Extremity MRI

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KNEE

ACL Tears

The ACL consists of two major bundles, the larger posterolateral bundle and the smaller anteromedial bundle. With extension, the posterolateral bundle is stressed first, whereas with flexion the anteromedial bundle is stressed first. The ACL is extrasynovial, with a surrounding synovial sheath separating the ligament from the joint space fluid.

External rotation and abduction, direct forward displacement of the tibia, or internal rotation with the knee in full extension.

With varus or valgus stress, the ACL is injured after the collateral ligament failure. Forced valgus in external rotation is the most common mechanism of injury and causes disruption of the MCL.

Pivot-Shift Injury

Internal tibial rotation relative to the femur and valgus torque with the knee in near full extension, results in substantial forces in the ACL that must resist anterior tibial translation. Another mechanism is hyperextension loading in which the ACL and PCL must both resist the hyperextension.

ACL Injuries

The ACL is a main stabilizer of the knee, preventing anterior translation of the tibia on the femur and anterior lateral rotation of the tibia beneath the femur. The typical mechanism of injury involves sudden deceleration, often a quick change in direction during a plant-and-pivot maneuver. Sometimes, the injury happens when an athlete lands on one foot. The rate of ACL injury is 2 times to 8 times higher in females than males who participate in the same sports.

The most discussed risk factor injuries of the female knee is the anatomic alignment of a women's lower limbs. The width of the pelvis, the angle of the femoral neck in the femoral shaft, and the angles of the thigh bone and leg bone differ in males and females. Many have theorized that the wider angles of a female's lower legs place more stress on the joints – and the knees in particular – putting them at a greater risk for injury.

The shape of the intracondylar notch (ICN) of the femur, the space in the middle of the knee throughout which the ACL traverses. Recently, researchers have speculated that the relatively smaller notch in females houses an ACL that is too small and too weak to hold up to the rigors of some sports with moves that involve planting and pivoting. There is some evidence that suggests that the dimensions of the ACL of females is smaller than that of males, thus supporting the theory that the ACL of females is more prone to injury because it is smaller.

Neuromuscular mechanisms for non-contact ACL injuries have been identified. The most frequent mechanisms that lead to injury involve sudden deceleration or a quick plant-and-pivot maneuver. Females tend to do these maneuvers in a more upright position and have less flexion at both the hip and the knee. Males tend to have more flexion in their knees and hips, allowing the hamstrings to stabilize the knee. Because females are more upright when they land and/or do cutting moves, the mechanical advantage goes to the quadriceps. A strong quadriceps pull may be detrimental to the anterior forces on the tibia, leading to an ACL tear. In addition, females are more likely to internally rotate their femur during knee flexion; this can cause an inward collapse of the knee when landing a jump or pivoting.

The buttock muscles mainly control the hip and femoral rotation underneath the pelvis. Females have less control over these muscles than males. Their upright stance, combined with their lesser core strength, leads to a lack of central control of limb rotation and makes them favor knee positions that make them susceptible to both ACL ruptures and PF dislocations. These problems are not exclusive to females, but researchers find females performing these riskier neuromuscular mechanisms more often than males when doing similar sporting moves.

PCL Tears

Mechanism is hyperextension injuries or severe pivot-shift injuries. The PCL is twice as strong as the ACL. Tears are most common in the middle portion, followed by avulsions from the femur and tibia. Rupture caused by excessive rotation, hyperextension, or dislocation or by direct trauma, while the knee is flexed.

Medial Collateral Ligaments Tears

MCL tears are frequently associated with ACL injuries. The MCL consists of a superficial ligament and a deep capsular component (including meniscofemoral and meniscotibial ligaments) separated by an intermediate to high-signal intensity fibro-fatty tissue.

Osseous Impaction or Contusion Injuries

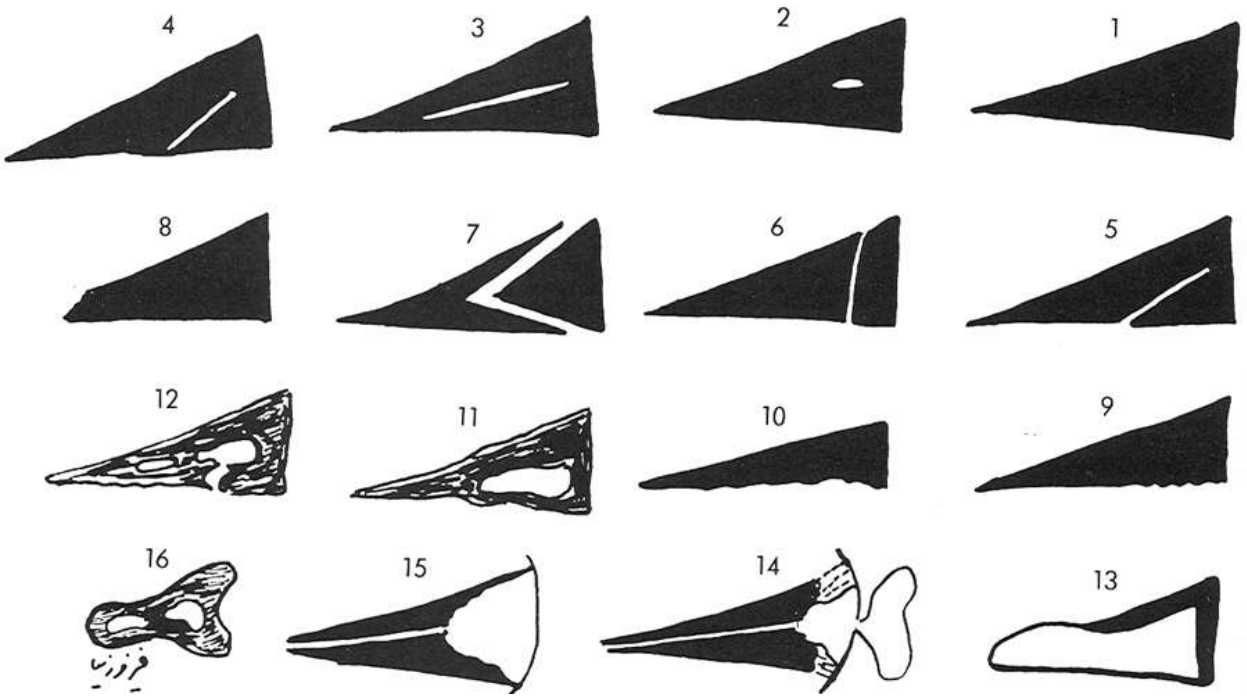
The posterolateral tibial plateau impacts against the anterior lateral femoral condyle with osseous and chondral injury and lateral meniscus crush-type injury or tearing.

Meniscal Tears

Meniscal tears more commonly involve the less mobile medial meniscus and are more common posteriorly than anteriorly. Lateral tears are noted in up to one-third of patients, and combined medial and lateral tears occur in between 3% to 9% of patients.

Spontaneous detachment (primary degeneration) occurs in menisci that are abnormal as a result of aging or of abnormal stress over long periods. The orientation is usually horizontal (horizontal cleavage lesions).

Acute traumatic tears occur in younger individuals and may be associated with joint locking. They are longitudinal, bucket-handle, or peripheral tears.



Menisci

The medial meniscus is C-shaped and is rather rigidly attached to the tibia. It is responsible for about 50% of the shock capacity of the medical compartment. The medial meniscus also helps to stabilize the knee from an anterior force and is the next-most-important structure for preventing anterior translation of the knee when the ACL is torn. A large number of patients with ACL tears also have tears of their medial meniscus.

The lateral meniscus is almost circular in shape and is more mobile than the medial meniscus. As the knee moves, it shifts back and forth across the tibia and is less likely to be torn than the medial meniscus. Probably the most important function of the lateral meniscus is its shock-absorbing capacity. The lateral meniscus can absorb up to 70% of the shock to the lateral compartment.

As we age, the menisci become less rubber-like and flexible and more tough and friable. The incidence of degenerative tears rises significantly in persons older than 40 years. With these types of tears, the meniscus tears on the inside, closer to the midline of the knee. Because there is no blood supply to this portion of the meniscus, the only viable treatment is to resect the tear back to a stable edge. It is important that patients recognize that having even a portion of their meniscus resected places them at a higher risk of developing osteoarthritis.

Posterolateral Corner Complex Injury

Associated with ACL tears, pivot-shift injuries or severe hyperextension injuries. The structures involved include the posterolateral capsule, arcuate ligament, and popliteus and lateral gastrocnemius muscles.

Usually the result of hyperextension. The posterolateral corner is composed of the lateral collateral ligament complex, the arcuate ligament, the popliteus tendon, and multiple small ligaments such as the popliteofibular ligament. If two or more of these structures, along wit the anterior or posterior cruciate ligament, are torn, the injury is deemed a posterolateral corner injury.

Popliteal Cysts

Cysts in adults are usually secondary to intra-articular abnormalities in which joint effusion occurs. The cysts are usually located posteromedially, deep to the medial head of the gastrocnemius muscle. These are thought to represent distended gastrocnemio-semimembranosus bursae that are usually communicate with the joint through a posterior defect in the joint capsule.

Anterior Drawer Test

In this test, the patient lies supine with the involved knee bent to a 90º angle. The examiner sits at the end of the examination table with his or her thigh against the patient's toes to restrain the foot. The examiner then grasps the tibia just below the joint line and asks the patient to relax. If the patient is properly relaxed, the lower limb should feel as if it would fall over to the side if the examiner released it. The examiner then pulls forward with both hands and assesses both the amount of anterior translation of the tibia with respect to the femur and the quality of the endpoint. In the case of ACL injury, the tibia is felt to translate forward more than on the uninvolved side, the endpoint feels soft.

Lachman's Test

The patient lies supine on the examination table. The examiner stands at the side of the table near the knee and grasps the lower leg with one hand. Usually, the examiner's thumb is placed just over the tibial tubercle and the other fingers are wrapped around the rest of the calf. The other hand is used to grasp the thigh just above the patella. The thumb of this upper hand presses against the femur through the quadriceps tendon while the other fingers wrap around the posterior thigh. If the patient is properly relaxed, the limb should feel like a dead weight. The fingers of the examiner's upper hand, which are supporting the thigh, are also able to sense any tightening in the hamstrings. If any of the hamstrings are felt to be tight, identifying the tight muscle to the patient and massaging it a bit often allows the patient to relax.

As with the valgus stress test, better relaxation may sometimes be obtained by abducting the lower limb and allowing the thigh to rest on the examination table. In this case, the knee is flexed over the side of the table and the foot rests on the lap of the seated examiner. Once the patient is adequately relaxed, the examiner pulls forward on the tibia with one hand while simultaneously pushing backward on the femur with the other hand in a reciprocating manner. As in the anterior drawer test, the amount of anterior excursion and the quality of the endpoint are assessed.

One of the differences that make the Lachman's test easier to assess than the anterior drawer test is that in most normal patients, there is little or no excursion of the tibia when the Lachman's test is performed. Either no translation at all or 1mm to 2mm of translation with a very firm endpoint is appreciated. In the presence of ACL tear, the translation is increased and the endpoint indefinite. A special case is the incomplete ACL injury in which the ACL is elongated but not totally disrupted. In these cases, increased anterior laxity is present but a firm endpoint is still noted. This endpoint is usually easier to appreciate after the swelling and stiffness of the acute injury have subsided.

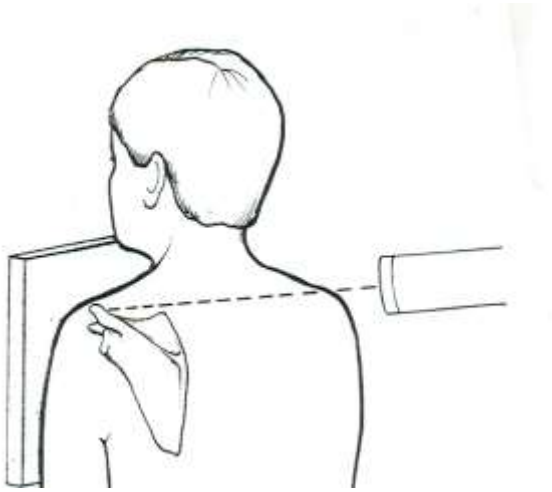
Posterior Drawer Test

The starting position is essentially the same as that for the anterior drawer test; the patient's knee is flexed 90º and the foot stabilized. In a patient with a torn PCL, a drop-back phenomenon usually occurs in this position; gravity causes the tibia to sublux posteriorly with respect to the femur, resulting in an abnormal appearance that is best appreciated when both knees are viewed in profile. When such a drop-back phenomenon occurs, the tibial tubercle appears less prominent than usual, and the patella appears more prominent than usual. Subtle changes may often be detected by comparing the injured with the normal knee. In the acute injury situation, the drop-back is less likely to occur or may be masked by acute swelling.

The posterior drawer test is completed by pushing posteriorly on the proximal tibia with both hands. In the abnormal case, the tibia is felt or seen to sublux further posteriorly with respect of the femur.

SHOULDER

Acromion View (PA Axial Oblique, Modified Y-Outlet) The patient stands with the spine of the scapula perpendicular to the cassette. The CR should be parallel to the spine with 12° caudal tilt. Use ½ the mAs for routine AP shoulder view. This view shows inferior spurring at the distal clavicle and acromion or an abnormally long anterior portion of the acromion.



Impingement Syndrome

In 95% of cases of rotator-cuff pathology, injury is preceded by subacromial impingement syndrome, which is a purely clinical diagnosis defined as a painful compression of the supraspinatus tendon, subacromial/subdeltoid bursa, and long head of the biceps tendon between the coracoacromial arch and the humeral head. Pain is usually progressive and aggravated by raising the arm in a position of abduction and external or internal rotation. Impingement syndrome commonly occurs in patients under the age of 40 and is usually secondary to repetitive elevation and abduction of the arm during occupational or athletic activities; it also commonly occurs in the elderly as a result of subacromial osteophyte formation and other degenerative changes around the acromioclavicular joint and coracoacromial arch.

Predisposing factors include certain acromial shapes, slopes, and positions, presence of an os acromiale, acromioclavicular joint degenerative and hypertrophic changes, chronic glenohumeral joint instability resulting in degenerative changes, a thickened coracoacromial ligament, supraspinatus muscle hypertrophy, posttraumatic deformities, calcific tendonitis, a prominent greater tuberosity, and posterior superior glenoid impingement. The supraspinatus tendon is by far the most frequently injured rotator-cuff tendon, largely because of its more superior location relative to the other rotator-cuff tendons, resulting in its closer proximity to the acromion and distal clavicle, two common offending agents.

Rotator-Cuff Pathology

There are four major types of tendon pathology: 1) tendonapathy or tendinosis; 2) surface degeneration of fraying; 3) partial-thickness tear; and 4) full-thickness tear. Early collagen fiber breakdown within a tendon is termed tendonapathy or tendinosis and is an early sign of impingement. Use of the term tendonitis should be avoided, as there is no histologic evidence of significant inflammation.

Tendon surface degeneration or fraying of the tendon surface is more common on the bursal side.

On MR imagines, a full-thickness tear of a tendon has the appearance of high signal involvement of the tendon, usually extending vertically or obliquely from the articular to the bursal surface.

The long head of the biceps tendon

The long head of the biceps tendon stabilized the anterosuperior portion of the rotator-cuff by its position in the bicipital groove anteriorly and its attachment to the glenoid labrum superiorly. Tears of the subscapularis tendon in particular have been associated with medial subluxation or dislocation of the biceps tendon or tendonapathy. The biceps tendon is also frequently injured in association with the tears of the superior and anterior portions of the rotator-cuff.

Glenoid Labrum

A triangular rim of fibrocartilaginous tissue surrounding the glenoid fossa, stabilizes the GH joint by deepening the glenoid fossa and providing attachment for the GH ligaments and the LBT.

Bankart Lesion

Can be cartilaginous or both cartilaginous and osseous. A cartilaginous Bankart lesion is an anteroinferior avulsion of the labrum from the glenoid fossa with a lifted and torn scapular periosteum. Sometimes, cartilaginous Bankart lesions are associated with a fracture of the osseous anteroinferior glenoid rim, termed a “bony Bankart”.

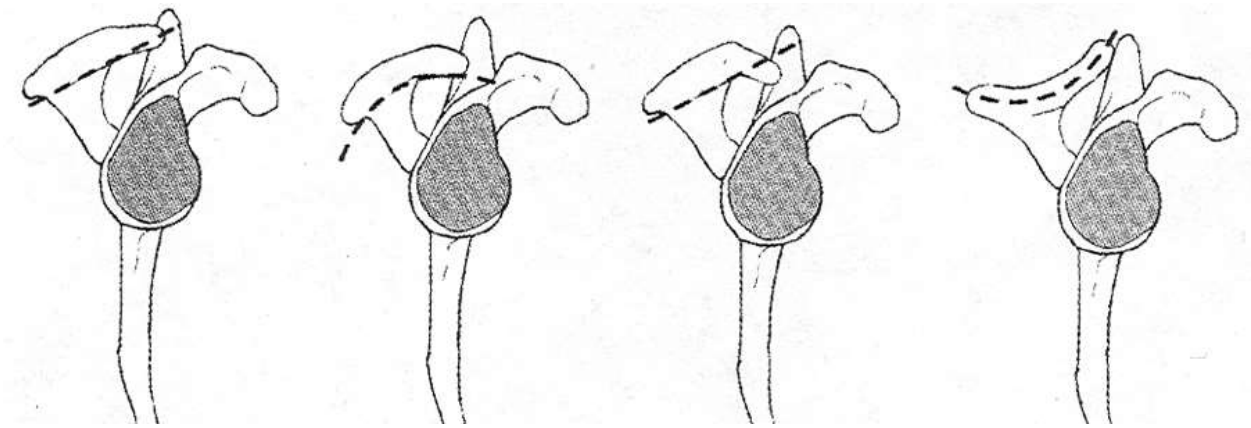
Hill-Sachs Deformity

Compression fracture of the posterolateral humeral head upon impacting against the anterior rim of the glenoid fossa and is associated with Bankart lesions in 75% of patients.

Acromion Morphology

Bigliani Classification
Type 1 – undersurface is flat;
Type 2 – undersurface is concave, following the contour of the humeral head;
Type 3 – anteroinferior acromial spur (hooked);
Type 4 - undersurface is convex

Acromion Slope
-Anterior down-slope
-Inferolateral tilt or down-slope



Acromiohumeral Interval

- 7-11mm (mean 9.3mm)
- ↓7mm, supraspinatus tendon degeneration (atrophy or tear)

AC Joint

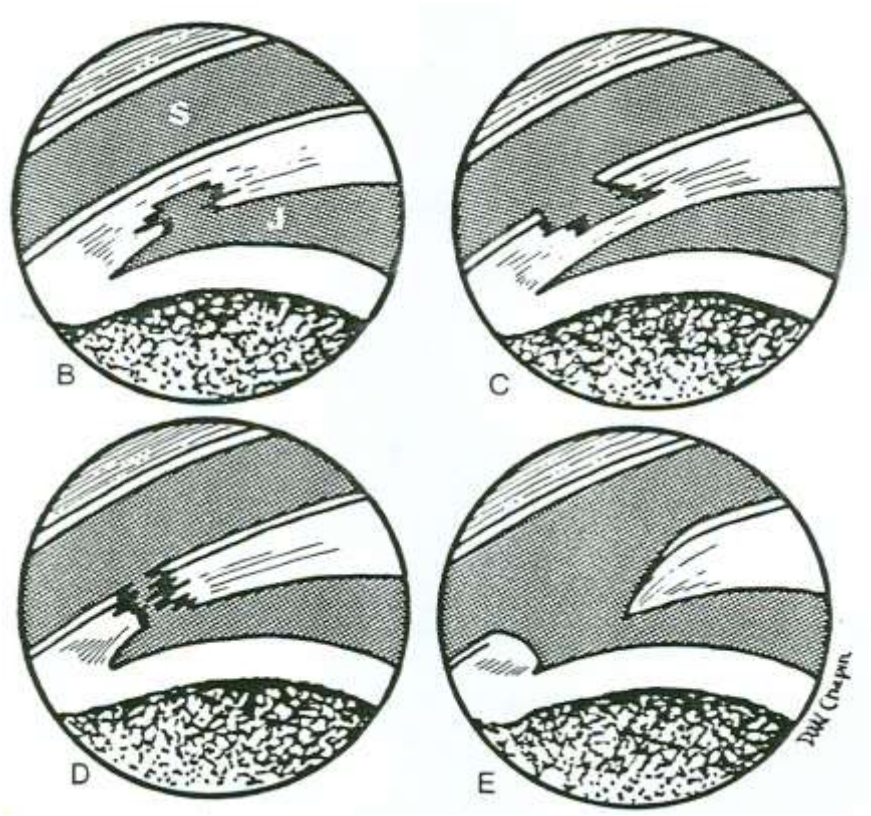
- Normally 3-5mm (≤8mm)
- Normal difference between sides, less than 2-3mm
- Inferior margin of clavicle lines up with inferior acromion

Coracoclavicular Space

- 11-13mm
- Normal difference between sides, less than 5mm

Rotator Cuff Tears

B – Partial tear of the inferior aspect of the rotator cuff (partial thickness tear joint surface of tendon)
C – Partial tear of the superior aspect of the rotator cuff (partial thickness tear bursal surface of tendon)
D – A complete tear of the rotator cuff (full thickness tear)
E – Chronic complete tear of the rotator cuff with atrophy and retraction of the tendon



SLAP Lesions

Tears or detachment of the superior labrum, called superior labrum anterior to posterior (SLAP) tears. A SLAP tear can be a debilitating injury for the throwing athlete.

Lesions typically begin posteriorly and progress anteriorly, involving the anchor of biceps brachii tendon and the glenoid labrum. The most common cause, accounting for 23% to 31% of all lesions, is falling onto an outstretched arm.

SLAP lesions are often associated with perilabral cysts, which form from extrusion of joint fluid through labrocapsular tears into the tissue plane between the supraspinatus and infraspinatus muscles. The cyst often extend into the spinoglenoid or suprascapular notch, compressing the suprascapular nerve and causing pain and atrophy of the supraspinatus and infraspinatus muscles.

Parsonage-Turner Syndrome (Acute Brachial Neuritis)

The onset of pain in the shoulder in these patients is dramatically sudden, sometimes waking them from sleep. It is characterized by severe neuritic pain that is accompanied in a few days by profound weakness. Parsonage-Turner syndrome is typically self-limited, with no known treatment other than palliative measures. The cause is unknown. In 20-30% of patients, the symptoms are bilateral, and about 10-25% report that they had undergone vaccination or had an infection in the weeks prior to the onset of pain. The MR imaging appearance is quite characteristic, with marked edema in the affected muscles of the shoulder.

Quadrilateral Space Syndrome

Quadrilateral space syndrome is a painful shoulder disorder that can mimic a rotator cuff tear. The cause is usually due to fibrous bands in the quadrilateral space causing impingement on the axillary nerve. The fibrous bands are thought to be secondary to prior trauma with resultant scarring. MR imaging will reveal fatty atrophy isolated to the teres minor muscle which is virtually pathognomonic of quadrilateral space syndrome.

Spinoglenoid Notch Cyst or Ganglion

Another cause of a painful shoulder that can mimic a rotator cuff abnormality is suprascapular nerve compression secondary to a cyst or ganglion in the spinoglenoid notch. This is almost always associated with a posterior labral tear. Diagnosis at MR imaging is established by noting a cyst or ganglion in the spinoglenoid notch. Atrophy or neurogenic edema involving the infraspinatus muscle can be an associated finding. Surgical decompression of the perilabral cyst and repair of the labrum are usually required for resolution of symptoms.

Neer Impingement Sign

The examiner passively flexes the patient’s shoulder to the position of maximal forward flexion while stabilizing the patient’s scapula with the other hand. Reproduction of the patient’s symptomatic pain at maximal forward flexion is designated a positive impingement sign and is considered evidence of impingement syndrome. This maneuver is thought to bring the pathologic anterolateral acromion into contact with the affected portion of the rotator cuff and greater tuberosity, thereby production pain. The discomfort of impingement may often be increased by flexing the patient’s elbow and internally rotating the shoulder before performing the impingement sign.

Detects: Impingement of long head of biceps tendon and/or supraspinatus tendon. Test Procedure: Pt sitting or standing. Pt's arm is passively elevated through forward flex by examiner, forcing greater tubercle of humerus against acromion. Positive Finding: Reproduction of Pt's Sx.

Hawkins Impingement Test

This test is performed by asking the patient to forward flex the shoulder 90º with the forearm parallel to the floor. The examiner then passively internally rotates the shoulder while keeping the arm in the forward flexed position. This maneuver is felt to drive the greater tuberosity and associated rotator cuff into the acromion and coracoacromial ligament. The production of pain with this maneuver suggests pathology of the rotator cuff or subacromial bursa.

Detects: Impingement of inflamed supraspinatus tendon. Test Procedure: Pt sitting or standing. Examiner forward flexes Pt's arm to 90 deg, and flexes Pt's elbow to 90 deg, then passively internally rotates shoulder, forcing supraspinatus tendon against coracoacromial ligament. Positive Finding: Reproduction of Pt's Sx.

Painful Arc Test

Detects: Pathology of subacromial origin (e.g., impingement, rotator cuff tendinitis). Test Procedure: Pt sitting or standing. Pt abducts arm in neutral position (no IR or ER). Positive Finding: Reproduction of Sx in a 60-120 deg arc. Pain stops or is dramatically reduced when humeral head glides inferiorly.

Supraspinatus Test (Empty Can Test)

Detects: Torn supraspinatus muscle or tendon. Supraspinatus tendinitis. Neuropathy of suprascapular nerve. Test Procedure: Pt sitting or standing. Pt in "empty can" position: 90-deg shoulder abduction, 30-deg horizontal abduction, and maximum IR. Examiner resists Pt's attempt to abduct. Positive Finding: Reproduction of Pt's Sx or weakness. Compare with uninvolved side.

Subscapularis Lift-Off Test

Because instability of the biceps is so often associated with a loss of integrity of the subscapularis tendon, the left-off test is an essential portion of the biceps evaluation. The left-off test, as described by Gerber, is performed by placing the arm just short of maximal internal rotation and extension. The patient is then asked to actively lift the back of the hand off the belt line or buttock, depending on the amount of internal rotation achievable. The modified lift-off test is performed by placing the arm in maximal internal rotation, with the back of the hand posterior to the belt line or the buttock. A positive result is seen when the patient cannot keep the hand in this position, and it falls to the buttock of belt line.

The hallmark of a positive test is a significant difference between active and passive maximal internal rotation and extension. Positive examination results are highly suggestive of subscapularis tears. Additionally, as noted by Gerber, pain during this test serves as a sensitive indicator of impingement. Placement of the humeral head in internal rotation and extension positions the posterior rotator cuff under stretch and up against the acromial arch.

The patient is asked to internally rotate the arm behind the back to the midlumbar region. The dorsum of the patient's hand rests on the back. The patient is then asked to left the hand off the back. The ability to perform this maneuver is thought to require the presence of a functioning subscapularis. Subscapularis strength can also be evaluated by asking the patient to hold the arm in the lifted position while the examiner tries to force the patient's hand toward the back.

STABILITY TESTS

Anterior Apprehension Test (Crank Test)

Detects: Anterior instability. Test Procedure: Pt sitting, standing, or supine. Examiner places Pt's shoulder in abduction and external rotation (90 deg/90deg). Then examiner applies an external rotation force. Positive Finding: Pt has look of alarm or apprehension and resists further motion. Pt may also have pain with this movement.

This is the classic provocative test for anterior instability. To perform it, the examiner asks the patient to relax and places the patient's shoulder in 90º of abduction and slight extension with the elbow flexed. The test may be performed with the patient standing, sitting or lying supine, although it is usually easier for the patient to relax in the supine position. The examiner then externally rotates the arm and, if necessary, further abducts and extends it. This position simulates the most common position of subluxation or dislocation in the patient with symptomatic anterior instability. In the presence of recurrent anterior dislocation and often recurrent anterior subluxation as well, the patient reacts by expressing concern or anxiety or even prevention the desired position from being achieved.

HIP

Osteonecrosis (ON), Avascular Necrosis (AVN)

Occurs more commonly in males (30-50 years of age). It is bilateral in 33% to 80% of patients. Hip pain that may be acute or gradual in onset. Aching and throbbing.

Radiographic Findings

1. Crescent sign – radiolucent crescent under the subchondral cortex.
2. Subchondral cysts and areas of sclerosis.
3. Loss of the usual round contour of the femoral head. Flattening of a portion of the femoral head. Step-off or step sign.

Causes of Osteonecrosis

Traumatic
- Intracapsular fracture
- Hip dislocation

Nontraumatic
- Excess glucocorticoids
  - Corticosteroid therapy
  - Cushing's syndrome
- Systemic lupus erythematosis
- Hemoglobinopathies such as sickle cell and sickle cell hemoglobin C diseases
- Metabolic disorders
  - Gout
  - Gaucher's disease
  - Alcoholism
  - Pancreatitis
- Dysbarism
- Idiopathic

Acetabular Labral Tears

The clinical presentation of a patient who has a labral tear may vary, and the correct diagnosis may not be considered initially. Young adult, active patients with a predominant complaint of groin pain with or without a history of trauma, the diagnosis of a labral tear should be suspected and investigated as radiographs and the history may be nonspecific for this diagnosis.

The acetabular labrum is a rim of fibrocartilaginous tissue around the margin of the acetabulum that deepens the acetabular fossa and provides additional coverage for the femoral head. The labrum is innervated by nerves that play a role in proprioception and pain production. The tear most often occurred at the anterosuperior aspect of the labrum.

Degenerative labral tears of the hip are association with developmental dysplasia and secondary degenerative osteoarthritis. The acetabular labrum also has been found to be abnormal is association with other hip disorders, including an aspherical femoral head, slipped capital epiphysis, Legg-Clave-Perthes disease and hip trauma. Athletic activities that involve repetitive pivoting movements or repetitive hip flexion are now recognized as additional caused of acetabular labral injuries. More recently, anterior femoroacetabular impingement has been associated with labral injury, articular cartilage damage and secondary osteoarthritis.

The patients are young adults from 25 to 40 years of age. The onset of the symptoms may be traumatic or acute, but occur in an insidious fashion in many patients. Sudden twisting or pivoting motions, traumatic event that led to a subluxation of the femoral head (MVA), chronic stress from athletic events such as cheerleading and running, developmental dysplasia of the hip, or osteoarthritis. Symptoms: Persistent pain in hip and/or groin, clicking (audible/palpable), transient locking, "giving way" or decreased range of motion. Night pain and pain with pivoting or walking are common complaints. The diagnosis of a labral tear must be considered for active patients who present predominantly with groin pain that is worsened be activity and impact even though these symptoms are signs are associated with no or minor radiographic evidence of hip diseases.

Anterior Labral Tear Test

This test is used to test for anterior-superior impingement syndrome, anterior labial tear, and iliopsoas tendinitis. The patient is placed in supine position. The examiner takes the hip into full flexion, lateral rotation, and full abduction as a starting position. The examiner then extends the hip combined with medial rotation and adduction. A positive test is indicated by the production of pain or the reproduction of the patient's symptoms with or without a click.

Posterior Labral Tear Test

The patient is placed in supine position. The examiner takes the hip into full flexion, adduction, and medial rotation as a starting position. The examiner then takes the hip into extension combined with abduction and lateral rotation. A positive test is indicated by the production of groin pain, patient apprehension, or the reproduction of the patient's symptoms, with or without a click. A positive test is an indication of a labral tear, anterior hip instability or posterior-inferior impingement. The test is sometimes called the apprehension test if apprehension occurs toward the end of ROM when doing the test.

McCarthy Hip Extension Sign

The patient is placed in supine position with both hips flexed. The examiner then takes the good hip and extends it from the flexed position, first in combination with lateral rotation, and then repeats the test in combination with medial rotation. The test is repeated with the affected hip. A positive test would be the reproduction of the patient's pain. McCarthy et al believed there were three positive tests that would help to predict labral pathology: pain with the McCarthy hip extension test, painful impingement with hip flexion abduction and lateral rotation (the anterior labial tear test), and inguinal pain on resisted straight leg raise (Stinchfield resisted in flexion test).

Stinchfield Resisted Hip Flexion Test

The patient lies supine and then actively elevates the straight leg (i.e., flexes the hip) to about 20º to 30º while the examiner applies gentle resistance, In a positive test, pain may be referred into the sensory distribution of the femoral, obturator, or sciatic nerves. A positive test indicates intra-articular pathology, which may include a labral tear, synovitis, arthritis, occult femoral neck fractures, iliopsoas tendinitis/bursitis, and prosthetic failure or loosening.

Femoroacetabular Impingement (FAI)

FAI generally occurs as two forms: Cam and Pincer. The Cam form describes the femoral head and neck relationship as aspherical or not perfectly round. This loss of roundness contributes to abnormal contact between the head and socket. The Pincer form describes the situation where the acetabulum has too much coverage of the ball or femoral head. This over-coverage typically exists along the front-top rim of the acetabulum and results in the labral cartilage being "pinched" between the rim of the socket and the anterior femoral head-neck junction. The Pincer form of the impingement is typically secondary to retroversion (a turning back of the socket) or profunda (a socket that is too deep). Most of the time, the Cam and Pincer forms exist together. The Alpha angle determines how much Cam impingement exits.

FAI is associated with cartilage damage, labral tears, early hip arthritis, hyperlaxity, sports hernias, and low back pain. FAI is common in high level athletes, but also occurs in active individuals.

Insufficiency Fractures

Fractures that occur when normal or physiological stress is applied to abnormally weakened bones.

- Osteoporosis
- RA
- Osteomalacia/rickets
- Paget's disease
- Hyperparathyroidism
- Renal osteodystrophy
- Radiation therapy
- Steroid-induced osteopenia

Location: lower extremity (femoral neck), sacrum, ilium, pubic bone

Stress Fractures

Fatigue or march fractures. Result from repeated application of abnormal stress on normal bone. Normally, bone remodeling occurs in response to applied stress and consists of bone resorption followed by new bone formation. If the applied stress is increased or is continuous during the period in which bone resorption predominates, a stress fracture may occur. Increased osteoclastic activity, microinfractions of bone, and finally frank fracture.

Characteristics of activities resulting in stress fractures:
1. Activity is strenuous. 2. Activity is often new or different. 3. Activity is repeated with frequency. Most common in the lower extremity: metatarsals>calcaneus>tibia.
Cancellous bone: thin zone of sclerosis. Cortical bone: thin cortical lucency followed by localized periosteal reaction.

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Advanced MRI: Extremities

MRI Sequences
T1 Weighted Images T1WI
Fat weighted
Fluids: Dark
Fat: Bright
Pathological processes are usually dark on T1 and bright on T2
T1 Fat Saturation T1FS
Suppresses the signal from normal adipose tissue
Fat: Dark

T2 Weighted Images T2WI
Water weighted
Fluids: Bright
Pathological processes are usually bright on T2WI and dark on T1WI
Pathological processes usually increase the water content in tissue

Proton Density PD
Tissues with higher concentration or density of protons (hydrogen atoms) appear brightest on the image
Fat: Bright
Fluids: Bright
Bone: Dark
White Matter: Darker than bright gray
Gray Matter: Bright gray
Used for brain and spinal cord injury because of great white matter-gray matter contrast

STIR

Short Tau inversion recovery
Used for fat suppression
Fluids: Very bright
Bone/bone marrow: dark
Pathological processes are usually bright on STIR

MEDIC (Merge)

Multiple Echo Data Image
Used for cervical imaging: Axial images
Fluids: Bright
Spinal cord: Gray
Bone marrow: Dark
Muscle and fat: Gray

FLAIR

Inversion recovery sequence
Fluids appear dark, lesions and pathological processes appear bright
Used for brain imaging

MRI Sequences

- T1 weighted
    - Gadolinium enhanced
    - Fat suppressed
- T2 weighted
    - Fat suppressed
    - Fluid attenuated
    - Susceptibility sensitive
- Proton density (PD) weighted
    - Fat suppressed

Fat Suppression
or fat attenuation
or fat saturated

- Used to suppress the bright signal from fat
- This allows fluid, which is of high signal, to stand out

PD Weighted Sequences

- Excellent signal distinction between fluid, hyaline cartilage and fibrocartilage
- Makes this sequence ideal in the assessment of joints

Femoracetabular Impingement (FAI)

Hip Impingement Syndrome
3 Types of FAI

1. CAM deformity (camshaft)
2. Pincer deformity
3. Mixed

CAM – the femoral head is not round and cannot rotate smoothly inside the acetabulum.
Pincer – extra bone extends out over the normal rim of the acetabulum.
Combined – both pincer and cam types

CAM deformities are more common in males.
Pincer deformities are more common in females.
70-80% are a combination of both.

Symptoms – Pain is often felt in the groin area or around the hip or in the lower back.

- Pain
- Stiffness
- Limping
- Turning, twisting and squatting may cause a sharp, stabbing pain
- Activity related groin or hip pain, exacerbated by hip flexion
- Difficulty sitting
- Mechanical hip symptoms
- Can present with gluteal or trochanteric pain →due to aberrant gait mechanics

Common cause of:

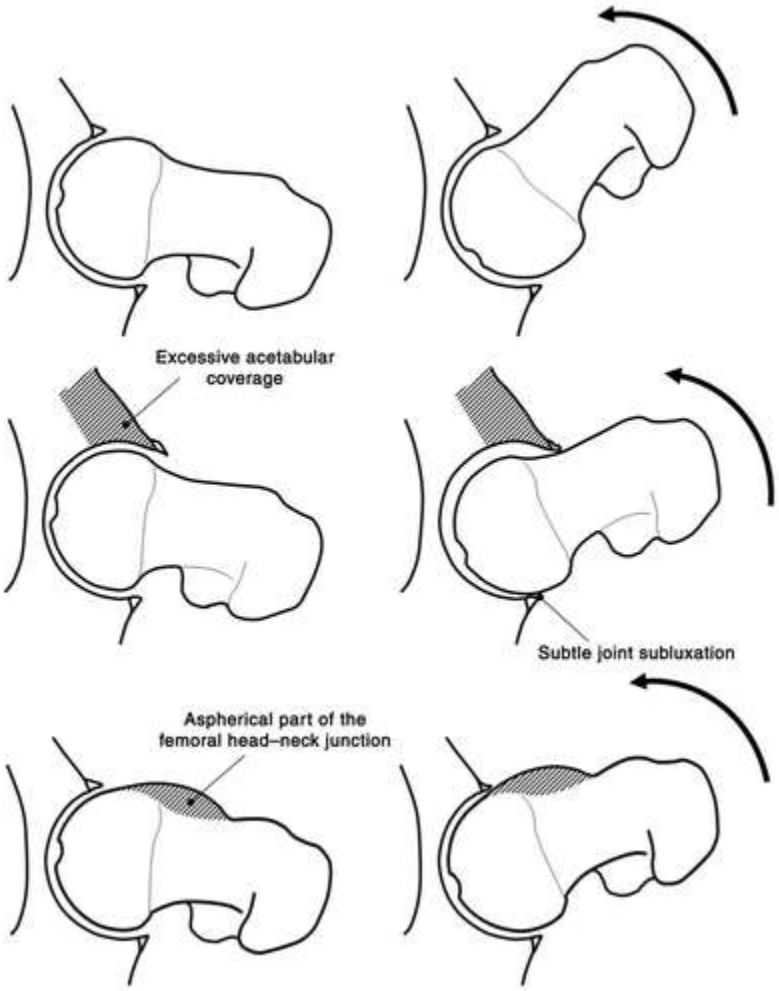
- Early onset of hip dysfunction
- Secondary osteoarthritis

CAM Impingement

- Decreased head-to-neck ratio
- Aspherical femoral head
- Decreased femoral offset
- Femoral neck retroversion

Pincer Impingement

- Active middle-aged women
- Anterosuperior acetabular rim overhang
- Acetabular retroversion
- Acetabular protrusion
- Coxa profunda



Associated Injuries

- Labral degeneration and tear
- Cartilage damage and flap tears
- Secondary hip osteoarthritis

Exam

Limited hip flexion, especially with internal rotation

Provocative Tests

Anterior Labral Tear:

- Pain if hip is brought from a fully flexed, externally rotated and abducted position to a position of extension, internal rotation and adduction.

Posterior Labral Tear:

- Pain if hip is brought from a flexed, adducted and internally rotated position to one of abduction, external rotation and extension

KNEE

Meniscal Injury

- Most common indication for knee surgery
- Medial tears more common than lateral tears
- Degenerative tears in older patients usually occur in the posterior horn medial meniscus
- Lateral tears more common in acute ACL tears
- Double PCL sign indicates a bucket-handle meniscal tear

ACL Tear

- Mechanism is a non-contact pivoting injury
- Often associated with a meniscal tear (lateral meniscal tears 54%)
- More common in female athletes (4.5:1 ratio)
- Females have ACL injuries at younger age than males
- Females supporting leg, males kicking leg

Presentation

- Felt a “pop”
- Pain deep in knee
- Immediate swelling (70%)

Lachman’s Test

- Most sensitive test

Segond Fracture

- Is pathognomonic for ACL tear
- Bony avulsion by the anterolateral ligament (ALL)
- Avulsion fracture of the lateral tibia
- Associated with ACL tears (75-100%)

PCL Injury

- Direct blow to proximal tibia with a flexed knee (dashboard injury)
- Non-contact hyperflexion with a plantar-flexed foot
- Hyperextension injury

MCL Injury

- Tibial collateral ligament
- Most commonly injured ligament of knee
- Valgus and external rotation force to lateral knee
- Pellegrini-Stieda Syndrome: Calcification at medial femoral insertion site

LCL Injury

- Fibular collateral ligament
- Direct blow or force to the weight-bearing knee
- Excessive varus stress, external tibial rotation and/or hyperextension

O'Donoghue Triad

- Unhappy Triad or Terrible Triad
- ACL, MCL and medial meniscus tears
- But, lateral meniscus tears are more common with ACL and MCL injuries
- Lateral compartment bone bruise

Posterolateral Corner Injury

- Missed PLC injury diagnosis is common cause of ACL reconstruction failure

PLC Structures
Static Structures:

- LCL
- Popliteus tendon
- Popliteofibular ligament
- Lateral capsule
- Arcuate ligament
- Fabellofibular ligament

Dynamic Structures:

- Biceps Femoris
- Popliteus muscle
- Iliotibial tract
- Lateral head of gastronemius

Rotator Cuff Tears

Chronic Degenerative Tear

- Usually involves the SIT muscles

Chronic Impingement

- Typically starts on the bursal surface or within the tendon

Acute Avulsion Injuries

- Subscapularis tears seen in younger patients following a fall
- Acute SIT tears in patients > than 40 years with a shoulder dislocation

Rotator Cuff Tears

- The articular side has only half the strength of the bursal side
- Most tears are articular sided

Rotator Cuff Footprint
Medial-lateral width of insertion

- Supraspinatus 12.7mm
- Infraspinatus 13.4mm
- Subscapularis 17.9mm
- Teres Minor 13.9mm

AP dimension of footprint is 20mm

SIT Tears

- Supraspinatus tear most common
- Associated with subacromial impingement
- Degenerative tears in older patients or a shoulder dislocation in patients > 40 years

Full-thickness tear
Partial-thickness tears

- Articular surface
- Bursal surface
- Interstitial or intratendinous or intrasubstance

Complete RC tear- full-thickness as well as full-width

Subscapularis Tears

- Associated with subcoracoid impingement
- Acute avulsion in younger patients with a hyperabduction/external rotation injury

RC Tear Symptoms

- Pain, insidious onset exacerbated by overhead activities
- Pain located in deltoid region
- Night pain, which is a poor indicator for nonoperative management
- Can have acute pain and weakness with a traumatic tear
- Weakness with loss of active ROM with greater or intact passive ROM

Subacromial Impingement

- Most common cause of shoulder pain
- Extrinsic compression of RC between the humeral head and:
  - Anterior acromion
  - Coracoacromial ligaments
  - AC joint
- Intrinsic Degeneration
  -Attrition of the SS, superior migration of the humeral head and narrowing of the subacromial space

- Associated Conditions
    - Hook-shape acromion
    - Os acromiale
    - Posterior capsular contracture
    - Scapular dyskinesia
    - Tuberosity fracture malunion
    - Instability

Bigliani Classification of Acromion Morphology
-Type I →flat
-Type II →curved
-Type III →hooked

Subcoracoid Impingement
- Impingement of the subscapularis between the coracoid and lesser tuberosity
- Position of maximal impingement is arm adduction, flexion and external rotation
- Anterior shoulder pain worsened by flexion, adduction and external rotation

Calcific Tendonitis
- Associated with subacromial impingement
- Patients age 30 – 60
- More common in women
- Supraspinatus tendon is most often involved
- Associated with diabetes and hypothyroidism