

THE PEDIATRIC FOOT

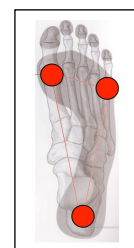
Introduction

Terminology

- Fixed ankle plantar flexion → Equinus.
 - Fixed ankle dorsal flexion → calcaneus
 - High arch → pes cavus (forefoot pronation, Plantarflexion of the first ray)
 - Flat arch → pes planus
 - Fixed Eversion of the hindfoot (subtalar) → valgus
 - Fixed Inversion of the hindfoot (subtalar) → varus
 - Forefoot deviated medially → supination (it is similar to varus of the hindfoot=same direction)
 - Forefoot rotated laterally → pronation (it is similar to valgus of the hindfoot=same direction)
 - Metatarsals deviated medially on tarsal bones → metatarsus adductus
 - Metatarsals deviated laterally on tarsal bone → metatarsus abductus
- Foot → 7 tarsal bones, 5 metatarsals, 14 phalanges
 - Joints
 - Inferior tibiofibular
 - Ankle proper (tibiotalar) → plantarflexion and dorsiflexion
 - Subtalar → inversion and eversion
 - **THE FOOT TRIPOD:**
 1. Center of the calcaneus (heel)
 2. Head of the 1st metatarsal.
 3. Head of the 5th metatarsal

*CLINICAL APPLICATION

 - Two deformities in an opposite direction for compensation
 - Varus heel + pronation of forefoot → high arch
 - Valgus heel + supination of forefoot → flat arch



Calcaneovalgus foot:

- A soft tissue contracture foot deformity characterized by excessively dorsiflexed hindfoot (ankle) (calcaneus) with hindfoot (subtalar) valgus, no dislocation or bony deformity
- Caused by intrauterine "packaging" (tight intrauterine space)
- More in first born and low birth weight.
- Management: stretch the heel and physiotherapy.
 - Nonoperative
 - Observation & passive stretching exercises
 - Typically resolves spontaneously



- Physical exam:
 - Excessively dorsiflexed hindfoot that is passively correctable to neutral
 - Dorsal surface of the foot rest on the anterior surface of the tibia
 - Can be confused with congenital vertical talus
Differs on exam in that vertical talus has a rigid hindfoot equinus /valgus and rigid dorsiflexion through midfoot

Congenital Talipes equinovarus (CTEV) “club foot”:

- Pes (means foot), Equino (means plantarflexion), Varus (means twisted internally). Also, it comes with adduction of the midfoot/forefoot.
- In this deformity the foot is curved downwards and inwards – the ankle in equinus, the heel in varus, and the forefoot adducted, flexed and supinated
- 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 maneuver meets with varying degrees of resistance and in severe cases the deformity is fixed.
- Classified into:
 - Postural (physiologic): the deformity can be easily corrected by the examiner, not considered a real club foot.
 - Fixed (pathologic): could be idiopathic (most common), or syndromic (comes with other congenital deformities ex. myelomeningocele and arthrogryposis.)
 - Flexible → no specific treatment (stretching by family)
 - Fixed → stiff, needs treatment
- The deformities in a club foot are summarized in the mnemonic CAVE
- We start to manage it in sequence: "CAVE"
 1. Cavus
 2. Adductus
 3. Varus
 4. Equinus



- In a club foot, the Achilles tendon is too short, causing the foot to stay pointed — “fixing the foot in equinus.”
- Boys are affected twice as often as girls and it occurs bilaterally in nearly one-half of the cases. A family history increases the risk by 20–30 times.
- It affects 1/1000, 50% bilaterally.
- 10% chance of subsequent child being affected if +ve family history.
- Diagnosis is clinical, 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 prenatal US as early as 16 weeks, but nothing can be done.
- Treatment:
 - Golden method of treatment is Ponseti Casting which is a method of weekly gradual stretching and casting. Typically takes 5-6 weeks of casting.
 - The order of correction follows the mnemonic CAVE, cavus first and so on....

- Last cast stays on for 3 weeks after which boots and bars (foot abduction orthosis) is applied full time 24/7 for the first 3 months after the last casts comes off, and then night and nap time until the child is four years of age.
 - The aim of foot abduction orthosis is to maintain reduction and prevent recurrence.
 - Recurrence rate without using them is up to 70-80%, and with them is down to 20%
 - The fulcrum for correction during casting is the talar neck.
 - The last part of the deformity to correct is the equinus, and usually tendo-achilles tenotomy (complete percutaneous cut) is needed in 70-90% of the patients
 - It is better to start correction early, first few weeks of life.
 - Ponseti casting remains the gold standard for older patients, recurrence, persistent deformities and even for patients with previous surgical releases.
 - Surgical release is sometimes needed, and the surgical dose depends on the amount of deformity present, we try to minimize the dose as possible to decrease the amount of deep scarring, and reduce the incidence of future stiffness, premature degeneration and arthrosis. A frequently needed surgical procedure is tibialis anterior transfer to the lateral cuneiform to correct a dynamic supination deformity.
- One thing to remember is that a club foot is a structural as well as a cosmetic deformity, which means that even a fully corrected club foot will remain slight smaller and a different from the normal foot from the knee down i.e.; smaller calf size, smaller foot size....

Metatarsus adductus:

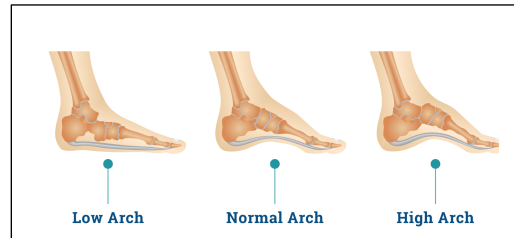
- Varies from a slightly curved forefoot to something resembling a mild clubfoot. In contrast to clubfoot, the deformity here is limited to the forefoot.
- The majority (90%) either improve spontaneously or can be managed non-operatively using serial corrective casts followed by straight-last shoes.

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.



- High incidence with various congenital anomalies and neuromuscular diseases; such as:
 - ✓ Myelomeningocele
 - ✓ DDH
 - ✓ Arthrogryposis
 - ✓ Trisomy 13
 - ✓ Marfan syndrome
- 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: due to contractures of the EDL, EHL and tibialis anterior tendons
- Treatment by serial casting (reverse ponseti) and a small surgical procedure is needed before applying the last cast



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 supinates at the forefoot.
- The appearance of flat-foot can be normal and without symptoms (the arch is not formed until 4–6 years of age and about 15% of the population have supple asymptomatic flat-feet) 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 (calcaneo-navicular, or talo-calcaneal (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 reforms. The medial arch also reforms on extending the great toe at the MTP joint.



- Clinical assessment:
 - In the common flexible flat feet, there are usually no symptoms, but the parents notice that the feet are flat or that the shoes wear badly.
 - 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 forms up, it is a flexible (or mobile) deformity. This can also be checked by performing the jack test (also called the great toe extension test (toe raise)): with the child seated, feet planted firmly on the floor, the examiner firmly dorsiflexes the great toe; the medial arch should re-appear while the heel adopts a more neutral position and the tibia rotates externally.
 - A tight Achilles tendon may induce a compensatory flat-foot deformity.

- X-rays are unnecessary for asymptomatic, flexible flat feet.
 - If painful or stiff flat feet → use x-ray
 - If tarsal coalitions → CT

- Treatment:
 - Physiologic “flexible” flat foot: reassurance “deformity’ will probably correct itself out if young enough“. (Medial arch support only if there was genuine medial foot pain, but this doesn’t get rid of the flat foot deformity.) remember 15-25% of adults have flexible flat feet.
 - Rigid type might need surgery if symptomatic enough however we always start conservatively

Tarsal coalition:

- Connection of two or more tarsal bones. This bridge could be bony (synostosis), cartilaginous (synchondrosis) or fibrous (syndesmosis).
- Fibrous then cartilaginous then bone
- Progress with age
- Presentation of pain with the commencement of ossification
- Etiology: Defect in the differentiation of primitive mesenchyme
- Age of onset:
 - Calcaneo-navicular usually 8-12 years old (most common 1/2-2/3 of cases) anteatator nose sign on x-ray
 - Talocalcaneal usually 12-15 years old. → c sign on x-ray
- Deformity
 - Flattening of longitudinal arch
 - Abduction of forefoot
 - Valgus hindfoot
 - Peroneal spasticity (also known as peroneal spastic flatfoot)
- CT scan necessary to confirm and rule-out other coalitions
- Pain onset correlates with age of ossification of coalition
- Treatment
 - Conservative (soft shoe inserts, walking-cast immobilization)
 - Surgery (arthrodesis, resection of coalition)

In-Toeing:

Causes:

- 1. Metatarsus adductus (infants):** (Lateral aspect of the foot is (c) shaped)
Mechanism thought to be related to packaging disorder caused by intra-uterine positioning (forefoot is adducted, lateral foot border is convex instead of straight, a medial soft-tissue crease indicates a more rigid deformity, normal hindfoot and subtalar motion)
 - 2. Internal Tibial Torsion (toddlers):**
Observe foot-thigh angle in prone position, and $> 10^\circ$ of internal rotation is indicative of tibial torsion (normal is $0-20^\circ$ of external rotation). Most common cause of in-toeing in toddlers.
 - 3. Excessive (High) femoral anteversion:**
Hip motion shows $>70^\circ$ internal rotation (normal is $30-60^\circ$), decreased external rotation ($<20^\circ$) and the patella internally rotated. Seen in early childhood (3-6 years), twice as frequent in girls than boys, often bilateral. Most correct spontaneously with growth. (W position)
 - Hip motion (tested in the prone position)
 - Increased internal rotation of $>70^\circ$ (normal is $30-60^\circ$)
 - Decreased external rotation of $< 20^\circ$ (normal $30-60^\circ$)
- Diagnosis: by lying the patient in prone position.
 - Treatment: If severe enough and persistent is surgical correction not before 5 years for MW, 8 years for TT, and 10 years for FA.

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 paralyzed, suggests that all forms of pes cavus are due to some type of neuromuscular imbalance.
- Clinical features
 - At 8–10 years, mostly bilateral
 - There might be a hx of spinal disorder
 - As discussed previously, usually we have two deformities in an opposite direction, a forefoot cavus (pronation) usually accompanies a hindfoot (subtalar) varus. The deformity usually starts in the forefoot (cavus) and the heel varus follows to restore the tripod position of the foot. To start with the compensatory deformity (hindfoot varus) is flexible and with time it becomes fixed. This is important when it comes to surgical correction as we only have to correct the fixed deformities.
 - One test to differentiate whether the varus has become fixed or is still flexible is:

- The Coleman block: The patient is helped to stand with the heel and lateral part of the foot resting on a 1-inch (2 cm) block and the medial part of the forefoot and great toe dipping over the edge of the block to touch the floor. If, in this position, the heel varus corrects then mobility of the subtalar joint is demonstrated and the hindfoot varus is still flexible.
- Treatment:
 - Often no treatment is required; apart from the difficulty of fitting shoes, the patient has no complaints.
 - If symptoms persist and the deformities are still passively correctable → tendon re-balancing operation
 - Painful foot with fixed deformities → surgery for pain-free, plantigrade, supple but stable foot.

Other foot disorders in adults

Not a pediatric foot conditions, included here because of its importance

Hallux valgus “bunion”

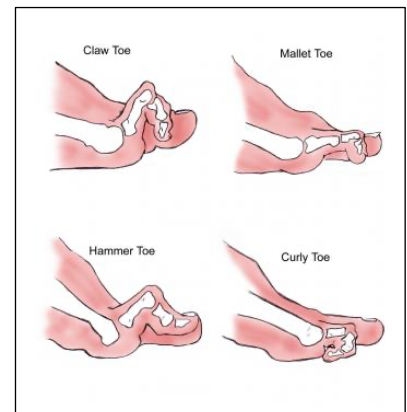
- Not a pediatric foot condition, included here because of its importance
- The commonest of the foot deformities (and probably of all musculoskeletal deformities).
- The elements of the deformity are lateral deviation and rotation of the hallux, together with a prominence of the medial side of the head of the first metatarsal (a bunion); there may also be an overlying bursa and thickened soft tissue. Lateral deviation of the hallux may lead to overcrowding of the lateral toes and sometimes over-riding
- Most common in women between 50 and 70 years, bilateral
- Proposed factors include wearing overly tight shoes, family history, and rheumatoid arthritis.
- Diagnosis is generally based on symptoms and supported by X-rays
- A similar condition of the little toe is referred to as a bunionette or Tailor's bunion, is a condition caused as a result of inflammation of the fifth metatarsal bone at the base of the little toe
- The patient is encouraged to wear shoes with deep wide toe-boxes, soft uppers and low heels
- Treatment may include proper shoes, orthotics, or NSAIDs. If this is not effective for improving symptoms, surgery may be done

Hallux rigidus:

- Hallux rigidus or stiff big toe is degenerative arthritis and stiffness due to bone spurs that affects the MTP joint at the base of the hallux (big toe).
- ‘Rigidity’ of the first MTP joint
- Pain and stiffness in the joint at the base of the big toe during use (walking, standing, bending, etc.)
- Swelling

Disorders of the Tendo-Achilles

- **Achilles tendinitis**
 - Athletes, joggers and hikers often develop pain and swelling around the tendo-achilles, due to local irritation of the tendon sheath or the paratenon
 - Function is inhibited because of pain in the heel cord, especially at push off
 - Rx: Advice on rest, ice, compression and elevation (RICE) and the use of NSAID drug (oral or topical) are helpful
- **Achilles tendon rupture**
 - Rupture probably occurs only if the tendon is degenerate. Consequently, most patients are over 40 years old. While pushing off (running or jumping), the calf muscle contracts; but the contraction is resisted by body weight and the tendon ruptures.
 - The patient feels as if he or she has been struck just above the heel, and is unable rise up on tiptoes.
 - Gap can be seen and felt about 5 cm above the insertion of the tendon.
 - Simmonds' test; with the patient prone, the calf is squeezed; if the tendon is intact the foot is seen to plantar flex involuntarily; if the tendon is ruptured the foot remains still.
 - Rx → conservative vs surgery



Deformities of the lesser toes:

- Hammer: flexion at the PIP joint and extended DIP joint.
- Mallet: flexion at the DIP joint.
- Curly toes: neutral at MTP, flexed at PIP and DIP.
- Claw toes: hyperextension of the MTP joint, flexion of the IP joints (Think of abnormal neurology)

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.
- 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.
- The longitudinal arch forms the medial border of the foot. Even when weightbearing the medial border normally forms a slight arch.
- The anterior or transverse arch is formed by the arrangement of the slightly splayed metatarsals in the forefoot.
- Pes planovalgus (flat-foot) describes a flattened longitudinal arch. A dropped metatarsal arch is called anterior flat-foot.
- Pes cavus is a foot with an excessively high arch.
- Hallux valgus means lateral deviation of the big toe.