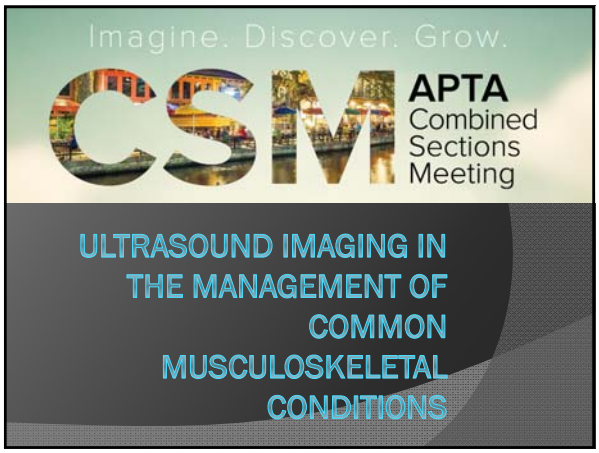
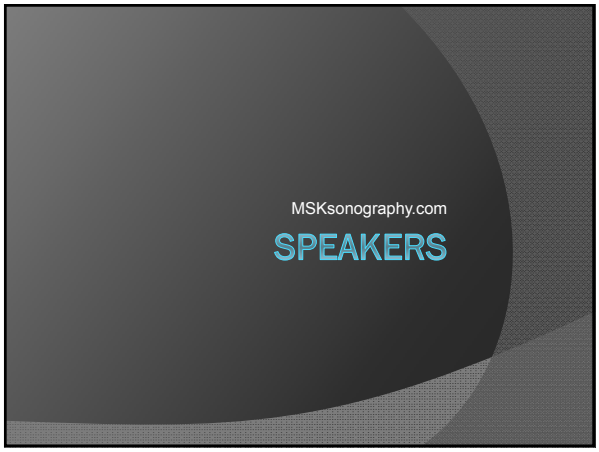
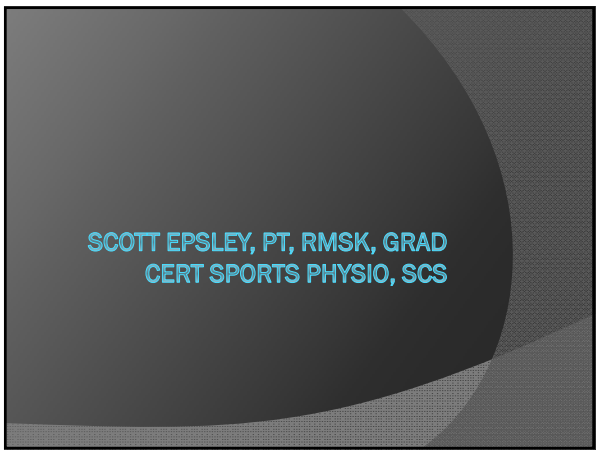

Imagine. Discover. Grow.
CSM
APTA
Combined
Sections
Meeting
ULTRASOUND IMAGING IN THE MANAGEMENT OF COMMON MUSCULOSKELETAL CONDITIONS


MSKsonography.com
SPEAKERS


SCOTT EPSLEY, PT, RMSK, GRAD CERT SPORTS PHYSIO, SCS

Meghan Poll, PT, DPT, OCS

douglas@msksonography.com
DOUGLAS M. WHITE, DPT, OCS, RMSK

Bio

- Owner Milton Orthopaedic & Sports Physical Therapy Milton, MA
- Past-President - Imaging Special interest Group, Orthopaedic Section, APTA
- Co-Chair – Hip Panel Clinical Practice Guidelines, Orthopaedic Section APTA
- Registered Musculoskeletal Ultrasound

Objectives

- Identify when USI is indicated to assist in managing common MSK conditions.
- Understand what information can be derived from USI.
- Understand the relevance of USI as compared to other imaging modalities
- Apply information presented in a laboratory setting to gain introductory experience in MSK USI.

PHYSICS & THE LANGUAGE OF ULTRASOUND

Ultrasound

- Human Hearing 20KHz/20,000Hz
- Ultrasound >20,000HZ
- Diagnostic Ultrasound 1-18MHz

Modes of Ultrasound

- B-mode: Brightness
- M-mode: Motion

- Doppler
  - Color Doppler
  - Spectral Doppler
  - Power Doppler

B Mode

- Linear array of transducers simultaneously scans a plane through the body that can be viewed as a two-dimensional image on screen.

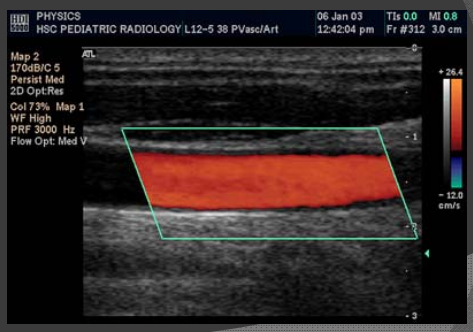
M Mode

- Pulses are emitted in quick succession – each time a B-mode image is taken as the structures move relative to the probe, this can be used to determine the velocity of specific structures such as blood flow.

Color Doppler

- Velocity information is presented as a colored overlay on a B-mode image
- Detects direction
- Velocity – high vs. low

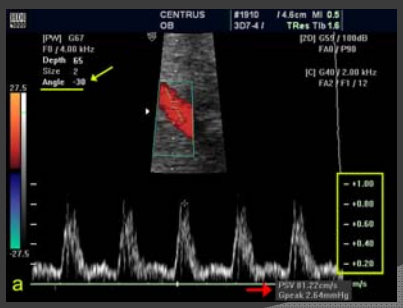
Color Doppler



Spectral Doppler

- Examines flow at one site
- Detailed analysis of distribution of flow
- Good temporal resolution – can examine flow waveform
- Allows calculations of velocity and indices

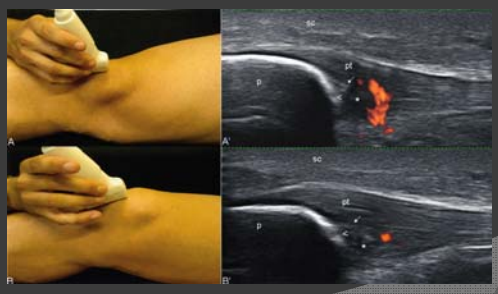
Spectral Doppler



Power Doppler

- Ideal for low flow
- Poor temporal resolution
- Susceptible to noise
- Neovascularization

Power Doppler



Echogenicity

- Echogenicity: the amplitude / brightness of the image
- Hyperechoic: more echogenic than surrounding tissue
- Hypoechoic: less echogenic than surrounding tissue
- Isoechoic: same echogenicity as surrounding tissue
- Anechoic: absence of echoes

Echogenicity

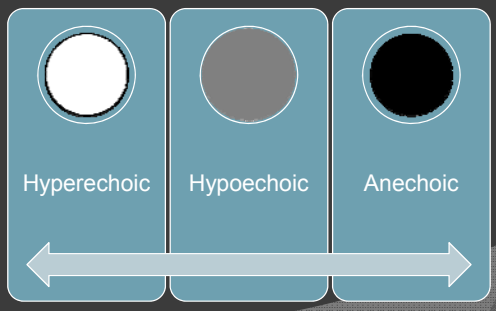


Image Balance

- Also called Optimized
- Goal: uniformity in image brightness and resolution from top to bottom

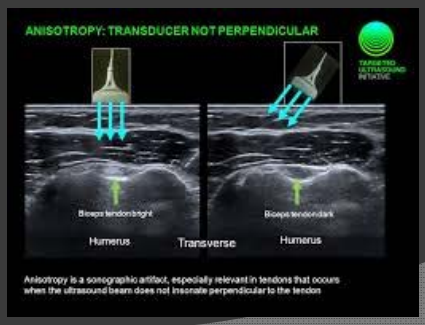
Impedance

- As sound travels through body tissue its intensity and amplitude will decrease.
- Material — Acoustic Impedance (Rayls)
  - air — 0.0004
  - fat — 1.38
  - water — 1.54
  - brain — 1.68
  - blood — 1.61
  - kidney — 1.62
  - Liver — 1.65
  - muscle — 1.70
  - lens of eye — 1.84
  - skull-bone — 7.8

Anisotropy

- Optimal image when transducer is 90 degrees from target
- Each degree from perpendicular will cause image to drop out
- Anisotropy appears black on screen
- Toggling transducer will fill in image
- Use caution with multi-planar structures

Anisotrophy



Transducer Maneuvers

- "Floating the Transducer"
- Variable compression is key
- Necessary in looking for inflammation.
- Will not obliterate small vessels, bursae and cysts

Floating

Heel - Toe

- Subtle rocking of transducer to optimize image.
- Necessary when target changes curves or changes direction to plane

WHAT IS MSK ULTRASOUND?

- MSK US high-frequency sound waves (1-17 MHz)
- Image soft tissues and bone
  - Dx pathology or guiding real-time procedures
- US machines provide exquisitely detailed images, submillimeter
- Resolution >/= MRI
- tendons, nerves, ligaments, joint capsules, muscles, bone

Advantages of MSK US

- US - hands-on and dynamic examination
- Information gained from the hx, PE, and available dx testing to define the clinical question.
- Sonopalpation
- US is generally unaffected by metallic artifacts
- No radiation to the patient or the user
- Comparative exams of the contralateral extremity

Disadvantages of MSK US

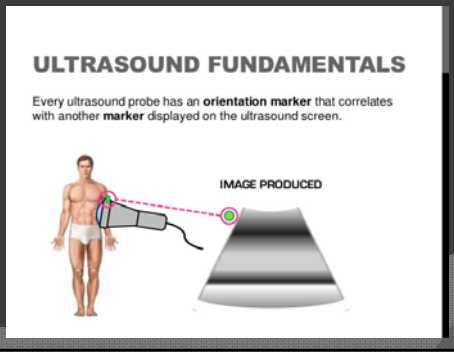
- Limited field of view
- Incomplete evaluation of bones and joints
- Limited penetration
- Operator dependent
- Lack of formal education
- Cost (?)
- Variable quality

KNOBOLOGY

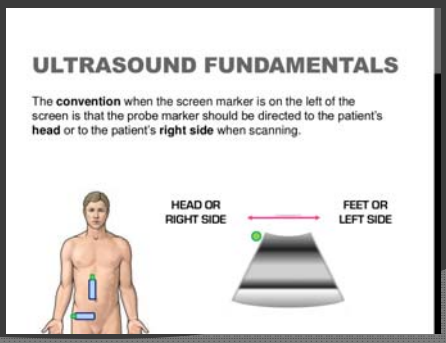
Musculoskeletal

TRANSDUCERS

Transducer Orientation



Transducer Orientation



Frequency

- Low frequency
  - Deep penetration
  - Lower resolution
- High Frequency
  - Superficial to medium penetration
  - Higher resolution
- Ultra-High Frequency
  - Very superficial penetration
  - Very high resolution

Linear

Linear

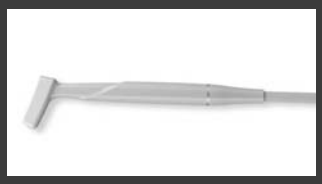
- High Frequency 7-18MHz
- Most commonly used for MSK

Curved Linear (Curvilinear)

Curvilinear

- Low frequency 1-6MHz
- Deep Penetration
- Commonly used for pelvis, abdomen, hip
- Also for spine for larger field of view

Compact Linear (Hockey Stick)

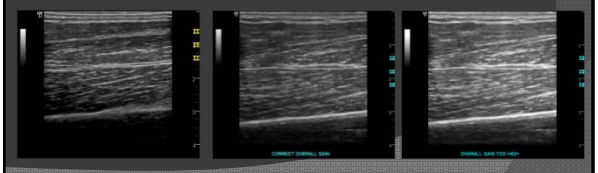


Hockey Stick

- Ultrahigh frequency 15-18MHz
- Ideal for small parts
  - Hand, foot

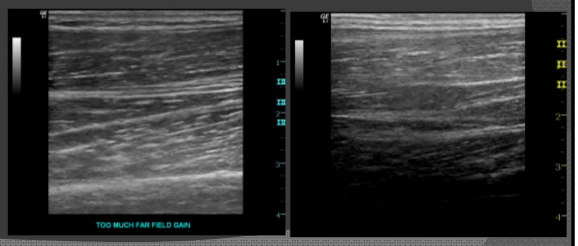
Gain

- Controls overall amplification of returning signal.
- Does not increase output power
- Think of gain control as volume control



Time Gain Compensation

- TGC : sound attenuates through tissue
- TGC is like image equalizer.

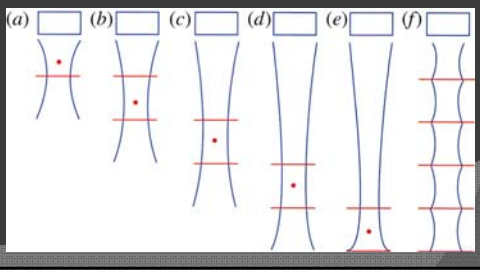


Auto

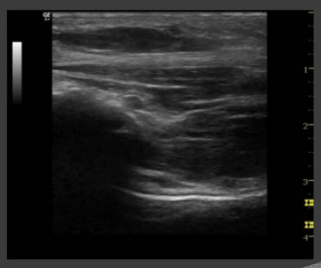
- Auto-Optimize: allows for single button optimization of B-mode and Doppler
- The Easy Button!

Focal Zone

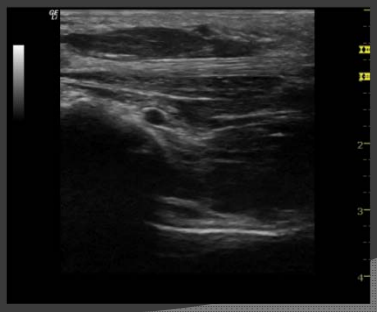
- Electronic image focus allows for energy to be directed to area of interest



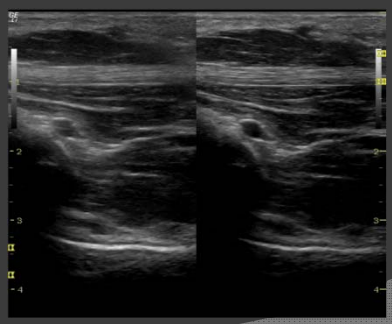
Focal Zones



Focal Zones



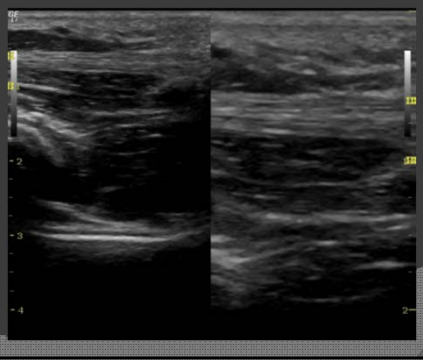
Focal Zones



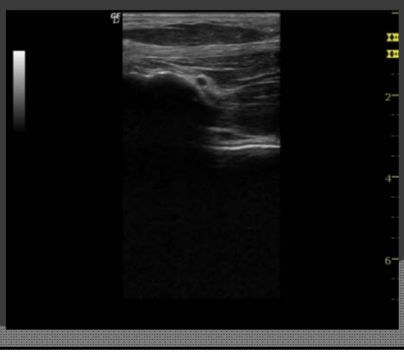
Depth

- Depth: Commonly referred to as field of view. How deep do you want to see in the image?
- Target all pertinent anatomy.
- Make image as big as possible

Depth



Depth



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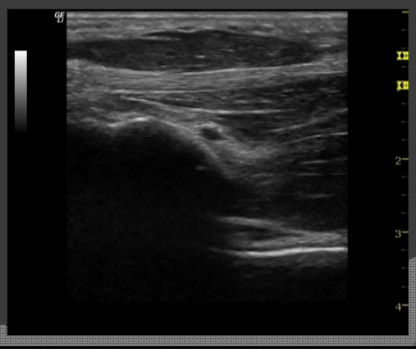

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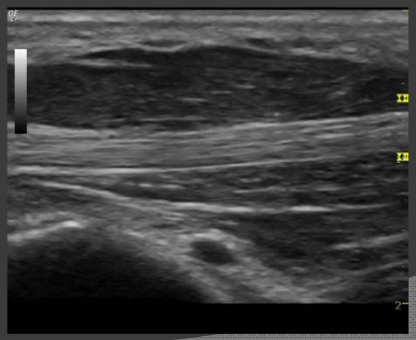

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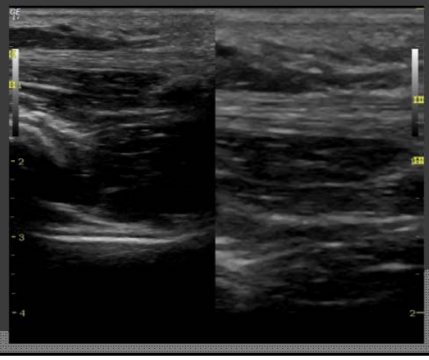


BASIC ECHO-IMAGES

Structures

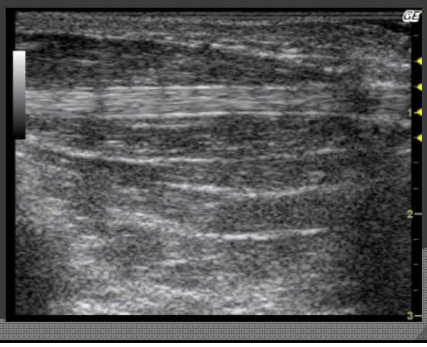
- Bone
- Tendon
- Ligament
- Muscle
- Nerve
- Cortex
- Cartilage
- Bursa
- Synovia

Axis Orientation

- Long axis
  - same plane as target
- Short/transverse axis
  - X-section
- “One image is no image”

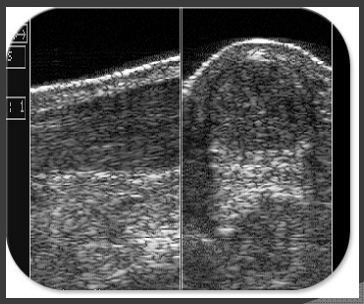
Long axis
Fibrillar appearance on long axis

Tendon



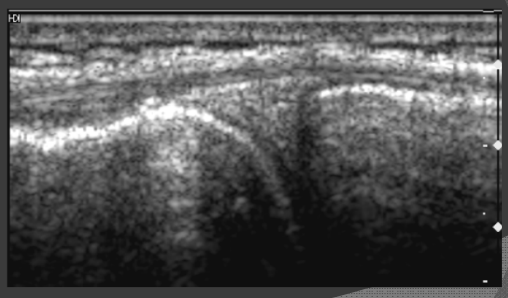
Left Fibrillar
Right Bristle

Tendon



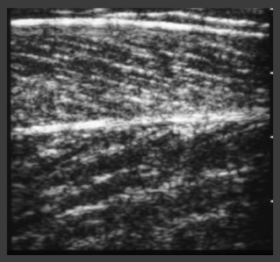
MCL

Ligament



Pennate

Muscles

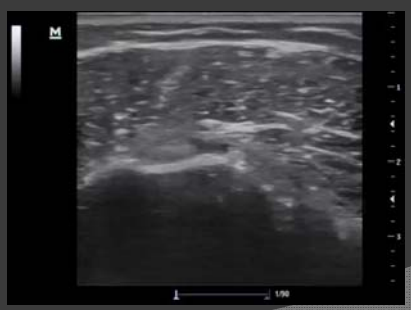


Starry Night

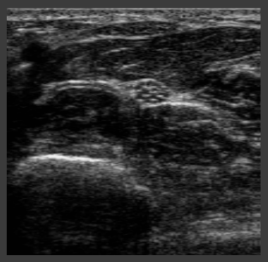
With credit to Antionio Buffard MD

Muscles

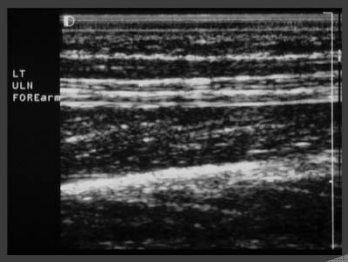
Muscle Transverse



Fascicular
Follicular
Nerves



Nerves



Cartilage & Cortex

BREAK

Douglas M. White, DPT, OCS, RMSK

MSK US FOR COMMON UPPER EXTREMITY ORTHOPAEDIC CONDITIONS

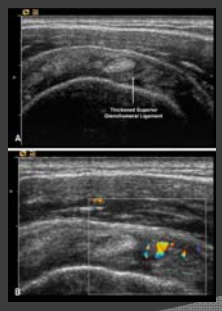
Accuracy of Ultrasound Versus MRI

Imaging Diagnosis	Accuracy (%)	
	Ultrasound	MRI
Rotator cuff tears		
• Full thickness	96	92–97
• Partial thickness	94	92
Ankle tendon tears	94	
• Peroneal tendon	90	
• Achilles tendon	92	
• Tibialis posterior tendon		96
• ATF ligament tear	100	94

AJR 2009; 193:619-627

Adhesive capsulitis: sonographic changesin the rotator cuff interval with arthroscopic correlation Skeletal Radiol (2005) 34: 522–527

Adhesive capsulitis: sonographic changes in the rotator cuff interval with arthroscopic correlation Skeletal Radiol (2005) 34: 522–527



MSK US Dx Imaging Uses

- Dx of synovial proliferation and synovitis
- Bursitis
- Bone and joint erosion
- Tendon injury
- Ligament tears
- Muscle injury (calf tear)
- Fatty Mass
- Dynamic testing

Rotator Cuff Management

- 'One-stop clinic' for the dx. & mgmt. of RC pathology: Getting the right diagnosis first time
- Mean time from GP referral to definitive management plan was 6.49 months (SD 2.74) in group 1, compared with 4.63 months (SD 1.43) in group 2 (US), overall reduction in half the number of clinic appointments

International J Clinical Pratice, Vol.62, #5, 750 - 753

Comparison of dynamic US & stress X-ray in inferior GH laxity

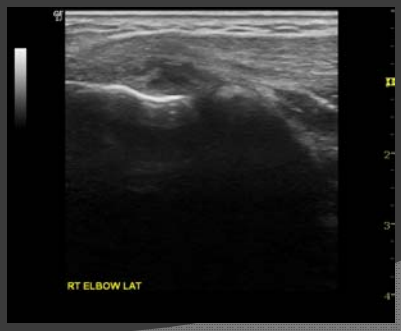
- Assessed 20 asymptomatic male subjects for inferior GH laxity
- Stress device to apply an inferior displacement force of 90 N
- Stress radiography and dynamic US
- Mean inferior translation
  - Stress radiography 4.7+/-4.1 mm
  - Dynamic US 4.4+/-2.3 mm
- Good agreement btwn 2 methods
- Dynamic US is a valid and reproducible method for assessment and quantification of inferior GH laxity

http://www.ncbi.nlm.nih.gov/pubmed/18030465

Radial Head Fx

US of the elbow Skeletal Radiol (2001) 30:605–614

Lateral Epicondyle Tear



Medial Evaluation of Elbow

- Sonography view is generally Hyperechoic

Medial Evaluation of Elbow

- UCL tear with valgus stress applied
- Look for the gaping of the joint

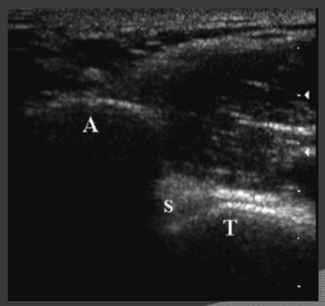
Dynamic Impingement Test

- Dynamic impingement view
  - The supraspinatus tendon and the subacromial bursa are scanned while passing beneath the acromion.

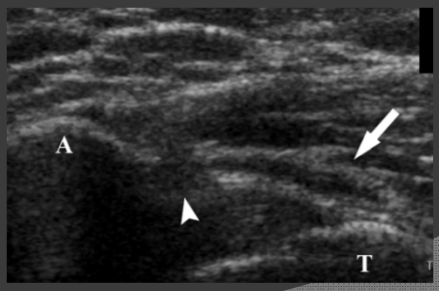
Dynamic Sonography Evaluation of Shoulder Impingement Syndrome

- Nathalie J. Bureau, Marc Beauchamp, Etienne Cardinal and Paul Brassard
- American Journal of Roentgenology 2006 187:1, 216-220

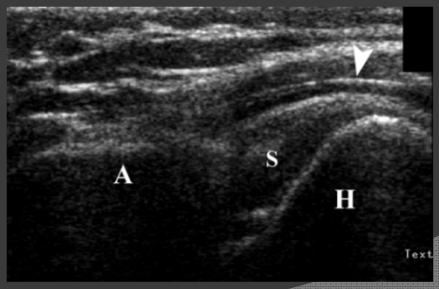
Normal



Impingement



Humeral Head Migration



Supraspinatus

MSK US OF COMMON LE CONDITIONS

Tendonopathy

- Thickened tendon with slight inhomogeneity
- Tenocyte hyperplasia, prominent neovascularization with endothelial hyperplasia,
- Loss of longitudinal collagenous architecture, and microtears with collagen fiber separation

Zanetti, Radiology May 2003

Partial Achilles Tears

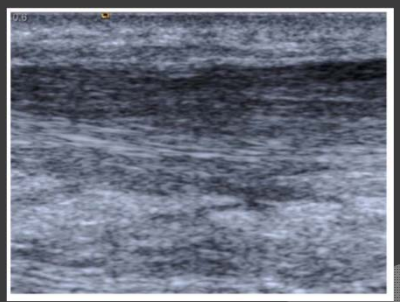
- Early dx can be difficult.
  - Clinical presentation unreliable,
  - imaging findings have been poorly described.
- Specific US changes correlated closely with macroscopic appearances from surgery.
  - irregularity of tendon structure on the posterior (skin) side of the tendon with disruption of the posterior tendon fibers.
  - Color Doppler examination revealed high blood flow within the region of tendon discontinuity.

Masci LA Journal of Biomedical Graphics and Computing, 2013, Vol. 3, No. 4
DOI: 10.5430/jbgc.v3n4p47 URL: http://dx.doi.org/10.5430/jbgc.v3n4p47

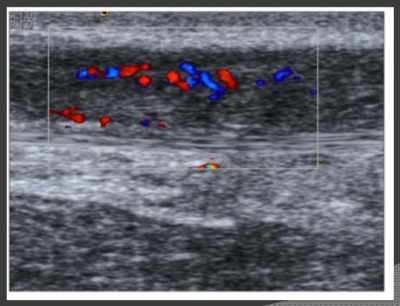
PROMISING RESULTS USING A SIMPLE REHABILITATION PROGRAM TO TREAT PARTIAL RUPTURES IN THE ACHILLES MID-PORTION

- **Previous treatments Number of subjects**
- Eccentric exercises 20
- Injections 15
- Shock wave 3
- Heel raises 2

Irregular & Disrupted Tendon.



Irregular & Disrupted Tendon High Blood Flow.



Physical Therapy

- 3-month program:
  - 0-6 weeks:
    - 2cm heel lifts
  - 7-12 weeks:
    - reduce heel lifts to 1cm
    - concentric calf raises
      - 3×15 daily

Physical Therapy

- After 3-months if pain-free
  - d/c heel lifts
  - 3×15 reps of eccentric heel drops 3 x wk
  - gradual return to previous activity.

Outcome Measures

- Pain at rest and during walking. Initially and at 3 months. (VAS)
- Patient satisfaction at 6m

Results

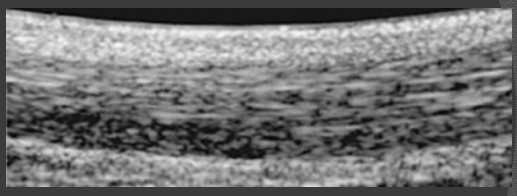
- 3 m f/u: reduced VAS at rest (p = 0.018) and walking (p= 0.014)
- Improvement in the US+DP findings in 25/26 patients
- 1 pt required surgery due to pain and no tendon healing on US+DP
- 6 m f/u 25/26 patients satisfied

Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at f/u

- US before and 3.8 y after 12 wk eccentric training
- 26 tendons with a mean age of 50 y
- All chronic pain Achilles tendinosis
- At f/u, 22 of 25 satisfied
- US tendon thickness decreased (p,0.005)
- Normal tendons, no difference in thickness
- All had structural abnormalities before treatment.
- After treatment, structure normal in 19 of 26 tendons.
- 6 of 7 patients remaining abnormalities pain

L O¨ hberg, R Lorentzon, H Alfredson
Br J Sports Med 2004;38:8–11. doi: 10.1136/bjsm.2001.000284

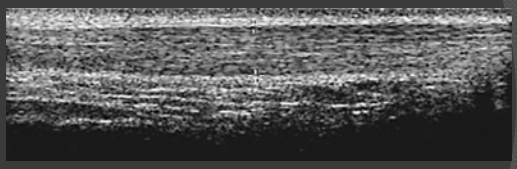
An Achilles tendon with chronic tendinosis shown by ultrasonography before treatment with eccentric calf muscle training.



Öhberg L et al. Br J Sports Med 2004;38:8-11

BJSM

Ultrasonographic image of an Achilles tendon after treatment with eccentric calf muscle training.



Öhberg L et al. Br J Sports Med 2004;38:8-11

BJSM

Sonographically Guided PT of Achilles Tendonpathy After PRP Injection

- 37 yo chronic Achilles Tendonpathy
- Series of US guided PRP injections
- Six week course of PT progression of tendon loading aided by US
- 1 year f/u pain free and US revealed normal tendon

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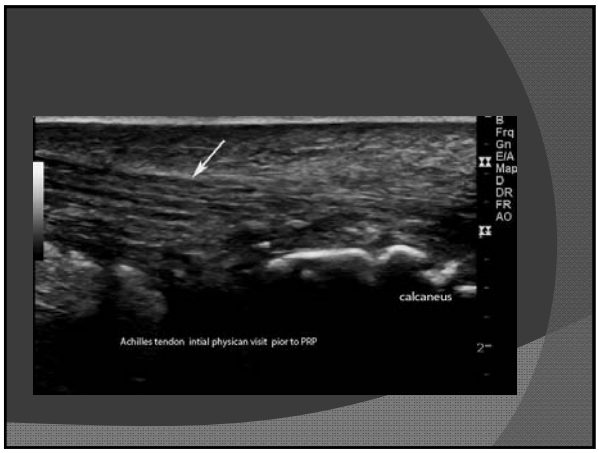
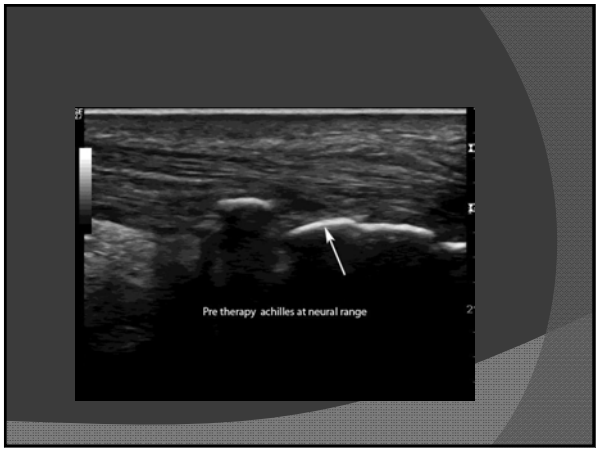
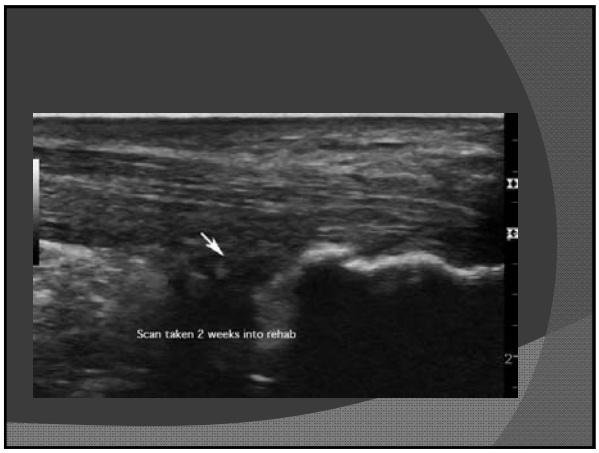
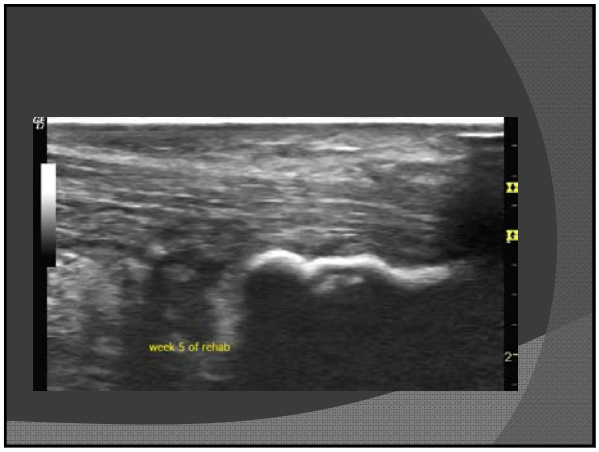
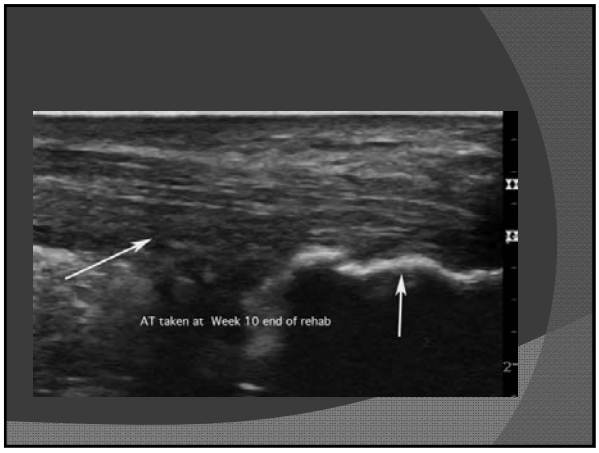

calcaneus
Achilles tendon intial physican visit pior to PRP


Pre therapy achilles at neural range

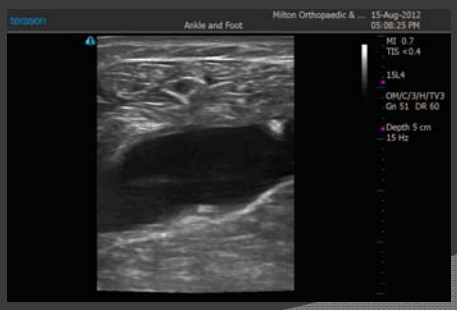

Achilles tendon with 5 degrees of passive DF


Scan taken 2 weeks into rehab


week 5 of rehab


AT taken at Week 10 end of rehab

Calf Tear


Ankle and Foot
Milton Orthopaedic & ...
15-Aug-2012
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TIS <0.4
15L4
OM/C3/H/TV3
Gn 51 DR 60
Depth 5 cm
15 Hz