Ultrasound of Upper Extremity Pathology with MRI Correlation

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Outline:
• Shoulder:
  – Rotator cuff
• Elbow:
  – Common extensor tendon
  – Ulnar collateral ligament
  – Ulnar nerve
• Wrist and hand:
  – Carpal tunnel syndrome
  – Ganglion cyst
  – Gamekeeper’s thumb

Ultrasound Appearance:
• Tendon: hyperechoic, fibrillar
• Muscle: relatively hyperechoic
• Bone cortex: hyperechoic, shadowing

Anisotropic Effect
• Tendon is artifactually hypoechoic
• Sound beam is not perpendicular to fibers
• Tendon, ligament > muscle

Note: all images from the textbook Fundamentals of Musculoskeletal Ultrasound are copyrighted by Elsevier Inc.
**Tendon Abnormalities:**
- Tendinosis: hypoechoic, swollen
- Partial-thickness tear: hypoechoic with anechoic focus or clefts
- Full-thickness tear: discontinuity
  - Dynamic imaging: retraction

**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%)

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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
- Massive tear: non-visualization

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

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**Supraspinatus: normal**

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**Supraspinatus Insertion**


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**Supraspinatus Tears: extent**

From: Fundamentals of Musculoskeletal Ultrasound
Supraspinatus Tears: extent

- Intrasubstance
- Full thickness

From: Fundamentals of Musculoskeletal Ultrasound

Articular Partial-thickness Tear: supraspinatus

Long Axis

Coronal T2w

Bursal Partial-thickness Tear: supraspinatus

Long Axis

Coronal T2w

Full-thickness Tear: supraspinatus

Note: Cartilage Interface Sign (open arrow)

Long Axis

T2w Coronal-oblique
**Tendinosis or Tendinopathy**

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


*Tendinosis: supraspinatus tendon

**Fatty Infiltration and Muscle Atrophy**

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

*Nazarian et al. 2008; 190:27.
Tendon Calcification:
- Degenerative: thin, linear deposit
- Calcific tendinosis:
  - Formative: well-defined, dense shadow
  - Resorptive:
    - Globular, amorphous
    - Variable shadow
    - Best success with aspiration

Calcific Tendinosis
- Hydroxyapatite deposition: metaplasia
  - Usually do not have cuff tear
- Appearance:
  - 79% hyperechoic & shadowing
  - No shadow: 7%
- Two phases:
  - Formative
  - Resorptive: painful

Degenerative Calcification

Calcific Tendinosis
Subscapularis: calcific tendinosis

Biceps Tendon:
- Glenohumeral joint effusion:
  - Collects around biceps tendon
  - Tendon sheath communication
  - Seen in 97% with joint effusion
  - Abnormal: > 1 mm

Zubler et al. Eur Radiol 2011; 21:1858

Inflammatory Tenosynovitis: biceps tendon

Biceps Tendon (long head): full-thickness tear

Biceps Tendon: Dislocation into subscapularis tendon
Subacromial-subdeltoid Bursa: fluid

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Lateral Elbow

Lateral Collateral Ligament Complex
- Common extensor tendon (curved arrow)
- Radial collateral ligament (arrowheads)
- Annular ligament (a)

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

Potter, Radiology 1995; 196:43

Common Extensor Tendon: elbow
- Often called “tennis elbow” or “lateral epicondylitis” or “epicondylitis” 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
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**Ulnar Collateral Ligament Tear**

- T1w Coronal post-gadolinium
- T2w Coronal post-gadolinium
- Normal

**Ulnar Collateral Ligament: partial tear**
Ulnar Collateral Ligament: valgus stress

- >1 mm asymmetric gapping = 87% accuracy in diagnosis of UCL tear
  - MR arthrography accuracy = 88%
  - US + MR arthrography: accuracy = 98%
- Asymmetric joint space widening with stress:
  - Normal: 1.3 mm or less
  - Partial tear: 1.2 – 3.0 mm
  - Full thickness tear: 2.8 – 4.8 mm

Roedl JB et al. Radiology 2016

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Ulnar Nerve: cubital tunnel syndrome

- Hypoechoic and enlarged
  - > 8 mm² area
  - Ratio greater than 2.8 compared to proximal
- Mild hypoechoogenicity alone: may be normal
- Causes:
  - Idiopathic, overuse, joint process
  - Anconeus epitrochlearis: compression
- Normal variant accessory muscle

Thoirs K et al. J Ultrasound Med 2008; 27:737
Yoon JS et al. Muscle Nerve 2008; 38:1231
Cubital Tunnel Syndrome

- Normal variant: 34% of population
- Roof of cubital tunnel:
  - Residual muscle
  - In absence of normal attrition forming Osborn fascia
- Secondary ulnar nerve entrapment
- Diagnose in elbow extension!

Sem Musculoskel Radiol 2000; 14:814-473

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Ulnar Nerve: dislocation

- 20% of asymptomatic volunteers
- Dynamic imaging:
  - Dislocates in anterior to medial epicondyle of humerus in elbow flexion
  - Reduces in extension (normal MRI)
- Transducer pressure may inhibit movement

Okamoto, J Hand Surg Br 2000; 25:499

Technique: ulnar nerve subluxation

Isolated Ulnar Nerve Dislocation

- 20% of asymptomatic volunteers
- Dynamic imaging:
  - Dislocates in anterior to medial epicondyle of humerus in elbow flexion
  - Reduces in extension (normal MRI)
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Okamoto, J Hand Surg Br 2000; 25:499
Snapping Triceps Syndrome: dynamic imaging

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Carpal Tunnel Syndrome:
- Proximal median nerve swelling
  - >10 mm² cross-sectional area
  - >9 mm² circumferential
  - Measure at level of pisiform
- Distal nerve flattening & flexor retinaculum bowing

Carpal Tunnel Syndrome
- Compare areas:
  - Proximal: pronator quadratus
  - Distal: carpal tunnel
- ≥ 2 mm² = carpal tunnel syndrome
- 99% sensitivity
- 100% specificity

Klauser AS. Radiology 2009; 250:171

Carpal Tunnel Syndrome: ulnar bursa distention
**Postoperative Carpal Tunnel**

- Discontinuous or thickened transverse carpal ligament
- Anterior displacement of transverse carpal ligament
- Median nerve size:
  - May decrease
  - Does not correlate with success


**Bifid Median Nerve + CTS**

- Carpal tunnel syndrome
- Increase in cross-sectional area of ≥ 4 mm²
- Intraneural hypervascularity: 95% accuracy in diagnosis of CTS

1. Klauser et al. Radiology 2011; 259; 808
2. Matouhi et al. AJR 2006; 186:1240

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**Soft Tissue Mass: wrist ganglia**

- Most wrist masses are ganglion cysts
- Volar (69%):
  - Radial artery & flexor carpi radialis
  - Proximal from radioscaphoid joint capsule
- Dorsal: scapholunate ligament
  - Not compressible (unlike joint recess)

*Skeletal Radiol 1994; 23:201

**Soft Tissue Mass: wrist ganglia**

- Anechoic or hypoechoic
- Well-defined, lobular
- Joint or tendon sheath communication
- <10 mm: hypoechoic without posterior acoustic enhancement


**Ganglion Cyst: volar**

Axial color Doppler
Ganglion Cyst: dorsal

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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

Ulnar Collateral Ligament: thumb

- Acute Mechanism
- Chronic Mechanism

Note: sliding of adductor aponeurosis with isolated interphalangeal joint flexion

UCL: tears

- Partial-thickness tear
- Full-thickness tear

Radiographs 2006;26:1007
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


Take Home Points
- Rotator cuff: US is equal to MRI
- Common extensor tendon: anatomy
- UCL elbow: dynamic
- Ulnar nerve: dynamic
- Carpal tunnel: 2 mm²
- Ganglion: multilocular, non-compressible
- Gamekeeper: dynamic, Stener