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\textsuperscript{nd}, 3\textsuperscript{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)
  • 4\textsuperscript{th} and 5\textsuperscript{th} 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.

Anatomy – Midfoot Bony

• Note alignment of talonavicular (TN) and naviculocuneiform joints
Midfoot Anatomy

- Trapezoidal configuration
- Recessed 2\textsuperscript{nd} 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

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 intraarticular extension
- MRI – evaluate ligamentous structures
  - Limited use as static evaluation
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 2\textsuperscript{nd} 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 injuries often misdiagnosed
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.

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
TMT Joint Disruption – Evaluation

• Complete evaluation of entire midfoot
  • Fluoroscopic stress
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*
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 metatarsals (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
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

• Avulsion fractures
  • Non operative management
    • Minimal displacement
    • No articular involvement
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 sequela
  • 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 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
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
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 than 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
References

• AO Surgery Reference
• Ly T, Coetzee JC. Treatment of Primarily Ligamentous Lisfranc Joint Injuries: Primary Arthrodesis Compared with Open Reduction and Internal Fixation, JBJS: March 2006 - Volume 88 - Issue 3 - p 514-520.
References (cont)


