Pediatric Ankle Fractures

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Pediatric Ankle Fractures

The Ankle is the 2nd most Common Site of Physeal Injury in Children

10-25% of all Physeal Injuries Occur About the Ankle
Pediatric Ankle Fractures

Primary Concerns Are:

• Anatomic Restoration of Articular Surface

• Restoration of Symmetric Ankle Mortise
  • Preservation of Physeal Growth
  • Minimize Iatrogenic Physeal Injury

• Avoid Fixation Across Physis in Younger Children
Salter Harris Classification

Prognosis and Treatment of Pediatric Ankle Fractures is Often Dictated by the Salter Harris Classification of Physeal Fractures

Type I and II Fractures: Often Amenable to Closed Tx / Lower Risk of Physeal Arrest

Type III and IV: More Likely to Require Operative Tx / Higher Risk of Physeal Arrest

ISOLATED DISTAL FIBULA FRACTURES
Distal Fibula Fractures

- The Physis is Weaker than the Lateral Ankle Ligaments
  - Children Often Fracture the Distal Fibula but….
  - …ligamentous Injuries are Not Uncommon

- Mechanism of Injury = Inversion of a Supinated Foot

- SH I and II Fractures are Most Common
  - SH I Fractures: Average Age = 10 Years
  - SH II Fractures: Average Age = 12 Years
Distal Fibula Fractures

Mild Lateral Swelling

Lateral Ankle Tenderness

Normal Radiographs

SH I Distal Fibula Fracture vs. Lateral Ligamentous Injury (Sprain)
Distal Fibula Fractures

• Sankar et al (JPO 2008)
  – 37 Children
  – All with Open Physes, Lateral Ankle Tenderness + Normal Films
  – 18%: Periosteal Bone Formation at 3 Weeks

• Boutis et al (JAMA Pediatr 2016)
  – 140 Children with Ankle Injuries - Prospectively Enrolled
  – All With Normal Films
  – 135 Underwent Ankle MRI
  – 3%: Salter Harris I Distal Fibula Fractures
  – 80%: Isolated Ligamentous Injuries
Non-Displaced Distal Fibula Fractures: Treatment

• Removable Walking Boot vs Short Leg Cast (4 Weeks)
• Weight Bearing as Pain Permits

• Boutis et al (Pediatrics 2007):
  – Randomized Single Blind Study
  – Short Leg Walking Cast versus Removable Brace
  – Brace Group:
    • Quicker Return to Baseline Activities
    • More Cost Effective
Displaced SH I and SH II Distal Fibula Fractures: Treatment

• Successful Closed Reduction
  – Short Leg Cast X 6 Weeks
  – Non-Weightbearing

• Failed Closed Reduction ➔ Open Reduction
  – Percutaneous Pin Fixation (>2 Years Growth Remaining)
  – Internal Fixation (>2 Yeats Growth Remaining)

• SH I and SH II Fractures Are Often Associated with Distal Tibia Fractures. Treatment is Dictated by Displacement, Ankle Mortise Symmetry and Nature of the Tibia FX
DISTAL TIBIA FRACTURES
SH II Distal Tibia Fractures

- Most Common Distal Tibial Physeal Injury
- 40% of All Pediatric Ankle Fractures
- Associated Fibula Shaft Fracture Present in 20%
- Average Age at Injury = 12.5 Years
Periosteum Can Become Entrapped Anteriorly

Size of Posterior Metaphyseal Fragment Varies
SH II Distal Tibia Fractures: Treatment

- Most Can Be Managed with Reduction and Casting

- Reduction:
  - ER or OR Conscious Sedation is Mandatory
  - Flex Knee and Plantar-Flex Ankle to Relax Gastrocsoleus
  - Apply Axial Traction Manipulation Opposite of Deforming Force

- Cast:
  - Long Leg Cast
  - Knee Flexed 30-90 Degrees
  - Inversion or Eversion of the Foot Dictated by Initial Direction of Displacement
SH II Distal Tibia Fractures: Treatment

Axial Traction -> Reverse Deforming Force -> Position Foot to Maintain Alignment

SH II Distal Tibia Fractures: Treatment

Anterior Physeal Gapping > 3 mm s/p Reduction May Indicate Entrapped Periostium and be Predictive of Early Physeal Arrest

SH II Distal Tibia Fracture: Case Example

10 yo Male: Fell During Soccer
SH II Distal Tibia Fracture: Case Example

Emergency Room Reduction and Long Leg Cast
SH II Distal Tibia Fracture: Case Example

3 Months Following Treatment with Osseous Union and Anatomic Alignment
MEDIAL MALLEOLUS FRACTURES
Medial Malleolus Fractures

- 20% of All Distal Tibial and Fibula Fractures in Kids
- Average Age at Injury = 11 to 12 Years
- SH III Fractures are Most Common
- SH IV and V (Physeal Crush Injuries) Occur as Well
- Associated Distal Fibula Fracture in 25%
Medial Malleolus Fracture

Salter Harris III

Salter Harris IV

Medial Malleolus Fractures: Concerns

- Risk for Nonunion Due to Intra-articular Nature of Fracture
- Risk for Delayed Union and Late Displacement
- Rate of Physeal Arrest May be > than the Literature Suggests

Abbott et al (POSNA 2015)
  - 42 Pediatric Medial Malleolus Fractures with > 3 Months Follow-Up
  - 52% Developed a Physeal Bar
  - 27% of These were Diagnosed > 6 Months from Injury
  - SH Classification and Amount of Displacement not Predictive of Bar
  - Adequacy of Reduction = Only Predictive Factor of Bar Formation

TAKEHOME = Low Threshold to TX Operatively and Vigilant FU for Physeal Arrest
Medial Malleolus Fracture

5 yo Female: All Epiphyseal Fixation of Displaced SH IV Medial Malleolus Fracture
Medial Malleolus Fracture

12 Months s/p ORIF
Medial Malleolus Fracture

Mild Ankle Varus Deformity

Probable Physeal Bar

12 Months s/p ORIF
Medial Malleolus Fracture

Standing Films: Confirm Varus Deformity
Medial Malleolus Fracture

CT Scan: Confirms Physeal Bar
Medial Malleolus Fracture

Status Post Physeal Bar Resection
Medial Malleolus Fractures: Treatment

- **Nondisplaced:**
  - Short Leg Cast
  - Non-Weightbearing
  - Close Follow-Up

- **Displaced:**
  - Open Reduction
  - Anatomic Restoration of Physis and Joint Line
  - Screw, K-Wire or Hybrid Fixation
  - Avoid Screws Across Open Physis Unless Absolutely Necessary
Medial Malleolus Fracture: Case Example

12 yo Female: Twisted Ankle During Soccer Match
Medial Malleolus Fracture: Case Example

12 yo Female: Twisted Ankle During Soccer Match

SH I Distal Fibula FX

SH IV Med Malleolus FX
Medial Malleolus Fracture: Case Example

Intra-Op Varus Stress Shows Gross Instability of Fibula FX
Medial Malleolus Fracture: Case Example

Hybrid Fixation Med Mall
Screw Fixation Fibula

Med Mall Fixed with 3.5 mm Cannulated Screws/Washers and K-Wire
Medial Malleolus Fracture: Case Example

3 Month FU Showing Osseous Union (Wire Was Removed in Clinic at 6 Weeks)
Medial Malleolus Fracture: Case Example

3 yo Female: Backseat Unrestrained Passenger in MVC
Medial Malleolus Fracture: Case Example

3 yo Female: Backseat Unrestrained Passenger in MVC
Medial Malleolus Fracture: Case Example

Open Reduction and Percutaneous All-Epiphysseal .062 K-Wire Fixation
Medial Malleolus Fracture: Case Example

Osseous Union 6 Weeks Following Surgery – Pins Removed
Medial Malleolus Fracture: Case Example

Harris Arrest Line Parallel to Physis

2 Year Follow-Up Showing Normal Physeal Growth
TRANSITIONAL ANKLE FRACTURES

Common Intra-articular Ankle fractures Typically occurring in Adolescents as a result of Asymmetric closure of the distal tibial physis
Asymmetric Distal Tibial Physeal Closure

Central Physis Closes First
Medial Closure Follows
Lateral Physis Closes Last

An Open Lateral Physis in the Presence of Closure Elsewhere Represents a Weak Point that is Vulnerable to Rotational Force
Tillaux Fracture

• Avulsion Injury of the Anterolateral Epiphysis

• Mechanism of Injury = External Rotation

• The Anterior-Inferior Tibiofibular Ligament is Stronger than the Lateral Physis and Avulses the Anterolateral Epiphysis Creating a Salter Harris III Fracture
Tillaux Fracture
Tillaux Fracture

Tillaux Fracture

- Medial Closure: 13-14 yrs
- Lateral Closure 14.5-16 yrs
- Mechanism: Ext Rotation
- XR: SH III Fracture
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- XR: SH III Fracture
Tillaux Fracture: Treatment

Non-displaced (<1-2 mm): Cast and Close Follow-Up

Displaced:

- **Closed Reduction:**
  - Internal Rotation
  - Long Leg Cast
  - CT Scan to assess reduction

- **ORIF:** Failed Closed Reduction / Delayed Presentation

*Lemburg et al. Arch Orthop Trauma Surg 2010*
Tillaux Fracture: ORIF

Tillaux Fracture: ORIF

• Exposure: Anterior Approach

• Reduction
  – Mobilize Fragment
  – Reduce Articular Surface Anatomically
  – Reduction Clamps or Dental Pick to Hold Reduction

• Fixation
  – 3.5 mm or 4.0 mm Partially Threaded Cannulated Screw + Washer
  – Screw Placed Lateral to Medial - Separate Percutaneous Incision
  – May Cross Physis Due to Eminent Closure
  – Screw Must Not Violate Joint
Tillaux Fracture: ORIF

Tillaux Fracture: Case Example

14 yo Female: Ankle Pain After a Twisting Injury
Tillaux Fracture: Case Example

14 yo Female: Ankle Pain After a Twisting Injury
Tillaux Fracture: Case Example

CT Scan Following Attempted Closed Reduction Shows Significant Displacement
Tillaux Fracture: Case Example

CT Scan Following Attempted Closed Reduction Shows Significant Displacement
Triplane Fracture

- 6-8% of Pediatric Distal Tibia Fractures

- Mechanism of Injury = External Rotation w/ Supinated Foot

- Average Age at Injury is 1 to 1.5 Years Younger than Children with Tillaux Fractures

- Fracture Lines Occur in the Transverse, Coronal and Sagittal Planes
Triplane Fracture

- **Avg. Age:** 13.5 years
  - Girls: 12-14 yrs
  - Boys: 13-15 yrs

- **Mechanism:**
  - Twisting Injury
  - Eversion

- **Radiographs**
  - AP: SH III
  - Lateral: SH II or IV
  - Fibula Fx ≈ 50%

Triplane Fracture

Two Part, Three Part (Separate Tillaux Fragment) and Four Part (Separate Medial Malleolus and Tillaux Fragments) Can Occur

Intramalleolar Triplane Variant

Extra-articular Epiphyseal Fractures Are Often Amenable to Non-Op Treatment
CT Scan Useful POST-REDUCTION if Fractures Appear Amenable to Non-op Treatment on Post-Reduction Radiographs
Treatment

Non-displaced / Extra-articular Fractures: Long Leg Cast

Displaced (>2mm):

- Closed Reduction:
  - Anterolateral Fragment: Internal Rotation
  - Anteromedial Fragment: External Rotation
  - Long Leg Cast
  - CT Scan to Assess Reduction if it Appears Well Aligned on Plain Films

- ORIF: Failed Closed Reduction / Wide Displacement

- Ertl (JBJS 1988)
  - No successful closed reductions if displaced > 3mm at presentation
  - This had not been verified with follow-up studies
  - Many recommend attempted reduction despite amt. of initial displacement
Triplane Fracture: ORIF

• Exposure: Anterior Approach

• SH II Component Reduction
  – Usually Amenable to Manipulative Reduction
  – Posterolateral Approach and Clamp Reduction if Closed Means Fail (Rare)

• SH III Component Reduction
  – Mobilize Fragment
  – Reduce Articular Surface Anatomically
  – Reduction Clamps or Dental Pick to Hold Reduction

• Fixation
  – 3.5 mm or 4.0 mm Partially Threaded Cannulated Epiphyseal Screw + Washer
  – Direction of Screw Based on Epiphyseal FX Location - Percutaneous Incision
  – Do Not Cross Physis in Younger Children
  – Screw Must Not Violate Joint
  – Second Anterior to Posterior Screw if Needed to Maintain SH II Reduction
Open Treatment

• 2 Part / Minimally Displaced SH II Component
Open Treatment

- 2 Part / Minimally Displaced SH II Component
3 Part Fractures

Order of Treatment

1. Exposure and Displacement of Anterolateral Fragment
2. Reduction +/- Fixation of Posterior Metaphyseal Fragment
3. Reduction and Fixation of Fibula (if needed)
4. Reduction and Fixation of Anterolateral Fragment
Post-Operative Care

• Short Leg Cast: 6 Weeks
• Non-Weight Bearing: 6 Weeks
• Return to Activity: 3 months / Good Ankle ROM

• Chalton et al (*JPO 2005*): Screw Removal?
  – Cadaveric Study
  – Screw: Significant ↑peak contact pressure / total force
  – Screw Removal: Decreased force and peak pressure values

• Routine Screw Removal Remains Controversial
Triplane Fracture: Case Example

12 yo Female: Ankle Pain After a Twisting Injury
Triplane Fracture: Case Example

CT Scan Following Attempted Closed Reduction Shows 4mm Intra-articular Diastasis
Triplane Fracture: Case Example

ORIF with two 4.0 mm Partially Threaded Cannulated Screws
• For questions or comments, please contact the OTA Business Office at OTA@ota.org