Pediatric Fractures of the Foot

Nicholas Frane DO
Zucker/Hofstra School of Medicine Northwell Health
Disclosure

• Radiographic Images Courtesy of: Dr. Jon-Paul Dimauro M.D or Christopher D Souder, MD, unless otherwise specified
Overview

• Talar Fractures
• Calcaneal Fractures
• Metatarsal Fractures
• Phalangeal Fractures
Epidemiology

• <10% of fractures in children
• More common in adolescents and teenagers
• Pediatric foot
  • Cartilaginous → more elastic, absorptive, and flexible
    • As ossification occurs, injuries will more closely resemble adult patterns
• Incidence: 10.5/10,000 (Cooper et al 2004)
• Avg age of injury is 13 years
• M=F
• Most treated with nonoperative management
Pediatric Foot Anatomy

• Anatomic Subdivisions:
  • Hindfoot
    • Talus, Calcaneus
  • Midfoot
    • Navicular
    • Cuboid
    • Cuneiforms
  • Forefoot:
    • Metatarsals
    • Phalanges
• Variable number of sesamoids/accessory ossicles

Rockwood and Wilkins’ Fractures in Children, 9e, 2019
Talus Fractures

• Rare, incidence between .01% and .08%
• <2% of all pediatric foot fractures
• **Talar neck fractures most common**
• Tenuous blood supply
• MOI:
  • Direct trauma (object falls on foot)
  • Axial load with a dorsiflexed foot
• Majority treated with immobilization
• Adolescent fractures treated like fractures in adults
• Complication: AVN

Crawford AH. Fractures about the foot in children. A radiographic analysis. Cincinnati Children’s Hospital, Cincinnati, OH
Talus Anatomy

Fracture Locations

- **Neck**
- **Body**
- **Medial Process**
- **Lateral Process**

Superior and inferior views of the talus (stippling indicates the posterior and lateral processes)
Vascular anatomy of the Talus

A. Medial
1. Anterior tibial artery
2. Medial recurrent tarsal artery
3. Medial talar artery
4. Posterior tibial artery
5. Posterior tubercle artery
6. Deltoid branches
7. Artery of tarsal canal
8. Medial plantar artery
9. Lateral plantar artery

B. Lateral
1. Anterior tibial artery
2. Lateral talar artery
3. Lateral tarsal artery
4. Posterior recurrent branch of lateral tarsal
5. Perforating peroneal artery
6. Anterior lateral malleolar artery

*Anastomosis in pediatric patients more evenly distributed amongst the contributing arteries*
**Imaging**

- AP, lateral, oblique XR of foot & dedicated ankle
  - Canale-Kelly view
  - Talus largely cartilaginous until 2nd decade
- CT
  - Fracture plane, comminution, degree of displacement
  - Useful when pain prohibits appropriate radiographs
  - Preoperative planning
- MRI
  - Classifying osteochondral talus fractures
  - Evaluate AVN
Special Radiographs

• Canale and Kelly view of the foot

• The foot is pronated to 15° and the xray tube is angled 75° to the tabletop
Talar Neck Fractures

- Hawkins’ Classification (same as in adults)
  - Type I: nondisplaced
  - Type II: displaced talar neck involving subtalar joint
  - Type III: displaced talar neck fractures involving ankle and subtalar joints
  - Type IV: displaced talar neck fractures involving ankle, subtalar and talonavicular joints

- <8, remodeling potential affords less than perfect reduction

- Outcome in patients <12 years old is favorable in most cases

# Treatment of Talar Neck Fractures

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Treatment</th>
<th>Blood Supply</th>
<th>ON Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Nondisplaced fracture through talar neck (&lt;5mm and 5 degrees).</td>
<td>6-8 weeks in cast, 4 weeks in CAM Walker.</td>
<td>Theoretical damage to only one vessel entering talar neck.</td>
<td>0–10</td>
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<tr>
<td>Type II</td>
<td>Displaced fracture with subtalar joint involvement.</td>
<td>Immediate closed reduction. A near anatomic reduction delays surgical treatment. If displaced K wires can be used to hold.</td>
<td>Two of three blood supply vessels lost: Neck vessel and one entering the tarsal canal.</td>
<td>20–50</td>
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<tr>
<td>Type III</td>
<td>Same as type II but with subluxation/dislocation of both the ankle and subtalar joint.</td>
<td>Direct to operating room for combined approach fixation w/ K wires vs Screws</td>
<td>All three sources of blood affected.</td>
<td>80–100</td>
</tr>
<tr>
<td>Type IV</td>
<td>Very Rare. Type III with talonavicular joint displacement.</td>
<td>Same</td>
<td>Not related to blood supply.</td>
<td>100</td>
</tr>
</tbody>
</table>
Adolescent with a displaced talar neck fracture with associated medial malleolar fracture
Talar AVN

Hawkins 3

CRC

AVN at 10m f/u
Hawkins Sign (A Good Sign)

• Resportion of subchondral bone at talar dome

• Indicates adequate vascularity

• May not be visualized in children
  • Mostly cartilaginous talus

• MRI or bone scan may be needed to evaluate for AVN
Osteochondral Talus Injuries

• Inversion/plantar flexion injury
  • Posteromedial lesion (more common)

• Eversion/dorsiflexion injury
  • Anterolateral lesion

• Consider if pain and swelling persist following ankle injury over 2 months

• MRI/MRI Arthrogram

• Lateral lesions are more often associated with trauma and more symptomatic than medial lesions
Osteochondral Talus Injuries

• Berndt and Harty Classification
  • Stage I lesions: nondisplaced
  • Stage II lesions: partially detached
  • Stage III lesions: detached but not displaced
  • Stage IV lesions: detached and displaced or rotated

Short Leg Cast/Walking boot (Weeks 1-6)

ROM and activity modification (Weeks 7-12)

If fail conservative treatment

• Drilling lesion (antegrade or retrograde)
• Curettage and Microfractures
• Internal Fixation w/ bioabsorbable implant
• Bone Graft and internal fixation

Talar Dome OCD Lesion, treated with arthroscopy and microfracture

Images Courtesy of: Dr. Adam Bitterman D.O.
Lateral Process of Talar Body Fractures

• “Snowboarders Fracture”
  • 13% of snowboarding foot/ankle injuries
• Initially missed in 40-50% of patients, mistaken for sprained ankle
  • Best viewed on ankle mortise film
• MOI: Dorsiflexion, Internal Rotation
  • Produces pain over ATFL

Lateral Process of Talar Body Fractures

Treatment

• Nondisplaced fractures → 6-8 weeks of NWB in a SLC
• Displaced fractures may require ORIF
  • ORIF if joint surface step-off > 2-3mm
    • Cannulated or mini frag screw(s) from lateral to medial
    • Mini frag plates for comminuted or large fragments
• Nonunion has been reported when untreated

Calcaneal Fractures

• Rare
  • 0.005% of fractures before 15 yo

• MOI: Falls

• Extra-articular fractures are more frequent
  • Approximately 65%

• Associated soft tissue or skeletal injuries present in 50%
  • Lacerations/open fractures in lawn mower injuries
  • Less common (5.4%) incidence of spinal fractures than in adults

Calcaneal Fractures

• Can be nondisplaced and missed in young children

• Stress fractures:
  • Toddlers beginning to walk
  • Patients with cerebral spasticity

• Pain appreciated with squeezing the heel

Classification

- Sanders Classification appropriate to use for adolescents

- CT-based classification of intra-articular fractures of the calcaneus

Imaging

- PA, Lateral, Axial Views
  - Bohler’s Angle (B)
    - Normal 20-30 degrees
  - Crucial Angle of Gissane (A)
    - Normal: 95-105 degrees
- Child's calcaneus does not resemble that of an adult until after 10 yo
- CT to evaluate intraarticular extension
- MRI

Anatomic angles for evaluation of fracture displacement and surgical reduction.
Treatment

• Extra-articular fractures can be treated with Cast for 6 weeks

• Tongue type fractures can be treated nonoperatively if posterior gap <1cm and not tenting the skin
  • Essex-Lopresti reduction if displaced

• Intraarticular fractures with displacement and joint depression
  • ORIF when soft tissues amenable

Axial “Harris” View of Calcaneus Fracture

• Demonstrates presence of heel varus displacement
• Sustentaculum tali is visualized
Complications

- Wound complications
  - Incidence lower in children than adults
- Complex Regional Pain Syndrome
- Peroneal Tendonitis/Dislocation

Lisfranc Injuries

- Direct/indirect mechanisms of injury
- Represent significant force
  - Fracture of base of 2nd MT → increased suspicion for Lis Franc injury
    - Associated cuboid fx → pathognomonic for TMT injury
Lisfranc Injuries: Clinical Signs

- Plantar ecchymosis
- Inability to bear weight
- TMT Compression test
- Abduction Pronation test

Crawford AH. Fractures about the foot in children: a radiographic analysis. The Children’s Hospital Medical Center: Cincinnati.

Lisfranc Injuries: Imaging

• Radiographs
  • AP, Lateral, Oblique
    • Weightbearing when subtle injury is suspected
    • Contralateral comparison views allow detection of subtle widening
  • Lateral border of 1st MT and medial cuneiform should line up
  • Medial border of 2nd MT and intermediate cuneiform should line up
  • Distance between base of 2nd MT and medial cuneiform should be **less than 2mm in children >6 years of age**

• CT/MRI can helpful in suspected cases with normal XR to identify ligamentous involvement
Lisfranc Injuries

• Treatment - requires anatomic reduction
  • Treat soft tissues first with elevation

• Non-displaced \(\rightarrow\) SLC x 4-6 weeks

• Displaced
  • Closed reduction ± pinning can be useful in young children
  • ORIF with screws in older children/adolescents
  • Suture button fixation can be used for ligamentous injuries
  • Keystone is base of 2\textsuperscript{nd} MT to medial cuneiform

• Compartment syndrome can occur

Rockwood and Green's Fractures in Adults, 9e, 2019
Lis Franc Injuries: Case Example

- Injury
- Contralateral (normal)
- Suture button fixation—internal ligament brace
Metatarsal Fractures

- Account for 60-70% of pediatric foot fractures
- 1\textsuperscript{st} metatarsal most common (<5yo)
  - Physis located on proximal end
  - “Bunk bed injury”
- 5\textsuperscript{th} metatarsal most common (>10yo)
- 2\textsuperscript{nd} metatarsal prone to stress fractures from repetitive trauma (2\textsuperscript{nd} decade)
  - “March Fractures”
Metatarsal Fractures

• MOI: Direct trauma, torsional stress, sports
  • <5 years old most commonly associated with a fall from height
    • “Bunkbed injury” with base of 1st metatarsal buckle fracture
  • >5 years old most likely results from sporting injury
• Metatarsal base fractures produce concern for Lis Franc disruption

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Treatment

• Closed Reduction:
  • Completely displaced fracture
  • >20 degrees angulation
  • Significant dorsal/plantar angulation is not well tolerated
  • Below knee walking cast x 3-6 weeks

• CRPP
  • Unstable reductions

Treatment

• Surgical Treatment
  • Retrograde pinning → 1-2 K-wires in distal fragment exiting plantar skin
  • IM pinning
  • ORIF
  • Short Leg Non weight bearing cast, remove pins at 4-6 weeks

• Absolute indications
  • Open fracture, associated compartment syndrome, nonunion, or displaced articular fracture

• Relative
  • Adolescents
  • Multiple metatarsal fractures
  • Significant (75% shaft width) translation

• 15% delayed union rate

Adolescent female with multiple metatarsal fractures and proximal phalanx fracture of the hallux
5th Metatarsal Fractures

• Types of fractures:
  1. Apophyseal avulsions (involving either part or all of the variably ossified apophysis)
  2. Apophyseal stress fractures (Iselin disease)
  3. Tuberosity avulsion fractures
  4. Jones-type fractures through the metaphyseal-diaphyseal water-shaded area (typically a transverse fracture extending into the common articular facet of the fourth and fifth metatarsals)
  5. Acute diaphyseal fractures
  6. Stress fractures of the diaphysis

Mencio, Gregory A, Marc F. Swiontkowski, and Neil E. Green. Green’s Skeletal Trauma in Children
5th Metatarsal Base Fractures

- Most common pediatric metatarsal fracture
  - 50% of all metatarsal fractures

- Apophysis is often misdiagnosed as a fracture
  - Os vesalianum appears by age 9 years
    - Unites with the metaphysis between ages 12 and 15 years

- Apophysis runs parallel to metatarsal
  - Fractures are perpendicular

Fracture ➔ thin arrow
Apophysis ➔ thick arrow

Rockwood and Wilkins’ Fractures in Children, 9e, 2019
5th Metatarsal Base Fractures

- **Zone I**
  - Most commonly an avulsion injury
  - Protected weightbearing for 4-6 weeks
  - Radiographic healing lags behind clinical healing

- **Zone II**
  - Jones type fractures
  - Most commonly in adolescents
  - Acute injuries do well with non-operative treatment
  - Chronic injuries often require IM screw fixation

- **Zone III**
  - Typically stress fractures
  - Require prolonged immobilization
  - Occasionally require IM screw fixation + bone grafting

Images Courtesy of: Dr. Adam Bitterman D.O.
Pediatric Phalangeal Fractures

• 18% of children’s foot fractures
  • Proximal Phalanx > Middle Phalanx > Distal Phalanx

• MOI: Direct trauma, barefoot stubbing

• Look for a break in the skin
  • Base of nail avulsion with distal phalanx fractures → open fracture

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Pediatric Phalangeal Fractures

• **Treatment**
  • Traction, closed reduction, buddy taping, hard sole shoe

• **Open injuries require I&D/IV antibiotic**
  • Pin if reduction is unstable
  • Meticulous nailbed repair if disrupted

• **Intra-articular fractures**
  • Anatomic reduction and pinning
  • Indications:
    • >30% of articular surface involved
    • Displacement >2mm

Proximal Phalanx SHIII Fracture 11 yo F

Loss of reduction 1 weeks into conservative management
Barefoot Stubbing Injuries to the Great Toe in Children

• High prevalence of hallux injuries from barefoot sports and activities in children

• Open injuries at risk for osteomyelitis

• HAbd-F, HF, HE, and HE-Add are associated with great outcomes

• The HAbd-E group showed the worst prognosis

• Conclusions:
  • Lateral condyle avulsion fractures of the proximal phalanx should be regarded as a high-risk sign for nonunion
  • Propose aggressive approach for this group
  • Minimally displaced fragments may benefit from open reduction and pinning.

A. Type I (HAbd-F) injury, showing reduction of an open proximal interphalangeal dislocation.
B. Type I (HAbd-F) injury, showing typical dorsolateral wound of an open interphalangeal dislocation.
C. Type II (HF) injury showing mallet toe-like Salter-Harris type I distal phalanx fracture.
D. Type II (HF) injury showing an open wound on the eponychium.
E. Type III (HAbd-E) injury showing avulsion fracture of the lateral volar condyle of the proximal phalanx.
F. Type IV (HE) injury showing dorsal interphalangeal dislocation.
G. Type V (HE-Add) injury showing medial proximal phalanx base fracture.

Summary

• Fractures of the Pediatric Foot are infrequently described in the literature

• The majority of these injuries can be managed conservatively with immobilization and follow up

• Fractures in adolescents are treated similar to adults

• Operative indications should be kept in mind as complications can occur
References


Crawford AH. Fractures about the foot in children. A radiographic analysis. Cincinnati Children’s Hospital, Cincinnati, OH.


References


References


