Musculoskeletal and Peripheral Nerve Ultrasound

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- Consultant: Bioclinica
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- Not relevant to this talk

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Fundamentals of Musculoskeletal Ultrasound are copyrighted by Elsevier Inc.

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

MRI versus Ultrasound:
- Examine entire joint
- Intraarticular assessment
  - Cartilage
- Intraosseous abnormalities
- Deep structures
- Less operator dependent

Equipment: cart-based
- Advantages:
  - Powerful: fast, software
  - High resolution: 15 – 17 MHz
- Disadvantages:
  - Not portable
  - Relatively expensive

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

Plugs into any tablet or android smartphone via microUSB
Ultrasound Appearance:
- Tendon: hyperechoic, fibrillar
- Muscle: relatively hypoechoic
- Bone cortex: hyperechoic, shadowing

Sonography: abnormalities
- Tendon abnormality: hypoechoic
- Fluid: anechoic + acoustic enhancement

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

From: Siebold et al.

Supraspinatus Insertion

Supraspinatus Tears: extent

From: Fundamentals of Musculoskeletal Ultrasound

Supraspinatus Tears: extent

Intrasubstance
Full thickness

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

Bursal Partial-thickness Tear: supraspinatus

Full-thickness Tear: supraspinatus

Tendinosis

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

*Radiology 2004; 230:234


Tendon Tear versus Tendinosis

*both may appear hypoechoic*

<table>
<thead>
<tr>
<th>Tear</th>
<th>Tendinosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anechoic</td>
<td>Hypoechoic</td>
</tr>
<tr>
<td>Well-defined</td>
<td>Ill-defined</td>
</tr>
<tr>
<td>Homogeneous</td>
<td>Heterogeneous</td>
</tr>
<tr>
<td>Thinned</td>
<td>Swollen</td>
</tr>
<tr>
<td>Bone irregularity*</td>
<td>Smooth cortex</td>
</tr>
</tbody>
</table>

*At supraspinatus tendon footprint in patients over 40 years old*

Peroneal Tendon: subluxation

- Implies retinaculum injury
- Associated with tendon tear
- Examine with dorsiflexion and eversion
- Lateral subluxation or dislocation
- Retrofibular intrasheath subluxation

Neustadter J et al. AJR 2004; 183:985

Peroneal Retinaculum

Rosenberg et al. AJR 2003; 181:1551

Peroneal Subluxation: dynamic imaging

Posterior

Anterior

Transverse
Dislocation: peroneus brevis & longus

Intrasheath Peroneal Subluxation

- Abnormal snapping of peroneal tendons
- No lateral displacement, intact retinaculum
- 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

Intrasheath Peroneal Subluxation: Type A

Intrasheath Peroneal Subluxation: Type B

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
Snapping Hip Syndrome: iliopsoas

- Transverse over greater trochanter
- Hip external rotation / flexion
- Abrupt motion of iliotibial tract over greater trochanter

Snapping Hip: iliotibial tract

- Transverse over greater trochanter
- Hip external rotation / flexion
- Abrupt motion of iliotibial tract over greater trochanter

Snapping Gluteus Maximus / Iliotibial Band

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

Achilles Tendon: dynamic imaging

- Long Axis

Achilles Tendon: healing tear

- Prox
- Distal
- Longitudinal
Accepted Indications:
• Tendon abnormalities
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• Soft tissue mass

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

Synovitis: dorsal wrist

Erosions
• Ultrasound not very good for erosions:
  – Better than radiographs
  – 40% sensitivity\(^1\), 29% false positives\(^2\):
    wrist/hand compared with CT
  – Very non-specific, time consuming
• Adjacent synovitis adds specificity
• Correlate with radiographs, labs, distribution

\(^1\)Dohn UF, M Arthritis Res Ther 2006; 8:1
\(^2\)Finzel S. et al. Arth Rheumatism 2011; 63:1231
**Rheumatoid Arthritis**

- ECU
- Ulna
- Triquetrum

**Cortical Irregularity**

- Psoriatic Arthritis
- Osteoarthritis
- Rheumatoid Arthritis
- Normal

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**Gout: intra-articular**

- Monosodium urate crystal deposition in joint
- Joint effusion\(^1\):
  - Microtophi
    - Cartilage icing: double contour sign (ultrasound)
- Synovitis
- Erosions
- Knee: common site\(^2\)

\(^1\)Thiele RG, Rheumatol Int 2010; 30:495

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**Tophi**

- Ultrasound\(^1\): *specific*
  - Hyperechoic heterogeneous with hypoechoic rim
  - "wet clump of sugar" appearance
  - Variable shadowing: even without calcification
- MRI\(^1\): *non-specific*
  - T1w: low to intermediate
  - T2w: heterogeneous mixed signal
  - Heterogeneous enhancement

\(^1\)Fernandes et al. Skeletal Radiol 2011; 40:309

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**Gout: tophus and intra-articular microtophi**

- 1\(^{st}\) Metatarsophalangeal Joint

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**Gout: tophus**

- 1\(^{st}\) Metatarsophalangeal Joint
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Ulnar Collateral Ligament: laxity
- With valgus stress

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

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

Roedl JB et al. Radiology 2016

Ulnar Collateral Ligament: thumb
- Note: sliding of adductor aponeurosis with isolated interphalangeal joint flexion

Ulnar Collateral Ligament: thumb
- Normal
- Sprain
- Partial Tear
- Non-displaced Complete Tear (+ fracture)
- Displaced Complete Tear (Stener lesion)

Radiographics 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

UCL: tears

Stener Lesion: variations

Normal
Non-displaced tear
Displaced Full-thickness Tears

Stener Lesion: dynamic

White arrows = adductor aponeurosis
Yellow arrows = Stener lesion

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Normal Peripheral Nerve

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


Median Nerve

Volar Wrist: median nerve

Median Nerve

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

Carpal Tunnel Syndrome

- Compare areas:
  - Proximal: pronator quadratus
  - Distal: carpal tunnel
- $\geq 2 \, \text{mm}^2 = \text{carpal tunnel syndrome}$
- 99% sensitivity
- 100% specificity

Klauser AS. Radiology 2009; 250:171

Cubital Tunnel Syndrome:

- Ulnar nerve entrapment at elbow
- 2nd most common upper extremity entrapment neuropathy
- Etiologies:
  - Trauma, valgus deformity,
  - Nerve subluxation, cyst, arthritis
Ulnar Nerve Compression
- Hypoechoic, enlarged >9.5 mm²
- US + electrodiagnostic tests:
  - Sensitivity increase from 78 to 98%
  - Localized lesions not identified with electrodiagnostic tests

Thoirs, J Ultrasound Med 2008; 27:737
Beekman, Muscle and Nerve 2004;30:202

Cubital Tunnel Syndrome

Ulnar Nerve Dislocation
- Occurs in elbow flexion
- Reduces in extension
- Nerve irritation, predisposes to injury
- Found in 20% asymptomatic volunteers

Okamoto, J Hand Surg 2000; 25B:85

Isolated Ulnar Nerve Dislocation

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

Radiology 2001; 220:601
**Snapping Triceps Syndrome:** *dynamic imaging*

**Anterior Posterior**

**Transverse**

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**Morton Neuroma:**

- Interdigital nerve entrapment
- Edema, fibrosis, necrosis
- 3rd intermetatarsal space > 2nd
- Sharp, burning pain from metatarsal head to toes
- Females: pliable foot, high-heeled narrow-toed shoes

From: Martinoli, Radiographics 2000; 20:S199

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**Morton Neuroma**

- Hypoechoic 5 mm mass
  - Sensitivity: 100%; Specificity: 83%
  - Accuracy equal to MRI
  - Nerve continuity: sagittal plane
- Intermetatarsal bursa
  - Associated with neuroma
  - “Neuroma-bursal complex”

Quinn T et al. AJR 2000; 174:1723

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**Dynamic Evaluation**

- Compression
  - Between transducer and palpation
  - Bursae (dorsal) compress, neuromas (plantar) do not
- Sonographic Mulder Sign
  - Scan plantar: coronal plane
  - Neuroma displaces: plantar
  - Palpable click

Torriani M et al. AJR 2003; 180:1121
Zanetti M et al. Radiology 1997; 203:516

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**Dynamic imaging: Mulder’s Maneuver**
Transection Neuroma:

- Neuroma formation:
  - Disorganized and tangled nerve end
  - Normal response to nerve transection
  - US important to determine if symptomatic

  J Clin Ultrasound 1997; 25:85

Accepted Indications:

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

Radiography:

- Non-radiopaque objects: wood, plastic
- Glass: opaque
  - Regardless of tint or color
  - Visualization requires optimized positioning and technique

  Radiology 1998; 206:45
Wooden Foreign Body: finger

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

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

Baker Cyst: rupture

Ganglion Cyst: dorsal
Ganglion Cyst: volar

Axial Sagittal

Flexor Carpi Radialis

Radial Artery

Radius

Take Home Points

- 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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