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In this foundational, opening lecture in The MSK Masters Series, Dr. Moore presents the fundamentals of musculoskeletal sonography. The principles and information lay the groundwork enabling the newcomer to MSK scanning to quickly embrace the skill set to confidently perform examination protocols.

Universal Interpretation Formula: The necessity of firmly grasping normal musculoskeletal sonography is clearly presented. Efficient, reproducible imaging techniques is the basic skill that leads to confidently detecting and identifying abnormal findings on the musculoskeletal ultrasound image.

3 Steps to Successful Imaging:  
 Constructing the image from standardized bony landmarks and employing the 3 "R's", Identifying... Individual... Interfaces keeps image acquisition simple and sequential. No need to EVER feel lost about what is shown on the ultrasound image.

Principles from this lecture are carried forward throughout the The MSK Masters Series.

Visit [www.mskmasters.com](http://www.mskmasters.com) for the complete MSK Masters Series!  
 Also, 4th Revision 2015, Sonography of the Extremities now available.  
 The straight-forward, highly illustrated, step-by-step, MSK protocol manual that takes you through scan protocols like no other text. The MSK "How to" book!

"The pre-requisite to identifying pathology, is developing the skill to accurately and efficiently identify normal musculoskeletal anatomy."-REM

Randy E. Moore DC RDMS RMSK

## SONOGRAPHY OF THE EXTREMITIES

### TECHNIQUES AND PROTOCOLS

Imaging Fundamentals and Tissue Characterization

# Musculoskeletal Sonography

## Imaging Fundamentals and Systematic Scan Protocols

presented by  
**Randy E. Moore , DC, RDMS RMSK**  
 General Musculoskeletal Imaging, Inc.

No relevant financial relationships

*knobology*, a newly coined term that describes the relationship of instrument controls to their function

### Ultrasound...

#### The New *Standard of Care*

Musculoskeletal sonography has become the “standard of care” in physical medicine for diagnostic exam and guided interventions.

Ultrasound has the unique and exceptional capability to reveal the “*current physiologic state*” of the musculoskeletal anatomy.

Placing the ultrasound probe on the patient immediately displays

the entire physiologic spectrum

from active inflammation to resolved fibrosis.

*The pre-requisite to identifying pathology, and utilizing ultrasound for injection guidance, is developing the skill to accurately and efficiently identify normal musculoskeletal anatomy on ultrasound examination. REM*

**Basic Concepts for MSK “Knobology”**

**Image Optimization**

**Image Orientation**

**3 Steps to Successful Imaging**

**Normal Musculoskeletal Anatomy**

**Artifacts in MSK**

***What kind of imaging is this anyway ? ...***

*(this is all the ultrasound physics I cover...don't worry. ☺)*

**Real-Time** → A series of frames or pictures displayed in rapid sequence

**Pulse – Echo** → Sound pulses produced with time interval between to receive an echo

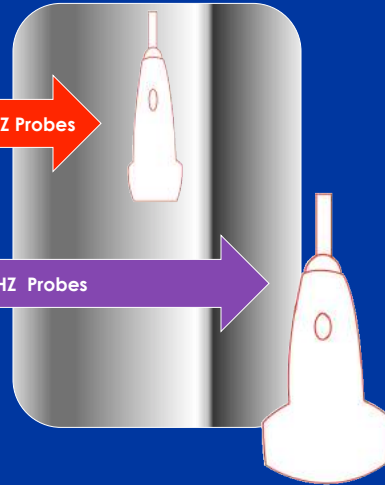
**B – Mode** → “Brightness “ Mode  
Proportional to amplitude of ... returning echo

## Which Probe ?? !

High Frequency  
For Superficial  
Structures



Low Frequency  
For  
Deeper Structures



## Image Optimization

**First !...**

Select the appropriate PRESET  
Pre-programmed settings established to adjust the  
more intricate grayscale parameters of the image.

Relieves you of the burden of becoming  
a sonographer .

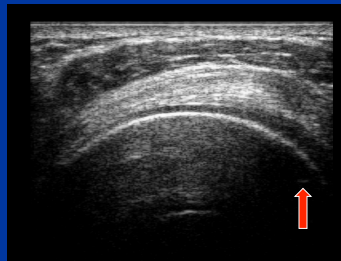


## Image Optimization

"There's so many buttons" !

Accurate and reproducible image production begins with initially visualizing the acoustic bony landmarks.

All navigation to... and identification of... anatomy starts with the bright...hyperechoic cortical bone.

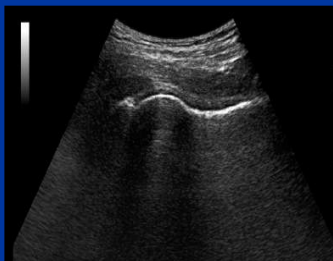
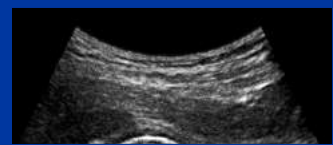


## Image Optimization

What to do if the bony landmarks are not seen

### 1. Increase the depth setting.

Typically occurs with larger patients or deep structures.

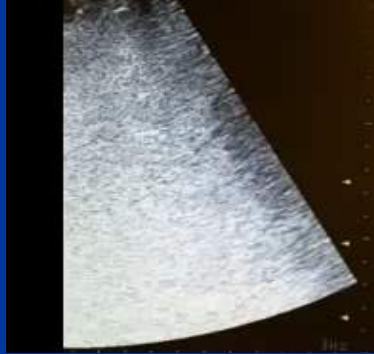


## Image Optimization

Stay focused...

### 2. Move focal points to area of interest .

This will be area of highest resolution.

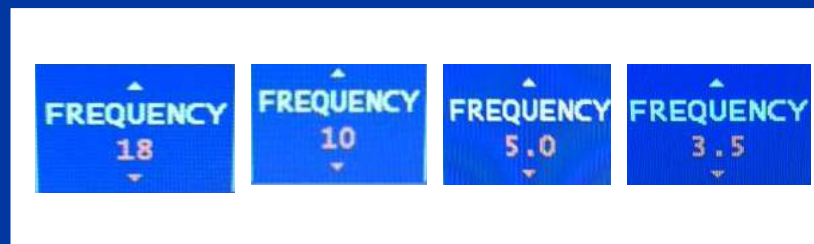


## Image Optimization

Don't Freq-out! ...

### 3. Decrease Probe Frequency

Increased penetration...BUT...diminished resolution



## Image Optimization

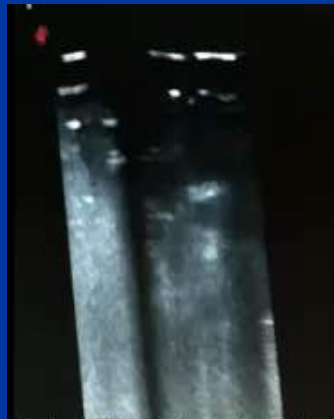
1. Increase the depth setting: Bony landmark 1<sup>st</sup> !
- 2 . Focal points at area of interest: Highest Rez
3. Decrease Probe Frequency: Increase penetration

### Image Optimization

#### Additional settings to consider.

TGC' s aka...Depth Sensitive Controls

Increase or decrease brightness at specific depth



**Image Optimization  
Additional settings to consider.**

**Overall Gain Control**

Increase or decrease brightness at all depths simultaneously

**Make only minor changes**



**3 Steps to Successful Imaging  
The Solution...**

**A SYSTEMATIC... STANDARDIZED  
approach .**

All newcomers to this imaging modality have the universal concern of how long it will take to become proficient ,and how to read the images !



# 3 Steps to Successful Imaging

## 1. Image GENERATION

\* Patient & Probe Position, Grayscale settings

## 2. Image RECOGNITION

\* **I**dentify ... **I**ndividual ... **I**nterfaces

From the bony cortex UP !

## 3. Image INTERPRETATION

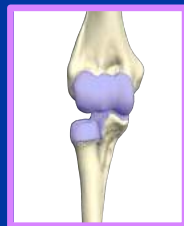
\*determine abnormal findings by knowing normal !

**TIP !!! ...It is NOT your job to find pathology !**  
**Follow scan protocol. Endeavor to produce normal image**

## A Universal Interpretation Algorithm Interface Identification



Hyper-echoic  
**BONE**



Anechoic  
**CARTILAGE**



Hypo-echoic  
**SYNOVIUM**



Hypo-echoic  
**CAPSULE**

*\*Normal synovium does not produce substantial echoes.\**

# Image Orientation

## Keeping It Straight

*Proximal or Distal ?*

*Medial or Lateral ?*

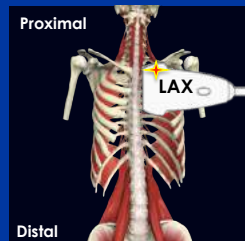


# Image Orientation

Probe placement relative to AXIAL spine

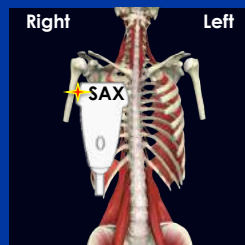
## Long Axis/Longitudinal Views

Left side of the image is **CEPHALAD**



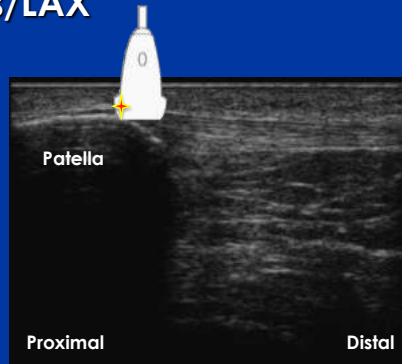
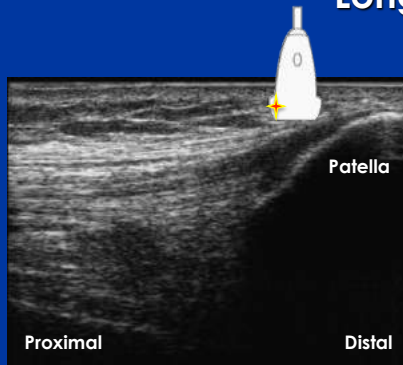
## Short Axis/Transverse Views

Left side of the image is **PATIENT RIGHT**



Note: Use bony landmarks !

## Image Orientation Long Axis/LAX



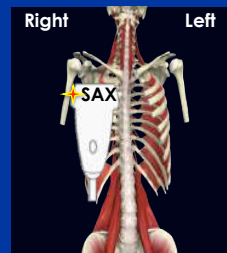
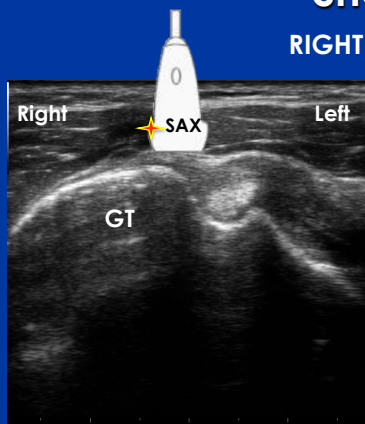
LONGITUDINAL Supra-patellar



LONGITUDINAL Infra-Patellar

## Image Orientation Short Axis/SAX

### RIGHT SHOULDER SHORT AXIS



## **Image Orientation**

**“One View... Is No View”**

**Accepted protocol is to obtain both long  
and short axis views of most all  
musculoskeletal structures...**

**To completely visualize the anatomy  
in multiple planes.**

## **Normal Sonographic Appearance**

**Bony Cortex  
Hyaline Cartilage  
Skeletal Muscle  
Ligaments  
Tendons  
Peripheral Nerves  
Bursae  
Fibro Cartilage**

## Sonographic “Signature”

GRAYSCALE IMAGING

All musculoskeletal anatomy has a normal Grayscale appearance on ultrasound.

A “starting point” on a linear scale.



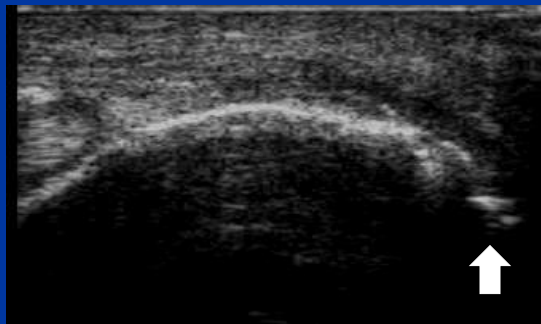
## Normal Sonographic Appearance

### Bony Cortex

Latin = external rind or bark

Highly echogenic/bright

Smooth and Intact

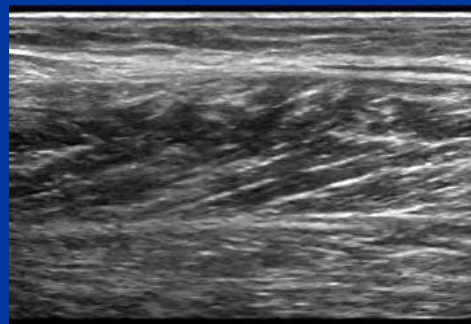


## Normal Sonographic Appearance Hyaline Cartilage



Homogenous, *anechoic* layer covering the bone surface.  
Smooth, *variable thickness* dependent on location  
Cortex is deep to the hyaline cartilage

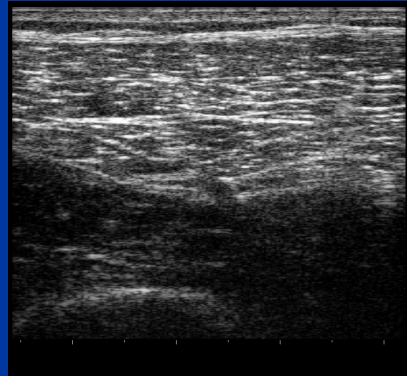
## Normal Sonographic Appearance Skeletal Muscle : Long Axis “ UNIFORM Bands and Bundles ”



LAX Gastrocnemius Muscle

Muscle *septa* are bright linear bands  
surrounding darker/hypoechoic muscle *bundles*

## Normal Sonographic Appearance Skeletal Muscle : Short Axis

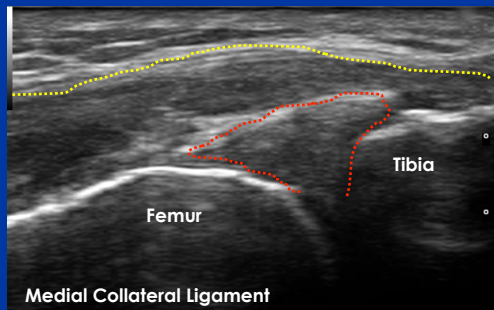


SAX Quadriceps Muscle

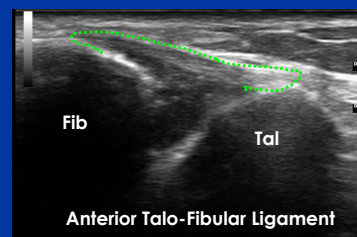
Muscle appears “speckled” echoes with bright curvilinear lines.

## Normal Sonographic Appearance Ligaments : Long Axis

Attach Bone to Bone



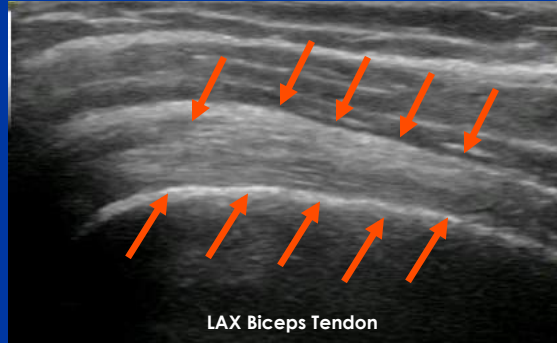
Medial Collateral Ligament



Anterior Talo-Fibular Ligament

Less collagen gives ligaments *inconsistent brightness*  
Use bony landmarks, and a hypoechoic  
echogenicity of ligament vs. tendon

## Normal Sonographic Appearance Tendons : Long Axis



Parallel fibers are brighter than ligaments...  
due to collagen density. A consistent, bright appearance  
\*Hyperechoic...Fibrous...Echotexture

Tendons attach muscle to bone.

## Normal Sonographic Appearance The Tendon “Footprint”

Two visual criteria for normal tendon attachment

1. *Conformity*

2. *Uniformity*



As the tendon tapers to a bony attachment. Collagen in Sharpey's  
fibers mineralize, and penetrate into bone at a  
perpendicular angle to the ultrasound beam.

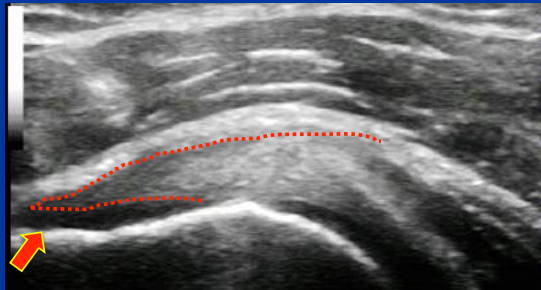


Normal Sonographic Appearance

The Tendon “Footprint”

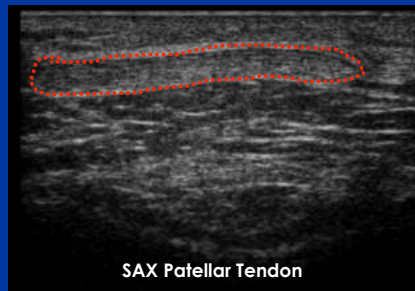
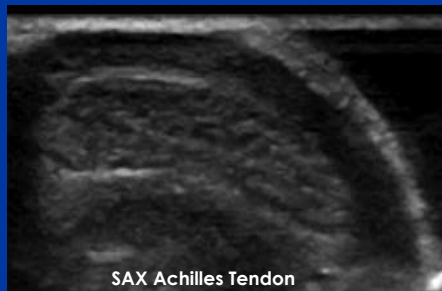
Two visual criteria for normal tendon attachment

1. *Conformity of the tendon to the bone*
2. *Uniformity of the linear anechoic footprint*



Normal Sonographic Appearance

Tendons : Short Axis

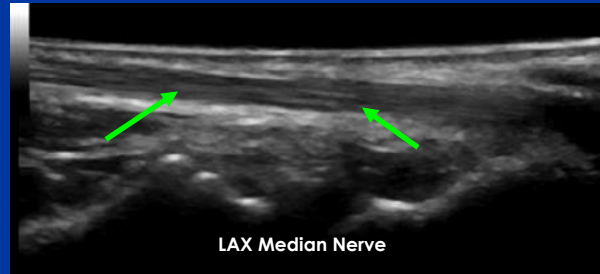


WELL-DEFINED, hyper-echoic, with a dense pattern  
A “bristle-like” appearance



## Normal Sonographic Appearance

### Peripheral Nerve : Long Axis

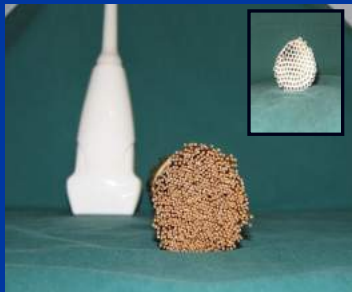


Less bright/echogenic than tendons  
Parallel hyper-echoic lines with dark separations  
Often adjacent to anechoic vascular bundle

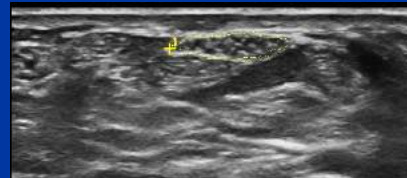
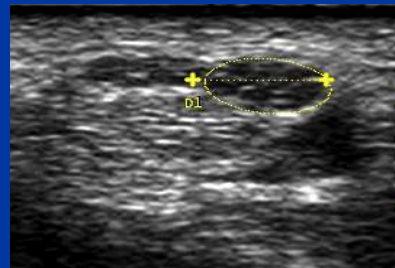
*“Railroad track” ...or “collection of rods”*

## Normal Sonographic Appearance

### Peripheral Nerve : Short Axis



Individual fibers present  
multiple, punctate foci .  
“Starry Night” or  
“Honeycomb”  
appearance



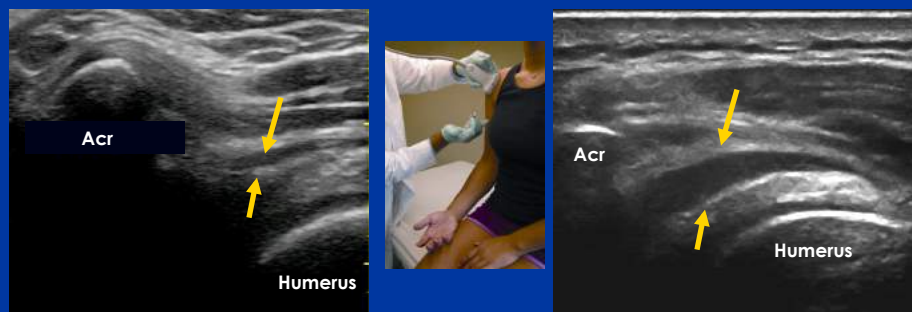
## Normal Sonographic Appearance

### *Bursae*

1. A **"POTENTIAL SPACE"**, normally not visible  
(With the exception of the Suprapatellar bursa)
2. Anechoic/black line, less than 2mm thick
3. Surrounded by hyper-echoic peribursal fat
4. If the bursa communicates with the joint, it is compressible, and fluid is forced into the joint.

## Normal Sonographic Appearance

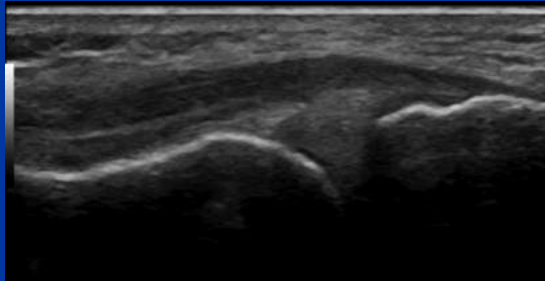
### *Bursae*



A black or anechoic (without echoes) interface measuring less than 2mm is considered "within normal limits"

## Normal Sonographic Appearance

### Fibro cartilage



Triangular in appearance.  
Homogenous (no anechoic areas)

TMJ  
Shoulder  
AC Joint  
Hip  
Knee  
TFCC Wrist

## Artifacts in MSK

### Anisotropy (An/Iso/Tropy)

**An** = Without

**Iso** = Equal

**Tropy** = Properties

To **NOT** have equal properties...characteristics... or  
appearances on...

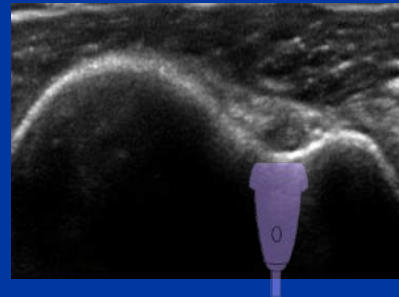
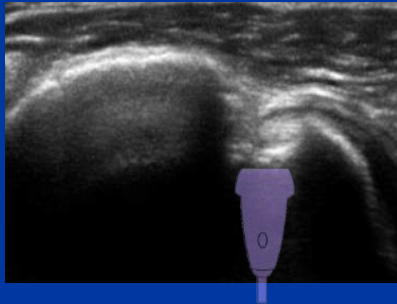
**ALL** axes or orientations

## Anisotropy is..

The property of being *directionally dependent*  
Produced when the probe angle is NOT perpendicular  
with the structure being evaluated

Incorrect "angle of insonation"

Primarily seen when scanning tendons, and  
most common artifact in MSK ultrasound



## Artifacts in MSK

### Anisotropy is..

- The property of being directionally dependent  
All depends on "how you look at it"



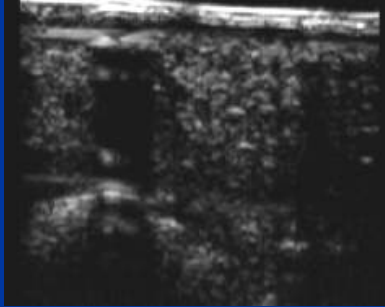
What do you see ?

A Frog ?... Or A Horse ? ?

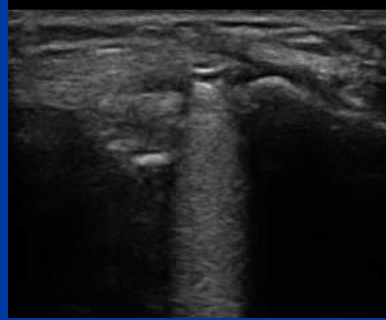
Tip: Use only enough  
"toggle" and "heel-toe"  
probe movement to  
minimize artifact  
WITHOUT LOSING BONY  
LANDMARKS !

## Artifacts in MSK

### Acoustic Shadowing



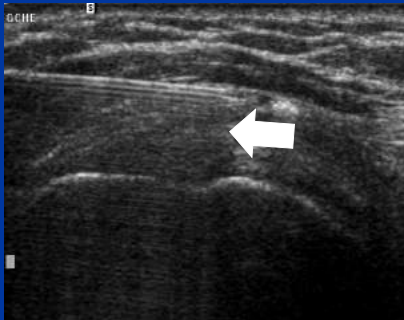
Foreign Body Localization  
Posterior Shadowing



Surgical Hardware  
"Comet tail"

## Artifacts in MSK

### Reverberation

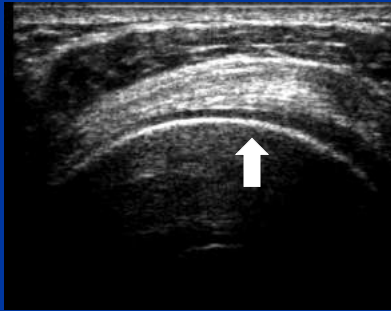


White Arrow = Multiple, equally spaced,  
linear echoes deep to needle

## Building The Image

**ALWAYS ... ALWAYS !**

Build the image from the bony cortex to the surface



## Thank You !

*Ancora Imparo...*

*I' m still learning...*



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