# Paediatric Orthopaedics

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# Paediatric Orthopaedics:

**Growth Phase:**

- Cells proliferate, undergo differentiation, move
- To produce a normal, mature individual
- The period of growth can be divided into 6 phases

**6 phases:**

| Category | period |
|---|---|
| Early Embryo | 0-2 weeks |
| Embryo | 2-8 weeks |
| Fetus | 8 weeks to birth |
| Infant | Birth to 2 years |
| Child | 2 years to puberty |
| Adolescent | Transition to Maturity |



# Growth / Joints:

**Synovial Joints:**

- Condensations of mesenchyme, Cavitation
- Chondrification
- Synovial differentiation
- Ossification
- Basic structure



# Growth / Bone:

**Bone:**

- Mesenchyme
- Chondrification
- Ossification



**Ossification Centers:**

- Primary Ossification Centers:
  - For long bones
  - Usually before birth
- Secondary Ossification Centers:
  - Develop during infancy and early childhood, adolescence ad early adult life
  - In an orderly fashion
  - Radiographically documented has become the standard for assessing maturation

# Ossification Centers / Elbow:

**C-R-I-P-T-O:**

**Ossification centres**

There are 6 ossification centres around the elbow joint. They appear and fuse to the adjacent bones at different ages.
It is important to know the sequence of appearance since the ossification centers always appear in a strict order. This order of appearance is specified in the mnemonic **C-R-I-T-O-E** (Capitellum - Radius - Internal or medial epicondyle - Trochlea - Olecranon - External or lateral epicondyle).
The ages at which these ossification centres appear are highly variable and differ between individuals.
It is not important to know these ages, but as a general guide you could remember 1-3-5-7-9-11 years.



# Growth Plate:

**Different Zones:**

**Perichondral Ring**

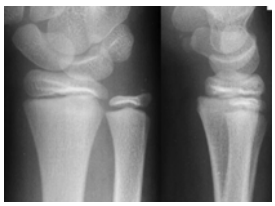
- These structures support and expand the width of the growth plate



# Growth Plate:

**Types**

- Long bone epiphysis
- Apophysis
- Ring epiphysis
- Traction apophysis





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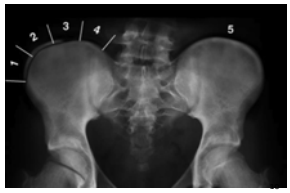





# Growth Plate:

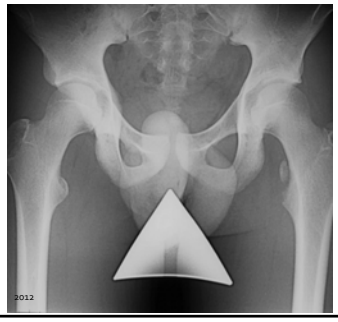
**Types**

- Long bone epiphysis
- Apophysis
- Ring epiphysis
- Traction apophysis

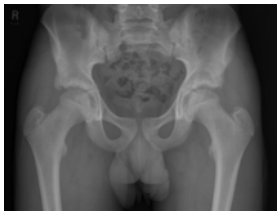


# Growth Plate:

**Lesser Trochanter (a traction apophysis):**



**Avulsion of anterior inferior iliac spine fracture:**



Avulsion by the rectus (often seen in soccer and ruby players)



# A Growing Child's Bone:

**Greek words:**

- Epiphysis:
  - Epi = "upon"
- Physis (growth plate)
- Metaphysis:
  - Meta = beside, next to
- Diaphysis:
  - Dia = asunder, apart





# Evaluation:

- History:
  - Birth history
  - Development
  - Mother's intuition
    - Surprisingly accurate
  - Family History
- Physical examination:
  - Look
  - Feel
  - Move
  - Specific tests:
- Investigations:



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# Problems:

**Categories of symptoms:**

- Deformity
- Altered function
- Pain

**Categories of Diseases:**

- Traumatic
- Congenital
- Inflammatory / Autoimmune
- Neoplastic
- Infective
- …



# Management:

**Managing the Family:**

- Children:
  - Resist the pressure to treat the child
  - Order treatment only when intervention is both necessary and effective
  - The job of a child is PLAY
- Parents:
  - Family coping ability
  - Informed consent
  - Support and reassurance
- Grandparents



- Traction
- Casting
- Orthotics:
  - To control alignment, facilitate function, provides protection
- Prosthetics:
  - Artificial substitutes for body part
- Therapy
- Medication
- Operation

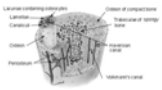


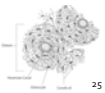


# Trauma:

# Fractures:

- Haversian canals occupy a greater portion
- More porous
- May limit the extension of a fracture line







# Fractures:

**Types:**

- Plastic deformation:
- Buckle or Torus fracture:
- Greenstick Fracture:
- Complete:

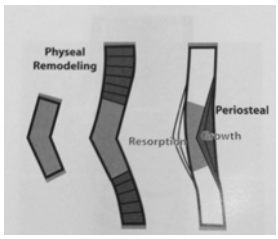


# Physiological Differences:

**Growth remodeling:**

- Growth allows greater degree of remodeling than Is possible in an adult
- The deformity produced by a fracture is corrected by asymmetric growth of the physis and the periosteum.
- Most correction:
  - Early during healing
  - Younger
  - Closer to the joint
  - If the deformity is in the axis of the rotation

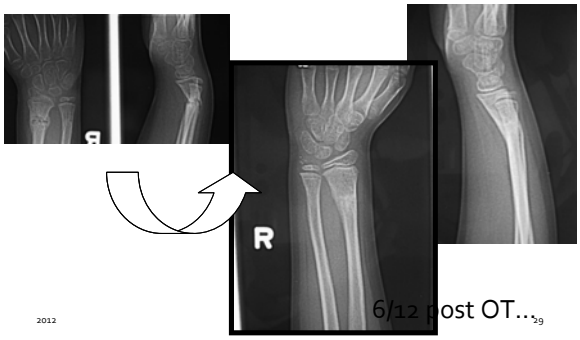
**Basis of remodeling:**






# Case showing Remodeling:

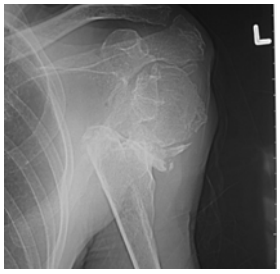
# Case (534) Remodeling:




6/12 post OT...



- Remodeling is not so effective in adult patient

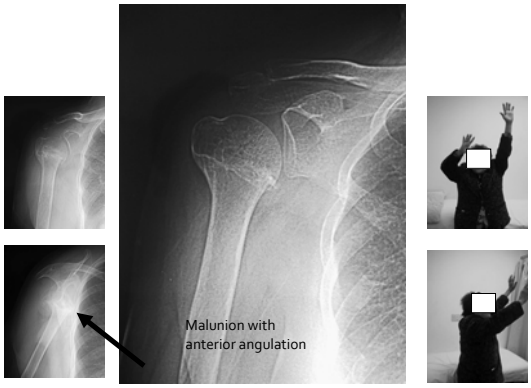


):

- F/75
- ADL independent
- S/F
- Right shoulder pain

- XR: …






**1965: malunion at age of about 35**

**2000: Age 69**





# Child Abuse:

•Look out for child abuse in all paediatric patients with fractures…..

- Physical
- Emotional
- Neglect
- Sexual

**Warning sign of physical abuse:**

- Frequent injuries or unexplained bruises, welts, or cuts.
- Is always watchful and "on alert," as if waiting for something bad to happen.
- Injuries appear to have a pattern such as marks from a hand or belt.
- Shies away from touch, flinches at sudden movements, or seems afraid to go home.
- Wears inappropriate clothing to cover up injuries, such as long-sleeved shirts on hot days.



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# Plastic Deformation:

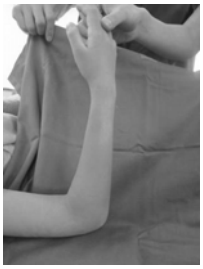
**Traumatic Bowing of Bone:**

- Most commonly recognized in the ulna and fibula
- Without any evidence of acute angular deformity




•F/6
•Well all along

•Admitted fro right elbow injury after a fall injury
•No other injury
•Limited flexion
•
•P/E:
•Tenderness at the lateral aspect of the elbow
•No compartmental syndrome
•No tenderness along ulna

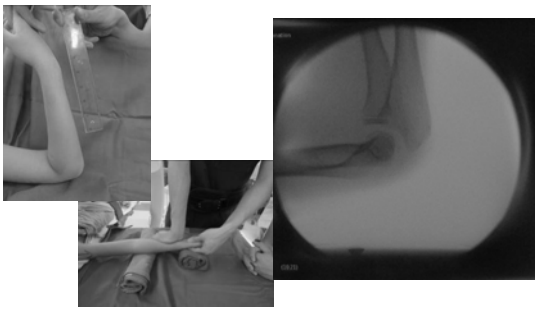




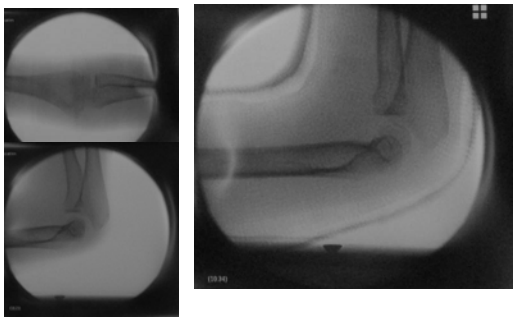



- Right side anterior radial dislocation + ulnar plastic deformation



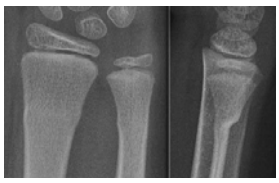







# Buckle Fracture:

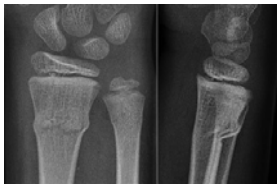
- A fracture in which one side of the bone bends, but does not actually break.
- Torus fractures normally heal on their own within a month with rest, although they can cause soreness and discomfort.





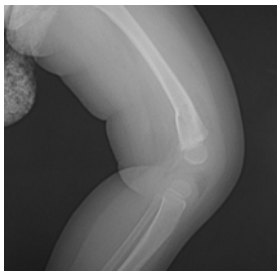
# Greenstick Fracture:

- Partial fractures, since only one part of the bone is broken and the other side is bent.
- An analogy of breaking a young, fresh tree branch.
- Conservative treatment.





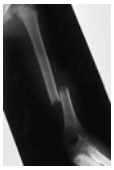
**10 months old:**





# Complete Fracture:

- Rarely comminuted in children
- Most can be treated conservatively





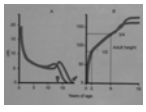
- Some needs operative treatment with ORIF

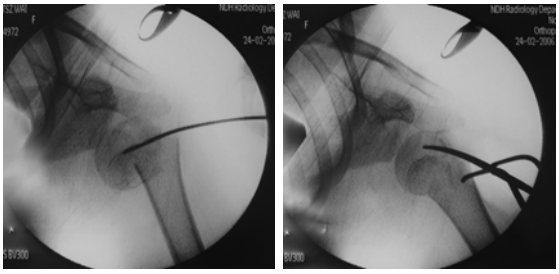


**13+ year old**

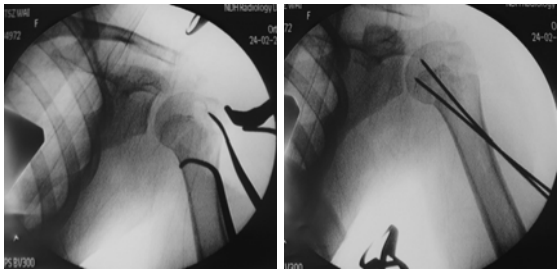
**Significant angulation**

**13+ years old already…**













# Epiphyseal Fracture:

- Usually involve the growth plate but occasionally occur in isolation
  - Avulsion at the site of ligamentous attachment
  - Comminuted compression fracture
  - Displaced osteochondral fragment



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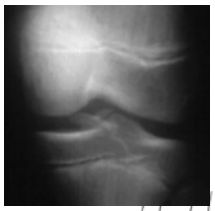



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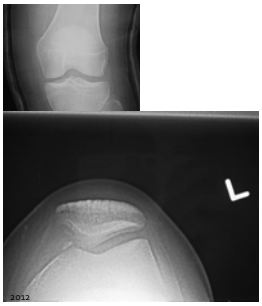
# Epiphyseal Fracture:

**Displaced osteochondral fragment:**





# Physeal (Growth Plate) Injuries:

**Significance:**

- 1/3 of skeletal trauma in children
- Effects:
  - Progressive angular deformity
  - Progressive limb-length discrepancy
  - Joint incongruity

**Salter-Harris Classification:**



**Type I:**

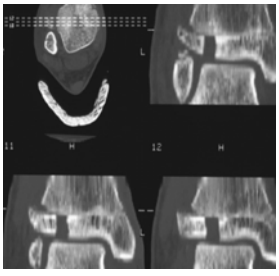
- History
- Palpation for local tenderness



**Type II:**



**Type III:**





**Type IV:**

**Type V:**



# Cases with elbow injury:



# Ossification Centers / Elbow:

**C-R-I-P-T-O:**

**Ossification centres**

There are 6 ossification centres around the elbow joint. They appear and fuse to the adjacent bones at different ages.
It is important to know the sequence of appearance since the ossification centers always appear in a strict order. This order of appearance is specified in the mnemonic **C-R-I-T-O-E** (Capitellum - Radius - Internal or medial epicondyle - Trochlea - Olecranon - External or lateral epicondyle).
The ages at which these ossification centres appear are highly variable and differ between individuals.
It is not important to know these ages, but as a general guide you could remember 1-3-5-7-9-11 years.



# Radial Neck Fracture:

- F/9
- Fell from height
- Left elbow injury
- No other injury

- P/E:
  - Swelling
  - Limited Supination
  - N/V intact

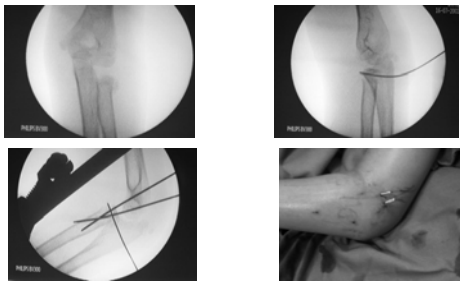
- XR: …



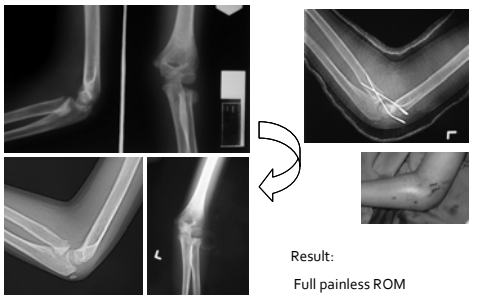
- FPS, F/9
- Fell from height
- Left elbow injury
- No other injury

- P/E:
  - Swelling
  - Limited Supination
  - N/V intact
- Treatment:
  - Choice ? , How ?





 Percutaneous Reduction is achieved with a K-wire… 



Result:

Full painless ROM



# Medial Epicondyle Avulsion Fracture:



- P/E:
  - Painful elbow with point tenderness
  - Elbow flexion contracture that may be in excess of 15 degree
- XR:
  - Range from minimal displacement to marked displacement with or without entrapment in the joint
  - Gravity Stress Test:
    - Patient supine, shoulder 90 abduction, ER
    - Take XR
    - If displaced => soft tissue continuity have been lost



- Operative treatment:
  - If displacement > 5 mm or a positive gravity valgus stress test .
  - Need to inspect UCL thoroughly because it can be torn at the same injury
  - Need to open cubital tunnel and visualize the ulnar nerve.
  - Reattachment with Sutures / K-Wire / Screw

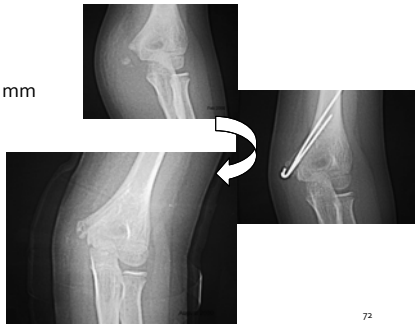


# Case with Medial Epicondyle Avulsion Fracture:

- M/7
- Fell
- Right elbow pain
- No other injury
- Definite Tenderness at the medial epicondyle
- Ulnar nerve function normal
- XR: …



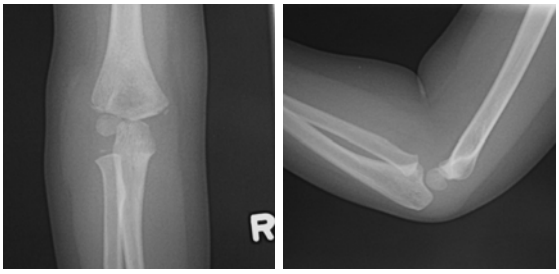

- OT:
  - ORIF with 2.0 mm KW
- Result:
  - Full ROM



# Lateral Condyle Fracture:



**Age 3Y2M**



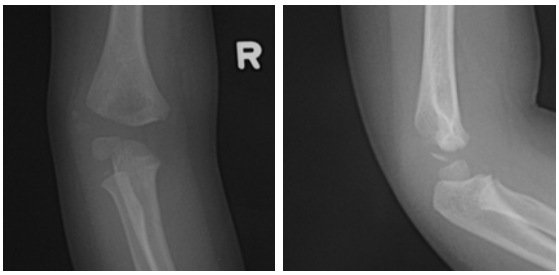



**Injured side:**


**Normal side:**

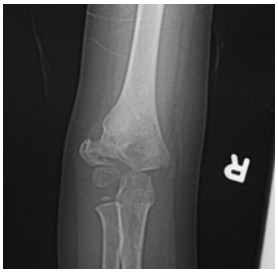



**1M+:**






**4M+:**

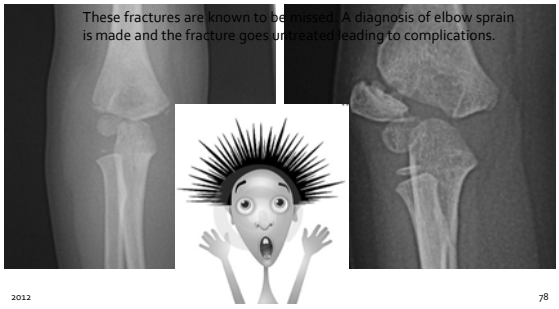



**1Y:**

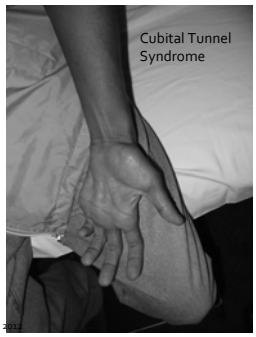


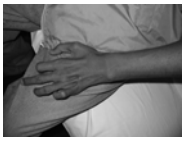
**1 Y later**

These fractures are known to be missed. A diagnosis of elbow sprain is made and the fracture goes untreated leading to complications.



## Lateral Condyle Nonunion::





## Monteggia's Fracture Dislocation:

- A fracture of shaft of ulna with an associated radial head dislocation.
- Various mechanisms
  - falls, vehicular trauma, and direct blows
  - usually involves an application of axial load combined with rotation



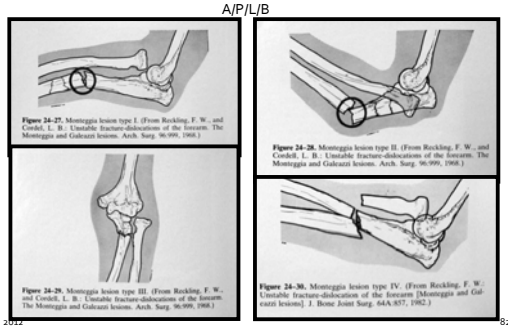

## Classification:

- Bado et al (1967)
  - I (60%):
    - extension type with ulna having an anterior angulation and an ant. dislocation of the radial head
  - II (15%):
    - flexion type with ulna having a posterior angulation and a posterior dislocation of the radial head
  - III (20%):
    - ulnar metaphyseal fracture associated with a lateral or anterolateral dislocation
  - IV (5%):
    - fractures of proximal ulna and radius with an anterior dislocation



## Bado Classification:

A/P/L/B

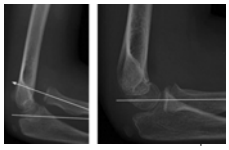




- The region of the elbow and the forearm is painful
- The radial head is palpable in some types of injuries
- Check for the posterior interosseous nerve (PIN)
  - extension of the metacarpophalangeal joints

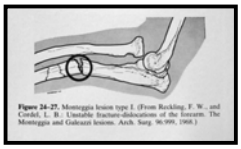


- Do not miss the diagnosis….Normally the radial head and the capitellum are aligned on ALL radiographic projections, including the oblique views
- The radial head is examined carefully for the presence of an occult fracture



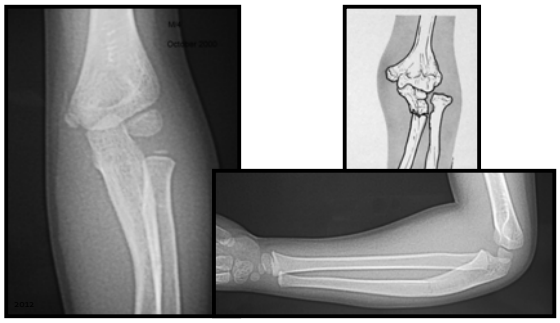
# Bado Classification Type I:

- Right side anterior radial dislocation + ulnar plastic deformation






# Bado Classification Type III:

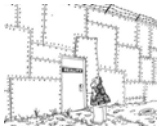




# How to avoid mistakes:

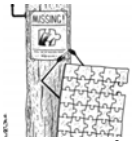
**Principle:**

- Knowledge
- Clinical suspicion
- P/E: look, feel and move
  - Local tenderness



**XR:**

- 2 views
- 2 ends (joints)
- 2 sides
- 2 occasions

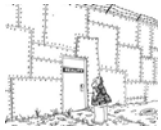




# How to Stay Away from Troubles:

**Principle:**

- Knowledge
- Clinical suspicion
- P/E: look, feel and move
  - Local tenderness



**XR:**

- 2 views
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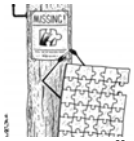
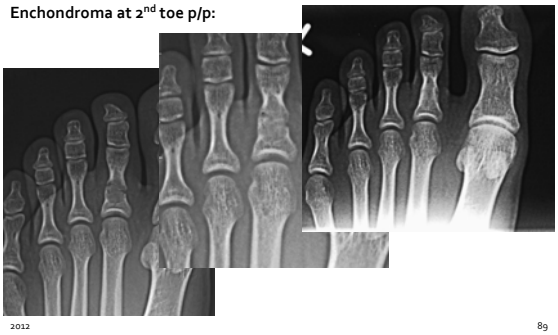




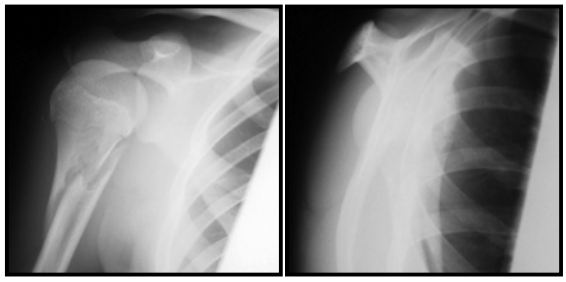
**Enchondroma at 2nd toe p/p:**

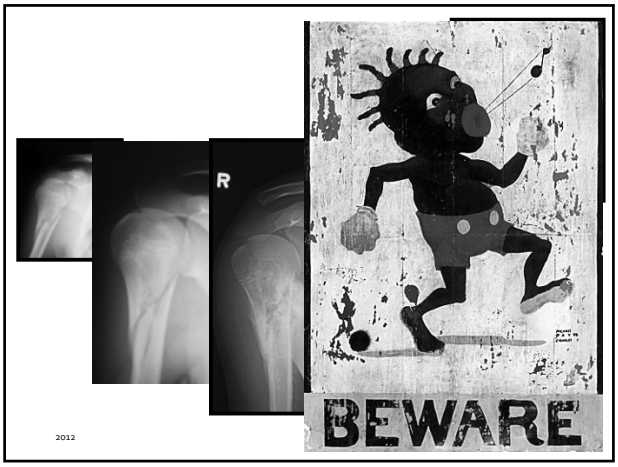




# Case 3

**M/14 after a trivial trauma:**








- Consult if in doubt….

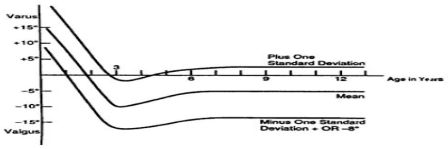


# Deformity:



# Deformity:

**Genu Varum (bowlegs) and Genu Valgum (knock knees):**






**Hx:**

- Onset?
- Injury / Illness?
- Progressing?
- Old photos?
- General health?
- Normal diet?
- Family members?

**P/E:**

- Normal height and body proportion?
- Other deformities?
- Symmetrical?
- Rotational profile?

- Record with charting
  - Knee Angle
  - Intermalleolar / Intercondylar distances



**Ix:**

- Metabolic screening:
  - Ca, phosphorus, ALP, Creatinine, Haematocrit

**Imaging:**

- AP
- Standing (patellar forward)
- Including femora and tibiae

- Generally will resolve spontaneously and require no treatment.
- No use:
  - Corrections, splints and exercise programs
  - May lead to hazardous complications
- Factors suggestive of pathologic conditions:
  - failure of genu varum to correct by age two years
  - increasing deformity
  - unilateral bowleg,
  - and a marked lateral thrust with weight bearing.



- Refer if:
  - Obviously asymmetrical,
  - Clearly progressive,
  - Associated with pain. Blount's disease



**Physiological bowlegs:**

- Symmetrical
- Before 2 years old
- Normal height
- -ve Family history
- Screening normal

**Physiological knock knees:**

- Symmetrical
- 2-6 years old
- Normal height
- -ve Family history
- Screening normal

Mx: Observe



# In-toeing / out-toeing:



# In-toeing / out-toeing:

**Normal:**

- Version:
  - Normal variations in limb rotation / <+/- 2 SD
- Tibia version:
- Femoral version:
  - Anteversion
  - Retroversion

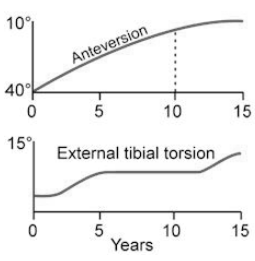
**Deformity:**

- Torsion:
  - >2SD from mean
- Tibial torsion:
  - ITT (internal) / ETT (External)
- Femoral torsion:
  - IFT
  - EFT



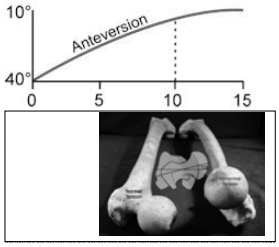
**Principle:**

- Lower limbs laterally(externally) rotates with age:
  - Until adult values are reached (between ages 8 and 10 years)
- Femoral anteversion:
  - Declines
  - 30° at birth to 10° at maturity
  - IR of hip (prone) is measured
  - Increased femoral torsion may be evident during gait, with medially facing patellar alignment.



**Femoral anteversion:**

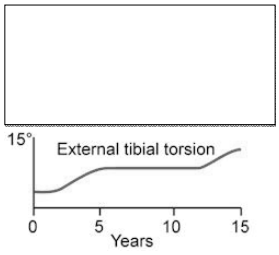
- Declines: 30° at birth to 10° at maturity
- Clinical Observation:
  - IR of hip (prone) is measured
  - Increased femoral torsion may be evident during gait, with medially facing patellar alignment.
- Femoral neck anteversion, as a cause of internal rotation posturing of the limb, does not become clinically recognizable until complete resolution of the external rotation contracture of the hip has occurred, that is, usually after 18 months of age.
- Approximately 70 per cent of children over age 2 years who toe-in have excess femoral neck anteversion as the cause.
  - Clin Orthop Relat Res. 1975 Jul-Aug;(110):139-45.






**Principle:**

- Tibial version becomes more laterally
  - 5° at birth to 15° at maturity
- TMA is measured:
  - The angular difference between the transmalleolar axis and the axis of the thigh






**Hx:**

- Onset?
- Severity?
- Disability?
- Previous treatment?
- Developmental history?

**P/E:**

- Gait, Co-ordination, Balance, Muscle tone, Static deformities, Muscle contracture at each joint, Laxity
- Torsional and other deformities of bone
- Tripping, falling, and shoe wear problems should be examined.



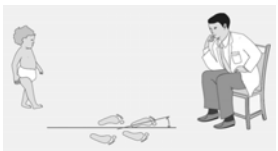
# Rotation Profile:

- *The five components are*:
  - Foot progression angle during gait,
  - Internal and external hip rotation,
  - Thigh-foot axis,
  - Transmalleolar axis,
  - Heel-bisector angle.



# Rotational Profile:

**Foot Progression angle:**



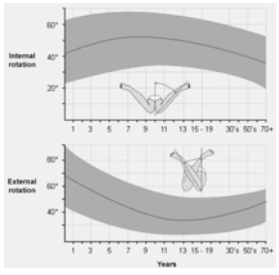
- Summation of torsional alignments of femur, tibia, and foot.



# Assess Femoral Version:

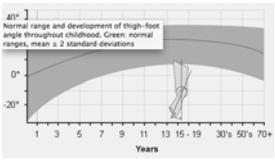
**Internal Rotation:**

- Infants:
  - 40° of internal rotation
  - limited by the tight posterior capsule even though they have increased femoral anteversion and should potentially have a larger internal rotation arc.
- By age 10 years:
  - averages 50°
- Normally less than 60 to 70 degrees
  - 70°, 80°, or 90° is evidence respectively of a mild, moderate, or severe increase in femoral torsion



**Thigh Foot Angle (TFA):**

- Prone
- A natural resting position
- Measures the tibial and hindfoot rotational status

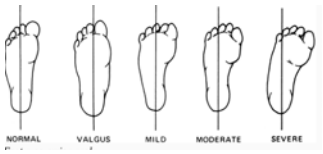



- TFA – TMA = measure of hindfoot rotation



**Assess the foot:**

- Line bisecting the heel should be pointing (Normally) to 2nd toe
- For forefoot adductus
- Flatfoot => contribute to out-toeing





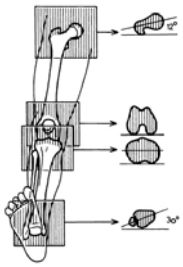

**XR:**

- This is not needed during initial evaluation of most torsional problems.
- Radiographical techniques are not superior to clinical assessment.

- Suspect hip pathology:
  - SCFE, Hip dysplasia…
  - A recent change in gait and knee or hip pain
- Foot x-rays:
  - club foot, skew foot, congenital vertical talus…



# Computed tomography (CT) scan



- by measuring the angle between the transverse axes on CT cuts of the proximal and distal juxta-articular regions.
- For patients with severe torsional deformities.



# Infant:

**Lateral hip rotational contracture (extended hip):**

- common in young infants, decreasing progressively with growth so that it appears to be present in less than 5 per cent of the children over age 18 months.
- Physiologic infantile out-toeing
- Persistence of the external rotation contracture was the main cause of toeing-out gait.
- The turned out foot is the more normal one

–Approximately 80 per cent of children under 18 months of age who toe-in have internal tibiofibular torsion; most of these also have significant talar neck adductus!

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**Metatarsus Adductus:**

- Medial deviation of the forefoot on the hindfoot with a neutral or slightly valgus heel.
- The hindfoot will be neutral or in valgus, but never in varus.
- Range of motion of the ankle and subtalar joint will be normal.
- Flexible deformities resolve spontaneously with time.
- Even when it does not, it rarely leads to pain in adulthood.

**Metatarsus Primus Varus:**

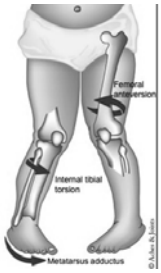
- Rigid forefoot adductus
- Tends to persist
- Less common
- Stiffness
- The lateral border of the foot has a normal alignment, and there is often a deepened vertical skin crease on the medial border of the foot at the tarsometatarsal joint.
- Cast treatment (6-24/12)



# Toddler:

**Internal tibial torsion:**

- A common cause of in-toeing
- Observational management is best
- Correction occurs spontaneously but often requires 1-2 years



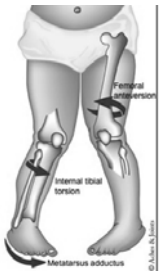



# Children:

**In-toeing:**

- Usually due to femoral anteversion. Rarely due to persisting ITT.

- Most severe between 4-6 years old then resolve
- In adult femoral anteversion dose not cause degenerative arthritis and rarely any disability








# Bring Home Message:

- "Children are not just small adults" Mercer Rang
- "Trauma is part of a child's life" Lynn T Staheli
- Categories:
  - Deformity
  - Altered function
  - Pain



# Bring Home Message:

- + Birth History + Family History + mother intuition
- Look, Feel and Move
  - Look for Asymmetry, Pain, Reluctance to play
- Use of charting
  - Serial monitoring
- XR:
  - 2 views
  - 2 ends (joints)
  - 2 sides
  - 2 occasions

THANK YOU