Traumatic Injuries to the Foot and Ankle

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Disclosure

Smith-Nephew
Wright Medical
Calcaneus Fractures
Talus Fractures
Lisfranc Complex Injuries
CALCANEUS FRACTURES
Objectives

- Anatomy
- Mechanisms of Injury
- Imaging
- Fracture Patterns
- Treatment Options / Timing of Surgery
Anatomy
Mechanisms of Injury

• Axial load
  – fall from height
  – MVA

• Inversion / eversion injuries

• Forceful muscular contractions
Imaging

- Assumed WB AP, lateral and Mortise views ankle
- Assumed WB AP, lateral and oblique views foot
- Harris heel view
Bohler’s angle
25°-40°

Gissane’s angle
120°-145°

Neutral triangle
Imaging

- CT scan
  - 2 mm transaxial, coronal, sagittal and 3-D reconstruction views
  - Semi-coronal CT = most important view
Fracture Patterns

- Direction of force
- Quality of bone
- Position of foot

Extra-Articular: 25%
Intra-Articular: 75%
Extra-Articular Fractures
Anterior Process Fracture

- Anterior inferior tibiofibular ligament
- Anterior talofibular ligament
- Bifurcate ligament

comminuted frx
Calcaneal Body Fracture

Type 3

(a.)

[Diagram and images of calcaneal body fracture]
Sustentaculum Tali Fracture
Calcaneal Tuberosity Fracture

Achilles avulsion fractures
Peroneal Tubercle Fracture, Lateral Process Fracture, Medial Calcaneal Process Fracture
Intra-Articular Fractures
Intra-Articular Fractures

• Associated injuries:
  – spine frx
    • thoracolumbar
  – lower extremity injuries
  – bilateral frx
Primary Fracture Line
CCJ extension

lateral wall blow-out

medial wall shortening

varus mal-alignment
Bohler’s angle ↓
Gissane’s angle ↑
Sanders Classification

- Type IIA
- Type IIB
- Type IIC
- IIIAB
- IIIAC
- IIIBC

Lateral
Central
Medial
Intra-Articular Fracture Management

- Fracture pattern:
  - displacement (2 mm)
  - classification
- Open fracture

- Relative contraindications:
  - edema / blisters
  - DM
  - severe PVD
  - smoking
  - elderly with minimal demands
  - non-compliance
  - surgeon experience
Non-op CRUA Perc. Stabilization ORIF Primary Arthrodesis +/- ORIF
Sanders Classification

- Non-operative:
  - Type I (non-displaced / minimally displaced frx)
  - relative contraindications
| Non-op | CRUA | Perc. Stabilization | ORIF | Primary Arthrodesis +/- | ORIF |
Open Calcaneus Fracture

I & D traumatic wounds until clean

medial / plantar

< 4cm

epithelium re-approximated

stable wound @ 7 days

ORIF

wound location

No

No

perc. stabilization

Yes

Yes

Yes
Open Calcaneus Fracture
Open Calcaneus Fracture
Non-op CRUA Perc. Stabilization ORIF Primary Arthrodesis +/ ORIF
Sanders Classification

• Operative:
  – ORIF
    • Type II, III, IV
  – primary arthrodesis +/- ORIF
    • Type IV
• Formal ORIF
• Primary subtalar arthrodesis +/- ORIF
• Formal ORIF
• ORIF with primary subtalar arthrodesis
Calcaneus Fractures Treatment Summary

• Non-operative:
  – non-displaced / minimally displaced frx
  – relative contraindications

• Operative:
  – displaced extra-articular frx with skin tenting; impending skin compromise
  – anterior process frx with > 25% CCJ involvement
  – calcaneal body frx with ↑ width; ↓ height; arch disruption
  – displaced intra-articular frx
  – certain open frx
<table>
<thead>
<tr>
<th>Fracture</th>
<th>Non-op</th>
<th>CRUA</th>
<th>Perc.</th>
<th>ORIF</th>
<th>Primary Arthrodesis</th>
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</thead>
<tbody>
<tr>
<td>anterior process</td>
<td>&lt; 25% CCJ</td>
<td></td>
<td></td>
<td>&gt; 25% CCJ</td>
<td></td>
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<tr>
<td>calcaneal body</td>
<td>X</td>
<td></td>
<td></td>
<td>↑ width; ↓ height</td>
<td></td>
</tr>
<tr>
<td>susten. tali</td>
<td>X</td>
<td>PF + I</td>
<td></td>
<td>displacement</td>
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<tr>
<td>calcaneal tuberosity</td>
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<td>skin tenting; impending compromise</td>
<td>skin tenting; impending compromise</td>
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<td>peron. tub. / med. calc. process</td>
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<td>joint depression type</td>
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<td></td>
<td></td>
<td>Sanders II, III, IV</td>
<td>Sanders IV</td>
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<td>tongue type</td>
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<td></td>
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<td>Sanders II, III, IV</td>
<td>Sanders IV</td>
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<tr>
<td>open</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
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</tbody>
</table>
• **Emergent:**
  - compartment syndrome*
  - open fracture*
  - skin tenting; impending skin compromise
  - cannot reduce frx-dislocation

• **Urgent (within 3 wks):**
  - displaced intra-articular frx
  - displaced extra-articular frx
  - anterior process frx with > 25% CCJ involvement

• **Elective:**
  - massive edema; medical co-morbidities
  - non-reconstructable intra-articular frx
  - symptomatic frx nonunion / malunion
Talus Fractures
Objectives

- Incidence
- Anatomy
- Mechanisms of Injury
- Imaging
- Fracture Patterns
- Treatment Options / Timing of Surgery
Incidence

- 3% of all foot fractures
- < 1% of all fractures
- Types:
  - Neck: 50%
  - Body: 7-38%
  - Head: 10%
Anatomy

• Talus
  – Vital part of ankle + subtalar complex of joints
    • Vertical WB forces transferred to horizontal support structures of foot
  – Small; irregular shape
  – No muscular attachments
  – 70% surface covered with articular cartilage
  – Vascular supply tenuous
Anatomy

• Articulations btwn:
  – Tibial plafond and dome of talus
  – Posterior facet of talus with calcaneus
  – Medial and anterior facets of talus and calcaneus and btwn head of talus and posterior surface of navicular
Anatomy

• Articulations:
  – Posterior facet
    • Inferior surface talus = concave
    • Superior surface calcaneus = convex
  – Anterior + middle facets
    • Inferior surface talus = convex
    • Superior surface calcaneus = concave
Anatomy

- Subtalar joint motion
  - Screw mechanism
- Talonavicular joint motion
  - Ball and socket mechanism
# Mechanisms of Injury

<table>
<thead>
<tr>
<th>Fracture Location</th>
<th>Mechanism</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talar neck</td>
<td>axial compression + DF</td>
<td>high energy trauma</td>
</tr>
<tr>
<td>Talar Head</td>
<td>DF + I</td>
<td>MVA; fall from ht</td>
</tr>
<tr>
<td>Talar Body</td>
<td>axial compression</td>
<td>high energy trauma</td>
</tr>
<tr>
<td>Lateral Process</td>
<td>DF + I</td>
<td>snowboarding</td>
</tr>
<tr>
<td>Posteromedial</td>
<td>pronation + DF</td>
<td>sports; MVA; fall from ht</td>
</tr>
</tbody>
</table>
Imaging

- Assumed WB AP, lateral and Mortise views ankle
- Assumed WB AP, lateral and oblique views foot
Imaging

• CT scan
  – 1.5 mm transaxial, coronal, sagittal and 3-D reconstruction views
Fracture Patterns

• Talar neck fracture:
  – MOI: axial compression and DF
  – Hawkins classification
    • Type I: non-displaced; no sublux or disloc of STJ
    • Type II: displaced; ankle nl; STJ sublux or disloc
    • Type III: complete disloc of ankle + STJ
    • Type IV: complete disloc of ankle + STJ + TNJ
Fracture Patterns

• Talar head fracture:
  – MOI: DF + I
  – Involves: middle facet + TNJ
Fracture Patterns

- Talar body fracture:
  - MOI: axial load
Fracture Patterns

• Lateral process fracture:
  – AKA “snowboarder’s frx”
  – MOI: DF + I
Fracture Patterns

- Posteromedial fracture
  - MOI: direct impact; pronation + DF
Treatment

• Talar neck fracture:
  – ORIF
Talar head fracture:
Treatment

• Talar body fracture:
  – ORIF +/- medial malleolar osteotomy
Treatment

- Posteromedial fracture
  - MOI: direct impact; pronation + DF
Lisfranc Complex Injuries
Objectives

- Incidence
- Anatomy
- Mechanisms of Injury
- Clinical Examination
- Imaging
- Treatment Options / Timing of Surgery
- Complications
Incidence

• Uncommon
  – 0.2% of all frx
  – 55,000 Lisfranc injuries annually
    • Does not include ligamentous injuries
Incidence

- M > F
- Avg age: mid 30’s
- Up to 40% missed
  - Most commonly on multi-trauma patients
Anatomy and Biomechanics

• Tarsometatarsal Joints (TMTJ’s)
  – Articulation btwn 1\textsuperscript{st} 3 MT and their respective cuneiforms
  – Articulations btwn 4\textsuperscript{th} and 5\textsuperscript{th} MT and cuboid
  – Stability
    • osseous
    • ligamentous
    • tendinous
Anatomy and Biomechanics

Osseous configuration

• Greatest stability
• Coronal plane and transverse plane
Anatomy and Biomechanics

osseous configuration

• Coronal plane stability
  – TMTJ’s form symmetric “Roman” arch
  • Wider dorsal wedge shape
    – 2d and 3d MT bases
    – middle and lateral cuneiforms
Anatomy and Biomechanics
osseous configuration

- Transverse plane stability
  - 2d MT
    - Longest
    - Keystone
    - Surrounded by 5 bones
      - limits medial – lateral translation
Anatomy and Biomechanics

ligamentous configuration

• Stronger plantarly
• MT’s attached to more proximal articulations
• Lesser MT’s attached via interosseous ligaments
• No IM ligament bwtw 1\textsuperscript{st} and 2d MT’s
Anatomy and Biomechanics
ligamentous configuration

- 1\textsuperscript{st} MT attached only to medial cuneiform
- 2d MT attached to medial cuneiform via Lisfranc ligament
  - 2 separate bands in 22\% of population
    - Dorsal weaker
    - Plantar stronger
Anatomy and Biomechanics

tendinous configuration

• Tibialis Anterior
  – Insertion: medial aspect proximal 1\textsuperscript{st} MT

• Peroneus Longus
  – Insertion: plantar lateral aspect 1\textsuperscript{st} MT
Anatomy and Biomechanics

primary stabilizers

- 2d MT
  - Keystone
  - Surrounded by 5 adjacent bones
    - 1st and 3d MT
    - Recessed between medial, middle and lateral cuneiforms
- Lisfranc ligament
  - Plantar 2d MT base to medial cuneiform
Anatomy and Biomechanics

secondary stabilizers

• Plantar fascia
• Intrinsic muscles
• Insertions of Tibialis Posterior, Tibialis Anterior and Peroneus Longus
Mechanisms of Injury

- MVA
  - 65%
- Fall
- Crushing Injury
- Twisting Injury
Mechanisms of Injury

• Forces
  – Direct
  – Indirect
Mechanisms of Injury

• Direct Forces
  – Less common
  – Crushing injury
  – Outcome:
    • Fracture comminution
    • Soft tissue damage
    • Compartment syndrome
Mechanisms of Injury

- F distal to Lisfranc complex $\Rightarrow$ plantar displacement of MT bases

- F proximal to Lisfranc complex $\Rightarrow$ dorsal displacement of MT bases
Mechanisms of Injury

• Indirect Forces
  – More common
  – Rotational Injury
    • Foot: sl. equinus
    • MT: firmly planted
    ➔ body projected over forefoot
      – twisting + rotation + abduction
Mechanisms of Injury

• Indirect Forces
  – Rotational injury
    • Failure under tension dorsally
    • Continued abduction leads to:
      – 2d metatarsal base dislocation
      – Lateral displacement of lesser metatarsals
      – Compression fracture of cuboid
Mechanisms of Injury

- Dorsal displacement of MT bases
Mechanisms of Injury

• Direct or indirect forces:

• Perforating branch of dorsalis pedis aa may disrupt
  – Hemmorhage with ↑’d interstitial fluid P ➔ compartment syndrome
Clinical Examination

- Routine foot and ankle examination
  - NV
    - Sensation
    - Motor power
    - Capillary refill
  - PROM ankle, subtalar, Chopart complexes
  - Forefoot examination
Clinical Examination

• Specific Foot and Ankle Examination
  – Tenderness, crepitus and deformity at Lisfranc complex
  – Compartments
    • soft
    • TTP
    • compressible
Clinical Examination

• Specific Foot and Ankle Examination
  – Skin integrity
    • Tenting
    • Frx blisters
    • Ecchymosis
      – Plantar mid foot
        » Classic finding
  – Pronation abduction maneuver
Imaging

- Assumed WB AP, lateral and 30° IO images
- If unable to perform WB images and ?? midfoot injury, repeat films in 2 wks in WB posture
Imaging

- AP:
  - Frx pathology
Imaging

• AP:
  – Frx pathology
  – Fleck sign
    • Avulsion frx off medial base of 2d MT or lateral border of medial cuneiform
Imaging

- **AP:**
  - Frx pathology
  - Fleck sign
    - Avulsion frx off medial base of 2d MT
  - Alignment
- **Alignment:**
  - Medial border 2d MT with medial border middle cuneiform
Imaging

- **Alignment:**
  - 1st intermetatarsal space continuous with space between medial and middle cuneiforms
  - NI: 1.3 mm
Imaging

- Lateral:
  - Frx pathology
Imaging

• Lateral:
  – Frx pathology
  – Evaluate for dorsal displacement of MTs relative to cuneiforms
Imaging

• Lateral:
  – Frx pathology
  – Evaluate for dorsal displacement of MTs relative to cuneiforms
  – Change in distance between plantar aspect medial cuneiform and 5th MT
Imaging

• 30° IO:
  – Frx pathology
– Alignment:
  • Lateral border 3d MT with lateral border of lateral cuneiform
Imaging

- Alignment:
  - Medial border 4th MT with medial border cuboid
Imaging

– Alignment:
  
  • 2d IM space continuous with space btwn lateral cuneiform and cuboid
Imaging

• **Stress Radiographs:**
  – Ligamentous injury with equivocal examination
  – Ankle block anesthesia or O.R. setting
Imaging

• Malreduction:
  – > 15° abduction of 1st MT
  – > 2 mm lateral shift of at least 1 MT
Imaging

• **Magnetic Resonance Imaging:**
  – Clear diastasis on WB AP image
    • do not MRI
  – Equivocal or nl radiographs with pronounced mechanism and/or clinical examination
    • Consider MRI
Imaging

- **CT Scan:**
  - Image all Lisfranc complex injuries
  - 1.5 mm transaxial, sagittal and coronal cuts in assumed WB position
Treatment

• Optimal Treatment:
  – Anatomic stable reduction of TMTJ’s
WB AP, lat and 30 degree IO

stable
(<2mm displacement)
repeat WB films in 2 wks
stable
stable
closed treatment
unstable
surgery

unstable
(>2mm displacement)
surgery
Treatment

• Midfoot Sprain
  – Stable:
    • SLNWBC until asymptomatic then SLWC or boot with WBAT X 6-8 wks
    • Activity level to tolerance
Treatment

• Midfoot Sprain
  – Unstable:
    • >15° 1st MT abduction
    • >2 mm lateral shift of any MT
    • ORIF vs. arthrodesis
Treatment

• Midfoot Sprain
  – Equivocal:
    • MRI
      – No tear or partial tear of Lisfranc ligament (< 50%)
        » treat as sprain
      – > 50% tear of Lisfranc ligament
        » ORIF
        » arthrodesis
Treatment

• Operative:
  – Indications:
    • Any degree of displacement of frx of TMTJ’s (unstable)
    • Pure ligamentous injury with instability
Treatment

• Operative:
  – Timing of surgery based upon:
    • Presence of compartment syndrome
    • Degree of soft tissue swelling
    • Can be performed up to 6 wks after injury
Treatment

- Fracture Fixation Options:
  - K-wire
  - ORIF
  - arthrodesis
Treatment

- **K-wire:**
  - Easy to insert
  - Easy to back out
  - Rarely used as sole means of fixation
  - Useful with:
    - Severe frx comminution
    - Compartment syndrome with poor soft tissue envelope
    - Can be performed up to 6 wks after injury
Treatment

- Fracture Fixation Options:
  - ORIF
    - 3.5 or 4.0 screws
      - Cannulated
      - Non-cannulated
Treatment

- Fracture Fixation Options:
  - ORIF
  - Mini-fragment plates
Treatment

- Fracture Fixation Options:
  - Arthrodesis
  - Joint preparation and mode of fixation different
Treatment

- Lee et al. Foot and Ankle International May 2004
Treatment

• Pure Ligamentous Injury Options:
  – K-wire
  – K-wire + screw fixation
  – Screw fixation
Treatment

• Operative:
  – In absence of compartment syndrome, ORIF
  – Algorithm of stabilization based on column involvement
Treatment

- Operative:
  - Isolated medial column or medial + middle column injury, reconstruct medial to lateral
Treatment

- Operative:
  - Lateral column injury
    - Ex fix lateral column
    - Stabilize lateral column
    - Stabilize medial column
    - Stabilize middle column
Rehabilitation

- NWB 6-12 wks
- HWR s/p ORIF at 12-16 wks
  - Retention of HW?
- WBAT
- Custom B/L MLA support x 6 mo
- Avoid high impact L.E. athletic activity x 3 mo
Complications

• Acute:
  – Compartment syndrome

• Long term:
  – Post-traumatic arthritis
    • 30%
  – Pes planus + forefoot abduction
Thank you

“BE ASHAMED TO DIE UNTIL YOU HAVE DONE SOMETHING GOOD FOR MANKIND”
Dr. Vernon Johnson, American Pastor during the Revolutionary War