Musculoskeletal Ultrasound: Basics, Utility, and Clinical Applications

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Disclosures

• Andrew Lavigne, MD
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  - Nothing to disclose

• Eugene Maida, MD
  Resident, Physical Medicine and Rehabilitation, McMaster University, Hamilton, Ontario, Canada.
  - Nothing to disclose
Objectives

• To gain an understanding of the basic science behind diagnostic ultrasound as an imaging modality

• To outline some clinical uses of ultrasound, including examples, as well as discussion of scanning pearls and pitfalls.

• To review the anatomy of the shoulder and surrounding structures, with emphasis on the use of bony landmarks for accurate identification of specific joints, tendons and bursae.
Outline

• Basics of ultrasound
• How can it be used?
• Clinical examples
• Some shoulder anatomy
• Take home points
Basics of Ultrasound

Outline

Basics of Ultrasound

How can it be used?

Clinical examples

Shoulder anatomy

Take Home Points
What is Ultrasound?

Involves the use of high-frequency sound waves to image soft tissues and bony structures in the body.

Relies on properties of acoustic physics to localize and characterize different tissue types for the purposes of:

1. **Assessing** structural morphology of soft tissues.
2. **Guiding** real-time interventional procedures.
What is Ultrasound?

• At each acoustic interface, an ultrasound transducer sends an acoustic pulse into tissue and receives a reflected sound wave or echo.

• These echoes contain spatial and contrast information which gathers data to form a rapidly moving two-dimensional gray scale image.
What is Ultrasound?

- Strong returning echoes appear as **BRIGHT** and **WHITE HYPERECHOIC** areas on the ultrasound screen.

- While weaker returning echoes appear as **DARK GRAY** and **BLACK HYPOECHOIC** areas.

- The tissue interface in which echoes return to the probe enable the clinician to identify and assess soft tissue morphology.
Transducers

High-frequency (17-5 MHz), Linear Array transducer, “Hockey Stick” transducer.

Medium-High frequency (15-7 MHz) Linear Array transducer

Low- to medium-frequency (5-2 MHz) Curvilinear Array transducer
High-frequency small footprint linear array transducer

Low frequency curvilinear array transducer
**High-frequency**
small footprint
linear array transducer

**Low frequency**
curvilinear array transducer
What is Ultrasound?

**PROS**

– **Technical**\(^1\)
  - High-resolution soft tissue imaging
  - 3x better spatial resolution than MRI (150 vs 460 microns)\(^2\)
  - Ability to image in real-time
  - Minimally affected by metal artifact (i.e. implants and hardware)

– **Clinical**\(^{1-2}\)
  - Facilitates dynamic examination of anatomic structures
  - Can interact with the patient while imaging
  - Ability to guide procedures (e.g. aspirations, injections)
  - Enables rapid contralateral limb examination for comparison

– **Other**\(^{1-2}\)
  - Portable
  - Relatively inexpensive
  - Lacks radiation
  - No known contraindications

\(^{1}\)Hall M. et al., Curr Phys Med Rehabil Rep (2013) 1:38–47
\(^{2}\)Link TM., Magn Reson Imaging 1998; 16:147–155
What is Ultrasound?

CONS

- Technical
  - Limited field of view
  - Incomplete evaluation of bones and joints
  - Limited penetration (large body habitus)

- Examiner
  - Operator dependent
  - Lack of educational infrastructure
  - Lack of certification or accreditation process

- Equipment
  - Initial cost
  - Variable quality

\(^1\)Hall M. et al., Curr Phys Med Rehabil Rep (2013) 1:38–47
How can it be used?
Ultrasound in Practice

• Enables to:
  – Instantaneously confirm physical exam findings in the office setting and view tissues of interest both statically and dynamically.

  – With significant reductions in:
    • Wait time to assessment and treatment
    • Unnecessary expensive diagnostic examinations

Ozcakar et al., Arch Phys Med Rehabil. 2010
Clinical Applications

• Spasticity management
  – Botulinum toxin
  – Neurolysis

• Entrapment neuropathies

• Pain medicine
  – Facet blocks
  – Nerve blocks

• Musculoskeletal medicine
  – Dynamic evaluation
  – Therapeutic injections
Primum non nocere

- Important to know:
  - What is the underlying pathology?
  - Where is your injectate is going?
Role of Guided Interventions In Clinical Practice

- **First Generation Techniques**
  - Intra-articular injections
  - Peritendinous injections
  - Perineural Injections
  - Regenerative therapy
    - Dextrose
    - Autologous Blood
    - Platelet-Rich Plasma

- **Second Generation Techniques**
  - Needle Tenotomy/Fasciotomy
  - Calcific Tendinosis Barbatoge
  - Neo-vessel ablation
  - Tendon release
  - Peripheral Nerve Hydro-dissection for compression / adhesive neuritis

- **Third Generation Techniques**
  - A-1 pulley release
  - Carpal Tunnel Release
  - Debridement and resection of scar tissue

# USGI vs. LMGI

## Large Joint Injection Accuracy

<table>
<thead>
<tr>
<th>Joint</th>
<th>Level 1 Mean, % (Range, %)</th>
<th>Level 2 Mean, % (Range, %)</th>
<th>Level 3 Mean, %</th>
<th>Level 4 Mean, %</th>
<th>Level 5 Mean, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>GH joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>USGI</td>
<td>100 (97-100) [8,15,39,42,46,49]</td>
<td>91 (89-93) [5,38]</td>
<td>—</td>
<td>100 [16]</td>
<td>—</td>
</tr>
<tr>
<td>LMGI</td>
<td>64 (27-100) [7,10,24,31,40,43,47]</td>
<td>73 (10-100) [5,11,17,25,26,28,38,60,61]</td>
<td>—</td>
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<tr>
<td>Hip joint</td>
<td></td>
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</tr>
<tr>
<td>USGI</td>
<td>99 (77-100) [8,27,41,44,45]</td>
<td>—</td>
<td>—</td>
<td>100 [30]</td>
<td>100 [44]</td>
</tr>
<tr>
<td>LMGI</td>
<td>—</td>
<td>73 (67-78) [12,50]</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Knee joint</td>
<td></td>
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</tr>
<tr>
<td>USGI</td>
<td>95 (75-100) [8,21,23,32,36,37]</td>
<td>98 (96-100) [5,9]</td>
<td>—</td>
<td>100 [16]</td>
<td>100 [20]</td>
</tr>
<tr>
<td>LMGI</td>
<td>81 (62-100) [10,19,21-23,31,32,36,37,48]</td>
<td>74 (55-100) [5,9,10,13,26]</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>SI joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td>40 [8]</td>
<td></td>
<td></td>
<td>100 [34]</td>
<td>—</td>
</tr>
<tr>
<td>LMGI</td>
<td>—</td>
<td></td>
<td>—</td>
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</tr>
</tbody>
</table>

GH = glenohumeral; USGI = ultrasound-guided injection; LMGI = landmark-guided injection; SI = sacroiliac.

## Table 4
Intermediate joint injection accuracy

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean, %</td>
<td>Mean, %</td>
<td>Mean, %</td>
<td>Mean, %</td>
<td>Mean, %</td>
</tr>
<tr>
<td></td>
<td>(Range, %)</td>
<td>(Range, %)</td>
<td>(Range, %)</td>
<td>(Range, %)</td>
<td>(Range, %)</td>
</tr>
<tr>
<td>SC joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>USGI</td>
<td>LMGI</td>
<td>USGI</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>78 (74-82)</td>
<td>79</td>
<td>—</td>
</tr>
<tr>
<td>AC joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>95 (90-100)</td>
<td>70</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>LMGI</td>
<td>—</td>
<td>52 (33-72)</td>
<td>69,70,72,78</td>
<td>40</td>
</tr>
<tr>
<td>Elbow joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>97 (83-100)</td>
<td>31</td>
<td>—</td>
</tr>
<tr>
<td>Distal RU joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>100 [77]</td>
<td>50</td>
<td>—</td>
</tr>
<tr>
<td>Wrist joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>100 [8]</td>
<td>50-97</td>
<td>74</td>
</tr>
<tr>
<td>STT joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>100 [74]</td>
<td>80 [74]</td>
<td>—</td>
</tr>
<tr>
<td>Proximal TF joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>100 [76]</td>
<td>58 [76]</td>
<td>—</td>
</tr>
<tr>
<td>TT joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>64 (50-77)</td>
<td>26,31</td>
<td>87 (78-100)</td>
</tr>
<tr>
<td>ST joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>97 (90-100)</td>
<td>75</td>
<td>—</td>
</tr>
<tr>
<td>Elbow, wrist, TT joint</td>
<td>USGI</td>
<td>LMGI</td>
<td>100 [52]</td>
<td>29 [52]</td>
<td>—</td>
</tr>
</tbody>
</table>

**SC** = sternoclavicular; **USGI** = ultrasound-guided injection; **LMGI** = landmark-guided injection; **AC** = acromioclavicular; **RU** = radioulnar; **STT** = scaphotrapeziotrapezoidal; **TF** = tibiofibular; **TT** = tibiotarsal; **ST** = subtalar.
### Table 6: Small joint injection accuracy

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Level 1 Mean, %</th>
<th>Level 2 Mean, %</th>
<th>Level 3 Mean, %</th>
<th>Level 4 Mean, %</th>
<th>Level 5 Mean, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMC joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td>94 [32]</td>
<td>100 [52]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td>0 [26,52]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCP joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td>97 [31]</td>
<td></td>
<td></td>
<td></td>
<td>0 [26]</td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP joint</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td></td>
<td></td>
<td>100 [52]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td></td>
<td>0 [52]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMT joint</td>
<td></td>
<td>64 [66]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td></td>
<td>25 [66]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTP joint</td>
<td></td>
<td></td>
<td>100 [52]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td></td>
<td>71 [83]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td></td>
<td>0 [52]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCP and PIP joints</td>
<td></td>
<td></td>
<td>96 [81]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td></td>
<td>59 [81]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CMC = carpometacarpal; USGI = ultrasound-guided injection; LMGI = landmark-guided injection; MCP = metacarpophalangeal; IP = interphalangeal; TMT = tarsometatarsal; MTP = metatarsophalangeal; PIP = proximal interphalangeal.
## Soft Tissue Injection Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean, %</td>
<td>Mean, % (Range, %)</td>
<td>Mean, %</td>
<td>Mean, % (Range, %)</td>
<td>Mean, %</td>
</tr>
<tr>
<td><strong>SA-SD bursa</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>USGI</td>
<td>65 [91]</td>
<td>78 [29-90]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td>65 [91]</td>
<td>78 [29-90]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BT sheath</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGI</td>
<td>87 [99]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td>87 [99]</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Pes anserinus bursa</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>USGI</td>
<td></td>
<td>92 [88]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td>92 [88]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Achilles region</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>USGI</td>
<td></td>
<td>100 [71]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td>100 [71]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peroneal tendon sheath</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>USGI</td>
<td></td>
<td>100 [13]</td>
<td></td>
<td>100 [89]</td>
<td></td>
</tr>
<tr>
<td>LMGI</td>
<td></td>
<td>100 [13]</td>
<td></td>
<td>100 [89]</td>
<td></td>
</tr>
</tbody>
</table>

Clinical examples
Trigger finger

A2 Pulley
Acromioclavicular joint
Supraspinatus
Long Head Biceps
Subscapularis
Glenohumeral joint
How good are you at palpating?
How good are you at palpating?
Take Home Points

Outline
Basics of ultrasound
How can it be used?
Clinical examples
Shoulder anatomy
Take Home Points
Take Home Points

• MSUS has revolutionized how clinicians diagnose and treat many musculoskeletal conditions.

• In the past, we relied on, physical examination maneuvers and often costly imaging techniques to diagnose and confirm acute and chronic musculoskeletal conditions.

• Recent advances in ultrasound has enabled it to become a mainstay in the day-to-day management of patients.

• For the first time, we are able to instantaneously confirm physical exam findings in the office and view tissues of interest both statically and dynamically.

• MSUS has proved to be a useful tool to assist with the real-time visualization of target and surrounding structures.
Thank You