Use of Ultrasound Imaging (USI) in Physical Therapy

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Two areas of application

- Diagnostic Imaging:
  - examining the effects of injury or disease on ligament, tendon, and muscle tissues

- Rehabilitative USI (RUSI):
  - evaluation of muscle structure (morphology) and behavior, as well as the use of USI as a biofeedback mechanism.


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USI

- 3.5 to 15 MHz
- Transducers:
  - Linear
  - Curved
  - Can be dual or multifrequency
- Modes:
  - B-Mode
  - M-Mode

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Image Adjustment

- A: unadjusted image
- B: Increased Depth
- C: Focal Zone adjustment
- D: Gain Adjustment

Sonographic Appearance of Musculoskeletal Tissue

- Bone Surface
- Tendons
- Ligaments
- Muscles
- Nerves
- Meniscal/Discoid tissue
- Articular cartilage
- Bursa

Bone

- Bone appears hyperechoic
- Most important landmark when performing sonographic evaluation
- Surface should be smooth and continuous
- No lifting off of the periosteum
- Enthesis (Sharpey’s fibers) is where the tendon attaches to the bone

Tendon

- Normal tendon tissue appear hyperechoic
- Tendon fibers are visible as parallel bands linearly arranged

Quadriceps tendon LAX and SAX view

Ligament

- Hyperechoic
- Less organized than tendons
- Image prone to anisotropy due to the angle of the soundwave
- Can appear relatively hypoechoic when surrounded by hyperechoic subcutaneous fat

Medial Collateral Ligament of the knee (Jacobson, 2013)
**Muscle**
- Muscle fibrils appear hypoechoic (due to high fluid content)
- Fibrils are surrounded by hyperechoic connective tissue, giving a striated appearance
- Pennate structure of muscles can also be evaluated

**Nerve**
- Nerves have a fascicular appearance
- Nerve fascicles are hypoechoic, with the surrounding connective tissue (epineurium) appearing hyperechoic
- SAX shows honeycomb appearance
- LAX shows “railroad track” appearance

**Meniscoid/Discoid structures**
- Fibrocartilaginous
- Have medium brightness and echogenicity
- Difficult to make definitive diagnosis with US

**Articular Cartilage**
- Articular (hyaline) cartilage appears hypoechoic
- Adjacent to hyperechoic subchondral bone
Bursa

- Thin, hypoechoic layer between potential friction areas

Key terms

- **Penetration** Depth of sound wave
- **Attenuation** Reaction of sound wave with tissues encountered:
  - Reflection
  - Scattering
  - Refraction
  - Absorption
- **Artifact:**
  - Anisotropy
  - Enhancement
  - Shadowing
  - Reverberation

Enhancement

- **FIGURE 3.** (A) Depiction of the enhancement of a region deep to a fluid-filled structure. Enhancement occurs as there is less attenuation of the propagating sound wave as it travels through a fluid-filled structure. (B) Transverse ultrasound image demonstrating enhancement of the midline pelvic floor structures deep to the bladder.


Anisotropy

- **Fibrillar tissues** (tendons, ligaments, muscles) will display as hyperechoic when the angle of the sound beam increases.
Shadowing

FIGURE 4. (A) Depiction of how an acoustic shadow forms behind a strongly attenuating (hyperechoic) structure such as bone. (B) A transverse ultrasound image demonstrating edge shadowing (ES) caused by the bladder. Abbreviations: L, lamina; MF, multifidus; SP, spinous process.

Refration

FIGURES. (A) Depiction of an edge shadow produced when a sound wave is refracted (bent) around the edges of a fluid-filled structure. (B) A transverse ultrasound image demonstrating edge shadowing (ES) caused by the bladder.

From: Whitaker et al. Rehabilitative Ultrasound Imaging: Understanding the Technology and its applications. JOSPT 2007; 37;434-449

Reverberation

Depiction of reverberation which is caused when a portion of the ultrasound echo from a highly reflective surface, such as the transducer, is reflected back to the transducer. The time delay may falsely portray that interface at 1 or more levels deeper in the tissue structure.

From: Whitaker et al. Rehabilitative Ultrasound Imaging: Understanding the Technology and its applications. JOSPT 2007; 37;434-449

Imaging Modes

FIGURES. (A) A brightness mode (b-mode) image of the lateral abdominal wall. (B) A split-screen image with a brightness mode on the left and a motion mode on the right. The motion mode image provides additional information from the brightness mode. From: Whitaker et al. Rehabilitative Ultrasound Imaging: Understanding the Technology and its applications. JOSPT 2007; 37;434-449
Some examples of pathology

- **Bone**: Avulsion fracture of talus

Tendon Pathology

- Tenosynovitis of the long head of the biceps

- Tendon tear (Patella Tendon)

- Supraspinatus tear
Ligament pathology
  • Ulnar Collateral Ligament tear (pre and post)

Muscle Pathology
  • Intramuscular hemorrhage

Nerve Pathology
  • Carpal Tunnel Syndrome:

  • Partial thickness tear of rectus femoris
Bursa and Cysts

- Baker's cyst:
- Ganglion cyst (LAX):
RUSI: Lumbar Stabilization

- Image on left demonstrates an anteriorly placed transducer which allows for visualization of superficial soft tissue (SST), External Oblique (OE), Internal Oblique (OI) and Transverse Abdominis (TrA)
- Right hand image demonstrates the entire length of TrA

Abdominal Drawing in Maneuver

- Optimal pattern of activation
  - TrA shortens and places tension of thoracolumbar fascia
  - TrA thickens in width indicating contraction
  - TrA forms an arc laterally (corset action)
  - Dimensions of OE and OI remain unchanged
  - Pattern is symetrical
- Features of non-optimal pattern of activation
  - TrA, OI and OE all thicken simultaneously
- Common substitution patterns
  - Breath holding / forced expiration
  - Bracing of superficial abdominal muscles : Rectus Abdominis
  - Posterior pelvic tilt

Ultrasound imaging of the lateral abdominal wall muscles during the abdominal drawing in maneuver

- Relaxed
- Contraction

Schematic diagram of a cross section at the level of the fourth lumbar vertebra (L4)

The lumbar multifidus muscle (M) lies lateral to the spinous process, superior to the lamina (L), and medial to erector spinae (ES). Abbreviations: AT, adipose tissue; A, discal ligament; S, skin; SP, spinous processes, TP, transverse processes, VB, vertebral body.
Bilateral transverse ultrasound image at L4

The spinous process (SP) is in center of the image, Laminae (L) on either side of base of SP and Multifidus (M)

Identifying the Multifidus

- Have patient lift ipsilateral leg
- Raise contralateral upper extremity

Resources

- JOSPT Special Issues August/October 2007
- www.essr.org (scan protocols for peripheral joints)