Appendicular Skeletal Trauma

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Types of cognitive error

- Satisfaction of search;
  - Once a diagnostic finding is identified the search stops and additional potentially important finding is missed

- Alliterative error;
  - Bias from prior reports influencing the current report

- Watching the grass grow;
  - The finding is compared to only the most recent previous exam and not to older exams, thereby missing the slow growth/change over a long period of time

- Ascertainment bias;
  - Personal bias toward certain patient characteristics

- Anchoring;
  - Early determination of diagnosis and “fitting the findings” to the diagnosis

- Gambler’s fallacy;
  - Thinking that if one has recently seen several patients with a certain pathology, the chances that the next patient has the same pathology are slim

- Availability bias;
  - Recent exposure to a diagnosis, especially a missed call, increases sensitivity to that abnormality, leading one to overcall this in the future

- Framing bias;
  - Misdirection by clinical history

- Distraction;
  - Distraction during the interpretation of a case can interfere with the search pattern and increase the chances of missing relevant findings.
Top 10 Missed Fractures

- 1. Base of skull
- 2. Odontoid process
- 3. Zygomatic arch and orbit
- 4. C7 Fracture dislocation
- 5. Posterior dislocation of humerus
- 6. Scaphoid, lunate and perilunar dislocation
- 7. Sacroiliac fractures
- 8. Undisplaced neck of femur
- 9. Dislocated hip with ipsilateral femoral fracture
- 10. Tibial plateau fractures
5. Posterior dislocation of humerus
Top 10 Missed Fractures

6. Scaphoid, lunate and perilunar dislocation
Top 10 Missed Fractures

7. Sacroiliac fractures
Top 10 Missed Fractures

8. Undisplaced neck of femur

Fulde GWO (1994) Emergency Medicine
9. Dislocated hip with ipsilateral femoral fracture

Fulde GWO (1994) Emergency Medicine
Top 10 Missed Fractures

10. Tibial plateau fractures

Fulde GWO (1994) Emergency Medicine
Reasons for Misses

- Simple miss
- Satisfaction of Search
- Inadequate study
- Not what was expected
- Corner of film finding
- Inappropriate history
- Working conditions
Reasons for Misses

Satisfaction of Search

• One of the commonest reasons to miss injuries
• See most obvious injury
• Miss other (more significant) injury
Satisfaction of Search

SH2 fracture distal tibia with base of 5th MT fracture
Reasons for Misses

Satisfaction of Search

SOS wrist 68M

[Image of X-ray with arrows indicating areas of interest]
Reasons for Misses
Satisfaction of Search

Trans scaphoid and triquetral peri lunate 15M
Reasons for Misses

Satisfaction of Search

- Simple miss
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- Inappropriate history
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Talar neck fracture with subtalar dislocation
Reasons for Misses

Satisfaction of Search

Missed scaphoid fracture
Reasons for Misses

Inadequate Study

- Need two or more views to assess for fracture or dislocation
- Need appropriate study
- Insist on good quality studies
  - With empathy
- If equivocal, ask for more
Reasons for Misses

Inadequate Study

Scaphoid fracture on ulna deviation view 19F
Reasons for Misses

Inadequate Study

- All films need
  - Patients name
  - Patients number
  - Date and time of study
  - Side marker (lead, not added later)
  - Cone marks
  - Appropriate exposure
Reasons for Misses - Inadequate Study

Two or more Views

- One view is never enough to assess for fractures

Posterior process fracture of calcaneus
Reasons for Misses - Inadequate Study

Two or more Views

Circular saw injury
Reasons for Misses - Inadequate Study

Two or more Views

Car door
Reasons for Misses

Not what was expected

Dislocated right shoulder
Ways to Avoid Missing Fractures

• Look for fracture patterns
• Look at regions that should align
• Look for secondary signs of fracture
• Look for the common sites of fractures
• Have check lists for each region
• Special circumstances
Fracture Patterns

• Patterns help us know where to look
  • Transtriquetral / scaphoid perilunate fracture dislocation
  • Maisonneuve
  • Essex Lopresti
  • Galeazzi
  • Monteggia
  • Waist of Scaphoid
  • Femoral shaft and neck
Fracture Patterns

- Patterns help us know where to look
  - Transtriquetral / scaphoid perilunate fracture dislocation
  - Maisoneuve
  - Essex Lopresti
  - Galeazzi
  - Monteggia
  - Pelvic ring fractures
  - Waist of Scaphoid
  - Don Juan
  - Femoral shaft and neck
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  • Galeazzi
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• Femoral shaft and neck
Pattern Approach

Occult basicervical fx NOF 32F
Pattern Approach

Occult basicervical fx NOF 32F
Pattern Approach

Occult basicervical fx NOF 32F
Pattern Approach
Pattern Approach

4th fx 5th dis 26M
Pattern Approach

Triple CMCJ dislocation 37M
Pattern Approach
Volar Plate of Phalanx

Adjacent structures
Pattern Approach
Mallet Fracture
Ways to Avoid Missing Fractures

- Look for fracture patterns
- Look at regions that should align
- Look for secondary signs of fracture
- Look for the common sites of fractures
- Have check lists for each region
- Special circumstances
Alignment Rules

• These are helpful at various sites
  • ACJ
  • SCJ
  • Lisfranc joint
  • Elbow in children
  • Carpal bones

• Also check for rotation
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- Also check for rotation

If in doubt recommend weight bearing
Alignment Rules
Childhood Elbow Fractures

Medial epicondyle fracture • With dislocation in children • Can become trapped in joint
Radial head dislocation • Radiocapitellar line • Should bisect capitellum
Supracondylar fracture • Anterior humeral line • Middle 1/3 of capitellum

Can Radiology Make Trauma Less Obscure
1 3 5 7 11 11

CRITOE

http://bonepit.com/
Alignment Rules

- These are helpful at various sites
  - ACJ
  - SCJ
  - Lisfranc joint
  - Elbow in children
  - Carpal bones

- Also check for rotation

Many distal radial fractures have a SCL injury
Alignment Rules

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  - Lisfranc joint
  - Elbow in children
  - Carpal bones

- Also check for rotation
Alignment Rules

- These are helpful at various sites
  - ACJ
  - Lisfranc joint
  - Elbow in children
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- Also check for rotation
Alignment Rules - Rotation
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Ways to Avoid Missing Fractures

• Look for fracture patterns
• Look at regions that should align
• Look for secondary signs of fracture
• Look for the common sites of fractures
• Have check lists for each region
• Special circumstances
Secondary Signs
Joint Effusion

- Secondary signs
- Joint effusion
- Lipohemarthrosis
- Gas in joint
- ST swelling
- Obliteration of fat planes
- Fat in joint on CT
- Bone edema on CT
- Intraosseous Vacuum
- Delayed resorption
- Delayed sclerosis

The hinge joints
Secondary Signs
Joint Effusion

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  - Delayed sclerosis
Secondary Signs

Joint Effusion

Acute

6w later
Secondary Signs
Lipohemarthrosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Lipohemarthrosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Tibial Plateau Fracture
Secondary Signs

Lipoheamarthrosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Tibial Plateau Fracture
Secondary Signs

Lipohemarthrosis

• Secondary signs
  • Joint effusion
  • Lipohemarthrosis
  • Gas in joint
  • ST swelling
  • Obliteration of fat planes
  • Fat in joint on CT
  • Bone edema on CT
  • Intraosseous Vacuum
  • Delayed resorption
  • Delayed sclerosis

Stellate patella fracture 61F
Secondary Signs

Lipohemarthrosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Stellate patella fracture 61F
Secondary Signs

Lipothemarthrosis

- Secondary signs
  - Joint effusion
  - Lipothemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Lipohemarthrosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
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Secondary Signs

Gas in Joint

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Open tibial plateau Fx
Secondary Signs

Gas in Joint

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Open tibial plateau Fx
Secondary Signs

Gas in Joint

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Open tibial plateau Fx
Secondary Signs

Soft Tissue Swelling

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Soft Tissue Swelling

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Fat plane obliteration

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Between the radial collateral ligament and APL/EPB
Obliterated in Fx / Infection
Secondary Signs

Fat in joint on CT

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Lipoheparthrosis

Anterior recess of the posterior subtalar joint
Secondary Signs

Lipohemarthrosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Lipoheamarthrosis

Fat fluid level in iliopsoas bursa 61F
Secondary Signs

Lipothromatosis

60 y/o female with pain s/p fall
Secondary Signs

Lipothemarthrosis

60 y/o female with pain s/p fall
Secondary Signs

Lipothemarthrosis

60 y/o female with pain s/p fall
Secondary Signs

Lipo-hemarthrosis – Radial head Fx
Secondary Signs

Lipohemarthrosis

Lateral patella dislocation with patella Fx

Bubbles may be more acute
Secondary Signs

Lipoheamarthrosis

Bubbles may be more acute
Secondary Signs

Lipothecarthesis

Lateral patella dislocation with patella Fx

Ax PDFS

Bubbles may be more acute
Secondary Signs

Bone edema on CT

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - **Bone edema on CT**
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Bone edema on CT

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - Bone edema on CT
  - Intraosseous Vacuum
  - Delayed resorption
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Secondary Signs

Bone edema on CT

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
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  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis

Sacral fracture edema CT 66F
Secondary Signs

Lipohemarthrosis

- Secondary signs
  - Joint effusion
  - **Lipohemarthrosis**
  - Gas in joint
  - ST swelling
  - Obliteration of fat planes
  - Fat in joint on CT
  - **Bone edema on CT**
  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Lipohemarthrosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
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  - Intraosseous Vacuum
  - Delayed resorption
  - Delayed sclerosis
Secondary Signs

Intraosseous Vacuum Phenomenon

93 y/o right hip pain s/p fall

1+8+7+1
Secondary Signs

Intraosseous Vacuum Phenomenon

93 y/o right hip pain s/p fall

4+7+1
Secondary Signs

Intraosseous Vacuum Phenomenon

93 y/o right hip pain s/p fall
Secondary Signs

Intraosseous Vacuum Phenomenon

Cor T1

Cor PDFS

93 y/o right hip pain s/p fall
Secondary Signs

**Delayed resorption**

- Secondary signs
- Joint effusion
- Lipothrombrosis
- Gas in joint
- ST swelling
- Obliteration of fat planes
- Fat in joint on CT
- Bone edema on CT
- Intraosseous Vacuum
- **Delayed resorption**
- Delayed sclerosis
Delayed resorption

6w follow up
Secondary Signs

Delayed sclerosis

- Secondary signs
  - Joint effusion
  - Lipohemarthrosis
  - Gas in joint
  - ST swelling
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Ways to Avoid Missing Fractures

• Look for fracture patterns
• Look at regions that should align
• Look for secondary signs of fracture
• Look for the common sites of fractures
• Have check lists for each region
• Special circumstances
Bony Bankart

Consider Westpoint
Greater Tuberosity of Humerus

One of the most commonly missed fractures
Hook of Hamate Fracture

Hook not seen on AP
Beak Ligament Avulsion Fracture
Acetabular fracture
Femoral Neck Stress Fracture
Proximal Femoral Stress Fracture
Tibial Plateau Fracture

- Fall with twist
- Ped V’s MVA
- 50% > 50Y
- 80% lateral due to valgus
- Obliques useful
- MRI for diagnosis
- CT to stage
- Schatzker classification
Segond fracture suggests the presence of significant pathology. A small, vertically oriented, avulsed bony fragment involves the lateral aspect of the proximal lateral tibia. Nearly always associated with a tear of the anterior cruciate ligament in the older population. Alternatively, an avulsion of the tibial spines is seen in younger patients.
Proximal Fibula Fractures

- Can indicate an unstable posterolateral corner
- Ass. ACL injury
Deep lateral condylopatellar notch
Longitudinal Stress Fracture
Metatarsal Stress Fractures

2nd metatarsal neck stress fx 28F
Ways to Avoid Missing Fractures

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Ankle Injury - Check List

- Malleoli
- Lateral process of Talus
- Talar dome
- Anterior process of Calcaneus
- EDB avulsion
- Base of 5th metatarsal
- Jones fracture
- Does ankle fracture suggest Maisoneuve
- Dorsal chip fractures
Ankle Injury - Check List

- Malleoli
- Lateral process of Talus
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Special circumstances
Elderly

- Fractures often hard to see
- Degenerative changes obscure fractures
- Fatty marrow makes bone edema useful sign
- Fractures more often fatal
- If alters management, low threshold for MRI
Pelvic Insufficiency Fractures

- Iliac wing
- Sacrum
- Superomedial ileum
- Supracetabular
- Symphysis
- Public rami
Bisphosphonate fractures proximal femur

84 year old female with bilateral hip pain
Pathologic lesser trochanteric avulsion
Special circumstances
Childhood Fractures

- Tendons stronger than bone
  - Apophyseal avulsion

- Fracture patterns
  - Salter Harris

- Incomplete fractures
  - Plastic bowing
  - Torus / Buckle
  - Greenstick

- Remember NAI

11M ACL avulsion
Childhood Fractures

- Tendons stronger than bone
  - Apophyseal avulsion

- Fracture patterns different
  - Salter Harris

- Incomplete fractures more common
  - Plastic bowing
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- Remember NAI
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- Remember NAI

- SCFE is Salter 1 fracture of femoral epiphysis
  - Bilateral in 25%
  - Best seen on frog-leg lateral
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- Remember NAI
Problem solving

- Repeat
- Oblique views
  - Tibial plateau
  - Radial head
- Dedicated views
  - Scaphoid
  - Radial head
- Single emulsion
  - Periphery
- Tomography, CT, MRI, Scintigraphy