Musculoskeletal Consequence of Uncontrolled Diabetes: A Case of Charcot Foot

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Patient Presentation

• 62 year-old obese female presents with increased pain, swelling, erythema and purulent exudate x1 week from R foot.
• Swelling has increased significantly over two weeks, with pain becoming unbearable 3 days prior to admission; no radiation and multiple foci, 7/10, worse with movement
• Subjective fevers and chills, temperature not measured
• PMH significant for uncontrolled type 2 diabetes complicated by significant neuropathy and Charcot foot
• 6 weeks prior to admission had reconstructive surgery with and placement external fixator
• 4 falls in rehab since surgery; has just completed 5 week course of vancomycin given after infectious complications after surgery
• Uses walker; no weight-bearing R foot since 1/2011
Physical Exam – significant findings

- **Vitals:** T 100.6 deg. F
- **RLE:** warm, erythematous below knee, markedly edematous with 4+ non-pitting edema, external fixator pins in place with sanguinous and purulent exudate particularly around most distal and lateral pins; skin is cracked and peeling; notable 4cm superficial ulcer with central eschar ball of R foot laterally
- **Neuro:** loss of light touch and vibratory sense LLE up to knee

**Appearance of Foot:**
*Note, these pictures are merely representations of how patient’s R foot appeared. They are not of this patient specifically. Bottom R image shows device that was over foot.*
Agenda

Part 1 – Neuropathic Arthropathy (aka Charcot’s Foot/Joint)
• Review foot anatomy
• Approach to evaluating foot radiograph
• Introduction to neuropathic arthropathy
• Assessment of patient’s radiographs prior to surgical intervention

Part 2 – Osteomyelitis in the setting of Charcot and surgery
• Defining osteomyelitis; clinical signs
• Radiographic evaluation of osteomyelitis: modalities and utility
• Reassessment of patient’s radiographs at time of presentations
Foot Anatomy: Bones

From imagerradiology.blogspot.com/

From http://www.podcare.com/foot-anatomy.html
Anatomic Zones of the Foot

3 Anatomic Zones
1. **Hindfoot** = talus, calcaneous
   → *Chopart’s joint* (talnoavicular + calcaneocuboid joints)
2. **Midfoot** = remaining tarsal bones
   → *Lisfranc joint* (tarsometatarsal joint)
3. **Forefoot** = metatarsals, phalanges

*From Britannica.com*
Plain Film Evaluation of Foot

1. Views: AP + lateral (wt-bearing, if possible)
   a. Supplemental: internal + external oblique
      *(tarsals and metartarsals in arch and so an AP has overlap)*

2. Evaluate soft tissues and osseous alignment
   a. Soft tissue changes suggests underlying osseous pathology and can help focus interpreter
   b. Metatarsal *Mis*alignment – should be mostly *parallel* in orientation (allow for some congenital differences)
Step-wise Radiographic Evaluation of the Foot

1. Ankle joint 3-4mm width
2. Medial clear space 3-4mm
3. Lateral clear space 5mm
4. Tibiofibular syndesmosis should have slight overlap
5. Soft-tissue swelling
6. Ankle effusion
7. Pre-Achilles triangle or Kager fat pad
8. OCD: talus, tibial plafond, navicular
9. Subtalar jt (calcaneonavicular coalition – anteater nose sign; talocalcaneal coalition Complete C-sign)
10. Anterior process calcaneus
11. Check base of 5th metatarsal for Jones fracture
12. Medial aspect of 2nd metatarsal aligns with medial aspect of middle cuneiform
Introduction to “Charcot foot”

- **Origin**: Named after 19th century French neurologist and anatomical pathologist who noticed certain clinical features of foot in patients with *syphilis*

- **Today**: 24 diseases have demonstrated “Charcot” findings but *DM is leading etiology*
  - Common denominator: sensory modality changes > motor function

- **Clinical findings**: erythema, edema, increased temperature of joint, neuropathy, +/- plantar ulcers

- **Path**: Many theories, but all include some aspects of:
  - **1. Neurotrauma** – neuropathy ➔ repetitive microtrauma ➔ unnoticed ➔ inflammatory response ➔ weaker, more susceptible ➔ more trauma (cycle)
  - **2. Neurovascular Compromise** – Dysregulation ANS ➔ desensitized joints receive more blood flow ➔ *hyperemia* = ↑osteoclastic bone resorption (+mechanical stress) ➔ bony destruction

- **Terminology**: Despite its frequent use, some believe “Charcot” as a diagnostic or descriptive term is misuse. The better term to use is *Neuropathic Arthropathy*
Stages of Disease on Radiograph

- **Early** – very little is seen, possibly *diffuse tissue swelling*, occasionally *mild offset of joint*
- **Rapid progression** – erosions and frank joint destruction
  - Midfoot involvement leads to collapse of arch with superior subluxation of metatarsal bases, thus exposing cuboid to weight-bearing stresses
- **Late** – *excessive bone production* (sclerosis + spurring) +/- subchondral cystic change
  - *callus, ulceration, infection*
- **SUM:** articular surfaces degenerate over time and can fragment, thus becoming *distorted, incongruent, and generally disorganized, with debris and body formation*
The **5** (or **6**) **Ds** of Neuropathic Arthropathy on Plain Film

- **D**ensity (increased or normal)
- **D**istention (due to joint effusion)
- **D**ebris (bony)
- **D**islocation (Lis-franc)
- **D**isorganization (cartilage destruction occurs early, erosive + productive changes can coexist)
- **(D)**estruction (sometimes included within disorganization)

*Proceed to learn about 2 specific findings that found together can be pathognomonic*
Specific Finding #1: Lisfranc Dislocation: Anatomy of the Ligament

- Named after 18th-19th century French surgeon/gynecologist Jacques Lisfranc de St. Martin
- Ligament extends obliquely from 2nd metatarsal to medial cuneiform

Images from:
L - healthtips24.com
R - orthobullets.com

*See next slide for dislocation
Lisfranc Dislocation

Dislocation
• The lateral aspect of the base of 1st metatarsal should align with lateral border 1st/medial cuneiform
• Disruption = subluxation or dislocation of 2nd → 5th metatarsals dorsolaterally
• Homolateral vs. Divergent pattern:
  – If 1st metatarsal dislocates laterally, with the others (2nd→5th) = Homolateral (less common)
  – If 1st metatarsal stays medial with respect to others → Divergent

Keys to vulnerability of ligament
1. 2nd metatarsal is inset within tarsal bones relative to others (“keystone”) – this gives midfoot stability but also results in more vulnerable, ligamentous attachment
2. Intertarsal ligaments are between all cuneiforms and cuboid with 3rd→5th metatarsals, but no intertarsal ligaments exist between 1st + 2nd metatarsals
3. Thus, the lisfranc ligament is uniquely responsible for keeping the 2nd metatarsal in place

Risks associated with dislocation:
• Can lead to deformity, chronic pain, premature OA
• Must be dealt with emergently: reduction + fixation to restore alignment, often involving fusion of 1st+2nd tarsometatarsal joints
Lisfranc Dislocation: Appearance on Plain Film

*This is a divergent dislocation*

From [http://www.radiologyassistant.nl/en/4b6e855359a09](http://www.radiologyassistant.nl/en/4b6e855359a09)
Specific Finding #2: **Rocker-bottom foot**

- Collapse of longitudinal arch leads to appearance of “rocker-bottom” (see below)
- Abnormal pressure now rests on cuboid bone, now at risk for ulcer formation (see L)

*Images from:*
L: Pmj.bmj.com
Top R: From [http://www.radiologyassistant.nl/en/4b6e855359a09](http://www.radiologyassistant.nl/en/4b6e855359a09)
Index Patient’s Radiographs, Pre-surgery: Lateral View

*Below*, images of R foot. Non-weight-bearing as patient unable to stand without assistance

For reference, patient’s left foot (no Charcot):

Proceed to next slide for highlighted findings...

All images: PACS, BIDMC
**Findings - Index Patient’s Radiographs, Pre-surgery:**

**Lateral View**

Below, R foot

- **Subluxation** metatarsals **dorsally**
- **Ulcer** under area of cuboid bone
- **Rocker-bottom foot** with **Collapsed joint**, leading to rocker-bottom appearance *(See L for reference)*

All images: PACS, BIDMC

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Disorganization of cuneiforms, cuboid, naviculum and metatarsals making it impossible to fully differentiate the bones.

Divergent Lisfranc fracture.
Index Patient’s Radiograph:
Post-surgery with external fixator in place

From

From PACS, BIDMC
Complications of Surgery:
Osteomyelitis

Osteomyelitis = infection of the bone; resulting from:

a) Direct inoculation from penetrating trauma
b) Adjacent soft tissue infection
c) Hematogenous dissemination from remote site

*EMERGENCY!* – frequently requires surgical debridement, prolonged antibiotics, and occasionally results in loss of limb
Evaluation of Osteomyelitis: Plain Film

• **1st modality**, sometimes can see *soft tissue swelling* but it is **nonspecific** and **not sensitive**

• **Later**: cortical destruction, periosteal reaction and new bone formation, radiographic evidence destructionos but can take weeks

• **43-75% sensitive; 75-83% specific for acute osteomyelitis**

*Image from Christian et al.*
Evaluation of Osteomyelitis: CT

- This modality is somewhat better than a radiograph
- Theoretically, *could* see **hypervascular** state that is associated with infections. This is not sensitive nor specific
- *In general, after Xray ➔ MRI*
Evaluation of Osteomyelitis: MRI

- **Most sensitive** but lacks specificity
- **Primary findings**
  1. Dec. signal T1 marrow
  2. Inc. signal T2 marrow (hyperintense)
  3. Enhanced bone marrow w/ gadolinium
    - *If all 3 best sensitivity; less = less certain*
    - *neuropathic jts, trauma, and acute/subacute bone infacts can mimic (e.g. reactive marrow can have all of these features w/o infection)*
- **Secondary findings** (can improve diagnostic confidence)
  - Cutaneous ulcer
  - Cellulitis
  - Soft-tissue abscess
  - Sinus tract
  - Cortical interruption

*The only direct MRI signs of osteomyelitis are bone destruction and a draining sinus tract.*
Example of Ostemyelitis of Calcaneus on MRI:

Image A: appreciate T1-weighted image showing low signal in calcaneus
Image B: appreciate a coronal T2-weighted fat saturated image showing high signal and marrow edema in the same region as T1-weighted image

From Christian et al.
Evaluation of Osteomyelitis: Scintography

• Also sensitive and specific for osseous infection

• 3-phase scintography scan: 1. flow phase, 2. blood pool phase, 3. delayed bone phase
  – Osteo has increased activity at ROI all 3 phases (Cellulitis is just first two)
  – 94% sensitive, 95% specific but only possible if no other osseous abnormalities in Ddx e.g. Neuropathic Arthropathy radiographically occult fracture(s)

• I-111-labeled WBCs w/ Tc-99m sulfur colloid
  – 90% accuracy
  – positive = uptake of WBCs without uptake sulfur colloid
Osteomyelitis of the 4th and 5th metatarsal heads:
(B) Angiographic phase Tc-99m MDP frontal images demonstrate increased flow to the ankle as well as the 4th and 5th metatarsal heads that persists on blood pool (c) and delay (d) images worrisome for osteomyelitis
(E) Indium-111 tagged white blood cell scan demonstrates increased uptake at the 4th and 5th metatarsal heads confirming osteomyelitis, but there no ankle activity indicating benign bony remodeling as the source of increased activity on bone scan

Tc-99m WBC - accumulation in proximal phalanx of fifth digit L foot at 4 hrs post-injection

Both images and accompanying captions from:
http://www.radiologyassistant.nl/en/4b6e855359a09
Decision to use MRI vs. Nuclear Medicine in Evaluation of Osteomyelitis

• There is extensive literature that has evaluated the accuracy of MRI vs. nuclear medicine studies, particularly for the workup of diabetic foot infections

• Result: comparable in diagnosis osteomyelitis

• Conclusion: Use MRI – it is cheaper and faster and has better resolution for mapping out extent of infection
Index Patient: Evaluating Possible Post-surgical Osteomyelitis at Presentation: Plain Film

*Only assessment radiologist was able to make is that there was marked diffuse soft tissue swelling. This is partly because this is a plain film, and partly because the remaining hardware largely obscures the picture.

*Again, a view of Lisfranc dislocation, this time with hardware meant to fuse bones together in view

**Follow-Up:**
A CT was ordered, despite MR being a preferred test
- Cortical irregularity and widening associated with soft tissue thickening, stranding, and edematous changes noted in multiple areas as well as neuropathic degenerative changes and sites of periosteal reaction and tendinous disruption in Achilles, peroneus longus and brevis

*Again, unable to make
Follow-Up for Index Patient

A CT was ordered, despite MR being a preferred test. It showed:
- Cortical irregularity and widening associated with soft tissue thickening, stranding, and edematous changes in multiple areas
- Neuropathic degenerative changes
- Multiple sites of periosteal reaction
- Tendonous disruption in Achilles, peroneus longus and brevis

*Again, unable to make assessment on whether or not the patient had osteomyelitis. As mentioned in previous slides, the difficulty for the teams involved (medical, surgical, radiology) is that many of the findings on any modality could be post-operative changes, Charcot-specific changes, or signs of osteomyelitis

Ultimately, decision was made for radiologic follow-up after patient’s medical condition was stabilized and more healing of the lower extremity had occurred.
An Overview of Topics Discussed

- **The case**: Bony changes in diabetic foot with overlying infection
- **Menu of tests**: Xray, MRI; +/- scintography
- **Anatomy**: Bones and ligaments in foot
- **Film Interpretation**: Lisfranc dislocation, rocker-bottom foot, 5 D’s, infectious changes
- **Accurate terminology**: *Neuropathic arthropathy*! (not Charcot)
References


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