Ultrasound of the Upper Extremity with MRI Correlation

Jon A. Jacobson, MD
FACR, FSRU, FAIUM, RMSK

Professor of Radiology
Lenox Hill Radiology, NYC
University of California, San Diego

Syllabus PDF

1

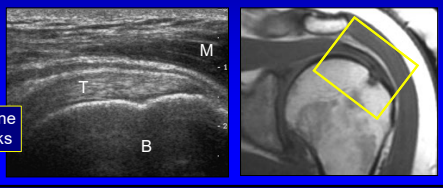
Outline:

- Tendons:
  - Rotator cuff and lateral epicondylitis
- Ligaments:
  - Ulnar collateral ligament (elbow)
  - Gamekeeper's thumb
- Nerves:
  - Cubital tunnel syndrome
  - Carpal tunnel syndrome
- Inflammatory arthritis
- Soft tissue foreign bodies

2

Ultrasound Appearance:

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

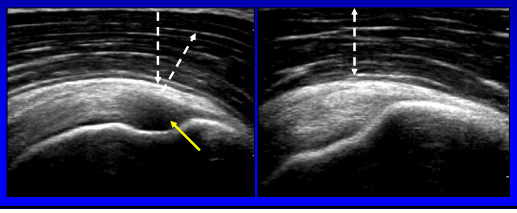


*Note: Bone Landmarks

3

Anisotropic Effect

- Tendon is artifactually hypoechoic
- Sound beam is not perpendicular to fibers
- Tendon, ligament > muscle



4

Tendon Abnormalities:

- Tendinosis: hypoechoic, increased size
- Partial-thickness tear: hypoechoic with anechoic focus or clefts
- Full-thickness tear: discontinuity
  - Dynamic imaging: retraction

5

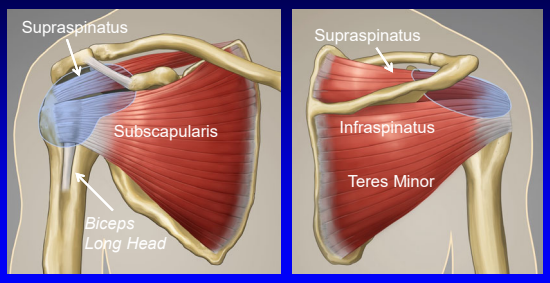
Rotator Cuff Tear:

- 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, AJR 2009; 192:1701

6

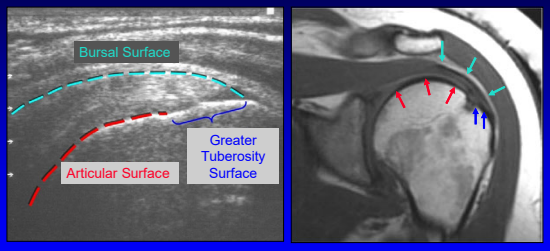
Rotator Cuff



Note: Subacromial-subdeltoid Bursa (light blue)

7

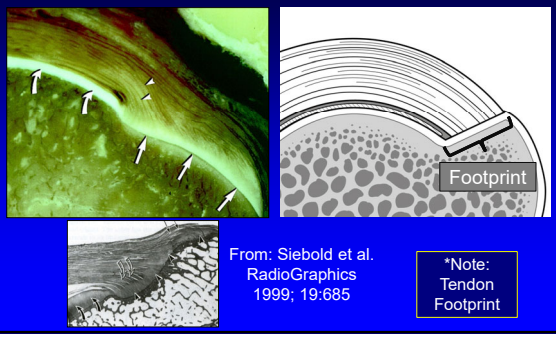
Supraspinatus: normal



Long Axis

8

Supraspinatus Insertion



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

*Note: Tendon Footprint

9

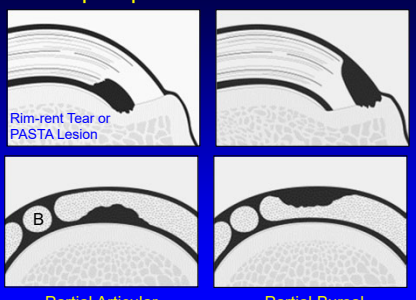
Rotator Cuff Abnormalities:

Categories:

- Partial-thickness tear
  - Articular-sided
  - Bursal-sided
  - Intrasubstance (or interstitial)
- Full-thickness tear
- Tendinosis

10

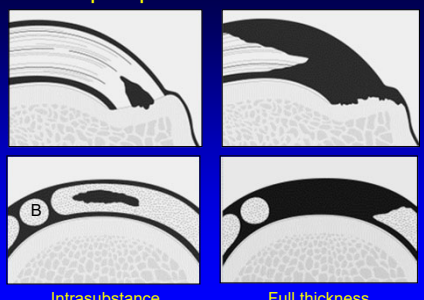
Supraspinatus Tears: extent



From: Fundamentals of Musculoskeletal Ultrasound

11

Supraspinatus Tears: extent



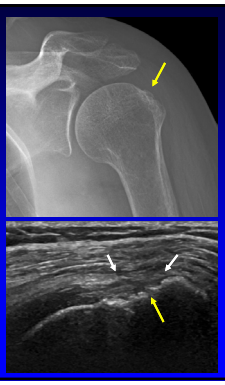
From: Fundamentals of Musculoskeletal Ultrasound

12

Cortical Irregularity:

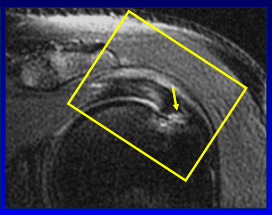
- Greater tuberosity: at supraspinatus insertion
- When present: 75% have rotator cuff tears
  - Patient over 40 years old
- When absent: 96% normal cuffs by sonography

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



13

Articular Partial-thickness Tear: supraspinatus



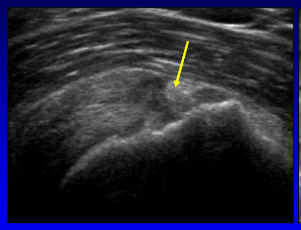
Long Axis

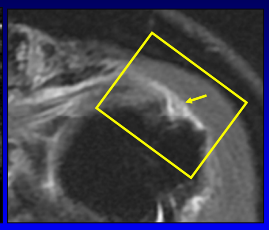
Coronal T2w

*Note: Imaging findings are gray scale inverted

14

Bursal Partial-thickness Tear: supraspinatus



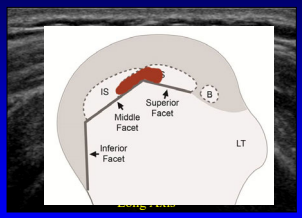


Long Axis

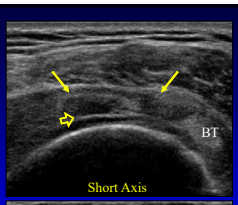
Coronal T2w

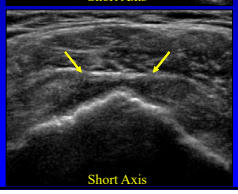
15

Full-thickness Tear: supraspinatus (focal)



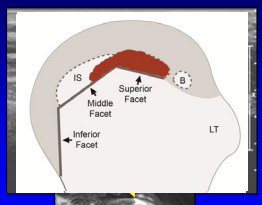
Note: Cartilage Interface Sign (open arrow)

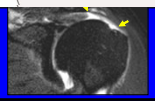


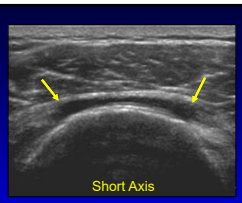


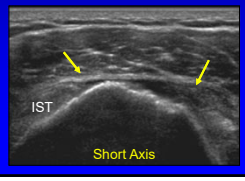
16

Full-thickness Tear: supraspinatus (full-width)



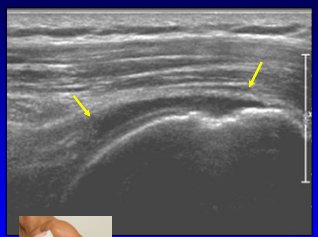


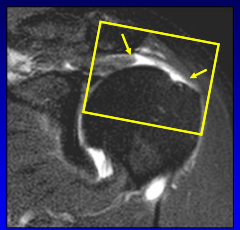




17

Full-thickness Tear: supraspinatus



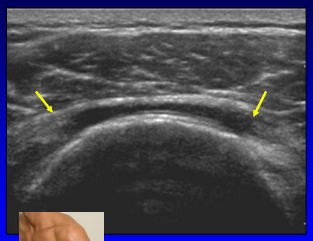


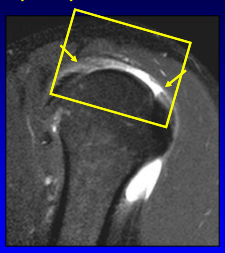
Long Axis

T2w Coronal-oblique

18

Full-thickness Tear: supraspinatus





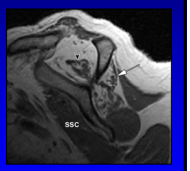
Short Axis

T2w Sagittal-oblique

19

Fatty Infiltration and Muscle Atrophy

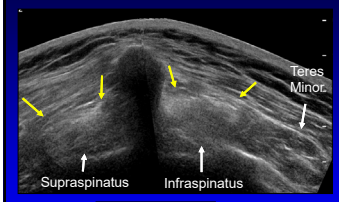
- Supraspinatus and infraspinatus
  - Infraspinatus: only variable to predict cuff healing[1]
- Associations:
  - Chronic, large, anterior supraspinatus tears[2]
- Ultrasound:
  - Moderate to good correlation with MRI[3]
  - Improved reliability with extended field-of-view[4]

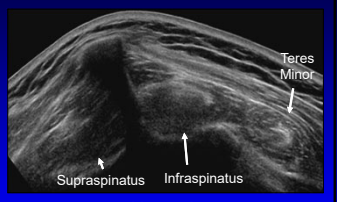


[1]Chung et al. Am J Sports Med; 2013; 41:16764
[2]Hodler et al. Radiology 2005; 237:584.
[3]Khoury et al. AJR 2008; 190:1105.
[4]Nazarian et al. 2008; 190:27.

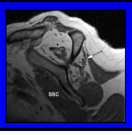
20

Atrophy: supraspinatus and infraspinatus





Normal

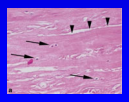


Short Axis (extended field-of-view)

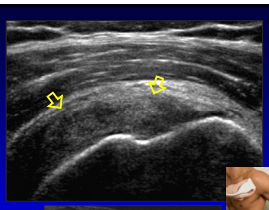
21

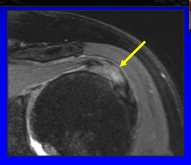
Tendinosis

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



From: Hodler J, et al. J MRI; 2010: 32:165





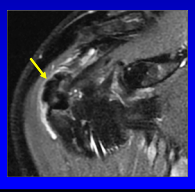
*Radiology 2004; 230:234

22

Calcific Tendinosis/Tendinitis

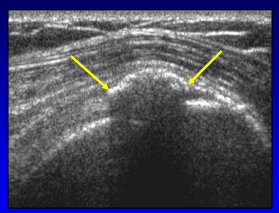
- Tendon metaplasia: calcium hydroxyapatite deposition
- Two phases:
  - Formative: well-defined, dense shadow
  - Resorptive: amorphous
- Percutanous US-guided lavage/aspiration

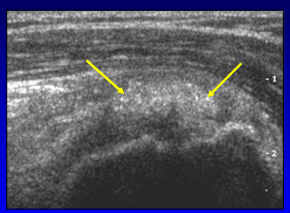
Uhthoff. J Am Acad Ortho Surg 1997; 5:183



23

Calcific Tendinosis/Tendinitis



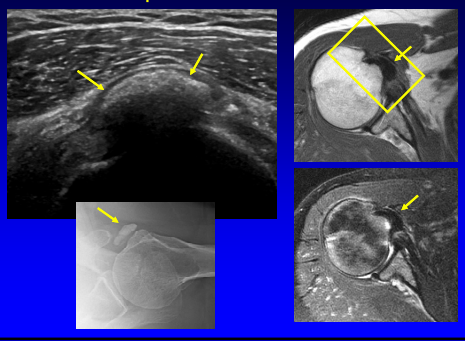


Formative
Defined, shadow

Resorptive
Amorphous, little shadow

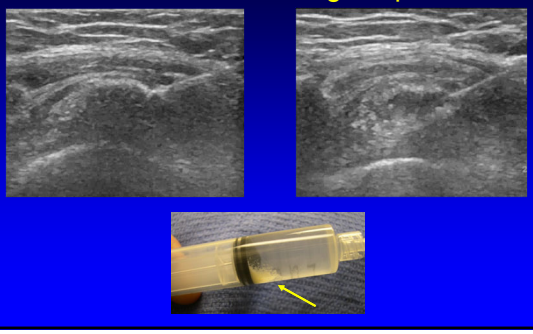
24

Subscapularis: calcific tendinosis



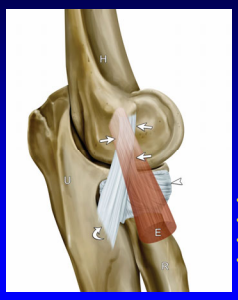
25

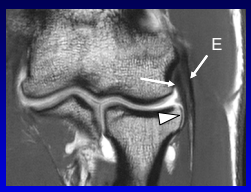
Calcific Tendinosis: lavage/aspiration



26

Lateral Elbow





- Radial collateral ligament (arrows)
- Common extensor tendon (E)
- Annular ligament (arrowhead)
- Lateral ulnar collateral ligament (curved arrow)

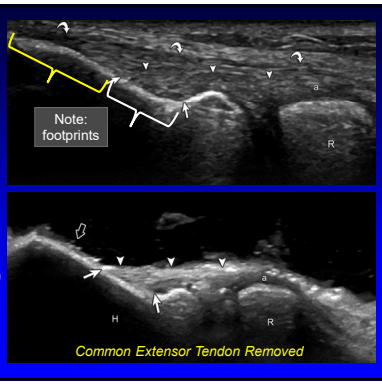
Jacobson J. et al. J Ultrasound Medicine 2014; 33:1041.

27

Lateral Collateral Ligament Complex

- Common extensor tendon (curved arrows)
- Radial collateral ligament (arrowheads)
- Annular ligament (a)

Jacobson J. et al. J Ultrasound Medicine 2014; 33:1041.



Common Extensor Tendon Removed

28

"Epicondylitis"

- Common flexor and extensor tendons
- Abnormal hypoechogenicity
  - Mucoid degeneration, tendinosis
- Anechoic: partial-thickness tear
- No inflammatory cells*

Potter, Radiology 1995; 196:43

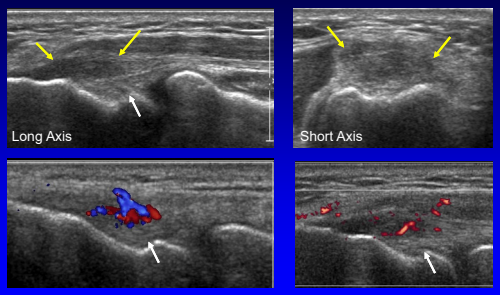
29

Common Extensor Tendon: elbow

- Often called "tennis elbow" or "lateral epicondylitis" or "epicondylosis" or ……
- All terms are misnomers
- Those inflicted usually do not play tennis (professionally or correctly)
- It is not inflammatory
- It is not a primary problem of the epicondyle

30

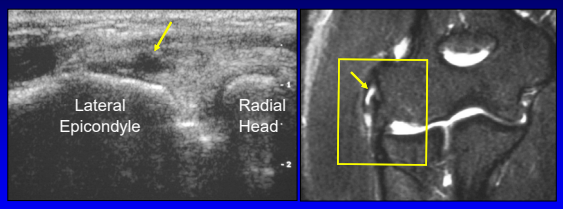
Common Extensor Tendon: tendinosis



Note: normal radial collateral ligament (white arrow)

31

Common Extensor Tendon: partial tear



Longitudinal | Coronal T2w

32

Outline:

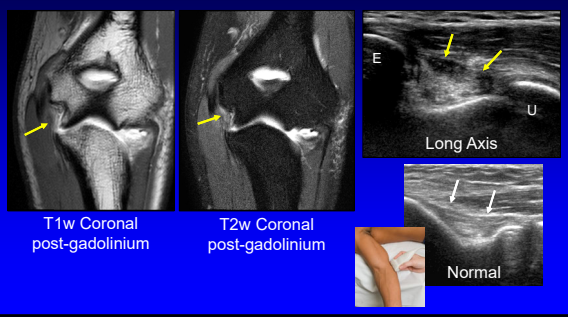
- Tendons:
  - Rotator cuff and lateral epicondylitis
- Ligaments:
  - Ulnar collateral ligament (elbow)
  - Gamekeeper's thumb
- Nerves:
  - Cubital tunnel syndrome
  - Carpal tunnel syndrome
- Inflammatory arthritis
- Soft tissue foreign bodies

34

One of the many causes for elbow injury

35

Ulnar Collateral Ligament Tear



T1w Coronal post-gadolinium | T2w Coronal post-gadolinium

36

Ulnar Collateral Ligament

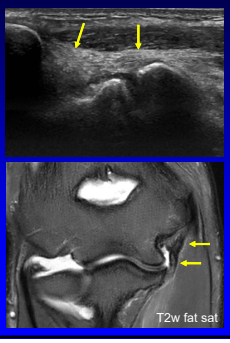
- Valgus stress: 30 degrees elbow flexion
  - Unlock the olecranon
  - Stress: UCL anterior bundle
- Gravity stress is adequate, equal to Telos[1]
- Ultrasound measurements:
  - Reliable and precise[2]

[1]Harada M et al. J Sho Elb Surg 2014; 23:561
[2]Bica D et al. J Ultrasound Med 2015; 34:371

Ulnar Collateral Ligament: partial tear

37

Ulnar Collateral Ligament: laxity



US + MR arthrography: accuracy = 98%

Roedl JB et al. Radiology 2016; 279:827

MIND THE GAP

39

Outline:

- Tendons:
  - Rotator cuff and lateral epicondylitis
- Ligaments:
  - Ulnar collateral ligament (elbow)
  - Gamekeeper's thumb
- Nerves:
  - Cubital tunnel syndrome
  - Carpal tunnel syndrome
- Inflammatory arthritis
- Soft tissue foreign bodies

40

Gamekeeper's or Skier's Thumb

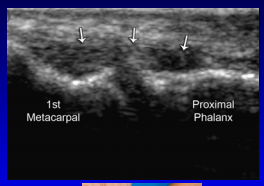
- Injury: ulnar collateral ligament of first MCP joint
- Chronic (gamekeeper's thumb): historically in Scottish gamekeepers
- Acute (skier's thumb): acute hyperabduction

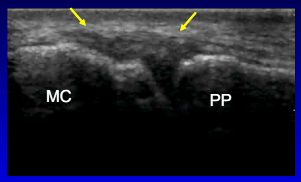
Acute Mechanism

Chronic Mechanism

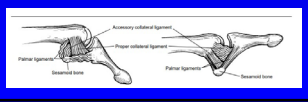
41

Ulnar Collateral Ligament: thumb



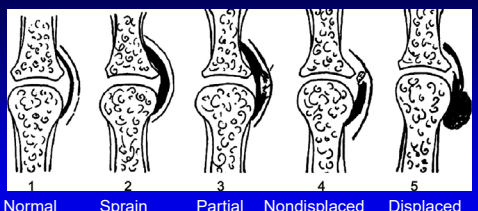


Note: sliding of adductor aponeurosis with isolated interphalangeal joint flexion



42

Ulnar Collateral Ligament: thumb



1 Normal | 2 Sprain | 3 Partial Tear | 4 Nondisplaced Complete Tear (+ fracture) | 5 Displaced Complete Tear (Stener Lesion)

Radiographics 2006;26:1007

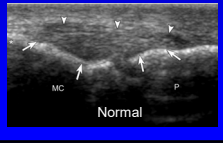
RadioGraphics

43

UCL: tears

Partial-thickness tear

Full-thickness tear

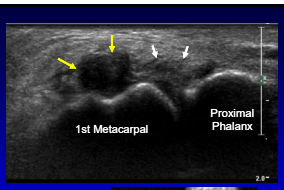


Normal

44

Stener Lesion

- Displaced proximal stump of UCL
  - Hypoechoic & 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*

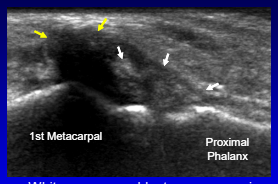


Yellow arrows: Stener
White arrows: aponeurosis

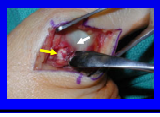
*Melville D. et al. Skeletal Radiology 2013; 42:667

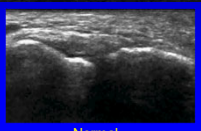
45

Stener Lesion: dynamic



White arrows = adductor aponeurosis
Yellow arrows = Stener lesion

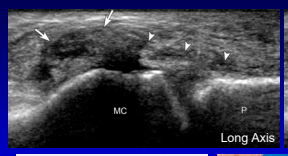


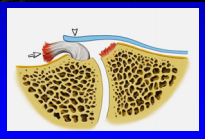


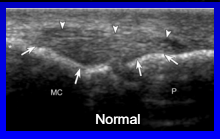
Normal

46

Stener Lesion



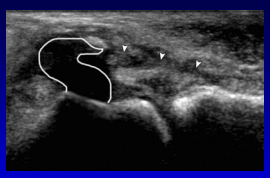


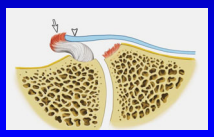


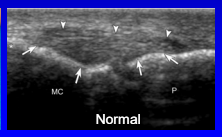
From: Melville D. et al. Skeletal Radiology 2013; 42:667

47

Stener Lesion

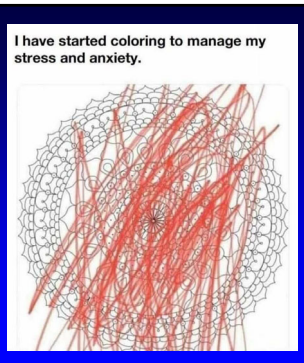






From: Melville D. et al. Skeletal Radiology 2013; 42:667

48



49

Outline:

- Tendons:
  - Rotator cuff and lateral epicondylitis
- Ligaments:
  - Ulnar collateral ligament (elbow)
  - Gamekeeper's thumb
- Nerves:
  - Cubital tunnel syndrome
  - Carpal tunnel syndrome
- Inflammatory arthritis
- Soft tissue foreign bodies

50

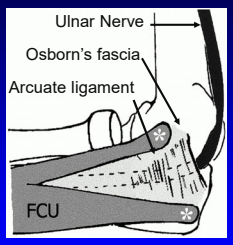
Nerve Entrapment

- 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

51

Ulnar Nerve: anatomy

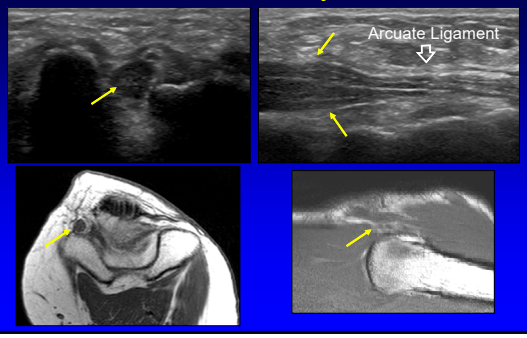
- Behind medial epicondyle of humerus:
  - Cubital tunnel retinaculum or Osborn's fascia
- Distal to epicondyle:
  - True cubital tunnel
  - Between ulnar and humeral heads: flexor carpi ulnaris
  - Under arcuate ligament



Martinoli, C. et al. Radiographics 2000;20:S199-S217 RadioGraphics

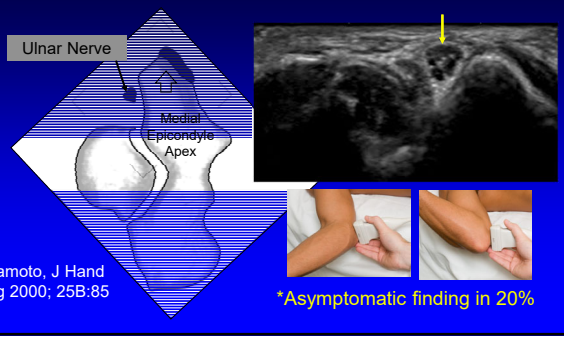
52

Cubital Tunnel Syndrome



53

Isolated Ulnar Nerve Dislocation



Okamoto, J Hand Surg 2000; 25B:85

*Asymptomatic finding in 20%

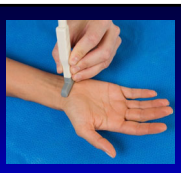
54

Outline:

- Tendons:
  - Rotator cuff and lateral epicondylitis
- Ligaments:
  - Ulnar collateral ligament (elbow)
  - Gamekeeper's thumb
- Nerves:
  - Cubital tunnel syndrome
  - Carpal tunnel syndrome
- Inflammatory arthritis
- Soft tissue foreign bodies

55

Carpal Tunnel Syndrome:

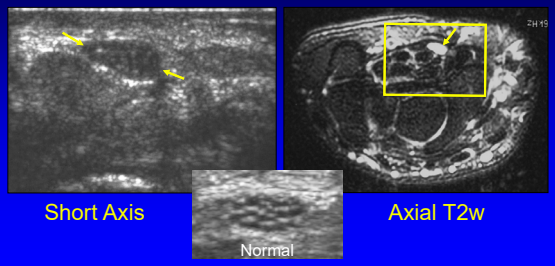


- Proximal median nerve swelling
  - Area: circumferential trace
  - Normal: <9 mm^2
  - Borderline: 9 – 12 mm^2
  - Abnormal: > 12 mm^2
    - 12.8 mm^2 = moderate (83% sens, 95% spec)
    - 14.0 mm^2 = severe (77% sens, 100% spec)

Klauser AS et al. Sem Musculoskel Rad 2010; 14:487
Ooi et al. Skeletal Radiol 2014; 43:1387

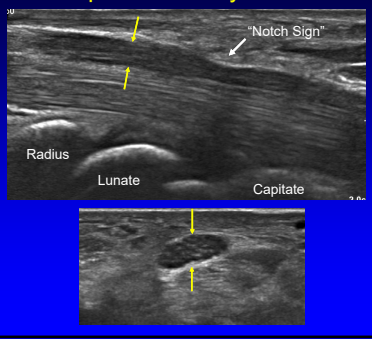
56

Carpal Tunnel Syndrome: proximal



57

Carpal Tunnel Syndrome



58

59

Outline:

- Tendons:
  - Rotator cuff and lateral epicondylitis
- Ligaments:
  - Ulnar collateral ligament (elbow)
  - Gamekeeper's thumb
- Nerves:
  - Cubital tunnel syndrome
  - Carpal tunnel syndrome
- Inflammatory arthritis
- Soft tissue foreign bodies

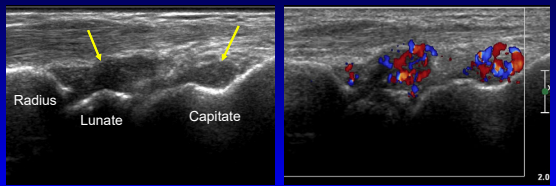
60

Inflammatory Arthritis: role

- Identify synovitis and erosions
  - Prior to initiating treatment
- Determine activity: hyperemia
- Aspirate or inject
- Follow-up after therapy
  - Decreased hyperemia
  - Decreased synovial thickness

61

Synovitis: dorsal wrist

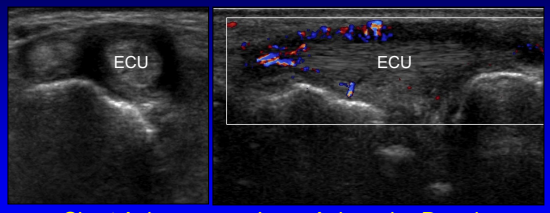


Sagittal Plane: Radiocarpal and Mid-carpal Joints

*Note: Know synovial spaces

62

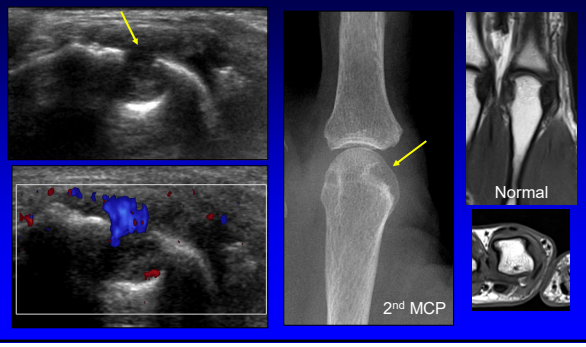
Tenosynovitis: rheumatoid arthritis



Short Axis Long Axis: color Doppler

63

Rheumatoid Arthritis



64

Outline:

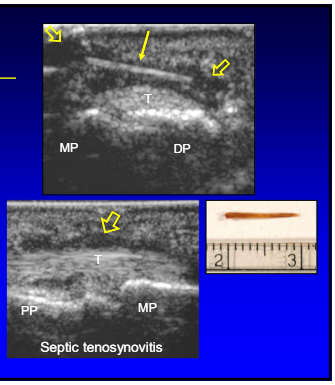
- Tendons:
  - Rotator cuff and lateral epicondylitis
- Ligaments:
  - Ulnar collateral ligament (elbow)
  - Gamekeeper's thumb
- Nerves:
  - Cubital tunnel syndrome
  - Carpal tunnel syndrome
- Inflammatory arthritis
- Soft tissue foreign bodies

66

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

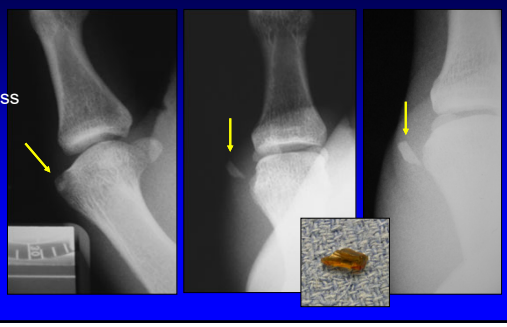


67

Glass Foreign Body

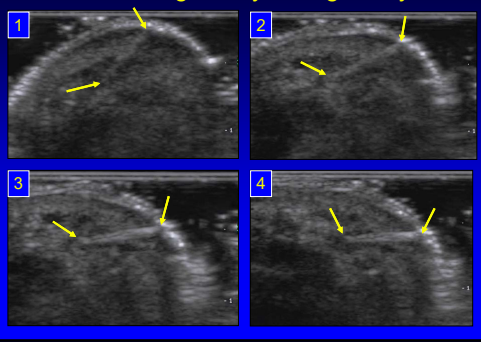
- Glass:
  - Opaque
  - Regardless of tint or color

Radiology 1998; 206:45



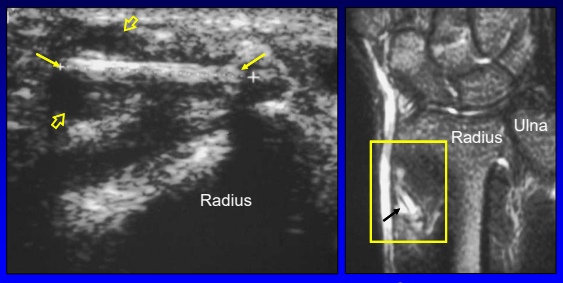
68

US: foreign body echogenicity



69

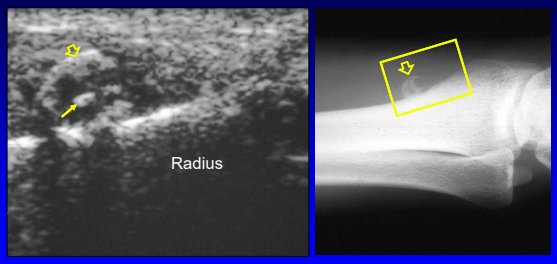
Foreign Body: wood



Longitudinal Coronal T2w

70

Foreign Body: wood



Transverse

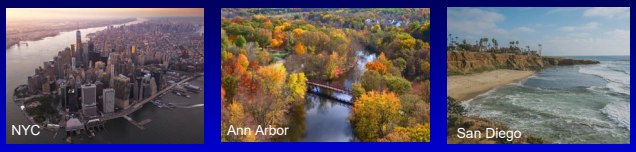
71

Take Home Points

- Rotator cuff: US is equal to MRI
- Common extensor tendon: anatomy
- UCL elbow: dynamic evaluation
- Gamekeeper: dynamic, Stener
- Ulnar nerve: dynamic evaluation
- Carpal tunnel: nerve enlargement and edema
- Inflammatory arthritis: focus on synovitis
- Foreign bodies: high resolution

72

Thank you!



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

73