Lisfranc Injuries

Omar Qureshi
6.25.2015
37 year old female
Rule out stress fracture
Lisfranc Fractures/Injuries

• Prevalence
  – 0.2% of all fx
  – 1/55000
  – 2 to 3 times more common in males

• Poor long-term prognosis
  – Inadequate or inappropriate Rx
  – Delayed or initially missed dx
  – Chronic pain, instability, arthritis, deformity
Litigious Joint?

- ~20% missed initially (Goossens and De Stoop)

- Gupta (2008): “one of the most common reasons for malpractice lawsuits against radiologists and emergency medicine physicians”

- Calder and Saxby (2003)
  - Over 50% of patients with Lisfranc had pursued legal claims by 2 years after initial injury
  - Many patients with poor outcomes
Jacques Lisfranc de Saint Martin

- French surgeon and gynecologist
- 1787–1847
- Removal of rectal carcinoma
- Female lithotomy
- Amputation of cervix uteri
Napoleonic’s Surgeon

- Studied medicine in Lyon and Paris
- Assistant to Guillaume Dupuytren*
- War of Sixth Coalition, 1815
- Stirrup injuries and amputations
Lisfranc Joint Complex

• Complex polyarticular system
  – Tarsometatarsal
  – Intertarsal
  – Intermetatarsal

• Capsules

• Ligaments

• Tendons and expansion

• Bones
Anatomy

Lisfranc Joint Ligamentous Complex: MRI With Anatomic Correlation in Cadavers
Miguel Castro1, Lina Melão1 2, Clarissa Canella2, Marcio Weber2, Pedro Negrão3, Debra Trudell2 and Donald Resnick2

- TMT = tarsometatarsal
- C1 = medial cuneiform
- C2 = intermediate cuneiform
- C3 = lateral cuneiform
- Cu = cuboid
- M1, M2, M3, M4, M5 = corresponding metatarsals
- p = plantar
- d = dorsal
Capsules

• 3 capsules \(\rightarrow\) 3 articular compartments
  – Medial
    • C1-M1
  – Central
    • C2-M2, C3-M3, C1-C2, C2-C3, M2-M3, C3-M2, C3-M4
    • Communicates with cuneonavicular joint
  – Lateral
    • Cu-M4/M5, M4-M5
Ligaments

• Dorsal TMT
• Interosseous TMT
  – Thicker and more prominent; stronger (?)
  – Signal: low (50%); intermediate (50%)
  – Homogenous (60%); striated (40%)
• Plantar TMT
• Intermetatarsal
• Intertarsal
Dorsal Ligaments

- Short and flat
- Ribbon-shaped
- Weakest
Lisfranc Ligament (C1-M2)

- Aka medial or 1st interosseous (cuneometatarsal) ligament; some literature dC1-M2*
- Lateral surface of C1 – inferomedial M2
- Largest; 8-10mm long and 5-6mm thick
- May have superior and inferior bundles

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2\textsuperscript{nd} Interosseous Cuneometatarsal Ligament

- Aka central, middle, intermediate interosseous ligament
- Between C2-C3 and M2-M3
- MRI – if present, always visible on coronal sequences
- Configuration best on axial and transverse oblique
Absent 2\textsuperscript{nd} Interosseous Cuneometatarsal Ligament
3rd Interosseous Ligament

- Aka lateral

Castro et al
Plantar Ligaments

- **2\textsuperscript{nd} plantar ligament (pC1-M2M3) aka plantar Lisfranc ligament**
- **Arises inferolateral C1**
- **Proximal and deep to peroneus longus tendon**
- **Oblique course, laterally and distally**
- **Splits**
  - Deep (superior) component M2
  - Superficial component M3
Plantar Lisfranc Ligament

Castro et al
Tarsal and metatarsal interosseous ligaments

*No M1-M2

Castro et al
Secondary Stabilizers

• Tendinous insertions
  – Peroneus longus
  – Tibialis anterior
  – Tibialis posterior
• Intrinsic muscles
• Plantar ligaments
• Plantar fascia
Keystone Concept

- 2\textsuperscript{nd} metatarsal wedged into cuneiforms
- Weak link, prone to injury
- Shallow recess
Normal 3-Column Anatomy

- Medial – rigid
- Middle – most rigid
- Lateral - mobile
Neurovascular Considerations

- Medial branch of the deep peroneal nerve (M1-M2)
- Perforating branch of dorsalis pedis artery (M1-M2)
- Compartment syndromes
- Arthropathy
Deep Peroneal Nerve

- Divides at midfoot
- Sensory medial branch
  - First interspace
- Sensorimotor lateral branch
  - EHB
  - EDB
- Acute injury $\rightarrow$ muscle edema
- Chronic injury $\rightarrow$ muscle atrophy
- Deep to the EHB myotendinous junction
Injury Mechanisms

High Impact vs Low Impact
High Impact (67%)

- Direct forces
- MVAs
  - Floorboard impact
- Falls from height
- Industrial accidents
- Crush type mechanism
- Plantar or dorsal displacement of metatarsals
Low Impact Midfoot Sprains (33%)

- Indirect forces
- Sports-related
- Dorsal displacement of metatarsals
- Forefoot abduction
- Forced plantarflexion
- Transverse vs longitudinal instability (Kaar)
Forefoot Abduction

- Fixed hindfoot
- Weight of body rotates around TMT joint
- Ligament failure
- Lateral displacement of lesser metatarsals
- Horse stirrup
- Sailborders
- Planted cleated foot with sudden rotational change
Nutcracker Fracture

Forced external rotation
Forced Plantarflexion

- Forefoot rigidly planted in plantar-flexed position (toes extended)
- Axial force applied through metatarsals in a longitudinal axis
- Compressive force through TMT joint
- Football players
  - Falling body applied to heel of plantar-flexed player whose knee is on ground
- Ballerinas, dancers, gymnasts
- Misstep/fall from curb or stairs
- “Bunk bed” fx
Traditional Diagnosis

- **Imaging**
  - Fx base of M1, M2
  - Step-off at C2-M2 “positive gap sign”
  - Tarsal fractures

- **Clinical**
  - Focal pain
  - Midfoot/forefoot edema
  - Plantar arch ecchymosis
  - Inability to bear weight
21 year old male status post injury
Classification Systems

- Quenü and Küß (high grade)
- Myerson (high grade)
- Nunley-Vertullo (low grade)
Qüenu and Küss

• 1909

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Incongruity</th>
<th>Direction of Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homolateral</td>
<td>Complete</td>
<td>All five metatarsal bases are displaced in the same direction</td>
</tr>
<tr>
<td>Isolated</td>
<td>Partial</td>
<td>Displacement of one or two of the metatarsal bases</td>
</tr>
<tr>
<td>Divergent</td>
<td>Complete</td>
<td>M1 is displaced medially and M2–M5 are displaced laterally</td>
</tr>
</tbody>
</table>

Note.—M = metatarsal.
Fracture-Dislocations

Homolateral

Isolated

Divergent

Siddiqui et al
Isolated

Slipped with abduction force while wearing flip-flops
Divergent

13 year old female, status post trauma
Myerson

- Most common current system
- Not always useful for directing treatment or outcomes

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Subtype</th>
<th>Incongruity</th>
<th>Direction of Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (homolateral complete)</td>
<td>…</td>
<td>Complete</td>
<td>M1–M5 are displaced together in any direction</td>
</tr>
<tr>
<td>B (homolateral incomplete)</td>
<td>1</td>
<td>Partial</td>
<td>Only M1 is medially displaced</td>
</tr>
<tr>
<td>2</td>
<td>Partial</td>
<td>Only M2–M5 are laterally displaced</td>
<td></td>
</tr>
<tr>
<td>C (divergent)</td>
<td>1</td>
<td>Partial</td>
<td>M1 and only some of the lesser metatarsals are displaced in opposite directions</td>
</tr>
<tr>
<td>2</td>
<td>Complete</td>
<td>M1 is displaced in the opposite direction of the lesser metatarsals, which move as a unit</td>
<td></td>
</tr>
</tbody>
</table>

Note.—M = metatarsal.
Myerson B2 (Homolateral Incomplete)
Nunley-Vertullo

Table 3: Nunley-Vertullo Classification of Low-Grade Midfoot Sprains

<table>
<thead>
<tr>
<th>Stage</th>
<th>Clinical Findings</th>
<th>Findings at Weight-bearing Radiography and Bone Scintigraphy</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Low-grade Lisfranc ligament complex sprain</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased radiotracer uptake</td>
</tr>
<tr>
<td>II</td>
<td>Lisfranc ligament insufficiency or disruption; intact plantar ligament</td>
<td>Anteroposterior: 2–5-mm M1-M2 diastasis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lateral: no loss of arch height</td>
</tr>
<tr>
<td>III</td>
<td>Interosseous and plantar Lisfranc ligaments disrupted</td>
<td>Anteroposterior: &gt;5-mm M1-M2 diastasis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lateral: decreased distance between the plantar surfaces of C1 and M5 (loss of arch height)</td>
</tr>
</tbody>
</table>

Note.—C = cuneiform, M = metatarsal.
Loss of Arch Height

C1-M5 relationship

Hawkes et al

Siddiqui et al
IF SURGERY IS BRILLIANT WHEN IT OPERATES,
IT IS MUCH, MUCH MORE WHEN
WITHOUT BLOODSHED
WITHOUT MUTILATION,
IT GETS HEALING THE SICK
Aggressive Surgeon

- Never described fracture-dislocation
- Quick amputation time
- “So obsessive a scalpel-wielder that he lamented the passing of the Napoleonic age when the grenadiers had provided him with so many splendid opportunities for amputations”

*Medical Revolution in France by David Vess*
Imaging Characteristics

- Radiography
- Bone Scintigraphy
- Ultrasonography
- Computed Tomography
- MR Imaging
# Normal Alignment of Tarsal-Metatarsal Joints

<table>
<thead>
<tr>
<th>Metatarsal</th>
<th>AP Projection</th>
<th>Oblique Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td><img src="https://via.placeholder.com/150" alt="AP Projection" /></td>
<td><img src="https://via.placeholder.com/150" alt="Oblique Projection" /></td>
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<tr>
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<td><img src="https://via.placeholder.com/150" alt="AP Projection" /></td>
<td><img src="https://via.placeholder.com/150" alt="Oblique Projection" /></td>
</tr>
</tbody>
</table>

- **1<sup>st</sup> Metatarsal**: Lateral border of 1<sup>st</sup> metatarsal is aligned with lateral border of 1<sup>st</sup> (medial) cuneiform.
- **2<sup>nd</sup> Metatarsal**: Medial border of 2<sup>nd</sup> metatarsal is aligned with medial border of 2<sup>nd</sup> (intermediate) cuneiform.
- **3<sup>rd</sup> Metatarsal**: Medial and lateral borders of the 3<sup>rd</sup> (lateral) cuneiform should align with medial and lateral borders of 3<sup>rd</sup> metatarsal.
- **4<sup>th</sup> Metatarsal**: Medial border of 4<sup>th</sup> metatarsal aligned with medial border of cuboid.
- **5<sup>th</sup> Metatarsal**: Lateral margin of the 5<sup>th</sup> metatarsal can project lateral to cuboid by up to 3mm on oblique.

*On lateral view*: Line drawn along long axis of talus should intersect long axis of 5<sup>th</sup> metatarsal.
X-rays

- Initial workup
- Small chip fx from base of M2 or C1
  - Fleck sign
  - Pathognomonic for high impact injury (90%)
- Cuboid compression fx
- Weightbearing; bilateral feet
  - Limited secondary to pain
- C2-M2 malalignment
Stress Views

• Under anesthesia

• > 2 mm diastasis at M1-M2
  – Abnormal
  – Instability
56 year old male status post fall
Os Intermetatatarseum

- Dorsal foot pain
- Parasthesias in 1st web space
- Compression of medial branch of deep peroneal nerve
- < 2% radiographs
- Bilateral
48 year old male slip and fall

- Medial midfoot pain
- No numbness
- Non weightbearing
Bone Scan

- Low grade injuries
- Nunley and Vertullo (2002): 100% sensitivity for low grade stage I sprains
- Nonspecific
- Supplanted by CT/MR
- Unexplained pain
- Unsuspected (polytrauma)
63 year old with right foot pain

Elgazzar et al
Ultrasound

• Assess dC1-M2
  – 2ndary sign for Lisfranc ligament tear
• Woodward (2007)
  – Non-visualization of dC1-M2
  – C1-M2 > 2.5mm
  – Dynamic widening of C1-M2 with weight-bearing
CT Imaging

• High velocity trauma

• Radiographically occult fx

• Priedler (1999): 50% more metatarsal and 100% more tarsal fx vs radiographs

• Limited use in low-impact injuries
29 year old with injury
MR Imaging

• Low-grade midfoot sprains

• Soft tissue and ligamentous injuries
  – *Frank ligament disruption*
  – *Ligament elongation*
  – *Periligamentous edema*

• Small FOV midfoot/forefoot
MRI-Based Grading Scheme

• None exists

• Nunley-Vertullo
  – Low grade
    • Isolated to dorsal capsule
    • Elongation of interosseous Lisfranc ligament
  – High grade
    • Complete interosseous or plantar Lisfranc ligament disruption
    • Fluid tracking lateral margin M1
Fluid tracking along lateral margin of M1
MacMahon (2008)

- Grade 1
  - Periligamentous edema

- Grade 2
  - Abnormal signal in ligament

- Grade 3
  - Complete disruption of ligament
26 year old with skateboard injury
1\textsuperscript{st} webspace swelling and pain
Raikin Study (2009)

- 21 suspected Lisfranc sprains
- 17 ruptured pC1-M2M3*
- 13 ruptured dC1-M2 (interosseous)
- 3 ruptured pC1-C2
- 18 ruptured pC2-M2
- Fluid along lateral margin of M1
- 9 fractures
- 81% unstable on stress under anesthesia
Raikin Conclusions

• Predictor of instability
  – pC1-M2M3 (94% PPV)

• Not predictors of instability
  – dC1-M2*, pC1-M1, pC2-M2, dC1-C2

• pC2-M2
  – Clinical confounder
  – May result in unnecessary surgery
  – MRI can help differentiate
Kaar Study (2007)

- Cadaver study (10 specimens)
- Instability > 2 mm C1-M2 space
- Disruption of interosseous C1-M2
  - Insufficient to produce instability
- Transverse instability
  - C1-M2 and pC1-M2M3
  - Abduction stress > WB x-rays
- Longitudinal instability
  - C1-M2 and C1-C2
  - Adduction stress > WB x-rays for C1-C2 widening
  - C1-M2 diastasis better seen on fluoroscopy
Stress Maneuvers
Kaar - Additional Conclusions

• Difficult to detect low-energy injuries on WB x-rays
• Absent C1-M2 and pC1-M2M3, WB x-rays actually decreased diastasis at TMTs
  – Tie-rod effect of plantar fascia
  – Dorsal translation of M2 on C2 (transverse)
  – Dorsal translation of C1 on M2/C2 (longitudinal)
Potter (1998)

- Referred to interosseous Lisfranc (C1-M2) as dorsal
- Dorsal weaker than plantar
- Diastasis measured vs contralateral foot
- No MRI if clear diastasis on WB x-rays
- MRI beneficial if x-rays/clinical are equivocal
Lisfranc could not become a professor of the Faculty of Medicine in Paris because of his enmity with Dupuytren.

“The best of surgeons, the worst of men.”

- Pierre-François Percy, chief surgeon to the Grand Armée of Napoléon I
46 year old female with volleyball injury
Therapeutic Algorithm (Raikin)

Fig. 6
Diagnostic and therapeutic algorithm for the treatment of a suspected subtle midfoot Lisfranc ligament complex injury. MRI = magnetic resonance imaging.
Treatment – Low Grade

• N&V Stage I – conservative
  – Non-weightbearing cast 6 wks
  – If pain, removable boot for + 4 wks
  – F/u x-ray in 2 wks for increasing diastasis
  – Risk of OA

• N&V Stage II and III
  – Surgical
  – Anatomic alignment
    • Prevent OA and midfoot collapse
  – Non-weightbearing for 8-12 wks
Closed Reduction

- Fluoroscopy
- Percutaneous screws
- Higher likelihood of failure
  - Entrapped osseous fragments
  - Entrapment of ATT or PLT
ORIF

• Screw fixation of medial and middle TMT joints > Kirschner wires
  – Rigidity
• Removal of hardware
• Hardware failure
• Articular surface damage
• OA
  – 50% radiographic signs; 8% require arthrodesis
• Arthrodesis for comminuted fx
Lateral Column Injuries

- 4\textsuperscript{th} and 5\textsuperscript{th} TMT
  - Reduced: no surgical Rx
  - Not reduced: percutaneous fixation for 6 wks
48 year old professor tripped and fell with persistent forefoot pain
3 month follow up

Brady Huang MD
6 month follow up
• Compression along the Lisfranc ligament

• Allows visualization of Lisfranc joint during healing process

• Eliminates joint damage that occurs with screws and wires

• Preserves joint surfaces and larger surface area for bony fusion
Kuo (2000) - Outcomes

• Best long-term
  – Anatomic reduction
  – Early accurate diagnosis
  – Prompt treatment

• Purely ligamentous injuries worse prognosis

• Posttraumatic arthritis: non-anatomic > anatomic reduction
Recommendations

• High index of suspicion

• Cross-sectional imaging
  – Limitations of radiographs

• Be consistent with anatomy
References

17. http://radiology.bidmc.harvard.edu/LearningLab/musculo/cvietanovich2.pdf