Foot and Ankle

- Anatomy

- Pathology
OBJECTIVES

- Review the osseous anatomy, major normal variants, and clinically important contours of the calcaneus and talus
- Review traumatic pathology of the calcaneus and talus with an emphasis on pathomechanics and accurate description
Sonography - Embryonic hindfoot
Anatomy - Calcaneal articular surfaces

Figure 1. Drawings of the calcaneus. (a) Lateral surface. (b) Superior surface. a = anterior articular facet, m = medial articular facet, p = posterior articular facet, pb = groove for peroneus brevis, pl = groove for peroneus longus, s = sustentaculum tali, t = tubercle (trochlear process), tu = tuberosity.
Anatomy- Lateral Contours Calcaneus

Medial Surface Calcaneus
Normal anatomy - Talus

From above

- For medial malleolus
- Head
- Neck
- For lateral malleolus
- For inferior transverse ligament
- Medial tubercle
- Sulcus for Flexor hallucis longus
- Trochlea for tibia
- Lateral tubercle

From below

- For plantar calcaneonavicular ligament
- For navicular bone
- Anterior calcaneal articular surface
- Sulcus tali
- Lateral tubercle
- Sulcus for Flexor hallucis longus
- Middle calcaneal articular surface
- Posterior calcaneal articular surface
Radiographs
Normal Variation

Calcaneal apophysis - fuses at age 12-15 in both sexes
Transient Calcaneal Spur

Disappears by age 1!
Normal Variant - Pseudocyst
Prominent Vascular Remnant
Os Trigonomum
Os Supratalare - Normal Variant
Trauma
Calcaneus Fractures

- Most common tarsal fracture
- Accounts for 2% of all fractures
- 70-75% Intraarticular
- 20-25% Extrarticular
- Historically poor prognosis
- No consensus on management due to lack of standard, unified classification system and understanding of fracture pathoanatomy
- High variability in fracture pattern based on magnitude and direction of impacting force, foot position, muscle tone, and bone mineralization
Intraarticular Fx-Pathomechanics

Axial loading mechanism results in typical pattern of the primary shear (sagittal) and secondary compression (coronal) type fracture lines.

Sagittal fracture (parallel to long axis of the calcaneus) - occurs due to wedge force of the talus on calcaneus.

If energy of impact is not expended completely, compression or secondary fracture lines may occur and may result in a “tongue” type or “joint depression” type fracture.
Pathoanatomy

- Diverging axis of the calcaneus and talus results in shear separation of the sustenatalcular and tuberosity portions.
- Hindfoot varus - medial fx line
- Hindfoot valgus - lateral fx line
Calcaneus Fracture - Shear Force

Shear- Typical Split

Shear- Unusual Double Split
Calcaneus Fractures

- Marked rotation of mobile posterolateral tuberosity fragment resulting in marked widening of the calcaneus.
Calcaneus Fractures - Compression

Tongue Type Fracture

Intraarticular depressed
CT Appearance

Tongue type

Intraarticular Depressed
# Classification

## Schmidt-Weiner Classification of Calcaneal Fractures and Their Prevalence

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A*‡</td>
<td>Fracture of calcaneal apophysis</td>
<td>6</td>
</tr>
<tr>
<td>1B*</td>
<td>Sustentaculum tali fracture (intraarticular)</td>
<td>3</td>
</tr>
<tr>
<td>1C*</td>
<td>Anterior process fracture (intraarticular)</td>
<td>15</td>
</tr>
<tr>
<td>1D*</td>
<td>Inferolateral fracture (intraarticular)</td>
<td>1</td>
</tr>
<tr>
<td>1E*</td>
<td>Avulsion fracture</td>
<td></td>
</tr>
<tr>
<td>2A‡</td>
<td>Beak fracture</td>
<td>4</td>
</tr>
<tr>
<td>2B‡</td>
<td>Achilles tendon avulsion</td>
<td></td>
</tr>
<tr>
<td>3$</td>
<td>Linear extraarticular fracture</td>
<td></td>
</tr>
<tr>
<td>4$</td>
<td>Linear intraarticular fracture</td>
<td></td>
</tr>
<tr>
<td>5A$</td>
<td>Tongue-type fracture</td>
<td></td>
</tr>
<tr>
<td>5B$</td>
<td>Joint depression or comminuted fracture</td>
<td></td>
</tr>
<tr>
<td>6‖</td>
<td>Posterior calcaneal fracture including tuberosity and Achilles tendon with extensive soft-tissue damage</td>
<td></td>
</tr>
</tbody>
</table>

Source.—Reference 11.

* Caused by avulsion or twisting injury and usually has a benign course.
‡ Occurs in children.
§ Caused by direct trauma.
$ Usually occurs following a fall from heights.
‖ Usually seen in victims of lawn-mower accidents, especially children.
# Classification

## Modified Essex-Lopresti Classification of Calcaneal Fractures

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraarticular fractures</td>
<td>Calcaneal tuberosity fractures</td>
</tr>
<tr>
<td></td>
<td>Beak type</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
</tr>
<tr>
<td></td>
<td>Medial avulsion</td>
</tr>
<tr>
<td>Intraarticular fractures</td>
<td>Subtalar joint involvement</td>
</tr>
<tr>
<td></td>
<td>Undisplaced</td>
</tr>
<tr>
<td></td>
<td>Displaced</td>
</tr>
<tr>
<td></td>
<td>Comminuted</td>
</tr>
<tr>
<td>Calcaneocuboid joint</td>
<td>involvement</td>
</tr>
</tbody>
</table>
Figure 11: Schematically depicts the Sanders classification of intraarticular fractures.
Sanders Classification

- Most useful system for intraarticular fracture classification
- Improved interobserver variability
- Has both clinical and prognostic implications
- Type 1: Excellent results with conservative management
- Type 2 and 3: Excellent results with surgical management
- Type 4: Poor results with surgical management
Intraarticular Fractures: Typical Osseous Features

- Loss of Height due to impaction and/or rotation of the more mobile tuberosity fragment
- Widening due to displacement of tuberosity fragment
- Posterior subtalar joint disruption
- Axial loading associated with TL burst fractures
- Superior peroneal retinacular avulsions
Intraarticular Calcaneus Fractures - Extraosseous Associations

Peroneal tendon entrapment
Entrapment Complication

Fibrosing tenosynovitis related to untreated peroneal tendon entrapment
Associated injury- SPR Avulsion
Intraarticular calcaneus fractures - Extraosseous Findings
MR Imaging
MR Imaging

Diagnosis: Calcific Myonecrosis related to a remote compartment syndrome
Calcific myonecrosis

- Relatively rare, late sequela of trauma
- Plate/Sheet-like calcifications are characteristic
- Only 1 case reported in the foot in the English literature
- May erode adjacent bone
- Spontaneous draining sinus-tracts and culture positive infections may develop
- Appropriate treatment: compartmental excision or debridement
Miscellaneous Calcaneus fx

Axial loading with extreme hindfoot varus or inversion

May be intra or extra articular depending on if the fracture line involves the calcaneal facet

Conservative treatment

Isolated sustentacular fracture
Miscellaneous fx

Isolated medial tubercle fx- axial load
In extreme hindfoot valgus

Extraarticular, conservative treatment
Miscellaneous- Anterior Process Calcaneus Fracture

- Type 1: Forced plantar flexion and inversion resulting in Bifurcate ligament injury and avulsion. Clinically mimics ankle sprain
- Type 2: Eversion and dorsiflexion with shear injury to anterior process
- Both susceptible to nonunion/AVN with recurrent pain
- Early detection can prompt surgical management- displaced fractures involving more than 25% of the calaneocuboid are treated surgically
Beak Fracture

Treated surgically

Greater displacement = greater functional loss of the Achilles tendon
Stress fracture
How can we make the report sound sweet and help with management?

- Intraarticular/extrarticular?
- Think about the mechanism and why the fracture appears the way it does
- Describe the displacement and comminution of the various named fragments (tuberosity, sustenacular, middle)
- Describe the position of the IA fracture line with respect to the posterior calcaneal facet (Sanders)
- Bohler’s and Gissane’s angle
- Soft tissue entrapment
Talus Fractures

- Fractures divided into head, neck and body fractures
- Approximately 50% of talar fractures involve the neck
- Most common body fractures are osteochondral, less common involve the lateral or posterior process
Hawkins Classification of Talar Neck Fractures

Radiographic findings | Risk of AVN
--- | ---
Type I Nondisplaced fracture line | 0-13%
Type II Displaced fracture, plus subluxation or dislocation of subtalar joint | 20-50%
Type III Displaced fracture, dislocation subtalar AND tibiotalar joints | 69-100%
Type IV Displaced fracture and disruption of talonavicular joint | high
Talar Neck Fractures (Aviator’s Astragalus)

- Most common mechanism: Dorsally directed force on a braced foot (MVA)

- Complication - Since most of the blood supply to the talar body comes via the talar neck, fractures of the neck place the patient at risk for AVN

Hawkins Type III
Talar Neck Fractures

Hawkins
Type II
Talar Neck Fractures

Hawkins Type I
Postoperative Talar Neck Complication

Partial Hawkins Sign - Indicates Intact Vascularity on side and ischemia on the other
Complication - AVN

Peree et al. Radiographics 25: 399-410. 2005
Lateral Process of the Talus - Radiography
Lateral Process Talus Fracture

PURE DORSIFLEXION, INVERSION AND AXIAL LOADING
CEDELL FRACTURE
Osteochondral Fractures

Inversion Injuries
<table>
<thead>
<tr>
<th>Radiographs</th>
<th>MRI T2WI *</th>
<th>Arthroscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Normal</td>
<td>Diffuse high-signal intensity</td>
<td>Normal, or softening of cartilage</td>
</tr>
<tr>
<td>2 Semicircular lucent line</td>
<td>Semicircular low-signal line</td>
<td>Break in cartilage, fragment not displacement</td>
</tr>
<tr>
<td>2a Subcortical round lucency (cysts)</td>
<td>High-signal fluid within fragment</td>
<td>None</td>
</tr>
<tr>
<td>3 Same as 2</td>
<td>High-signal fluid surrounds fragment</td>
<td>Displaceable fragment</td>
</tr>
<tr>
<td>4 Loose body</td>
<td>Defect talar dome, possibly loose body</td>
<td>Defect plus loose body</td>
</tr>
</tbody>
</table>
35 yo s/p MCA
35 yo s/p MCA
Conclusion

- Osseous anatomy of the talus and calcaneus can seem complex
- Using a systematic approach
Distal fibular fracture

Weber A
Bi-malleolar fracture
Maisonneuve fracture
Weber Classification

- Determine level of fracture with respect to the syndesmosis.
- Correlates with prognosis and treatment.
- Type A= transverse fracture of lateral malleolus below syndesmosis.
- Type B= oblique fracture at the level of the ankle joint; partial disruption of syndesmosis.
- Type C= fibular fracture proximal to the ankle joint with tear of tibiofibular ligaments and syndesmosis.
Metatarsal fractures
Stress fracture foot
Stress fracture
medial malleolus
fracture 5th proximal phalanx - renal osteodystrophy
fracture sesamoid
Avulsion tib.post. tendon
Tibialis anterior tendon tear
Tear of the anterior Syndesmosis ligament
Achilles tendon tear
Tear ant. talofibular lig
Fracture of the calcaneus and talus
Osteochondritis dissecans

- Repeated microtrauma causes injury
- Occurs in typical locations at the knee and ankle.
- In the ankle the talar dome is typical location.
Bone marrow infarction and stress fracture in 50 yo patient with chemotherapy for lymphoma.
Inflammation
Osteomyelitis / Arthritis

foot
Osteomyelitis ankle
Tuberculous dactilitis

- frequent in children
- multiple foci in 25-30%
- Soft tissue swelling
- Periostitis
- May be cystic = spina ventosa
Rheumatoid arthritis
Gout
Reactive arthritis - Reiter’s syndrome
Pathology of the foot and ankle

Tumor
Plantar fibromatosis

STIR

fs-T2

fs-T1+Gd
Metastatic Prostate Cancer
Chondrosarcoma
Various
Calcaneonavicular coalition

- Fusion of tarsal bones
- Talocalcaneal and calcaneonavicular are most common types
- Fibrous, cartilaginous or osseous.
- Result in limited motion at these joints and over time pain, arthritis, tendonopathy develop.
Clubfoot

- 1 in 1000 births.
- Unclear etiology.
- Hindfoot equinus, hindfoot varus, and forefoot varus.
Osteogenesis imperfecta
Chronic venous stasis
Necrosis/bone bruise of the navicular bone?

Follow-up 6 months later

Transient migratory osteoporosis

STIR
Summary and Discussion

I. Anatomy

II. Pathologies

III. What pathologies are important at your level?