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.

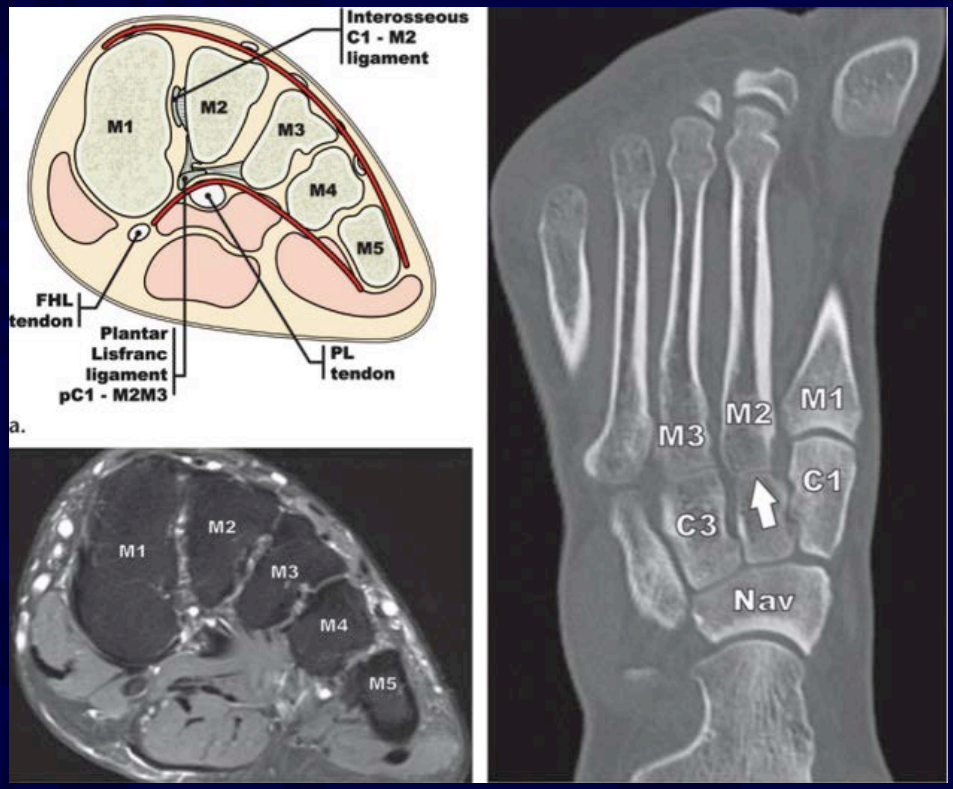
Acknowledgement to Dr. Matt Graves for this concept

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

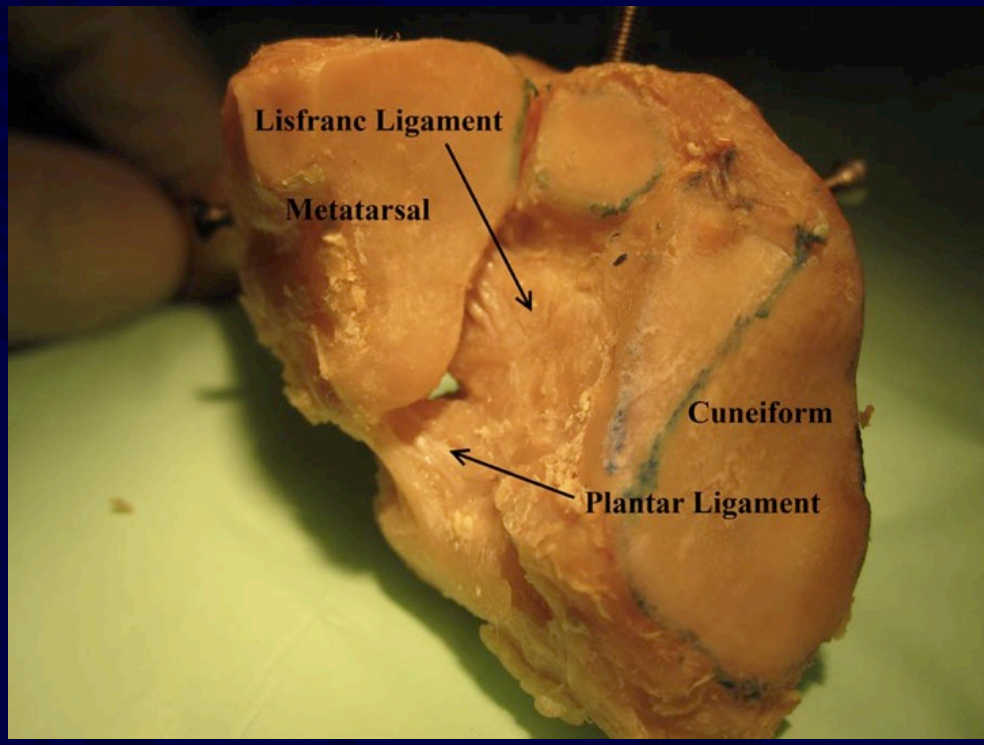
- Trapezoidal configuration
- ***Recessed 2nd Tarsometatarsal (TMT) joint**
  - **"keystone" of the transverse arch***
- Individual joints are "flat on flat"



Siddiqui et al. Evaluation of the tarsometatarsal joint using conventional radiography, CT, and MR imaging. Radiographics. 2014

Anatomy

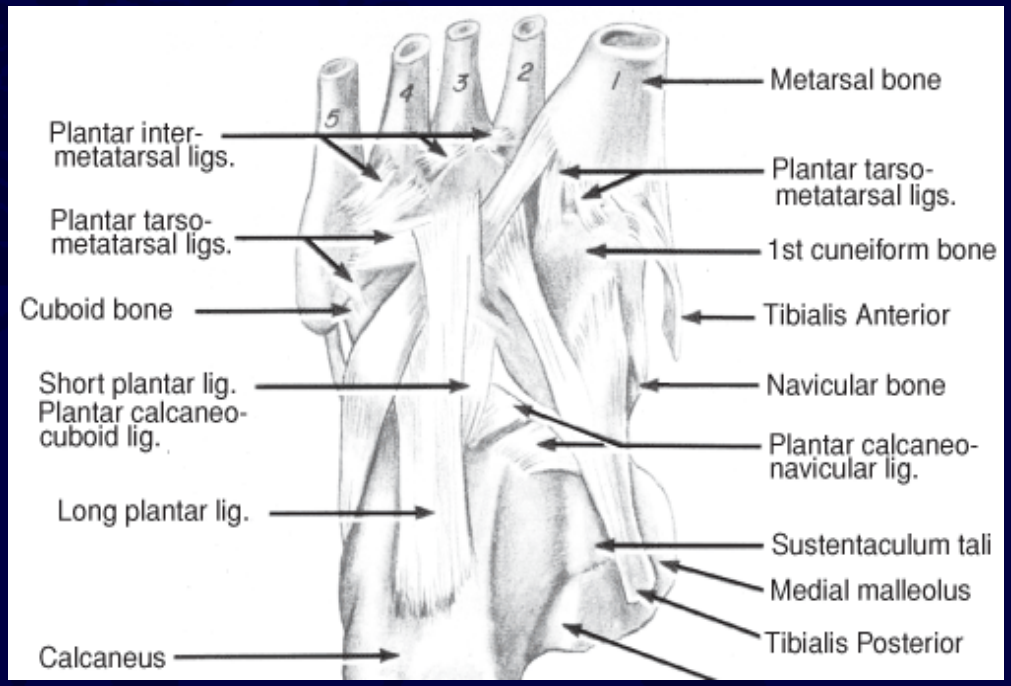
- Transverse Intermetatarsal ligaments secure M2-M5
- ***No intermetatarsal ligament between M1-M2***
- ***Interosseous C1-M2 ligament = Lisfranc ligament***
- Plantar ligaments stronger than dorsal ligaments



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

Functional Anatomy

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

Functional Anatomy

Column Theory

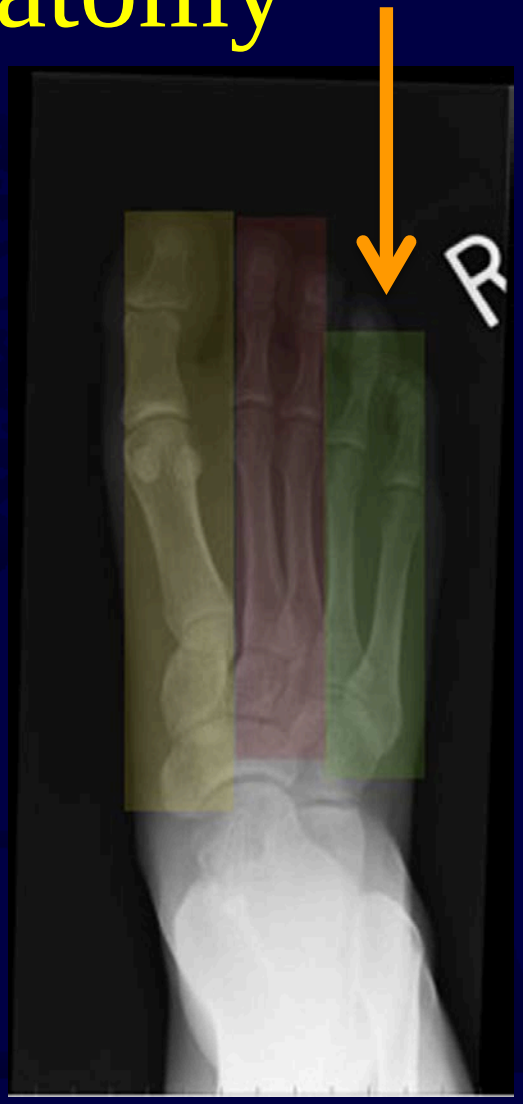
- Intermediate column (Red)
  - 2nd , 3rd TMT joints and NC joints
  - Rigid (no motion)

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

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 1st and 2nd metatarsal bases
  - Lateral base 1st MT in-line with lateral aspect of medial cuneiform
  - Medial base 2nd MT in-line with medial aspect of middle cuneiform

Imaging

- 30 degree 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

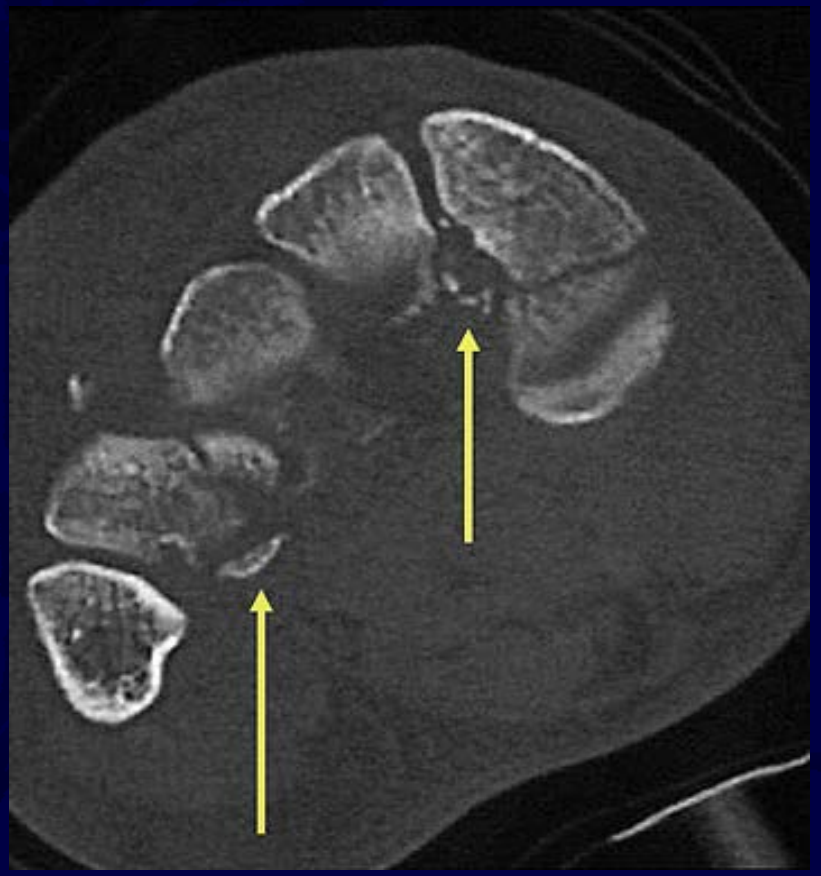
Lateral: A metatarsal should never be more dorsal than its respective tarsal bone

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

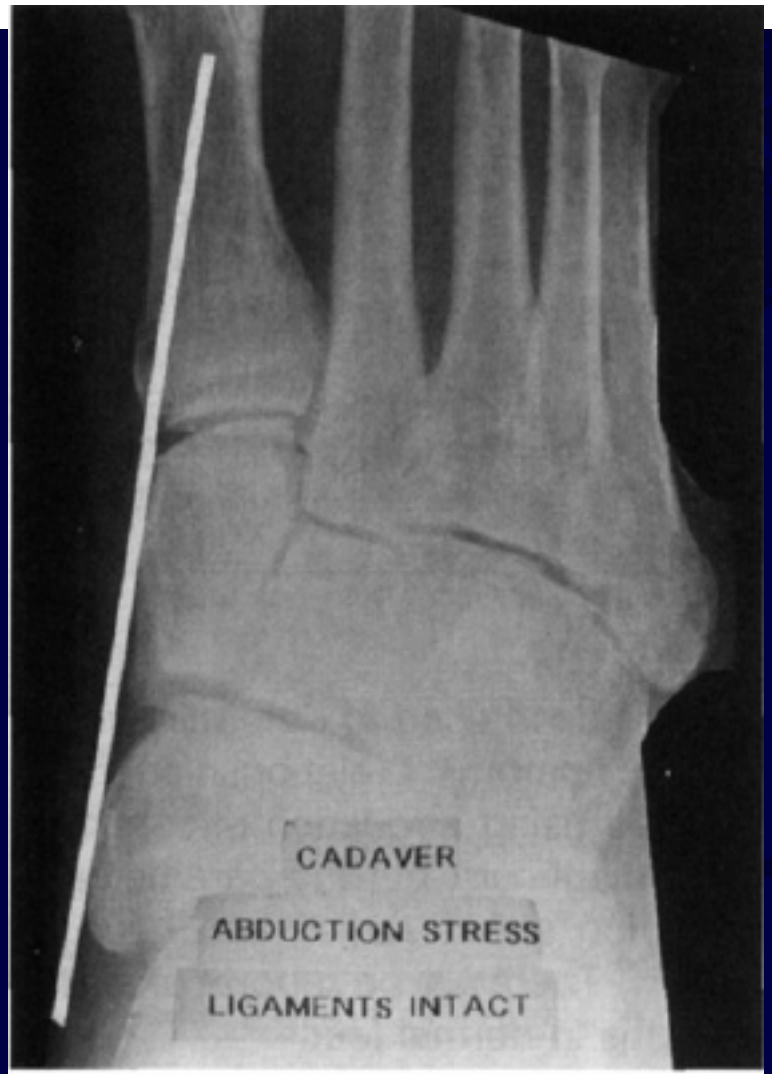
- MRI
  - Ligamentous injury
  - *Plantar Oblique Ligament*
    - Disruption is predictive of instability on EUA
    - Raikin et al, JBJS 2009
  - ***Not dynamic!***
    - Does not demonstrate how foot tolerates physiologic load

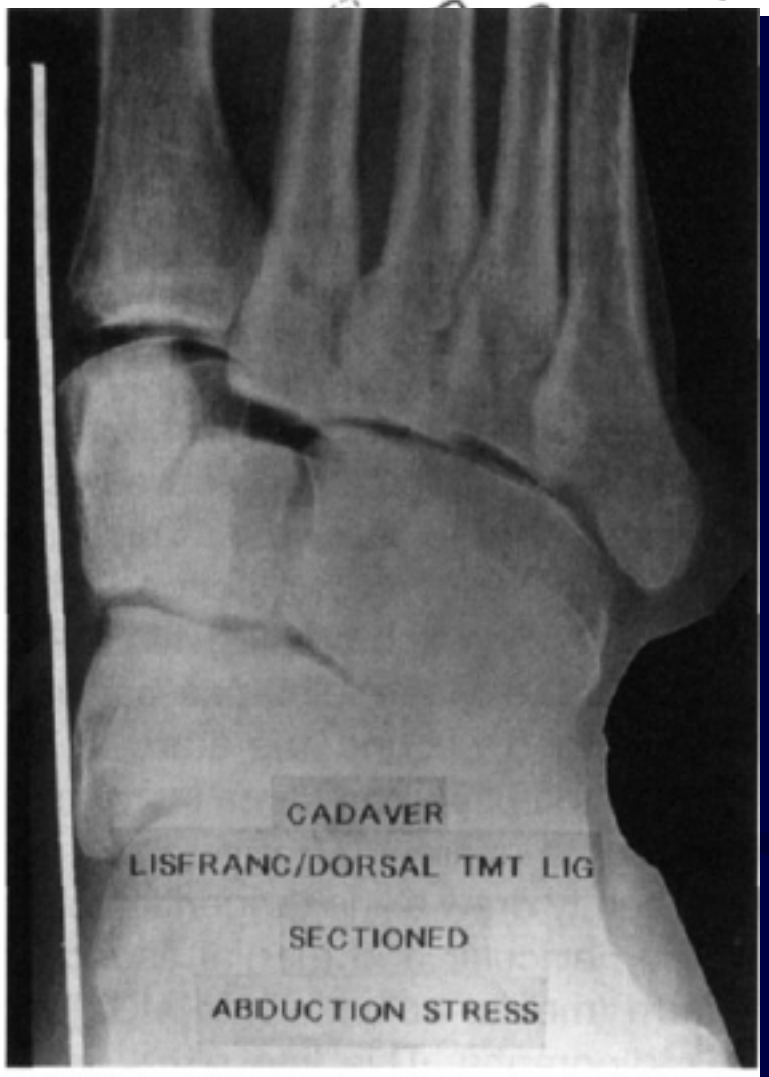
Stress Imaging

- 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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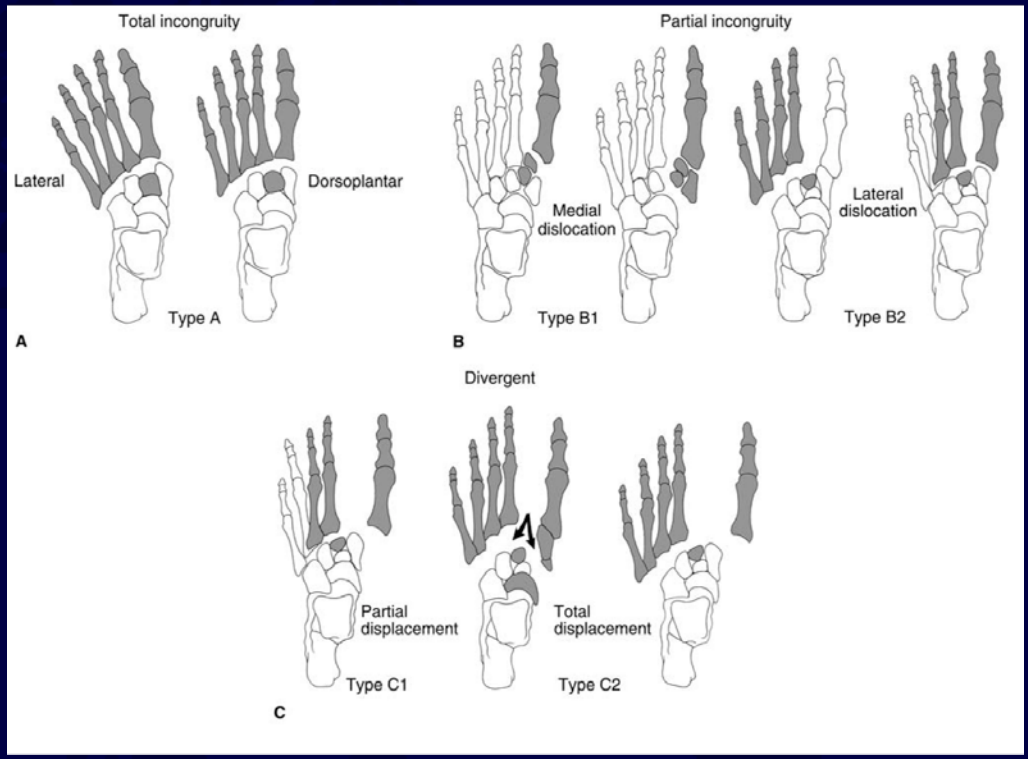
Classification

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



Watson TS, Shurnas PS, Denker J. Treatment of Lisfranc joint injury: current concepts. J Am Acad Orthop Surg. 2010 Dec;18(12):718-28.

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

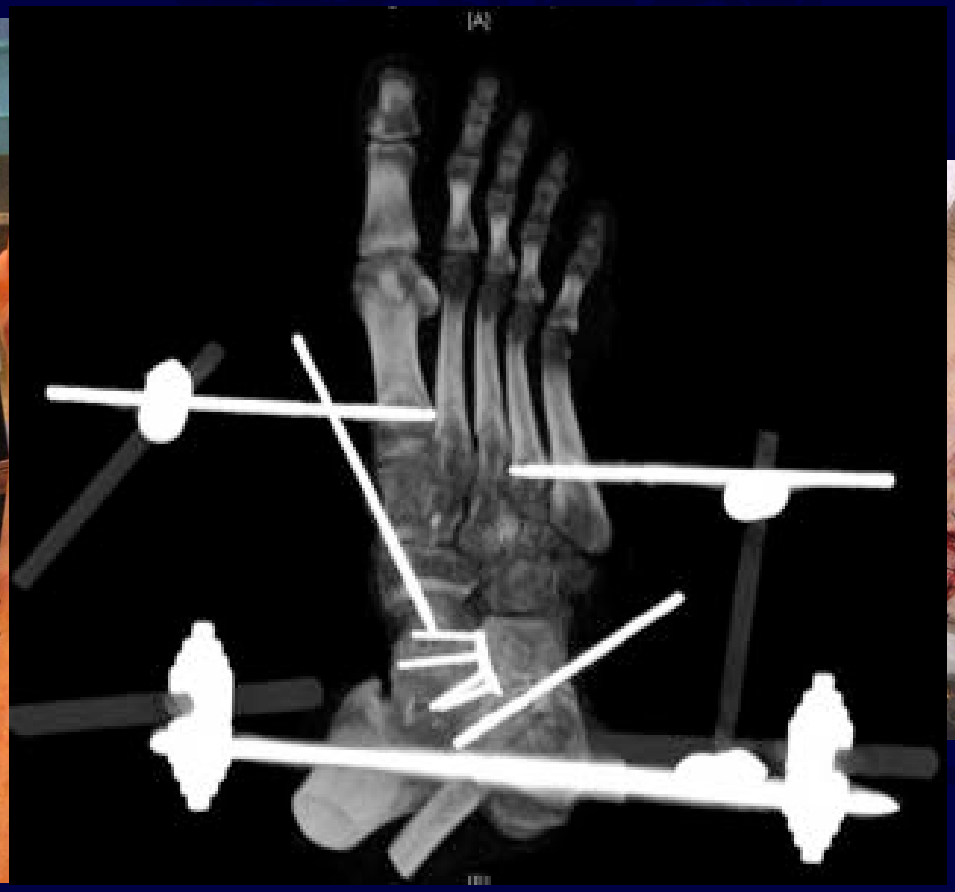
- **Operative**
  - Multiple base fractures
  - Articular displacement
  - Static instability
  - Dynamic instability (How much?)

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

Thakur NA, McDonnell M, Got CJ, Arcand N, Spratt KF, DiGiovanni CW. Injury patterns causing isolated foot compartment syndrome. J Bone Joint Surg Am. 2012 Jun 6;94(11):1030-5

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

Outcome After Open Reduction and Internal Fixation of Lisfranc Joint Injuries*

BY R. S. KUO, M.B.B.S., F.R.A.C.S.†, N. C. TEJWANI, M.D.‡, C. W. DIGIOVANNI, M.D.§, S. K. HOLT, M.S.P.H.#, S. K. BENIRSCHKE, M.D.#, S. T. HANSEN, JR., M.D.#, AND B. J. SANGEORZAN, M.D.#

Investigation performed at the Department of Orthopaedics, Harborview Medical Center, Seattle, Washington

- 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

Temporary Internal Fixation for Ligamentous and Osseous Lisfranc Injuries: Outcome and Technical Tip

Foot & Ankle International®
2015, Vol. 36(8) 976–983

DOI: 10.1177/1071100715577787
fai.sagepub.com

Mohammad Reza Abbasian, MD[1], Felix Paradies, MD[1], Martin Weber, MD[2], and Fabian Krause, MD[1]

- 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**

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VOLUME 98-A · NUMBER 9 · MAY 4, 2016

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

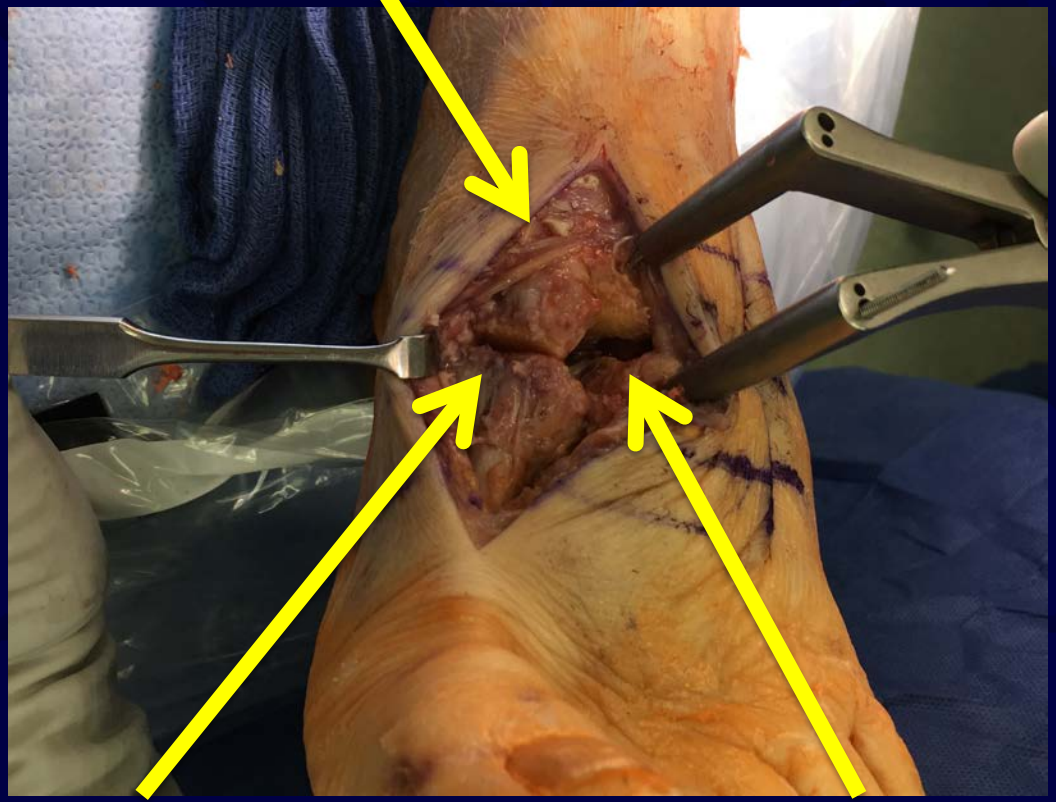
- Level I, Prospective randomized
- 41 patients (21 ORIF, 20 PA), 2 year followup
- All results in favor of PA
  - AOFAS Midfoot, Patient function
- ORIF group
  - 15 of 21 ORIF with radiographic arthritis
  - 5 of 21 converted to arthrodesis
    - 2 more scheduled for fusion at time of publication

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 4th ray
  - Check under fluoro
  - AVOID NARROW SKIN BRIDGE
  - Visualize:
    - Lateral aspect of 2nd TMT, 3rd/4th TMT, Lateral IC joint

Sequence of Reduction

- Start medial/proximal
- Work lateral/distal

Intercuneiform Joint

⬇

First TMT joint

⬇

2nd 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
  - 1st/2nd/3rd TMT joints
  - 4.0/3.5/2.7 solid screws
- Flexible fixation for mobile joints
  - 4th/5th 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

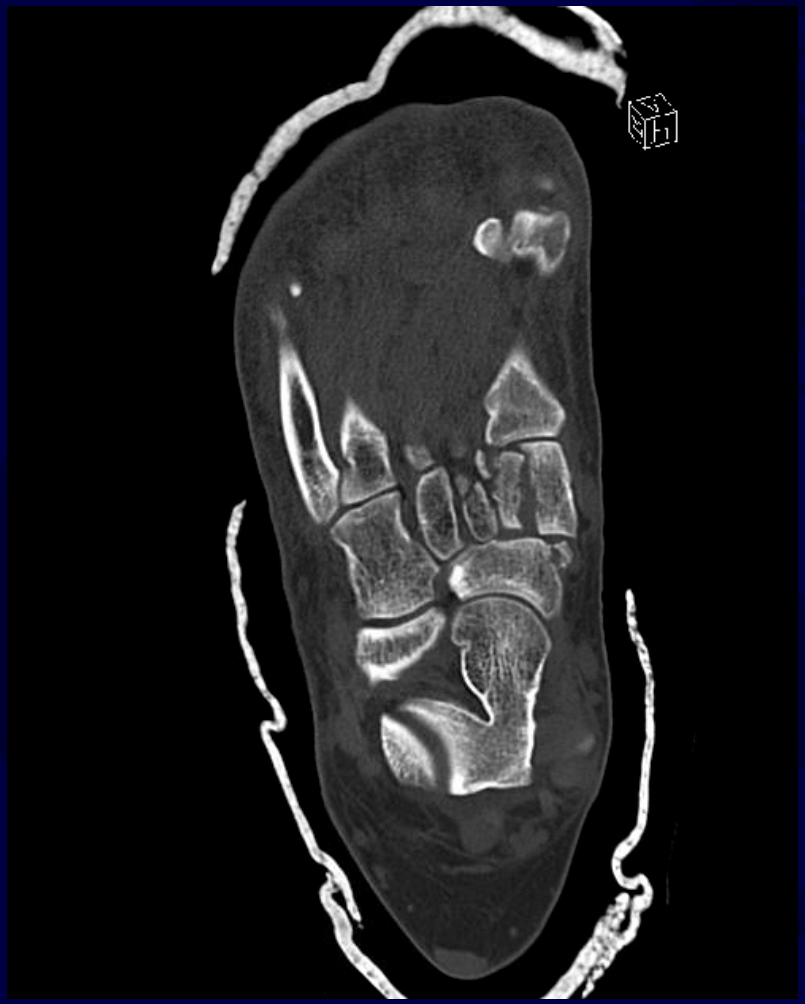
Case Example # 1

Fixation for Case #1

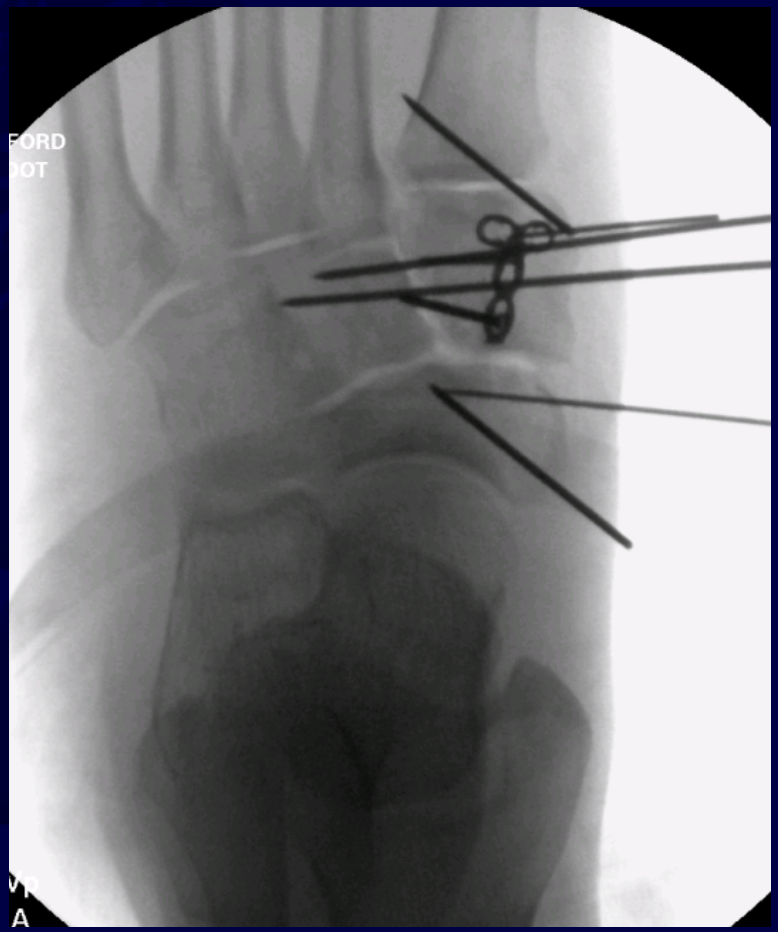
Follow up

Follow up

Case example # 2
Bridge plating to maintain length



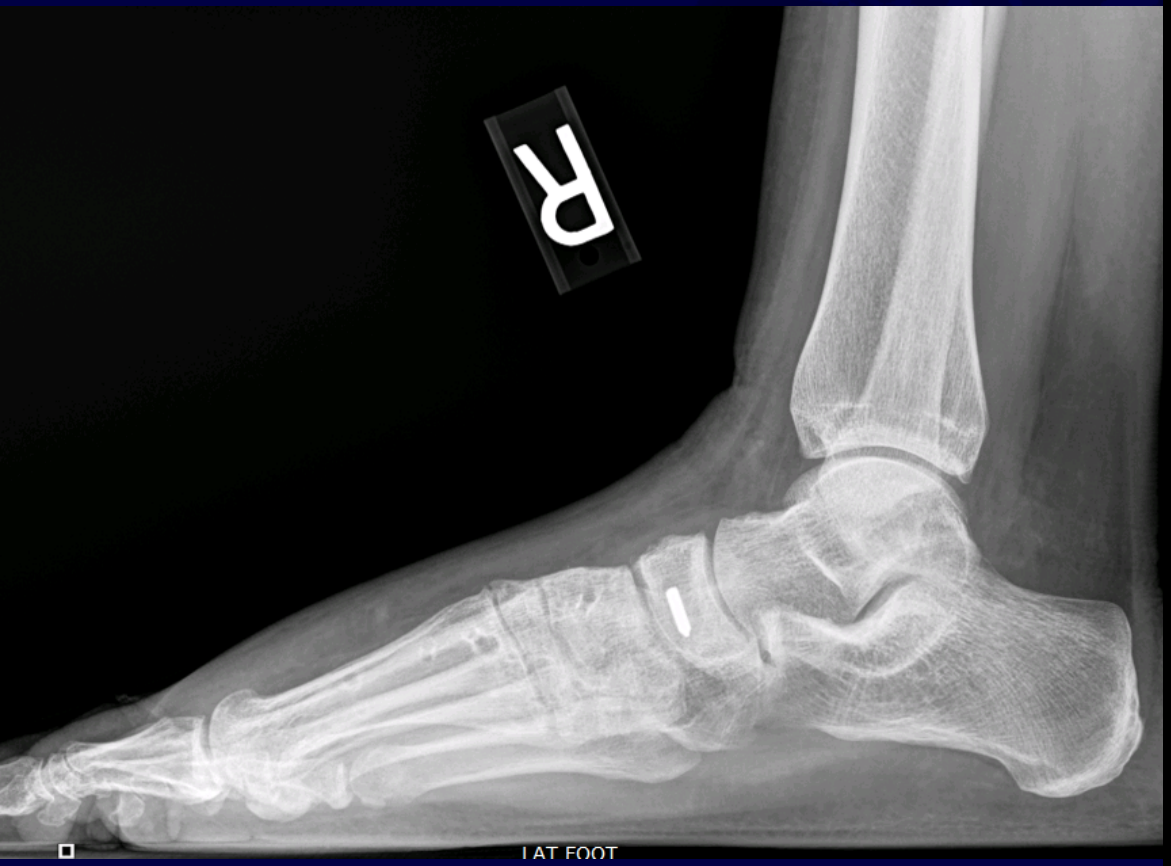
ORIF



Bridge plate to maintain medial column

Schildhauer TA, Nork SE, Sangeorzan BJ. Temporary bridge plating of the medial column in severe midfoot injuries. J Orthop Trauma. 2003

Follow up



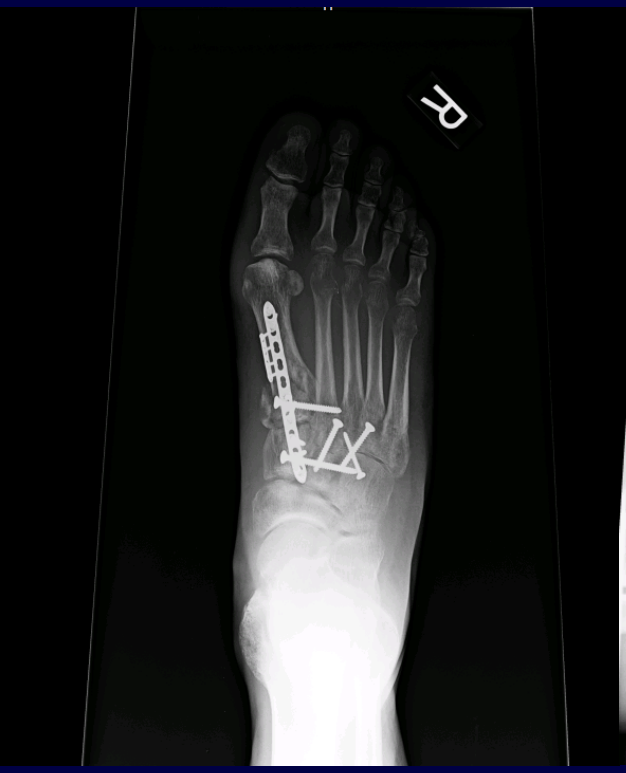
Case Example # 3: Plate fixation for comminution

Post reduction

Unable to maintain closed reduction

Note the flexible fixation of the lateral column

Follow Up



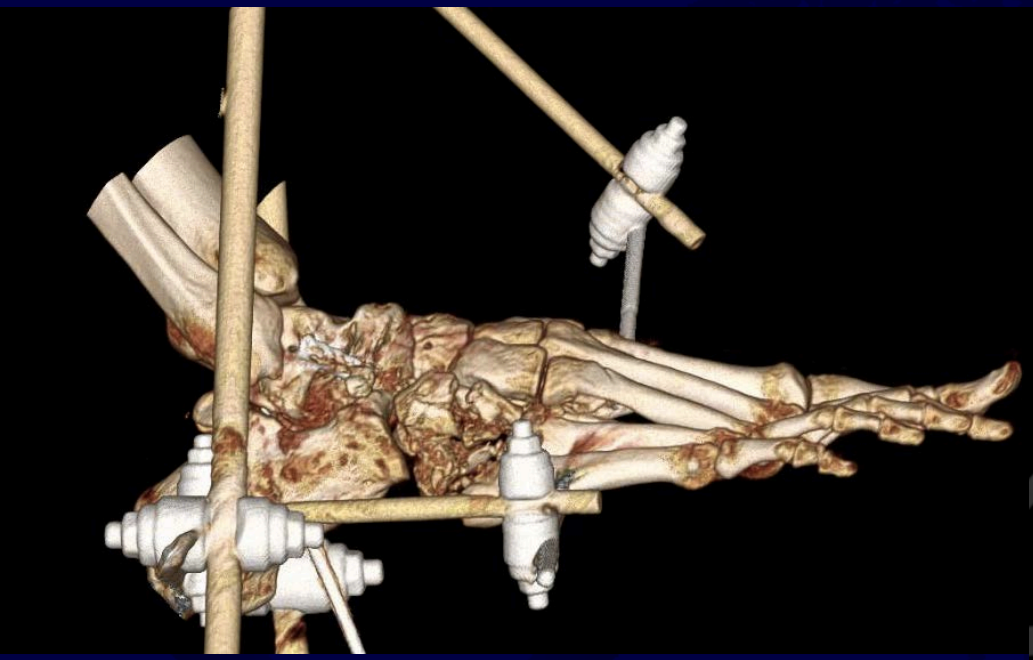
Associated Injuries: Cuboid Fracture

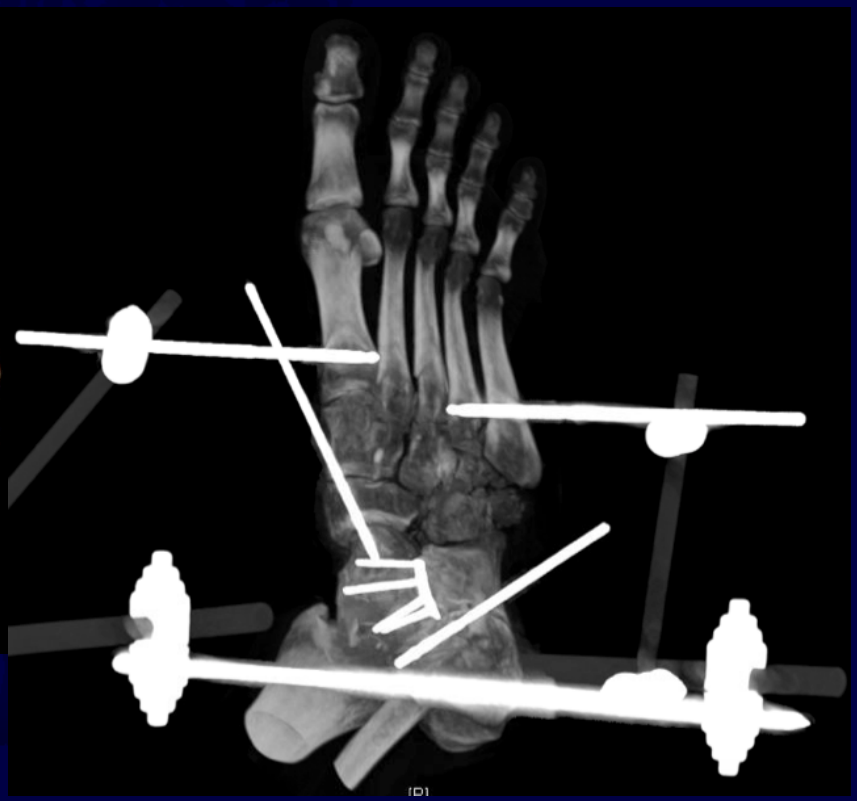
- Abduction force
  - Compressive failure
- “Nutcracker” fracture
- Indications for ORIF
  - Articular displacement
    - 2mm?
  - Lateral column shortening
- Complex fractures/significant shortening
  - Consider bridge plate or external fixator

Cuboid Fracture

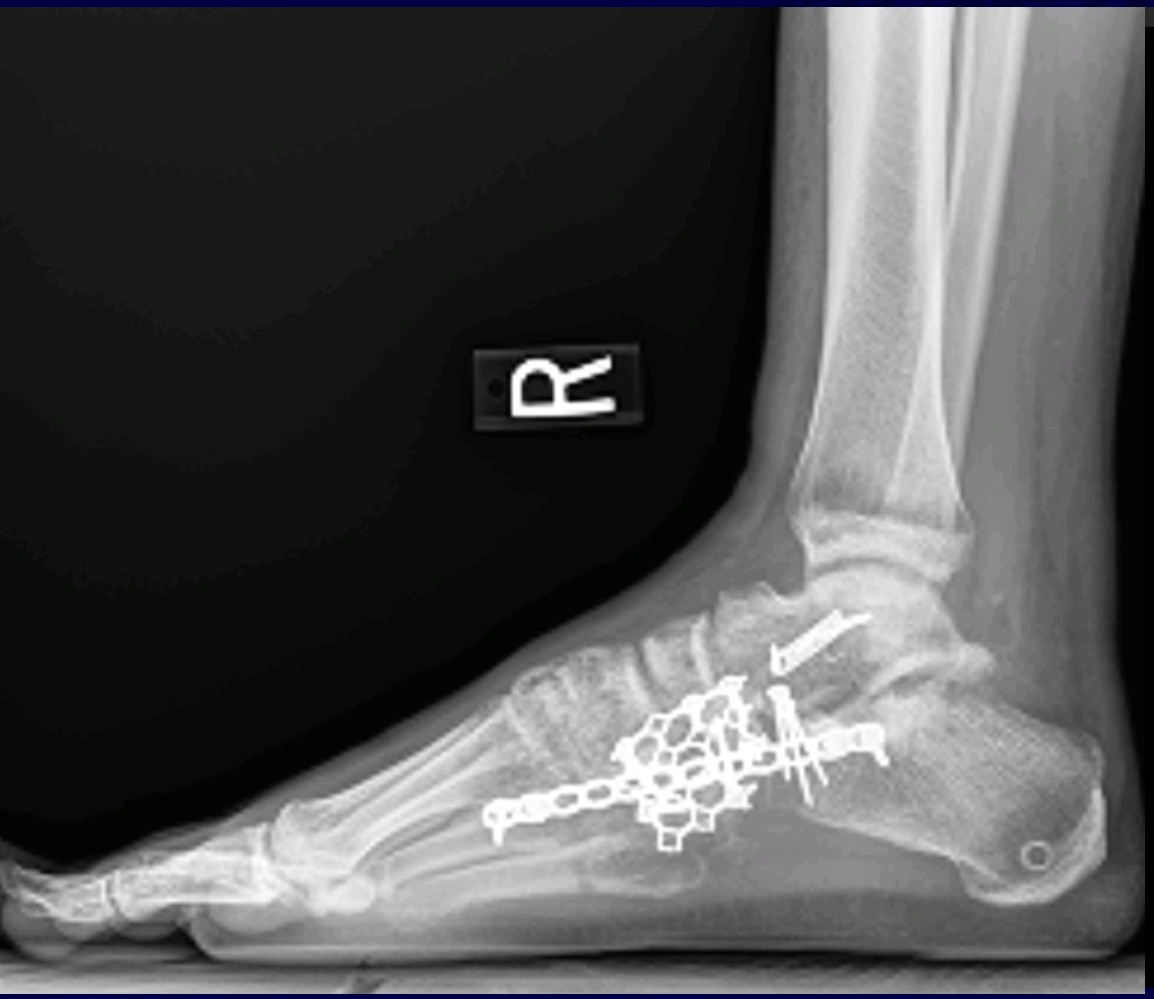
Simple patterns can be treated with direct reduction and fixation

Cuboid Fractures: Bridge Plating

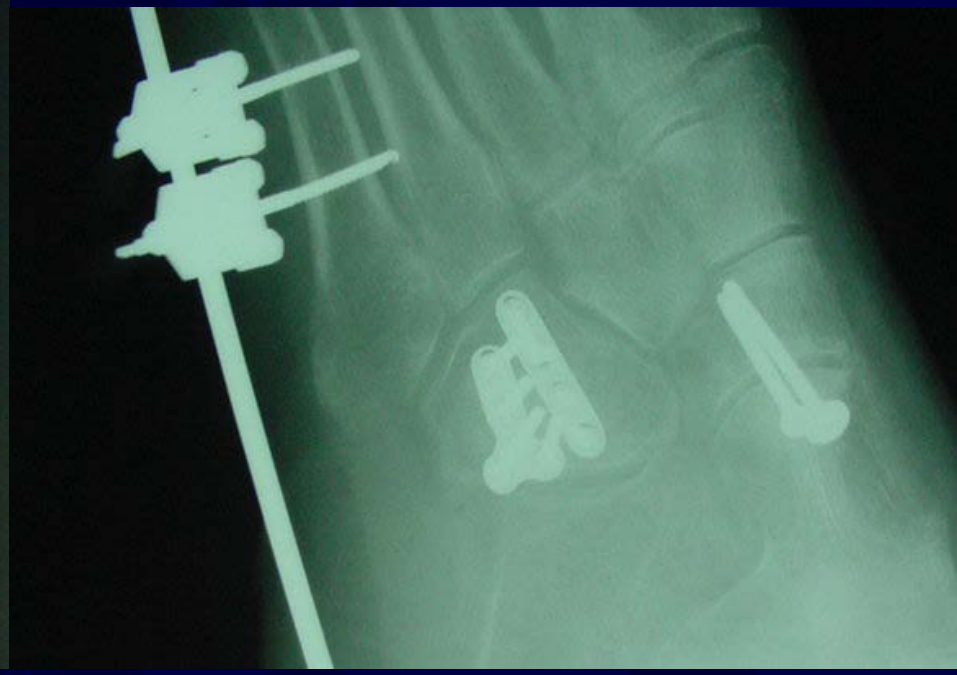




Cuboid Fractures: Bridge plate



Cuboid Fractures: Ex-Fix
Courtesy of John Anderson, MD



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

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