Ultrasound of Upper Extremity Pathology with MRI Correlation

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Disclosures:
- Consultant: Bioclinica
- Advisory Board: Philips
- Book Royalties: Elsevier

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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

Rotator Cuff

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

Anisotropic Effect
- Tendon is artfactually hypoechoic
- Sound beam is not perpendicular to fibers
- Tendon, ligament > muscle
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

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

Supraspinatus: normal

Supraspinatus Insertion

From: Siebold et al.

Supraspinatus Tears: extent

From: Fundamentals of Musculoskeletal Ultrasound

Supraspinatus Tears: extent

From: Fundamentals of Musculoskeletal Ultrasound
Articular Partial-thickness Tear: supraspinatus

Bursal Partial-thickness Tear: supraspinatus

Full-thickness Tear: supraspinatus

Bursal Partial-thickness Tear: supraspinatus

Full-thickness Tear: supraspinatus

Full-thickness Tear: supraspinatus
**Full-thickness Tear: supraspinatus**

- T2w Sagittal-oblique
- Short Axis

**Tendinosis**

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


**Tendinosis: supraspinatus tendon**

- Long Axis
- Coronal-oblique T2w

**Fatty Infiltration and Muscle Atrophy**

- Supraspinatus and infraspinatus
  - Supraspinatus: 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

3 Khoury et al. AJR 2008; 190:1105.
4 Nazarian et al. 2008; 190:27.

**Fatty Infiltration and Muscle Atrophy**

- Indistinct tendon-muscle border
- Increased muscle echogenicity
  - Compare to teres minor
- Decreased muscle bulk
  - Compared to teres minor
  - Bone landmark: ridge in scapula
  - Short axis: infraspinatus 2x size

**Atrophy: supraspinatus and infraspinatus**

- Short Axis (extended field-of-view)
Tendon Calcification:
- Degenerative: thin, linear deposit
- Calcific tendinosis:
  - Formative: well-defined, dense shadow
  - Resorptive:
    - Globular, amorphous
    - Variable shadow
    - Best success with aspiration

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

Calcific Tendinosis
- Subscapularis: calcific tendinosis
  - Formative: Defined, shadow
  - Resorptive: Amorphous, little shadow
**Biceps Tendon:**

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

*Zuber et al. Eur Radiol 2011; 21:1858*

**Inflammatory Tenosynovitis: biceps tendon**

**Biceps Tendon (long head): full-thickness tear**

- Short Axis: proximal
- Short Axis: distal

**Biceps Tendon: Dislocation into subscapularis tendon**

**Subacromial-subdeltoid Bursa: fluid**

**Subluxation**

**Dislocation**

**Coronal**

**Coronal T2w**
Artificial Intelligence Failure: #21
Labradoodle versus Fried Chicken

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Lateral Collateral Ligament Complex

Epicondylitis:

- Common flexor and extensor tendons
- Abnormal hypoechoogenicity
  - 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 “epicondylodynia” 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

**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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Anatomy: posterior

From: Netter’s Atlas of Human Anatomy

Ulnar Collateral Ligament: laxity

With valgus stress

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Anatomy: posterior

From: Netter’s Atlas of Human Anatomy

Technique: cubital tunnel

Ulnar Nerve: cubital tunnel syndrome

- Hypoechoic and enlarged
  - > 9 mm² area¹
  - Ratio greater than 2.8 compared to proximal²
- Mild hypoechoogenicity alone: may be normal
- Causes:
  - Idiopathic, overuse, joint process
  - Anconeus epitrochlearis: compression
  - Normal variant accessory muscle

¹Thoirs K et al. J Ultrasound Med 2008; 27:737
²Yoon JS et al. Muscle Nerve 2008; 38:1231
Cubital Tunnel Syndrome

Anconeus Epitrochlearis
- 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 Radial 2000; 14:814-473

Anconeus Epitrochlearis

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
Snapping Triceps Syndrome: *dynamic imaging*

Artificial Intelligence Failure: #43
Chihuahua versus Blueberry Muffin

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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

1Chen et al. AJR 1997; 168:533
2Duncan et al. AJR 1999; 173:681

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


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Bifid Median Nerve + CTS

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

2. Mallouhi et al. AJR 2006; 186:1249

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)


Soft Tissue Mass: wrist ganglia

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

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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

- Note: sliding of adductor aponeurosis with isolated interphalangeal joint flexion

Ulnar Collateral Ligament: thumb

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

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