Midfoot Fractures and Dislocations

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Outline

1. Anatomy of the Tarsometatarsal joint complex
2. Physical exam and imaging findings
3. Treatment options
   - Nonoperative
   - ORIF
   - Arthrodesis
4. Review current literature
5. Case examples
6. Associated injuries
   - Cuboid
7. Summary
Objectives

Understand

1. Functional anatomy of the midfoot
2. Stress imaging
3. Goals of treatment
4. Indications for operative treatment
5. Primary Arthrodesis versus ORIF
Recommendations to Improve Retention of this Material

1. Write down the objectives

2. Search for the answers to the objectives in the powerpoint talk (hint: look for orange text)

3. Test yourself at the end by reviewing the objectives

4. Watch the show on “presenter view” and look at the notes at the bottom of the slides. References are listed throughout.

Acknowledgement to Dr. Matt Graves for this concept
Incidence

- Rare injuries
- 0.2% of all fractures
- *Up to 20% initially missed*
- High index of suspicion is necessary
  - Lisfranc injury until proven otherwise
Anatomy

- Trapezoidal configuration
- *Recessed 2\textsuperscript{nd} Tarsometatarsal (TMT) joint
  - “keystone” of the transverse arch*
- Individual joints are “flat on flat”

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

Panchbhavi et al. Three-dimensional, digital, and gross anatomy of the Lisfranc ligament. Foot Ankle Int. 2013
Anatomy

- **Dynamic Stabilizers**
  - Peroneus Longus
  - Tibialis posterior
  - Tibialis Anterior
    - May block reduction

- **Dorsalis pedis artery**
  - Forms plantar arch
  - May be avulsed causing hematoma or compartment syndrome

Schildhauer et al. Ligamentous Structure of the midfoot. In: Bucholz et al., editors. Rockwood and Green’s fractures in adults. 8th ed
Column Theory

- 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
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
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

Column Theory

- **Medial and Intermediate Columns are rigid**
  - Lever for propulsion

- **Lateral column is mobile**
  - Shock absorber
  - Accommodate to uneven surfaces

Yellow shading = medial column, red shading = intermediate column, green shading = lateral column
Mechanism of Injury

Direct vs Indirect

• Indirect with axial force to plantarflexed foot
  – Weaker dorsal ligaments fail under tension

• Direct = crushing mechanism
  – Concern for soft tissue compromise or compartment syndrome
Initial Evaluation

• Careful History
  – Ability to weight bear?
  – Push off?

• Physical Exam
  – *Plantar arch ecchymosis*
  – Gap sign
  – Provocative maneuvers
    • Pronation abduction stress
    • Dorsal/plantar translation
Gap sign
Imaging

- AP
  - Up to 3 mm normal between $1^{st}$ and $2^{nd}$ metatarsal bases
  - Lateral base $1^{st}$ MT in-line with lateral aspect of medial cuneiform
  - Medial base $2^{nd}$ MT in-line with medial aspect of middle cuneiform
Imaging

- 30 degree oblique
  - Medial base 3\textsuperscript{rd} MT in-line with medial aspect of lateral cuneiform
  - Medial base 4\textsuperscript{th} MT in-line with medial aspect of cuboid
Imaging

Lateral: A metatarsal should never be more dorsal than its respective tarsal bone
Fleck Sign

- Indicative of avulsion of the Lisfranc ligament
- High suspicion for ligamentous instability
Advanced Imaging

• CT scan
  – Articular comminution
  – Non displaced fracture lines
  – Helpful for preop planning
  – *Not dynamic!*

• Does not demonstrate how foot tolerates physiologic load
Advanced Imaging

- **MRI**
  - Ligamentous injury
  - *Plantar Oblique Ligament*
    - Disruption is predictive of instability on EUA
    - Raikin et al, JBJS 2009
  - *Not dynamic!*
    - Does not demonstrate how foot tolerates physiologic load
Stress Imaging

- Weight bearing X-ray
  - Contralateral view for comparison
- Dynamic evaluation
  - How foot responds to physiologic load
- First line of imaging
  - Before more costly advanced studies
Abduction Stress and AP Weightbearing Radiography of Purely Ligamentous Injury in the Tarsometatarsal Joint

LCDR H. Steven Coss, MC USNR, LCDR Richard E. Manos, MC USNR, LT Anthony Buoncristiani, MC USNR, and LCDR William J. Mills, MC USNR

San Diego, California

Foot & Ankle International/Vol. 19, No. 8/August 1998
Classification

- Multiple classifications
- Does not direct treatment
- Myerson classification most commonly used
  - Based on Quenu and Kuss

Treatment Principles

• MUST
  – Restore alignment
  – Protect talonavicular motion
  – Protect 4,5 TMT motion

• Motion of other joints not essential for function
Treatment Principles

- Hindfoot: Protect ankle, subtalar, and talonavicular joints
- Midfoot: restore length and alignment of medial and lateral “columns”
- Forefoot: Even weight distribution across metatarsal heads

• GOAL IS A STABLE, PLANTIGRADE FOOT
Management

- **Nonoperative**
  - Rule out instability
  - Negative stress imaging
  - *Examine under anesthesia if necessary*
  - Short leg cast or boot, NWB x 6-8 weeks
Management

- **Operative**
  - Multiple base fractures
  - Articular displacement
  - Static instability
  - Dynamic instability
    (How much?)
Initial Management

- Closed reduction
  - Minimize risk of skin compromise
- Provisional Fixation
  - Indications:
    - Inability to maintain reduction
    - High energy patterns
    - Multiply injured patient
  - Ex-Fix
  - Percutaneous screws or wires

Kadow TR, Siska PA, Evans AR, Sands SS, Tarkin IS. Staged treatment of high energy midfoot fracture dislocations. Foot Ankle Int. 2014 Dec;35(12):1287-91
Initial Management
Courtesy of John Anderson, MD
Compartment syndrome

- Highest incidence with forefoot crush
- Consider compartment pressure measurement
- Treatment is controversial
- Calcaneal compartment communicates with deep posterior compartment of leg

Definitive Management is Controversial

**ORIF**
- Joint preserving surgery
- Hard to make the multiple fractures and a fusion heal
- Better than previous treatments (K-wires/cast)
- Established treatment with reasonable outcomes

**Primary Arthrodesis**
- Medial and intermediate columns are rigid
  - Fusion restores FUNCTIONAL anatomy
- Lateral column is mobile
  - Preserve if at all possible
- One operation
- Fusion after failed ORIF is technically difficult
  - With worse outcomes
- High rates of arthritis despite ORIF
The Problem

They are not the same in any way
...Like comparing Apples to Elephants

These are both midfoot injuries
These are both ankle injuries
The Problem

• Heterogeneity
  • High energy midfoot crush injury will have a different outcome than low energy midfoot sprain regardless of surgical treatment
  • Both injuries are grouped under the umbrella of “Lisfranc injuries”
OUTCOMES
Kuo et al, JBJS 2000

- 48 patients – 55 month followup
  - AOFAS score 77
  - 12 post-traumatic OA (6 fusion)
    - 6 of 15 with ligamentous injury*
  - Better results with anatomic reduction
58 patients (29 ligamentous vs 29 osseous)
   – All treated with ORIF
No significant difference in AOFAS Midfoot score, FFI, SF 36
Authors relate their improved results to longer immobilization (3 months vs 2 months) and the use of an arch support...
   – “The formation of solid and reliable SCAR after ligamentous Lisfranc likely takes longer…”
Clinical Outcomes and Development of Symptomatic Osteoarthritis 2 to 24 Years After Surgical Treatment of Tarsometatarsal Joint Complex Injuries

Victor Dubois-Ferrière, MD, Anne Lübbeke, MD, DSc, Ashwin Chowdhary, MS, Richard Stern, MD, Dennis Dominguez, MD, and Mathieu Assal, MD

• 61 patients at mean of 10.9 years
  – 50 ORIF (82%) and 11 PA (18%)
• 72% radiographic arthritis
• 54% clinically symptomatic arthritis
  – 33 of 61 patients
  • Should this be 33 of 50 (66%)??
• Worse functional outcomes with arthritis
Primary Arthrodesis (PA) vs ORIF

Treatment of Primarily Ligamentous Lisfranc Joint Injuries: Primary Arthrodesis Compared with Open Reduction and Internal Fixation

A Prospective, Randomized Study

By Thuan V. Ly, MD, and J. Chris Coetzee, MD, FRCSC
PA vs ORIF
Ly and Coetzee, JBJS 2006

• Level I, Prospective randomized
• 41 patients (21 ORIF, 20 PA), 2 year followup
• All results in favor of PA
  – AOFAS Midfoot, Patient function
• ORIF group
  – 15 of 21 ORIF with radiographic arthritis
  – 5 of 21 converted to arthrodesis
    • 2 more scheduled for fusion at time of publication
Operative Technique

- Dorsomedial incision between 1st and 2nd TMT joints
  - *Superficial peroneal nerve
  - Lateral to EHL
  - NV bundle lateral to EHB
- Visualize:
  - 1st TMT joint, 2nd TMT joint, IC joint
Exposure: Dorsomedial

Superficial peroneal nerve branches

1st TMT joint  2nd TMT joint
Exposure: Dorsolateral

• Dorsolateral incision in line with 4\textsuperscript{th} ray
  • Check under fluoro
  • AVOID NARROW SKIN BRIDGE
  • Visualize:
    • Lateral aspect of 2\textsuperscript{nd} TMT, 3\textsuperscript{rd}/4\textsuperscript{th} TMT, Lateral IC joint
Sequence of Reduction

- Start medial/proximal
- Work lateral/distal

Intercuneiform Joint

First TMT joint

2\textsuperscript{nd} metatarsal base in “keystone”

Third TMT joint, etc…

DISCLAIMER: This is just one approach to the sequence of reduction. This is not the only way it can be done.
Fixation
Fixation

- Rigid Fixation for rigid joints
  - 1\textsuperscript{st}/2\textsuperscript{nd}/3\textsuperscript{rd} TMT joints
  - 4.0/3.5/2.7 solid screws
- Flexible fixation for mobile joints
  - 4\textsuperscript{th}/5\textsuperscript{th} TMT joints
  - K wires
Fixation: ORIF

- For open reduction and internal fixation screws are placed in positional mode
- Maintain alignment
  - No compression
Fixation: Arthrodesis

• For arthrodesis screws are placed in lag mode

• Generate compression to assist with fusion
Closure
Case Examples
Case Example # 1
Fixation for Case #1
Follow up
Follow up
Case example #2
Bridge plating to maintain length
Schildhauer TA, Nork SE, Sangeorzan BJ. Temporary bridge plating of the medial column in severe midfoot injuries. J Orthop Trauma. 2003
Case Example # 3: Plate fixation for comminution
Post reduction

Unable to maintain closed reduction
Note the flexible fixation of the lateral column
Follow Up
Associated Injuries: Cuboid Fracture

• Abduction force
  • Compressive failure
• “Nutcracker” fracture
• Indications for ORIF
  • Articular displacement
    • 2mm?
  • Lateral column shortening
• Complex fractures/significant shortening
  • Consider bridge plate or external fixator
Cuboid Fracture

Simple patterns can be treated with direct reduction and fixation.
Cuboid Fractures: Bridge Plating
Cuboid Fractures: Bridge plate
Indications for Fusion of Lisfranc Injuries

- Ligamentous injuries with multiplanar instability
- Multiple joint dislocations or fracture dislocations
- Intra-articular comminution

Recommend Reading: Coetzee JC. Making sense of lisfranc injuries. Foot Ankle Clin. 2008 Dec;13(4):695-704,
Objectives (Again)

Understand

1. Functional anatomy of the midfoot
2. Stress imaging
3. Goals of treatment
4. Indications for operative treatment
5. Primary Arthrodesis versus ORIF
Summary

- Complex injuries with historically poor outcomes
- Do not miss subtle injuries
- Arthrodesis vs. ORIF – still controversial
- Arthrodesis is not a panacea
  - Long term outcomes?
  - Adjacent joint arthritis?
- Goal → Stable, plantigrade foot
References

- Panchbhavi et al. Three-dimensional, digital, and gross anatomy of the Lisfranc ligament. Foot Ankle Int. 2013
- Schildhauer et al. Ligamentous Structure of the midfoot. In: Bucholz et al., editors. Rockwood and Green’s fractures in adults. 8th ed
- Reid JJ, Early JS. Osseous anatomy of the midfoot. In: Bucholz et al., editors. Rockwood and Green’s fractures in adults. 7th ed
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- Schildhauer TA, Nork SE, Sangeorzan BJ. Temporary bridge plating of the medial column in severe midfoot injuries. J Orthop Trauma. 2003