Atraumatic Orthopedics

Pediatric RC Exam Review
February 28, 2019

Dr. Naminder Sandhu, FRCPC
Pediatric Emergency Medicine

Objectives to cover today

- Anatomy, structure and function of bone, joint and connective tissues
- Normal bone growth and function
- Common radiographic abnormalities in MSK diseases

- Part 1: Atraumatic
  - Congenital abnormalities
  - Joint and limb pain
  - Joint deformities (not rheumatology)
  - MSK infections
  - Bone tumors
  - Common gait disorders

- Part 2: Traumatic
  - Common fractures > other injuries

What's different in kids' bones?

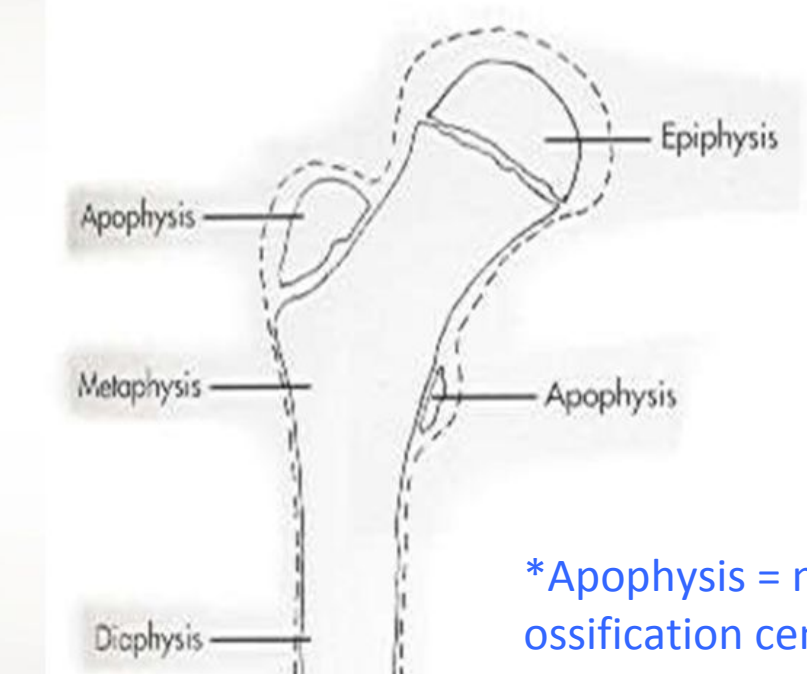
- Presence of a growth plate
- Ligaments and tendons are stronger than growth plates (□ SH fractures)
- Bones are more porous and pliable
  - Thicker periosteum (outer covering) □ more likely to stay intact
- Great remodeling potential
  - Thicker periosteum (more vascular supply to bone)
  - More rapid ossification of callus

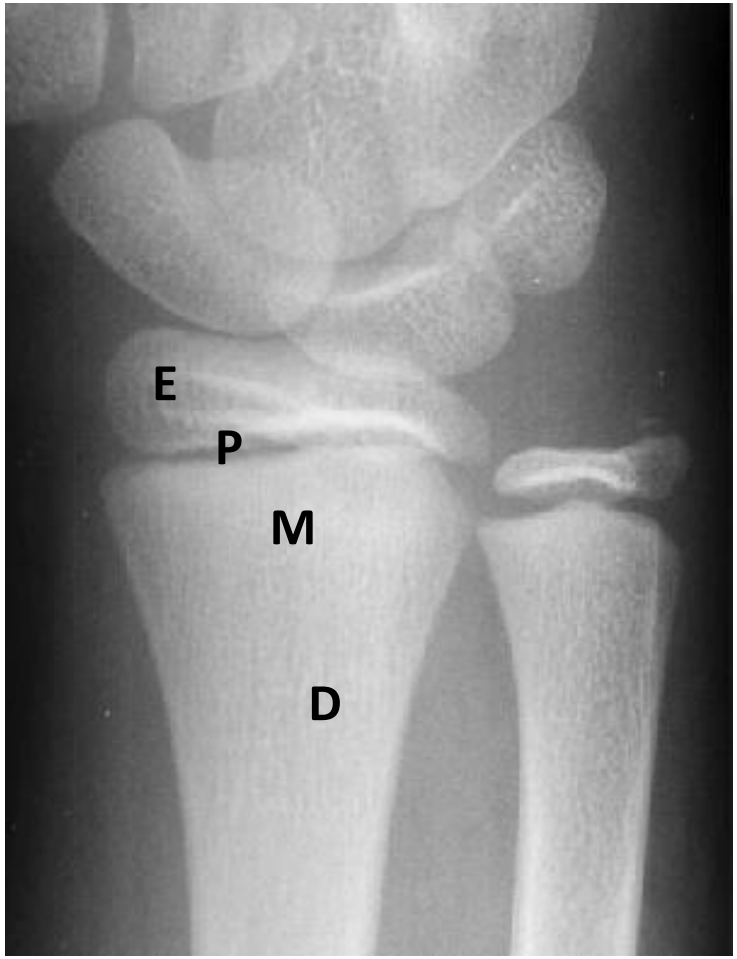
Developing Bone - Anatomy

- Name the parts of the bone

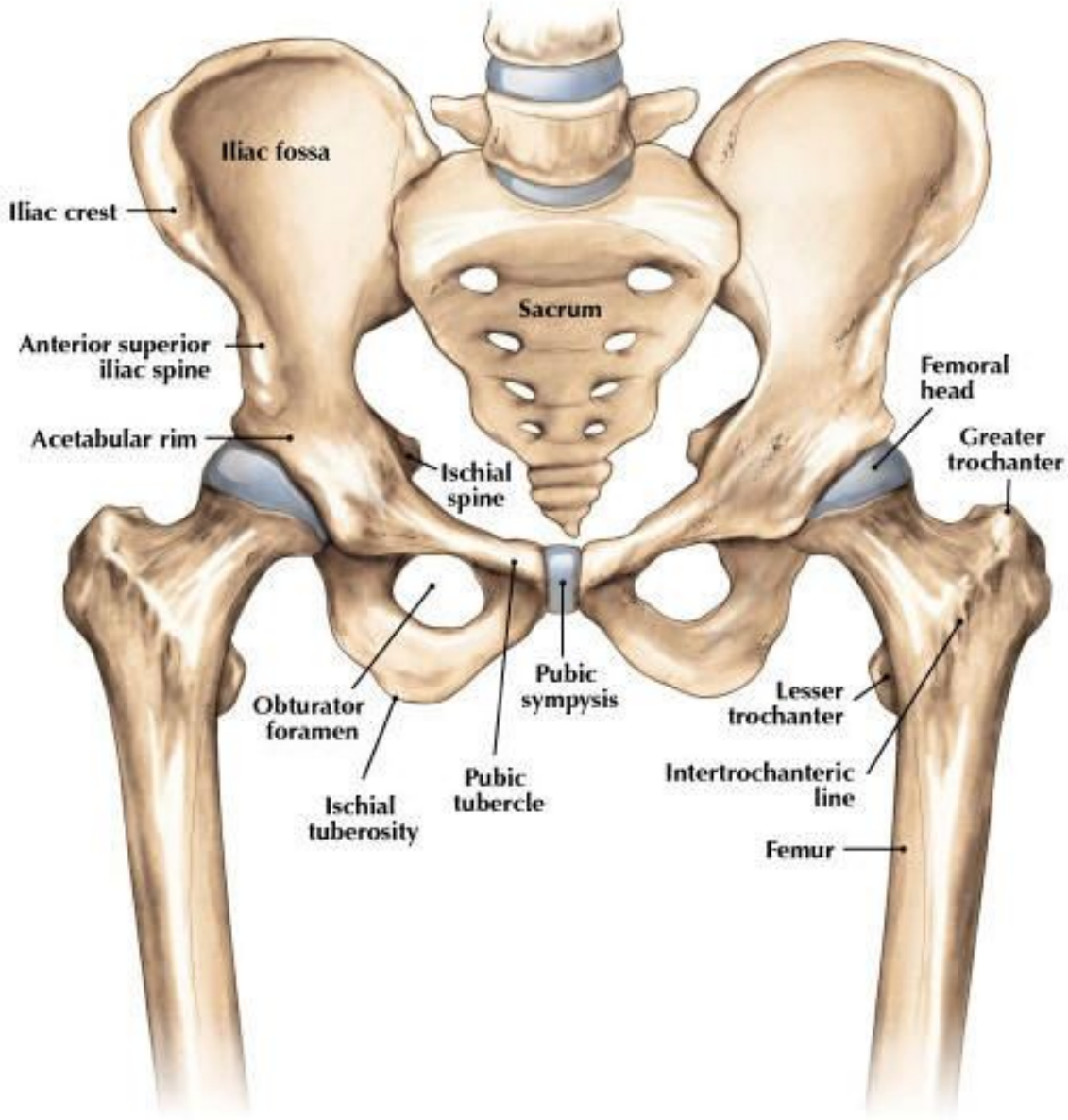
Developing Bone - Anatomy

- Epiphysis
- Physis (growth plate)
- Metaphysis
- Diaphysis





*Apophysis = natural protruberance from a bone (2ndary ossification centres, often where tendons attach)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Iliac crest
Sacrum
Anterior superior iliac spine
Acetabular rim
Ischial spine
Femoral head
Greater trochanter
Obturator foramen
Pubic sympysis
Pubic tubercle
Ischial tuberosity
Lesser trochanter
Intertrochanteric line
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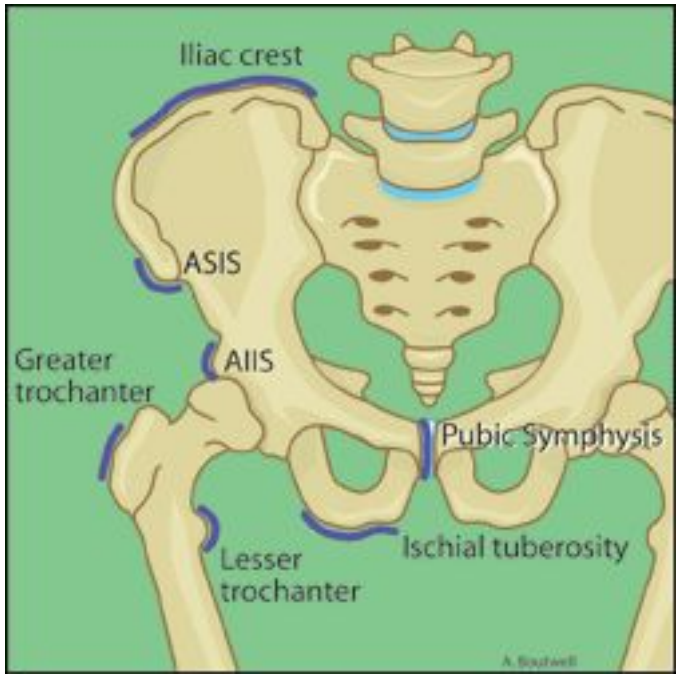
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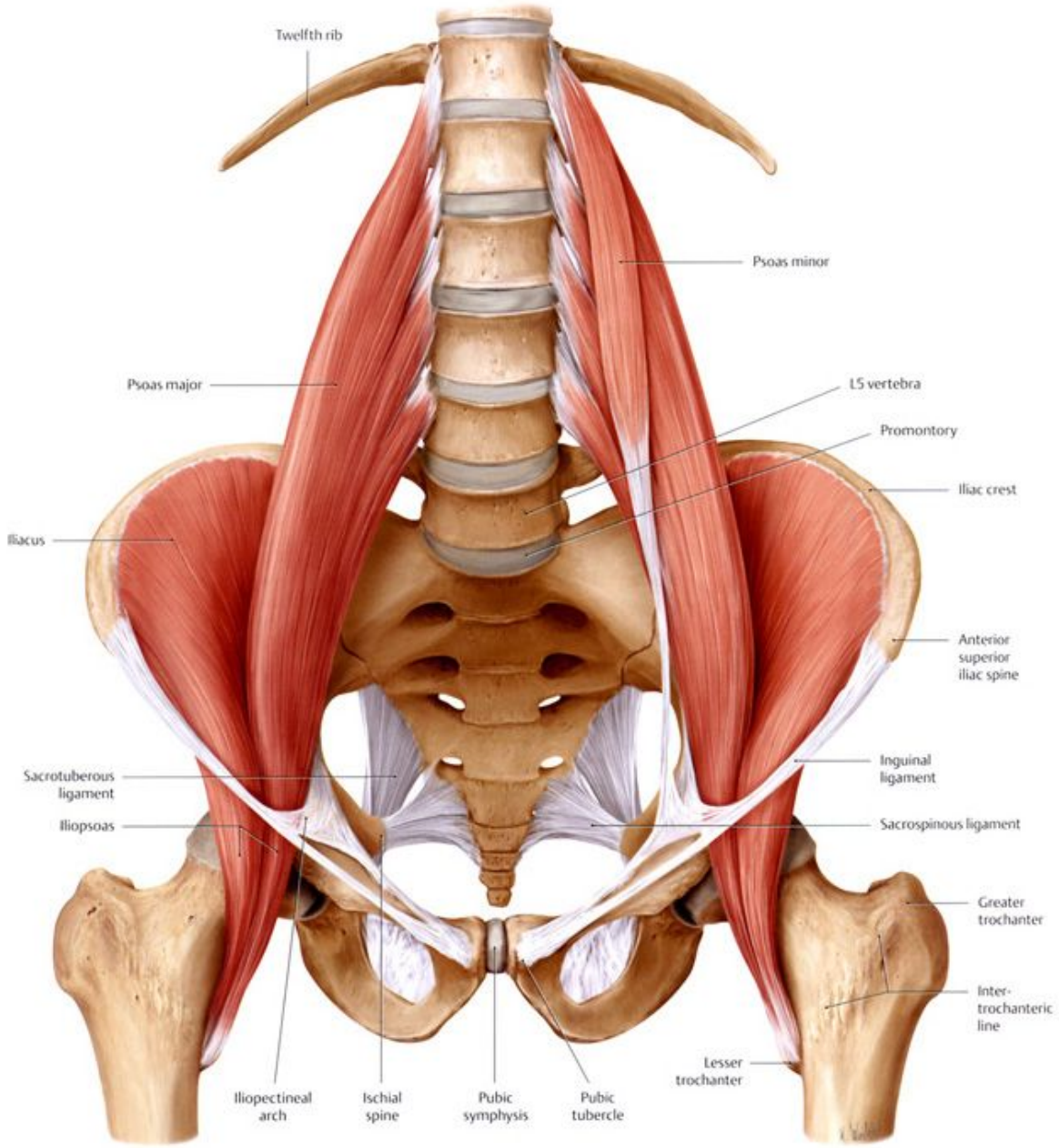
Greater trochanter
Pubic Symphysis
Lesser trochanter
Ischial tuberosity

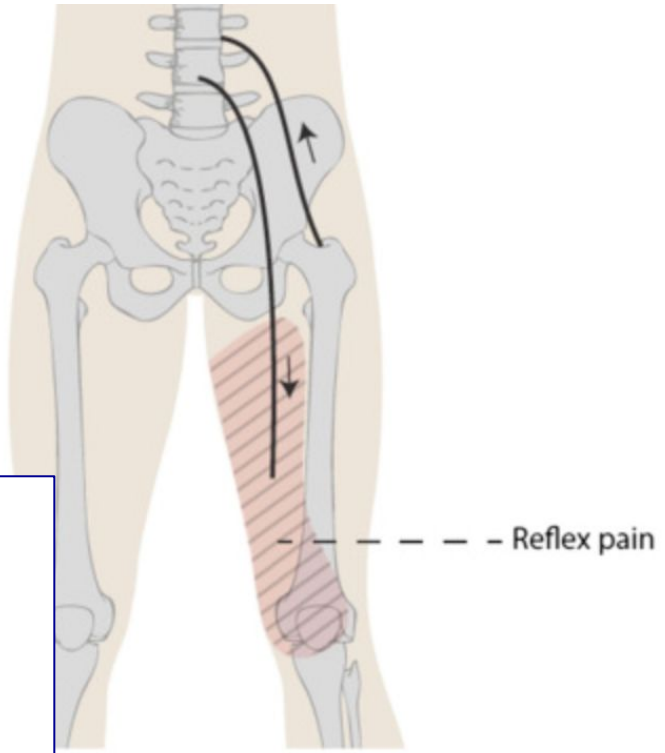

Twelfth rib
Psoas minor
Psoas major
L5 vertebra
Promontory
Iliac crest
Iliacus
Anterior superior iliac spine
Inguinal ligament
Sacrotuberous ligament
Iliopsoas
Sacrospinous ligament
Greater trochanter
Inter-trochanteric line
Lesser trochanter
Iliopectineal arch
Ischial spine
Pubic symphysis
Pubic tubercle

Atraumatic orthopedics

- Ddx and approach to pediatric limp
- Imaging considerations
- Cases, cases, and more cases
  - Acquired and Congenital cases of….
    - Limp: Hip/knee
    - Back deformities
    - Feet deformities/pain

Atraumatic Limp

- Affects all age groups
- Pain can be localized or referred
  - Hip
  - Spine
  - Abdomen
  - Pelvis/groin
  - Knee



Exam:

- Examine abdo/GU/spine and entire lower extremity
- **Internal rotation** most sensitive for hip pathology

Common causes of limp by age

TABLE 1. **Age-specific Diagnosis in Patients Presenting With a Limp**

TODDLER (<3 YEARS)	CHILD (3–10 YEARS)	ADOLESCENT (>10 YEARS)
Developmental dysplasia of the hip	Legg-Calvé-Perthes disease	Slipped capital femoral epiphysis
Congenital limb deficiencies	Stress fractures	Legg-Calvé-Perthes disease
Neuromuscular abnormalities	Tumors	Juvenile idiopathic arthritis
Painful gait	Osteochondrosis	Overuse syndromes
Toddler fracture	Kohler disease	Osteochondrosis
Septic arthritis	Osteochondritis dissecans	Tumors
Reactive arthritis	Osgood-Schlatter disease	Osteochondritis dissecans
Transient synovitis	Transient synovitis	Stress fractures
Osteomyelitis	Osteomyelitis	Tarsal coalition
Foreign object in knee or foot	Leg-length discrepancy	Discoid meniscus

Herman MJ et al. **The Limping Child**. Pediatr Rev. 2015 May;36(5):184-95

Another approach to the ddx…

Infection	**Inflammatory**	**Trauma**
Septic arthritis Osteomyelitis (Pyo)myositis	Transient synovitis Reactive arthritis Autoimmune eg. JIA	Fractures (including NAT) Overuse syndromes/ stress fractures Soft tissue (eg strains/sprains)
Avascular necrosis	**Bony deformities/ congenital**	**Osteochondrosis/ apophysitis**
Legg-Calve-Perthes Osteochondritis dessicans	SCFE DDH Tarsal coalition Coxa vara	Kohler disease Sever Osgood-Schlatter Sinding-Larsen
Tumors	**Neuromuscular**	**Non-MSK**
Benign Malignant: Ewing, Osteo, hematologic	Peripheral neuropathy Muscular dystrophy Reflex sympathetic dystrophy	Spinal pathology: discitis, tumor, epidural abscess Abdominal: appendicitis etc Gu: Testicular torsion

Clinical presentations

- Infectious
  - Acute, localized, severe
  - Fever, elevated WBC/CRP/ESR
- Inflammatory
  - Insidious onset
  - Systemic symptoms, other joint involvement
- Traumatic/congenital/degenerative
  - Acute or insidious onset
  - Pain worse with activity, improved with rest
- Neoplastic
  - Night time pain, no relation to activity
  - Associated systemic symptoms

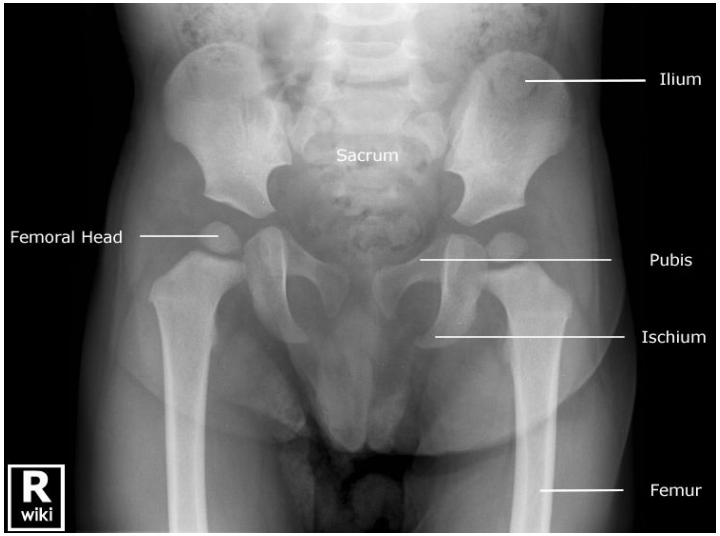
Organizing your thoughts…

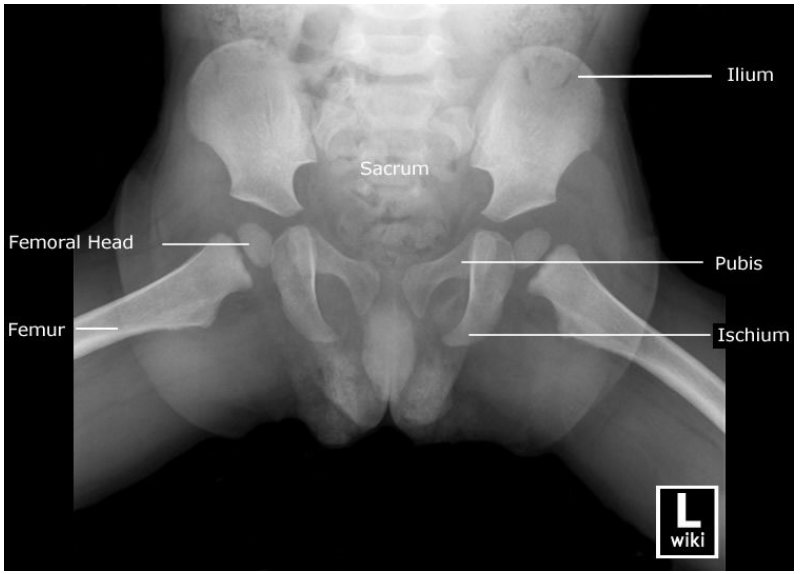
1. What is the age of the child?
2. Chronic? Or Acute?
3. Painful? Or Painless?
4. Trauma related or atraumatic?
5. Local symptoms only or systemic?

IMAGING CONSIDERATIONS

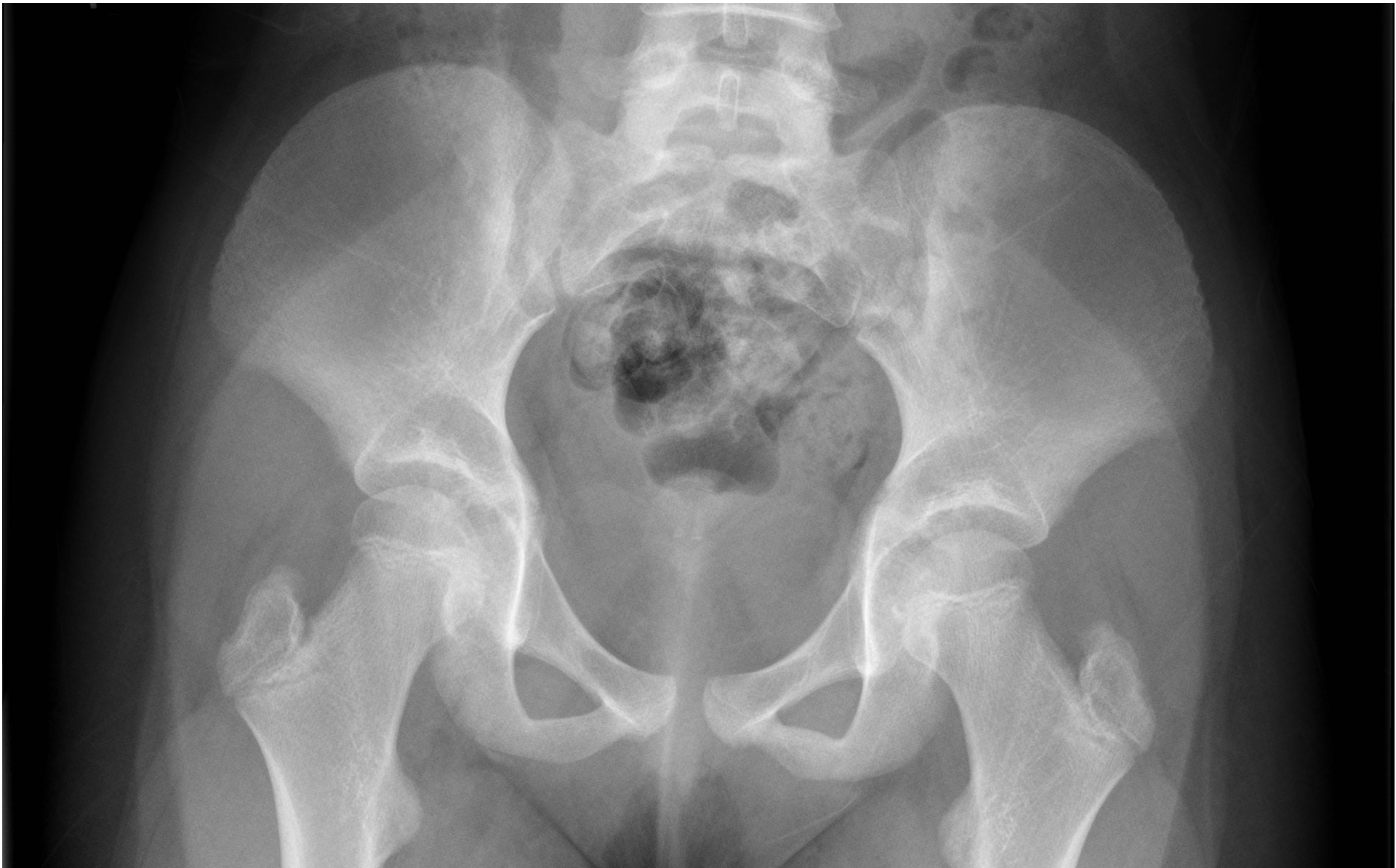
Plain film

- AP and Frog leg views
- Compare bilateral hips
- Sensitive for:
  - Fractures
  - Benign / Malignant lesions
- Less useful/not sensitive:
  - Early bone destruction or necrosis
  - Small joint effusions





Normal pelvic x-ray



Joint space narrowing in connective tissue disease

Ultrasound

- Ideal for hip effusions (95 - 100% sensitive)
  - Compare both sides for small effusions
- Can not differentiate reactive effusion from infection
- Helpful to guide aspiration
  - Therapeutic
  - Diagnostic

MRI

- Visualize joints, soft tissue, cartilage, bone marrow
- High sensitivity and specificity
  - Confirm osteomyelitis
  - Delineate malignancies
  - Early stress fractures or AVN
- Gadolinium to differentiate synovitis from effusion
- May require sedation

Bone Scan

- Helpful in localizing multifocal disease
  - Multifocal osteomyelitis
- Acutely can differentiate osteomyelitis / transient synovitis / septic arthritis
- High sensitivity
- Low specificity
- Sedation may be required
- Useful if MRI not an option

CT Scan

- Limited use due to radiation
- Most useful in complex bone lesions

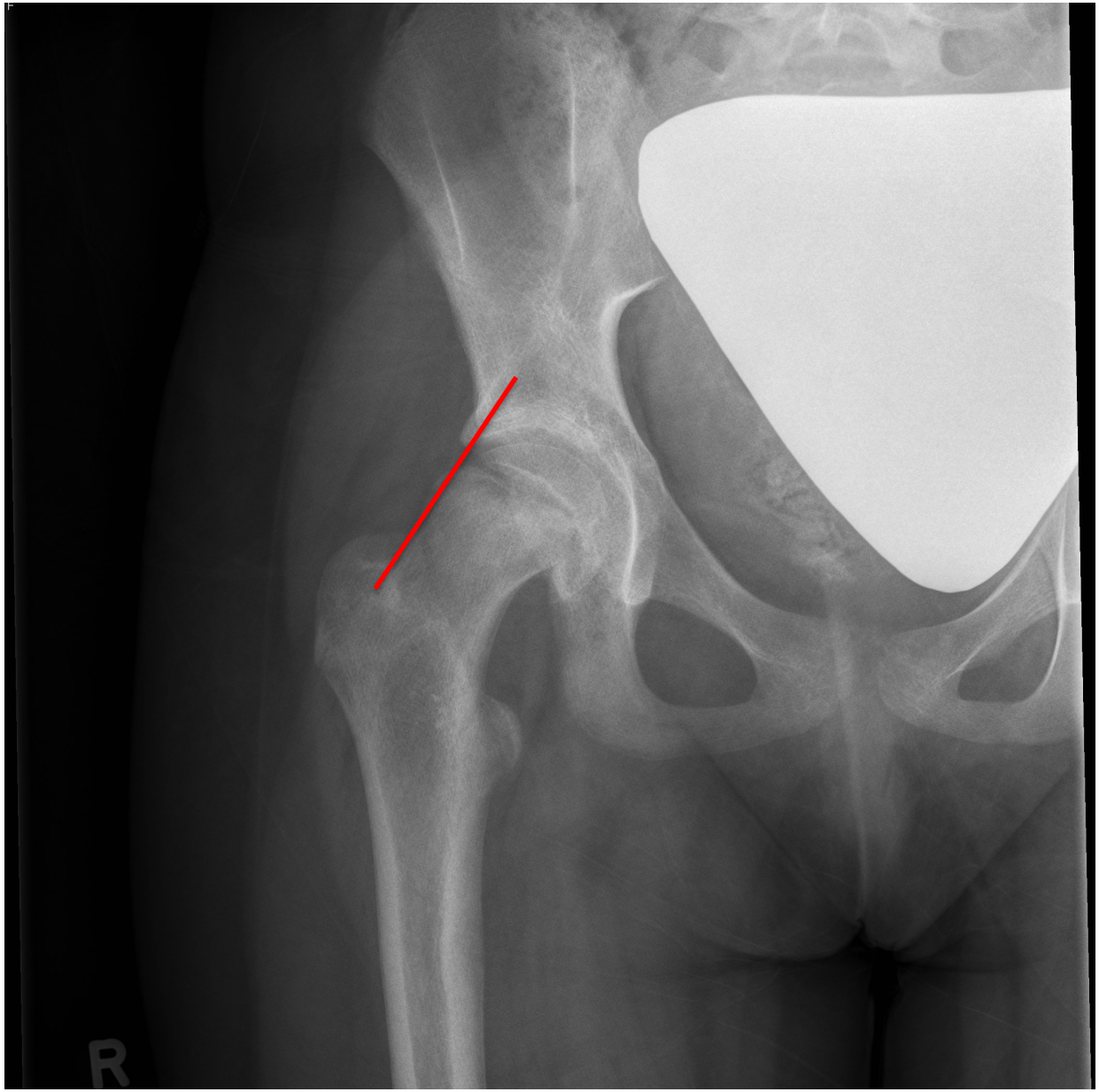
CASE EXAMPLES

Case 1

- 12 year old female
- 2 month history right hip pain
- Worst in the past week

Build your ddx….

1. What is the age of the child?
2. Chronic? Or Acute?
3. Painful? Or Painless?
4. Trauma related or atraumatic?
5. Local symptoms only or systemic?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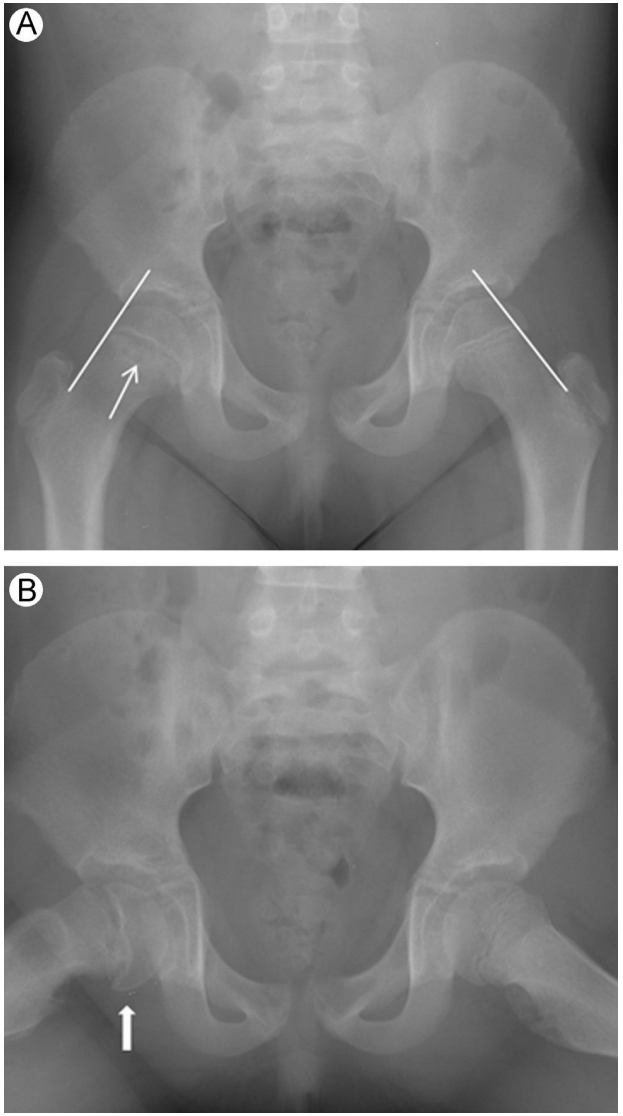
Slipped Capital Femoral Epiphysis

- Medial or posterior slipping of epiphysis
- M:F = 2:1.4
- Risk factors:
  - Age: Premenarchal /Tanner 4 adolescents
  - Ethnicity: African (2:1 = Black:White) and polynesian
  - 60-70% are obese
  - Endo: Hypothyroid, hypopit, rickets, renal osteodystrophy

- Bilateral 20-50%
- Mechanical and endocrine factors
- Long history of limp, pain with hip movement, referred knee pain; possible trivial trauma

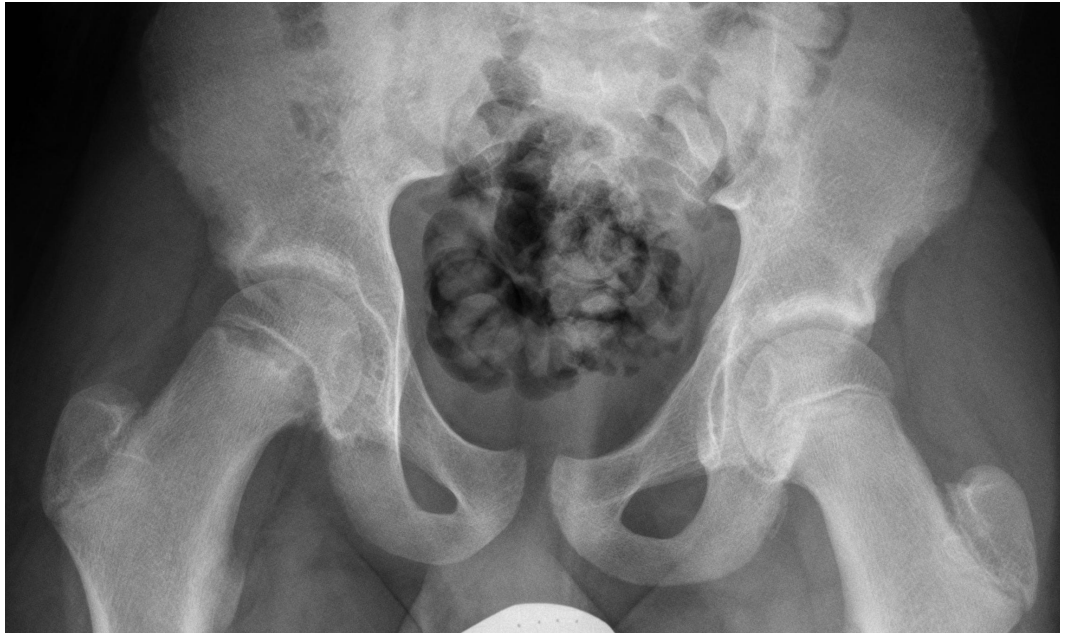
SCFE - Imaging

- SH1 type fracture
- Posterior and medial slippage of femoral epiphysis with respect to metaphysis
  - Kline line – AP view
  - Displaced femoral head
  - Widened and blurred femoral physis



Another case

Kline line (AP view)



SCFE – what's the big deal?

- 15% risk AVN
- Chondrolysis (breakdown of articular cartilage)
- Osteoarthritis

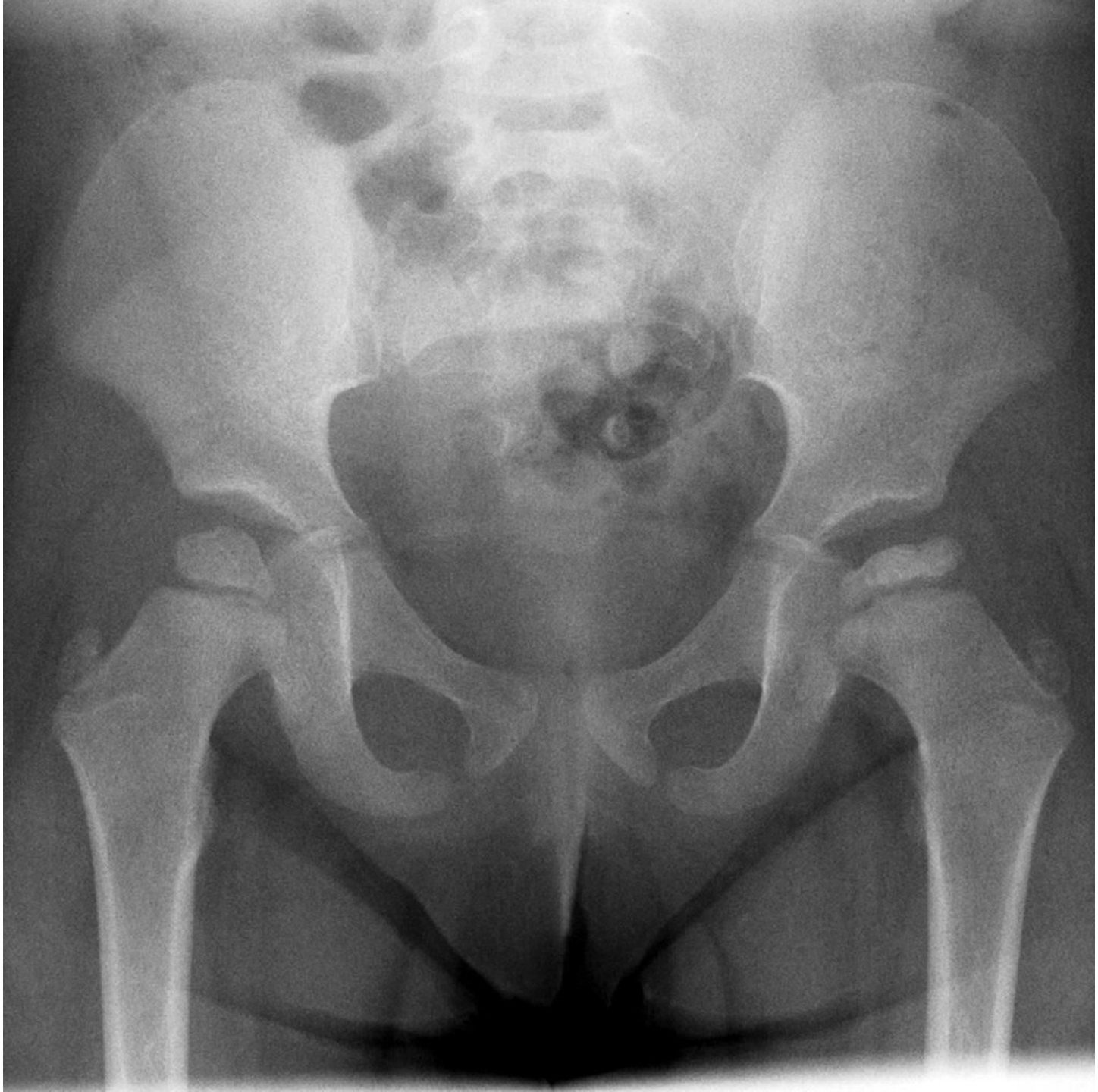
<u>Management</u>

- Non weight-bearing
- Urgent ortho consult
- Surgical fixation without reduction

Case 2

- 6 year old male
- Previously well
- Pain to left hip for a month

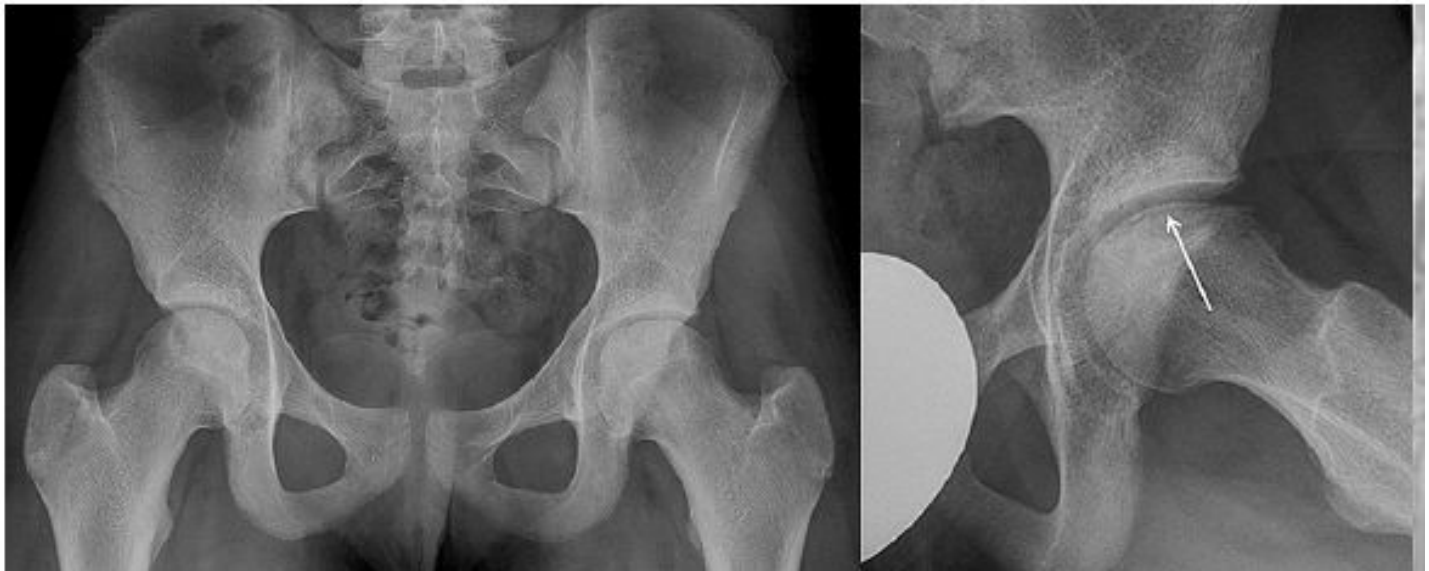
What else do you want to know?



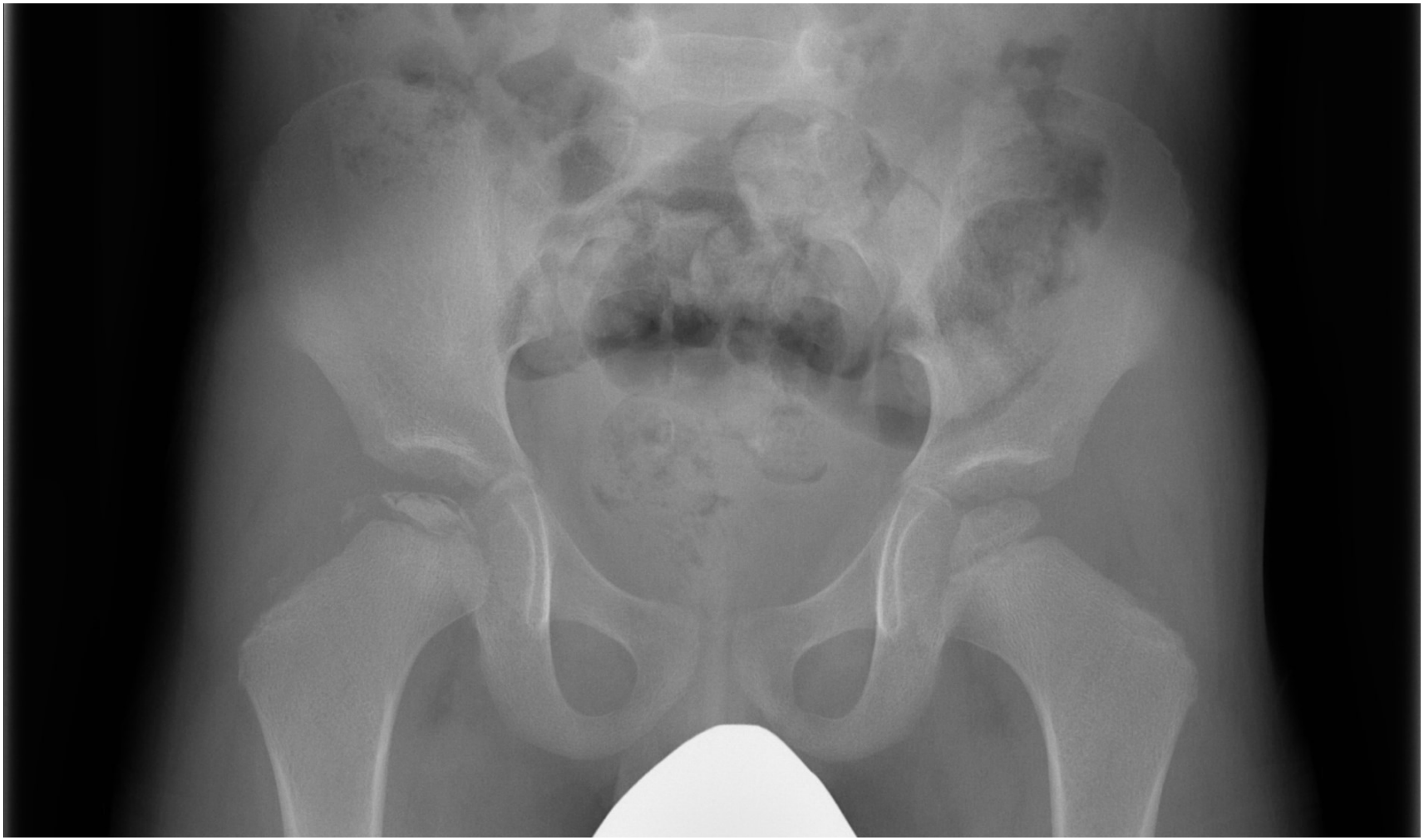
Legg-Calve-Perthes Disease

- *Idiopathic* osteonecrosis of hip
- Typically limp that is painless (pain with activity)
- 3-12 years old, peaks 5-7 year old
- M:F = 4-5:1
- Insidious acute hip pain and limp, activity related
- Bilateral 10-20%

LCP - Imaging



A case of a 4 year old male…



Case 3

- 16 year old female
- 6 week history left knee pain
- Now involving upper thigh and pelvis

- Exam of knee appears normal, significant pain on left hip ROM and limping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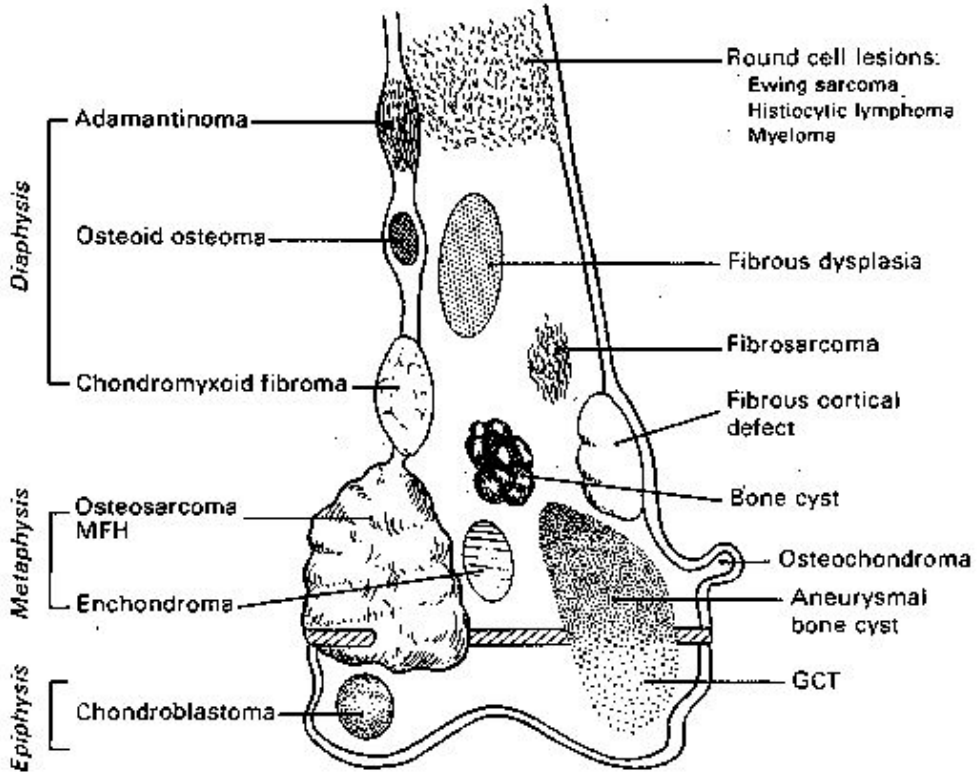
Ewing Sarcoma

Bone tumors: benign

- Osteoid, or bone-forming tumors
  - Osteoid osteoma
  - Osteoblastoma
- Cartilage-forming tumors
  - Osteochondroma (exostosis), chondroma, chondroblastoma
- Fibrous lesions
  - Fibrous dysplasia
  - Ossifying and nonossifying fibroma
- Cystic/vascular lesions
  - Unicameral bone cyst
  - Aneurysmal bone cyst

Benign Bone Tumors

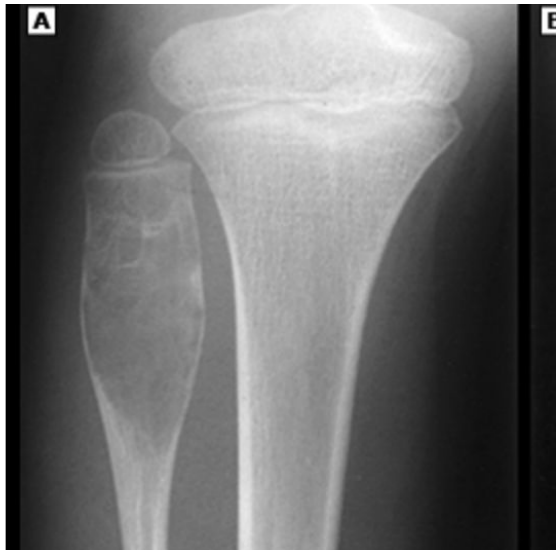


Simple bone cyst

Benign Bone Tumors

Nonossifying fibroma

Chondroblastoma



Aneurysmal bone cyst

Osteoid osteoma

Osteoid Osteoma

- Most common benign skeletal neoplasm
- Long bones of lower extremities
- Frequently present in teenage years
- History of night pain and relief with NSAIDS

Bone tumors: Malignant

Ewing Sarcoma

- Diaphysis and flat bones of pelvis
- Slightly younger children
- “Onion peel” – periosteal reaction producing layers of reactive bone
- Metastatic workup:
  - CT Chest
  - PET scan

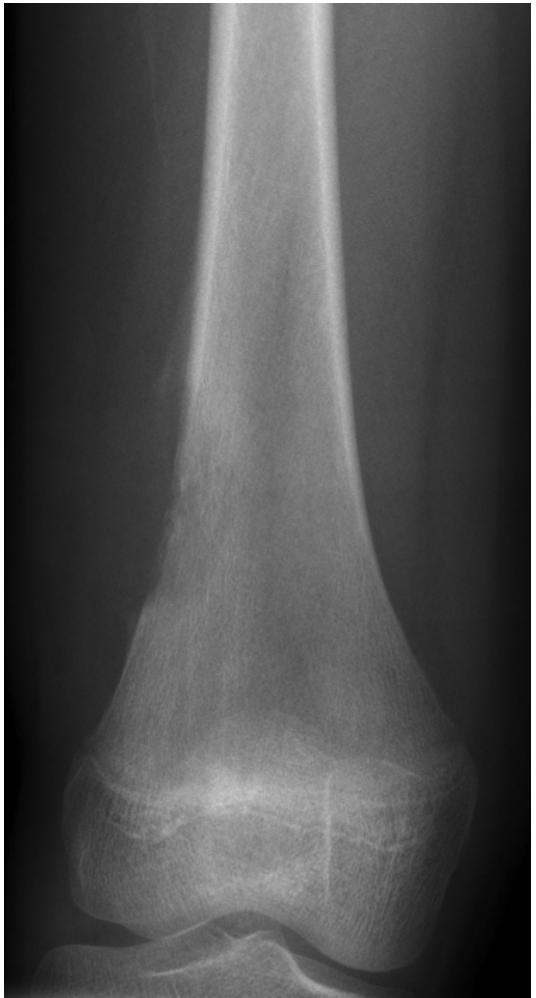
Osteosarcoma

- Metaphysis of long bones
- Older children
- “Sunburst pattern” – radial soft tissue ossification pattern
- Metastatic workup:
  - CT Chest
  - PET scan

Malignant bone tumors

Ewing sarcoma

Osteosarcoma



Case 4

- 5 year old male
- 2 day history of left hip pain, now refusing to walk
- ? fevers

Ddx?

Approach?

Septic arthritis

- Acute onset, unwell appearing child
- 80% in hip, knee, or ankle
- Early peak in neonates, then 3-6 year olds
- Pathogens?
  - S aureus (most common), GAS, and S. pneumoniae
  - Kingella has replaced Hib as most common G neg
  - Neonates: GBS, gram negative bacilli
  - Sexually active: N gonorrhea
  - Other: Lyme disease

- Blood cultures positive in up to 40%

- Gold standard for diagnosis??

Septic arthritis

- Synovial fluid aspirate!

- Decision rules: Kocher criteria (1999)
  - Non-weight bearing on affected side
  - ESR > 40
  - Fever > 38.5C
  - WBC > 12

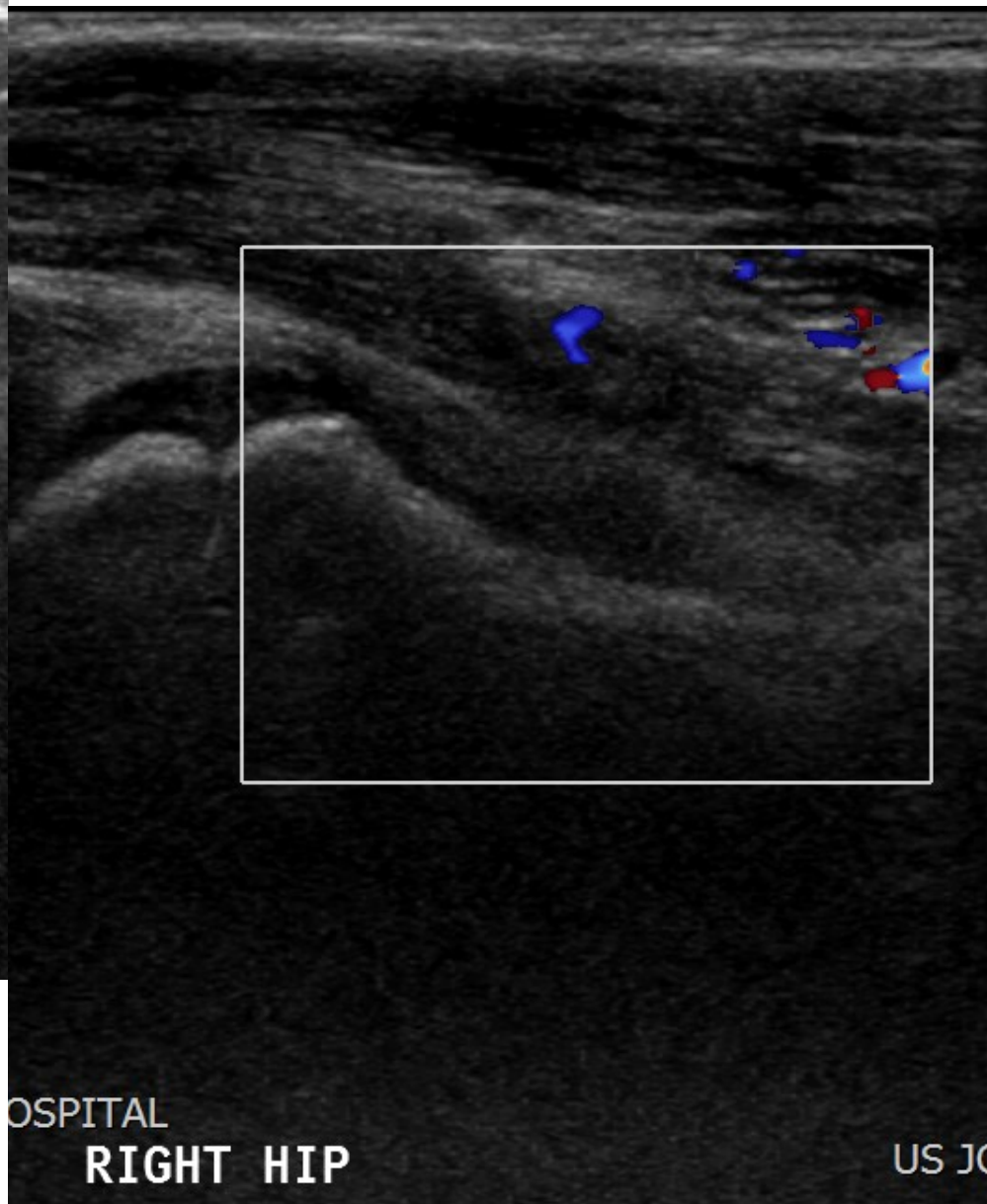
Our patient: CRP 25, WBC 12, ESR 8

Score	Likelihood of septic arthritis
1	3%
2	40%
3	93%
4	99%

Septic arthritis or not?

So what to do with our kid??


S HOSPITAL
LEFT HIP


OSPITAL
RIGHT HIP
US JC

Transient Synovitis

- Common
- Ages 2-9, peak 5-6 years old. M 2-4x > F
- Self-limited, recurrence risk ~15%
- Etiology unclear - ?preceding viral illness
- Typically unilateral pain for 1 week prior to presentation
- Systemically well

Transient Synovitis - Dx

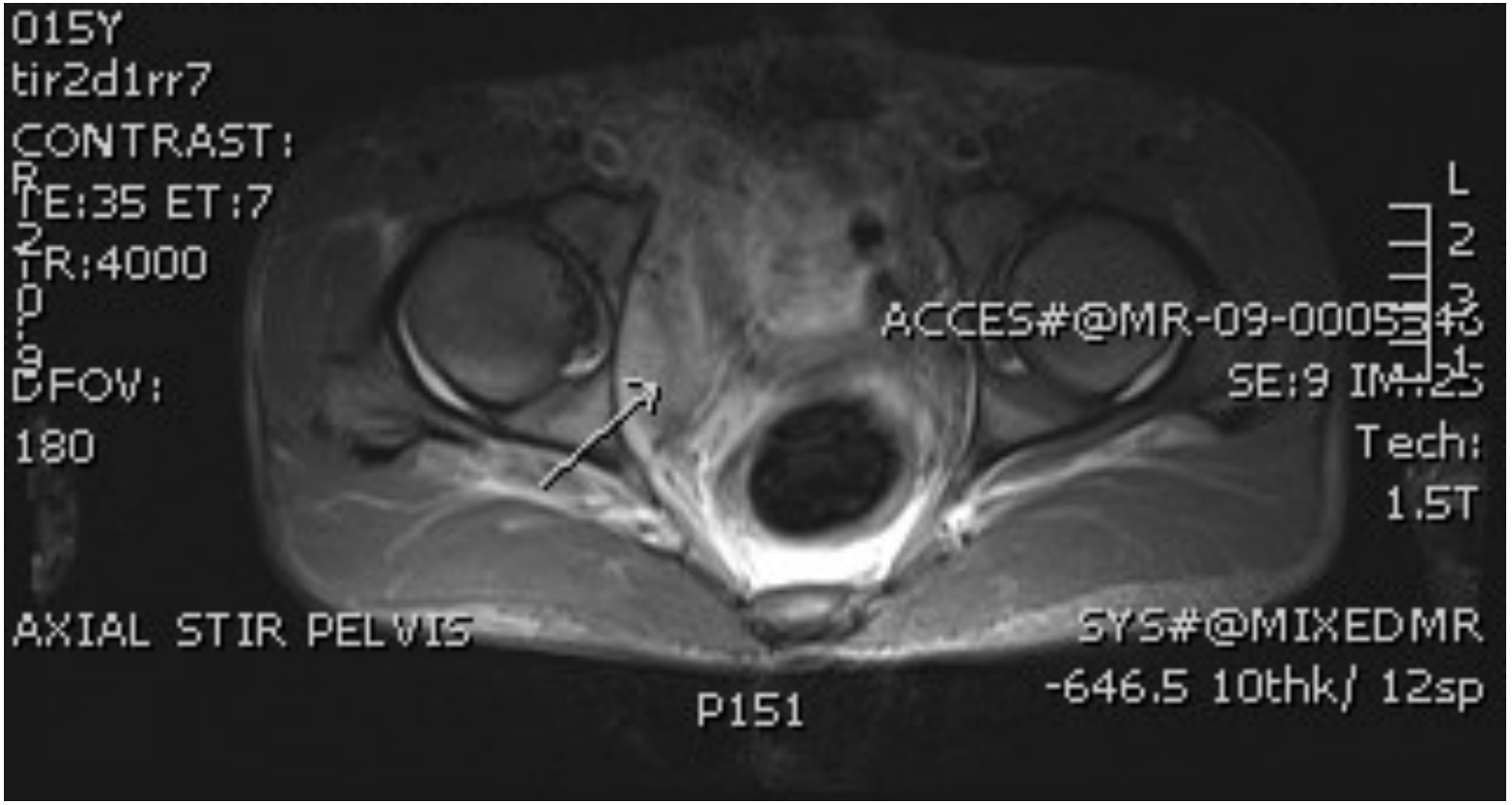
- Diagnosis of exclusion
- U/S to assess joint effusions
  - ~85% will have small joint effusions
  - ~50% will have contralateral effusions
- MRI
  - Joint effusions (100%)
  - Synovial enhancement (78%)

Case 5

- 15 year old female, soccer and hockey player
- Right hip pain started 1 week ago but worsening

- Exam: Pain to right SI joint and hip/groin on ROM

Faber (or Patrick's) test: Flexion, abduction, ext rotation pain in SI area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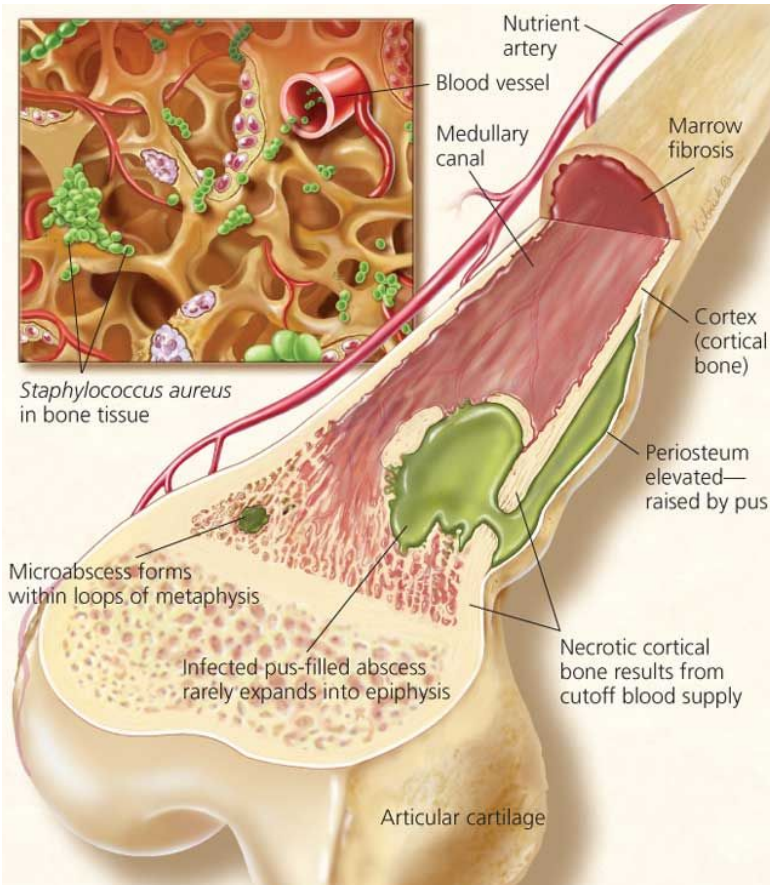
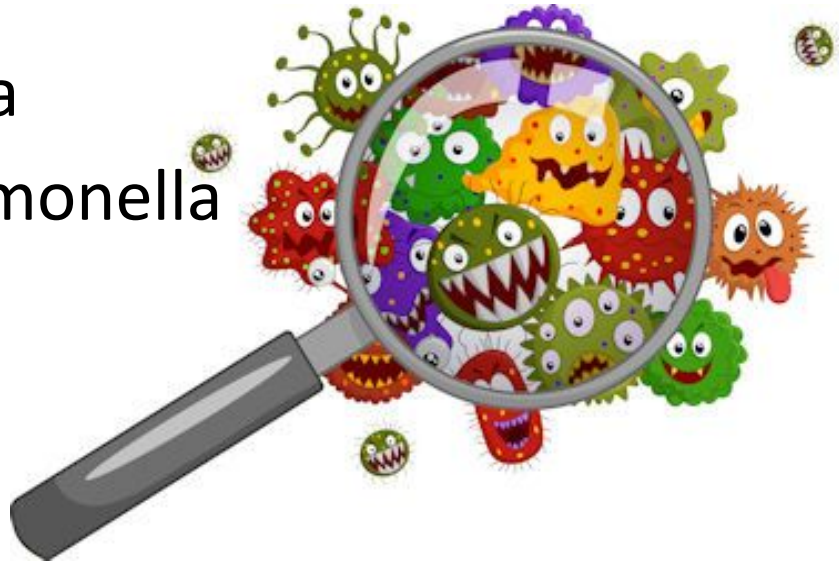
Osteomyelitis



- Fever, pain and decreased ROM
  - Infants: "pseudoparalysis"
- Most common site = metaphysis of long bones
- Femur most common, tibia, humerus
  - Pelvis less common

Osteomyelitis

- Pathogens
  - S. aureus most common
  - Other: S pneumonia, GAS, Kingella Kingae
    - Kingella usually if <2yo and can follow URTI/pharyngitis
  - In neonates: GBS
  - Sexually active: gonorrhea
  - Hemoglobinopathies: Salmonella



Osteomyelitis

- Labs
  - CBC, ESR, CRP (ESR up in 90% of hematogenous cases, CRP in 98%)
  - Blood cultures in 50-80% of cases of hematogenous
- Imaging
  - X-ray: 30% sensitive for bone destruction
    - Lytic lesions, periosteal new bone, periosteal elevation may not appear 10-20 after ssx
  - Bone scan
    - 80-100% sensitive early on (but still up to 20% are normal in early days)
    - limited specificity
  - MRI
    - Imaging of choice (sens 92-100%)

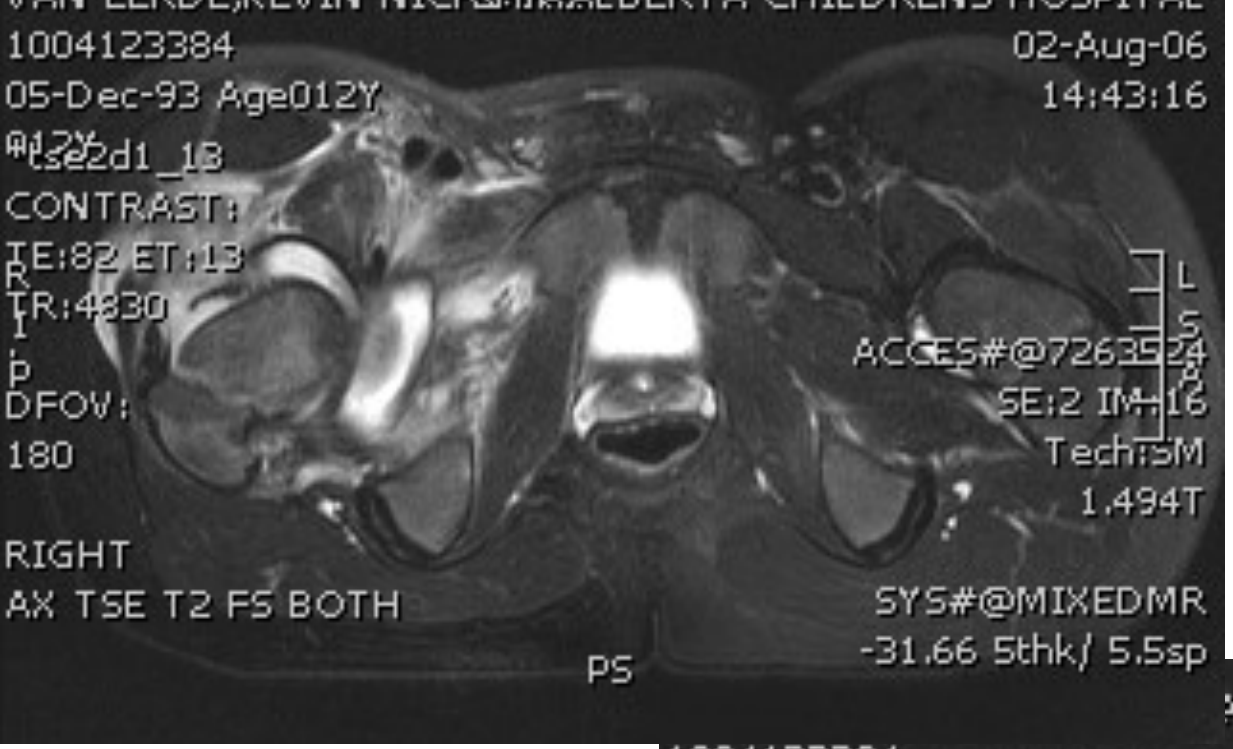
Case 6

- 12 year old male
- Initial presentation: hip pain x 3 days without fever
  - 2 days later: Fever, right groin pain worsening
- Unwilling to weight bear on right hip, limited ROM of right hip on exam


R

Now what???

- Ddx acute painful limp?
  - Septic arthritis??
  - Osteomyelitis?
  - Psoas abscess/Pyomyositis?
  - Malignancy?
  - Referred?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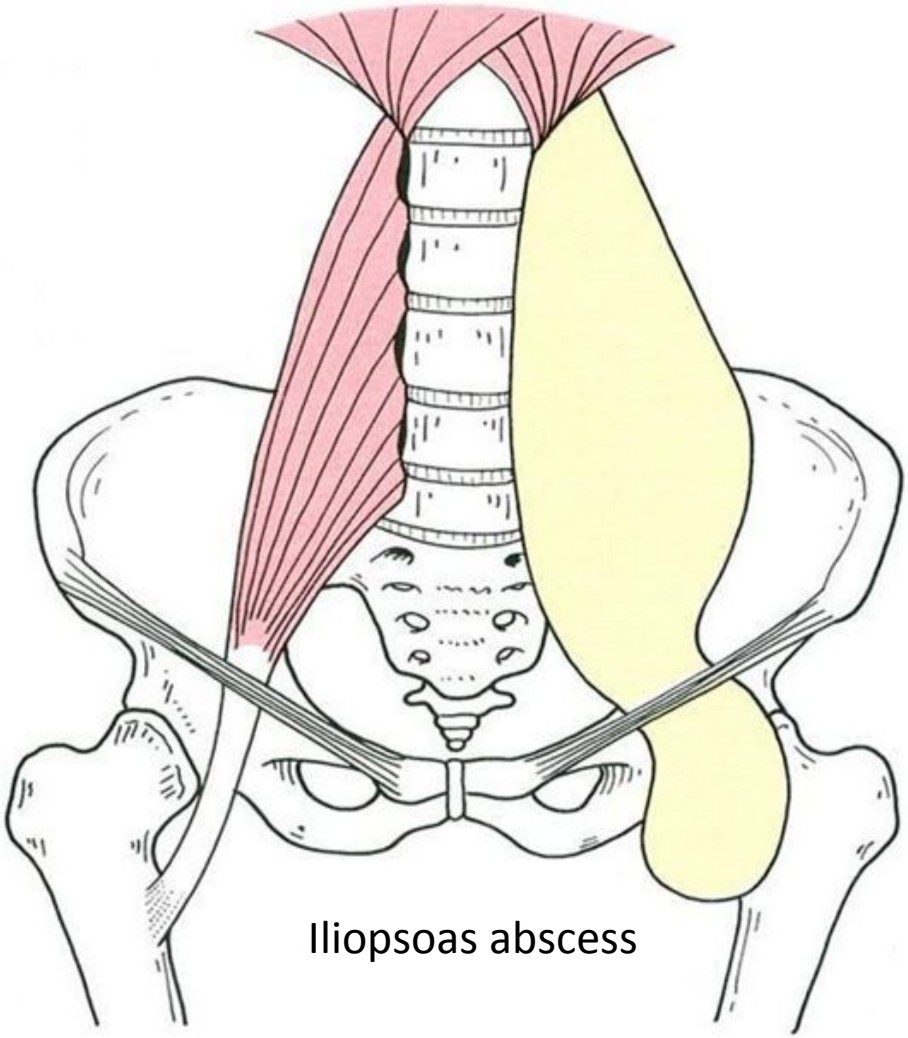
Pyomyositis

- Uncommon
- Deep infection of large muscle groups of pelvis and lower extremities
- SSx: fever, muscle swelling, no overlying skin changes, guarded hip motion
  - Pain with passive stretch affected muscle
- Often delayed diagnosis!

Pyomyositis



Primary

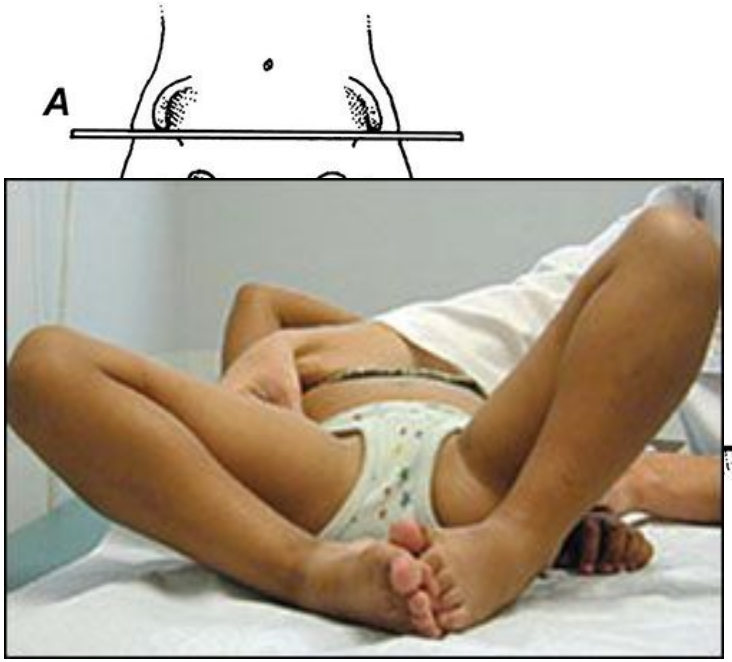
- Hematogenous or lymphatic spread
- Predisposed by trauma/hematoma

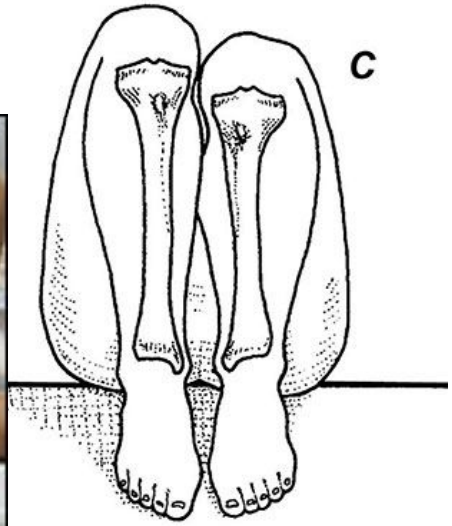
Secondary

- Direct spread by adjacent structure
- Vertebrae, GI tract, GU tract

Case 7

- 7 yo F, past history of septic arthritis treated at 2 years of age; just moved here from Quebec
- Followed for chronic limp x 1 year, relatively asx



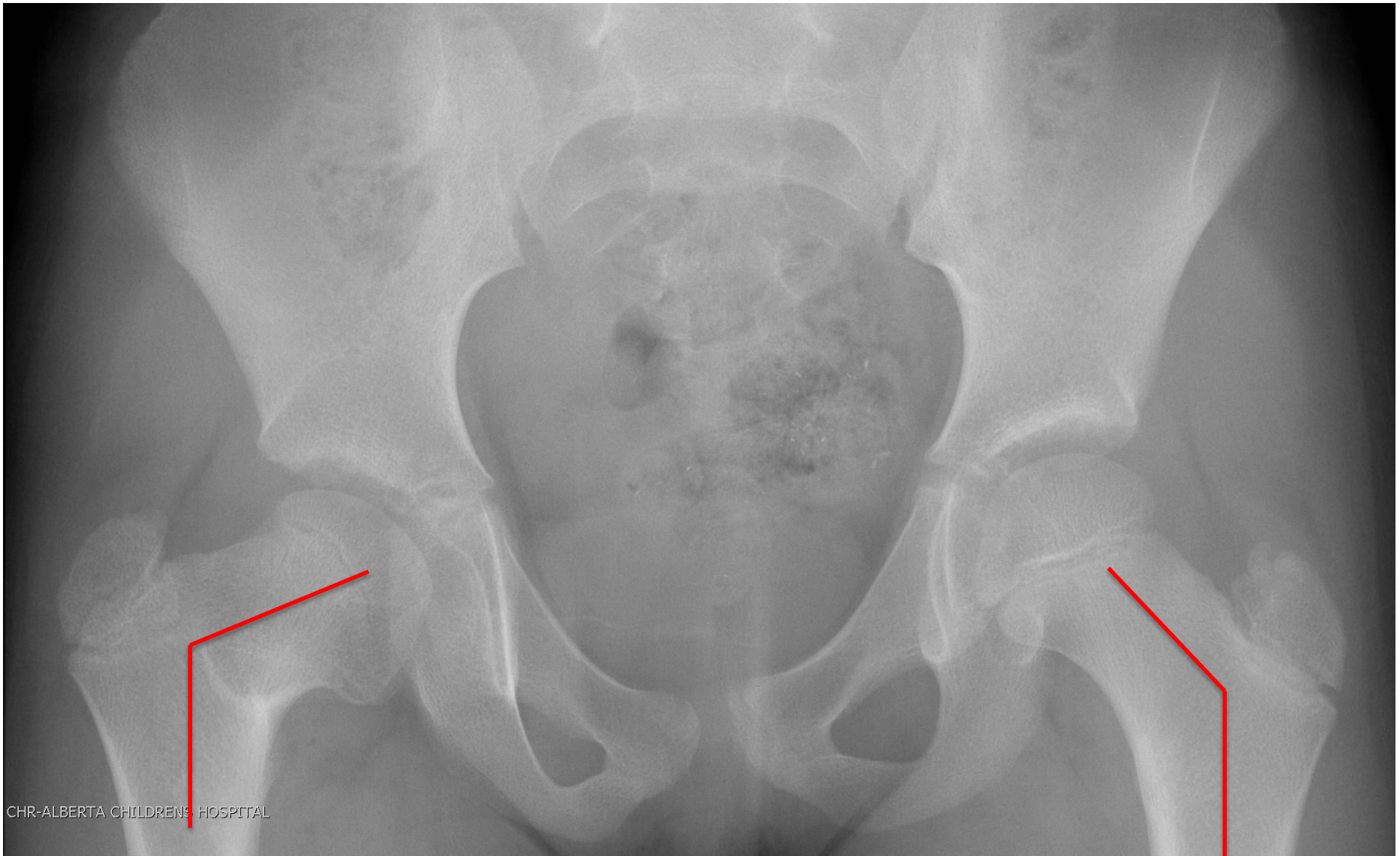


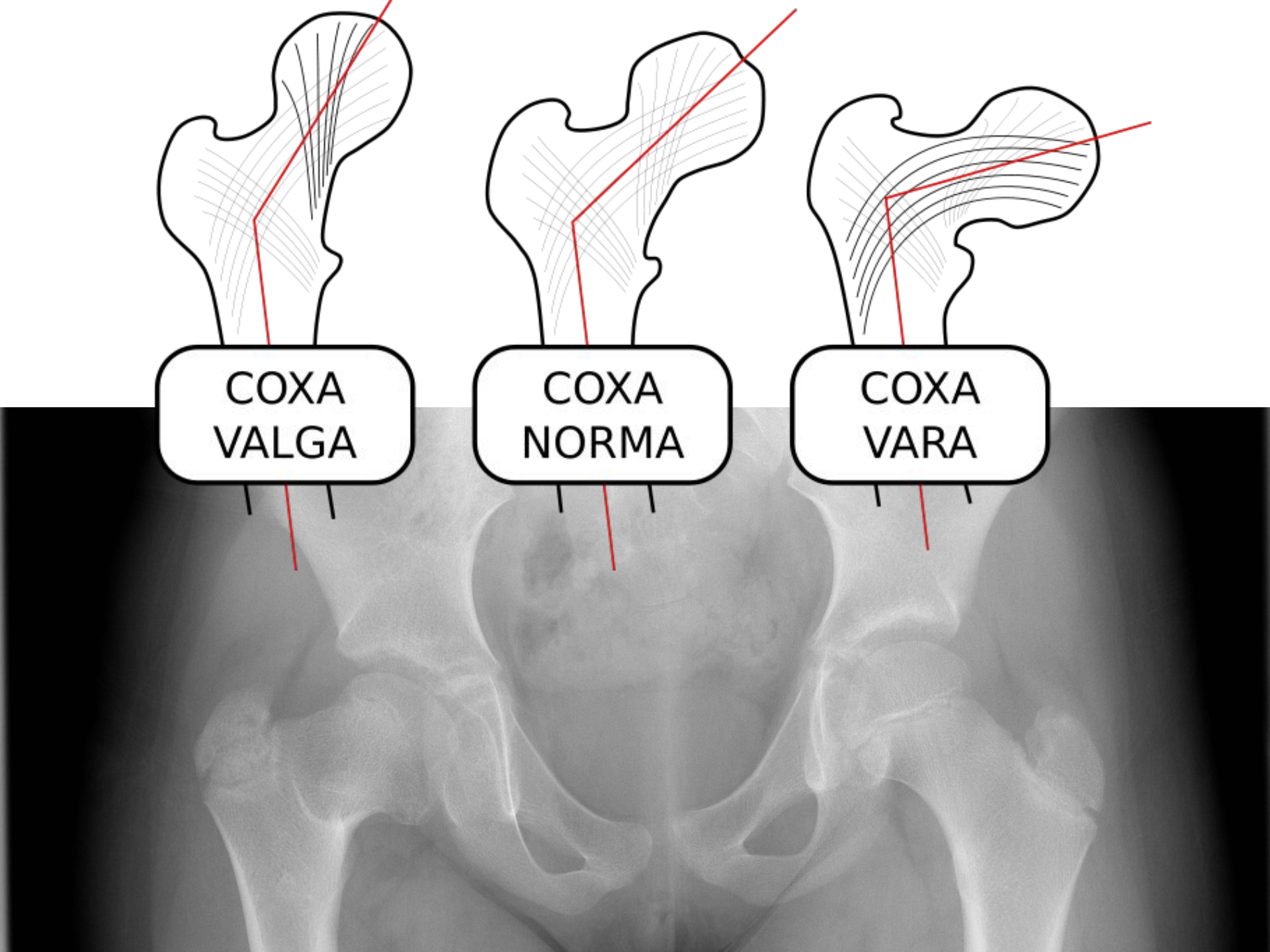
Galeazzi sign: lie on back, knees flexed feet on table, looking at level of knees **leg length discrepancy**

Ddx chronic painless limp?

- Congenital
  - Proximal femoral focal deficiency
  - Congenital short femur
  - Congenital absence of fibula
  - Congenital hemihypertrophy
  - Congenital pseudoarthrosis of tibia
  - Fibular hemimelia
  - Skeletal dysplasia
  - Neurofibromatosis
  - Enchondromatosis
  - Osteogenesis imperfecta
  - Russell Silver syndrome
  - Klippe; Trenaunay Weber syndrome
  - Proteus syndrome
- Acquired
  - Trauma with overriding fracture or epiphyseal fracture with growth plate damage
  - Septic arthritis / osteomyelitis
  - Developmental dysplasia of the hip
  - Malignancy
  - Cerebral palsy
  - Myelodysplasia
  - JIA

Coxa Vara




COXA
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COXA
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COXA
VARA

Case 8

3yo M immigrated from Colombia, first well check up in a couple of years. Noted to have a limp but no complaints of pain

What is your approach to this boy's limp?

You wonder if he has untreated DDH

What exam features would support your diagnosis?

- Leg length discrepancy (affected side shorter)
- Toe walking on affected side
- Limited hip abduction * most reliable sign in older kids (shortened adductor muscles)
- Lordosis
- Trendelenburg gait (weak abductors)
- Waddling gait

Risk factors for DDH

- Females 80% (more susceptible to hormones like relaxin)
- First born (intrauterine environment smaller)
- Family history in 12 – 33%
- Frank breech in up to 25%
- Small intrauterine environment eg. oligohydramnios, being LGA

Investigations

- US
  - Infants <6mo (acetabulum and femur mostly cartilage)
- Xray
  - > 6 mo when proximal femoral epiphysis ossifies

Management

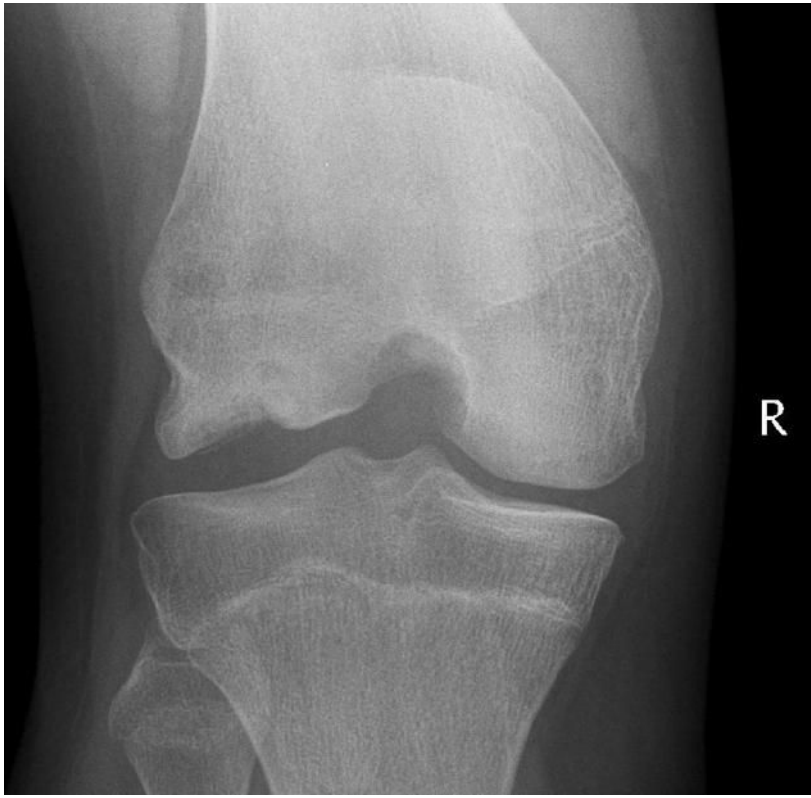
- Screening
  - All newborns require physical exam – Ortolani/Barlow up until 2nd month of life
  - Universal screening not recommended although some centers have selected high risk populations eg. breech
- Treatment
  - If Barlow positive, repeat exam and US 4-5 weeks and if still positive then treat
  - If Ortolani positive, treat and follow with US
  - Treatment
    - < 6 month old: Pavlik harness full time x 6 weeks
    - 6 month – 2yo: Spica cast x 12 weeks
    - > 2yo: open reduction

Case 10

- 15yoM c/o left knee pain intermittently for 3 weeks. He describes stiffness as well as an occasional locking/catching sensation; no joint swelling nor systemic symptoms.
- Exam is abnormal only for tenderness to the lateral condyle.

- What is your ddx?

Osteochondritis dissecans



Case 11

- A parent brings in their 8 year old concerned that his “spine isn’t straight” and wants to see an orthopedic surgeon. How do you assess this child?

Scoliosis

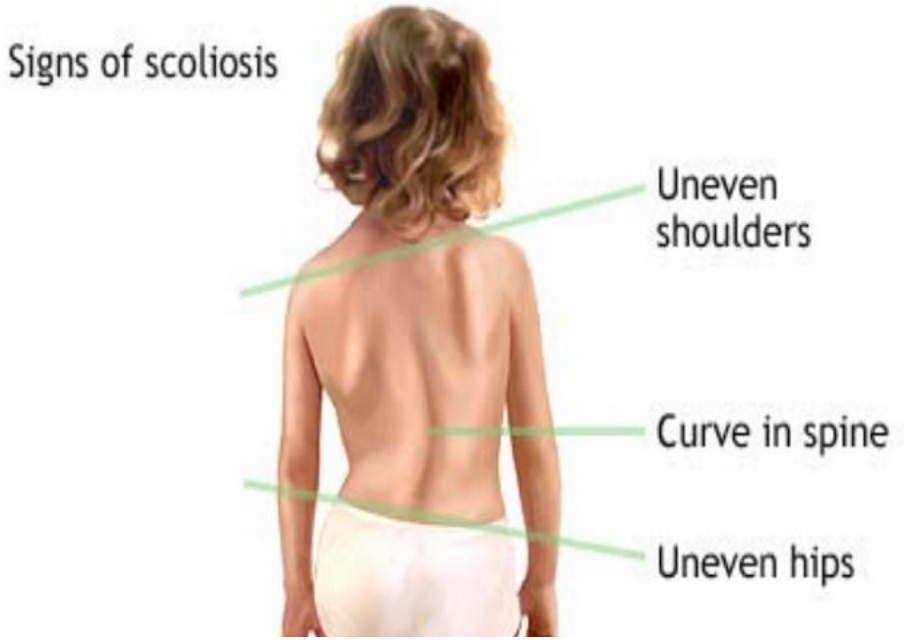
- Definition: lateral curvature of spine with a Cobb angle > 10 degrees

- Etiology: most idiopathic
  - Congenital vertebral abN
  - Spinal lesions: tumors, degenerative dz
  - Neuromuscular: CP, muscular dystrophies
  - Syndromes: NF, Marfan
  - Compensatory: leg length discrepancy

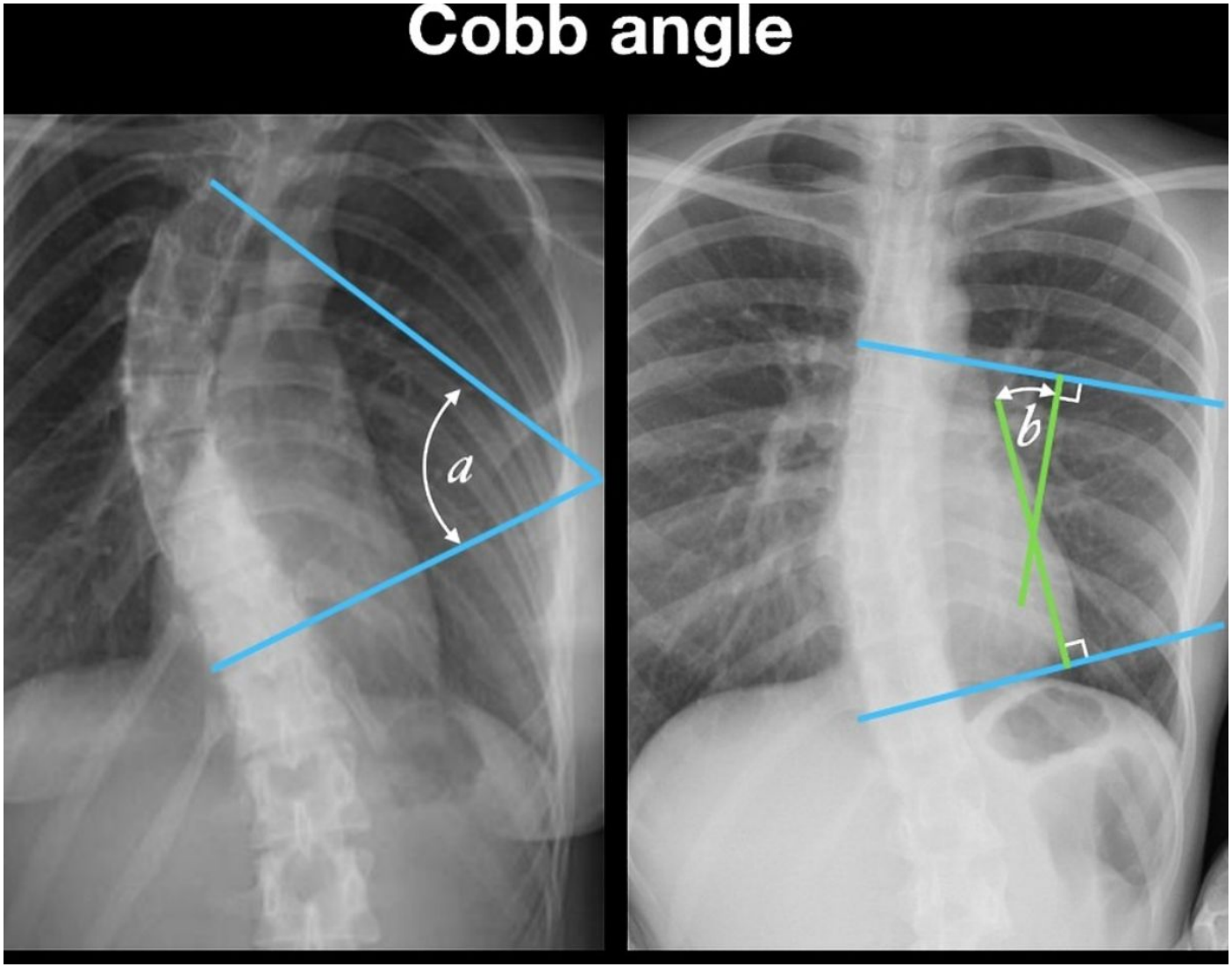
- Prevalence: equal M:F but F 10x higher likelihood of progressing to curve >30deg

Clinical assessment

- Elevation of shoulder
- Lateral shift of drunk
- Apparent leg length discrepancy
- Anterior chest may be flattened
- Adams test: earliest finding



Imaging



Management

- <20 degree Cobb angle: observe
- Refer to ortho if:
  - >30 degrees
  - Progression of >5 degrees
  - Concerned re: secondary/neuromuscular scoliosis
- Bracing considered when angle > 30 degrees or rapid progression
- Surgery indicated for:
  - majority of infantile patients
  - Other measures failed
  - Further progression would lead to unacceptable physiologic or cosmetic results
  - adolescents >50 degrees

Case 12

- Mom of a 4 year old concerned about her child's intoeing.

- What is your approach to feet concerns in general?

Feet Issues

- Deformed
  - Fixed/pathologic
  - Flexible/positional
- Intoeing
- Flat/ hyperarched (Planus vs Cavus)
- Pain

Feet deformities

- Ddx
  - Positional (intrauterine environment)
    - eg. metatarsus adductus
  - Isolated structural
    - Club foot
  - Neuromuscular/syndromic
    - Congenital vertical talus
    - Eg in arthrogryposis, rocker bottom feet
    - Often rigid and hard to treat

Club Feet – Talipes Equinovarus

What are the 4 deformities that define this anomaly?

Club feet deformities:

- Cavus (plantar flexion) of forefoot
- Adduction of forefoot
- Varus of hind foot
- Equinus of hind foot

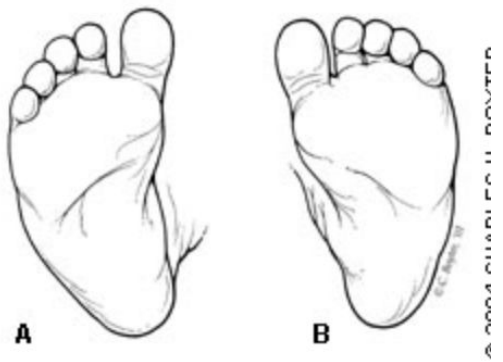
Club feet

- Management
  - Confirm with xrays with foot held in maximally corrected position
  - Serial casting from birth via Ponseti method (weekly)
  - 80% require Achilles tenotemy
  - Surgical realignment = definitive treatment

What is shown here?

Calcaneovalgus foot

How about here?



Metatarsus adductus

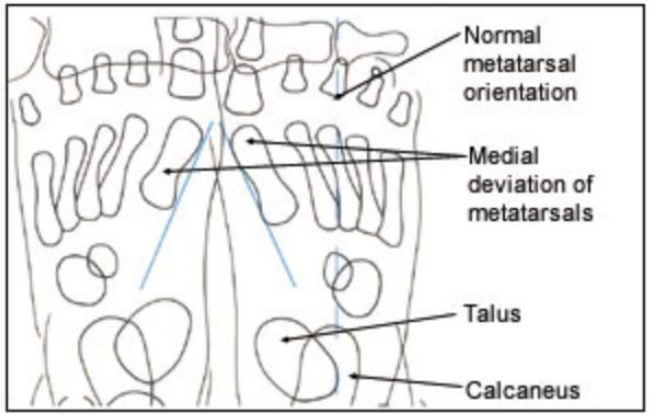
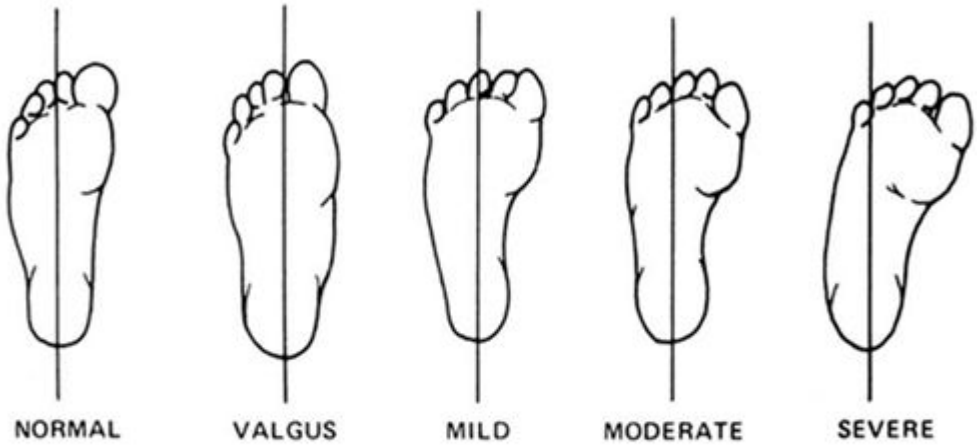


FIGURE 2.

Metatarsus adductus: medial deviation of all metatarsals with normal relationship between talus and c

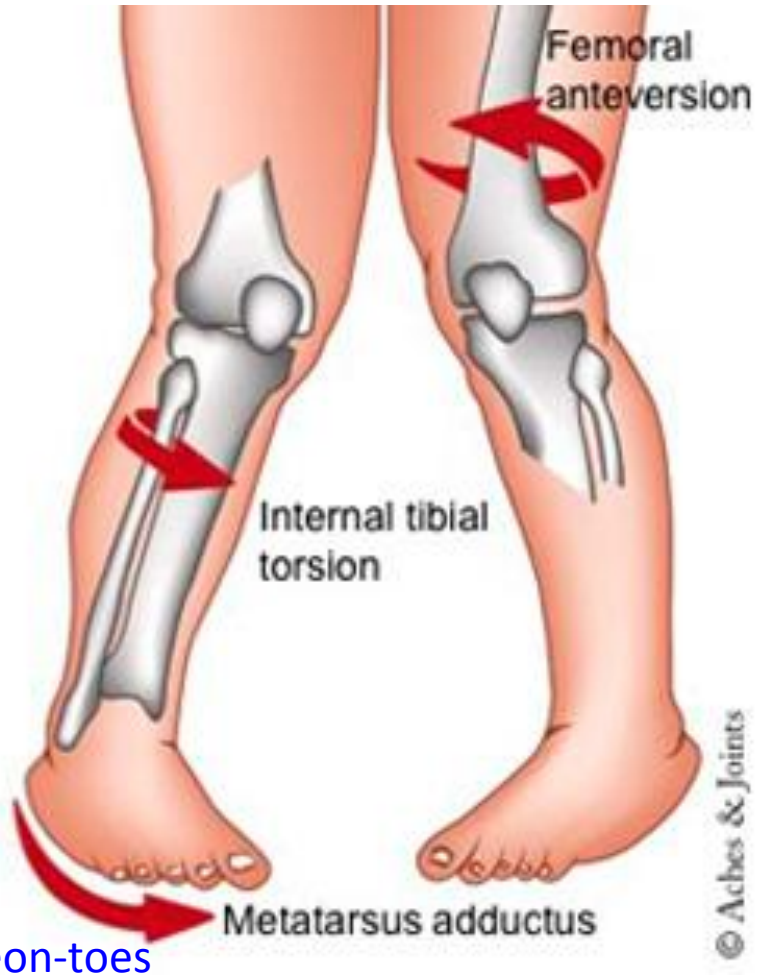


Feet Issues

- Deformed
  - Fixed/pathologic
  - Flexible/positional
- Intoeing
- Flat/ hyperarched (Planus vs Cavus)
- Pain

Intoeing

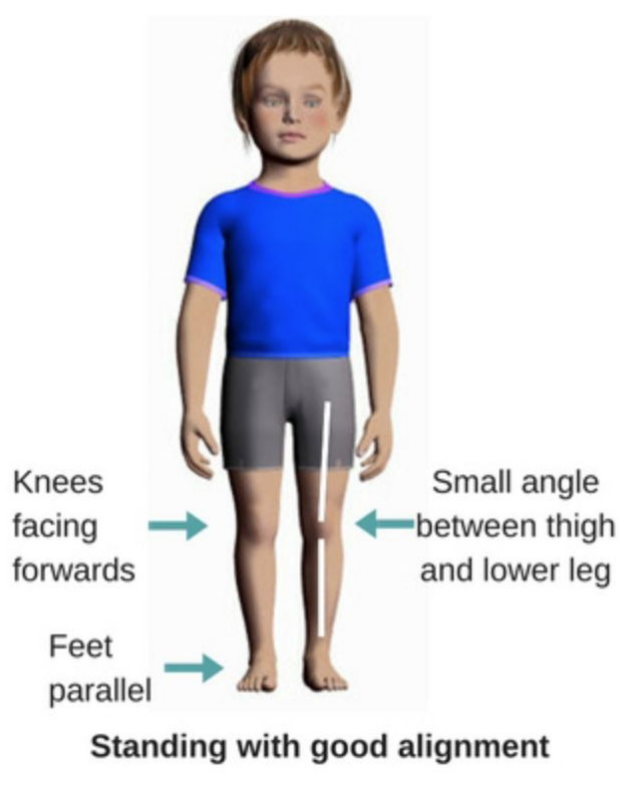
Causes:

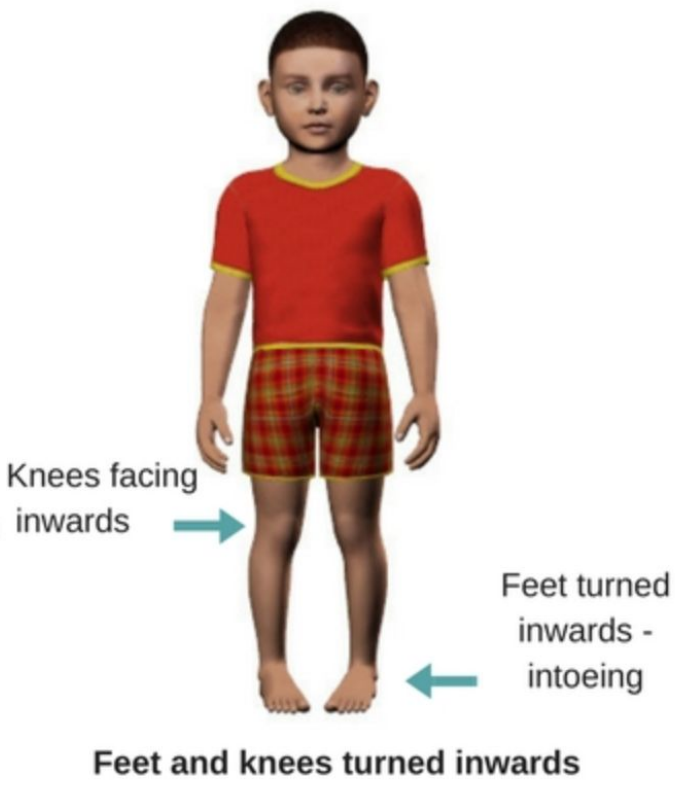


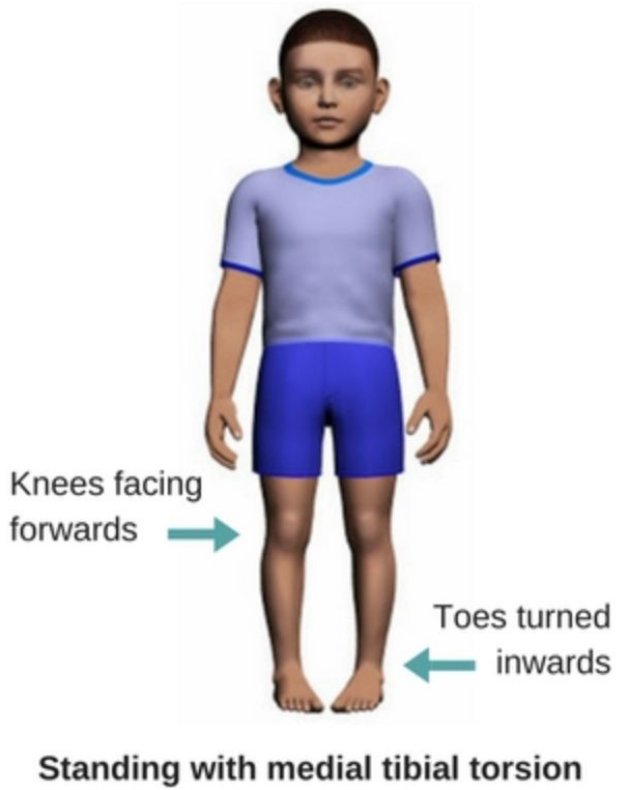
https://skillsforaction.com/pigeon-toes-femoral-anteversion

Our 4 year old patient with a concerned mom….

- How do you assess this child?

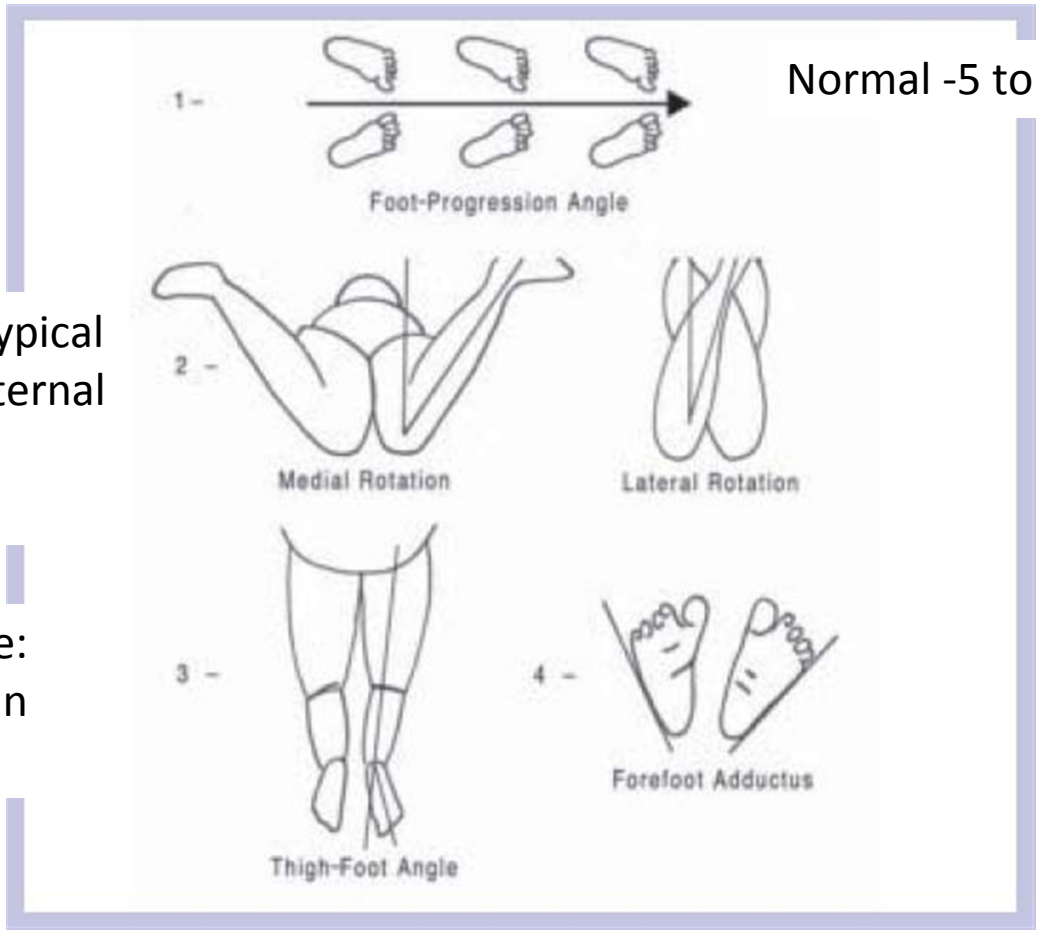






Our 4 year old patient with a concerned mom….

- How do you assess this child?

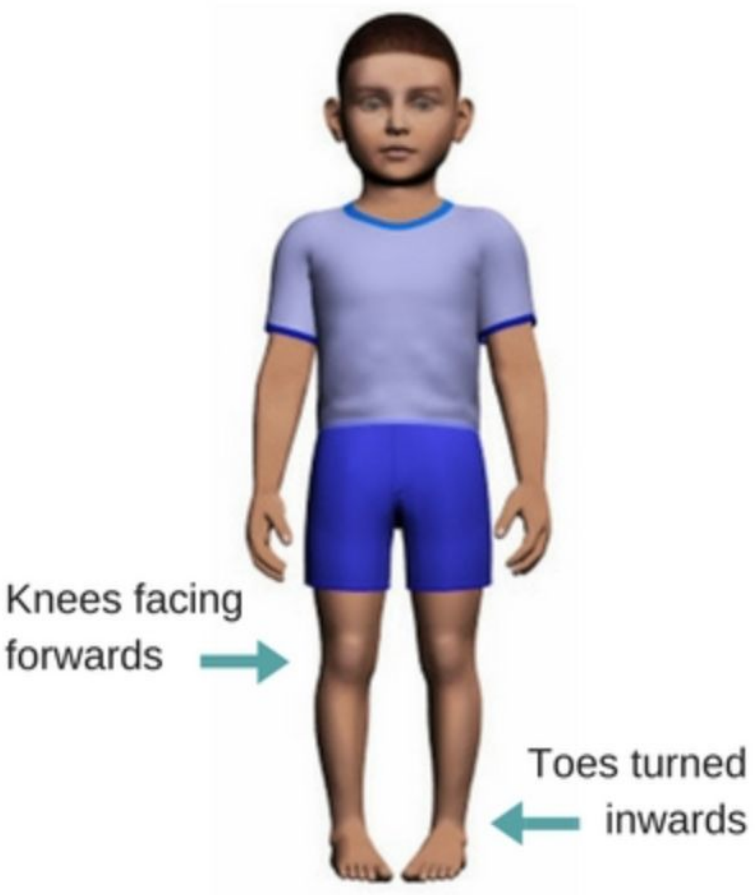


Normal -5 to +20deg

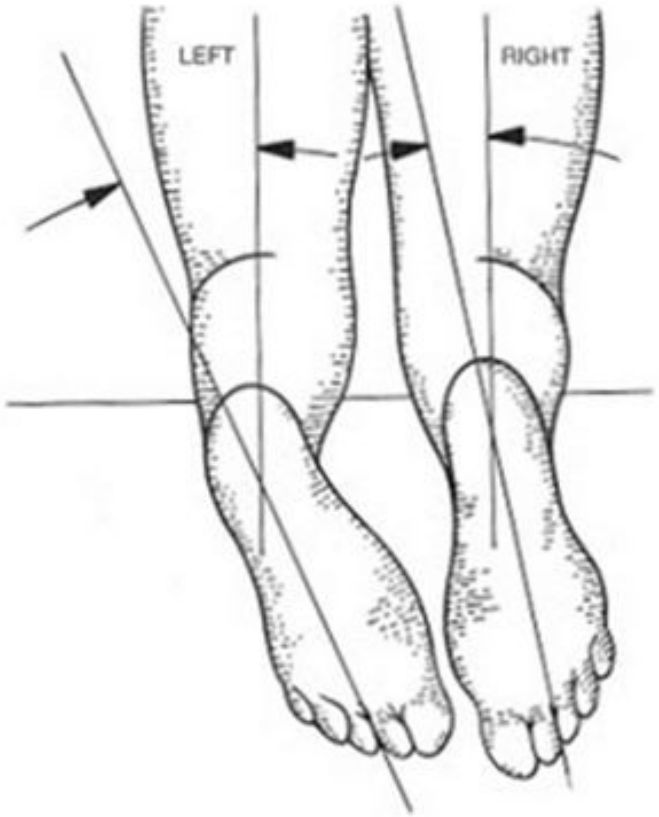
Hip rotation: Typical up to 45deg internal and external rotation

Thigh foot angle: Normal less than 10deg internal

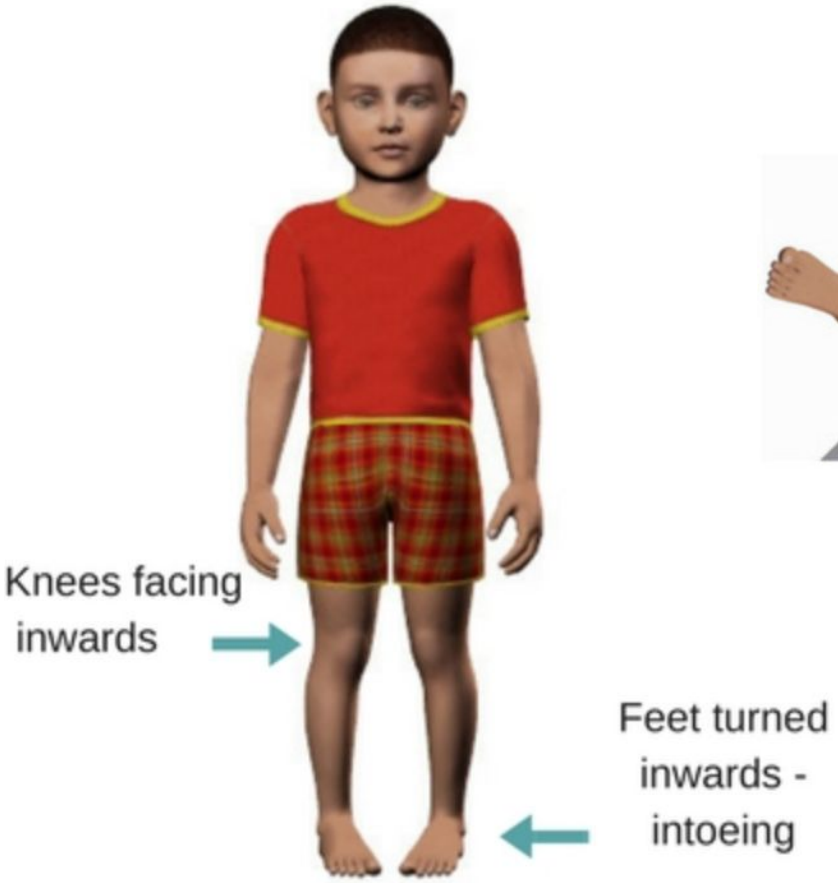
Internal tibial torsion



Standing with medial tibial torsion



Femoral anteversion



Feet and knees turned inwards

Hip medial rotation: 75 deg

Hip lateral rot: 15 deg

Intoeing

- When to be concerned:
  - Moderate to severe deformity
  - Marked asymmetry
  - Deterioration in gait or worsening deformity
  - Other findings eg developmental delay

Pes planus and cavus

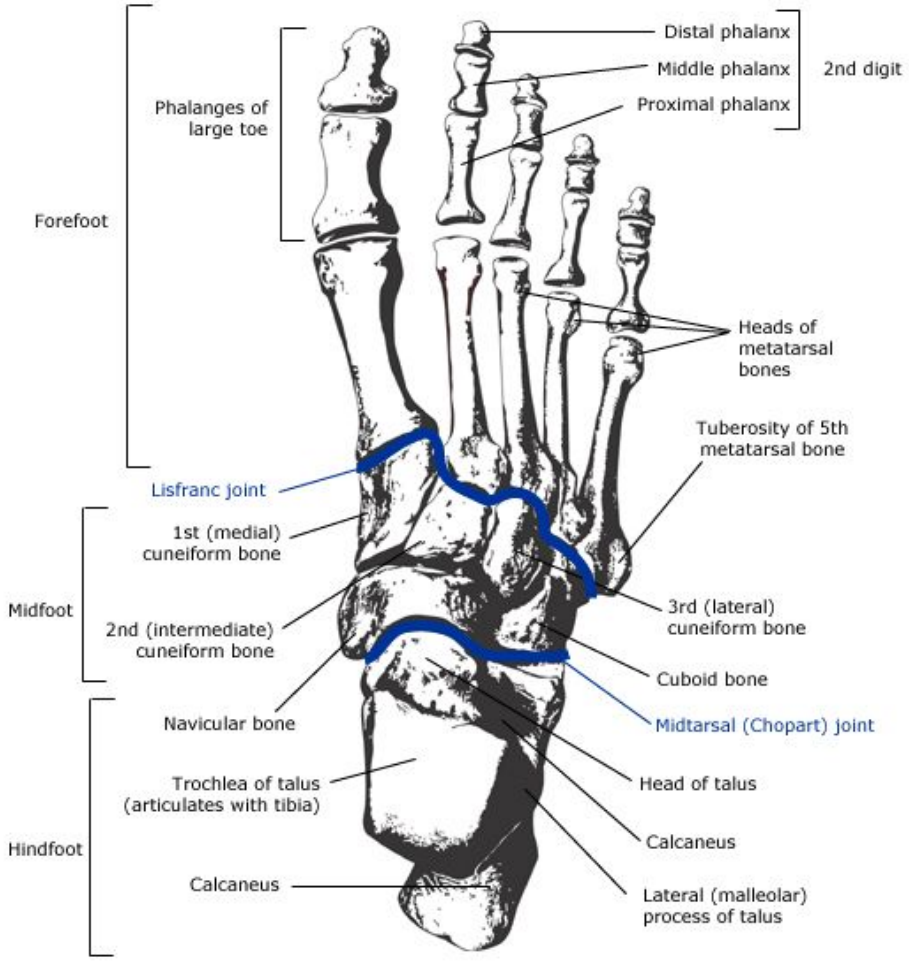
- Pes planus aka flat foot
  - 3 types: Flexible, flex with contracture of achilles, rigid

- Pes cavus aka hyperarched foot
  - Charcot Marie Tooth!!

Case 13

- 14yoM with pain to right foot for 2 weeks, worse when playing sports
- O/E: rigid flat foot, painful limited inversion of foot

Tarsal Coalition



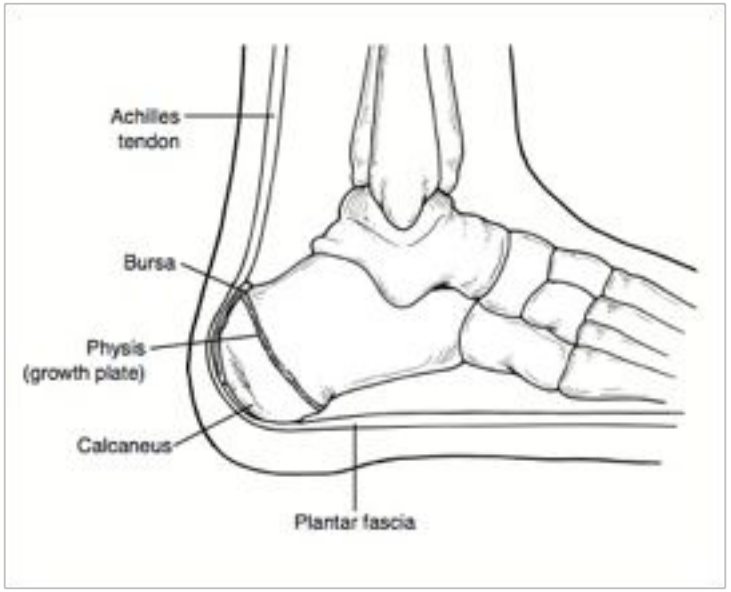
Case 14

9yoM with bilateral heel pain for the past week, leading him to toe walk. Significant pain when you dorsiflex his feet.

What is your ddx for this boy's pain?

Heel pain:

Overuse syndrome (tendonitis, plantar fasciitis)
Achilles bursitis
Stress fractures
Sever disease (calcaneal apophysitis)




Break
Time