Ankle fractures and the Ottawa ankle rules

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Agenda

- Focused H&P for the injured ankle
- Epidemiology of ankle injury
- Ottawa ankle rules
- Gross and radiologic ankle anatomy
- Approach to injured ankle radiographs
- Examples of ankle fractures
Patient #1: History

A 52-year-old man with no PMH presents to the emergency room 3 hours after tripping over his wife’s cat and “rolling” his left ankle. The pain is worst on the outside of his ankle, which is moderately swollen. When the pain didn’t improve, his wife helped him into a cab which brought him to BIDMC.
Ankle injury: Focused history

- Mechanism
- Timing
- Audible injury
- Associated injuries
- Distal sensation, tingling
- Able to ambulate

- Significant PMH
  - Diabetes
  - Peripheral sensory impairment
  - Steroids
  - Immunosuppression

- Previous injuries
Ankle injury: Focused exam

- Vitals
- General
- MSK
  - Appearance / deformity
  - ROM
  - Point tenderness
  - Vascular: Pulses, capillary refill
  - Neuro: sensation, distal motor
  - Ambulate four steps
- Don’t forget nearby and contralateral joints!
Patient #1: Physical exam

T 98.2   HR 102   BP 152/92

Knee, hip and bones above ankle all OK.

Left ankle swollen and tender to palpation. Active/passive ROM limited by pain.

Neurovascularly intact: DP/PT pulses intact, capillary refill <2s, toes are warm with intact sensation to light touch. Able to wiggle toes.
Patient #1: A&P

Resident: Great. What do you want to do next?

Student: An ankle film?

Attending: Do we really need one? Can you make an evidence-based decision?
Assessing the need for ankle radiographs
Epidemiology: Ankle injuries

- 1.8 million ED visits per year nationally

- Chief complaint for 4.3% of ED patients but as high as 10% at some centers

- But just 15% of patients presenting with an ankle injury patients have a fracture

Heyworth, 2003
McCraig, 2004
Epidemiology: Ankle injuries at BIDMC

- BIDMC — 2007
  - 4,375 ankle films
  - 3.5% of all plain films
  - $85 per film

- Can estimate 2,200 ED visits/year for ankle injuries at BIDMC
The Ottawa ankle rules

A series of ankle x-ray films is required only if there is any pain in malleolar zone and any of these findings:
- Bone tenderness at A
- Bone tenderness at B
- Inability to bear weight both immediately and in emergency department

A series of ankle x-ray films is required only if there is any pain in mid-foot zone and any of these findings:
- Bone tenderness at C
- Bone tenderness at D
- Inability to bear weight both immediately and in emergency department

OAR: Sensitivity and specificity

Sensitivity: 98-100%

Specificity: 20-40%

## OAR: Test characteristics

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Sensitivity</td>
<td>Excellent</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>Excellent</td>
</tr>
<tr>
<td>Specificity</td>
<td>Poor</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>Poor</td>
</tr>
</tbody>
</table>

OAR: Effects

- 28% fewer ankle films
- 600 less ankle films/year at BIDMC
- 14% fewer foot films
- ED stay shorter by 36 minutes
- Patient satisfaction: no change

OAR: Cost effects

- Saves $85* per ankle patient

- Nationally, up to $153 million** in annual savings for ED patients alone
  – Does not include PCP patients!

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* $70 technical, $15 professional

** Based on data from 2004 CDC survey of ED utilization and BIDMC reimbursement

OAR: Caveats

May not apply if:

- Impaired lower extremity sensation
  - Diabetes
  - Nerve damage
- Impaired inflammation
  - Steroids
  - Immunosuppressed
- Under 18 years
Patient #1: Additional physical exam

Left ankle tender to palpation over the lateral malleolus and possibly the fifth metatarsal.

OAR positive

Obtain ankle and foot radiographs
Interpreting ankle radiographs
Menu of radiologic tests for the acutely injured ankle

- **Plain film**
- **CT**: useful for assessment of complex fractures, detailed assessment of talus and calcaneus, and pre-operative planning
- **MRI**: assessment of ligamentous injury
Standard radiographic views of the ankle & foot

- Ankle plain film: assess for fracture, joint asymmetry, or effusion
  - Core: AP + lateral + mortise
    - Mortise view (AP with 15-20° internal rotation) assesses joint widening and integrity of tibiotalar articulation
    - Additional: Stress view (both ankles)

- Foot plain film
  - AP
  - Lateral
  - Internal oblique (lateral foot elevated 30°)
Normal ankle plain film
Ankle and foot gross anatomy
Bony ankle anatomy

Fibula

Tibia

Talus

Navicular

Calcaneus

“Interactive ankle.” http://anatomy.tv
Ligamentous ankle anatomy: Lateral

Anterior tibiofibular (syndesmotic) ligament
Lateral collateral ligament

“Interactive ankle.” http://anatomy.tv
Ligamentous ankle anatomy: Medial

Deltoid / medial collateral ligament
Fifth metatarsal anatomy

Peroneus brevis muscle/tendon

Styloid process of 5th metatarsal
Radiologic “living” anatomy of the ankle and foot
Living anatomy: Lateral ankle

- Tibia
- Talus
- Fibula
- Calcaneus
- Achilles fat triangle
- Fifth metatarsal

Lateral view
Living anatomy: Ankle mortise

Mortise view

Fibula

Lateral malleolus

Medial malleolus

Talus

Fifth metatarsal
Living anatomy: Ankle mortise detail

- Normal tibial-fibular overlap
- Mortise
- Lateral clear space
- Medial clear space

PACS, BIDMC
Normal foot plain film
Living anatomy: Lateral foot

PACS, BIDMC

Talus
Calcaneus
Achilles fat triangle
Living anatomy: AP foot

- Sesamoids
- First metatarsal
- Fifth metatarsal
- Medial cuneiform
- Navicular
Approach to radiographs of the injured ankle I

- QC
- Soft tissue:
  - Effusions (Achilles fat pad)
  - FB
- Bone from far:
  - Density
  - Shape
  - Position
Approach to radiographs of the injured ankle II

- Bone from near:
  - Cortical or periosteal disruptions
  - Trabeculation

- Joint (mortise view):
  - Congruent
  - Symmetric
  - No widening:
    - Medial clear space < 4 mm
    - Lateral clear space < 5 mm
**Patient #1: Lateral malleolar fracture**

<table>
<thead>
<tr>
<th>Fracture</th>
<th>Unimalleolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details</td>
<td>Avulsion fracture affecting the tip of the lateral malleolus</td>
</tr>
<tr>
<td>Mech</td>
<td>Ankle inversion</td>
</tr>
<tr>
<td>Weber</td>
<td>A</td>
</tr>
<tr>
<td>Stable</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Ankle motion and injury mechanism

- Plantarflexion
- Dorsiflexion
- Inversion
- Eversion

85% of ankle injuries
## Classifying ankle fractures

<table>
<thead>
<tr>
<th>System</th>
<th>Criteria</th>
<th>Benefits</th>
<th>Problems</th>
</tr>
</thead>
</table>
| Lauge-Hausen    | 1) Ankle position at time of injury  
2) Direction of force          | Predicts type of injury                      | Injury mechanism is rarely provided on requisition                          |
| Danis-Weber     | Level of fracture of the fibula/lateral malleolus. Can be subdivided based on medial malleolar/tibial involvement. | Evaluation based on radiographic assessment  | Poor prognostic usefulness, only predicts the minor determinant of need for ORIF |
Weber classifications I

Weber classifications II

Companion patient #1: Medial malleolar fracture

PACS, BIDMC

<table>
<thead>
<tr>
<th>Fracture</th>
<th>Unimalleolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details</td>
<td>Oblique fracture of medial malleolus with widening of the lateral mortise and edema seen as opacification of the Achilles fat triangle</td>
</tr>
<tr>
<td>Mech</td>
<td>Ankle eversion</td>
</tr>
<tr>
<td>Weber</td>
<td>—</td>
</tr>
<tr>
<td>Stable</td>
<td>No</td>
</tr>
</tbody>
</table>
Companion patient #1: Medial malleolar fracture (lateral view)

Fracture: Unimalleolar

Details: Oblique fracture of medial malleolus with widening of the lateral mortise and edema seen as opacification of the Achilles fat triangle

Mech: Ankle eversion

Weber: —

Stable: No
Companion patient #2: Bimalleolar fracture s/p ORIF

<table>
<thead>
<tr>
<th>Fracture</th>
<th>Bimalleolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details</td>
<td>Spiral fracture of lateral malleolus. Widened medial and lateral clear spaces and loss of tibiofibular overlap suggest another injury. A closer look: oblique medial malleolus</td>
</tr>
<tr>
<td>Mech</td>
<td>More forceful ankle inversion</td>
</tr>
<tr>
<td>Weber</td>
<td>B</td>
</tr>
<tr>
<td>Stable</td>
<td>No</td>
</tr>
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</table>
Comparison patient #3:  
5th metatarsal avulsion fx (ankle)

<table>
<thead>
<tr>
<th>Fracture</th>
<th>5th metatarsal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details</td>
<td>Avulsion fracture of styloid process of 5th metatarsal at the insertion site of the peroneus brevis ligament</td>
</tr>
<tr>
<td>Mech</td>
<td>Ankle inversion tenses peroneus brevis ligament</td>
</tr>
<tr>
<td>Weber</td>
<td>—</td>
</tr>
<tr>
<td>Stable</td>
<td>Yes</td>
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PACS, BIDMC
Comparison patient #3:
5th metatarsal avulsion fx (lateral foot)

<table>
<thead>
<tr>
<th>Fracture</th>
<th>5th metatarsal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details</td>
<td>Avulsion fx 5th metatarsal styloid at peroneus brevis ligament insertion</td>
</tr>
<tr>
<td>Mech</td>
<td>Inversion tenses peroneus brevis ligament</td>
</tr>
<tr>
<td>Weber</td>
<td>—</td>
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<tr>
<td>Stable</td>
<td>Yes</td>
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</table>
Companion patient #4: Jones fracture

<table>
<thead>
<tr>
<th>Fracture</th>
<th>Fifth metatarsal</th>
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<tbody>
<tr>
<td>Details</td>
<td>Jones fracture: Transverse fx of fifth metatarsal shaft</td>
</tr>
<tr>
<td>Weber</td>
<td>—</td>
</tr>
<tr>
<td>Mech</td>
<td>Ankle inversion with force on lateral foot</td>
</tr>
<tr>
<td>Stable</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>High risk (up to 50%) of non-union without operative intervention</td>
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</tbody>
</table>
Companion patient #5: Trimalleolar fracture

<table>
<thead>
<tr>
<th>Fracture Details</th>
<th>Tri-malleolar Fracture</th>
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</thead>
<tbody>
<tr>
<td>Spiral lateral malleolar fracture</td>
<td>Transverse medial malleolar avulsion</td>
</tr>
<tr>
<td>Oblique posterior malleolar fracture</td>
<td></td>
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<tr>
<td>Weber Stable</td>
<td>B Stable</td>
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Barron and Branfoot, *Imaging*, 2003
Companion patient #6
Maisonneuve fracture

<table>
<thead>
<tr>
<th>Fracture</th>
<th>Proximal fibula</th>
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<tbody>
<tr>
<td>Details</td>
<td>Maisonneuve fx: spiral fx of proximal fibular shaft and disruption of tibiofibular syndesmosis</td>
</tr>
<tr>
<td>Mech</td>
<td>External rotation at ankle transmits through interosseous membrane</td>
</tr>
<tr>
<td>Weber</td>
<td>C</td>
</tr>
<tr>
<td>Stable</td>
<td>No</td>
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</tbody>
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Courtesy Jean-Marc Gauget, MD
Summary

- Application of Ottawa ankle rules safely avoids unneeded radiographs
- Reviewed anatomy and developed approach to interpretation of ankle plain film
- Reviewed classic malleolar and fifth metatarsal fractures
- Joint stability (widening, subluxation) decides need for ORIF in non-displaced fractures
Acknowledgements

- Gillian Lieberman, MD
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- Jean-Marc Gauget, MD
- Maria Levantakis
- Larry Barbaras


Bibliography II

- Wheeless 3rd CR. *Wheeless’ Textbook of Orthopaedics*.
- “Interactive Ankle.” Anatomy.tv