Chapter 3
Exam

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Introduction

After formulating a list of potential diagnoses based on a detailed history, the clinician uses the physical examination to confirm or discard possible etiologies. If one consistently approaches the examination in a methodical manner, the process becomes almost second nature. While the exact sequence of the exam may vary from clinician to clinician, if the examiner uses a similar approach each time, details are less likely to be overlooked. The exam typically begins with inspection for visual clues, is followed by an evaluation of range of motion and strength, and is concluded with special testing of specific structures.

Visual Clues

Inspection actually begins the moment the patient enters the exam room with regard to the patient's general disposition, pain, and comfort level. The clinician should also assess the patient's ambulation for antalgic gait, limping, or an inability to bear weight on the extremity, which would likely indicate a serious injury. The examiner should also note the presence of erythema or significant swelling, which may indicate infection or autoimmune arthritis. With swelling, the fluid may be intra-articular, which can be difficult to assess visually unless the amount is significant, or extra-articular, which may be easier to visualize. Focal extra-articular swelling directly over the patella, for example, may indicate pre-patellar bursitis, which can

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be a fairly common occurrence after a direct fall or trauma to the anterior knee, while localized swelling or prominence over the tibial tuberosity is a typical finding in Osgood–Schlatter apophysitis [1].

The clinician should inspect both knees for muscular symmetry. The presence of unilateral atrophy of the quadriceps muscle suggests chronic pathology with the extension mechanism or significant disuse of the affected knee. If there appears to be a difference, precise circumferential measurement of the quadriceps can be entertained.

The clinician should also visually inspect for signs indicative of anatomical or biomechanical factors, which may contribute to knee pain or pathology. Significant genu valgum or genu varum may play a role in knee pain. Fortunately, most valgus or varum deformities are congenital and mild; however, significant unilateral genu valgum or varum should raise the suspicion of growth arrest or deformation of a physis, or primary growth plate, in the distal femur or proximal tibia. As anterior knee pain syndromes are common, clinical attention to the patella is recommended. A patella that sits higher, or more superior, than expected is referred to as patella alta, while one that sits more caudal is called patella baja; either can contribute to patellar pain. Patellar mal-tracking refers to abnormal gliding of the patella in the trochlear groove, while moving the knee between flexion and extension. On exam this can be seen by lateral displacement of the patella, when the patient is seated and asked to extend the knee actively ("J-sign"—patellar motion transcribes a "J" as it moves).

Mobility Clues

Range of motion can be assessed actively, passively, or against resistance. Active range of motion refers to the degree to which a patient can voluntarily move a joint. Passive motion refers to movement of the joint solely by the examiner, with no effort by the patient. Normal range of motion for the adult knee is generally considered to be 0 degrees of extension and 135–140 degrees of flexion. Commonly many individuals have slightly increased passive extension of the knee by a few degrees; however, excessive, unilateral extension is referred to as genu recurvatum and may represent prior injury. Always examine both knees, starting with the unaffected knee first. Inability to extend one knee fully, especially when there is a history of locking or catching, should alert the clinician to the possibility of an unstable meniscus tear or a loose body, such as an osteochondral fragment. Inability to flex the knee past 90–100 degrees or significant pain with flexion could indicate a meniscal tear, quadriceps injury, or large intra-articular effusion. Pain with active or resisted motion, but no pain with passive motion of the same muscle, suggests tendinitis or apophysitis.

When assessing motion, one can also evaluate motor strength. To measure quadriceps strength, the clinician typically has the seated patient extend the knee against resistance. To gauge hamstring strength, the ideal patient position is prone and then the patient flexes the knee against resistance applied by the examiner. Universally,

Table 3.1 Strength grading scale

Grade	Significance
0	No contraction (complete paralysis)
1	Slight contractility without any movement
2	Active movement, with gravity eliminated
3	Active movement, against gravity, but tolerates no resistance
4	Active movement, against gravity and resistance
5	Active movement, against gravity, plus full resistance / Normal power

strength is evaluated on a graded scale from 0 to 5 (Table 3.1). Again, comparison to the unaffected knee is helpful.

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In addition to simple resisted strength testing, the clinician may consider performing a functional evaluation for a more global assessment of true joint performance. Simple maneuvers, such as having the patient perform a double or single leg squat, duck walk (walking in a partially squatted position for several steps), or jogging in the clinic hallway can provide clues to the regular function of the quadriceps and hamstrings, in addition to pelvic stabilizers and lower leg muscles. The ability to complete these motions satisfactorily without pain, particularly the duck walk, is reassuring to the examiner and decreases the likelihood that the patient has a large effusion, ligamentous tear, significant tendinopathy, or meniscal tear [2].

Exam Maneuvers

Palpation

Palpation is a simple yet effective tool for examining the knee. In order to palpate successfully, the clinician must become familiar with the detailed anatomy of the knee joint. Although one should also consider palpating in a methodical fashion so as not to overlook any critical anatomical areas, clinicians will often palpate the expected area of pain last. Important areas to palpate in the young athlete include the apophyses, the medial and lateral joint lines, as well as the distal femur and proximal tibia (Table 3.2). Most of these structures are more easily palpable with the patient supine and the knee flexed to 90 degrees.

Palpation may also be helpful in the evaluation of swelling, particularly with differentiating an intra-articular effusion from extra-articular fluid. Intra-articular effusions typically result from internal derangement, such as injury to the articular cartilage, menisci, or ligaments. If the fluid accumulates quickly, the swelling likely represents hemarthrosis and may be evidence of a fracture or significant bone contusion, such as that seen in a patellar dislocation or rupture of the anterior cruciate ligament (ACL). The presence of intra-articular swelling can often be appreciated

Table 3.2 Important landmarks for pediatric knee palpation

Anatomic Landmark	Potential significance
Tibial tuberosity	Osgood–Schlatter (tibial tuberosity apophysitis)
Inferior pole patella	Sinding–Larsen–Johansson (inferior patellar apophysitis) or patellar tendinitis
Superolateral patella	Bipartite patella
Medial joint line	Medial meniscus, medial collateral ligament
Lateral joint line	Lateral meniscus
Medial or lateral distal femur or proximal tibia	Physeal injury (i.e. Salter–Harris fracture)
Medial or lateral patellar facet	Patellofemoral pain syndrome
Fibular head	Lateral collateral ligament, biceps femoris tendinitis
Gerdy's tubercle, distal iliotibial band	Iliotibial band syndrome

Fig. 3.1 Palpation of intra-articular effusion. With the superiorly placed hand, the fluid is compressed from the suprapatellar pouch toward the inferiorly placed hand which palpates the fluid wave

both on visual inspection and palpation in the supra-patellar pouch. If a significant amount of fluid is present, the patient will often "lose" the normal indentations seen alongside the patella when the knee is fully extended. Fluid here can also be detected using a "milking maneuver" by first gently milking the fluid from the medial side of the patella with the palm of the hand and then applying gentle compression to the superolateral aspect—this will elicit a fluid wave, which is often visible and/or palpable along the medial side of the patella (see Fig. 3.1). Comparison to the contralateral knee is important.

Extra-articular collections of fluid may result from simple contusions, bursitis, or tearing of the quadriceps muscle–tendon unit. Pre-patellar bursitis can result from direct trauma to the anterior knee, seen commonly in wrestlers, and may present as focal swelling and tenderness of the anterior aspect of the patella. Pes anserine bursitis results in local swelling and tenderness over the insertion of the gracilis, sartorius, and semitendinosus on the anteromedial knee.

Ligament Testing

Ligamentous injuries can occur in young athletes and, therefore, familiarization with common testing techniques of the major ligaments is essential.

Medial Collateral Ligament

Medial collateral ligament (MCL) injuries typically occur from a direct blow to the lateral aspect of the knee resulting in stretching or, possibly, failure of the ligament. Typically, there will be localized swelling and tenderness over the ligament as it crosses the medial joint line or over its more proximal aspect. The valgus stress test is used to evaluate the integrity of the MCL. To perform the valgus stress test, the knee should be held and passively flexed to approximately 20–30 degrees, and then a medially directed force is applied with the palm of the hand on the lateral aspect of the knee. A mild sprain may result in medial-sided pain with this maneuver; a severe sprain or complete tear will result in palpable opening or "gapping" along the medial side. The test should be repeated at 0 degrees of flexion (see Fig. 3.2). Normally there should be no gapping at 0 degrees; the presence of joint opening in full extension indicates a more severe injury, likely a concomitant injury to a cruciate ligament.

Lateral Collateral Ligament

The lateral collateral ligament (LCL) is often injured with a direct blow to the medial knee or a non-contact extension/varus overload mechanism. The patient will likely have localized tenderness and swelling laterally. To evaluate the LCL, the varus stress test is performed similarly to the valgus stress test but with the hand position reversed and a laterally directed force applied to the medial aspect of the knee, forcing the knee into varus. Again, the clinician assesses for the presence of lateral pain or laxity. After performing the varus stress test at 20–30 degrees of flexion, the examiner should repeat the test at 0 degrees of flexion (see Fig. 3.3). Gapping at both 20–30 degrees and 0 degrees suggests a more severe injury, such as a concurrent tear of the anterior or posterior cruciate ligament (PCL) or other stabilizing structures.

Fig. 3.2 Valgus stress test. The patient is relaxed, and the knee is in 20–30 degrees of flexion. The examiner places one hand along the lateral side of the knee joint and applies a valgus stress to the knee. The examiner assesses for laxity of the medial collateral ligament. The test is then repeated at 0 degrees of flexion

Anterior Cruciate Ligament

Unfortunately, anterior cruciate ligament (ACL) injuries are relatively common among young athletes and represent a significant cause of morbidity. Classically, the method taught to evaluate the ACL is the Anterior Drawer Test. To perform this test, the patient is in a supine position, the hip is flexed to 45 degrees, and the knee is flexed to 90 degrees. The examiner grasps the knee on both the medial and lateral aspects just below the joint line, placing the thumbs over the anterior tibial plateaus. With the foot stabilized, the examiner pulls the tibia anteriorly (see Fig. 3.4). The test is considered positive if there is the lack of a solid palpable endpoint, when compared to the uninjured knee [3]. Unfortunately, the results of the Anterior Drawer Test can be affected by hamstring spasm and guarding; therefore, the test carries a relatively low sensitivity and specificity, reported as 18–92% and 78–98%, respectively [4]. A more sensitive and specific means to examine the integrity of the ACL is Lachman's test. To perform Lachman's test, the patient is supine and relaxed. The examiner grasps the knee with one hand above the knee joint and places the other hand below the knee joint with thumbs on the anterior aspects. The more superior hand controls and positions the leg to approximately 15–25 degrees of flexion;

Fig. 3.3 Varus stress test. Similar to the valgus stress test, the patient is relaxed with the knee flexed to 20–30 degrees. The examiner places one hand along the medial side of the joint and applies a varus stress to the knee, assessing for laxity, or opening, of the lateral collateral ligament. The edge of the exam table can be used as a fulcrum, as seen in the picture here

this hand remains still for the exam (see Fig. 3.5). The other hand is then used to pull the tibia anteriorly. Typical anterior translation is less than 5 mm often with a firm endpoint noted; a significant side-side difference is considered abnormal. Sensitivity and specificity of Lachman's test have been reported as 63–93% and 55–99% respectively [4]. The presence or absence of an endpoint may be the most reflective of the state of the ACL [5]. The examiner may note difficulty obtaining either of these tests in the sub-acutely injured knee and may experience more accurate results, if the exam is performed either immediately post-injury or, conversely, after the swelling and pain have subsided.

Posterior Cruciate Ligament

Injury to the posterior cruciate ligament (PCL) is less commonly seen in the young athlete but can occur from either hyperextension or when the tibia is suddenly forced in a posterior direction with respect to the femur. The Posterior Sag Sign and Posterior Drawer Test can be used to assess the integrity of the PCL. For these tests, the patient is supine and relaxed with the knee flexed to 90 degrees and feet resting

Fig. 3.4 Anterior drawer test. The patient is supine and relaxed with hips flexed to 45 degree and the knee flexed to 90 degree. The examiner places both thumbs on the anterior tibial plateaus and stabilizes the patient's foot with their body or an assistant. Then the examiner exerts an anteriorly directed force. The knee with an intact ACL will demonstrate minimal translation; however, an ACL-deficient knee will show increased anterior translation with no solid endpoint

flat on the exam table. For the Posterior Sag Sign, the examiner visually inspects the knee joints from the side and notes the position of the tibial plateaus with respect to the femoral condyles. This "sag" can also be appreciated on palpation as typically the anterior aspect of the medial tibial plateau will sit 5–10 mm anterior to the anterior aspect of the medial femoral condyle; however, in the PCL-deficient knee, gravity will allow the tibia to "fall back," and the plateau will appear to sit more posterior, when compared to that of the contralateral knee. The normal step-off will be absent. For the Posterior Drawer Test, similarly to the Anterior Drawer Test, the examiner approaches the patient from the front and places the thumbs over the anterior tibial plateaus and the fingers behind the flexed knee medially and laterally. Then the examiner applies a posteriorly directed force against the tibia and should note increased posterior translation, typically more than 10–12 degrees in the PCL-deficient knee, compared to the uninjured joint (see Fig. 3.6).

Patellofemoral Instability

Instability at the patellofemoral joint can be a significant cause of morbidity in the young athlete. Injury to the medial patellofemoral ligament can lead to patellar subluxation or frank dislocation. If the clinician encounters a patient with an acutely

Fig. 3.5 Lachman test. The examiner grasps the knee with the one hand above the knee joint and places the other hand below the knee joint with thumbs on the anterior aspects. The more superior hand controls and positions the leg to approximately 15–25 degrees of flexion; this hand remains still for the exam. The inferior hand is then used to pull the tibia anteriorly. In a patient with an intact ACL, a firm endpoint should be noted

Fig. 3.6 Posterior drawer test. Similar to its anterior counterpart, in the posterior drawer test, the patient is supine and relaxed with the knee flexed to 90 degrees and foot resting flat on the exam table. The examiner places the thumbs over the anterior tibial plateaus and the fingers behind the knee medially and laterally. Then the examiner applies a posteriorly directed force against the tibia and should note increased posterior translation, typically more than 10–12 degrees in the PCL-deficient knee, compared to the uninjured joint

dislocated kneecap, the knee will usually be semi-flexed and the patella in an obviously abnormal position laterally. To reduce, the clinician can simply extend the knee slowly, while applying a slight medially directed pressure along the lateral border of the patella; the kneecap should return to its normal anatomic position by the time the joint is fully extended. Following a patellar dislocation, the patient will usually have a large, swollen knee with tenderness along the medial aspect of the patella and the lateral femoral condyle, due to bone contusions with resulting hemarthrosis. Sub-acutely and chronically, the clinician can test for instability by performing the patellar apprehension test. To perform the test, the patient should be supine on the exam table with the legs fully extended and relaxed. The clinician places the index finger or thumb along the medial border of the patella and applies slight laterally directed pressure. In the case of patella instability, often the patient will abruptly instruct the clinician to stop the maneuver as this recreates the sensation of instability. If compared to the contralateral knee, the clinician will also typically note increased lateral translation of the patella with respect to the trochlear groove.

Meniscal Injury

Meniscal cartilage is susceptible to injury. Tears can occur in the medial or lateral meniscus; however, in both cases the majority of tears occur in the body and posterior horns. Most meniscal tears will present with pain localizable on either the medial or lateral side, tenderness over the respective joint line, and intra-articular effusion. Several physical exam maneuvers exist to aid in confirming the presence of a meniscal tear. In all tests, the objective is essentially to compress the affected meniscus between the tibia and femur. McMurray's test is performed in a supine patient by passively internally rotating and flexing the knee to test the lateral meniscus and externally rotating and flexing the knee to test the medial meniscus (see Fig. 3.7). Classically, a test is described as positive, when the examiner feels a "click" during the maneuver; however, more commonly elicitation of pain along either joint line, when flexing the knee during McMurray's, is considered a positive result. The sensitivity of McMurray's test ranges from 16 to 88% in the medical literature, while the specificity ranges from 20 to 98% [6]. The Thessaly test is performed actively by the patient, who stands on one leg with the knee in approximately 20 degrees of flexion and then rotates medially and laterally upon the leg. Elicitation of pain, which localizes to the respective joint line, is described as a positive test. The sensitivity and specificity of Thessaly's test have been described as 62–66% and 39–55%, respectively [7].

Fig. 3.7 The McMurray test. The examiner places the finger and thumb of one hand along the joint lines and grasps the foot with the other hand. The knee is then brought into maximum flexion with the foot externally rotated to compress the posterior portion of the medial meniscus. Then the examiner extends the knee, internally rotates the foot, and repeats the flexion maneuver to compress the posterior horn of the lateral meniscus. Classically, the test is positive if a "click" is palpable over the injured meniscus, but commonly many clinicians consider elicitation of pain as a positive test

Chapter Summary

Learning and practicing a methodical approach to examining the knee will aid the clinician in narrowing the differential diagnosis. Examination often begins with inspection and observation for visual clues, followed by assessment of range of motion and strength. Palpation for swelling and areas of tenderness is often helpful. Specific exam maneuvers can then be employed to evaluate for injuries to the major ligaments or menisci. One important point to recall is that not all knee pain originates in the joint itself. The clinician who encounters a patient with reported knee pain, but a completely unremarkable exam, would be well served to examine the hip and/or lumbar spine for any potential sources of referred pain.

References

1. Patel DR, Villalobos A. Evaluation and management of knee pain in young athletes: overuse injuries of the knee. Translat Pediat. 2017;6(3):190–8.
2. Schraeder TL, Terek RM, Smith CC. Clinical evaluation of the knee. N Engl J Med. 2010;363(4):e5.
3. Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain: part I. history, physical examination, radiographs, and laboratory tests. Am Fam Physician. 2003;68(5):907–12.
4. Ostrowski JA. Accuracy of 3 diagnostic tests for anterior cruciate ligament tears. J Athl Train. 2006;41(1):120–1.
5. Mulligan EP, McGuffie DQ, Coyner K, Khazzam M. The reliability and diagnostic accuracy of assessing the translation endpoint during the Lachman test. Inter J Sports Phys Therapy. 2015;10(1):52–61.
6. Hing W, White S, Duncan R, Marshall R. Validity of the McMurray's test and modified versions of the test: a systematic literature review. J Manual Manipulat Therapy. 2009;17(1):22–35.
7. Blyth M, Anthony I, Francq B, Brooksbank K, et al. Diagnostic accuracy of the Thessaly test, standardised clinical history and other clinical examination tests (Apley's, McMurray's and joint line tenderness) for meniscal tears in comparison with magnetic resonance imaging diagnosis. Health Technol Assess. 2015;19(62):1–62.