Occult Fractures and Dislocations

The Sports Medicine Core Curriculum Lecture Series
Sponsored by an ACEP Section Grant
Author(s): Jolie C. Holschen, MD FACEP
Editor: Jolie C. Holschen, MD FACEP

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Normal variants vs fractures: Bipartite patella

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Lipohemarthrosis

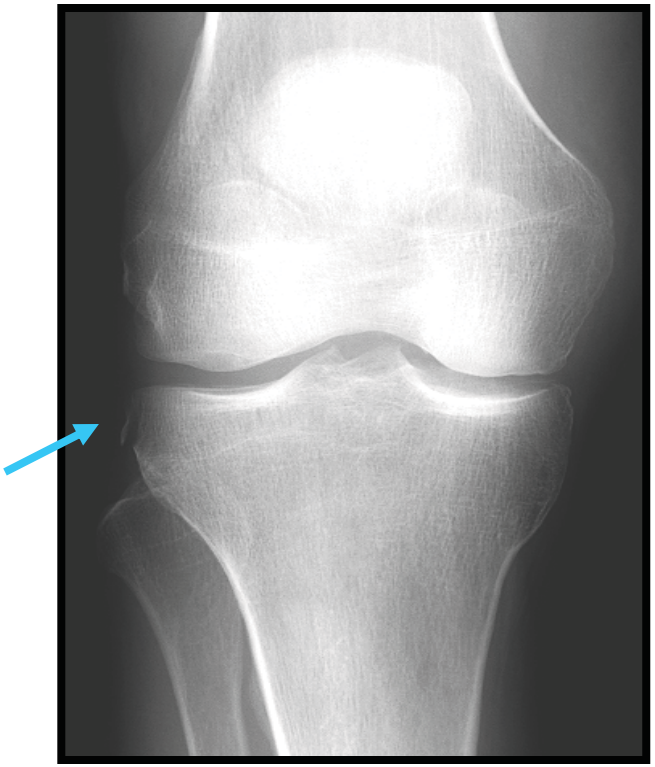
American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Segond Fracture

Avulsion of the lateral capsular ligament

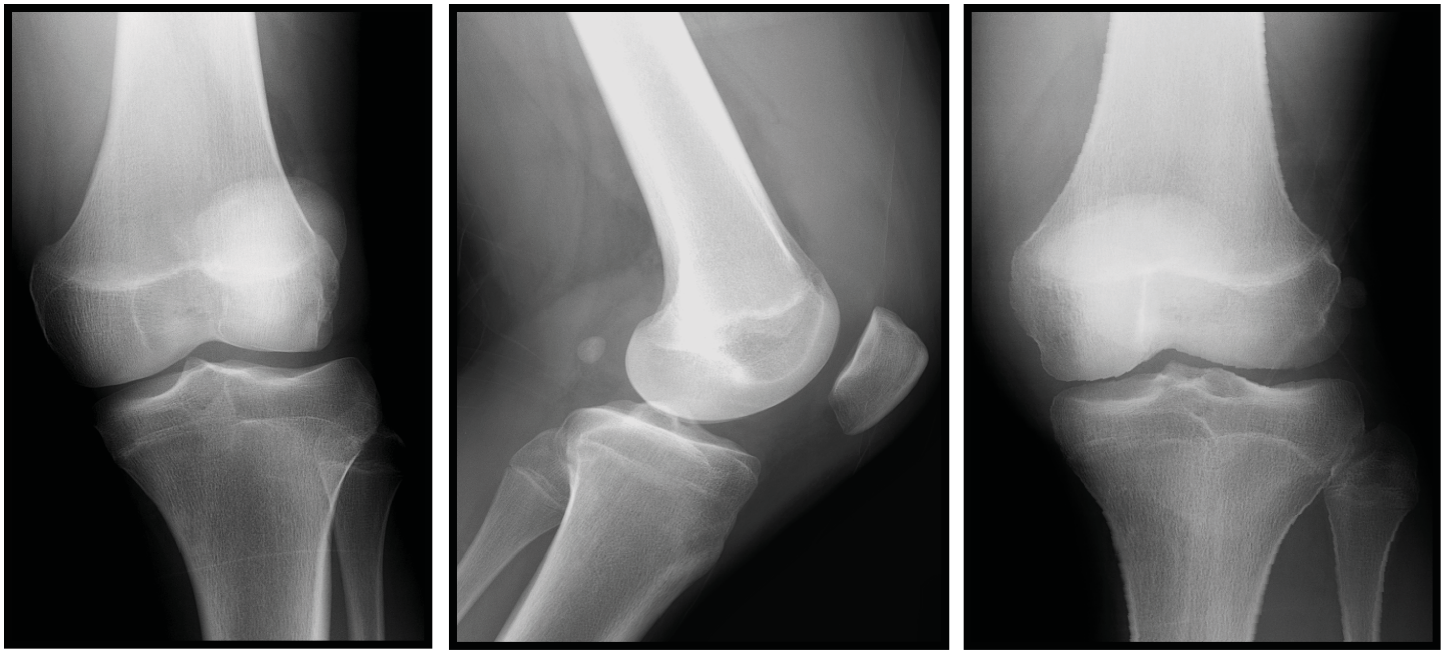
*correlates with concurrent ACL tear

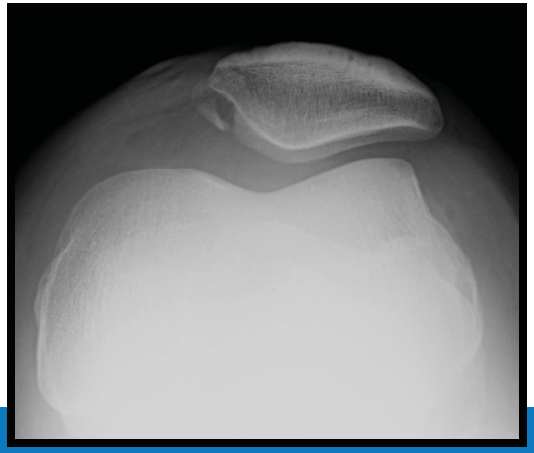


American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Case: 17 yo M s/p first time Patellar Dislocation





American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Black et al.* Usefulness of the skyline view in the assessment of acute knee trauma in children. *Can Assoc Radiol J 2002;53(2)92-4.

Abnormal in 1 of 158 cases

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

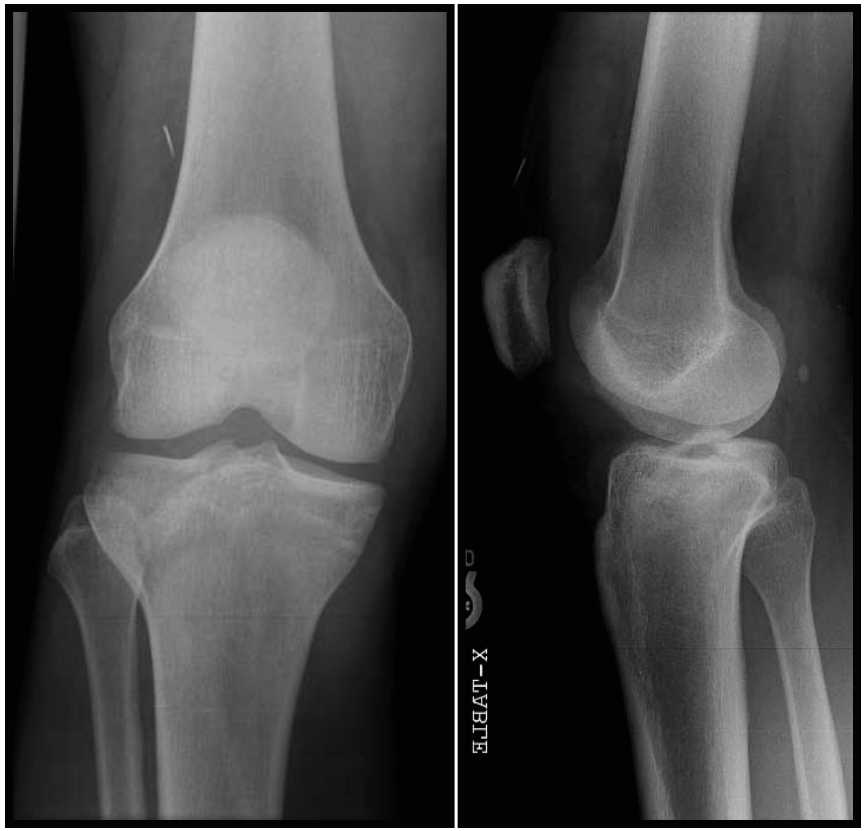
*Intra-articular osteochondral fractures complicate approximately 5% of acute dislocations of the patella in children

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

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

*Noyes FR, Bassett RW, Grood ES, Butler DL. Arthroscopy in acute traumatic hemarthrosis of the knee. Incidence of anterior cruciate tears and other injuries. *J Bone Joint Surg Am 1980 Jul;62(5):687-95, 757.* [included stable knees only]

Lipohemarthrosis v Case

Lipohemarthrosis

Case ED xray

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

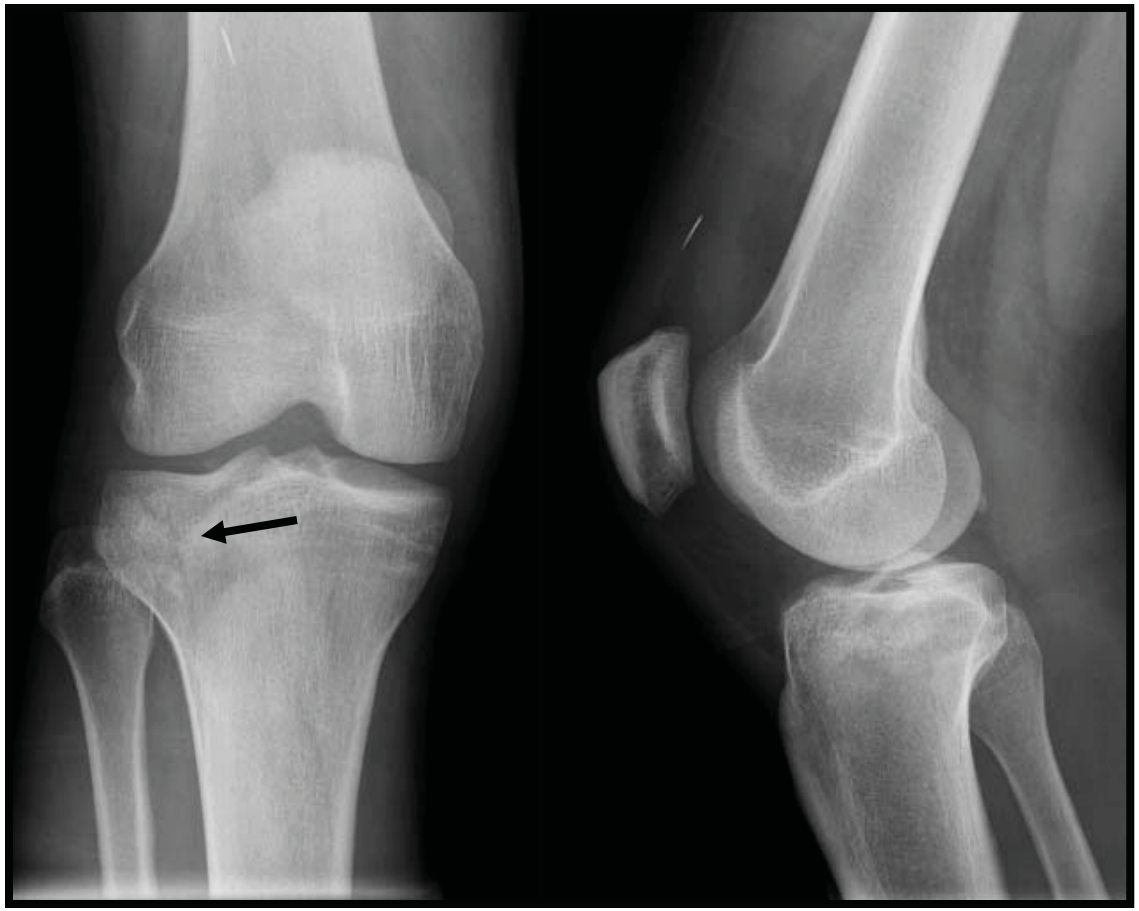
Followup MRI ~ 3 weeks later…

Distal Grade III MCL tear

LCL/ACL/PCL intact

Lateral tibial plateau fracture depressed and impacted >1.0 cm (Schatzker grade 3)

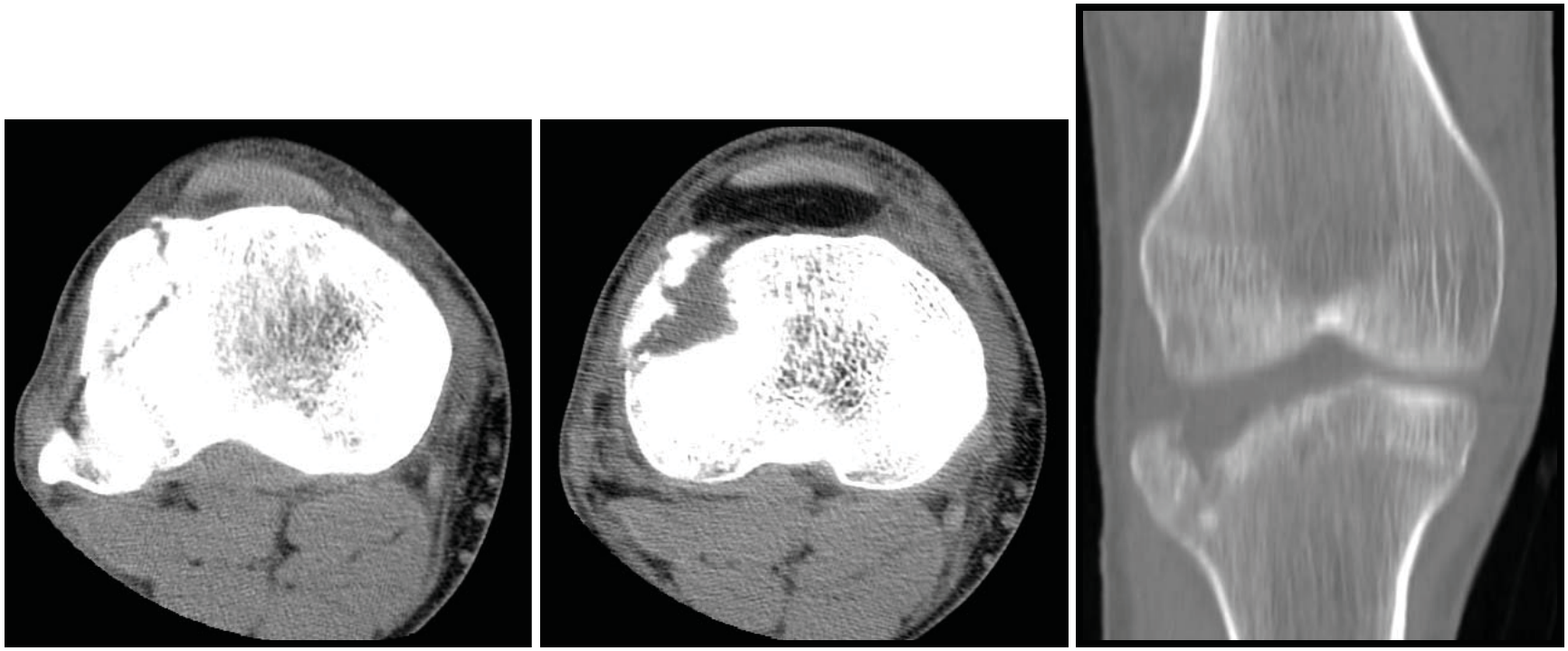
3 Week Followup Xrays



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

CT scan



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

Stiell IG, Greenberg GH, Wells GA, McKnight RD, Cwinn AA, Cacciotti T, et al. Derivation of a decision rule for the use of radiography in acute knee injuries. *Ann Emerg Med 1995;26:405-13.*

Stiell IG, Greenberg GH, Wells GA, McDowell I, Cwinn AA, Smith NA, et al. Prospective validation of a decision rule for the use of radiography in acute knee injuries. *JAMA 1996;275:611-5.*

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

Bauer SJ, Hollander JE, Fuchs SH, Thode HC Jr. A clinical decision rule in the evaluation of acute knee injuries. *J Emerg Med 1995;13:611-5.*

Seaberg DC, Yealy DM, Lukens T, Auble T, Mathias S. **Multicenter comparison of two clinical decision rules for the use of radiography in acute, high-risk knee injuries.** ***Ann Emerg Med 1998;32:8-13.***

	Ottawa Knee Rules	Pittsburgh Decision Rules
Sensitivity	97%	99%
Specificity	27%	60%
Reduces radiographs	28% *three missed fx	52% *one missed fx

Case Teaching Points

Consider Oblique Views in Trauma

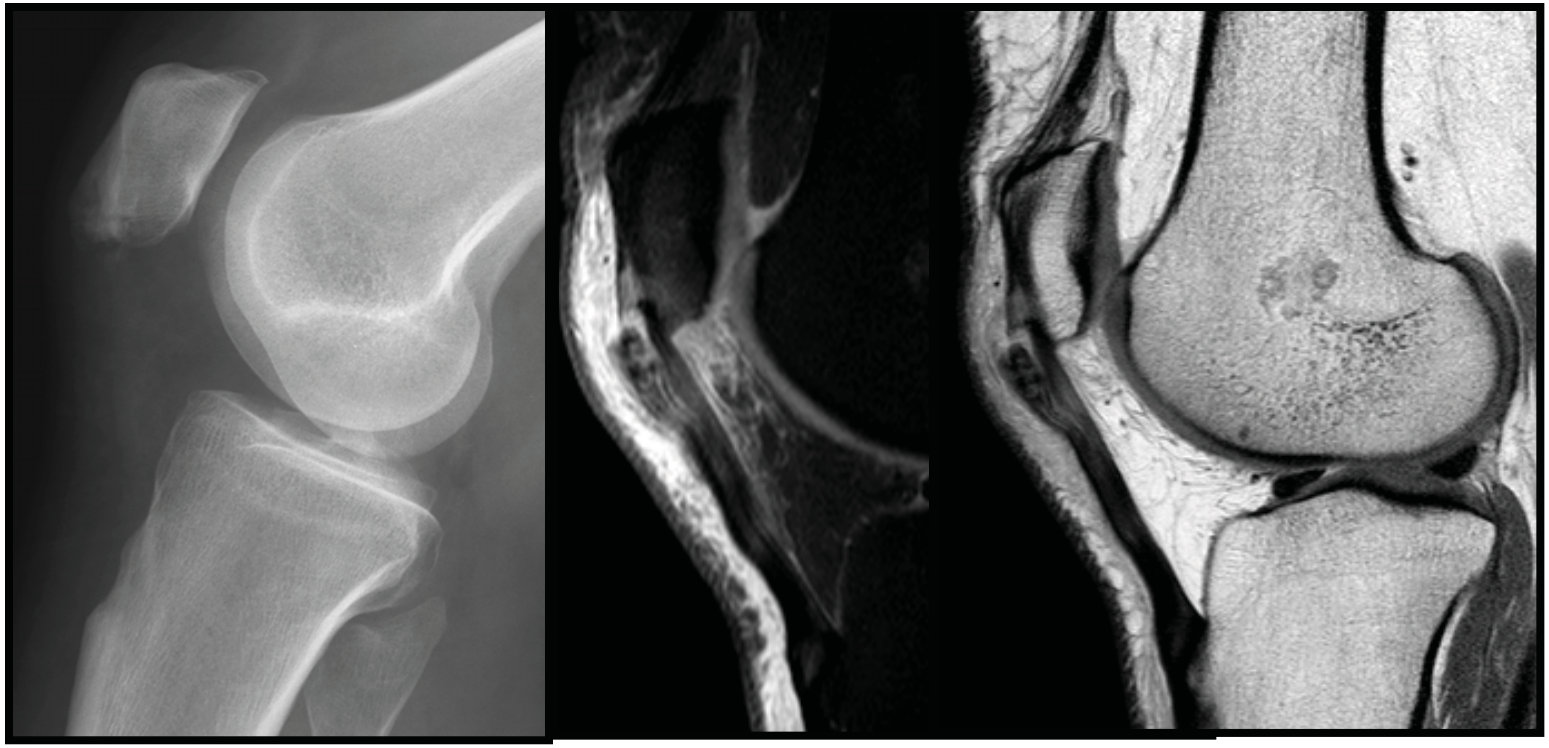
Inability to Bear Weight

Distracting Injury

Know the Mechanism of Injury

Differential Diagnosis of Traumatic Hemarthrosis

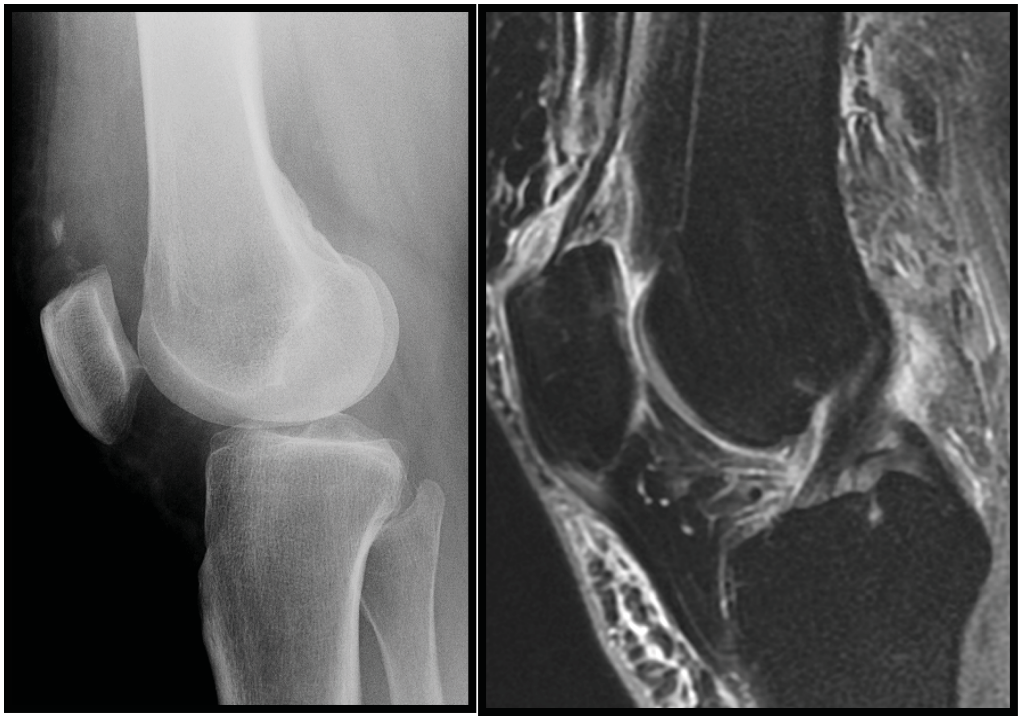
Patellar Tendon Injury w/ Avulsion Fracture



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Quadriceps Tendon Injury w/ Avulsion Fracture



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

American College of Emergency Physicians
ADVANCING EMERGENCY CARE

DeBakey, Ann Surg 1946
Almekinders, CORR 1992

ACEP sportsmed

Ischemic Time

Amputation Rate

- < 8 hrs - 11%
- > 8 hrs - 86%

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Green JBJS 1977

Case: 48 yo M s/p hyperextension injury trying to stop his canoe under a bridge

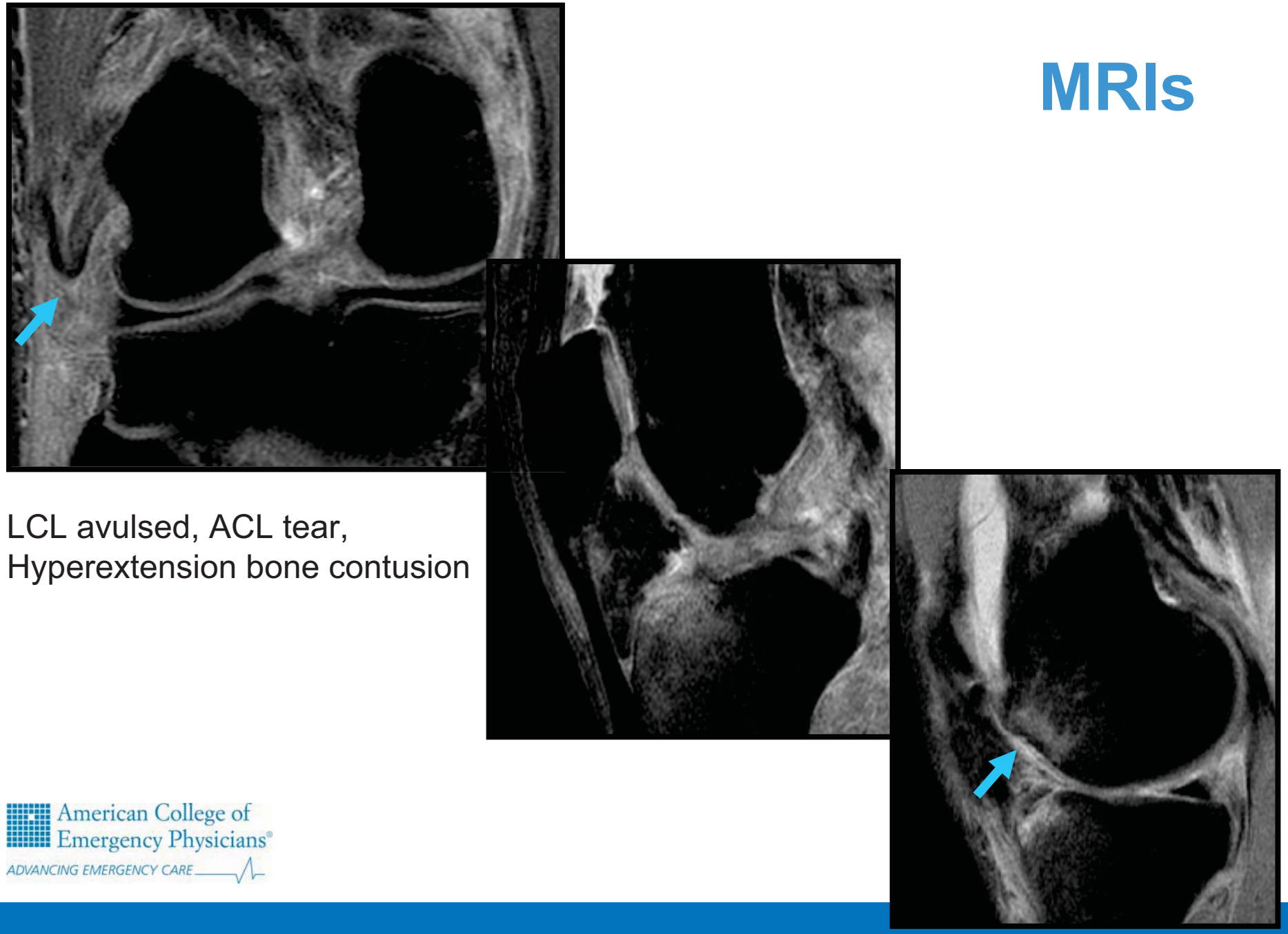
Seen in E.R. -> xrays (-), normal pulses, knee immobilizer, crutches

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

*** Common peroneal nerve injury rate – 35%**

Shields. J of Trauma, 1969.

MRIs



LCL avulsed, ACL tear,
Hyperextension bone contusion

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

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)
- McCoy, et al (1987)
- 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

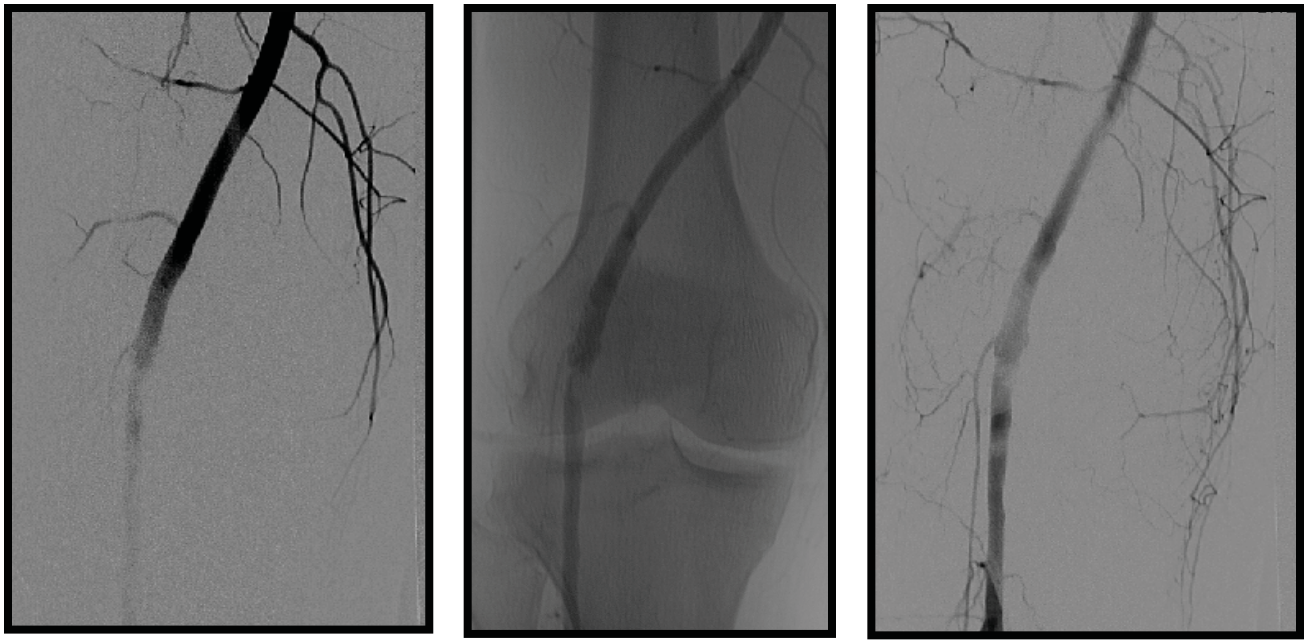
American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

McDonough and Wojtys. Multi-ligamentous Injuries of the Knee and Associated Vascular Injuries

Am J Sports Med 2009 37: 156

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, 74 due to **penetrating trauma***

Mills et al. *The value of the ankle-brachial index for diagnosing arterial injury after knee dislocation.* J Trauma. 2004;56:1261-1265.

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

-R. B. Frobell1, L. S. Lohmander, H. P. Roos. Acute rotational trauma to the knee: poor agreement between clinical assessment and magnetic resonance imaging findings. Scand J Med Sci Sports 2007: 17: 109–114

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Detection of a Reduced Knee Dislocation Requires Examination of the Ligaments

Stress Views can be helpful

LCL

PCL

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Foot and Ankle

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

Stiell I et al*. Multicentre trial to introduce the Ottawa ankle rules for use of radiography in acute ankle injuries. Multicentre Ankle Rule Study Group. *BMJ. 1995 Sep 2;311(7005):594-7.

Only ~15% xrays (+)

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

American College of Emergency Physicians
ADVANCING EMERGENCY CARE

ACEP sportsmed

Stiell IG, et al. Implementation of the Ottawa ankle rules. JAMA 1994;271:827-32.

Plint et al. Validation of the Ottawa Ankle Rules in Children with Ankle Injuries. *Acad. Emerg. Med.* 1999;6:1005-1009.

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

***Bachmann et al*. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. *BMJ* 2003;326:417-417.**

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

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

Widening of joint on weight bearing view.
CT shows fracture at base of 2nd Metatarsal.

ACEP sportsmed

Maissoneuve- syndesmotic injury, proximal fibular fracture with….

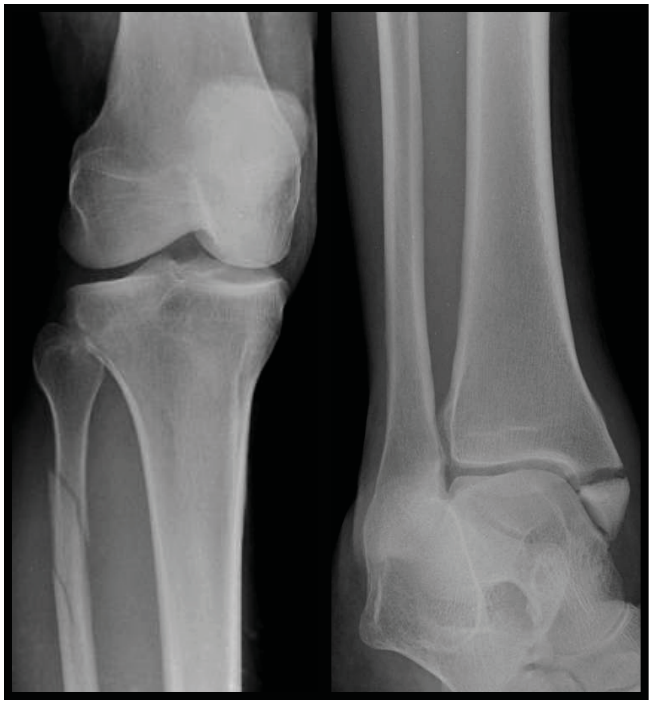
Medial malleolar fracture

or

Posterior malleolar fracture

or

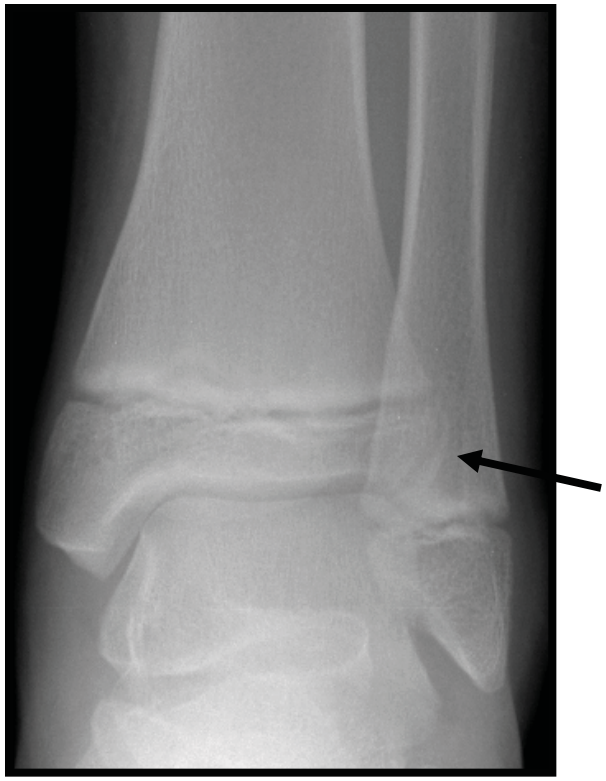
Deltoid tear



Maissoneuve- syndesmotic injury

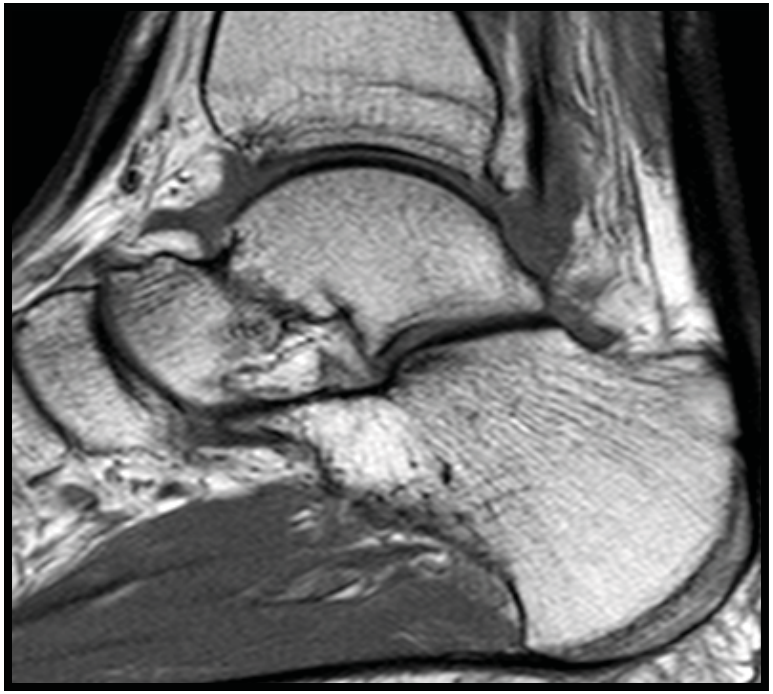
Posterior malleolar fracture Maissoneuve

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



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

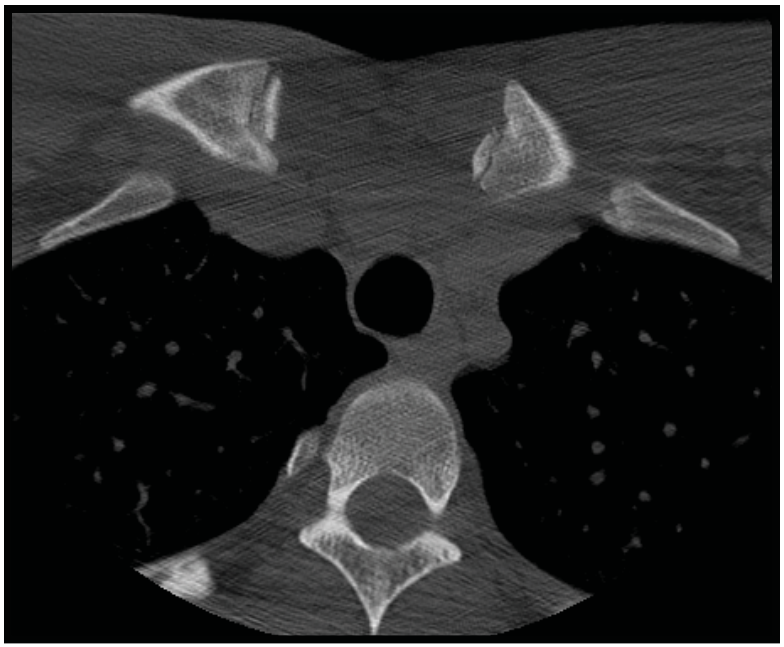
ACEP sportsmed

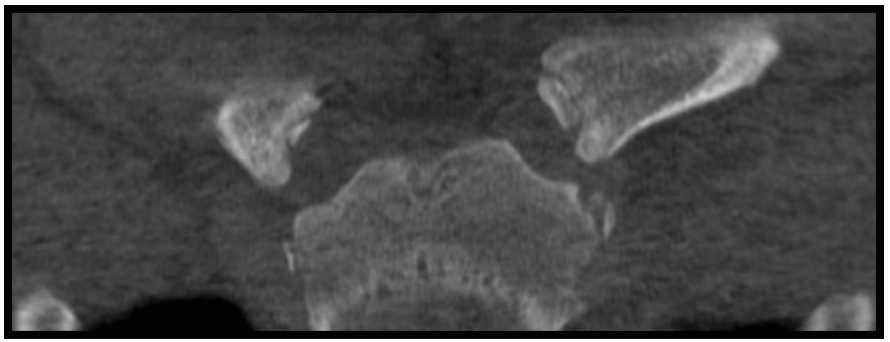
Sternoclavicular Joint

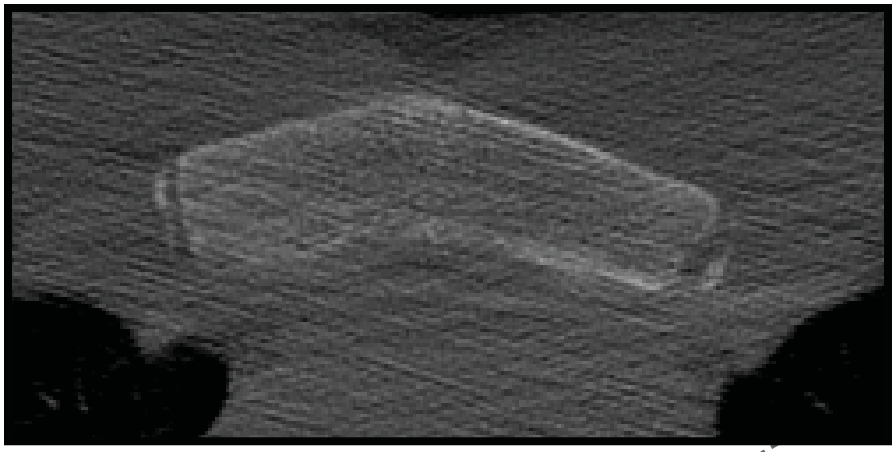
American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Normal adolescent SCJ anatomy: with physes



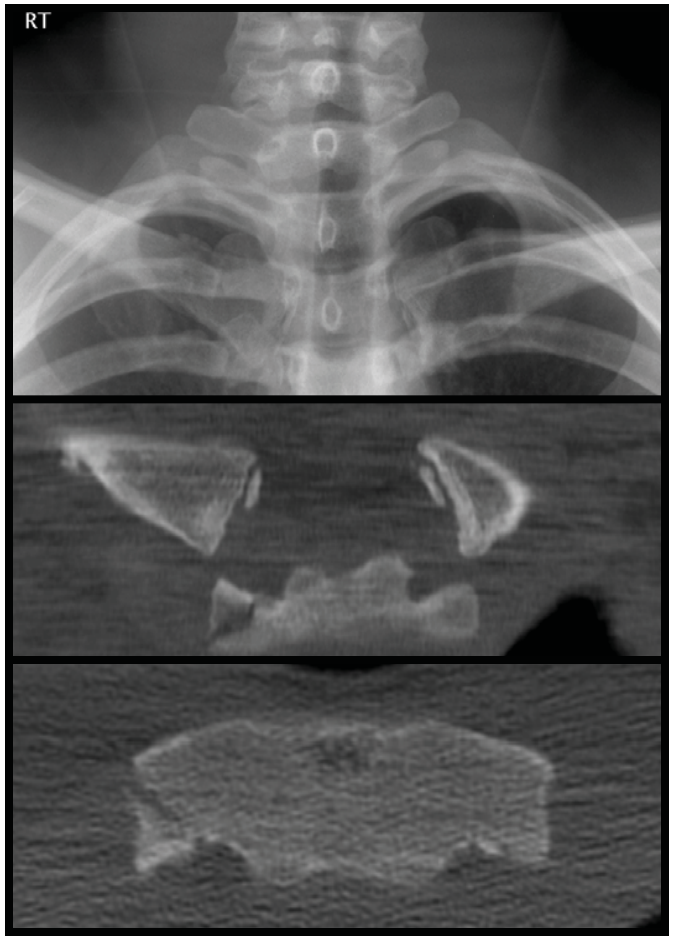




American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Case: 17 yo M Hockey Player w/ SCJ Pain s/p Lateral Blow to the Shoulder in a Game Sternal fractures



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

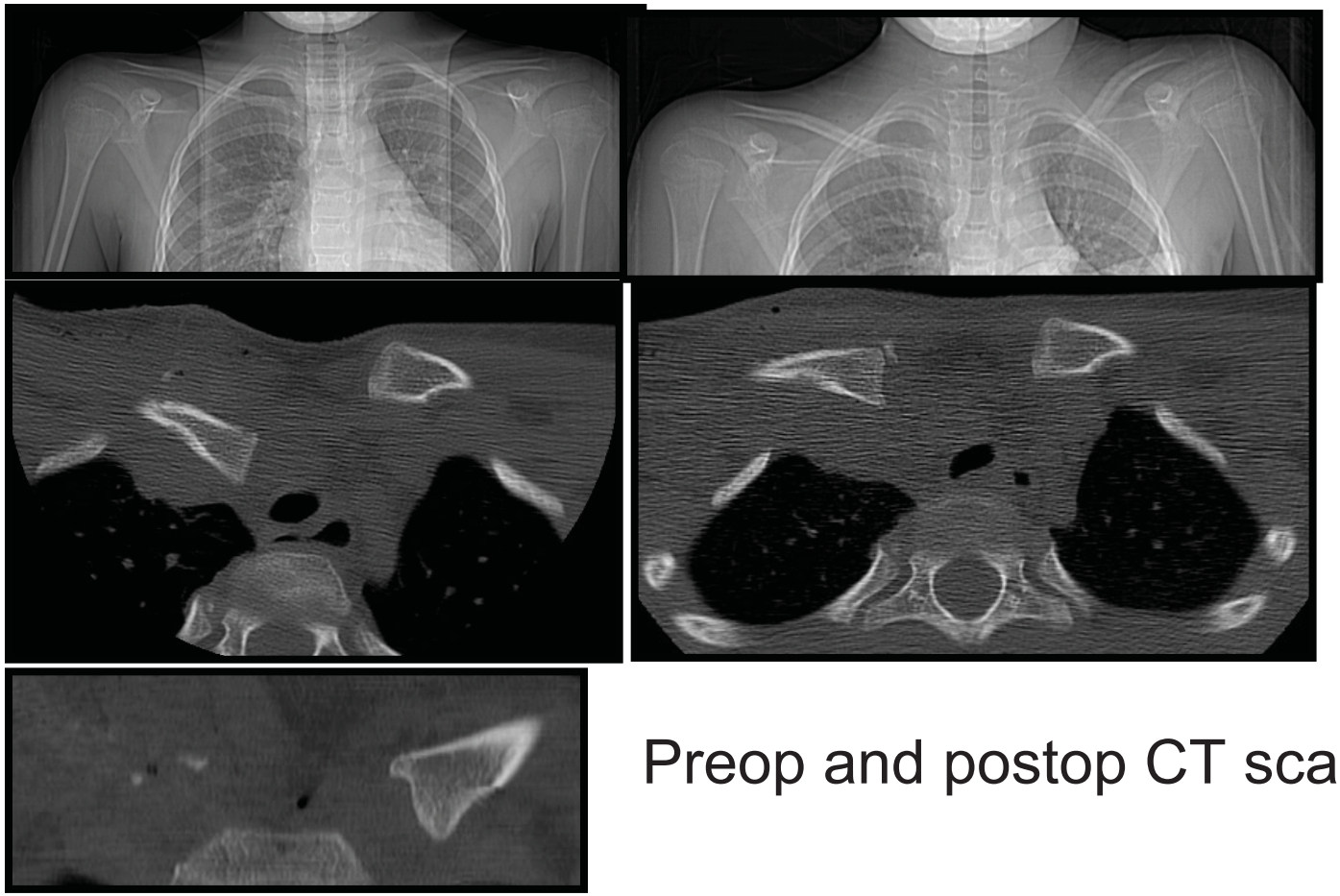
Case: 12 yo M Wrestler c/o Pain s/p Fall on R Shoulder 1 d PTA

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

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Hobbs. Sternoclavicular joint: a new axial radiographic view. *Radiology.* Apr;90(4):801, 1968.
Dislocations of the sternoclavicular joint. *Skeletal Radiology* 22(4):233-238, 1993.

Glenohumeral Fractures and Dislocations

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Shoulder Dislocations- Radiography

Pre-reduction xrays?

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

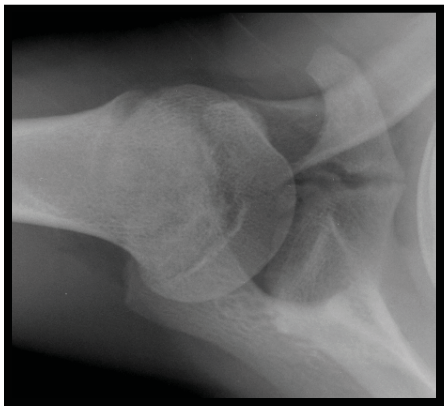
- Fractures associated in up to 25% anterior dislocations

- 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

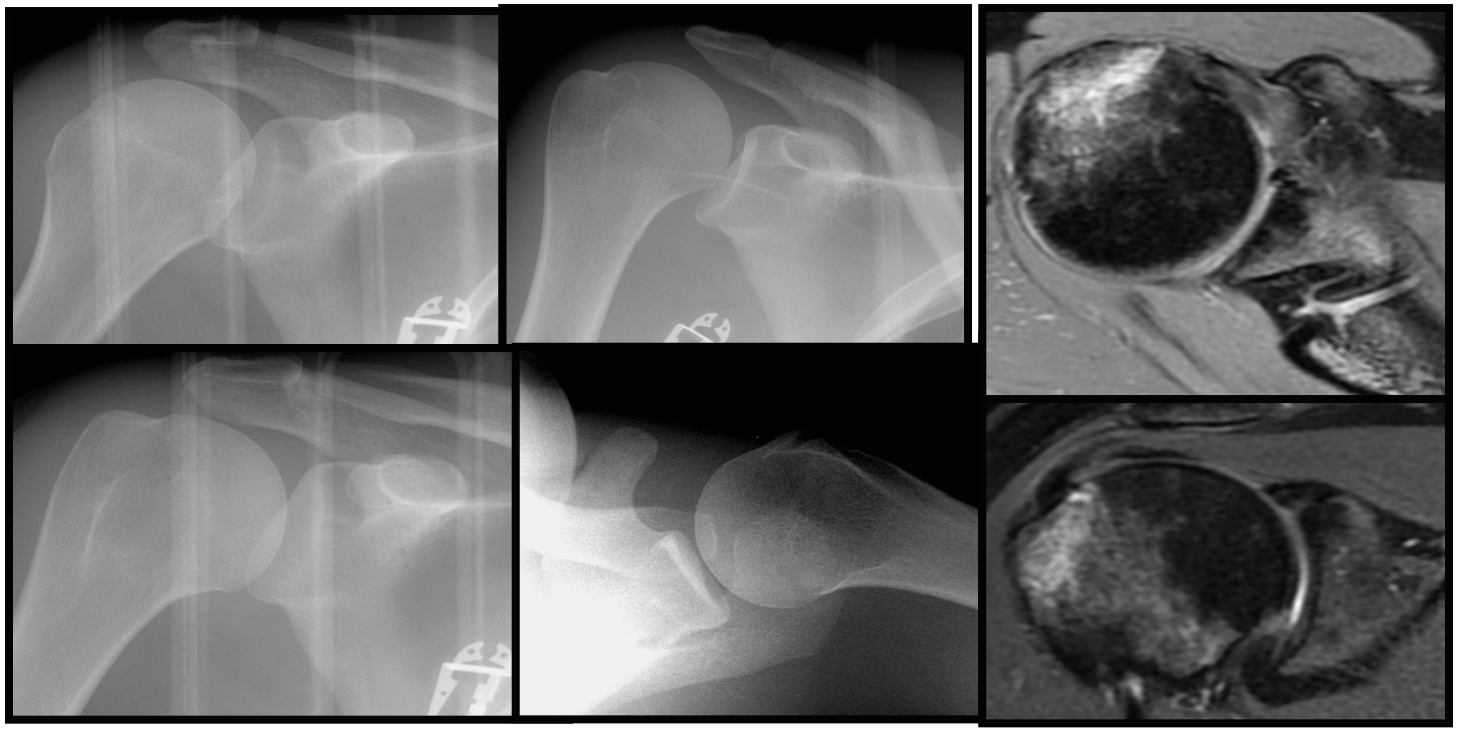


Normal physis at base and tip of coracoid

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

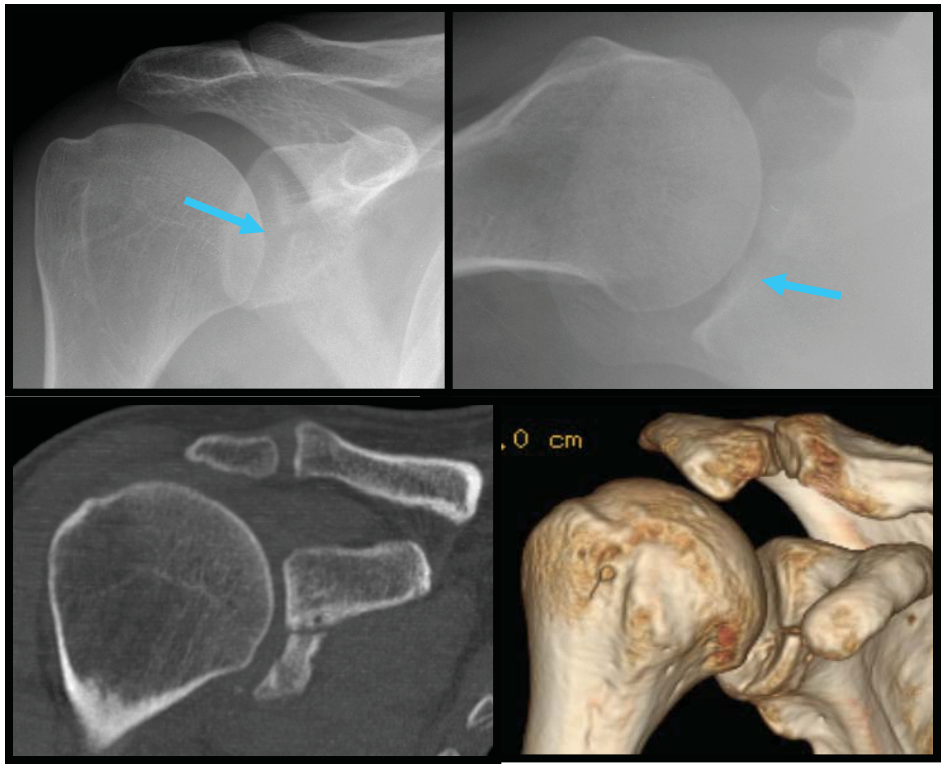


These can be occult- only seen on MRI

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

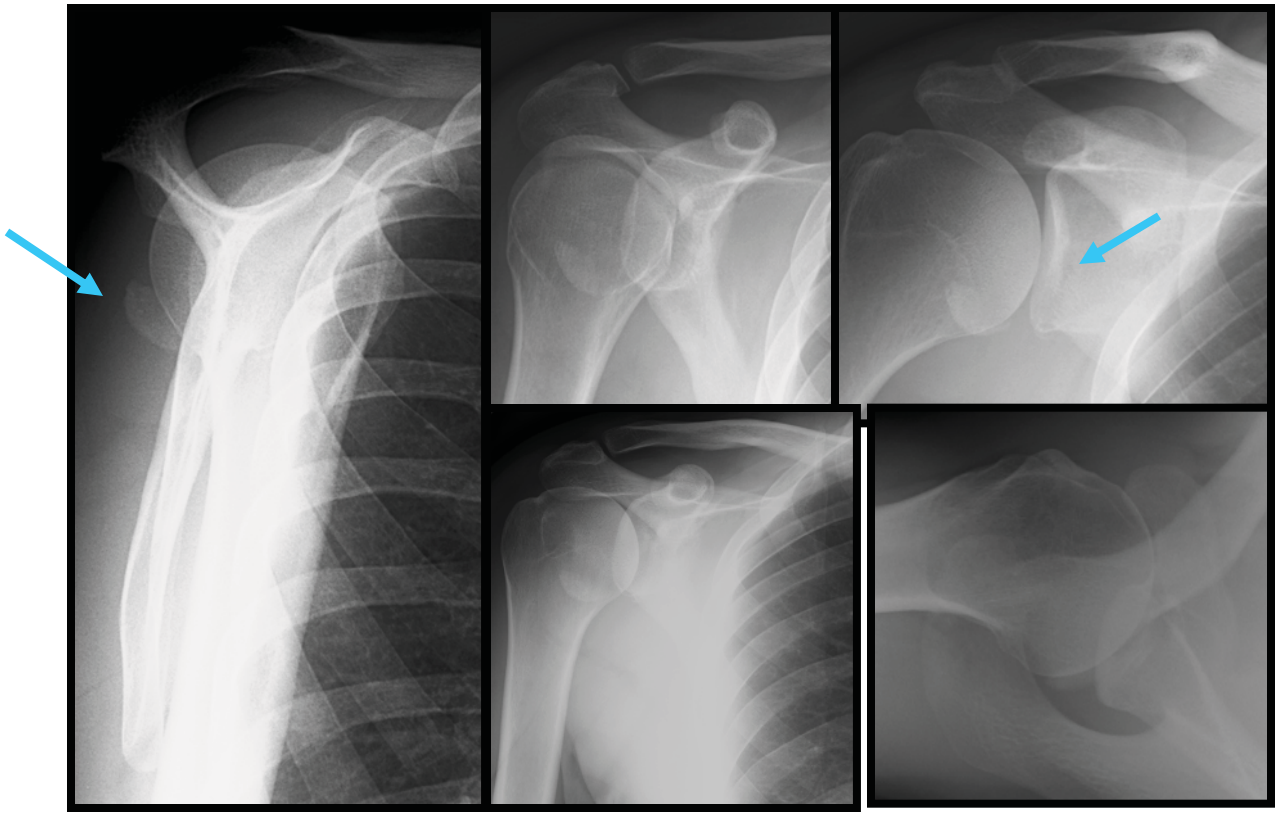
Glenoid Fracture



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Case: 34 yo M s/p 1st anterior dislocation requiring reduction in ER

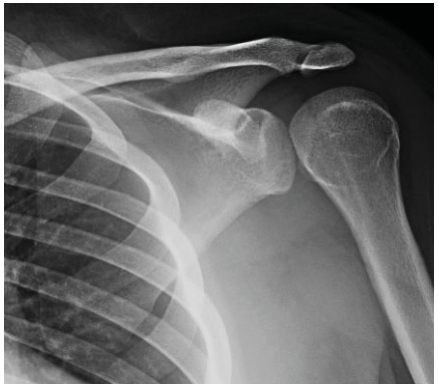


American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

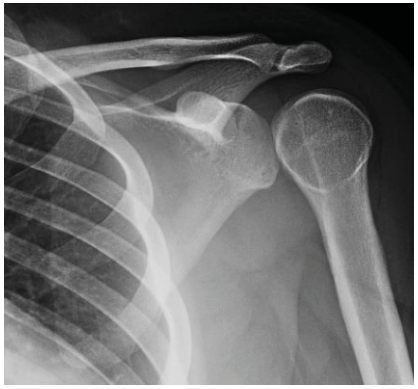
ACEP sportsmed

Posterior Dislocation

Note lack of overlap on glenoid

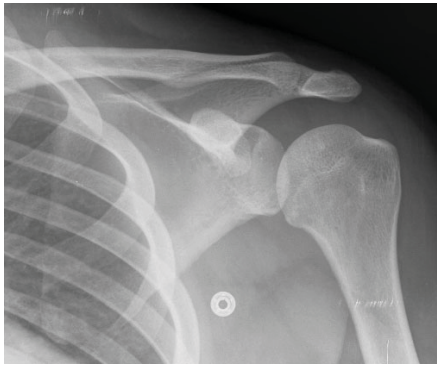


Lightbulb Sign

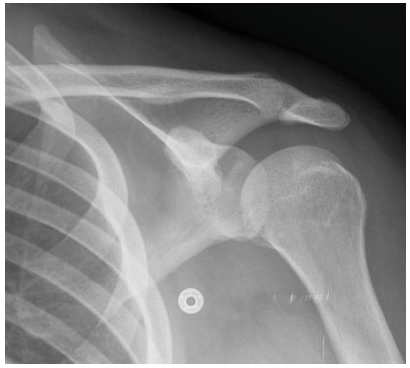


Head not centered on Y scapular view

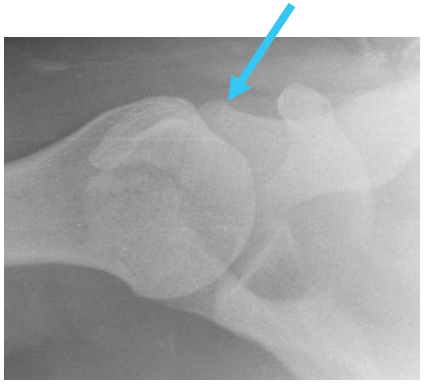
Postreduction with overlap



Postreduction



Reverse Hill Sachs Fracture



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Pediatric

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Buckle 'Torus' Fractures

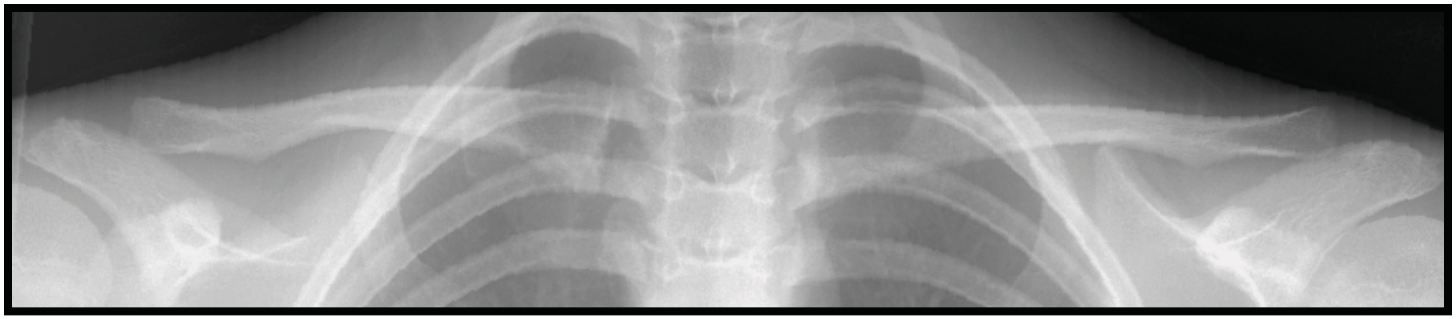
American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

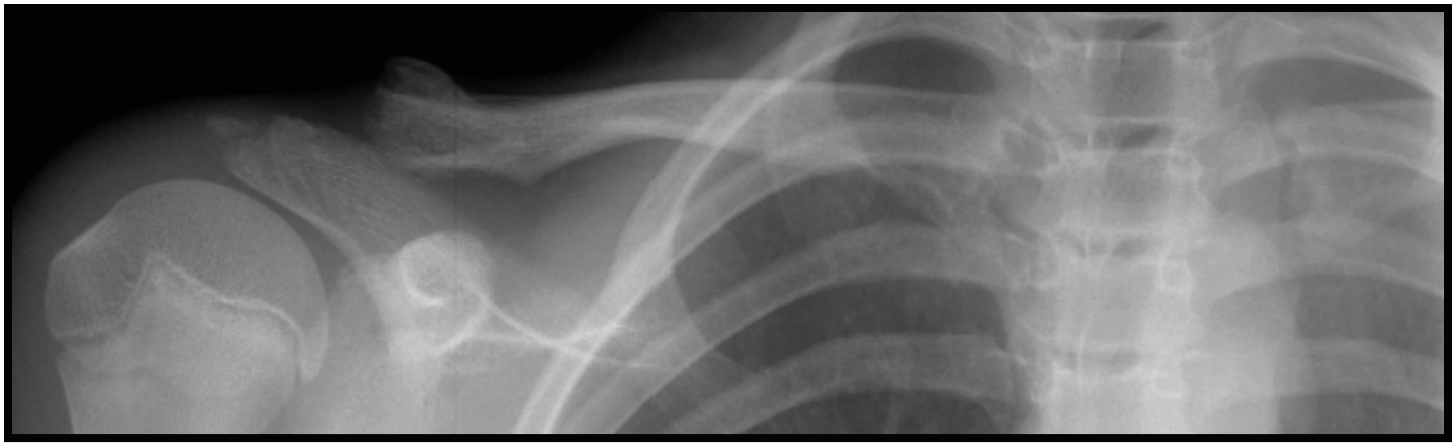
Distal Clavicle Salter I

Do not mistake for AC Joint Sprain

Initial xray



Followup xray with periosteal healing reaction



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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: xrays (-), posterior splint, f/u

PE: massive effusion, diffuse tenderness,

unable to extend due to pain,

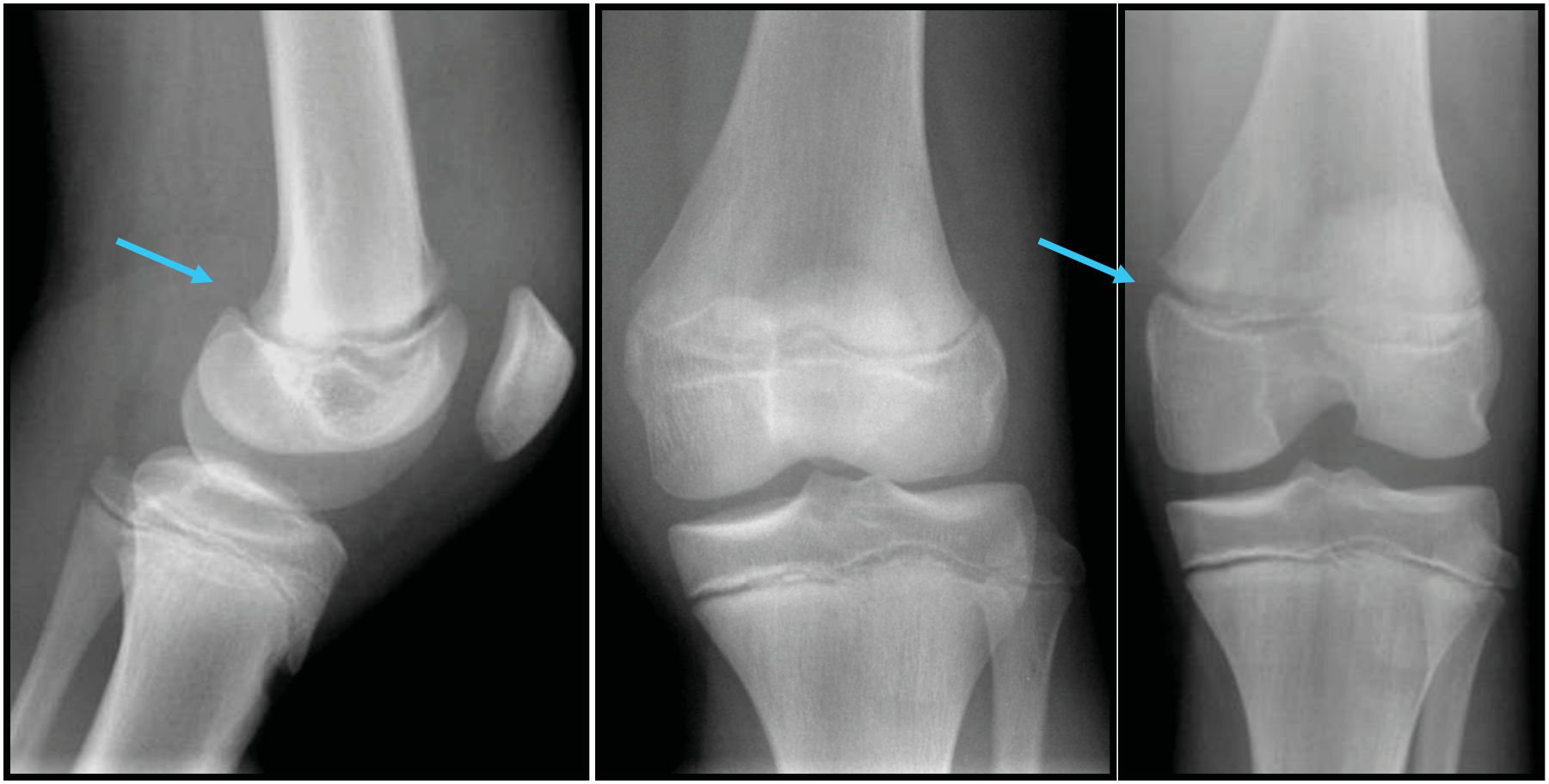
significant laxity with valgus stress / lachman /

posterior drawer, w/ posterior sag

?Multiple ligament injuries

?Knee dislocation

Unstable Salter I of Distal Femoral Physis



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Bulloch et al. Validation of the Ottawa Knee Rule in children: a multicenter study.

Ann Emerg Med. 2003 Jul;42(1):48-55.

2 to 16 years w/ knee injury < 7 days

750 enrolled: 670 with xrays

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.
Am J Sports Med 23:668-671, 1995.
Abstract in Annals of Emergency Medicine 27(5): 680, *1996*

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

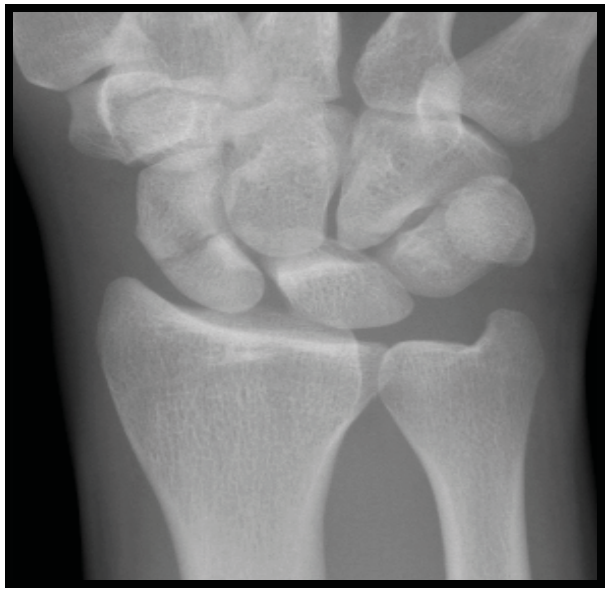
ACEP sportsmed

Wrist and Elbow

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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.

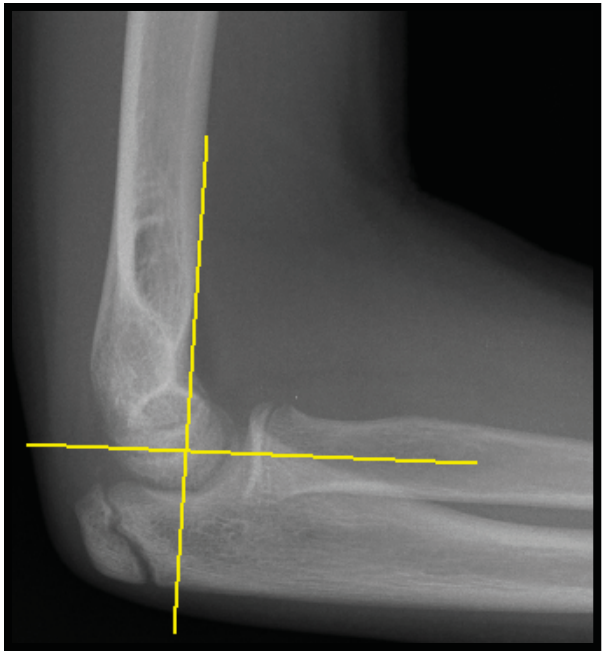
J Hand Surg [Br] 1993;18:403-6

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

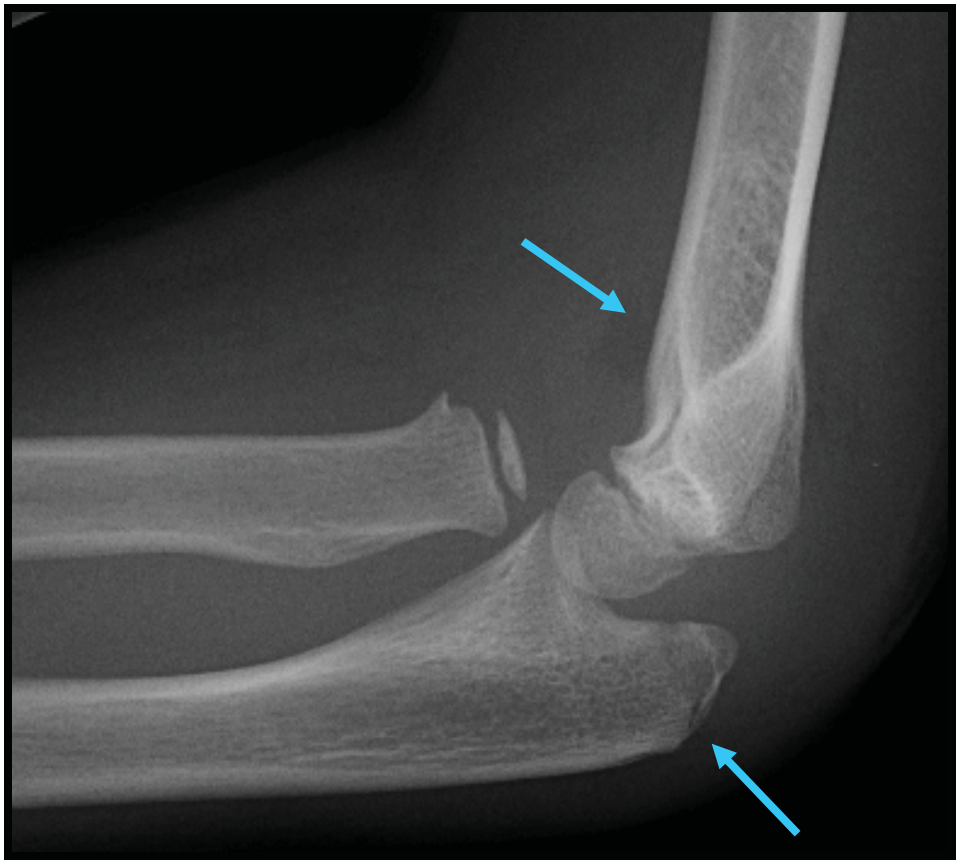
Radiocapitellar Line- along radial shaft intersects capitellum



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

8 yo M s/p FOOSH
Radial head dislocation, ulnar fracture



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Supracondylar Fracture

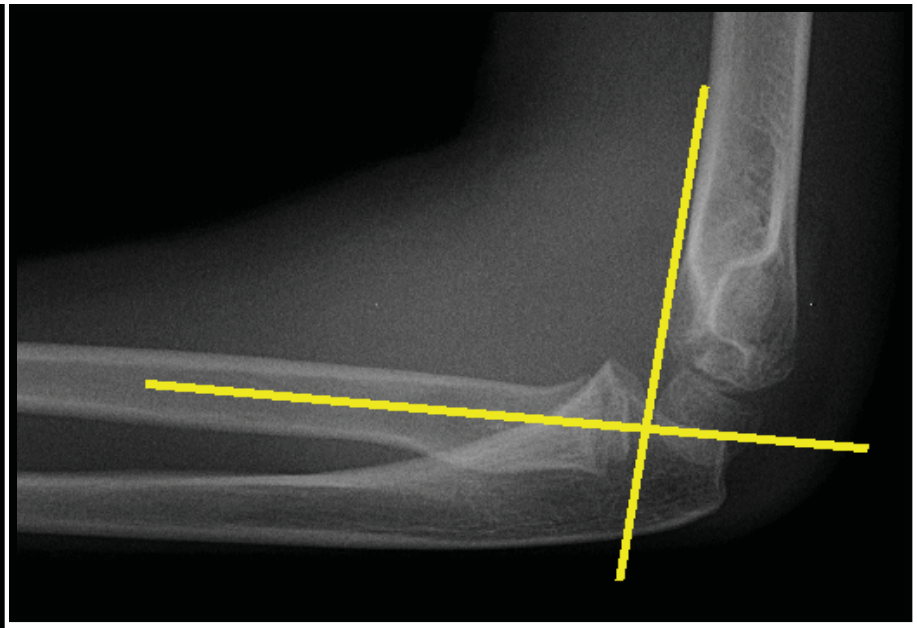
Cardinal signs of supracondylar fracture are

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



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

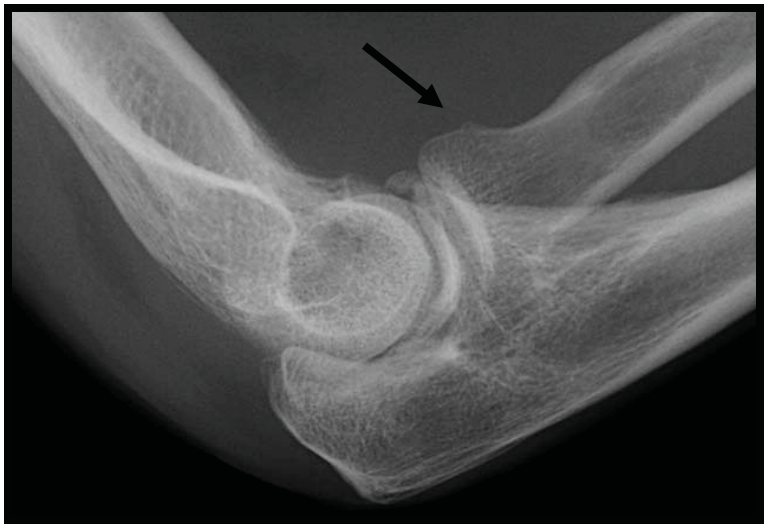
Elbow ossification centers

Order of Appearance of the individual ossification centers is

C-R-I-T-O-E:	(F/M)
Capitellum	1 yo/2 yo
Radial head	3 yo/4 yo
Internal (medial) epicondyle	5 yo/6 yo
Trochlea	7 yo/8 yo
Olecranon	9 yo/10 yo
External (lateral) epicondyle	11 yo/12 yo

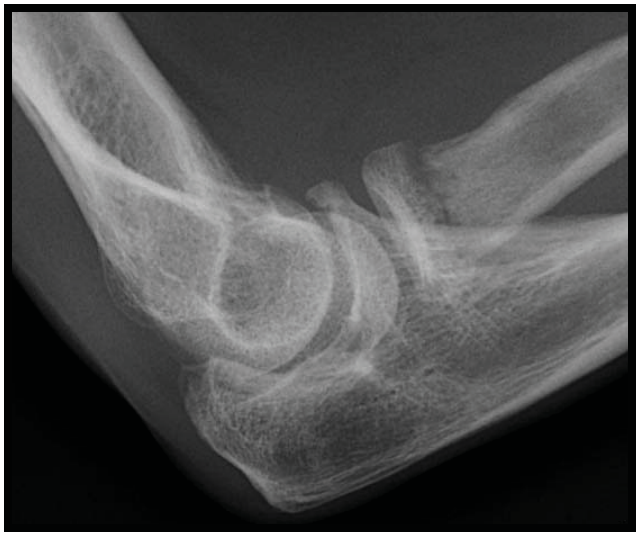
Occult Radial Head/Neck Fractures

Get an oblique view



May just be a buckle fracture.

4 months later



Beware the 180 degree rotation!

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

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

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

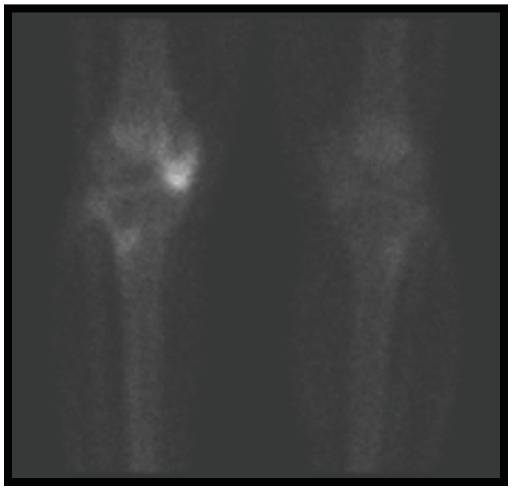
ACEP sportsmed

Osteopenia Insufficiency Fractures

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Case: Insufficiency fracture of medial femoral condyle due to AVN (smoker, osteopenic, diabetes)



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

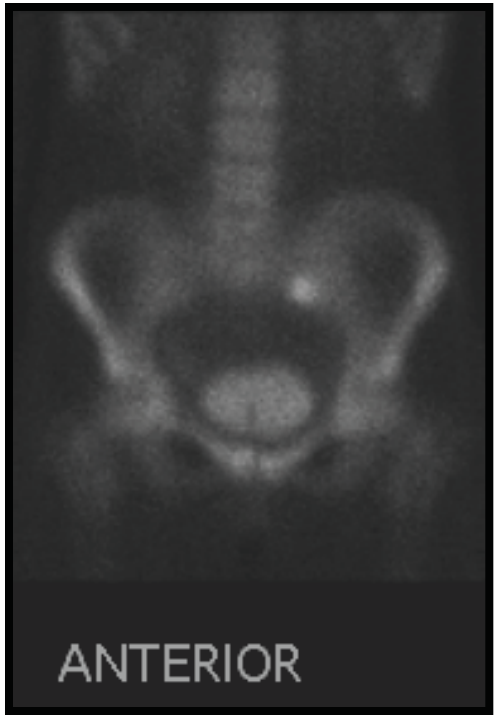
Case: 22 yo F lawstudent w/ Athletic Triad

Eating disorder

Amenorrhea

Osteoporosis/Osteopenia

Stress fracture sacrum x 2



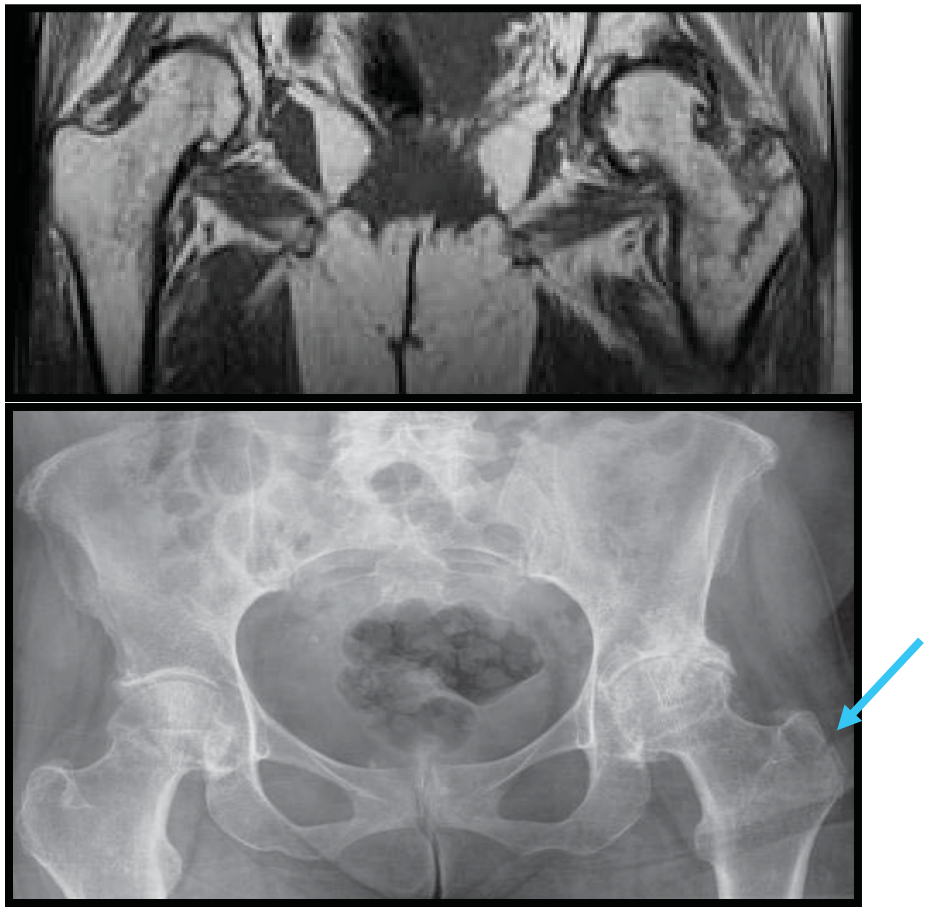
Marx et al. Stress fracture sites related to underlying bone health in athletic females. *Clin J Sports Med 2001, 11:73-76.*

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



American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

ACEP sportsmed

Dominguez et al. Prevalence of Traumatic Hip and Pelvic Fractures in Patients with Suspected Hip Fracture and Negative Initial Standard Radiographs--A Study of Emergency Department Patients**. *Acad. Emerg. Med.* 2005;12:366-369.**

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***

Rajkumar, Tay: **Clinical Triad For Diagnosing Occult Hip Fractures With Normal Radiographs.** ***The Internet Journal of Orthopedic Surgery.*** **2006. 3(1).**

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 xrays

*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)