Musculoskeletal Ultrasound with MRI Correlation

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

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

University of Michigan, Ann Arbor
• 120 radiologists
  ➢ 10 bone
  ➢ 4 bone fellows
• Population 120,000
• Big House 115,000
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


Ultrasound Appearance:

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

Anisotropic Effect

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

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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

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

Intrasubstance Bursal Surface Articular Surface

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

Supraspinatus Insertion

Footprint

Supraspinatus Tears: extent

Partial Articular Partial Bursal

Rim-vent Tear or PASTA lesion

Full thickness Intrasubstance

From: Fundamentals of Musculoskeletal Ultrasound

Articular Partial-thickness Tear: supraspinatus

Long Axis Coronal T2w

Bursal Partial-thickness Tear: supraspinatus

Long Axis Coronal T2w
**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*

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**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: 72:01*

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*Radiology 2004; 230:234*
**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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**Dislocation: peroneus brevis & longus**

Anterior           Posterior

Short axis

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**Intrasheath Peroneal Subluxation: Type A**

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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; 190:578

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**Iliopsoas Complex**

Snapping Hip Syndrome: iliopsoas

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

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Achilles Tendon: healing tear

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
**Synovitis: dorsal wrist**

- Sagittal Plane: Radiocarpal and Mid-carpal Joints

**Tenosynovitis: rheumatoid arthritis**

- Short Axis
- Long Axis: color Doppler

**Complicated Fluid vs. Synovium**

- Both may appear hypo- or isoechoic
- **Findings that suggest effusion:**
  - Displacement with transducer pressure
  - Joint recess collapse w/ joint movement
  - Negative flow on color Doppler imaging
  - Swirling with transducer pressure

**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

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

Gout: tophus and intra-articular microtophi

1\(^{st}\) Metatarsophalangeal Joint

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

Tophi
- Ultrasound\(^1\): specific
  - Hyperechoic heterogeneous with hypoechoic rim
  - “wet clump of sugar” appearance
  - Variable shadowing: even without calcification
- MRI\(^2\): non-specific
  - T1w: low to intermediate
  - T2w: heterogeneous mixed signal
  - Heterogeneous enhancement

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

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**Ulnar Collateral Ligament: thumb**

Note: sliding of adductor aponeurosis with isolated interphalangeal joint flexion
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


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Normal Peripheral Nerve

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


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

Median Nerve

Carpal Tunnel Syndrome

Cubital Tunnel Syndrome

Isolated Ulnar Nerve Dislocation

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
**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

**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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**Radiography:**

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

Radiology 1998; 206:45
Glass Foreign Body:
- All foreign bodies: initially hyperechoic
  - Organic matter: less echogenic over time
- Most echogenic if ultrasound beam perpendicular to surface of foreign body

Soft Tissue Foreign Bodies:
- Hypoechoic halo: foreign body response
- Smooth and flat: reverberation
- Irregular and small radius of curvature: shadowing

Radiology 1991; 181:231

US: foreign body echogenicity

Rose Thorn: foot
- Calcaneus
- Longitudinal
- Transverse T2w

Wooden Foreign Body: finger
- Longitudinal
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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

AJR 2001; 176:373

Baker Cyst: rupture

Soft Tissue Mass: wrist ganglia
- Anechoic or hypoechoic, well-defined, lobular
- Joint or tendon sheath communication
- <10 mm: hypoechoic without posterior acoustic enhancement
- Dorsal: over scapholunate ligament
- Volar: between radial artery and FCR

**Pitfall Alert!**

Ganglion Cyst vs Dorsal Recess

- Ganglion: not compressible
- Recess: compressible

*Sagittal with Wrist Flexion*

Muscle Hernia

- Cause: trauma, activities, weak fascia
- Lower leg: especially anterior tibialis
- Swelling with muscle contraction
- US: muscle bulge, possible fascial defect
  - Site of perforating vessel

Beggs, AJR 2003; 180:395

Muscle Hernia: *anterior tibialis*

Patent #1

Patent #2

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

Syllabus on line and other educational material:

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