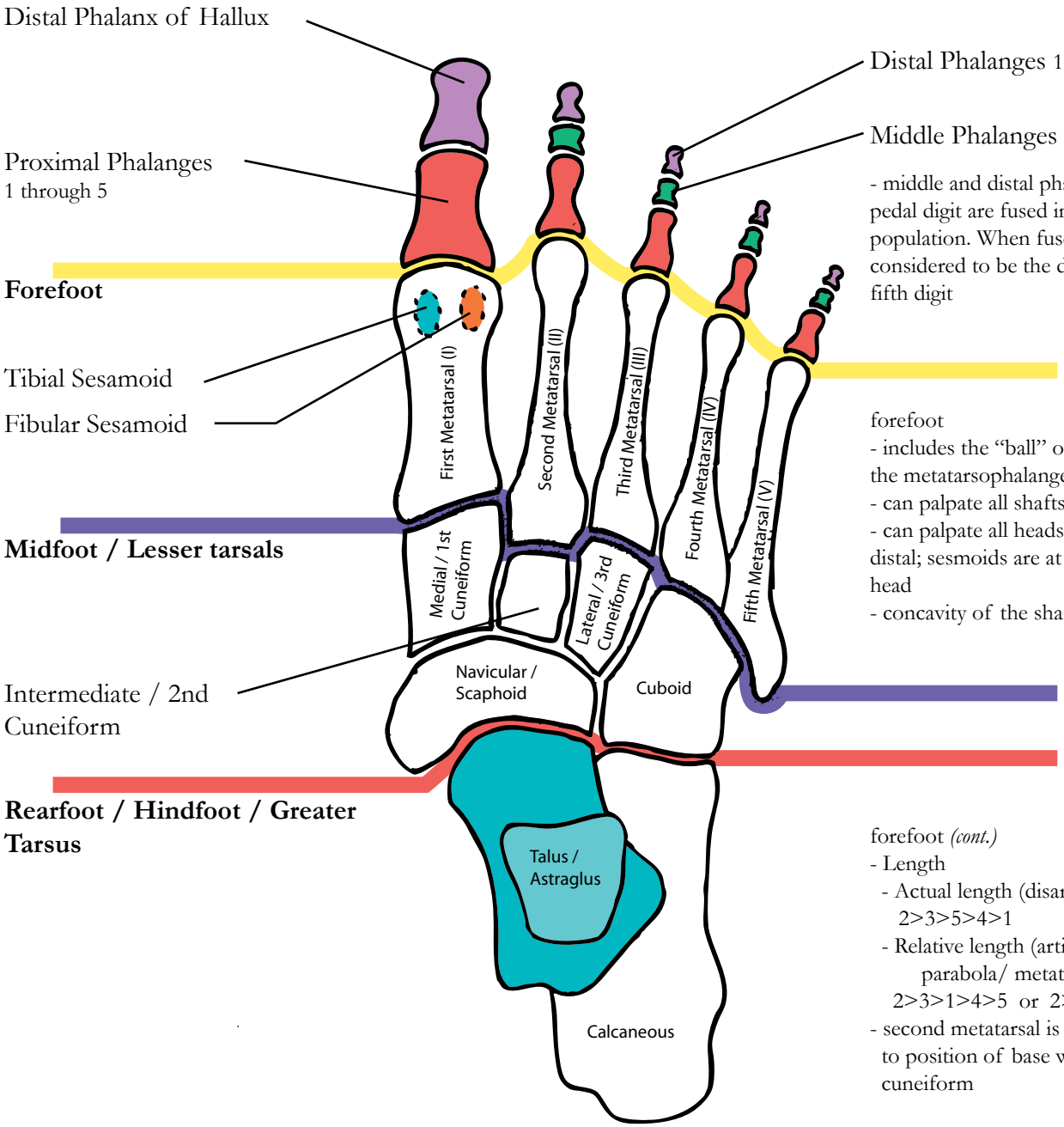
Osteology of the Foot
Dorsal View

Medial **Lateral**



Distal Phalanges 1 through 5

Middle Phalanges of 2 through 5

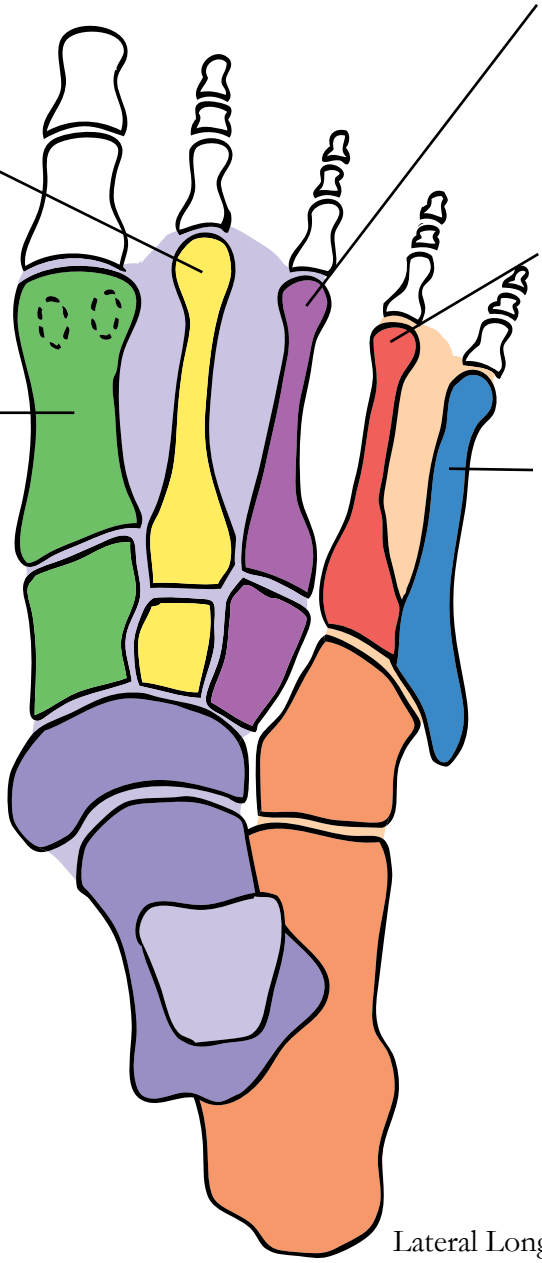
- middle and distal phalanges of the fifth pedal digit are fused in about 40% of the population. When fused they are considered to be the distal phalanx of the fifth digit

forefoot
- includes the "ball" of the foot which is the metatarsophalangeal joints
- can palpate all shafts dorsally
- can palpate all heads dorsal, plantar and distal; sesmoids are at the 1st metatarsal head
- concavity of the shafts is plantar

forefoot *(cont.)*
- Length
  - Actual length (disarticulated)
    2>3>5>4>1
  - Relative length (articulated); metatarsal parabola/ metatarsal protrusion
    2>3>1>4>5 or 2>3=1>4>5
- second metatarsal is the most stable due to position of base wedged between cuneiform

Functional Units - Foot
Dorsal View

Medial **Lateral**



Second Ray
- has least amount of motion because the metatarsal base is wedged between the medial and lateral cuneiform, the small amount of motion is directly dorsal and plantar

First Ray
- has the largest range of motion, in an arc around the second ray in the frontal plane

Third Ray
- motion describes an arc around the second ray, opposite direction to that of the first ray.
- greater amount of motion than the second ray; less motion than the fourth ray

Fourth Ray
- motion describes an arc, with a larger excursion than the same direction as the third ray
- less motion than the fifth ray

Fifth Ray
- motion describes an arc, with a larger excursion and the same direction as the fourth ray
- less motion than the first ray

Medial Column
- sometimes known as the mobile adaptor

Function: adapts to the terrain or ground differences

Includes: calcaneus, talus, navicular and the first through third rays (cuneiforms and metatarsals)

Lateral Column
- sometimes referred to as the rigid lever

Function: allows for efficient gait or propulsion

Includes: calcaneus, cuboid, fourth and fifth rays (metatarsals)

Arches of the foot
- **function**: allow the foot to absorb shock

Medial Longitudinal Arch
- layman's arch
- formed by the medial column of the foot
- from the heel to the first through third metatarsal heads, plantarly
- normally is a smooth curve of variable height, but higher than the lateral longitudinal arch

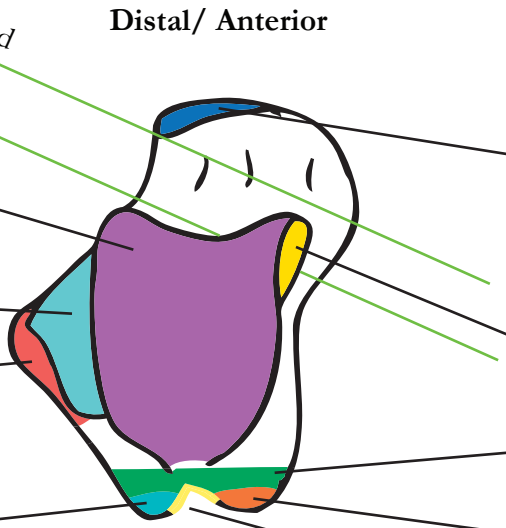
Lateral Longitudinal Arch
- formed by the lateral column of the foot
- from the heel to the fourth and fifth metatarsal heads, plantarly
- normally is a smooth curve of low height

Transverse Arch
- formed by the plantar aspect of the cuneiforms and the cuboids; 1/2 of this arch is in each foot
- some consider more than one transverse arch
  - also at the metatarsal heads, one in each foot
  - also at the metatarsal bases, 1/2 in each foot

Talus
Dorsal View

Lateral **Medial**

Distal/ Anterior



- Talus has **NO** muscular attachment

Trochlea Tali
- articular surface
- wider anteriorly than posteriorly; the reason flexed ankle is less stable
- articulates with the tibial plafond

Navicular Articular Surface

Lateral Malleolar Facet
- articulates with the lateral malleolus

Medial Malleolar Facet
- articulates with medial malleolus

Lateral Process

Posterior Talar Process

Medial Tubercle
- ligamentous attachment

Lateral Tubercle
- for ligamentous attachment

Flexor Hallucis Longus Sulcus

Plantar View

Navicular Articular Surface

Anterior Calcanean Facet / Anterior Facet of Talus
- articulates with anterior facet of calcaneous/ anterior talar facet

Facet for Spring Ligament/ Plantar Calcaneonavicular ligament
- rests on and articulates with cartilage on the spring ligament

Sulcus Tali
- narrow medially and wide laterally
- forms superior part of sinus tarsi
- angles from proximomedial to distolateral in the articulated foot
- for ligamentous attachment and soft tissue structure passage

Middle Calcanean Facet / Middle Facet of Talus
- articulates with middle facet of calcaneous/ middle talar facet

Posterior Calcanean Facet/ Posterior Facet of the Talus
- articulates with posterior facet of calcaneus/posterior talar facet
- this articulation is the anatomic or structural subtalar joint

Medial Tubercle

Lateral Tubercle

Flexor Hallucis Longus Sulcus

Medial **Lateral**

Proximal/ Posterior

Primary Center of Ossification
- normally a single center in body of talus
- appears by **6th fetal month**

Secondary Center of Ossification
- occasionally Present
- in the lateral tubercle of the posterior process of talus

Os Trigonum - accessory ossicle usually present when secondary ossification center did not fuse to primary ossification center.

Morphologic Changes
- talus normally undergoes torsional changes during development that change the relative position of its parts
- when these do not occur, have persistent talor torsion and get flatfoot.

Frontal Plane - changes from infancy to adulthood (adult 40)
- due to external rotation of head and neck which raises the talor head relative to the floor.

Transverse Plane - decreases from infancy (35) to adulthood (15)
moves laterally
- considered to be a result of the torsional change within the neck of the talus

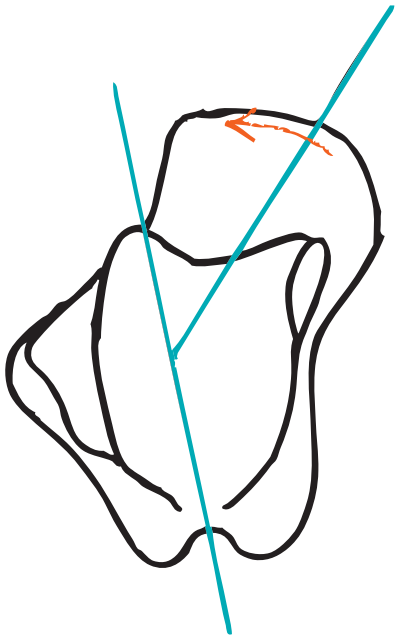
Talus
Morphologic Changes

Lateral

Distal/ Anterior

Medial

Transverse Plane
Dorsal View



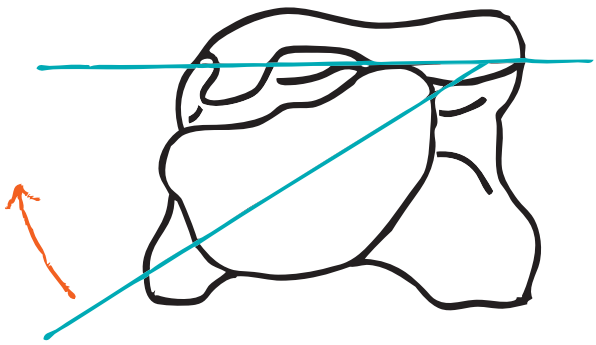
Proximal/ Posterior

Navicular Articular Surface

- longitudinal bisection of the body to the longitudinal bisection of the head and neck
- decreases from infancy (near 35) to adulthood (near 15)
- moves laterally
- this is considered to be a result of the torsional change within the neck of the talus

Frontal Plane
Anterior View

Superior



Medial

Lateral

Inferior

- the horizontal bisection of the head to the horizontal plane of the talar body
- changes from infancy to adulthood (adult 40)
- due to external rotation of the head and neck which raises the talar head relative to the floor.

- talus normally undergoes torsional changes during development that change the relative position of its parts
- When these do not occur, have persistent talar torsion and get flatfoot

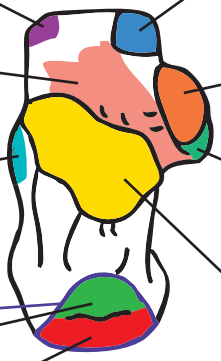
Calcaneus

Largest bone of the foot

Dorsal View

Lateral **Medial**

Dorsal / Anterior



Anterior Process
- best viewed on lateral radiograph of foot/ankle

Sulcus Calcanei
- wider laterally than medially
- forms the inferior part of the sinus tarsi
- for ligamentous attachment and passage of soft tissue structures

Peroneal Tubercle or Trochlea / Fibular Trochlea or Tubercle
- for attachment of the inferior fibular retinaculum/ inferior peroneal retinaculum

Posterior Calcaneal Surface
- Superior 1/3 / Trigonum Achilleum
  - smooth area where a bursa is located
  - called bursal projection of calcaneus
- Middle 1/3
  - Roughened area for insertion of Achilles Tendon

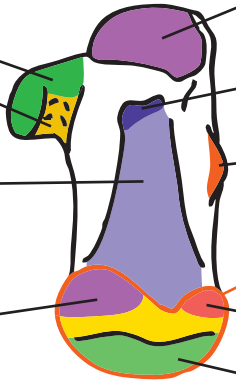
Anterior Talar Facet / Anterior Facet of Calcaneus
- smallest of 3 articular facets
- articulates with anterior facet of talus

Middle Talar Facet / Middle Facet of Calcaneus
- articulates with middle facet of the talus

Sustentaculum Tali
- medial shelf like projection of calcaneous
- provides pulley type advantage for some muscles and attachment for ligaments

Posterior Talar Facet/ Posterior Facet of Calcaneus
- largest of articular facets on superior surface
- articulates with posterior facet of the talus

Plantar View



Sustentaculum Tali

Groove for Flexor Hallucis Longus Tendon

Trigonum Plantare
- roughened triangular area which extends from the anterior tubercle of the calcaneus to the calcaneal tuberosity
- provides ligamentous and muscular attachment

Medial Tubercle

Cuboid Articular Facet
- convex from medial to lateral and concave from superior to inferior

Anterior Tubercle
- ligamentous attachment

Fibular Tubercle or Trochlea

Calcaneal Tuberosity
- for muscular and fascial attachments
- weight-bearing prominence
  - Medial Tubercle - larger inferor medial
  - Lateral Tubercle - smaller inferior lateral

Inferior 1/3 of the posterior surface
- weight-bearing area which is continuous with calcaneal tuberosity

Proximal / Posterior

Sinus Tarsi
- tunnel formed by the sulcus tali and the sulcus calcanei
- includes the straight narrow medial parts and funnel-shaped lateral parts
- can palpate the lateral opening anterior to the lateral malleolar summit
- provides attachment and passage of soft tissue structures
  - *Canalis Tarsi* - the narrow medial part of the sinus tarsi
    - provides attachment for a ligament

Development - only tarsal bone that regularly develops from two ossification centers

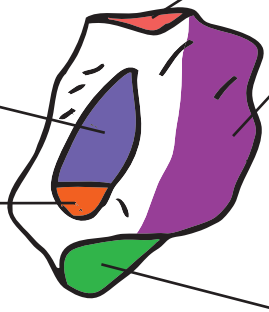
Primary Center of Ossification - center of the bone
- appears during the 3rd fetal month

Secondary Center of Ossification - inferior 2/3 of posterior surface and calcaneal tuberosity
- appears between ages 6 and 8 years at posterior inferior border of calcaneus
- called the *calcaneal apophysis*

Internal Structure
- trebeculae of calcaneus are arranged such that weight is transferred to the forefoot and to the ground from its superior articular facets
- Neutral Triangle - roughly triangular area with few trebeculae
- created by weight-bearing forces through the bone
- visible on a lateral radiograph of the foot/ankle

Cuboid
Dorsomedial View

Plantarmedial **Distal / Anterior** **Dorsolateral**



Facet for Fourth Metatarsal
(Proximal Base)

Facet for Lateral Cuneiform

Dorsal Surface

Facet for Navicular
- present in 50% of population (then is synovial joint)

Calcaneal Articular Surface
- Saddle-shaped (concave from medial to lateral and convex from superior to inferior)

Plantar View

Facet for Fourth Metatarsal

Facet for Fifth Metatarsal
(proximal base)

Fibular Sulcus or Groove / Peroneal Sulcus
- provides passage for fibularis longus tendon

Fibular Ridge / Peroneal Ridge
- prominent proximal border of the fibular sulcus
- for ligamentous attachment

Tuberosity of Cuboid
- projection that is lateral termination of the peroneal ridge

Calcaneal Process / posterior process of the cuboid
- inferomedial projection that extends under the calcaneus

Calcaneal Articular Surface

Proximal/ Posterior

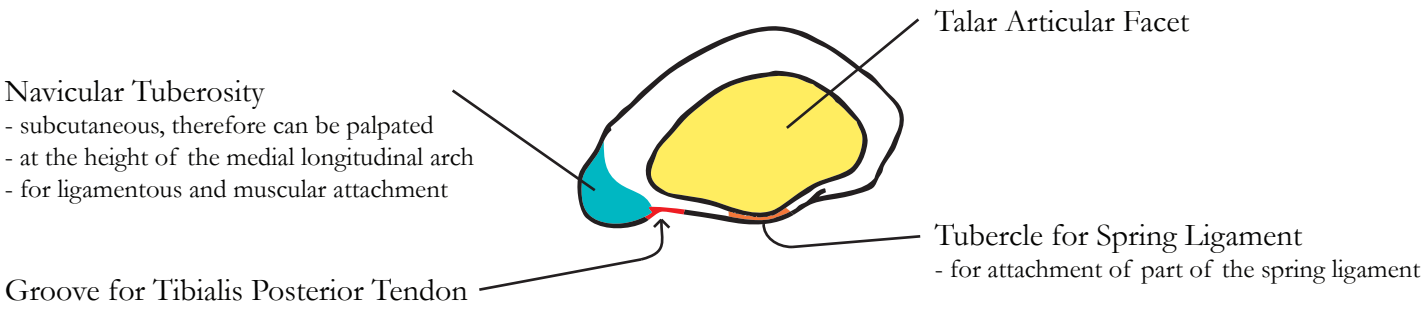
- Cuboid's entire superior surface is roughened for capsular / ligamentous attachment
    - this surface faces laterally in the articulated foot

Development

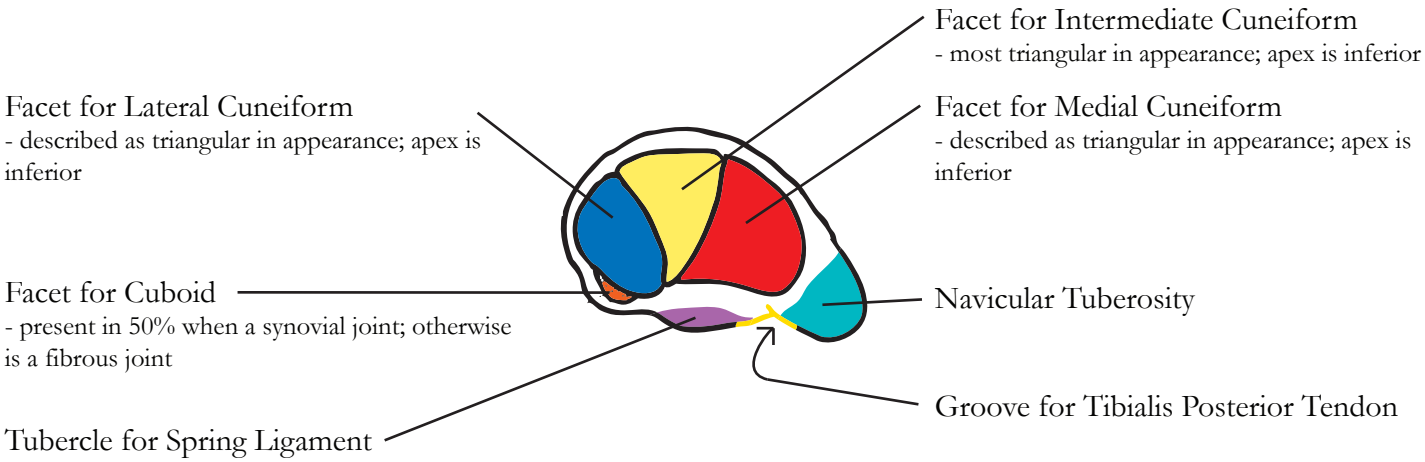
Primary center of ossification
- single central center
- appears **near the time of birth**, usually present at birth

Navicular
Proximal View

Medial **Dorsal / Superior** **Lateral**



Distal View



Plantar / Inferior

Development

- the navicular is last bone of the foot to begin ossification.

Bones begin ossification at their primary centers. It may be used as an indicator of age from pediatric pedal radiographs

Primary Center of Ossification

- appears in center of bone near **age 3 years**

Secondary Center of Ossification

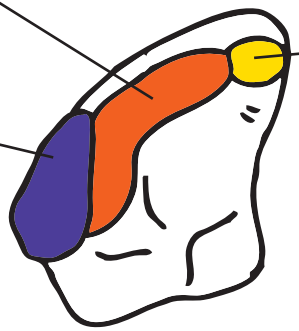
- occasionally present, in the medial part of the bone
- if it does not fuse, results in a bipartite navicular

Medial Cuneiform
First Cuneiform
Dorsal View

Proximal / Posterior **Superior / Dorsal** **Lateral**

Facet for Intermediate Cuneiform
- an inverted "L" shape, along the superior and proximal borders

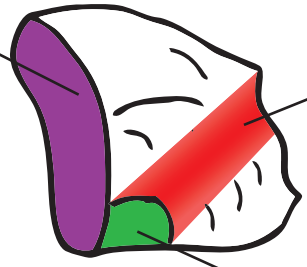
Posterior Articular Facet
- sligthtly concave facet
- articulates with the medial facet on the anterior surface of the navicular
- roughly triangular with apex superior and base inferior



Facet for Second Metatarsal Base

Medial View

Facet for First Metatarsal Base (proximal)
- Larger than the posterior surface



Groove from tibialis Anterior Tendon

Smooth Surface for Accessory Sesamoid or Tibialis Anterior Tendon

Inferior / Plantar

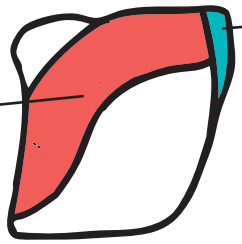
- Largest of the cuneiform bones
- dorsal, plantar and medial surfaces are roughened for ligamentous and muscular attachment.
- situated in the body with its apex superior and base inferior

Development

Primary Center of Ossification - Center of bone **near age 1.5 to 2 years**
Secondary Center of Ossification - occassionally will have one center of ossification located plantar to the primary ossification center.

Intermediate Cuneiform
Second Cuneiform
Medial View

Proximal / Posterior **Superior / Dorsal** **Distal / Anterior**

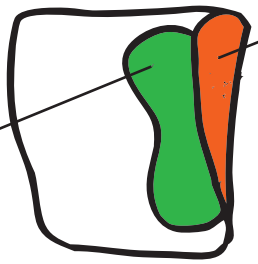


Facet for Second Metatarsal Base
(proximal)

Facet for Medial Cuneiform
- an inverted "L" shape, along the posterior and superior borders

Lateral View

Distal / Anterior **Proximal / Posterior**



Posterior Articular Facet
- slightly concave triangular facet
- articulates with the middle facet on the anterior surface of the navicular
- base is superior, apex is inferior

Facet for Lateral Cuneiform
- "B" - shaped facet along the proximal border of the lateral surface
- the dorsal part of the "B" extends farther distal, normally

Inferior / Plantar

- smallest of the cuneiform bones
- wedge shaped with apex inferior and base superior
- dorsal / superior and plantar / inferior surfaces are roughened for ligamentous and muscular attachment
- Recognized by its wedge shape, a large inverted "L" - shaped facet is on its medial surface and a "B" - shaped facet is on its lateral surface.

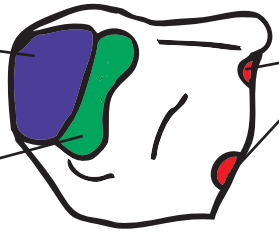
Development
Primary Center of Ossification
- appears in the center of the bone near **age 2.5 years**

Lateral Cuneiform
Third Cuneiform
Medial View

Proximal / Posterior **Superior / Dorsal** **Distal / Anterior**

Posterior Articular Facet
- articulates with lateral facet on anterior surface of navicular

Facet for Intermediate Cuneiform
- "B" - shaped facet



Facet for Second Metatarsal Base
(proximolateral)
- usually two demi-facets
  - dorsal or superior facet usually larger while the inferior may be absent

Lateral View

Distal / Anterior **Distal / Anterior**

Facet for Fourth Metatarsal Base
(proximomedial)

Facet for Third Metatarsal Base
(proximal)
- triangular with base superior and apex inferior
- covers the anterior surface

Facet for Cuboid

Plantar / Inferior

Development
Primary Center of Ossification
- appears in center of bone **near age 1 year**

First Metatarsal
Lateral View

Dorsal / Superior **Distal / Anterior** **Plantar / Inferior**

Distal Articular Facet
- articulates with hallucal proximal phalangeal base

Lateral Condyle
- weight-bearing projection
- contains groove for articulation with lateral sesamoid
- weight is transferred from the lateral sesamoid to lateral condyle of the head of first metatarsal

Lateral Tubercle
- for ligamentous attachment

Medial Condyle
- weight-bearing projection
- contains groove for articulation with medial sesamoid
- weight is transferred from the medial sesamoid to the medial condyle of the head of the first metatarsal

Crista
- ridge at center of head plantarly
- seperates two grooves which articulate with sesamoid bones

First Metatarsal tuberosity
- for insertion of peroneus longus muscle

Medial View

Plantar / Inferior **Dorsal / Superior**

Lateral Condyle

Crista

Distal Articular Facet

Medial Condyle

Medial Tubercle
- for ligamentous attachment

First Metatarsal Tubercle
- for insertion of tibialis anterior muscle

Posterior Articular Facet
- articulates with the medial cuneiform

Proximal / Posterior

- shortest, thickest and heaviest metatarsal bone
- easy to palpate the shaft, base and head - dorsal and medial
- nutrient forament is located on the lateral surface of the shaft and generally in the proximal 1/2 or may be at the distal end
- nutrient artery is from dorsal metatarsal artery 1, usually
  - there may be dual supply from both the dorsal and plantar metatarsal arteries 1

Development

Primary Center of Ossification
- appears in the shaft during **10th intrauterine week**

Secondary Center of Ossification
- appears in the base near **age 3 years**
  - fuses near 18 years of age
- this places the growth plate proximal between the base and the shaft
- occasionally a secondary center is also present in the head

Second Metatarsal
Lateral View

Dorsal / Superior **Distal / Anterior** **Plantar / Inferior**

Distal Articular Facet
- articulates with proximal phalanx of the 2nd toe

Lateral Tubercle
- for ligamentous attachment

Lateral Condyle
- plantar lateral weight-bearing projection from head

Facets for Third Metatarsal Base (proximomedial)

Facets for Lateral Cuneiform

Medial View

Plantar / Inferior **Dorsal / Superior**

Lateral Condyle

Groove for Flexor Tendons

Medial Condyle
- plantar medial weight-bearing projection from the head

Posterior Articular Facet
- triangular - base superior and apex inferior
- for articulation with intermediate cuneiform

Distal Articular Facet

Medial Tubercle
- for ligamentous attachment

Facet for Medial Cuneiform

Proximal / Posterior

- longest metatarsal bone
- easy to palpate parts of the head, shaft and base
- nutrient forament is located on the lateral surface of the shaft and generally in the proximal 1/3
- nutrient artery is from dorsal metatarsal artery 2, generally plantar

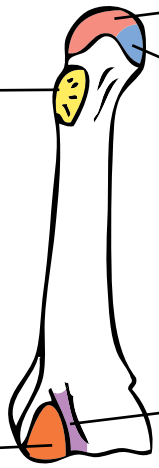
Development

Primary Center of Ossification
- appears in the shaft during **9th intrauterine week**

Secondary Center of Ossification
- appears in the head between **ages 3 and 4 years**
  - fuses near 18 years of age
- this places the growth plate distally between the head and the shaft

Third Metatarsal
Lateral View

Dorsal / Superior **Distal / Anterior** **Plantar / Inferior**



Distal Articular Facet
- articulation with proximal phalanx of the 3rd toe

Lateral Tubercle
- for ligamentous attachment

Lateral Condyle
- plantar lateral weight-bearing projection from the head

Groove for Interosseus Intermetatarsal Ligament
- may be linear or rectangular

Facet for Fourth Metatarsal
(proximomedial)

Dorsal View

Medial **Dorsal / Superior**

Distal Articular Facet

Lateral Condyle

Groove for Flexor Tendons

Medial Tubercle
- for ligamentous attachment

Medial Condyle
- plantar medial weight-bearing projection on the head

Facets for Second Metatarsal Base
(proximolateral)

Proximal Articular Facet
- triangular - base superior and apex inferior
- articulates with the lateral cuneiform

Proximal / Posterior

- easy to palpate parts of the head, shaft and base
- nutrient forament is located on the lateral surface of the shaft in the proximal 1/3
- nutrient artery is from dorsal or plantar metatarsal artery 3, generally plantar

Development

Primary Center of Ossification
- appears in the shaft during **9th fetal week**

Secondary Center of Ossification
- appears in the head between **ages 3 and 4 years**
- fuses near 18 years of age
- this places the growth plate distally between the head and the shaft

Fourth Metatarsal
Lateral View

Dorsal / Superior **Distal / Anterior** **Plantar / Inferior**

Distal Articular Facet
- articulates with proximal phalanx of the 4th toe

Lateral Tubercle
- for ligamentous attachment

Lateral Condyle
- plantar lateral weight-bearing projection on the head

Groove for 3rd Interosseous Intermetatarsal Ligament

Facets for Fifth Metatarsal Base
(proximomedial)

Medial View

Plantar / Inferior **Dorsal / Superior**

Lateral Condyle

Groove for Flexor Tendons

Medial Condyle
- plantar medial weight-bearing projection from the head

Posterior Articular Surface
- for articulation with cuboid

Distal Articular Facet

Medial Tubercle
- for ligamentous attachment

Facet for Third Metatarsal Base
(proximolateral)

Facet for Lateral Cuneiform

Proximal / Posterior

- easy to palpate parts of the head, shaft and base
- base is usually cube shaped
- nutrient forament is located on the lateral surface of the shaft in the proximal 1/3
- nutrient artery is from dorsal metatarsal artery 4, generally plantar

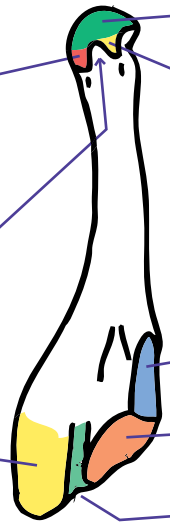
Development

Primary Center of Ossification
- appears in the shaft during **9th fetal week**

Secondary Center of Ossification
- appears in the head between **ages 3 and 4 years**
  - fuses near 18 years of age
- this places the growth plate distally between the head and the shaft

Fifth Metatarsal
Plantar View

Lateral **Distal / Anterior** **Medial**



Distal Articular Facet
- articulation with proximal phalanx of the 5th toe

Medial Condyle
- plantar Medial weight-bearing projection on the head

Lateral Condyle
- plantar lateral weight-bearing projection from the head

Groove for Flexor Tendons

Facet for Fourth Metatarsal (proximomedial)

Styloid Process / tuberosity of 5th metatarsal
- for attachment of muscle and ligament
- subcutaneous and can be palpated

Posterior Articular Facet
- for articulation with the cuboid

Groove for Abductor Digiti Minimi Muscle

Dorsal View

Medial **Lateral**

Distal Articular Facet

Lateral Tubercle
- for ligamentous attachment

Medial Tubercle
- for ligamentous attachment

Facet for fourth Metatarsal

Posterior Articular Facet

Styloid Process

Proximal / Posterior

- easy to palpate parts of the head, shaft and base
- nutrient forament is located on the medial surface of the shaft at the junction of proximal and middle thirds
- nutrient artery is from plantar metatarsal artery 4, usually

Development

Primary Center of Ossification
- appears in the shaft during **10th fetal week**

Secondary Center of Ossification
- appears in the head between **ages 3 and 4 years**
- fuses near 18 years of age
- this places the growth plate distally between the head and the shaft
- may be an additional secondary center in the styloid process of the bone
- when present and does not fuse is called a *Vesalianum*