

# Pediatric Ankle Fractures

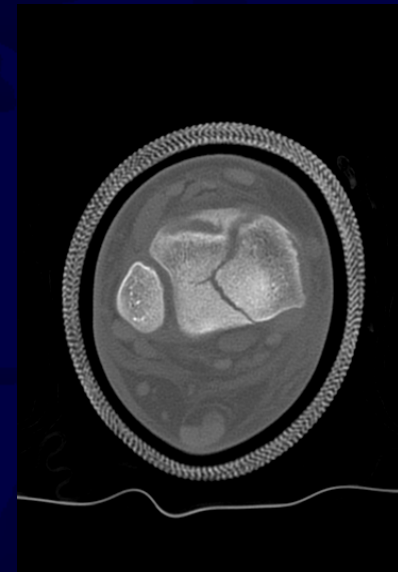
Anthony I. Riccio, MD

Texas Scottish Rite Hospital for Children

Update 07/2016

# Pediatric Ankle Fractures

The Ankle is the 2<sup>nd</sup> most Common Site of Physcal Injury in Children



10-25% of all Physcal Injuries Occur About the Ankle

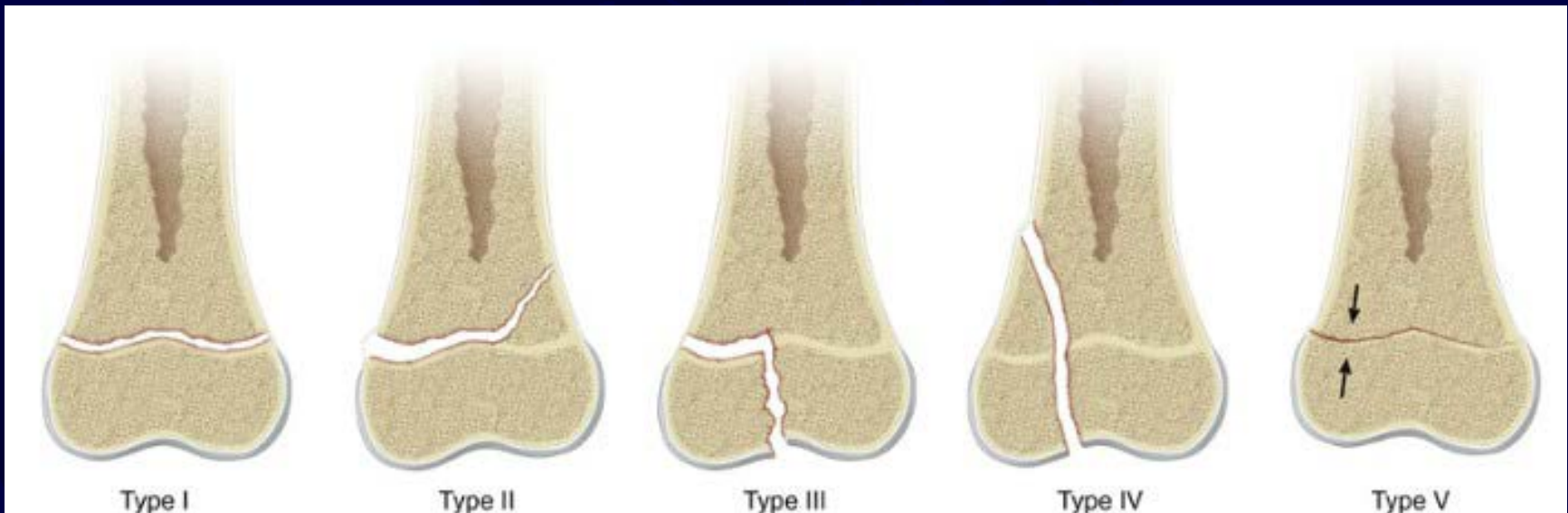
# Pediatric Ankle Fractures

## 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

Herring JA, ed. *Tachdjian's Pediatric Orthopaedics*, 5<sup>th</sup> Ed. 2014. Elsevier. Philadelphia, PA.

# 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 Years 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

# SH II Distal Tibia Fractures



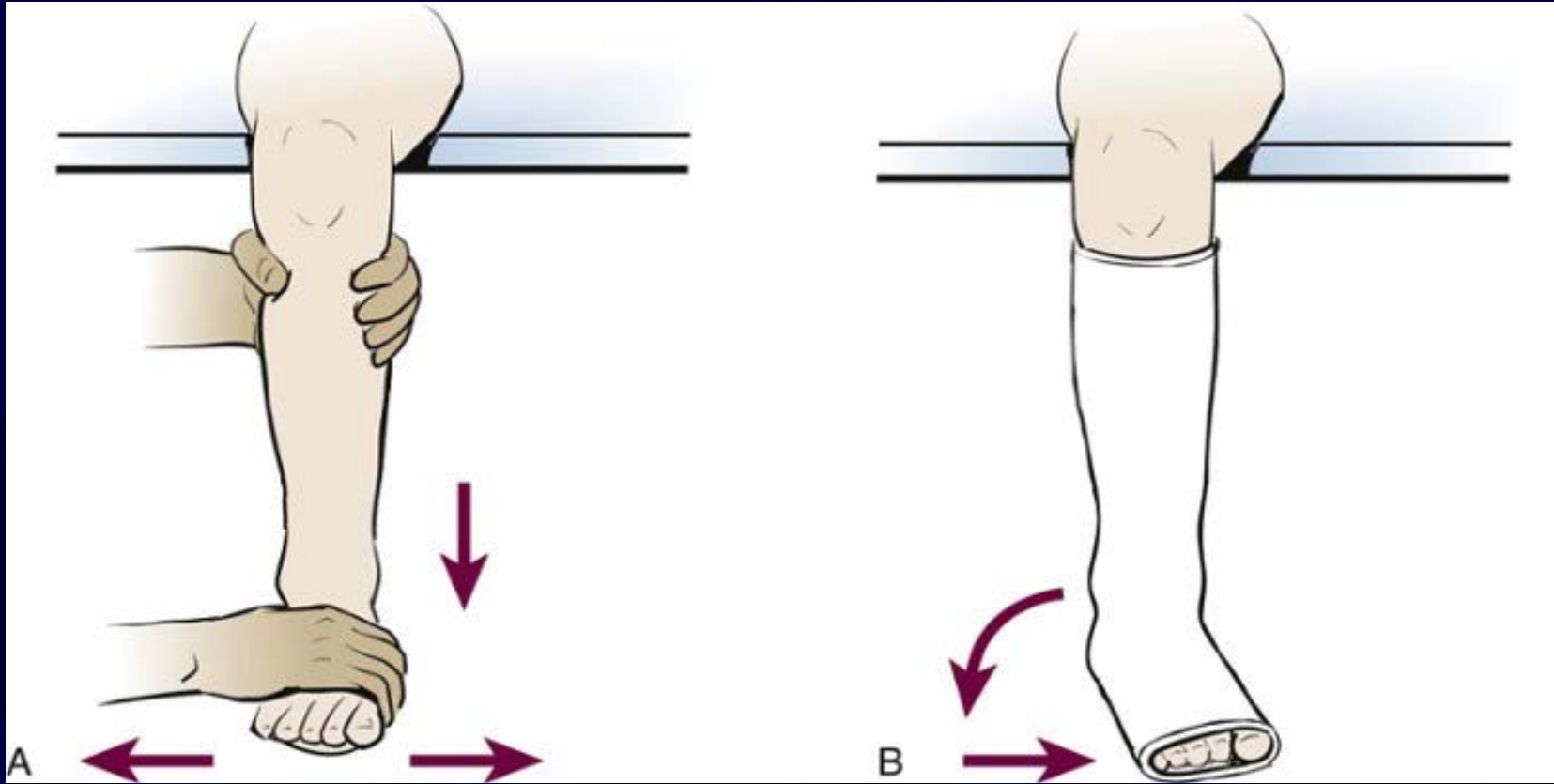
Periosteum Can  
Become Entrapped  
Anteriorly

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 Gastrocnemius
  - 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



Herring JA, ed. *Tachdjian's Pediatric Orthopaedics*, 5<sup>th</sup> Ed. 2014. Elsevier. Philadelphia, PA.

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

# SH II Distal Tibia Fractures: Treatment



Closed  
Reduction





# 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



Salter Harris

# 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



# Medial Malleolus Fracture



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

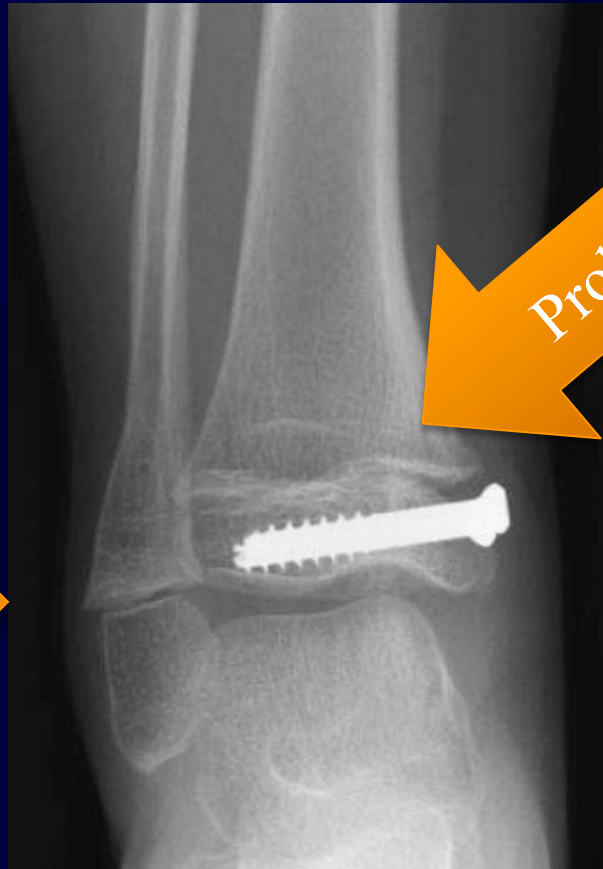
# Medial Malleolus Fracture



12 Months s/p ORIF

# Medial Malleolus Fracture

Probable Physeal Bar



Mild Ankle  
Varus Deformity

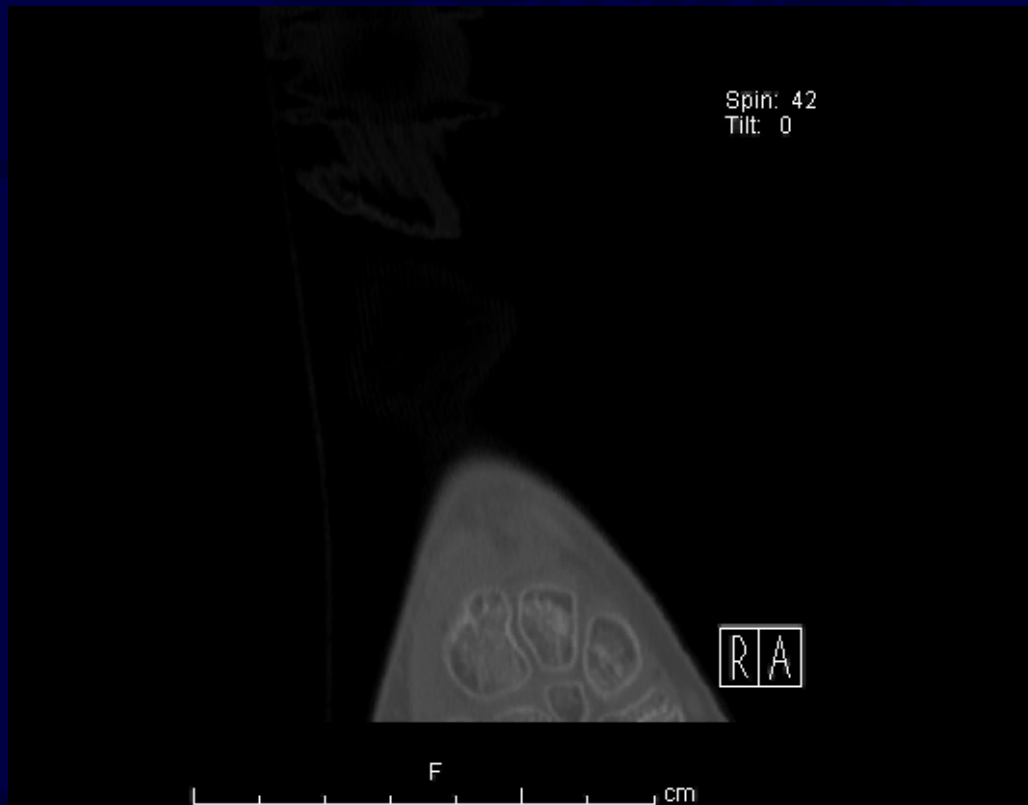
12 Months s/p ORIF

# 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 Pysis and Joint Line
  - Screw, K-Wire or Hybrid Fixation
  - Avoid Screws Across Open Pysis Unless Absolutely Necessary

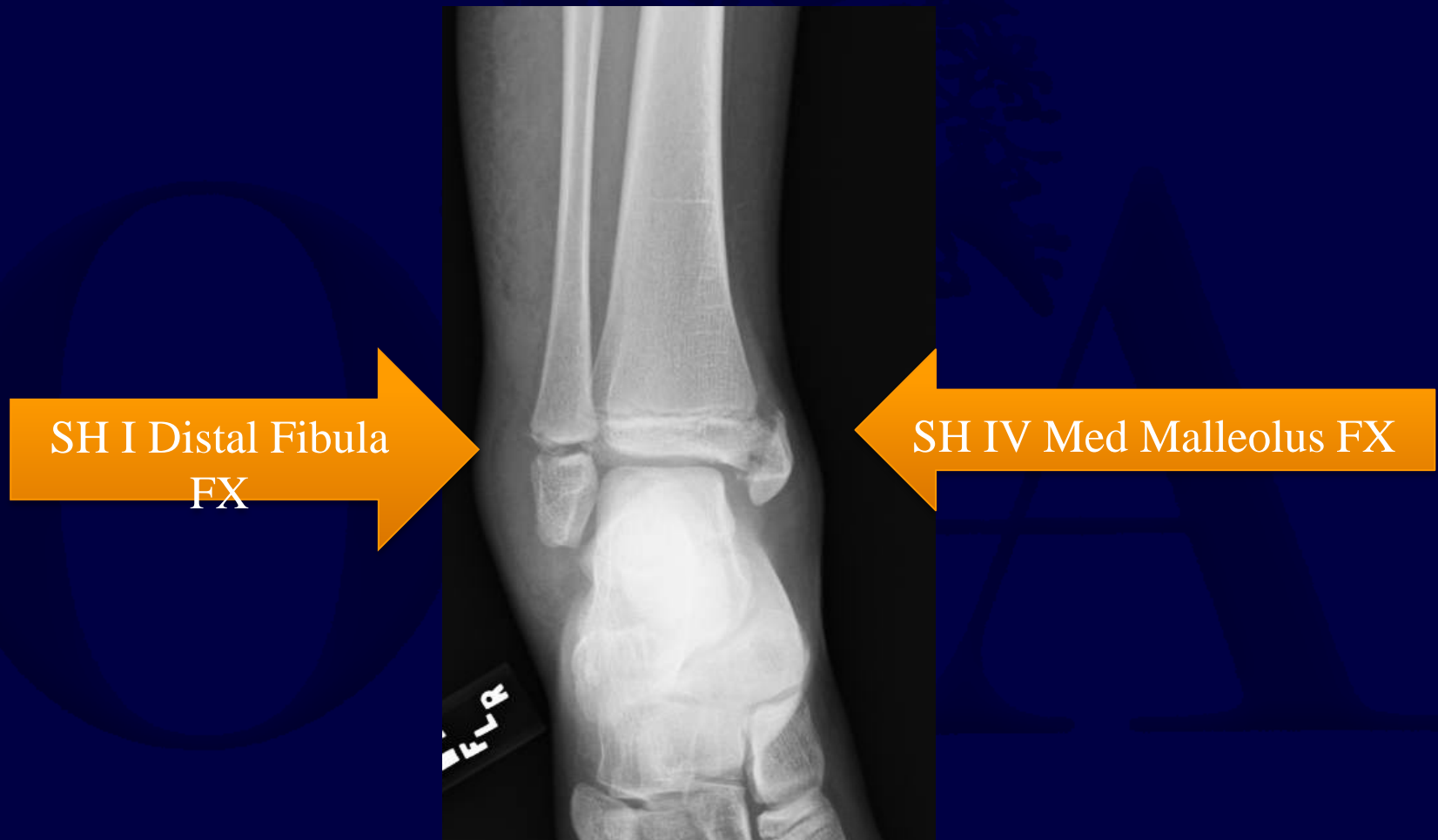
# Medial Malleolus Fracture: Case Example



12 yo Female: Twisted Ankle During Soccer Match



# Medial Malleolus Fracture: Case Example



12 yo Female: Twisted Ankle During Soccer Match

# 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



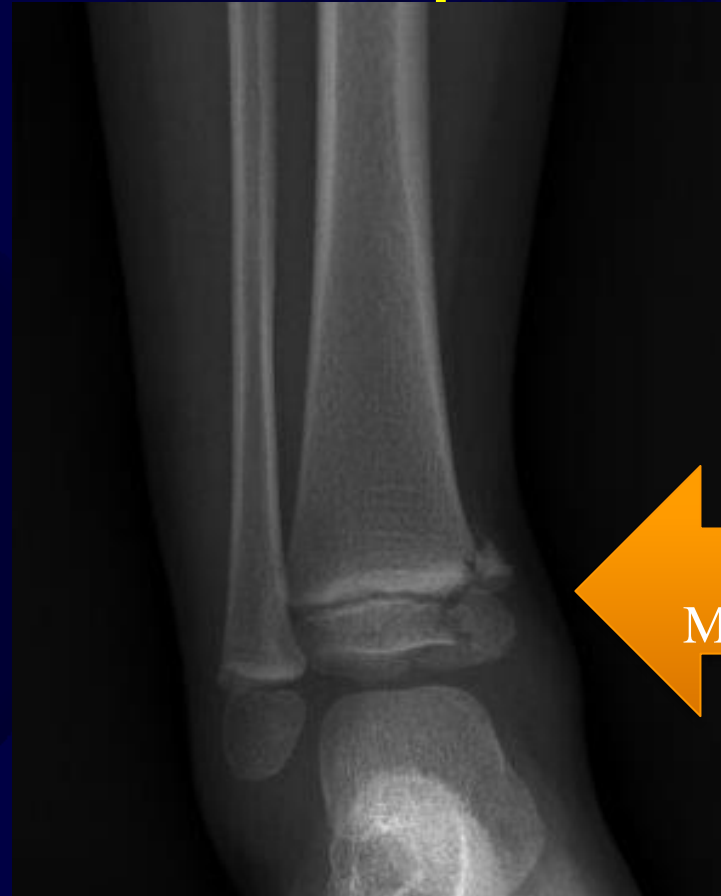
3 Month FU Showing Osseous Union (Wire Was Removed in Clinic at 6 Weeks)

# Medial Malleolus Fracture: Case Example



3 yo Female: Backseat Unrestrained Passenger in MVC

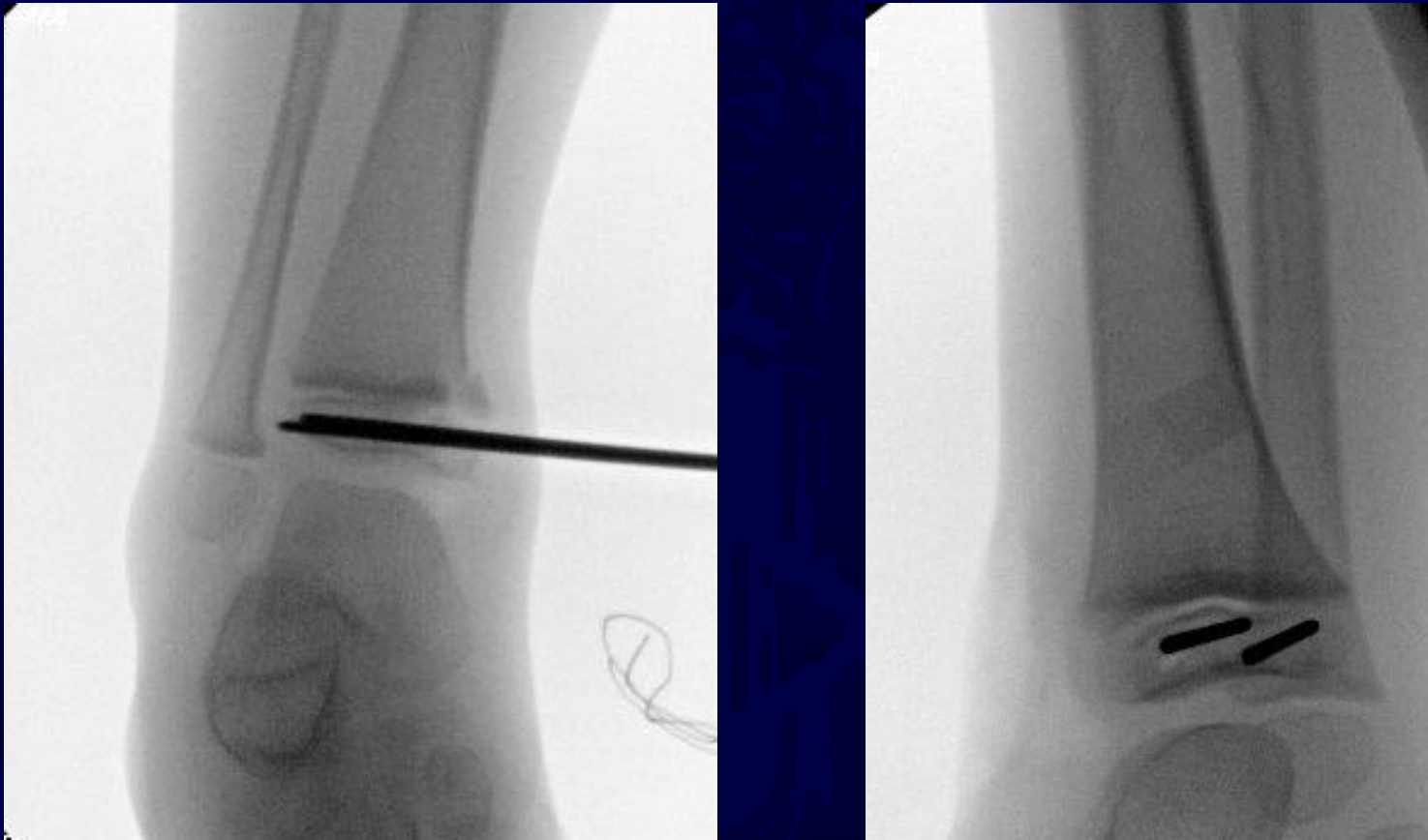
# Medial Malleolus Fracture: Case Example



SH IV Displaced  
Medial Malleolus FX

3 yo Female: Backseat Unrestrained Passenger in MVC

# Medial Malleolus Fracture: Case Example



Open Reduction and Percutaneous All-Epiphyseal .062 K-Wire Fixation

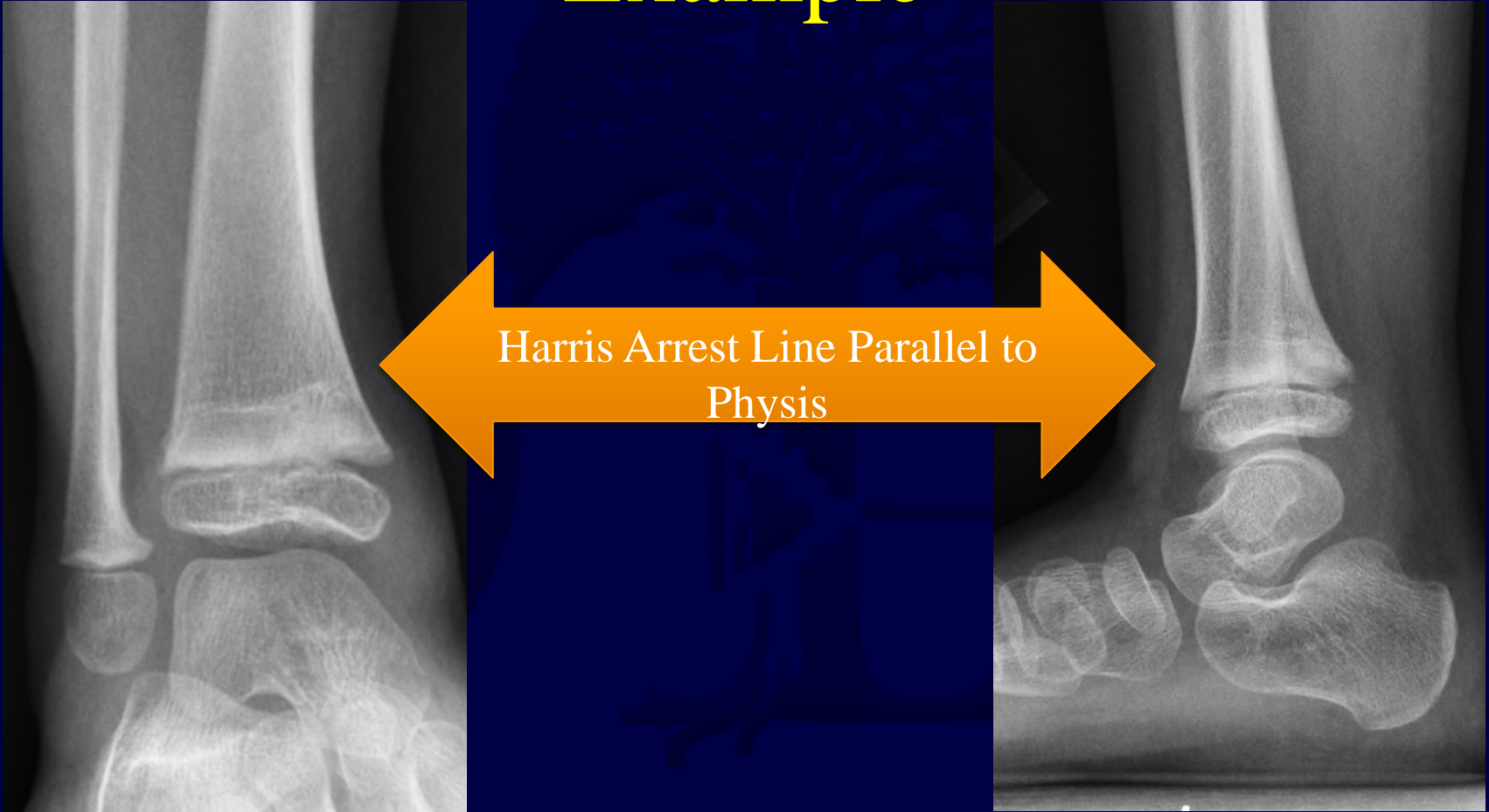
# Medial Malleolus Fracture: Case Example



Osseous Union 6 Weeks Following Surgery – Pins Removed



# Medial Malleolus Fracture: Case Example

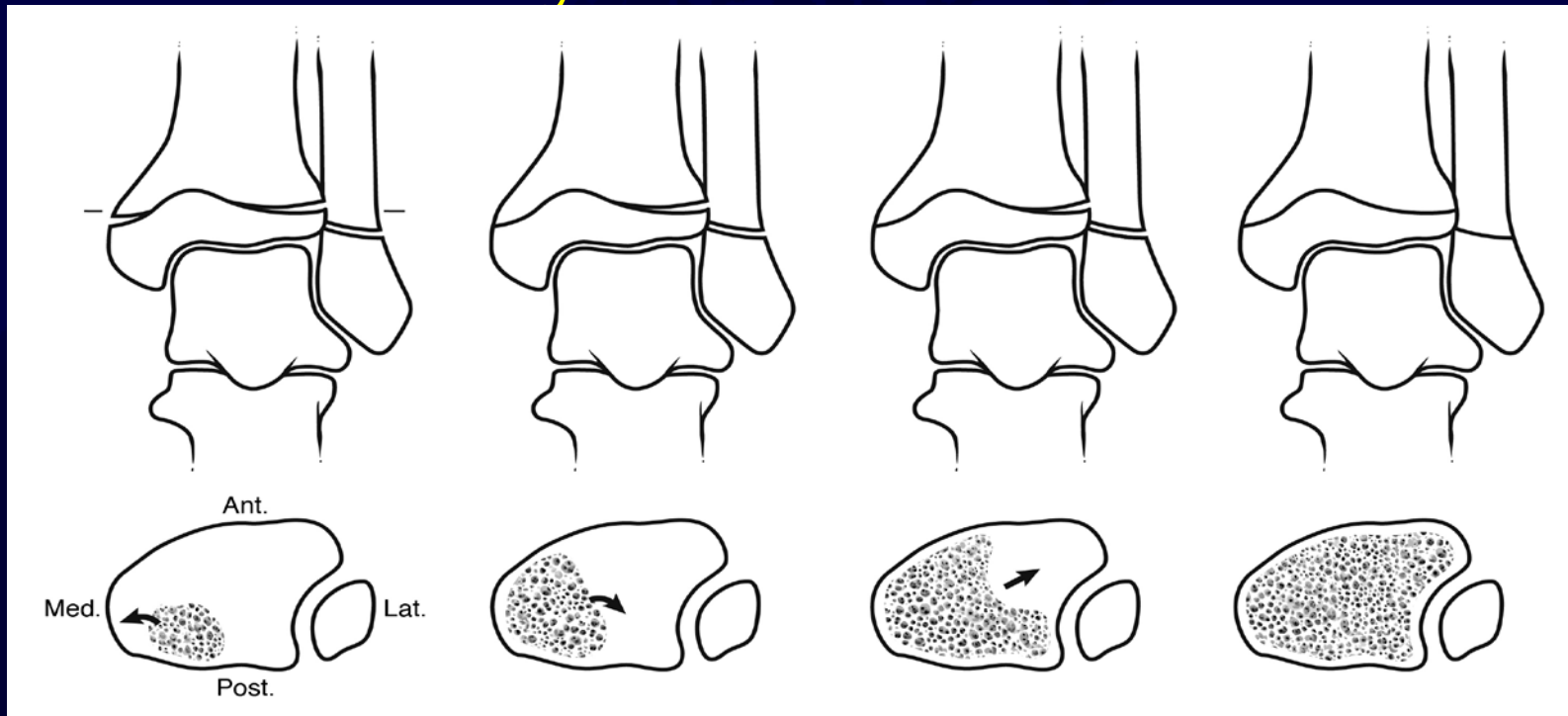


2 Year Follow-Up Showing Normal Physeal Growth

# 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

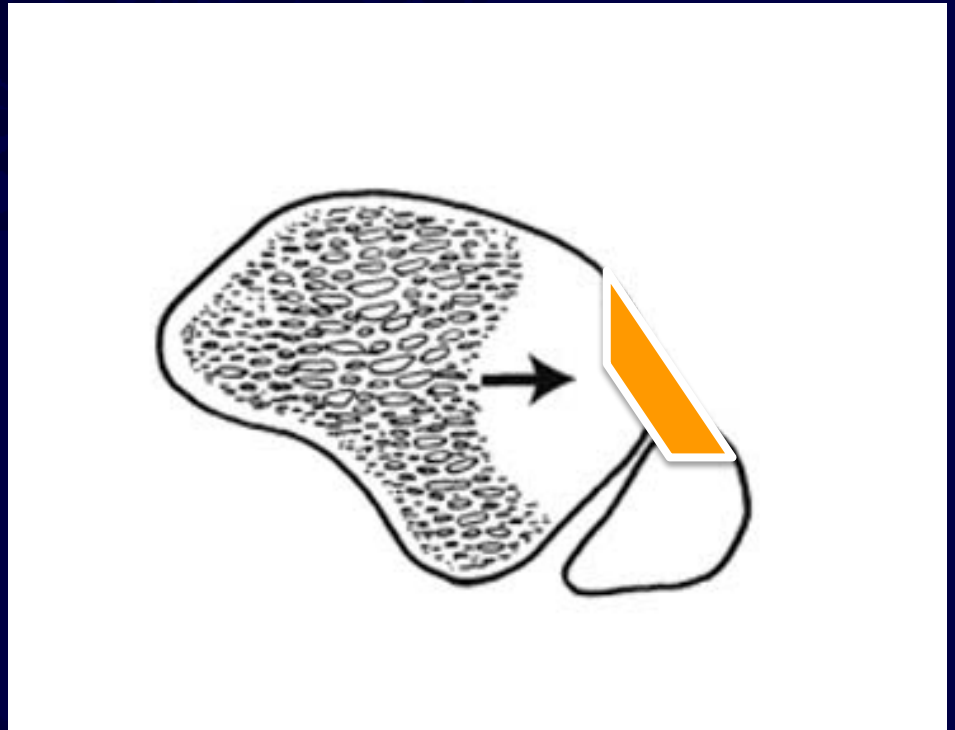
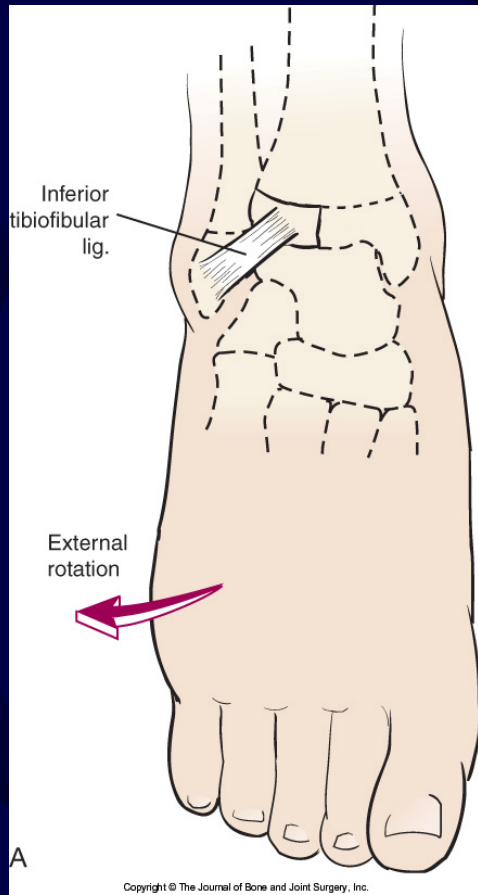
Last

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

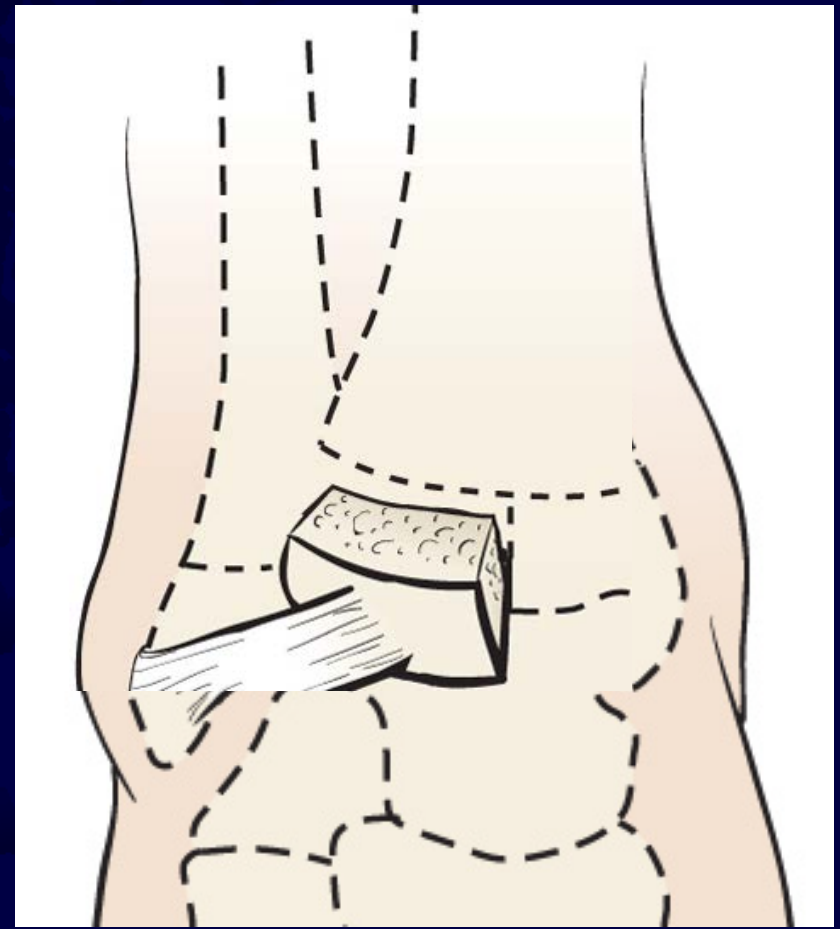
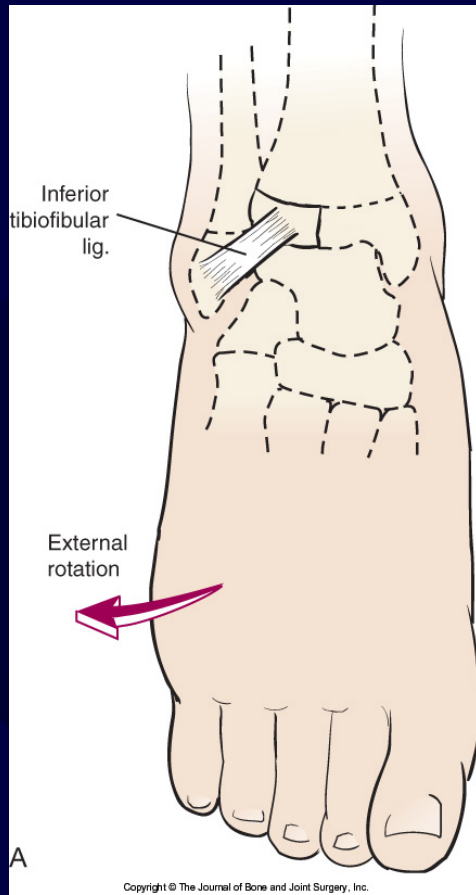
# Tillaux Fracture

- Avulsion Injury of the Anterolateral Epiphysis
- Mechanism of Injury = External Rotation
- The Anterior-Inferior Tibiofibular Ligament is Stronger than the Lateral Pysis 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



# Tillaux Fracture

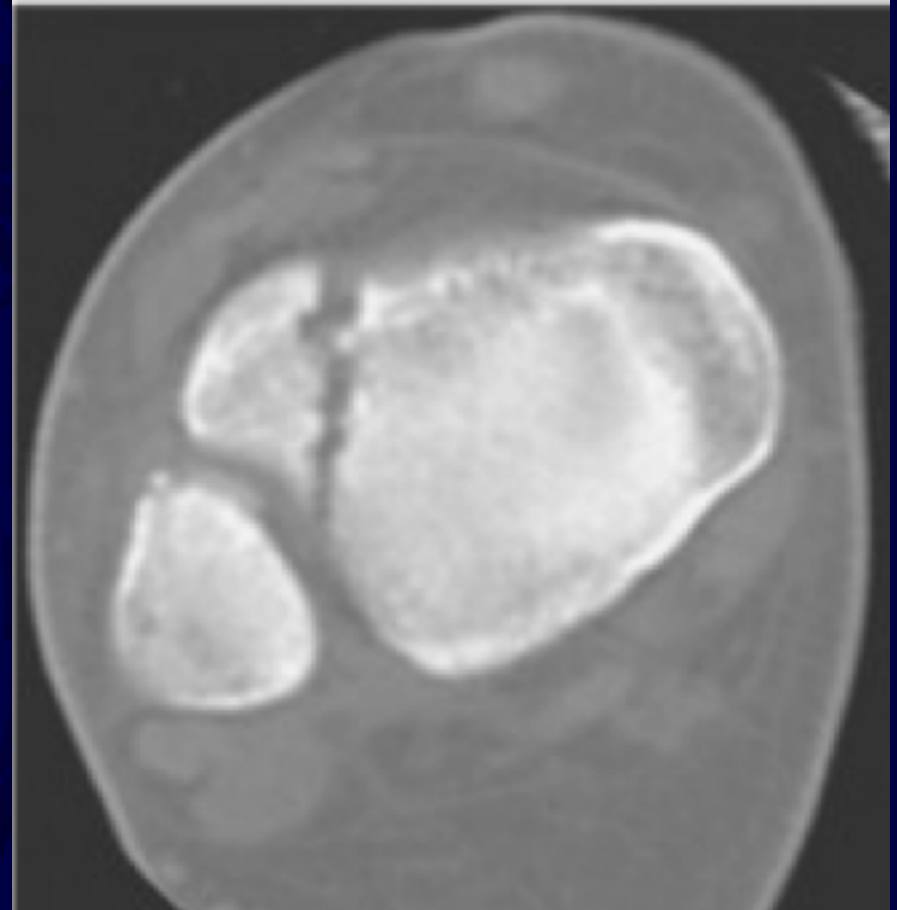
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# Tillaux Fracture

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



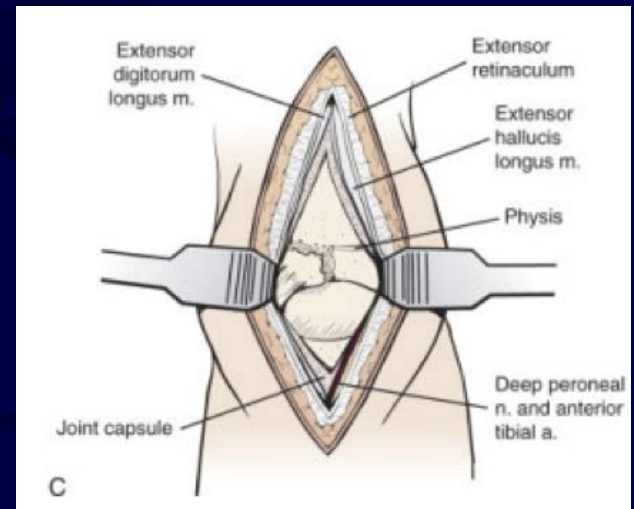
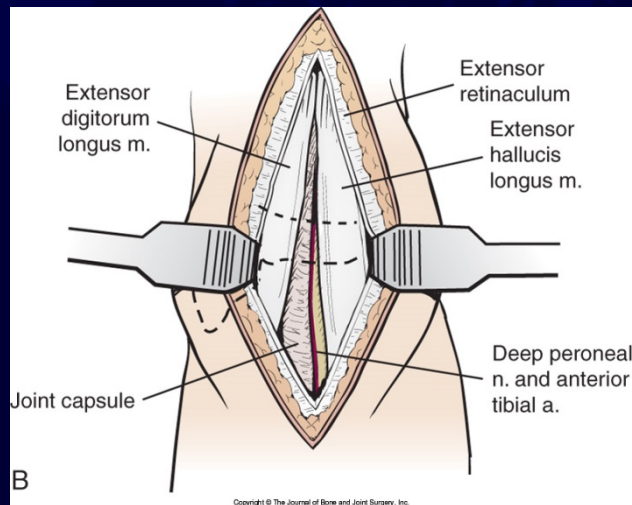
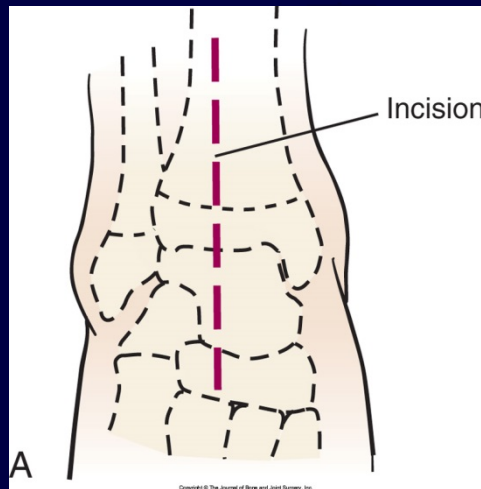
# Tillaux Fracture: Treatment

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

# 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 Pysis Due to Eminent Closure
  - Screw Must Not Violate Joint

# Tillaux Fracture: ORIF

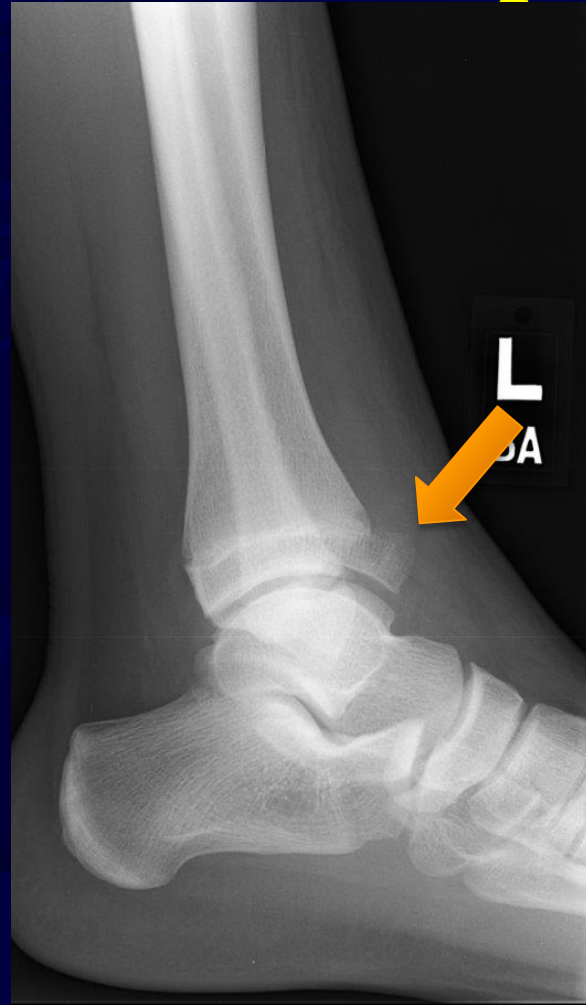


# Tillaux Fracture: Case Example



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  $\approx$  50%

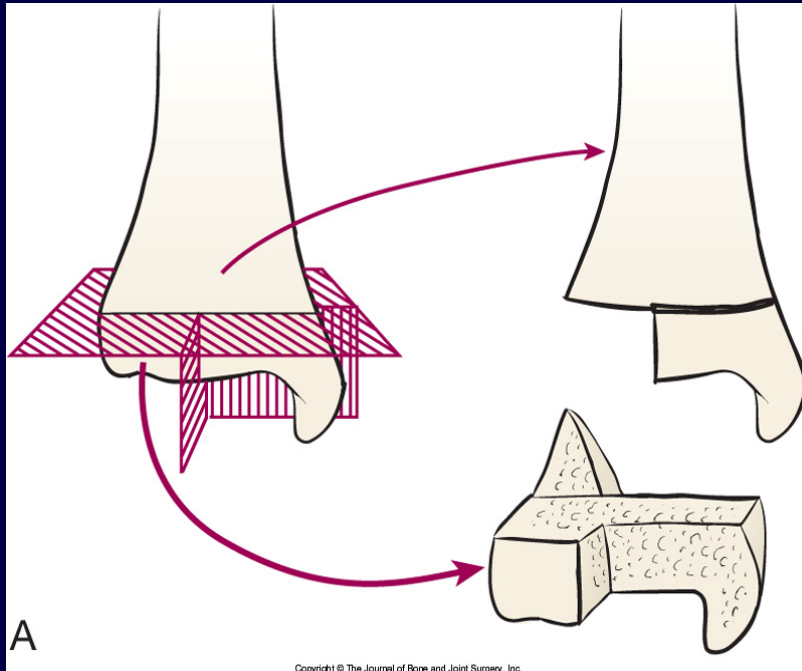


**SH III**

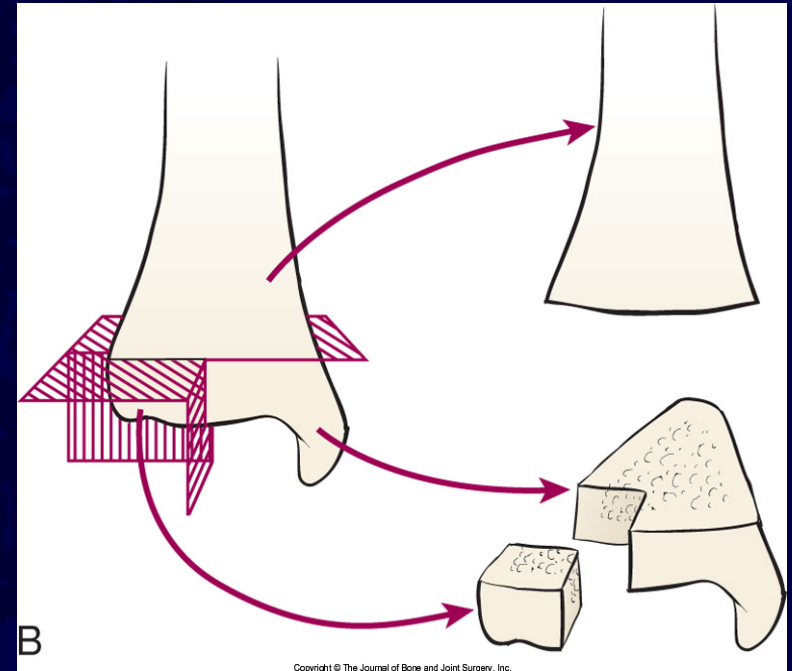


**SH II**

# Triplane Fracture



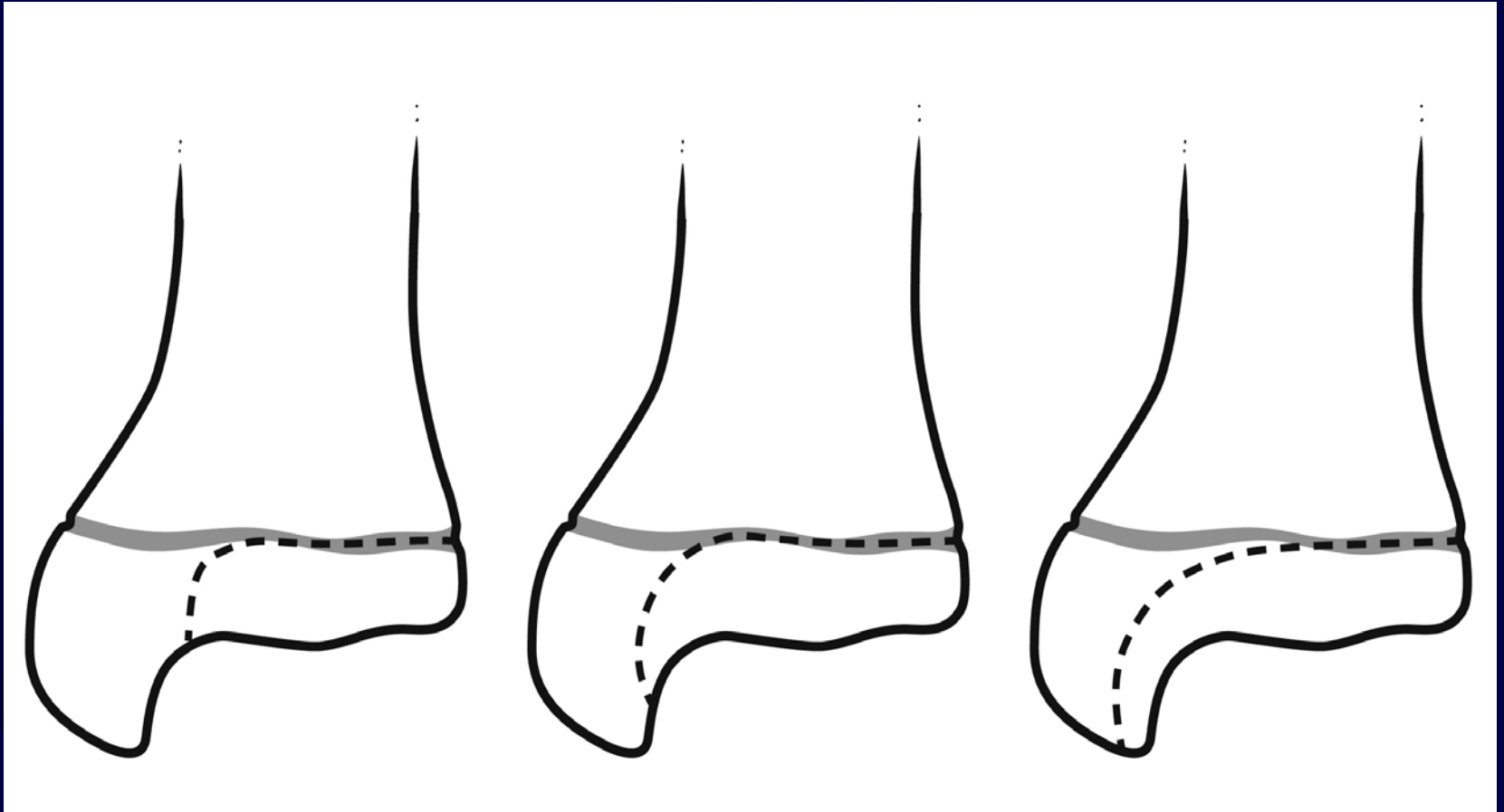
**Two Part**



**Three Part**

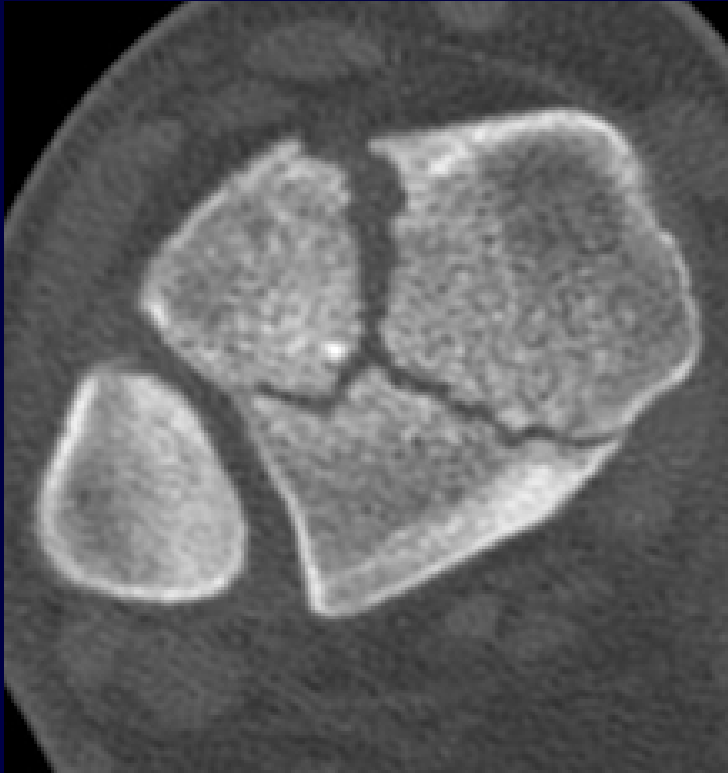
Two Part, Three Part (Separate Tillaux Fragment) and Four Part (Separate Medial Malleolus and Tillaux Fragments) Can Occur

# Intramalleolar Triplane Variant



Extra-articular Epiphyseal Fractures Are Often Amenable to Non-Op Treatment

# Diagnostic Imaging



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

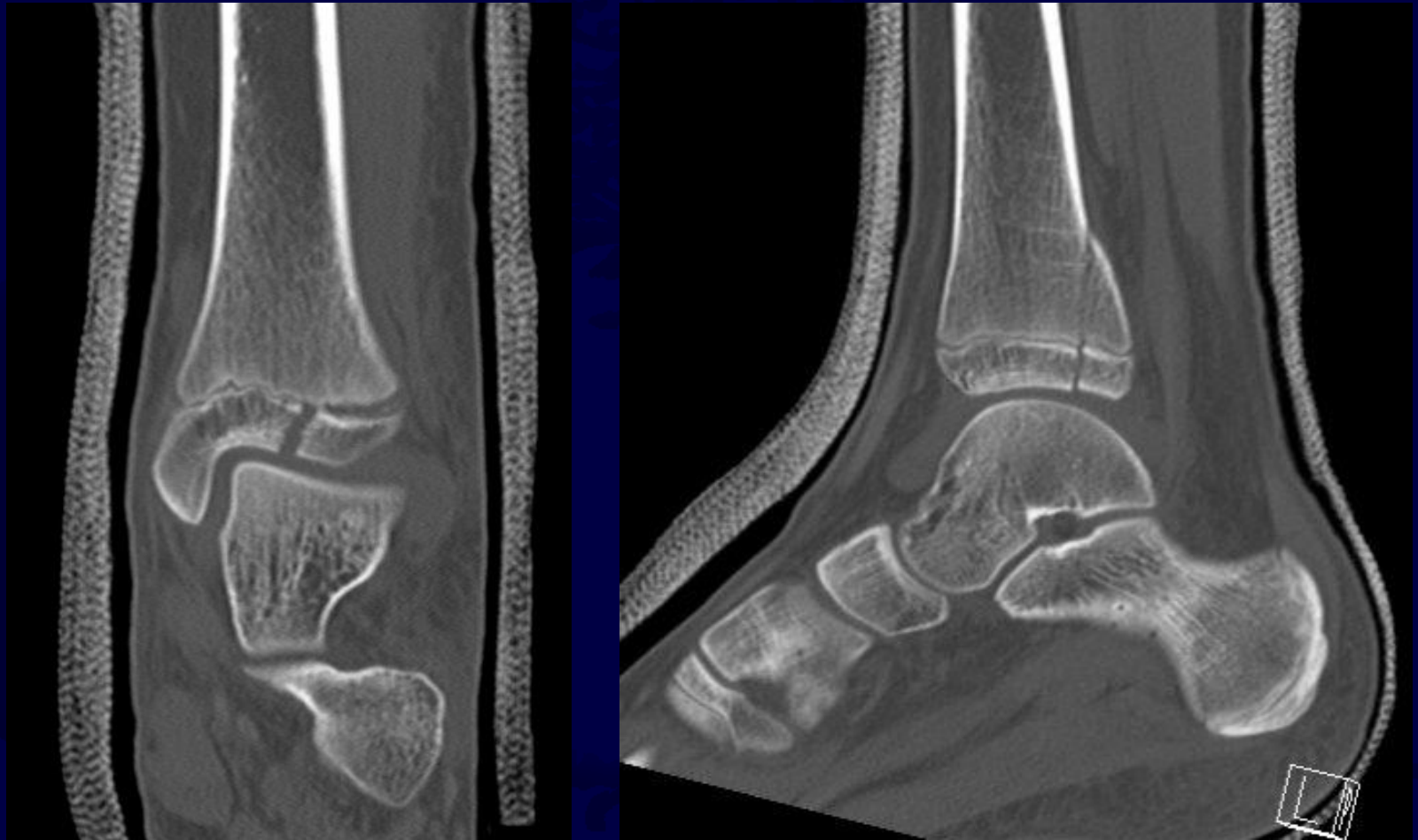
- Short Leg Cast: 6 Weeks
- Non-Weight Bearing: 6 Weeks
- Return to Activity: 3 months / Good Ankle ROM
- Chalton et al (*JPO* 2005): Screw Removal?
  - Cadaveric Study
  - Screw: Significant  $\uparrow$  peak contact pressure / total force
  - Screw Removal: Decreased force and peak pressure values
- 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

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FOR CHILDREN







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