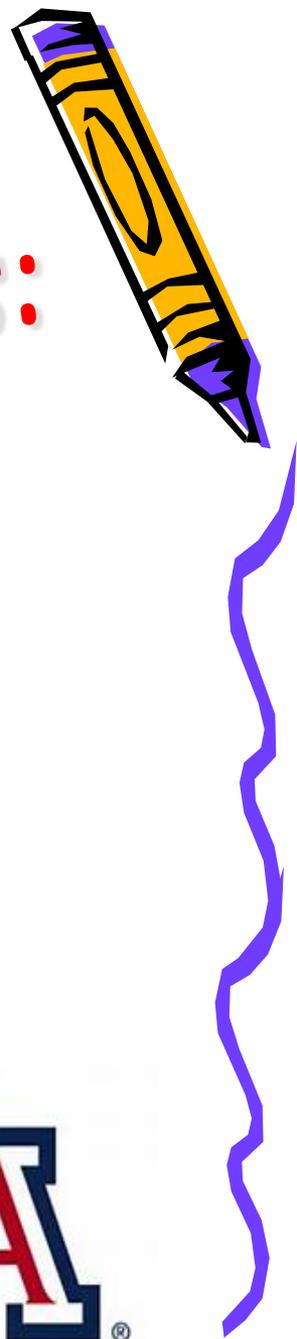
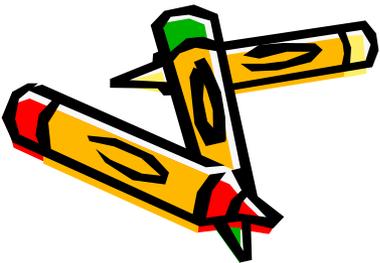


# Pediatric Orthopedics: Basics and Beyond

- Dale Woolridge, MD, PhD
- Professor, EM, Pediatrics, Biochemistry
- University of Arizona

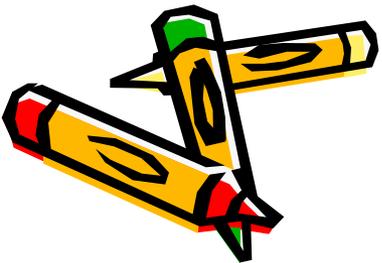
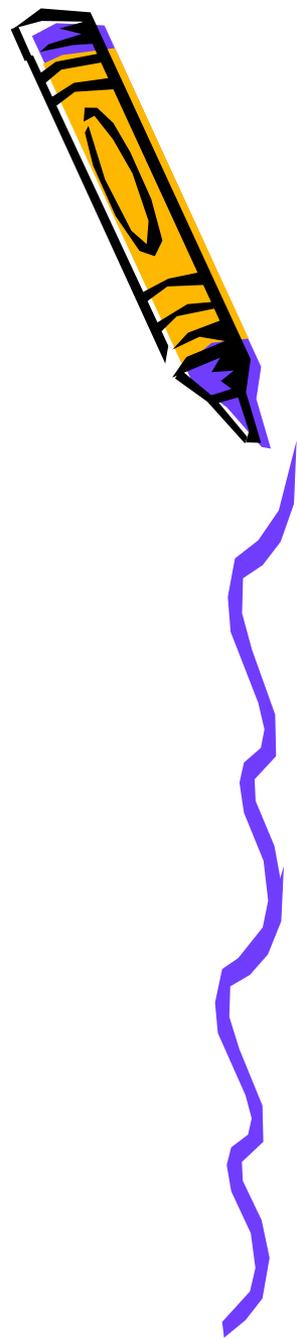


# Disclosures

- No financial disclosures

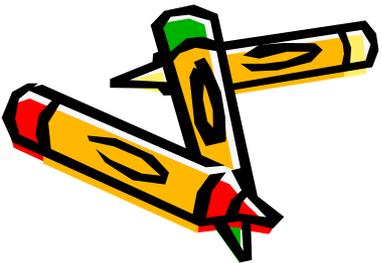
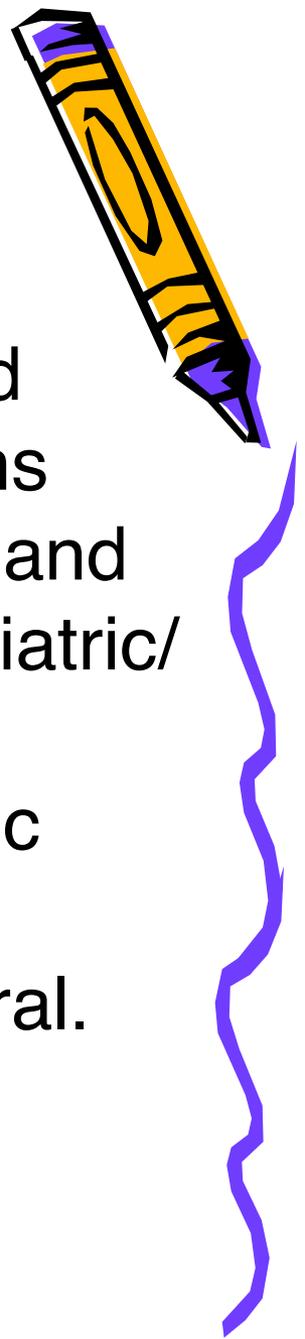
# Conflicts

- No conflicts of interest



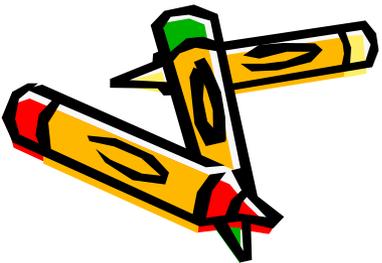
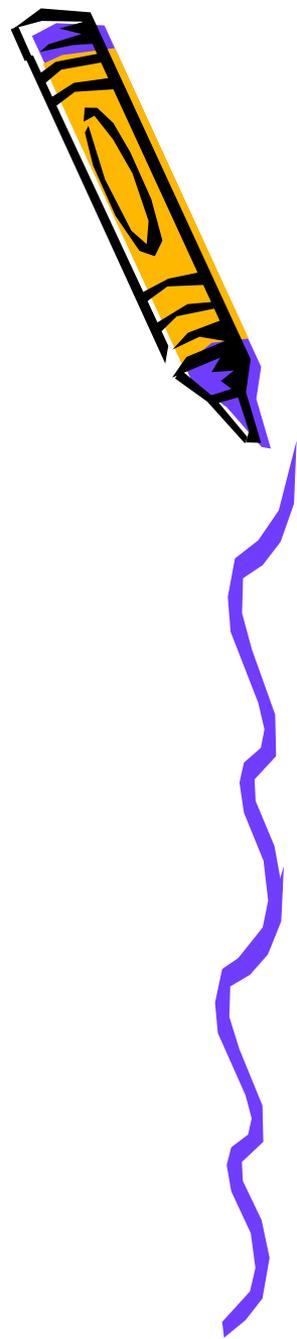
# Objectives

- Summarize the differences between adult and pediatric MSK systems and injury mechanisms
- Identify common pediatric orthopedic injuries and problems, particularly those that relate to pediatric/adult MSK differences
- Review treatment options of common pediatric orthopedic injuries and problems
- Discuss indications for immobilization & referral.



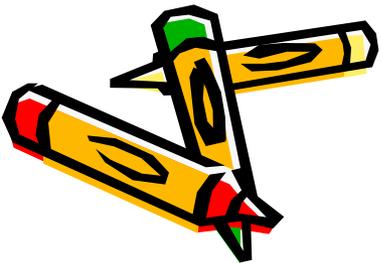
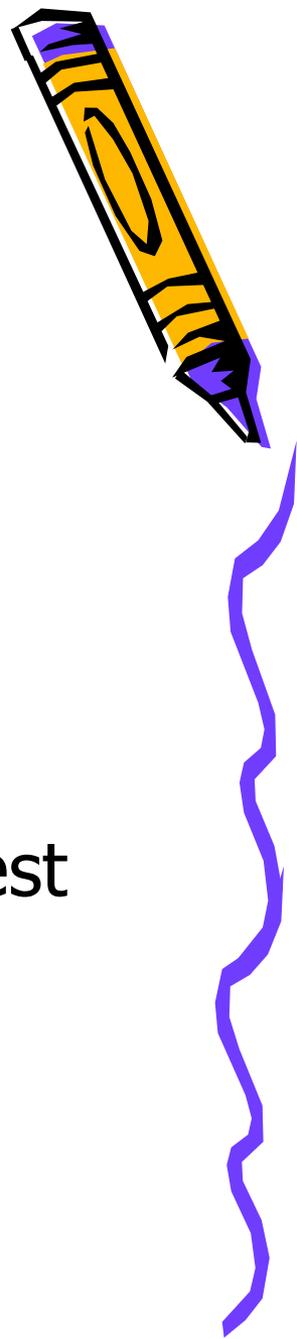
# Scope of the Problem

- Kids fall down and go boom, often.
- Ortho injury = 15 % peds ED visits.
- Musculoskeletal injuries on the rise:
  - Inc. participation in organized athletics.
  - Emergence of “extreme sports”.
  - Dreaded scooters and trampolines.
- Anatomic & Physiologic Differences...



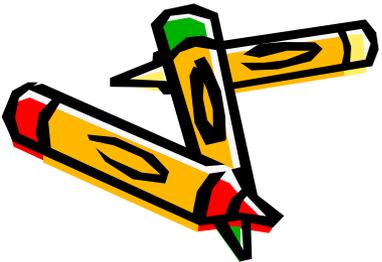
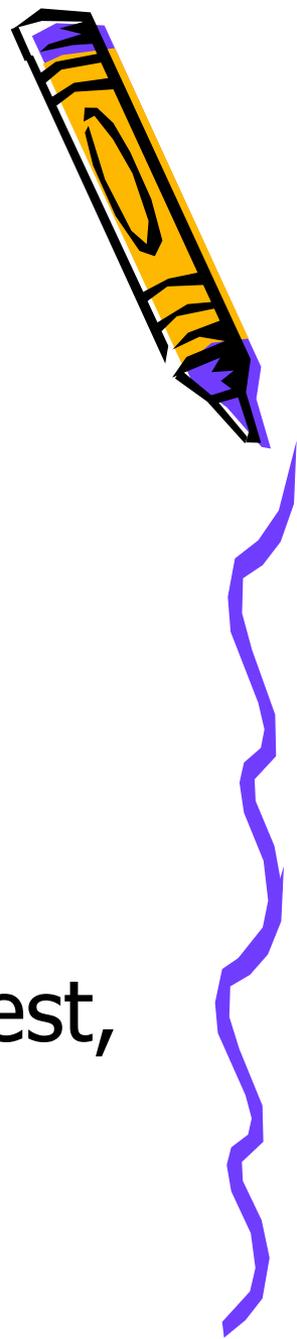
# Pediatric Differences

- Bony Architecture in Children:
  - Thick & active periosteum.
  - Open growth plate (physis).
  - Presence of epiphysis (2° ossif center).
  - More porous and pliable than adults.
  - Ligaments relatively stronger than weakest part of bone (physis, etc.)



# Pediatric Differences

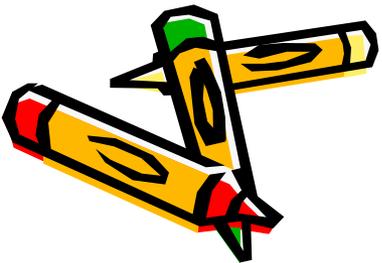
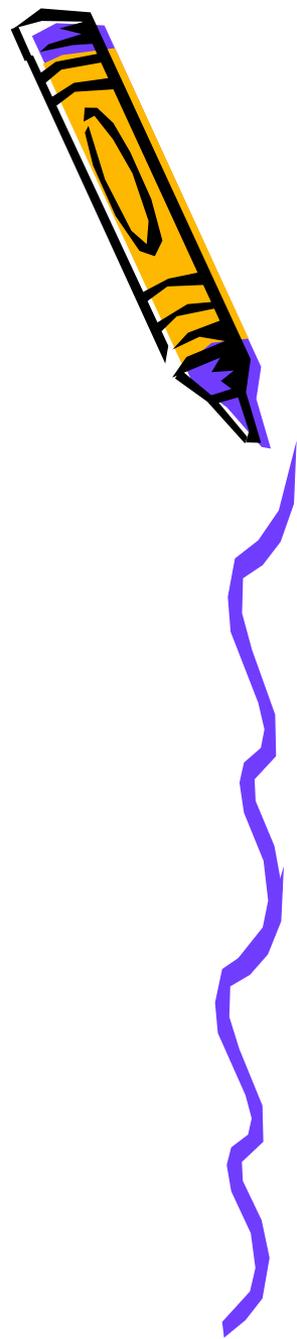
- Fractures more common in children.
- Ligament injuries are uncommon.
- Bone more plastic and deformable.
- Bone healing is rapid in children and capacity for remodeling is greater.
- Associated complications: growth arrest, loss of ROM, deformity.



# Description of Fractures

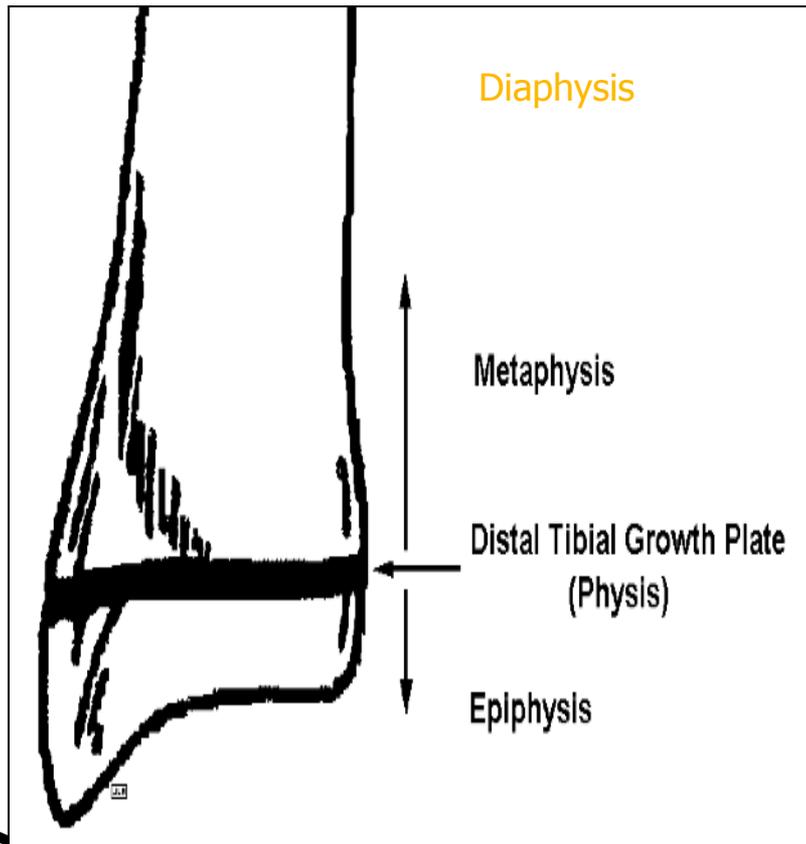
## A Systematic Approach

1. Open or Closed
  - (Clinical, not radiographic!)
2. Anatomic Location
3. Direction of Fracture Line
4. Position and Alignment
5. Salter Harris Classification

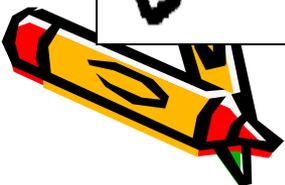
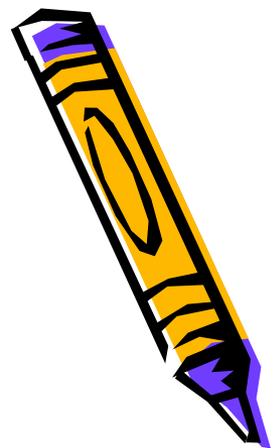


# Description of Fractures

## Anatomic Location

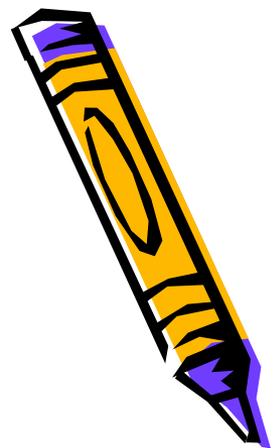
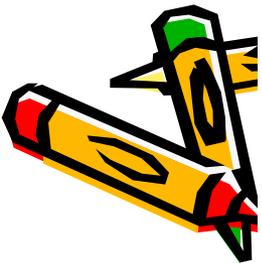
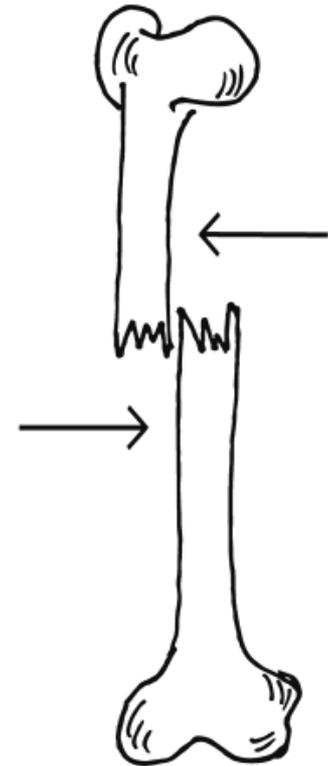
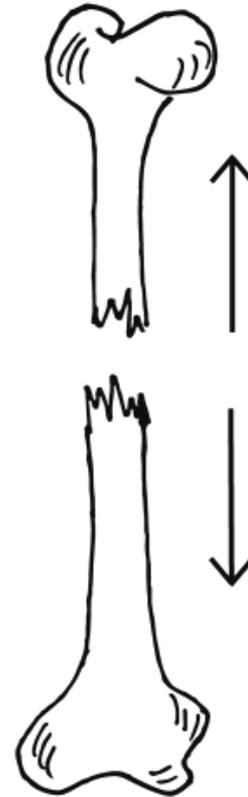


- Name of Bone.
- Segment of Bone: Distal/Proximal/ Mid-shaft/Physis
- Intra-articular.



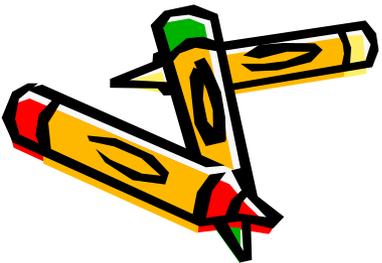
# The Lingo

- Angulation
- Shortening/Distrraction
- Displacement
- Open/Closed
- Comminuted
- Intra-articular

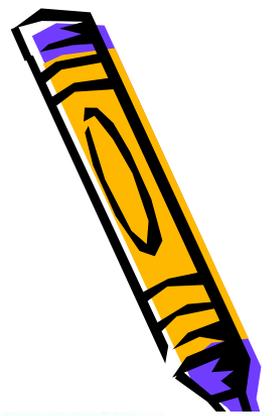


# Pediatric Orthopedic Basics

- Children's bones:
  - Withstand greater force and heal more rapidly
  - Remodeling potential allows for more malalignment and angulation to be accepted.
  - New bone is laid down in the plane of motion of the joints (typically accept up to 30° angulation).
- Children rarely need PT as part of their treatment plan for their fractures and tolerate lengthy immobilization



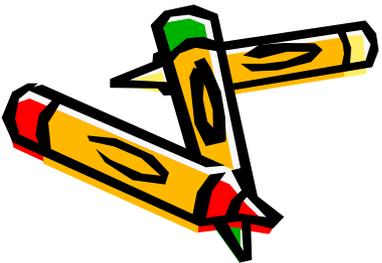
# Remodeling



1 month

4 months

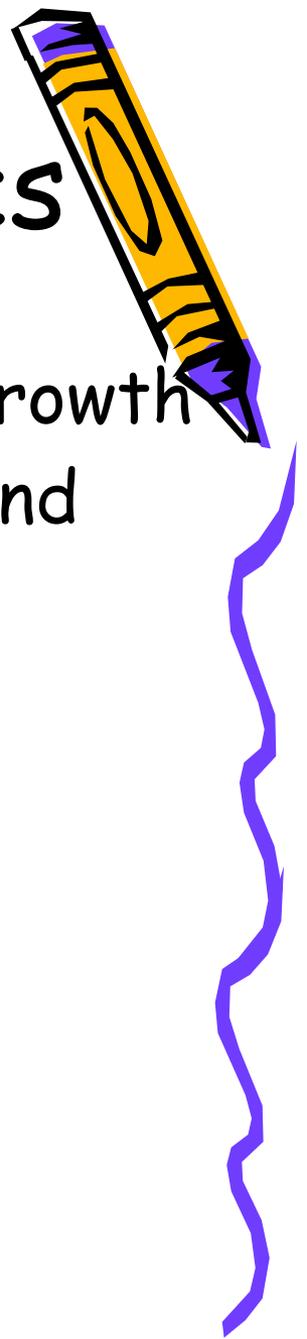
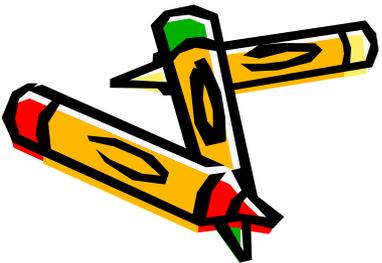
6 months



# Pediatric Orthopedic Basics

General rule: Kids are more likely to have growth plate injuries or fractures than sprains and dislocations.

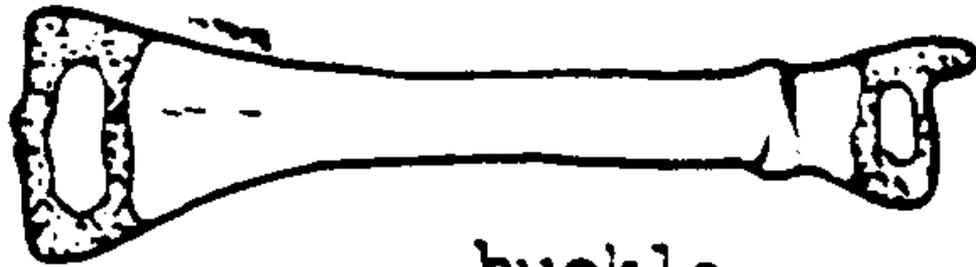
- Fractures unique to kids
  - Plastic deformity
  - Torus (buckle) fracture
  - Greenstick fracture
  - Fractures involving the physis



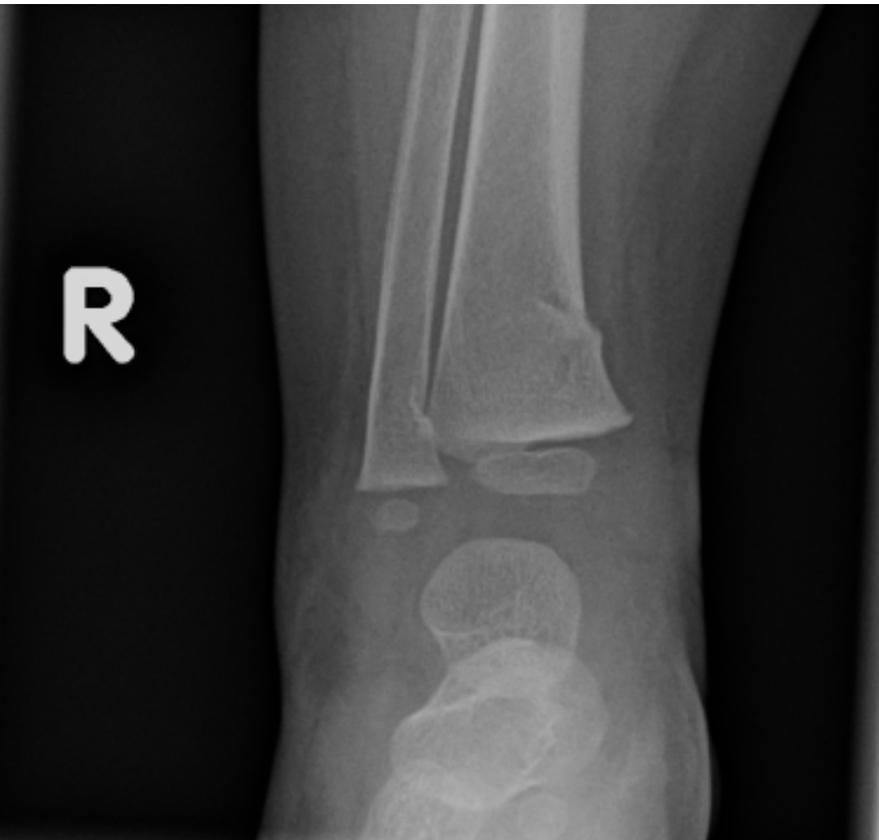
# Plastic Deformity



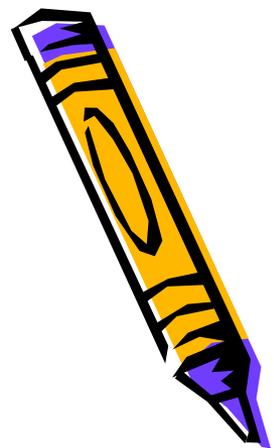
# Torus (Buckle) Fracture



buckle

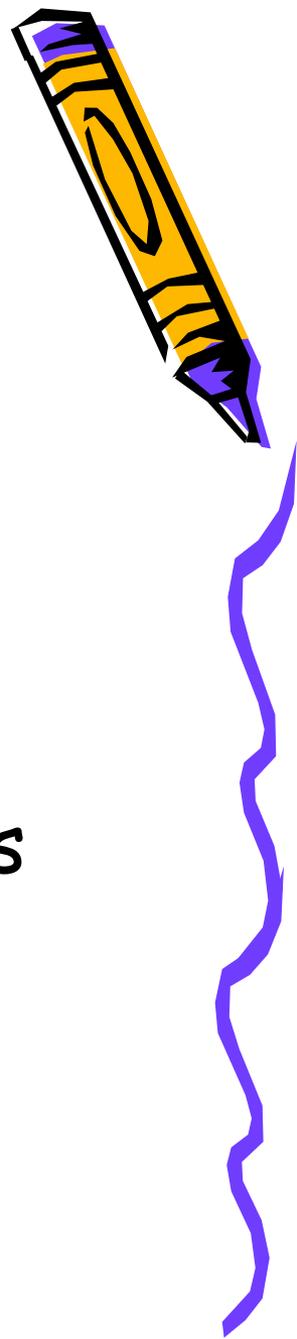
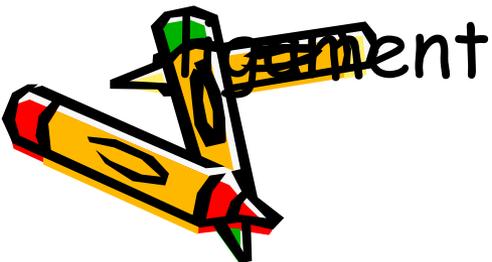


# Greenstick Fracture



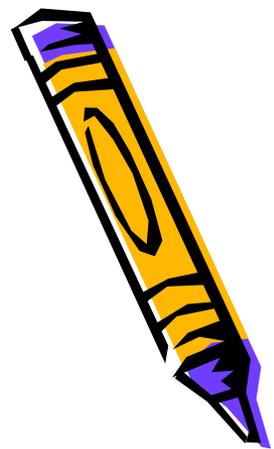
# Physeal fractures

- Physis = Growth plate
- Composed of cartilage
- The Site of "bone growth"
- Well vascularized
- Heal in  $\frac{1}{2}$  the time of long bone injuries
- Will separate or fracture before disruption or spraining of an adjacent



# Physeal fractures

Or... "S-A-L-T-E-R"



Slipped



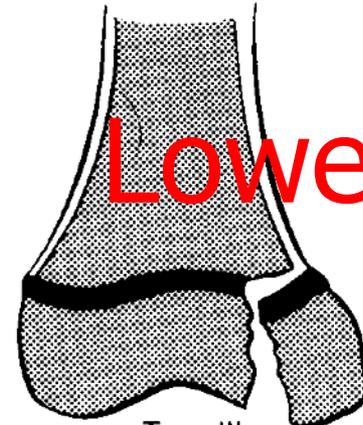
Type I

Above



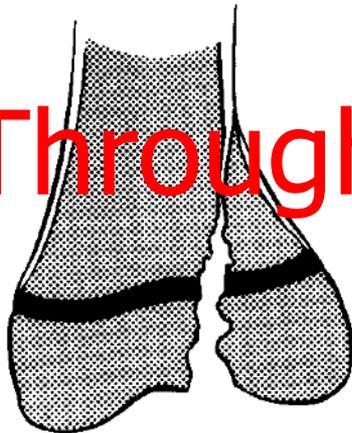
Type II

Lower



Type III

Through

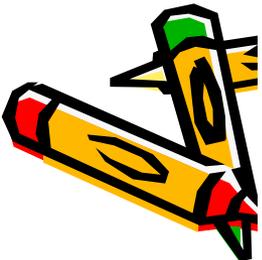


Type IV

Rammed

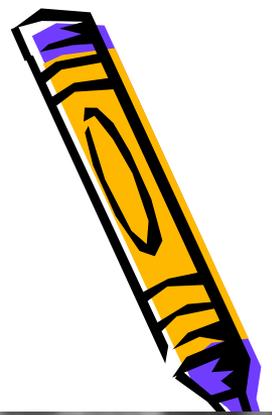
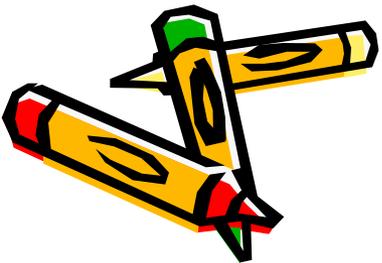


Type V



# Salter Harris I

- Fracture along the physis only (5%).
- Mostly a clinical diagnosis of tenderness over the physis.
- May see a widening or displacement
- Comparison views may help

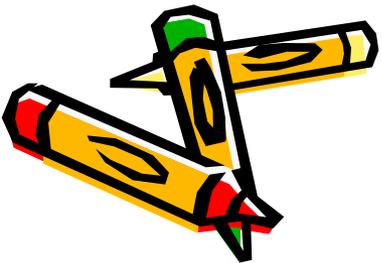


# Salter Harris I

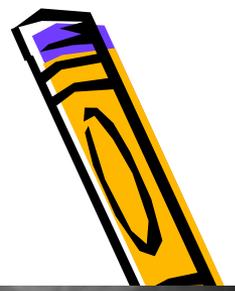


- Therapy
  - Ice/elevate
  - Reduction if needed
  - Immobilization for 2-3 weeks.
  - Follow up with Ortho 5-7 days.
  - Prognosis is excellent if near anatomic reduction is achieved.
  - Very low likelihood of growth abnormalities.

Tenderness at the growth plate without Xray findings = SH I



# Salter Harris II



- Fracture along the physis and the metaphysis with a fragment attached to the epiphysis.
- 75% of physeal fx's
- Thurston Holland fragment.

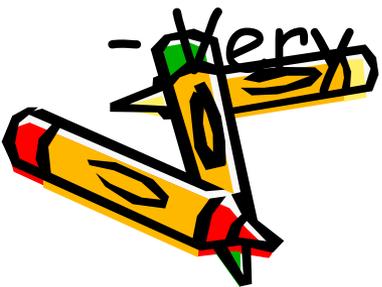




# Salter Harris II

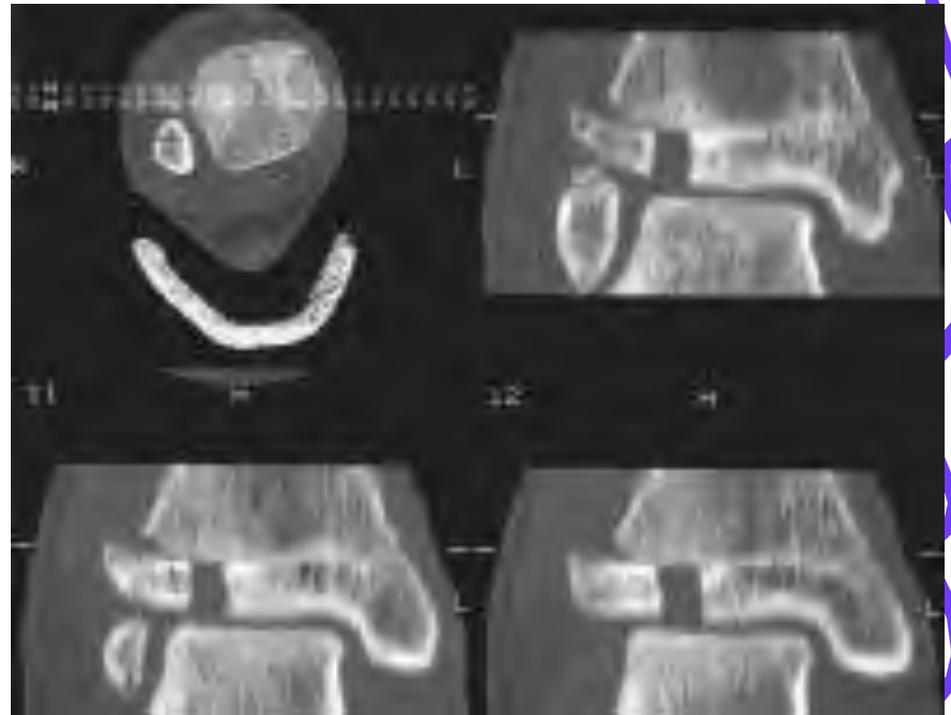


- Therapy
  - Reduction if needed.
  - Immobilization.
  - Follow up with Peds Ortho 5-7 days.
  - Prognosis is good in near anatomic reduction.
  - ~~Very~~ low likelihood of growth abnormalities.



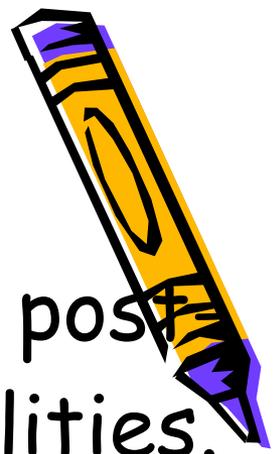
# Salter Harris III

- Fracture that begins intrarticularly and travels through the epiphysis into the physis (10%)
- Often occur in children with partially closed physis



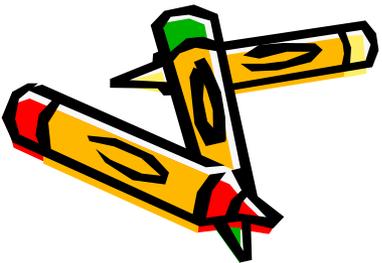
# Salter Harris III

- Adequate reduction needed to avoid post traumatic arthritis/growth abnormalities.
- Prognosis is favorable if adequately reduced and depends on the preservation of perfusion to the fragment.
- Therapy
  - Ortho consult in the ED.
  - Open vs closed reduction/Immobilization.
  - Follow up with Peds Ortho.



# Salter Harris IV

- Fracture line begins intraarticularly and travels through the epiphysis, physis and metaphysis
  - 10% of physeal injuries
- injuries



# Salter Harris IV

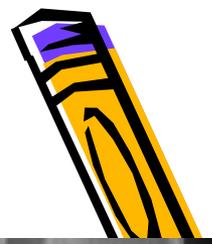


- Therapy
  - Orthopedic consult.
  - Open reduction/Immobilization.
  - Perfect reduction needed to avoid growth arrest.
  - Prognosis depends on the preservation of the physis and perfusion to the bony fragment.

Increased likelihood of growth abnormalities/post traumatic arthritis



# Salter Harris V

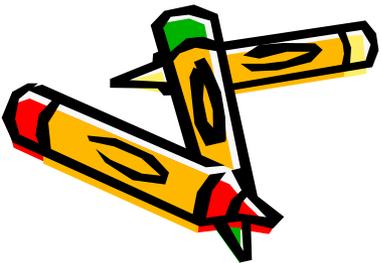


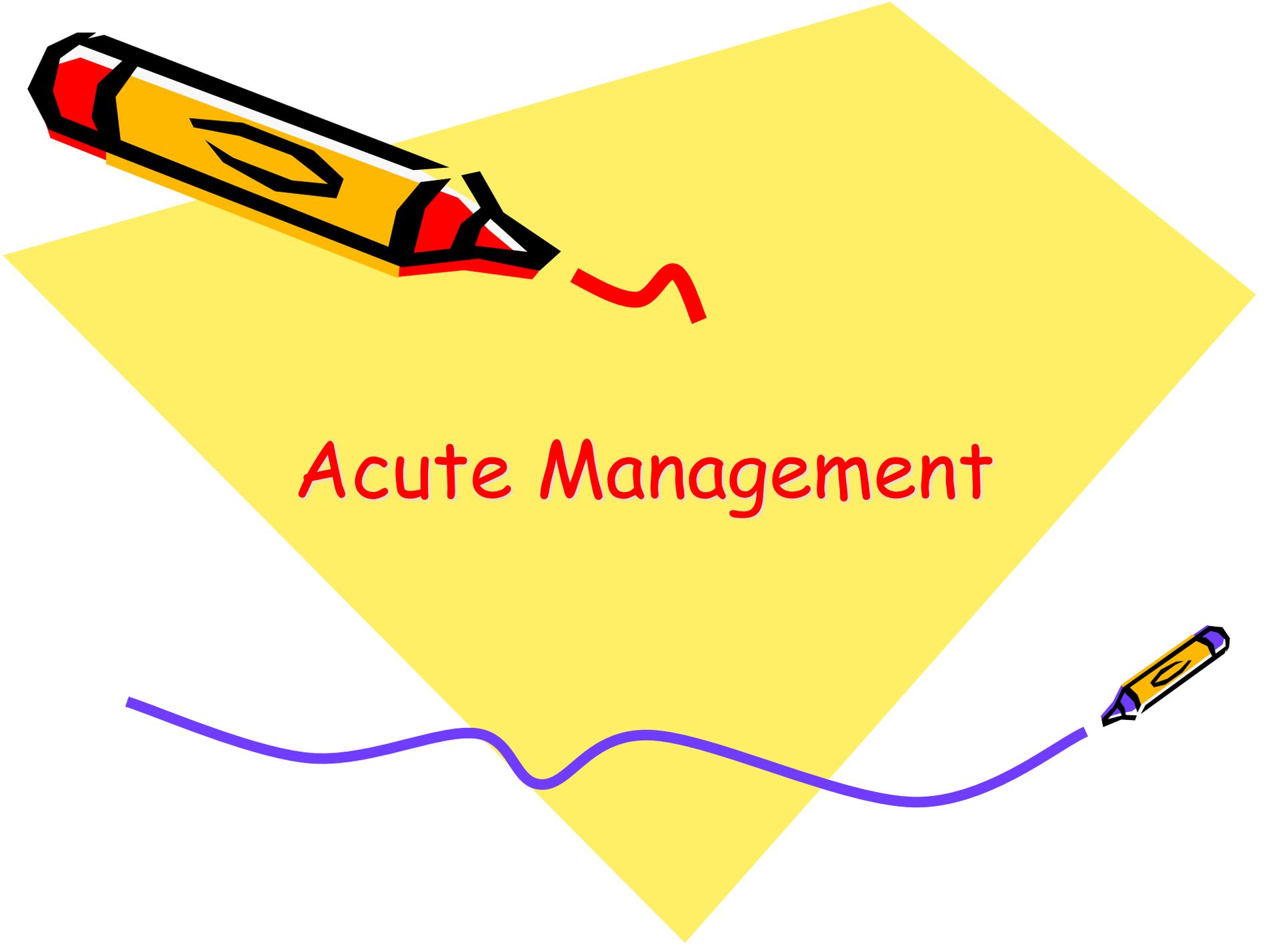
- Pysis is crushed
- Typical Mechanism of severe abduction or adduction.
- 60% diagnosed as sprain or SH I !!
- True Dx often made in retrospect after growth arrest.
- Often associated with an effusion.



# Salter Harris V

- Therapy
  - Orthopedic consult.
  - Immobilization/Non-weight bearing.
  - Follow up to monitor nearly inevitable focal bone growth arrest.

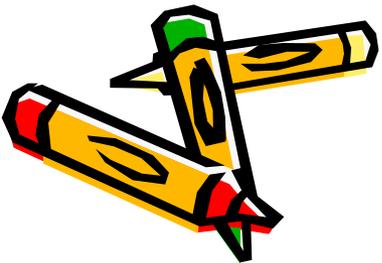
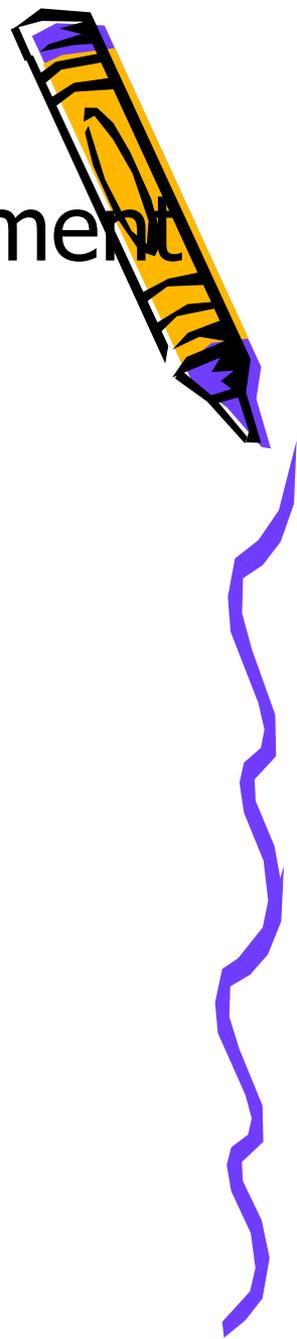




Acute Management

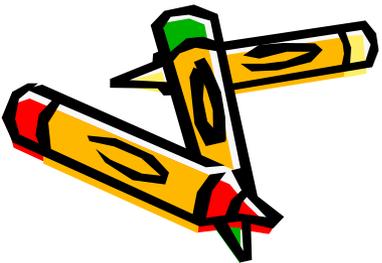
# Approach to Acute Fracture Management in the ED/Clinic

- NPO
- Analgesia
  - Ice
  - Elevation
  - Parenteral analgesia (e.g. morphine)
  - Immobilization with temporary splint



# Approach to Acute Fracture Management

- Rationale for splinting in
  - Prevents movement of fracture fragments
    - Decrease potential for neurovascular injury
    - Decrease risk of converting to open fracture
  - Decrease pain
  - Facilitate patient transport (x-ray, etc)



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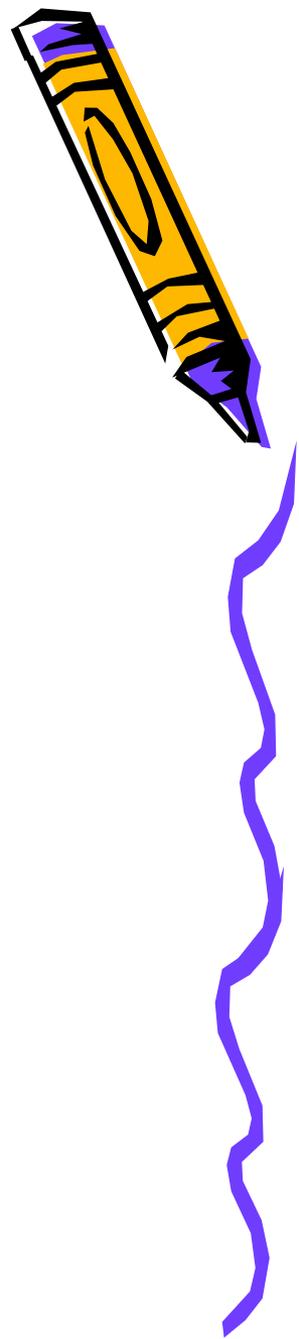
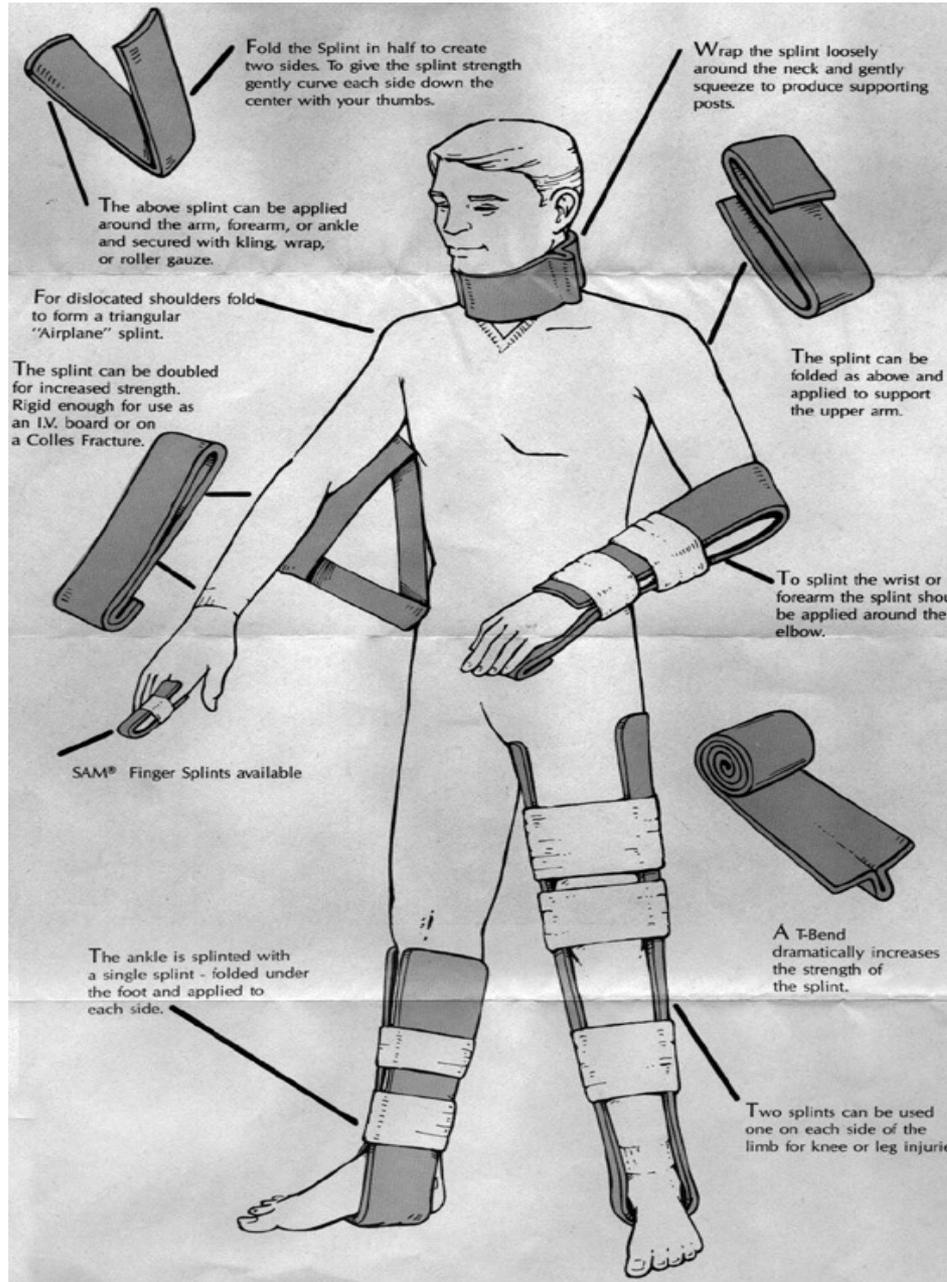
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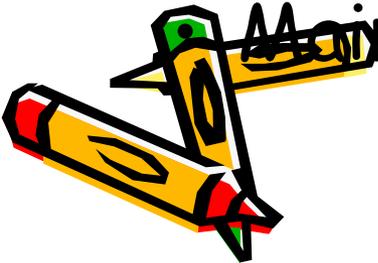


# Splinting Basics



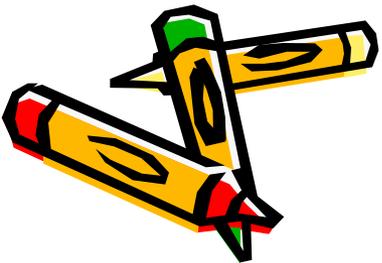
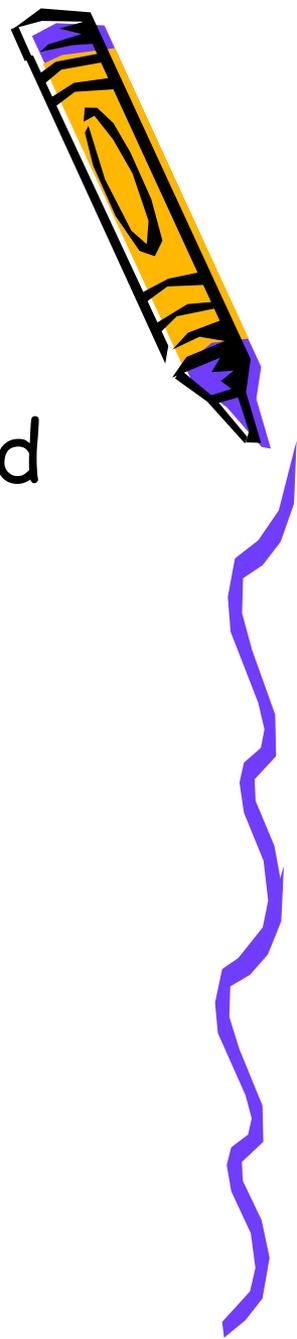
- Temporary Immobilization of Fractures, Dislocations, Sprains, or Soft Tissue Injury.
- Maintain position of comfort; avoid realignment unless N/V necessary
- Extra padding over bony prominences
- Plaster vs fiberglass vs prefabricated Splint Rolls.

Maintain access to assess: N/V injury



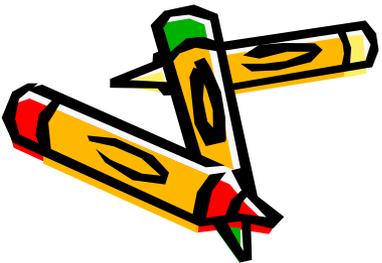
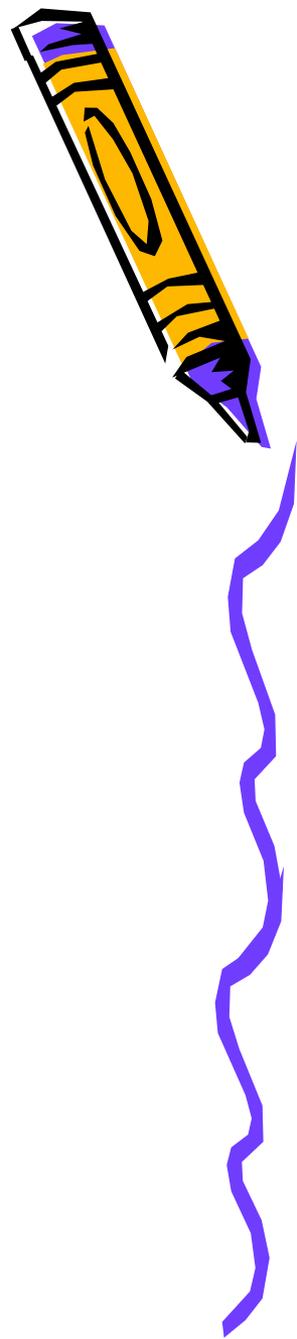
# Case

- 2-year-old boy playing in playground at day care.
- Noted by attendant to be running back to class room crying.
- Not using right arm



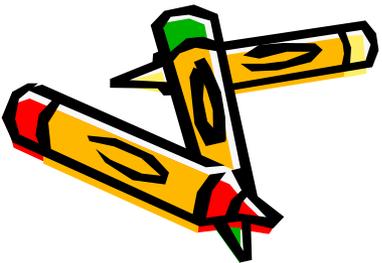
# Exam

- NCAT, well appearing
- Cries/resists with any movement of arm
- Pain appears localized to elbow
- No swelling, deformity, or focal tenderness



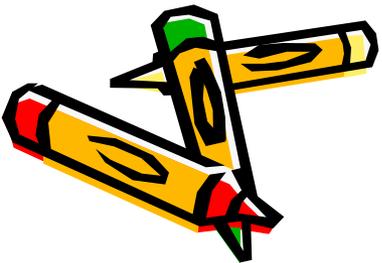
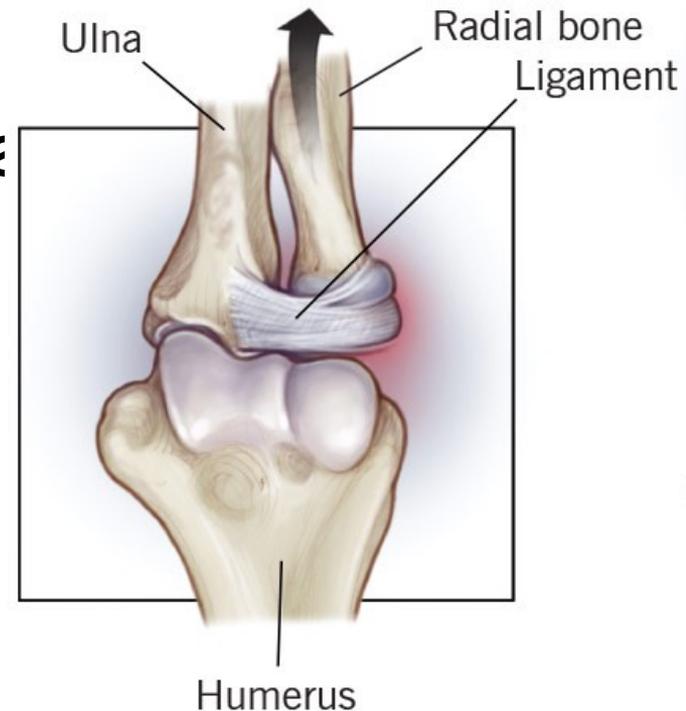
Differential Diagnosis?

Management?



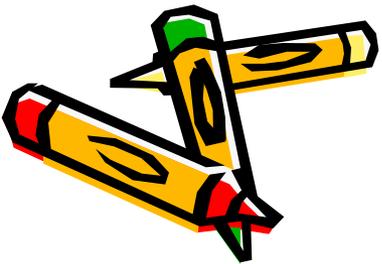
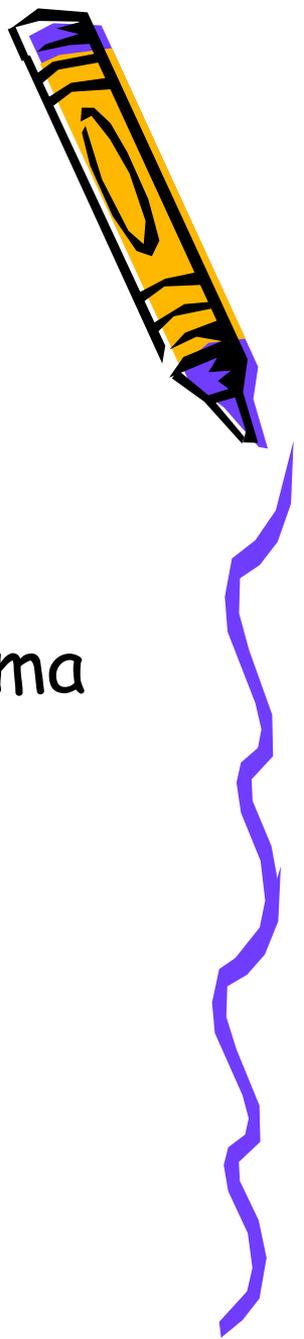
# Nursemaid Elbow:

- Peak incidence between 18-36 months
- Precipitated by traction on arm
  - Swinging by wrists
  - Pulling by arms
  - Struggling into a coat
- Entrapment of annular ligament radial head and capitellum



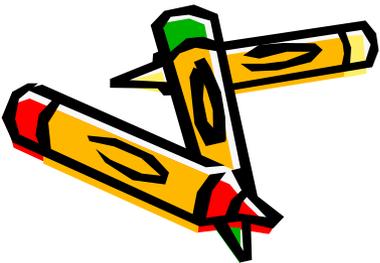
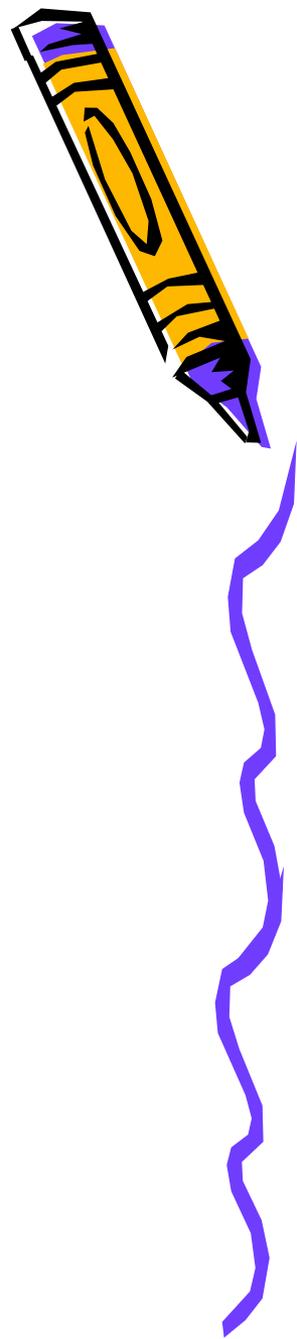
# Diagnostic Studies

- None needed if diagnosis is secure
  - Classic history
  - No focal tenderness, bruising, or edema
- Radiographs of elbow in equivocal cases

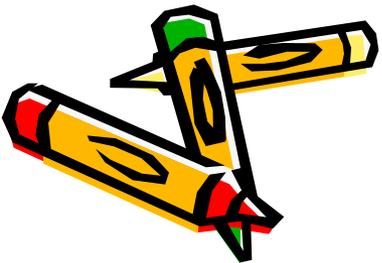
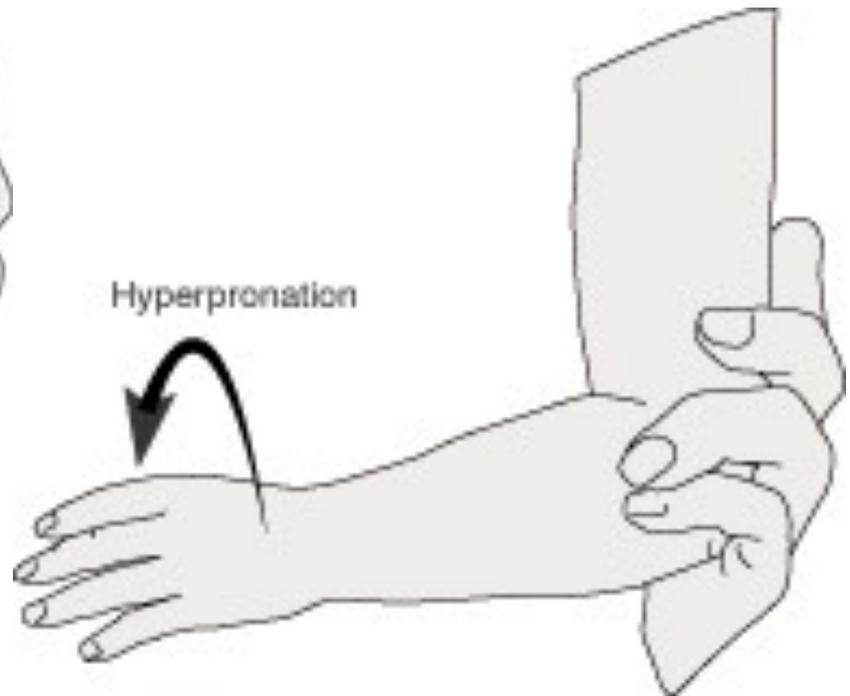
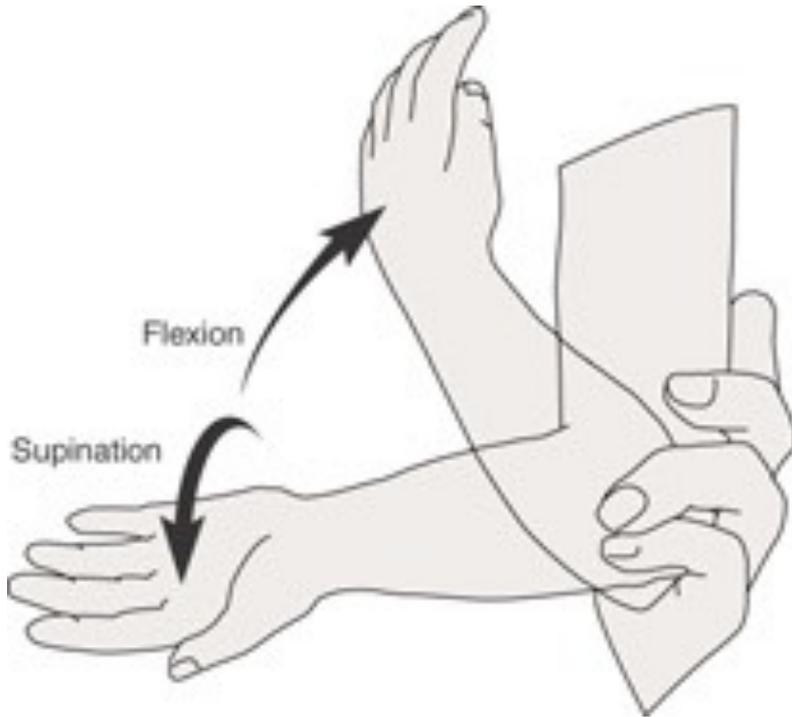


# Management

- Reduce in ED
- Two methods
  - Hyperpronation
  - Supination-flexion
- higher success rate and less pain with hyperpronation technique
  - absolute risk difference - 26%
  - NNT of 4
    - (Bexhens, 2017; Meta-analysis)

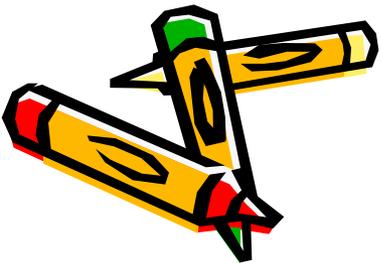
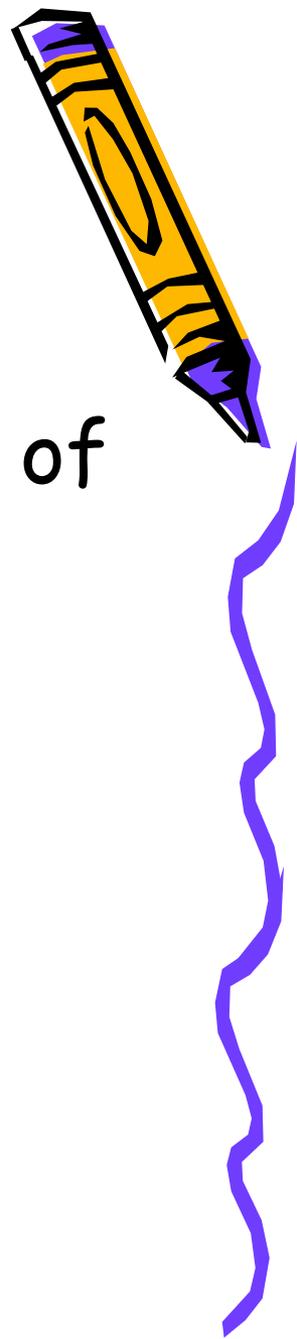


# Maneuvers

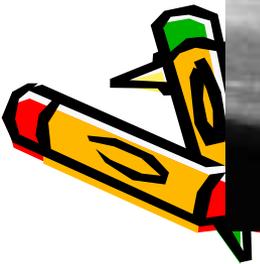
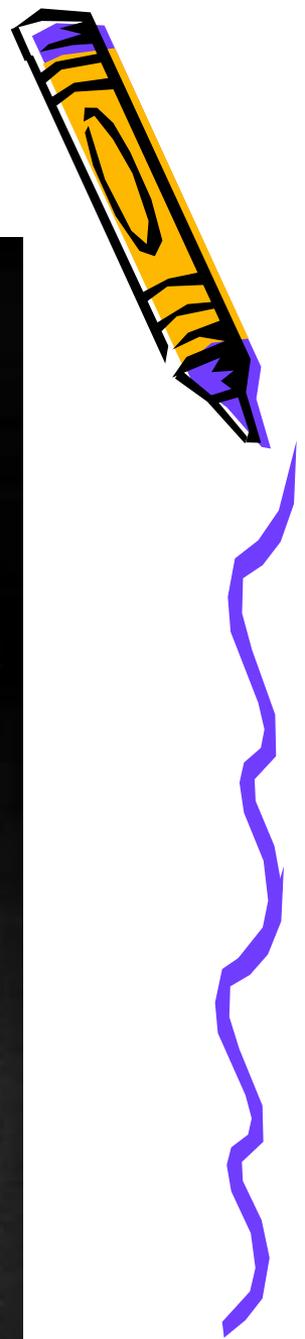


# Disposition

- Patient should demonstrate return of use.
- Ongoing disuse
  - Xray (if not done already)
  - Followup in 5-7 days
  - NSAIDS for pain

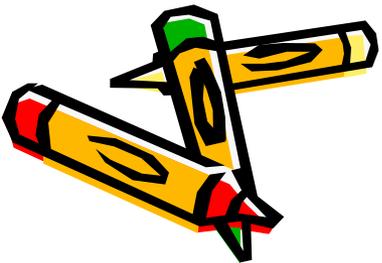
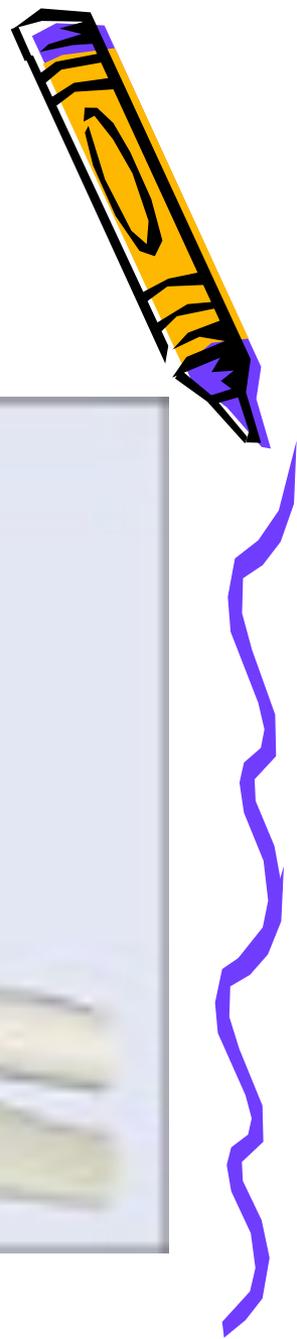


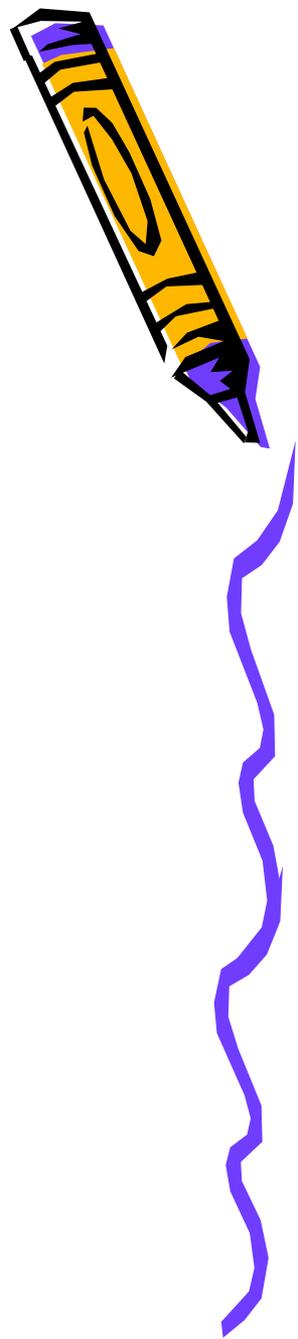
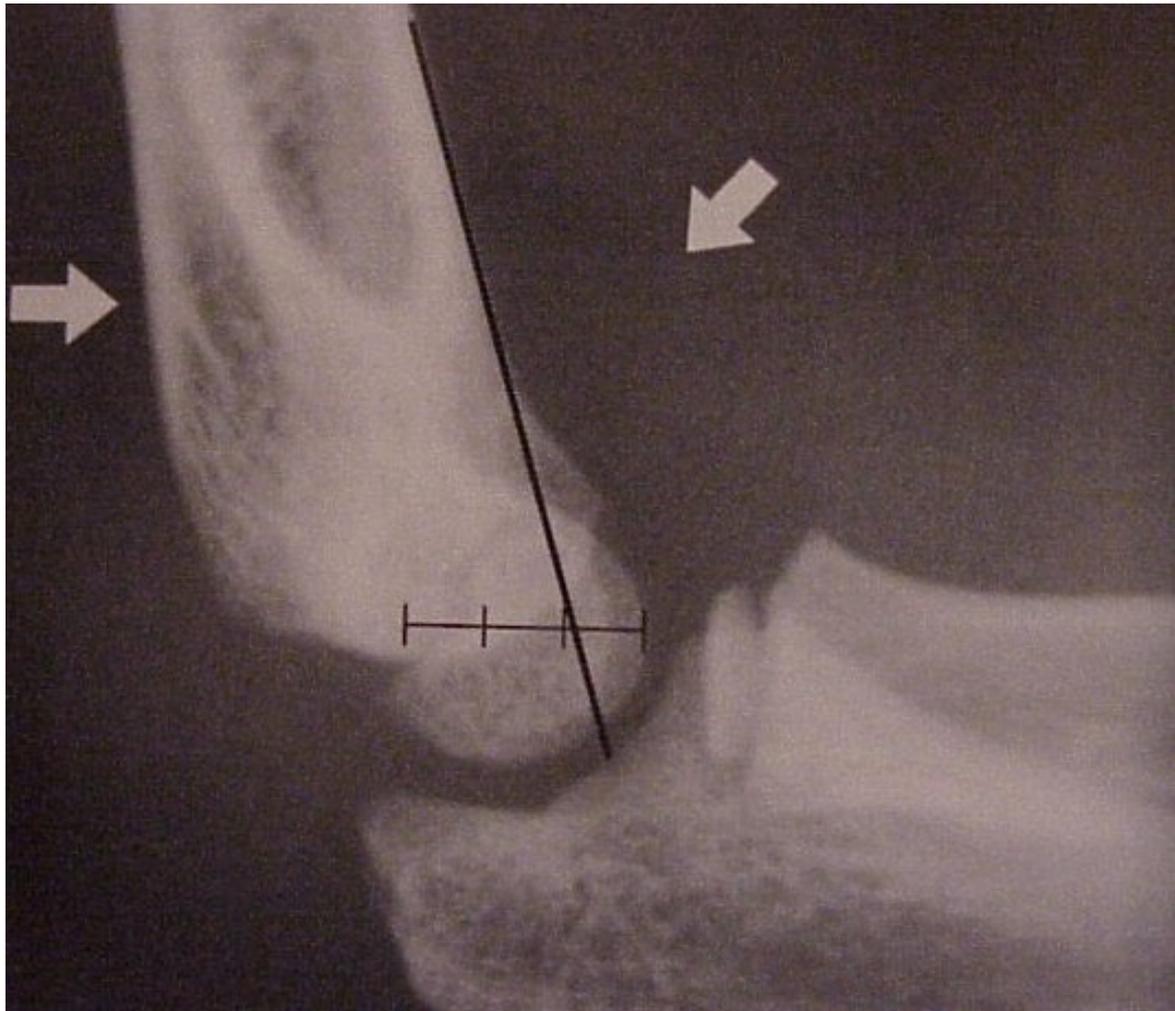
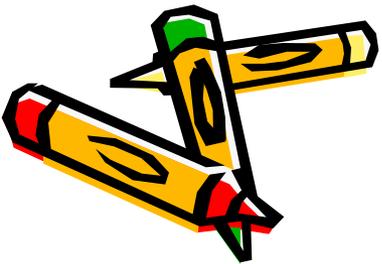
# Anterior humeral line



# Anterior humeral line

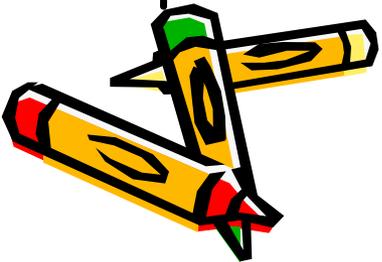
- X-rays: AP in extension and lateral in 90 degrees flexion
- Anterior humeral line: anterior margin of the humerus should intersect capitellum in posterior 2/3;





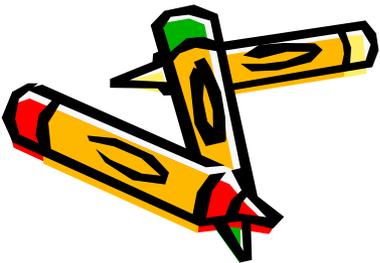
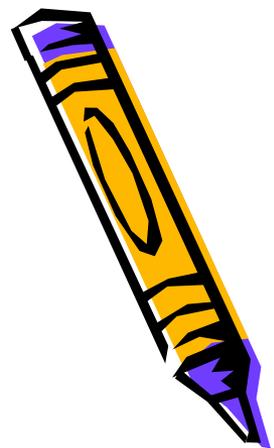
# True lateral

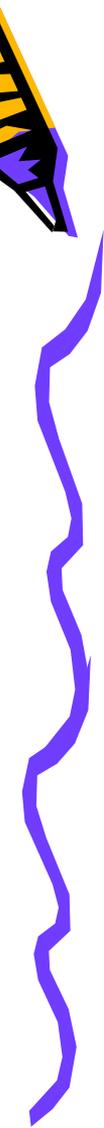
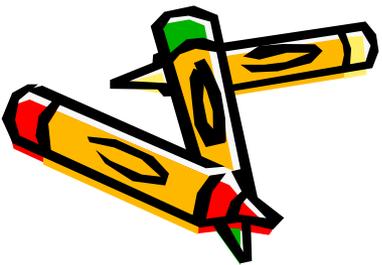
- Figure 8 - hourglass of distal humerus
- Anterior humeral line intersecting anterior 1/3
- Buckle fracture posterior aspect of supracondylar region



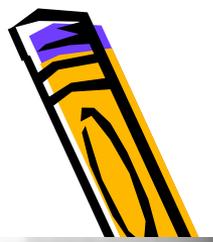
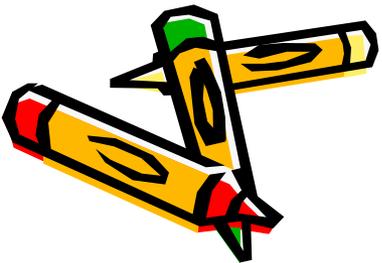
# Supracondylar Fractures

- Most Common elbow fracture (50%)
- Age: 3-10, boys > girls
- Mechanism: Fall onto extended arm which forces the distal fragment upward and posteriorly after fracturing the supracondylar area.
- Vascular compromise (Brachial artery) in up to 5%
- Nerve injury in up to 20%.



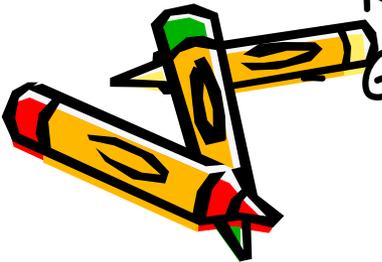
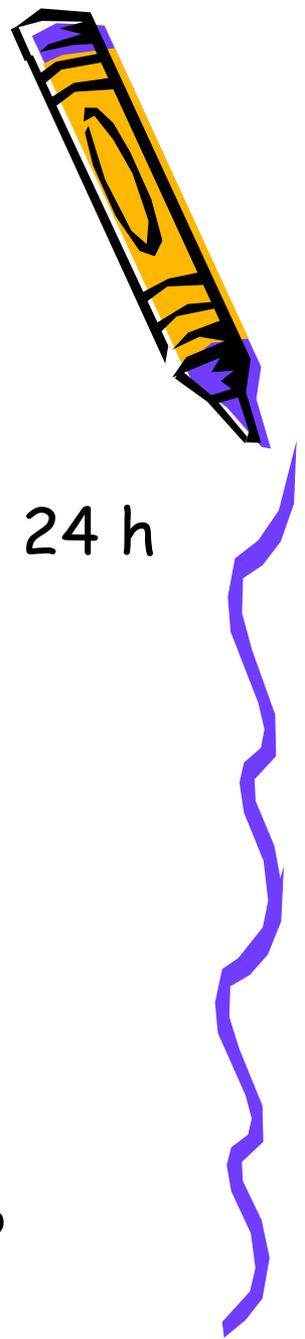


# Fat Pads



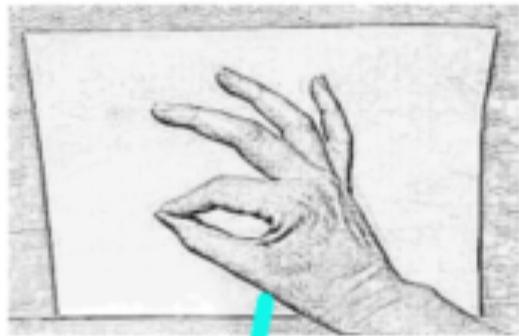
# Treatment

- Fractures non-displaced without NV compromise can be splinted in the ED
  - long arm splint at 80° and discharged with 24 h f/u.
- Displaced fractures without NV compromise
  - Splint at 40° for comfort before surgery
- Displaced with NV compromise
  - Reduced ASAP to avoid tissue necrosis
  - Gentle traction & elbow flexion to 20- 40°



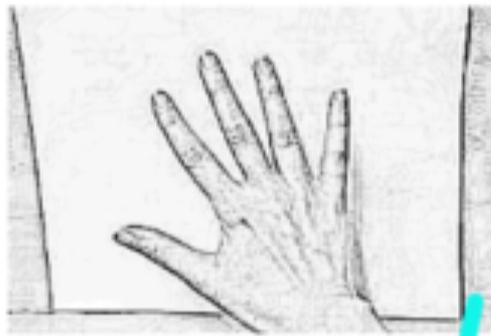


medial  
(C5-C8)



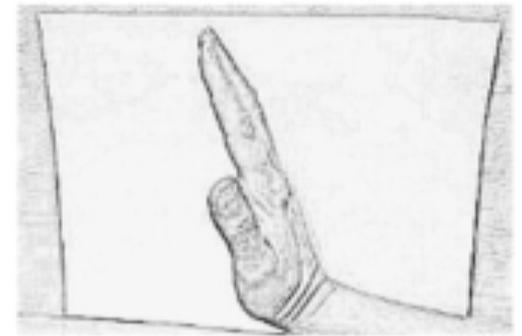
*ok*

ulnar  
(C8-T1)



*spread*

radial  
(C6-C8)



*stop*





# C-R-I-T-O-E



Capitulum  
1

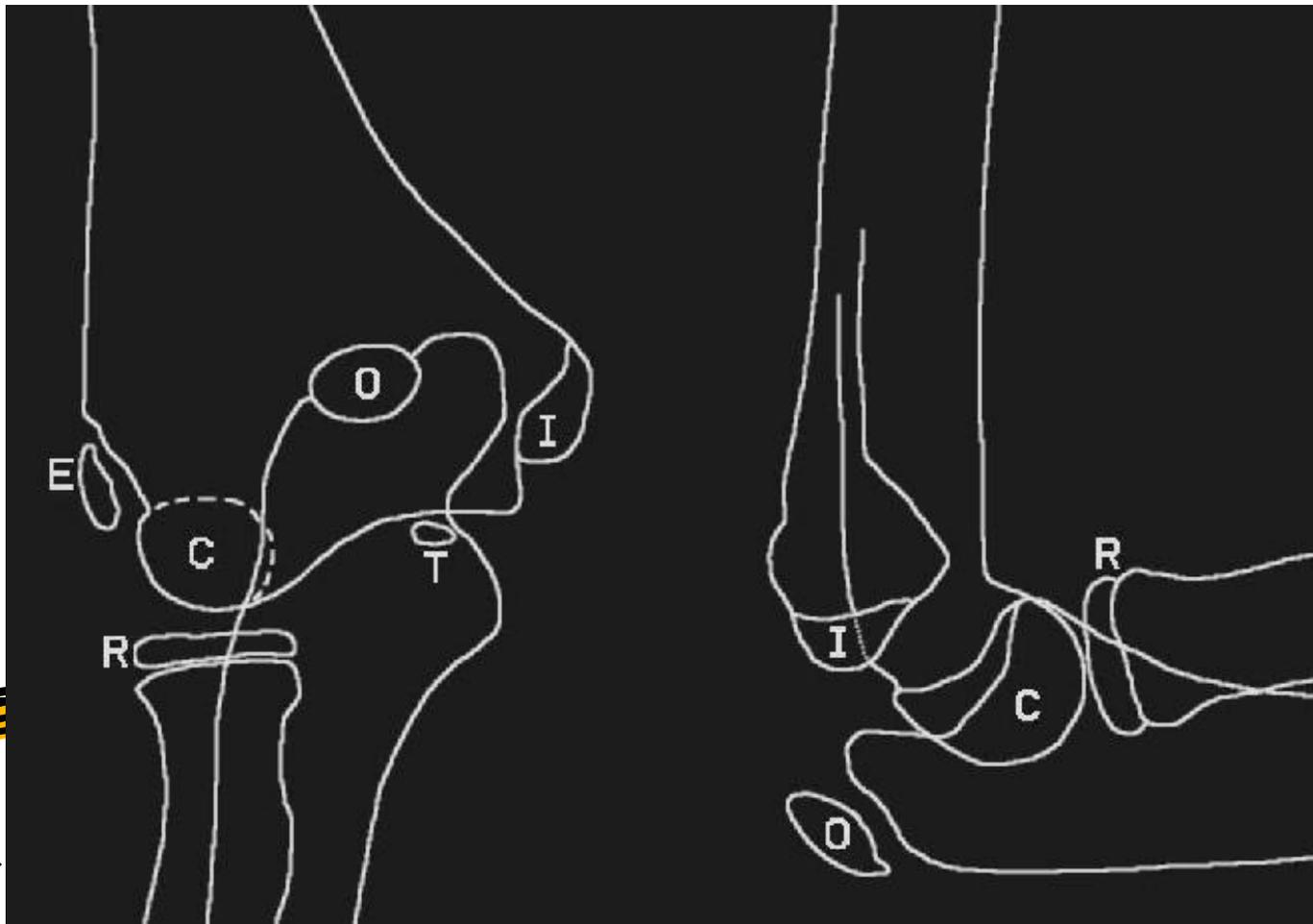
Radial Head  
3

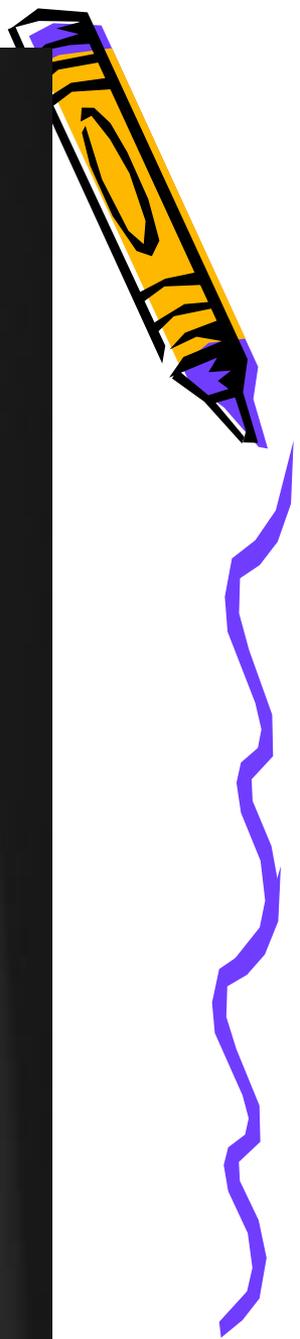
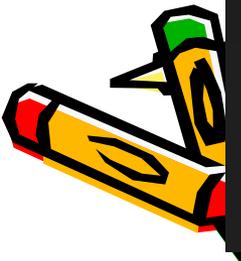
Internal epicondyle  
5

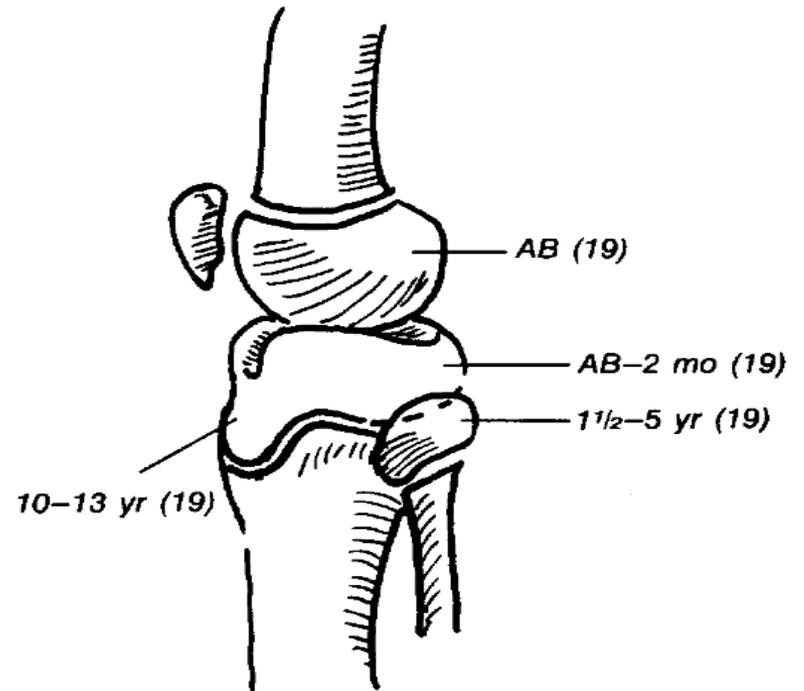
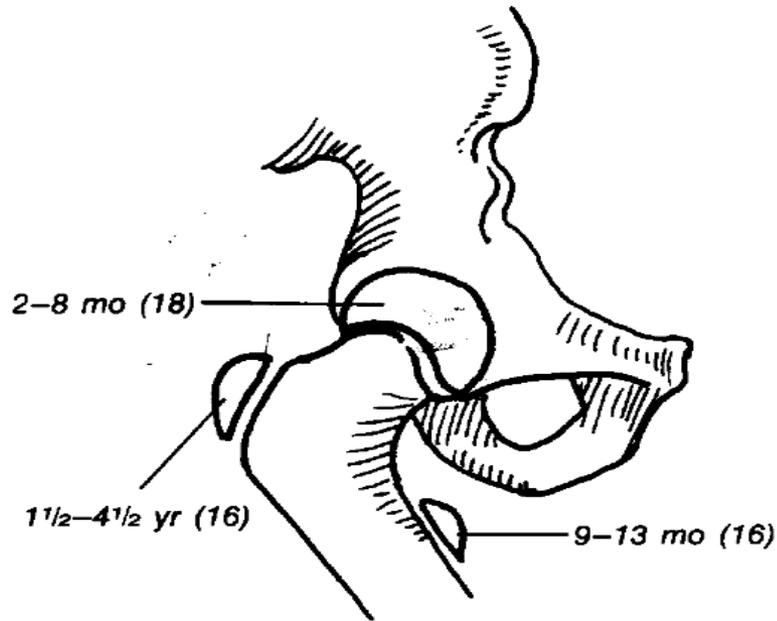
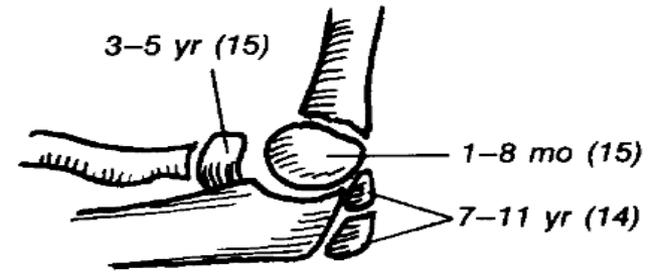
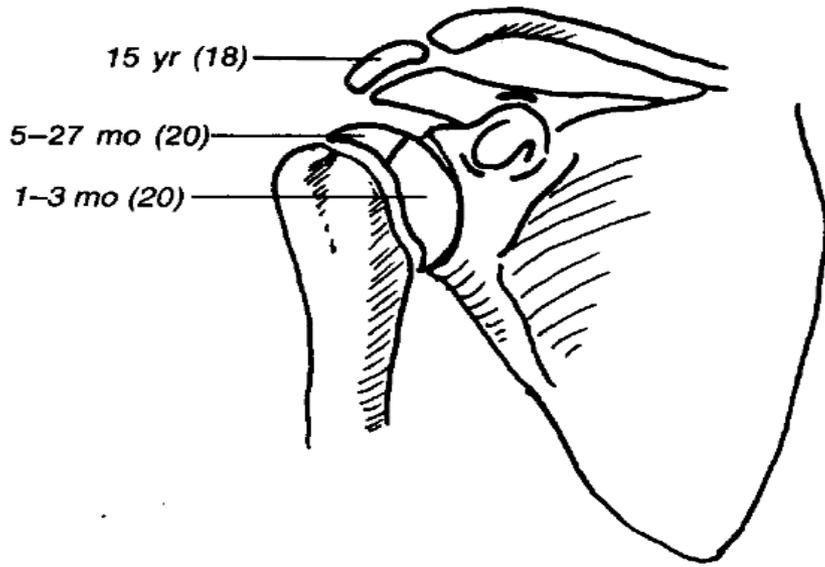
Trochlea  
7

Olecranon  
9

Ext. Epicondyle  
11 years





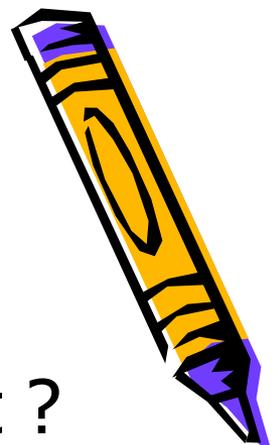


# Case

- 15 yo fall off tailgate.
- NVI distally.
- X-Ray:

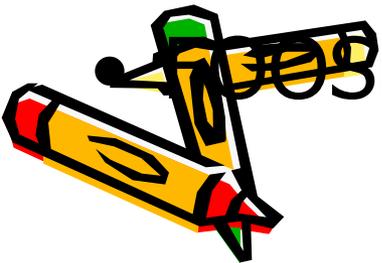


- Best Management ?
  - A. Sling & Swathe
  - B. Shoulder Spica
  - C. Closed Reduction
  - D. ORIF.
- 
- Answer: A

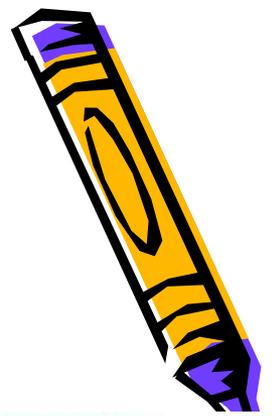


# Humerus Fractures - Proximal

- 80% humeral growth @ prox physis, the most bio-active physis in the body.
- Remarkable capacity for healing and remodeling, even c 100% displace.
- 20-50° angle & 50% displacement is generally considered tolerable.
- Nonunion nonexistent, malunion rare.
- 30-50°, Direct shoulder blows.



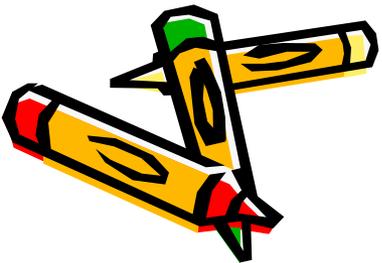
# Remodeling



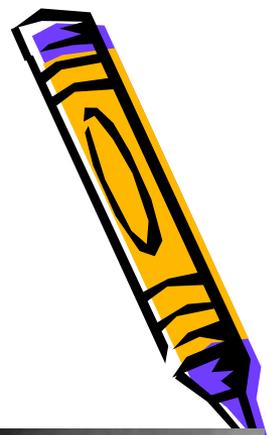
1 month

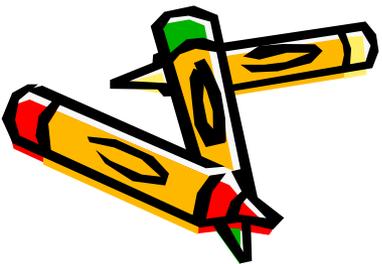
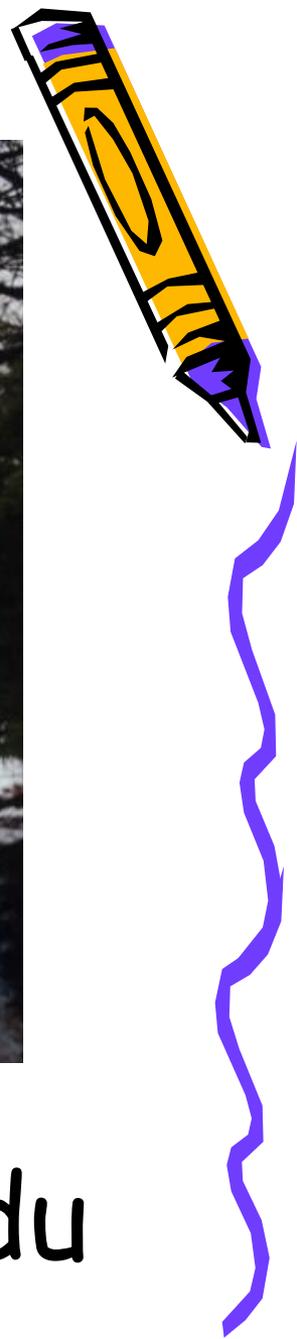
4 months

6 months



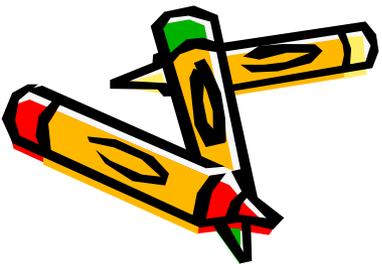
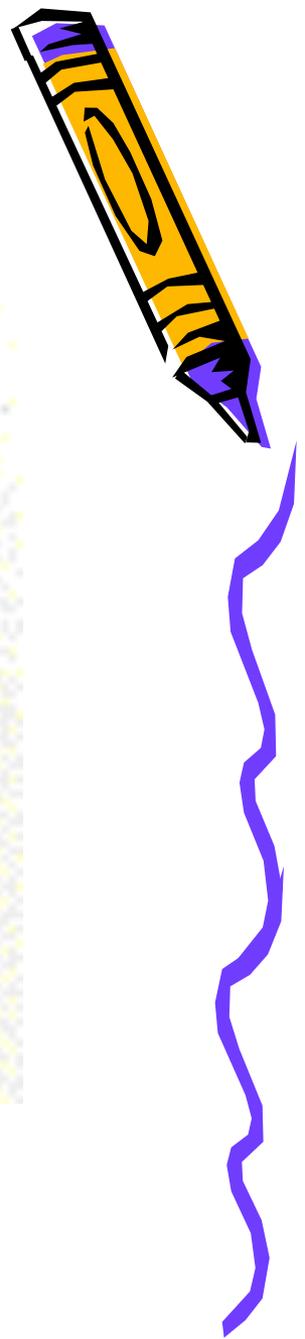
# Proximal Humerus (Infant)





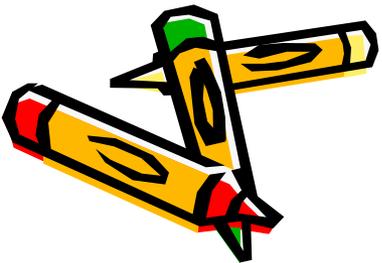
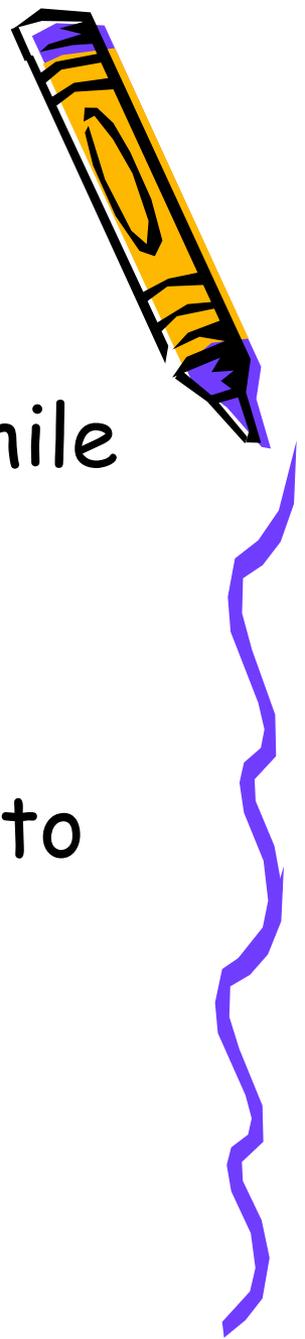
[dale@aemrc.arizona.edu](mailto:dale@aemrc.arizona.edu)

# Questions?



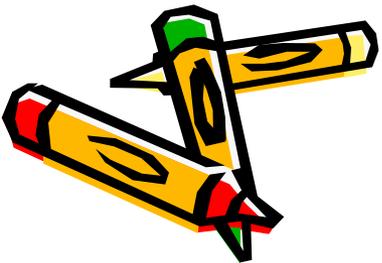
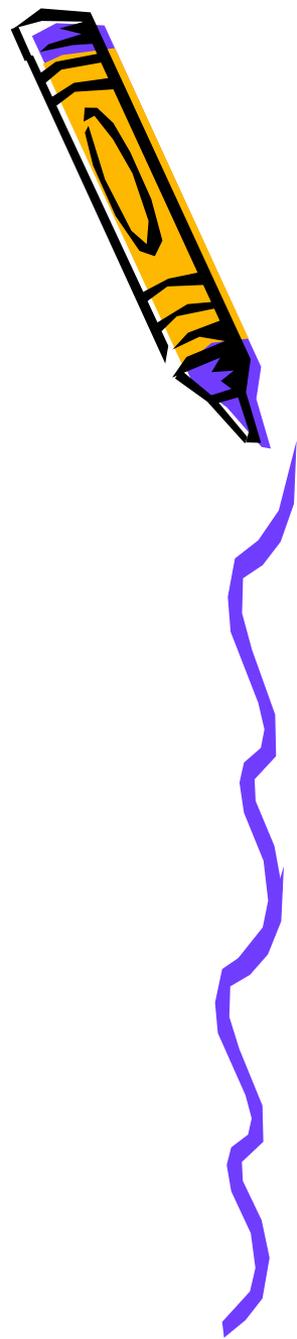
# Next case:

- 12-year-old boy fell on the field while playing baseball.
- C/O right knee pain
- Slight limp noted while ambulating to the exam room.

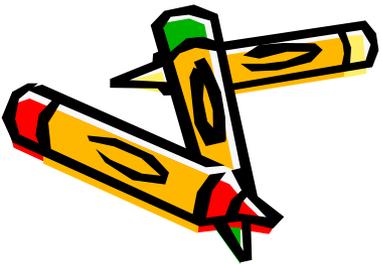
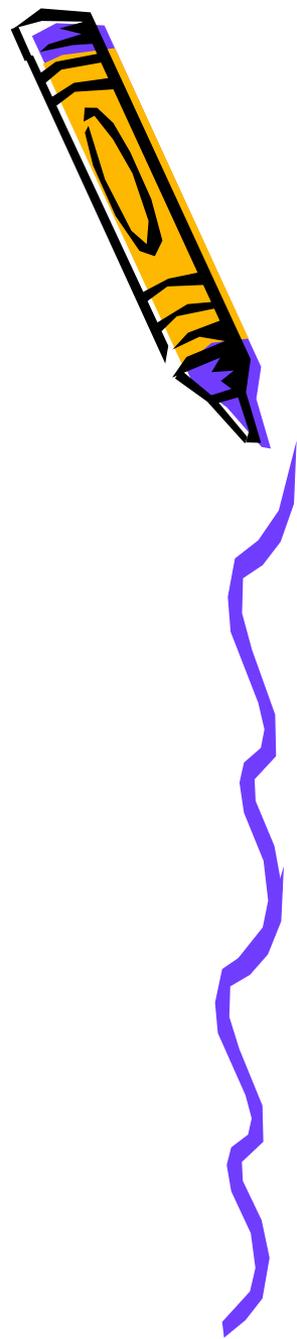


# Physical Exam

- What do you want?



Differential Diagnosis?

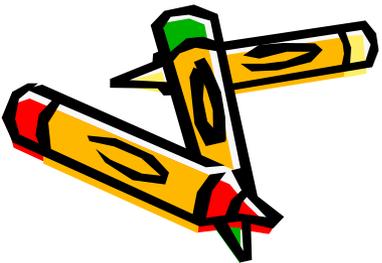






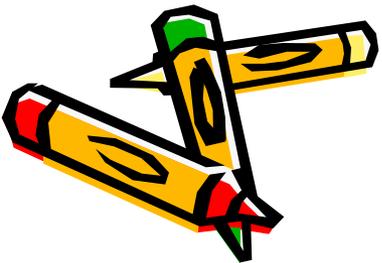
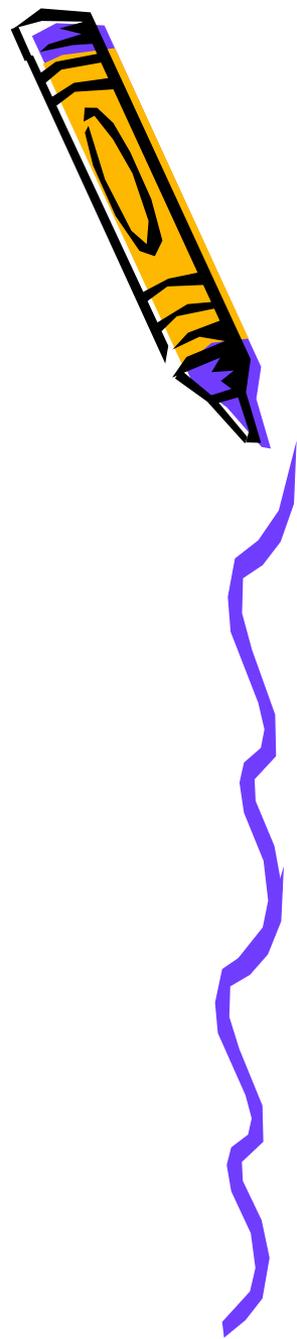
# SCFE: Background

- Incidence: 2/100,000
- Occurs during early adolescence: 11-15y
- Increased forces during growth spurt
- Males 2 times as frequent as females
- Obese in 2/3 of cases
- Bilateral in up to 20% of children



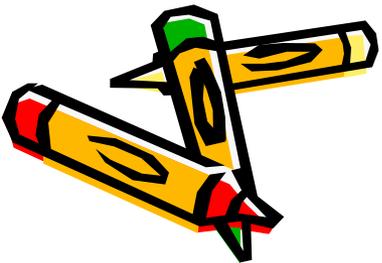
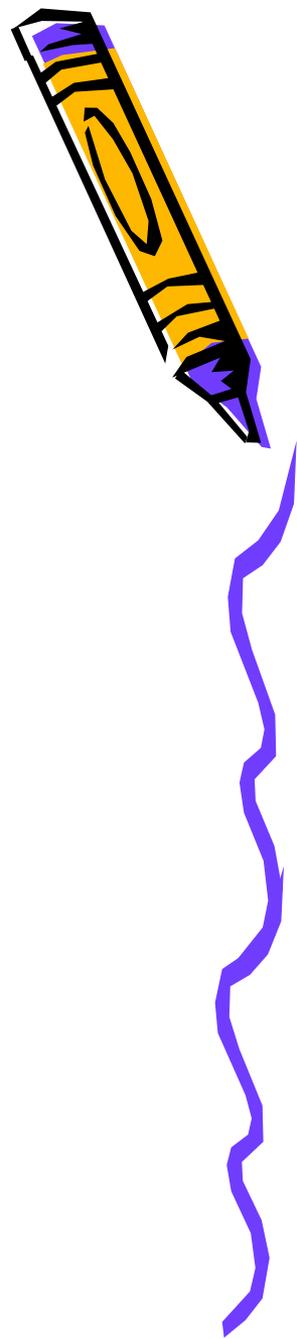
# Clinical Features:

- Obese preadolescent or adolescent
- Often weeks to months of discomfort
  - Acute visit precipitated by trauma
- Limp
- Hip, thigh, groin, or knee pain
- Decreased range of motion of hip

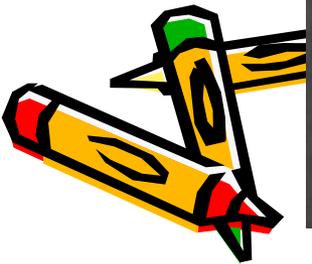
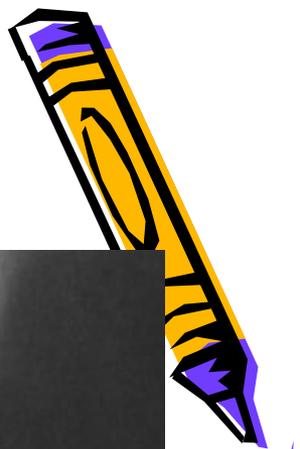
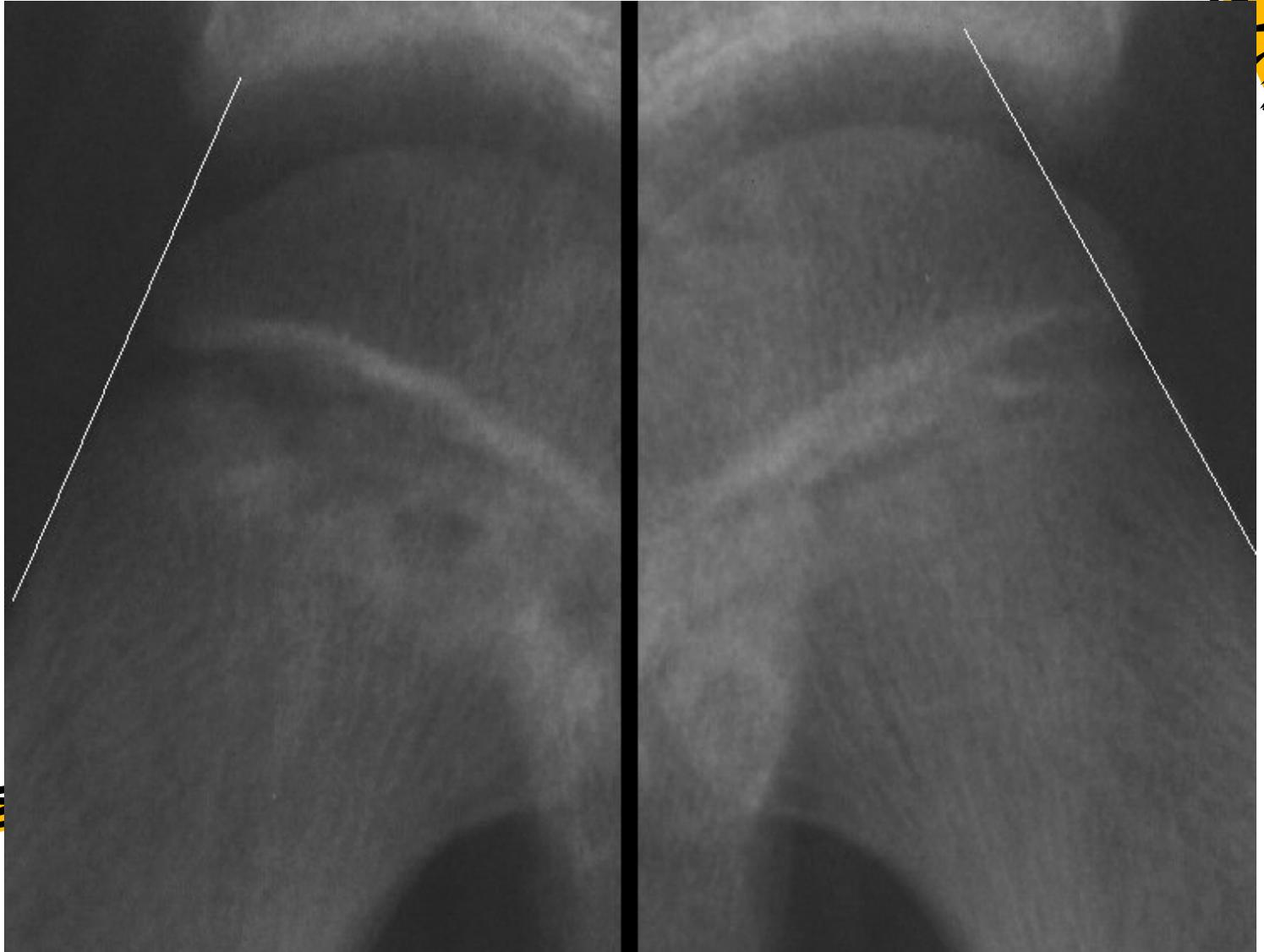


# Diagnostic Studies

- Radiology
  - AP pelvis and frog-leg of hips
- Signs
  - Physeal widening
  - Klein line
  - Epiphysis inferior and posterior

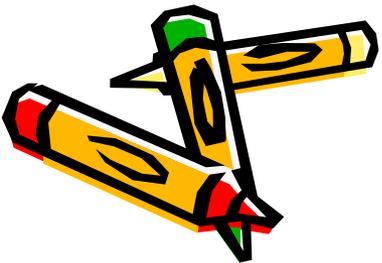


# Klein Line



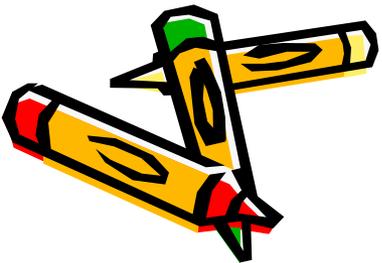
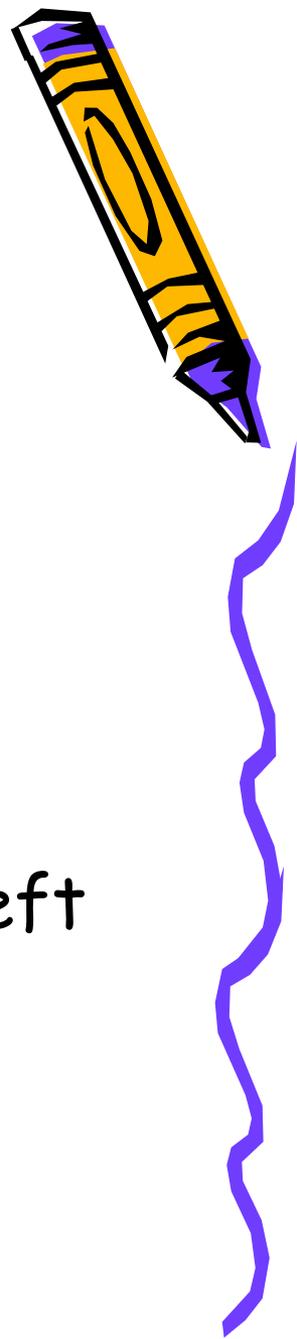
# Management

- Bed rest
- Pain management/Relief of muscle spasms
- Definitive treatment is surgical.
  - Screw placed through femoral neck

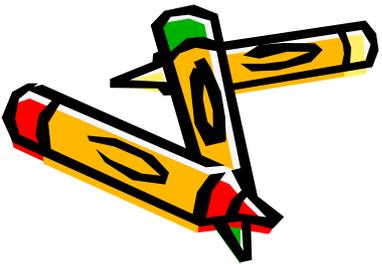
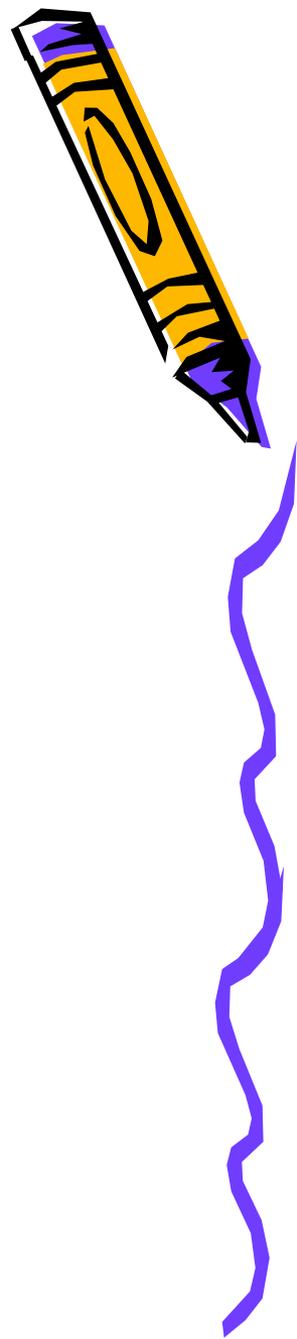


# Next case:

- 6-year-old boy with left-sided limp for 3 months.
- No fever, chills, or recent illnesses
- Normal examination including range of motion in ankle, knee, and no bony tenderness except pain on movement of left hip

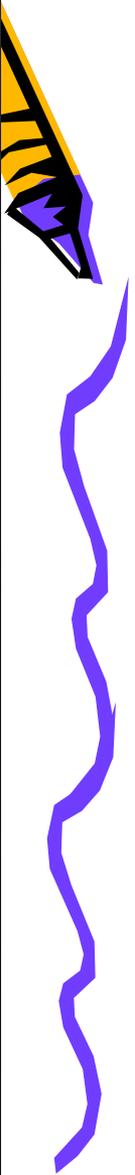
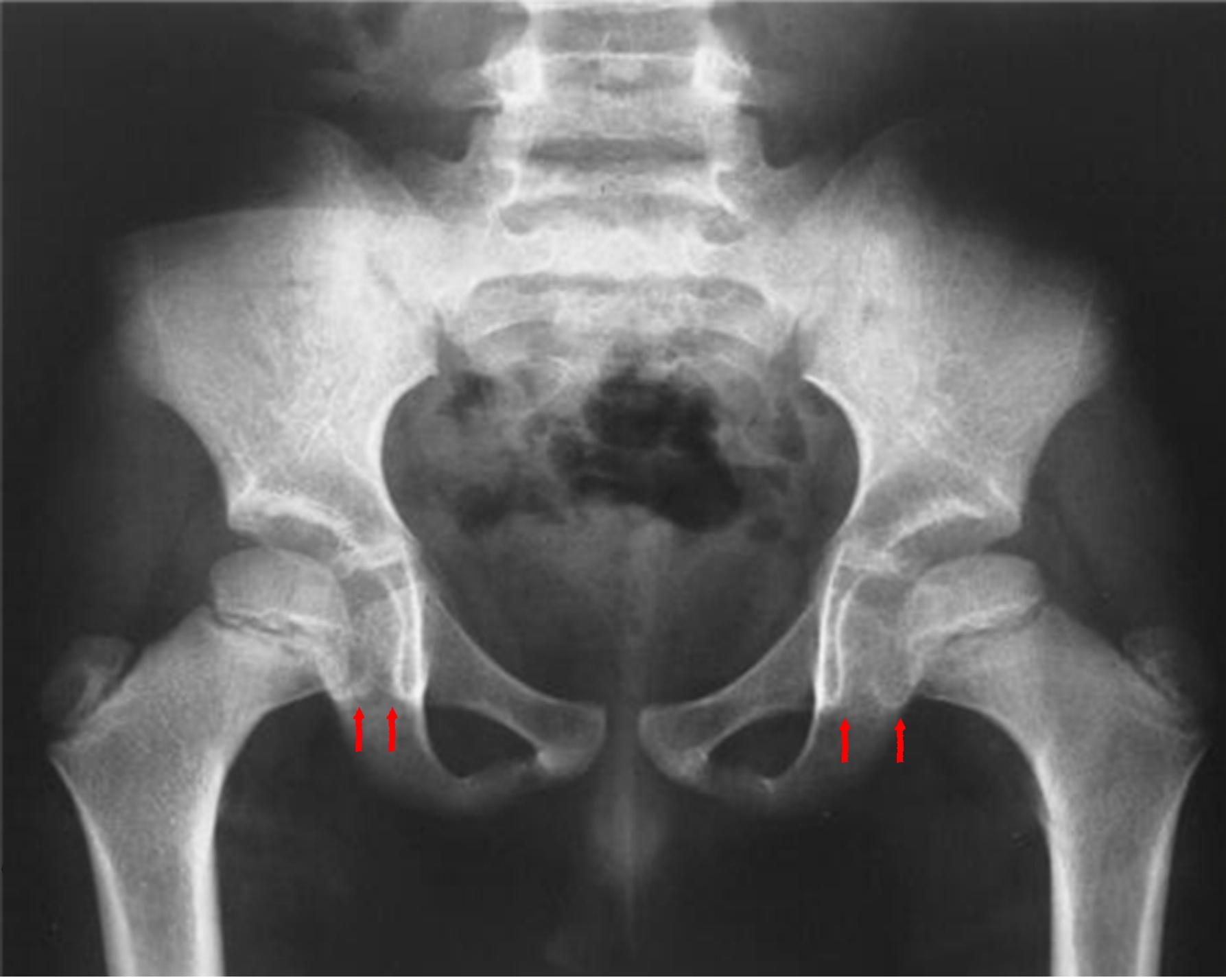


Differential Diagnosis?



R



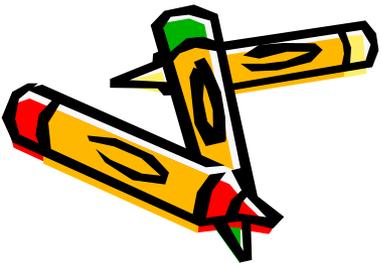
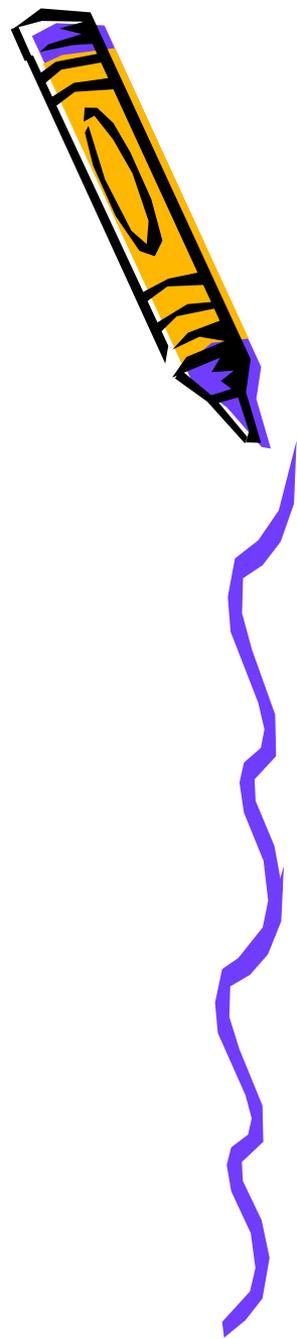


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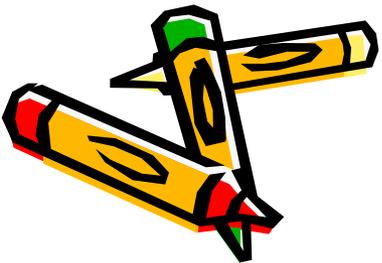
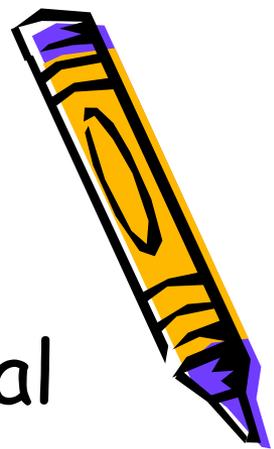
# Legg-Calvé-Perthes Disease

- Avascular necrosis leading to collapse, fragmentation, and then reossification.
- Assoc with factor V Leiden deficiency.
- Most frequent between 4 and 9 years
- Boys more often than girls
- Bilateral in 10% of cases
- MRI may be helpful



# LCPD

- Clinical: Limp with limited hip internal rotation and abduction. Pts have no pain or pain that is referred to thigh or knee.
- X-ray findings: dependent on phase
  - Small femoral head, widened joint space
  - Crescent sign along proximal femoral head
  - Femoral head collapses and ossifies



# Management

- Disease is self-limited - limp can last 2 to 4 years
- NSAIDS
- Limit activities
- Crutches/braces occasionally needed
  - May help maintain spherical femoral head
- Better outcomes in younger children
- Associated with early arthritis and need for arthroplasty

