Occult Fractures and Dislocations

The Sports Medicine Core Curriculum Lecture Series
Sponsored by an ACEP Section Grant
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Why is it occult?

Can’t see it
Didn’t suspect it
Rare and unusual

*will not discuss spine, most hand/wrist
Medico-Legal Implications

8-11% disagreement between emergency physicians and radiologists
1-3% change of treatment

Misinterpretation of Radiographs
Missed Fractures
represent 10-20% malpractice cases
Knee
Normal variants vs fractures: Bipartite patella
Lipothemarthrosis
Segond Fracture

Avulsion of the lateral capsular ligament
*correlates with concurrent ACL tear
Case: 17 yo M s/p first time Patellar Dislocation

Abnormal in 1 of 158 cases
Abnormal in 7 (54%) of 13 cases that included a history of subluxation or dislocation

*Intra-articular osteochondral fractures complicate approximately 5% of acute dislocations of the patella in children
Case: 24 yo M Division III Football Player w/ Lateral Blow to the Knee during Practice

Initial exam in the E.D.:
- Obvious 4 cm lac to mid-anterior tibia, depth to bone
- (+) effusion
- Pain medially
- Valgus laxity
- LCL/extensor mechanism intact
- ACL/PCL unable to be assessed
- Patellar apprehension test negative
- Able to bear partial weight with difficulty
Emergency Department 2 view Knee

Discharged w/ knee immobilizer, WBAT
Day 2: Follow up: Orthopaedic Office

Physical exam:
- Moderate ecchymosis medially
- Moderate effusion
- Minimal lateral tenderness
- Lachman unable to be assessed
- Valgus stress with moderate opening
- Aspiration performed- 70 cc frank blood
*Traumatic Hemarthrosis

ACL tear partial/complete 72%
Meniscal tears 62%
Femoral chondral fracture 20%

Also include fractures: patella/intraarticular/other chondral, PCL tear, patellar dislocation, tear of joint capsule

Lipoemarthrosis v Case

Lipoemarthrosis

Case ED xray
Followup MRI ~ 3 weeks later…

Distal Grade III MCL tear
LCL/ACL/PCL intact
Lateral tibial plateau fracture
depressed and impacted >1.0 cm
(Schatzker grade 3)
3 Week Followup Xrays
CT scan
Gray SD, et al. “Acute Knee Trauma: How Many Plain Film Views are Necessary for the Initial Examination?” Skeletal Radiology, 1997; 26: 298-302

Two-view sensitivity 79%

Addition of two oblique views increases sensitivity to 85%
Ottawa Knee Rules

Age 55 years or older
Tenderness at head of fibula
Isolated tenderness of patella
Inability to flex knee to 90 degrees
Inability to walk 4 weight-bearing steps immediately after the injury and in the emergency department

Pittsburgh Decision Rules

Blunt trauma or a fall as mechanism of injury
plus either of the following:

Age younger than 12 years or older than 50 year

Inability to walk four weight-bearing steps in the emergency department


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<tr>
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<th>Ottawa Knee Rules</th>
<th>Pittsburgh Decision Rules</th>
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<tbody>
<tr>
<td>Sensitivity</td>
<td>97%</td>
<td>99%</td>
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<tr>
<td>Specificity</td>
<td>27%</td>
<td>60%</td>
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<tr>
<td>Reduces radiographs</td>
<td>28% *three missed fx</td>
<td>*52% *one missed fx</td>
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Case Teaching Points

Consider Oblique Views in Trauma
Inability to Bear Weight
Distracting Injury
Know the Mechanism of Injury
Differential Diagnosis of Traumatic Hemarthrosis
Patellar Tendon Injury w/ Avulsion Fracture
Quadriceps Tendon Injury w/ Avulsion Fracture
Top Myths in Sports Medicine

A knee dislocation only occurs in the setting of both ACL and PCL disruption
Knee Dislocations

Associated with **any 2** or more complete ligament tears of the 4 (ACL, PCL, MCL, LCL)

Most commonly bicruciate

Seen with and without external force (plant and twist, fall, land from jump, tackle, MVC)
Popliteal Artery Injuries

Rate of Knee Dislocations w/ Popliteal Artery Injury range 10-80%
Green JBJS 1977: 32% of 245 knee dislocations

WWII: 73% amputation rate

1966-1991: 10% amputation rate
Ischemic Time

Amputation Rate

• < 8 hrs - 11%
• > 8 hrs - 86%
Case: 48 yo M s/p hyperextension injury trying to stop his canoe under a bridge

Seen in E.R. -> xrays (-), normal pulses, knee immobilizer, crutches

Followup in clinic normal pulses, poor peroneal nerve* function, ACL/PCL/LCL tears

* Common peroneal nerve injury rate – 35%

LCL avulsed, ACL tear, Hyperextension bone contusion
Top Myths in Sports Medicine

Normal distal pulses and ABIs are adequate to exclude associated popliteal artery injury in the dislocated knee
Normal Distal Pulses

Estimated to occur in 5% - 15% of cases of Popliteal artery injury

- Gable, Allen, Richardson (1997)
- Lohmann, Lauridsen, Vedel (1990)
- McCutchan, Gillham (1989)
Selective Arteriography

Meta-analysis of 116 articles
Abnormal pedal pulses:
sensitivity of 0.79, a specificity of 0.91

Conclusion: abnormal pulses are not sensitive enough to detect a surgical vascular injury

Barnes, Pietrobon, and Higgins (2002)
Case Arteriograms

Diffuse irregularity in the popliteal artery with intimal dissection
Arteriograms

“All knee dislocations require an arteriogram.”
(Controversial)

**“Selective arteriography based on serial physical exams is a safe and precedent policy following knee dislocation.”**

*(Stannard, JBJS, 2004)*
- reviewed 138 dislocations
- 9 popliteal artery injuries – all detected on PE
- 1 false positive
McDonough and Wojtys. Multi-ligamentous Injuries of the Knee and Associated Vascular Injuries


72 Dislocated Knees – 12 vascular injuries
  4 – No pulses
  8 – Normal pulses
    • 5 – Abnormal arteriograms
      → 4 – Vascular bypass
    • 3 – Normal arteriograms*
      *Intimal injuries clotted off with tourniquet at surgery

Conclusion: Arteriograms are not 100% successful in detecting intimal injuries

**Fourteen injuries result of a fall. Two in obese- fall while walking.
Ankle Brachial Index and Detection of Arterial Injuries

*Lynch and Johansen (1991)*
- Compared ABI’s with arteriography
- Reported an ABI <0.9
  - Sensitivity of 87%
  - Specificity of 97%
  
  \(N=100, \text{ 74 due to } \text{penetrating trauma}\)

Prospective
ABI < 0.9 underwent arteriography
➢ 0.9 admitted for serial observation and delayed arterial duplex

11 patients with an ABI < 0.9 had a vascular lesion requiring surgical intervention

27 had no vascular abnormality on serial exams or duplex ultrasound and had no vascular complications

Sensitivity and Specificity ABI < 0.9 = 100%
How good is an emergency physicians’ examination?

159 consecutive patients, mean age 27 years, 36% ♀
MRI examination < 8 days after the initial visit
ACL: assessed in 79 (90%) of the ACL injured knees
Agreement between clinical and MRI findings in only 50%
3 of 25 patellar dislocations were clinically suspected
1/2 patellar dislocations misdiagnosed as a knee ligament injury
24 (15%) fractures on MRI - the majority minor depressions

Detection of a Reduced Knee Dislocation Requires Examination of the Ligaments

Stress Views can be helpful
Foot and Ankle
Misdiagnosed as Simple Foot/Ankle Sprain

- Salter Harris injury
- Tendon injury - peroneal/posterior tibial
- Achilles rupture - partial v complete, acute v chronic
- Navicular fracture
- Cuboid fracture
- Anterior process of calcaneus fracture
- 5th metatarsal fracture - avulsion/Jones
- Lateral process of talus fracture = ‘snowboarder’s ankle’
- Osteochondral fracture of talar dome
- LisFranc fracture/dislocation
- Maisonneuve injury

Only ~15% x-rays (+)
8 hospitals, 200+ physicians
Reduced radiograph ordering ~80% to ~60%
Reduced length of stay 33 minutes
*fractures > 3 mm
Six (0.6%) of the 1090 fracture diagnosed w/ negative OAR
Ten (0.5%) of the 2033 patients: diagnosed after discharge
No long term bad outcomes and no litigation reported

670 patients aged 2-16 years
*clinically significant >3mm size fracture
Ankle: OAR were 100% sensitive, 24% specific
Midfoot: OAR were 100% sensitive, 36% specific

27 studies describing 15,581 patients
47 patients (0.3%) falsely negative OAR
Sensitivities: range 93.8-100%
Specificities: range 19.4-77.1%

Ottawa Ankle Rules…Do Not Always Apply
20 yo F s/p acute inversion injury

Osteochondral fracture talar dome
22 yo M Div I College Football Player with ‘Foot Sprain’

*midfoot pain and swelling
*plantar ecchymosis
*pain/inability with weightbearing or heel raise
? instability
LisFranc Joint Injury

Widening of joint on weight bearing view. CT shows fracture at base of 2nd Metatarsal.
Maisonneuve- syndesmotic injury, proximal fibular fracture with….

Medial malleolar fracture

or

Posterior malleolar fracture

or

Deltoid tear
Maissoneuve- syndesmotic injury

Posterior malleolar fracture Maissoneuve
Case: 14 yo M hockey player with pain at tibial physis s/p injury: Tillaux fracture- Salter Harris III misdiagnosed as a syndesmotic ankle sprain
Case: 15 yo M s/p inversion injury: Lateral sprain and medial contusion, talus fracture seen only on MRI
Sternoclavicular Joint
Normal adolescent SCJ anatomy: with physes
Case: 17 yo M Hockey Player w/ SCJ Pain s/p Lateral Blow to the Shoulder in a Game
Sternal fractures
Case: 12 yo M Wrestler c/o Pain s/p Fall on R Shoulder 1 d PTA

S/S of “stinger” resolved

Outside clinic: Xrays (-). Referred to ortho.

Ortho referred to ED for concern of “growth plate fracture” and clavicle dislocation
CT confirms diagnosis

Preop and postop CT scans
SCJ Injuries

Associated mediastinal injury in 25% posterior dislocations.

*The medial clavicular epiphysis may not be radiographically apparent until age 18 years and may not close until age 25 years.

It is the last physis to close.

Many presumed sternoclavicular dislocations are actually fractures through the physeal plate.
Sternoclavicular Joint Imaging

Rockwood view
Hobbs view
Heinig view
Kattan view

None of the above reliable - GET THE CT SCAN

Glenohumeral Fractures and Dislocations
Shoulder Dislocations - Radiography

Pre-reduction x-rays?

Post-reduction radiographs to detect fractures (missed or iatrogenic)

Fractures associated in up to 25% anterior dislocations

Anterior Dislocation: Greater tuberosity
Posterior Dislocation: Lesser tuberosity
Coracoid Fractures

Mechanisms: direct blow, anterior dislocation, avulsion by coracoclavicular ligament, repetitive stress (rifle)

Do not mistake fracture for physis

Normal physis at base and tip of coracoid
Bankart

Fracture of the lip of the glenoid associated with Glenohumeral dislocations and instability
Case: 34 yo F w/ Anterior Dislocation and a Greater Tuberosity Fracture

These can be occult- only seen on MRI
Glenoid Fracture
Case: 34 yo M s/p 1st anterior dislocation requiring reduction in ER
Posterior Dislocation

- Note lack of overlap on glenoid
- Lightbulb Sign
- Head not centered on Y scapular view

- Postreduction with overlap
- Postreduction
- Reverse Hill Sachs Fracture
Pediatric
Buckle ‘Torus’ Fractures
Distal Clavicle Salter I
Do not mistake for AC Joint Sprain

Initial xray

Followup xray with periosteal healing reaction
Case: 13 yo M s/p snowboarding injury to the knee 2d PTA

Off a jump, hit a pole and fell, unable to walk
Mountain clinic: x-rays (-), posterior splint, f/u
PE: massive effusion, diffuse tenderness,
unable to extend due to pain,
*significant* laxity with valgus stress / lachman /
posterior drawer, w/ posterior sag

?Multiple ligament injuries
?Knee dislocation
Unstable Salter I of Distal Femoral Physis

2 to 16 years w/ knee injury < 7 days
750 enrolled: 670 with x-rays
Mean age was 11.8 +/- 3.1 years
70 fractures
OKR 100% sensitive, 43% specific
Pediatric Hemarthrosis

Acute traumatic hemarthrosis -> arthroscopy
21 consecutive patients, average 14 yo
14 (67%) had osteochondral fractures,
5 missed on xray

– Acute hemarthrosis of the knee in children.
Matefic TM, Aronsson DD, Boyd DW, et al.
Wrist and Elbow
Triquetral and Scaphoid Fractures
17 yo M football player with wrist pain: chronic scaphoid fracture

Follow up xray 7-10 d
Bone scan or MRI to diagnose occult fractures
Treatment delay > 4 weeks increases frequency of nonunion:
   45% v 5% in patients who were immobilized day 1.
   *J Hand Surg [Br] 1993;18:403-6*
19% scaphoid fx detected on MRI after normal radiographs w/ snuff box tenderness. *Br J of Rad 2003; 76:296-300*
Normal Elbow Radiology

Anterior Humeral Line- thru middle 1/3 capitellum

Radiocapitellar Line- along radial shaft intersects capitellum
8 yo M s/p FOOSH
Radial head dislocation, ulnar fracture
Supracondylar Fracture

Cardinal signs of supracondylar fracture are

1) a posterior fat pad sign
2) posterior displacement of capitellum relative to the anterior humeral line (94%)

Check Baumann angle in true AP view

70% pediatric elbow fractures
Supracondylar fx: Baumann angle

**Humeral Capitellar Angle**: between long axis of humeral shaft & physis of lateral condyle

Carrying angle after reduction:
- normal ~ 85-89 deg
- compared to the uninjured side:
- a deviation > 5 deg unacceptable
Elbow ossification centers

*Order of Appearance* of the individual ossification centers is

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<thead>
<tr>
<th>C-R-I-T-O-E:</th>
<th>(F/M)</th>
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<tbody>
<tr>
<td>Capitellum</td>
<td>1 yo/2 yo</td>
</tr>
<tr>
<td>Radial head</td>
<td>3 yo/4 yo</td>
</tr>
<tr>
<td>Internal (medial) epicondyle</td>
<td>5 yo/6 yo</td>
</tr>
<tr>
<td>Trochlea</td>
<td>7 yo/8 yo</td>
</tr>
<tr>
<td>Olecranon</td>
<td>9 yo/10 yo</td>
</tr>
<tr>
<td>External (lateral) epicondyle</td>
<td>11 yo/12 yo</td>
</tr>
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Occult Radial Head/Neck Fractures

Get an oblique view

May just be a buckle fracture.

4 months later

Beware the 180 degree rotation!
Fat Pad Sign or ‘Sail Sign’

Effusion is associated with a fracture 70-90% kids
Risk of occult fracture is approximately 30%-75%
Posterior or elevated anterior fat pad abnormal
Osteopenia
Insufficiency Fractures
Case: Insufficiency fracture of medial femoral condyle due to AVN (smoker, osteopenic, diabetes)
Case: 22 yo F law student w/ Athletic Triad

Eating disorder
Amenorrhea
Osteoporosis/Osteopenia

Stress fracture sacrum x 2

Cancellous bone stress fractures: 89% are osteopenic
Pubic rami, sacrum, calcaneus, femoral neck
Cortical bone stress fractures: 27% are osteopenic
Occult Hip Fractures - Trochanteric
Difficult to visualize w/ osteopenia

764 of 895 patients (85.3%) had follow-up
219 patients (29%) fracture on initial XR
62 (11.4%) of 545 patients with (-) XR underwent hip MRI during the ED visit
24 (4.4%) additional hip fractures found
Lim et al. Limited Magnetic Resonance Imaging (MRI) and the Occult Hip Fracture
Ann Acad Med Singapore 2002; 31:607-10

422 patients post-traumatic hip pain
365 (86%) hip fx on xray
57 (14%) patients had a negative or equivocal radiograph
 8 of 57 (14%) patients sustained a femoral neck fracture
 5 of 57 (9%) had an intertrochanteric fracture
1) Inability to straight leg raise
2) Limitation of rotation due to pain
3) Groin tenderness to deep palpation
2/3 or 3/3 signs correlates with fracture on MRI

9% femoral neck fractures have normal x-rays
*delayed union or nonunion occurs in 5-25% of intracapsular femoral fractures
Take Home Points

Maintain a high index of suspicion for fracture
Recognize worrisome locations
Look for associated injuries
Know the mechanism of injury
Find the indirect signs of fracture on imaging
Obtain additional views (oblique, skyline, axillary)
Obtain additional imaging in high risk areas (CT or MRI)