Expert Review  Examination of the Knee

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Abstract  Knee pain affects a significant proportion of the adult population and is second only to back pain among musculoskeletal complaints - accounting for three to five percent of new presentations to primary care physicians. As such the examination of the knee is important for generalists and specialists. This article describes a comprehensive and concise evidence-based approach to clinical examination of the knee. word count: 5801.

Key words: clinical examination, knee examination, knee joint.

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Introduction

Ten to fifteen percent of adults report knee symptoms – this rises to 37% in people aged over 50 [1, 2] – and knee complaints make up three to five percent of the new presentations in primary care. The most common diagnoses of adults with new onset knee pain in primary care are: osteoarthritis (34%), meniscal injuries (9%), collateral ligament injuries (7%), cruciate ligament injuries (4%), gout (2%), fractures (1.2%), rheumatoid arthritis (RA) (0.5%), septic arthritis (0.3%), and pseudogout (0.2%) with the remaining 42% of cases being made up of other largely self limiting muscular and ligamentous injuries [2, 3].

The knee is a modified synovial hinge joint with tibio-femoral (both medial and lateral) and patellofemoral components – see Figure 1. There is little congruency between the articular surfaces of the tibia and femur and as a result there is a well developed system of ligaments to give knee stability and an arrangement of intra-articular menisci to reduce contact loading between the femur and tibia. The joint is largely subcutaneous allowing easy palpation of many of its structures.

Bursae are closed fluid filled sacs that serve to reduce friction between bones and overlapping muscles, tendons and skin around the large joints. A normal bursa is impalpable and non-tender. If a bursae becomes inflamed – known as bursitis – it’s membrane becomes more vascular and the sac can fill with fluid which may be detected as a lump on examination.

There are eleven associated bursae around the knee of which four are commonly clinically significant – see Figure 1. The prepatella bursa lies over the lower pole of the patella. Knee flexion causes increased tension over the bursa resulting in pain. Previously described as ‘housemaids knee’ it is seen in many occupations. More distally lies the infrapatella bursa which can be divided into superficial and deep components. The superficial component lies between the patellar ligament and the skin, while the deep component lies between the patellar ligament and the proximal anterior tibia. Like prepatella bursitis pain is evoked on flexion but in infrapatella bursitis swelling may be seen either side of the patella ligament. It is seen in occupations that involve excessive upright kneeling and historically is referred to as ‘clergyman’s knee’. The anserine bursa lies on the medial aspect of the knee 5cm below the joint line over the insertions of the sartorius, gracilis, and semitendinosus tendons, that resemble a goose’s foot. It is commonly inflamed in older, obese females and pain is elicited at the extremes of range of movement and on stair climbing. In the posterior aspect of the knee lies the popliteal bursae – also known as a Baker’s cyst - which may become inflamed and cause pain on walking, jumping and squatting.

It is essential to understand the anatomy of the knee as well as the normal function of its components to perform a rational examination and accurately interpret the signs.
The following textbooks of clinical examination were reviewed:

Evidence Based Physical Diagnosis [5]
Macleod’s Clinical Examination [6]
Clinical Orthopaedic Examination [7]
Orthopaedic Examination Made Easy [8]
Essential Orthopaedics and Trauma [9]

The PubMed database was searched using the Medical Subject Headings (MeSH) terms: knee, gait, patella, collateral ligaments, anterior cruciate ligament, posterior cruciate ligament and patellofemoral pain syndrome. The free text terms: effusion, fluid displacement, anterior draw, Lachman’s, pivot shift, posterior draw, meniscus, McMurray, Apley and patella apprehension test were also searched. These terms were combined with the MeSH terms ‘physical examination’ or ‘diagnostic tests, routine’.

Clinical prediction rules were searched for the knee. The Rational Clinical Examination Series of the Journal of the American Medical Association; clinicalevidence.com and Evidence Based Medicine Online were also searched with the terms ‘knee’ and ‘clinical examination’ [4, 36].

Selection criteria were relevant papers written in English and available through Oxford University e-resources.

Preparation
Select an appropriate setting, wash your hands, introduce yourself and confirm the patient’s identity. The procedure should be explained to the patient and informed consent should be obtained. Before proceeding with the examination establish the presence and site of any pain. Ideally, both lower limbs should be exposed from above the knee to the ankle. This can be achieved by asking the patient to remove their trousers or skirt whilst. There is no need to remove underwear but you should arrange a chaperone if appropriate. Alternatively patients may change into a pair of shorts or they may prefer to tie a gown around the waist. Shoes and socks should be removed. In practice, less complete forms of exposure may be feasible and examiners should be pragmatic.

Inspection (‘Look’)

Initial Global Inspection
Begin the examination with an initial global inspection. Look for signs of disease, walking aids and medical equipment. Explain what you are doing to the patient to avoid embarassment. Any sign is potentially relevant at this stage of the examination – signs of rheumatological disease [37] are especially important - but a full list is obviously beyond the scope of this article. The key point is that signs of systemic disease may be an indication for a more formal examination of other systems at the end of the examination of the knees. Walking aids and medical equipment are also important signs of disease and their details should be noted.

Gait
Next assess the patients’ gait. Ask him/her to walk in a straight line for ten steps, turn, and return ten steps – see Figure 2. Observe the patient whilst analysing the foot, ankle, knee, hip, pelvis, trunk and spine in turn.

The normal gait consists of two phases. Stance is initiated with a ‘heel strike’, extensor muscles are then contracted until the end of stance, ‘toe off’. Swing phases begin with ‘toe off’, flexors are then activated until ‘heel strike’. Look for symmetry,
deformity, abnormal movement, and stiffness. This should be repeated in the patient’s ‘everyday shoes’ (if the initial assessment was in bare feet) however this maybe impractical and can be omitted if necessary.

Figure 2 Analysing gait.

Asking children to walk quickly or run can unmask hidden abnormalities [6]. If the patient requires a walking aid, such as cane, it should be an appropriate length, from the distal wrist crease to the ground with ‘everyday shoes’ on and arms by the side. The cane is typically held in the hand on the contralateral side to a painful joint [10].

A detailed account of abnormal gait is beyond the scope of this article but we shall describe the features of an antalgic gait. This is an abnormal gait which is adopted by the patient to minimise pain – the so called ‘dot dash’ mode of walking. Antalgic gaits have a characteristic short step on the painful limb (dot) with a falling centre of gravity (sinking) followed by a prolonged phase on the opposite unaffected limb (dash) as the centre of gravity rises again to normal. Painful joints can also be stiff, so the knee may not extend or flex fully during the swing phase. This results in the foot dragging on the floor and the development of adaptive movements such as contralateral trunk lean or contralateral vaulting [11, 12]. A detailed review of gait analysis has been published elsewhere [13].

Figure 3 Analysing alignment.

Move round to the side of the patient and look for hyperextension of the knee joint, genu recurvatum. This is present if the knees extend over 10 degrees beyond neutral. If hyperextension is severe you may wish to look for other signs of joint laxity (hyperextension in the elbow, wrist, and fingers) at the end of the examination.

The most common cause of varus deformity in adults is osteoarthritis (OA) as there is narrowing of the medial joint compartment because the weight bearing axis of the body goes through the medial compartment of the knee. Varus deformity can also occur in Paget’s disease and rupture of the lateral collateral ligament. It rarely occurs in rheumatoid arthritis (RA) in the absence of secondary OA. Genu varum is a common growth abnormality of early childhood and usually resolves spontaneously. In the 10 to 16 years age group a space between the medial epicondyles of the knee in varus deformity and between the medial maleoli of the ankle in valgus and deciding whether this is secondary to unilateral or bilateral deformity [9]. The degree of deformity can be accurately measured using a goniometer however these are not used routinely in clinical practice.
In adults genu valgum is most often seen in RA secondary to bone softening and ligamentus stretching. It may also occur secondary to medial collateral ligament tear, or it may be a consequence of an uncorrected fracture of lateral tibial plateau with depression. In young children valgus deformity may be seen in association with flat feet. However nearly all cases resolve by the age of six.

Valgus deformity may also be seen in obese adolescent girls where it is a contributory factor in recurrent patella dislocation. The intramalleolar gap can be measured in the 10 to 16 years age group with up to 8cm in females and 4cm in males being considered normal. In both valgus and varus deformity serial measurements every six months can be used to check progress, note that in growth a static intramalleolar/intraepicondylar measurement represents angular improvement. Normal alignment is for the knee to be in 5 to 7 degrees of valgus.

In addition to generalised joint hypermobility, hyperextension may also be seen after rupture of the anterior cruciate ligament (ACL). In genu recurvatum growth of the upper tibial epiphysis may be retarded from excess point work in ballet classes or wearing high heeled shoes in adolescence resulting in hypoplasia of the proximal tibial epiphysis. This combined with hyperextension and associated patella alta lead to a tendency to dislocation. Rarely, this abnormality is seen in congenital joint laxity, poliomyelitis and Charcot’s disease.

Inspection of the Knees
The rest of the examination of the knees is conducted with the patient supine. Ask him/her to lie on an examination couch. The couch should be inclined at 45 degrees and there should be a pillow behind the head for comfort.

Inspect the knees in detail. Compare one with the other looking for asymmetry. Note the colour of the overlying skin and look for rashes, scars and sinuses. Look for lumps around the knee and note the presence of localised swellings such as cysts or fluid filled bursae. Look to see if there is swelling of the knee joint. Swelling confined to the limits of the synovial cavity and suprapatella pouch suggests joint effusion and intra-articular pathology. Swelling beyond the limits of the joint cavity suggests infection, tumour, or major injury to the femur or tibia.

Effusions are detectable most easily by inspection. Look for bulging at the sides of the patella ligament and obliteration of the hollows at the medial and lateral edge of the patella. The normal volume of synovial fluid is 1-2 ml and this may be increased in pyarthrosis (suppurative arthritis), RA, synovitis, space occupying lesions or haemoarthrosis secondary to intra-articular fracture or tear to a vascular structure such as one of the cruciate ligaments.

Look for muscle wasting in the thigh and the calf by inspecting for loss of muscle mass and asymmetry in the contours of the skin. Muscle wasting is almost invariably with inflammation, or chronic pain and develops in the first days up to a fortnight. In the thigh this is frequently referred to as quadriceps wasting however it should be noted that the hamstrings are a larger muscle group than quadriceps alone and it is not possible to differentiate between the two based on thigh circumference. To evaluate muscle wasting measure thigh girth in both legs 15cm above the tibial tuberosity – see Figure 4. Measurements of muscle mass may be over-estimates secondary to soft tissue swelling, joint effusions, or callus round a fracture site which may result in an increase in thigh circumference.

Palpation ('Feel')
Next assess the temperature of the knee by palpation using the back of your hands where possible. Palpate both knees simultaneously to compare the temperature in each knee. Begin by palpating about 5cm proximal to the patella and slowly move the backs of the hands distally along
the limb over the knee to a point about 5cms distal to the patella. Then palpate the medial and lateral sides of each knee close to the joint line. The temperature of the knee may be normal, increased or decreased. The main causes of an increased temperature are infection and inflammation. The main cause of a decreased temperature is complex regional pain syndrome (CRPS) - also known as reflex sympathetic dystrophy.

Specifically palpate any lumps detected during inspection. These should be characterised in the normal way\(^3\). In particular, decide if it is hard, perhaps representing bone, or soft and fluctuant representing an effusion or bursitis. Test the texture of the swelling and also note if there is soft tissue or bony tenderness.

There are two tests for effusion: the patella tap test and the fluid displacement test (also known as the bulge test or ripple test) – see Figures 5 and 6. To perform the patella tap test with the knee extended fully and quadriceps relaxed empty the suprapatella pouch by sliding your hand down the thigh until you reach the upper edge of the patella. Keep your hand there, and with your other hand briskly press down firmly over the patella. In moderate sized effusions a tapping sensation, as the patella strikes the femur, is felt. A fluid impulse in your other hand may also be noted. To detect smaller effusions the fluid displacement test may be used. Empty the suprapatella pouch as described above. With your other hand stroke the medial side of the patella followed by the lateral side of the patella. Look for fluid reaccumulation on the medial side of the patella. Note in a gross tense effusion this test will be negative. The fluid displacement test should be used as a screening tool to detect effusions with the patella tap test performed subsequently if positive to establish if an effusion is moderate to large in size.

With the knee extended systematically palpate the joint line. Start anteriorly and work posteriorly one side at a time remembering to palpate the popliteal fossa. At the medial and lateral aspects of the knee examine the upper and lower attachments of the collateral ligaments. Note if there is tenderness of the joint line or of the ligamentous attachments and try to localise it as accurately as possible. Localised tenderness is most common in meniscal, collateral ligament and fat pad injuries and may be associated with bruising and oedema\(^6\).

To assess the extensor mechanism start by palpating the tibial tuberosity working proximally up the patella tendon, over the patella to the quadriceps tendon. Localised tenderness over the tibial tuberosity is a sign of Osgood-Schlatter disease (which is a traction osteochondritis) or avulsion of the patella ligament from its tibial attachment. Tenderness over the lower pole of the patella is found in Sinding-Larsen-Johansson disease. Next ask the patient to perform the straight-leg raise by instructing him/her to lift their heel off the couch with the knee in full extension. If the patient cannot achieve full active extension then an extensor lag is present suggesting quadriceps weakness or abnormality of the extensor apparatus. Patients with quadriceps rupture are still able to lock out the knee to achieve a straight leg raise using the pes anserinus hence it is essential to exclude this by asking the patient, when their leg is raised, to flex their knee 20 degrees then re-straighten from the flexed position.

If an extensor lag is present a detailed examination of the extensor apparatus should be performed to identify the underlying pathology. Ensure that quadriceps tone is normal by palpating the muscle on active extension. Assess the tone and muscle

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\(^3\) See Figures 5 and 6 for illustrations of the patella tap test and fluid displacement test.
bulk of vastus medialis by asking the patient to dorsiflex the inverted foot as weakness of this muscle has been implicated in recurrent patella dislocation [6]. Reduced tone may suggest abnormality of the motor innervation or intrinsic abnormality of the muscle. On extension note the position of the patella in relation to the joint line and tibial tuberosity, a high patella, compared to the contralateral side, suggests that it is proximally displaced secondary to patella fracture, rupture of the patella ligament or avulsion of the tibial tubercle. Inspect and palpate the different levels working distally down the extensor mechanism to differentiate between these different pathologies. If the patella lies normally ask the patient to relax, and palpate just proximal to the superior pole of the patella as the patient contracts their quadriceps, loss of normal soft tissue resistance suggests rupture of the quadriceps tendon [6].

**Manipulate (‘Move’)**

**Range of Movement in Flexion and Extension**

Range of movement is the most sensitive indicator of joint disease [5]. First test active movement of the knee. Ask them to flex their knee up as far as it will go and extend back down whilst palpating for crepitus – see Figure 7. Crepitus is a sign of OA in older patients or in younger, particularly female patients, suggestive of chondromalacia patellae. Establish whether the range of movement is normal or reduced and estimate the degree of extension and flexion achieved. This can be accurately measured using a goniometer but this is not part of the routine examination of the knee. Normal range of movement is from neutral (-5 degrees, full extension) to 135 degrees (full flexion). You should always compare the range of movement to the contralateral knee.

![Figure 7 Assessing active range of movement of the knee.](image)

Repeat flexion and extension manoeuvres passively this time taking the weight of the patients leg and asking them to relax. Extend the knee fully, ensuring full extension by lifting heels off the couch and checking for hyperextension by looking from the foot along the leg. Note if there is any block to full passive extension and record whether this is springy, or rigid (a fixed flexion deformity). Blocks to full extension, or flexion and locking of the knee can be longstanding, or intermittent. There main causes are: loose bodies which can develop in the knee secondary to OA, osteochondritis dissecans, or synovial chondromatosis and meniscal tears, particually bucket handle and anterior beak tears. The latter result in a springy block to full range of movement and are particularly associated with locking [6]. Testing for meniscal tears will be discussed later. Compare passive range of movement to active movement and that of the contralateral knee.

**Knee Stability**

Knee stability is dependent on the joint capsule plus two pairs of ligaments: the collateral ligaments and the cruciate ligaments. Any of the four main ligaments may rupture with trauma, or become loose with degenerative disease giving rise to instability at the knee. Diagnosis and interpretation of instability of the knee can be difficult as several structures may be damaged at once and each ligament has a primary as well as secondary supportive function. Furthermore symptoms and clinical signs may be masked during the initial stages and only become clear later as secondary structures stretch and give rise to further disability.

Test each of the pairs of ligaments and the menisci in turn. Each of the components of the knee joint can be tested in many ways and the best way for the medical student or generalist it is to become competent with one method of testing each of the structures of the knee in the first instance. As confidence and competence grows additional tests can be added to the repertoire. Specialists should be able to use all the techniques described in this article. In the following section a variety of examination methods are described that test the soft tissue structures of the knee.

**Collateral Ligaments**

During inspection localised bruising, oedema or tenderness overlying the attachments of the collateral ligaments (the medial and lateral femoral epicondyles proximally and medial surface of the
tibia and fibula head distally for the medial and lateral ligaments respectively) may have been noted.

Begin by passively extending the knee fully, then using one hand as a fulcrum on the lateral side of the joint attempt to abduct the leg, applying a valgus force to the knee testing the medial collateral ligament. Use your thumb to palpate the medial joint line to assess for opening. With an intact ligament no movement should be possible, however pain may be reproduced in the case of a partial tear to the ligament. Moderate valgus suggests collateral laxity, or rupture with severe deformity suggesting other structures may also have been damaged within the knee. If no movement is detected with the leg fully extended repeat the test with knee flexed to 30 degrees and foot internally rotated to test for minor collateral laxity. In this position some opening of the knee is normal as in this position the collateral ligaments are not taught. It is important to compare with the contralateral side. The test should be repeated with the fulcrum on the medial aspect of the joint and varus pressure applied to test the lateral collateral ligament. Figure 8. Grade the extent according to the system shown in Table 1.

Figure 8 Valgus and varus stress testing.

Several studies have assessed the accuracy of valgus and varus stress testing – see Evidence Box 1. The medial collateral ligaments are more commonly injured, however, where clinically lateral collateral rupture is suspected it is always important check the integrity of the common peroneal nerve by ensuring the patient is able to dorsiflex the foot and that there is no evidence sensory disturbance within the nerve distribution [6].

The Anterior Cruciate Ligament

The cruciates are named after their attachment to the tibial surface. The anterior cruciate ligament prevents anterior subluxation of the tibia on femoral condyles, and is also a key ligament in resisting internal rotation of the tibia on the femur. Ruptures of anterior cruciate ligament are most often seen in combination with tears of the medial meniscus either simultaneously, or following a chronic meniscal tear. In the latter, a locking fragment leads to progressive stretching and attrition rupture when attempting to reach full extension. In the most severe injuries the medial ligament may also be affected. This is known as the triad of O’Donoghue.

Three commonly used tests for anterior cruciate integrity are the anterior draw, Lachman’s test and the pivot shift test.

Anterior Draw Test

Perform the anterior draw test with the patient lying supine, the hips flexed at 45 degrees and the knees flexed at 90 degrees – see Figure 9. Sit gently on patient’s feet placing your hands behind the upper tibia with thumbs on tibial tuberosity. Apply anterior pressure on the proximal tibia try to draw the knee towards you. Abnormal anterior subluxation with a soft endpoint is a positive test. If significant movement is detected the anterior cruciate is lax, subluxation greater than 1.5cm suggests rupture. In the event of a negative test some authors suggest repeating the test at 70 degrees flexion of the knee [6]. Whilst it has been suggested that this may result in an increase in sensitivity, see below, there is little data comparing the anterior draw test at 90 degrees and 70 degrees. It is important to exclude posterior sag, see below, as this may result in a false positive test.

Lachman’s Test

The Lachman’s test is performed in the same position as the anterior draw test but with the knee flexed to 20 degrees – see Figure 10. One hand is placed on the anterior aspect of the distal femur with thumb on the joint line and one hand on the proximal tibia. The tibia is pulled forward to stress the anterior cruciate ligament. The test is considered positive if anterior tibial movement is detected with a spongy endpoint. An active
Lachman’s test has also been described, yet is used less commonly. In this version of the test the knee is supported at 30 degrees and the patient is asked to extend their knee. Anterior subluxation of the lateral tibial plateau occurs as the quadriceps contract. This is best seen from medial side. Posterior subluxation on relaxation is considered a positive test. Repeat the test with resisted extension at ankle.

Figure 9  Anterior draw test.

Figure 10  Lachman’s test.

Pivot Shift Test
Many versions of the pivot shift test (for example the McIntosh test and the Losee test) have been described. In the most common variant the patient is supine with the hip and knee extended – see Figure 11. The examiner lifts the patient’s leg with two hands placed around the mid shaft of the tibia. The leg is internally rotated with valgus stress applied at the knee by attempting to abduct the tibia on the femur. The knee is then slowly flexed to 90 degrees. In the anterior cruciate deficient knee the tibia subluxes forward almost imperceptibly during the first 30 degrees of flexion, however once past 40 degrees the tibia spontaneously reduces by subluxing posteriorly and the test is considered positive [39]. The underlying mechanism of this test is unclear, however, it is thought to be due to the pull of the ileotibial tract which changes from knee extensor to knee flexor beyond 40 degrees combined with the ‘geometric peculiarities’ of the convex tibial surface.

Figure 11  Pivot shift test.

Interpretation of the Anterior Cruciate Ligament Tests
Several meta-analyses of the anterior draw, Lachman’s and pivot shift test have been published – see Evidence Box 2. The authors conclude that a negative Lachman’s is best to exclude anterior cruciate rupture with the best sensitivity of the three tests at around 85%. As such in clinical practice and OSCEs a Lachman’s test should be used to screen for ACL rupture. If the Lachman’s test is positive the pivot shift test may be used to confirm the diagnosis. Whilst the pivot shift test has a low sensitivity it has a high specificity of around 98%. The anterior draw test performed well in chronic anterior cruciate rupture but had variable results in acute presentations [19].

It has been proposed that Lachman’s test is more accurate than the anterior draw test for several reasons. In the acute setting haemarthrosis from anterior cruciate ligament injury may impair flexion of knee preventing the anterior draw test from being performed, furthermore pain on flexion may result in contraction of the hamstring muscles directly opposing forward subluxation of the tibia at 90
degrees, in the anterior draw test, but not at 20 degrees as in the Lachman’s test \[^5\]. It has also been suggested that the thick posterior edge of the medial meniscus may act as a wedge against the curved femoral condyles preventing subluxation of the tibia at 90 degrees. This hypothesis is supported by a study that noted that the sensitivity of the anterior draw test increased from 50% to 100% after medial meniscectomy \[^6\].

The Posterior Cruciate Ligament

The posterior cruciate ligament is the least likely of the internal structures of the knee to be injured \[^7\]. It acts to resist posterior subluxation of tibia on femur. With posterior cruciate ligament rupture the tibia is often posteriorly subluxed and this is easily visible on inspection from the lateral side with the patient supine and knees flexed to 30 degrees, a sign called the posterior sag. To confirm, draw the tibia anteriorly, as described above for the Lachman’s test, and the joint line can be felt to reduce into normal anatomical alignment. Occasionally subluxation may not have occurred despite a ruptured posterior cruciate ligament, in this instance the posterior draw test, the reverse of the anterior draw test with posterior pressure applied to the proximal tibia, is used to test its integrity. Figure 12. The data shows that this test has a sensitivity of 51-100% and a specificity of 99% – see Evidence Box 3.

The Menisci

The menisci also form an important function in the integrity of the knee joint by reducing contact loading between the femur and tibia. In young patients injuries to the menisci are often the result of twisting on a flexed weight bearing leg. In the middle aged, injuries may be the result of degenerative horizontal cleavage, with no history of trauma. Both types of injury are associated with well localised joint pain, which is the most sensitive test for meniscal injury at around 76%. Small effusions, particularly on weight bearing or after exercise, may also be observed. As the menisci are relatively avascular, bruising is not a sign of meniscal injury. Tears of menisci, particularly anterior or large bucket handle tears, displace tissue between the articular surfaces of the anterior tibia and femur. This results in a springy block to full extension of the knee and ‘locking’ which is a classical sign of meniscal injury. Internal and external rotation may release the torn or dislodged menisci resulting in a palpable reduction click.

Figure 12 Posterior draw test.

There are two commonly used tests for meniscal tears: the McMurray test (also known as the meniscal provocation test) and Apley’s grinding test.

McMurray’s Test

With the patient supine and the knee in full flexion, externally rotate the tibia to bring the medial meniscus forward. Extend the knee slowly, bringing the meniscus towards the anterior curved surface of the femoral condyle. Palpate the medial joint line with your thumb and index finger. Clicking, associated with pain, is suggestive of a meniscal tear. Watch the patient’s face for signs of pain - not the knee. Repeat the test internally rotating the tibia to test the lateral meniscus. Palpat ing just medial to the patella ligament when performing this manoeuvre can help identify anterior horn tears. Figure 13. Some studies add valgus or varus stress, however, this wasn’t described by McMurray and has not been used in clinical studies testing the signs accuracy.
Apley’s Grinding Test

In Apley’s grinding test the meniscus is subjected to compression and shearing stresses with sharp pain suggestive of a tear. With the patient prone externally rotate the foot, and flex the knee to 90 degrees. Load the joint in line with the tibia and slowly internally rotate the foot identifying and localising any pain. Repeat with a greater degree of flexion to test the posterior horn. Figure 14.

Weight Bearing Tests for Meniscal Damage

Recently, two weight bearing tests for meniscal injury have been described [18, 19]. Ege’s test is performed with the patient standing with their feet 25cm apart. To test the medial meniscus, the feet are externally rotated and the patient is asked to squat. Replication of pain with an audible and palpable click over the medial aspect of the knee is considered a positive test. The test is repeated with the feet internally rotated to test the lateral meniscus.

Thessaly’s test is performed with the patient standing on one leg, arms outstretched supported by the examiner. The patient is asked to flex their knee 5 degree and then to rotate their body externally and internally three times. The test is repeated with the knee flexed to 20 degrees. The test is considered positive if the patient reports medical or lateral joint line discomfort, clicking, or locking of the knee. Initial reports suggest that these tests, whilst simple to perform, have high sensitivities and specificities - see Evidence Box 4. However, it must be noted that only a small number of studies, each with under 250 patients, have assessed the validity of these tests and as such, they are not yet commonly used in orthopaedic practice.

The Patella

Finally, it is important to assess the patella. As mentioned previously the normal knee has a small, 5 to 7 degree, valgus angle and as a consequence the patella is prone to dislocate laterally [8]. Lateral dislocation is accentuated further by: valgus deformity with an increased quadriceps (Q) angle, a hypoplastic lateral femoral condyle, lateral insertion of quadriceps muscle, a shallow condyle sulcus, genu recurvatum and a hypoplastic patella [9]. All these factors lead to the patella not engaging in condylar gutter as the knee flexes. This leads to recurrent dislocation and patello-femoral pain. First assess the patella and measure the Q angle. This is the angle between the line joining anterior superior iliac spine and the centre of patella and the line of the patella ligament with the knee in full extension. This is normally 14 (+/- 3) degrees in males, and 17 (+/- 3) degrees in females, due to a wider pelvis [20]. Next perform the patella apprehension test applying lateral pressure to the patella as the knee is slowly...
flexed and observing for anxiety or resistance to movement suggesting previous patella dislocation or instability – see Figure 15 and Evidence Box 5.

Figure 15  Patella apprehension test.

Completing the Examination
Remember to examine the back of the joint by inspecting and palpating the popliteal fossa. Always examine the hip, as hip pain is often referred to the knee, and finish your examination by assessing neurovascular status distal to the knee. Depending on your findings it may be appropriate to examine other joints or systems to look for signs of systemic disease.

Finally, wash your hands, thank the patient and allow him/her redress in privacy.

Acknowledgements
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Conflicts of Interest
None declared.

References
[18] Akseki D, Ozcan O, Boya H, Pinar H. A new weight-bearing meniscal test and a comparison
<table>
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<th>Grade</th>
<th>Description</th>
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<tr>
<td>Grade I (mild sprain)</td>
<td>Pain but with normal opening of the joint space: 0-5 mm.</td>
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<tr>
<td>Grade II (moderate sprain)</td>
<td>Pain and opening of the joint space up to 10 mm with an endpoint.</td>
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<tr>
<td>Grade III (severe sprain)</td>
<td>Complete joint space opening of more than 10 mm.</td>
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Table 1 Grades of collateral ligament sprains. * Grade III sprains are often associated with other ligament injuries [14].

**Question** Does this patient have a ruptured medial collateral ligament? **Reference(s)** Harilainen (1987) [39].

**Population** 350 consecutive acute knee injuries presenting to an emergency department. Fractures excluded.

**Incidence.** 17.7%

**Details of study** Valgus stress testing at 20 degrees, test considered positive with laxity on valgus stress testing. **Comparator.** Examination under anaesthetic plus arthroscopy or arthrotomy. **Sensitivity** 82.6%, **Specificity** 96.7%, **Kappa** Not assessed

**Conclusion** Clinical examination is unreliable at diagnosing fresh knee ligament injuries. Examination under anesthetic improved the accuracy of valgus stress testing.

**Evidence Box 1a: Examination of the medial collateral ligament of the knee.**

**Question** Does this patient have a lateral collateral ligament sprain? **Reference(s)** Harilainen (1987) [39].

**Population** 350 consecutive acute knee injuries presenting to an emergency department. Fractures excluded.

**Incidence.** 1.1%

**Details of study.** Varus stress testing at 20 degrees flexion, test considered positive with laxity on varus stress testing. **Comparator.** Examination under anaesthetic plus arthroscopy or arthrotomy. **Sensitivity** 25%, **Specificity** 98.6%, **Kappa** Not assessed

**Conclusion.** Varus stress testing is a poor test for detecting LCL injuries. Examination under anesthetic improved the accuracy of varus stress testing.

**Evidence Box 1b: Examination of the lateral collateral ligament of the knee.**
Question. Does this patient have an anterior cruciate ligament rupture? Reference(s). Benjaminse et al. (2006) [15] Population. Predominantly patients seen in secondary, 54%, and tertiary care, 39%. Incidence. 15 – 22.5% Details of study. Meta-analysis of 28 studies assessing the clinical accuracy of tests for ACL rupture. Comparator. Arthroscopy / arthrotomy, 7 studies, arthroscope, 14 studies, arthrotomy, 6 studies, MRI, 1 study. Sensitivity. See Table. Specificity. See Table. Kappa. Not assessed. Conclusion. The Lachman's test is the most valid test to determine ACL tears. In case of suspected ACL injury it is recommended to perform the Lachman's test followed by the pivot shift test which is very specific both in acute and as well in chronic conditions. If both tests are positive this is highly suggestive of ACL injury.

Question. Does this patient have an anterior cruciate ligament rupture? Reference(s). Scholten et al. (2003) [22] Population. Not stated. Incidence. 17 - 81% Details of Study. Meta-analysis of 17 studies assessing which diagnostic tests can provide an accurate diagnosis during physical examination. 8 studies assessing the anterior draw test, 9 assessing Lachman's test and 6 assessing the pivot shift test. Comparator. Arthroscopy / arthrotomy, 5 studies, arthroscope, 6 studies, arthrotomy, 4 studies, MRI, 2 studies. Sensitivity. See Table. Specificity. See Table. Kappa. Not assessed. Conclusion. A positive result for the pivot shift test is best for ruling in an ACL rupture, whereas a negative result to the Lachman's test is best for ruling out ACL rupture. Overall the Lachman's test is best for ruling in and out ACL ruptures.


Anterior Draw Test

<table>
<thead>
<tr>
<th>Author</th>
<th>Studies</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benjaminse et al.</td>
<td>28</td>
<td>92*</td>
<td>91*</td>
</tr>
<tr>
<td>Scholten et al.</td>
<td>8</td>
<td>62</td>
<td>88</td>
</tr>
<tr>
<td>Solomon et al.</td>
<td>12</td>
<td>62</td>
<td>67</td>
</tr>
</tbody>
</table>

*In chronic anterior cruciate ligament rupture. Reported to perform poorly in acute rupture.

Lachman's Test

<table>
<thead>
<tr>
<th>Author</th>
<th>Studies</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benjaminse et al.</td>
<td>28</td>
<td>85</td>
<td>94</td>
</tr>
<tr>
<td>Scholten et al.</td>
<td>9</td>
<td>86</td>
<td>91</td>
</tr>
<tr>
<td>Solomon et al.</td>
<td>12</td>
<td>84</td>
<td>100</td>
</tr>
</tbody>
</table>

Pivot Shift Test

<table>
<thead>
<tr>
<th>Author</th>
<th>Studies</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benjaminse et al.</td>
<td>28</td>
<td>24</td>
<td>98</td>
</tr>
<tr>
<td>Scholten et al.</td>
<td>6</td>
<td>18 to 48</td>
<td>97 to 99</td>
</tr>
<tr>
<td>Solomon et al.</td>
<td>12</td>
<td>38%</td>
<td>not reported</td>
</tr>
</tbody>
</table>

Evidence Box 2: Testing the anterior cruciate ligament
**Question.** Does this patient have a posterior cruciate ligament rupture as assessed by the posterior sag sign?  
**Reference(s).** Rubinstein *et al* (1994) [42] Population. 39 volunteers with 19 chronic isolated posterior cruciate ligament tears, 9 anterior cruciate deficient knees and 47 normal knees. 75 knees examined, 3 excluded due to previous surgery. Incidence. 25.3%. Details of study. Examination by sports fellowship trained orthopaedics surgeons blinded to the patient’s history, identity and diagnosis. Comparator MRI diagnosis of posterior cruciate ligament deficiency. Sensitivity. 79%. Specificity. 100%. Kappa. 96%. Conclusion. Further, larger prospective trials are needed; however initial results suggest that the posterior sag sign, if present, is highly suggestive of posterior cruciate ligament rupture.

**Question.** Does this patient have a posterior cruciate ligament rupture as assessed by the posterior draw test?  

**Question.** Does this patient have a posterior cruciate ligament rupture?  

<table>
<thead>
<tr>
<th>Author</th>
<th>N</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubinstein <em>et al</em> (1994) [42]</td>
<td>75</td>
<td>90</td>
<td>99</td>
</tr>
<tr>
<td>Harilainen (1987) [39]</td>
<td>9</td>
<td>33.3</td>
<td>99.4</td>
</tr>
<tr>
<td>Loos (1981) [25]</td>
<td>59</td>
<td>51</td>
<td>not reported</td>
</tr>
<tr>
<td>Clendenin (1980) [26]</td>
<td>10</td>
<td>100</td>
<td>not reported</td>
</tr>
<tr>
<td>Moore &amp; Larson (1980) [27]</td>
<td>20</td>
<td>67</td>
<td>not reported</td>
</tr>
<tr>
<td>Hughston (1976) [28]</td>
<td>54</td>
<td>55.5</td>
<td>not reported</td>
</tr>
</tbody>
</table>

*Evidence Box 3: Testing the posterior cruciate ligament*
Question. What is the value of McMurray’s test in detecting meniscal injury? Reference(s). Meserve et al. (2008) [29], Jackson et al. (2003) [3], Solomon et al. (2001) [23].

**Population.** All studies reported on patients assessed in secondary care with clinically likely meniscal injuries. Solomon et al. also included 2 studies of patients with 2 studies with known meniscal tears. **Incidence.** 60–87%, 52%-87%, 75–100% in each meta-analysis respectively.

**Details of study.** Meta-analysis of 8, 4 and 4 studies respectively assessing the clinical accuracy of McMurray’s test. **Comparator.** Arthroscopy **Sensitivity.** See Table. **Specificity.** See Table. **Kappa.** Not assessed.

**Conclusion.** The sensitivity of McMurray’s test was less than that of joint line tenderness which was found to be the best ‘common’ test. However composite testing by adding McMurrays test could improve the overall diagnostic accuracy.

<table>
<thead>
<tr>
<th>Author</th>
<th>Studies</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meserve et al. (2008)</td>
<td>8</td>
<td>55</td>
<td>77</td>
</tr>
<tr>
<td>Jackson et al. (2003)</td>
<td>4</td>
<td>52</td>
<td>97</td>
</tr>
<tr>
<td>Solomon et al. (2001)</td>
<td>4</td>
<td>53</td>
<td>59</td>
</tr>
</tbody>
</table>

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Question. What is the value of Apley’s Grinding Test in detecting meniscal injury? Reference(s). Meserve et al. (2008) [29], Solomon et al. (2001) [23].

**Population.** All studies reported on patients assessed in secondary care with clinically likely meniscal injuries. Solomon et al. also included 2 studies of patients with 2 studies with known meniscal tears. **Incidence.** 60 – 87% & 75 – 100% in each metaanalysis respectively.

**Details of study.** Meta-analysis of 8 and 9 studies respectively assessing the clinical accuracy of Apley’s Grinding Test. **Comparator.** Arthroscopy **Sensitivity.** See Table. **Specificity.** See Table. **Kappa.** Not assessed.

**Conclusion.** The sensitivity of Apley’s Grinding Test is poor. However in the study by Meserve et al. the specificity was high. Overall examination using all three techniques improves diagnostic accuracy.

<table>
<thead>
<tr>
<th>Author</th>
<th>Studies</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meserve et al. (2008)</td>
<td>3</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>Solomon et al. (2001)</td>
<td>1</td>
<td>16</td>
<td>not reported</td>
</tr>
</tbody>
</table>

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Question. What is the value of localised joint line tenderness in detecting meniscal injury? Reference(s). Meserve et al. (2008) [29], Jackson et al. (2003) [3], Solomon et al. (2001) [23].

**Population.** All studies reported on patients assessed in secondary care with clinically likely meniscal injuries. Solomon et al. also included 2 studies of patients with 2 studies with known meniscal tears. **Incidence.** 60 – 87%, 52% - 87% & 75 – 100% in each metaanalysis respectively.

**Details of study.** Meta-analysis of 8, 3 and 4 studies assessing the clinical accuracy of joint line tenderness. **Comparator.** Arthroscopy **Sensitivity.** See Table. **Specificity.** See Table. **Kappa.** Not assessed.

**Conclusion.** Joint line tenderness was found to be the most sensitive test. However composite examination however for meniscal injuries performed much better than specific manoeuvres.

<table>
<thead>
<tr>
<th>Author</th>
<th>Studies</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meserve et al. (2008)</td>
<td>8</td>
<td>76</td>
<td>77</td>
</tr>
<tr>
<td>Jackson et al. (2003)</td>
<td>3</td>
<td>76</td>
<td>29</td>
</tr>
<tr>
<td>Solomon et al. (2001)</td>
<td>4</td>
<td>79</td>
<td>15</td>
</tr>
</tbody>
</table>

Evidence Box 4a: Testing the menisci
Question. Does this patient have a meniscal injury as assessed by Ege’s Test? Reference(s). Akseki D et al. (2004) [30] Population. 150 consecutive symptomatic patients referred to a sports injury clinic with symptoms related to intra-articular knee pathology. Incidence. 84.7% Details of Study. All patients were examined with the Ege Test. The test was considered positive if, on squatting, an audible and palpable click was heard/felt over the area of the meniscus tear. The patient's feet are turned outwards to detect a medial meniscus tear, and turned inwards to detect a lateral meniscus tear. Comparator. Arthroscopy. Sensitivity. 67%. Specificity. 81%. Kappa. Not assessed. Conclusion. Accuracies of traditional clinical meniscus tests may be improved by including Ege’s test in the clinical examination. Further studies are needed to confirm these findings.

Question. Does this patient have a meniscal injury as assessed by the Thessaly’s test? Reference(s). Karachalios et al. (2005) [31] Population. 213 symptomatic patients referred to a sports injuries clinic with knee pain compared to 197 asymptomatic volunteers. Incidence. 86.8% (excluding controls). Details of study. All patients examined with the Thessaly test at 20° of knee flexion. Test considered positive with subjective reporting of medial or lateral joint line tenderness, catching or locking. Comparator. MRI & Arthroscopy. Sensitivity. 89 (medial) / 92 (lateral). Specificity. 97 (medial) / 96 (lateral). Kappa. >95%. Conclusion. The Thessaly test at 20° of knee flexion had a high diagnostic and low rates of false-positive and false-negative recordings. Other traditional clinical examination tests, with the exception of joint line tenderness, which presented a diagnostic accuracy rate of 89% in the detection of lateral meniscal tears, showed inferior rates. Further studies are needed to confirm these findings.

Evidence Box 4b: Testing the menisci: Weight bearing meniscal tests

Question. Does this patient have patella instability? Reference(s). Ahmad et al. (2009) [32] Population. 51 consecutive patients undergoing examination under anaesthesia in which preoperative assessment reported symptoms suggestive of patella instability including knee instability or giving way, anterior knee pain, or effusions. Incidence. 49% Details of study. Patellar apprehension test performed in the outpatient setting as described in the text and repeated under general anaesthetic. Comparator. Ability to dislocate the patella under general anaesthetic combined with operative findings. Sensitivity. 100%. Specificity. 88.4%. Kappa. Not assessed. Conclusion. The patellar apprehension test is an accurate physical examination technique that, when performed and interpreted correctly, is highly sensitive and specific for patellar instability.

Question. Does this patient have patella instability? Reference(s). Sallay et al. (1996) [33] Population. 19 patients presenting with documented patella dislocation to a sports injury clinic. Incidence. N/A. Details of study. Patellar apprehension test performed in the outpatient setting as described in the text and repeated under general anaesthetic. Comparator. Ability to dislocate the patella under anaesthetic combined with arthroscopy. Sensitivity. 39%. Specificity. Not reported. Kappa. Not assessed. Conclusion. The patella apprehension test has a poor sensitivity, as was positive in only 39% of the study group despite documented patella dislocation and gross lateral laxity observed under anaesthetic.

Evidence Box 5: Testing patella apprehension
Question. Does this patient have osteoarthritis of the knee? Reference(s). Altman et al. (1986) [44] Population. 264 patients referred into the study from 14 contributing secondary care centres. 107 patients, 55 of whom had rheumatoid arthritis and the remaining other disease affecting the knee served as controls. Incidence. 89.8% (in study group) Details of Study. 85 historical, physical, laboratory and radiological features were incorporated into a prospective data collection set. Comparator. Independent clinical diagnosis by 3 experienced physicians. Sensitivity. See Table. Specificity. See Table. Kappa. Not assessed. Conclusions. Indicators of OA of the knee are: palpable bony enlargement, genu varum, stiffness less than 30 minutes in duration and the presence of at least 3 of the 6 combined findings below. The most compelling arguments against OA of the knee are: 2 or fewer of the 6 combined findings below, morning stiffness greater than 30 minutes and the absence of crepitus.

<table>
<thead>
<tr>
<th>Individual Findings</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiffness&lt;30m</td>
<td>85</td>
<td>72</td>
</tr>
<tr>
<td>Crepitus, passive motion</td>
<td>89</td>
<td>58</td>
</tr>
<tr>
<td>Bony enlargement</td>
<td>55</td>
<td>95</td>
</tr>
<tr>
<td>Palpable increase temp</td>
<td>14</td>
<td>52</td>
</tr>
<tr>
<td>Valgus deformity</td>
<td>24</td>
<td>83</td>
</tr>
<tr>
<td>Varus deformity</td>
<td>22</td>
<td>93</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Combined Findings (3 of 6)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 50 years</td>
<td>95</td>
<td>69</td>
</tr>
<tr>
<td>Stiffness &gt; 30 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crepitus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint line tenderness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone enlargement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No palpable warmth</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evidence Box 6: Diagnosis Osteoarthritis in a patient with chronic knee pain [5]
Question. Does this patient have a knee fracture? Reference(s) Stiell IG et al. (1996) [43] Population. Several studies of between 351 and 1047 patients presenting to the emergency department with knee trauma. Incidence. 6% - 7% Details of Study. Prospectively administered surveys combined with clinical examination. Comparator. Knee radiograph. Sensitivity. See Table. Specificity. See Table. Kappa. Not assessed. Conclusions. Indicators of a clinically significant knee fracture are: inability to flex the knee more than 60 degrees, inability to weight bear, tenderness at the head of the fibula, and age of 55 years or more. Negative Ottawa knee rules argues strongly against a fracture.

<table>
<thead>
<tr>
<th>Individual Findings</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 55 years</td>
<td>23-48</td>
<td>87-88</td>
</tr>
<tr>
<td>Joint effusion</td>
<td>54-79</td>
<td>71-81</td>
</tr>
<tr>
<td>Ecchymosis</td>
<td>19</td>
<td>91</td>
</tr>
<tr>
<td>Unable to flex beyond 90 deg</td>
<td>42-65</td>
<td>90</td>
</tr>
<tr>
<td>Unable to flex beyond 60 deg</td>
<td>46-49</td>
<td>90</td>
</tr>
<tr>
<td>Isolated tenderness of patella</td>
<td>26-31</td>
<td>85-89</td>
</tr>
<tr>
<td>Tenderness at head of fibula</td>
<td>12-32</td>
<td>92-95</td>
</tr>
<tr>
<td>Inability to weight bear</td>
<td>46-58</td>
<td>81-89</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Combined Findings</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ottawa knee rule positive*</td>
<td>83-99</td>
<td>19-54</td>
</tr>
</tbody>
</table>

≥ 55 years or over, isolated tenderness of the patella, tenderness at the head of the fibula, inability to flex to 90 degrees, inability to weight bear both immediately and in the casualty department (4 steps - unable to transfer weight twice onto each lower limb regardless of limping)

*X-ray should be performed if any of the Ottawa knee rules are positive.

Evidence Box 7: Diagnosing a clinically significant knee fracture [5]