Injuries of the Foot and Ankle

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Introduction

• The average person takes 1 million steps per year
• Approximately 30 bones in the foot and ankle are subjected to forces of 3-7 times body weight
• Trauma to the foot and ankle, even minor, can have profound effects on one’s ability to ambulate and work effectively

Introduction

• Goals of Foot and Ankle Fracture Management
  – Restoration of normal anatomy
  – Avoidance of prolonged casting
  – Rapid mobilization
  – Early return to weight bearing
Introduction

• Distal Tibia Fractures
• Talus Fractures
• Calcaneus Fractures

Introduction

• Mechanism of Injury
  – Motor vehicle collision
    • Improved vehicular safety (airbags)
    • ATLS protocols
  – Industrial injuries
    • Most frequently injured body part
  – Fall from heights
  – Motorcycle injuries
  – Sport Injuries

Pilon Fractures

• Among most difficult fracture to treat
• Axial loading – talus forced into distal tibia (explosive type pattern)
• Soft Tissue injury
  – Swelling, fracture blisters
  – Larger percentage are open fractures
Pilon Fractures

• AO Classification
  • Type A – Extra articular
  • Type B – Partial articular
  • Type C – Complete Articular

Pilon Fractures

• Treatment
  • Non-operative
    — Bedridden patients
    — Parapalegics
    — Significant medical co-morbidities
  • Operative
    — Displaced or unstable fractures
    — Open fractures
    — Inability to maintain alignment
    — Polytrauma
    — Intra-articular displacement

Pilon Fractures

• Surgical Goals
  — Anatomic reduction of articular surface
  — Restoration of length and alignment
  — Rigid fixation
  — Early range of motion
Pilon Fractures (Treatment Evolution)

- Initial good results in Swiss (1970s)
  - Early ORIF
  - Skiing injuries
  - Lower energy
- North American experience
  - Disastrous outcomes
  - High infection rate
  - High wound complication rate
- External fixation
  - Limited incision ORIF with ankle spanning external fixation
    - Ankle stiffness
    - Lower wound complication
- Two-staged protocol
  - Early ORIF of fibula fracture
  - Temporary spanning external fixation
  - Definitive ORIF 7-21 days later
  - Allows soft tissues to recover

Pilon Fractures

- Treatment Algorithm
- Emergent gross realignment (prevent further skin compromise)
- Closed reduction of tibia fracture
- Open reduction of Fibula
- Temporary spanning external fixation
- sd

Pilon Fractures

- Preoperative Planning
- CT scan
Pilon Fractures

• Definitive ORIF
  – Ex-fix removal
  – Application of femoral distractor
  – Reconstruction of articular segment
  – Alignment of metaphysis and diaphysis
  – Rigid internal fixation

Pilon Fractures (Outcomes)

• Pollak et al, JBJS, 2003
  – Outcomes after treatment of high-energy tibial plafond fractures
  – 80 patients evaluated at mean of 3.2 years
  – General health scores lower than age matched controls
  – 35% ankle stiffness
  – 29% persistent swelling
  – 33% significant pain
  – 43% unemployed at F/U

• Predictors of poor outcomes
  – 2 or more medical co-morbidities
  – Being married
  – Treated with definitive external fixation
  – No high school diploma
  – Annual income of < $25,000

Pilon Fractures (Outcomes)

• Marsh et al, JBJS 2003
  • 35 ankles 5-12 post-operative
  • External fixation with limited internal fixation
  • Osteoarthrosis
    – three grade 0
    – six grade 1
    – Twenty grade 2
    – Six grade 3
  • half of patients changed jobs
  • Subjective improvement for 2.4 years
Pilon Fractures (Outcomes)

- Sirkin et al, JOT, 1999
  - A Staged Protocol for Soft Tissue Management in the Treatment of Complex Pilon Fractures
- 34 closed fractures
  - 17% partial thickness skin necrosis
  - 3.4% osteomyelitis
- 22 open fractures
  - 10.5% deep infection

Talus

- 60% of its surface area is covered by cartilage
  - "Universal joint of the foot"
    - Couples dorsiflexion/plantarflexion ankle
    - Inversion/ eversion through subtalar and talonavicular joints
- Limited area for vascular penetration
  - High risk of avascular necrosis after fracture

Talar neck fractures

- Hawkin's Classification (JBJS 1970)
  - Type 1 Nondisplaced
    - AVN risk 14%
  - Type 2 Dislocated Subtalar joint
    - AVN risk 25-50%
  - Type 3 Dislocated subtalar and ankle joint
    - AVN 75-100%
  - Type 4 complete talar dislocation
Talar neck fractures

- Non-operative Management
  - Reserved for true non-displaced fractures
  - Confirm on CT scan
- Short leg cast for 6 weeks
- 2mm of displacement alters contact pressures in subtalar joint (Sangeorzan et al, J Orthop Res, 1992)

Talar neck fractures

- Operative Management
  - All displaced fractures
  - Open fractures
- Surgical Timing
  - Historically a surgical emergency (6-8 hours)
  - Reestablish blood flow
- Vallie et al, JBJS 2004
  - No association with surgical timing and rates of AVN
  - AVN and outcome related to severity of injury (comminution and soft tissue injury) and quality of surgical reduction

Talar neck fractures

- True surgical emergency
  - Irreducible dislocation
  - Skin tension with impending skin breakdown
  - Compartment syndrome
  - Neurovascular injury
  - Open wounds
Talar neck fractures

- Technique
- Dual incision
  - Medial
    - Often medial comminution
  - Lateral
    - Allows subtalar joint access to remove articular debris
    - No comminution, aids in fracture reduction
- Fixation
  - Typically 2 screws
  - Add plates when excessive comminution

Talar Neck Fractures - Outcomes

- Sanders et al, JOT, 2004
- Functional Outcomes Following Displaced Talar Neck Fractures
  - 70 talar neck fractures
  - Mean follow-up 5.2 yrs (2-10)
- 44 patients – no secondary reconstructive procedures
  - 52% pain with VAS score of 4.2/10
  - 70% employed
  - 26% disabled
  - Overall satisfaction 79%
  - Functional level 63% of pre-injury level
- 26 patients required secondary reconstructive surgery (SRS)
- Lifetime table analysis
  - 25% at one year
  - 48% at 10 years
- Comminuted fractures and Hawkins 3 and 4 associated with SRS
  - BKA, subtalar, triple, pantalar arthrodesis

Talar Neck Fractures - Complications

- Arthritis
  - Subtalar ankle
  - Chondral injury, malreduction and malunion
  - 40-75% incidence
- Avascular Necrosis
  - Range 30-35%
  - Associated with comminution, displacement, and open wounds
- Infection
- Nonunion, and malunion
- Arthrofibrosis
  - Goal
    - 75-100% ankle ROM
    - 50%–75% subtalar ROM

Courtesy of Mike Swords, MD
Calcaneus

- Superior Surface:
  - Subtalar (anterior, middle, posterior facets)
  - Spatial relationship
- Plantar surface:
  - Medial and lateral processes
- Tuberosity:
  - Achilles tendon insertion
- Lateral surface:
  - Relatively flat
  - Groove for peroneal tendons
- Medial surface:
  - Sustentaculum tali (FHL)
  - Slopes sharply
  - Neurovascular bundle
- Anterior surface:
  - Calcaneocuboid articulation

Calcaneus

- Principle Function
  - Lever arm for GS complex
  - Foundation for body weight
  - Support/maintain lateral column of the foot
- Thin Cortical Shell
- Neutral Triangle

Injury mechanism

- Axial loading
- Primary fracture line
- anteromedial/ posterolateral fragments
- Secondary fracture lines
  - stellate pattern from sinus tarsi
Fracture Characteristics

- 3 dimensional deformity
  - Intra-articular deformity
  - Loss of height - (ankle impingement)
  - Varus deformity
  - Heel widening (Subfibular impingement)

Classification

- Essex Lopresti, 1952
- Described 2 fracture patterns
  - Tongue type – tuberosity attached to articular fragment
  - Joint-depression – 2 separate fragments

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Intra-articular Classification

- Crosby et al, JBJS, 1990
  - Associated clinical outcome with fracture type based on CT scan
    - Type I: Nondisplaced
    - Type II: Displaced
    - Type III: Comminuted
- Sanders et al, J. Orthop. Trauma, 1992
  - Coronal CT scans
    - Type I: Nondisplaced
    - Types II-IV: Displaced/posterior facet articular fragments

Treatment – Intra-Articular Fx

- Operative Treatment
  - Indications
    - Displaced intra-articular fractures
    - Heel widening (calcaneofibular impingement)
    - Horizontally oriented talus (talar impingement)
    - Contiguous fractures
    - Open fractures
    - Skin compromise

Operative Treatment

- Initial treatment
  - Respect soft tissues
  - Blistering
  - Swelling
  - Jones dressing
  - Splint

Courtesy of Armen Kelikian, MD
### Operative Treatment

- **Goals of ORIF**
  - Restore Articular Integrity
  - Restore Height
  - Restore Width
  - Correct Tuberosity Malalignment
- **Preoperative Planning**
  - Quality Radiographs, CT images
  - Optimal Soft-Tissue Status
  - Hardware On-site

### Percutaneous Fixation

- Essex Lopresti Technique
- **Indications** —
  - Tongue type fracture
    - Extra-articular
    - Sanders Type 2C
    - Some Type 2B
- Fixation within 5 days of presentation

### Open Technique - Lateral Approach

- L-shaped incision (peroneal artery)
- Subperiosteal flap
- "No touch technique"
- K-wires into talus, fibula, and cuboid
- Sural nerve
- Peroneal tendons
- Calcaneofibular ligament
Fracture Reduction

• Step 1 – anterior calcaneus
  – Reduce anterior and middle facets
  – Reduce calcaneocuboid joint fracture

Fracture Reduction

• Step 2 - Tuberosity
  – Axial traction
  – Correct varus
  – Restore height

Fracture Reduction

• Step 3 - posterior facet
Operative vs. Conservative

- Thorardson et al, FA Intl, 1996
  - 1st prospective, randomized trial
  - 30 patients with Sanders type 2 or 3
  - 17 month follow-up
  - Subtalar ROM 20° vs 17°
  - 25 % vs 100% pain at extremes of motion
  - Operative: 7 excellent, 5 good results
  - Nonoperative: 1 excellent, 3 good
  - Functional score 86.7 vs. 55.0

Operative vs. Conservative

- Buckley et al, JBJS, 2002
  - Randomized controlled trial of 471 fractures
  - 2-8 year follow-up
  - Overall similar results of ORIF vs non-operative care
  - When stratified, superior results with ORIF if:
    - Women
    - Not Worker’s Comp
    - Lighter workload
    - Simple, displaced fractures

Complications

- Harvey et al, FAI, 2001
- Morbidity Associated with ORIF of the Calcaneus using the Lateral Approach
  - 183 patients with 218 displaced calcanei fractures
  - 194 (89%) – uneventful primary wound healing
- One deep infection – BKA in neuropathic patient
- 43.5% patients – subsequent procedures
  - 88 patients (93%) - hardware removal
  - 5 subtalar fusions
  - 7 claw toe corrections
  - 4 calcaneal valgus osteotomies
  - 1 arthrolysis
- Conclusion: ORIF of calcaneal fractures through a lateral approach is a safe and reliable method of treatment
Complications

- Deep Infection rates
  - Closed fractures – 0-20%
  - Open fractures – 19-31%
- Benireschke et al, JOT, 2004
  - Retrospective review
  - 341 closed calcaneal fractures
  - 39 open calcaneal fractures
- Deep infection
  - Closed fracture – 1.8%
  - Open fracture - 7.7%
- Procedures performed
  - I and D - 2
  - IV abx - 6
  - Hardware removal - 4
  - Placement of Abx beads - 1