

Musculoskeletal Ultrasound

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Disclosures

- Consultant: Bioclinica
- Book Royalties: Elsevier
- Contractor: POCUS PRO
- Advisory Board: Philips
- Not relevant to this talk

Syllabus and other educational material can be found at www.jacobsonmskus.com

Note: all images from the textbook Fundamentals of Musculoskeletal Ultrasound are copyrighted by Elsevier Inc.

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University of Cincinnati

- 54 radiologists
- 48 radiology residents
- 8 musculoskeletal radiologists
- 2 musculoskeletal fellows



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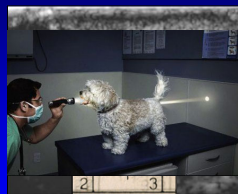
Accepted Indications:

- 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



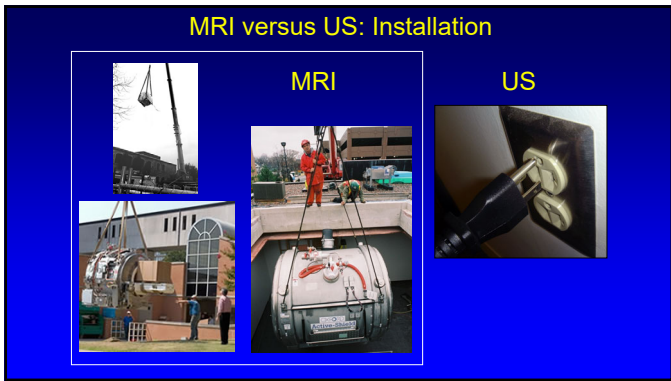
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MRI versus Ultrasound:

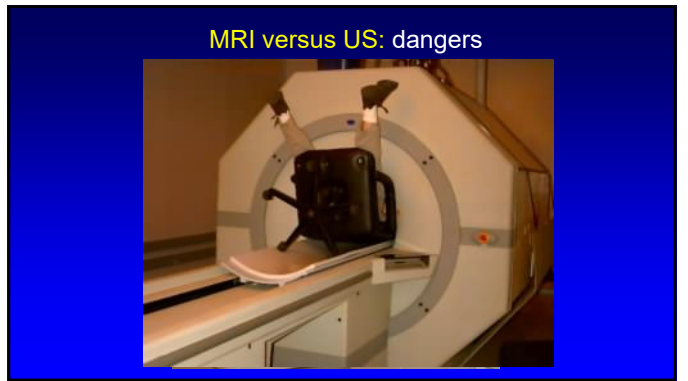
- Examine entire joint
- Intraarticular assessment
 - Cartilage
- Intraosseous abnormalities
- Deep structures
- Less operator dependent



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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)

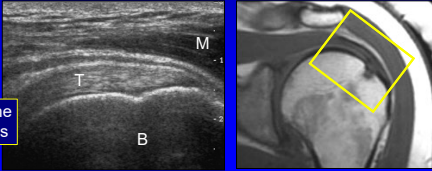
- 31% of diagnoses with MSK MRI could have been made with US
- With appropriate substitution of US for MRI: estimated **\$6.9 billion** dollar savings from 2006 - 2020

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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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

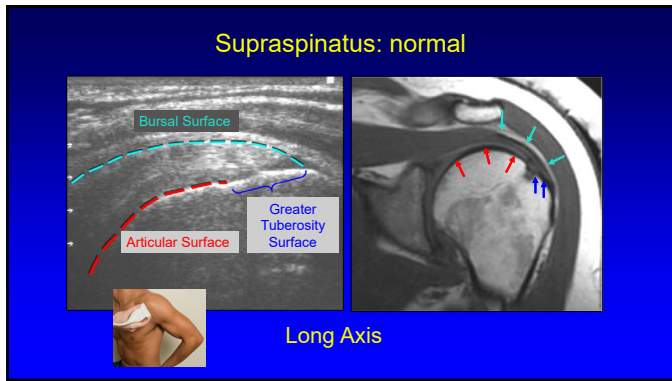
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Rotator Cuff Tears

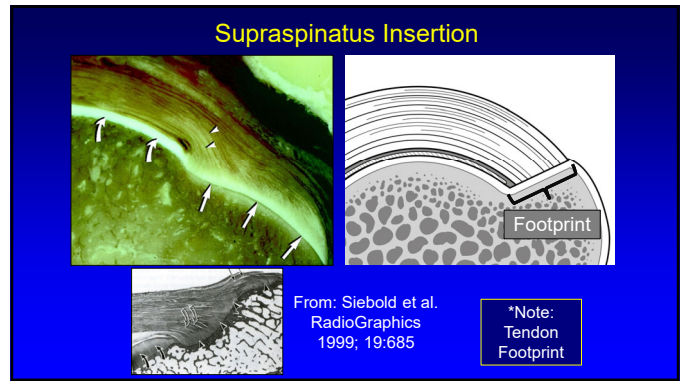
- Tears are hypoechoic / anechoic
- Indirect signs at ultrasound:
 - Cortical irregularity: supraspinatus footprint
 - If present on radiographs, 75% have tear
 - Volume loss
 - Cartilage interface sign
- Massive tear: non-visualization

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

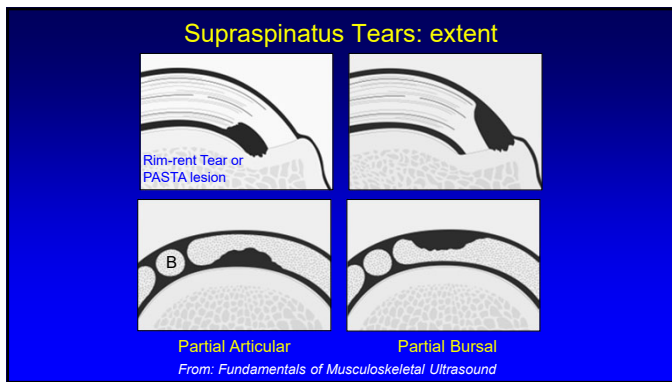
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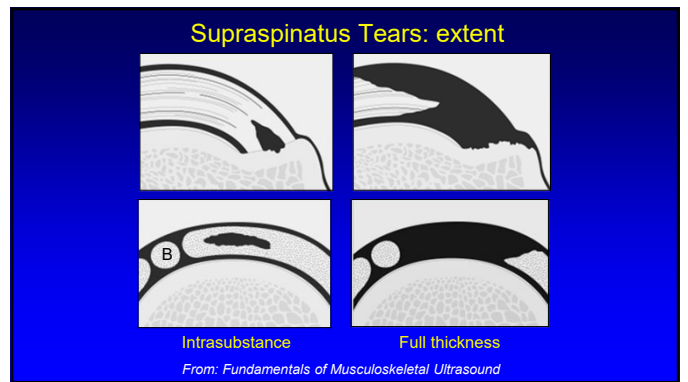
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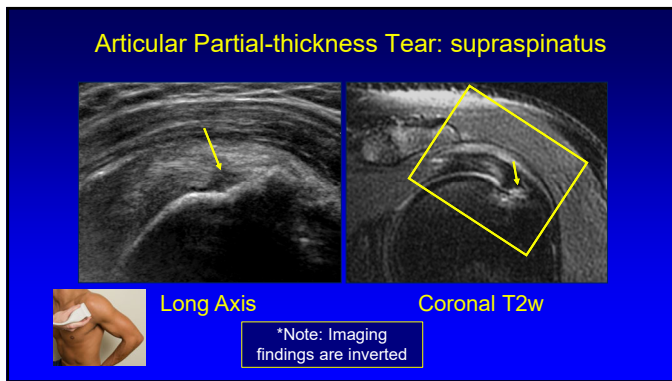
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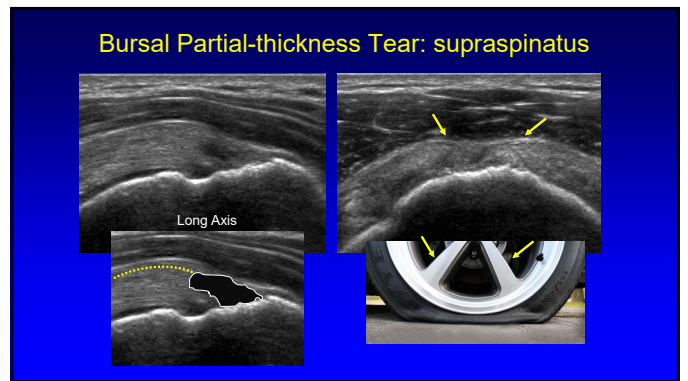
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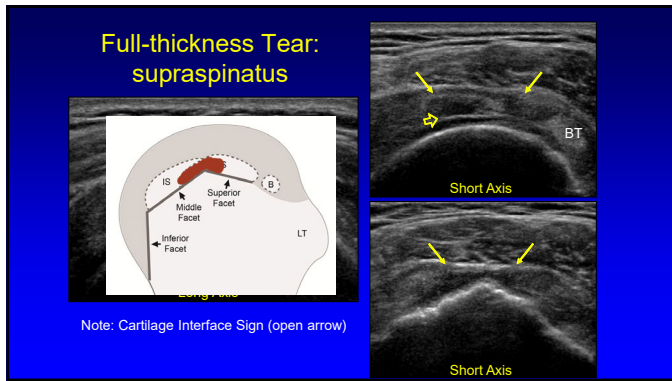
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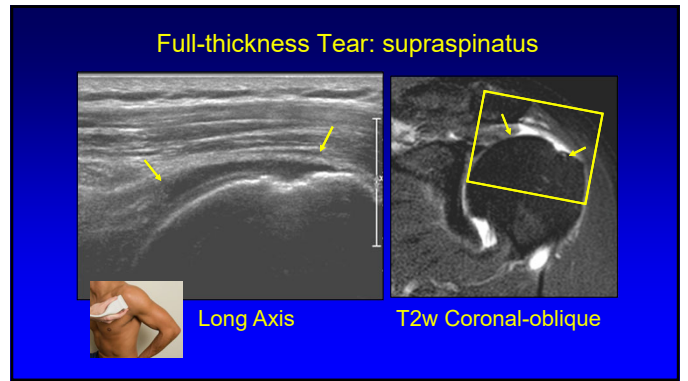
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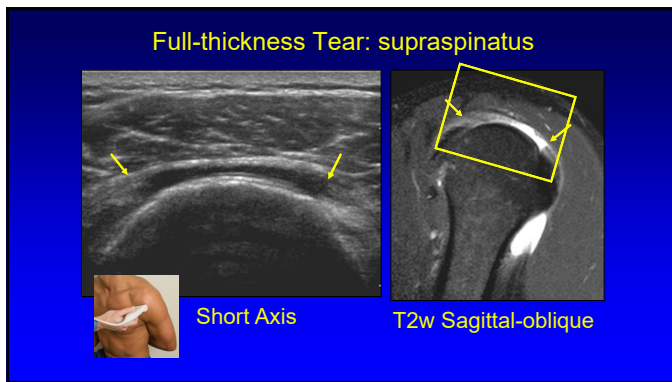
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Tendinosis

- No inflammatory cells
 - Mucoïd 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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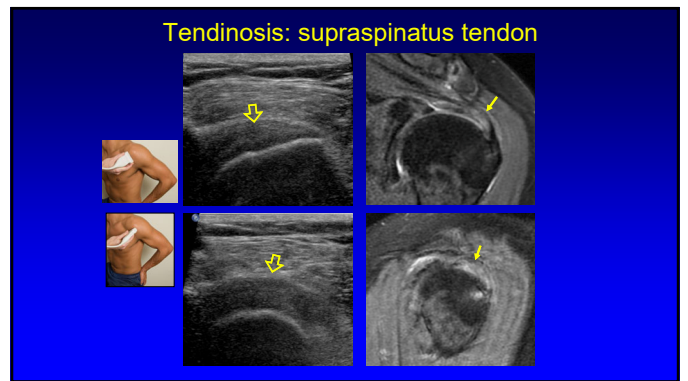
Tendon Tear versus Tendinosis

**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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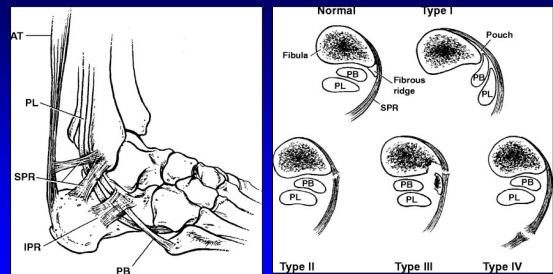
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Tendons: dynamic imaging

- 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

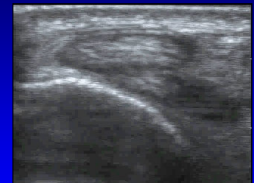


Neustadter et al. AJR 2004; 183:985

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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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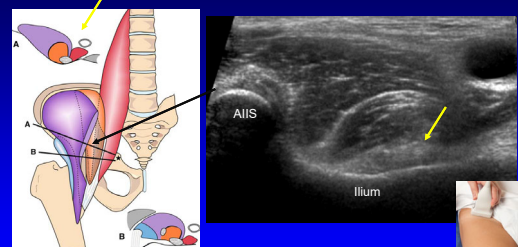
Snapping Hip Syndrome: iliopsoas

- 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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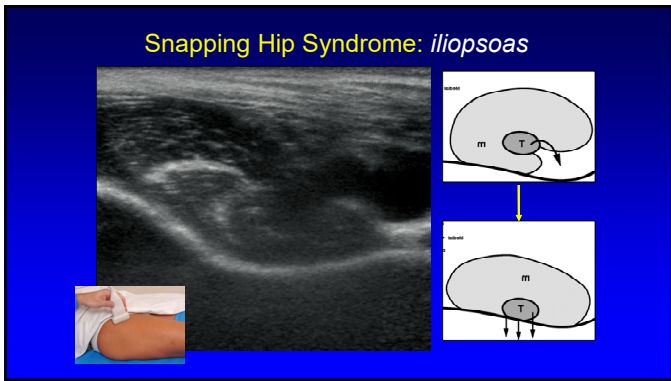
Iliopsoas Complex



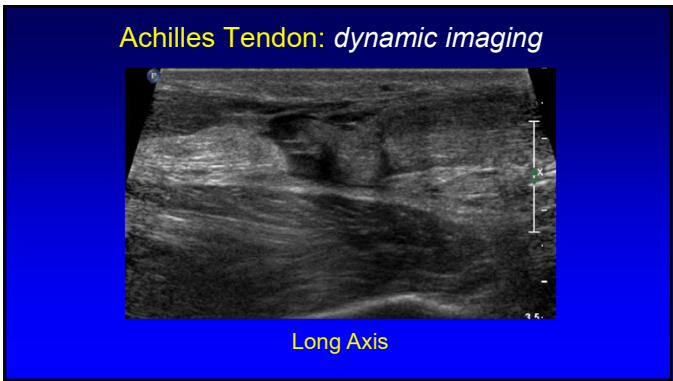
Red: psoas major
Orange: medial iliacus fibers
Purple: lateral iliacus fibers

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

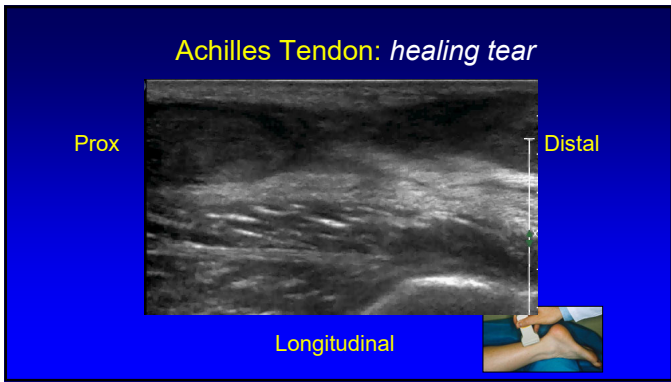
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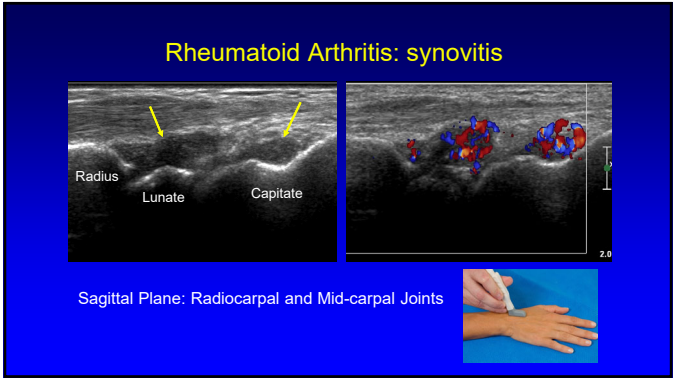
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- ### Accepted Indications:
- Tendon abnormalities
 - Rheumatologic applications
 - Ligament tear
 - Peripheral nerves
 - Foreign bodies
 - Soft tissue mass

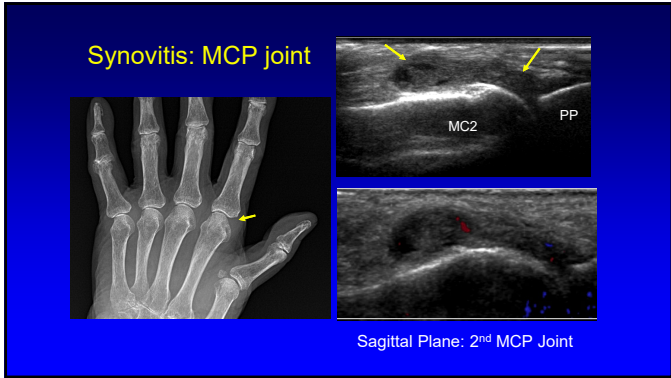
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- ### Arthritis: synovitis
- Synovial locations:
 - Joint recess, bursa, tendon sheath
 - Hypoechoic compared to adjacent subcutaneous fat
 - May be isoechoic or hyperechoic
 - Hyperemia: variable
 - Represents activity of inflammation
 - Decreased: treatment (even NSAIDS)
- Backhaus M, Arthritis and Rheum 1999; 42:1232

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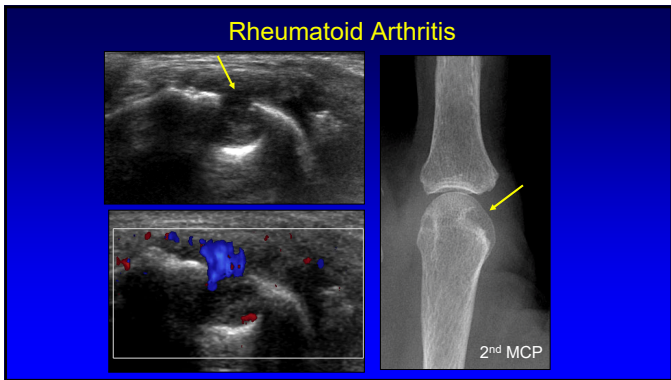
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Erosions

- US criteria:
 - Disrupted cortex, two planes
 - Adjacent synovitis increases specificity
- US better than radiographs¹
- 29% false-positive rate compared to CT²
- 40% sensitivity³

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

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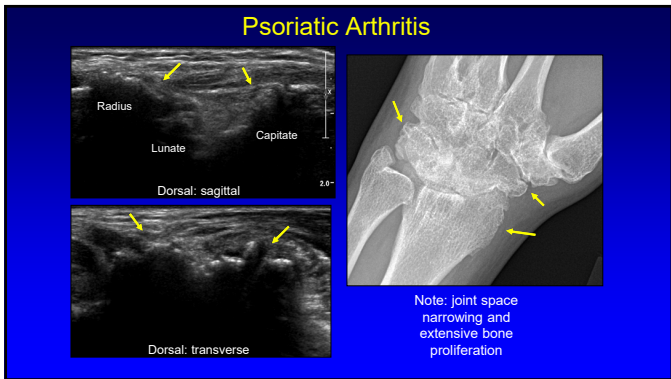
Pitfall Alert! Pseudoerosions Are Everywhere!

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

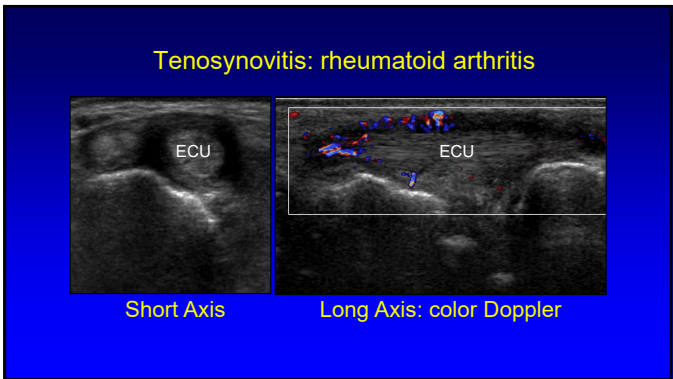
**Falkowski A et al. Eur J Radiology 2020; 124*

**Note lack of adjacent synovitis*

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Synovitis: screening (<10 minutes)

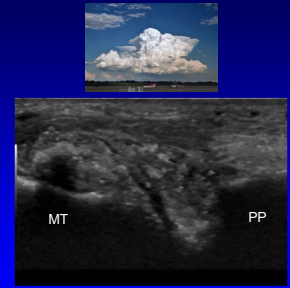
- Hand and wrist: (6 joints – actually 10)
 - Radiocarpal, midcarpal, distal radioulnar (dorsal)
 - MCP2 and 3 (dorsal): transverse and sagittal
 - Any symptomatic site
 - Cine: flexor and extensor tendons (short axis)
- Ankle and Foot:
 - Ankle joint
 - MTP5 (dorsal and plantar)
 - Any symptomatic site

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

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Tophi

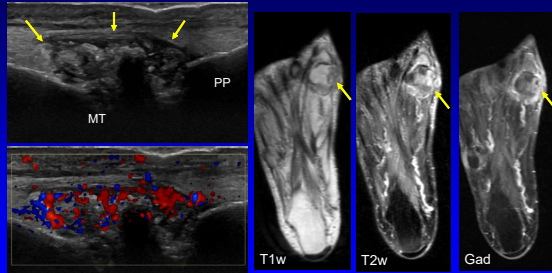
- Hyperechoic heterogeneous with hypoechoic rim
- Tiny internal speckles*
- “wet clump of sugar” appearance
- Variable shadowing: even without calcification



Fernandes et al. Skeletal Radiol 2011; 40:309

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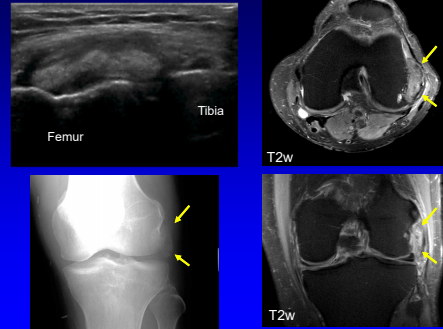
Gout: tophus



1st Metatarsophalangeal Joint

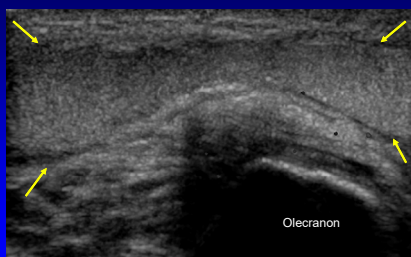
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Gout: popliteus



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Gout: olecranon bursa

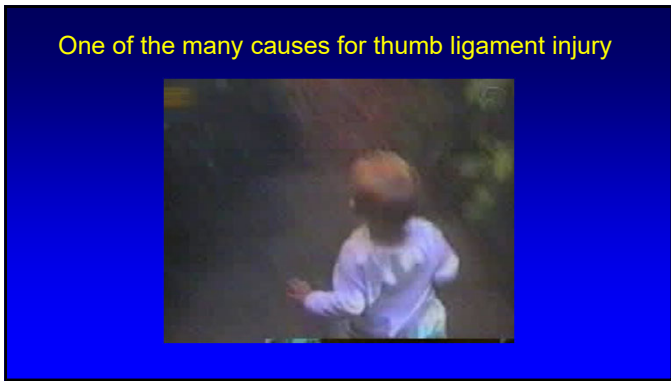


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- Peripheral nerves
- Foreign bodies
- Soft tissue mass

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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 Displaced Complete Tear (Stener Lesion) (+ fracture)

Radiographics 2006;26:1007 **RadioGraphics**

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UCL: tears

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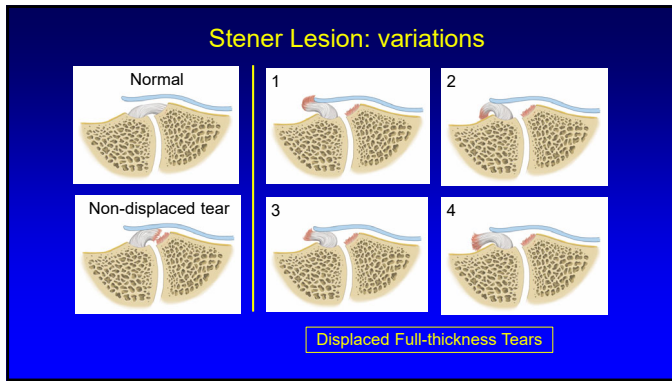
Stener Lesion

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

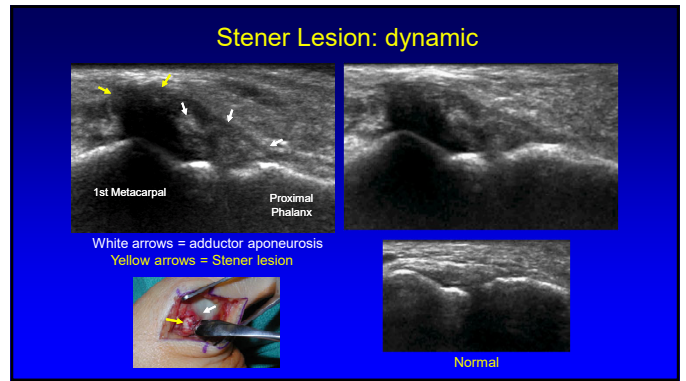
Yellow arrows: Stener
White arrows: aponeurosis

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

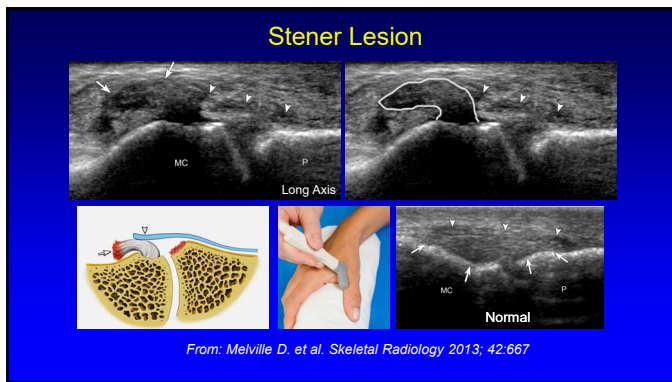
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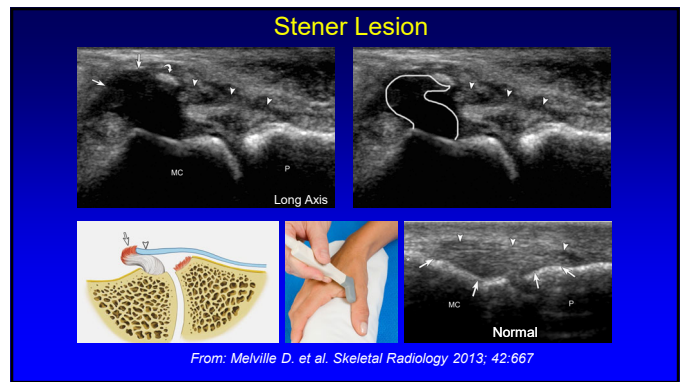
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 - Foreign bodies
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- ### Normal Peripheral Nerve
- Ultrasound appearance:
 - Hypochoic nerve fascicles
 - Hyperechoic connective tissue
 - Transverse:
 - Honeycomb appearance
-
- Median Nerve
- Silvestri et al. Radiology 1995; 197:291

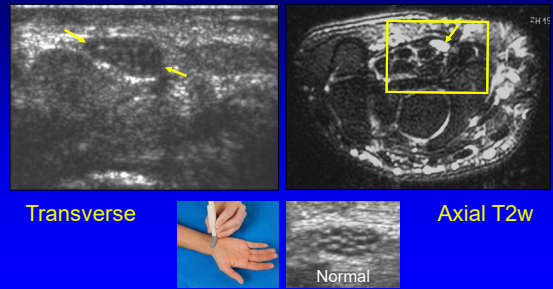
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Nerve Entrapment

- 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

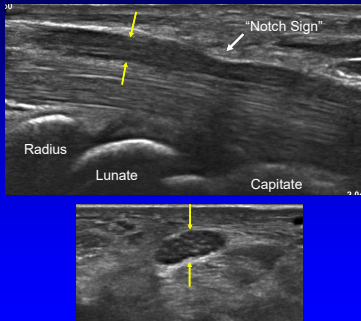
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Carpal Tunnel Syndrome: proximal



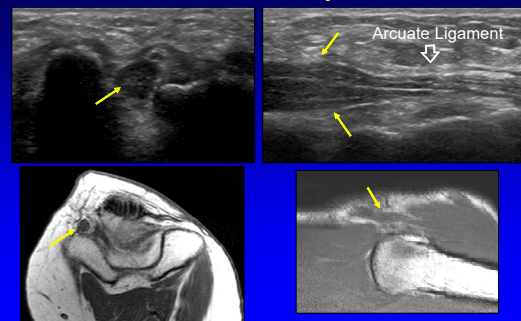
68

Carpal Tunnel Syndrome



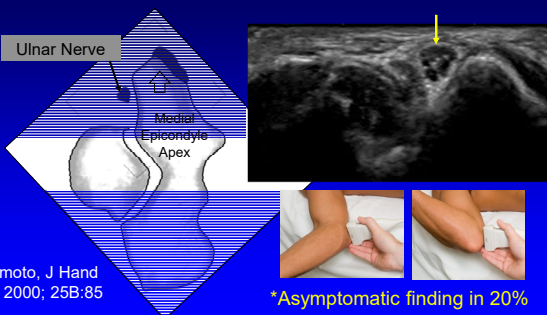
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Cubital Tunnel Syndrome



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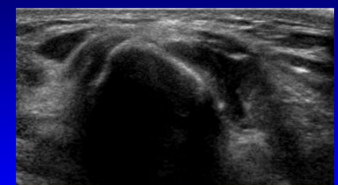
Isolated Ulnar Nerve Dislocation



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Snapping Triceps Syndrome

- Ulnar nerve and medial triceps dislocate over apex of medial epicondyle
- Ulnar nerve and medial triceps remain in contact with each other
- Palpable snap felt through transducer



Jacobson JA et al. Radiology 2001; 220:601

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Accepted Indications:

- Tendon abnormalities
- Rheumatologic applications
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- 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

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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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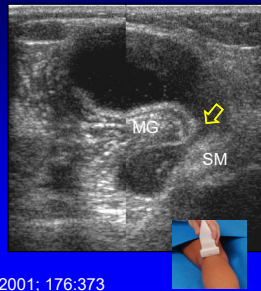
Accepted Indications:

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Baker Cyst

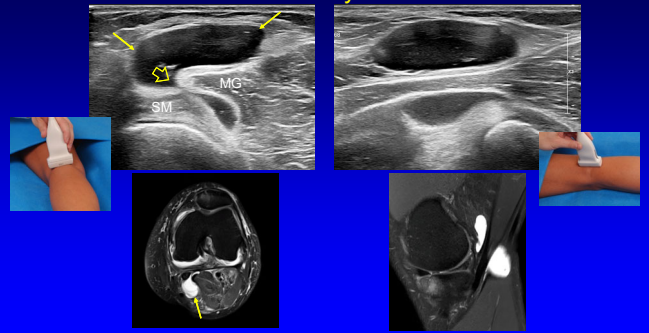
- Semimembranosus-medial gastrocnemius bursa
- 50% over age of 50 have communication with knee joint
- Cyst communication to posterior knee between SM-MG tendons required (yellow arrow)



Ward EE et al. AJR 2001; 176:373

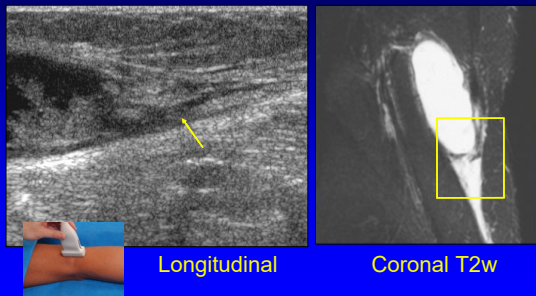
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Baker Cyst



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Baker Cyst: rupture

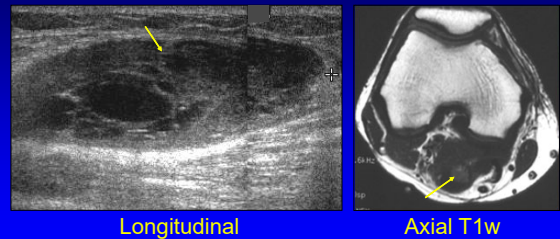


Longitudinal

Coronal T2w

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Baker Cyst: hemorrhage



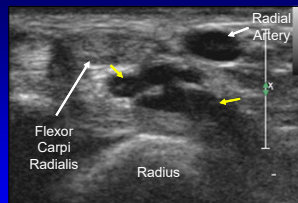
Longitudinal

Axial T1w

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Soft Tissue Mass: ganglion

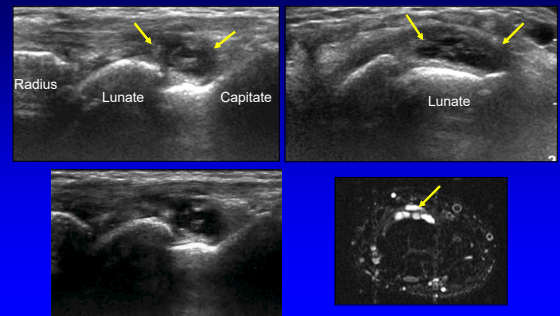
- Anechoic or hypoechoic
- Multilocular (except digits)
- Non-compressible
- Joint or tendon sheath communication
- Wrist: volar between radial artery and FCR (69%) and dorsal over scapholunate ligament



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

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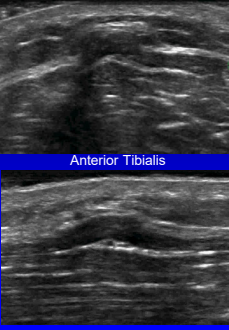
Ganglion Cyst: dorsal



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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

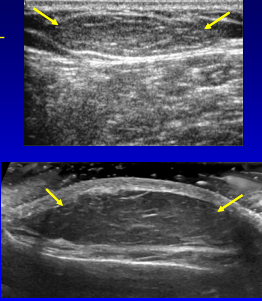


Beggs, AJR 2003; 180:395

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Lipoma

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

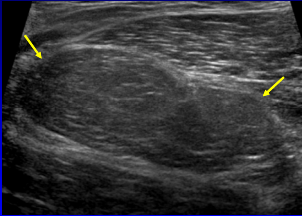


Inampudi et al. Radiology 2004; 233:763

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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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