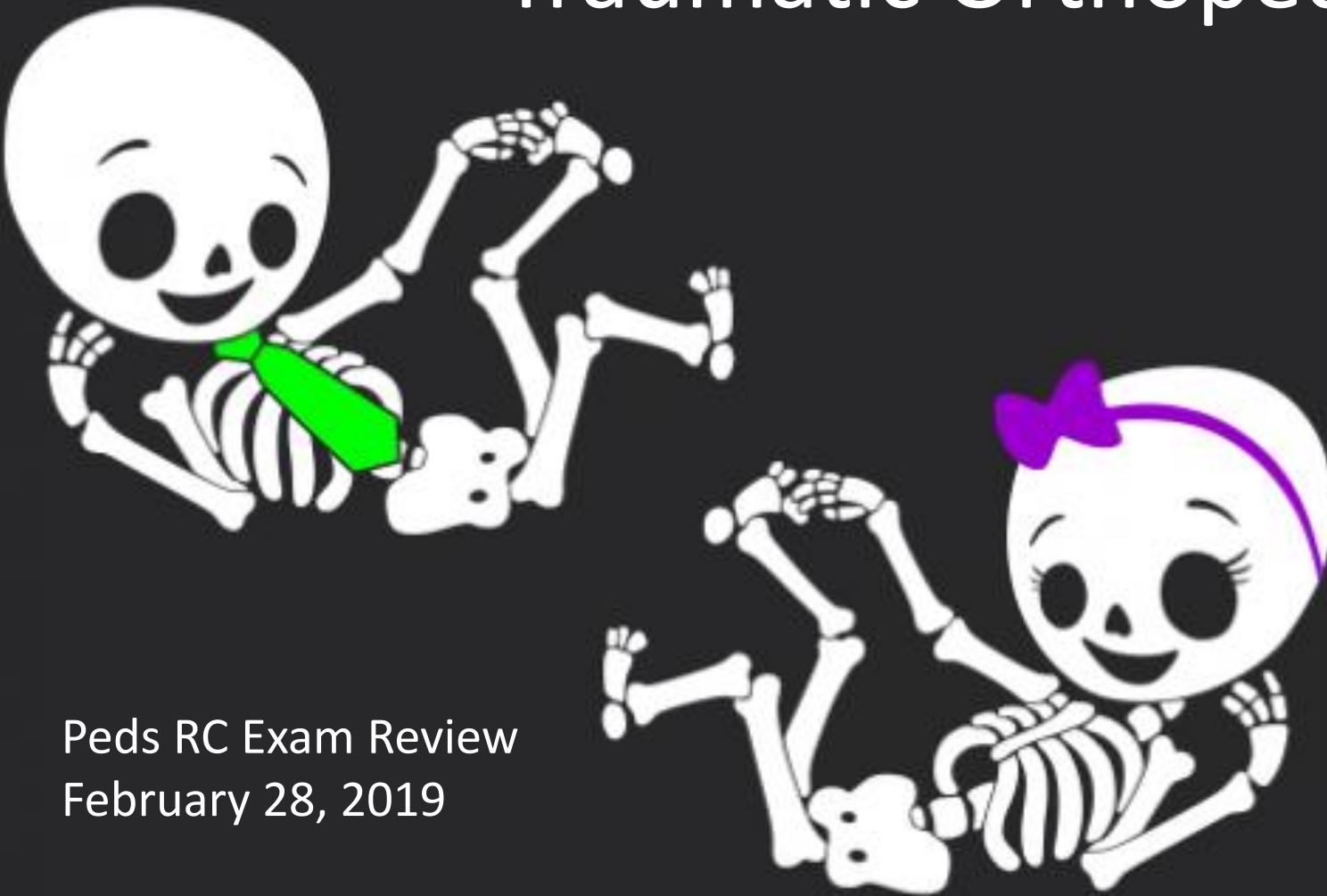


# Traumatic Orthopedics



Peds RC Exam Review  
February 28, 2019

Dr. Naminder Sandhu, FRCPC  
Pediatric Emergency Medicine

# Objectives to cover today

- Normal bone growth and function
- Common radiographic abnormalities in MSK diseases
- Part 1: Atraumatic
  - Congenital abnormalities
  - Joint and limb pain
  - Joint deformities
  - MSK infections
  - Bone tumors
  - Common gait disorders
- Part 2: Traumatic
  - Common pediatric fractures and soft tissue injuries by site

# Overview of traumatic MSK pain

## Acute injuries

- Fractures
- Joint dislocations
  - Most common in ED: patella, digits, shoulder, elbow
- Muscle strains
  - Eg. groin/adductors
- Ligament sprains
  - Eg. Ankle, ACL/MCL, acromioclavicular joint separation

## Chronic/ overuse injuries

- Stress fractures
- Tendonitis
- Bursitis
- Fasciitis
- Apophysitis

# Overuse injuries in the athlete

**WHY do they happen??**

Extrinsic factors:

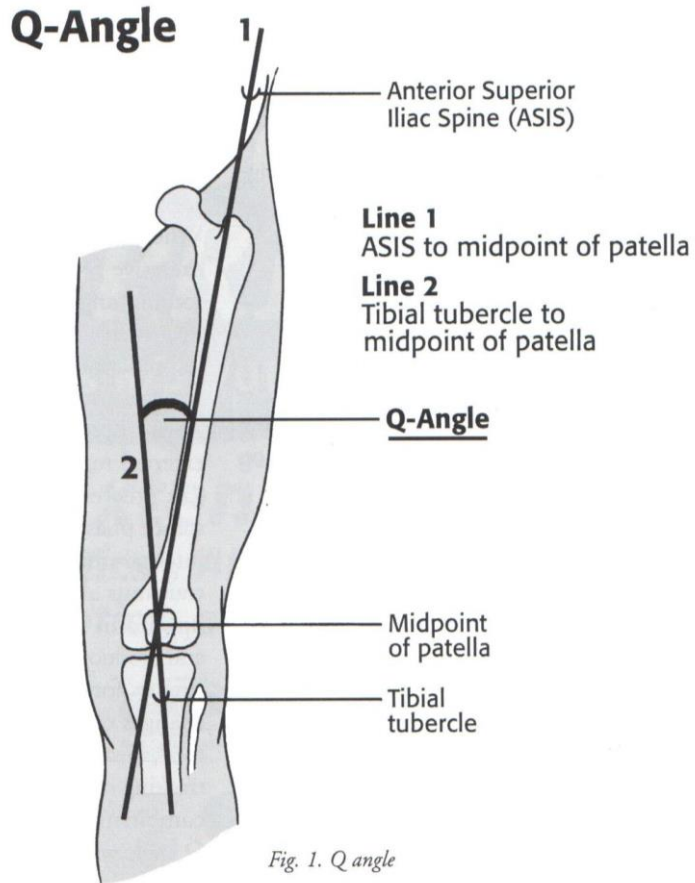
- Errors in training
- Inappropriate footwear

# Overuse injuries

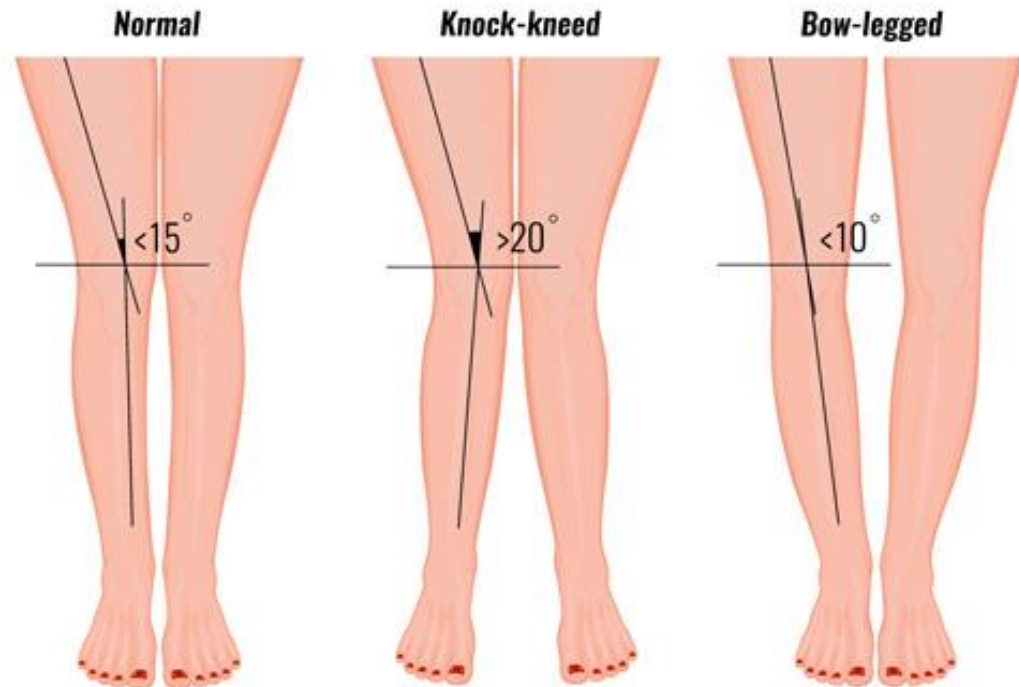
## Intrinsic:

- *Poor conditioning*
  - increased injuries early in season
- *Muscle imbalances*
  - Weak muscle near strong (vastus medialis vs lateralis → patellofemoral pain)
  - Excessive tightness: IT band, gastroc/soleus → Sever disease
- *Anatomic misalignments*
  - eg. pes planus, genu valgum or varum
- *Growth*
  - strength and flexibility imbalances
- *Nutrition*
  - eg. female athlete triad

# Misalignment – an intrinsic factor

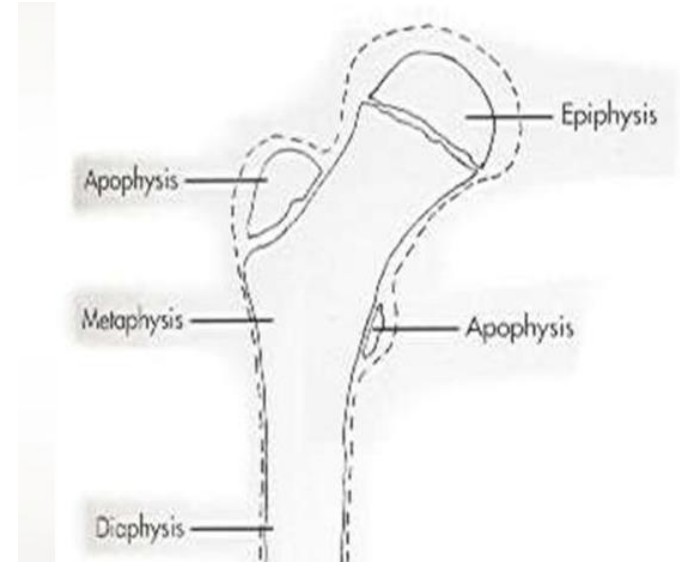


## Q Angle of the Knee



# Apophysitis

- \*Apophysis = natural protruberance from a bone (2ndary ossification centres, often where tendons attach)



- Examples
  - Sever disease (Calcaneal)
  - Osgood Schlatter disease (Tibial tubercle)
  - Sinding-Larsen-Johansson disease (Inferior patella)
  - “Little league elbow” (medial epicondyle of elbow)

# Tendonitis/ Bursitis





# *The PRICE principle*

- **P**ROTECTION – bracing etc.
- **R**EST\* – but not for too long....
- **I**CE\* – vasoconstriction → reduce inflammation  
– 15-20 min every 1-2 hours x48-72hrs
- **C**OMPRESSION – protects and reduces swelling
- **E**LEVATION – lessens edema

## **NSAIDs**

- *\*Good/decent evidence accelerates healing*

# There's always rehab....

- Don't forget your friendly neighbourhood physiotherapist!
  - Strengthening
  - Range of motion and flexibility
  - Modalities
  - Home program
  - Appropriate braces etc.



# A tough one to manage

- 12 year old with 2 weeks of severe ankle pain. Xrays done by GP 1 week ago normal. The ankle is swollen, mottled, and she does not tolerate light palpation. What could be going on?

# Reflex sympathetic dystrophy

- Aka **Complex regional pain syndrome type 1**
- Usually after minor injury
- Severe pain; described as burning/pins/needles, highly sensitive
- Changes in skin temperature, color, swelling, abnormal positioning (eg. dystonia)

# Management

- Prognosis highly variable
- Management principles:
- Rehab/physio – keeping the painful limb moving (reduce circulatory symptoms, improve ROM, strength, function, lessen chance of more chronic symptoms)
- Psychotherapy – can develop mood disturbances that heighten perception of symptoms
- Medications?

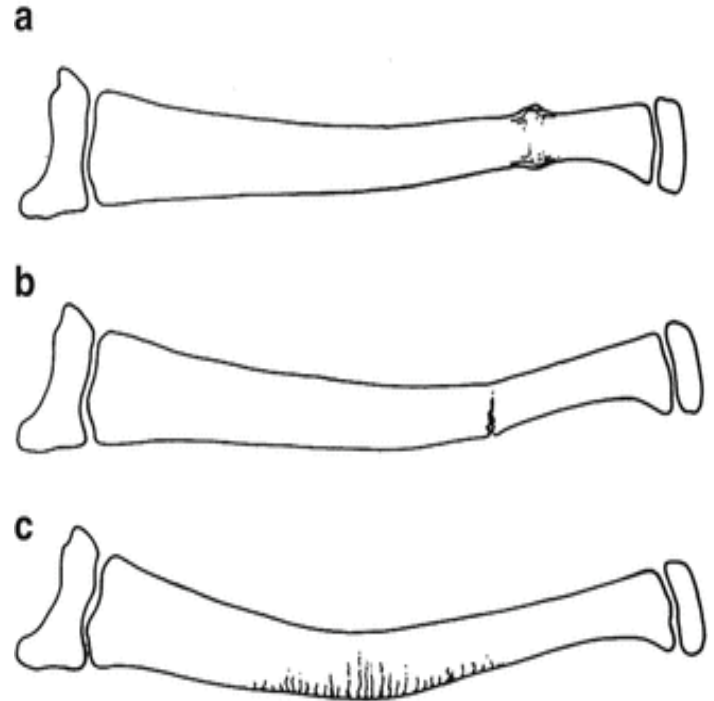
# Pediatric Fractures



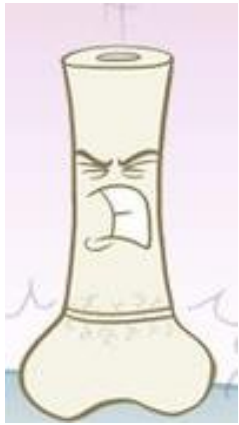
- Heal more rapidly than adults
- Capable of remodeling deformity
- *What favors remodeling?*
  - Younger > older
  - Location on bone:  
metaphyseal/near growth plate >  
middle of bone
  - Fracture angulation in the plane  
of joint movement

# Injury patterns in growing bones

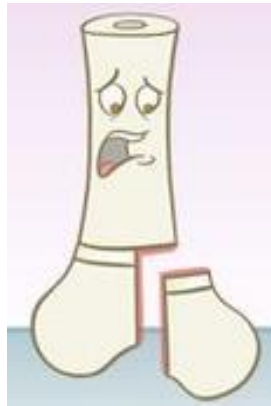
- Torus fracture
- Greenstick fracture
- Plastic Deformation
- Salter Harris fractures (~20% of pediatric #s)



# Growth Plate Injuries: Salter-Harris Classification



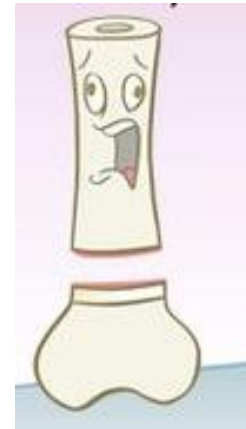
5



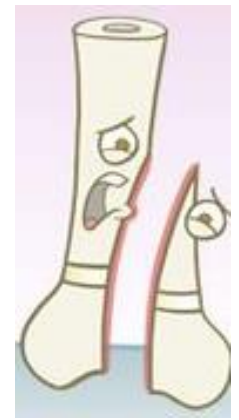
3



2



1



4

What SH type are these fractures?





SH1



SH2



SH3



SH4

# General Principles of # Management

- Adequate analgesia
  - Drugs
  - Splinting
- (Reduce)/ Immobilize
  - Neurovascular status
  - Correct any misalignment
  - Wound dressing prn
  - Pad pressure points
  - Include joints above and below
  - Ice, elevate



# Complications of fractures: Bone

- Union issues: malunion, nonunion, cross-union
- Limb length discrepancy
- Physeal arrest
- Osteonecrosis

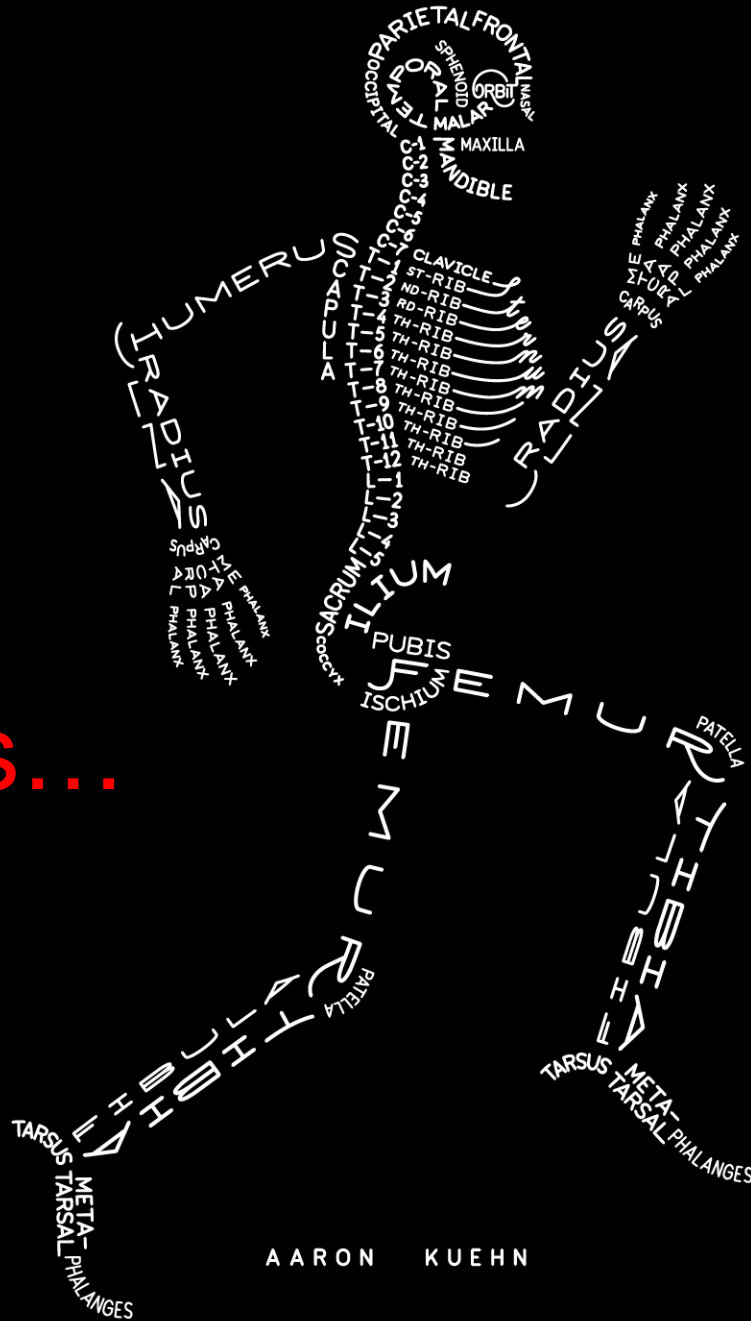


# Complications of fractures: Soft tissue

- Vascular injury
  - Knee, elbow
- Neurologic injury
  - Usually neuropraxia
- Compartment syndrome
  - Anterior tibia, forearm, foot, hand
- Cast sores / pressure ulcers
- Cast burns



Fractures...  
. let's  
practice!



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# Case 1: 13yo Male, middle finger injury

Buckle fracture at the base of the (3<sup>rd</sup>) middle phalanx on the right hand



# Case 2: 15yo Male

Comminuted midshaft fracture of the left clavicle (complete caudal displacement of distal fracture fragment)

There is approximately 2 cm shortening.



# Case 3: 4yo Female



Left mid/proximal shaft radius and ulna greenstick fractures:

- Ulna angulated volar about 15 degrees and radially 5 degrees
- Radius angulated volar about 15 degrees and radially 10 degrees

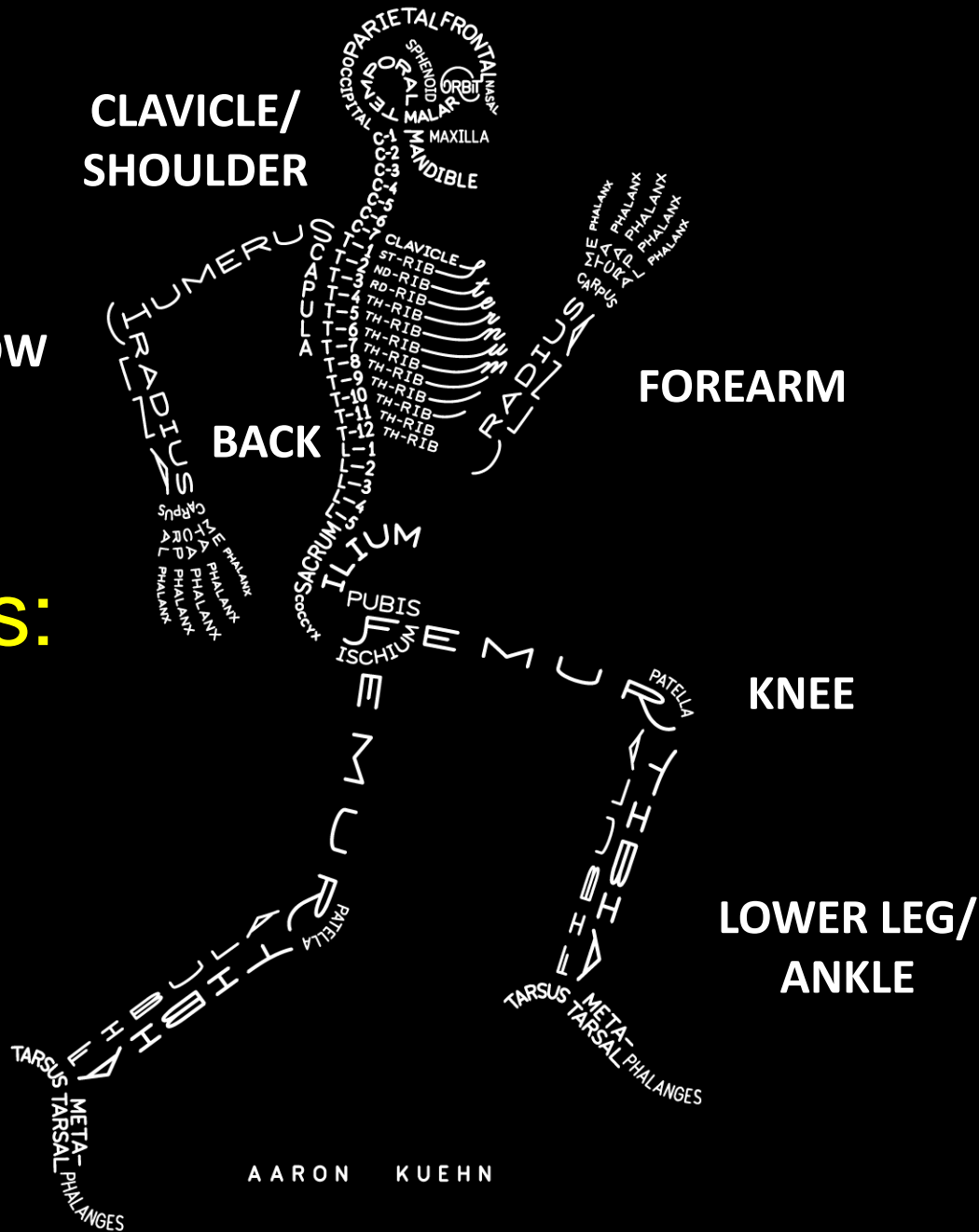


# Case 4: 13 year old Female

Right supracondylar (or distal humerus) fracture, with 100% posterior and mild lateral displacement



# MSK injuries: Let's get specific...



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# FOREARM FRACTURES

- Most common site of fracture (50% of all #)



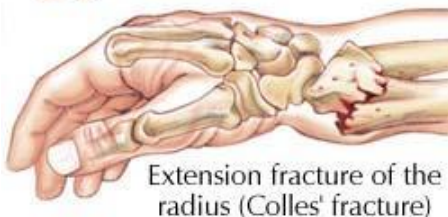
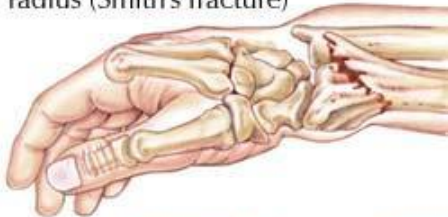
Here a FOOSH there a  
FOOSH everywhere a  
FOOSH FOOSH



# Physeal Injuries of the Radius

- Usually Salter I or II
- Usually dorsally displaced (colles-type) b/c of FOOSH
  - Volarly displaced (Smith's-type) less common
- Complications uncommon

Flexion fracture of the radius (Smith's fracture)









# Buckle #



Buckle #.... How do you manage this?



# Distal Forearm Buckle #

- Stable fractures, management has evolved...
- *A randomized controlled trial of removable splinting vs casting for wrist buckle fractures in children. Plint et al. Pediatrics 2006;117(3):691-7*
  - *Splint = better physical functioning, easier to bath*
  - *Cast = increased return visits for cast problems*
  - *Pain scores same, no fracture complications in either group*
- *Who might benefit from cast? More severe buckle, very young, very active*
- *How long do we immobilize? 3 wks*

# Buckle vs Greenstick

- ***Be careful!!!***
- Buckle #
  - Buckling of bone without cortical disruption
  - Stable
- Greenstick #
  - These are unstable – tend to move back to the position of maximal deformity



# Greenstick # on day of injury



21 days post



# Other fractures of the forearm

- If the injury is closed, neurovascularly intact, and in acceptable position:
  - Above elbow cast if mid-shaft or up, or both bones
  - Ortho follow-up in 7-10 days
- *What is acceptable position???*
  - More forgiveness if... younger, further from centre of bone, more of a displacement issue vs angulation or angulated in plane of joint movement



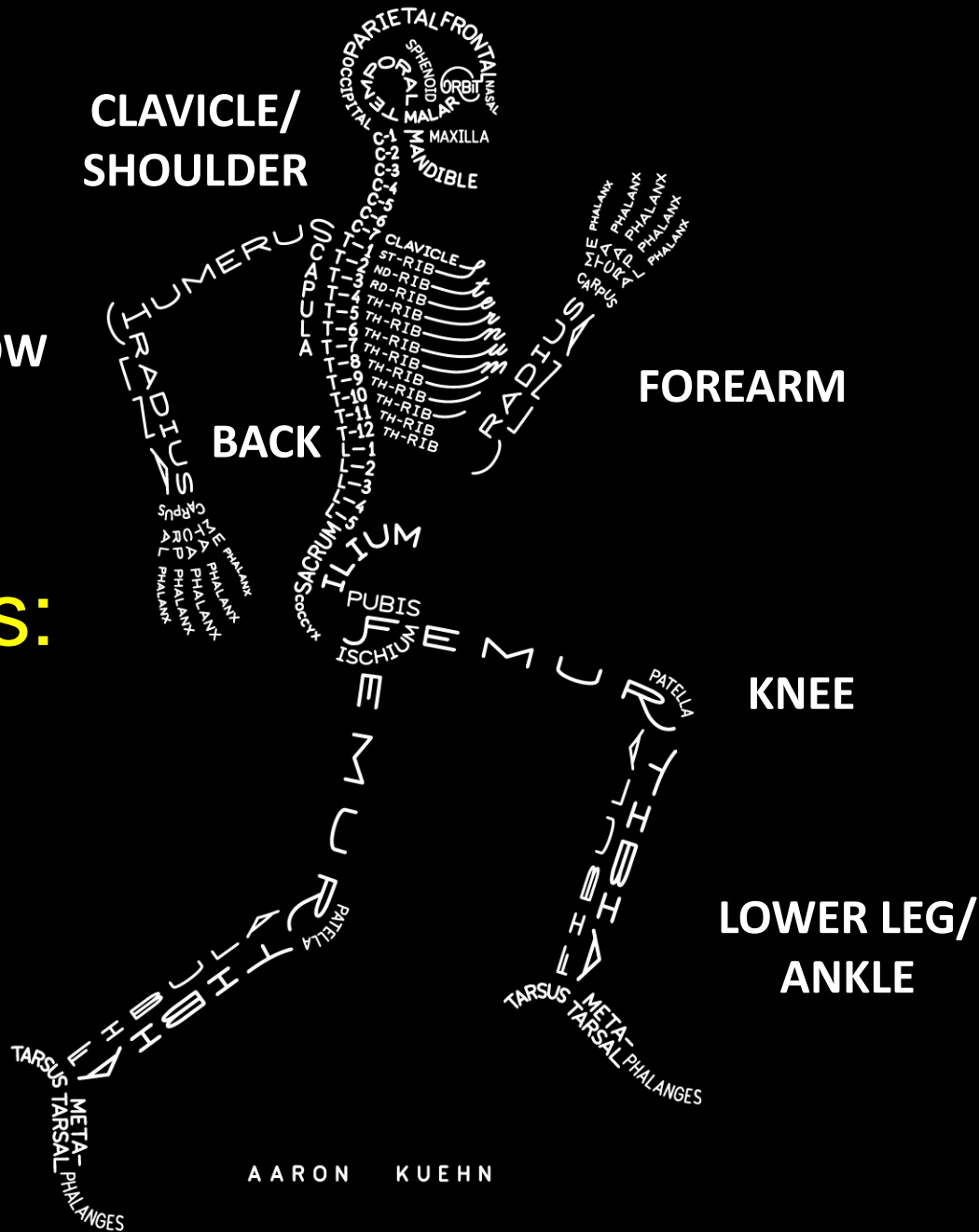


# Bowing deformity

- Hard to diagnose
- **These will NOT remodel !!**
- Must be reduced if visible deformity or restricted ROM – but difficult
- Need early ortho f/u



# MSK injuries: Let's get specific...



# **THE (DREADED) ELBOW**

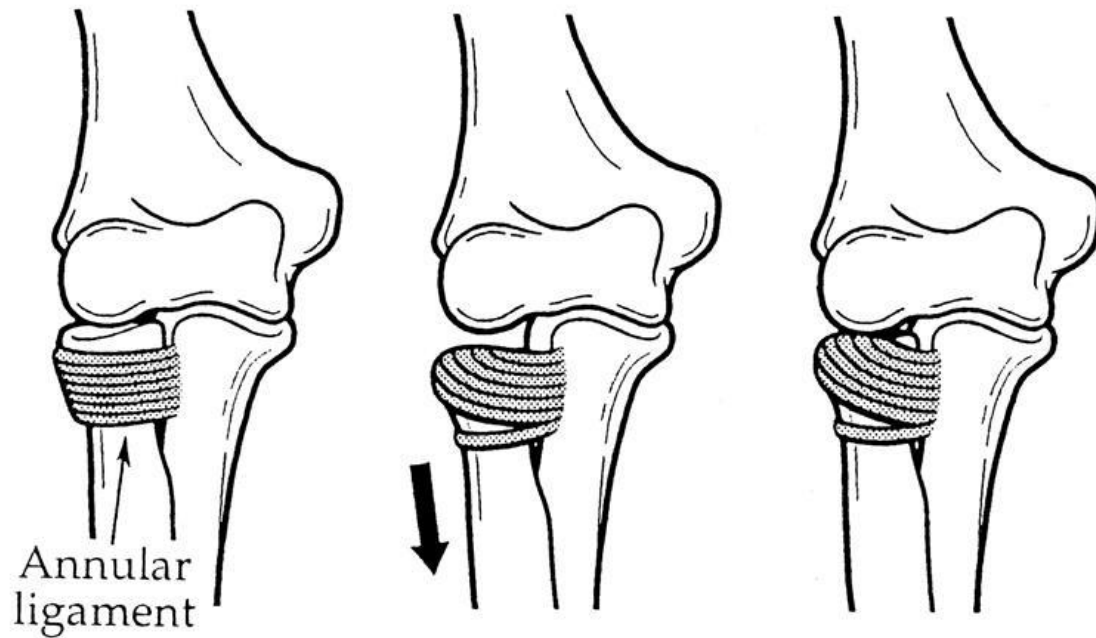
# Case

- A 3 year old female is brought to the ER because she won't use her arm and cries if parents try to bend it. She was playing with her cousin this morning so they wonder if she injured it then.
- On exam there is no visible swelling or deformity to her upper extremity; she won't move her arm but she cries when you touch around her elbow. What is the most likely diagnosis?



# Radial head subluxation

Aka Nursemaid's (pulled) elbow



# Ossification Centers of The Elbow

Pneumonic	Ossification Site	Age of Appearance		
C	Capitellum	2 months – 2 years	1	2
R	Radial head	3 – 6 years	3	4
I	Internal (medial) epicondyle)	4 – 7 years	5	6
T	Trochlea	8 – 10 years	7	8
O	Olecranon	8 – 10 years	9	10
E	External (lateral) epicondyle	10 – 13 years	11	12

***When the epiphyses SHOW UP (not fuse)***

# Ossification Centers - CRITOE



# Approach to reading the elbow XR

- Is the film adequate
  - Lateral view,  
hourglass
- Fat pads
- Lines
- Look for the most common ped  
elbow #s





# Pediatric Elbow – Fat Pads

- A flat anterior fat pad is often present and normal
- A bulging anterior fat pad “sail sign” is always abN
- A visible posterior fat pad is always abN



# Anterior Humeral Line



[www.hawaii.edu](http://www.hawaii.edu)

Should pass through the middle third of the capitellum in the lateral view

# Radiocapitellar Line

Should bisect the capitellum in ALL views



[www.hawaii.edu](http://www.hawaii.edu)



[www.embbs.com/img](http://www.embbs.com/img)

# *2yo fell off stool - What's this?*

C 1  
R 3  
I 5  
T 7  
O 9  
E 11



# Supracondylar Fracture

- 75% of elbow #s
- 95% due to FOOSH
- Classification:
  - Type 1 – non-displaced / minimally displaced
  - Type 2 – displaced, but hinged on posterior cortex
  - Type 3 – completely displaced, posterior cortex disrupted

# Type I



# Type II



# Type III





# Supracondylar Fracture Complications

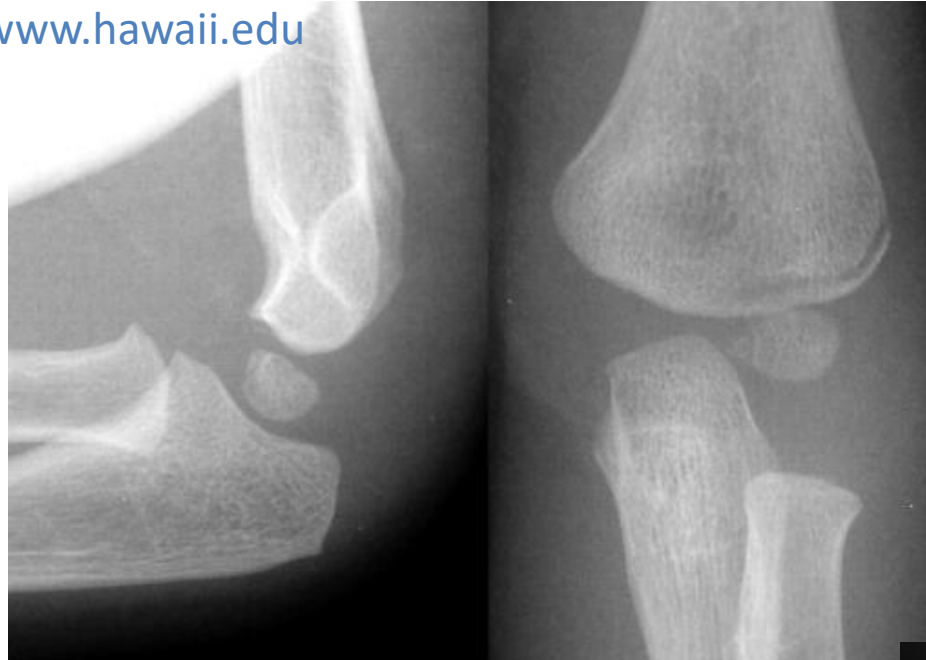
- Very high rate of complications!!
  - Neurologic injury (8-15%)
    - Ant interosseous branch of median n
    - Radial and ulnar nerves also may be involved
  - Radial artery (2% overall, 50% in Type III)
  - Compartment Syndrome

# Supracondylar Fracture Management

- Type I
  - Backslab at 90°, ortho in 1 week
- Type II
  - Sometimes operative; consult ortho
- Type III
  - Posterior backslab and consult ortho immediately
  - If pulseless...child usually holding arm in extension... flex the elbow to 15°



# What are these?

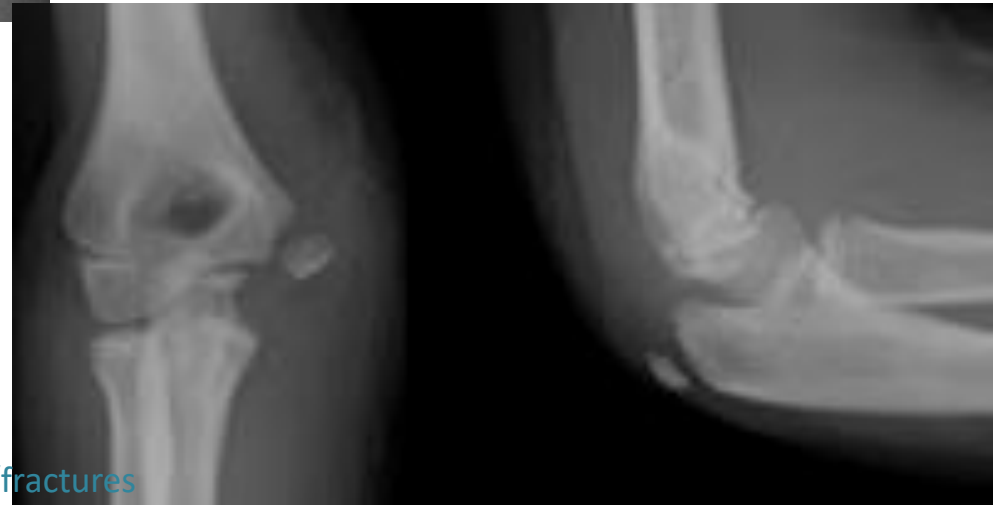


*2 year old left arm*

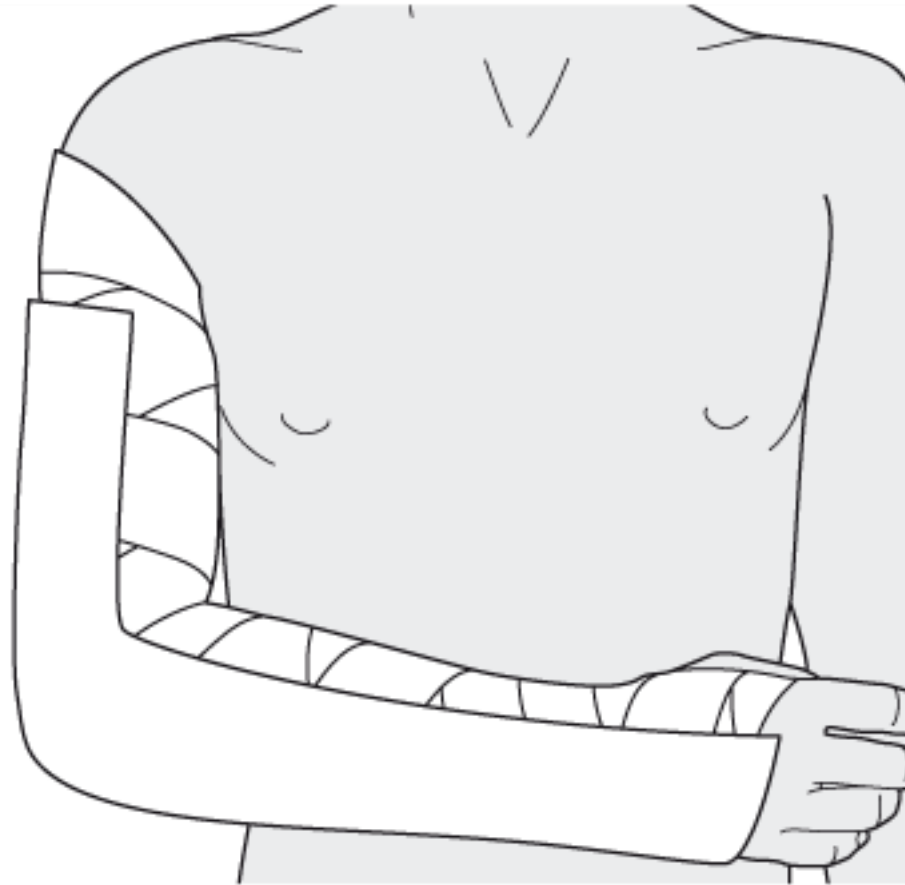
Lateral epicondyle fracture  
2<sup>nd</sup> most common elbow fracture

*9 year old right arm*

Medial epicondyle fracture

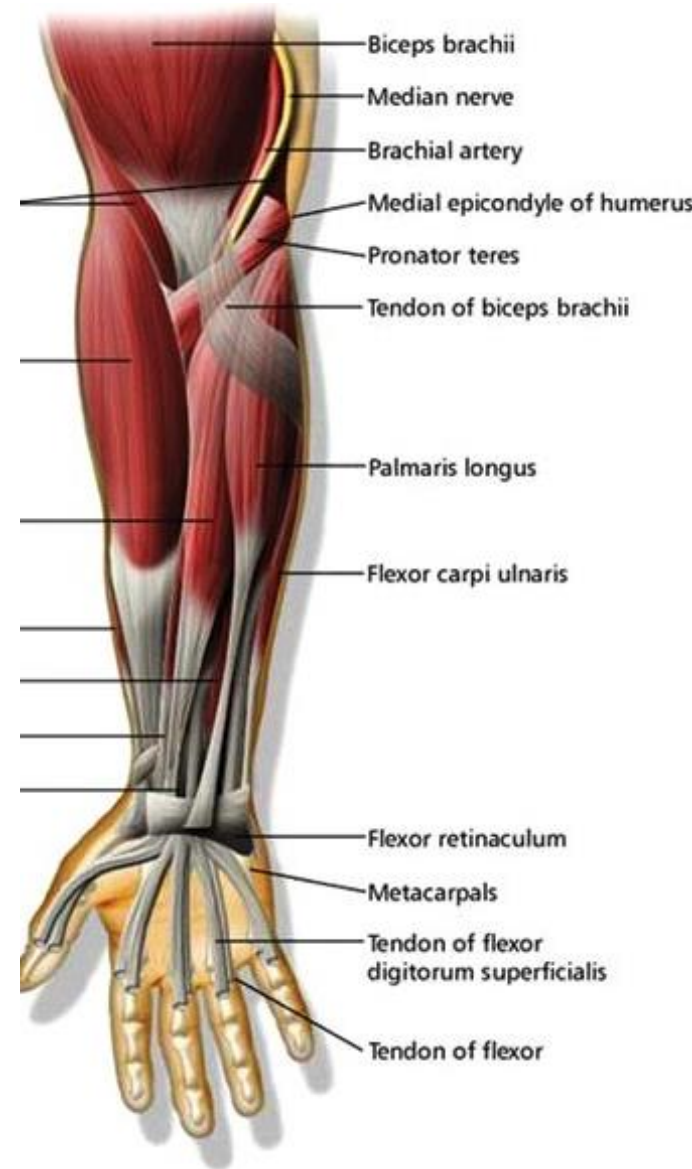


What does immobilization of the elbow look like?



# Case

- 11 year old baseball pitcher with pain and swelling to the inside of his elbow
- Parents tense bc “he’s aiming for the major leagues”
- What is likely going on and what is your management plan?



# Little league elbow “medial apophysitis”

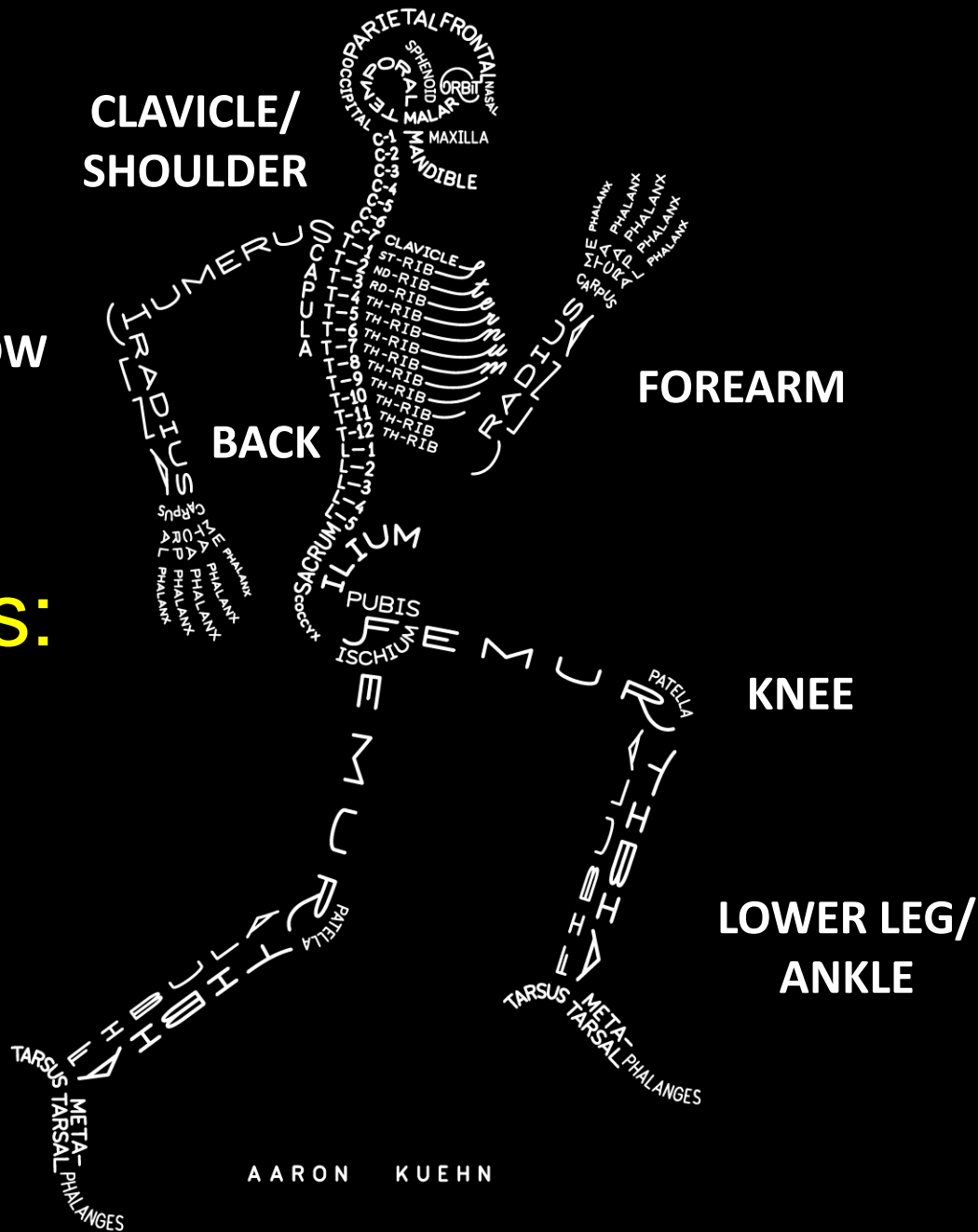
- Spectrum of injuries to medial side of elbow:
  - Medial epicondyle stress fractures
  - Ulnar (medial) collateral ligament injuries
  - Risk osteochondritis dissecans
- Repetitive valgus stress and microtrauma



# Little league elbow “medial apophysitis”

- Acute: RICE principles
- Activity modification: limits on how many pitches per week
- Rarely surgery if persists over age, esp if loose bony fragments from microtrauma

# MSK injuries: Let's get specific...



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# **CLAVICLE/ SHOULDER**

# Clavicle

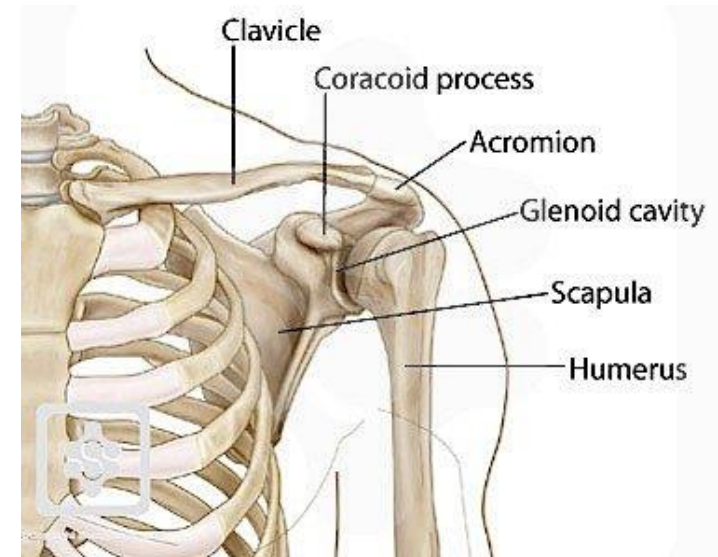
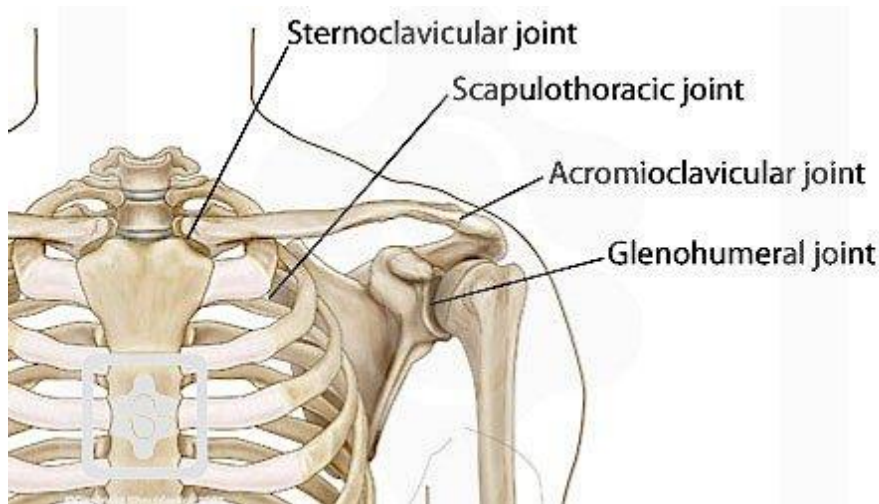
- 10–15% of all pediatric #s
- 95% middle third
  - Sling
  - Pain management
  - Warn parents about the bump
  - F/U fam doc in 6-8 weeks
- Proximal #
  - If grossly unstable, F/U with ortho or sports med





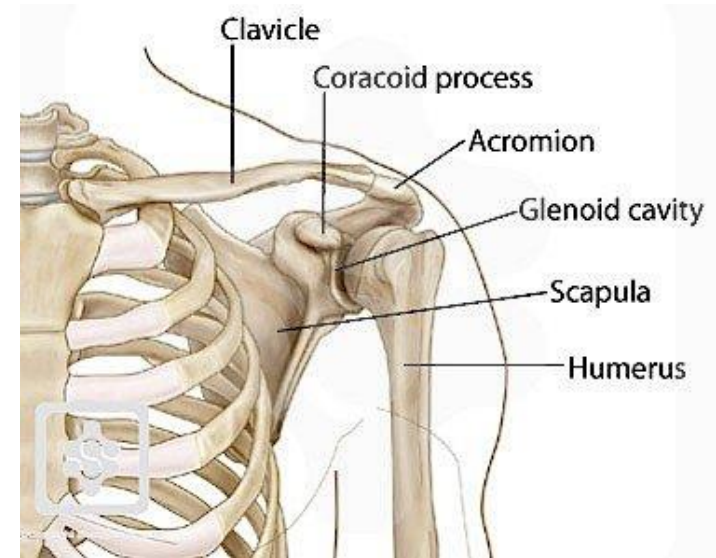
# Shoulder injuries

- Joint dislocation
- Humerus fractures
- Ligament sprain: AC joint separation
- Impingement



# GH joint dislocation

- Anterior dislocations – arm abducted and ext rotated
- Risk of associated injuries eg. Bankart lesion (labrum), Hill Sachs lesion (impaction of posterolateral humeral head), axillary nerve injury



# GH joint dislocation

- Reduce, xray, sling and f/u PT for ROM/strength
- 66% - 100% recurrence rate in adolescents

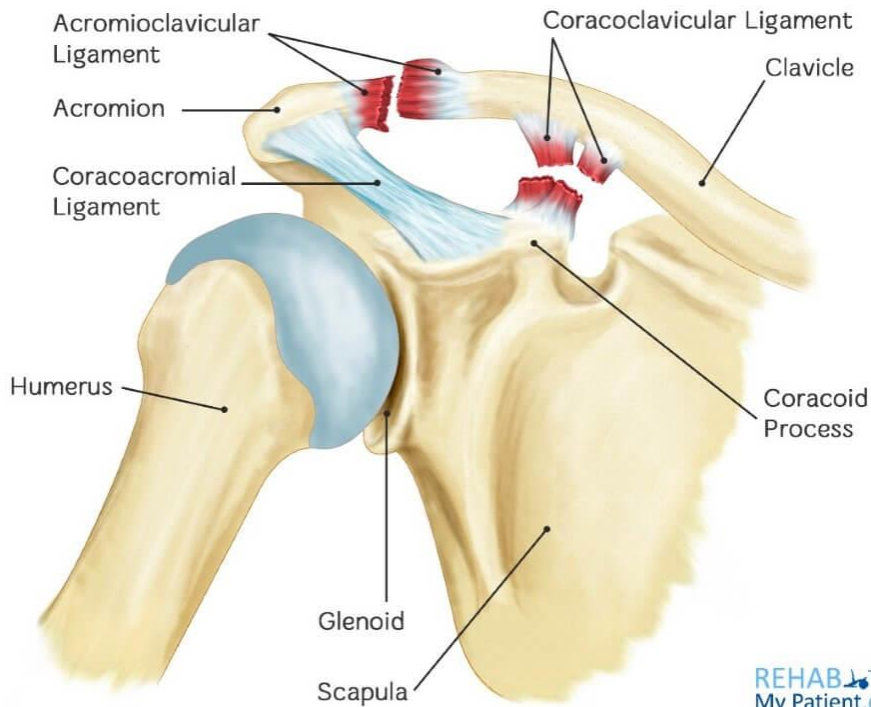


# Case 1

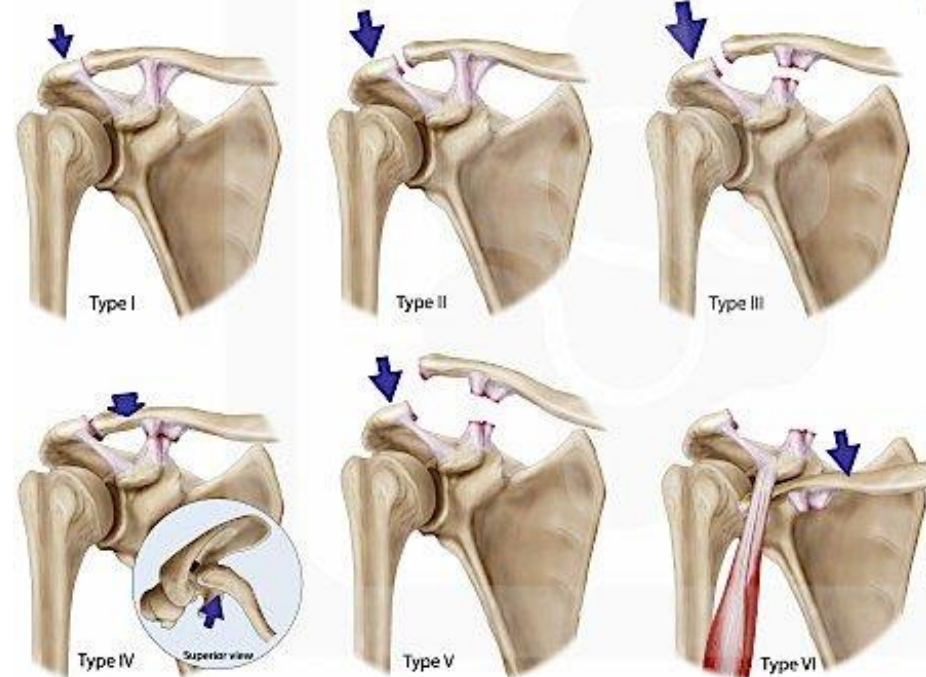
- 16 year old playing football takes a direct hit to his shoulder during a tackle
- No obvious joint dislocation or clavicle deformity, ++pain with ROM
- What are the possible injuries?

# AC joint separation

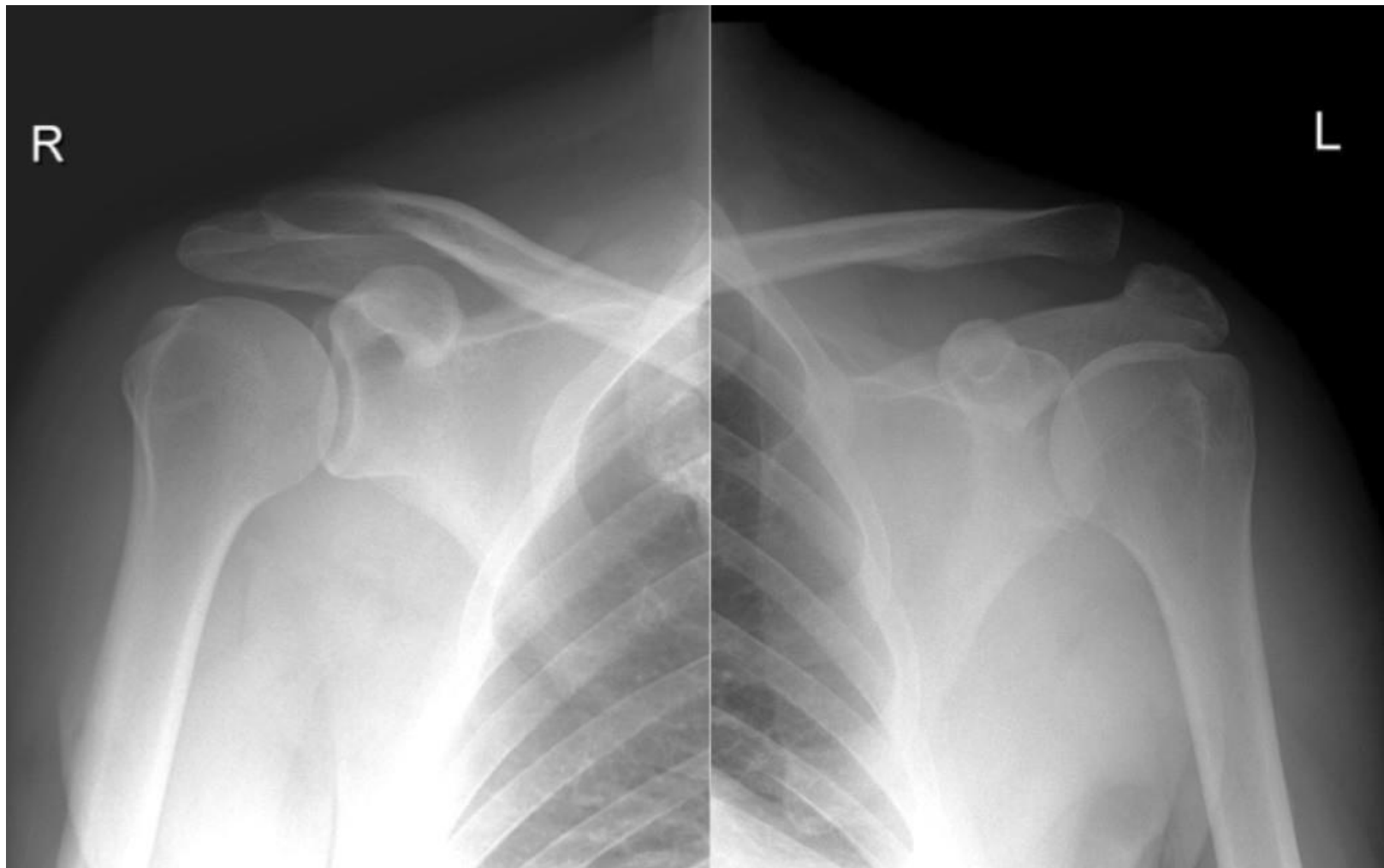
## Acromioclavicular Joint Separation



## Rockwood Classification







## Case 2

- A 10yo boy fell off his skateboard onto his left shoulder
- Mild deformity on exam; too much pain to range. Tender around the joint and below



What now?????

Proximal humerus fracture

# Case 3

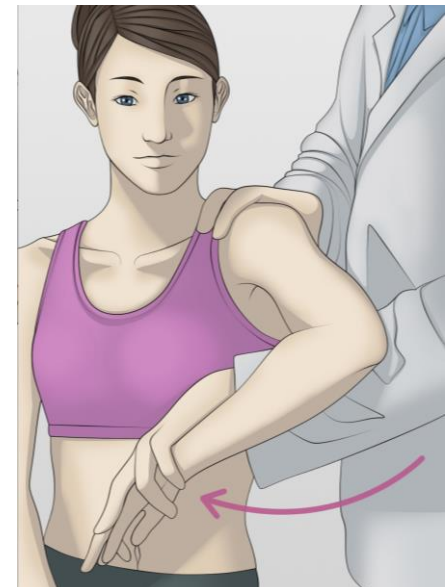
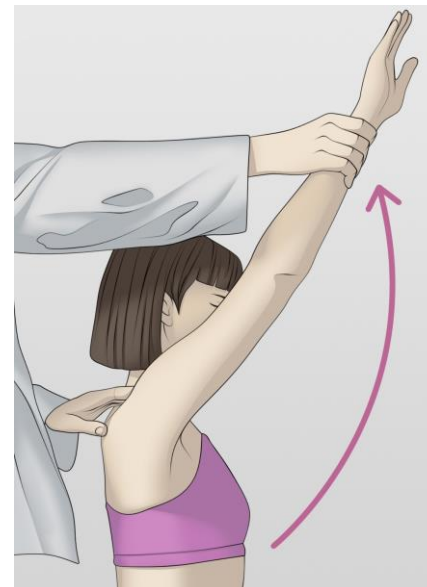
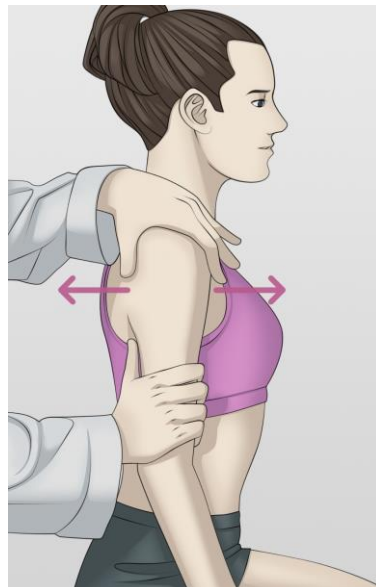
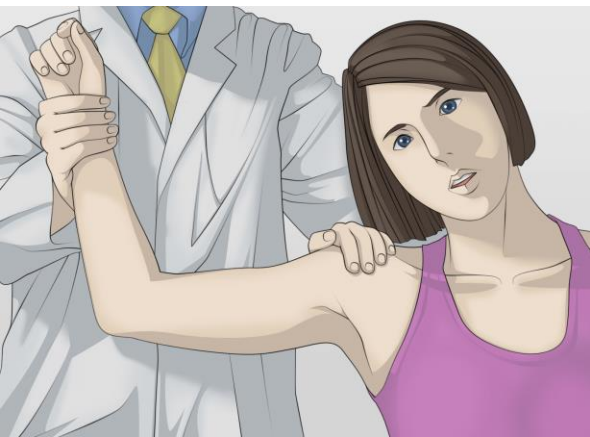
- A 13 year old competitive swimmer comes in with chronic pain in her right shoulder, limiting her ability to swim
- Dull, achy, vague
- What are some special tests you should perform on exam?

Apprehension test

Load and shift

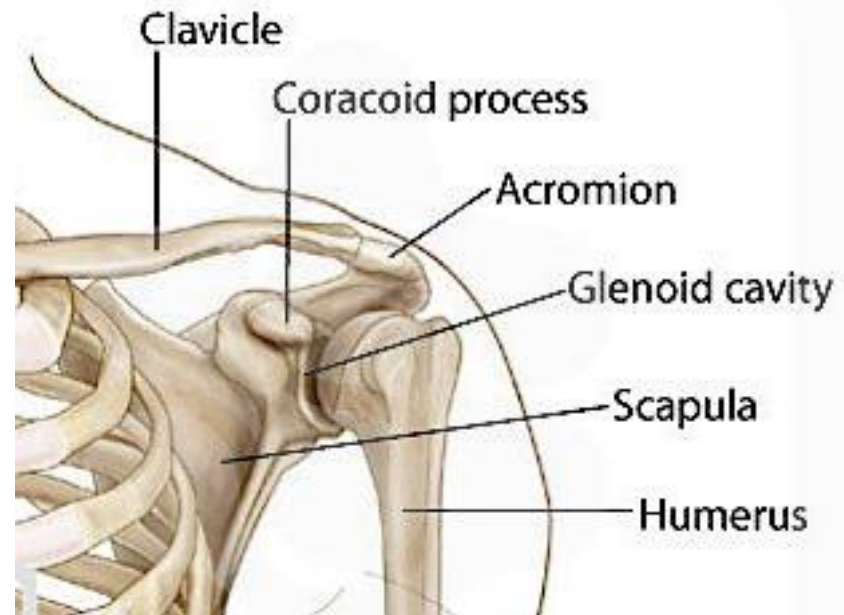
Neer's

Hawkins



# Impingement

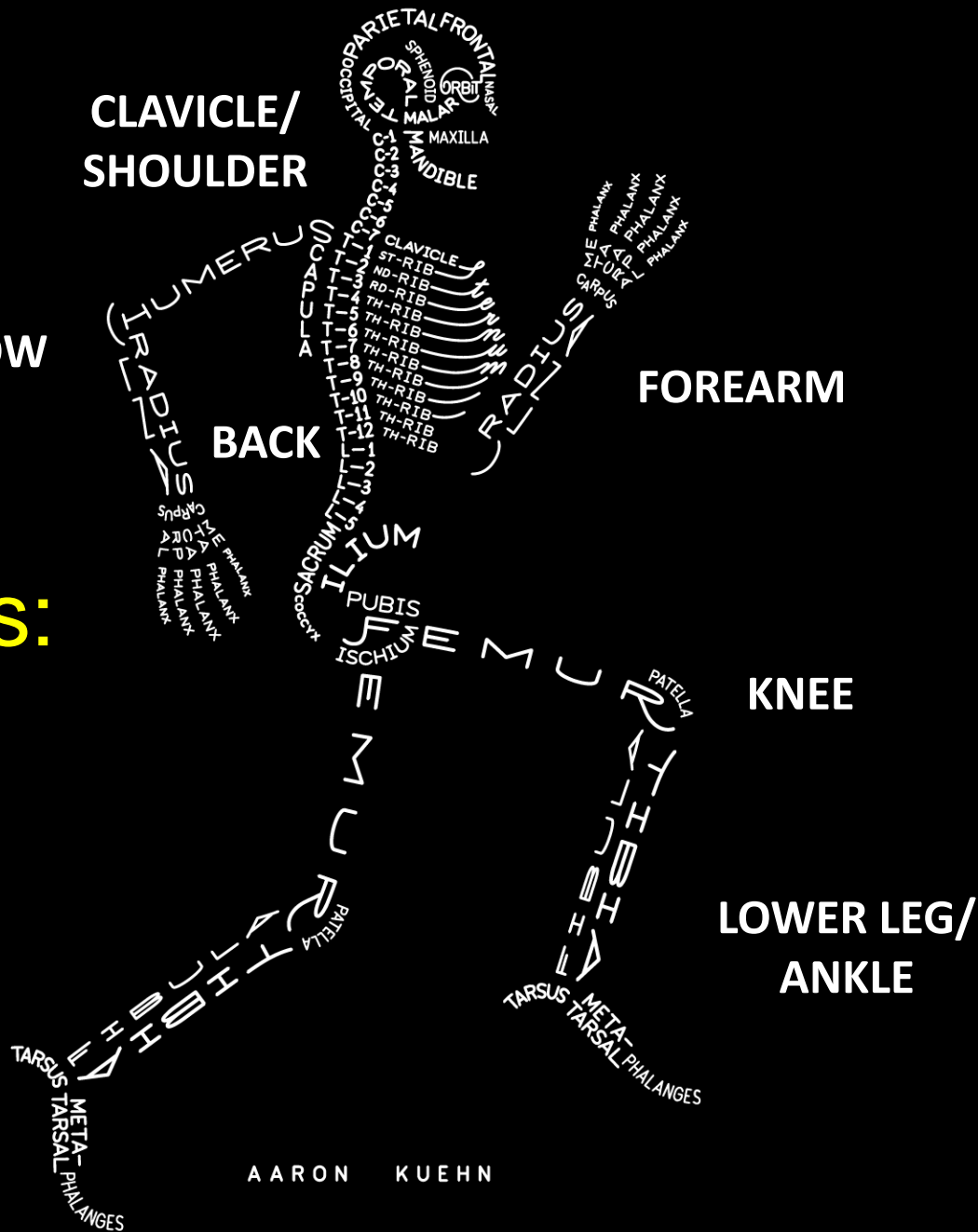
- Impingement of rotator cuff, or biceps tendon, or bursa
- Secondary to GH joint instability (lax ligaments, rotator cuff weakness, capsule deformity → overhead athletes
- Special tests:
  - Hawkins and Neer's
  - Usually +veimpingement tests: eg. apprehension





- Activity modification 4+ weeks
- Physio:
  - Rotator cuff/ periscapular strengthening
  - Core/ strength stabilization

# MSK injuries: Let's get specific...

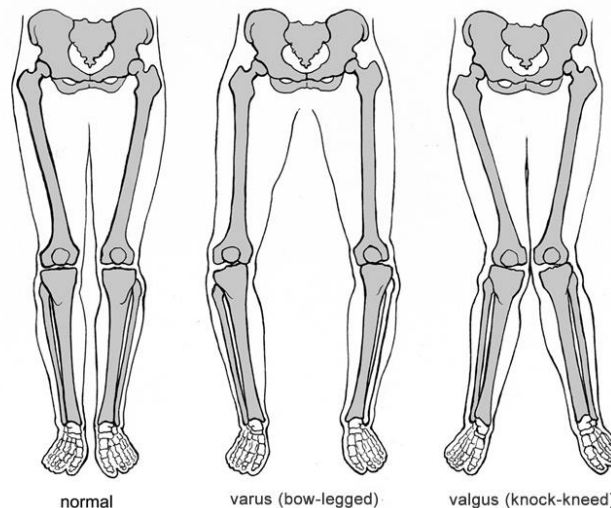


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# **LOWER LEG & ANKLE**

# Tibia Fractures

- Tibia and fibula fractures often occur together
  - Tibial # should prompt looking for a fibular one
- Mechanism
  - Falls and twisting injury of the foot
- High risk of long-term deformities if not managed well





What's this?



# Toddler's Fracture

- Common!
- Low energy mechanism
- Spiral/oblique fracture of tibia – often subtle
- Above knee walking cast for 3 weeks

# Tib/Fib Shaft Fractures

- If undisplaced: above-knee cast, NWB, f/u ortho
- Minimally displaced – often reduce quite easily during casting (use sedation)
- Always do post-cast films and be careful of foot position
- For significant displacement, or *involvement of the growth plate* – d/w ortho

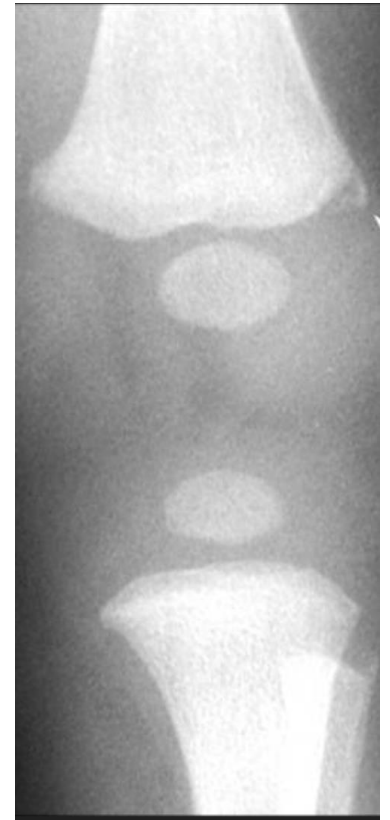
# Case 1

- 1 year old brought in by mom irritable and not weight bearing on left leg since last night

You do an xray.

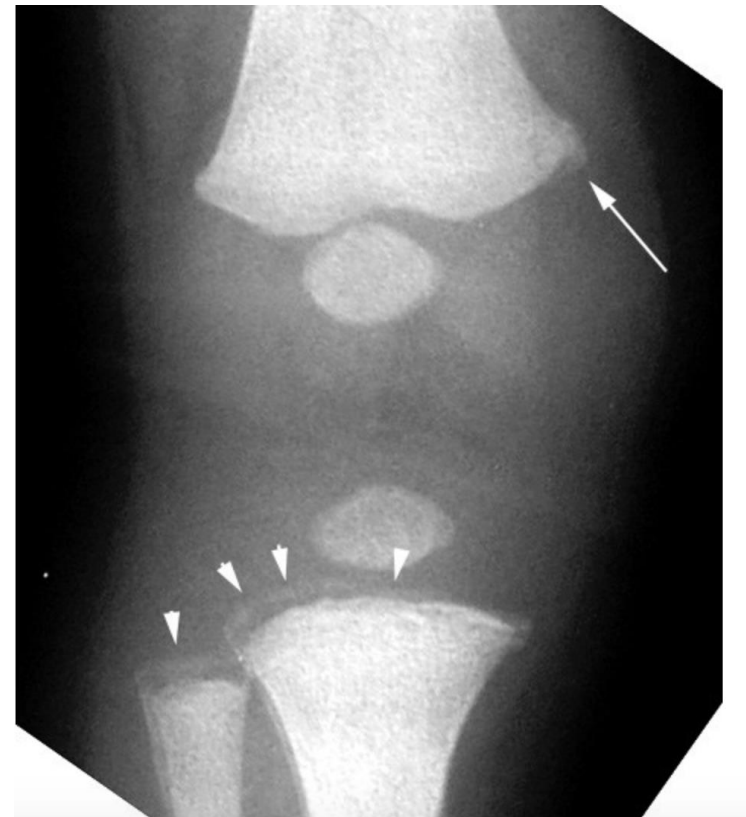
What is your management plan?

*Metaphyseal chip/corner fracture*



# Metaphyseal corner fracture

- Aka bucket handle fracture on perpendicular view



# High risk fractures for child maltreatment?

- Rib (strongest a/w inflicted injury)
- Metaphyseal
- Humerus <18mo
- Femur in non-ambulatory
- Multiple numbers
- Fractures of different ages
- Scapular, spinous process, sternal

# DDx for medical conditions a/w skeletal injuries?

- Genetic bone
  - Osteogenesis imperfecta
  - Hypophosphatasia
  - Menkes disease
- Nutritional/metabolic
  - Vit D deficiency rickets
  - Osteopenia of infancy
  - Copper deficiency
  - Renal disease
- Infection
  - Osteomyelitis
  - Congenital syphilis
- Malignancy
  - Leukemia
  - Langerhans cell histiocytosis

## *Case 2*

- You are concerned about a possible stress fracture in a 13yo competitive gymnast presenting with 1 week of lower leg pain. How will you proceed?

?Stress fracture

Xray

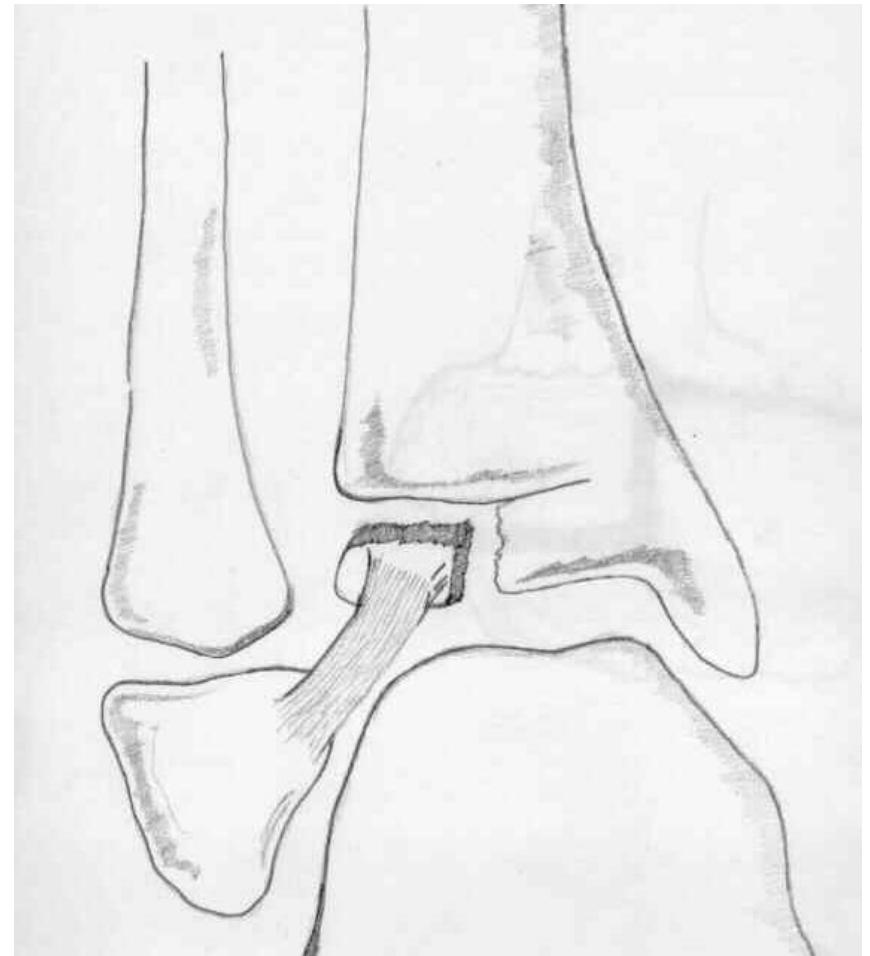
Bone scan?

MRI?



# Tillaux Fracture

- SH3 injury: Fracture of the antero-lateral tibial epiphysis
- Risk of joint abnormality if too displaced
  - Will accept max of 2mm displacement – many require operative management
- Low threshold for CT; Call ortho



# *What 's This?*



**A**

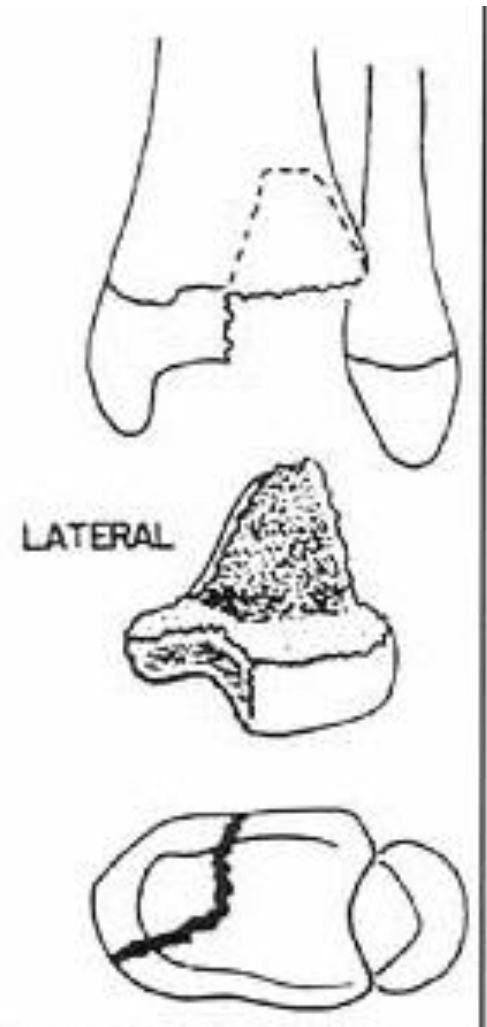


**B**

<http://www.jaaos.org/content/15/12/738/F4.large.jpg>

# Triplane Fracture

- SH4 fracture in 3 different planes
- Talk to ortho; Often need CT
- Operative management in 50-70%



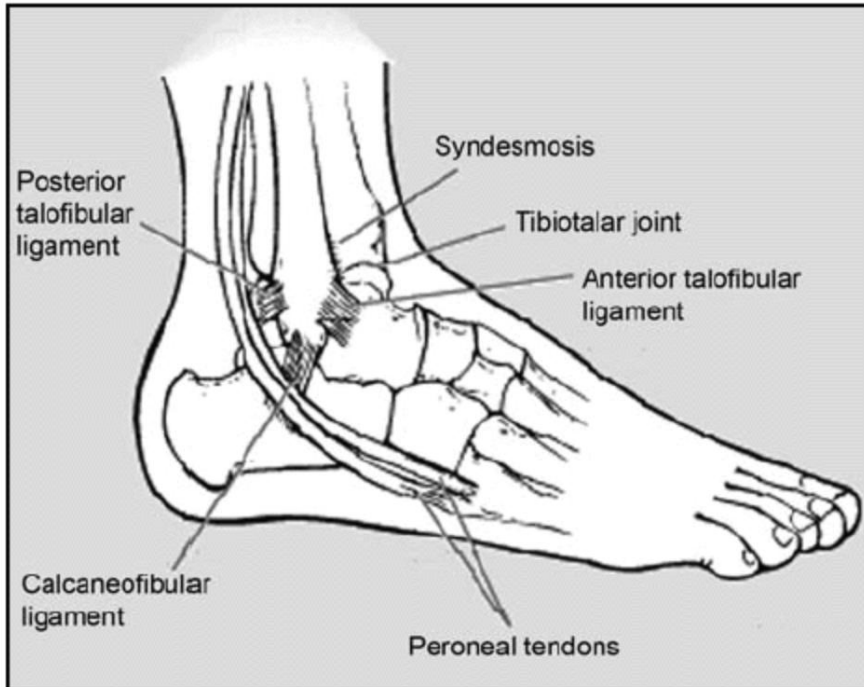
# Fibular fractures

- Overall not as significant as tibial fractures;
  - Depending on how misaligned, and if associated with tibia fracture or joint instability, can just air cast and allow WB as tolerated
- Most common: distal fibula (aka lateral malleolus) → “Twisted my ankle”
  1. Fibula avulsion fractures
    1. Fibular growth plate #'s
      - Overall considered stable
      - SH1 very hard to diagnose on xray, but... does it really matter??



# Ankle injuries

- Vast majority due to inversion mechanism
  - Ligament sprain >> fibular fracture
  - BUT the younger child is more likely than older to have SH fracture vs sprain



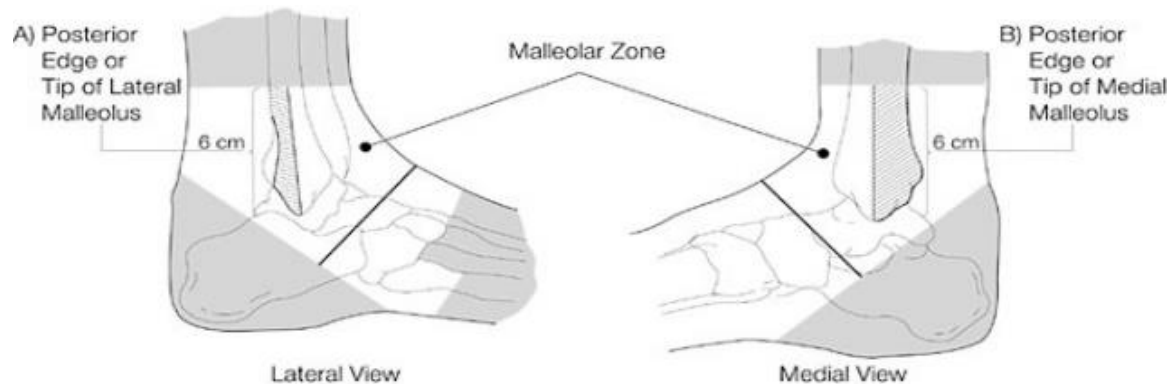
PRACTICE POINT

**Ankle sprains in the paediatric athlete**

**Posted:** Feb 1 2007

# When to x-ray ankles...?

- Clinical decision rules for ankle fractures in children
  - **Ottawa Ankle Rule (OAR)**
  - Low Risk Ankle Rule (LRAR)
  - Malleolar Zone Algorithm



An ankle x-ray series is required only if there is any pain in the malleolar zone and any of these findings:

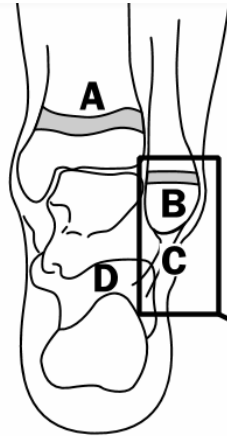
1. Bone tenderness at A  
or
2. Bone tenderness at B  
or
3. Inability to bear weight both immediately and in emergency department

# When to x-ray ankles...?

What injuries are not clinically significant?

- Lateral ankle sprains
- Non-displaced SH I/II of distal fibula
- Avulsion fractures of the distal fibula or lateral talus
  
- Clinical decision rules for ankle fractures in children
  - Ottawa Ankle Rule (OAR)
  - **Low Risk Ankle Rule (LRAR)**
  - Malleolar Zone Algorithm

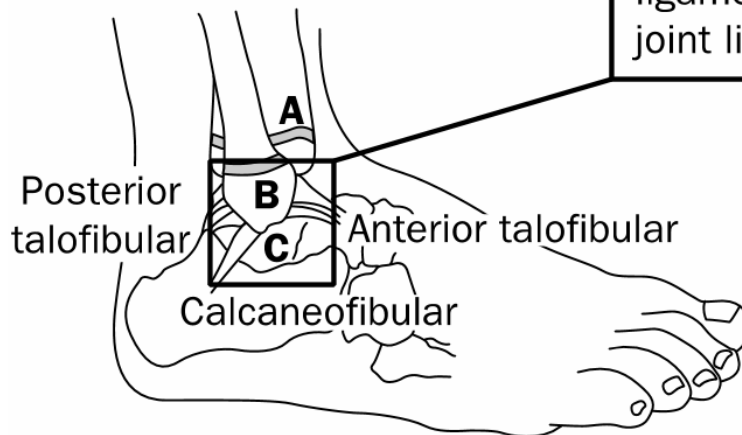
# Low Risk Ankle Rules



- A** Distal tibia including growth plate
- B** Distal fibula including growth plate
- C** Lateral ligaments including anterior talofibular, calcaneofibular, and posterior talofibular
- D** Calcaneous

**Anteroposterior view**

Tenderness with or without oedema of the distal fibula and/or adjacent lateral ligaments distal to the ankle joint line



**Lateral view**

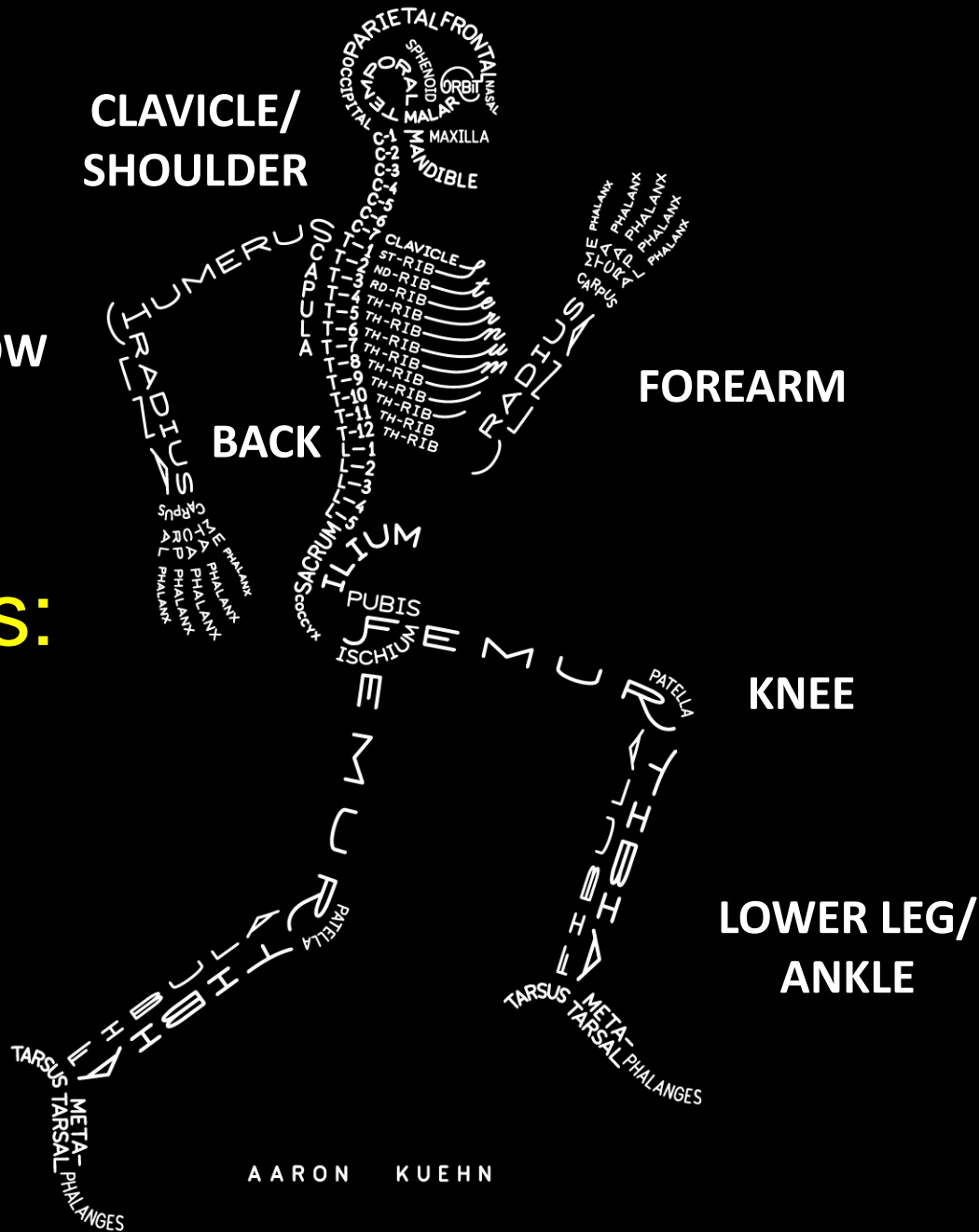


# Which one to use?

- Head to head comparison:
  - OAR best sensitivity (100%; spec of 21%), reduce radiographs by 7%
  - LRAR best specificity (54%; sens of 98%), reduce radiographs by 45%

*Effect of Low Risk Ankle Rule on the frequency of radiography in children with ankle injuries, CMAJ 2013.*

# MSK injuries: Let's get specific...



AARON KUEHN

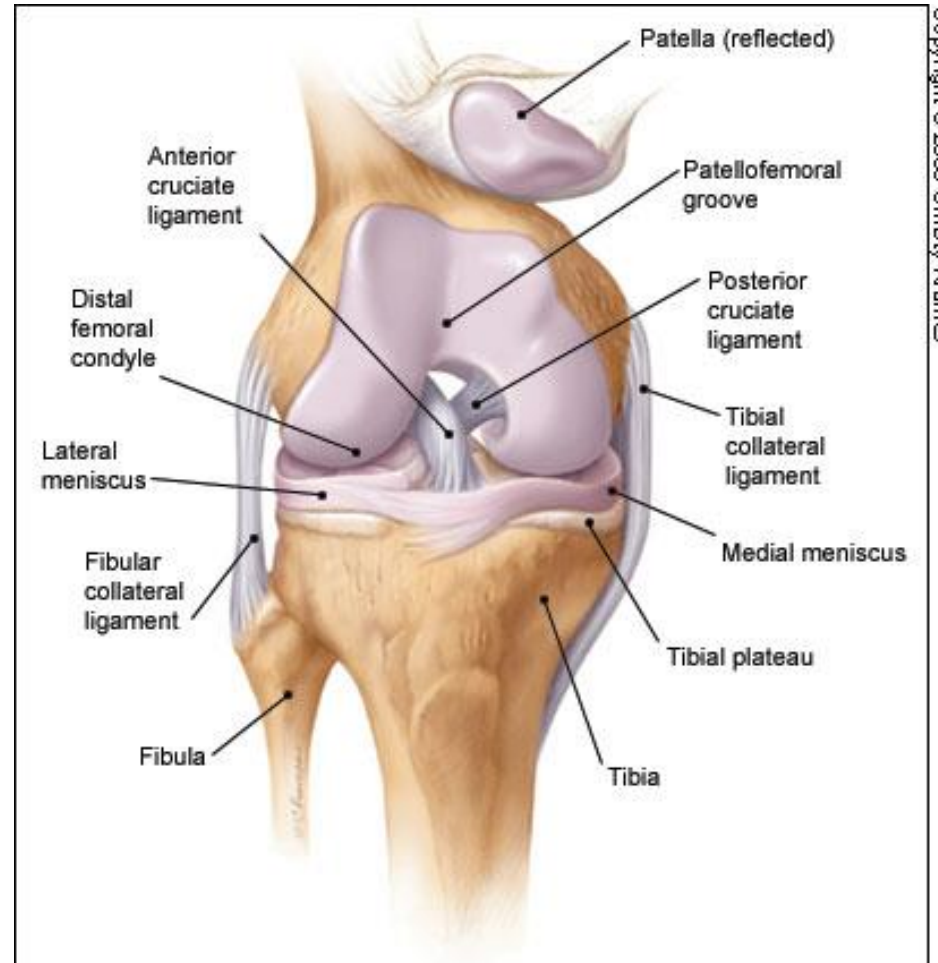
**KNEE**

# Traumatic knee pain

## Injuries:

- Ligamentous
- Meniscal
- Tendon
- Bone:
  - Fractures
    - Femoral growth plate
    - Tibial spine, tubercle
  - Dislocation (patella)
- Bursae

*Knee pain but normal exam? Check hip!*



# When to x-ray? Ottawa Knee Rules

- Xray if any of the following:
  - Age 55 years or older
  - Tenderness at head of fibula
  - Isolated tenderness of patella
  - Inability to flex to 90°
  - Inability to bear weight both immediately and in ED (4 steps)

*Use common sense....*

- *Bony or joint line tenderness + decent mechanism*

- *2003 Plint et al Validation study*
  - 750 kids 2 – 16yo (positive outcome = fracture of knee)
  - 100% sensitive, 43% specific

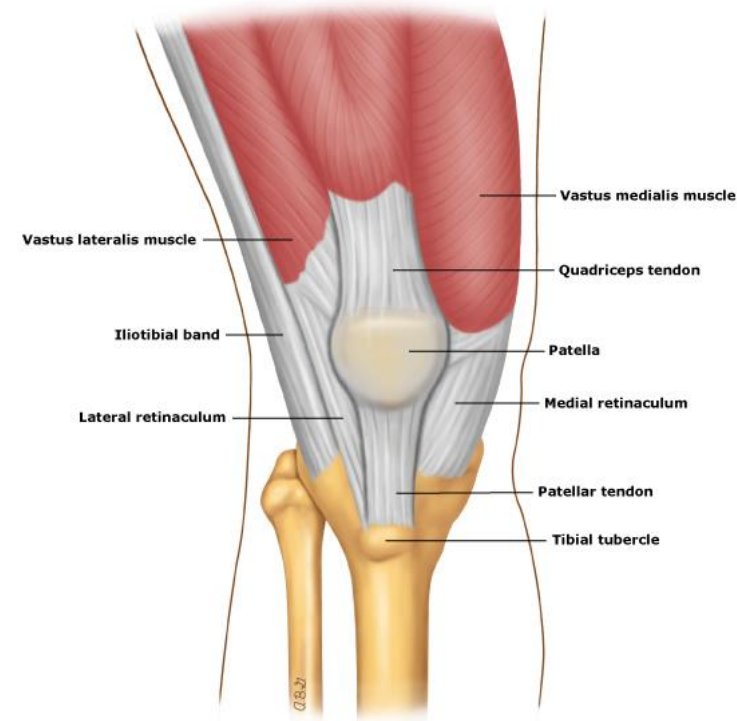
# Always image!



- Joint effusion
- “Locked” knee sensation
  - Means true intra-articular pathology
  - I.e. meniscal tears

# Case 1

- 15 year old female on high school track team, complains of knee pain especially with running hills
- Ddx??



# Patellofemoral pain syndrome

- Overuse syndrome – multifactorial
  - Abnormal patellar tracking (typically more pull laterally) from misalignment of extensor mechanism
- Pain anterior knee/ around patella
- Aggravated by weight bearing on flexed knee
  - Sitting “theatre-goers knees”
  - Soccer, track

**Exam???**

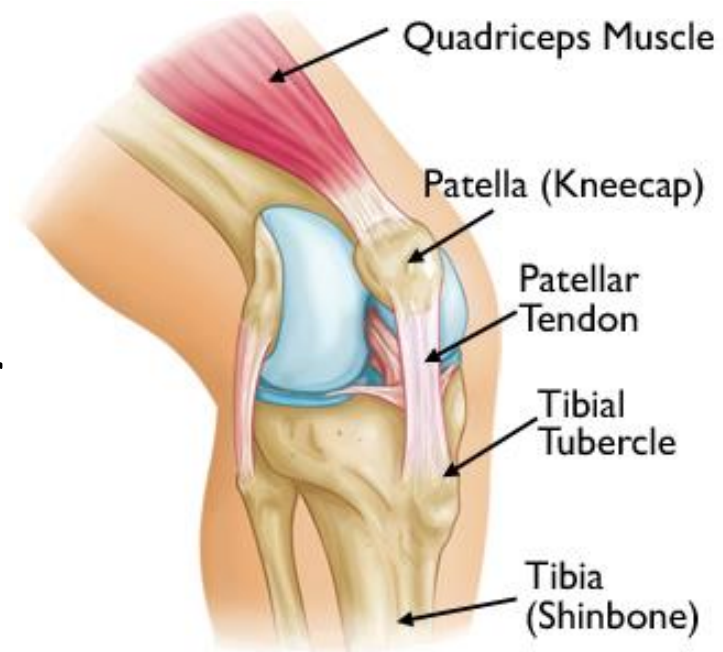
Small vastus medialis  
Tight hamstrings/ quads  
Weak gluteal muscles  
Increased Q angle  
No effusion



# Case 2

12 year old basketball player  
anterior knee pain and swelling  
x 2 months

- What features would make you consider Osgood Schlatter disease as the dx?
  - Pain a/w pull of patellar tendon ie. quad contraction
  - Swelling/tenderness to tibial tubercle, with passive knee flexion



# Osgood-Schlatter

## Management

- Rest from offending activity/  
partial workouts
- PT: stretch, strengthen
- Ice, NSAIDs
- Cho pat strap



# Case 3

- 14 year old playing rugby got tackled – heard a pop in his knee. He can't weight bear and is in a lot of pain....

What is his most likely injury?

# ACL injury

- Deceleration injury, heard pop, can't weight bear, swollen knee = ACL tear until proven otherwise
- Exam: *\*compare to other side*
  - Anterior drawer
  - Lachman (more sensitive)
  - Pivot shift test (specific not sens)



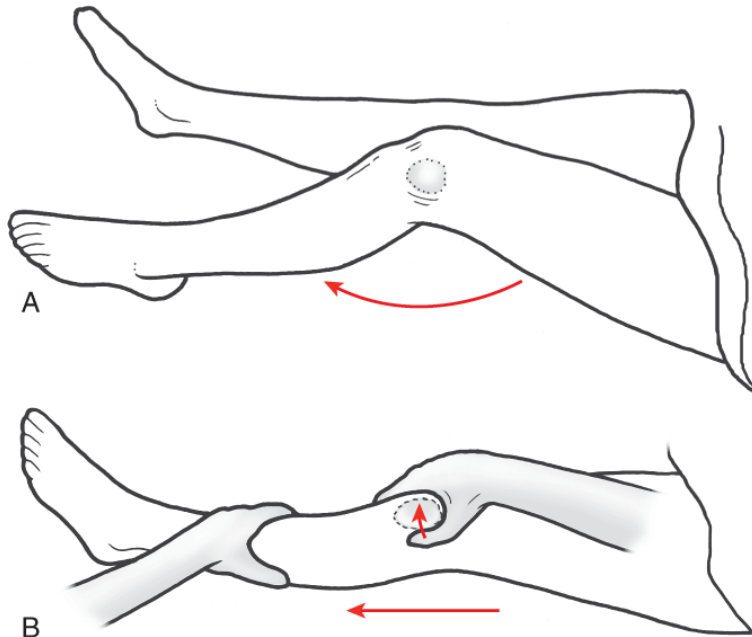
# ACL injury – dx/ management

- X-ray?
- MRI?
- Return to activity?
- Surgery?
- Follow-up is the key.... Physio, sports med

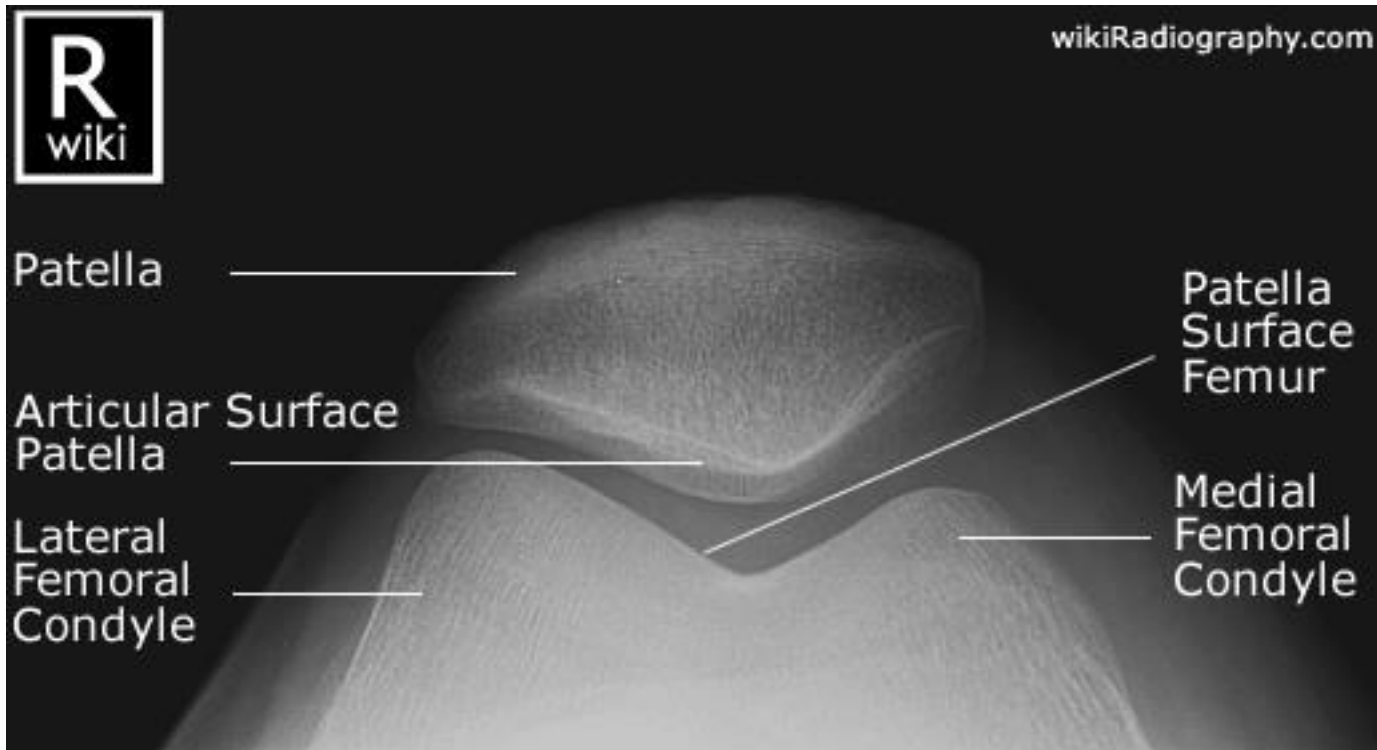
# Patellar dislocation

How do you manage after the dislocation has been reduced?

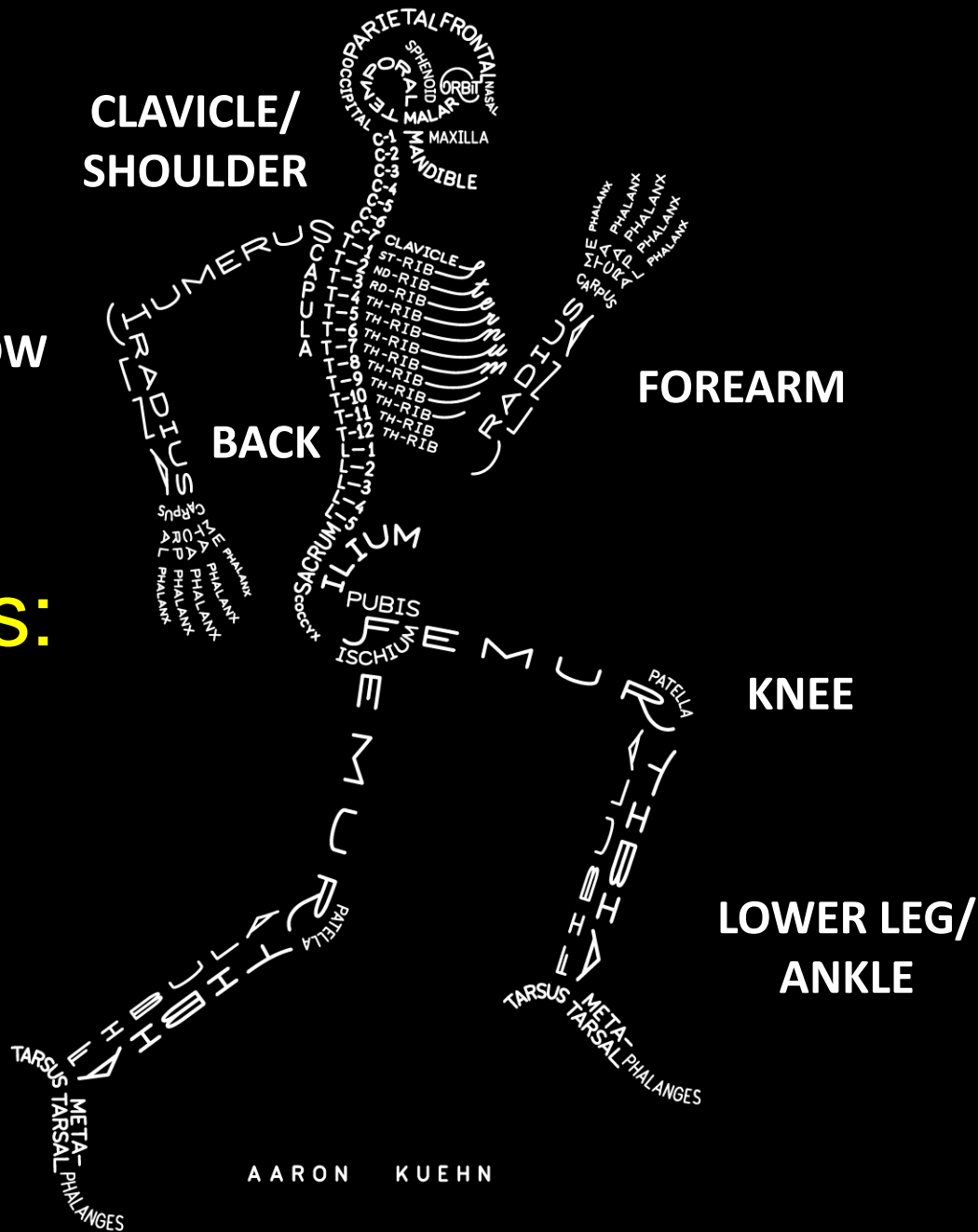
2-4 weeks; wb as tolerated



# X-rays skyline view



# MSK injuries: Let's get specific...





**BACK**

# *Case 1*


14 year old previously healthy girl who has been suffering from lower back pain for 3 weeks that limits her physical activities

- What could be going on?
  - Trauma
    - ?
  - Atraumatic....
    - Infectious (spinal vs referred)
    - Inflammatory eg. transverse myelitis or discitis
    - Autoimmune/rheum
    - Neoplastic

# LOWER BACK PAIN

- Causes?
  - Spondylolysis
  - Posterior element overuse
  - Vertebral avulsion fracture
  - Disc herniation

Distinguish causes by  
pain with flexion vs  
extension



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PRACTICE POINT

## Causes and prevention of low back pain in young athletes

Posted: Oct 1 2009

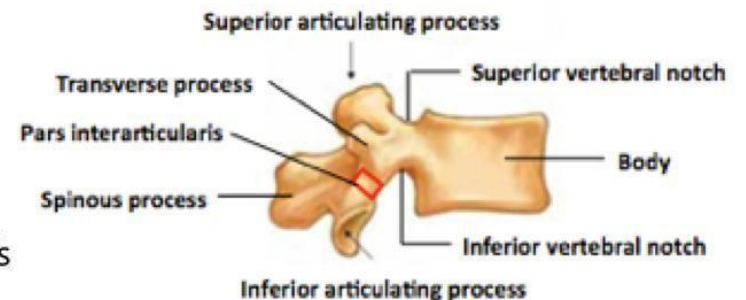
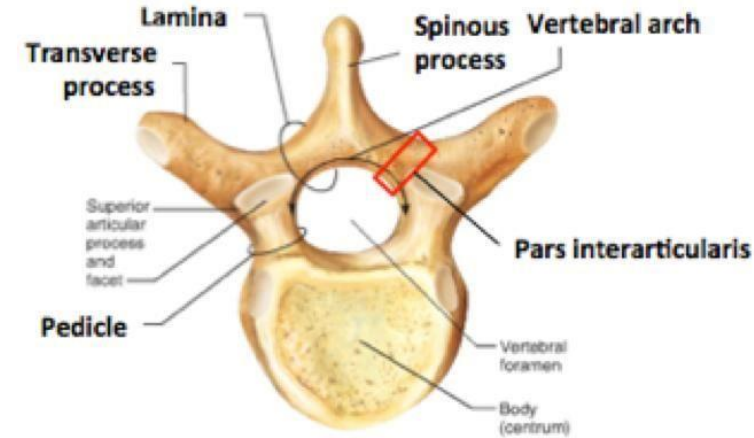
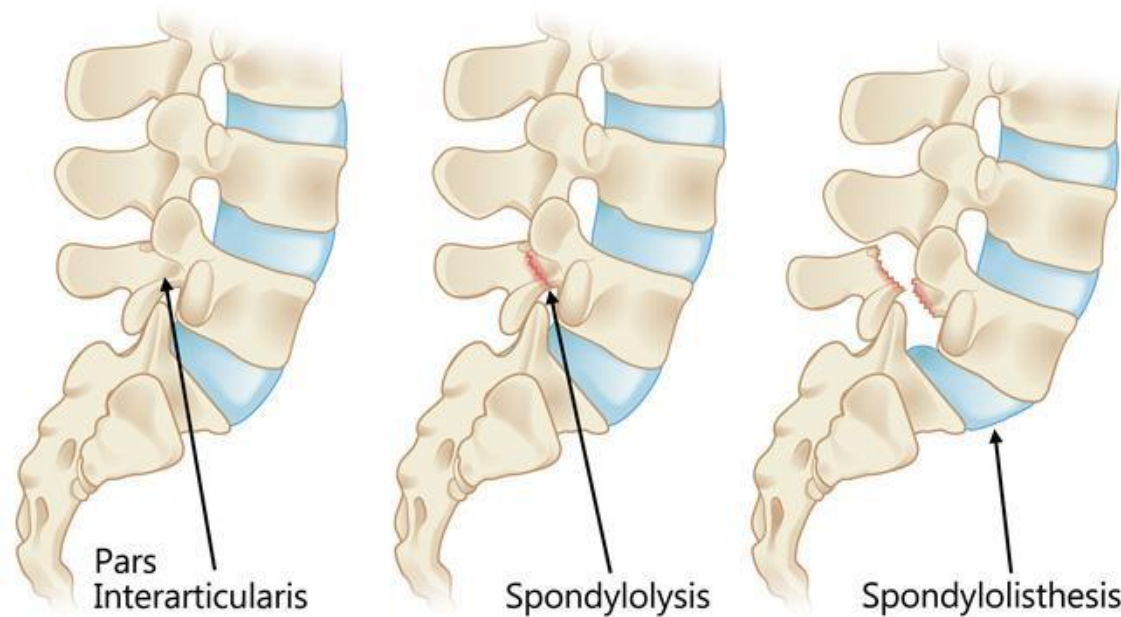
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# Spondylolysis

- Who is at risk?
  - Athletes performing repeated extension/rotation
- How does someone present with it?
- What is spondylolisthesis?

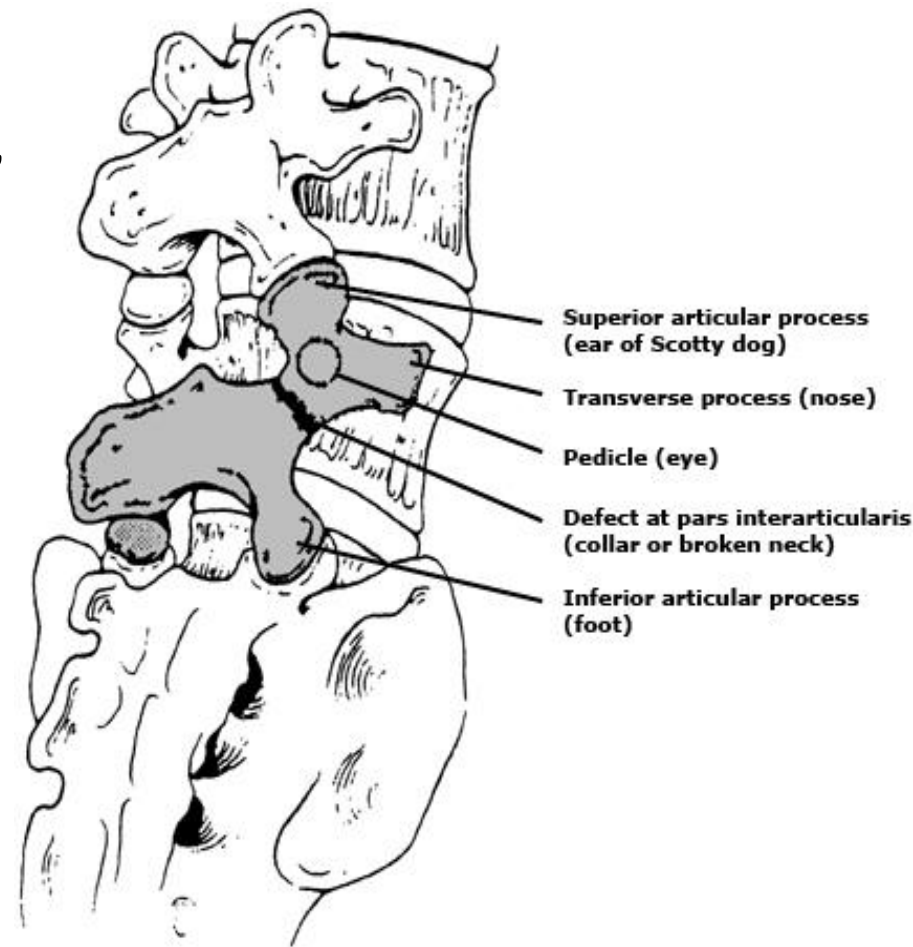
# Spondylolysis

- Stress fracture in pars interarticularis Posterior arch of spine
- L5 >> L4



# Spondylolysis

- Can order oblique view lumbar x-rays, bone scan, CT
- Principles of rest, NSAIDs to start, physio
- Rarely need surgical intervention:
  - unless persistent ++ pain
  - Neurologic sx
  - forms of spondylolisthesis



# LOWER BACK PAIN

- Causes?
  - Spondylolysis
  - Posterior element overuse
  - Vertebral avulsion fracture
  - Disc herniation



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PRACTICE POINT

## Causes and prevention of low back pain in young athletes

**Posted:** Oct 1 2009

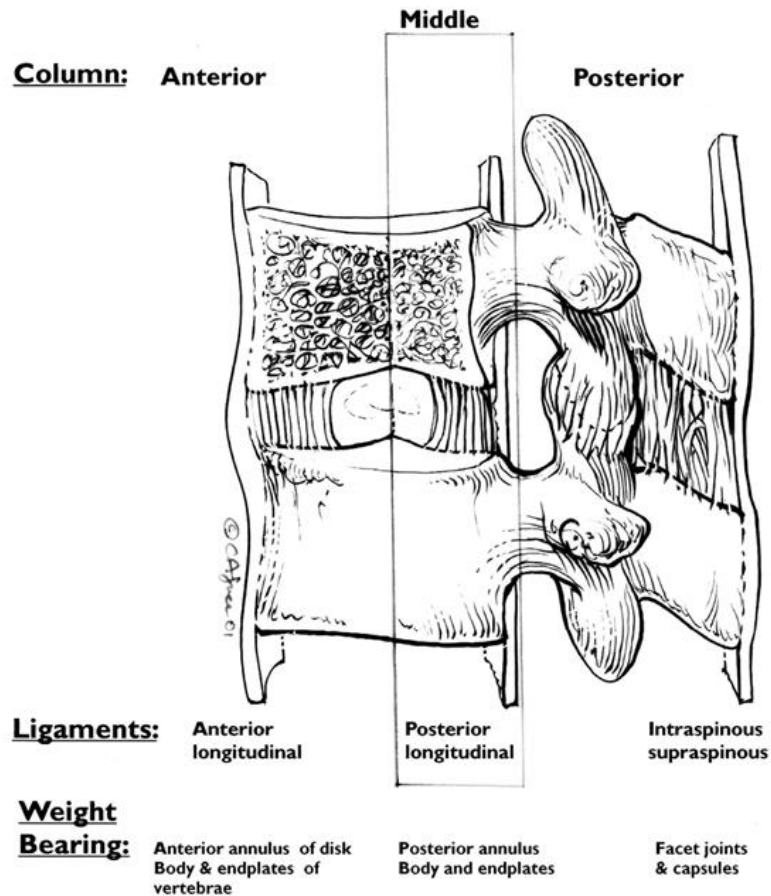
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## ***Case 2***

- 7 year old at the playground, falls off the side of a slide, gets up and walks away from it, but complains of persistent mid-back pain
- How do you assess the child's back pain?



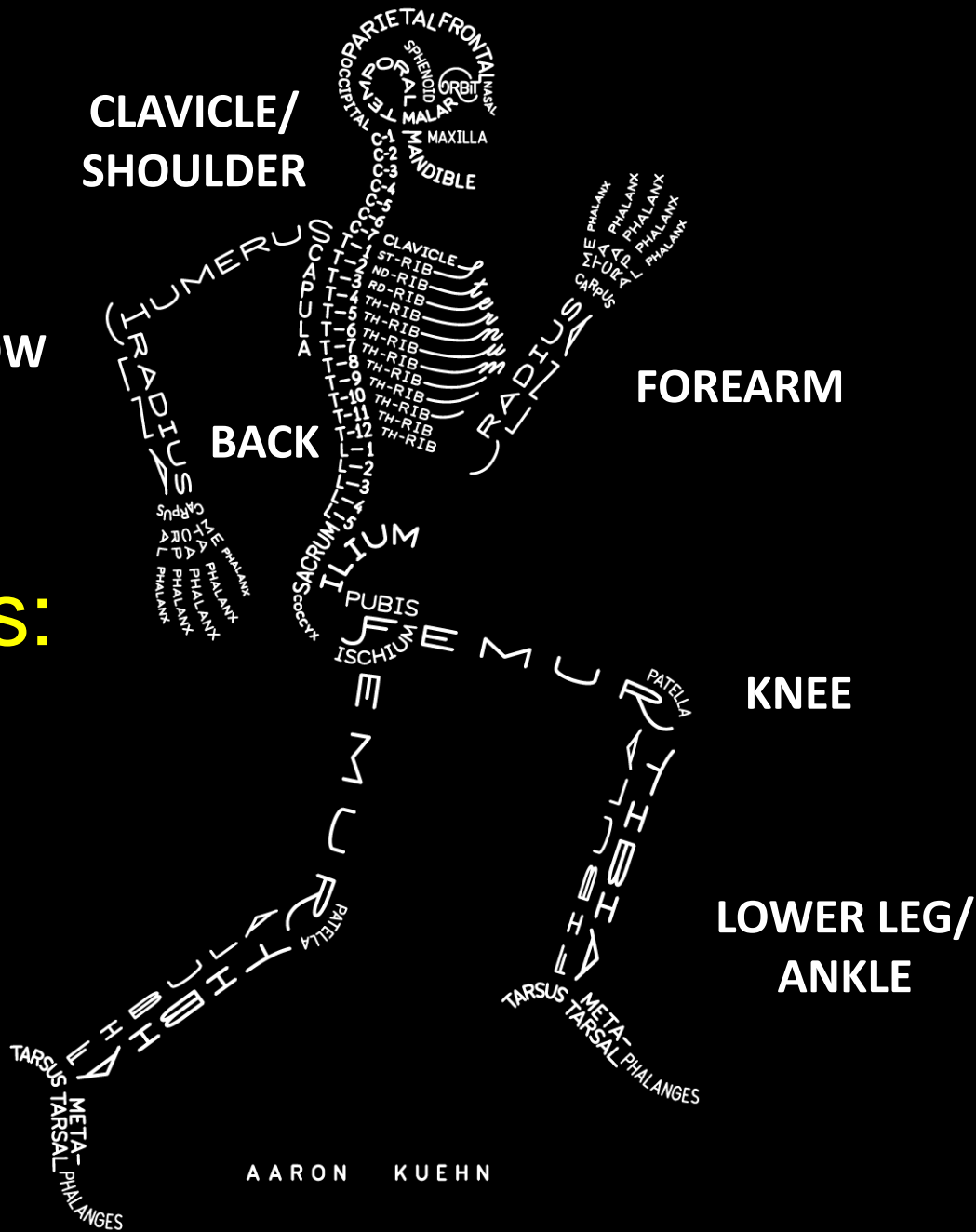
# L1 compression fracture



# Compression fractures

- Hyperflexion and axial/compressive loading
- Anterior column compressed
- CT used to confirm that vertebral body pedicles and lamina are intact
  - Consider if more than 50% compression or medial or posterior columns not intact on x-ray
- Often managed conservatively; ortho consultation
- Do not return to sport unless no pain

# MSK injuries: Let's get specific...



# Summary

- Approach injuries as acute vs chronic/overuse
- Create ddx based on the different tissues at the site of pain
- Know your anatomy and MSK exam!
- Remember basic injury management principles
- Some fractures are more common in peds than others, and management is typically conservative
- Emphasize the right time to return to play to avoid longer-term issues/ re-injury

# QUESTIONS?

