Pediatric foot

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Regions of Foot

- Forefoot
  - Metatarsals
  - Phalanges
- Midfoot
  - Navicular
  - Cuboid
  - 3 Cuniforms
- Hindfoot
  - Calcaneus
  - Talus
The ankle includes three joints:

1- the ankle joint proper (tibiotalar) → plantarflexion and dorsiflexion
2- the subtalar joint → inversion and eversion
3- the Inferior tibiofibular joint.
Glossary of foot postures

- **Plantigrade** is the normal neutral position of the foot – i.e. when the patient stands the sole is at right angles to the leg.

- **Talipes equinus** refers to the shape of a horse’s foot – i.e. the hindfoot is fixed in plantarflexion (pointing downwards).

- **Plantaris** looks similar, but the ankle is neutral and only the forefoot is plantarflexed.

- **Equinovarus** describes a foot that points both downwards and inwards.

- **Calcaneus** is fixed dorsiflexion at the ankle. A dorsiflexion deformity in the midfoot produces a rocker-bottom foot.
Congenital Talipes equinovarus (CTEV) “club foot”
Talipes (means foot), Equino (means flexed), Varus (means twisted internally). Also, it comes with adduction of the forefoot.

- In this deformity the foot is curved downwards and inwards.
- Three main deformities:
  (i) ankle joint: plantarflexed/equines
  (ii) subtalar joint inverted/varus
  (iii) forefoot adducted

In a normal baby the foot can be dorsiflexed and everted until the toes almost touch the front of the leg. In club-foot this manoeuvre meets with varying degrees of resistance and in severe cases the deformity is fixed.
**Incidence:**

- Common birth defect 1:1000
- Male: Female 2:1
- 50% bilateral.
- A family history increases the risk by 20–30 times.
Classification of CTEV:

- **Postural (physiologic):** the deformity can be easily corrected by the examiner, not considered a real club foot.
- **Fixed (pathologic):** could be idiopathic (most common), syndromatic (comes with other congenital deformities, ex: myelomeningocele and arthrogryposis.)
Diagnosis

- Diagnosis is clinically, no need for X-ray.
  - Newborn babies have only calcified calcaneus, talus, cuboid (we see them on x-ray), we don't see the navicular bone
  - Can be detected on US, but nothing can be done.
Treatment depends on the age mainly or recurrence:

1- Less than 3 months we treat it conservatively by Ponseti method which includes:
   ✓ Serial casting (supination of the foot), fix point: talar neck.
   ✓ Tendo-achilles lengthening, needed in 70% of patients.
   ✓ Bracing (Dennis- brown)
   ✓ Tibialis tendon transfer.

2- More than 3 months or recurrent: surgery. By complete soft tissue release usually performed at 6-12 months. The goal is to correct all the components of the clubfoot deformity at the time of surgery.
Congenital vertical talus (rocker-bottom foot)
Irreducible dorsal dislocation of the navicular on the talus producing a rigid flatfoot deformity:

- irreducible dorsolateral navicular dislocation
- vertically oriented talus
- calcaneal eversion with attenuated spring ligament
- soft tissue contractures:
  - displacement of peroneal longus and posterior tibialis tendon so they function as dorsiflexors rather than plantar flexors
  - contracture of the Achilles tendon
- Worse prognosis than club foot.
The x-ray A, there is a vertical talus, with the corresponding appearance seen in picture C. In x-ray B, the talus is positioned in its normal horizontal position.
incidence

- High incidence with various congenital anomalies and neuromuscular diseases:
  such as:
  ✓ Myelomeningocele
  ✓ DDH
  ✓ Arthrogryposis
  ✓ Trisomy 13
  ✓ Marfan syndrome
Clinical presentation:

- Rigid rocker-bottom deformity:
  - fixed hindfoot equinovalgus
- due to contracture of the Achilles and peroneal tendons
  - rigid midfoot dorsiflexion
- secondary to the dislocated navicular
  - forefoot abducted and dorsiflexed

- Treatment by serial casting if failed → surgery.
Pes planus
flat foot
The term ‘flat-foot’ applies when the apex of the longitudinal arch has collapsed and the medial border of the foot is in contact (or nearly in contact) with the ground; the heel becomes valgus and the foot pronates at the midfoot. The appearance of flat-foot can be normal and without symptoms but some conditions are characterized by flat-feet that are stiff and painful.
Classified into either:

1. Rigid (Stiff, which cannot be corrected passively should), caused by
   - Congenital vertical talus
   - Coalition of tarsals (calcaionavicular, (often a bar of bone connecting the calcaneus to the talus or the navicular)
   - Juvenile chronic arthritis.

2. Flexible (Mobile, most common), asymptomatic but is associated with peroneal spasm.
   - Often appears in toddlers as a normal stage in development, and it usually disappears after a few years when medial arch development is complete.
   - Ask the patient to stand on his tip toes and look from behind, heel valgus corrects on tip toe and the medial arch appears on extending the great toe at MTP joint.
Clinical assessment

The deformity becomes noticeable when the youngster stands. The first test is to ask him or her to go up on their toes: if the heels invert and the medial arches form up, it is probably a flexible (or mobile) deformity. This can be checked by performing the jack test (also called the great toe extension test): with the child seated, feet planted firmly on the floor, the examiner firmly dorsiflexes the great toe; the medial arch should re-appear
Physiologic “flexible” flat foot: reassurance “deformity’ will probably correct itself in time“. (Medial arch support only if there was genuine medial foot pain, but this doesn’t get rid of the flat foot deformity.)

Rigid type needs surgery.
Pes cavus

- Foot is highly arched and the toes are drawn up into a ‘clawed’ position, forcing the metatarsal heads down into the sole.
- Think of abnormal neurology until proven otherwise
- Treat according to symptoms → no pain, no surgery
- Can be seen in neurological disorders (Neurological examination is important), where the intrinsic muscles are weak or paralysed, suggests that all forms of pes cavus are due to some type of muscle imbalance.
Common deformities of the toes are:

- lateral deviation of the big toe *(hallux valgus)*,
- proximal interphalangeal flexion of one of the lesser toes *(hammer-toe)*
- flexion of both interphalangeal joints of several toes *(claw-toes)*
FRACTURES IN CHILDREN

Marah Marahleh
Fractures in growing bones are subject to influences which do not apply to adult bones:

1. The presence of growth plate increases longitudinal growth

2. The presence of perichondral plate increases the bone thickness

3. In very young children, the bone ends are largely cartilaginous and therefore do not show up in x-ray images. Fractures at these sites are difficult to diagnose; it helps to x-ray both limbs and compare the appearances on the two sides.

4. Children’s bones are less brittle, and more liable to plastic deformation, than those of adults. Hence the frequency of incomplete fractures – torus fractures (buckling of the cortex) and greenstick fractures, injuries which are very rare in adults.

5. The periosteum is thicker than in adult bones; this may explain why fracture displacement is more controlled. Cellular activity is also more marked, which is why children’s fractures heal so much more rapidly than those of adults. The younger the child, the quicker is the rate of union. Femoral shaft fractures in infants will heal within 3 weeks, and in young children in 4–6 weeks, compared to 14 weeks or longer in adults.
6. Non-union is very unusual.

7. Bone growth involves modelling and remodelling, processes which determine
   the structure and overall form of the bone. This makes for a considerable
   capacity to reshape fracture deformities (other than rotational deformities)
   over time.

8. Injuries of the physis have no equivalent in adults. Damage to the growth plate
   can have serious consequences however rapidly and securely the fracture
   might heal.

- Common sites of bone fracture according to age group seen on X-ray
  - Infants: diaphysis (midshaft) → 1st site of ossification
    - Toddlers: metaphysis
    - Adolescent: epiphysis
Fractures of the growth plate

The epiphyseal plate (growth plate) is a hyaline cartilage plate in the metaphysis at each end of a long bone. It is the part of a long bone where new bone growth takes place.

The plate is found in children and adolescents; in adults, who have stopped growing, the plate is replaced by an epiphyseal line. This replacement is known as epiphyseal closure.

14 years old +/- 2 years is the age of growth plate closing → Transitional fractures occur in this period.
Layers of growth plate:
1. Germinal: the most important, the source of all layers and it’s the first layer near the epiphysis. [Remember: Growth is from epiphysis toward metaphysis]

2. Proliferative

3. Hypertrophic: the weakest; because of increased size of cells so less number of cells in same area + increase fluids and less connections between cells.

4. Zone of provisional calcification
Parts of a Growing Bone

- Wrist Bones
- Wrist joint
- Epiphysis
- Physis (Growth Plate)
- Metaphysis
- Diaphysis

Ulna  Radius
Fractures of the growth plate

- More than 10 per cent of childhood fractures involve injury to the physis (or growth plate).
- The fracture usually runs transversely through the hypertrophic (calcified) layer of the growth plate, often veering off towards the shaft to include a triangular piece of the metaphysis. This has little effect on longitudinal growth, which takes place in the germinal and proliferating layers of the physis.
- However, if the fracture traverses the cellular ‘reproductive’ layers of the plate, it may result in premature ossification of the injured part and cessation of growth or deformity of the bone end.
Classification

- The most widely used classification of physeal injuries is that of Salter and Harris, which distinguishes five basic types of injury.

**Type 1**
- A transverse fracture through the hypertrophic or calcified zone of the plate. Even if the fracture is quite alarmingly displaced, the growing zone of the physis is usually not injured and growth disturbance is uncommon.

**Type 2**
- This is similar to type 1, but towards the edge the fracture deviates away from the physis and splits off a triangular piece of metaphyseal bone. Growth is usually not affected.
Type 3

- A fracture running partly along the physis and then veering off through the epiphysis into the joint. Inevitably it damages the reproductive zone of the physis and may result in growth disturbance.

Type 4

- As with type 3, the fracture splits the epiphysis, but it continues through the physis into the metaphysis. These fractures are particularly liable to displacement and a consequent misfit between the separated parts of the physis, resulting in asymmetrical growth.

Type 5

- A longitudinal compression injury of the physis. There is no visible fracture, but the growth plate is crushed and this may result in growth arrest, diagnosed after long time like for example one year with retrospective history of falling down because nothing seen on x-ray acutely, after one year you see shortening of limb disproportionately. You can not prevent it!
**Salter-Harris Fractures**

Injury to Growth Plate

- **Type 1**: Through Growth Plate
- **Type 2**: Through Growth Plate and Metaphysis
- **Type 3**: Through Growth Plate and Epiphysis
- **Type 4**: Through All Three Elements
- **Type 5**: Crush Injury of Growth Plate

**Types of Salter-Harris Fractures**

- Normal
- Type I: Straight across
- Type II: Above
- Type III: Lower
- Type IV: Through Everything
- Type V: cRush
The higher the grade of classification the higher the severity, the worse the prognosis, with the younger the age (5>4>3>2>1)
Clinical Features

- Physeal fractures usually result from falls or traction injuries; they occur mostly in road accidents and during sport or playground activities and are more common in boys than in girls.

- Deformity is usually minimal, but any injury in a child followed by pain and tenderness near the joint should arouse suspicion, and x-ray examination is essential.
The physis itself is radiolucent and the epiphysis may be incompletely ossified; this makes it hard to tell whether the bone end is damaged or deformed. The younger the child, the smaller the ‘visible’ part of the epiphysis and thus the more difficult it is to make the diagnosis; comparison with the normal side is a great help. Tell-tale features are widening of the physeal ‘gap’, incongruity of the joint or tilting of the epiphyseal axis.

If there is the faintest suspicion of a physeal fracture, a second x-ray examination after 4 or 5 days is essential.

Type 5 injuries are usually diagnosed only in retrospect.
Treatment

1. Undisplaced fractures:

These may be treated by splinting the part in a cast or a close-fitting plaster slab for 2–4 weeks (depending on the site of injury and the age of the child). However, with type 3 and 4 fractures, a check x-ray after 4 days and again at about 10 days is mandatory in order not to miss late displacement.
2. Displaced fractures:

must be reduced as soon as possible.

With types 1 and 2, this can usually be done closed; the part is then splinted securely for 3–6 weeks.

Type 3 and 4 fractures demand perfect anatomical reduction.

An attempt can be made to achieve this by gentle manipulation under general anaesthesia; if this is successful, the limb is held in a cast for 4–8 weeks (the longer periods for type 4 injuries).

Here again, check x-rays at about 4 and 10 days are essential to ensure that the position has been retained. If a type 3 or 4 fracture cannot be reduced accurately by closed manipulation, immediate open reduction and internal fixation is called for. The limb is then splinted for 4–6 weeks, but it takes that long again before the child is ready to resume unrestricted activities.
Complications

1. **Premature fusion**

   - Type 1 and 2 injuries, if properly reduced, usually have an excellent prognosis and bone growth is not adversely affected. Exceptions to this rule are injuries involving the distal femoral and proximal tibial physis; both are undulating in shape, so a transverse fracture may pass through several zones in the physis and result in a focal point of fusion.

   - Type 3, 4 and 5 injuries are more likely to cause premature fusion of part of the growth plate, resulting in cessation of growth or asymmetrical growth and deformity of the bone end.
2. **Deformity**

Established deformity, whether from asymmetrical growth or from malunion of a displaced fracture (e.g. a valgus elbow due to proximal displacement or non-union of a lateral humeral condylar fracture), should be treated by corrective osteotomy. If further growth is abnormal, the osteotomy may have to be repeated.
FRACTURES OF THE DISTAL HUMERUS IN CHILDREN

- The elbow is second only to the distal forearm for frequency of fractures in children.
- Most of these injuries are supracondylar fractures, the remainder being divided between condylar, epicondylar and proximal radial and ulnar fractures.
- Boys are injured more often than girls and more than half the patients are under 10 years old.
- The usual accident is a fall directly on the point of the elbow or onto the outstretched hand with the elbow forced into valgus or varus.
- Pain and swelling are often marked and examination is difficult.
- X-ray interpretation also has its problems: the bone ends are largely cartilaginous and therefore radiographically incompletely visualized.
Normal Anatomy

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Supracondylar Fractures

- These are among the commonest fractures in children.
- The distal fragment may be displaced and/or tilted either posteriorly or anteriorly, medially or laterally; sometimes it is also rotate.
- Posterior displacement and tilt is the commonest (95 per cent of all cases), suggesting a hyperextension injury, usually due to a fall on the outstretched hand. The jagged end of the proximal fragment pokes into the soft tissues anteriorly, sometimes injuring the brachial artery or median nerve.
- Anterior displacement is rare, but may result from over-reduction of the usual posterior displacements.
26.13 Supracondylar fractures  X-rays showing supracondylar fractures of increasing severity. (a) Undisplaced. (b) Distal fragment posteriorly angulated but in contact. (c) Distal fragment completely separated and displaced posteriorly. (d) A rarer variety with anterior angulation.
* Extension type ... Posterior displacement of the distal fragment

**MECHANISM OF INJURY**

- **Extension type**:
  - Fall on outstretched hand
  - Elbow hyperextended
  - Forearm pronated or supinated
* Flexion Type ... Anterior displacement of the distal fragment.

**MECHANISM OF INJURY**

- *Flexion type:*
  Fall directly on the elbow rather than out stretched hand
- **Special features**
- Following a fall, the child is in pain and the elbow is swollen; with a posteriorly displaced fracture, the S-deformity of the elbow is usually obvious.
- It is essential to feel the pulse and check the capillary return.
Undisplaced fractures are easily missed; there may be no more than subtle features of a soft-tissue haematoma.

The anteroposterior x-ray is often difficult to interpret because it is taken with the elbow flexed. The degree of sideways tilt (angulation) may therefore not be appreciated.

This is where Baumann’s angle is most helpful; wherever possible it should be accurately measured and compared with that of the uninjured side. More than 5 degree variation indicates coronal plate deformity and is not accepted.

Baumann’s angle: This is the angle subtended by the longitudinal axis of the humeral shaft and a line through the coronal axis of the capitellar physis. Normally this angle is less than 80 degrees. If the distal fragment is tilted in varus, the increased angle is readily detected.
26.14 Baumann’s angle  Anteroposterior x-rays are sometimes difficult to make out, especially if the elbow is held flexed after reduction of the supracondylar fracture. Measurement of Baumann’s angle is helpful. This is the angle subtended by the longitudinal axis of the humeral shaft and a line through the coronal axis of the capitellar physis, as shown in (a) the x-ray of a normal elbow and the accompanying diagram (b). Normally this angle is less than 80 degrees. If the distal fragment is tilted in varus, the increased angle is readily detected (c).
Treatment

- If there is even a suspicion of a fracture, the elbow is gently splinted in 30 degrees of flexion to prevent movement and possible neurovascular injury during the x-ray examination.

1. **Undisplaced fractures** The elbow is immobilized at 90 degrees and neutral rotation in a light-weight splint or cast and the arm is supported by a sling. It is essential to obtain an x-ray 5–7 days later to check that there has been no displacement. The splint is retained for 3 weeks and supervised movement is then allowed.
Treatment

2. **Posteriorly angulated fracture**  If the posterior cortices are in continuity, the fracture can be reduced under general anaesthesia by the following step-wise manoeuvre:

1. traction for 2–3 minutes in the length of the arm with counter- traction above the elbow;

2. correction of any sideways tilt or shift and rotation (in comparison with the other arm);

3. gradual flexion of the elbow to 120 degrees, and pronation of the forearm, while maintaining traction and exerting finger pressure behind the distal fragment to correct posterior tilt.
X-rays are taken to confirm reduction, checking carefully to see that there is no varus or valgus angulation and no rotational deformity. If the acutely flexed position cannot be maintained without disturbing the circulation, or if the reduction is unstable, the fracture should be fixed with percutaneous crossed Kirschner wires (take care not to skewer the ulnar nerve!). Following reduction, the arm is held in a collar and cuff; the circulation should be checked repeatedly during the first 24 hours. An x-ray is obtained after 3–5 days to confirm that the fracture has not slipped. If it has, do not delay – a further attempt at reduction is still possible. If reduction is satisfactory, the splint is retained for 3 weeks, after which movements are begun.
3. Posteriorly displaced fractures

These are usually associated with severe swelling, are difficult to reduce and are often unstable; moreover, there is a considerable risk of neurovascular injury or circulatory compromise due to swelling. The fracture should be reduced under general anaesthesia as soon as possible, by the method described above, and then held with percutaneous crossed Kirschner wires; this obviates the necessity to hold the elbow acutely flexed. Care should be taken not to injure the ulnar and radial nerves. Postoperative management is the same as for simple angulated fractures.
Treatment

4. Anteriorly displaced fractures

The fracture is reduced by pulling on the forearm with the elbow semi-flexed, applying thumb pressure over the front of the distal fragment and then extending the elbow fully. A posterior slab is bandaged on and retained for 3 weeks. Thereafter, the child is allowed to regain flexion gradually.
Complications

1. Vascular injury:
   - The great danger of supracondylar fracture is injury to the brachial artery

2. Nerve injury:
   - The median nerve may be injured. Fortunately, loss of function is usually temporary and recovery can be expected in 6–8 weeks

3. Malunion: Malunion is common
   Cubitus varus is disfiguring and cubitus valgus may cause late ulnar palsy. If deformity is marked, it will need correction by supracondylar osteotomy.
Complications

4. **Elbow stiffness**: Full movement may take months to return and must not be hurried. Forced movement will only make matters worse and may contribute to the development of heterotopic ossification.
Thank you