Midfoot Fractures and Dislocations

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Objectives

1. Understanding of midfoot anatomy
2. Identify indications for advanced imaging/stress exam
3. Identify specific injury patterns
4. Comprehend goals of treatment
5. Understand indications for arthrodesis versus ORIF

Outline

- Midfoot anatomy
- Physical exam
- Imaging
- Treatment/Outcomes
  - Tarsometatarsal joint complex injuries
  - Navicular Fracture/Dislocations
  - Cuboid Fractures
  - Cuneiform Fractures

Anatomy

Functional Anatomy

- Column Theory
  - Mid/forefoot
- Medial column (Yellow)
  - First TMT and NC joints
  - Limited mobility at first TMT
  - Mobile segment is the talonavicular joint

Yellow shading = medial column, red shading = intermediate column, green shading = lateral column

Functional Anatomy

- Column Theory
  - Intermediate column (Red)
    - 2^{nd} , 3^{rd} TMT joints and NC joints
    - Rigid (no motion)

Yellow shading = medial column, red shading = intermediate column, green shading = lateral column

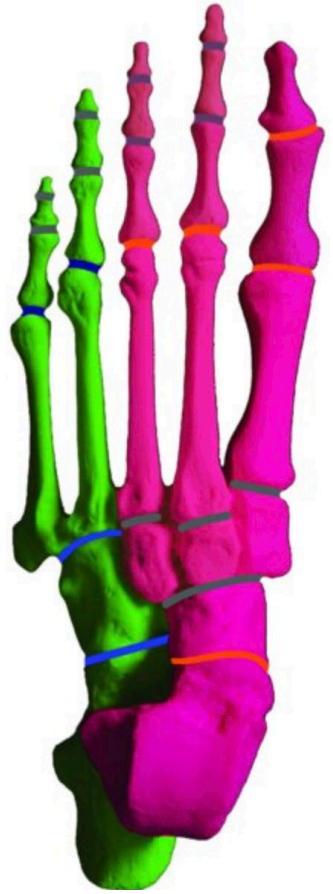
Functional Anatomy

- Column Theory
- Lateral Column (Green)
  - 4th and 5th TMT joints
  - Mobile
  - Essential
    - Shock absorber

Yellow shading = medial column, red shading = intermediate column, green shading = lateral column

Functional Anatomy

- 2 Column Theory
- **Medial column**
  - Rigid
  - Lever for propulsion
- **Lateral column is mobile**
  - Shock absorber
  - Accommodate to uneven surfaces
- Essential v non-essential joints



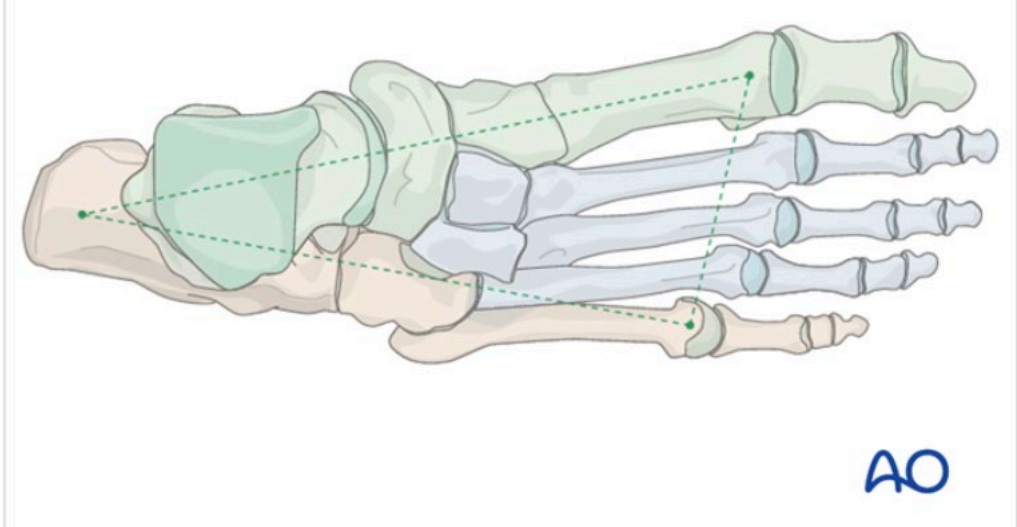
Columns and essential joints of the foot.

Pink: The medial column of the foot. ***Green:*** The lateral column of the foot. ***Blue and orange lines:*** Essential or nonessential, but useful, joints. ***Gray lines:*** Unnecessary joints.

Thomas A. Schildhauer, Martin F. Hoffmann. Fractures and Dislocations of the Midfoot and Forefoot. In: Tornetta P, Ricci WM, eds. Rockwood and Green's Fractures in Adults, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.

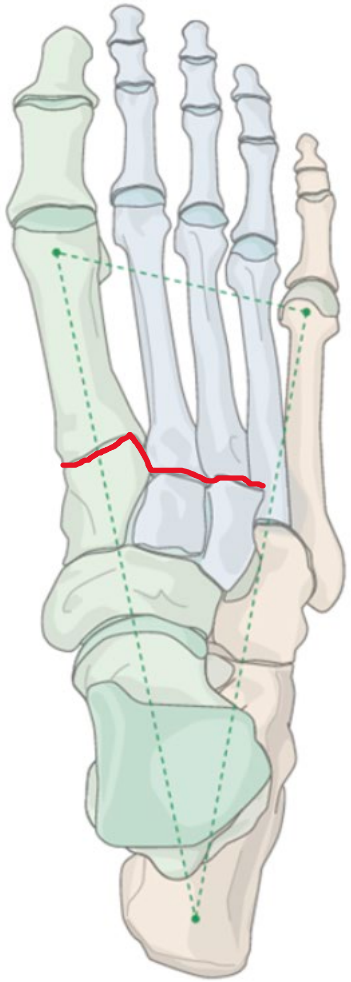
Anatomy – Midfoot Bony

- Note alignment of talonavicular (TN) and naviculocuneiform joints



Midfoot Anatomy

- Trapezoidal configuration
- Recessed 2nd Tarsometatarsal (TMT) joint
  - “keystone” of the transverse arch
- Individual joints are “flat on flat”
- TMT joints have little inherent stability due to shallow articulation



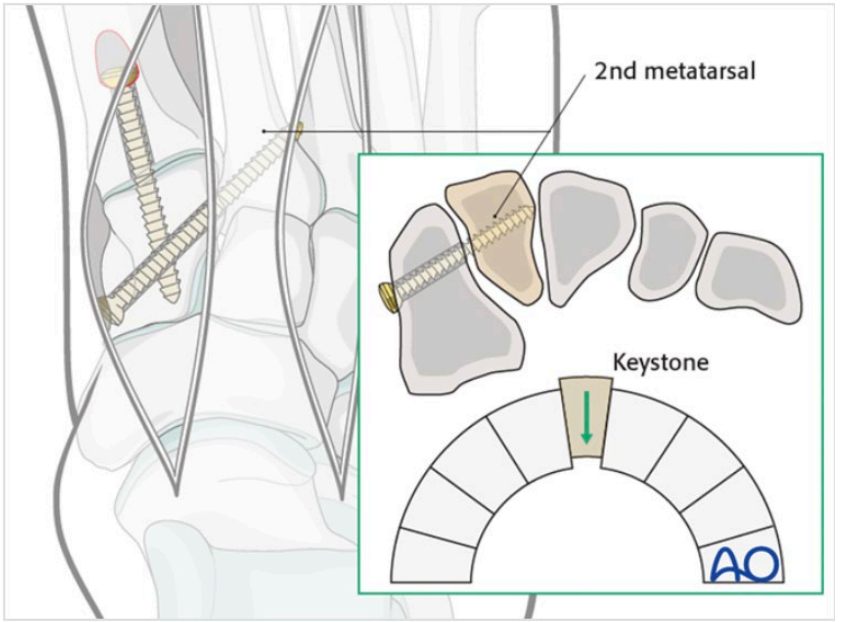
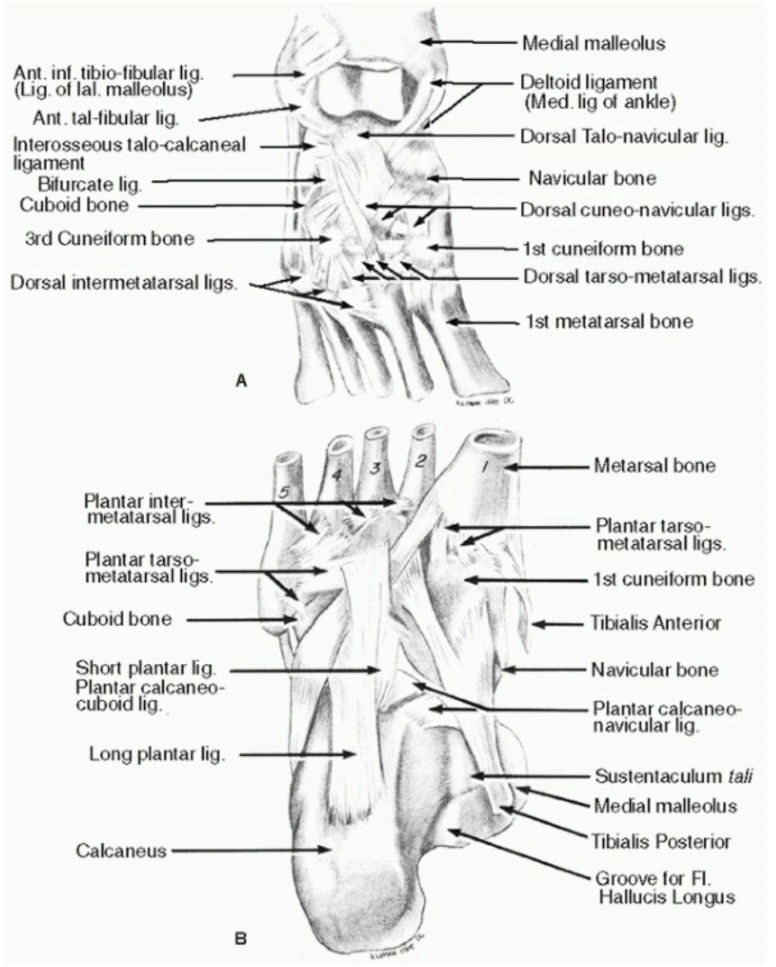


Image obtained from AO surgery reference

Midfoot Ligamentous Anatomy

- Transverse Intermetatarsal ligaments secure M2-M5
- No intermetatarsal ligament between M1-M2
- Interosseous C1-M2 ligament = Lisfranc ligament
- Plantar ligaments stronger than dorsal ligaments
- Dorsal ligaments are first to fail under tension leading to dorsal subluxation of metatarsal bases



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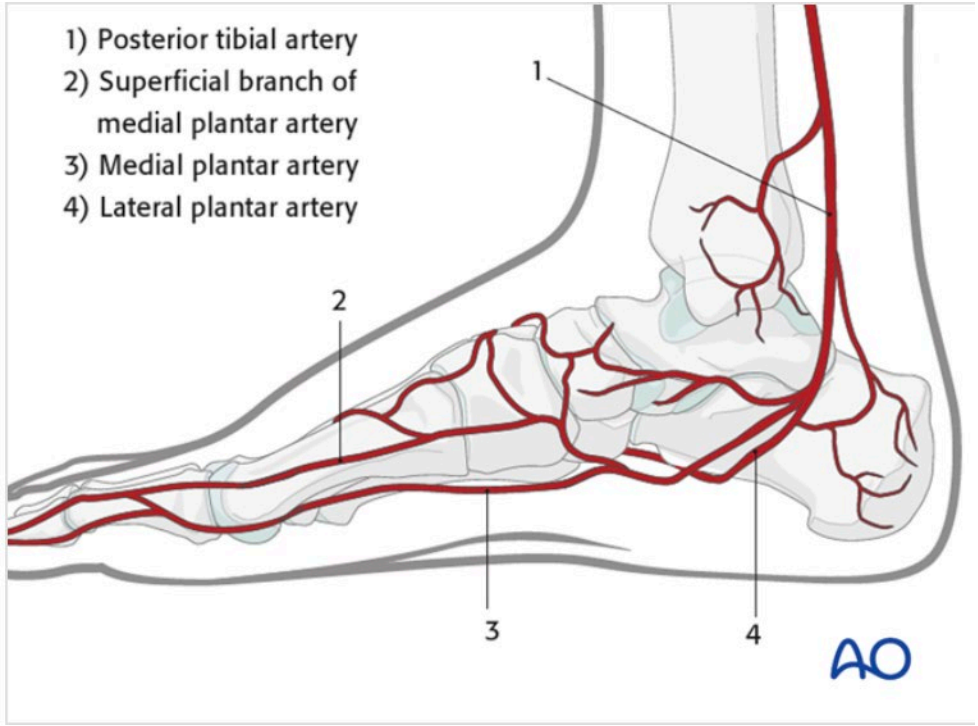
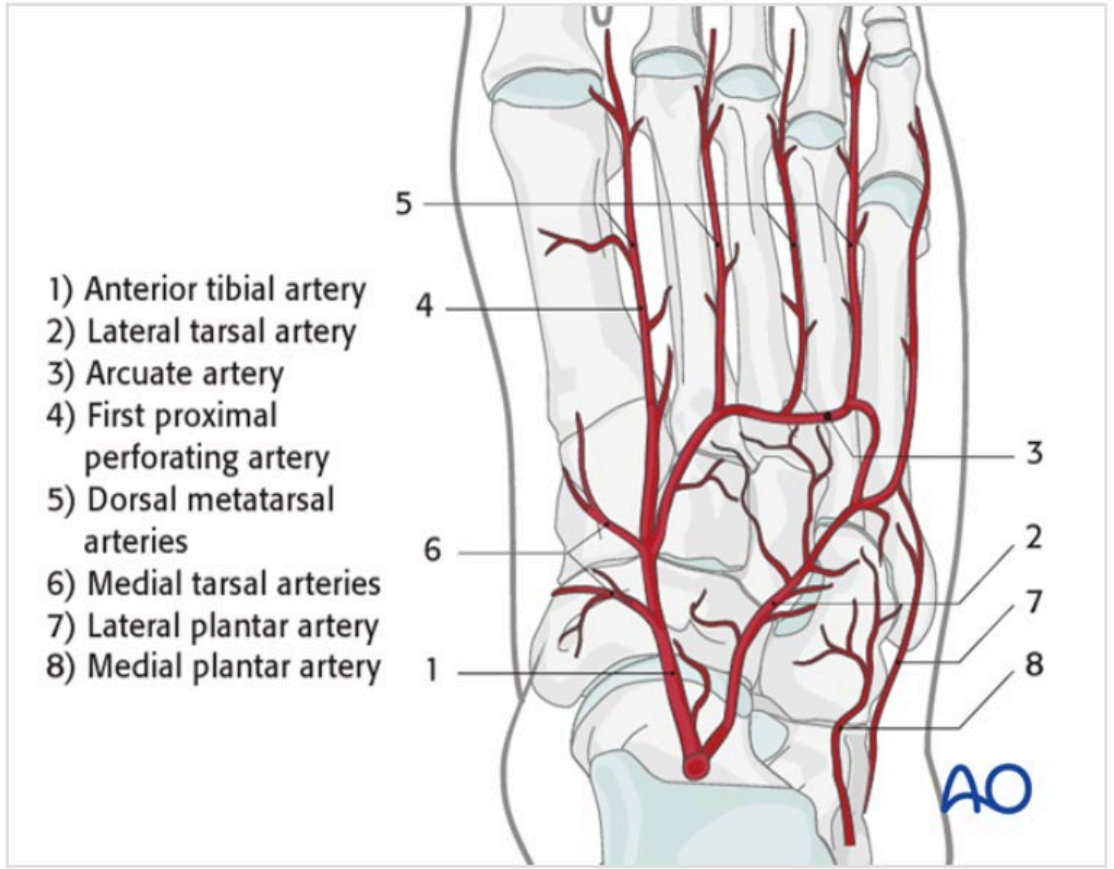
Midfoot Vascular Anatomy

- Local blood supply should always be considered in evaluation surgical planning

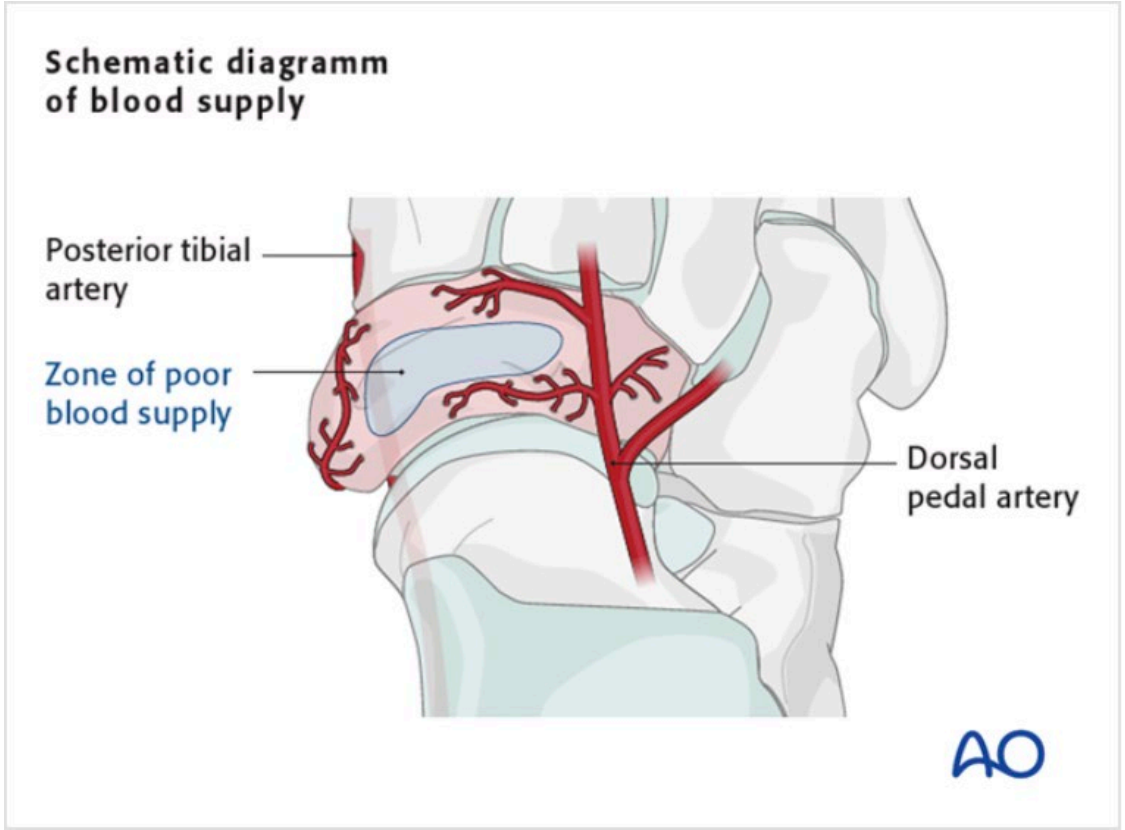




Images obtained from AO surgery reference

Vascular Anatomy - Navicular

- Tenuous dorsal blood supply
- Avoid dorsal soft tissue stripping during ORIF to prevent injury



Dorsal navicular blood supply
Image obtained from AO surgery reference

Initial Evaluation

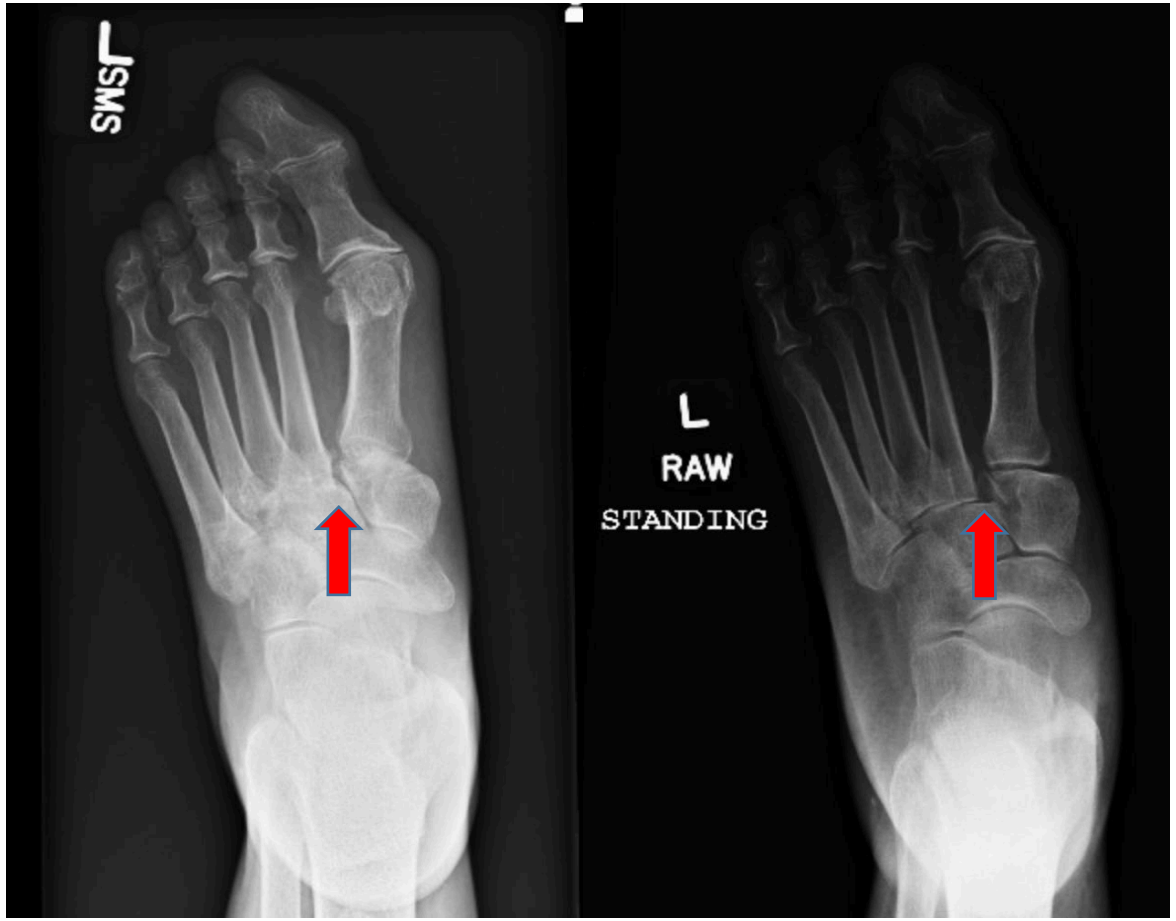
- Soft tissues
- Skin tenting
- Neurovascular evaluation
- Plantar Ecchymosis
  - High suspicion of midfoot ligamentous injury

Plantar ecchymosis in patient with Lisfranc injury

Imaging

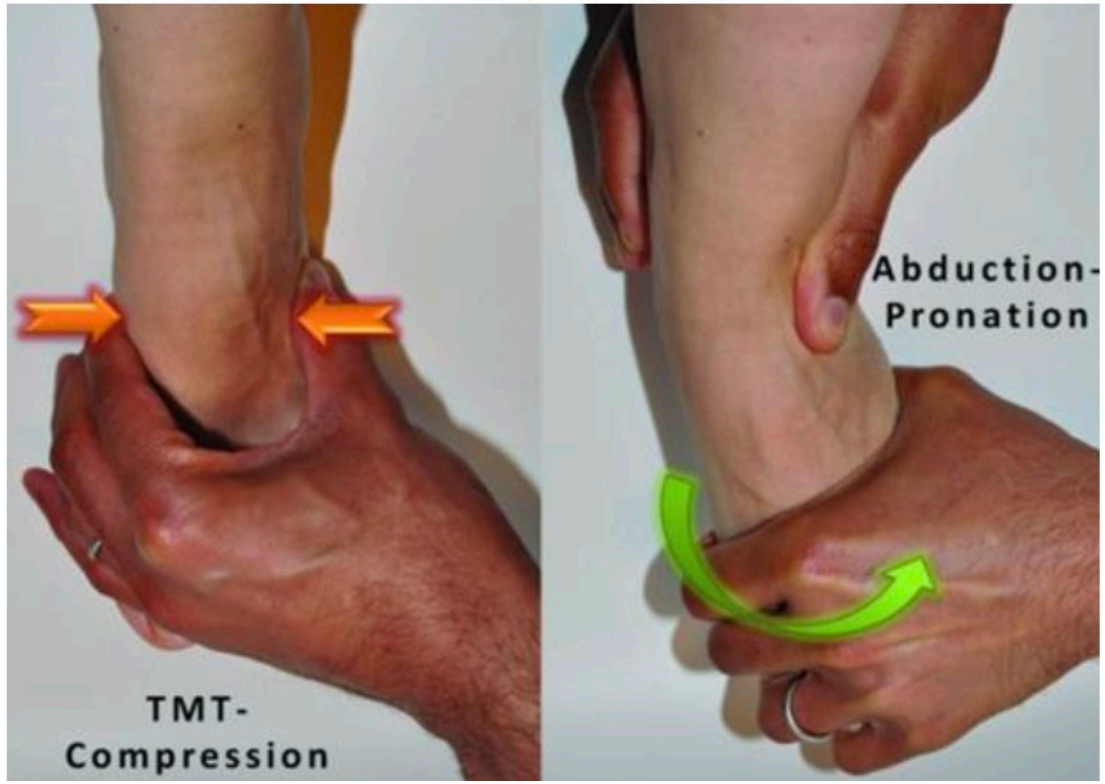
Imaging

- XR
  - AP/Oblique/Lateral of the foot
    - AP
    - Oblique
  - Standing AP bilateral feet on same plate if tolerable
  - Intraoperative stress exam
- CT – useful for evaluation of intra articular extension
- MRI –evaluate ligamentous structures
  - Limited use as static evaluation



NWB AP XR Standing AP XR

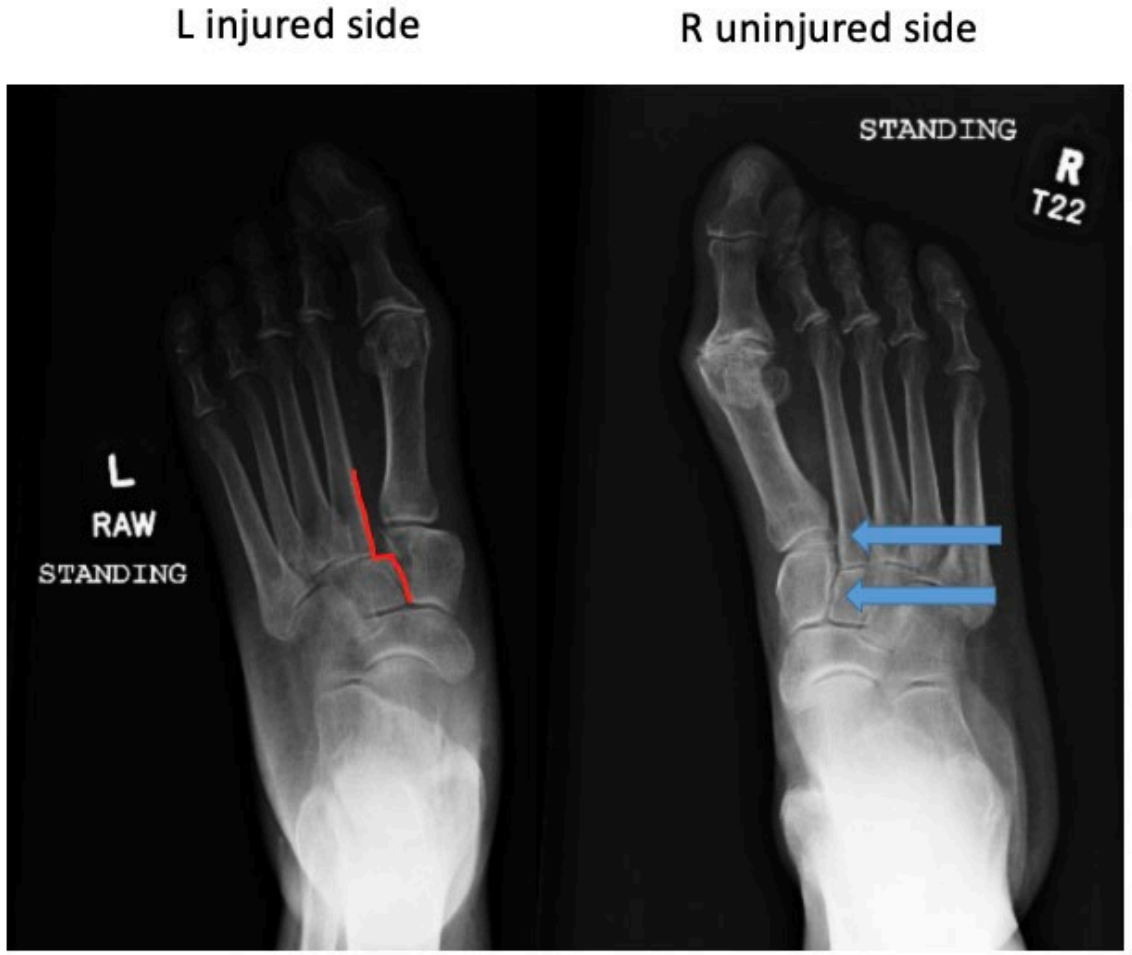
Imaging– Stress exam



- Clinical test to identify TMT joint injury
  - Left: TMT squeeze test
  - Right: abduction-pronation maneuver

Imaging

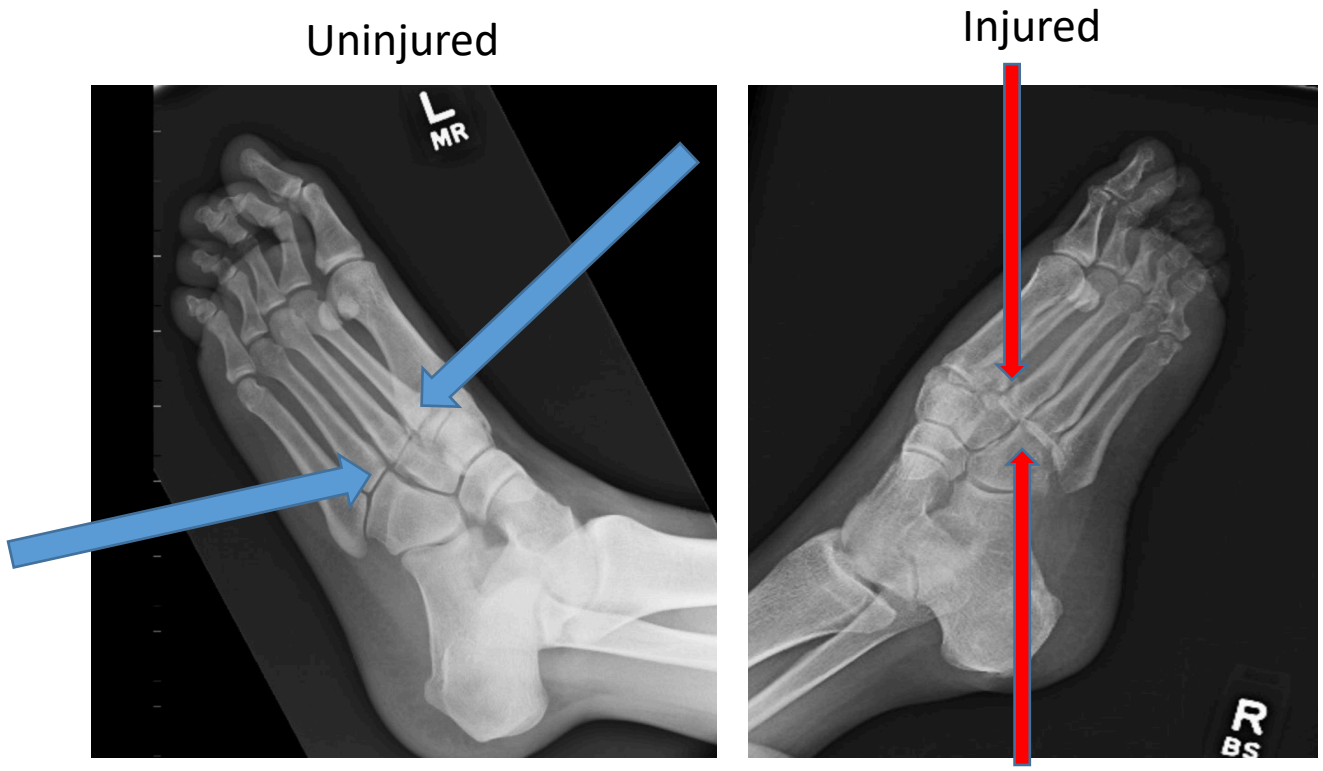
- XR
  - AP/Oblique/Lateral of the foot
    - AP
      - Medial base 2nd MT in-line with medial aspect of middle cuneiform



AP standing XR of bilateral feet displaying normal alignment on right with evidence of TMT disruption on the left

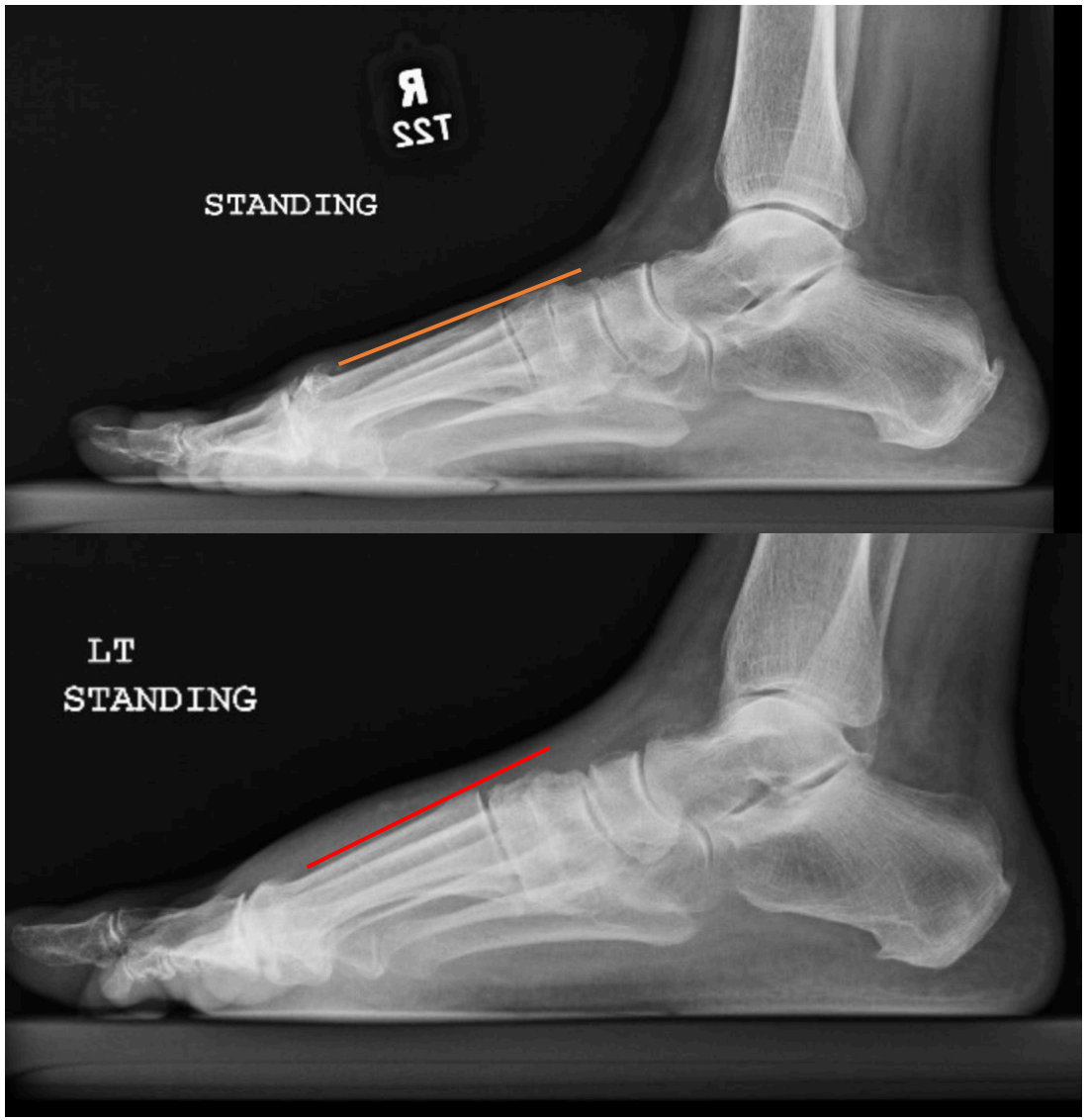
Imaging

- XR
  - AP/Oblique/Lateral of the foot
    - AP
    - Oblique
      - Medial base 3rd MT in-line with medial aspect of lateral cuneiform
      - Medial base 4th MT in-line with medial aspect of cuboid



Imaging

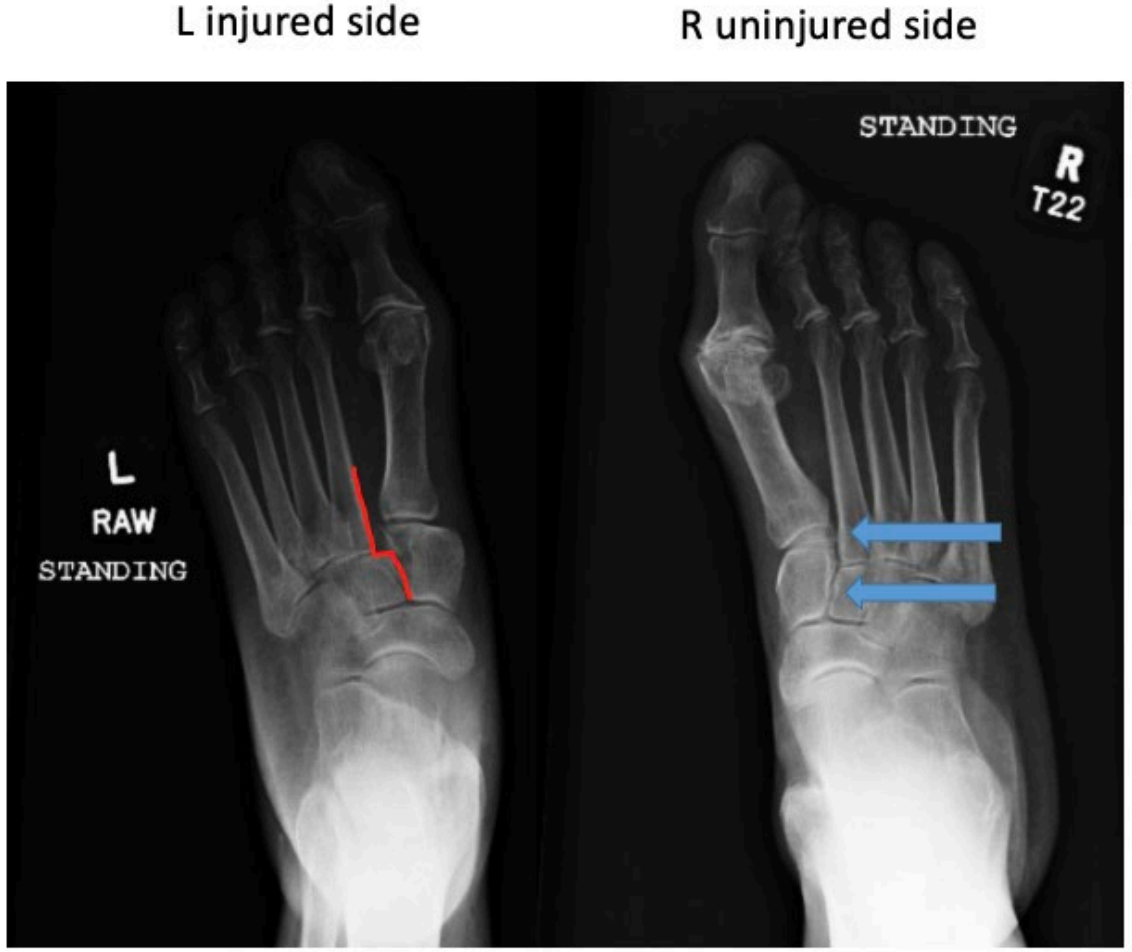
- XR
  - AP/Oblique/Lateral of the foot
    - AP
    - Oblique
    - Lateral
      - Metatarsal base should never be more dorsal than its respective tarsal bone
      - Standing view – better appreciate any discrepancy



L injured side (bottom image) with MT dorsal to cuneiform
Also note dorsal soft tissue swelling

Imaging

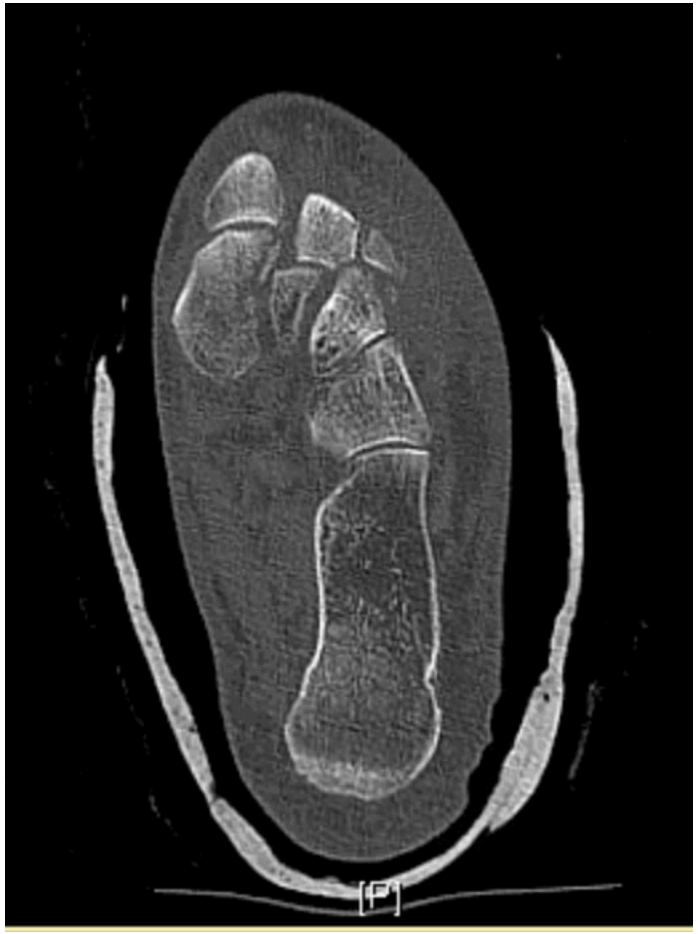
- XR
  - AP/Oblique/Lateral of the foot
    - AP
    - Oblique
  - Standing AP bilateral feet on same plate
    - Uninjured side as reference



AP standing XR of bilateral feet displaying normal alignment on right with evidence of TMT disruption on the left

Imaging

- XR
  - AP/Oblique/Lateral of the foot
  - Standing AP bilateral feet on same plate
  - ”Fleck sign” - small avulsion fracture from base of second metatarsal or medial cuneiform.
- CT – useful for evaluation of intra articular extension
- MRI –evaluate ligamentous structures
  - Limited use as static evaluation



Axial CT displaying fracture of the medial cuneiform with lateral translation of the 1st – 3rd TMT joints

Specific Midfoot Injuries

Tarsometatarsal (Lisfranc) Joint Injuries

- Jacques L. Lisfranc, French gynecologist
  - First to describe amputation technique through TMT joint
- Rare injuries (0.1-0.4% of all fractures)
  - Rockwood and Green's Fractures in Adults 9th Ed
- Purely ligamentous injures often misdiagnosed

TMT joint disruption

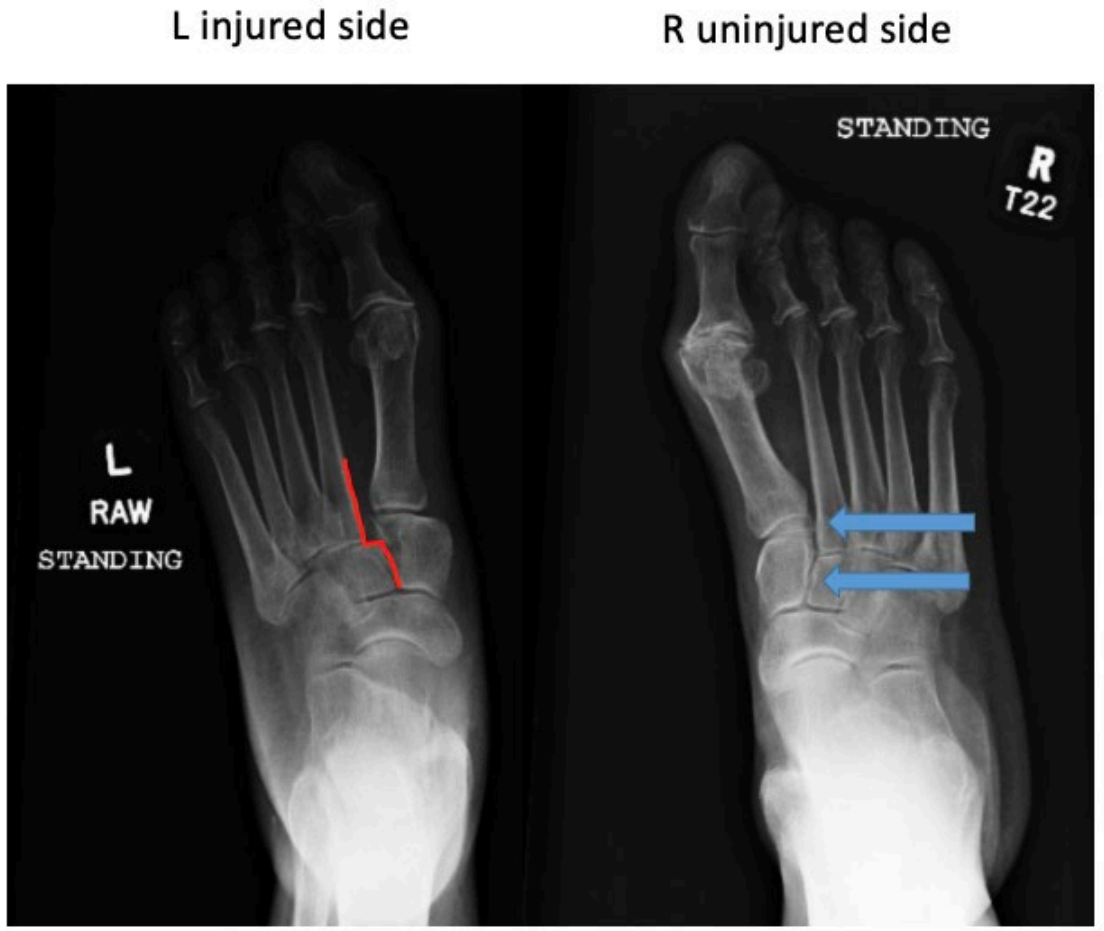
TMT Joint Injuries - Evaluation

- As frequently overlooked must have high index of suspicion
- Plantar ecchymosis often present

Plantar ecchymosis in patient with Lisfranc injury

TMT Joint Injuries - Evaluation

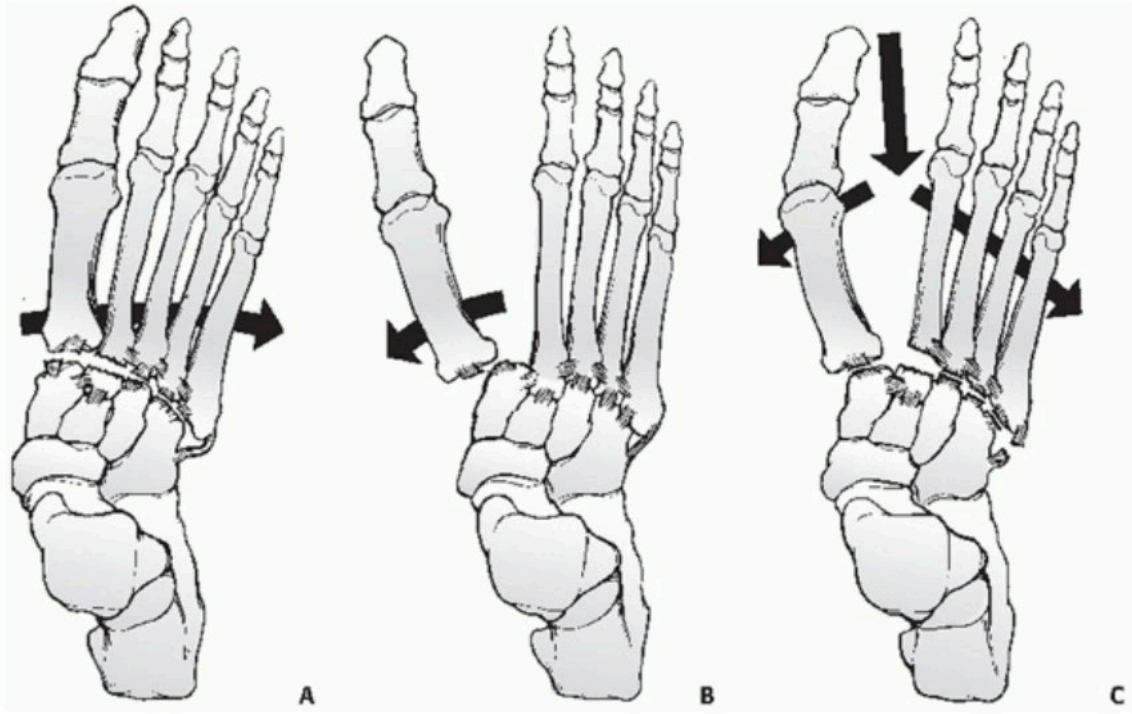
- If concern present and no findings on static XR
  - Stress XR
    - Standing XR with boot feet on same plate for AP
  - Fluoroscopic stress exam
  - MRI – less helpful as static exam
    - Strain of ligament may not correlate with instability
- Often occur with other midfoot injuries
  - Cuboid fracture
  - Intercuneiform instability/fracture



Standing radiographs of a patient with left TMT joint disruption

TMT Joint Injuries - Classification

- OTA
- Quenu and Kuss
  - Directional
  - Partial v complete



The common classification devised by Quénu and Küss.[307]

A: Depicts homolateral disruption where all metatarsals travel in the same direction. This group can be subdivided into medial or lateral to denote the direction of disruption. **B:** Partial disruption involves only the first metatarsal or all the lesser rays. **C:** Divergent dislocation occurs when there is complete disruption of the tarsometatarsal joints but the first ray and the lesser rays displace in opposite directions.

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TMT Joint Disruption – Acute Management

- Reduce dislocation
  - Split
  - CRPP
    - Unstable midfoot injuries with skin compromise or potential for such
    - Urgent when skin under tension

Pre and post reduction radiographs of patient with TMT disruption after crush injury

TMT Injuries – Soft Tissue Crush

- Severe TMT disruption secondary to crush injury; presented 6 hours from injury
- CRPP immediately (center image). Note dorsal eschar already forming upon presentation to OR same day of injury
- Follow up image 1 week later (far right)

TMT Joint Disruption – Treatment

- Acute ligamentous
  - ORIF v. arthrodesis
    - Purely ligamentous lesions treated with arthrodesis have been shown to have superior AOFAS scores
      - Ly ET al. JBJS 2006
- Acute Fracture
    - ORIF
      - Traversing screws
      - Spanning dorsal plate
        - Avoids disruption of articular surface
      - No difference in clinical outcomes plate v screws
        - Lau et al JOT 2017
- Subacute (>3 months) & chronic
  - Arthrodesis

Purely ligamentous TMT disruption

TMT Joint Disruption – Evaluation

- Complete evaluation of entire midfoot
  - Fluoroscopic stress

Compliments Brian Weatherford, MD
OTA core curriculum V4

TMT Joint Disruption – Operative Management

- Critical to have thorough surgical planning including approach, reduction sequence and fixation methods
- Approaches
  - Plan surgical incisions accordingly
    - 5cm skin bridge
    - Typically medial and lateral incisions

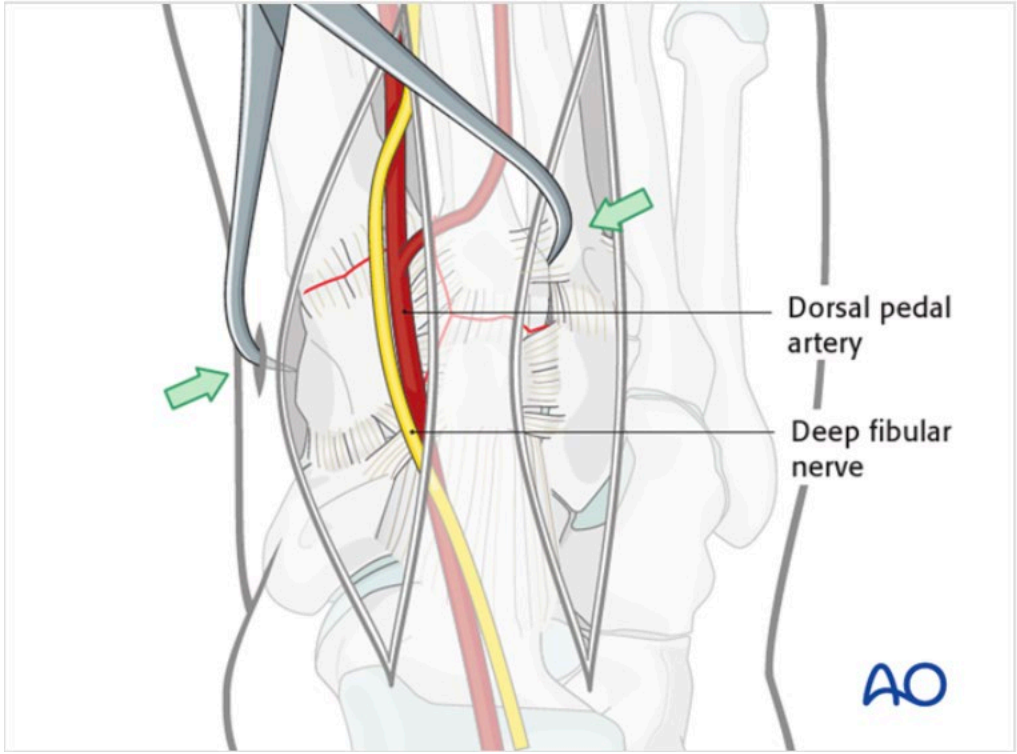
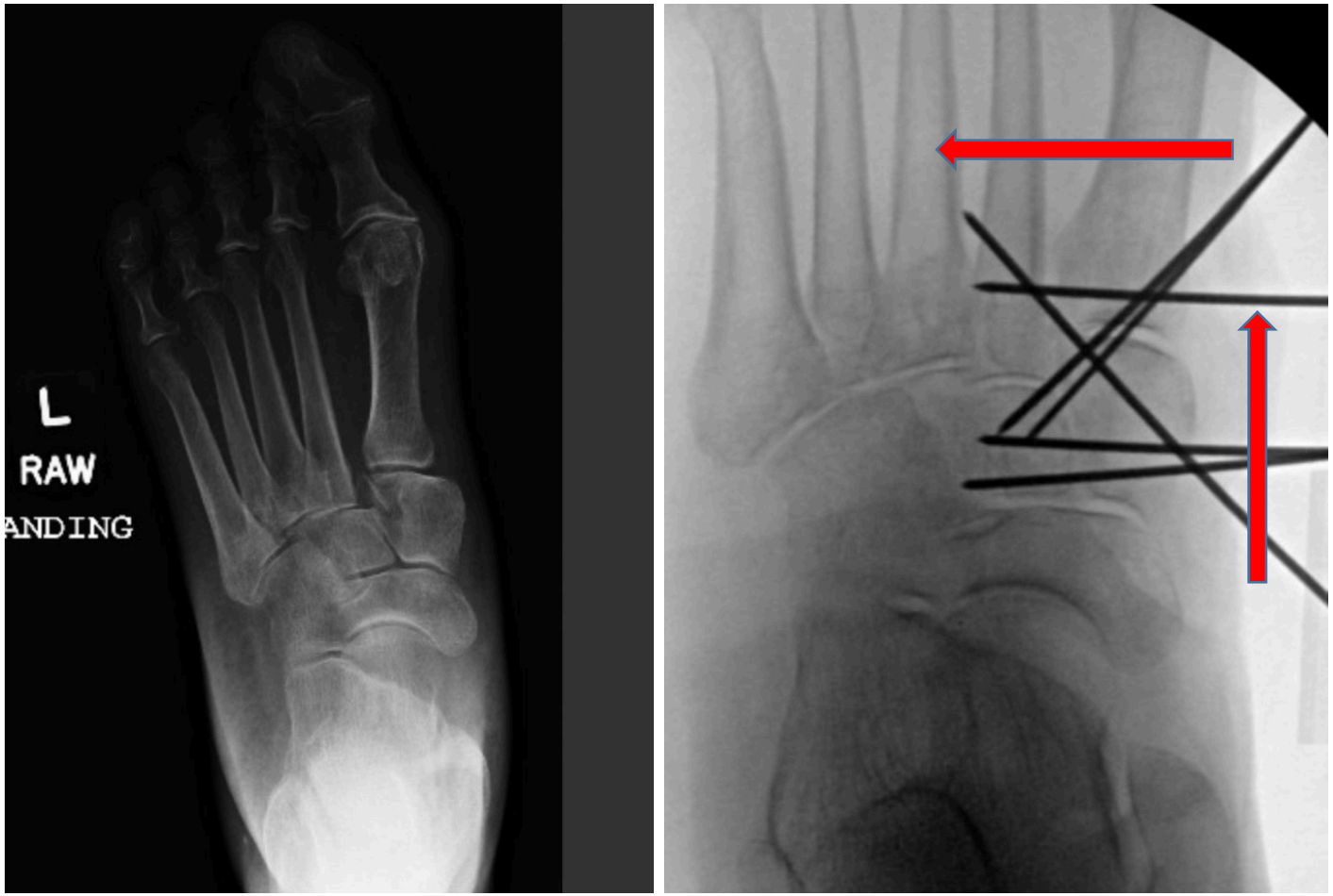


Image obtained from AO surgery reference

TMT Joint Disruption – Operative Management

- Reduction sequence
  - Stabilize from proximal to distal and medial to lateral
  - Always assess for naviculocuneiform and intercuneiform disruption
    - Stabilize accordingly
    - Image on right displays reduction sequence with intercuneiform instability identified intraoperatively*



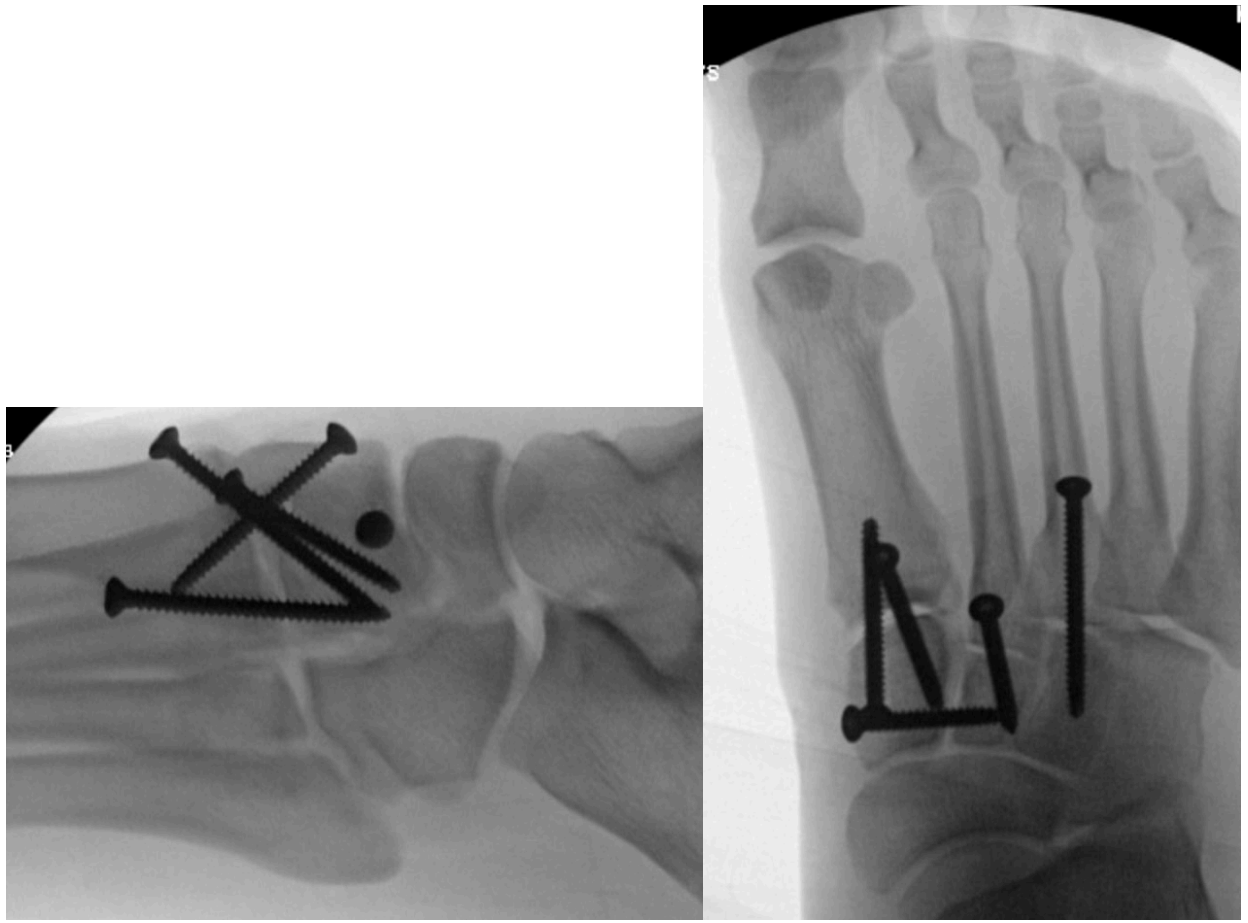
Reduction sequence

TMT Joint Disruption – Operative Management

- Rigid fixation for 1-3rd metatarsals (medial column)
  - Screws crossing joint
    - Best for purely ligamentous
  - Spanning plate fixation
    - Fracture/comminution
- Flexible fixation (CRPP) for 4&5th metattarsals (lateral column)
  - Typically 0.062 K-wires
    - Remove at 6+ weeks

TMT Joint Disruption – Surgical Outcomes

- Average AOFAS score, 79.0; FFI, 16.9, and VAS for pain, 2.5.
  - Stern R JBJS Am 2016
- Accuracy of reduction correlates with clinical outcome
  - Kuo et al JBJS 2000
  - Lau et al. JOT 2017
- Purely ligamentous injuries have superior outcomes when tx with arthrodesis over ORIF
  - Both with lower AOFAS scores compared to baseline
    - Ly et al. JBJS 2006
    - Henning FAI 2009



Midfoot arthrosis s/p TMT disruption

TMT Joint Disruption - Complications

- Symptomatic implants
  - Higher rate of secondary surgery (implant removal and salvage arthrodesis) for ORIF v arthrodesis; 78.6% vs. 16.7%
  - Henning et al Foot Ankle Int 2009
- Midfoot arthritis
  - Poor association between radiographic (72% of patients) and symptomatic (54% of patients) arthritis
  - Dubois-Ferrière JBJS Am 2016

Midfoot arthrosis s/p TMT disruption

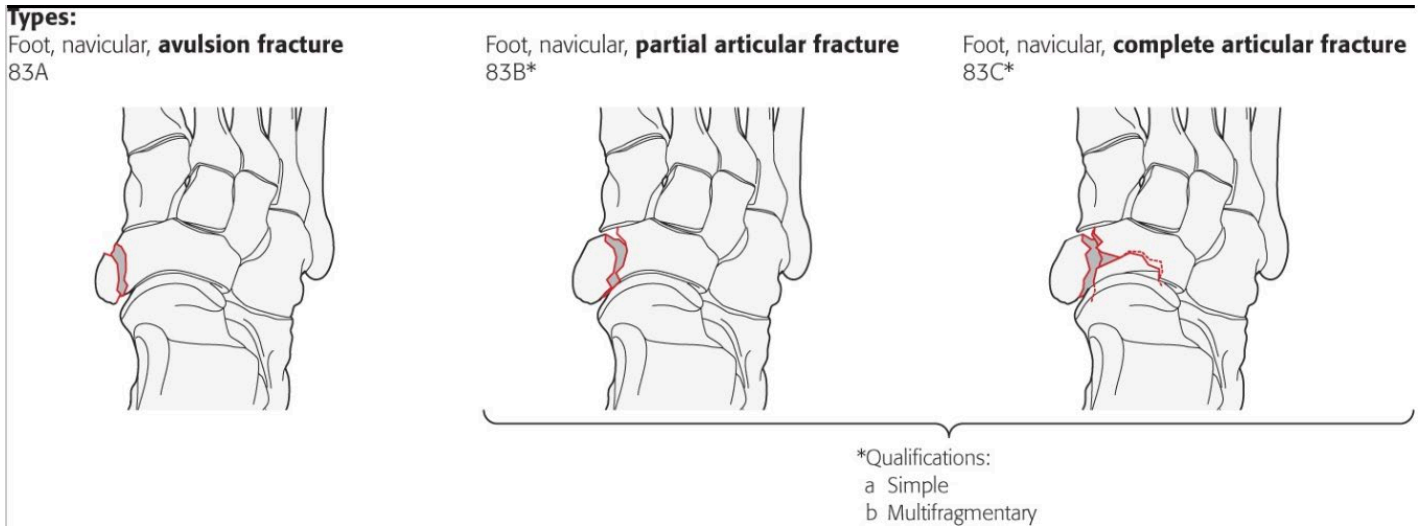
Tarsal Navicular Fractures

- Rare injuries
- Traumatic fractures most commonly occur with other associated midfoot trauma

Displaced navicular body fracture

Tarsal Navicular Fractures - Classification

- Stress fractures
- Acute fractures
  - Avulsion
  - Tuberosity
  - Body
- OTA classification



OTA/AO Fracture and Dislocation Classification Compendium

Tarsal Navicular Fractures - Imaging

- XR
- CT scan particularly useful to determine full extent of injury/displacement

Displaced navicular body (red arrow) and cuboid fractures

Tarsal Navicular Fractures - Management

- Stress fracture
  - 6-8 weeks short leg cast
    - Equivalent outcomes to operative management
    - Potter NJ et al. Br J Sports Med. 2006
    - Khan KM et a. Am J Sports Med. 1992
- Avulsion fractures
  - Non operative management
    - Minimal displacement
    - No articular involvement

Nondisplaced navicular body fracture

Management of Navicular Body fractures

- Non operative management –
  - Isolated fractures without articular involvement
  - Nondisplaced articular fractures
    - Can be considered for conservative management but must be followed closely

CT scan confirming nondisplaced navicular body fracture

Management of Navicular Body Fractures

- Operative management
  - Indications
    - Articular involvement with displacement
    - Unstable medial column
    - Those occurring with associated midfoot injuries
  - Techniques
    - As with any operatively managed injury it is critical to have thorough surgical planning including approach, reduction sequence and fixation methods

Navicular body fracture dorsal plating

Management of Navicular Body Fractures

- Techniques
  - Lag screw fixation
    - Simple fractures without significant comminution
  - Plate fixation
    - Fractures not amendable to screw fixation alone
    - Multifragmentary/comminuted fractures
    - Fractures associated with dislocation and/or impaction that require spanning fixation to cuneiforms and/or talus

Navicular body fracture dorsal plating

Tarsal Navicular Fractures - Outcomes/Complications

- Post traumatic arthrosis most common sequala
  - Complex fracture patterns tend to result in long-term disability of foot
  - Simple patterns often have more promising outcome
- Osteonecrosis
- Deformity
- Nonunion

Comminuted navicular fracture

Navicular Dislocation

- Typically occur along with fracture
- Reduce acute dislocations
  - For unstable injuries with current or risk for skin compromise CRPP
    - Should be performed urgently to prevent further skin compromise
    - CRPP allows for earlier resolution of soft tissue swelling

Navicular fracture dislocation

Navicular Dislocation - Definitive Management

- Spanning plate fixation often required due to instability
- Dependent on injury pattern can span to cuneiform alone or may require spanning fixation of entire medial column
  - Schildhauer et al JOT 2003
- Spanning of TN joint must be temporary as this is an essential joint – remove at 2-4 months

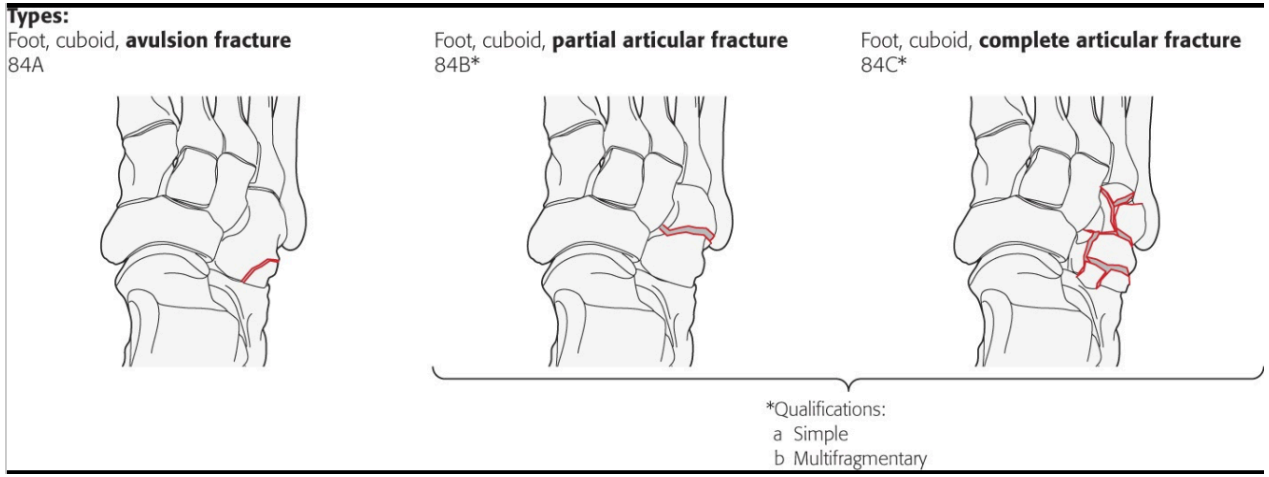
Spanning medial column fixation

Cuboid Fractures

- Most frequently occur in conjunction with other midfoot injuries
- High index of suspicion for TMT ligamentous or other mid foot fracture
- “Nutcracker fracture”
- Lateral column length

Cuboid Fractures – Imaging/Classification

- CT scan
  - Operative planning
  - Articular impaction/comminution
- Classification
  - OTA



AO/OTA classification

Cuboid Fractures – Management

- Nonoperative Criteria
  - Isolated cuboid fractures
  - Non/minimally displaced
  - Maintained lateral column length
  - NWB in cast 6-8 weeks
- Operative
  - Displaced fractures
  - Shortened lateral column
  - Associated injuries

Comminuted cuboid fracture with associated midfoot injuries

Cuboid Fractures – Operative treatment

- ORIF
  - Most common intervention
  - Generally plate fixation
    - Anatomic plates or mini fragment
- Lateral column external fixation
  - Can be used for intraoperative distraction during ORIF
  - As an adjunct to plate fixation
  - Extensively comminuted fractures not amendable to plate/screw fixation
- Lateral column bridge plating
  - Can be utilized in severely comminuted fractures
  - Requires removal as prevents lateral column motion (essential joints)

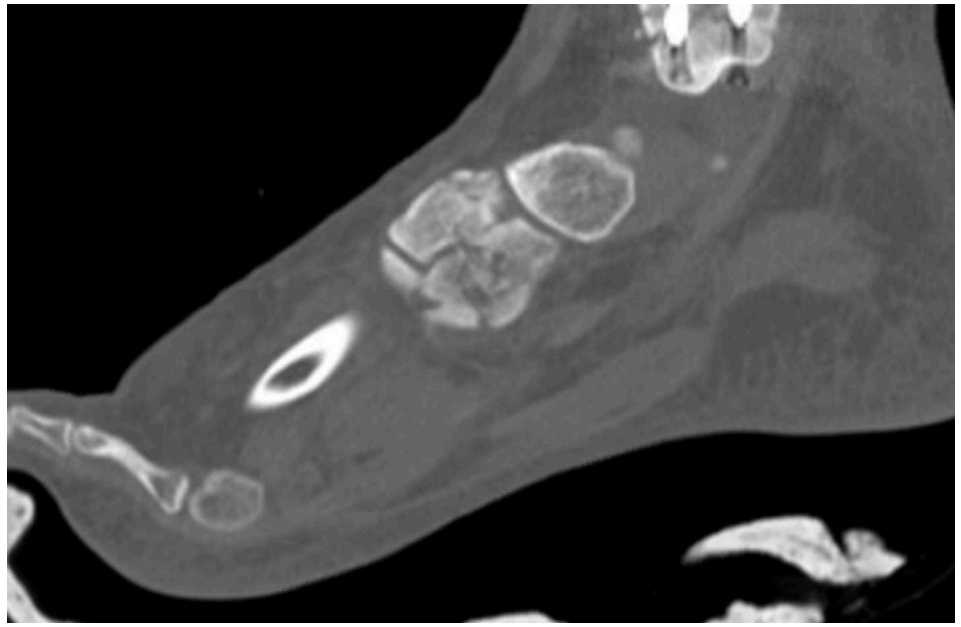
Cuboid ORIF with lateral column external fixator utilized for intraoperative distraction

Cuboid Fractures – Outcomes

- Arthritis in CC joint as well as 4/5 TMT joints is poorly tolerated
- Shortening of lateral column can lead to foot abduction/deformity and subsequent pain
- No long-term studies utilizing validated scoring systems
- Simple, isolated fractures tend to have more favorable outcome that comminuted fractures with associated injuries

Cuneiform Injuries

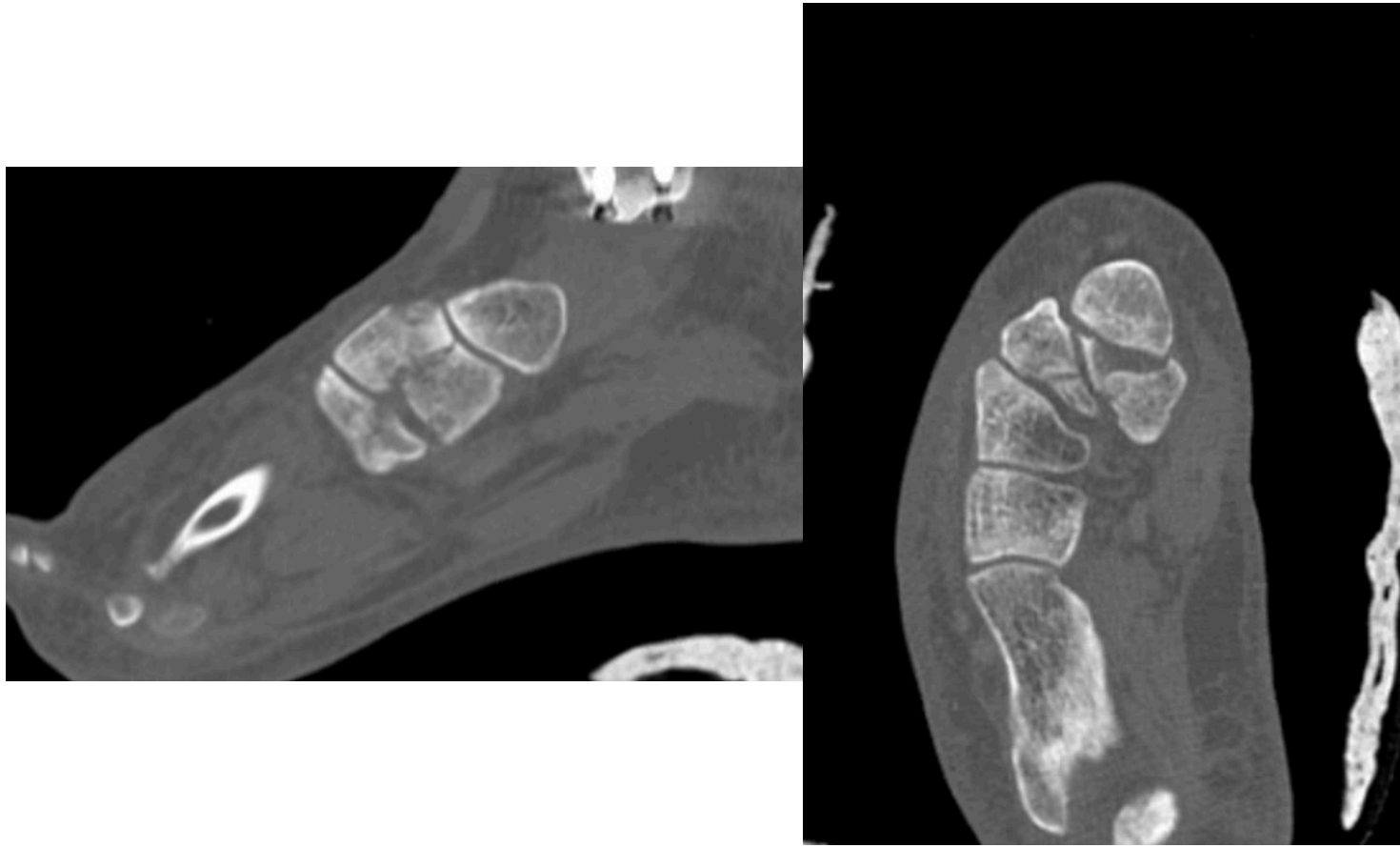
- Rarely occur in isolation
- Most often occur in conjunction with TMT joint injuries
- Bony disruption (fracture) or ligamentous (intercuneiform or naviculocuneiform joint disruption)
- Stress XR – eversion/pronation stress to assess for midfoot ligamentous injury
- CT scan for evaluation



Comminuted cuneiform fracture in multiply injured patient

Cuneiform Injuries - Treatment

- Non operative
  - Isolated
  - Nondisplaced
- Operative
  - Displaced
  - Occurring with associated
  - midfoot injuries



CT scan displaying a comminuted cuneiform fracture with impaction

Cuneiform Injuries – Operative Treatment

- Joint Disruption
  - Intercuneiform disruption most often treated with screw fixation traversing effected joints
  - Should be reduced and stabilized prior to reduction of TMT joints
  - Naviculocuneiform disruption most often stabilized by spanning plate fixation
- Fractures
  - Spanning plate
    - Comminuted
    - Joint disruption
  - Screw fixation
    - Simple pattern

Comminuted cuneiform fracture with significant articular impaction treated with reduction and spanning plate fixation
Note disruption of 2nd and 3rd TMT joints identified intraoperatively

Summary

- Midfoot injuries are rare
- Often associated with concomitant foot injuries
- Always assess for other injuries – advanced imaging (CT scan, stress x-rays) as needed
- Develop thorough surgical plan
- Chronic discomfort is not infrequent

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