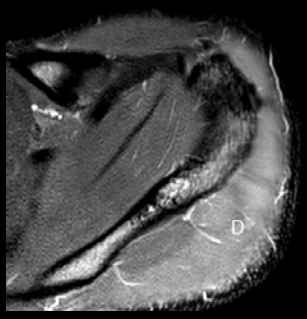
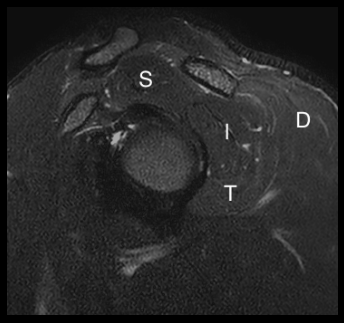
Musculoskeletal MRI

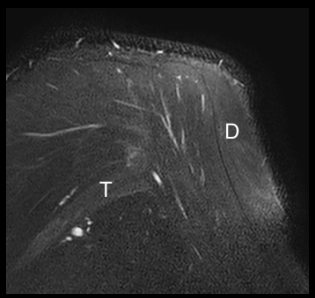
Jack Porrino, MD
University of Washington
Department of Radiology



Axial PD FS



Sagittal T2 FS



Coronal T2 FS

The imaging findings may be attributable to a mass within the:

A.Suprascapular Notch.
B.Spinoglenoid Notch.
C.Quadrilateral Space.
D.No mass, more likely Parsonage-Turner Syndrome.

Shoulder Denervation

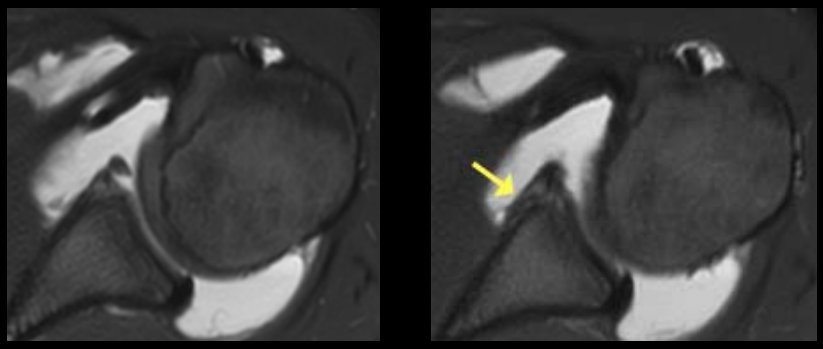
- **Findings of denervation:**
  - Acute:
    - Increased signal on fluid sensitive sequences
  - Chronic:
    - Fatty atrophy on T1W imaging
  - Affected nerve may exhibit abnormal size and signal
  - Search for a pattern of denervation and a mechanical cause
  - Our case → **Quadrilateral space**

- **Mechanical causes of denervation:**
  - Fracture deformity
  - Neoplasm
  - Cyst (paralabral)
  - Hematoma
  - Varices

PATTERN	NERVE	ENTRAPMENT
Supraspinatus and infraspinatus muscle	Suprascapular nerve	Suprascapular notch
Infraspinatus muscle	Suprascapular nerve	Spinoglenoid notch
Teres minor +/- deltoid muscle	Axillary nerve	Quadrilateral space (bound by the humerus, long head triceps, teres major, and teres minor)
Variable, as the entire brachial plexus can be affected	Parsonage-Turner Syndrome/Brachial plexus neuropathy (idiopathic brachial plexopathy)	Not applicable

Table 4. Denervation patterns of the shoulder. (23)

Yanny S, Toms AP. MR patterns of denervation around the shoulder. AJR Am J Roentgenol. 2010 Aug;195(2):W157-63.



Axial PD FS

What is the yellow arrow pointing to on the right?

A.Periosteal attachement of a torn labrum.
B.Intra-articular body.
C.Periosteal attachment of a torn and displaced labrum.
D.Inferior glenohumeral ligament.

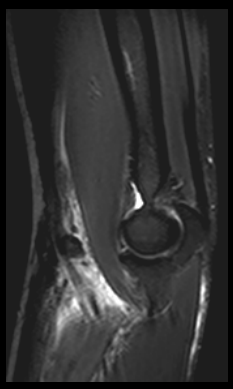
Bankart Tear and Variants

- **Findings of labral tear:**
  - Abnormal increased signal within the labrum
  - May have an accompanying paralabral cyst
  - With arthrography, fluid insinuation into the tear may be present
- **Bankart tear:**
  - The consequence of anterior shoulder dislocation (glenohumeral instability)
  - Tear involving the inferior glenoid labrum
  - Distinguishing the difference amongst these lesions may be challenging.
  - Our case → **Perthes**

TYPE	DESCRIPTION
Soft tissue Bankart lesion	Detachment of the anteroinferior glenoid labrum (if fracture is present of the anteroinferior glenoid, this is termed an osseous Bankart lesion)
Reverse soft tissue Bankart lesion	Involves the posteroinferior glenoid labrum
Perthes *and* Anterior Labroligamentous Periosteal Sleeve Avulsion (ALPSA)	Avulsion of the anteroinferior labrum that remains attached to the glenoid by a strip of periosteum (Perthes); if the avulsed, but still attached by a strip of periosteum, fragment is displaced inferomedially, it is termed an ALPSA lesion
Posterior Labroligamentous Periosteal Sleeve Avulsion (POLPSA)	Involves the posteroinferior glenoid labrum
Glenolabral Articular Disruption (GLAD)	Anteroinferior labral injury with concomitant glenoid articular cartilage defect
Bennett lesion	Extra-articular crescentic posterior ossification associated with posterior labral injury and capsular avulsion

Mohana-Borges AV, Chung CB, Resnick D. Superior labral anteroposterior tear: classification and diagnosis on MRI and MR arthrography. AJR Am J Roentgenol. 2003 Dec;181(6):1449-62
Jana M, Gamanagatti S. Magnetic resonance imaging in glenohumeral instability. World J Radiol. Sep 28, 2011; 3(9): 224-232.
Sheehan SE, Gaviola G, Gordon R, Sacks A, Shi LI, Smith SE. Traumatic shoulder injuries: a force mechanism analysis-glenohumeral dislocation and instability. AJR Am J Roentgenol. 2013 Aug; 201(2): 378-93.

Sagittal PD



Sagittal STIR

What structure prevents retraction when the above tendon is ruptured?

A.Brachialis muscle.
B.Lacertus fibrosis.
C.Surrounding neurovascular bundle.
D.Ulnar collateral ligament.

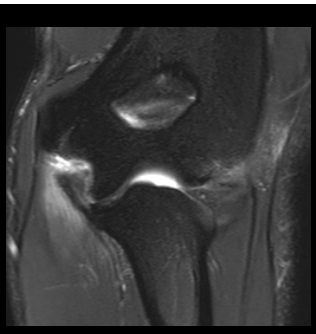
Rupture of the Biceps Tendon

- **Findings of biceps tendon rupture:**
  - Fiber discontinuity
  - Complete – absence of the distal biceps tendon with replacement by edema (our case)
  - Partial – thinned or thickened tendon, abnormal intrasubstance signal, marrow edema at radial tuberosity, fluid within bicipitoradial bursa
- **Background:**
  - Tear is rare, more often complete than partial
  - Usually the result of a single traumatic event
  - Tear typically occurs at radial tuberosity
- **Bicipital aponeurosis/Lacertus fibrosis:**
  - Continuation of the anteromedial fascia of the distal biceps, inserting onto the deep fascia of the forearm
  - If intact, the tendon will not retract

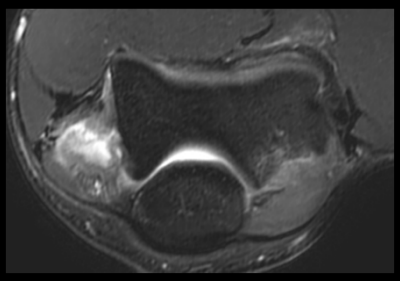
Rupture of the Biceps Tendon

- **DDx for biceps tendon tear**
  - There is considerable overlap between chronic tendinosis and partial thickness tearing
  - Beware isolated bicipitoradial bursitis, which may also simulate a mass

Kijowski R, Tuite M, Sanford M. Magnetic resonance imaging of the elbow. Part I: normal anatomy, imaging technique, and osseous abnormalities. Skeletal Radiology. 2004 Dec;22(12):685-97.
Kijowski R, Tuite M, Sanford M. Magnetic resonance imaging of the elbow. Part II: Abnormalities of the ligaments, tendons, and nerves. Skeletal Radiology. 2005 Jan;34(1):1-18.



Coronal T2 FS



Axial T2 FS

The structure avulsed in these images is comprised of how many components?

A.1
B.2
C.3
D.4

Ulnar Collateral Ligament Tear

- **Findings of UCL tear:**
  - o Typically full thickness, and usually midsubstance
  - o Partial tears usually affect the undersurface
  - o Amorphous, redundant appearance, fiber discontinuity, abnormal intrasubstance signal, and periligamentous edema
- **Background:**
  - o 3 bundles: anterior, posterior, and transverse
    - ▪ Anterior bundle is clinically relevant (major stabilizer against valgus and rotary stress)
      - • 2 bands: anterior and posterior
      - • From medial humeral epicondyle to sublime tubercle of coranoid process
      - • Most often injured due to chronic repetitive stress from overhead throwing
  - o Usually the result of a single traumatic event
  - o Tear typically occurs at radial tuberosity

Ulnar Collateral Ligament Tear

- **DDx of UCL tear:**
  - Partial versus complete
  - Common flexor tendon injury

Kijowski R, Tuite M, Sanford M. Magnetic resonance imaging of the elbow. Part I: normal anatomy, imaging technique, and osseous abnormalities. Skeletal Radiology. 2004 Dec;22(12):685-97.
Kijowski R, Tuite M, Sanford M. Magnetic resonance imaging of the elbow. Part II: Abnormalities of the ligaments, tendons, and nerves. Skeletal Radiology. 2005 Jan;34(1):1-18.
Wear SA, Thornton DD, Schwartz ML, Weissmann RC 3rd, Cain EL, Andrews JR. MRI of the reconstructed ulnar collateral ligament. AJR Am J Roentgenol. 2011 Nov; 197(5):1198-204.

Contrast within the DRUJ following injection into the RCJ implies discontinuity of the:

A.Scapholunate ligament.
B.Lunotriquetral ligament.
C.Triangular fibrocartilage.
D.Dorsal intercarpal ligament.

Coronal T1 FS

Triangular Fibrocartilage

- **Findings of TFC tear:**
  - Hypointense centrally/radially, with two peripheral arms that appear striated
  - Full thickness (communicating) or partial thickness (non-communicating)
  - Contrast extravasation into the DRUJ with RCJ injection
- **Components of the TFCC:**
  - Triangular fibrocartilage (TFC) proper/disk
  - Dorsal and volar radioulnar ligaments
  - Meniscal homologue
  - Sheath of extensor carpi ulnaris tendon
  - Ulnar collateral ligament
  - Ulnolunate and ulnotriquetral ligaments

Triangular Fibrocartilage

Traumatic (I)		Degenerative (II)	
A.	Central perforation	A.	TFC partial thickness tear
B.	Ulnar avulsion	B.	TFC partial thickness tear and chondromalacia (not reliably seen by MRI)
C.	Distal avulsion (ulnolunate or ulnotriquetral ligament injury)	C.	TFC perforation (which occurs centrally) and chondromalacia
D.	Radial avulsion	D.	TFC perforation, chondromalacia, and lunotriquetral ligament perforation
		E.	TFC perforation, chondromalacia, lunotriquetral ligament perforation, and ulnocarpal/ radioulnar arthritis

Palmer Classification of TFC Tears

Triangular Fibrocartilage

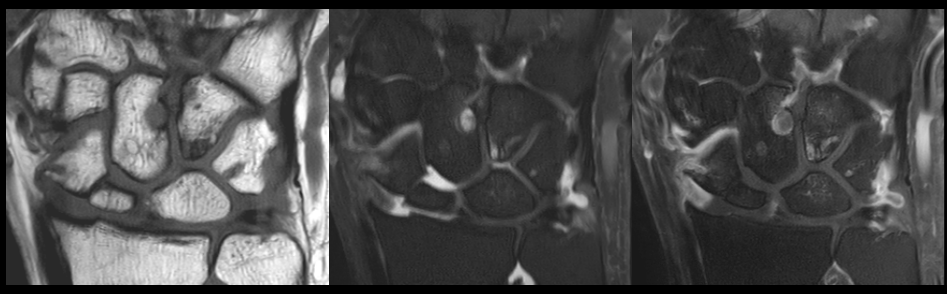
Vezeridis PS, Yoshioka H, Han R, Blazar P. Ulnar-sided wrist pain. Part I: anatomy and physical examination. Skeletal Radiol. 2010 Aug;39(8):733-45. doi:10.1007/s00256-009-0775-x. Epub 2009 Sep 1. Review.

Watanabe A, Souza F, Vezeridis PS, Blazar P, Yoshioka H. Ulnar-sided wrist pain. II. Clinical imaging and treatment. Skeletal Radiol. 2010 Sep;39(9):837-57. doi: 10.1007/s00256-009-0842-3. Epub 2009 Dec 10.

Burns JE, Tanaka T, Ueno T, Nakamura T, Yoshioka H. Pitfalls that may mimic injuries of the triangular fibrocartilage and proximal intrinsic wrist ligaments at MR imaging. Radiographics. 2011 Jan-Feb;31(1):63-78. doi: 10.1148/rg.311105114. Review.

Bateni CP, Bartolotta RJ, Richardson ML, Mulcahy H, Allan CH. Imaging key wrist ligaments: what the surgeon needs the radiologist to know. AJR Am J Roentgenol. 2013 May;200(5):1089-95. doi: 10.2214/AJR.12.9738.

Oneson SR, Scales LM, Timins ME, Erickson SJ, Chamoy L. MR imaging interpretation of the Palmer classification of triangular fibrocartilage complex lesions. Radiographics. 1996 Jan;16(1):97-106.



Coronal T1 | Coronal T2 FS | Coronal T1 FS Post IV Gad

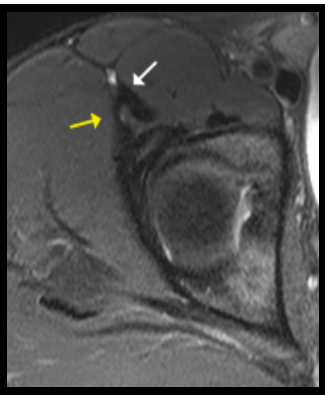
A non-viable proximal scaphoid pole following fracture will appear:

A.Dark on T1 and T2 FS.
B.Dark on T1 and bright on T2 FS.
C.Bright on T1 and bright on T2 FS.
D.Bright on T1 and dark on T2 FS.

Avascular Necrosis of the Scaphoid

- **Findings of AVN involving the fractured scaphoid:**
  - o Hypointense signal on T1 and fat-suppressed fluid sensitive imaging
  - o Hyperintense signal on fat-suppressed fluid sensitive imaging is non-specific
  - o IV gad is confusing → necrotic bone can enhance
- **Background:**
  - o AVN of the scaphoid is a potential complication of fracture
  - o If non-union, bone graft is typically necessary during operative fixation
  - o Vascularized bone graft is necessary if there is proximal pole AVN
- DDx:
  - Our case → viable proximal pole following fracture non-union
  - Non viable proximal pole following fracture non-union

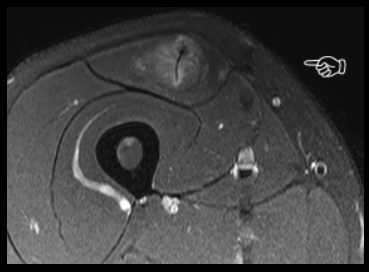
Fox MG, Gaskin CM, Chhabra AB, Anderson MW. Assessment of scaphoid viability with MRI: a reassessment of findings on unenhanced MR images. AJR Am J Roentgenol. 2010 Oct;195(4):W281-6.



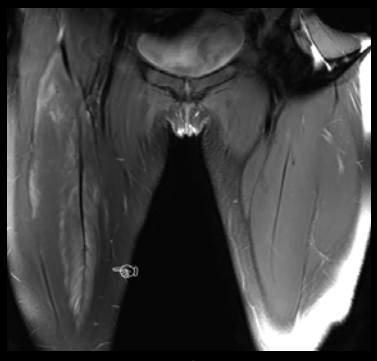
Axial T2 FS

The white and yellow arrows above point to (respectively):

A.Indirect and direct head rectus femoris.
B.Direct and indirect head rectus femoris.
C.Sartorius and rectus femoris.
D.TFL and sartorius.



Axial T2 FS



Coronal T2 FS

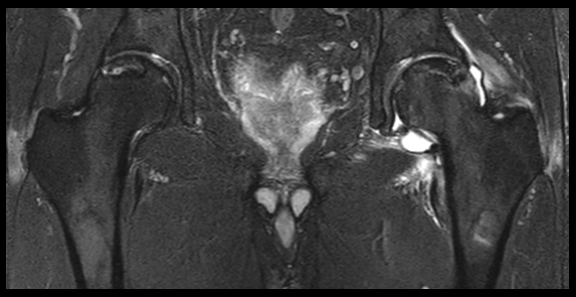
Rectus Femoris Strain

- **Anatomy of biceps femoris strain/tear:**
  - Proximal
    - Direct head – arises from AIIS
    - Indirect head – arises from superior acetabular ridge and joint capsule
  - Form a conjoined but still distinguishable tendon 2 cm distal to their origin
    - Direct head forms the superficial anterior tendon covering the proximal 1/3rd of the muscle
    - Indirect head forms the deep intramuscular tendon and bipennate muscle, and is surrounded by the unipennate muscle of the direct head
- **Variations of biceps femoris strain/tear:**
  - AIIS avulsion
  - Injury at the tendon origin
  - Myotendinous junction injuries, both proximal and distal

Rectus Femoris Strain

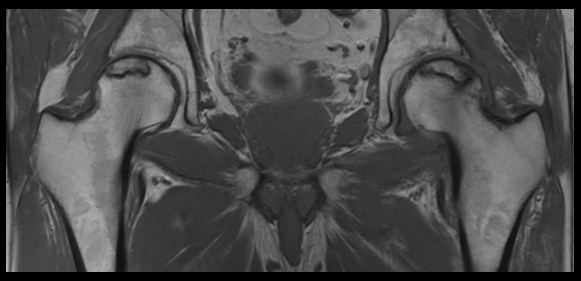
- **Features of biceps femoris strain/tear in our case:**
  - Bull's eye sign
    - Edema about the inner indirect tendon and its surrounding bipennate muscle
    - Normal signal within the peripheral unipennate muscle

http://radsource.us/rectus-femoris-quadriceps-injury/



Coronal STIR

Sagittal T1 Left



Coronal T1

What does the arrow indicate?

A.Edema.
B.Subchondral collapse.
C.Unaffected bone.
D.Cartilage delamination.

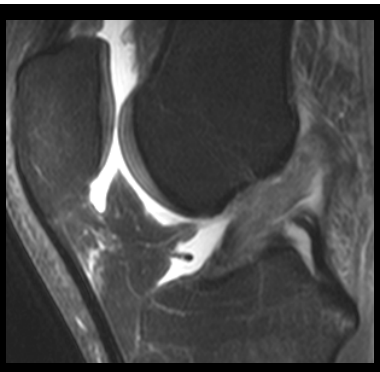
Avascular Necrosis of the Femoral Head

- **Features of femoral head AVN:**
  - o Ring-like serpiginous subchondral hypointense signal abnormality (represents the interface of repair tissue with the necrotic zone)
  - o Inner border of the signal abnormality is bright on T2 weighted imaging, creating a double line sign (may be related to chemical shift artifact)

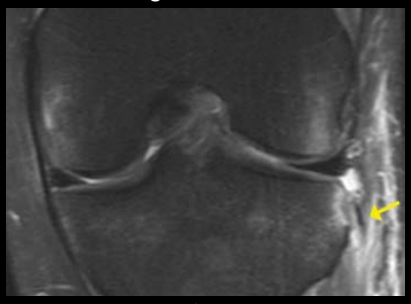
- **Pain with AVN:**
  - o Pathogenesis: elevated pressure within medullary space, subchondral fracture, or increase in hydrostatic pressure caused by effusion are all theories
  - o The presence of bone marrow edema, often associated with joint effusion, has a strong association with pain, and may be related to impending subchondral fracture

Huang GS, Chan WP, Chang YC, Chang CY, Chen CY, Yu JS. MR imaging of bone marrow edema and joint effusion in patients with osteonecrosis of the femoral head: relationship to pain. AJR Am J Roentgenol. 2003 Aug;181(2):545-9.

http://emedicine.medscape.com/article/386808-overview#a21



Sagittal T2 FS



Coronal PD FS

What does the arrow point to?

A.Arcuate fracture.
B.Gerdy's tubercle avulsion.
C.Segond fracture.
D.Popliteus tendon.

ACL Injury and Segond Fracture

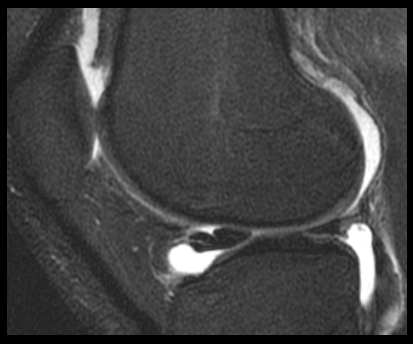
- **Findings of ACL tear:**
  - Fiber discontinuity
  - Absent ACL
  - Abnormal horizontal or vertical orientation
  - Wavy contour
  - Edematous mass
- **Secondary signs of ACL tear:**
  - Bone bruise of posterolateral tibial plateau/lateral femoral condyle
  - Buckling of PCL
  - Posterior displacement of the posterior horn of lateral meniscus

ACL Injury and Segond Fracture

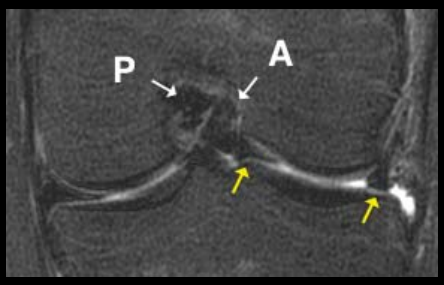
- **DDx:**
  - Partial thickness tear/sprain
  - Mucoid degeneration
    - Celery stalk appearance
    - Prior trauma, degeneration, or congenitally displaced synovial tissue

- Segond fracture:
  - Cortical avulsion fracture of proximal tibia, behind Gerdy's tubercle
  - Excessive internal rotation and varus stress
  - High association with ACL and meniscal tears

Chan WP, Peterfy C, Fritz RC, Genant HK. MR diagnosis of complete tears of the anterior cruciate ligament of the knee: importance of anterior subluxation of the tibia. AJR Am J Roentgenol. 1994 Feb;162(2):355-60.
Ha T, Li K, Beaulieu CF, et al. Anterior cruciate ligament injury - fast spin-echo MR imaging with arthroscopic correlation in 217 examinations. AJR Am J Roentgenol 1998; 170:1215-1219.
McCauley TR, Moses M, Kier R, Lynch JK, Barton JW, Jokl P. MR diagnosis of tears of anterior cruciate ligament of the knee: importance of ancillary findings. AJR Am J Roentgenol. 1994 Jan;162(1):115-9.
Bergin D, Morrison WB, Carrino JA, et al. Anterior cruciate ligament ganglia and mucoid degeneration: coexistence and clinical correlation. AJR Am J Roentgenol 2004; 182:1283-1287.
Hensen JJ, Coerkamp EG, Bloem JL, De Schepper AM. Mucoid degeneration of the anterior cruciate ligament. JBR-BTR. 2007 May-Jun;90(3):192-3.
Kumar A, Bickerstaff DR, Grimwood JS, Suvarna SK. Mucoid degeneration of the cruciate ligament. J Bone Joint Surg [Br] 1999; 81:304-305.
Porrino J Jr, Maloney E, Richardson M, Mulcahy H, Ha A, Chew FS. The anterolateral ligament of the knee: MRI appearance, association with the segond fracture, and historical perspective. AJR Am J Roentgenol. 2015 Feb;204(2):367-73.



Sagittal T2 FS



Coronal T2 FS

What sign is depicted on the sagittal image above?

A. Double PCL sign.
B. Anterior drawer sign.
C. Double delta sign.
D. Ghost meniscus sign.

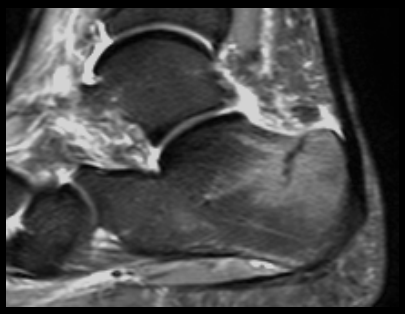
Bucket Handle Meniscal Tear

- **Findings of bucket handle meniscal tear:**
  - Vertical longitudinal tear with displacement of the inner meniscal fragment into the intercondylar notch
  - Double PCL Sign
  - Absent bow tie sign – truncated body seen only on a single sagittal slice
  - Double delta sign – two apparent anterior horns
- **Alternative forms of meniscal tear (ddx):**
  - Horizontal cleavage
  - Vertical longitudinal
  - Radial
  - Oblique/flap

Bucket Handle Meniscal Tear

- **General criteria for mensical tear:**
  - Abnormal signal that breaches the superior or inferior articular surface, or the meniscal apex
  - Look for a parameniscal cyst

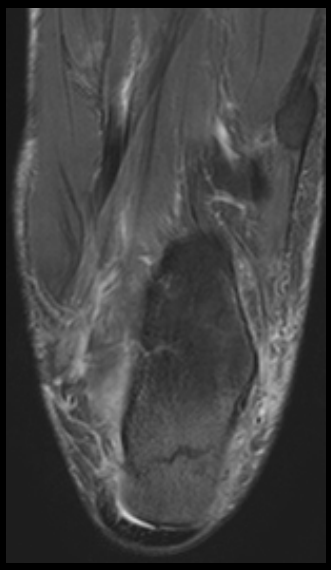
http://www.eurorad.org/eurorad/case.php?id=8459
Helms CA, Laorr A, Cannon WD. The absent bow tie sign in bucket-handle tears of the menisci in the knee. *AJR Am J Roentgenol 1998;170;57-61.*
Costa CR, Morrison WB, Carrino JA. Medial meniscus extrusion on knee MRI: is extent associated with severity of degeneration or type of tear? AJR Am J Roentgenol. 2004 Jul;183(1):17-23.



Sagittal STIR

What disorder predisposes patients to insufficiency fractures of the calcaneus?

A.Scleroderma.
B.Hypertension.
C.Rheumatoid arthritis.
D.Diabetes mellitus.



Axial T2 FS

Calcaneal Fatigue and Insufficiency Fractures

- **Findings of stress and insufficiency fractures:**
  - Hypointense linear fracture line with surrounding bone marrow edema
  - Fracture fragment may be displaced
  - Vascular calcifications often present in those with DM
- **Background**:
  - Fatigue fracture
    - Most often appears as line perpendicular to the primary trabeculae of the posterior process
  - Insufficiency fracture
    - Occurs most frequently at the posterior tuberosity of the calcaneus as well
    - Influencing factors include osteopenia and diabetic neuropathy

Platts-Mills TF, Burg MD, Pollack ZT. Calcaneal avulsion fracture. Emergency Medicine Journal : EMJ 2007;24(3):231. doi:10.1136/emj.2006.036855.