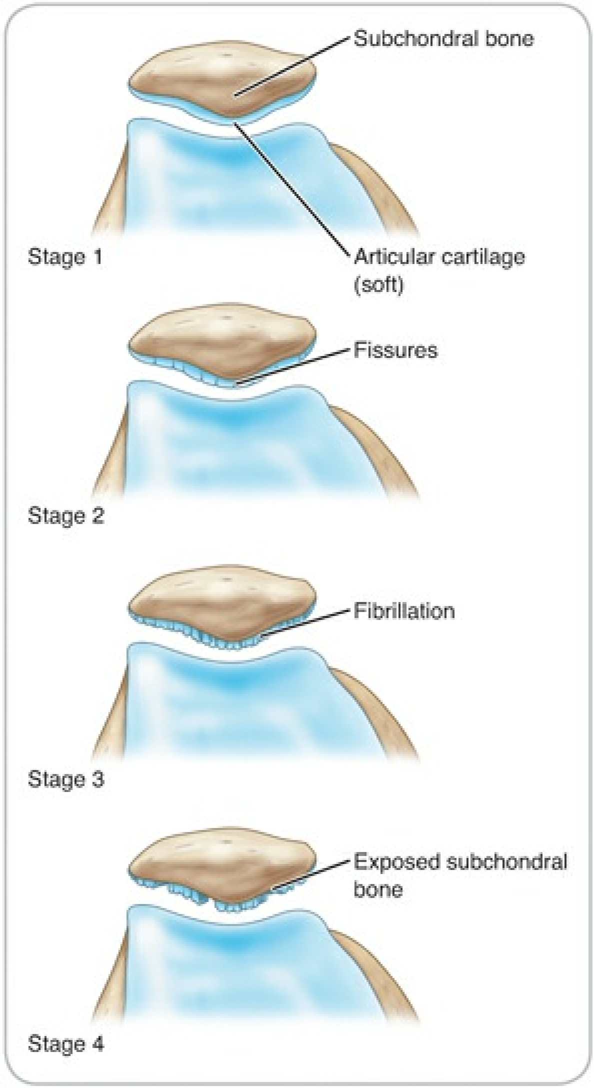

Figure 15.29. Four stages of chondromalacia patellae. Stage 1 involves softening or blistering of the cartilage. Stage 2 reveals fissures in the cartilage. Stage 3 is reached when fibrillation of the cartilage occurs, causing a "crabmeat" appearance. Stage 4 reveals cartilage defects with subchondral bone exposed.

Management

Asymptomatic chondromalacia does not require treatment; if the condition becomes symptomatic, standard acute care is the appropriate protocol. Most patients respond well to mild anti-inflammatory medication, quadriceps strengthening, and a hamstring flexibility program. All resisted exercises with knee extension from a fully flexed position, crouches, and deep knee bends should be avoided, because these positions may aggravate the condition. A knee sleeve with a patellar cutout may be helpful. If this does not reduce the symptoms, the condition may require surgical intervention, such as arthroscopic patellar debridement, lateral retinacular release, extensor mechanism realignment, or elevation of the tibial tubercle to relieve patellar compression forces.

Patellar Instability and Dislocations

Etiology

Patellar instability occurs when the patella has normal or abnormal alignment in the trochlear groove but is displaced by internal or external forces. Displacement can range from microinstability to subluxation or gross dislocation. Factors that may lead to congenital malalignment of the extensor mechanism include VMO dysplasia, vastus lateralis hypertrophy, high and lateral patellar posture, increased Q-angle, and bony deformity.

Signs and Symptoms

In a subluxation, transient partial displacement of the patella from the femoral trochlea may occur acutely, as in a patellar dislocation, or be intermittent, with spontaneous reduction of the displacement. The patient may or may not have a history of complete dislocation or patellofemoral pain but reports a feeling of the patella slipping when cutting, twisting, or pivoting. Joint effusion may develop, but it improves rapidly when the patient resumes activity.

Chronic subluxations produce less swelling, pain, and disability. The condition is verified by observing patellar position during active knee flexion and extension and by a positive patellar apprehension test. The patellar apprehension test should only be performed in the absence of obvious deformity. A patient with patellofemoral stress syndrome is not apprehensive with this test, whereas one with patellar pain resulting from subluxation resists any attempt to displace the patella laterally.

Acute patellar subluxations and dislocations appear the same and generally occur during deceleration with a cutting maneuver (**Fig. 15.30**). Distinguishing one from the other depends on patient history. In a dislocation, the patient reports that the patella moved and had to be pushed back into place; with a subluxation, the patient reports that the patella slipped out and then went back into place spontaneously. The majority of the medial muscular and retinacular attachments are torn from the medial aspect of the patella, leading to an audible pop and violent collapse of the knee. Localized tenderness also may occur along the medial extensor retinaculum or at the adductor tubercle, which is the origin of the medial patellofemoral ligament. In addition, there may be localized tenderness along the peripheral edge of the lateral femoral condyle, where impaction from the patella occurs with flexion of the knee.

Figure 15.30. Dislocated patella. A dislocated patella often displaces laterally and is accompanied by an audible pop and violent collapse of the knee following deceleration involving a cutting maneuver.

Typically, a traumatic displacement has acute effusion associated with a hemarthrosis occurring within the first 2 hours. A dislocation without acute effusion should signal chronic laxity; the tissues are so lax that the patella moves in and out of the groove without traumatizing surrounding tissues. The clinician should palpate the area to assess any defects in the medial retinaculum and VMO before they are obscured by swelling. Occasionally, a fracture of the patella or lateral femoral condyle occurs, resulting in a loose, bony fragment in the joint.

Management

Treatment includes ice, elevation, immobilization, and immediate referral to a physician. Following reduction of the dislocation by the physician, aspiration of the hemarthrosis may be indicated for comfort or to determine the presence of fat in the blood secondary to an osteochondral fracture. Immobilization of a first-time dislocation is only needed to control acute symptoms and is followed by an extensive rehabilitation program and functional patellar bracing. During immobilization, isometric quadriceps exercises and straight leg raises can be performed. When immobilization is removed, a full rehabilitative program to strengthen the dynamic stabilizers of the patellofemoral joint, particularly the VMO, and a flexibility program for the hamstrings and IT band should be initiated. A knee sleeve with a lateral pad to restrict lateral excursion and activity modification may be helpful. Most patients with patellofemoral tracking disorders and instability can improve and return to activity without surgical intervention. An obvious disruption of the VMO insertion into the medial patellar edge, however, or a rupture of the medial patellofemoral ligament from the adductor tubercles responds best with early surgical repair.[45]

Patella Plica Syndrome

Etiology

The patella plica shelf is a fold in the synovial lining that projects into the joint cavity. This congenital abnormality is a remnant of the embryological walls that divide the knee into medial, lateral, and suprapatellar pouches. Typically, it is crescent-shaped and extends from the infrapatellar fat pad medially (medial plica), loops around the femoral condyle, crosses under the quadriceps tendon in the suprapatellar region (suprapatellar plica), and then passes laterally over the lateral femoral condyle to the lateral retinaculum

(Fig. 15.31). Normally, a synovial plica remains asymptomatic until traumatized by a direct blow to the capsule or it becomes inflamed and thickened from overuse, resulting from friction caused as the plica bowstrings across the medial femoral condyle. This bowstringing results in two reservoirs for synovial fluid—namely, a suprapatellar reservoir and the cavity of the knee joint itself.

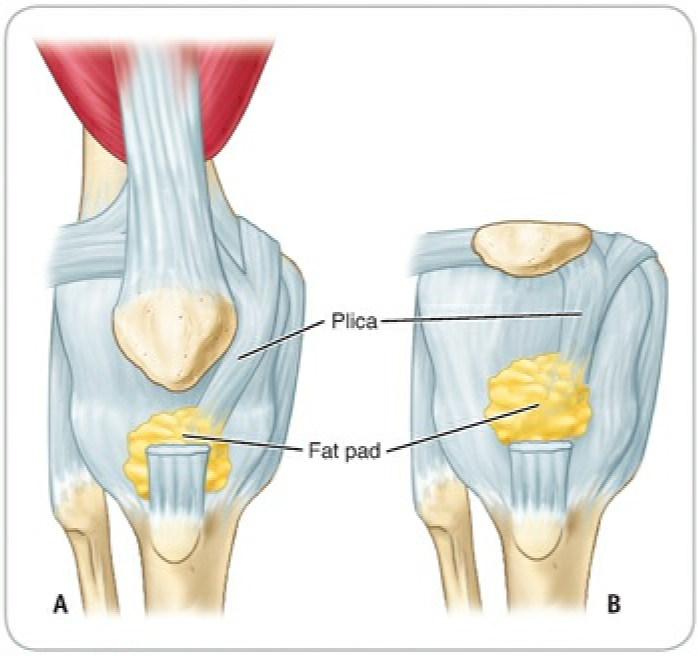

Figure 15.31. Patella plica. The patella plica is a fold in the synovial lining of the knee joint that can become inflamed and thickened by trauma where it extends over the femoral condyle or by microtrauma from overuse. **A,** Fully extended. **B,** Flexion of 90°.

Signs and Symptoms

Anterior knee pain comes on gradually and is aggravated by quadriceps exercises. Approximately 25% of cases have a positive "moviegoer sign" (i.e., pain with prolonged sitting). As the patient stands and begins to walk, a sharp pain is felt for 8 to 10 steps and then disappears. The pain is caused by the plica being maximally stretched and impinged within the patellofemoral joint. As the articularis genus muscle contracts several times, it elevates the plica enough to prevent further impingement. Occasionally, adhesions in the plica lead to a distinctive pop or snap as the patient extends the knee, or pseudolocking may occur over the medial patellofemoral joint, mimicking a torn meniscus. Assessment reveals slight joint effusion, palpable pain, and crepitus in the medial and lateral retinacular regions, particularly along the edge of the medial femoral condyle with the knee flexed at 45°. The test for medial synovial plica and the stutter test are positive.

Management

Treatment is symptomatic, with ice therapy, NSAIDs, activity modification, phonophoresis, and use of an external patellar support device. The condition may improve with hamstring stretching, heel cord stretching, and VMO strengthening exercises, especially if the VMO is dysplastic (abnormally developed). If the condition warrants, the plica shelf can be removed arthroscopically.

Patellar Tendinitis (Jumper's Knee)

Etiology

The patellar tendon frequently becomes inflamed and tender from repetitive or eccentric knee extension activities; these occur in running and in sports, such as volleyball and basketball, in which jumping is a critical action, hence, the name "jumper's knee." Patellar subluxation, patellofemoral stress syndrome, and other conditions also can overload the patellar tendon, predisposing a patient to this condition. Extrinsic factors that can lead to the condition include frequency of training, years of play, playing surface, type of training, stretching and warm-up practices, and type of shoe that is worn. Some intrinsic factors that may have a role in contributing to the condition include lower extremity malalignment, leg length discrepancies, muscle imbalance, anthropometric variables, muscle length, and muscle strength.[46]

Signs and Symptoms

Most patients will complain of chronic anterior knee pain of insidious onset, which might be described as a sharp or aching pain. Initially, pain after activity is concentrated on the inferior pole of the patella or the distal attachment of the patellar tendon on the tibial tubercle. As the condition progresses, pain is present at the beginning of activity, subsides during warm-up, and then reappears after activity. Increased pain often is reported while ascending and descending stairs or after prolonged sitting. Eventually, pain is present both during and after activity and can become too severe for the patient to participate. Pain can be elicited during passive knee flexion beyond 120° and during resisted knee extension. It also is common to find tightness in the hamstrings, quadriceps, and heel cord, with weakness in the ankle dorsiflexors. Chronic tendinitis occasionally may lead to cystic changes at the distal pole of the patella or ectopic calcification and nodule formation in the tendon.

Management

Immediate treatment involves standard acute care and NSAIDs. Application Strategy 15.4 summarizes the management of patellar tendinitis.

APPLICATION STRATEGY 15.4

Management of Patellar Tendinitis

- Rest for 2–3 weeks to allow symptoms to subside.
- Modalities that may be used during the early stages of healing include heat therapy, electrical stimulation, phonophoresis, iontophoresis, and ultrasound.
- Transverse friction massage for 6–8 minutes.
- Initiate early flexibility exercises for the gastrocnemius–soleus complex, quadriceps, and hamstrings.
- Aquatic therapy during the early stages can reduce gravitational forces.
- Progressive resistance strengthening exercises may include the following:
  - Straight leg raises in all directions
  - Short-arc knee extension exercises
  - One-quarter knee squats
- Eccentric strengthening exercises for the quadriceps and dorsiflexors, such as drop squats (i.e., landing from a jump). Focus on the

deceleration between the upward and downward phase. Increase deceleration as tolerated by the patient.

- Cardiovascular fitness should be maintained with exercises that do not involve powerful knee extension (i.e., upper body ergometer, swimming, and stationary bike with minimal tension).
- During the later stages, plyometrics may be incorporated (i.e., single-leg hop, double-leg hop, single-leg vertical jump, and bounding).
- A patellofemoral knee sleeve may reduce mobility of the patellar tendon during activity.

Osgood-Schlatter Disease

Etiology

Osgood-Schlatter disease is a traction-type injury to the tibial apophysis where the patellar tendon attaches onto the tibial tubercle (**Fig. 15.32**). Osgood-Schlatter disease typically develops in girls between the ages of 8 and 13 years and in boys between the ages of 10 and 15 years at the beginning of their growth spurt. It is estimated that the condition occurs in 21% of adolescent athletes, compared with 4.5% of age-matched nonathletes.[47] The condition has been more common in boys, but with girls' increased participation in sports, the ratio may be equalizing.

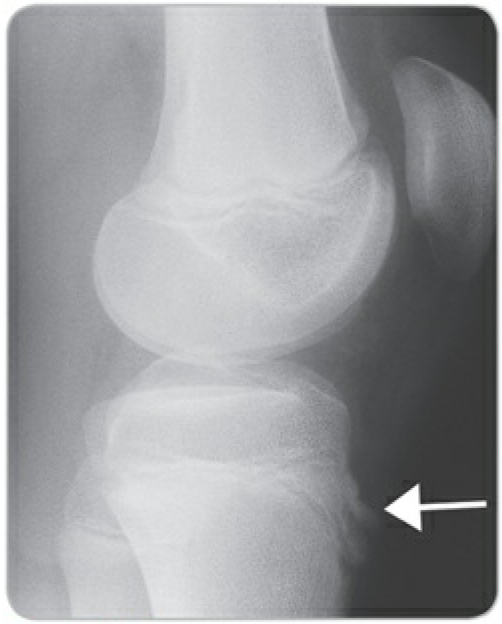

Figure 15.32. Patellar tendon traction-type injuries. Patellar tendon traction-type injuries may involve Sinding-Larsen-Johansson disease or Osgood-Schlatter disease. The location of pain typically defines which problem is present.

Signs and Symptoms

Assessment of the condition usually is straightforward. Patients point to the tibial tubercle as the source of pain, and the tubercle appears to be enlarged and prominent. Patients report that pain generally occurs during activity and is relieved with rest. Point tenderness can be elicited directly over the tubercle, but ROM is unaffected. Pain is present at the extremes of knee extension and forced flexion. Severity is rated in three grades, depending on the duration of pain:

- **Grade I**—pain after activity that resolves within 24 hours
- **Grade II**—pain during and after activity that does not hinder performance and resolves within 24 hours
- **Grade III**—continuous pain that limits sport performance and daily activities

Management

Treatment is symptomatic and self-limiting, but it may take 12 to 24 months for the condition to run its course. In most cases, activity is unrestricted unless pain is disabling. Shock-absorbent insoles in shoes may decrease peak stress on the tendon and tubercle. Application of cold for 20 minutes after activity should be beneficial, as should hamstrings and quadriceps stretching. Knee pads may protect the tibial tubercle when kneeling, or a knee strap (e.g., Cho-Pat straps) may decrease the traction forces on the tibial tubercle. The condition rectifies with closure of the apophysis, but a small percentage of patients develop a painful ossicle, which can necessitate surgical excision. Others may develop painful kneeling as adults.

Sinding-Larsen-Johansson Disease

Etiology

A condition similar to Osgood-Schlatter disease is **Sinding-Larsen-Johansson disease**, but the excessive strain occurs on the inferior patellar pole at the origin of the patellar tendon (see **Fig. 15.32**). The condition usually is seen in children 8 to 13 years of age.

Signs and Symptoms

The onset of pain over the inferior patellar pole is gradual and seen in children who are involved in running and jumping sports. The condition often is missed unless the clinician palpates the inferior patellar pole with the patient's knee extended and the patellar tendon relaxed. Repeating the examination with the knee flexed at 90° should reveal diminished tenderness as the patellar tendon becomes taut.

Management

Treatment is symptomatic and similar to that for Osgood-Schlatter disease. Symptoms generally resolve quickly with standard acute care, NSAIDs, and activity modification.

Extensor Tendon Rupture

Etiology

Extensor tendon ruptures can occur at the superior or inferior pole of the patella, the tibial tubercle, or within the patellar tendon itself. Ruptures result from powerful eccentric muscle contractions or in conjunction with severe ligamentous disruption at the knee. The rupture may be partial or total.

Signs and Symptoms

A partial rupture produces pain and muscle weakness in knee extension. If a total rupture occurs distal to the patella, assessment reveals a high-riding patella, a palpable defect over the tendon, and an inability to perform knee extension or perform a straight leg raise. If the quadriceps tendon is ruptured from the superior pole of the patella and the extensor retinaculum is still intact, knee extension is still possible, although it is weak and painful. Patients with a history of previous corticosteroid injections, anabolic steroid abuse, or use of systemic steroids are at a greater risk for tendon ruptures. Steroid use can cause softening or weakening of collagen fibers in the muscle tendon, predisposing the tendon to premature rupture.

Management

Treatment involves standard acute care, use of a knee immobilizer, fitting the patient for crutches, and immediate referral to a physician. Treatment depends on the location and displacement of any bony fragment. In partial ruptures involving a shredded tendon, wiring through the patella may be necessary to relieve tension on the healing tendon. Surgical repair is necessary in total ruptures. Overall, the results of a delayed repair are less satisfactory than the results with an acute repair, but a delayed repair still provides an extensor mechanism and adequate function.[48]

The high school wrestler complains of lateral patellofemoral pain that increases with certain maneuvers during practice. Precipitating factors that increase stress on the patellofemoral region include patellar instability, a weak VMO, hypermobility of the patella, and anatomical malalignment conditions. Following standard acute care, a total assessment of the lower extremity should be conducted to address deficiencies in muscle strength or biomechanical problems that contributed to the condition.

ILIOTIBIAL BAND FRICTION SYNDROME

? Following an evening practice session on the third day of preseason, a field hockey player complains of a sharp ache over the lateral epicondyle of the femur that has gotten progressively worse since the start of the week. A history reveals that the daily double sessions have concentrated on technique drills and conditioning exercises. Observation reveals excessive foot pronation and genu varum. What actions might be taken to reduce the pain and correct the injury?

A common condition in runners, cyclists, weight lifters, and volleyball players is IT band friction syndrome. The band originates on the lateral iliac crest and continues the line of pull from the tensor fasciae latae and gluteus maximus muscle; the deep fibers are associated with the lateral intermuscular septum. The distal fibers become thicker at their attachment on the Gerdy tubercle adjacent to the tibial tubercle on the lateral proximal tibia. The band drops posteriorly, behind the lateral femoral epicondyle, with knee flexion and then snaps forward over the epicondyle during extension (**Fig. 15.33**).

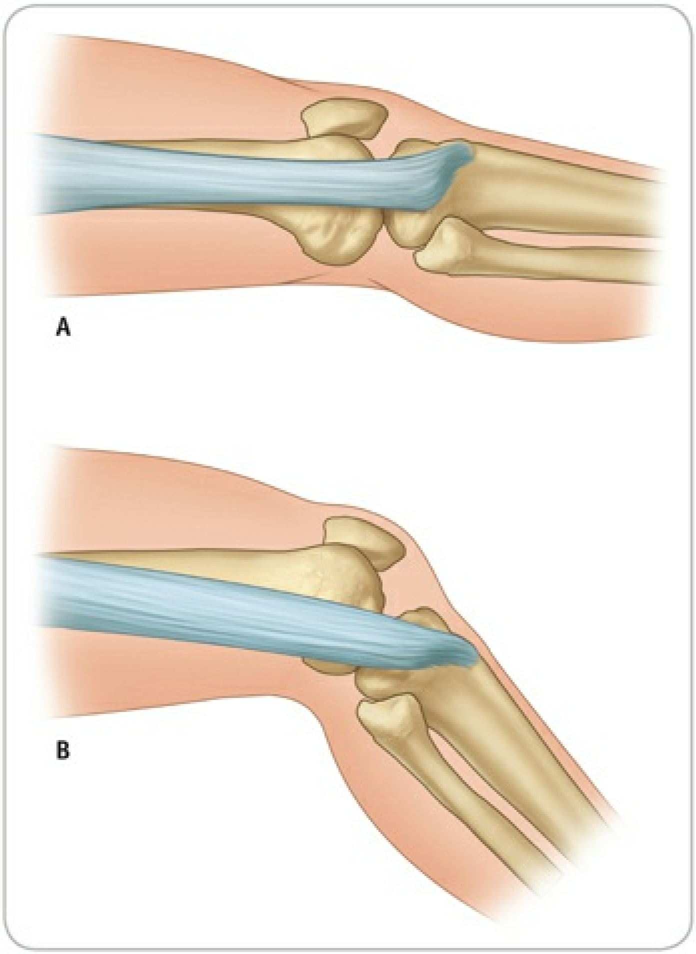

Figure 15.33. Iliotibial band. The IT band drops posteriorly behind the lateral femoral epicondyle during knee flexion and then snaps forward over the epicondyle during extension. Malalignment problems or constant irritation can inflame the IT band or lead to bursitis. **A,** Extension. **B,** Flexion.

Etiology

Weight bearing increases compression and friction forces over the greater trochanter and lateral femoral condyle. Friction between the posterior edge of the IT band and underlying lateral femoral epicondyle is particularly intense near foot strike through foot contact (midstance). Patients with a malalignment problem are predisposed to this condition; see Box 15.6 for a listing of predisposing factors.

BOX 15.6 Predisposing Factors for Iliotibial Band Friction Syndrome

- Genu varum
- Excessive pronation in feet
- Leg length discrepancy
- Prominent greater trochanter of femur
- Preexisting IT band tightness
- Muscle weakness in knee extensors, knee flexors, and hip abductors
- Training errors, such as excessive distance in a single run, increasing mileage too quickly, inadequate warm-up, and running on the same side of a crowned road

Signs and Symptoms

Initially, pain is present over the lateral aspect of the knee after running a certain mileage, typically late in the run, but does not restrict distance or speed. As the condition progresses, the pain begins to occur earlier and earlier with distance and speed affected. Pain may be present while running uphill, downhill, and climbing stairs. With continued activity, the initial ache progresses into a more painful, sharp, stinging discomfort over the lateral femoral condyle approximately 2 to 3 cm above the lateral joint line and, occasionally, radiates distally to the tibial attachment or proximally up the thigh. Swelling may be noted at the distal IT band, and palpation of the affected limb may reveal multiple trigger points in the vastus lateralis, gluteus medius, and biceps femoris.[49] Palpation of these trigger points may cause referred pain to the lateral aspect of the affected knee. Flexion and extension of the knee may produce a creaking sound. Positive Noble and Ober compression tests confirm the condition. Magnetic resonance images have shown that the distal band becomes thickened and that the potential space deep to the IT band over the femoral epicondyle becomes inflamed and filled with fluid.[49] Eventually, pain restricts all running and becomes continuous during activities of daily living.

Management

The immediate treatment should be focused on alleviating inflammation with standard acute care and NSAIDs. Any activity that requires repeated knee flexion and extension should be limited. Functional exercises focusing on strengthening the posterior and lateral muscles of the hip and pelvis should be a core component of the corrective exercise program. Application Strategy 15.5 describes the management of IT band friction syndrome.

APPLICATION STRATEGY 15.5

Management of Iliotibial Band Friction Syndrome

- Ice, compression, elevation, NSAIDs, and rest until acute symptoms subside.
- Roll out iliotibial band, hamstrings, and quadriceps using a foam roller.
- Use dynamic warm-up exercises that function on hip and pelvis as well as lower leg muscle groups.
- Use active release techniques for hip and thigh muscles.
- Hill running should be avoided until asymptomatic.
- Foot orthotics may correct some structural problems.
- Non–weight-bearing strengthening exercises, such as leg lifts and isometric exercises for knee flexion, extension, hip abduction, and adduction, can be initiated when pain-free, followed by concentric and eccentric strengthening of the hip and thigh muscles.
- Work on strengthening posterior chain muscles of the hip and pelvis through exercises such as claim shells, hip thrusts, side steps/shuffles, double- and single-leg squats and hip hikes.
- Running or training should be modified to the point of little or minimal pain during activity. Initially, this may necessitate an easy pace on level ground, progressing to increased mileage while maintaining pain-free activity.
- Cardiovascular fitness can be maintained with swimming; biking should be avoided.
- Ice massage before and after running may be helpful.
- Steroid injections may be used in resistant cases.

- Full return to participation should be gauged on pain-free completion of all functional tests.

The field hockey player has IT band friction syndrome. The double sessions, coupled with the preexisting genu varum and pronated feet, have added strain to the IT band. Following standard acute care to control inflammation, an extensive flexibility program for the IT band should be initiated.

FRACTURES AND ASSOCIATED CONDITIONS

A 14-year-old soccer player complains of an aching, diffuse pain in his right knee. The pain increases with strenuous activity and twisting motions. Because of the pain, he tends to walk with the leg externally rotated. What condition should be suspected, and what is the immediate management for this condition?

Traumatic fractures about the knee area are rare in sports competition, except for high-velocity sports, such as motorcycling and auto racing. These fractures usually are associated with multiple traumas. Other, more common fractures and associated bony conditions can occur with regular participation in sport and physical activity. Displaced and undisplaced fractures of the femoral shaft are discussed in Chapter 16.

Avulsion Fractures

Etiology

Direct trauma, excessive tensile forces from an explosive muscular contraction, repetitive overuse, or a tensile force can pull a ligament from its bony attachment. For example, getting kicked on the lateral aspect of the knee may avulse a portion of the lateral epicondyle, or the tibial tubercle may be avulsed when the extensor mechanism pulls a fragment away.

Signs and Symptoms

Localized pain and tenderness will occur over the bony site, and if displaced, a fragment may be palpated. If a musculotendinous unit is involved, muscle function is limited. When the anterior cruciate is involved, the bony fragment may lodge in the joint, causing the knee to lock.

Management

Treatment involves standard acute care and application of a knee immobilizer. The patient should be referred immediately to a physician for further care. If necessary, the patient should be fitted for crutches and instructed to use a non–weight-bearing gait en route to the physician.

Epiphyseal and Apophyseal Fractures

Adolescents in contact sports are particularly susceptible to epiphyseal fractures in the knee region. A shearing force across the cartilaginous growth plate may lead to disruption of growth and a shortened limb.

Tibial Tubercle Fractures

Etiology

The tibial tubercle, a common site for apophyseal fractures in boys, may occur as a result of Osgood-Schlatter disease. The typical patient is a muscular, well-developed patient who has almost reached skeletal maturity and who almost always is involved in a jumping sport, most commonly basketball. These fractures usually result from forced flexion of the knee against a straining quadriceps contraction or a violent quadriceps contraction against a fixed foot.

Signs and Symptoms

The patient has pain, ecchymosis, swelling, and tenderness directly over the tubercle. Difficulty going up and down stairs also is reported. When the fracture extends from the tubercle to the tibial epiphysis (type II) or through the secondary epiphysis and into the joint (type III), quadriceps insufficiency makes knee extension both painful and weak. In larger fractures involving extensive retinacular damage, the patella rides high, and knee extension is impossible.

Management

Treatment involves standard acute care and application of a knee immobilizer. The patient should be referred immediately to a physician for further care. If necessary, the patient should be fitted for crutches and instructed to use a non–weight-bearing gait en route to the physician. Displaced fractures need open reduction and internal fixation.

Distal Femoral Epiphyseal Fractures

Etiology

Fractures to the distal femoral epiphysis are 10-fold more common than proximal tibial fractures and are more serious because of possible arterial damage to the growth plate. They may occur at any age but often are seen in boys between 10 and 14 years of age. These fractures occur when a varus or valgus stress is applied on a fixed, weight-bearing foot, as when someone falls on the outer aspect of the knee while the foot is planted.

Signs and Symptoms

The patient complains of pain around the knee and is unable to bear weight on the injured leg.

Management

Treatment involves standard acute care and application of a knee immobilizer or vacuum splint. The patient should be referred immediately to a physician for further care. Undisplaced type I fractures usually are treated with closed reduction and casting and with use of crutches and protective weight bearing for 4 weeks, followed by rehabilitation to restore motion and strength. This fracture has a history of fairly good resolution, although such resolution may take weeks to occur. More serious fractures require internal fixation and may result in angular or leg length discrepancy.

Stress Fractures

Etiology

The femoral supracondylar region, medial tibial plateau, and tibia tubercle are common regions for stress fractures. These fractures occur when

- Load on the bone is increased (e.g., jumping or high-impact activity).
- The number of stresses on the bone increase (e.g., changes in training intensity, duration, frequency, or running surface, or unevenly worn shoes).
- The surface area of the bone that receives the load is decreased (i.e., during the normal process of bone repair, certain portions of the bone remain immature and less able to tolerate stress for a period of time).

Signs and Symptoms

Localized pain before and after activity is relieved with rest and non–weight bearing. In a stress fracture of the medial tibial plateau, pain runs along the anteromedial aspect of the proximal tibia just below the joint line. Localized tenderness and edema are present, but initial radiographs of the stress fracture may be negative. As the condition progresses, pain becomes more persistent. Follow-up radiographs 3 weeks postinjury may show periosteal new bone development. Early bone scans are highly recommended.

Management

Once a stress fracture is identified, treatment involves rest, crutches, and/or casting.

Chondral and Osteochondral Fractures

Etiology

A chondral fracture is a fracture involving the articular cartilage at a joint. An osteochondral fracture involves the articular cartilage and the underlying bone (Fig. 15.34). These fractures result from compression with a direct blow to the knee, causing shearing or forceful rotation. A substantial amount of articular surface on the involved bone can be damaged.

Figure 15.34. Osteochondral fracture. This traumatic osteochondral fracture involves the articular cartilage and subchondral bone on the medial epicondyle of the tibia.

Signs and Symptoms

The patient usually feels a painful "snap" and reports considerable pain and swelling within the first few hours after injury. Displaced fractures can cause locking of the joint and produce crepitation during ROM.

Management

Following standard acute care and immobilization in a vacuum splint, the patient should be referred immediately to a physician for further care. Aspiration of the joint often yields bloody fluid containing fat. Magnetic resonance images may be indicated, because some fractures may not appear on standard radiographs. Small fragments can be removed during arthroscopic surgery; internal fixation is necessary with larger fragments. Following surgery, ROM exercises are performed to improve articular cartilage nutrition, limit joint adhesions, and prevent muscular atrophy.

Osteochondritis Dissecans

Etiology

Osteochondritis dissecans (OCD) occurs when a fragment of bone adjacent to the articular surface of a joint is deprived of its blood supply, leading to avascular necrosis (**Fig. 15.35**). The bone fragment may be in its normal anatomical location with a smooth articular surface (i.e., stable), or the lesion may displace and form a loose body within the joint space, leaving a defect in the articular cartilage (i.e., unstable). The cartilage remains healthy even if the fragment is loose, because cartilage is nourished by synovial fluid rather than a direct blood supply. Repetitive trauma and loss of mechanical support, however, may cause the cartilage to undergo softening and degenerative changes. Although found in other joints, it more commonly affects the knee joint, particularly in males from 10 to 20 years of age, with the femoral condyles accounting for 75% of all lesions. Of these, the medial femoral condyle accounts for 75% to 85% of all femoral lesions.[50] Causes include direct and indirect trauma, skeletal abnormalities associated with endocrine dysfunction, a prominent tibial spine that impacts the medial femoral condyle, and generalized ligamentous laxity.

Figure 15.35. Osteochondritis dissecans. Osteochondritis dissecans occurs when a fragment of bone adjacent to the articular surface of a joint is deprived of its blood supply, leading to avascular necrosis. In this patient, a portion of the medial epicondyle of the femur is damaged.

See **Classification and Prognosis of Osteochondritis Dissecans**, available on the companion Web site at thePoint.

Signs and Symptoms

The most common symptom is an aching, diffuse pain, or swelling, with activity. Locking or giving way of the knee may develop as the disease progresses. Pain increases with strenuous activity and twisting motions, especially internal rotation of the tibia, which causes the medial tibial spine to strike the lateral aspect of the medial femoral condyle (the site of most OCD lesions). As a result, the patient walks with the affected leg externally rotated. Lesions of the lateral femoral condyle may produce a painful "clunk" with knee flexion and extension. Patients with OCD of the patella usually present with retropatellar pain and crepitus. Thigh circumference may be diminished because of muscle disuse atrophy.

Management

Following standard acute care and immobilization with a knee immobilizer or vacuum splint, the patient should be referred immediately to a physician for further care. Treatment depends on the age of the patient, the size and location of the lesion, and the radiographic appearance of the fragment and articular cartilage.

Patients in categories 1 and 2 (those younger than 20 years of age) are treated nonsurgically if the fragment has not separated. A soft knee immobilizer is worn, and activity is restricted for 1 to 2 weeks, with minimal weight bearing to control pain and initiate healing. Activities are then modified for 6 to 12 weeks; younger patients generally require a shorter period of activity modification compared with older patients. Rapid or strenuous movement of the lower extremities should be avoided, especially high-impact activities, such as running, cutting, and jumping. Plain radiographs usually reveal evidence of healing between 3 and 6 months after treatment. Full activity may be permitted once the following criteria are met:

- The patient is pain-free.
- Physical examination is normal, including full ROM, and no joint effusion or tenderness is present.
- Radiographic evidence of healing is present, as noted by disappearance of the radiolucent line that outlined the fragment.

If the patient is older than 20 years, the fragment is unstable (regardless of the patient's age), or a chronic lesion does not respond to conservative measures, internal fixation or removal of the fragment is indicated. Older patients do not heal as well, because degenerative joint changes may have already developed within the joint. For OCD lesions of the patella, conservative management often is unsuccessful, necessitating early surgical intervention to excise the fragment. For these patients, brief postsurgical immobilization followed by activity limitations usually brings about gradual healing.

Patellar Fractures

Etiology

Stress fractures of the patella are rare and typically involve the inferior pole of the patella. Traumatic fractures can be transverse, stellate or comminuted, or longitudinal (**Fig. 15.36**). Displaced patellar fractures, which generally are associated with disruption of the quadriceps retinaculum, require open reduction and internal fixation. These fractures occur as a result of a fall onto the knee, a direct blow to the knee, or an eccentric contraction of the quadriceps that overloads the intrinsic tensile strength of the bone, as occurs in jumping activities. Patellar fracture also is a rare complication of ACL reconstruction using a bone–patellar tendon–bone **autogenous** (i.e., from within the body) graft. These fractures occur an average of 7 weeks postsurgery and result from external trauma, rapid flexion movement while preventing a fall backward, or a twisting maneuver. A **bipartite** (i.e., having two parts) patella, although not a fracture, is present in 1% to 4% of patients and is more common in males than in females. It typically is seen on the superolateral corner of the patella and has rounded rather than sharp edges. The patient lacks point tenderness over the area and can maintain knee extension, which differentiates the condition from a true fracture.

Figure 15.36. Traumatic patellar fracture. This radiograph provides a lateral view of a transverse fracture of the patella.

Signs and Symptoms

Generally, 2 mm of articular incongruity signifies a displaced fracture, which produces diffuse extra-articular swelling on and about the knee. A portion of the patella is retracted proximally. A visible and palpable defect lies between the fragments, which are mobile. A straight leg raise is impossible to perform.

Management

Initial treatment involves ice, elevation, immobilization in a knee immobilizer, and immediate referral to a physician. Radiographs are needed for verification. Nondisplaced patellar fractures are treated nonoperatively, with either a long-leg cylinder cast or a knee immobilizer for 4 to 6 weeks. Partial weight bearing is then allowed, and a full rehabilitation program is initiated. Surgery is indicated in a displaced fracture with major disruption to the extensor mechanism.

The 14-year-old soccer player may have OCD. Following standard acute care and immobilization with a knee immobilizer or vacuum splint, the patient should be referred immediately to a physician for further care.

REHABILITATION OF KNEE INJURIES

? The basketball player is diagnosed with patellofemoral syndrome. Explain the focus of a rehabilitation program for this condition.

A rehabilitation program attempts to minimize inflammation and the effects of immobilization by initiating early mobilization and controlled movement to allow healing tissues to be stressed gradually and progressively until normal joint function is restored. The rehabilitation program should restore motion and proprioception, maintain cardiovascular fitness, and improve muscular strength, endurance, and power, predominantly through closed chain exercises. Sample exercise programs for specific injuries are listed in **Application Strategies 15.1** to **15.5**.

Restoration of Motion

Some loss of motion occurs following most knee injuries. Passive ROM exercises normally can begin on the first day after injury. Because of potential damage to the graft, however, some concern has been raised about the use of continuous passive motion (CPM) machines following autogenous patellar tendon reconstruction of the ACL. The literature does support the early use of the CPM in this population.[51] The unit moves the knee through a protected ROM to stimulate the intrinsic healing process. The benefits of CPM following ACL surgery include the following:

- Maintaining articular cartilage nutrition and preventing articular cartilage degradation
- Preventing adhesions, joint stiffness, and muscle spasm

- Improving collagen remodeling and joint dynamics
- Reducing pain, thereby reducing amount of pain medication
- Decreasing joint swelling and effusion
- Producing no significant deleterious effects on the stability of the ligament
- Increasing knee ROM sooner

When a CPM machine is not needed, ROM exercises, such as the supine wall slide, heel slide, assisted knee flexion and extension, half squats, or proprioceptive neuromuscular facilitation stretching exercises, can be performed (**Fig. 15.37**). Extension usually is the most difficult motion to restore, and it is critical in achieving normal gait. The patient is placed prone, with the thigh resting on the table. The lower leg is extended off the end of the table. A weight can be added on the distal tibia so that a gradual stretch is achieved. Following the exercise bout, the knee should be iced in the supine position, with the heel elevated to assist with extension.

Figure 15.37. Range of motion exercises. A, Half squat. **B,** Assisted heel slide. **C,** Assisted knee flexion and hip flexion. **D,** Assisted knee flexion.

In addition to active and passive ROM exercises at the tibiofemoral joint, stretching exercises to improve passive glide of the patellofemoral joint, particularly medial glide, can stretch tight lateral structures to correct patellar positioning and tracking (Fig. 15.38). Normal passive glide of the patellofemoral joint should be restored before full flexion exercises, resisted exercises, or bicycling is initiated.

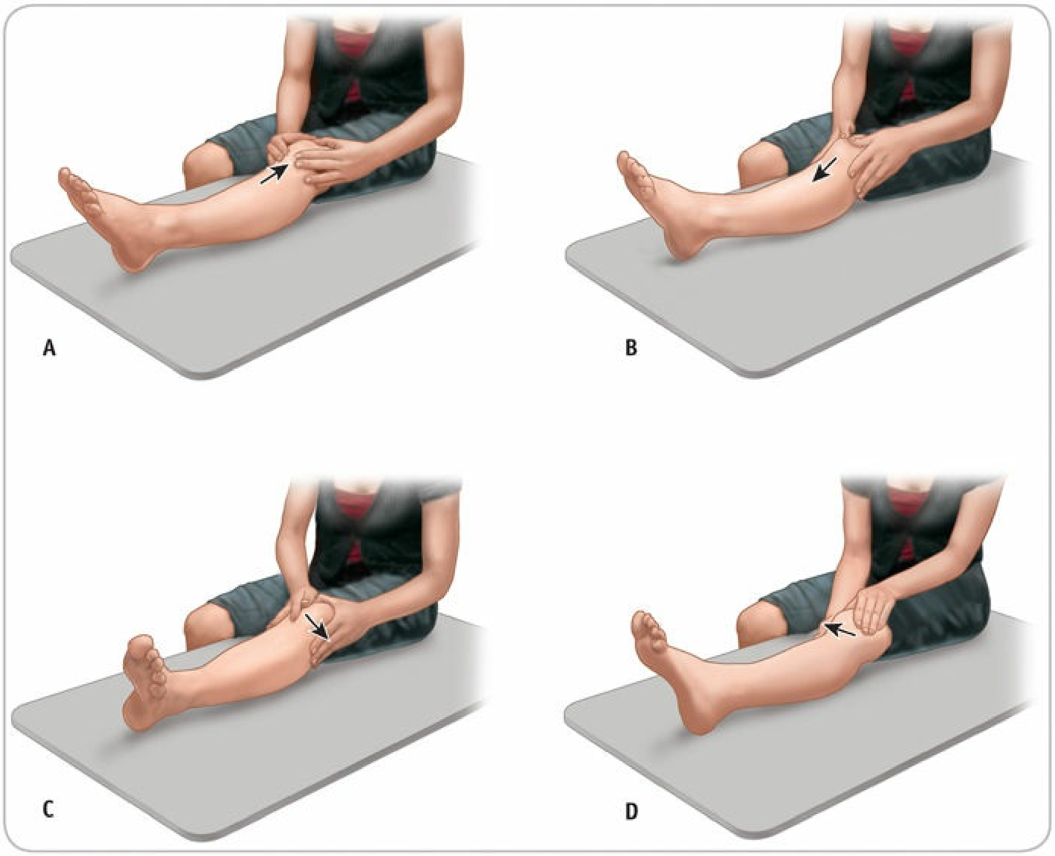

Figure 15.38. Patellar self-mobilization. A, Proximal. B, Distal. C, Medial. D, Lateral.

Restoration of Proprioception and Balance

Proprioception and balance must be regained to return safely to activity. During the early stages following injury, when weight bearing is allowed, closed chain exercises, such as shifting one's weight while on crutches, straight leg raises, bilateral minisquats, or use of a biomechanical ankle platform system (BAPS) board with support, may be helpful. As balance improves, unassisted use of the BAPS board, closed chain exercises, running in place on a minitramp, or use of a slide board may be incorporated along with other closed chain exercises that are used to develop strength.

Muscular Strength, Endurance, and Power

Early emphasis should be placed on strengthening the quadriceps femoris musculature, particularly the vastus medialis and VMO. These muscles aid in the stabilization of the patella both superiorly and medially. Isometric contractions, called quad sets, are performed at or near 0°, 45°, 60°, and 90° of flexion. Isometric hip adduction exercises also are used to recruit the VMO and can be performed by squeezing a rolled towel between the knees in a seated position. Open chain exercises may include straight leg raises in all directions, supplemented by ankle weights or tubing to increase resistance. Knee extension and flexion exercises may be done with free weights or on several commercially available isotonic or isokinetic machines.

Closed chain exercises performed during weight bearing may include terminal knee extension (**Fig. 15.39**), step-ups, step-downs, lateral step-ups, minisquats from 0° to 40°, leg presses on a machine from 0° to 60°, or use of a stepping machine or stationary bicycle. Several of these exercises are detailed in **Application Strategy 15.1**. Closed chain exercises can be made progressively more difficult by increasing the resistance or speed of movement or by changing the patient's visual feedback (e.g., looking at the ceiling, looking at the floor, or closing the eyes). Ensuring proper performance of closed chain exercises is critical. For example, when doing a minisquat or leg press, if the hip is not strong enough to control adduction and internal rotation, the knee assumes a valgus alignment, with the foot pronated. This leads to an increased Q-angle, predisposing the patient to patellofemoral pain.

Figure 15.39. **Closed chain terminal extension. A,** Starting position. **B,** Ending position.

Plyometric jumping during the later stages of rehabilitation can be performed using small boxes and directional changes to improve power and proprioceptive function. Because of the increased eccentric contraction and the associated muscle microtrauma that results from the power maneuvers, these exercises should only be performed two or three times weekly.

Cardiovascular Fitness

Cardiovascular fitness exercises can begin immediately after injury with use of an upper body ergometer or hydrotherapeutic exercise. Running in water and performing sport-specific exercises in deep water can allow the patient to maintain activity-specific functional skills in a non–weight-bearing position. When ROM is adequate, a stationary bicycle may be used. The seat should be adjusted so that the knee is flexed by 15° to 30°. The patient should be instructed to pedal with the ball of the foot, using toe clips, and to pull through the bottom of the stroke. A low to moderate workload is recommended to reduce patellofemoral compressive forces. Other exercises, such as walking, light jogging, and functional activities, can progress as tolerated.

Rehabilitation for the basketball player with patellofemoral syndrome should focus on recruiting the VMO, normalizing patella mobility, and increasing flexibility and muscle control of the lower extremity. Resisted terminal knee extension exercises, straight leg raises in hip flexion and adduction, as well as quadriceps isometric, isotonic, and high-speed isokinetic exercises in a 60° to 90° arc may be performed. Closed chain exercises often are preferred because of the decrease in patellofemoral compression forces. Strengthening of the hip muscles to prevent adduction and internal rotation is critical to allow the progression of closed chain exercises. Restoring proprioception also is critical in reestablishing neuromuscular control. Weight training programs that load the patellofemoral joint, such as bent-knee exercises, should be avoided.

SUMMARY

1. The knee (tibiofemoral joint) functions primarily as a modified hinge joint, with some lateral and rotational motions allowed.
2. The cruciate ligaments are intracapsular and extrasynovial. They prevent anterior and posterior translation of the tibia on the femur. The ACL frequently is subject to deceleration injuries, with internal tibial torque being the most dangerous loading mechanism, particularly when combined with an anterior tibial force. The shorter and stronger PCL is considered to be the primary stabilizer of the knee.
3. The collateral ligaments prevent valgus (medial) and varus (lateral) stress at the knee.
4. The menisci aid in lubrication and nutrition of the joint, reduce friction during movement, provide shock absorption by dissipating stress over the articular cartilage, improve weight distribution, and help the capsule and ligaments to prevent hyperextension.

5. Tracking of the patella against the femur is dependent on the direction of the net force that is produced by the attached quadriceps. Factors such as patellar instability, a weak VMO, hypermobility of the patella, anatomical malalignment conditions, plica syndromes, or repetitive minor trauma can lead to chronic patellofemoral pain.
6. Because of its location, the prepatellar bursa is the bursa most commonly injured by compressive forces. The deep infrapatellar bursa often is inflamed by overuse and subsequent friction between the infrapatellar tendon and structures behind it (fat pad and tibia).
7. A straight plane instability implies instability in one of the cardinal planes. A multidirectional instability involves instability in more than one plane.
8. Isolated anterior instability is rare. Instead, an anteromedial or anterolateral laxity usually occurs. The rate of ACL injuries is higher in women, in part because of an imbalance of muscle strength as well as both intrinsic and extrinsic factors.
9. Menisci become stiffer and less resilient with age. Tears are classified according to age, location, or axis of orientation, and they include longitudinal, bucket-handle, horizontal, and parrot-beak. Because the menisci are not innervated by nociceptors, synovial inflammation and joint effusion may not develop for more than 12 hours after the initial injury.
10. Patellofemoral stress syndrome often occurs when either the VMO is weak or the lateral retinaculum that holds the patella firmly to the femoral condyle is excessively tight. This condition is much more common than chondromalacia patellae, which is a true degeneration in the articular cartilage of the patella.
11. Adolescents are particularly prone to Osgood-Schlatter disease, Sinding-Larsen-Johansson disease, and fractures to the distal femoral epiphysis.
12. Pain in the knee region can be referred from the lumbar spine, hip, or

ankle.

13. A rehabilitation program should minimize inflammation and the effects of immobilization by initiating early mobilization and controlled movement to allow healing tissues to be stressed, gradually and progressively, until normal joint function is restored.

14. A patient should be referred to a physician if any of the following conditions are suspected:

    - Obvious deformity suggesting a dislocation or fracture
    - Significant loss of motion or locking of the knee
    - Excessive joint swelling
    - Gross joint instability
    - Reported sounds, such as popping, snapping, or clicking, or giving way of the knee
    - Possible epiphyseal injuries
    - Abnormal or absent reflexes
    - Abnormal sensations in either segmental dermatomes or peripheral cutaneous patterns
    - Absent or weak pulse
    - Weakness in a myotome
    - Any unexplained or chronic pain that disrupts a patient's play or performance

APPLICATION QUESTIONS

1. Shoe design, specifically cleat length and placement, has been associated with increased risk of ACL injury. What type of cleat length and placement would you recommend to athletes playing on a sod field if the

goal is to reduce the risk of injury?

2. A 17-year-old female basketball player is complaining of a deep, aching pain in the knee during activity. What open-ended questions could be asked to determine the medical history of this injury? What factors would the athletic trainer be looking for during the inspection/observation of this injury?
3. A 37-year-old tennis player complains of mild swelling and tenderness on the medial joint line. Slight joint effusion is present, and pain can be elicited with external rotation of the tibia on a fixed femur, and during extreme knee flexion. In assessing this condition, what stress and special tests could be performed to determine the possible injury?
4. A 20-year-old basketball player fell on the court directly on the knee and felt an intense pain on the anterior aspect of the knee. There is palpable pain on either side of the patellar tendon but not directly on the tendon. When the knee is moved into full extension, pain significantly increases. What condition may be present? What is the immediate management for this injury?
5. A 27-year-old female reported to the athletic training room complaining of anteromedial knee pain. She does not remember when her knee began hurting, but it has gotten more painful over the past 2 weeks. She describes a locking sensation and increased deep pain going up and down stairs. How would you differentiate between patellofemoral pain with patellar maltracking and a medial meniscus tear?
6. A 30-year-old cyclist is complaining of pain on the proximal, medial tibia just distal to the knee joint. It has been bothersome for nearly 2 weeks, especially after the completion of the workout. What structure(s) may be inflamed? Are there any factors which may contribute to this condition?
7. A 13-year-old male participates on his school swimming and diving team. He is complaining of anterior (patellar) knee pain in his takeoff and landing leg used for diving. The pain has developed over the past month.

How would you differentiate between Sinding-Larsen-Johansson disease and Osgood-Schlatter disease?

8. A cross-country runner complains of an aching pain on the lateral side of the patella that increases during the workout, particularly when running downhill. Slight effusion is present in the patellofemoral joint, and palpable pain is elicited over the lateral patellar border. Intense pain is felt when the patella is pushed downward into the patellofemoral groove. What factors may contribute to this condition? What long-term management might be considered after acute symptoms have subsided?
9. A patient has been diagnosed with patellofemoral stress syndrome. Your evaluation findings include an atrophied VMO and laterally displaced patella. One of the rehabilitation goals is to recruit the VMO. What type of exercises would be appropriate to implement?

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