Radiographic Evaluation of the Pediatric Foot and its Deformities

Amy C. Wu, MD
UCSD Department of Radiology

Acknowledgement

Melvin O. Senac, Jr., MD

Associate Clinical Professor of Radiology
University of California, San Diego

Educational Objectives

- Present a systematic approach to evaluating pediatric foot alignment abnormalities
- Discuss the normal and abnormal radiographic lines, angles, and measurements utilized in evaluating common alignment abnormalities
- Improve understanding of four major foot deformities most commonly encountered by orthopedists

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Pretest

Which congenital foot deformity do these celebrities have in common?

Dudley Moore

Mia Hamm

Kristie Yamaguchi

Troy Aikman

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Unknown Case 1:

- Case 1: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Unknown Case 2:

- Case 2: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Unknown Case 3:

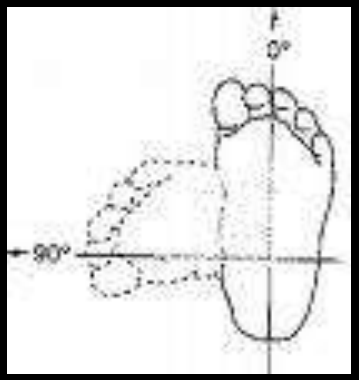
- Case 3: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Unknown Case 4:

- Case 4: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Definitions

- Talipes: Pertaining to foot deformities that are congenital in origin
- Adduction: Displacement on a transverse plane toward the axis of the body



- Abduction: Displacement on a transverse plane away from the axis of the body
- Pes: Pertaining to acquired deformities
- Valgus: Bent outward away from the midline of the body, distal to the joint/point of interest

- Varus: Bent inward toward the midline of the body, distal to the joint/point of interest

Normal Foot (AP)

- The long axis of the talus falls on the axis of the 1st metatarsal.
- The long axis of the calcaneus falls on the axis of the 4th metatarsal.
- Normal talocalcaneal angle (on both AP and lateral) is 20-40°, with average in the adult of 35°.

Normal Foot (Lat)

- The long axis of the talus falls on the long axis of the 1st metatarsal.
- Normal talocalcaneal angle is 20-40°, with average in the adult of 35°.

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Mechanism of Foot Deformities

- The talus serves as point of reference
- Any change in relationship of the talus and calcaneus thus results from motion of the calcaneus
- Calcaneus moves in two planes: (1) transverse, (2) sagittal

- When the calcaneus is in valgus position, the anterior portion of the calcaneus slants downward and abducts, increasing talocalcaneal angle

- When the calcaneus is in varus position, the anterior portion of the calcaneus adducts, decreasing the talocalcaneal angle

Evaluation of Foot Deformities: Ankle Joint

- Consider the movement of 3 main joints of the foot and ankle:
  - Ankle joint
  - Subtalar joint
  - Midtarsal joints

- Ankle joint:
  - Plantarflexion deformity – Equinus
    - Fixed plantarflexion of the hindfoot
    - The calcaneus is plantar flexed (anterior end down) on the lateral view, making an angle of >90° anteriorly with the tibia
  - Dorsiflexion deformity – Calcaneus
    - An abnormal dorsiflexion of the calcaneus (anterior end up)
    - The calcaneus is in an increased vertical position

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Evaluation of Foot Deformities: Subtalar Joint

- Inversion deformity: Hindfoot varus
  - AP view: Mid-talar line falls lateral to the first MT base because of adduction of the anterior end of the calcaneus and foot
  - Lat view: The talus cannot plantarflex because of the adduction of the anterior calcaneus under the talus, thus the axes of the two bones become parallel to each other
  - Summary: Decreased talocalcaneal angle on both AP and lat views

a. Normal

b. Hindfoot varus

Lateral view shows the nearly parallel talus and calcaneus, with a decreased talocalcaneal angle.

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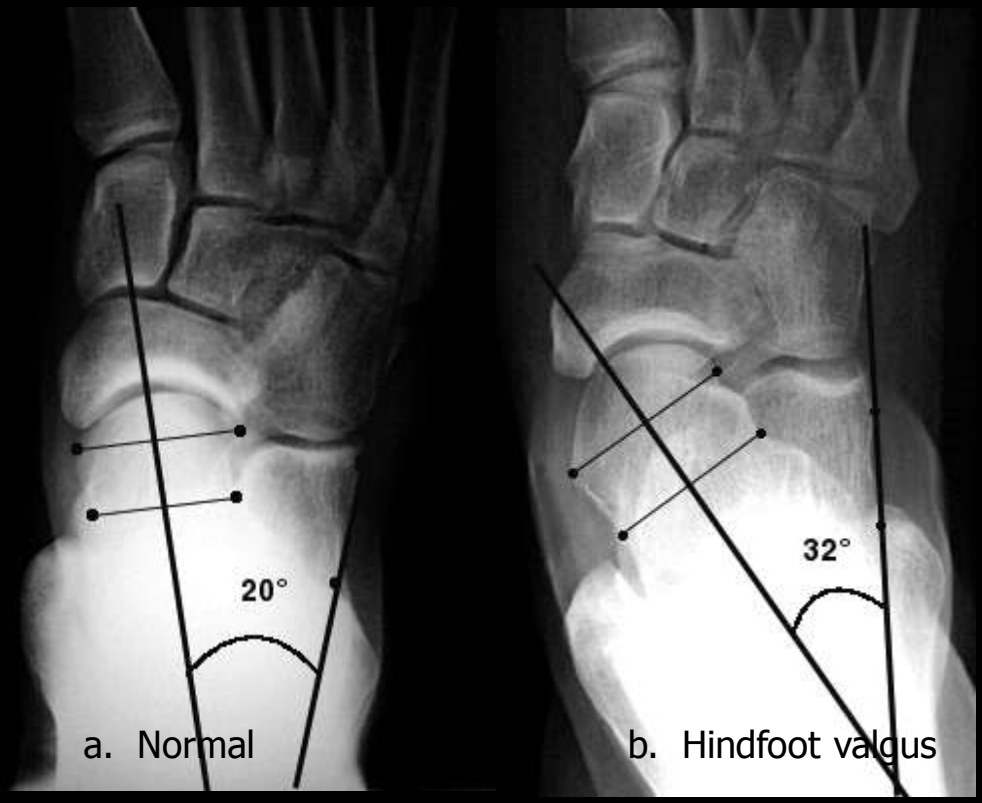
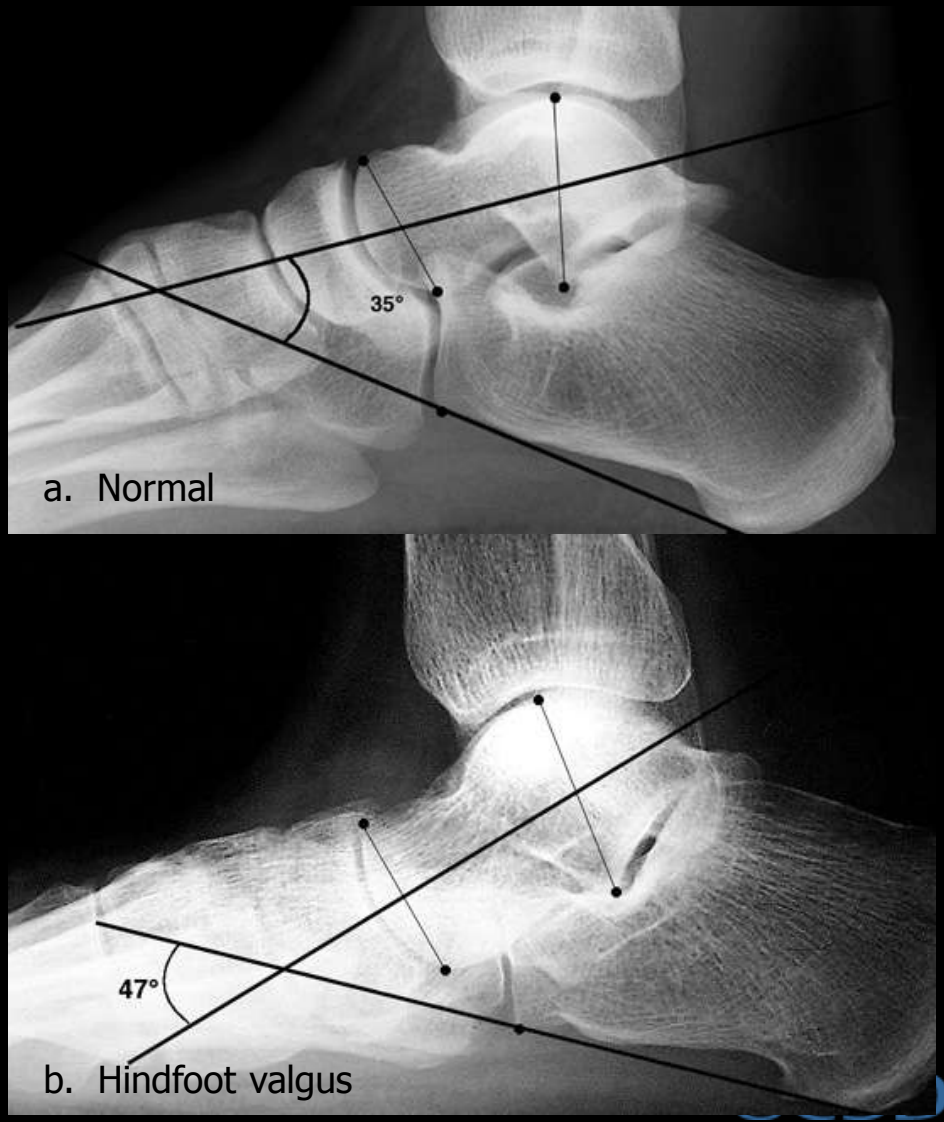
Evaluation of Foot Deformities: Subtalar Joint

- Eversion deformity: Hindfoot valgus
  - AP view: Due to abduction of the anterior end of the calcaneus and foot, the talar axis falls medial to the first MT
  - Lat view: Due to abduction of the anterior calcaneus, support is withdrawn from the anterior talus, causing the long axis of the talus and that of the first MT to angulate plantarward
  - Summary: Increased talocalcaneal angle on both AP and lat views



Evaluation of Foot Deformities: Subtalar Joint

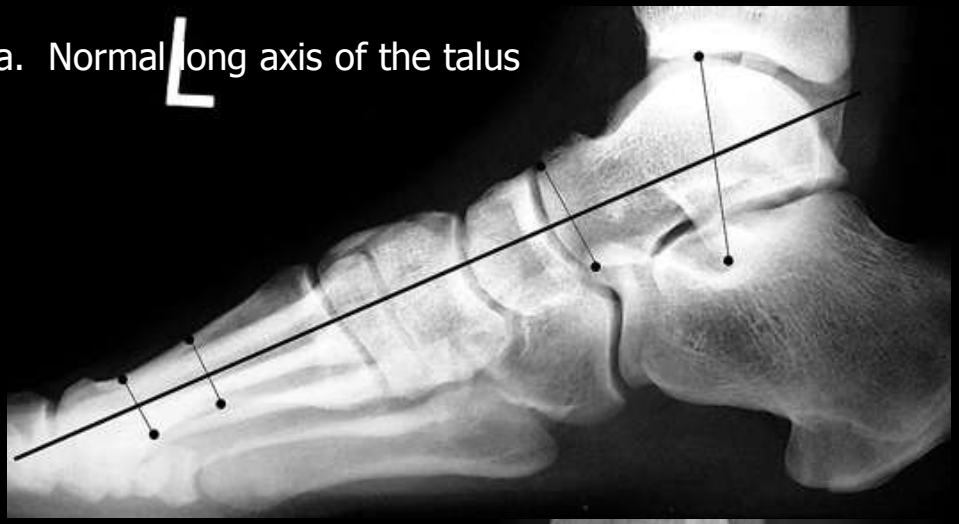
- Hindfoot valgus (Lat view):
  - The talus is plantarflexed
  - Lateral talocalcaneal angle:
    - formed by the intersection of the line bisecting the talus with the line along the axis of the calcaneus on lateral weight-bearing views (or a line can be drawn at the plantar border of the calcaneus)
    - The normal range is 20-40°
    - An increased angle indicates hindfoot valgus



Evaluation of Foot Deformities: Midtarsal Joints

- Normal Arch:
  - Long axis of talus aligns with long axis of first MT
  - Normal calcaneal pitch: Calcaneal inclination angle 18-20°
- Plantarflexion deformity:
  - Pes cavus – a high longitudinal arch of the foot
- Dorsiflexion deformity:
  - Pes planus – a flattened longitudinal arch of the foot

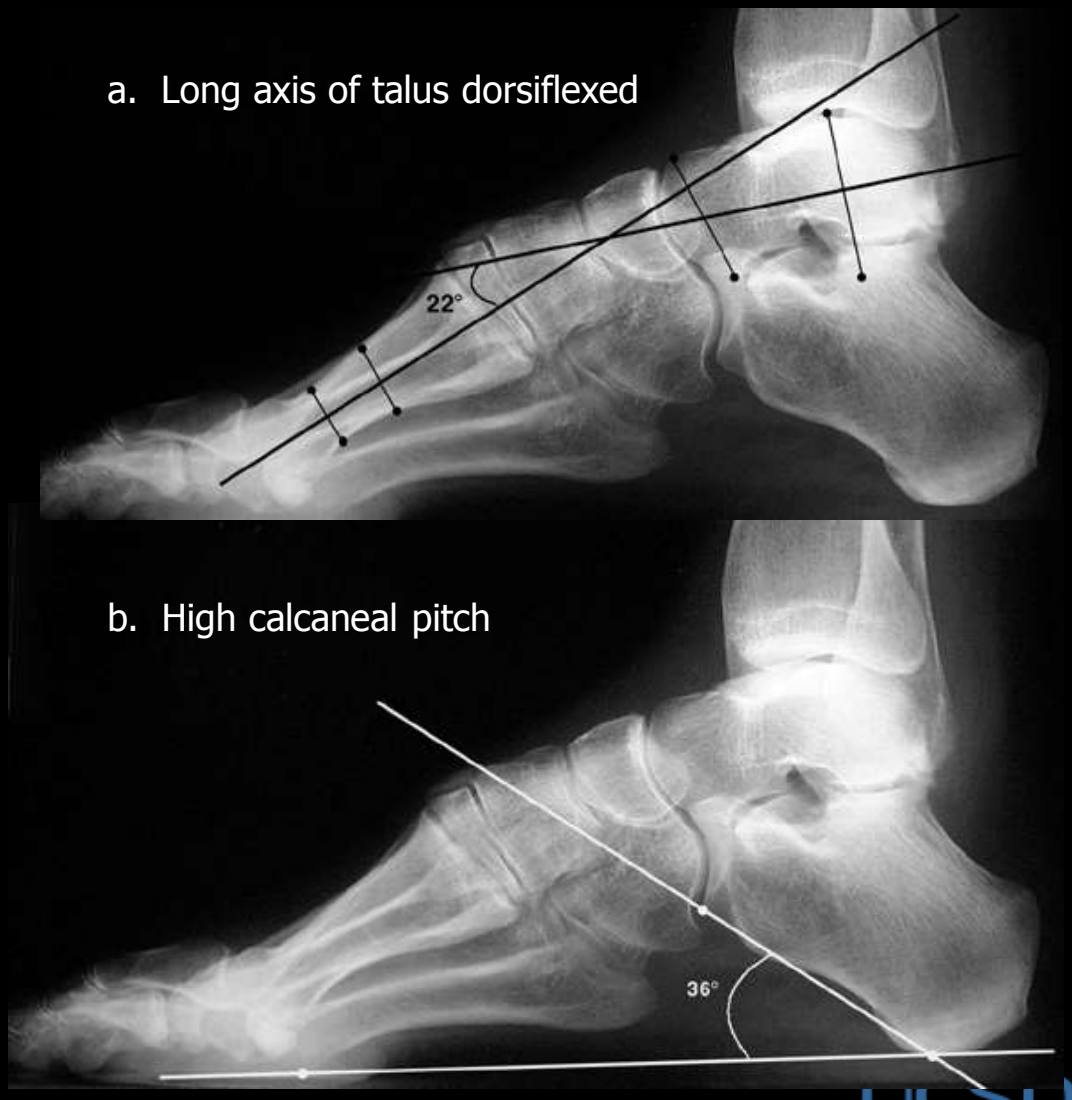
a. Normal long axis of the talus



b. Normal calcaneal pitch

Evaluation of Foot Deformities: Midtarsal Joints

- Pes cavus (high arch): High longitudinal arch of the foot with long axis of talus abnormally dorsiflexed with respect to first metatarsal on the lateral view.
- Pes cavus with abnormally high calcaneal pitch.



Evaluation of Foot Deformities: Midtarsal Joints

- Pes planus (flat arch): Low longitudinal arch of the foot. Long axis of talus is abnormally plantar flexed with respect to first metatarsal on lateral view.
- Decreased calcaneal inclination angle (calcaneal pitch):
  - 18-20° is generally considered normal, although measurements ranging from 17-32° have been reported to be normal.

a. Long axis of talus plantarflexed

b. Decreased calcaneal pitch

Evaluation of Foot Deformities: Midtarsal Joints

- Adduction deformity:
  Forefoot varus
  - AP view:
    - Axis of MTs angle toward midline of the body
    - Calcaneus axis points lateral to 4th MT head
    - Axis of 1st MT and talus form an obtuse angle with apex pointing laterally
  - Lat view:
    - ladderlike configuration of the metatarsals

Evaluation of Foot Deformities: Midtarsal Joints

- Abduction deformity:
  Forefoot valgus
  - AP view:
    - Axis of MTs angle away from midline of the body
    - Calcaneus axis points medial to 4th MT head
    - Axis of 1st MT and talus form an obtuse angle with apex pointing medially
  - Lat view:
    - metatarsal bones are nearly all superimposed

Unknown Case 1:

- Case 1: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Unknown Case 1:

Ankle joint – normal

calcaneus is in normal position (90^{o} to tibia)

Subtalar joint – hindfoot valgus

AP: Midtalar line falls medial to 1st MT

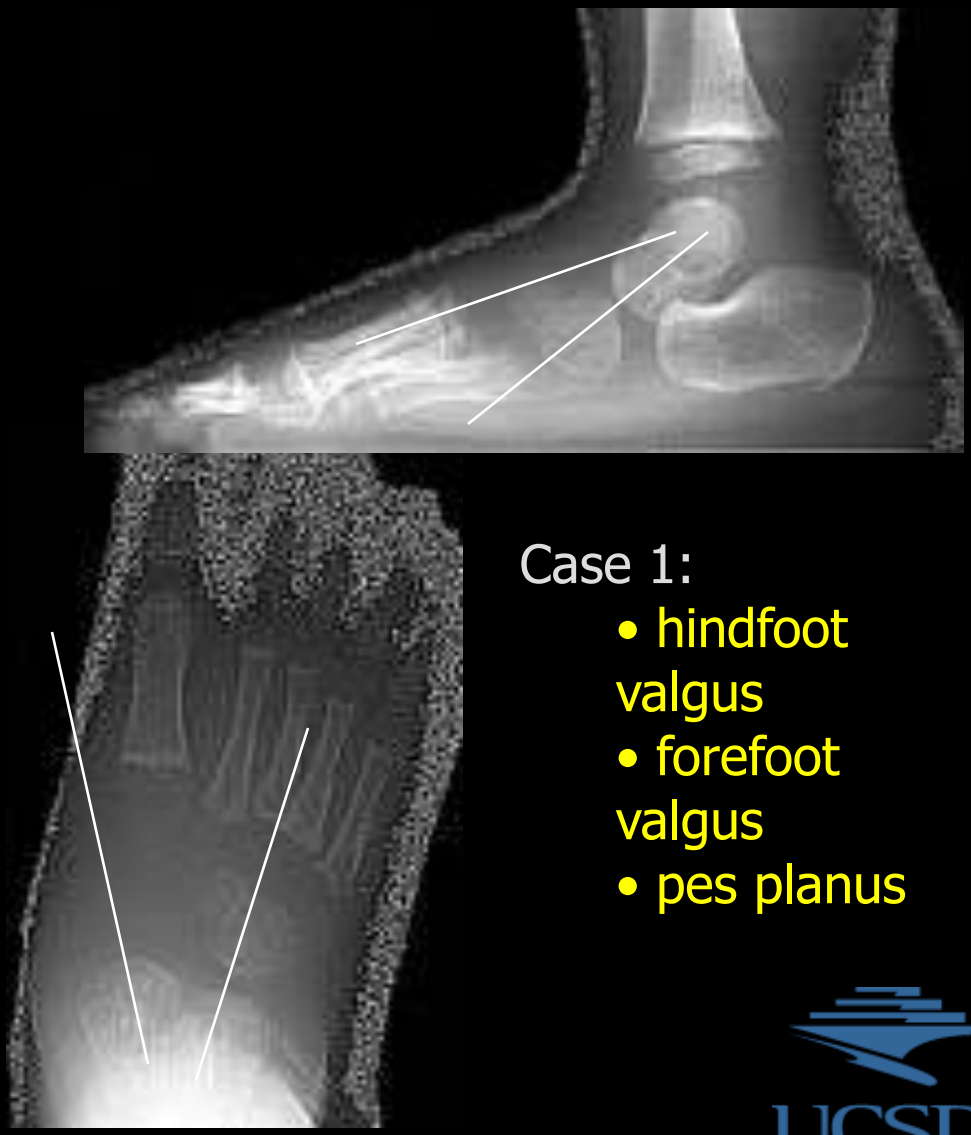
Lat: Talar long-axis is plantarflexed because of abduction of the anterior calcaneus resulting in lack of support from the anterior talus

Midtarsal joint – forefoot valgus

AP: Axis of MTs angles away from the midline, midcalcaneal line points medial to 4th MT head

Midtarsal joint – pes planus

Lat: midtalar axis plantar-flexed compared to 1st MT, decreased calcaneal pitch



Case 1:

- hindfoot valgus
- forefoot valgus
- pes planus

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Flexible Flatfoot Deformity: Pes Planus

- Incidence:
  - One of the most common foot malformations, usually bilateral with strong hereditary pattern
  - No gender predilection
- Clinical:
  - Limited plantarflexion with prominent medial and plantar aspect of foot
  - Foot dorsiflexes to a normal or greater than normal angle
- Radiographic findings:
  - Ankle joint – normal
    - Calcaneus lies horizontal, but not in equinus
  - Subtalar joint – hindfoot valgus
  - Midtarsal joint –
    - Pes planus deformity with long axis of the talus angulated plantarward, indicating sagging of the longitudinal arch
    - Forefoot valgus

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Unknown Case 2:

- Case 2: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Unknown Case 2:

- Ankle joint – normal
  - calcaneus is in normal position (90° to tibia)
- Subtalar joint – normal or in hindfoot valgus
  - AP: Midtalar line falls medial to 1st MT
  - Lat: Talar long-axis is plantarflexed because of abduction of the anterior calcaneus resulting in lack of support from the anterior talus
- Midtarsal joint – forefoot varus
  - AP: Axis of MTs angles toward midline of the body, midcalcaneal line points lateral to 4th MT head

Case 2:

- normal ankle joint
- hindfoot valgus
- forefoot varus

Metatarsus Adductus

- Incidence:
  - 1:1000 live births
  - 50% of cases bilateral
  - Slight female predilection
- Clinical:
  - Forefoot is adducted and inverted, the heel is in mild to moderate valgus
  - Those having normal hindfoot are classified as metatarsus varus
  - Range of dorsiflexion of the foot and ankle is normal
  - Deformity is present at birth, but frequent unrecognized until 3rd-4th month
- Clinical (cont):
  - Immediate treatment recommended as deformity will not spontaneously correct
  - After correction of forefoot deformity, infants with marked hindfoot valgus will have flatfoot
  - Infants with normal hindfoot usually corrects to normal foot
- Radiographic findings:
  - Ankle joint – normal
  - Subtalar joint – normal or in hindfoot valgus
  - Midtarsal joint – forefoot varus

Unknown Case 3:

- Case 3: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Unknown Case 3:

- Ankle joint – equinus deformity
  - calcaneus makes an angle > 90^{o} to tibia
- Subtalar joint – severe hindfoot valgus
  - AP: Midtalar line falls medial to 1^{st} MT
  - Lat: Talar long-axis is plantarflexed because of abduction of the anterior calcaneus resulting in lack of support from the anterior talus
- Midtarsal joint – forefoot valgus
  - AP: Axis of MTs angles away from midline of the body, midcalcaneal line points medial to 4^{th} MT head

Case 3:

- ankle equinus deformity
- severe hindfoot valgus
- forefoot valgus

Congenital Vertical Talus

- Incidence:
  - Unknown, more common in males
  - Condition may occur as an isolated primary deformity or in association with CNS and MSK abnormalities
  - May be one of multiple anomalies associated with Trisomy 13, 15, and 18
- Clinical
  - Rigid deformity with the sole of the foot convex resulting in rockerbottom appearance
  - Head of the talus is markedly prominent on the medial and plantar aspect
  - The forefoot is abducted and dorsiflexed at the midtarsal joint
- Pearls:
  - Severe pes planus has a vertical talus, but no equinus
  - Rockerbottom treated clubfoot has persistent equinus, but not a plantarflexed talus
- Radiographic findings:
  - Ankle joint – equinus deformity
  - Subtalar joint – hindfoot valgus
  - Midtarsal joint – forefoot valgus
  - There is primary dislocation of the talonavicular joint; the navicular articulates with the dorsal aspect of the talus, locking it in a plantarflexed vertical position
  - Subluxations of adjacent joints, resulting in rockerbottom deformity are secondary/adaptive

Unknown Case 4:

- Case 4: Diagnosis?
  - Congenital vertical talus
  - Metatarsus adductus
  - Talipes equinovarus
  - Hindfoot varus
  - Hindfoot valgus
  - Forefoot varus
  - Forefoot valgus
  - Pes cavus
  - Pes planus

Unknown Case 4:

- Ankle joint – equinus deformity
  - calcaneus makes an angle >90° to tibia
- Subtalar joint – hindfoot varus
  - AP: Midtalar line falls lateral to 1st MT
  - Lat: Talar long-axis is dorsiflexed because of adduction of the anterior calcaneus under the talus (talus and calcaneus appear parallel)
- Midtarsal joint – forefoot varus
  - AP: Axis of MTs angles toward midline of the body, midcalcaneal line points lateral to 4th MT head
- Midtarsal joint – pes cavus
  - Lat: midtalar axis dorsiflexed compared to 1st MT, increased calcaneal pitch

Case 4:

- ankle equinus deformity
- hindfoot varus
- forefoot varus
- pes cavus

Clubfoot

- Incidence:
  - 1:1000 live births
  - 2:1 male to female ratio
  - 57% unilateral
  - May be seen with spina bifida or arthrogryposis
- Clinical
  - Variable severity
  - Affected foot points downward, with the toes turned inward and the bottom of the foot twisted inward
  - Achilles tendon is tight and muscles in the calf are often smaller compared to a normal lower extremity
- Radiographic findings:
  - Ankle joint – equinus deformity
  - Subtalar joint – hindfoot varus
  - Midtarsal joint –
    - forefoot varus
    - cavus deformity (may not be apparent because of marked rotation of the forefoot in varus)

Foot mimics appearance of a golf club

Pretest Review

Which congenital foot deformity do these celebrities have in common?

Dudley Moore

Mia Hamm

Kristie Yamaguchi

Troy Aikman

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Notables with clubfoot

Comedian: Daman Wayans

Actor: Dudley Moore

Athletes: Kristie Yamaguchi (1992 Olympic figure skating gold)
Mia Hamm (1996 USA Women's Olympic soccer)
Jim Mecir (pitcher; bilaterally clubbed)
Freddie Sanchez (Pittsburgh Pirates infielder)
Troy Aikman (former Dallas Cowboys quarterback)

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