Musculoskeletal Ultrasound

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Disclosures

- Consultant: Bioclinica
- Contractor: POCUS PRO
- Book Royalties: Elsevier
- Not relevant to this lecture

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University of Cincinnati

- 54 radiologists
- 48 radiology residents
- 6 musculoskeletal radiologists
- 2 musculoskeletal fellows
- Football team is ranked #2 - 5

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Accepted Indications:

- Tendon abnormalities
- Rheumatologic applications
- Ligament tear
- Peripheral nerves
- Foreign bodies
- Soft tissue mass

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Ultrasound versus MRI:

- Inexpensive
- Examine multiple joints
- Better tolerated by patient
- Higher resolution
- Guide needle aspiration
- Improved evaluation of distal extremities

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MRI versus Ultrasound:

- Examine entire joint
- Intraarticular assessment
  - Cartilage
- Intraosseous abnormalities
- Deep structures
- Less operator dependent

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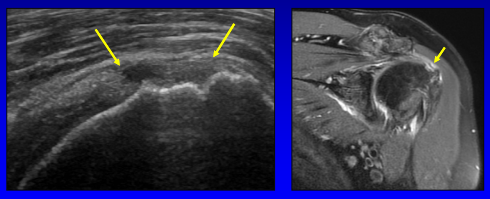
Resolution:

- Ultrasound:
  - High resolution: in-plane = 200 – 450 μm



Erickson SJ. Radiology 1997; 205:593
Qian Y. Journal of MRI 2011

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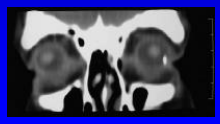
MRI: Contraindications

- Ferromagnetic devices or foreign bodies
  - Near critical organs or newly implanted
  - Adjacent to region of interest



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Equipment: *cart-based*

- Advantages:
  - Powerful: fast, software
  - High resolution: > 20 MHz
- Disadvantages:
  - Not portable
  - Relatively expensive

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Equipment: *portable*

- Advantages:
  - Small size
  - Less expensive
- Disadvantages:
  - Possible decreased resolution of superficial structures

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Economics: *National (USA)*

- 31% of diagnoses with MSK MRI could have been made with US
- With appropriate substitution of US for MRI: estimated $6.9 billion dollar savings from 2006 - 2020

Parker, et al. J Am Coll Radiol 2008; 5:182

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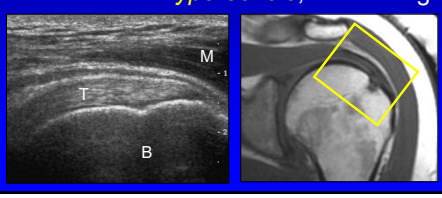
Ultrasound Appearance:

- Tendon: *hyperechoic*, fibrillar
- Muscle: relatively *hypoechoic*
- Bone cortex: *hyperechoic*, shadowing



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Accepted Indications:

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- Rheumatologic applications
- Ligament tear
- Peripheral nerves
- Foreign bodies
- Soft tissue mass

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Rotator Cuff Tear:

- Meta-analysis: 65 articles
- Full-thickness tears:
  - MRA, MRI, US = in sensitivity (92 – 95%)
  - MRA more specific
- Partial-thickness tears:
  - MRA most sensitive (86%) and specific
  - MRI (64%), US (67%)

de Jesus, 2009; 192:1701

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Rotator Cuff Tears

- Tears are hypoechoic / anechoic
- Indirect signs at ultrasound:
  - Cortical irregularity: supraspinatus footprint
    - If present on radiographs, 75% have tear
  - Volume loss
  - Cartilage interface sign
- Massive tear: non-visualization

AJR 1998; 171:229
Radiology 2004; 230:234

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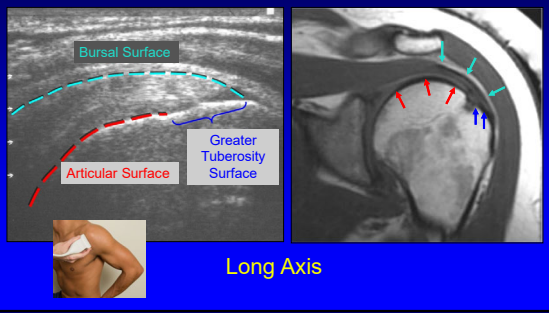
Supraspinatus: normal



Long Axis

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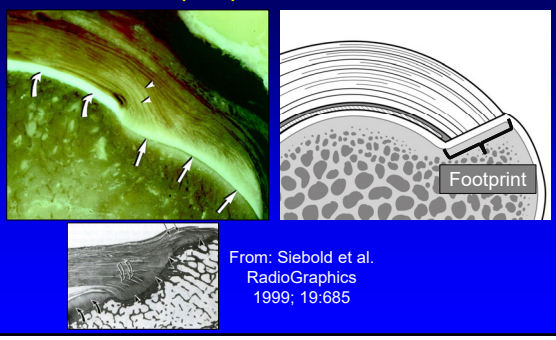
Supraspinatus Insertion



From: Siebold et al.
RadioGraphics
1999; 19:685

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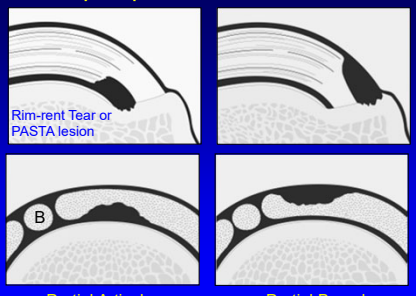
Supraspinatus Tears: extent



Partial Articular Partial Bursal

From: Fundamentals of Musculoskeletal Ultrasound

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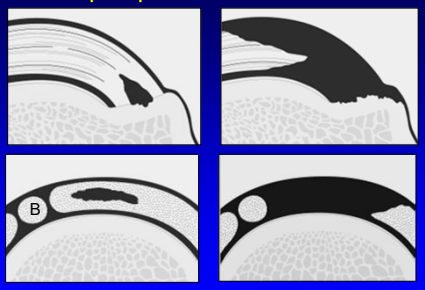
Supraspinatus Tears: extent



From: Fundamentals of Musculoskeletal Ultrasound

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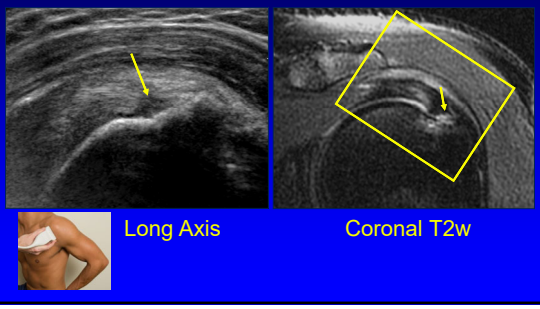
Articular Partial-thickness Tear: supraspinatus



Long Axis

Coronal T2w

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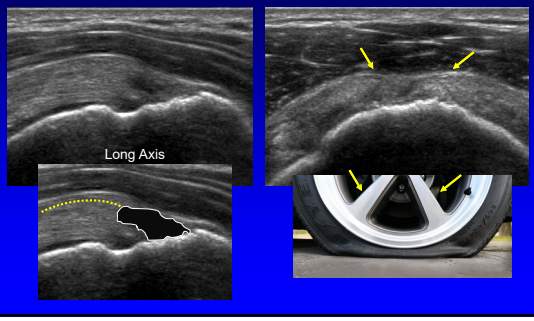
Bursal Partial-thickness Tear: supraspinatus



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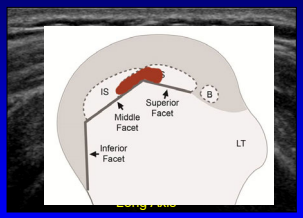
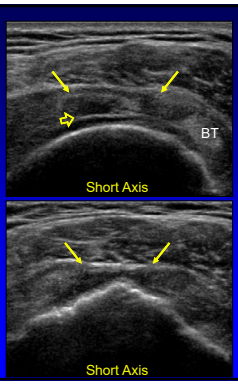
Full-thickness Tear: supraspinatus



Note: Cartilage Interface Sign (open arrow)



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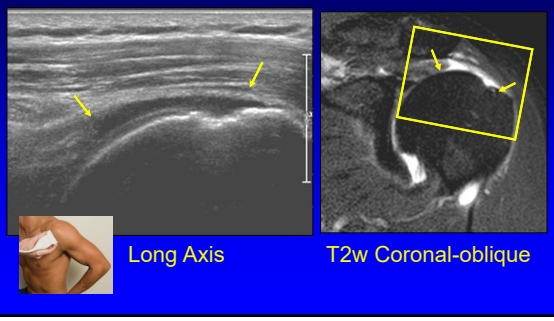
Full-thickness Tear: supraspinatus



Long Axis

T2w Coronal-oblique

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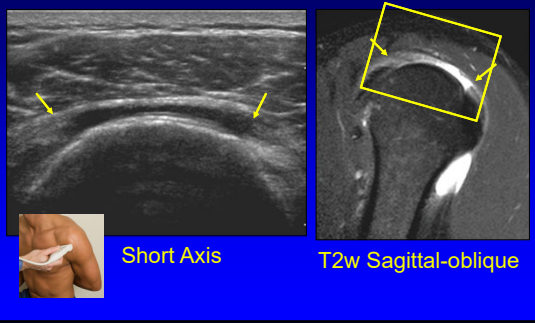
Full-thickness Tear: supraspinatus



Short Axis

T2w Sagittal-oblique

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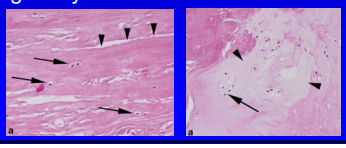
Tendinosis

- No inflammatory cells
  - Mucoid degeneration, chondroid metaplasia
- Hypoechoic, ill-defined
- Possible increased thickness
- No cortical irregularity*

From: Wilson JJ, et al. Am Fam Physician; 2005: 32:165

From: Hodler J, et al. J MRI; 2010: 72:811



*Radiology 2004; 230:234

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Tendon Tear versus Tendinosis

**both may appear hypoechoic*

Tear	Tendinosis
• Anechoic	• Hypoechoic
• Well-defined	• Ill-defined
• Homogeneous	• Heterogeneous
• Thinned	• Swollen
• Bone irregularity*	• Smooth cortex

*At supraspinatus tendon footprint in patients over 40 years old

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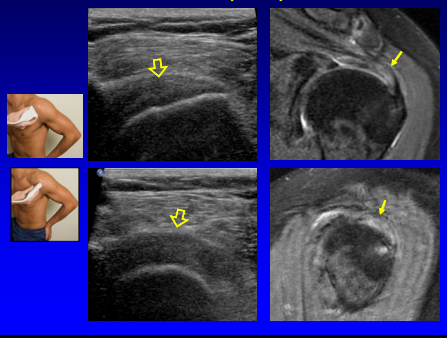
Tendinosis: supraspinatus tendon



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Tendons: dynamic imaging

- Peroneal tendon subluxation
- Snapping hip syndrome
- Tendon tear: partial vs. full tear
  - Achilles

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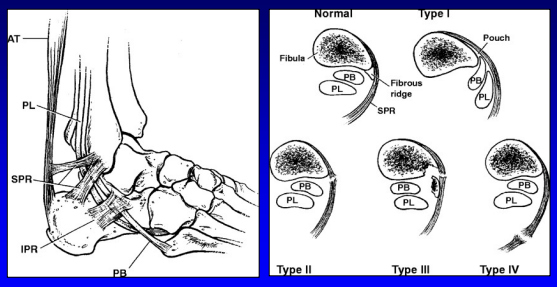
Peroneal Retinaculum



Rosenberg et al. AJR 2003; 181:1551

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Peroneal Tendon Subluxation

- Abnormal movement may only occur dynamically
- Predisposes to peroneal tendon tears
  - Longitudinal split of peroneus brevis
- US: examine with dorsiflexion / eversion
  - 100% accurate US diagnosis

Neustadter et al. AJR 2004; 183:985

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Intrasheath Peroneal Subluxation

- Abnormal snapping: peroneal tendons
- No lateral displacement, intact retinaculum
- Type A: no tear; B: tendon tear
- Associations:
  - Convex posterior fibula in 92%
  - Tendon tear in 86%
  - Low lying peroneus brevis muscle in 71%

J Bone Joint Surg Am 2008; 90:992
J Foot Ankle Surg 2009; 48:323

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Snapping Hip Syndrome: iliopsoas

- Image long axis to inguinal ligament superior to femoral head
- Extension of flexed abducted and externally rotated hip
- Abrupt movement of iliopsoas as iliacus muscle interposed between tendon and bone moves

Deslandes et al. AJR 2008; 190:576

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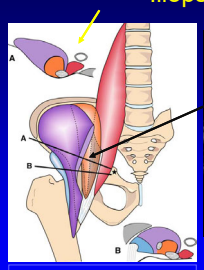
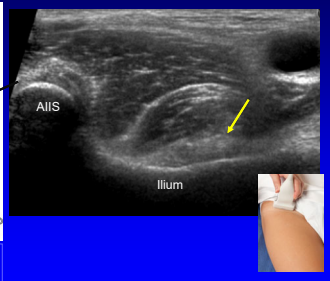
Iliopsoas Complex



Red: psoas major
Orange: medial iliacus fibers
Purple: lateral iliacus fibers



From: Guillin R. et al. Eur Rad 2009; 19:995

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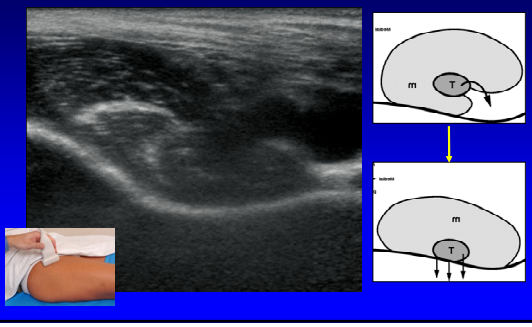
Snapping Hip Syndrome: *iliopsoas*



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Tendon Evaluation:

- Partial vs. complete vs. healing tear
- Dynamic imaging: look for
  - Widening of gap: passive or active motion
  - Lack of tendon movement across tear

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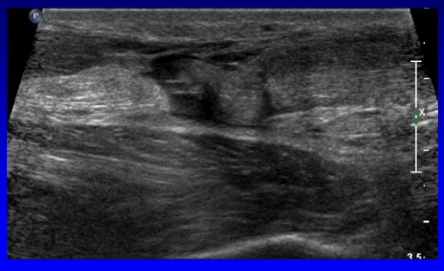
Achilles Tendon: *dynamic imaging*



Long Axis

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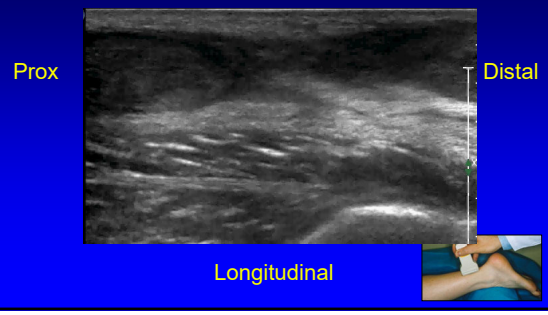
Achilles Tendon: *healing tear*



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Accepted Indications:

- Tendon abnormalities
- Rheumatologic applications
- Ligament tear
- Peripheral nerves
- Foreign bodies
- Soft tissue mass

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Arthritis: synovitis

- Synovial locations:
  - Joint recess, bursa, tendon sheath
- Hypoechoic compared to adjacent subcutaneous fat
  - May be isoechoic or hyperechoic
- Hyperemia: variable
  - Represents activity of inflammation
  - Decreased: treatment (even NSAIDS)

Backhaus M, Arthritis and Rheum 1999; 42:1232

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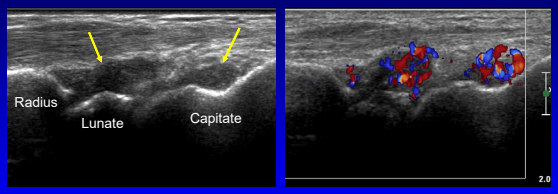
Rheumatoid Arthritis: synovitis



Sagittal Plane: Radiocarpal and Mid-carpal Joints

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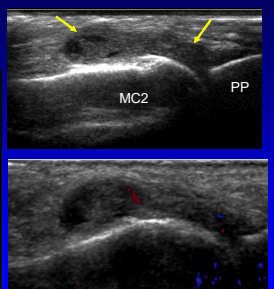
Synovitis: MCP joint



Sagittal Plane: 2nd MCP Joint

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Erosions

- US criteria:
  - Disrupted cortex, two planes
  - Adjacent synovitis increases specificity
- US better than radiographs[1]
- 29% false-positive rate compared to CT[2]
- 40% sensitivity[3]

[1]Lopez-Ben, et al. Skeletal Radiol 2004; 33: 80
[2]Finzel S. et al. Arth Rheumatism 2011; 63:1231
[3]Dohn UF M, Arthritis Res Ther 2006; 8:1

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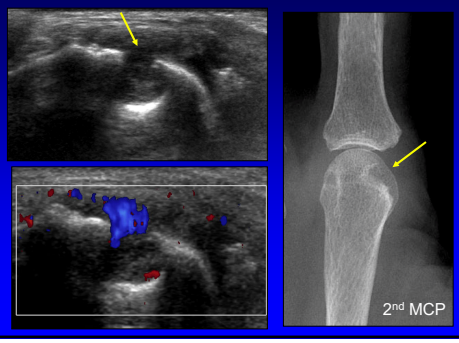
Rheumatoid Arthritis



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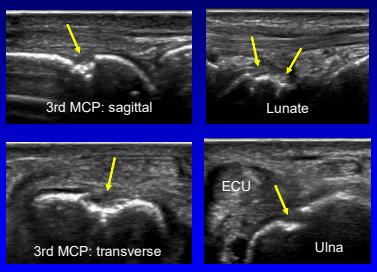
Pitfall Alert! Pseudoerosions Are Everywhere!

- Pseudoerosions: 100%
- Metacarpal heads: all
  - 2nd: 92%
  - 3rd: 86%
- Carpal bones:
  - Lunate: 82%
  - Triquetrum: 84%
  - Distal ulna: 22%

**Falkowski A et al. Eur J Radiology 2020; 124*



**Note lack of adjacent synovitis*

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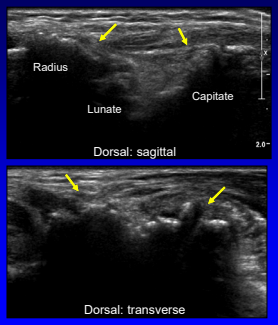
Psoriatic Arthritis



Note: joint space narrowing and extensive bone proliferation

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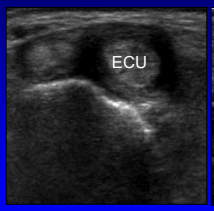
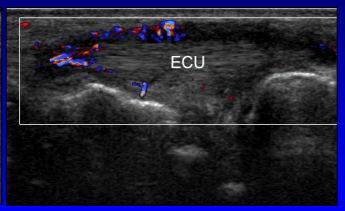
Tenosynovitis: rheumatoid arthritis



Short Axis



Long Axis: color Doppler

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Synovitis: screening (<10 minutes)

- Hand and wrist: *(5 joints per side)*
  - Radiocarpal, midcarpal, distal radioulnar (dorsal)
  - MCP2 and 3 (dorsal): transverse and sagittal
  - Any symptomatic site
  - Cine: flexor and extensor tendons (short axis)
- Ankle and Foot:
  - Ankle joint
  - MTP5 (dorsal and plantar)
  - Any symptomatic site

Rosa J et al. J Clin Rheumatol 2016; 22: 179

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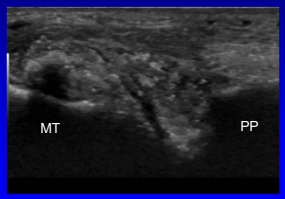
Tophi

- Hyperechoic heterogeneous with hypoechoic rim
- Tiny internal speckles*
- "wet clump of sugar" appearance
- Variable shadowing: even without calcification



Fernandes et al. Skeletal Radiol 2011; 40:309

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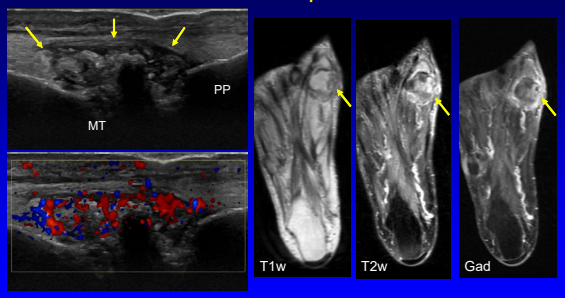
Gout: tophus



1st Metatarsophalangeal Joint

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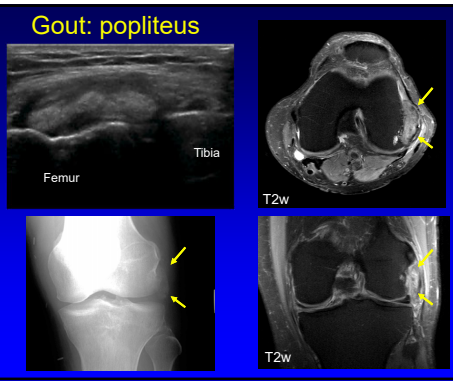
Gout: popliteus



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Gout: olecranon bursa

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Accepted Indications:

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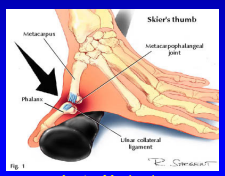
Gamekeeper's Thumb

- Injury of the ulnar collateral ligament (UCL) of the thumb
  - Historically, chronic injury in Scottish gamekeepers
  - Frequently, due to acute MCP joint hyperabduction
  - Skier's thumb: up to 86% of thumb base injuries



Acute Mechanism

Chronic Mechanism

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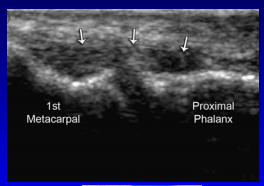
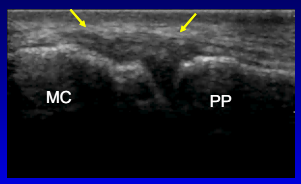
Ulnar Collateral Ligament: thumb





Note: sliding of adductor aponeurosis with isolated interphalangeal joint flexion

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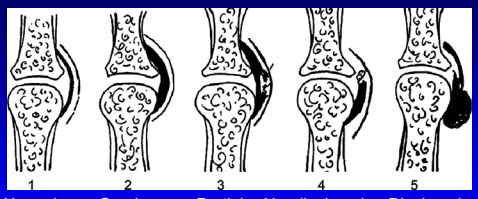
Ulnar Collateral Ligament: thumb



Normal | Sprain | Partial Tear | Nondisplaced Complete Tear (+ fracture) | Displaced Complete Tear (Stener Lesion)

Radiographics 2006;26:1007

RadioGraphics

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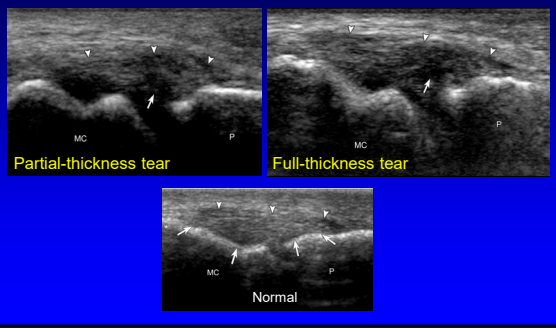
UCL: tears



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Stener Lesion:

- Displaced proximal stump of torn UCL
  - Hypoechoic & round
  - Proximal to MCP joint
  - At proximal edge of adductor aponeurosis
- No tissue spanning MCP joint
- "Yo-yo on a string" sign
- Ultrasound: 100% accuracy

*Melville D. et al. Skeletal Radiology 2013; 42:667

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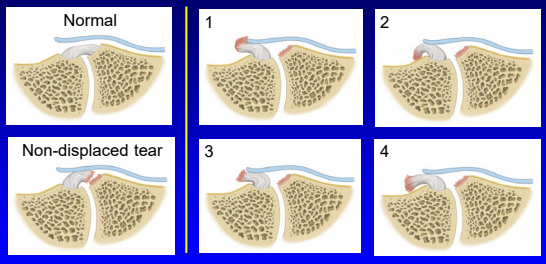
Stener Lesion: variations



Displaced Full-thickness Tears

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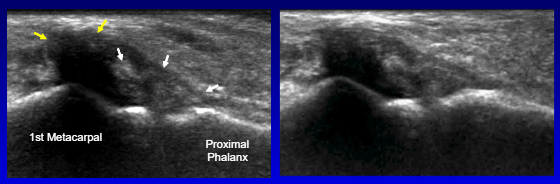
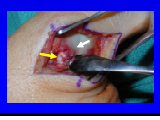
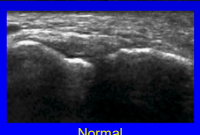
Stener Lesion: dynamic



White arrows = adductor aponeurosis
Yellow arrows = Stener lesion





Normal

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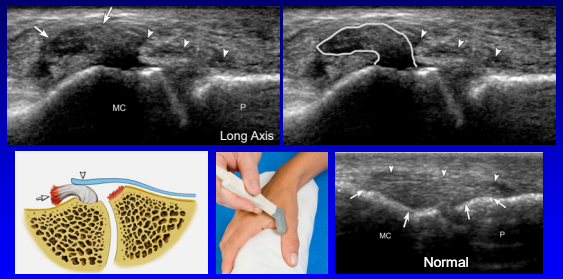
Stener Lesion



From: Melville D. et al. Skeletal Radiology 2013; 42:667

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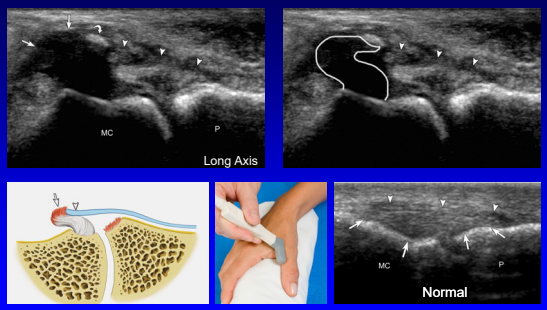
Stener Lesion



From: Melville D. et al. Skeletal Radiology 2013; 42:667

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Accepted Indications:

- Tendon abnormalities
- Rheumatologic applications
- Ligament tear
- Peripheral nerves
- Foreign bodies
- Soft tissue mass

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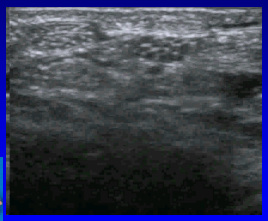
Normal Peripheral Nerve

- Ultrasound appearance:
  - Hypoechoic nerve fascicles
  - Hyperechoic connective tissue
- Transverse:
  - Honeycomb appearance



Median Nerve

Silvestri et al. Radiology 1995; 197:291

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Nerve Entrapment

- US findings:
  - Nerve enlargement proximal to entrapment
    - Best appreciated transverse to nerve
  - Abnormally hypoechoic
    - Especially the connective tissue layers
  - Variable enlargement or flattening at entrapment site

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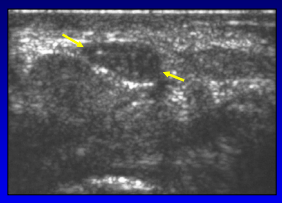
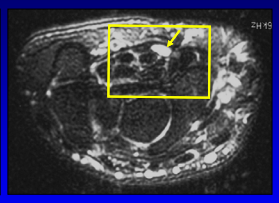
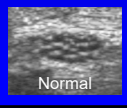
Carpal Tunnel Syndrome: proximal





Transverse



Axial T2w

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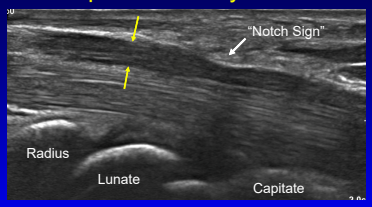
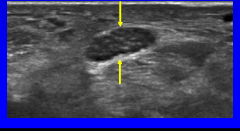
Carpal Tunnel Syndrome





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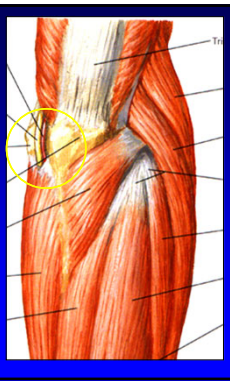
Cubital Tunnel Syndrome:

- Ulnar nerve entrapment at elbow
- 2nd most common upper extremity entrapment neuropathy
- Etiologies:
  - Trauma, valgus deformity,
  - Nerve subluxation, cyst, arthritis



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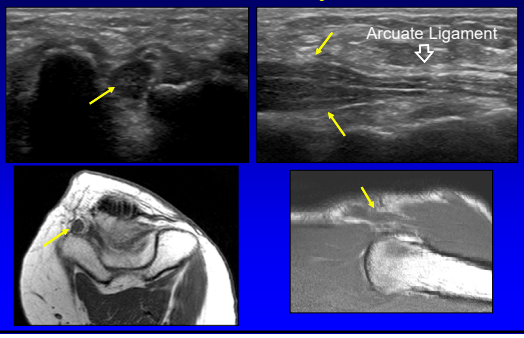
Cubital Tunnel Syndrome



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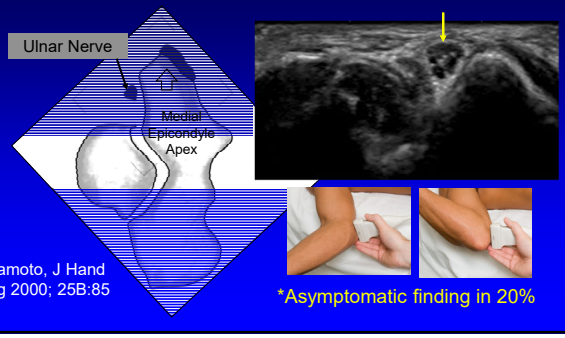
Isolated Ulnar Nerve Dislocation



Okamoto, J Hand Surg 2000; 25B:85

*Asymptomatic finding in 20%

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Accepted Indications:

- Tendon abnormalities
- Rheumatologic applications
- Ligament tear
- Peripheral nerves
- Foreign bodies
- Soft tissue mass

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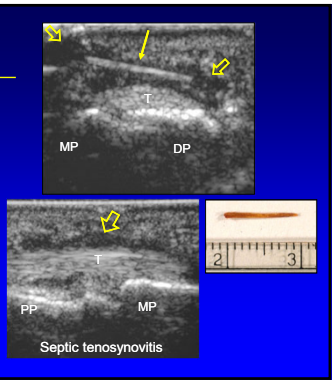
Soft Tissue Foreign Bodies

- Wood and plastic: not radiopaque on radiographs
- Echogenicity: initially hyperechoic
  - Pitfall: anisotropy
- Halo: hypoechoic inflammation
- Artifact:
  - Smooth and flat: reverberation
  - Irregular surface: shadowing

Radiology 1998; 206:45



Septic tenosynovitis

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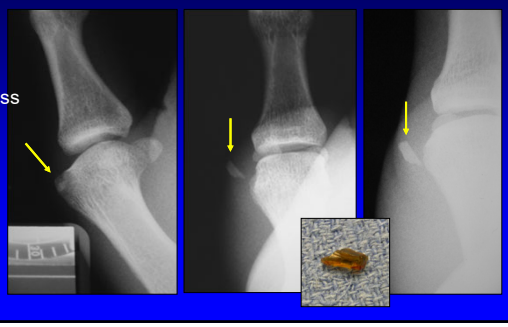
Glass Foreign Body

- Glass:
  - Opaque
  - Regardless of tint or color

Radiology 1998; 206:45



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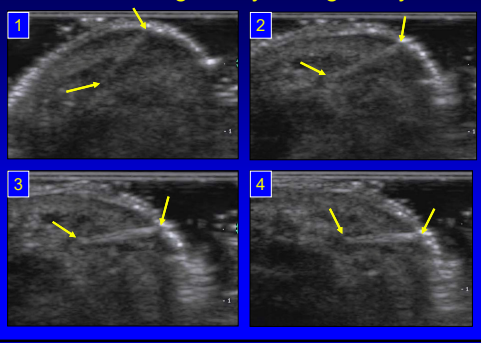
US: foreign body echogenicity



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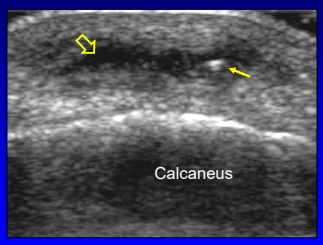
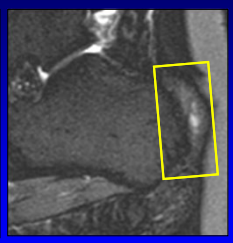
Rose Thorn: foot



Transverse



Sagittal T2w

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Accepted Indications:

- Tendon abnormalities
- Rheumatologic applications
- Ligament tear
- Peripheral nerves
- Foreign bodies
- Soft tissue mass

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Baker Cyst:

- Semimembranosus-medial gastrocnemius bursa
- 50% over age of 50 have communication with knee joint
- Cyst communication to posterior knee between SM-MG tendons required

AJR 2001; 176:373

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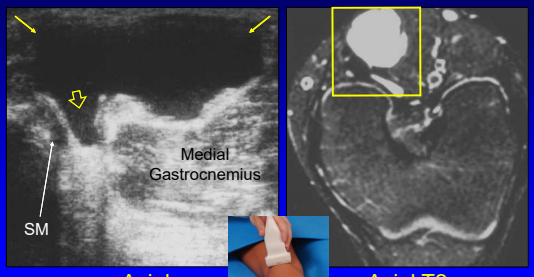
Baker Cyst



Axial

Axial T2w

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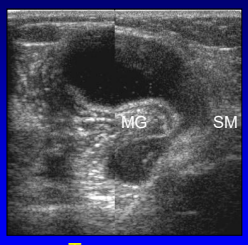
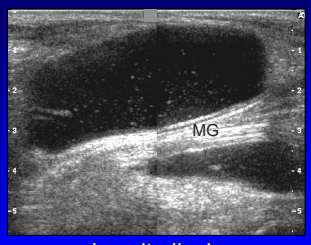
Baker Cyst



Transverse



Longitudinal

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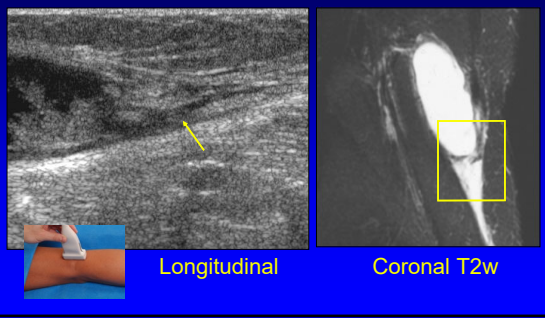
Baker Cyst: rupture



Longitudinal Coronal T2w

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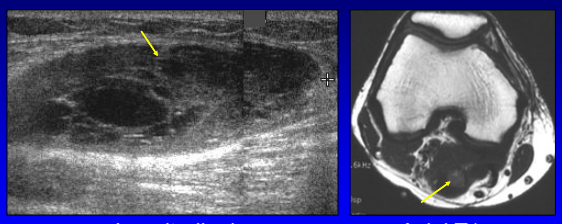
Baker Cyst: hemorrhage



Longitudinal Axial T1w

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Soft Tissue Mass: ganglia

- Anechoic or hypoechoic
- Multilocular (except digits)
- Non-compressible
- Joint or tendon sheath communication
- Wrist: volar between radial artery and FCR (69%) and dorsal over scapholunate ligament

*Wang et al. J Ultrasound Med 2007; 26:1323

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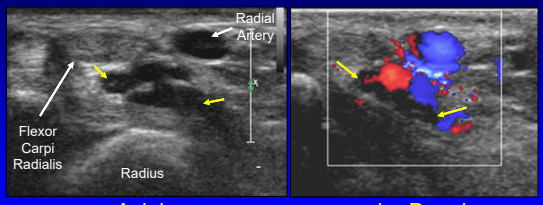
Ganglion: volar wrist



Axial color Doppler

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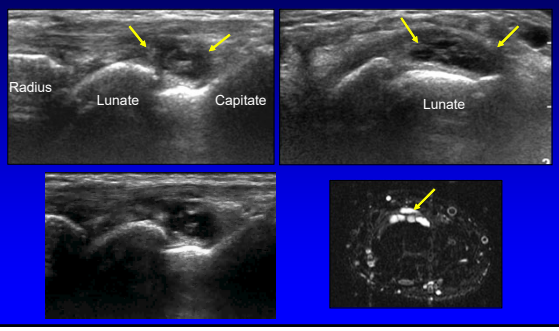
Ganglion Cyst: dorsal



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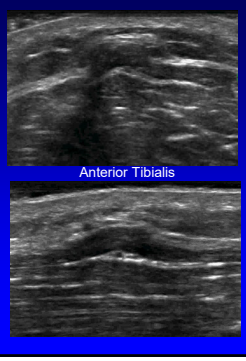
Muscle Hernia

- Cause: trauma, activities, weak fascia
- Lower leg: anterior tibialis
- Swelling with muscle contraction
- Ultrasound:
  - Muscle bulge
  - Possible fascial defect
  - Site of perforating vessel

Beggs, AJR 2003; 180:395



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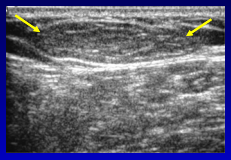
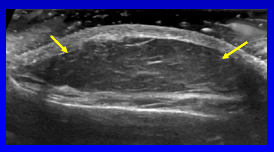
Lipoma: subcutaneous

- Oval, homogeneous
- Isoechoic to adjacent fat
- Hyperechoic:
  - With increased fibrous tissue components
- No internal vascularity
- Compressible
- No pain or growth





Inampudi et al. Radiology 2004; 233:763

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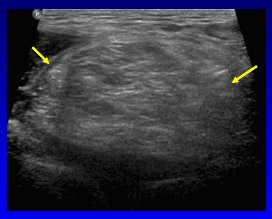
Lipoma: deep

- Variable echogenicity
- Often ill-defined
- Often difficult to assess
- Cannot reliably differentiate from low-grade liposarcoma!
- Need MRI



Paunipager et al. Insights Imaging 2010; 1:149

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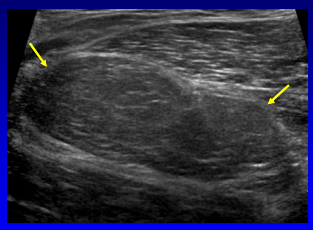
Liposarcoma: *well-differentiated*

- Hypoechoic
- Looks like a lipoma
- Need MRI with any mass deeper than subcutaneous!



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US: advantages

- Portable, accessible
- No issue: claustrophobia, hardware, metal foreign bodies or implants
- Less expensive compared to MRI
- Compare to other side, intervention
- High resolution
- Dynamic imaging

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Keys for Success in MSK US:

- Proper training
- Performed for the proper indications
- Ultrasound technologists are essential:
  - Perform MSK US like other US studies
- Radiologists must continue to learn, perform, and teach MSK US

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Syllabus on line and other educational material:
www.jacobsonmskus.com

Twitter handle: @jjacobsn

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