Selected Fractures of the Foot: Diagnosis and Treatment
Overview

- **Forefoot Fractures**
  - Lisfranc
  - MT
    - 5th MT

- **Hindfoot Fractures**
  - Calcaneus
  - Talus
Tarsometatarsal (Lisfranc’s) Fracture Dislocation

- Injury to Lisfranc complex can result in prolonged recovery, significant morbidity
- Important to recognize and treat early
  - 20% initially unrecognized
- Significant disruption can undergo spontaneous reduction
  - Masks underlying gross instability
  - Need high index of suspicion especially with high energy injuries (ex. MVA)
Lisfranc’s: Anatomy

- No ligament between bases of 1\textsuperscript{st} and 2\textsuperscript{nd} metatarsals
- Lisfranc’s ligament:
  - oblique attachment between medial cuneiform and 2\textsuperscript{nd} MT base
  - Plantar structure
Lisfranc’s: Mechanism

- Sports, fall from height, MVA
- Longitudinal loading of plantarflexed foot
- Hyperplantarflexion:
  - Dorsal ligaments rupture first
  - Plantar ligaments next, depending on amount of force
  - Variable bony injury (cuneiform, cuboid, MT fx’s common)

Direct mechanism

Indirect mechanism (more common)
Lisfranc’s:
Diagnosis

• Careful physical exam
  - Pain anywhere in TMT joint suggestive
  - Plantar ecchymosis

• Radiology
  - Weight bearing x-rays:
    • AP
    • Lateral
    • 30deg medial oblique
Lisfranc’s:
Diagnosis

- **AP**
  - Lateral borders of 1st MT and medial cuneiform
  - Medial borders of 2nd MT and middle cuneiform
- **Oblique**
  - Medial borders of 4th MT and cuboid
- **Lateral**
  - Dorsum of 2nd MT and middle cuneiform
- **2nd MT on AP & 4th MT on oblique are most consistent indicators of unstable injury**
Lisfranc’s:
Diagnosis

Non-weight bearing

Weight bearing
Lisfranc’s: Diagnosis

Oblique
Lisfranc’s:
Diagnosis

• **X-rays negative, but high suspicion:**
  - **Flouroscopic stress views**
    • Anesthesia (ankle block)
    • Hold hindfoot stable, supinate/pronate & adduct/abduct stress forefoot on AP and oblique views
  
• **CT**
  - To evaluate for intraarticular comminution
  - Preoperative planning
Lisfranc’s: Classification

- Quenu and Kuss
- 3 types based on resulting pattern
- Poor for determining treatment or predicting outcome

Homolateral (med or lat)  Partial disruption (1\textsuperscript{st} or lesser)
Lisfranc’s:
Treatment

• Stable Lisfranc “sprains”:
  - TMT pain with ROM/weight bearing/and palpation, but no instability
  - <2mm displacement of TMT joint on any view
  - Need immobilization
    • Short leg cast
    • Stress views at 10 days
    • NWB for 3-4 weeks, advance as comfort allows
  - Start rehab when pt able to heel raise out of cast without pain
Lisfranc’s: Treatment

• **Unstable Lisfranc injury**
  - >2mm displacement at TMT joint
  - Best results with anatomic ORIF
  - Closed reduction and splinting until surgery possible
Lisfranc’s:
Treatment

- **Surgical technique**
  - 2 incisions
    - 1-2 interspace
      - Identify NV bundle & fix medial 2 TMT joints
    - Over 4th MT
      - Fix lateral 3 TMT joints
  - Inspect all joints prior to reduction
  - K-wires vs. screws
Lisfranc’s: Treatment

- Clamp reduction of 2\textsuperscript{nd} TMT joint
- Order of fixation
  - 2\textsuperscript{nd} TMT (screw)
  - Assess instability
  - 3\textsuperscript{rd} TMT (screw)
  - 1\textsuperscript{st} TMT (screw)
    - Notch to prevent fx
  - Lateral joints (wires)
Lisfranc’s:
Post-op Care

- NWB in short leg cast 6-8 weeks
- Progress to WB as comfort allows
- Out of cast when pain free
- HW removal at 3-6 months
Metatarsal Fractures

- **5th MT fractures**
  - Unlike other MT fractures, usually indirect injury
  - Usually related to athletic activity
  - 2 types:
    - Proximal base fractures
      - Zones 1, 2, 3
    - Distal spiral fractures
      - “dancers fracture”
5th Metatarsal Fractures: Proximal Base Fractures

- **Zone 1 injury**
  - Avulsion fracture
  - Hindfoot inversion while weight on lateral MT
  - Lateral band of plantar aponeurosis pulls bone off (not peroneus brevis)
  - Usually min displaced and stable
5th Metatarsal Fractures: Proximal Base Fractures

• Zone 2 Injury
  - True Jones’ fracture
  - Acute forefoot adduction
  - Metaphysyeal/diaphyseal junction
5th Metatarsal Fractures: Proximal Base Fractures

- **Zone 3 Injury**
  - Proximal 1.5cm of diaphyseal shaft
  - Stress fracture from repetitive loads
  - Fx starts lat and propagates med
  - Athlete with weeks/months of lateral pain
5th Metatarsal Fractures: Distal Spiral Fractures

- Spiral oblique fractures
- "Dancer’s fracture"
- Distal lateral to proximal medial
- Mechanism: rotational force to an axially loaded foot in plantarflexed position
5th Metatarsal Fractures:
Treatment

• **Zone 1:**
  - Treat symptomatically
  - Hard soled shoe and walking casts equally effective
  - May have 6-8 weeks of symptoms
  - Expect full healing
Zone 2
- Controversial
- If preexisting sx:
  - Less healing potential
  - Treat like zone 3
- If acute:
  - Short leg walking cast 8-10 weeks, WBAT
5th Metatarsal Fractures: Treatment

• Zone 3
  - Tendency to non-union
    • Watershed area of blood supply?
    • Medial nutrient artery feeding proximally
  - Requires more aggressive Tx
    • SLC non-weightbearing up to 3 months
    • Some initially ORIF with compression and graft
5th Metatarsal Fractures: Treatment

- **Surgery**
  - Reserved for symptomatic nonunions usually in zone 3
  - Open debridement of nonunion & cancellous bone grafting, fill canal with compression screw (4.5 or 6.5 partial thread)
  - Approach risks: sural N., PB, DQ
  - Post-op: protected weight bearing
Calcaneus Fractures

• Most common of all tarsal bone fractures
• Very challenging injuries
• Wide variety of fracture patterns
• Once considered “inoperable”
  - New surgical technique, CT has made intervention more beneficial
Calcaneus Fractures: Anatomy

- “like an egg”: hard on outside, soft on inside
- Function: 1) lever arm for gastroc, 2) bear body weight, 3) maintain foot (lat column) length
- Anatomic keys:
  - Posterior facet
  - Sustentaculum tali
  - Bohler’s tuber angle (calcaneal height)
  - Gissane’s crucial angle (post facet depression)
Calcaneal Fractures: Anatomy

- Body
- Posterior articular surface for talus (posterior facet)
- Middle articular surface for talus (middle facet)
- Anterior articular surface for talus (anterior facet)
- Anterior process
- Articular surface for cuboid bone
- Tuberosity
- Lateral process of tuberosity
- Peroneal trochlea
- Groove for peroneus longus tendon
Calcaneal Fractures: Anatomy

- Middle articular surface for talus (middle facet)
- Posterior articular surface for talus (posterior facet)
- Articular surface for cuboid bone
- Sustentaculum tali
- Groove for flexor hallucis longus tendon
- Tuberosity
- Media process of tuberosity
Calcaneal Fractures: Anatomy

Normal values:
Bohler=25-40 deg
Gissane=100 deg
Calcaneal Fractures:
CT Anatomy

- Anterior articular surface for talus (anterior facet)
- Middle articular surface for talus (middle facet)
- Sustenaculum tali
- Articular surface for cuboid bone
- Posterior articular surface for talus (posterior facet)
- Peroneal trochlea
- Body
- Tuberosity
Calcaneal Fractures: CT Anatomy

- Middle articular surface (middle facet)
- Posterior articular surface (posterior facet)
- Sustentaculum tali
- Groove for flexor hallucis longus tendon
- Medial process of tuberosity
- Peroneal trochlea
- Tuberosity
- Lateral process of tuberosity
Calcaneal Fractures: CT Anatomy

- Tibia
- Medial malleolus
- Talus
- Lateral malleolus
- Posterior facet of calcaneus
- Subfibular space
- Body of calcaneus
Calcaneus Fractures:
Types

- **Extraarticular**
  - Anterior process
  - Body
- **Intraarticular**
  - Subtalar joint
    - Posterior facet
    - Anterior facet
    - Middle facet
  - Posterior facet
  - Posterior tuberosity
Calcaneus Fractures: Evaluation

• High energy injury, often polytrauma (femur, spine fx’s)

• Radiographs:
  – AP of hindfoot
    • Calcaneocuboid extension?
  – Lateral
    • Subtalar joint?
  – Harris (calcaneal) view
    • widening, loss of height, intraarticular extent?
  – Broden’s (posterior facet) view
  – Normal side comparison
Calcaneus Fractures: Evaluation

- **Computerized Tomography**
  - Routine for any possible surgical candidates
  - Supine, knees flexed, feet plantigrade
  - Feet well aligned for comparison
  - Axial cuts, coronal cuts, sagittal reconstruction
Calcaneus Fractures: Extraarticular

- Don’t involve posterior facet
- 25-30% of all calcaneus fractures
- Mechanism:
  - Lower energy
  - Heel inverted at impact?
- More benign course with better outcome than intraarticular
Calcaneus Fractures: Extraarticular

- **Anterior process**
  - Forced inversion
  - Avulsion or compression
  - Best seen on oblique view
  - Cam walker or cast, WBAT 4-6 weeks
  - Consider ORIF if >25% articular surface
Calcaneus Fractures:
Extraarticular

• **Body Fracture**
  - Distortion of architecture can affect articular surfaces
  - NWB or TTWB for 4-6 weeks
  - ORIF for loss of height or heel widening
Calcaneus Fractures: Extraarticular

- **Sustentaculum Tali**
  - Isolated fx = rare
  - Pain with PROM of FHL
  - Non-displaced
    - Protected WB 6-8 weeks
  - Displaced
    - Reduce by inversion/ plantar flexion and direct pressure
    - ORIF for large displaced fragment, excise if comminuted
Calcaneus Fractures: Extraarticular

• Posterior tuberosity
  - Avulsion by triceps surae or direct blow
  - Positive Thompson test
  - CRPP or screw if fx displace
    • Plantar flexion and bone tenaculum
    • 7.3mm cannulated screw
    • 6-8 weeks casting in equinus
    • Watch for skin complications
Calcaneus Fractures: Extraarticular
Calcaneus Fractures: Intraarticular

- 75% of all calcaneus fractures
- Usually fall from height
- Heel everted at time of injury
- Massive swelling
  - Compartment syndromes in 10%
  - Skin complications
- 50% have associated injuries
  - T&L Spine 10%, bilateral 5%, open fx (medial) 5%,
Calcaneus Fractures: Intraarticular

• **Classification**
  - 2 major fragments
    - Sustentacular (“constant”) fragment
    - Tuberosity fragment (more variable)
  - **Radiographs**
    - Essex-Lopresti 1952 described 2 types
      - Tongue
      - Joint depression (more common)
  - **CT**
    - Sanders classification
Calcaneus Fractures: Joint depression type
Calcaneus Fractures:
Joint depression type

Medial sustentacular fragment remains with talus
Remainder of body shifts into varus & laterally displaced
Calcaneus Fractures: Tongue type
Calcaneus Fractures:
Sanders CT classification

Type = number of intraarticular fragments
Type 1 = non or minimally displaced
Calcaneus Fractures: Treatment

• Closed treatment
  - Indications diminishing
  - Non-displaced fx’s, poor surgical candidates
  - Compressive splint for 5-10 days
  - Removable boot
    • Check skin, start ROM
  - NWB for 6 weeks, then advance slowly
Calcaneus Fractures: Treatment

- **Semiopen techniques**
  - **Bohler**
    - Tranverse traction pin and plaster
  - **Essex-Lopresti**
    - Tongue type fractures
    - Steinman pin used to reduce fracture, then advance for fixation, plaster
  - Evidence of poor outcomes with poor reduction of articular surface, semiopen techniques less useful
Calcaneus Fractures: Treatment

- ORIF
  - Thordarson & Kriegler (1996): prospective randomized trial ORIF vs non-op for intraarticular fx = clear advantage to ORIF
  - Extensile lateral approach most common
    - “L” incision
    - Peel flap directly off bone to maintain blood supply
    - Release calcaneofibular ligament, allow peroneal tendons to sublux over fibula, better exposure
Calcaneus Fractures: Treatment
Calcaneus Fractures: Treatment

• **Timing of surgery**
  - Positive “wrinkle test”
  - Edematous skin heals poorly
  - ORIF within first 24hrs or wait 1-3 weeks
Calcaneus Fractures: Treatment

• **ORIF technique**
  - Goals
    • 1) Reduction/fixation of posterior facet
    • 2) Correct loss of height/increased width
    • 3) Fix calcaneocuboid, ant/mid facet fx’s
Calcaneus Fractures: Treatment

• ORIF technique
  - Sloppy lateral
  - Prep iliac crest for bone graft
  - Explore sural N., retract with flap
  - K-wires for retraction
  - Usually need to remove lateral fragments to evaluate and reduce facet
  - Temporary K-wire fixation
  - Parallel screws, plate fixation
Calcaneus Fractures: Treatment

Broden’s view
Calcaneus Fractures

• Post operative care
  - Initial compressive short leg splint 10-14 days
    • Change at 48 hrs if wound healing concerns
  - Short leg, removable boot at 2 weeks
  - Start active ROM if wound OK
  - NWB for 6 weeks, then progress slowly
Calcaneus Fractures

- **Complications**
  - Gravity related swelling
    - Put on low compression hose in AM after 20-30min elevation
  - Skin and wound healing problems
  - Compartment syndrome
  - RSD
  - Sural N. injury
Talus Fractures

- 2\textsuperscript{nd} most common tarsal fracture
- Tenuous blood supply
- 3/5 covered by articular cartilage
  - Articulations allow 90\% foot & ankle motion
- No musculotendinous origins/insertions
Talus Fractures

- Talar neck
- Posterior process
- Lateral process
- Os trigonum
  - In 50% of normal feet, posterior to lateral tubercle
Talus Fractures

• **Blood supply**
  - Abundant cartilage, lack of muscle attachments limits blood supply
  - Vessels enter with ligamentous & capsular attachments
    • With injury these vessels often injured
    • High incidence of AVN
  - Anastomotic sling enters inferior talar neck
    • Artery of sinus tarsi, artery of tarsal canal
    • Peroneal, DP, and Post Tib arteries contribute
Talus Fractures

- Neck fractures
- Body fractures
- Process fractures
- Head fractures
Talus Fractures

- **Neck fractures**
  - MVA or fall from heights
  - Hyperdorsiflexion of foot on leg
  - Degree of displacement directly related to rate of AVN

- **Hawkins classification:**
  - Types I, II, III correlating to progressive displacement
  - Rare Type IV = Type III with head dislocated
Talus Fractures

Type I: non-displaced fracture
Talus Fractures

Type II: displaced fractures with subluxation/dislocation of subtalar joint
Talus Fractures

Type III: displaced fracture with dislocation of subtalar and ankle joints
Talus Fractures

• Associated injuries
  - 64% of talar neck fx’s associated with another fracture
  - High association with medial maleolus fractures (19-28%)
  - Calcaneus fractures (10%)
Talus Fractures

• **Evaluation**
  - **Radiographs**
    • AP, Lat, Mortisse
    • 75 deg AP with 15 deg pronation
      - Shows entire neck
Talus Fractures

- Treatment
  - Best results with prompt, perfect anatomic reduction
Talus Fractures

- **Type I fractures:**
  - Must be truly non-displaced
  - Short leg cast for 8-12 weeks
  - First 6 weeks NWB
Talus Fractures

• **Type II fractures:**
  - Displacement can tent skin, needs prompt reduction
  - **Closed reduction**
    - Traction, plantar flexion of foot, varus/valgus correction
    - If anatomic, SLC NWB in equinus for 6 weeks
    - Check reduction at 2, 4, & 6 weeks
    - NWB for 3 months
    - Can also percutaneously screw (post lat to ant med)
  - **ORIF if not anatomic**
Talus Fractures

- **Type III fractures:**
  - All require prompt ORIF
  - Anteromedial approach
  - Transverse calcaneal traction pin for manipulation
  - Medial maleolus osteotomy may be necessary to reduce difficult dislocations
    - Do not reflect deltoid ligament off of talus, it may be only remaining blood supply
Talus Fractures

• ORIF
  - Cancellous screws
  - May need DPC due to swelling
  - SLC NWB for 3 months
Talus Fractures

• Complications
  - Skin necrosis
  - Infection
    • Especially with open injuries
      - Historically was an indication for BKA
      - Delay closure
    • Infection persists, talar body becomes large sequestrum
  - Delayed union (common)
  - Non-union (rare)
  - Malunion (usually varus) with painful gait
Talus Fractures

- **Complications**
  - **Osteonecrosis**
    - #1 complication
    - Type I: 0-13%, Type II: 20-50%, Type III: 83-100%
  - Radiographic diagnosis
    - Increased density, later collapse
    - Hawkin’s sign:
      - 6-8 weeks post fx
      - Subchondral atrophy in dome of talus
      - Indicates vascularity/viability
  - May require MRI for confirmation
Talus Fractures

- If atrophy not present, don’t alter treatment
  - 1\textsuperscript{st} goal = union, will occur with AVN
- Symptomatic AVN with collapse:
  - Tibiotalarcalcaneal arthrodesis with IM fixation

Hawkin’s Sign
Talus Fractures

- **OCD fracture of talar dome**
  - Twisting, shearing injury
  - Vary in size
  - High index of suspicion
    - Can cause persistent pain after ankle sprain/fx
  - Treat aggressively
    - Debride small lesions
    - ORIF larger (>1cm) lesions with underlying bone
Talus Fractures:
OCD of talar dome
Talus Fractures

- **Process fractures**
  - rare

- **Talar body crush fx**
  - High complication/AVN rate
  - Usually displaced
  - ORIF recommended
  - NWB until union