



**SCS Continuing Education  
and  
Three Phase CEUs  
presents:**

# **Anatomy and Radiography of the Wrist, Hand, and Fingers**

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## **Introduction:**

Hello and welcome to this program from **SCS Continuing Education!** Knowledge is the key to success for ourselves and our patients. This easy-to-use point and click program allows you to navigate through text and visual aides designed to provide a comprehensive view of the material covered. Please feel free to contact **Shane Smith** at [ceuarmy@yahoo.com](mailto:ceuarmy@yahoo.com) if you have any questions.

## **Course Abstract and Objectives:**

The objective of this home study course is to provide the learner with a computer based tutorial that will give them the means to learn the anatomy and radiography of the ankle, foot, and toes. A mastery test will be administered at the end of this home study course in order to ensure that competency of the material has been achieved.

# Anatomy and Radiography of the Ankle, Foot and Toes



by Shane Smith PTA, RT(R)

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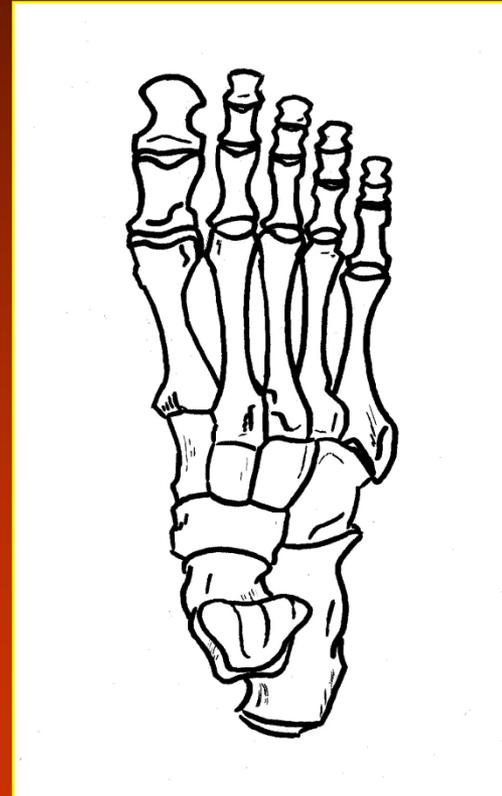
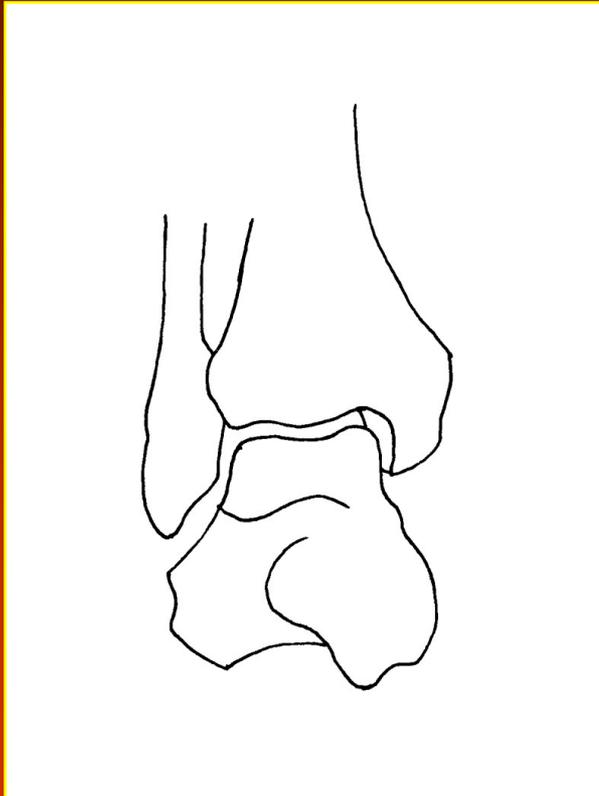
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# **Fundamentals of the Foot and Ankle**

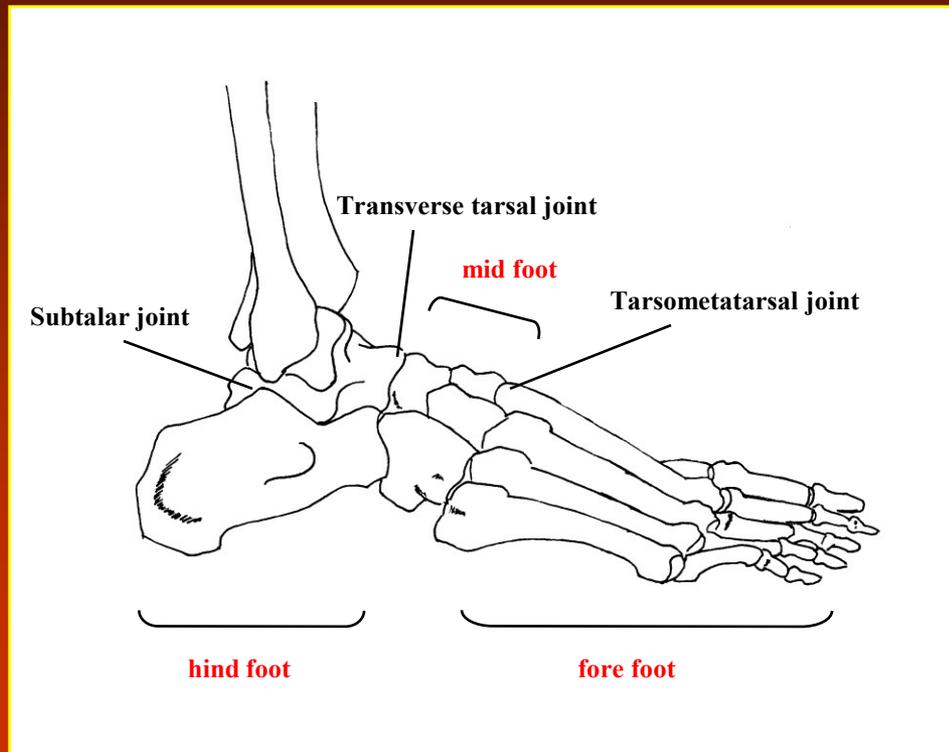
## Fundamentals of the Foot and Ankle:

There are 28 bones and 25 joints in the foot and ankle complex. These structures are configured to accommodate the stability and mobility responsibilities of the foot and ankle on various surfaces during varying degrees of weight bearing.

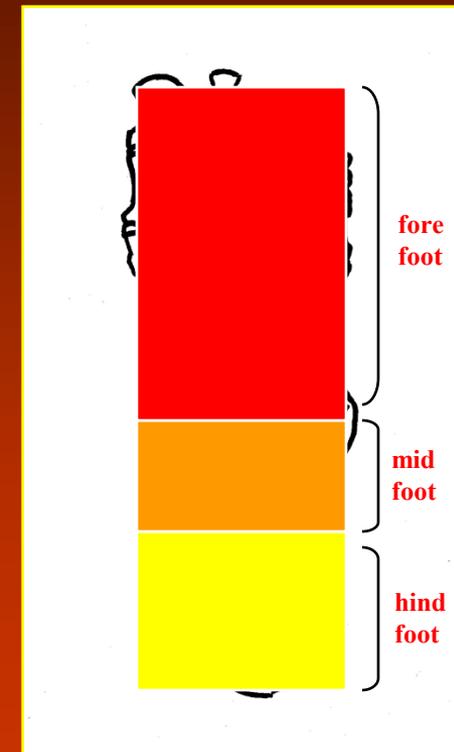


# Fundamentals of the Foot and Ankle:

The foot is divided into 3 categories; the fore foot (metatarsals and phalanges), mid foot (cuboid, navicular and 3 cuneiforms) and hind foot (talus and calcaneous).



Lateral foot



AP foot

Note: The joints will be discussed later in the tutorial.

## Fundamentals of the Foot and Ankle:

Now that we have been oriented to the basic structure of the foot and ankle, let's review the key concepts related to motion. This section is split into two sections: **joint classification** and the **arch**.

Let's begin by reviewing some terminology that will be used in the forthcoming slides.

- **synovial joint:** diarthrotic; allows one or more types of free movement; contain articular cartilage, synovial fluid, synovial membrane and a fibrous capsule.
- **inversion:** combination of supination, adduction and plantar flexion..
- **eversion:** combination of pronation, abduction and dorsiflexion.
- **compound joint:** made up of two or more bones and/or joints.
- **uniaxial joint:** 1 degree of freedom.
- **hinge joint:** monaxial; flexion/extension.
- **syndesmosis:** fibrous connection between a concave and convex surface.
- **condyloid joint:** allows all forms of angular movement except axial rotation.

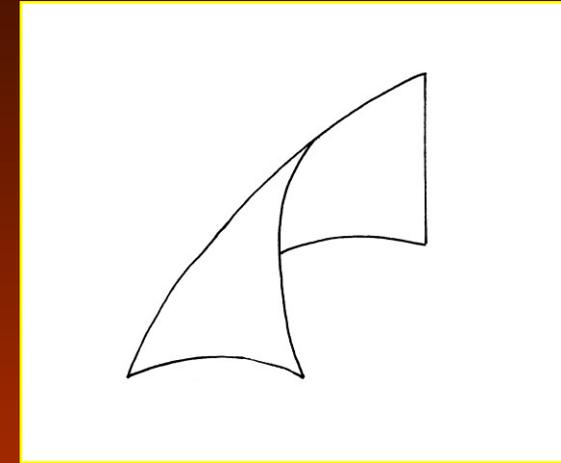
# Fundamentals of the Foot and Ankle: Joint Classification

<b>Joint</b>	<b>Bones involved</b>	<b>Type</b>
➤ <b>talocrural (ankle)</b>	<b>talus, tibia and fibula</b>	<b>synovial; hinge</b>
➤ <b>proximal tibiofibular</b>	<b>proximal tibia and fibula</b>	<b>synovial</b>
➤ <b>distal tibiofibular</b>	<b>distal tibia and fibula</b>	<b>syndesmosis</b>
➤ <b>subtalar</b>	<b>talus and calcaneous</b>	<b>uniaxial</b>
➤ <b>transverse tarsal</b>	<b>talus, navicular, calcaneous and cuboid</b>	<b>compound</b>
➤ <b>tarsometatarsal</b>	<b>metatarsals, cuneiforms and cuboid</b>	<b>synovial</b>
➤ <b>metatarsophalangeal</b>	<b>metacarpal and proximal phalanx</b>	<b>condyloid; synovial</b>
➤ <b>interphalangeal</b>	<b>adjacent phalanges</b>	<b>synovial; hinge</b>

## Fundamentals of the Foot and Ankle: The Arch

The **arch**, also referred to as a twisted osteoligamentous plate, is formed by the configuration of bones and ligaments in the foot. The arch plays a role in both mobility and stability.

In mobility, the arch acts as a shock absorber and allows the foot to adapt to changes in terrain.



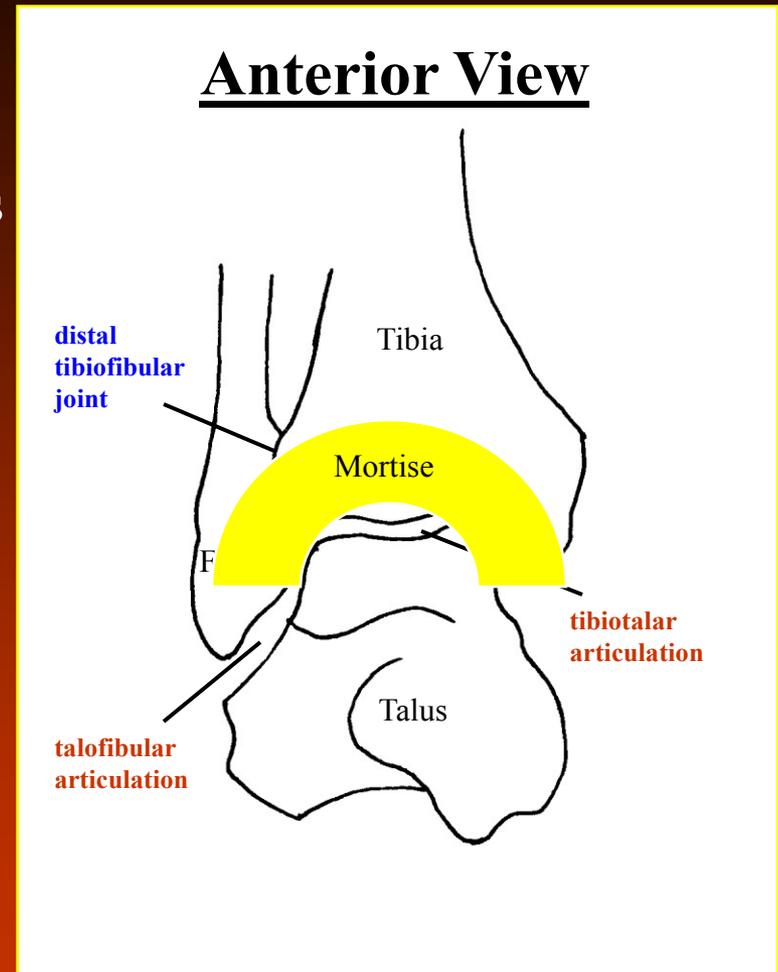
In stability, it allows for weight distribution through the foot during weight bearing and converts foot to a rigid lever when pushing off during gait. The **plantar fascia** tightens during extension at the metatarsophalangeal joint. This tightening results in a shortening of the plantar fascia that keeps the midfoot and hind foot locked in an supinated position as the heel lifts off the ground. This is known as the **windlass mechanism**.

# Bony Anatomy

## Bony Anatomy: The Ankle

The ankle joint or “talocrural joint” is a synovial hinge joint that is made up of the articulation of 3 bones. The 3 bones are the tibia, the fibula and the talus. The articulations are between the talus and the tibia and the talus and the fibula.

The “mortise” is the concaved surface formed by the tibia and fibula. The mortise is adjustable and is controlled by the proximal and distal tibiofibular joints. The talus articulates with this surface and allows dorsiflexion and plantar flexion.



# Bony Anatomy:

## Talocrural joint:

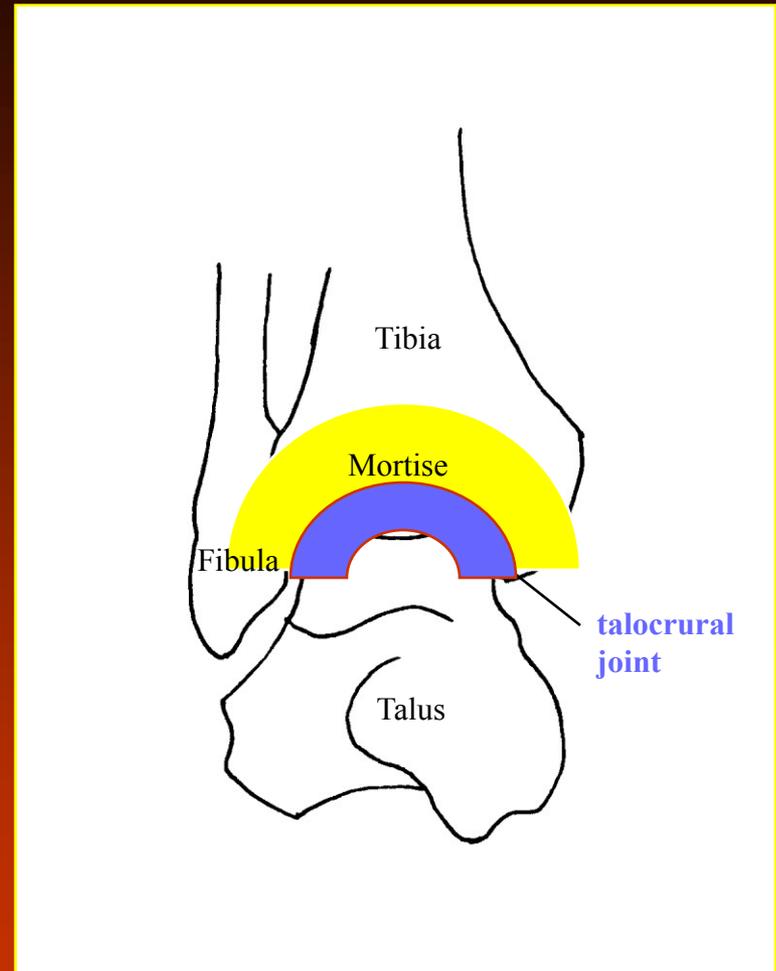
Most congruent joint in the body. It allows 1° of freedom: **dorsiflexion** and **plantar flexion**.

In open chain activity (non-weight bearing), the convex talus slides posteriorly during dorsiflexion and anteriorly during plantar flexion on the concave tibia and fibula.

In closed chain activity (weight bearing), the tibia and fibula move on the talus.

Total talocrural joint motion is approximately:

- **plantar flexion: 30°-50°**
- **dorsiflexion: 20°**



# Bony Anatomy:

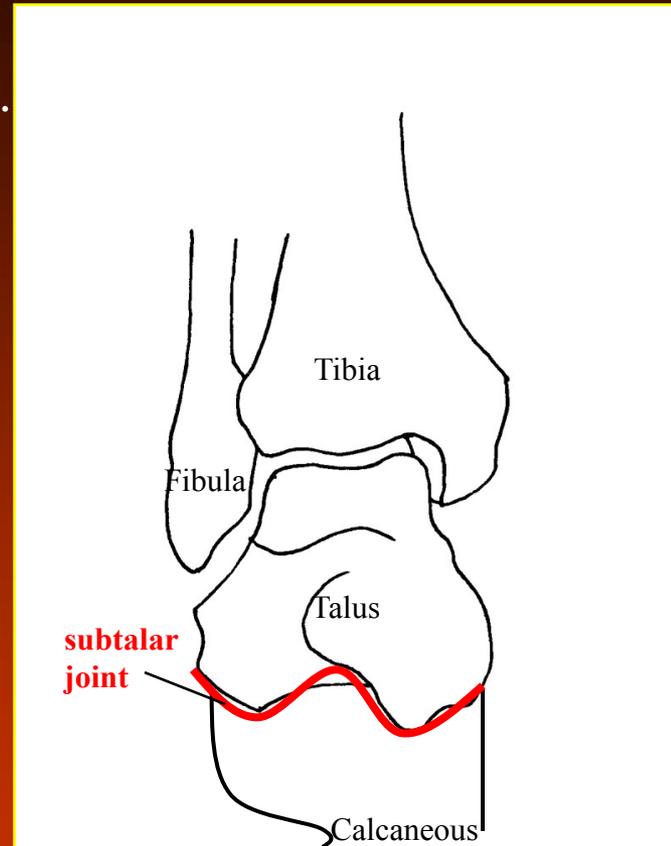
## Subtalar joint:

Also known as the **talocalcaneal** joint. It is a triplanar, uniaxial joint which allows 1° of freedom: **supination** (closed packed position) and **pronation** (open).

Supination is accompanied by calcaneal inversion (**calcaneovarus**) and pronation is accompanied by calcaneal eversion (**calcaneovalgus**).

Total subtalar joint motion is approximately:

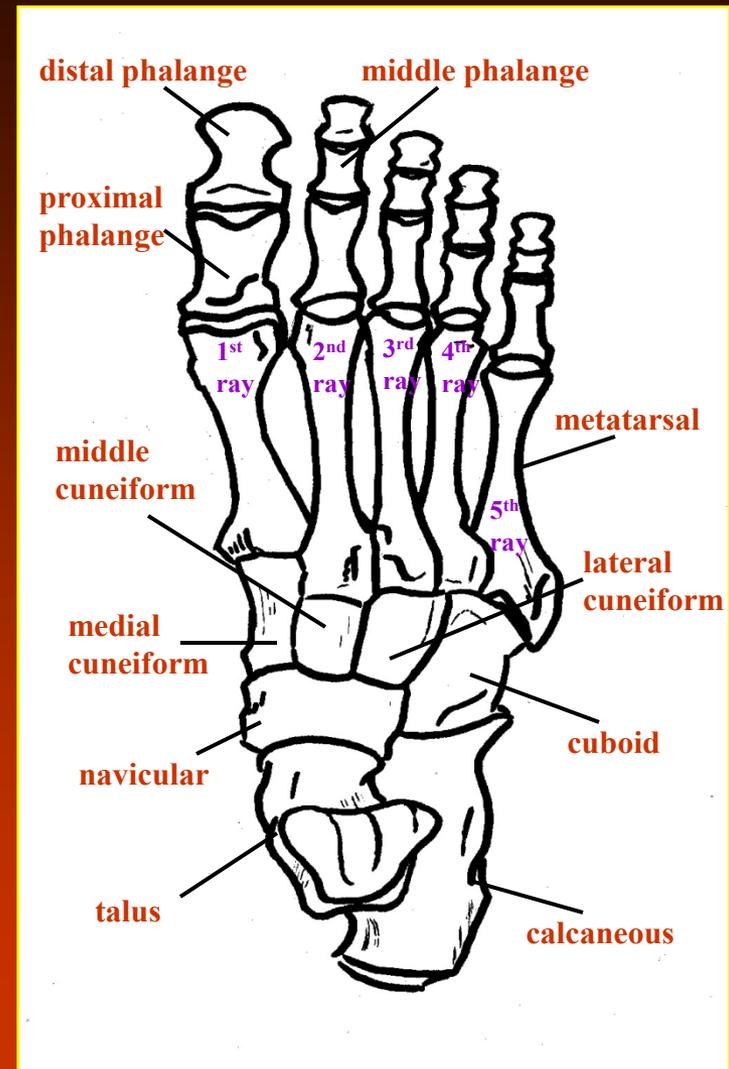
- **inversion: 20°**
- **eversion: 10°**



## Bony Anatomy: The Foot

Let's identify the bones of the foot. Notice that the great toe only has a proximal and distal phalange. There are also 2 sesamoid bones (not shown) located under the 1<sup>st</sup> MTP joint.

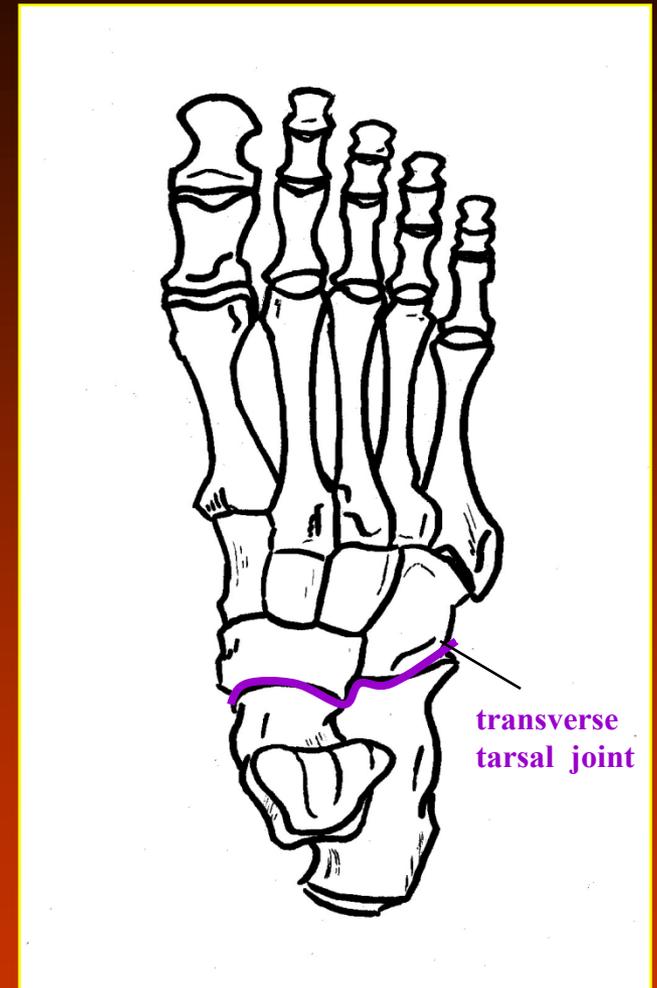
The toes are also known as “rays.” The great toe is the 1<sup>st</sup> ray, the next toe is the 2<sup>nd</sup> ray, the middle toe is the 3<sup>rd</sup> ray, the next lateral toe is the 4<sup>th</sup> ray and the “little” toe is the 5<sup>th</sup> ray.



## Bony Anatomy:

### Transverse tarsal joint:

Also known as the **midtarsal** joint. It is a compound joint which allows compensation between the hind foot and fore foot on uneven terrain. It is made up of four bones (talus, calcaneus, cuboid and navicular) and two joints (talonavicular and calcaneocuboid).



## Bony Anatomy:

### **Tarsometatarsal joint:**

Plane synovial joint formed by articulations with:

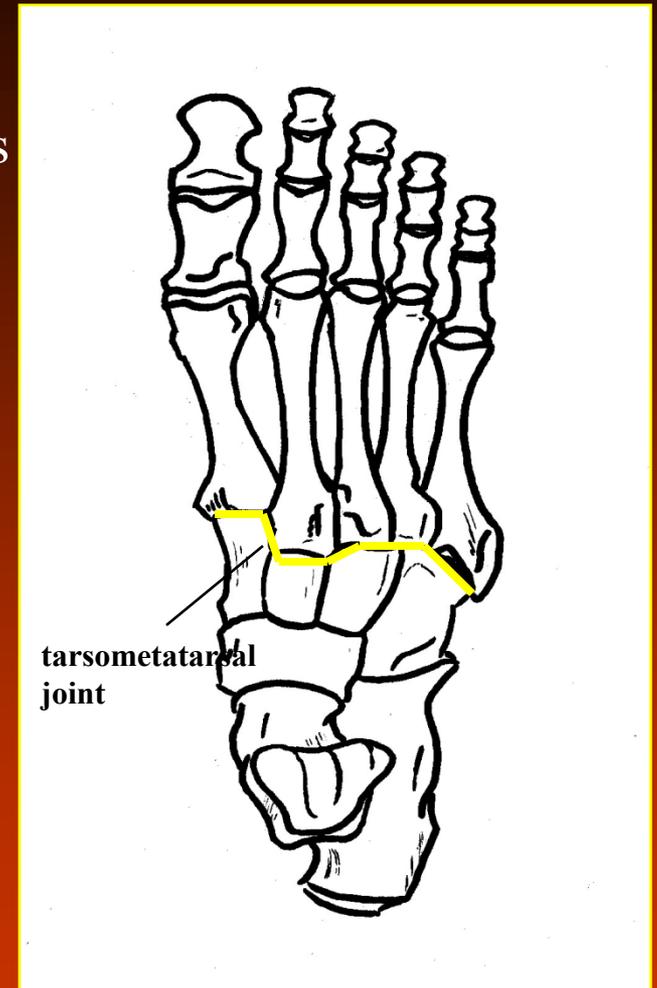
1<sup>st</sup> metatarsal and medial cuneiform

2<sup>nd</sup> metatarsal and middle cuneiform

3<sup>rd</sup> metatarsal and lateral cuneiform

4<sup>th</sup> and 5<sup>th</sup> metatarsals and cuboid

Continues the compensating movement available at the transverse tarsal joint once the maximum range of motion of that joint has been reached.



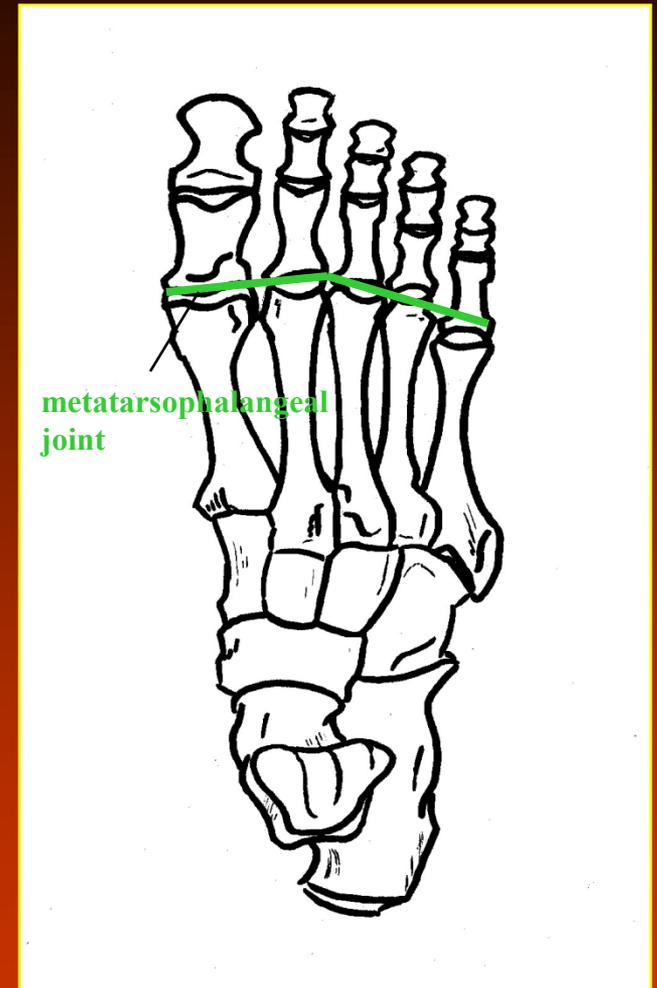
## Bony Anatomy:

### Metatarsophalangeal joint:

Also known as the “**ball of the foot.**” It is a condyloid synovial joint with 2° of freedom: flexion/extension and abduction/adduction.

Total MTP joint motion is approximately:

- **great toe flexion: 0°-45°**
- **toe flexion: 0°-40°**
- **great toe and toe extension: 0°-80°**



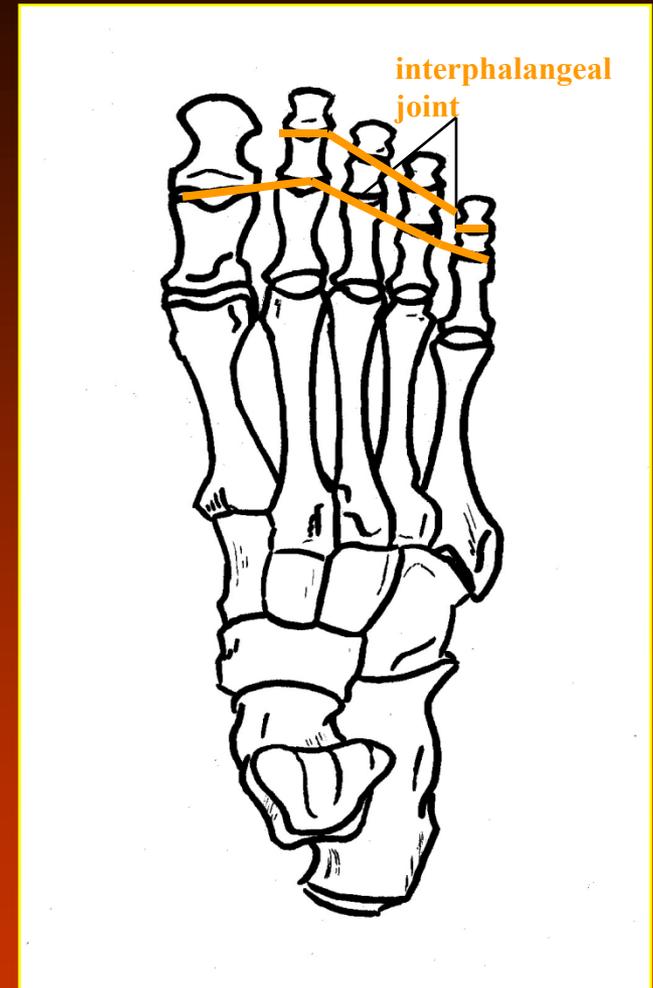
## Bony Anatomy:

### Interphalangeal joint:

IP joints are synovial hinge joints with 1° of freedom: flexion/extension.

Total IP joint motion is approximately:

- IP flexion of great toe: 0°-90°
- PIP flexion: 0°-35°
- DIP flexion: 0°-60°
- great toe and toe extension: 0°-80°



# Positioning

## Positioning: General Guidelines

- ✓ remove any jewelry that will interfere with the anatomy being radiographed.
- ✓ make patient as comfortable as possible; some positions that the patient must conform to and maintain in order for a diagnostic image to be obtained can be difficult due to disease process, trauma, etc. It is important to keep that in mind when positioning patients for an exam.
- ✓ always **shield** when possible; for the purpose of this program, shielding should always be utilized for radiography of the foot and ankle.
- ✓ use **collimation**; at minimum, collimation should not exceed the cassette size.
- ✓ the body part should be **parallel** to the film; the **central ray** (centering) should be **perpendicular (90°)** to the body part and the film.
- ✓ Lead markers should be used to identify **RIGHT** or **LEFT**.

## Positioning: AP foot

- Place foot flat onto the cassette.
- Angle tube  $10^{\circ}$  toward the heel (calcaneus).
- Center to the base of the 3<sup>rd</sup> metatarsal.
- Include toes, metatarsals, navicular, cunieforms and cuboid.



## Positioning: Oblique foot

- Place foot onto the cassette at a **30°-45°** angle medially.  
(45° is recommended)
- Center to the base of the **3<sup>rd</sup>** metatarsal.
- Include the entire foot and talus.



## Positioning: Lateral foot

- Place foot onto the cassette for a mediolateral projection (recommended).
- Center to the **medial cunieforn** (base of the 3<sup>rd</sup> metatarsal).
- Include the entire foot and 1 inch of distal tibia and fibula.



## Positioning: AP toe

- Place foot flat onto the cassette.
- Angle tube **10°-15°** toward the heel.
- Center to the appropriate **MP joint**.
- Include the entire toe and  $\frac{1}{2}$  of the metatarsal.



## Positioning: Oblique toe

- Place foot onto the cassette at a  $45^{\circ}$  angle medially.
- Center to the appropriate **MP joint**.
- Include the entire toe and  $\frac{1}{2}$  of the metatarsal.



## Positioning: Lateral toe

- Place foot onto the cassette for a lateromedial projection of the 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> toes and a mediolateral projection of the 4<sup>th</sup> and 5<sup>th</sup> toes.
- Center to the **IP joint** for the 1<sup>st</sup> toe and the appropriate **PIP joint** for the other toes.
- Include the entire toe (phalanges).



## Positioning: AP ankle

- Place ankle onto the cassette. (the intermalleolar line will not be parallel in a true AP projection).
- Center between the **malleoli**.
- Include the distal third of the tibia/fibula and proximal half of the metatarsals.



## Positioning: Oblique ankle

- Place ankle onto the cassette at **45°** of medial rotation.
- Center between the **malleoli**.
- Include the distal third of the tibia/fibula and proximal half of the metatarsals.



## Positioning: AP mortise

- Place ankle onto the cassette at **15°- 20°** of medial rotation.
- Center between the **malleoli**.
- Include the distal third of the tibia/fibula and proximal half of the metatarsals.



## Positioning: Lateral ankle

- Place ankle onto the cassette for a mediolateral projection. (recommended)
- Center to the **medial malleolus**.
- Include the calcaneus, talus, tarsals and the base of the 5<sup>th</sup> metatarsal.



## Positioning: Axial calcaneus

- Place ankle onto the cassette with the heel close to the bottom edge.
- Dorsiflex until plantar (bottom) surface of the foot is **perpendicular** to the cassette. (assistance may be necessary to achieve this).
- Angle tube **40° cephalad** (cross-hairs seen on the bottom of the foot).
- Center to the **base of the 3<sup>rd</sup> metatarsal**.
- Include entire calcaneus to the talocalcaneal joint.



Due to the reproduction quality of this x-ray to fit the format of this tutorial, the talocalcaneal joint is not visualized.

## Positioning: Lateral calcaneus

- Place ankle onto the cassette for a mediolateral projection.
- Center to 1½ inches below the **medial malleolus**.
- Include the calcaneus and talus.



# Technical Guidelines

## Technical Guidelines:

- ✓ Radiography of the foot and ankle is done at a **40 inch SID** (source image distance).
- ✓ Keep the body part as close to the cassette as possible in order to reduce **OID** (object image distance).
- ✓ Radiographs of the ankle and foot are of better diagnostic quality when an **extremity cassette** is utilized. **CR** (computerized radiography) does not use conventional cassettes or film. Instead, a digitized plate is utilized which can be programmed to act like an extremity cassette. The difference is, however, that it is advised to only put one image per cassette. Multiple images on one cassette do not always appear properly and are difficult to “window” correctly.
- ✓ Although x-ray machines vary, the general **kVp** ranges for radiography of the ankle and foot is between **50-65 kVp**.
- ✓ Adjustments in **kVp** and **MA**s should be considered in cases involving splints, casts, wraps, swelling, braces, etc.

**MRI**

## MRI: Overview

A comprehensive explanation of MRI physics is outside the scope of this program but in order to appreciate the following slides and gain the most value from them, a simplistic overview is provided.

Magnetic Resonance Imaging (MRI) is an imaging process that utilizes a magnetic field to magnetize tissues of the body in order to create a radio frequency signal (RF) that will, with the assistance of **coils** and a computer, produce an image.

The magnetic field primarily affects tissues with an adequate amount of **hydrogen**. A high concentration of hydrogen will produce a strong signal and a bright area on the image while a low concentration will produce little or no signal. No signal will produce a black area with the signals in between producing gray areas, **contrast**.

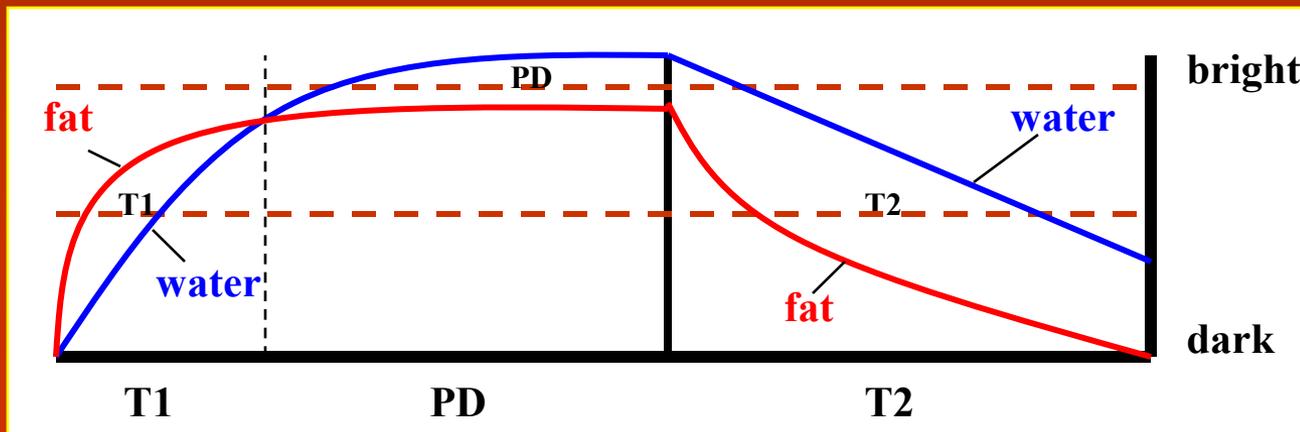
## MRI: Tissue Characteristics and Contrast:

One advantage to MRI is the ability to utilize the variety of tissues in the body to produce contrast. The tissues of the body are divided into three characteristics: **T1**, **PD** and **T2**. Images produced in MRI are often described as being T1, PD or T2 “weighted.” Let’s use the diagram below to help define these terms as they relate to the image that is produced.

**T1:** on a T1 weighted image, **fat is bright** and **water is dark**.

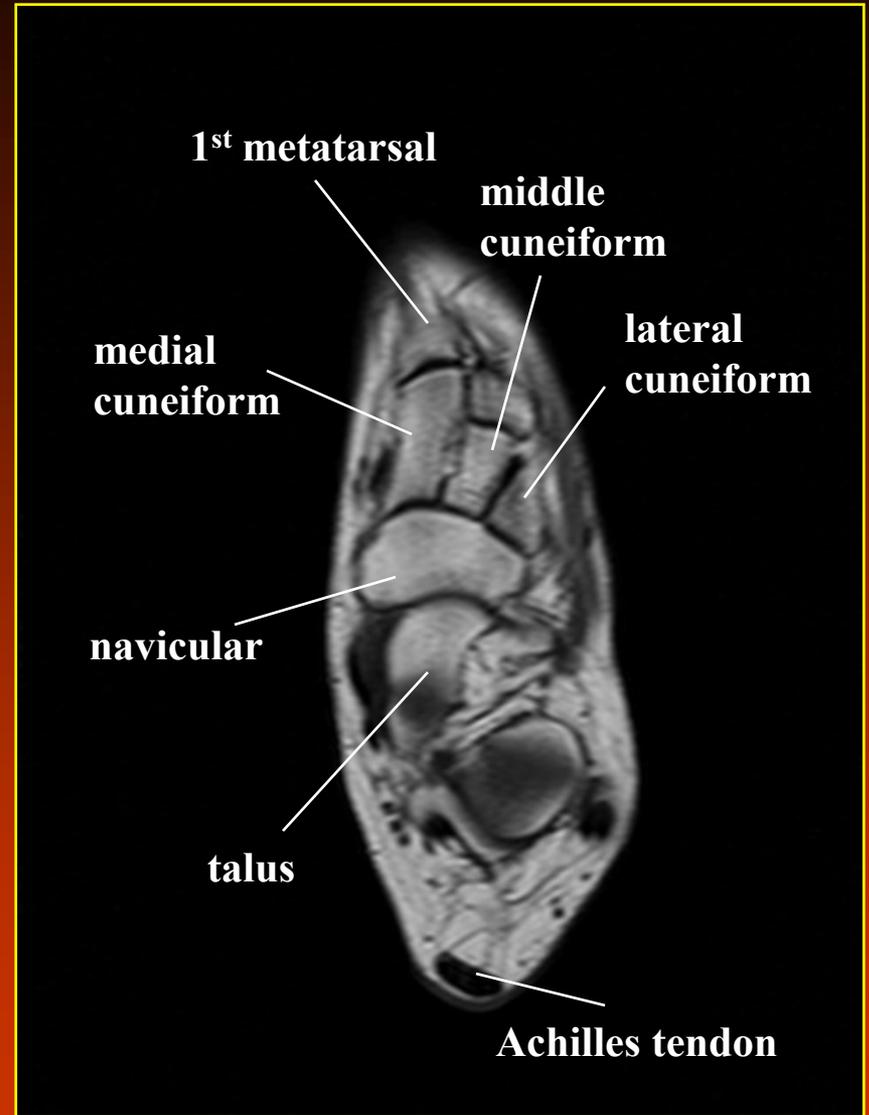
**PD:** on a proton density image, **water is bright** and **fat is dark** but the contrast between the two is less define.

**T2:** on a T2 weighted image, **water is bright** and **fat is dark** but the contrast is greater.



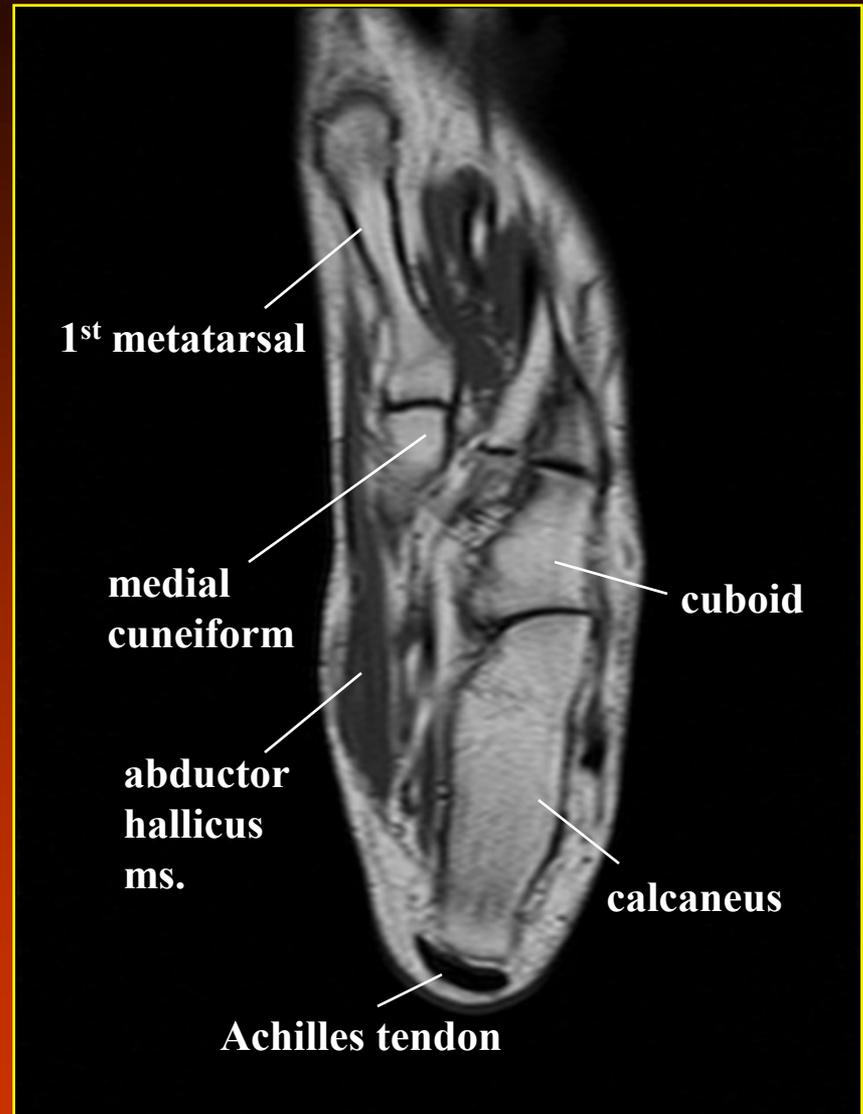
## **MRI: Axial T1**

The axial view of the foot in MRI is comparable to the AP view of the foot in x-ray. The image to the right is one slice of an axial sequence.



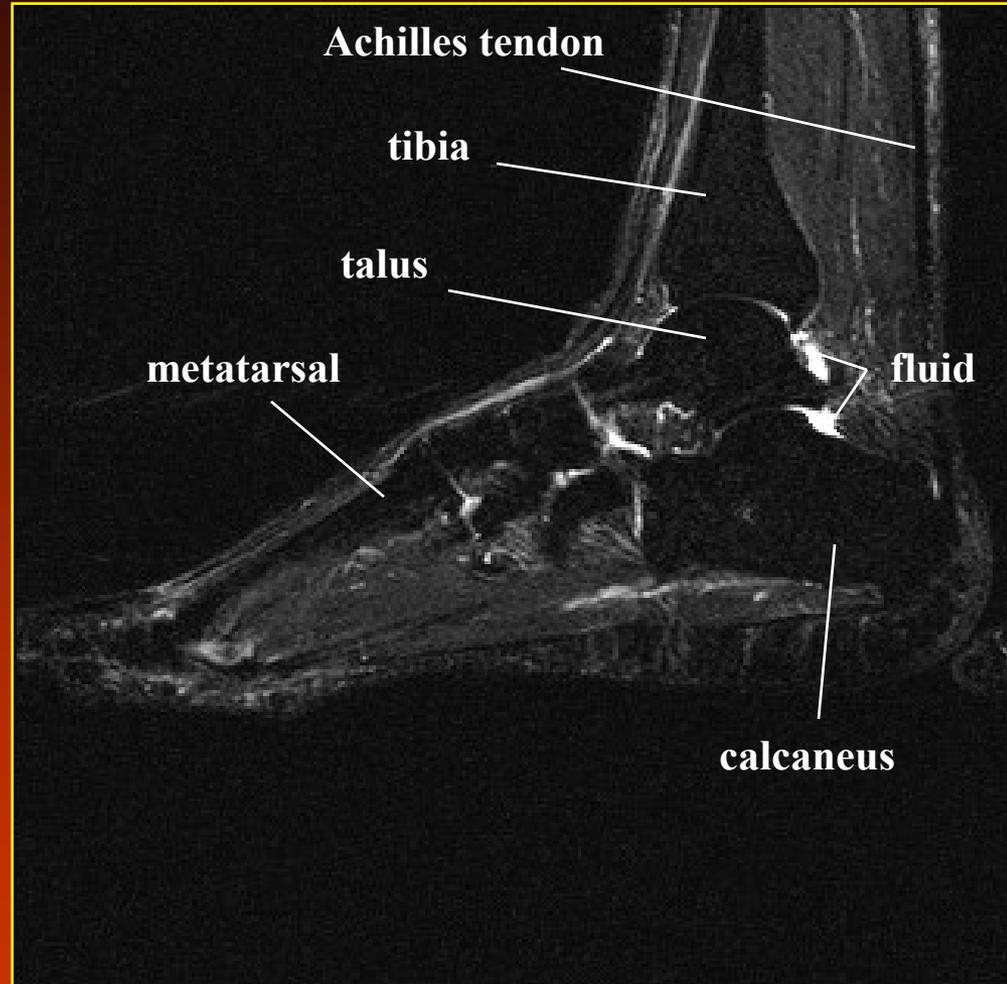
## **MRI: Axial T1**

The axial view of the foot in MRI is comparable to the AP view of the foot in x-ray. The image to the right is one slice of an axial sequence.



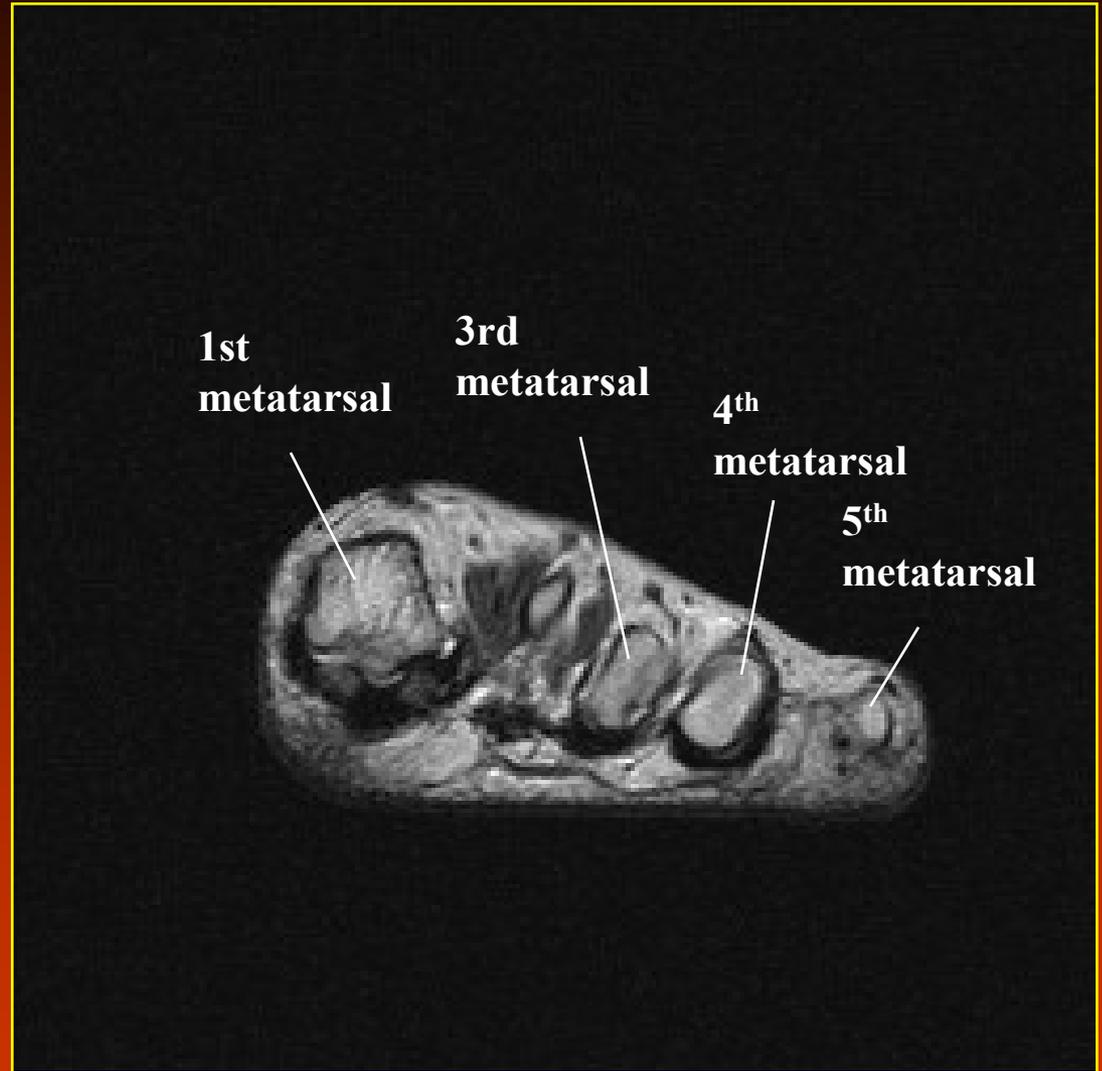
## **MRI: Sagittal T2**

The sagittal view of the foot in MRI is comparable to the lateral view of the foot in x-ray. The image to the right is one slice of a sagittal sequence.



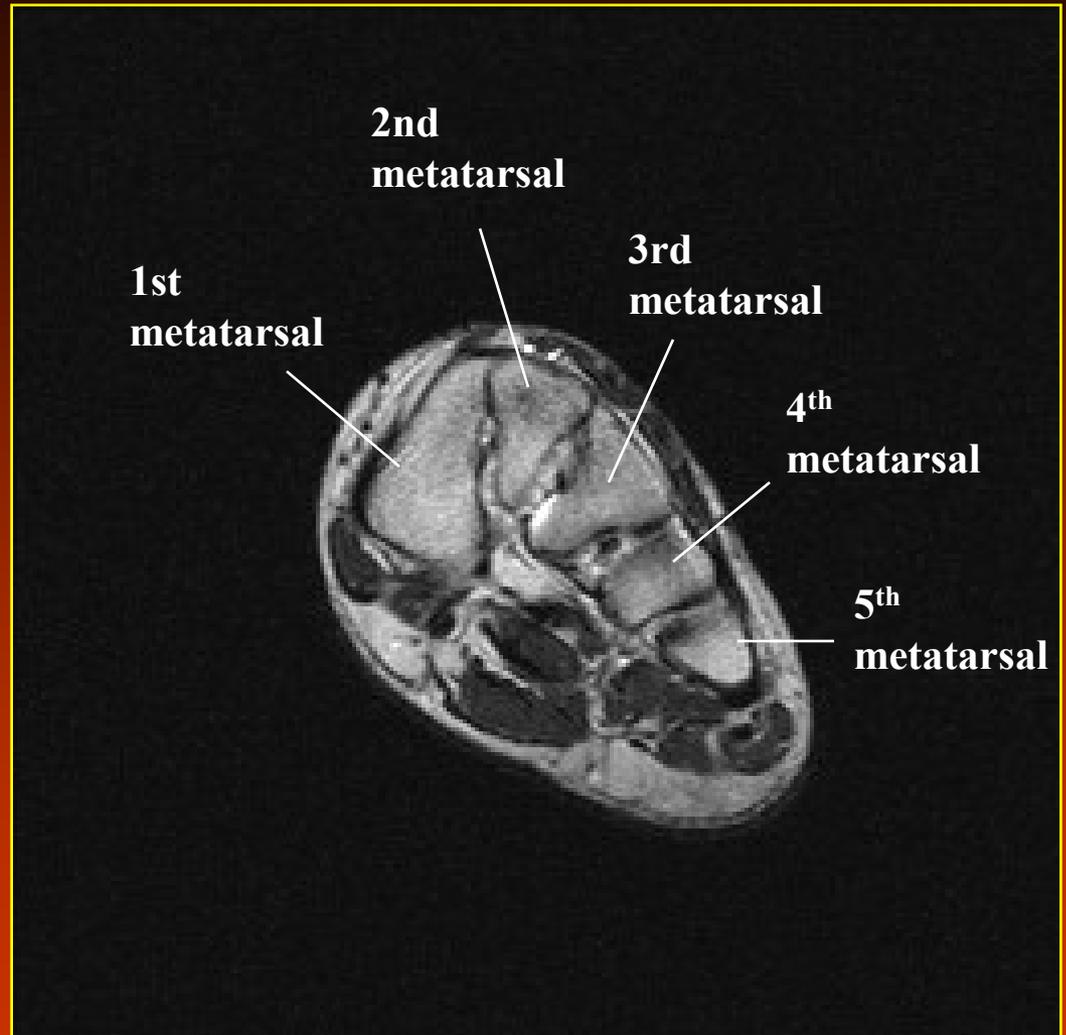
## MRI: Coronal T2

The coronal view of the foot in MRI has no comparable view in x-ray. The coronal slice is similar to slices in a loaf of bread. The image to the right is one slice of a coronal sequence.



## MRI: Coronal T2

The coronal view of the foot in MRI has no comparable view in x-ray. The coronal slice is similar to slices in a loaf of bread. The image to the right is one slice of a coronal sequence.



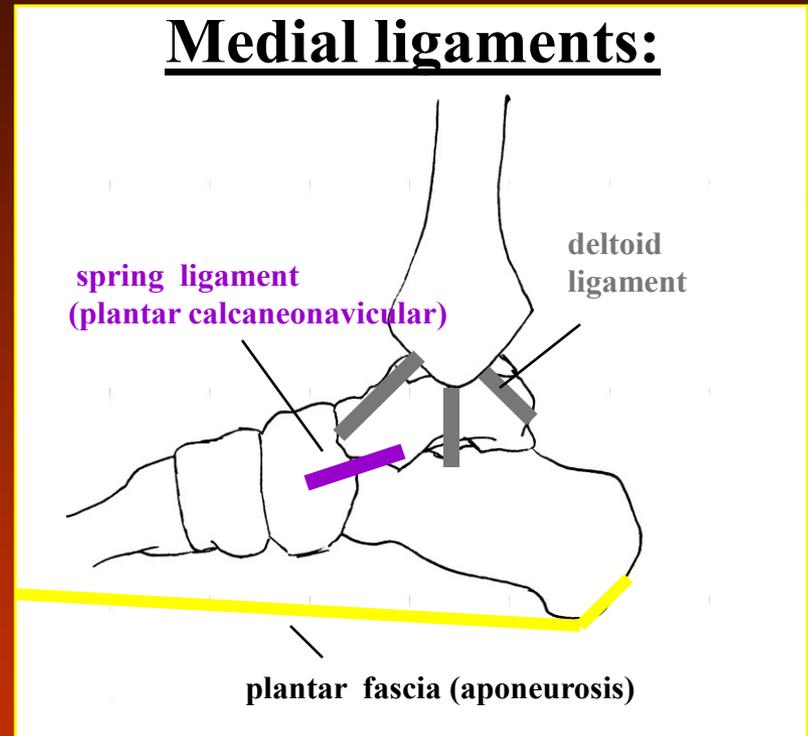
# Common Clinical Findings

## Common Clinical Findings: Ligaments:

The **MCL (medial collateral ligaments)** is made up of the three fan-shaped ligaments attached to the distal tibia, also known as the **deltoid ligament**. This group of ligaments limits valgus stresses on the ankle. This is a fairly strong group and not commonly torn.

The function of the **spring (or plantar calcaneonavicular) ligament** is to maintain the arch of the foot.

The **plantar fascia (aponeurosis)** is a sheet of connective tissue that runs from the calcaneous to the proximal phalanges.



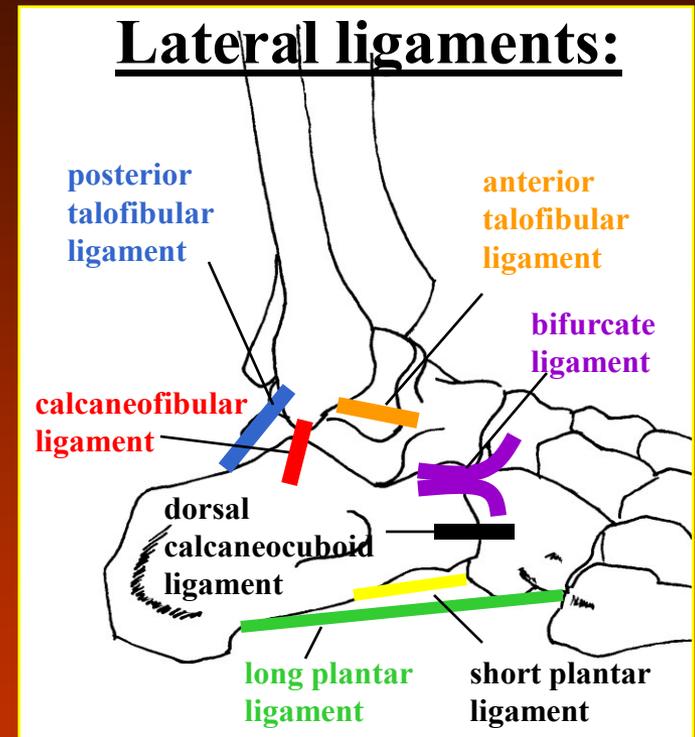
## Common Clinical Findings: Ligaments:

The **LCL (lateral collateral ligaments)** is made up of the **anterior talofibular ligament**, the **posterior talofibular ligament** and the **calcaneofibular ligament**. This group of ligaments limits varus stresses on the ankle. The weakest and most commonly torn of this group is the anterior talofibular ligament.

The function of the **long plantar** and **short plantar(or plantar calcaneocuboid ) ligaments** is to maintain the arch of the foot.

The **bifurcate ligament** attaches from the calcaneous to the navicular and the cuboid.

The **dorsal calcaneocuboid ligament** is found lateral and distal to the bifurcate ligament and also attaches from the calcaneous to the cuboid.



## **Common Clinical Findings:**

Now that we've reviewed and understand the basic structure and function of the foot and ankle, let's review some of the common clinical findings.

### **1. Achilles Tendinitis:**

- inflammation caused by repetitive motions involving the Achilles tendon.
- RX: rest/immobilization, ice, ultrasound, NSAIDs, massage, stretching, exercise.

### **2. Achilles Tendinosis:**

- progression of the inflammation of the Achilles tendon to degeneration of the tendon.
- RX: rest/immobilization, ice, ultrasound, NSAIDs, massage, stretching, exercise, surgery.

# Common Clinical Findings:

## 3. Ankle Sprain:

- injury involving one or more ligaments in the ankle.
- severity dependent upon number of ligaments involved, stretched vs torn and to the degree the ligament is torn.
- RX: rest/immobilization, ice, NSAIDs, compression wrap, elevation, surgery.

## 4. Ankle Fracture:

- injury involving one or more bones of the ankle.
- severity dependent upon number of bones involved, displaced vs non-displaced, protruding through skin.
- RX: rest/immobilization, ice, NSAIDs, compression wrap, elevation, surgery.

## Common Clinical Findings:

### 5. Plantar Fascitis:

- inflammation to the plantar fascia resulting in heel pain due to prolonged non-weight bearing (sitting) in some cases and prolonged weight bearing (standing) in others.
- RX: stretching exercises, ice, rest, NSAIDs, orthotics and/or shoe modification.

### 6. Pes Planus:

- also known as “flat foot”; partial or complete loss of arch.
- RX: weight loss, rest, NSAIDs, orthotics and/or shoe modification, surgery.

## Common Clinical Findings:

### 7. Chronic Instability :

- usually caused by a lateral ankle sprain that has not healed properly and/or repeated ankle sprains resulting in laxity in the LCL.
- RX: strengthening exercises, bracing, NSAIDs.

### 8. Osteoarthritis :

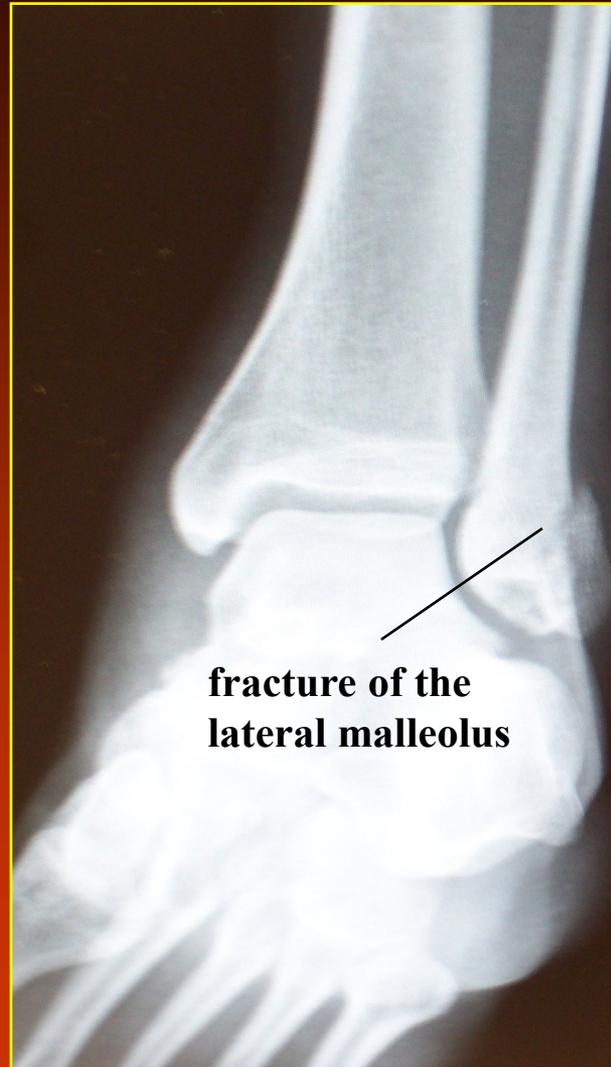
- breakdown and loss of cartilage in one or more joints.
- could be caused by flatfoot, jamming toe(s), fracture, severe sprain.
- RX: strengthening exercises, rest, NSAIDs, orthotics and/or shoe modification, bracing, steroid injections, surgery.

# Common Clinical Findings:

## 9. Pes cavus:

- excessively supinated foot as a result of a high arch
- loss of shock absorption ability or adaptation to uneven terrain
- RX: questionable results with conservative intervention.

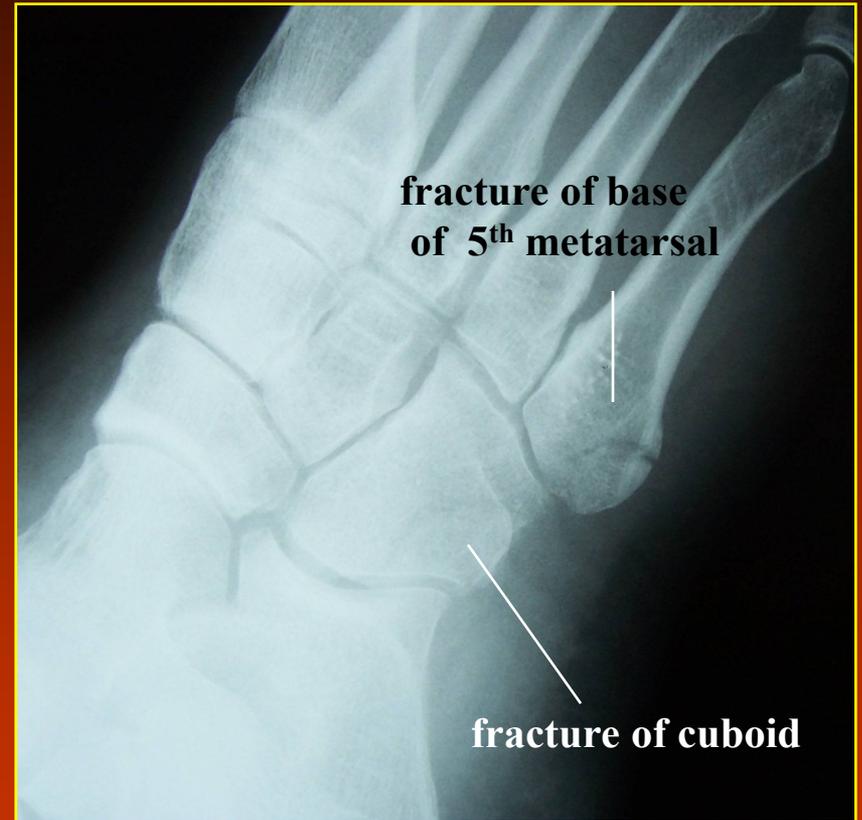
## Common Clinical Findings:



## Common Clinical Findings:



# Common Clinical Findings:



# Conclusion:

- Radiography of the foot, ankle and toes is done at a **40 inch SID** (source image distance).
- Keep the body part as close to the cassette as possible in order to reduce **OID** (object image distance).
- Although x-ray machines vary, the general **kVp** ranges for radiography of the wrist and hand is between **50-65 kVp**.
- Adjustments in **kVp** and **MAs** should be considered in cases involving splints, casts, wraps, swelling, braces, etc.
- The body part should be **parallel** to the film and the **central ray** (centering) should be **perpendicular (90°)** to the body part and the film unless otherwise indicated.
- Always **shield** when possible; use **collimation**, identify **LEFT** or **RIGHT** by utilizing lead markers, remove jewelry that may interfere with anatomy and be conscious of patient comfort when positioning.

# Test:

There are **60** questions on this test. All answers can be found within the context of this program. The “hint” button located next to each question will provide you the information needed to answer the question. At any time during the test you may skip a question and return to it later. You must successfully answer 70% of the questions in order to receive credit for the course. To access the test, please close out of this course by clicking the “x” in the top right corner.

**Good luck!!!**

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