Pediatric Musculoskeletal Medicine | Spine and Lower Extremity

Homepage

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Goals and Objectives

Home

By the end of this module, learners should be able to:

- Perform a general examination of the back and lower extremity.
- Select physical examination maneuvers to evaluate a specific sports medicine diagnosis.
- Explain the difference in the uses of splinting and casting.
- Recognize non-emergency injuries that should be urgently referred to an orthopedic surgeon.
- Recognize pediatric-specific musculoskeletal pathology such as apophysitis and osteochondritis dissecans.

Musculoskeletal Complaints

The "HIPROT" Mnemonic for Musculoskeletal Complaints
(adapted from the Curbsiders Internal Medicine podcast)

- History
- Inspection
- Palpation
- Range of motion (and strength)
- Other Tests (special maneuvers, imaging)

A General Approach to the History:

- Standard history items: Onset, Location, and Duration.
- Mechanism of injury and point of maximal tenderness (with one finger).
- Aggravating factors – does it interfere with…
    - …strenuous activity or longer practice?
    - …even mild or moderate activity?
    - …activities of daily living?
- Prior care and treatments tried (e.g. urgent care, chiropractor).
- The athletic medical history:
    - Sports played: days per week, months per year
      (Early specialization disposes to overuse and injury)
    - Prior injuries or pain
    - Change in training routine or lack of conditioning

Inspection/Palpation/Range of Motion

- Examine the joint above and below!
- Look for:
    - Body position and ease of movement
    - Anatomic alignment and asymmetry
    - Muscle bulk or atrophy
    - Ligamentous laxity (hyperextended knees, overpronated feet)
    - Nutritional concerns (systemic disease, female athletic triad)
- Feel for:
    - Effusion or redness
    - Active and passive range of motion for the affected joint.
    - Ligamentous stress tests

Imaging:

- Plain radiographs are most commonly ordered.
- Always get at least 2 views (AP and lateral), and consider a film of the opposite side if there might be an anatomic variant.

Special considerations in children

<u>Cartilage is the weakest link of the growing skeleton</u>

- Cartilage forms physeal growth plates and apophyses and can be stressed, fractured or avulsed.
- Chronic injuries can include apophysitis from traction on ossification centers or osteochondritis dissecans from focal ischemic necrosis of the bone beneath the articular cartilage.

<u>Children can suffer specific fracture types (buckle and greenstick) due to their relatively elastic bones.</u>

<u>Skeletal immaturity and maturity differentiate possible injuries</u>

- Some growth centers do not close until age 18 (such as the spine).
    - Boys: growth peaks 1.5 years and ends 3-4 years after the first signs of puberty.
    - Girls: growth peaks 1 year after the first signs of puberty develop, and ends 2-3 years after menarche.
- During growth spurts, skeletal growth can outpace muscle and ligament lengthening, reducing flexibility and disposing to apophysitis.

<u>Consider psychiatric concerns</u>

- Address the perception of disease and recovery. For example, Osgood Schlatter disease results from growth and should not be thought of as "disease".
- Some athletes may understate symptoms to avoid activity restriction.
- Consider nutrition and disordered eating in the setting of a possible stress injury.

References:

- Coleman, N. Sports Injuries. Pediatrics in Review Jun 2019, 40 (6) 278-290.

Examining the Back and Spine

Anatomy:
- Anterior column: Vertebral bodies and intervertebral discs.
- Posterior column: Vertebral arch and facet joints. The pars interarticularis is a growth center between the articular processes above and below.
- Low back pain in pediatrics associated with increased rate of structural anomalies (e.g. spina bifida occulta).

Pearls:
- Pain from the anterior column usually worsens with forward bending, turning or Valsalva. Pain from the posterior column usually worsens with back extension.
- Scoliosis alone does not usually cause pain.
- Parents can complain of slouching and express concern for kyphotic deformity. If the patient is able to extend their back to anatomic position or lie flat while supine, they can be reassured.

History:
- Muscular and soft tissue pain usually stays in the back, whereas nerve compression usually refers pain to the buttocks or legs.
- Red flags: morning stiffness, night pain, pain not helped by rest, constitutional or neurologic symptoms.

Inspection:
- Inspect from the side and behind for leaning and asymmetry.
- The back muscles may have asymmetric bulk, but the spine should be straight, as if traced by a weighted string hanging from the neck.

Palpation:
- Palpate the iliac crests to confirm that the pelvis is level.
- Palpate for stepoffs or tenderness. Percuss the spinous processes.
- To provoke sacroiliac pain, push with heel of hand on the prone patient over the dimples of Venus (posterior superior iliac spine).
- Palpate the distal hamstrings to make sure they are not tight.

Range of motion:
- The fingertips should pass mid-tibia when bending forward.
- Pain with flexion can suggest spasm or anterior column pathology. Painful extension (especially on one foot, Stork test) suggests posterior spine or SI joint pathology.
- When testing lateral bending and rotation – you may need to stabilize pelvis to keep the patient from pivoting the legs.

Imaging:
- Expert opinion suggests that lumbar pain lasting longer than 3 weeks in young athletes should warrants AP, lateral and oblique plain films.
- CT is ideal for detailed traumatic osseous injury.
- MRI imaging can identify soft tissue injury, stress reaction and fracture.

Other Tests:
- A neurologic exam is important – ask about numbness or tingling, test for decreased strength or asymmetric reflexes.
- See the exam index for other tests

Spinal level	Motor	Sensory distribution	Reflex
L4	Knee extension	Anterolateral thigh	Patella
L5	Dorsiflexion of great toe	First and second toe webspace	Medial hamstring
S1	Plantarflexion of ankle	Lateral foot	Achilles

References:

- Jordan Metzl Exam Videos
- Stanford 25 Back Exam
- Bunnell WP. Back Pain in Children. Pediatrics in Review Dec 1984, 6 (6) 183-189.
- d'Hemecourt P and Deede JF. Cervical and Thoracic Spine Injuries. In: Micheli LJ and Purcell L, eds. *The Adolescent Athlete: A Practical Approach*. 2nd ed. Cham, Switzerland; Springer; 2018: 65-73.
- Zetaruk M. Lumbar Spine Injuries. In: Micheli LJ and Purcell L, eds. *The Adolescent Athlete: A Practical Approach*. 2nd ed. Cham, Switzerland; Springer; 2018: 87-109.

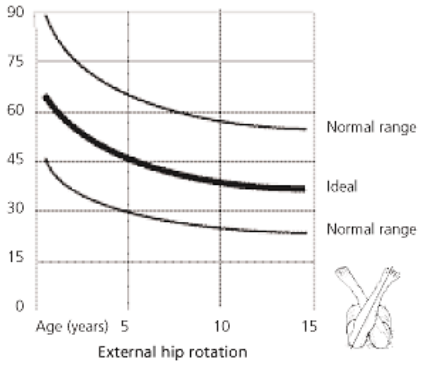
Examining the Hip and Thigh

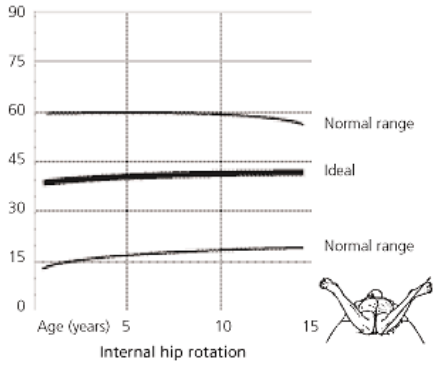
Overview of anatomy:
- Ball and socket joint with many stabilizing muscles and ligaments.
- Multiple muscles originate on the pelvis and can cause apophysitis.
- Femoral neck injury can cause femoral head avascular necrosis.

History:
- There are many descriptions of "hip pain". Hip pathology often localizes to the groin, although diseases such as SCFE can refer pain to the knee.

Inspection/Palpation:
- Examine the standing patient for gluteal atrophy or symmetry and palpate for pelvic obliquity.
- To measure leg length, measure from the ASIS to medial malleolus.
- It is important to palpate for possible referred sites of pain:
    - Examples: lumbar vertebrae, sacroiliac joint, iliac crest and femoral trochanters.

Range of motion/strength:
- Supine: look for an internally or externally rotated hip at rest.
- Prone: Compare internal and external rotation (normal ranges below).
- Patients can have anteversion (excessive internal rotation) or retroversion (excessive external rotation).

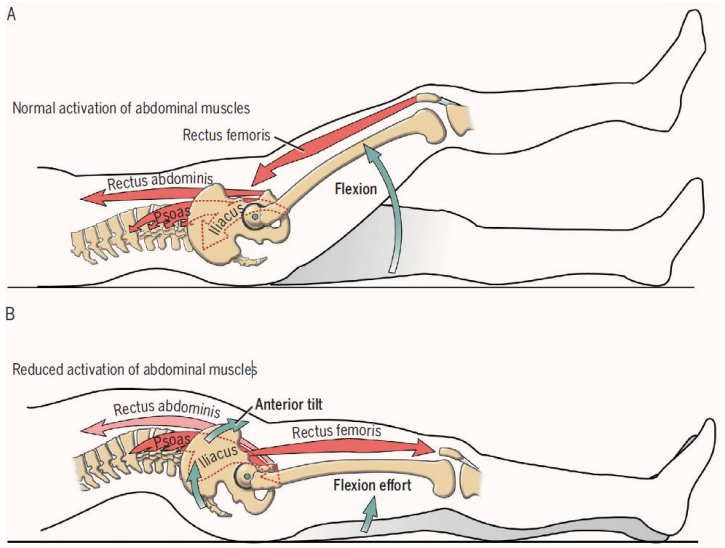




Range of motion/strength, continued:
- **Flexion and extension**: Patients can compensate for flexion contracture by hyperextending the spine (Thomas test, see index). Ensure the pelvis and lumbar spine are flat on the table.
- **Abduction and adduction**: Evaluate for Trendelenberg test (hip abductor weakness). Adductor pain can be seen in hip impingement.

Other Tests: See the exam index for other tests

Imaging: Hip films can be AP or lateral (frog-leg position).



References:

- Curbsiders Internal Medicine: The 8 second hip exam (adult-focused)
- Jordan Metzl Exam Videos
- Wenger DR, Rang M. The art and practice of children's orthopaedics. New York: Raven Press, 1993.
- Sass P, Hassan G. Lower extremity abnormalities in children. Am Fam Physician. 2003 Aug 1;68(3):461-8. Review.
- Neumann DA. Kinesiology of the hip: a focus on muscular actions. The Journal of orthopaedic and sports physical therapy. 2010;40(2):82-94.

Examining the Knee and Leg

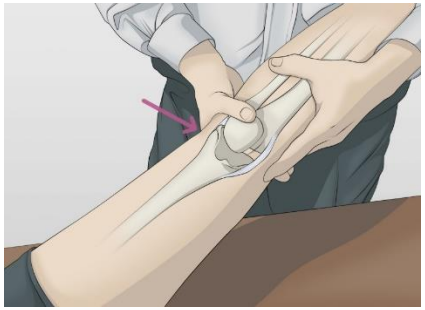
Overview:
- The knee has stabilizing ligaments that can tear, growth plates that can break, and bursae that can become inflamed.
- Trauma to the leg can injure the popliteal artery or cause compartment syndrome of the leg.
- Internally rotate and abduct the hip during an exam, as hip pain can refer to the knee!

History:
- Red flag symptoms for intraarticular injury: Painful locking, clicking or catching; feeling that the knee "will give out"; swelling and effusion.
- More chronic knee pain can be associated with growth spurt.

Inspection:
- Check alignment: genu varum/valgum, rotation (see hip exam), pes planus and pronation of feet.
- Check for obvious effusions (around dimples around patella), prior surgical scars and color changes, thigh atrophy or asymmetry.

Palpation:
- Palpate the knee at 90 degrees of flexion. Palpate the menisci at the joint lines, femoral condyles (ligamentous attachments, iliotibial band), muscle tendons and bursae (prepatellar, suprapatellar, pes anserine).
- "Milk" the knee to gather and detect an effusion. Effusions are moveable, while soft tissue swelling is not.

Range of motion:
- Flexion and extension: 0 degrees (extended) to 150 degrees (able to touch heel to buttocks when prone).
- A locked knee cannot fully extend and is concerning for a loose body or meniscal tear in the joint.
- Ligamentous laxity is common in pediatrics—the knees can slightly sag when supine and hyperextend when standing. Compare each side if there is a positive test!



Varus and valgus stress tests:
Hold leg between elbow and body at 20 degrees of flexion.
Feel for laxity or joint space widening. Testing in extension can be falsely negative due to added stability from the cruciate ligaments.

Milking an effusion; ballotting the patella:
In the swollen knee, sweep down fluid from the suprapatellar space and push down on the patella to feel if "floats" in an effusion.

Imaging:
- In addition the AP and lateral views, there are other plain film views:
  - Sunrise (aka Merchant, skyline): patellofemoral joint.
  - Notch view can help show osteochondritis dissecans.
- MRI can evaluate the menisci and ligaments and is best used for severe pain, hemarthrosis, a locked knee, and inability to bear weight despite negative plain films.

Other Tests: See the exam index for other tests

References:

- AAOS: Common Knee Injuries
- The Curbsiders Internal Medicine: The 30 second knee exam
- Jordan Metzl Exam Videos
- Cunill-De Sautu B, Gereige RS. Knee Conditions. Pediatrics in Review Sep 2014, 35 (9) 359-370.

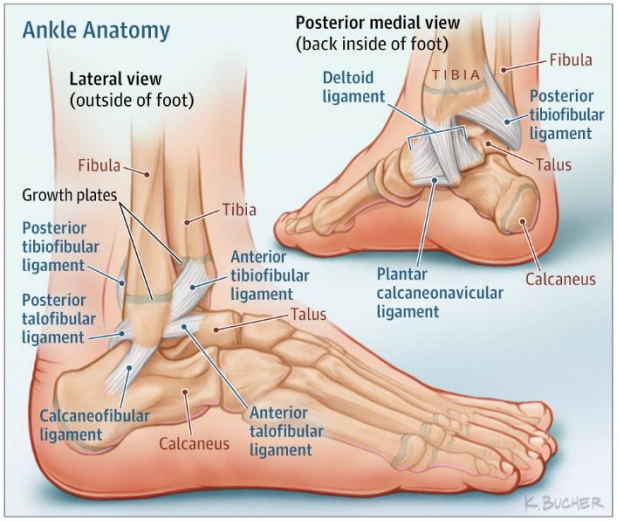
Examining the Ankle and Foot

Overview:
- The distal tibia and fibula form a mortise joint with the talus. There are multiple stabilizing ligaments:
    - Deltoid ligament resists ankle eversion.
    - Lateral ligament complex (anterior and posterior talofibular, calcaneofibular) resists ankle inversion.
- The foot consists of hindfoot (talus, calcaneus), midfoot (navicular, cuboid and cuneiforms) and forefoot (metatarsals, phalanges, great toe sesamoids). The spring ligament helps form the medial foot arch.
- Ankle tightness can be expected during growth, but clonus or asymmetric reflexes suggests neuromuscular pathology.

History:
- Give extra attention to chronic ankle pain or recurrent ankle injury as there may be proprioceptive or mechanical risk factors.
- Snapping, clicking or locking can suggest osteochondritis dissecans.

Inspection:
- Observe patient standing on feet, then on toes, then walking.
    - When tiptoeing, the heel should point inwards (adduct) and the foot arch should be more pronounced.
    - When standing and walking, note the direction of the patellae and foot progression ankle (inward, outward, forward).
    - With patient supine, flex the knees and compare the thigh foot angle (the line bisecting the foot).
- Note antalgic gait (less time on the affected foot in stance phase) or shifting weight away from the injury (e.g., heel walking in toe fracture).

Palpation:
- If on the field, palpate immediately before swelling obscures the ankle.
- Palpate systematically with attention to physeal sites in the immature athlete. Squeeze test the leg for syndesmotic injury and for compartment syndrome.
- Ankle effusions can be felt anteriorly medial to the anterior tibialis and laterally to the peroneus tertius.



Range of motion:
- Expect 10-15 degrees of dorsiflexion and 40 degrees of plantarflexion.
- Rock the midfoot and forefoot in and out to test subtalar motion
- The ATFL is stressed with the ankle in slight plantarflexion, and the CFL is stressed with the ankle in neutral.

Imaging:
- Plain films typically include: anteroposterior and lateral views.
- Consider mortise views to evaluate the ankle joint itself, and stress views if there is instability on exam.

Other Tests: See the exam index for other tests

References:
- Jordan Metzl Exam Videos
- Batson JP and Locke MD. Foot and Ankle Injuries. In: Micheli LJ and Purcell L, eds. *The Adolescent Athlete: A Practical Approach*. 2nd ed. Cham, Switzerland; Springer; 2018: 275-299.
- Harvey J. Ankle Injuries in Children and Adolescents. Pediatrics in Review Jan 1981, 2 (7) 217-222.

Salter Harris Fractures

Overview:
- Cartilage is the weakest link in the skeletally immature patient.
- The growth plates are 2-5 times weaker than the surrounding bone.
- Salter Harris II fractures are the most common type of fracture.
- Traumatic growth plate injuries most commonly affect the distal radius, distal femur and proximal and distal tibia.

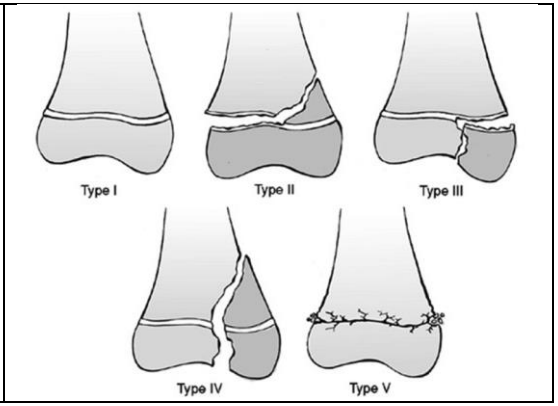
Evaluation:
- Generally note deformity, tenderness and ability to bear weight.
- Plain films comparing the injured and uninjured sides can help differentiate physeal widening from anatomic variation.
- CT scans are often used in Salter Harris III/IV fractures to help surgical planning.

Pearls:
- The most important risk with physeal fracture is growth disturbance that occurs at the time of injury – the risk of growth disturbance is not necessarily helped with reduction or surgery.
- Not all fractures require reduction due to potential for remodeling.
- If reduction is attempted, try only once. Additional attempts may result in further injury to the growth plate.

Special Cases:
- Salter Harris fractures around the knee (distal femur, proximal tibia) often occur from high energy injuries – evaluate neurovascular status and check for signs of compartment syndrome.
- A Salter Harris II fracture of the distal phalanx is called a Seymour fracture. This is an open fracture. The nailbed can entrap in the separated growth plate. Seymour fractures often require antibiotics, close follow-up and often require surgical exploration, repair and reduction with fixation.

Classification by Anatomy:

SALTER acronym for fracture in relation to the growth plate
- Type I (Straight across)
- Type II (Above)
- Type III (Lower)
- Type IV (Together)
- Type V (ERasure)



Classification by Management:
- **Salter Harris I and II** – These are generally reduced and splinted to be transitioned to a cast. Prognosis is generally good.
- **Salter Harris III and IV –** Because there articular surface is disrupted, urgent orthopedic consultation and operative reduction and fixation is necessary to restore the joint surface and limit the future development of osteoarthritis. Displaced fractures and those with vascular compromise to the avulsed fragment have a worse prognosis.
- **Salter Harris V** – Orthopedic consultation is important but ultimately a goals of care discussion is necessary in anticipation of growth arrest of the affected limb.

References:
- AAOS: Growth Plate Fractures
- Coleman, N. Sports Injuries. Pediatrics in Review Jun 2019, 40 (6) 278-290.
- Maffulli N, Via AG, Oliva F. Acute Lower Extremity Injuries in Pediatric and Adolescent Sports. In: Micheli LJ and Purcell L, eds. *The Adolescent Athlete: A Practical Approach*. 2nd ed. Cham, Switzerland; Springer; 2018: 108-110.

Stress Fractures: An Overview

Overview:

- Most stress fractures occur in the leg. The main extrinsic risk factor is the training regimen. Shoes are only weakly associated with stress fracture.
- Plain films may not yet show stress fractures. MRI is sensitive but not readily available — **clinical suspicion is key** to promptly make a patient non-weightbearing and refer high risk fractures to an orthopedist.

Clinical Presentation:

- Initially diffuse pain occurs from periosteal stress and becomes more focal with progressively inward breakage of the cortex.
- Pain develops progressively earlier in practice and can eventually occur with daily activity.

Evaluation:

- Dietary and menstrual history.
- Ask about recent increases in activity, diversity of activities or lack of conditioning regimen.

Physical examination:

Metatarsals	Focal tenderness on metatarsal shaft.
Tibia	Focal tenderness, usually at the junction of middle and distal thirds of tibial shaft. In contrast, shin splints usually painful along most of the medial tibial shaft.
Fibula	Point tenderness of fibular shaft.
Prox. humerus	Pain only when throwing.
Distal radius	Pain occurs with weight-bearing on the wrist.

(Adapted from Caine and Purcell, 2016)

Imaging: In general order of usefulness: MRI > XR > Bone scan > CT

- Plain films may be initially normal and need to be repeated in 1-2 weeks. There can be up to 3 months of radiographic lag.
- MRI is very sensitive and can predict stress fractures.

Is it a high risk stress fracture?

- High risk stress fractures are 1) under tension and 2) have poor blood supply.
- These fractures are at risk of delayed healing or nonunion.

More common high risk stress fractures

- **Superior femoral neck:** Frequently only seen on MRI, presents with pain with passive internal rotation of the hip.
- **Anterior tibia**: may have “dreaded black line” on lateral plain film.
- **Tarsal navicular**: tenderness over the mid-dorsal navicular.
- **Fifth metatarsal**: at the junction of metaphysis and diaphysis: proximal tenderness, may have cortical defect on plain film.

Management

- Fractures at are low risk for nonunion can be handled by the primary care provider.
    - The duration of cross training varies by location.
    - Generally speaking, cross train with supportive bracing for 3-4 weeks, then re-evaluate symptoms. If symptoms have resolved, advance the athlete to another 3-4 weeks of light activity.
    - General return to play criteria: No tenderness, gradual return to impact with sport-specific training. Mild injuries can take up to 13 weeks. Severe injuries can take up to 24 weeks to recover.
- Fractures at high risk for nonunion should be referred to an orthopedist to consider operative fixation. A complete fracture line should be seen within 24 hours.
- Consider malignancy or other pathologic fracture if pain fails to improve after a week of rest.

References

- See Index: High Risk Stress Fractures.

Index: High Risk Stress Fractures

Index of High Risk Lower Extremity Stress Fractures (McInnis, 2016):

Site/*Sports*	Initial Treatment
Femoral neck *Running, endurance athletes*	Compression-side: NWB × 4-6 wk Tension-side: surgical referral Displaced: urgent surgical referral
Patella *Running, basketball, gymnastics*	Stress reaction: Activity restriction, WB as tolerated Fracture line: NWB, knee extension brace immobilization × 4-6 wk Displaced: Surgical referral
Anterior tibia *Basketball, gymnastics*	NWB × 6-8 wk Consider surgical referral Refer if poor healing at 3-6 mo
Medial malleolus *Running, track and field, basketball, gymnastics*	Nondisplaced: NWB and cast immobilization × 4-8 wk Displaced: Surgical referral
Talus *Running, pole vaulting, basketball, gymnastics*	NWB × 6 wk ± cast immobilization
Navicular *Track and field, football, basketball*	Based on CT findings Dorsal cortex only: NWB and cast ≥6 wk Fracture into body or second cortex: Referral
Proximal fifth metatarsal *Soccer, basketball, football*	Stress reaction: NWB and immobilization × 6 wks Fracture line: Surgical referral
Sesamoid *Dance, gymnastics, racquet sports, basketball, soccer, volleyball, running*	NWB and immobilization × 6 wk; orthotics Surgical referral if poor healing at 3-6 mo

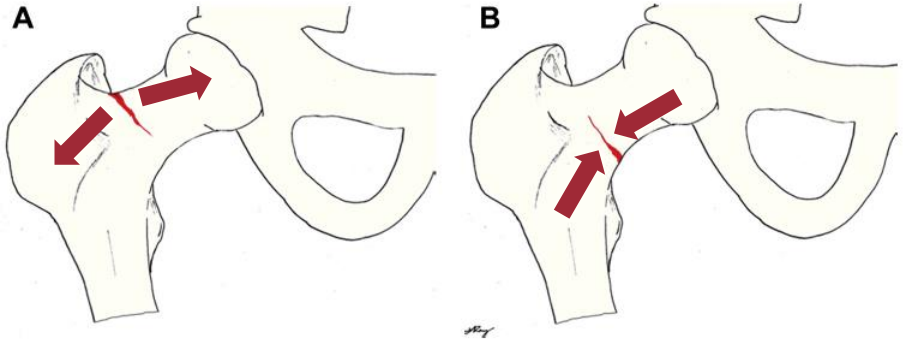
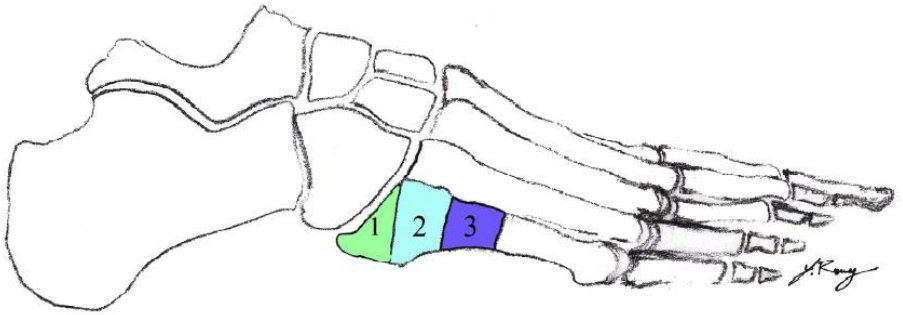


Illustration of forces that A) put high risk stress fractures under tension and B) lower risk stress fractures under compression.



Types of metatarsal stress fractures. Fractures in zone 2 and 3 are high risk and should be referred.

Stress Fractures — Section References

- Caine D, Purcell L, eds. Injury in Pediatric and Adolescent Sports: Epidemiology, Treatment and Prevention. Switzerland: Springer; 2016.
- McInnis, K. C. and Ramey, L. N. (2016), High-Risk Stress Fractures: Diagnosis and Management. PM&R, 8: S113-S124.
- Pegrum J, Crisp T, Padhiar N. Diagnosis and management of bone stress injuries of the lower limb in athletes. BMJ (Clinical research ed). 2012;344:e2511.

Apophysitis

Overview:

- An **apophysis** is a secondary ossification center to which a muscle tendon attaches.
- Cartilage is the weakest link in the skeletally immature athlete. The apophysis can become inflamed from traction and even pulled off from its originating bone in an avulsion injury.
- Generally, apophysitis can be prevented by limiting the load on the apophysis with regular stretching and warming up.

Evaluation

- Insidious and focal activity-associated pain at the site of an apophysis.
- An apophyseal avulsion can present with sudden onset pain and loss of function ("I kicked a ball and felt a pop and couldn't lift my leg").
- Palpation: Palpate firmly for point tenderness at the affected apophysis.
- Range of Motion: Stress the apophysis with resisted activity of the attached muscle (e.g. anterior inferior iliac spine apophysis pain worsens with resisted flexion of the hip).

Imaging:

- Imaging is helpful for a suspected avulsion injury or stress fracture. It can help to image the other side to compare for apophyseal widening.

Management:

- Conservative management (relative rest, ice and NSAIDs in anticipation of gradual return to play).
- Athletes may do limited activity as long as they do not have pain. However, playing through the disease risks progression to avulsion.
- Surgical intervention is indicated for:
    - Patellar sleeve fractures
    - Tibial tubercle avulsion
    - Avulsions that do not heal after 3-6 months
    - Avulsions with significant displacement (site-specific; for example, anterior inferior iliac spine avulsion with >2 cm of displacement).

List of common apophysitides (adapted from DeFiori, table 7.2)

Disease	Age (y)	Exam findings	Treatment specifics (non-avulsion)
Calcaneal "Sever's disease"	8–12	Tenderness at calcaneal insertion of the Achilles tendon	Heel cup
Tibial tubercle "Osgood-Schlatter disease"	8–14	Tenderness at the tibial tuberosity at the insertion of the patellar tendon	Counterforce brace over patellar tendon
Inferior patella "Sinding-Larsen-Johansson syndrome"	8–12	Tenderness at the proximal insertion of patellar tendon	Counterforce brace over patellar tendon
Pelvic	9–16	Multiple sites: ASIS, AIIS, iliac crest, ischial tuberosity, lesser trochanter, greater trochanter, with tenderness at tendon attachment of the specific apophysis	Relative rest
Medial epicondyle "Little League elbow"	8–14	Tenderness at medial epicondyle	Cessation of throwing initially Pitch counts

References

- DeFiori JP, Brenner JS and Jayanthi N. Overuse Injuries of the Extremities in Pediatric and Adolescent Sports. In: Micheli LJ and Purcell L, eds. *The Adolescent Athlete: A Practical Approach*. 2nd ed. Cham, Switzerland; Springer; 2018: 275-299.
- Jones C, Wolf M, Herman M. Acute and Chronic Growth Plate Injuries *Pediatrics in Review.* 2017;38 (3) 129-138.

Osteochondritis dissecans (OCD)

Overview:

- Osteochondritis dissecans is a **focal avascular necrosis** of the bone just beneath the joint cartilage. The etiology is not well known but theories suggest repetitive microtrauma (overuse) or local ischemia (many potential causes).
- The affected fragment can become unstable and dislodge into the joint space as a loose body.
- While overall an uncommon disease, OCD most commonly affects the knee, ankle and elbow. Patients with a history of SCFE or Legg-Calve-Perthes disease can develop OCD of the hip.
- The management and prognosis of OCD diverges greatly from that of other musculoskeletal conditions. Maintaining clinical suspicion for OCD is important in cases of longstanding joint pain.

Clinical Presentation:

- Patients are often 10-20 years of age who present with indolent nonspecific joint pain that may be refractory to physical therapy.
- An intraarticular loose body may have mechanical symptoms such as locking or catching.

Evaluation:

- Palpation: An effusion is sometimes present.
- Imaging: Plains films are good first step, though there are specific views to obtain as part of a workup for OCD.
    - Knee: Notch (tunnel) views
    - Elbow: Capitellar view
    - Ankle: dedicated views in plantarflexion, dorsiflexion and internal rotation
    - Ultimately MRI is necessary as it can easily show lesions and predict instability.

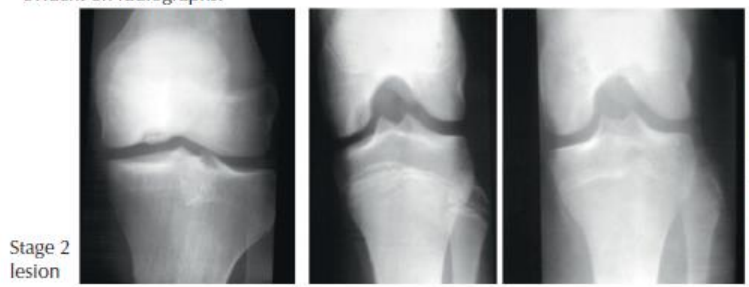
Management:

- Suspect OCD and refer for atraumatic indolent joint pain, especially if it lasts 4-6 months.
- Management is variable – for mild cases, rest can be attempted. For loose bodies surgical correction is necessary to remove the loose body, fixate an unstable fragment or drill the underlying bone to restore blood flow.
- Patients with open growth plates have a higher rate of healing with non-operative management compared to those with closed growth plates.

Stage 1. Bulge on medial femoral condyle due to partial separation of bone fragment. Articular cartilage intact, but defect evident on radiographs.

Stage 2. Fragment demarcated by separation of articular cartilage.

Stage 3. Fragment of cartilage and bone completely separated as loose body. This often migrates to medial or lateral.



Stage 2 lesion

Tunnel view radiographs of small OCD lesion involving medial femoral condyle treated with activity modification. Complete healing occurred.

References:

- AAOS: Osteochondritis dissecans
- Bauer KL. Osteochondral Injuries of the Knee in Pediatric Patients. *The journal of knee surgery.* 2018;31(5):382-391.
- Bauer KL, Polousky JD. Management of Osteochondritis Dissecans Lesions of the Knee, Elbow and Ankle. *Clinics in sports medicine.* 2017;36(3):469-487.

Splinting and Casting

Overview:

- Goal is to immobilize an injury
  - **Casts** are circumferential around the extremity.
  - **Splints** are a slab shaped onto the extremity, with a bandage affixing the extremity to the splint.
- **Casts** provide **more stability**, but are closed and do not accommodate swelling from the injury (exception: bivalve casts).
- **Splints** provide reasonable stability but are **open and allow swelling**.
- Materials: plaster, fiberglass, prefabricated plastic and Velcro (boots, wrists, air casts).

Immobilization	Splint = slab + bandage	Cast
Features	Non-circumferential Prefabricated or molded Removable	Circumferential Must be molded Must be sawn off
Why use	Simple stable fractures, sprains and strains Easy to apply Allows swelling (usually 1 week)	Definitive fracture management Superior immobilization
Complications	Insufficient immobilization Instability Noncompliance Pressure injury Thermal injury (molded)	Compartment syndrome Dermatitis Lodged foreign body Pressure injury Thermal injury (molded)

Technique-related complications

- Compartment syndrome if wrap is too tight.
- Inadequate support from a loose or short splint.
- Pressure necrosis over bony prominences from inadequate padding.

Referral to orthopedics

- It is appropriate to consult an orthopedist to determine follow-up interval to avoid a premature office visit at cost to the family. Generally, a splint is left on for 1 week to allow swelling to subside before transitioning to a cast.
- Casts that become wet or have an trapped foreign body (e.g., a pen cap that the child was using to scratch) should be sent to orthopedist for remove the cast and object followed by placement of a new cast.

References/Resources:

- **AAOS: Care of Casts and Splints**
- **PONSA: I Broke My Cast**
- Boyd AS, Benjamin HJ, Asplund C. Principles of casting and splinting. Am Fam Physician. 2009 Jan 1;79(1):16-22.
- Jackson TJ, Blumberg TJ, Shah AS, Sankar WN. Inappropriately Timed Pediatric Orthopaedic Referrals From the Emergency Department Result in Unnecessary Appointments and Financial Burden for Patients. J Pediatr Orthop. 2018 Mar;38(3):e128-e132.

Selecting and Applying a Splint

Applying a splint

- Reduce a displaced fracture or dislocation and document a follow up neurovascular exam.
- Splint should be well molded and extend past the joints above and below the fracture.
    - Example: splint a both bone forearm fracture above the elbow and past the wrist with a posterior long arm or sugar tong splint.
    - Exception: isolated distal radius or distal fibula fractures can be splinted with a short arm or short leg cast.
    - Measure out splint material to cover past each immobilized joint and apply 2-3 layers of web roll as padding.
    - Apply extra padding over bony prominences
    - Apply elastic bandage to secure splint. Do not use Coban wrap.
- Repeat neurovascular exam after placement of splint. If reduction was done, obtain post-reduction plain film.

Instruction to family:

- Elevate limb for 48 hours. Keep splint clean and dry.
- Wet dressings can become itchy. Children can insert foreign bodies (e.g. pen caps) in an attempt to scratch this itch. Can try a hairdryer for fiberglass splints. Otherwise, will need to change the cast if a foreign object becomes lodged.

References/Resources:

- **Handout:** ScotchCast (3M) splinting guide
- **Handout:** OrthoInfo: Cast Care
- AAOS: Care of Casts and Splints
- PONSA: I Broke My Cast
- Boyd AS, Benjamin HJ, Asplund C. Principles of casting and splinting. Am Fam Physician. 2009 Jan 1;79(1):16-22.

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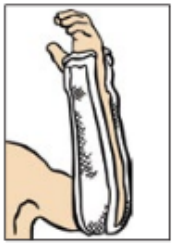
Ulnar Gutter Splint
Common Uses
5th Metacarpal Fracture, 4th Metacarpal Fracture

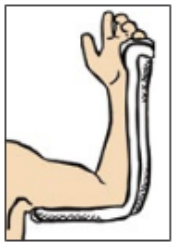
Volar Splint
Common Uses
Wrist Sprains/ Strains, Carpal Tunnel, Lacerations, Night Splints

Thumb Spica Splint
Common Uses
Navicular Fracture, Thumb Dislocation, Ligamentous Injuries, Bennett's Fracture



Sugar Tong Splint
Common Uses
Colles' Fracture, Forearm Fracture (Radial/Ulnar)

Sugar Tong Splint
Common Uses
Humeral Fracture



Posterior Long-Arm Splint
Common Uses
Supracondylar Fracture, Elbow Sprains/Strains

Posterior Short-Leg Splint
Common Uses
Tibia/Fibula Fracture, Ankle Fracture, Metatarsal Fracture

Posterior Long-Leg Splint
Common Uses
Ligamentous Injuries of the Knee, Dislocation of the Knee Joint, Tibia and Fibula Shaft Fractures, Femoral Shaft Fracture

Stirrup Splint
Common Uses
Ankle Fractures, Ankle Sprains/ Strains

Medial-Lateral Long-Leg Splint
Common Uses
Ligamentous Injuries of the knee, Tibia and Fibula Fractures

Sprains, Strains and Physiotherapeutics

Home

Overview:

- Ligaments connect bones to bones and are injured in **sprains**. Prior to skeletal maturity sprains are associated with avulsion injuries.
- Tendons connect muscles to bone. The muscle tendon unit is injured in **strains**.
- Grading sprains and strains can help estimate severity of injury but do not significantly guide conservative treatment or inform prognosis.

Evaluation:

- Grading sprains

Grade	What happened	Findings
1	Ligament stretched	Mild swelling or pain; no laxity
2	Partial ligament tear	Swelling or effusion; laxity but still has a firm end point
3	Complete ligament tear	Swelling, end point feels soft

- Grading strains

Degree	What happened	Findings
1	Few fibers torn	Mild swelling and pain Able to make strong contraction
2	Some fibers torn Muscle tendon intact	Pain, swelling and disability. Weak attempt at contractions
3	Complete rupture of muscle or tendon	Severe pain, “ball” of contracted muscle (e.g. quadriceps, calf) with weak attempt at contraction

Management:

- Healing time often not proportional to grade of injury and so even mild sprains can still take a long time to heal.
- Healing generally divided into three phrases:
    - First phase: RICE with NSAIDs for several days.
    - Second phase: From weeks 1-4, splint or brace while doing low resistance high repetition activity (or light play).
    - Third phase: From week 4-6, activity as tolerated.

Heat and cold

- Comparison of heat and cold

Mode	Heat	Cold
Effects	Increases blood flow	Decreased blood flow Decreases pain sensation
Uses	Chronic pain Stiffness Preparation for therapeutic exercise	Acute injury and swelling Pain
Methods	Insulated heat packs	Often paired with elevation Ice bags Cold soaks

Example: In the moments following an acute ankle sprain, apply ice over a wetted compression dressing to limit swelling. Afterwards, transition to insulation as below.

- Typically treat up to 15-20 minutes at a time every few hours.
    - Insulation is important to avoid injuring the skin in the time needed for the temperature of the deeper tissues to rise or fall.
    - Insulating materials or reusable packs can transmit skin disease.
- Other pearls
    - Fair skin can burn easily.
    - When in doubt, cold is less harmful than heat, which can increase swelling.

References:

- Madden CC, Putukian Mm NcCarty E et al. Netter’s Sports Medicine. Philidelphia: Elsevier; 2018;317-321, 330-336.

AAP Orthopedic referral criteria (2014)

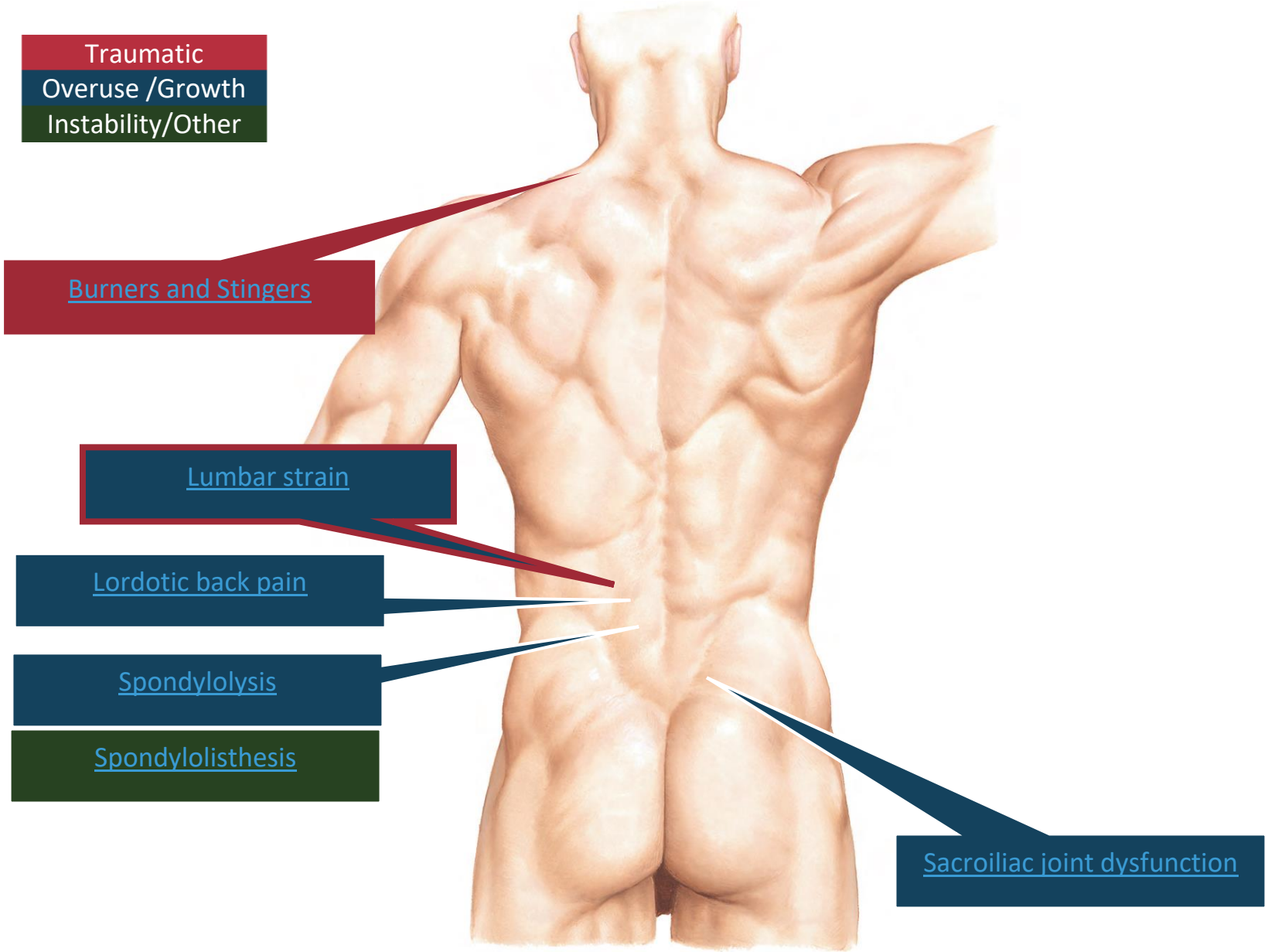
Home

Indication	Infants	Children	Adolescents
Multiple skeletal trauma or complex fractures and dislocations	X	X	X
Significant spinal deformity (scoliosis or kyphosis)	X	X	X
Neuromuscular disability, deformity, or gait abnormality (e.g., cerebral palsy, spina bifida, muscular dystrophy, spinal muscular atrophy)	X	X	X
Developmental dysplasia of the hip (screening by primary care pediatrician)	X	X	X
Bone or joint infection (osteomyelitis, septic arthritis) Co-manage with pediatrician and pediatric infectious disease specialist	X	X	X
Limb malformations (e.g., idiopathic clubfoot, congenital limb deficiency)	X		
Musculoskeletal extremity or spine injuries in suspected non-accidental trauma victims		X	
Perthes disease (ie,osteochondritis of the femoral head)		X	
Slipped capital femoral epiphysis		X	X
Sports injuries, such as anterior cruciate ligament tears, meniscal tears, cartilage injuries, ankle in-stability, or shoulder instability		X	X
Significant limb deformity secondary to metabolic bone disease or other types of growth arrest or with significant limb length discrepancy		X	X

Reference:

Surgical Advisory Panel AAoP, Klein MD. Referral to pediatric surgical specialists. Pediatrics. 2014;133(2):350-356.

Symptom Locator: Back and Spine



Symptom Locator: Hip and Thigh

Pelvic apophysitis

Femoral neck stress fracture

Hip impingement

Brief words:

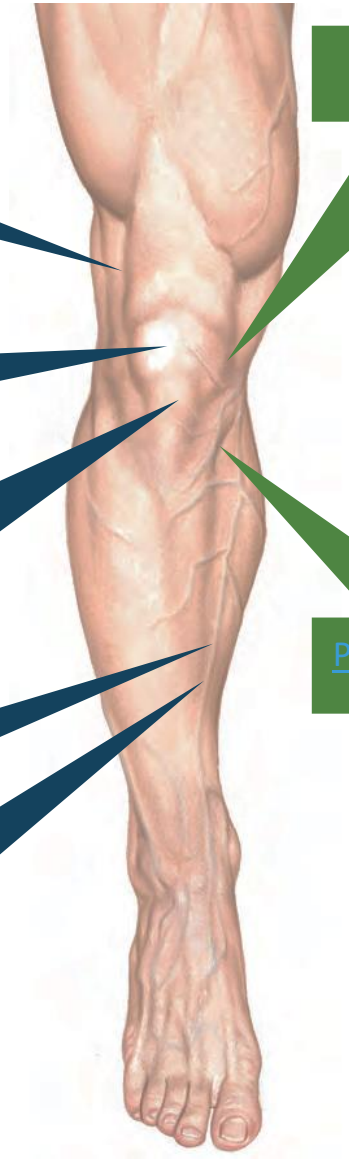
- SCFE
- Legg-Calve-Perthes disease

Traumatic

Overuse /Growth

Instability/Other

Symptom Locator: Knee and Leg



Patellar Dislocation

IT Band syndrome

Patellofemoral Pain Syndrome

Sinding Larsen Johansson syndrome and Osgood Schlatter Disease

Pes anserine bursitis

Medial Tibial Stress syndrome (Shin splints)

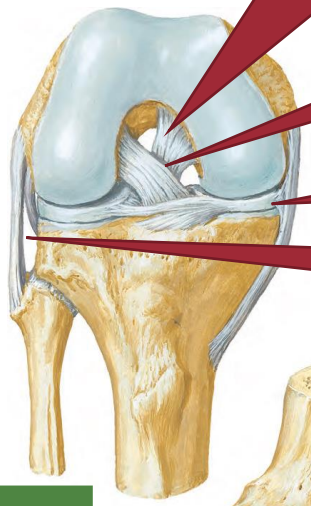
Tibial stress fracture

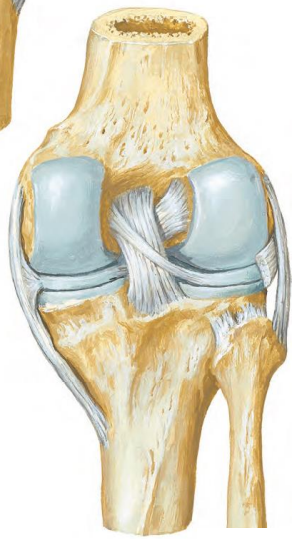
Brief: Posterior cruciate ligament tear

Anterior cruciate ligament tear

Meniscal tear

Medial and lateral collateral ligament tears





Traumatic

Overuse /Growth

Instability/Other

Symptom Locator: Ankle and Foot

Traumatic
Overuse /Growth
Instability/Other

High ankle sprain

Ankle sprain

Repeated sprains, consider:
- Osteochondritis dissecans
- Tarsal coalition

5th Metatarsal stress fracture

Navicular stress fracture

Severs disease

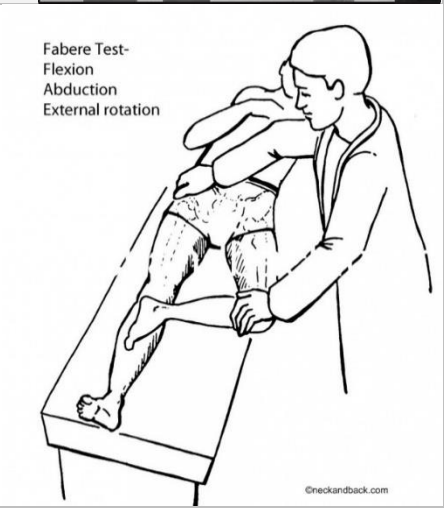
Plantar fasciitis

Conditions Index

Home

Symptom Locator	Traumatic	Overuse or Growth	Instability/Other
Back and spine **Exam Index**	Burners and stingers	Lordotic back pain Lumbar muscle strain Spondylolysis | Spondylolisthesis Sacroiliac Joint Dysfunction	
Hip and thigh **Exam Index**		Pelvic apophysitis Femoral neck stress fracture	Femoroacetabular impingement Brief: SCFE Brief: Legg-Calve-Perthes disease
Knee and leg **Exam Index**	Anterior cruciate ligament tear Brief: Posterior crucial ligament tear Collateral ligament injury Meniscal tear Brief: Compartment syndrome	Patellofemoral pain Extensor chain apophysitis - Sindig Larsen Johannsen syndrome - Osgood Schlatter disease Iliotibial band syndrome Tibial stress fracture Medial tibial stress syndrome Pes anserine bursitis	Patellar instability and dislocation Osteochondritis dissecans (OCD)
Ankle and foot **Exam Index**	Ankle sprain High ankle sprain	Achilles tendinopathy Severs disease Plantar fasciitis Stress fractures of the foot	Flat feet

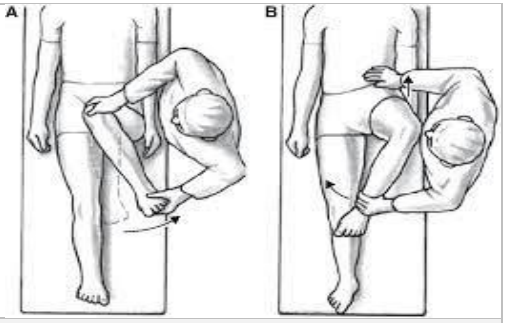
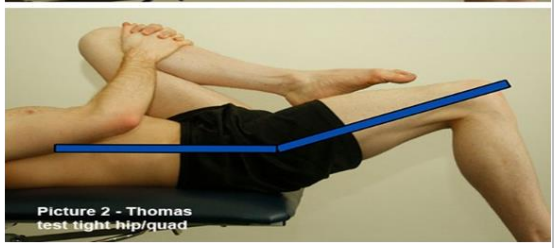
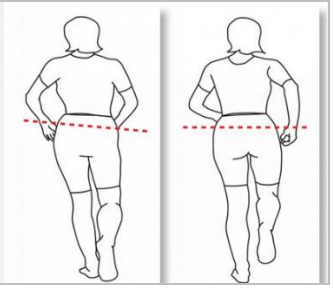
Exam Index: Spine and Back

Maneuver	Associated Conditions	How to Perform
Stork (Gillet) test	Spondylolysis Sacroiliac joint dysfunction	Stork test have the patient stand on one leg and lean backwards with the back in hyperextension. Pain reproduced in the lumbar area suggest spondylolysis. Lower pain around the posterior superior iliac spine suggests sacroiliac joint dysfunction. 
FABER test	Sacroiliac Joint Dysfunction Femoroacetabular impingement with suggestion of posterior impingement	Also known as Patrick's test. Put the hip in flexion, abduction and external rotation by having the patient supine in "a figure 4" position. Push down on the bent knee and the contralateral pelvis to end range of motion, checking for provoked lower back pain that would suggest sacroiliac joint dysfunction. 

Reference: Madden C, Putukian M, McCarty E et al. Netter's Sports Medicine E-Book. Elsevier Health Sciences; 2017.

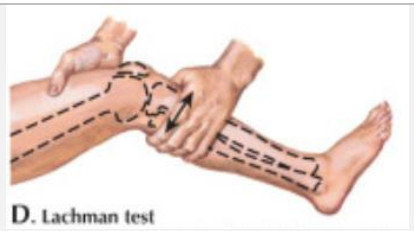
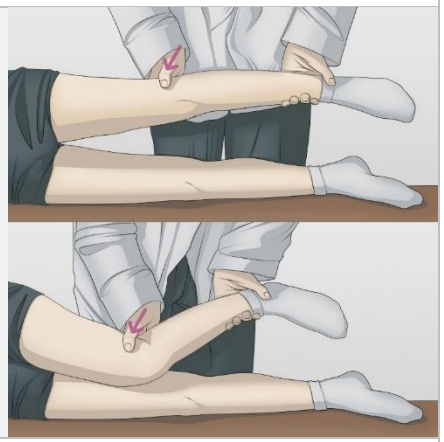
Exam Index: Hip and Thigh

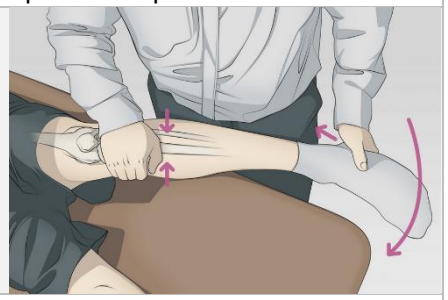
Maneuver	Associated Conditions	How to Perform
Adductor Squeeze Test	Adductor weakness Hip Impingement	Position patient supine with both hips flexed to 45 degrees. Examiner places fists between the knees and have patient squeeze both knees at the same time, with attention towards differential force. 
Bicycle test	Snapping hip	Can occur due to tight IT band or iliopsoas tendinitis 
FABER	Sacroiliac joint dysfunction Hip impingement	Put the hip in flexion, abduction and external rotation by having the patient supine in “a figure 4” position. Push down on the bent knee and the contralateral pelvis to end range of motion, checking for provoked groin pain and feeling for premature limitation in range of motion. 

FADIR	Hip impingement	See Figure A. Figure B is the FABER test. Flex, adduct and internally rotate the hip by driving the knee past midline with the foot pointed laterally. Worsening pain and tightness suggest anterior hip impingement. 
Pubalgia:	Pubalgia is frequently seen in patients with hip FAI in the form of rectus abdominus tendinitis	Patient is lying supine and is asked to perform a sit-up. Palpate the area of the pubis. Tenderness in this area corresponds with pubalgia or rectus abdominis tendinitis.
Thomas test	Tight hip flexors (rectus femoris)	Checks for flexion contracture of the hip, which make contribute to lordotic back pain. Position the patient supine on the exam table with the thigh dangling off the table. Have the patient hug the unaffected leg to their chest. Look at the dangling thigh from the side to ensure there is no compensatory lumbar hyperextension and that the thigh is able to fall at least level to the ground. A positive Thomas test will lift the dangling thigh off the table and represents flexion contracture of the hip.  
Trendelenberg test	Hip abductor weakness	Have the patient stand on one foot for 30 seconds and observe for a dip in the contralateral hip. Common to see in runners, and implicated in patellofemoral pain. Can also develop in other diseases such as hip instability or Legg-Calve-Perthes disease. 

Reference: Madden C, Putukian M, McCarty E et al. Netter's Sports Medicine E-Book. Elsevier Health Sciences; 2017.

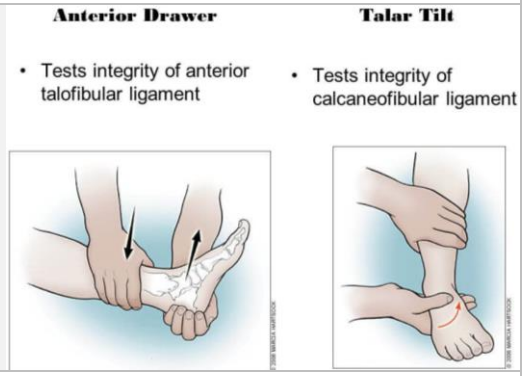
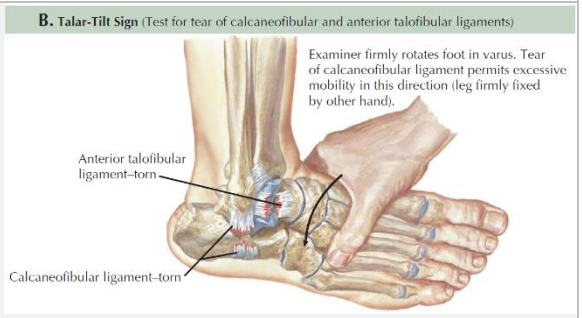
Exam Index: Knee and Leg

Maneuver	Associated Conditions	How to Perform
Lachman maneuver	Anterior cruciate ligament tear	With the affected knee flexed at 20 degrees, place one hand on the femur and another behind the leg. Quickly shift the tibia anteriorly to try to slide the tibia anteriorly. Feel for laxity and if the endpoint is firm or soft. Compare to the other side.  Pearl: The point of the Lachman is to flex that knee at an angle to prevent the hamstrings from stabilizing a knee with a torn ACL, which can cause a false negative test on the anterior drawer exam.
McMurray test	Meniscal tear	McMurray test: Hold the knee at the joint line and the foot. Range the knee from maximal flexion to extension, applying internal rotation and varus stress (lateral meniscus) and then external rotation and valgus stress (medial meniscus). 
Noble test	Iliotibial band syndrome	The patient is in the lateral decubitus position with the affected leg up. From behind the patient, flex the hip, support the knee and apply pressure over the IT band (lateral femoral epicondyle) and slowly flex the knee. Maximal pain at 30 degrees of flexion is a positive sign. 
Ober test	Iliotibial band syndrome	The Ober test is also done but less studied. In the same position as the Noble test, hyperextend the hip with the knee flexed in 90 degrees. Supporting the ankle, observe for hip adduction by seeing if the knee dips unsupported. If the knee does not passively fall, this suggests contracture of the IT band.

Patellar apprehension	Patellar instability and prior dislocation	With the patient supine and knee extended, move the patella laterally, which can provoke anxiety in anticipation of reproducing a patellar dislocation.
Patellar grind test	Patellofemoral pain syndrome	There are two ways to do this test: With the patient supine and the knee fully extended, place the palm of your hand and apply downward, gyrating pressure on the patellae to provoke pain and feel for crepitus. Alternatively, place pressure on the superior patella and have the patient flex the quadriceps to stress the patellofemoral joint, checking for pain or crepitus. 
Pivot shift test	Anterior Cruciate Ligament Injury (ACL)	With the knee extended, apply valgus stress to the leg and internally rotate will slowly flexing the knee. Look for subluxation or clunking of the tibia as the knee passes 30-40 degrees of flexion. 
Posterior drawer test	Posterior crucial ligament tear	Position the patient supine with the knee flexed to 90 degrees. It helps to anchor or sit on the patient's foot to stabilize the tibia. Grab the proximal tibia and apply a posterior impulse to feel for laxity, compared to the other side.
Thessaly test	Meniscal tear	With the patient standing on the unaffected leg with knee flexed to 20 degrees, hold their hands and rotate back and forth on the knee. Then test the affected leg. 
Varus and valgus stress	Lateral and medial collateral ligament tears, respectively	Flex the knee to 30 degrees. Stabilize the distal femur with one hand while adducting the leg (varus stress, lateral ligament) and then abduct the leg (valgus stress, medial ligament). Try to feel for laxity of "opening of the joint". Take care not to interpret rotation of the hip as laxity.

References: Madden C, Putukian M, McCarty E et al. Netter's Sports Medicine E-Book. Elsevier Health Sciences; 2017.
https://medisavvy.com/

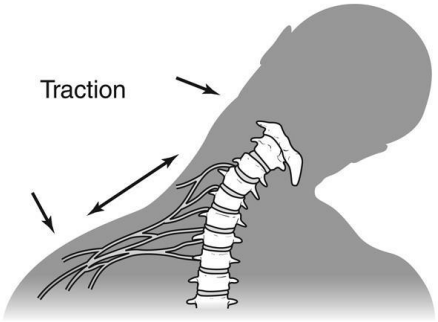
Exam Index: Ankle and Foot

Maneuver	Associated Conditions	How to Perform
Anterior drawer test	Ankle sprain	Holding the ankle by the distal tibia and the heel, attempt to translate the foot forward, feeling for the amount of laxity and firmness of endpoint. Testing the ankle in neutral position tests the CFL. Testing the ankle in plantarflexion tests the ATFL. 
Squeeze test	High ankle sprain (syndesmotic injury)	Squeeze the proximal fibula against the tibia. Repeat several times towards the ankle. Elicited pain suggests a fracture or diastasis of the tibia and fibula.
Talar tilt	Ankle sprain Tarsal Coalition	With the ankle slightly flexed, hold the ankle by the malleoli and the midfoot. Internally rotate and invert the foot to feel for laxity from a torn CFL. A lack of laxity in the setting of a non-supple pes planus (with possible history of recurrent ankle sprain) should raise concern for tarsal coalition. 
Thompson test	Achilles tendon rupture	Have the patient kneel on the exam table with the foot hanging downwards off the edge of the table. Squeeze the calf to ensure the foot can still dorsiflex, which confirms that the Achilles muscle tendon unit is intact.

Reference: Madden C, Putukian M, McCarty E et al. Netter's Sports Medicine E-Book. Elsevier Health Sciences; 2017.

Burners and Stingers

Overview:
- Also known as transient brachial plexopathy.
- Lateral force causing stretch injury of the cervical nerve roots and brachial plexus.
- “Burners” last seconds to minutes whereas “stingers” last hours to weeks. The mechanism is the same, but the name suggests duration.
- The risk of cervical spine injury is low (~1%).



Clinical Presentation:
- Usually presented immediately after a traumatic block or tackle in football, rugby or hockey.
- Patients often complain of burning or stinging sensation or weakness that starts above the clavicle and radiates into the arm or hand.

Evaluation: Rule out head, neck and cervical spine injury
- Inspection/Palpation: Patients often try to “shake out” the sensation of numbness. The neck may be tender.
- Range of motion: Carefully range the neck. Compare the active range of motion in the shoulder and elbow in the affected and unaffected sides.
- Other tests: A complete neurologic exam of the upper extremity is important to look for associated weakness. Sensory exam is also key.
- Imaging: Consider flexion-extension films of the neck in severe of focal neck pain or limited range of motion.
    - CT is generally less helpful unless there is a concern for fracture.
    - MRI is the modality of choice for suspected spinal cord injury, if the patient can tolerate imaging.

Management:
- Re-examination within 24 hours is important, as neurologic deficits improve within 24 hours in 70% of cases.
- Athletes should not return to play until they recover full strength, range of motion, and normal sensation. During this time they should follow up periodically to monitor symptoms.
- Neck rolls and higher shoulder pads can help prevent recurrent injury.
- Bilateral upper extremity weakness is an emergency and needs urgent cross sectional imaging (CT or MRI) of the spinal cord to rule out central cord syndrome or other causes of spinal cord injury.

References
- Burners and Stingers - AAOS
- Kasow DB, Curl WW: "Stingers" in Adolescent Athletes. Instr Course Lect 2006;55:711-716.

Spondylolysis

Overview:

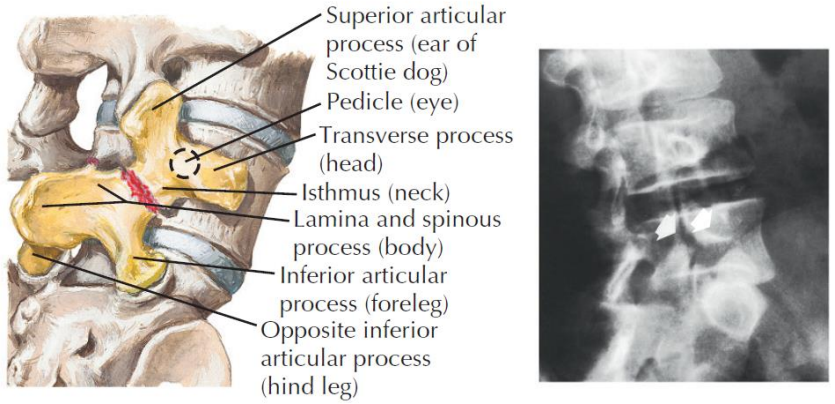
- Stress fracture of the pars interarticularis from trauma or overuse. An important diagnosis to consider in all adolescent athletes with back pain.
- Bilateral pars fractures can cause spondylolisthesis, which is anterior slippage of the spinal column. Spondylolisthesis can cause spinal stenosis and may need posterior spinal fusion.

Clinical Presentation:

- Repetitive hyperextension of the back (football linemen, wrestlers, gymnasts, and dancers) or repetitive rotation (swimmers, baseball, even bowling).
- Athletes may report radicular symptoms (pain that radiates to the buttocks) and pain worse with motion and running.

Evaluation: No specific signs or symptoms are sensitive or specific. Therefore, high clinical suspicion is important.

- Inspection: May have increased lordosis.
- Palpation: May have ipsilateral paraspinal tenderness.
- Range of motion: Pain with hyperextension of the back is common. Hamstrings are often tight on forward flexion of the back.
- Other tests:
    - Stork test: Stand on one leg and lean backwards. Reproduced or worsened pain is a positive test.
    - A lower extremity neurologic exam to rule out deficits.
- Imaging: Standing PA and lateral plain films are a reasonable start. Oblique views were may show a Scotty dog sign 32% of the time. Ultimately most patients may need a CT or MRI – MRI is more sensitive and is able to predict spondylolytic lesions.



Spondylolysis without spondylolisthesis. Oblique view demonstrates formation of radiographic Scottie dog. On oblique radiograph, dog appears to be wearing a collar.

Management:

- Activity modification, including restricted activity for 3-6 months.
- Consider SPECT or MRI in patients who do not improve after 2-3 weeks of rest, or those who want to continue playing.
- Physical therapy to address hamstring tightness, strengthen the core to address lordosis.
- Bracing is an option but needs to be worn 24 hours a day for 4-6 weeks.
- Return to play when there is painless extension and rotation of the spine.
- Refer to orthopedics for persistent pain or neurologic symptoms operative interventions include direct repair with bone graft or posterior spinal fusion.

References:

- AAOS: Spondylolysis and spondylolisthesis
- Madden CC, Putukian Mm NcCarty E et al, eds. Netter's Sports Medicine. Philidelphia: Elsevier; 2018;415-424.e2
- Micheli LJ, Wood R. Back pain in young athletes: significant differences from adults in causes and patterns. Arch Pediatr Adolesc Med. 1995;199:15–8.

Spondylolisthesis

Overview:
- Bilateral spondylolysis can allow the vertebral column to flip forward, which can cause spinal stenosis.
- Lysis of the single intact pars in spina bifida occulta can cause sponydylolisthesis in the setting of unilateral back pain.

Clinical Presentation:
- Usually athletes with frequent lumbar extension, who have had indolent back pain that persists despite rest.
- They may have prior negative plain films.

Evaluation:
- History: Inquire about symptoms of…
  - Radiculopathy (weakness, shooting pains)
  - Spinal stenosis (neurogenic claudication such as pain with walking or standing)
  - Cauda equina symptom (incontinence, saddle anesthesia)
- Inspection: Patients may walk with a crouch gait.
- Palpation: A bony stepoff may be felt. Hamstrings may be tight.
- Range of motion: Painful extension of the back.
- Other tests:
  - Neurologic exam is key (see examination of the back for table of spinal levels) and establishes baseline.
  - Straight leg raise is important to evaluate for radiculopathy
- Imaging: AP and lateral lumbar films would show slippage.
  - Meyerding classification: Spondylolisthesis is graded 1-4, for slippage along each quarter of the inferior vertebral body. Grades 1 and 2 are low grade, grades 3 and 4 are high grade.
  - MRI is useful for if back pain does not improve after 90 days of rest, or if the family does not wish to restrict activity.

L4 on L5 spondylolisthesis, grade 1, with about 25% slippage over the L5 vertebra.

Management:
- The evidence for treatment is limited but favors nonoperative management for grade I spondylolisthesis with NSAIDs, physical therapy to strength the trunk and relative rest for 90 days.
  - It is suggested do follow up every 3-4 weeks to facilitate gradual return to play if pain improves.
  - Bracing was done in the past, but does not improve outcome.
  - It is important that patients report all symptoms and have strict return precautions for new deficits.
- Grade II and above– refer to pediatric orthopedist and limit activity until consultation. Urgent referral for motor deficits.
- May have residual pain despite healing, and long term degenerative disc disease.

References:

- Donnally IC, Varacallo M. Lumbar Spondylolysis And Spondylolisthesis. In: StatPearls. Treasure Island (FL): StatPearls Publishing LLC.; 2018.
- Randall RM, Silverstein M, Goodwin R. Review of Pediatric Spondylolysis and Spondylolisthesis. Sports medicine and arthroscopy review. 2016;24(4):184-187.

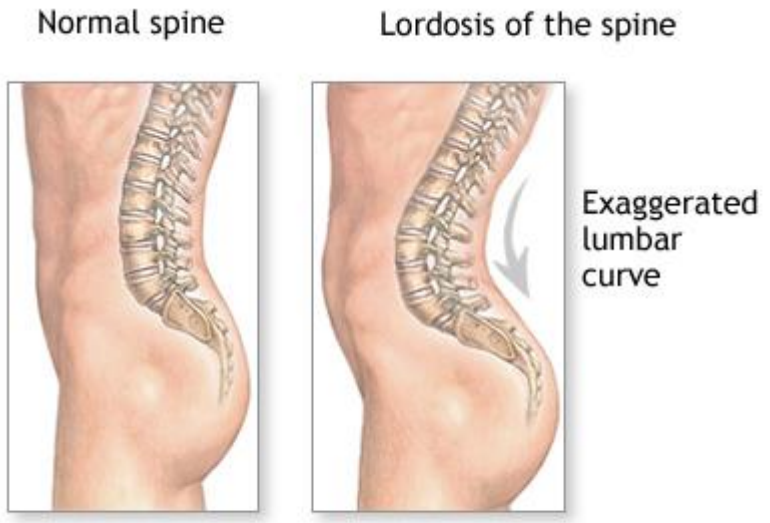
Lordotic back pain

Overview:
- Adolescents can develop back pain as their skeletal growth can outpace muscle and ligament lengthening.
- Mechanical causes include:
    - Tighter hip flexors and hamstrings
    - Tighter posterior ligaments in the spine with weaker abdominal muscles
    - Increased stress on the facet joints.
- Lordotic back pain is a diagnosis of exclusion because spondylolysis presents similarly, is more common and has greater potential for morbidity.

Clinical Presentation:
- Patient may present with indolent lower back pain.
- The patient may be in the midst of a growth spurt.

Evaluation:
- Inspection: May have increased lordosis with a “sway back”
- Palpation: Possible paraspinal tenderness.
- Range of motion: May have limited flexion of the lumbar spine with tightness of the hamstrings.
- Other tests:
    - Can have tight hip flexors (Thomas Test) or tight hamstrings.
    - Stork test important to evaluate for spondylolysis.
- Imaging: Useful in the at-risk athlete to to rule out spondylolysis.

Management:
- Strengthening exercises are important to stretch the hip flexors, hamstrings and strengthening the abdominal muscles.
- Return to play when pain with extension improves.
- Patients in whom facet joint disease is identified on MRI may benefit from referral for consideration of steroid injections.



References

- Riley PM, Micheli LJ. Back Pain in the Young Athlete. In: Caine D, Purcell L, eds. Injury in Pediatric and Adolescent Sports: Epidemiology, Treatment and Prevention. Cham, Switzerland: Springer International Publishing; 2016:135-147.

Lumbar strain

Overview:

- Injury tends to be acute and associated with bending, rotation or improper lifting form.
- Overall a diagnosis of exclusion given the possibility of spondylolysis.

Clinical Presentation:

- There should be no neurologic complaints such as numbness, tingling, weakness or signs of neurogenic bowel/bladder. One can ask about saddle anesthesia by inquiring if "it feels different to wipe."
- After an acute injury will have pain associated with activity. Other findings such as morning stiffness, alternating buttock pain, night pain or improvement of pain with activity suggest an inflammatory cause.

Evaluation:

- Inspection/Palpation: Examine posture. Palpate for tenderness and spasm. Exclude other sites of tenderness such as the sacroiliac joint.
- Range of motion: Often limited due to pain.
- Other tests: If pain has been lasting longer than three weeks, expert opinion suggests imaging for spondylolysis.
- Imaging: Pain lasting greater than three weeks should be imaged with AP and lateral plain films, with consideration of oblique films if spondylolysis is considered.

Management:

- Conservative treatment is the mainstay of management if the concern for fracture is low and the patient is neurologically intact.
- Acetaminophen and NSAIDs should provide adequate analgesia to facilitate mobility.
- Activity modification rarely requires complete rest.
- Underlying mechanical risk factors such as inflexbility or growth may prevent further injury. Physical therapy can be useful as the acute injury subsides to improve flexibility and increase core strength to stabilize the back.

References

- MacDonald J, Stuart E, Rodenberg R. Musculoskeletal Low Back Pain in School-aged Children: A Review. JAMA Pediatr. 2017 Mar 1;171(3):280-287.
- Madden CC, Putukian Mm NcCarty E et al. Netter's Sports Medicine. Philidelphia: Elsevier; 2018;53, 415-424.e2
- Purcell L, Micheli L. Low back pain in young athletes. Sports Health. 2009. May;1(3):212-22. PubMed PMID: 23015874; PubMed Central PMCID: PMC3445254.

Sacroiliac Joint Dysfunction

Overview:

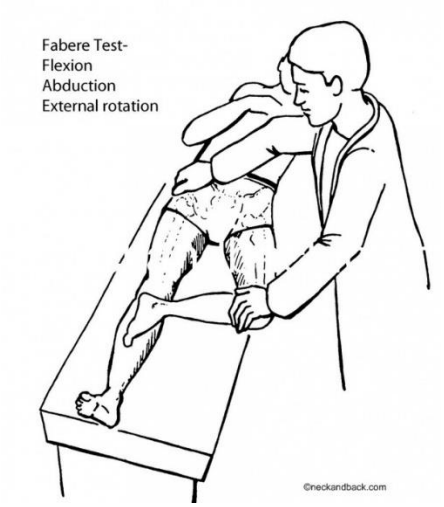
- The sacroiliac joint is a very strong joint connected with multiple ligaments. Forces across the trunk and lower extremities cross the sacroiliac joints.
- The SI joint can be involved in inflammatory arthritis such as those related to the HLA-B27 genotype, inflammatory bowel disease and ankylosing spondylitis.

Clinical Presentation:

- Lower back pain after trauma (rotation, axial strain) or sports with repetitive single leg use (jumping, kicking) can develop stress of the sacroiliac joint.
- This presentation can mimic spondylolysis.
- Consider inflammatory disease if febrile.

Evaluation:

- Inspection: Check for limb length discrepancy.
- Palpation: One can palpate the posterior superior iliac spine (beneath the dimples of Venus) for tenderness. This is usually lower than spondylolysis.
- Range of motion: Patients may have a positive Trendelenberg test due to weakness of the hip abductors.
- Other tests:
    - FABER test can stress the SI joint ipsilateral to the leg in flexion, abduction and external rotation. With the patient supine in "a figure 4" position, push down on the bent knee and the contralateral pelvis.
    - Stork test also stresses the sacroiliac joint by having the patient stand on the leg of the affected side and lean backward with the back in hyperextension.
- Imaging: Plain films are often normal but can serve as a baseline study.



Management:

- Conservative management is the mainstay of treatment – after a few days of RICE, pursue early mobilization, NSAIDs, physical therapy and activity modification.
- Some patients may want pelvic bracing but it is a second line treatment that needs to be quickly weaned before muscular weakness or dependency develops.
- SI joint dysfunction can take months to improve. Pain that does not improve after 6 weeks can be referred to an orthopedist or non-operative sports medicine physician, and to a rheumatologist if concern for inflammatory disease arises.

References

- Peebles R, Jonas CE. Sacroiliac Joint Dysfunction in the Athlete: Diagnosis and Management. Curr Sports Med Rep. 2017 Sep/Oct;16(5):336-342.

Femoroacetabular impingement (FAI, hip impingement)

Overview:

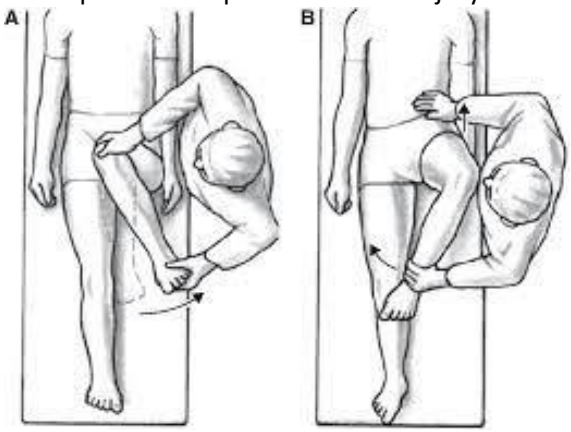
- Extra intraarticular tissue causing painful restriction of hip motion.
- Two types of FAI:
  Cam type: Redundant bone around the femoral neck. Can develop from prior SCFE, Legg-Calve-Perthes disease or other avascular necrosis.
  Pincer type: Labrum or acetabulum over-covers the femoral head.
- Disposes to labral tears and hip osteoarthritis.

Clinical Presentation:

- Anterior hip pain with hip flexion in sports such as baseball catching, dancing, gymnastics, football, horseback riding.

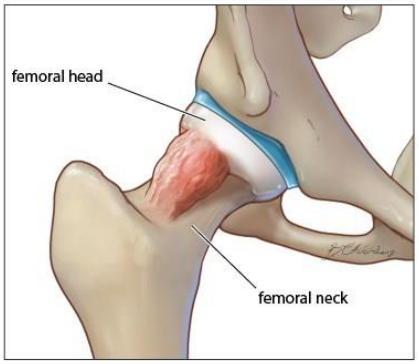
Evaluation:

- Palpation: Patients often make a "C" with their hand while clutching the lateral hip.
- Range of motion: Limitation in the arc of rotation in the hip.
- Other tests:
  - (A) FADIR test: Flexion, adduction and internal rotation can provoke pain from an anterior labral injury.
  - (B) FABER test: Flexion, abduction and external rotation can provoke pain from a posterior labral injury.

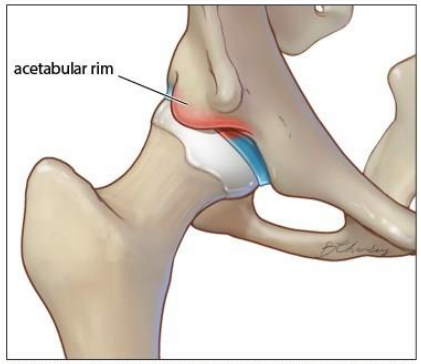


- Imaging: Obtain AP, frog-leg and lateral views of the hips. Look for an increased rim of acetabulum and for thickening around the femoral neck.

Cam impingement



Pincer impingement



Management:

- Rest from provoking activity and observe for improvement.
- Physical therapy can be tried to improve hip strength and soft tissue compliance.
- **Refer to an orthopedist to consider** excision of the lesion causing impingement.

References

- Pacheco-Carrillo A, Medina-Porqueres I. Physical examination tests for the diagnosis of femoroacetabular impingement. A systematic review. Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine. 2016;21:87-93.
- Tijssen M, van Cingel RE, de Visser E, Holmich P, Nijhuis-van der Sanden MW. Hip joint pathology: relationship between patient history, physical tests, and arthroscopy findings in clinical practice. Scandinavian journal of medicine & science in sports. 2017;27(3):342-350.

Pelvic (ASIS, AIIS) Apophysitis

Overview:

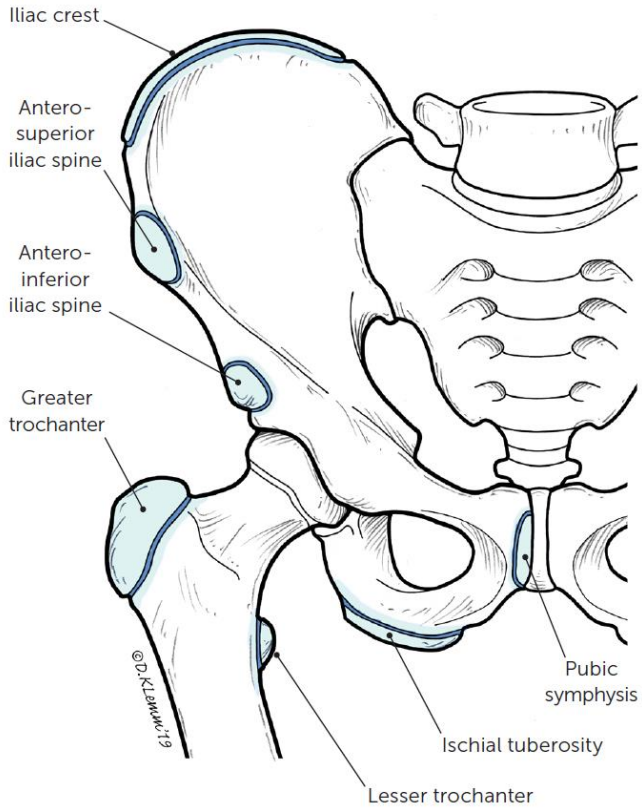
- The pelvis has ossification centers to which large muscles of the hip attach. The cartilage at these attachments are weak points during skeletal growth.
- The most commonly affected sites include:
    - ASIS: Sartorius muscle
    - AIIS: rectus femoris
    - Ischial tuberosity: hamstrings
    - Iliac crests: Abdominal muscles
    - Lesser trochanter of femur: iliopsoas
- Apophysitis can develop from chronic traction, overuse, or culminate in an acute avulsion injury.

Clinical Presentation:

- Athletes usually participate in sprinting or kicking spots. The average age is age 13, but patients can present as late as age 25. The highest risk occurs during growth spurts.
- Patients have activity-related pain, though avulsion fractures present with sudden pain and weakness after events such as a strong kick.
- Large avulsions can interfere with movement. For example, a large AIIS avulsion can limit hip flexion.

Evaluation:

- Palpation: Patients are tender at the affected apophysis.
- Range of motion: May be decreased with weakness of the hip.
- Other tests: Plain films of the pelvis can identify widening or frank avulsion of an apophysis compared to the other side. There are specific Judet and inlet/outlet views to evaluate hamstring injuries.



Management:

- Treatment is nonoperative and consists of rest from activity and ice, followed by stretching of the muscles and gradual return to play.
- Operative consideration is reserved for displaced avulsion fractures, depending on the site and distance (e.g. AIIS avulsion allows up to 2 cm of displacement, ischial tuberosity up to 3 cm of displacement).

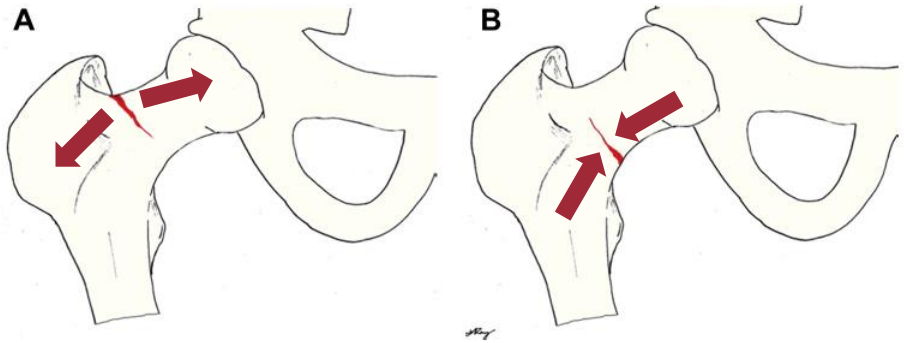
References

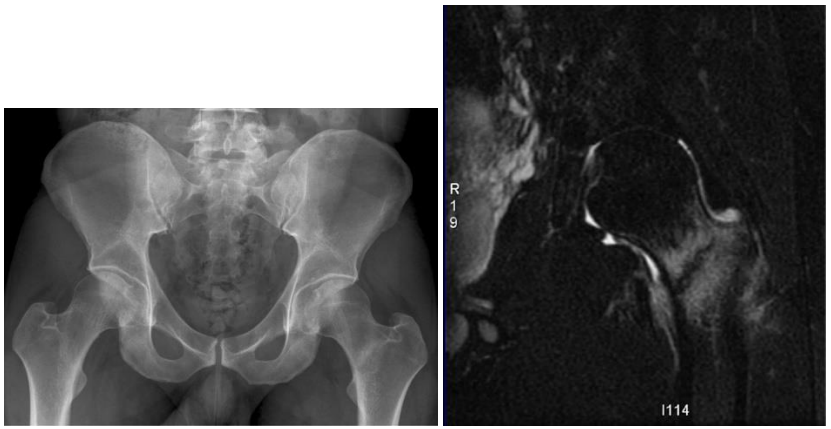
- Achar S, Yamanaka J. Apophysitis and Osteochondrosis: Common Causes of Pain in Growing Bones. Am Fam Physician. 2019 May 15;99(10):610-618.

Femoral Neck Stress Fracture

Overview:

- The superior femoral neck fractures under tension (A). The inferior femoral neck fractures under compression (B). Superior femoral neck fractures are at risk for delayed healing or nonunion.
- The femoral head receives blood retrograde from the femoral neck. Avascular necrosis can develop after femoral neck fracture.
- **A high index of suspicion is critical to a timely diagnosis.** Any athlete who develops anterior hip or groin pain in the setting of high training volumes should be removed from weight-bearing exercise and evaluated for a femoral neck stress fracture.





Fracture at the base of the left femoral neck on plain film and MRI.

Clinical Presentation:

- Insidious anterior hip or groin pain in the athlete with high volume running.
- Uncommon presentation in the setting of open growth plates.

Evaluation: Having clinical suspicion is key!

- History: As with other stress fractures, a menstrual, training and dietary history.
- Range of motion: Internal rotation of the hip may be limited.
- Other tests: Can attempt single leg hop on that side.
- Imaging: **Plain films can miss a high risk stress fracture – if suspicion is high, pursue an MRI**. MRI can identify the lesion and assess the risk of avascular necrosis.

Management:

- If you suspect a femoral neck stress fracture, the patient needs to be removed from weight bearing exercise
- If imaging confirms, needs to be non-weight bearing for 6 weeks, even if the fracture is not displaced. During this time, if having no pain can do non-weightbearing cross training such as swimming.
- **If imaging is negative and suspicion remains high, place the patient on crutches and pursue an MRI.**
- Superior stress fractures of the femoral neck need urgent orthopedic referral for consideration of surgical fixation or casting.

References

- McInnis KC and Ramey LN. (2016), High-Risk Stress Fractures: Diagnosis and Management. PM&R, 8: S113-S124.
- Pegrum J, Crisp T, Padhiar N. Diagnosis and management of bone stress injuries of the lower limb in athletes. BMJ (Clinical research ed). 2012;344:e2511.

Brief Word: Slipped Capital Femoral Epiphysis (SCFE)

Overview:

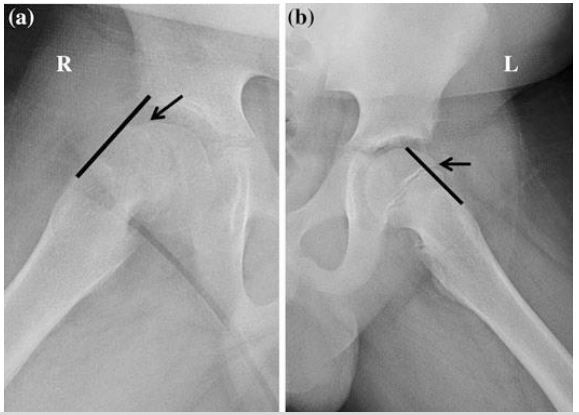
- Salter Harris fracture along the growth plate of the proximal femur.
- Associated with obesity, endocrine disorders (hypothyroidism, hypogonadism), renal disease, and chemotherapy.
- The most common hip condition in adolescence.
- Important to consider in the differential diagnosis of knee pain.

Clinical Presentation:

- Average age 12 in girls, 13 in boys.
- Presents with painful limp with pain either in the hip or the knee.
- Four patterns of presentation: pre-slip, acute slips, chronic slips, acute on chronic slips. **Chronic slippage is the most common presentation and is easily missed by general pediatricians.**
- Complications include avascular necrosis of the femoral head, femoroacetabular impingement and osteochondritis dissecans of the femoral head.

Evaluation:

- Inspection: The affected hip may be externally rotated. Patients with an unstable SCFE cannot bear weight. There may be leg length discrepancy.
- Range of motion: Painful restriction of internal rotation of the hip (log roll test). Flexion of the hip often causes obligatory external rotation.
- Imaging: AP and lateral (frog-leg) of both hips. Look for slippage of the femoral head or disruption of Klein's line. MRI can resolve indeterminate cases.



Lateral frog leg view showing R sided SCFE. Note that the epiphysis no longer crosses the line cast by the metaphysis (Klein line).

Management:

- Do not attempt to reduce the fracture!
- Non-weightbearing and urgent orthopedic referral for likely admission and surgical pinning. After pinning, patients gradually resume activities after a 6-8 week recovery period.
- Approximately half of patients will have a slip of the other side. Factors that increase the risk of slippage of the other hip are age under 10 years and severe obesity.

References

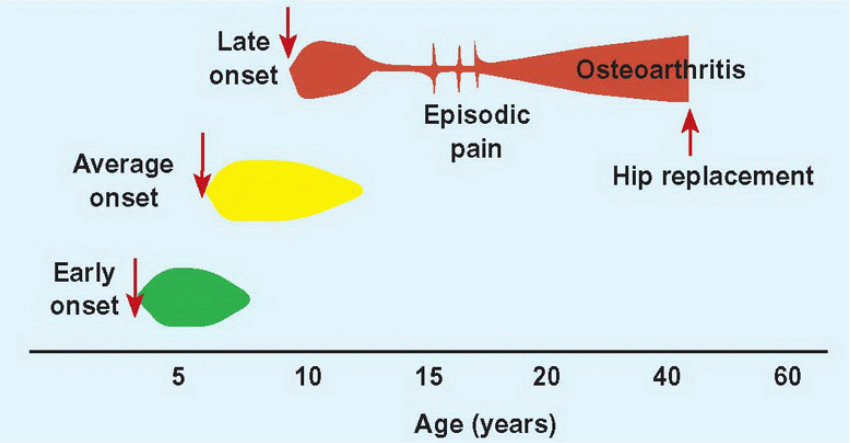
- AAOS: Slipped Capital Femoral Epiphysis
- Pediatric Hip Disorders: Slipped Capital Femoral Epiphysis and Legg-Calvé-Perthes Disease. Alexa J. Karkenny, Brandon M. Tauberg, Norman Y. Otsuka. Pediatrics in Review Sep 2018, 39 (9) 454-463

Brief Word: Legg-Calve-Perthes disease (LCP disease, LCPD)

Overview:
- Idiopathic avascular necrosis and collapse of the femoral head in childhood.
- Disease course takes place over years of childhood
  1) Femoral head necrosis
  2) Femoral head collapse over 6-12 months
  3) Revascularization and ossification over 1-2 years
  4) Reforming of the femoral head over several years.

Clinical Presentation:
- The classic patient is a boy between ages 4-8 with subacute onset of limp. 15% of cases are bilateral but in different stages.
- Pain can refer to the thigh or the knee.

Evaluation: LCP disease is a diagnosis of exclusion for avascular necrosis.
- Consider other causes (e.g. sickle cell disease, coagulopathy, septic joint, Gaucher disease, steroid use, SCFE)
- Inspection: There may be leg length discrepancy, as well as atrophy of hip and thigh muscles from disuse.
- Range of motion: The most prominent find is stiffness. Lost internal rotation of the hip is earliest sign. There may be limited abduction of the hip as well.
- Imaging: AP, frog-leg and lateral plain films of the hips. Look for flattening or irregularly of the surface of the femoral head.



Natural history of LCP disease by age

Management:
- Early orthopedic referral.
- The goal of treatment is to keep the femoral head spherical and hip joint reduced as the femoral head re-ossifies over the next few years to prevent further flattening, stiffness and later arthritis.
- Treatments range from physical therapy to immobilization or osteotomy, with more intervention for later-onset disease due to its poor prognosis.
- Late complications include growth arrest, osteochondritis dissecans and future femoroacetabular impingement. Half of patients with LCP disease will develop arthritis in late adulthood.

References
- AAOS: Perthes Disease
- Pediatric Hip Disorders: Slipped Capital Femoral Epiphysis and Legg-Calvé-Perthes Disease. Alexa J. Karkenny, Brandon M. Tauberg, Norman Y. Otsuka. Pediatrics in Review Sep 2018, 39 (9) 454-463

Iliotibial (IT) band syndrome

Overview:

- The iliotibialis muscle helps with abduction of the hip, and stabilizes the knee during running.
- A tight iliotibialis or tensor fascia latae can cause hip pain or rub the lateral femoral condyle and lateral meniscus to cause lateral knee pain.

Clinical Presentation:

- IT band syndrome is typically a disease of runners that presents with activity-associated lateral knee pain.
- A detailed history may reveal pain that is worst with the knee in near extension (just before foot strike).
- May have popping sensation from the tendon snapping on the condyle.

Evaluation:

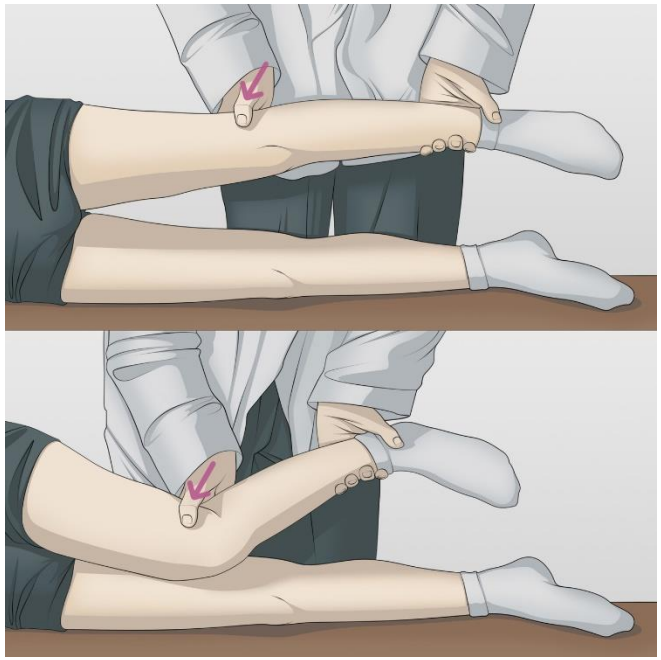
- Palpation: The IT band is tight and may feel tender. The femoral condyle may be tender. There should not be a knee effusion.
- Range of motion: Usually normal. Some patients may have weak hip abductors.
- Other tests:
    - The Noble test (see right) is the best test to stress the IT band. With patient in lateral decubitus position and affected leg up, flex the hip, support the knee and apply pressure on the IT band (lateral femoral epicondyle) while slowly flexing the knee. Maximal pain at 30 degrees of flexion is a positive sign.
    - The Ober test is less studied. In the same position as the Noble test, hyperextend the hip with the knee flexed in 90 degrees. Supporting the ankle and see if the knee can dip downwards. An inability to thigh adduction suggests contracture of the IT band.
- Imaging is usually not needed in IT band syndrome.

Management:

- While rigorous evidence is limited, conservative nonoperative management is the mainstay of treatment for IT band syndrome.
- NSAIDs, ice and rest for a few days.

Management, continued:

- Physical therapy or a prescribed home exercise program consisting of stretching exercise, foam rolling and muscle strengthening.
- For athletes, coaching to adjust their form and stride can help prevent recurrence.
- Most patients should improve within 6-8 weeks. Persistent pain should be re-evaluated for an alternative diagnosis, and surgical consultation can be considered for pain lasting more than 6 months.



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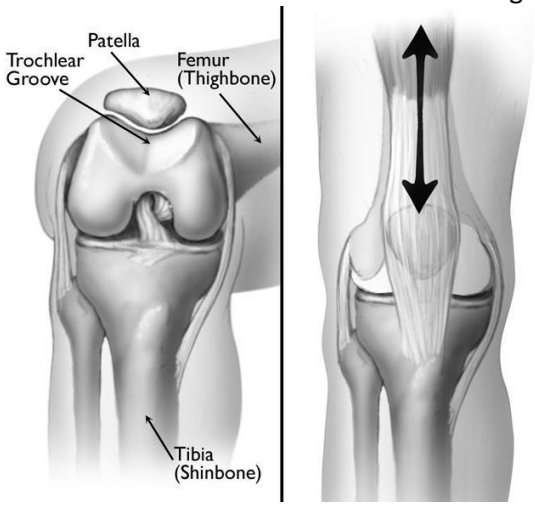
- Baker RL, Fredericson M. Iliotibial Band Syndrome in Runners: Biomechanical Implications and Exercise Interventions. *Physical medicine and rehabilitation clinics of North America.* 2016;27(1):53-77.
- Strauss EJ, Kim S, Calcei JG, Park D. Iliotibial band syndrome: evaluation and management. *The Journal of the American Academy of Orthopaedic Surgeons.* 2011;19(12):728-736.

Patellofemoral pain syndrome

Overview:

- Anterior knee pain often known as “runner’s knee” from abnormal tracking of the patella.
- There are multiple biomechanical theories that implicate anatomic factors, ligamentous laxity, and weakness of the abdominal wall, hip and thigh.
- The term chondromalacia is reserved for actual cartilage damage.



Clinical Presentation:

- Ill-defined anterior pain “behind the kneecap” associated with running, jumping, squatting and stairs (classically, descending > ascending)
- Pain with prolonged sitting (theater sign).

Evaluation: Because there are so many potential causes, not all the findings below will be present.

- Inspection: Increased Q-angle or genu valgum or varum. Decreased quadriceps bulk, especially of the vastus medialis oblique muscles.
- Palpation: There may be crepitus with range of motion. The present of an effusion is NOT consistent with patellofemoral pain.
- Range of motion: Patellar J sign – patella moves laterally as knee extends. Flat feet with hyperpronation.

Evaluation, continued

- Other tests: Patellar grind test – with the patient supine and knee extended, push down on the superior patella and have the patient contract the quadriceps. Painful crepitus is a positive test.
- Imaging: Plain films usually not needed, but if obtained get notch and sunrise views to look for osteochondritis dissecans, especially if the patient has symptoms refractory to physical therapy.
- Differential diagnosis: Sindig-Larson-Johansson disease, Osgood Schlatter disease, plica syndrome.

Management:

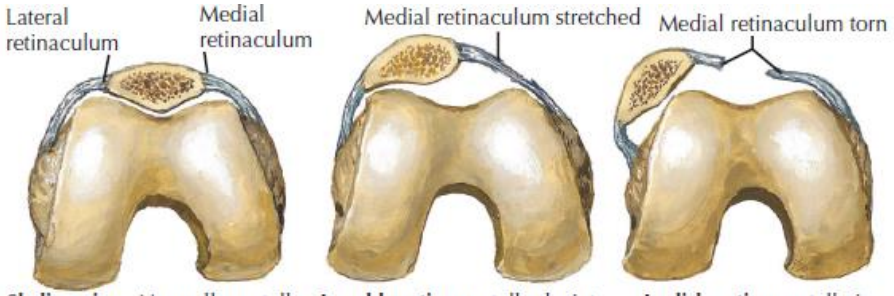
- Nonoperative management is the mainstay of care for PFPS.
- Initially, reduce activity and send for functional rehabilitation, which works to strengthen the abdominal core, gluteus medius and vastus medialis oblique.
- NSAIDs are generally not effective for pain from PFPS.
- Other treatments such as taping, bracing, foot orthoses and acupuncture have limited evidence but can be used as adjuncts.
- Failure of conservative therapy warrants reevaluation for osteochondritis dissecans.

References:

- Barton CJ, Lack S, Hemmings S, Tufail S, Morrissey D. The 'Best Practice Guide to Conservative Management of Patellofemoral Pain': incorporating level 1 evidence with expert clinical reasoning. Br J Sports Med. 2015 Jul;49(14):923-34.
- Dutton RA, Khadavi MJ, Fredericson M. Patellofemoral Pain. Physical medicine and rehabilitation clinics of North America. 2016;27(1):31-52.

Patellar Dislocation

Overview:
- The patella can laterally dislocate from the femoral groove.
- 25% of cases have concurrent osteochondral injury, and almost all cases have injury of the medial patellofemoral ligament, which restrains against lateral deviation of the patella.
- The patella can also subluxate without exiting the groove.



Skyline view. Normally, patella rides in groove between medial and lateral femoral condyles.

In subluxation, patella deviates laterally because of weakness of vastus medialis muscle and tightness of lateral retinaculum.

In dislocation, patella is displaced completely out of intercondylar groove.

Clinical Presentation:
- Patients present with patellar dislocation and knee pain. The event can be traumatic or nontraumatic, such as from twisting motions of the knee.
- Recurrent dislocation is more common among skeletal immature athletes and those with anatomic risk factors such as trochlear dysplasia.

Evaluation:
- Palpation: Even after reduction there is tenderness around the patella, especially at the medial aspect. There may be hemarthrosis or effusion
- Other tests: Patellar apprehension testing involves moving the patella laterally, which can provoke anxiety in anticipation of reproducing the dislocation.

Evaluation, continued:
- Imaging: Radiographs of the knee (AP, lateral, sunrise/Merchant views) may show osteochondral defects or avulsion of the medial patella from the patellar sliding over the condyles. MRI of the knee should be done if there is suspicion of osteochondral injury.

Management:
- Reduction is either spontaneous or should be done in the emergency department with analgesia. Clinicians can aspirate the effusion for pain relief or determine if there is fat in the effusion to suggest osteochondral fracture.
- Immobilize temporarily with crutches and weightbearing as tolerated.
- Refer to physical therapy to strengthen the thigh muscles to prevent recurrent dislocation. For patellar subluxation, physical therapy is useful as is a patellar brace.
- Osteochondral defects should be referred to the orthopedist for consideration of surgical repair.
- Recurrent dislocations should be referred to the orthopedist for consideration of a reconstruction of the medial patellofemoral ligament (MPFL).
- Patients tend to have lower rates of re-entry into sports after a patellar dislocation.

References
- Soprano JV. Musculoskeletal injuries in the pediatric and adolescent athlete. Curr Sports Med Rep. 2005;4(6):329–334

Anterior Cruciate Ligament Injury (ACL)

Overview:

- The ACL connects the lateral femoral condyle to the tibia. It restrains the tibia from anterior translation and internal rotation.
- **Cartilage is still the weakest link.** 80% of ACL tears in children younger than age 12 have a concurrent tibial avulsion or growth plate injury.
- Overall becoming more common due to sports specialization.

Clinical Presentation:

- The classic injury involves a pop in the knee while pivoting of a planted foot followed by a feeling of giving out, immediate swelling and inability to bear weight.

Evaluation:

- Inspection: Often non-weight bearing or with antalgic gait. Visible effusion and bruising suggest hemarthrosis. Documentation Tanner staging to help the orthopedist assess growth potential.
- Palpation: May have palpable effusion.
- Range of motion: may be limited due to pain
- Other tests:
    - Lachman test is the definitive exam maneuver – with the knee at 20 degrees of flexion attempt to slide the tibia anteriorly. The anterior drawer test is unreliable because the hamstrings stabilize the leg in ACL injury and can resist the examiner.
    - Pivot shift test: With the knee extended, apply valgus stress to the leg and internally rotate will slowly flexing the knee. Look for subluxation or clunking of the tibia as the knee passes 30-40 degrees of flexion.
    - While uncommon, test the knee for the unhappy triad (concurrent medial collateral ligament injury, meniscal testing).
- Imaging: Get plain films to exclude fracture and avulsion injury. MRI can confirm the diagnosis and evaluate for concurrent injuries.

Management:

- Initially, RICE and protection with an elastic bandage and crutches.
- Referral to a pediatric orthopedic specialist is key.
    - Unrepaired ACL tear often leads to sports cessation. A pediatric specialist is important to consider the risk of physeal injury.
    - Rehabilitation is less favorable in pediatrics as nonoperative management poses risks of instability and further meniscal injury.
    - If the ACL is partially torn and the patient is skeletally immature, can consider conservative treatment with physical therapy to avoid surgical reconstruction.
    - Postoperative rehabilitation and bracing depends on the repair taken.
- Return to play must take into account injury prevention with strengthening and proprioceptive training.
- All patients are at risk of developing long-term arthritis (up to 70% in 10-15 years).

References:

- Fabricant PD, Kocher MS. Anterior Cruciate Ligament Injuries in Children and Adolescents. Orthop Clin North Am. 2016 Oct;47(4):777-88.
- Solomon DH, Simel DL, Bates DW, Katz JN, Schaffer JL. The rational clinical examination. Does this patient have a torn meniscus or ligament of the knee? Value of the physical examination. Jama. 2001;286(13):1610-1620.

Medial and Lateral Collateral Ligament Injury (MCL)

Overview:

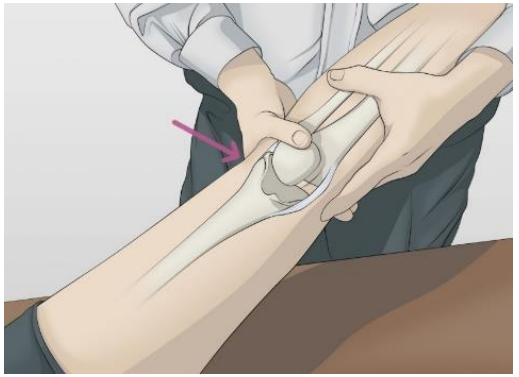
- The medial collateral ligament (and muscles such as sartorius and adductors) stabilize against valgus stress on the knee. The lateral collateral ligament stabilizes against varus stress.
- In pediatrics, isolated collateral ligament injury is uncommon as younger athletes usually suffer physeal and avulsion injuries.
- LCL injury is even more uncommon, but can avulse the lateral tibial plateau (Segond fracture).

Clinical Presentation:

- MCL injury is often traumatic with lateral leg collision or valgus stress while pivoting.
- LCL injury occurs with varus stress to the knee.

Evaluation: Look for other injuries (e.g. patellar dislocation, ACL tear).

- Inspection: Suspect additional injury and image if unable to bear weight. An effusion should raise suspicion for chondral or intraarticular injury.
- Palpation: Palpate the joint line and bones around the MCL (femoral condyle, medial tibia) to identify potential avulsion injury.
- Range of motion: Should be no normal in isolated injury. Patient with deep MCL injury may have laxity to external rotation of the tibia.
- Other tests:
    - Varus and valgus stress: Flex the knee 30 degrees and hold the leg between your elbow and body. Apply varus and valgus stress with your hands palpating the joint lines.
    - Perform thorough knee exam (e.g. Lachman test, McMcurray and Thessaly, posterior drawer).
- Imaging: Plain films if unable to bear weight, bony tenderness, or skeletally immature (rule out physeal injury). Get AP, lateral and patellar views (different from tunnel view).
    - MRI is best used for high energy injuries and to look for possible injury of the tibial posterolateral corner, menisci or cruciate ligaments.



How to apply varus and valgus stress

LCL injury with femoral condyle avulsion. Of note, Segond fracture affects the tibial plateau (the posterolateral corner)

Management:

- Isolated or partial tears of the MCL or LCL can be conservatively managed.
    - Most patients with isolated MCL injury do well with physical therapy.
    - If non-emergent, would see again after 1 week to allow swelling to subside and permit an accurate exam.
- Refer to orthopedic surgery for suspected corner injury, concurrent ligamentous injury or failed conservative management.
    - In LCL tears with a concurrent ACL tear, surgery is indicated to repair the posterolateral corner of the tibia to improve the likelihood of a successful ACL repair.

References

- Kramer DE, Miller PE, Berrahou IK, Yen YM, Heyworth BE. Collateral Ligament Knee Injuries in Pediatric and Adolescent Athletes. J Pediatr Orthop. 2017 Dec 8.

Brief Word: Posterior Cruciate Ligament Injury (PCL)

Overview:

- The PCL restrains the leg from sliding posteriorly and limits external rotation of the tibia.
- **PCL injuries are uncommon and tend to occur as part of multiligament injuries with concomitant meniscal and avulsion injuries.**

Clinical Presentation:

- Often traumatic injury from an anterior blow to the leg (e.g. tackled from the front), or from hyperflexion of the leg followed by effusion and instability.

Evaluation:

- Palpation: An effusion is often present and palpable.
- Other tests: There may be laxity on the posterior drawer test compared to the other side.
- Imaging: Plain films of the knee including an AP, lateral and notch view are important to identify possible avulsion injury though the avulsed fragment may not be visible if it has not yet ossified. While MRI can identify soft tissue injury, diagnostic arthroscopy is the most accurate means to assess the extent of injury.

Management:

- RICE and immobilize initially in extension with urgent referral to a pediatric orthopedist (given possibility of physeal injury from initial trauma and from possible surgical repair).
- Avulsion injuries of bone or soft tissue warrant surgical consultation for repair.
- In the rare case of a skeletally immature patient with an isolated partial tear of the PCL, conservative management can be attempted if stress views on stress radiographs show less than 8 mm of posterior laxity.

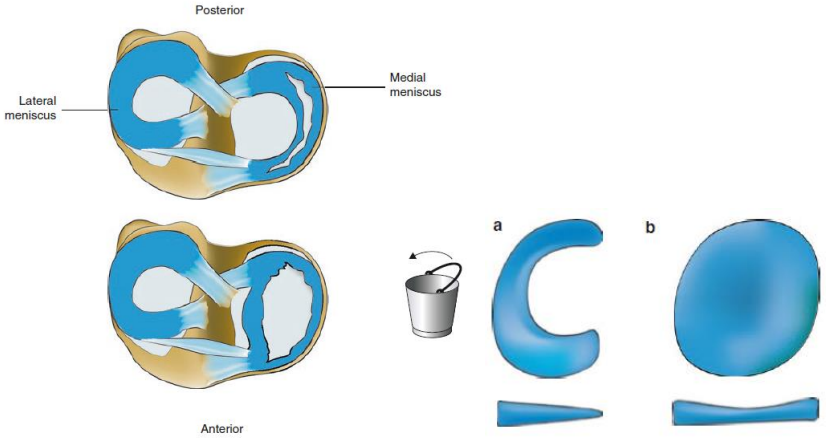
References:

- Kocher MS, Shore B, Nasreddine AY, Heyworth BE. Treatment of posterior cruciate ligament injuries in pediatric and adolescent patients. J Pediatr Orthop. 2012 Sep;32(6):553-60.
- Mariani PP, Margheritini F, Christel P, et al. Evaluation of posterior cruciate ligament healing: a study using magnetic resonance imaging and stress radiography. Arthroscopy. 2005;21:1354–61.

Meniscal Tears

Overview:

- The medial and lateral menisci are crescents of cartilage that nest the femoral condyles onto the tibia. They stabilize, cushion and give proprioception to the knee joint.
- The medial meniscus attaches to the medical collateral ligament, and both menisci attach roots to the joint capsule. Isolated meniscal injuries are uncommon.
- Tears in children younger than 10 are uncommon but usually due to a discoid meniscus.



Left: Bucket handle tear of the meniscus. Right (b): Discoid meniscus.

Clinical Presentation:

- Patients present with posttraumatic knee pain.
- The knee may click, catch, or feel unstable (as if it may give out).
- Locking refers to an inability to extend the knee and suggests a torn flap of cartilage has lodged into the joint space.

Evaluation: The goal is to gather a constellation of findings, as no one specific sign or symptom is diagnostic. Isolated meniscus injury is uncommon so testing for ACL tear and MCL injury is important.

- Inspection: An effusion can be present.
- Palpation: Joint line tenderness is sensitive but nonspecific.
- Range of motion: Check for full range of motion to make sure it is feels smooth and complete. Test a full squat and "duck waddle."
- Other tests: These maneuvers are operator dependent and so negative findings do not rule out a tear. Joint line pain, catching, and locking (a painful thud) are positive findings.
    - Thessaly test: With the patient standing on the unaffected leg with knee flexed to 20 degrees, hold their hands and rotate back and forth on the knee. Then test the affected leg.
    - McMurray test: Hold the knee at the joint line and the foot. Range the knee from maximal flexion to extension, applying internal rotation and varus stress (lateral meniscus) and then external rotation and valgus stress (medial meniscus).
- Imaging: MRI is the modality of choice. It is used for significant injury such as a bucket handle tear that may require surgery or to evaluate symptoms or effusion that persist despite conservative management.
    - Plain films (AP, lateral, notch and Merchant views) are important for identifying bony injuries and degenerative disease such as osteochondritis dissecans on the differential diagnosis.

Management:

- Patients with subacute onset of symptoms after injury, intact range of motion and pain only at end flexion can be conservatively managed with RICE and physical therapy. Bracing or crutches are optional depending on stability.
- Persistent effusion, catching, or instability should be referred to an orthopedist. Similarly, refer patients with persistent symptoms despite 6 weeks of conservative management.
- A locked knee that cannot be extended should be immediately referred to the orthopedist. Delayed referral can damage the cartilage and make repair difficult.

References:

- AAOS: Meniscal Tears
- McTimoney M. Knee Injuries. In: Micheli LJ and Purcell L, eds. *The Adolescent Athlete: A Practical Approach*. 2nd ed. Cham, Switzerland; Springer; 2018: 233-241.

Osteochondritis dissecans (OCD) of the knee

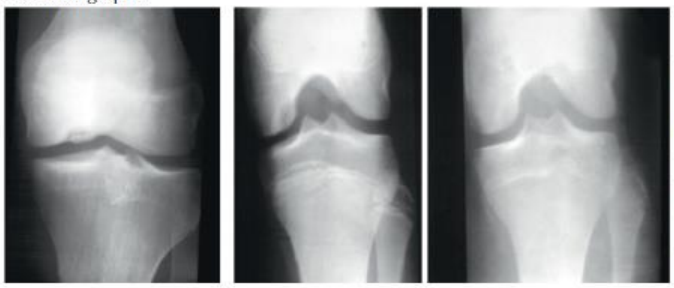
Overview:

- Focal avascular necrosis of the bone beneath the articular cartilage that can dislodge loose bodies into the knee joint.
- The posterolateral medial femoral condyle is most commonly affected.

Stage 1. Bulge on medial femoral condyle due to partial separation of bone fragment. Articular cartilage intact, but defect evident on radiographs.

Stage 2. Fragment demarcated by separation of articular cartilage.

Stage 3. Fragment of cartilage and bone completely separated as loose body. This often migrates to medial or lateral.



Tunnel view radiographs of small OCD lesion involving medial femoral condyle treated with activity modification. Complete healing occurred.

Clinical Presentation:

- Indolent atraumatic knee pain associated with activity.
- Usually adolescents. Children can develop the disease as well.

Evaluation:

- Palpation: Often normal, though sometimes the affected joint has an effusion.
- Range of motion: If there is a loose body, the joint will lock or catch.
- Imaging: AP, lateral, tunnel views and sunrise view plain films are a start, although MRI can identify disease and loose bodies, as well as predict fragment stability.

Management:

- Despite its relative rarity and controversial management in the dearth of evidence, **a high clinical suspicion and a low threshold to refer to the orthopedist is key.**
- Generally, OCD is managed with a trial of activity modification, physical therapy and bracing in anticipation of resolution over several months.
- Unstable lesions require arthroscopy to drill and stabilize the fragment.
- Most small OCD lesions (~90%) may heal spontaneously. Later onset and large lesions require aggressive treatment as their prognosis is guarded with a risk of arthritis later in life.

References:

- Chambers HG, Shea KG et al. American Academy of Orthopaedic Surgeons. American Academy of Orthopaedic Surgeons clinical practice guideline on: the diagnosis and treatment of osteochondritis dissecans. J Bone Joint Surg Am. 2012 Jul 18;94(14):1322-4.
- Shea KG, Carey JL et al. Management of Osteochondritis Dissecans of the Femoral Condyle. J Am Acad Orthop Surg. 2016 Sep;24(9):e102-4.

Sinding Larsen Johansson (SLJ) syndrome and Osgood Schlatter disease (OSD)

Overview:

- Traction apophysitis of the extensor mechanism of the knee:
  - SLJ syndrome: ossification center at inferior patellar pole
  - OSD: Tibial tuberosity apophysis. 30% of cases are bilateral.
  - Different from "Jumper's knee," which is patellar tendonitis.
- **Both can progress to severe avulsion injuries** (patellar sleeve fracture, tibial tubercle avulsion) that need urgent evaluation by an orthopedist.

Clinical Presentation:

- Patients are usually age 10-14 and present with activity-associated pain, especially with jumping.
- These patients are usually in the middle of a growth spurt.

Evaluation: Confirm an otherwise normal knee exam.

- Inspection: May have some swelling inferior to the patella.
- Palpation: Tenderness to the inferior aspect of the patella (SLJ) or tibial tubercle (OSD). There should not be tenderness of the patellar tendon.
- Range of motion: Should be normal. Painful resisted knee extension.
- Imaging: Plain films not routinely indicated.
  - In SLJ, may have thickening of the proximal patellar tendon or spur formation and can rule out a patellar sleeve avulsion.
  - In OSD, a fragmented tibial tubercle can be a normal variant. Soft tissue swelling over the apophysis is more specific.

SLJ syndrome with spur at the inferior patellar pole in lateral film.

OSD with a spur forming over the tibial tubercle.

Management:

- Normalize the diagnosis, as SLJ and OSD develop from growth. Both SLJ and OSD are self-limiting and resolves with skeletal maturity after 12-18 months.
- Conservative therapy with relative rest and stretching of the quadriceps, with return to limited play as tolerated.
  - Rest, ice, short course of NSAIDs with limited jumping activity.
  - In SLJ, patients can try using a patellar counterforce strap.
  - Patients can continue to play sports without significant squatting or jumping, but it is critical to **not play through pain**.
- Excessive bony growth in poorly controlled disease can dispose to patellar tendonitis later in life. Patients with significant overgrowth and pain of the tibial tuberosity can be referred to consider surgical excision.

References:

- AAOS: Osgood Schlatter Disease
- Achar S, Yamanaka J. Apophysitis and Osteochondrosis: Common Causes of Pain in Growing Bones. Am Fam Physician. 2019 May 15;99(10):610-618.
- Tuong B, White J, Louis L, Cairns R, Andrews G, Forster BB. Get a kick out of this: the spectrum of knee extensor mechanism injuries. Br J Sports Med. 2011;45(2):140-146.

Tibial Stress Fracture

Overview:

- Most of leg muscles act posteriorly to the tibia, which applies compressive load to the posterior tibia but apply traction to the anterior tibia.
- Posteromedial fractures are most common, but anterior tibial stress fractures (<5% of stress fractures) are at high risk of delayed healing and nonunion.

Clinical Presentation:

- Patients are runners, classically military recruits with sharp pain in the tibia associated with activity.
- These athletes may have concurrent shin splints, but point tenderness or focal pain suggests a stress fracture.

Evaluation:

- History: Training, menstrual and diet history.
- Palpation: Stress fractures have focal tenderness as opposed to diffuse tenderness along the medial tibial border in shin splints.
- Imaging:
    - AP and lateral plain films of the legs are important to identify and localize the fracture with the caveat of radiographic lag. A lucency of the anterior cortex is known as the dreaded black line and needs referral.
    - SPECT bone scans can show increased tracer uptake at the site of the fracture.
    - MRI is most sensitive and can show changes that precede stress fracture

Management:

- Delayed treatment leads to delayed healing. Rest from activity with protected weightbearing is critical to allow fracture healing.
    - If initial plain films are negative, they should be repeated after 2-3 weeks of rest to confirm the diagnosis and justify continued restriction from activity.
    - Healing takes 4-12 weeks to occur, whereas shin splints improve within 1-2 weeks.
    - Patients can do non-weightbearing cross training such as swimming as tolerated.
- Patients with anterior stress fractures should be seen by an orthopedist as they may need operative fixation. Mean return to sports from operative fixation is about 4 months.

References:

- Feldman JJ, Bowman EN, Phillips BB, Weinlein JC. Tibial Stress Fractures in Athletes. Orthop Clin North Am. 2016;47(4):733-741.
- McInnis, K. C. and Ramey, L. N. (2016), High-Risk Stress Fractures: Diagnosis and Management. PM&R, 8: S113-S124.

Medial Tibial Stress Syndrome (Shin Splints)

Overview:
- Overuse injury from running that causes repetitive traction and inflammation of the periosteum of the tibia.

Clinical Presentation:
- Patients usually consider pain along the medial tibial border. Onset tends to be relatively acute, over one to two days.
- One third of athletes will have another lower leg injury.

Evaluation: MTSS is a clinical diagnosis, but must consider stress fracture in evaluation.
- History: Ask about cramping, burning, pressure sensations along the calf or numbness and tingling in the feet, which could suggest chronic exertional compartment syndrome instead.
- Inspection: Patients may have hyperpronation of their feet when running.
- Palpation: Ill-defined tenderness along the medial tibial shaft (over more than 5 cm). Localized or point tenderness should raise concern for a tibial stress fracture.
- Range of motion: Normal, with normal strength that excludes strain.
- Imaging: Plain films are not necessary but should be unremarkable.

Management:
- Patient can continue running but with low mileage. Patients can also consider more cushioned shoes.
- Anticipate recovery within 1-2 weeks.
- Persistent pain with initially negative plain films should warrant re-evaluation for stress fracture as callus can take 2-3 weeks to form. These patients should cease running and switch to non-weightbearing activity.
- Other treatments exist such as iontophoresis and extracorporeal shockwave therapy, though the data for these are limited.

References:

- Reshef N, Guelich DR. Medial tibial stress syndrome. Clinics in sports medicine. 2012;31(2):273-290.
- Winters M, Eskes M, Weir A, Moen MH, Backx FJ, Bakker EW. Treatment of medial tibial stress syndrome: a systematic review. Sports medicine (Auckland, NZ). 2013;43(12):1315-1333.
- Winters M, Bakker EWP, Moen MH, Barten CC, Teeuwen R, Weir A. Medial tibial stress syndrome can be diagnosed reliably using history and physical examination. British journal of sports medicine. 2018;52(19):1267-1272.

Pes Anserine Bursitis

Overview:

- The pes anserine refers to the tendinous attachments of the sartorius, gracilis and semitendinosus muscles to the proximal medial tibia. A bursal sac lies beneath the tendons before their insertion.
- These muscles stabilize the knee against valgus stress and help internally rotate the tibia.
- Bursitis can develop from overuse, trauma or altered biomechanics, the last of which develops in adults from degenerative joint disease.

Clinical Presentation:

- Patients usually present with indolent medial knee pain associated with activity, especially flexion of the knee.
- The pain is often aching and can interfere with sleep.

Evaluation: Generally a clinical diagnosis aimed at excluding dangerous diagnoses such as malignancy or infection.

- Palpation: Tenderness or warmth at the pes anserine.
- Range of motion: Pain can be provoked with valgus stress to the knee, or with external rotation of the tibia.
- Imaging: Plain films are not necessary but should be done if an alternative diagnosis such as tumor or malignancy is suspected. Ultrasound and MRI can show characteristic inflammatory changes but are often not necessary.

Management:

- Conservative management is the mainstay of treatment - after a brief period of rest and NSAIDs, patients can pursue physical therapy.
- Ongoing bursitis can be referred for treatment with corticosteroid joint injections.

References

- Waldman SD. Atlas of Common Pain Syndromes E-Book. Elsevier Health Sciences; 2018. 118, 468-471 Philadelphia, PA

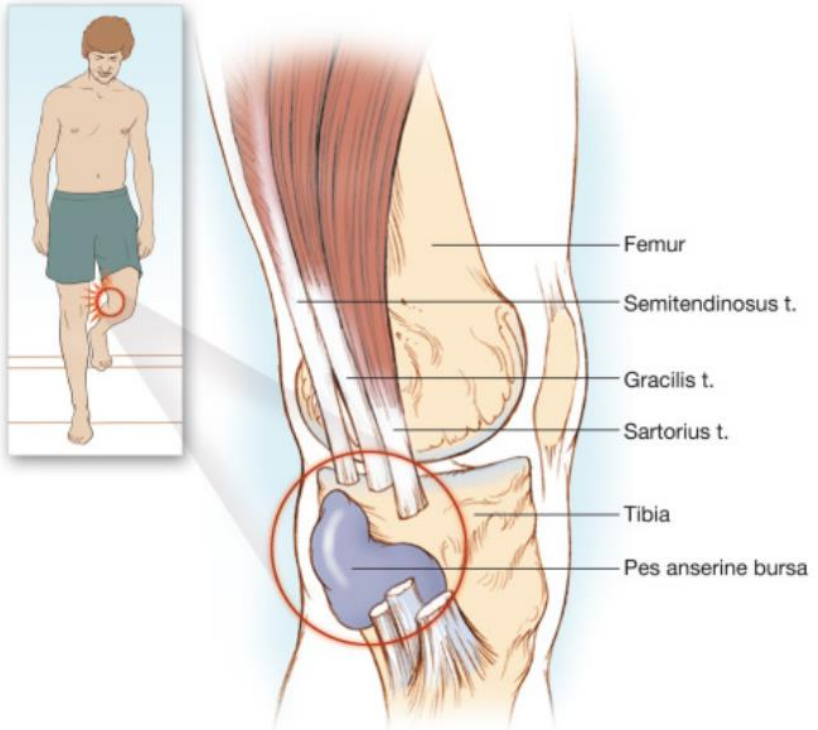


Illustration of the medial knee showing the location of the pes anserine bursa, with cutouts of the overlying muscles.

Brief Word: Compartment syndrome

Overview:
- The fascial membranes divide muscle groups into compartments.
- Trauma and fracture can cause swelling increase compartment pressure the point of circulatory compromise.

Clinical Presentation:
- Some athletes can develop a chronic exertional compartment syndrome with insidious activity-related pain.
- Acute compartment syndrome develops after trauma such as fracture, crushing or penetrating injury, burns, or swelling trapped within a cast.
- Permanent neurologic and muscle injury develops after 6-8 hours.

Evaluation:
- While classically taught as the 5 P's (pain, pallor, pulselessness, paresthesia, poikilothermia), consider the 3 A's (anxiety, agitation, increasing analgesia demand) in children.
- The **most reliable early symptom is pain out of proportion** to the injury. The affected compartment may have progressive swelling and feel tense to the touch.
- The **most reliable exam sign is worsening of pain by stretching the affected compartment**. If the deep posterior compartment of the leg is affected (figure B), the pain is worse with dorsiflexion of the ankle.
- **Open fractures can still develop compartment syndrome** as the affected compartment may still be intact.
- Check for pulses, perfusion and neurologic deficits.
- With the obtunded or sedated patient, compartment pressures can be measured with a needle. Compartment pressures above 30 mm Hg or within 30 mm Hg of the diastolic blood pressure are diagnostic of compartment syndrome and warrant urgent fasciotomy.

Management:
- **Clinical recognition is key to avoid limb loss or permanent contracture**.
- Urgent referral to emergency care and orthopedic consultation. Remove cast if present.
- Fasciotomy is done based on needle findings as above. If there is a fracture it often undergoes internal fixation. Properly treated, the main complication of compartment syndrome should only be the surgical scar.

Figure A

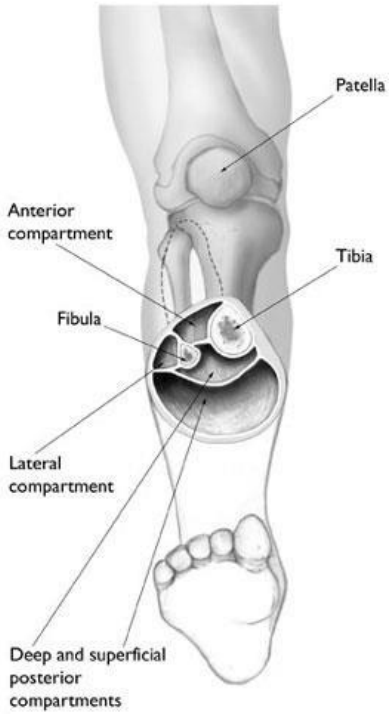


Figure B

References:
- AAOS: Compartment Syndrome
- Gresh M. Compartment Syndrome in the Pediatric Patient. Pediatr Rev. 2017;38(12):560-565.

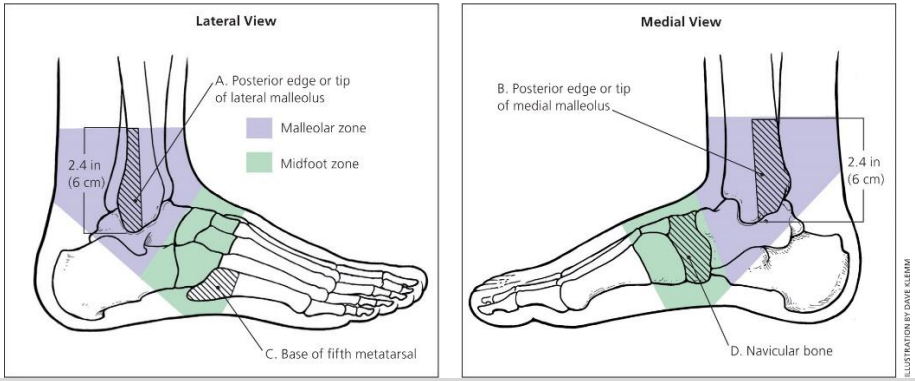
Ankle sprain

Overview and Clinical Presentation

- Ankle inversions and sprain of the lateral collateral ligament complex is the most common type of ankle injury.
- The complex is made up of the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL), and posterior talofibular ligament (PTFL).
- Generally, the severity of injury scales with injury from anterior through posterior, with isolated ATFL sprain being the least severe.
- Ligament tears are uncommon until after age 12 as skeletally immature children can suffer avulsion or physeal injuries instead, such as:
    - Salter Harris fracture of the distal fibular physis
    - Avulsion of the base of the fibular tip or base of the fifth metatarsal.

Evaluation:

- Inspection: Evaluate if patient is able to bear weight, walk 5 steps.
- Palpation: Elicit the point of maximal tenderness, looking for criteria for the Ottawa ankle rule (children older than 6, see figure) and above the lateral malleolus to look for high ankle sprain.
- Range of motion: Depending on the age of injury, may have pain or laxity on ankle inversion
- Other tests:
    - Anterior drawer test: Hold the heel and pull the foot forward in plantarflexion (ATFL laxity) and in neutral (CFL laxity).
    - Talar tilt test: Grab midfoot and invert to feel for CFL laxity.
    - Evaluate for syndesmotic ankle sprain if the pain is more proximal (next page)
- Imaging: The Ottawa Ankle rules have been validated in children (100% sensitivity, 27% specificity). Get plain films (AP, lateral, mortise views)
    - Unable to bear weight.
    - Tenderness of the distal 6 cm of the malleoli, the navicular bone, or the base of the fifth metatarsal.



Ottawa Ankle/Foot Rules to guide decision to image an ankle sprain.

Management:

- Rest, ice, compression, elevation – evidence thus far shows it does not accelerate recovery, but can be offered and tailored to what the family can do. Most sprains should resolve in 2-6 weeks.
- A lace-up brace or air cast and compression wrap are useful for initial immobilization.
    - If a distal fibular fracture is suspected, consider air stirrup splint, a short boot or short leg splint and re-evaluate symptoms.
- Early mobilization and ankle exercises to maintain muscle strength around the foot and ankle.
    - Return to sports is typically guided with physical therapy for proprioceptive training to reduce recurrent ankle sprain.
    - Prior to returning to activity, the patient should be able to walk and run in a straight line and change directions without discomfort.
- If dealing with multiple repeated ankle sprains with persistent pain, consider osteochondritis dissecans of the talus or tarsal coalition.

References

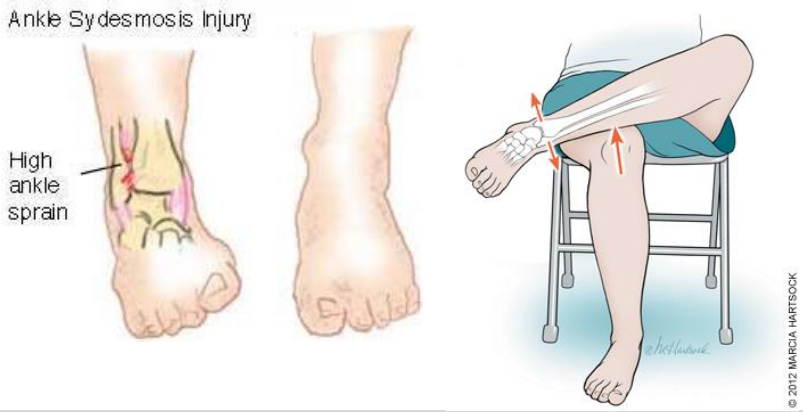
- Tiemstra JD. Update on acute ankle sprains. Am Fam Physician. 2012 Jun 15;85(12):1170-6.

High ankle sprain

Overview:
- The tibiofibular syndesmosis is a fibrous interosseous membrane that can be injured when external rotation of ankle pries apart the ankle (high ankle sprain) or fractures the fibula (Maisonneuve fracture).
- The tibia and fibula are a closed ring; fibular fracture should raise suspicion for a concurrent syndesmotic injury.

Clinical Presentation:
- External rotation injury of the ankle with anterolateral ankle pain with weightbearing.

Evaluation:
- History: Anterolateral ankle point tenderness. Difficult weight bearing.
- Palpation: Tenderness over the syndesmosis.
- Range of motion: May have pain with external rotation or dorsiflexion.
- Other tests: Positive tests provoke pain just proximal to the ankle.
    - The squeeze test – squeezing the leg laterally provoke pain.
    - Crossed leg test – cross the affected leg (see right) to apply lateral pressure to the leg.



Left: The location of an injured tibofibular syndemosis.
Right: Crossed leg test stressing the distal tibiofibular syndesmosis.

Evaluation, continued:
- Imaging: Obtain usual plain films (AP and lateral, mortise views) but also get an AP and lateral films of the tibia to look for proximal fibula fracture (Maisonneuve fracture).
- Syndesmotic ankle injuries show decreased overlap of the tibia and fibula (widening or diastasis of the distal tibiofibular joint).

Management:
- If there is no ankle instability or diastasis (separation of the tibiofibular joint), can manage non-operatively with boot or cast with follow-up after 2-3 weeks.
- Time to recovery may be 2-3 times that of a normal ankle sprain.
- Refer to an orthopedist to consider fixation of the tibia to fibula if symptoms persist despite conservative management, or for instability despite appropriate fixation of an associated fibular fracture.

References:
- Therese L. Canares, Gregory Lockhart. Sprains. Pediatrics in Review Jan 2013, 34 (1) 47-49; DOI: 10.1542/pir.34-1-47
- Tiemstra JD. Update on acute ankle sprains. Am Fam Physician. 2012 Jun 15;85(12):1170-6.

Achilles Tendinopathy

Overview:
- The gastrocnemius and soleus muscles have a common Achilles tendon that inserts into the calcaneus.

Clinical Presentation:
- Usually arises from increased running and impact exercise with posterior heel pain.
- Pain is often achy but can be occasionally sharp, associated with activity such as toe-raising, running, jumping.
- Common in basketball, soccer, running and dancing.

Evaluation:
- Palpation: The tendon itself is tender and occasionally tendon thickening can be felt.
- Range of motion: Painful reduced ankle dorsiflexion and pain with resisted plantarflexion or calf-raising.
- Other tests: The Thompson test involves having the patient kneel on an exam table with the foot downwards off the edge of the table. Squeeze the calf to ensure the integrity of the Achilles tendon.
- Imaging: Plain films often not needed. Ultrasound can show vascular changes and tendon thickening but is not needed to proceed with management.

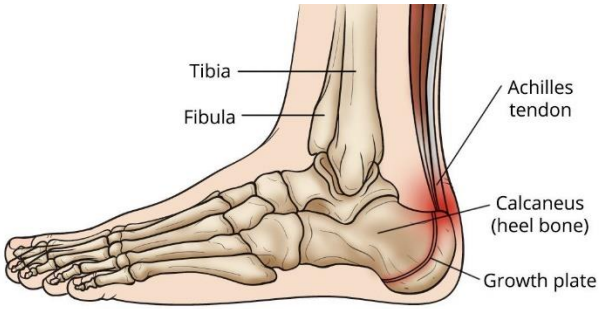
Management:
- Conservative therapy with activity modification, ice, stretching and eccentric calf exercises with or without physical therapy.
- Heel cups are an option as well to relieve tension on the Achilles tendon.
- Corticosteroid injections are contraindicated as they can increase the risk for tendon rupture.

References:
- Tu P. Heel Pain: Diagnosis and Management. Am Fam Physician. 2018 Jan 15;97(2):86-93.

Severs disease

Overview:

- Traction apophysitis of the calcaneus by the Achilles tendon.



Clinical Presentation:

- Patients are usually 8-12 years of age and complain of heel pain associated with activity.
- Patients are often beginning a new sports season or in the midst of a growth spurt.

Evaluation: Goal is to exclude Achilles tendonitis or plantar fasciitis.

- Inspection: Normal gait without deformity.
- Palpation: Tenderness over the calcaneus.
- Range of motion: Normal, however may complain of pain on calf raise. Check range of motion in the ankle to determine if the heel cords are tight.
- Imaging: If pain is persistent in the athletic patient consider calcaneal stress fracture or a bony lesion such as a cyst and obtain imaging.

Management:

- Limit activity to what is tolerable. Patients can get viscoelastic heel cups or shoes with higher heels. NSAIDs can be used as needed for pain.
- Calf stretching exercises to decrease traction on the calcaneus.
- For severe cases a walker boot may be needed to limit motion of the ankle.
- Pain that does not improve to heel cups and stretching exercises can be imaged or referred to the orthopedist. Findings of stress fracture or bone cyst prompt referral.
- Expect 6-9 months for recovery.

References

- AAOS Sever's Disease
- Tu P. Heel Pain: Diagnosis and Management. Am Fam Physician. 2018 Jan 15;97(2):86-93.

Stress fractures of the foot

Overview:
- Stress fractures can develop from repetitive impact.
- **Bones under tensile stress are at risk of nonunion or delayed healing.**
- In the foot, the base of the fifth metatarsal (the insertion of the peroneus longus) and the navicular bone (where the posterior tibialis inserts) are under tensile stress and have tenuous blood supplies.

Pearls:
- Menstrual and diet history to evaluate for decreased bone density or the female athletic triad.
- Plain films are important to acquire but are often negative. And while MRI can show stress reaction and visualize fracture, **clinical suspicion is key.**

Navicular Stress Fractures: Clinical Presentation and Evaluation:
- Sprinting, cutting, and jumping activities with worsening pain over the medial dorsal midfoot at the location of the navicular bone.
- Most tender over the dorsal mid-third of the navicular. There is often little swelling, but pain can be reproduced by tiptoeing or hopping on one foot.
- Plain films are frequently normal but should be done to exclude an accessory navicular or other anatomic issue.

Fifth Metatarsal Stress Fractures: Clinical Presentation and Evaluation:
- Soccer, basketball, or football players sprint, pivot, and cut frequently.
- These stress fractures usually presently acutely after 2-3 weeks of worsening activity-related pain.
- They present with lateral plantar midfoot pain and tenderness that may be worsened with inversion of the foot.

Management:
- For both of these stress fractures the patient should be made non-weight bearing and referred urgently to an orthopedist for consideration of either 6 weeks of non-weight bearing casting or surgical fixation.
- Stress reaction alone seen on MRI can be casted and non-weight bearing for 6 weeks.
- For surgical recovery, expect at least 3-4 months of recovery before return to play. Recovery times are even longer for stress fractures treated with non-operative management.
- There is a preference for operative treatment in the case of elite athletes, as the recovery is shorter and rates of poor healing are lower. Often, follow-up imaging may be done to confirm union of the fracture

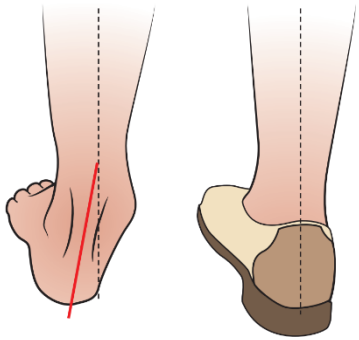
References:
- AAOS: Stress Fractures of the Foot and Ankle
- McInnis, K. C. and Ramey, L. N. (2016), High-Risk Stress Fractures: Diagnosis and Management. PM&R, 8: S113-S124.

Flat Feet

Overview:
- Common complaint in the pediatrician's office.
- 95% of supple pes planus is from benign ligamentous laxity. Some cases have a component of Achilles tightness.
- Non-supple pes planus can be due to anatomic issues such as tarsal coalition (developmental fusion of the tarsal bones), or from neuromuscular disease.

Clinical Presentation:
- Usually presents as a cosmetic or functional concern from parents.
- May have some cramping or easy tiring of the feet with prolonged walking.
- Pain or recurrent sprains is abnormal and should be evaluated.

Evaluation:
- History: Ask about prior ankle sprains and pain with walking.
- Inspection: Inspect for intoeing and flattening of the arch in weight bearing and non-weight bearing. The arch should reconstitute and the heel point medially when non-weight bearing (sitting with feet dangling, or tiptoeing).
- Range of motion: Dorsiflex the ankle to check for heel cord tightness. Dorsiflex the great toe normally can reform the arch (Jack test).
- Imaging: Three-view plain films of the ankle can show bony connections between the tarsal bones. Fibrous connections may not be apparent and require a CT scan.



Example of flat feet
Left: Flat foot with heel valgus (red line) and overpronation of the midfoot.
Right: Arch support or rigid heels can stabilize the foot.

A – bilateral pes planus, anterior view
B – posterior view with overpronation and heel valgus
C – normal reconstitution of arch when tiptoeing
D – pathologic non-supple flat foot

Management:
- Reassurance for supple pes planus.
- Conservative management such as rest and orthotics can temporarily help symptoms in non-supple pes planus but does not address the underlying anatomic pathology.
- Referral to an orthopedic surgeon is important for consideration of resection and possible interposition or fat or muscle tissue between the bones.

References
- Pediatric Pes Planus: A State-of-the-Art Review. Pediatrics. 2016 Mar;137(3):e20151230. doi: 10.1542/peds.2015-1230. Epub 2016 Feb 17.

Plantar Fasciitis

Overview:
- Overall less common in pediatrics.
- Plantar fascia is continuous with the Achilles tendons and fans out distally to insert at the toes.
- Repetitive compression trauma at the calcaneus can cause inflammation, tightening and progressive plantar pain.

Clinical Presentation:
- Patients are often runners who complain of plantar pain that is worst in the morning when walking and improves with activity.

Evaluation:
- Palpation: Tenderness at the calcaneus where the plantar fascia arises.
- Range of motion: Ankle dorsiflexion is often limited.
- Other tests: Passively dorsiflexing the toes tightens the plantar fascia and can worsen pain (Windlass test).
- Imaging: Often unnecessary unless there is concern for a stress fracture or other bony lesion. Plain films can show thickening of the plantar fascia. Ultrasound can show thickening or rupture of the fascia.

Example of plantar stretching exercise

Management:
- Nonoperative rehabilitation with stretching and strengthening of the calf and stretching of the plantar fascia can be recommended. Plantar fasciitis typically takes months to improve.
- Like with Severs disease, heel cups or shoe inserts can cushion the calcaneus. There is no evidence to favor custom orthotics over commercially available insoles.
- Steroid injections have low quality evidence for short-term improvement but not beyond one month.

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- Becker BA, Childress MA. Common Foot Problems: Over-the-Counter Treatments and Home Care. Am Fam Physician. 2018 Sep 1;98(5):298-303.
- Arnold MJ, Moody AL. Common Running Injuries: Evaluation and Management. Am Fam Physician. 2018 Apr 15;97(8):510-516.

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Other websites

1. AAOS: OrthoInfo
2. Dr. Jordan Metzl: Pediatric Exam Videos
3. OrthoBullets.com