Orthopedic Radiology

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Diagnostic Imaging Modalities

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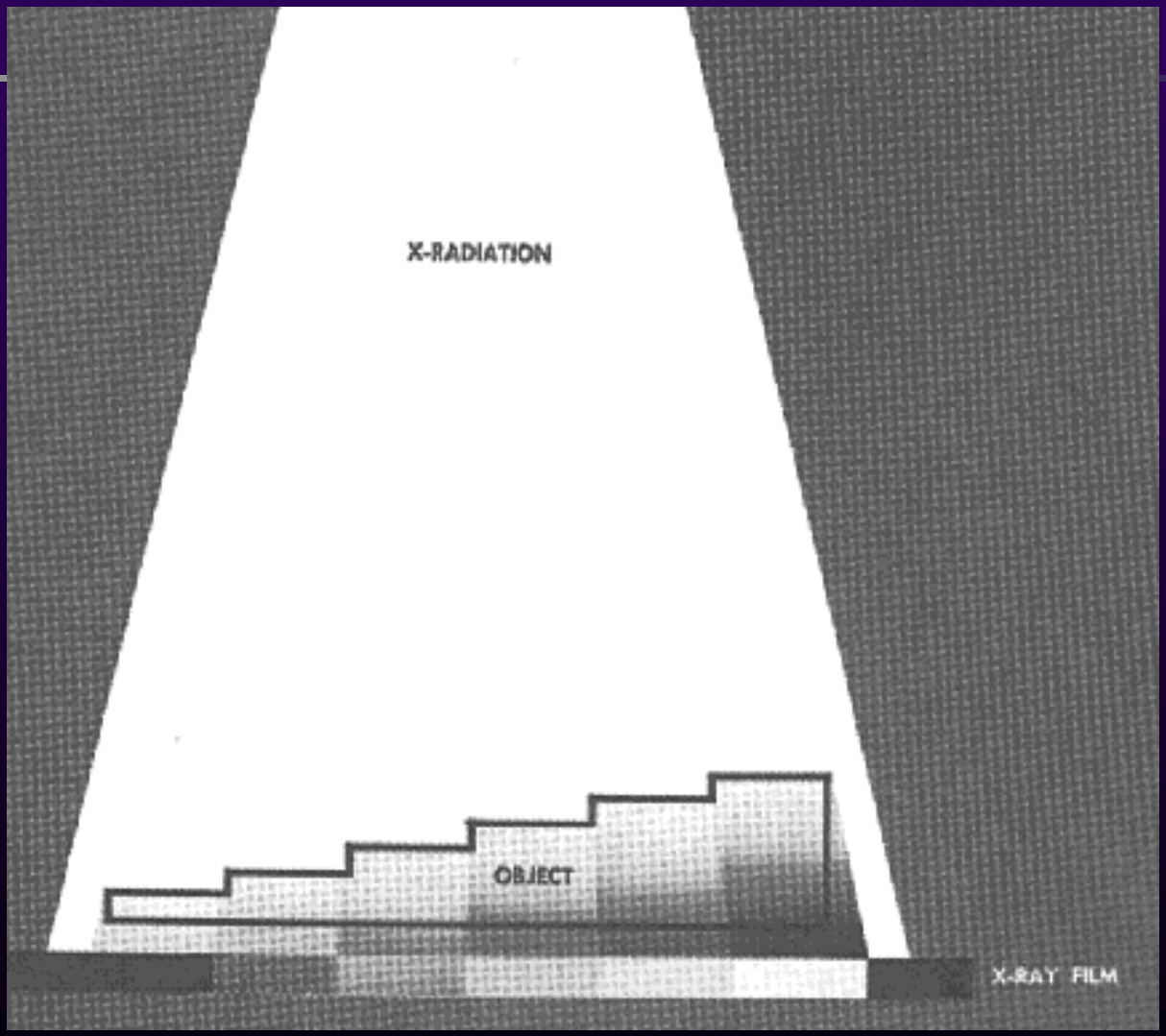
Plain film radiography

- Utilizes ionizing radiation to penetrate organic matter
  - Xrays are simply EM radiation of higher intensity/energy than visible light (Shorter wavelength, higher frequency)
  - Casts shadow of dense structures on a film

Plain film radiography



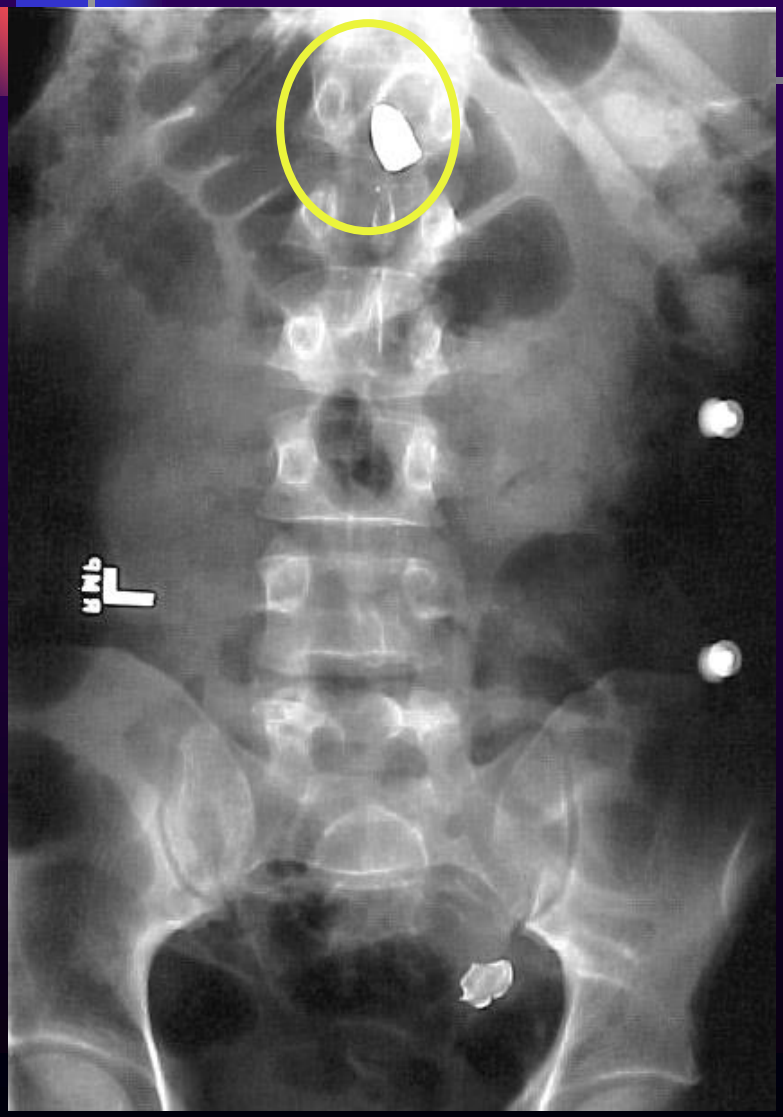
Plain film radiography

- **Recognizes only 5 densities:**
  - **Air (Gas)**
  - **Fat**
  - **Water**
  - **Bone (Calcium)**
  - **Metallic**

Plain film radiography

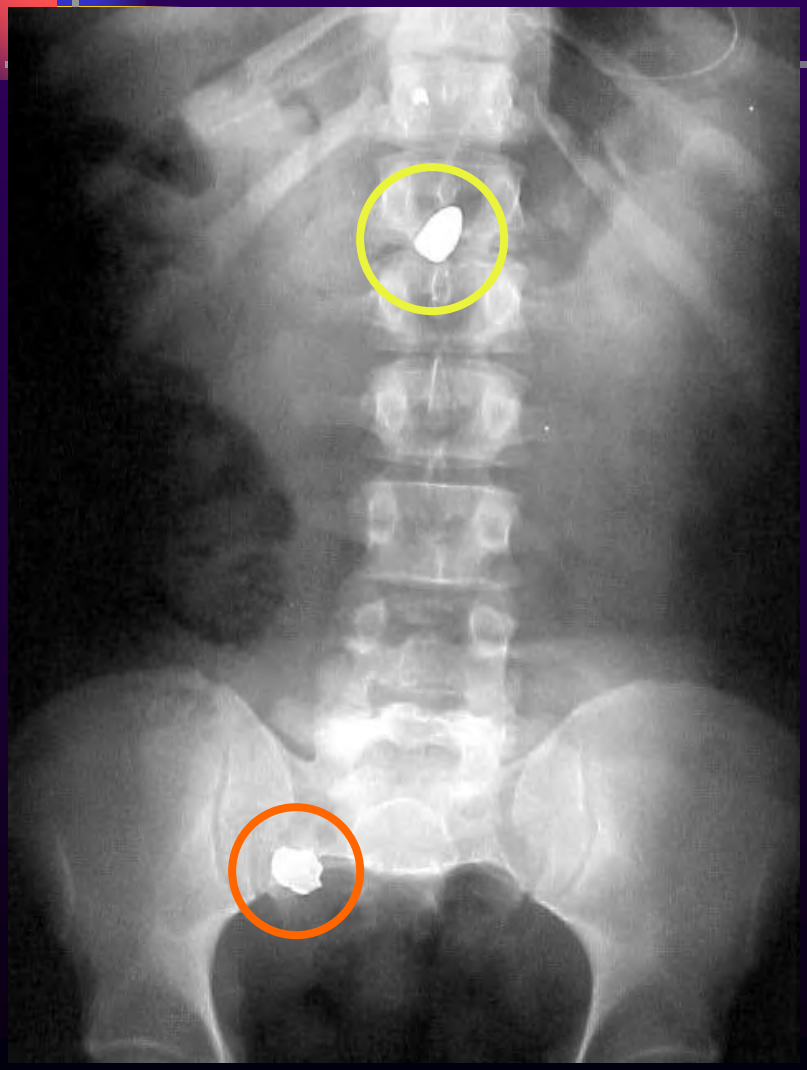
- Need mixture of all 4 physiologic densities to get diagnostic film.
  - Metallic density degrades image (in most cases)
- Need minimum of 2 views at 90 degrees to each other for localization of structures.

Plain film radiography



Patient 1

Plain film radiography

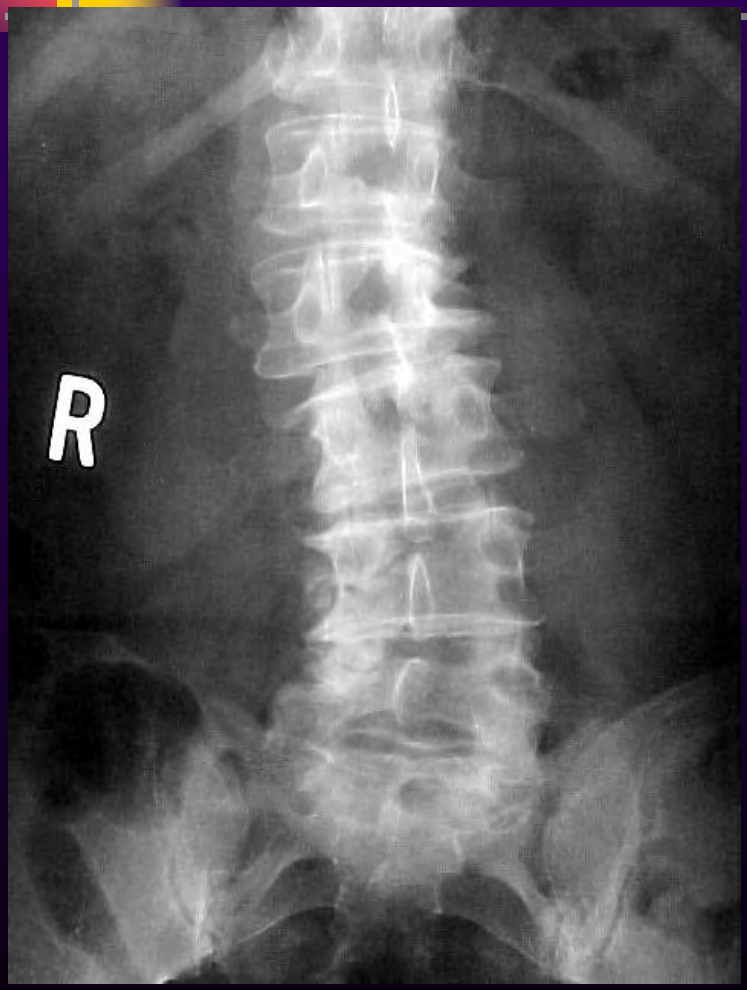


Patient 1

Plain film radiography

Patient 2

Plain film radiography



Patient 3

Plain film radiography

Patient 4

Plain film radiography

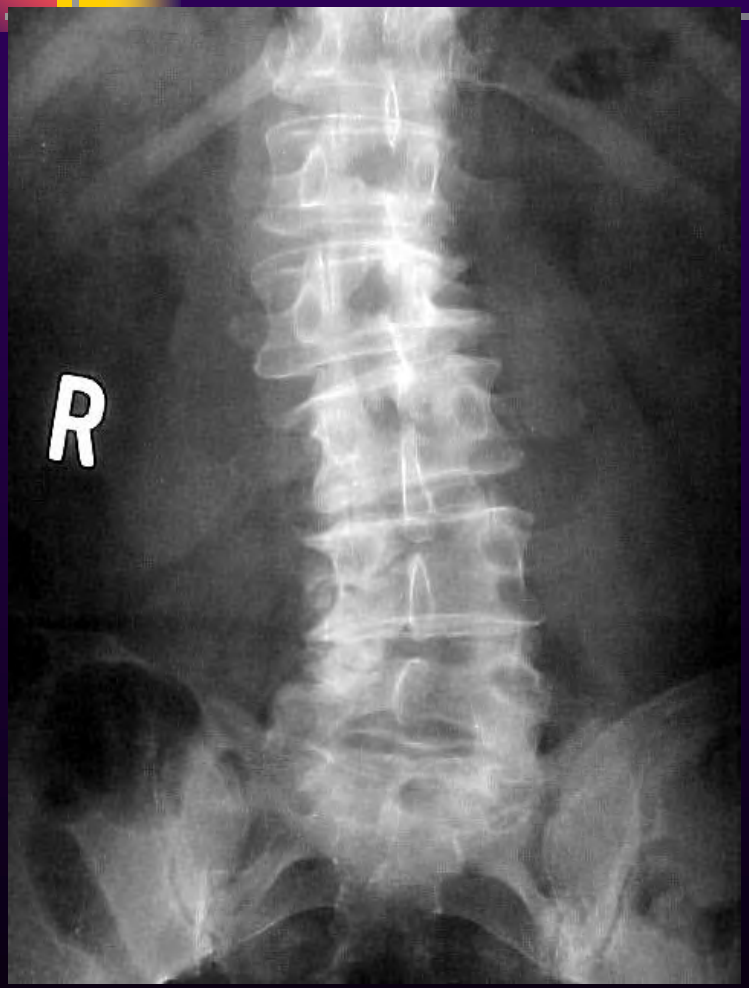
- Advantages:
  - Availability
  - Quick imaging
  - Relatively inexpensive
  - Good screening tool
- Disadvantages:
  - Ionizing radiation
  - Insensitivity
  - Shows only structure
  - Poor tissue differentiation

Contrast radiography

- Metallic density degrades images
  - In most cases
  - Contrast material (barium or iodine based) often used to opacify tubular structures for visualization

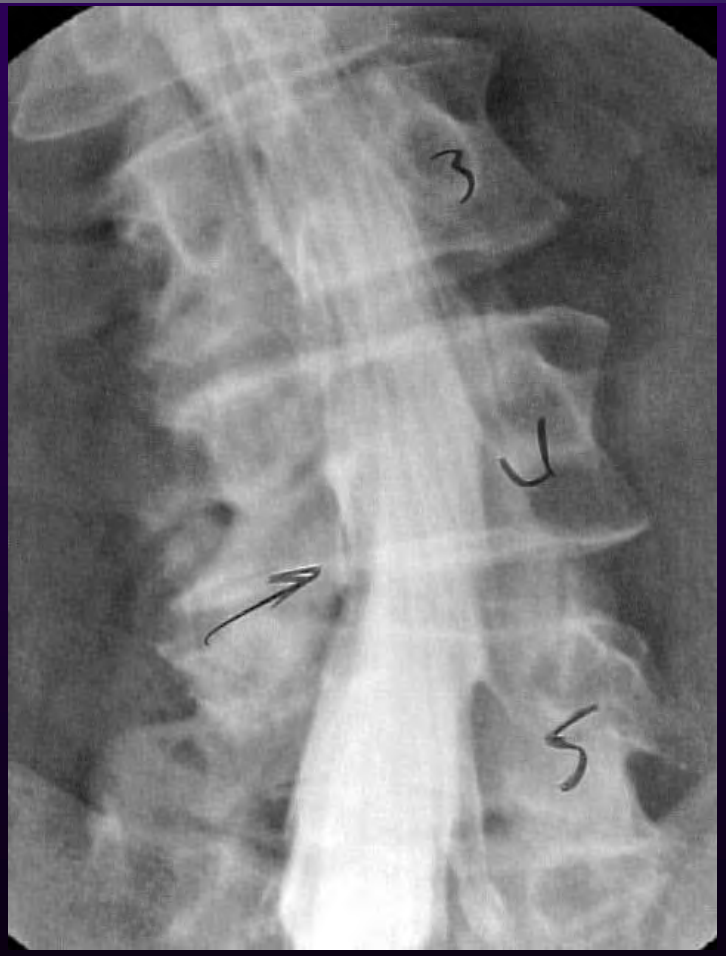
Contrast radiography

Patient #3



Patient 3

Contrast radiography

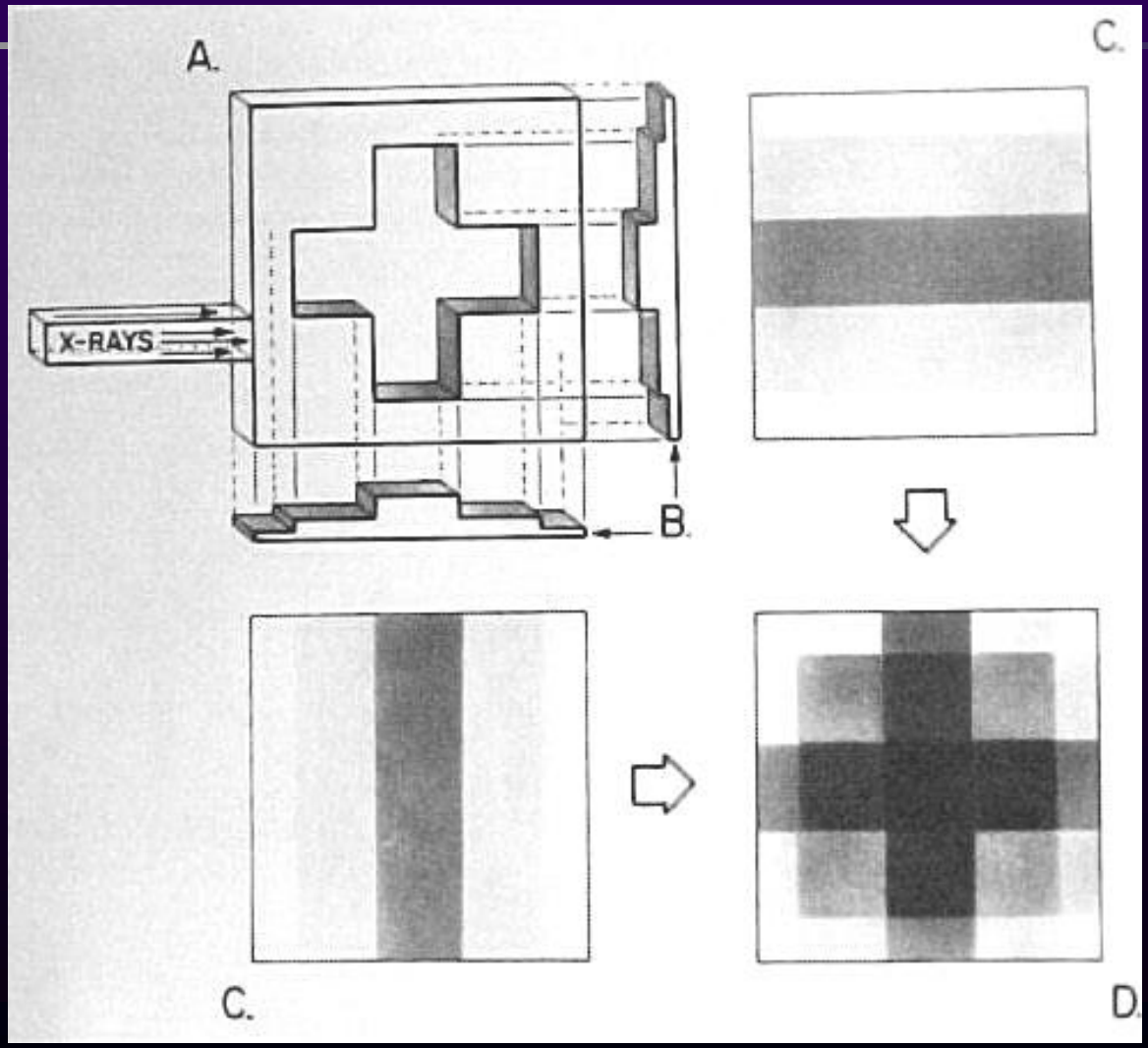


Patient 3

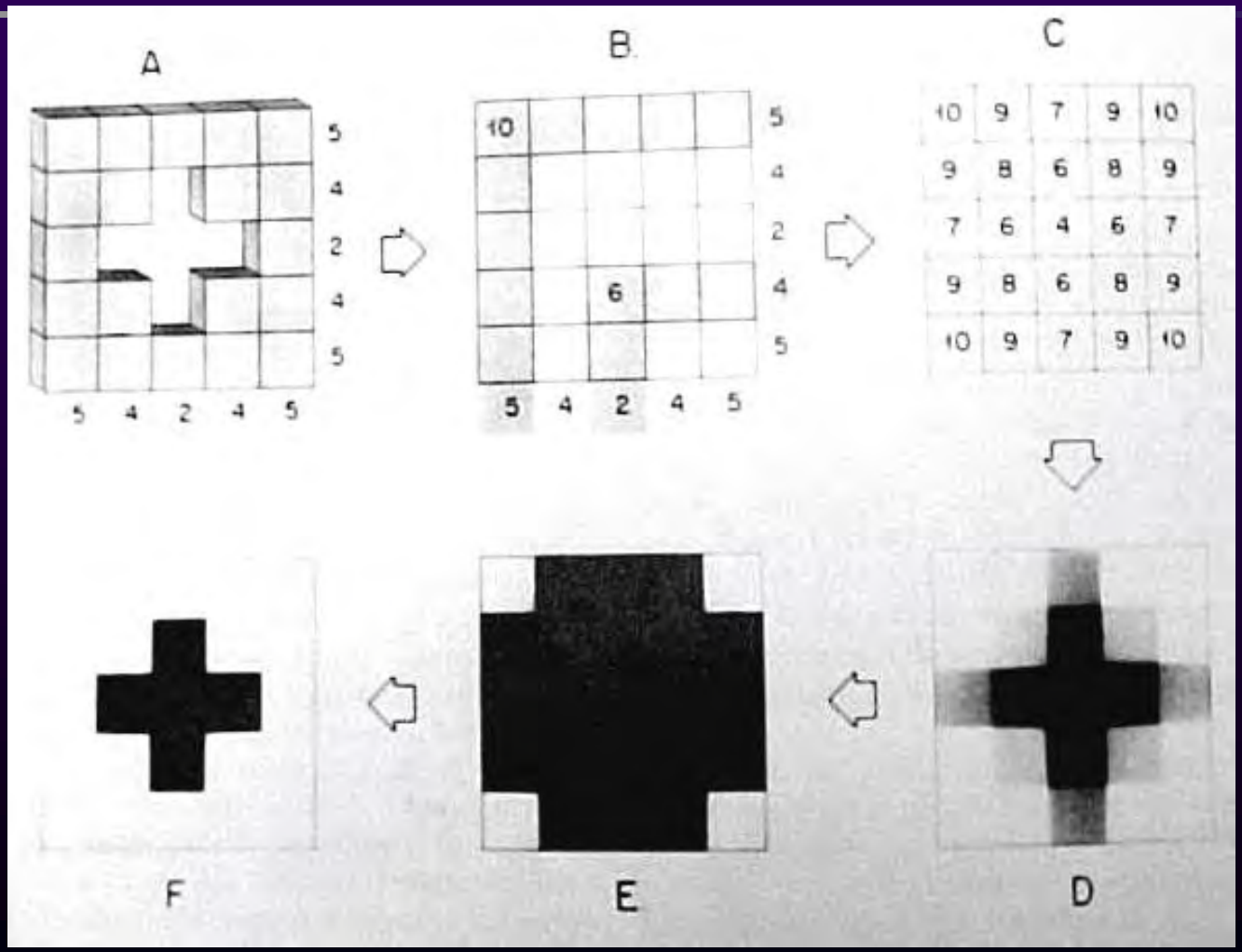
Computed Tomography

- Utilizes xray beam (ionizing radiation)
  - Encircles patient with xray beam and radiation detectors measure attenuation of beam.
  - Gives cross sectional images of the region of interest

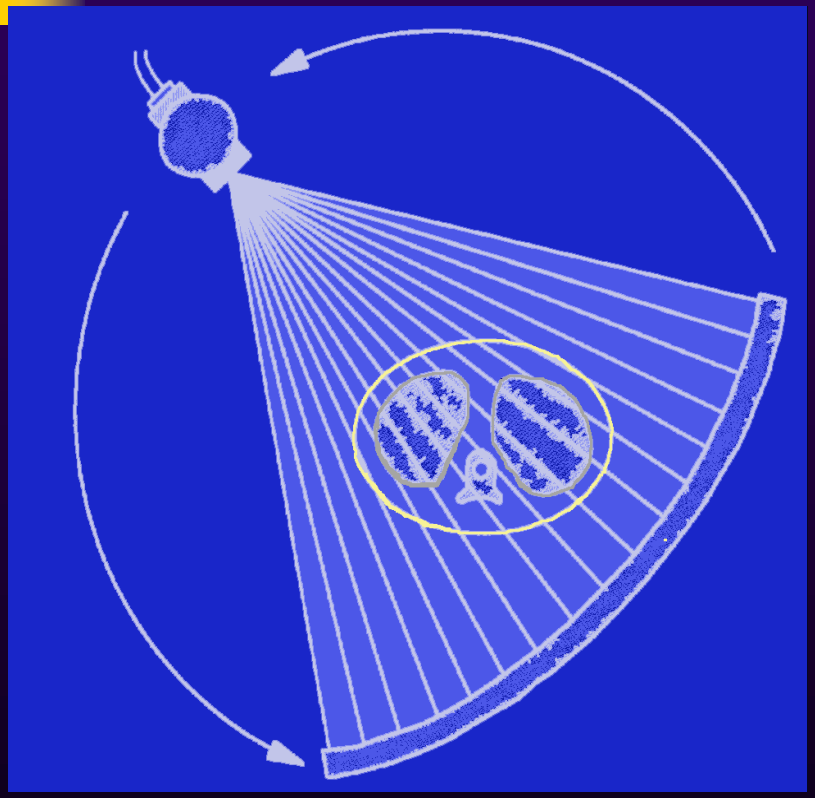
Computed Tomography



Computed Tomography

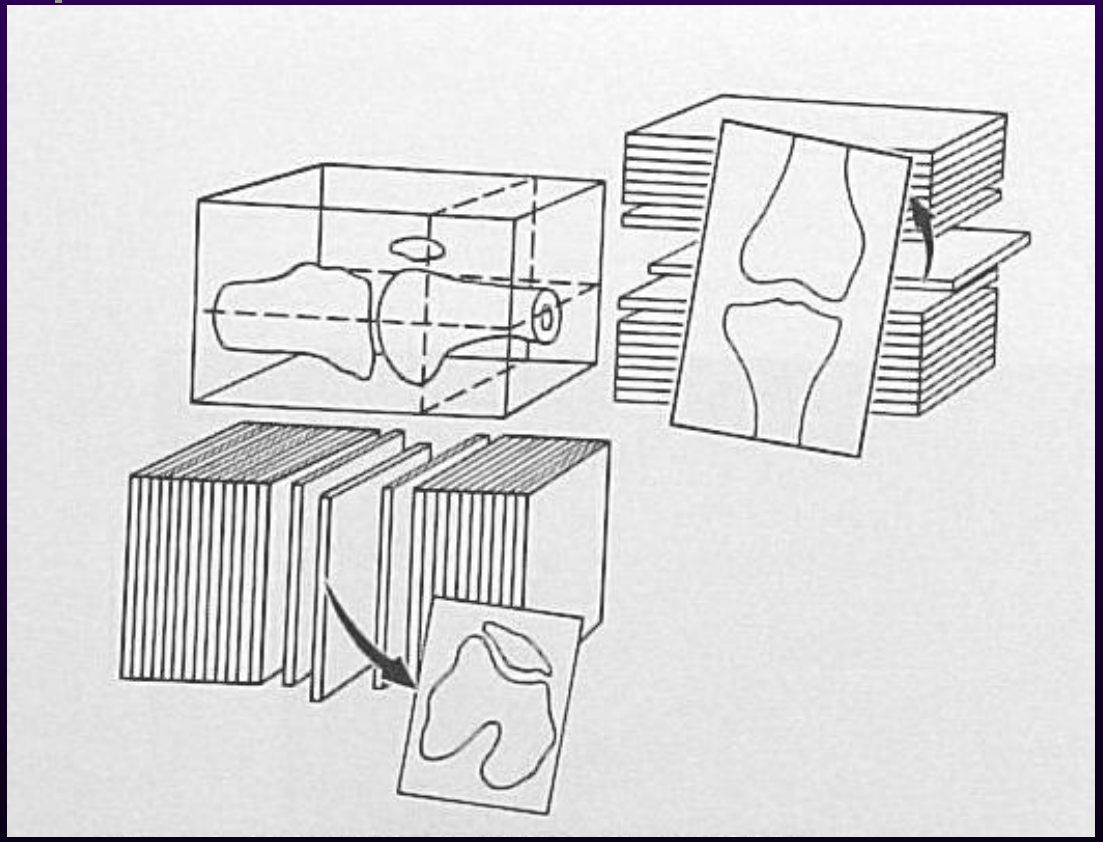


Computed Tomography



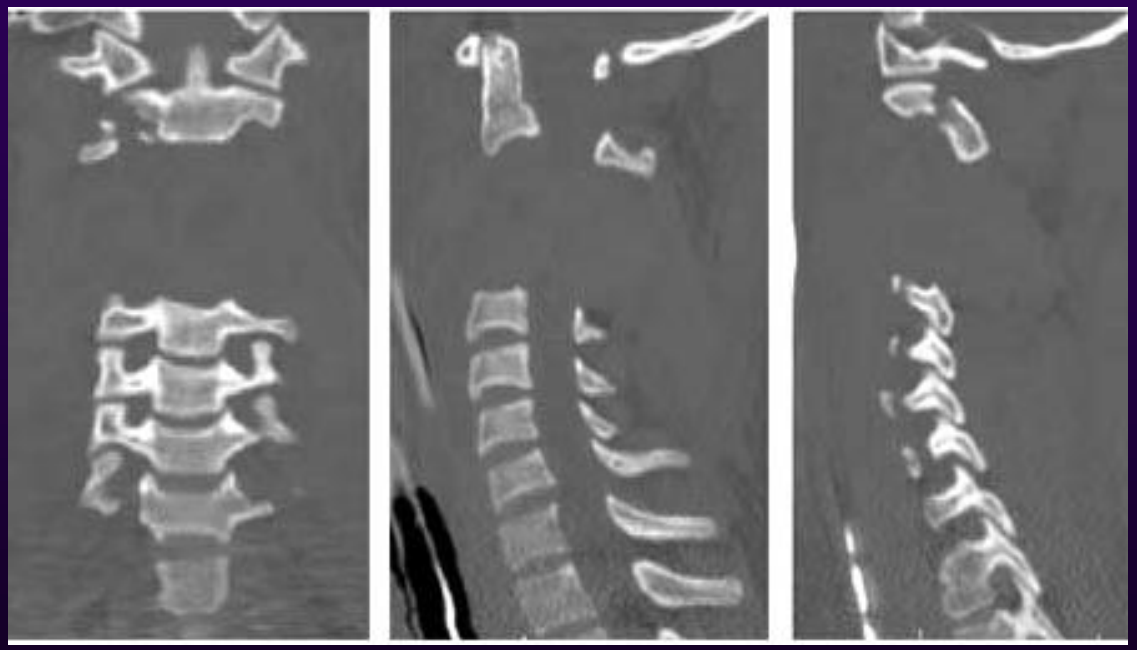
- All images are digital and stored in computer
- This digital information can be manipulated later to enhance certain tissues
- Creates bone and soft tissue “windows”

Computed Tomography



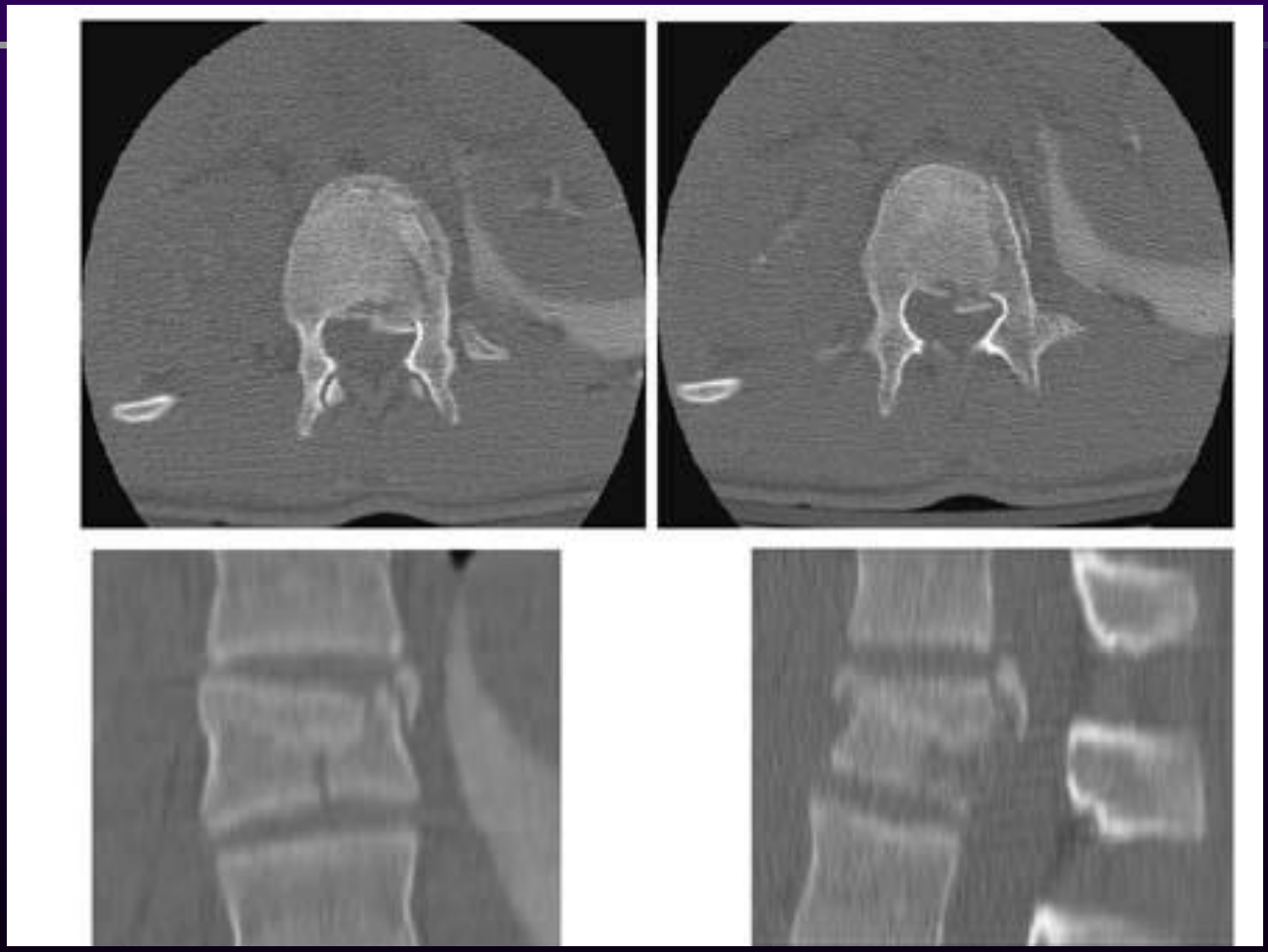
- Image reconstruction
- Digital grids can be reconstructed in many planes

Computed Tomography



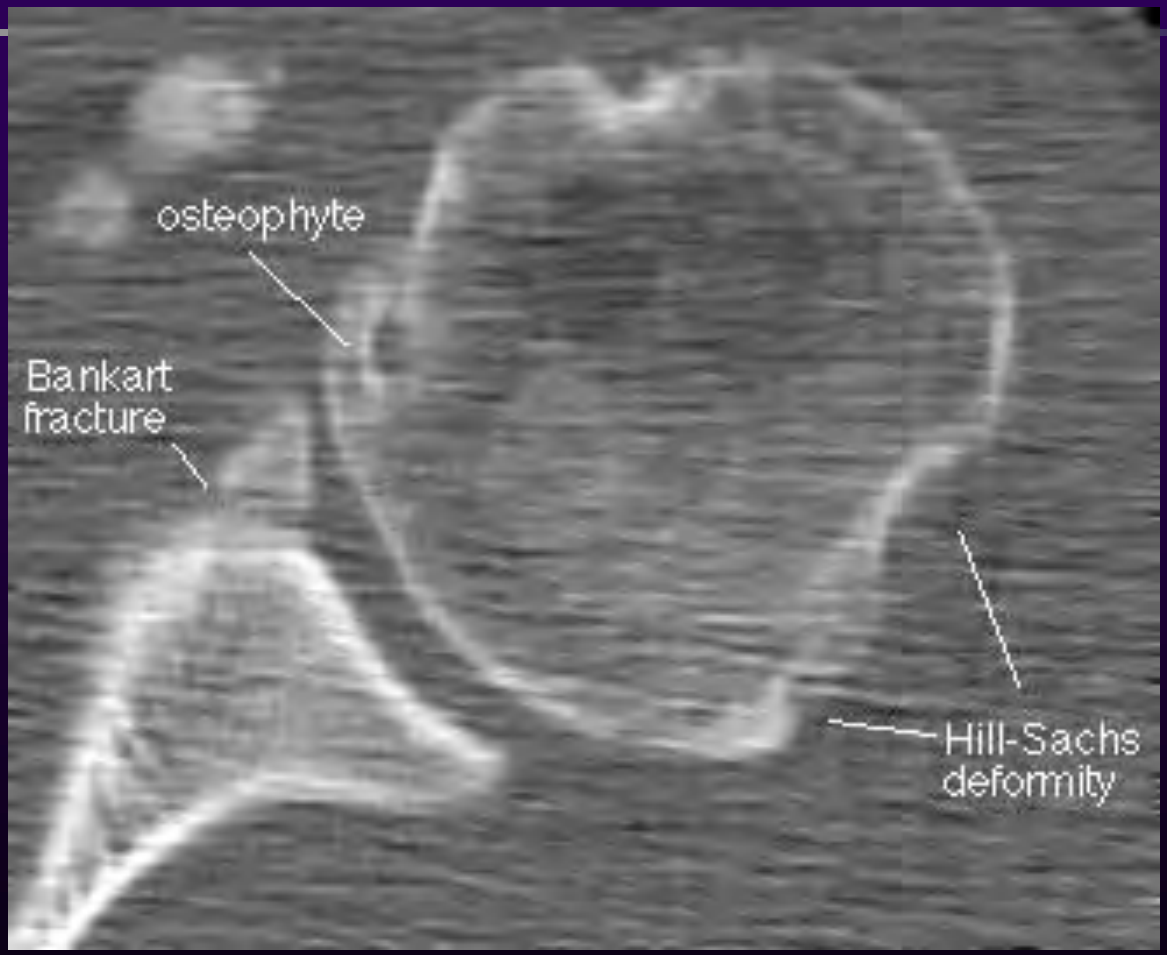
- Imaging reconstruction via computer reformatting can produce images in multiple planes

Computed Tomography



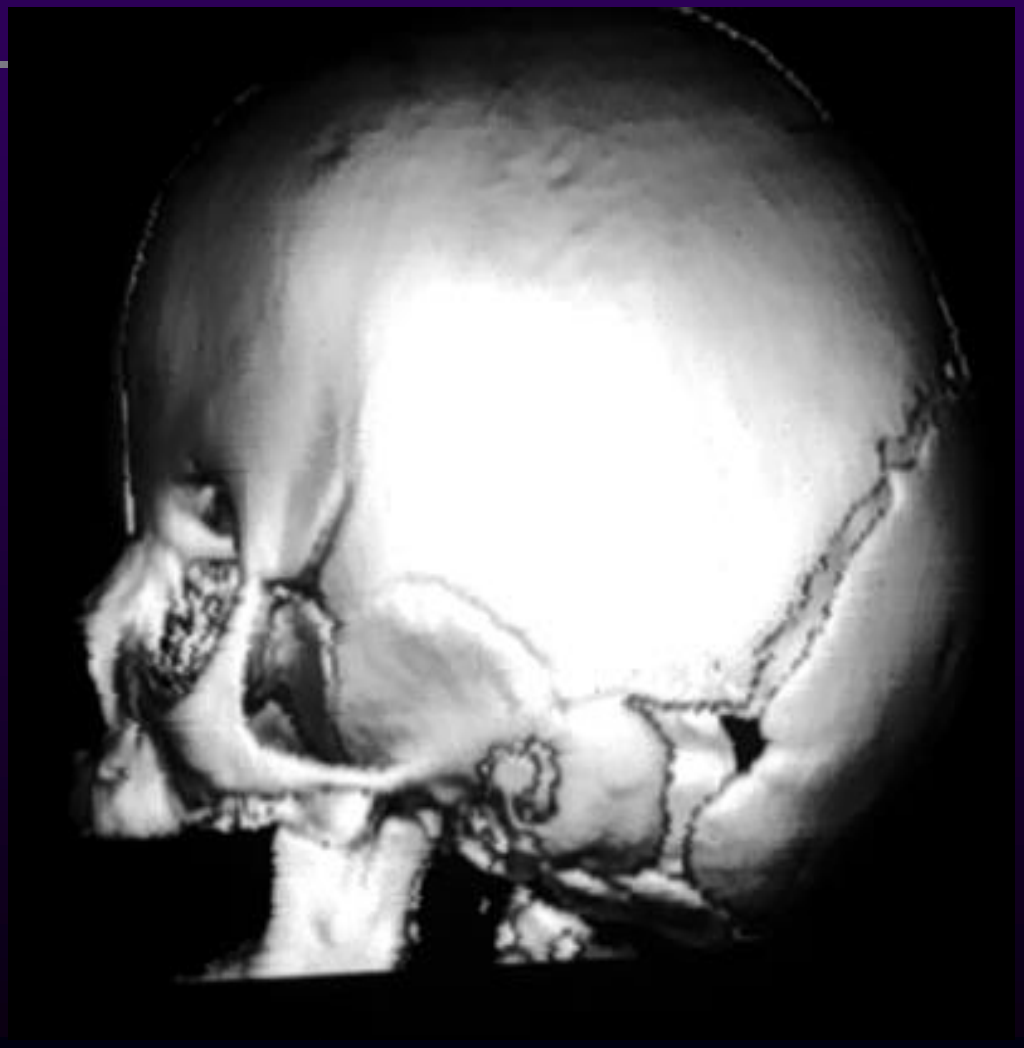
Computed Tomography

Computed Tomography

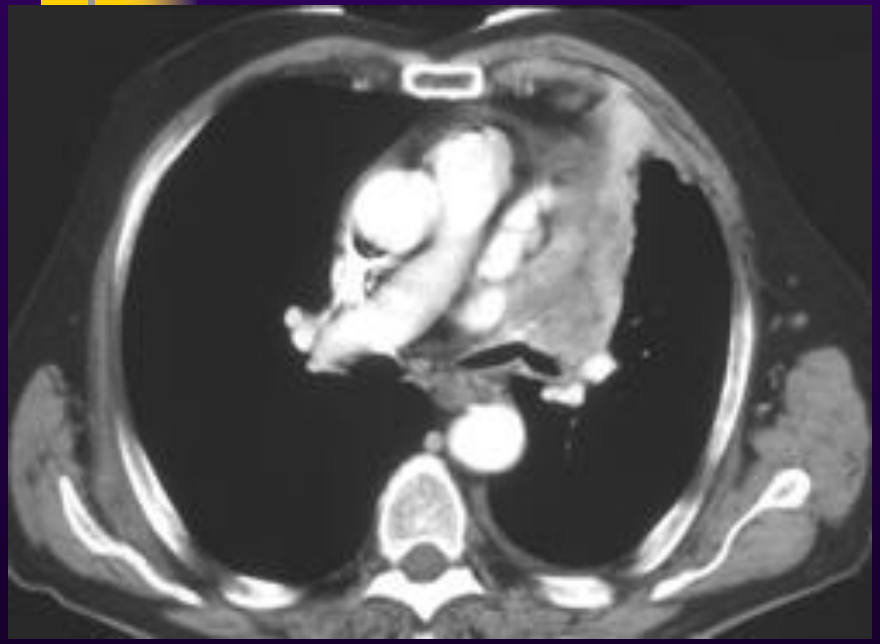


Computed Tomography

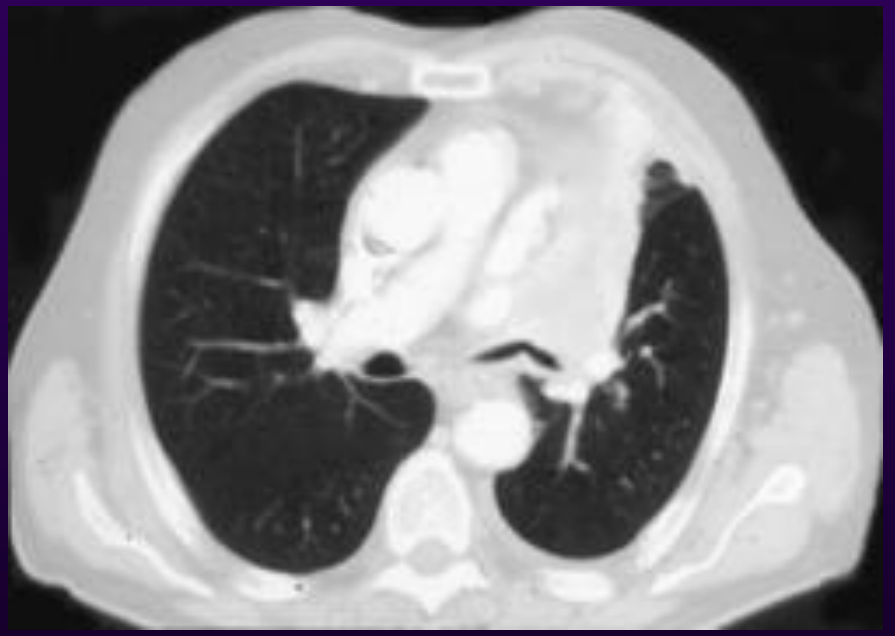
Computed Tomography



Computed Tomography

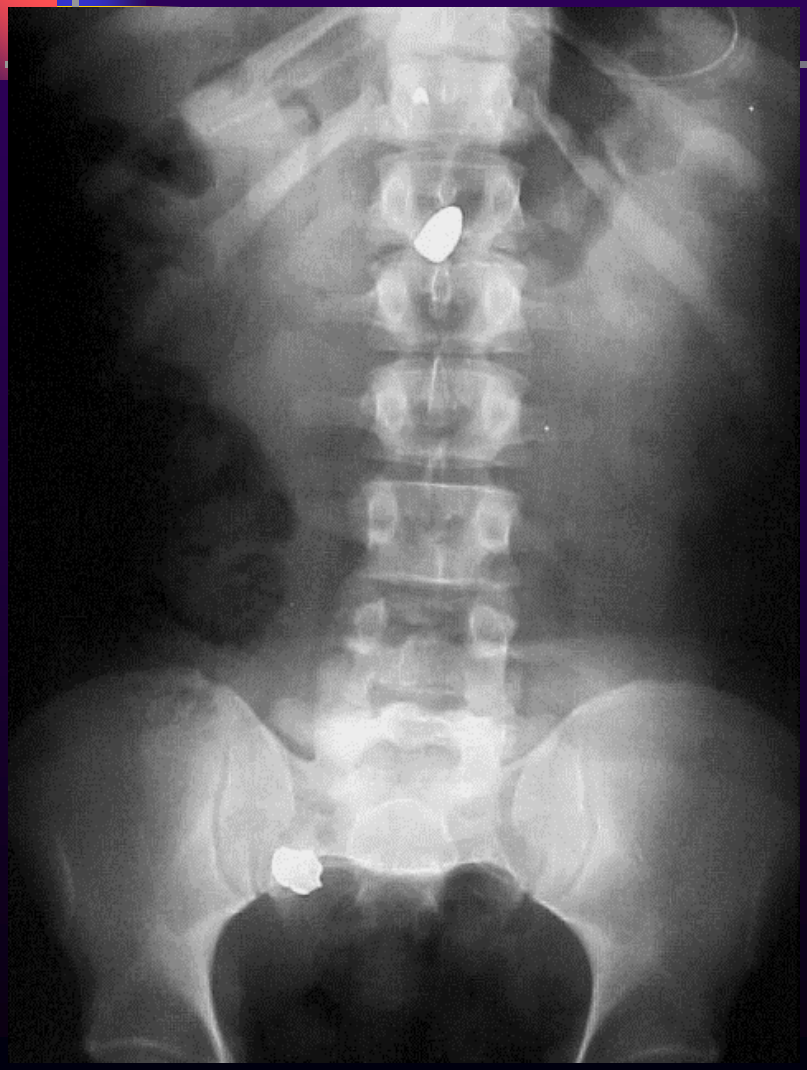


Bone window



Gas window

Patient #1

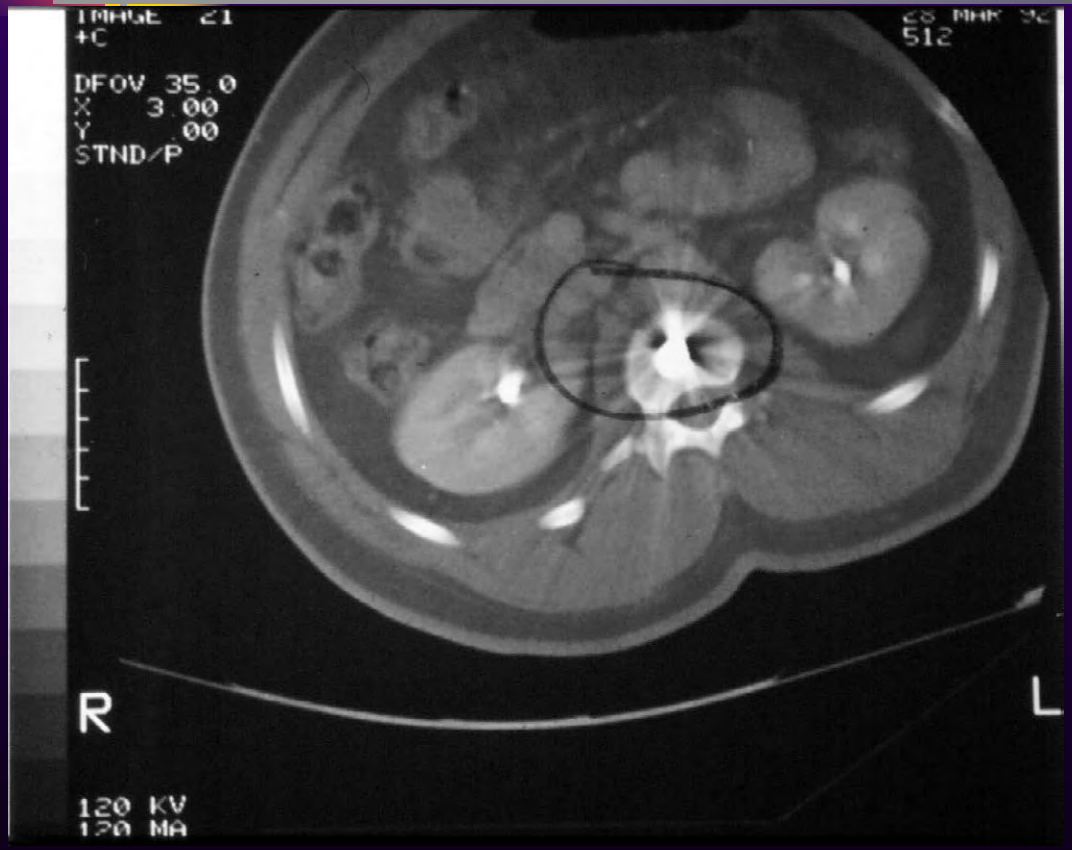


Patient 1

Computed Tomography

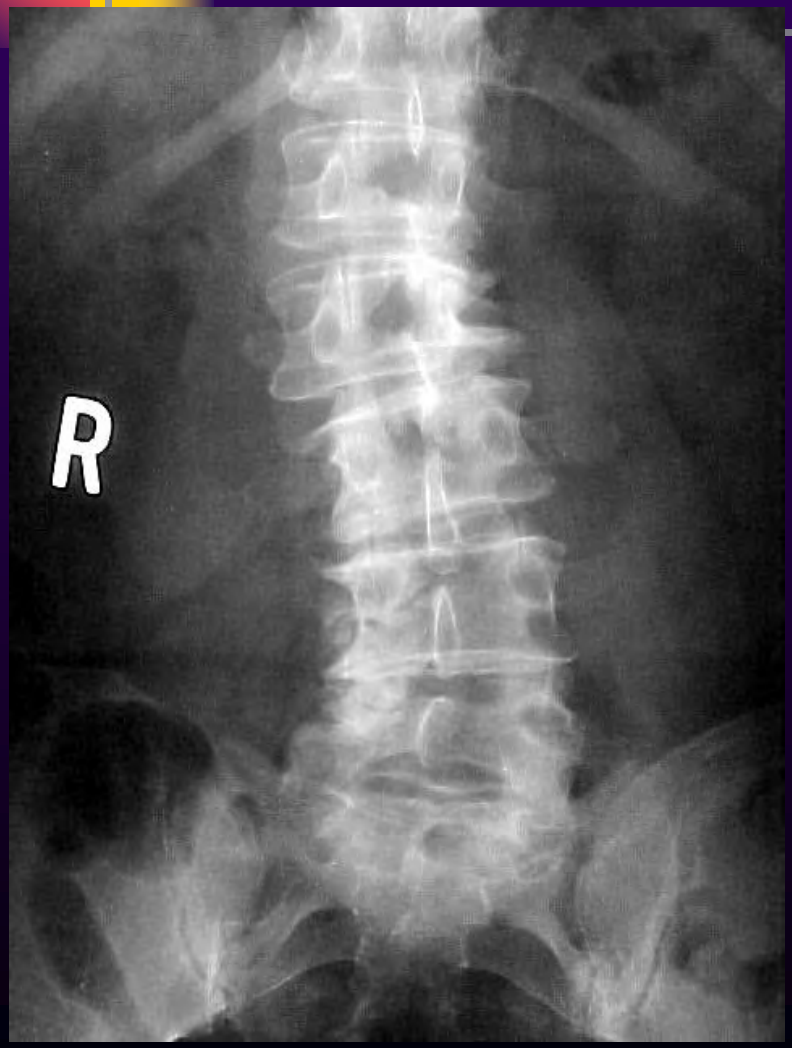
Patient 1

Computed Tomography



"Star" defect resulting from metallic artifact

Patient #3



Patient 3

Computed Tomography

Patient 3

Computed Tomography

- Advantages:
  - Highly sensitive
  - Quick acquisition times
    - Lung / G.I. Imaging
  - Available
- Disadvantages:
  - Ionizing radiation
  - Soft tissue differentiation not as good as MRI
  - Relative cost
  - Structure not function

Magnetic Resonance Imaging (MRI)

- Fat is very high in free hydrogen and gives off a very high signal
- Muscle gives off varying amounts of signal based upon various physiologic properties
- Bone, tendons, and ligaments have hydrogen bound in crystalline-like lattice and unable to be manipulated by RF,.. No signal

Magnetic Resonance Imaging

- Alterations of free hydrogen (water) content in tissues affect their ability to “relax” from RF pulse and re-align into the main magnetic field
  - These relaxations are designated T1 and T2
    - Each tissue has different values for T1 & T2 relaxation

Magnetic Resonance Imaging

- Bone, tendons and ligaments
  - Have hydrogen bound into crystalline-like lattice
    - Unable to manipulate with magnetic fields or RF pulses
      - Therefore no signal given off
      - Appears black on images
- Flowing blood also does not give an image
  - "Flow void" more about this later…,

MR Imaging Parameters

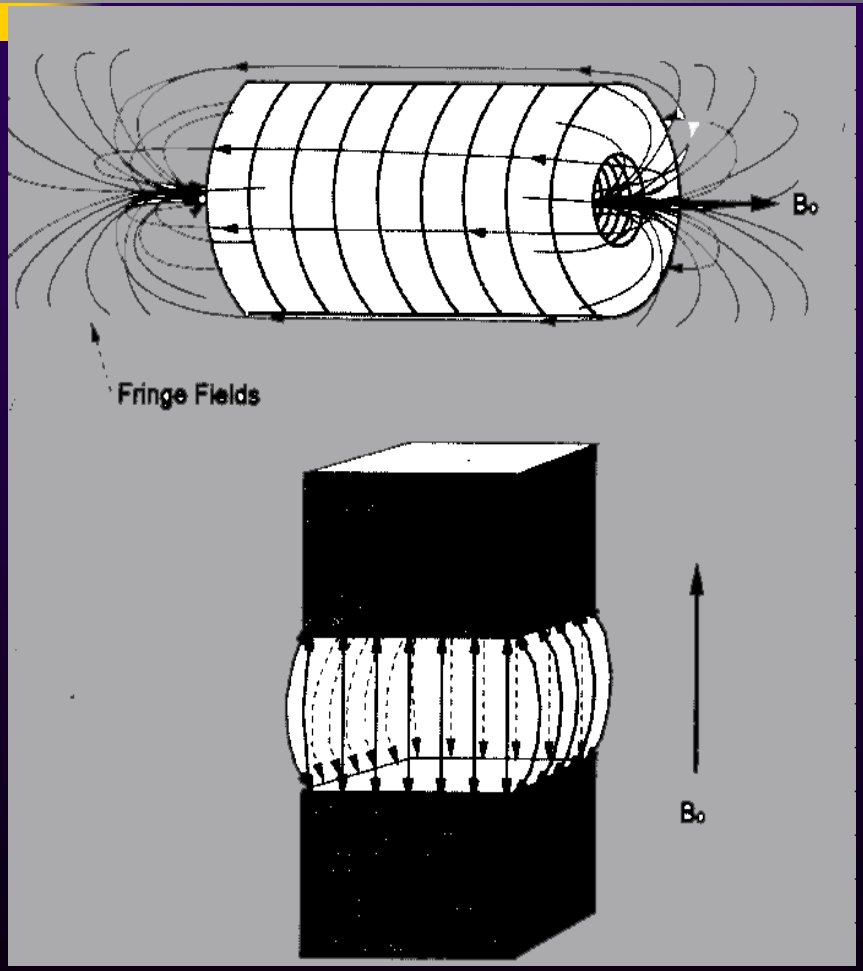
Type	TR (msec)	TE (msec)	CSF	FAT
T1 weighted	Short (400-800)	Short (20-25)	Dark	**Bright**
T2 weighted	Long (1500-2000)	Long (>60)	**Bright**	Less Bright
PD Intermed	Long (1500-3000)	Medium (30-50)	Gray	Gray

Magnetic Resonance Manipulation

T1-weighted Lumbar spine

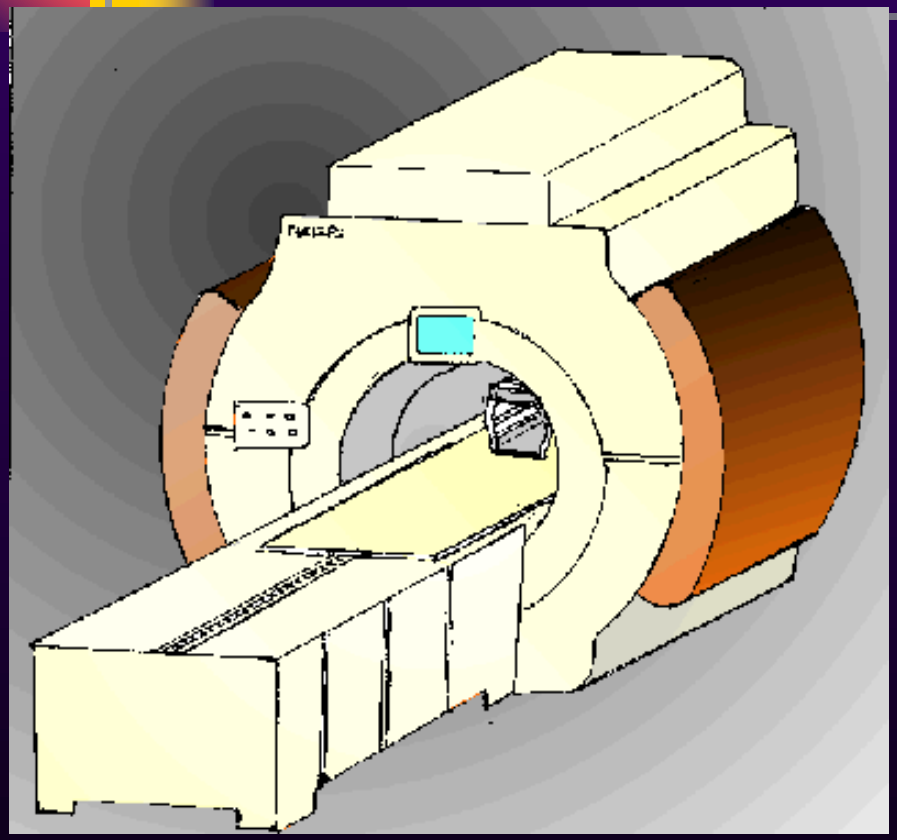
T2-weighted Lumbar spine

Magnetic Resonance Imaging



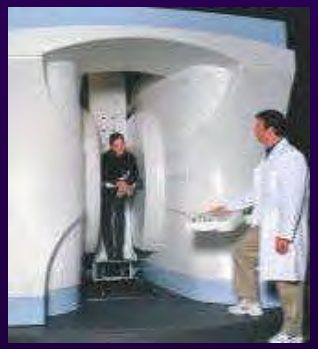
- 2 Major types of MR scanners
  - Air core (closed)
  - Solid Core (open)

Magnetic resonance imagers



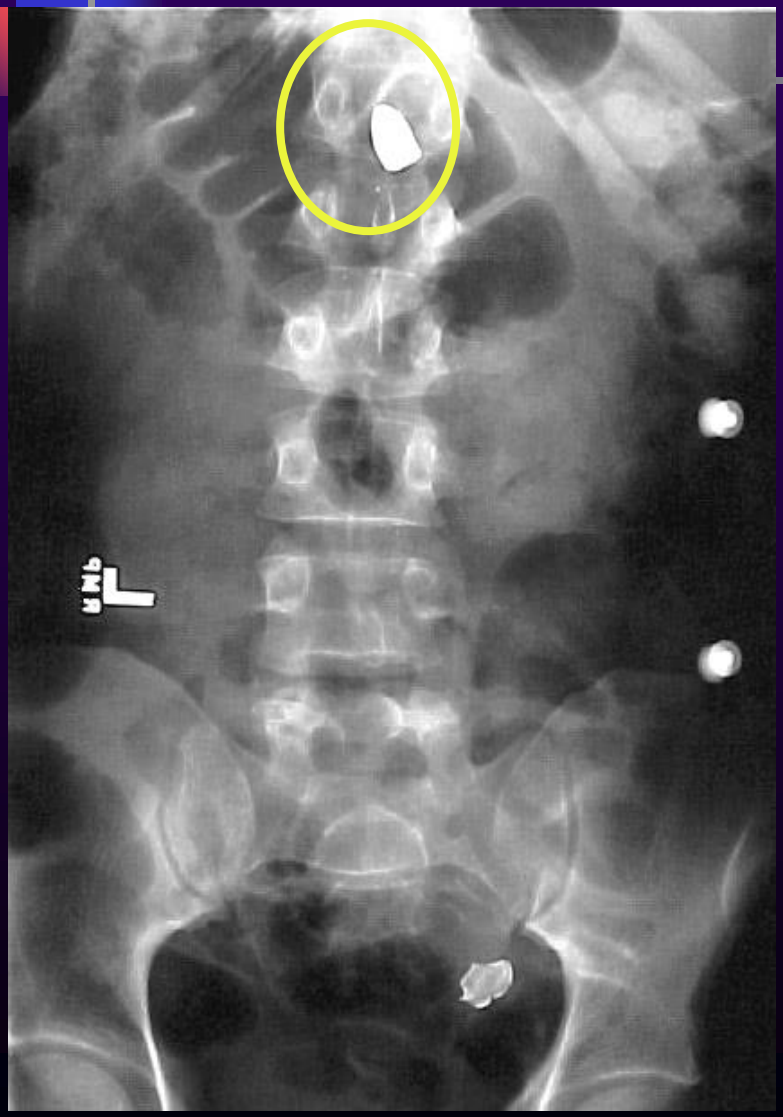
Air core (closed MR unit)

Magnetic resonance imagers



Solid Core (Open MR unit)

Patient #1



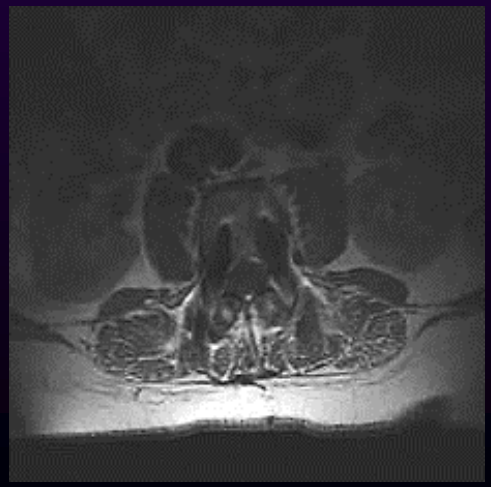
Patient 1

Magnetic Resonance Imaging

Patient 1

Artifact resulting
From metallic
Fragment distorting
Magnetic field

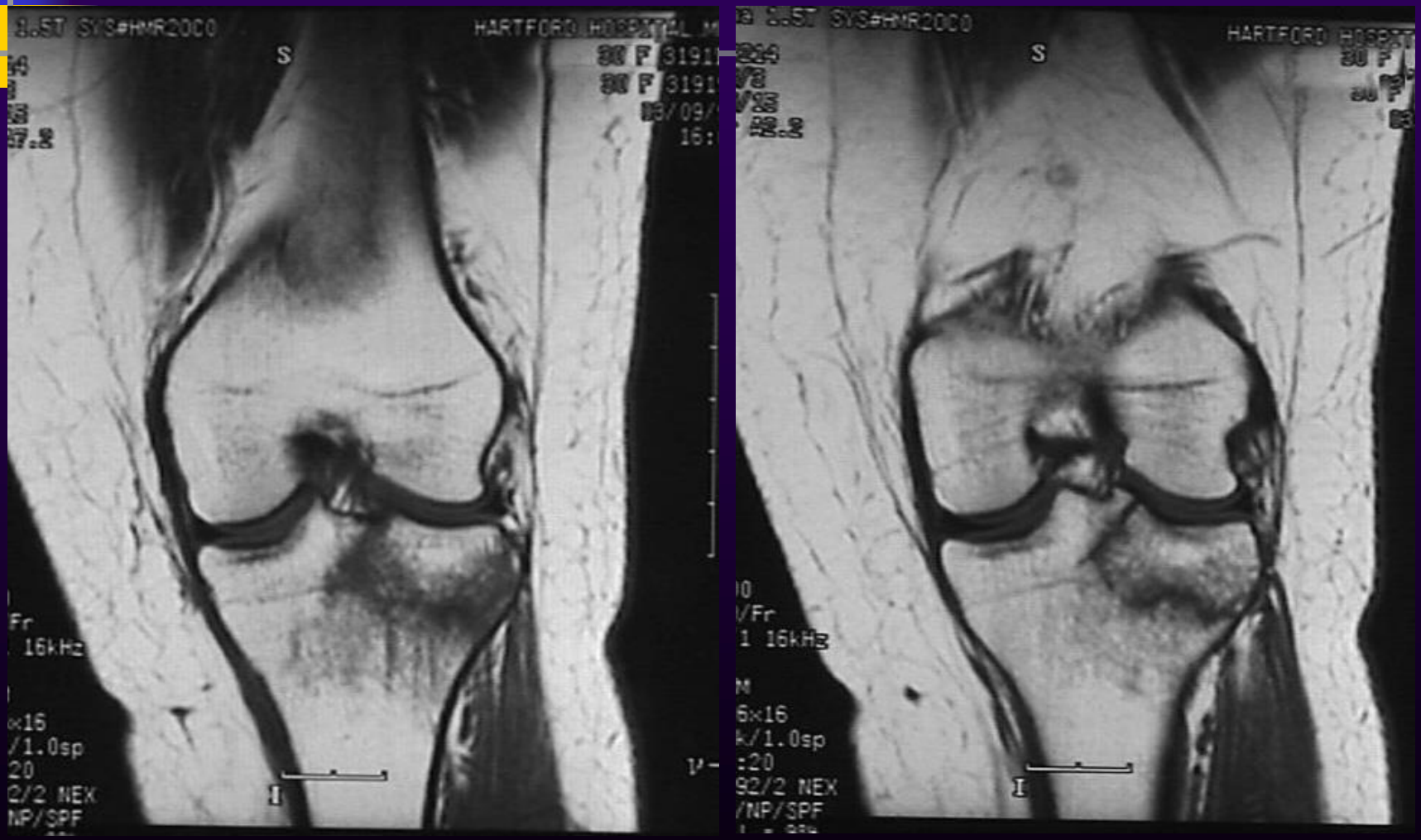
Magnetic Resonance Imaging Artifact



Patient 2

- This is the plain film xray from earlier in the lecture
  - Did you see any injuries
    - Patient 2

Magnetic resonance imaging

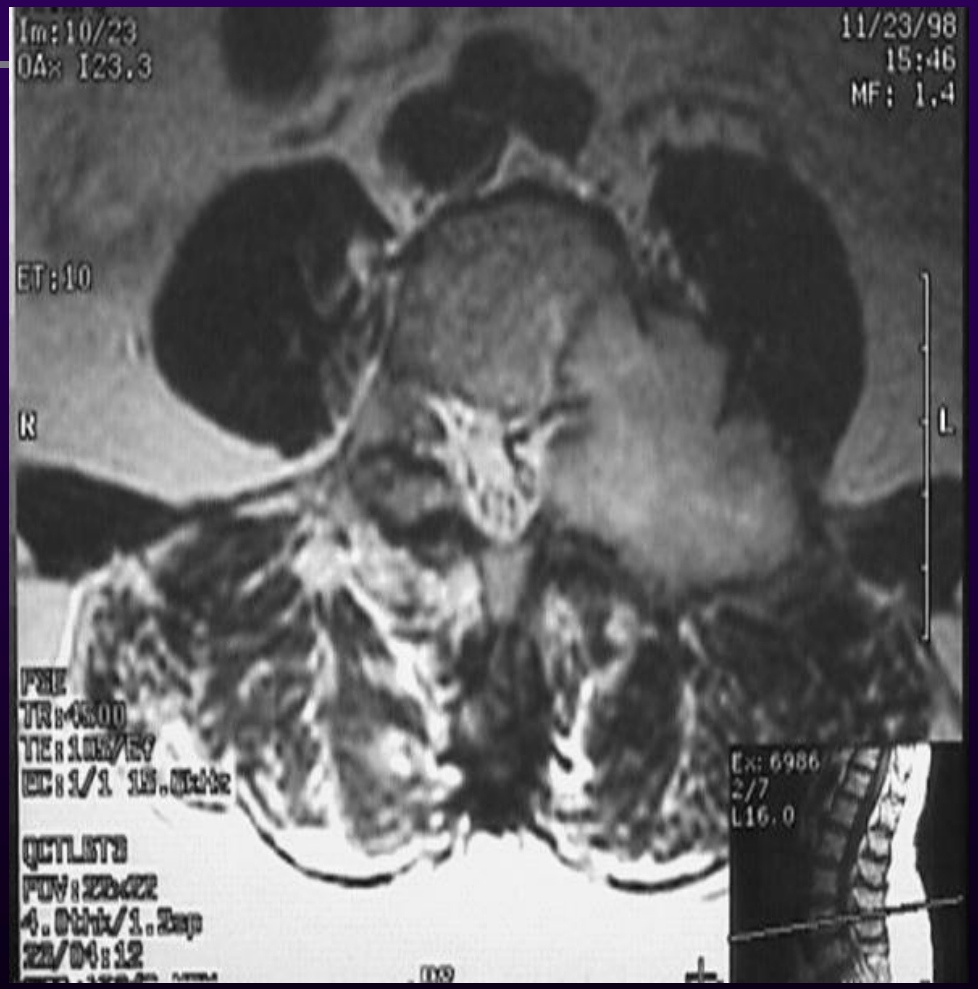


Patient 2

Magnetic resonance imaging

Patient 3

Magnetic resonance imaging



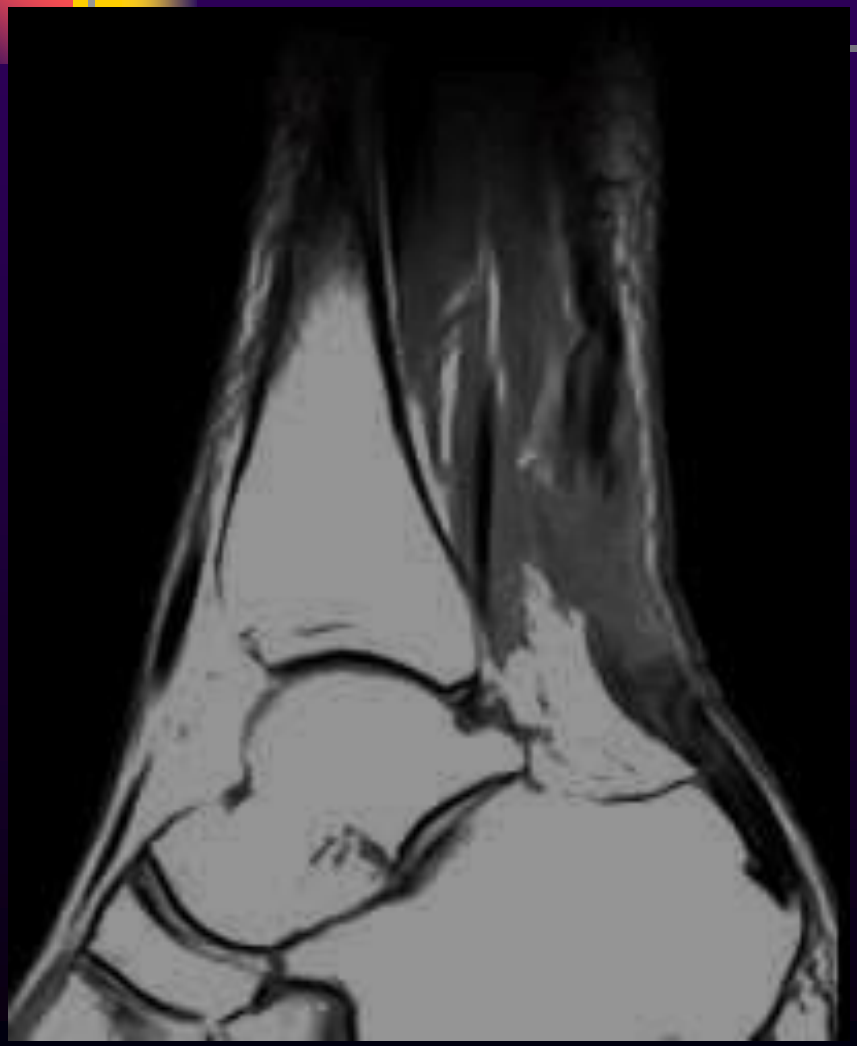
Patient 4

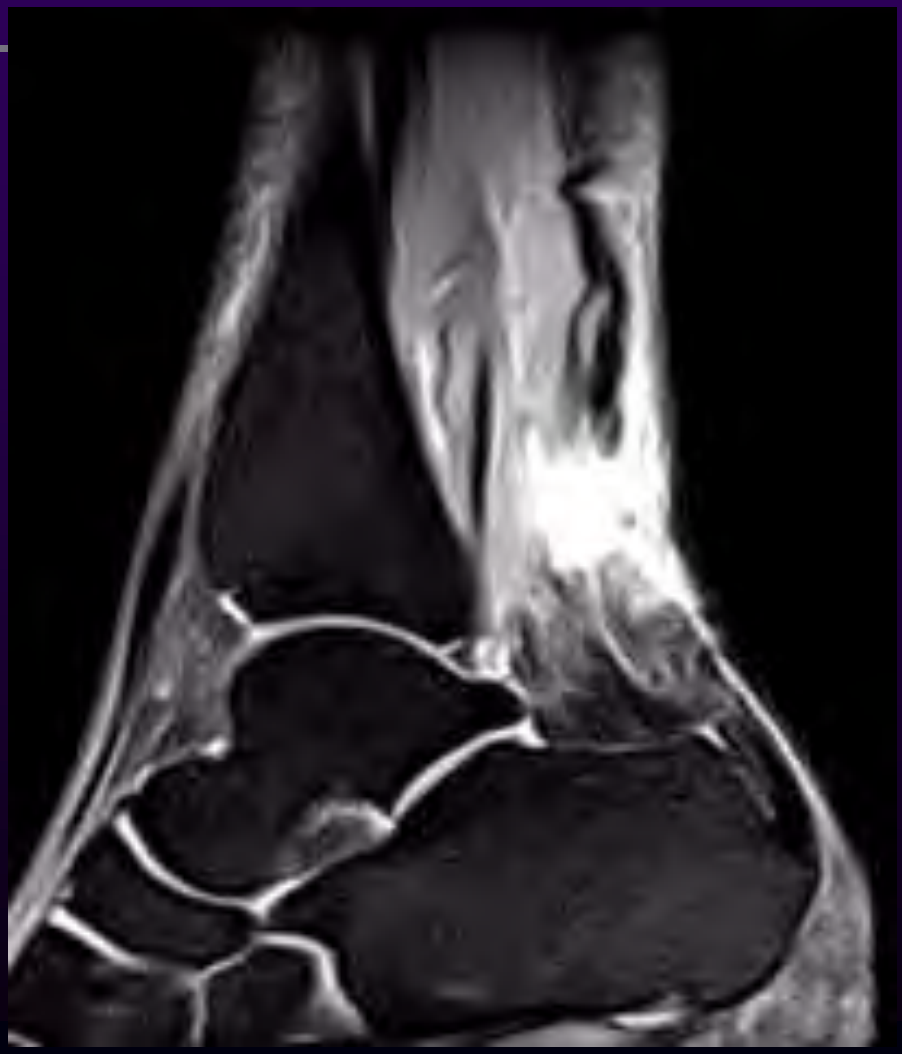
Magnetic resonance imaging

- **Advantages:**
  - No ionizing radiation
  - Excellent soft tissue demonstration
  - Very sensitize to tissue changes
  - Shows structure AND function
- **Disadvantages:**
  - Slow acquisition times
  - Expensive
  - Availability
  - Uncomfortable
  - Claustrophobic
  - Magnetic shielding problems
  - Heavy machinery

Magnetic Resonance Imaging

with Fat Saturation





Magnetic Resonance Imaging

with Flexion/Extension

MRI pulse sequences

- Collection of specific imaging parameters selected for a scan of a patient
  - Typical musculoskeletal exam contains 3-6 sequences in various planes

Pulse Sequence Strengths & Weaknesses

Sequence	Strength	Weakness
Spin Echo T1	Anatomic detail, Fat, Subacute Hemorrhage, Marrow, Menicus, Contrast	ST edema, other fluid
Fast Spin Echo T2	Marrow path when fat-sat. used, Good for pts with metal hardware, Fluid	Poor marrow w/o fat-sat
Gradient Echo T2*	Fibrocartilage, Loose bodies & Hemorrhage *(susceptibility effects)*	Poor marrow, metallic hardware
Short Tau Inversion recovery (STIR)	Marrow & ST Pathology d/t fat suppression	Not to be used with contrast
Fluid Attenuation Inversion Recovery (FLAIR)	Similar to STIR mostly for Brain and Neuro tissues	

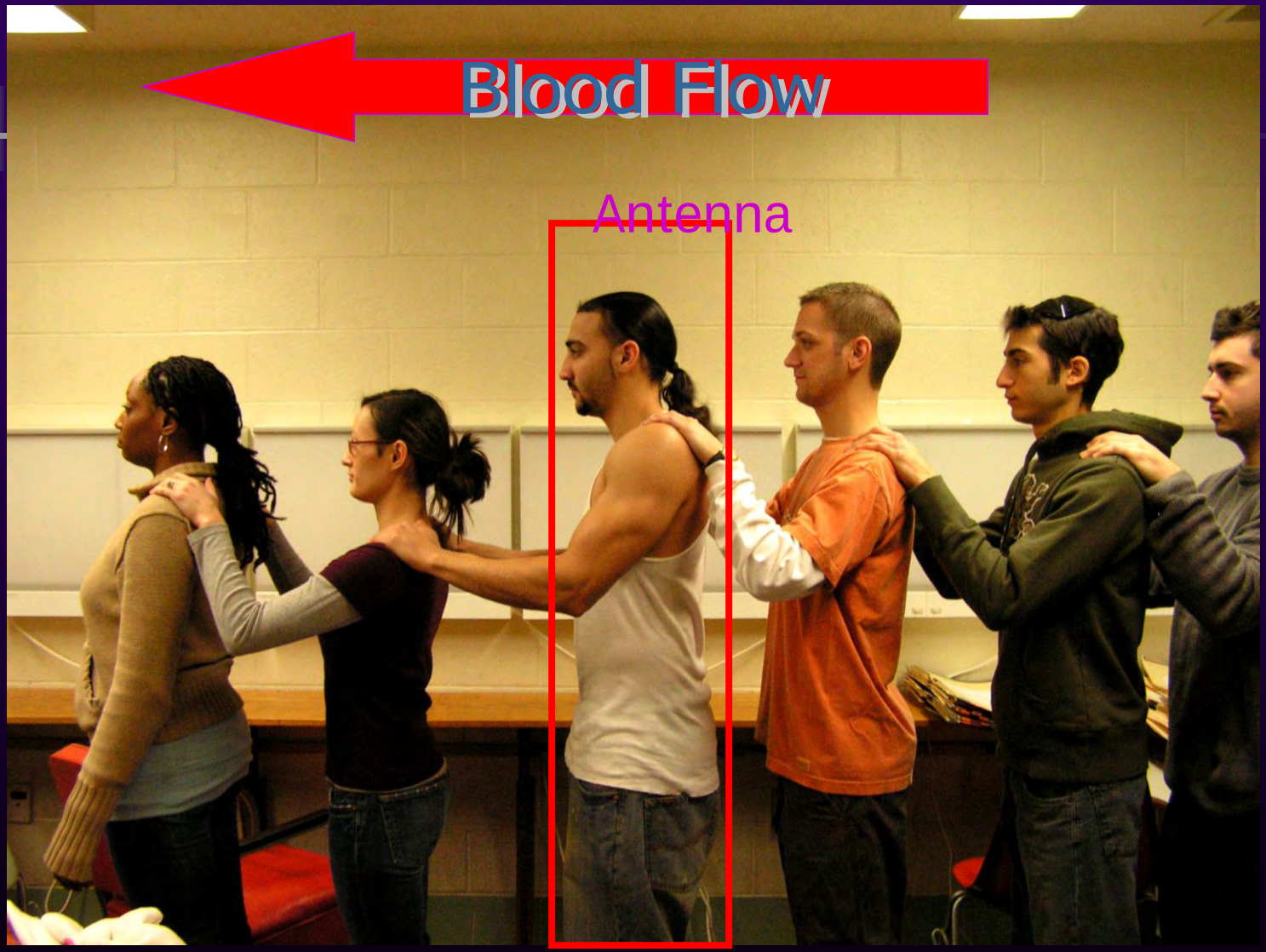
Magnetic Resonance Arteriography (MRA)

- Utilizing the "flow void" of blood to produce an image.
  - It is possible via the software to digitally eliminate the signal of most/all tissues with exception of flowing blood

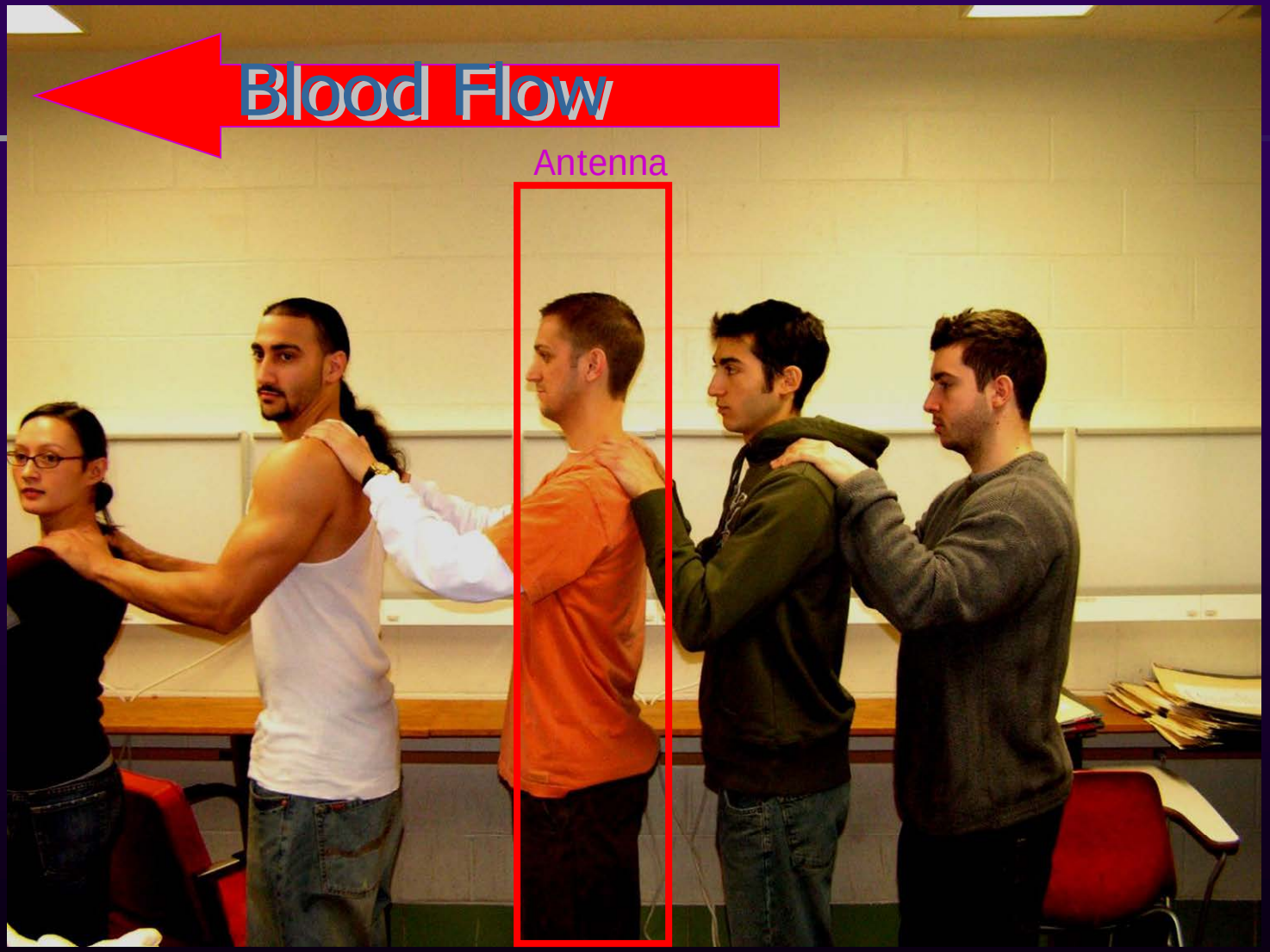
Magnetic Resonance Arteriography (MRA)

- This will produce the appearance of only the vascular structures and any abnormalities
  - The images appear as if contrast material was injected without the invasiveness of arteriography

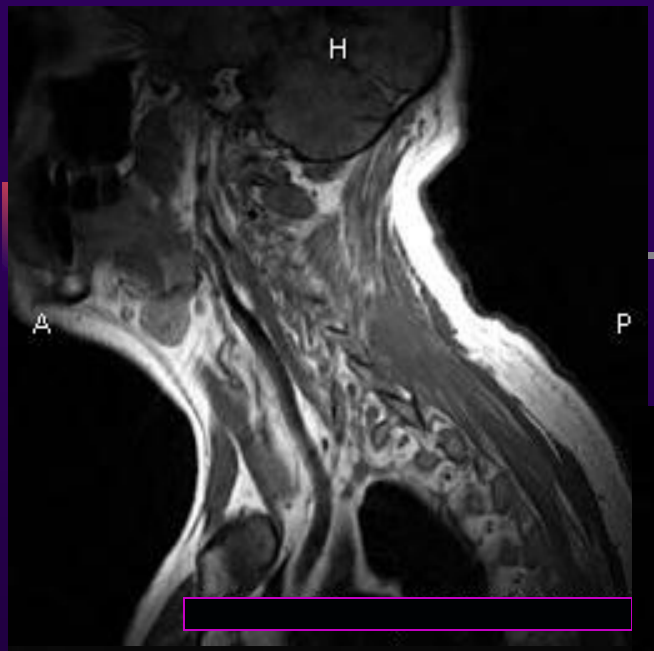
Flow Void

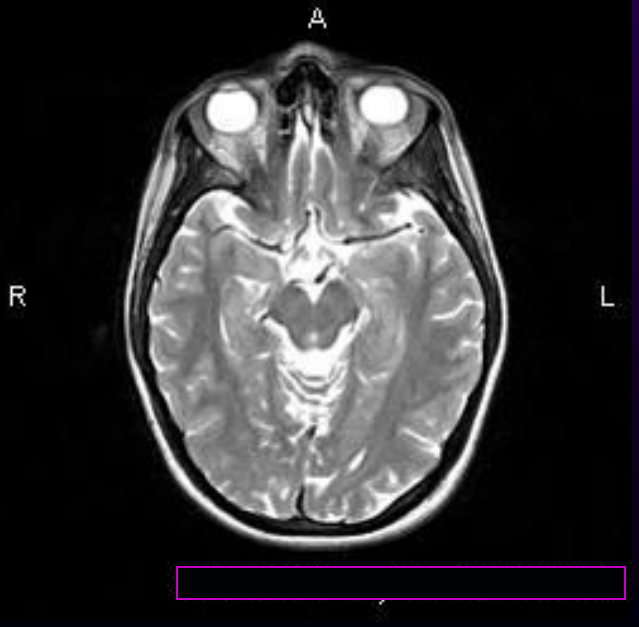


Flow Void



Flow Voids

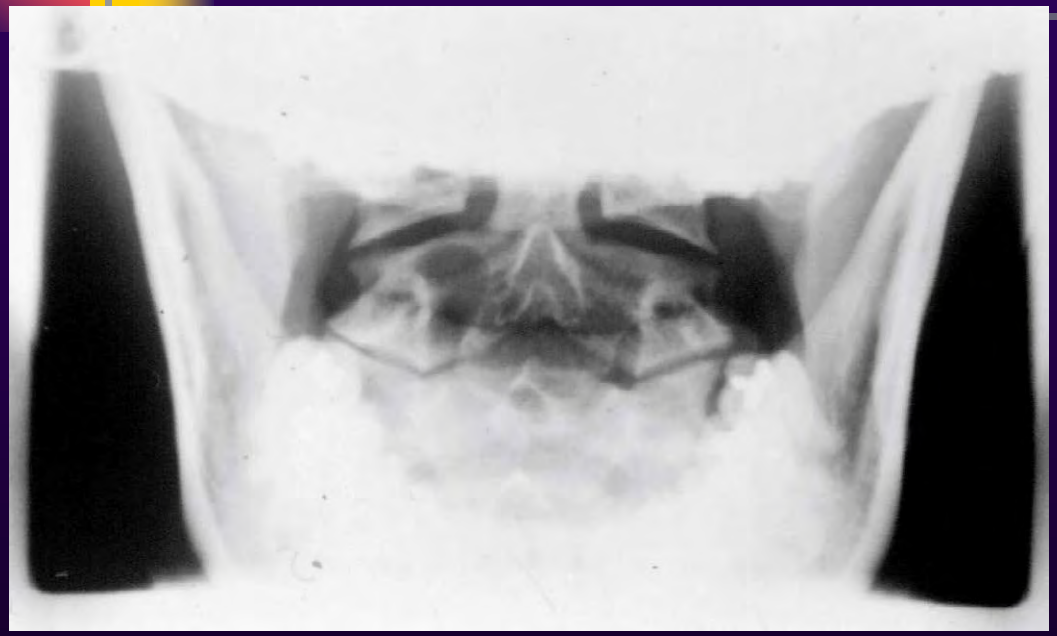




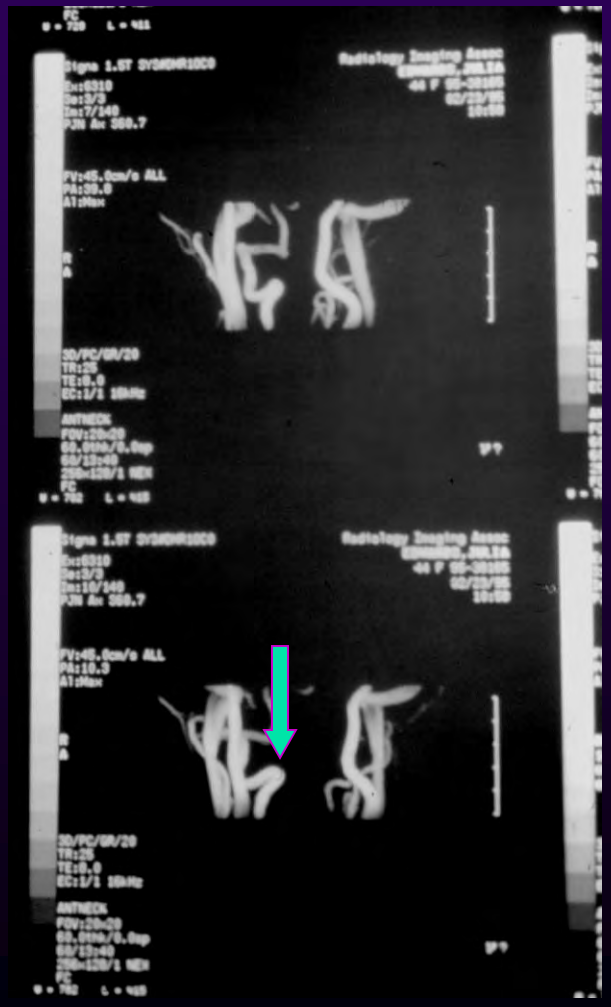
Magnetic Resonance Arteriography (MRA)

- Utilizing the "flow void" to produce an image

Magnetic Resonance Arteriography (MRA)



Middle aged male patient with chronic, progressive neck pain and no response to treatment

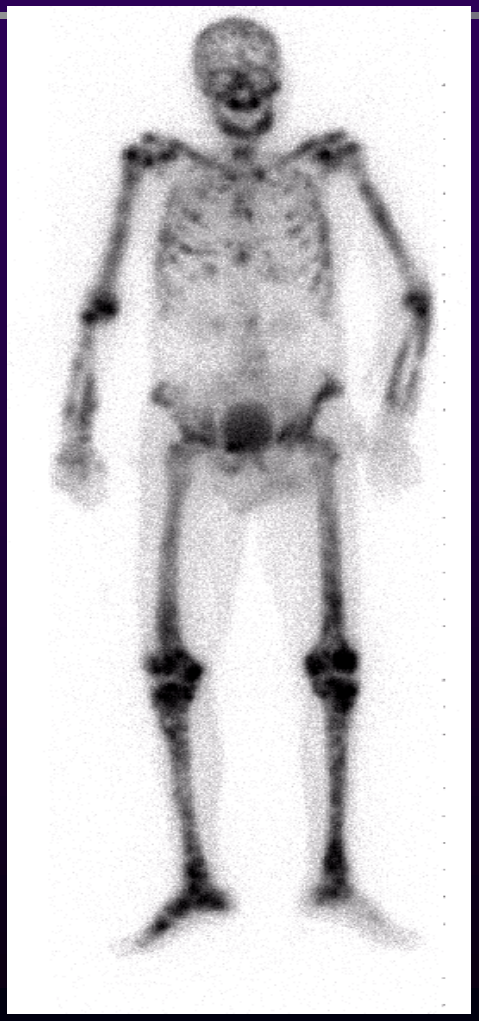


Special thanks to Dr. Terry Yochum

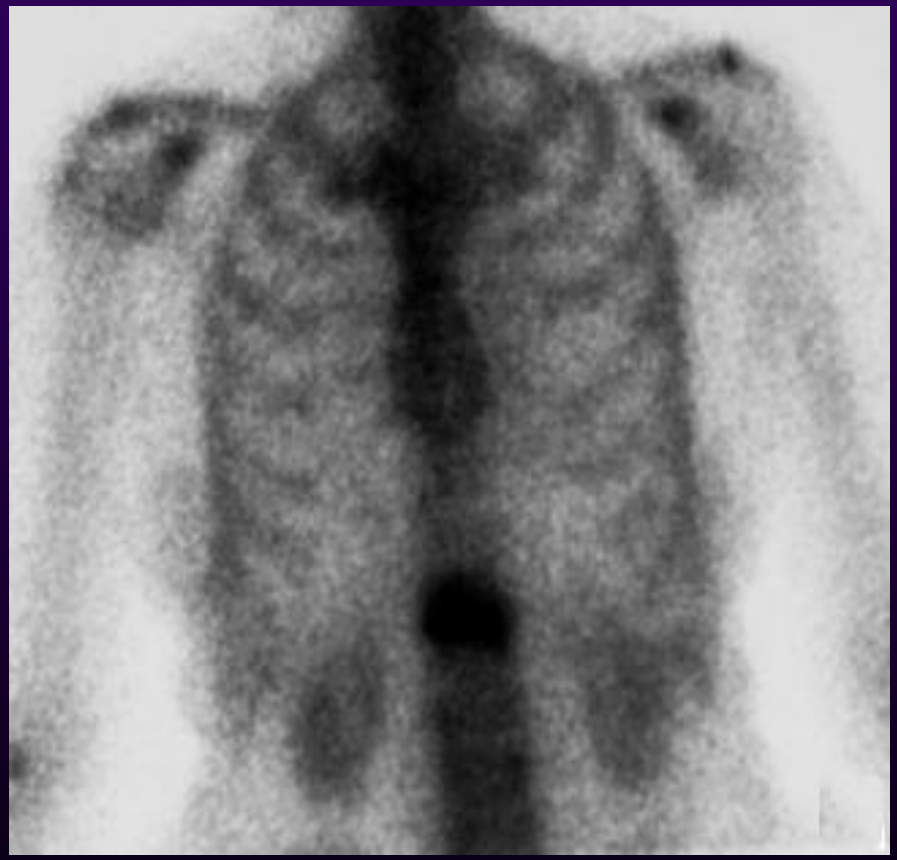
Bone scan (scintigraphy)

- Utilizes radioactive pharmaceutical injected into blood stream
  - Agent accumulates in regions of increased blood flow and increased bone metabolism
  - Patient is scanned, and “hot spots” demonstrate the areas of accumulation

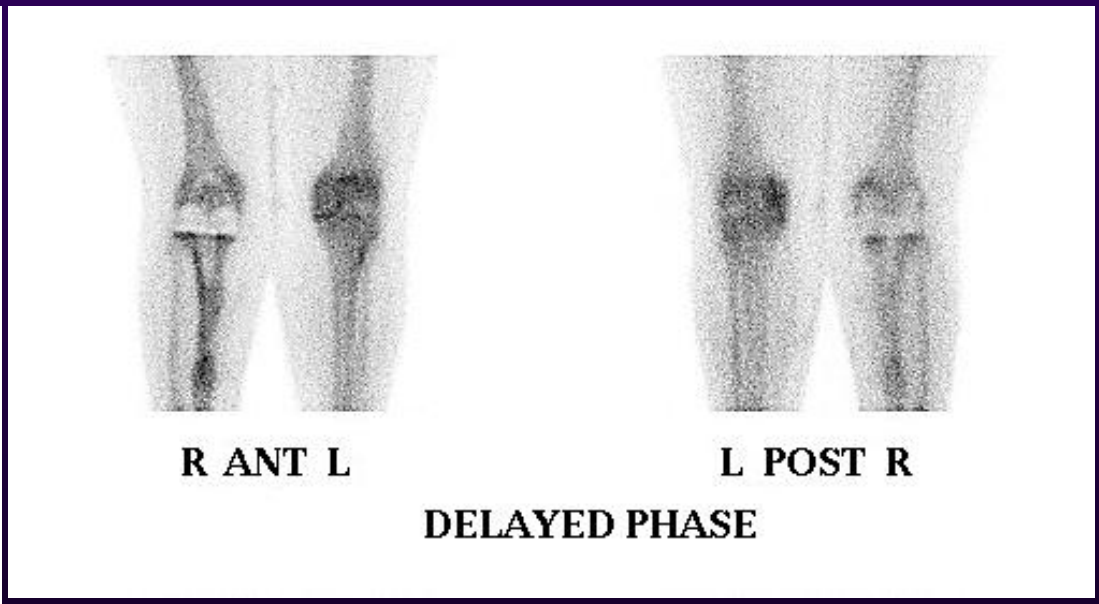
Bone scan (scintigraphy)



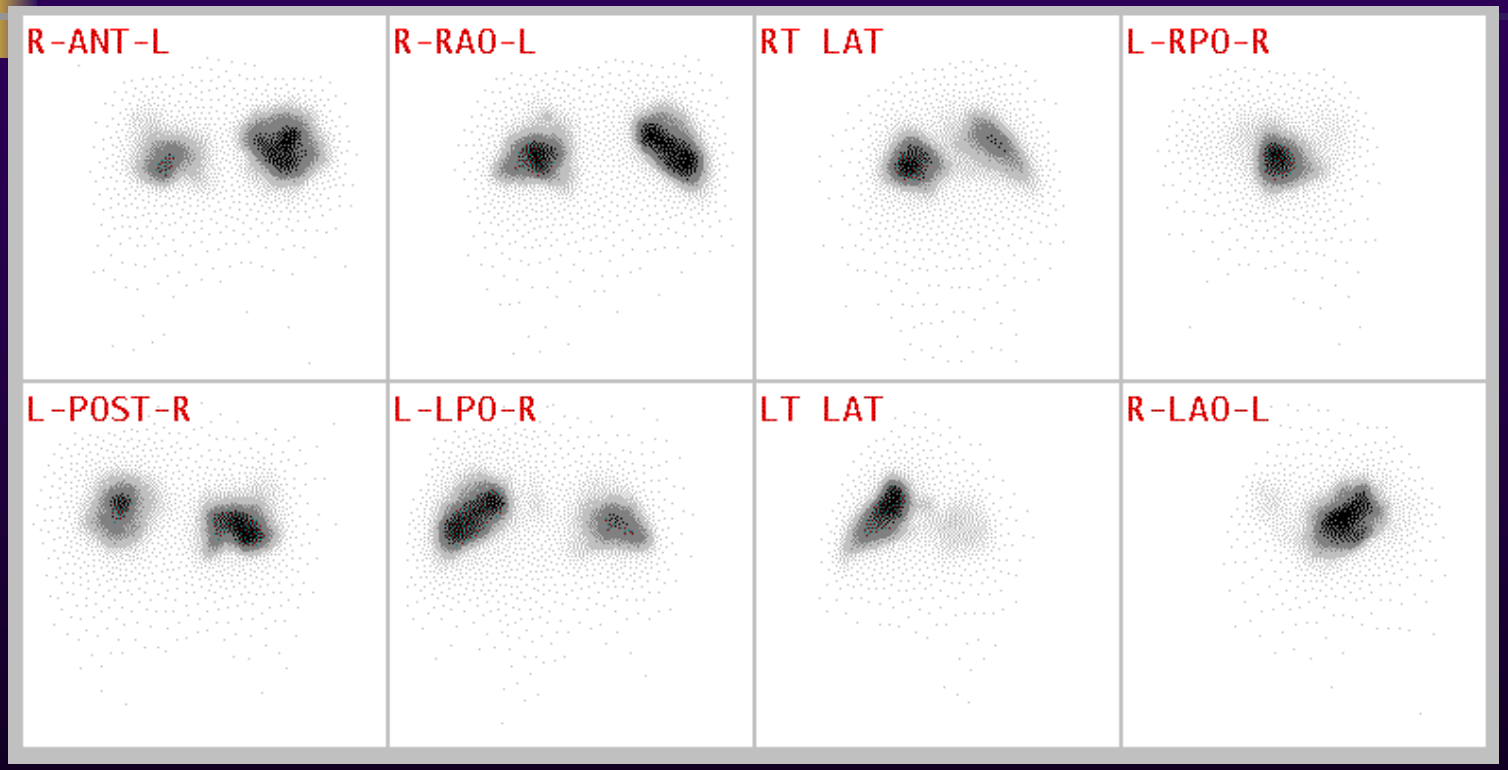
Bone scan (scintigraphy)



Bone scan (scintigraphy)

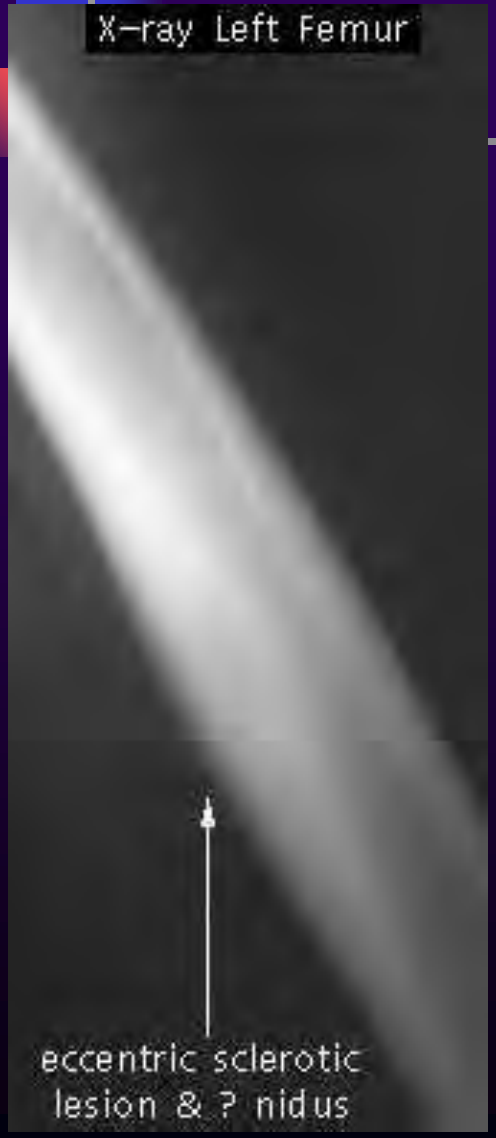


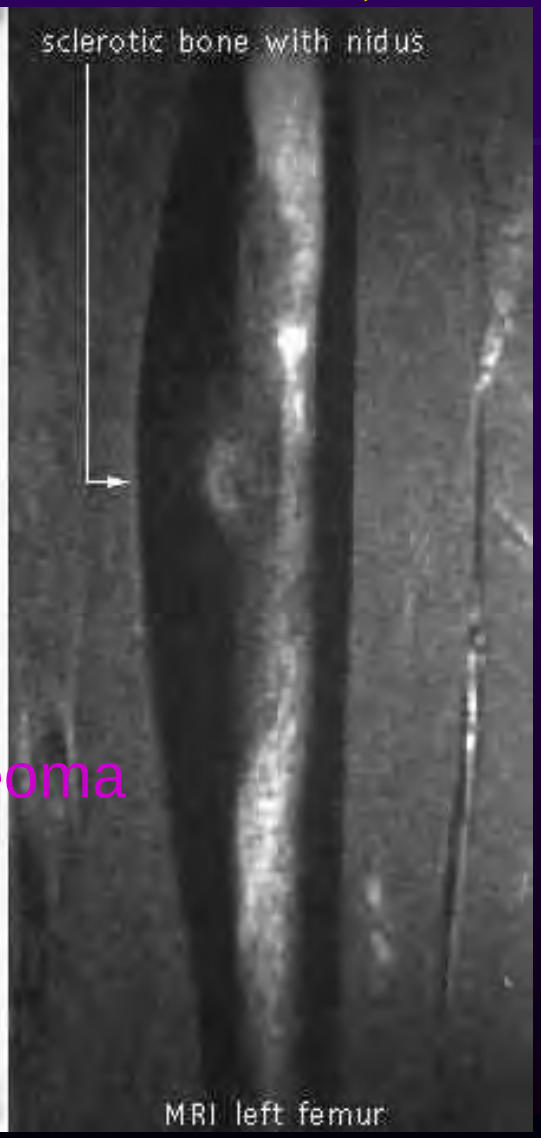
Bone scan (scintigraphy)



Lung perfusion scans

Scintigraphy (Bone scan)



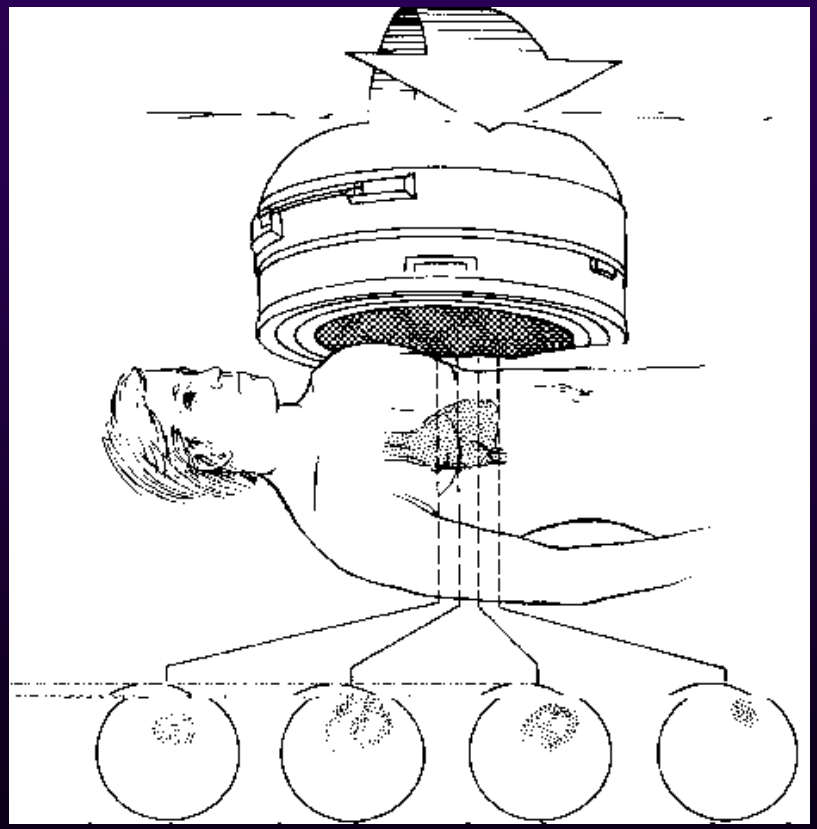


Dx: Osteoid Osteoma

Bone scan (scintigraphy)

- Advantages:
  - Highly sensitive to bone changes
  - Shows function changes early
  - Relatively cheap procedure
- Disadvantages:
  - Ionizing radiation
  - Poor specificity for lesions
  - Invasive procedure
    - Infection/allergies
  - Normal “hot spots”
    - Open epiphyses

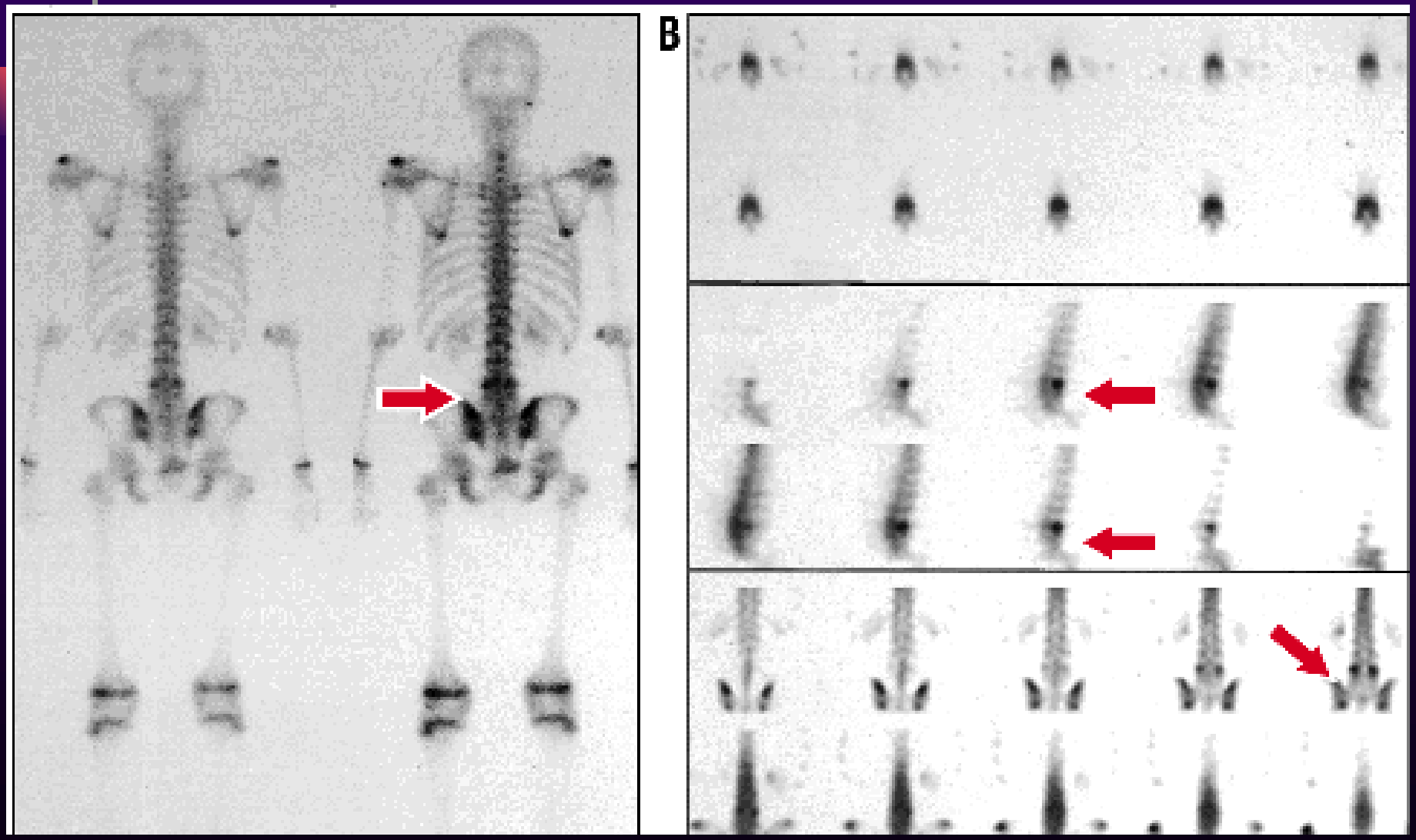
SPECT scan



- Single photon emission computed tomography
  - Combination of bone scanning with ability of CT to give tomographic “slices” through body

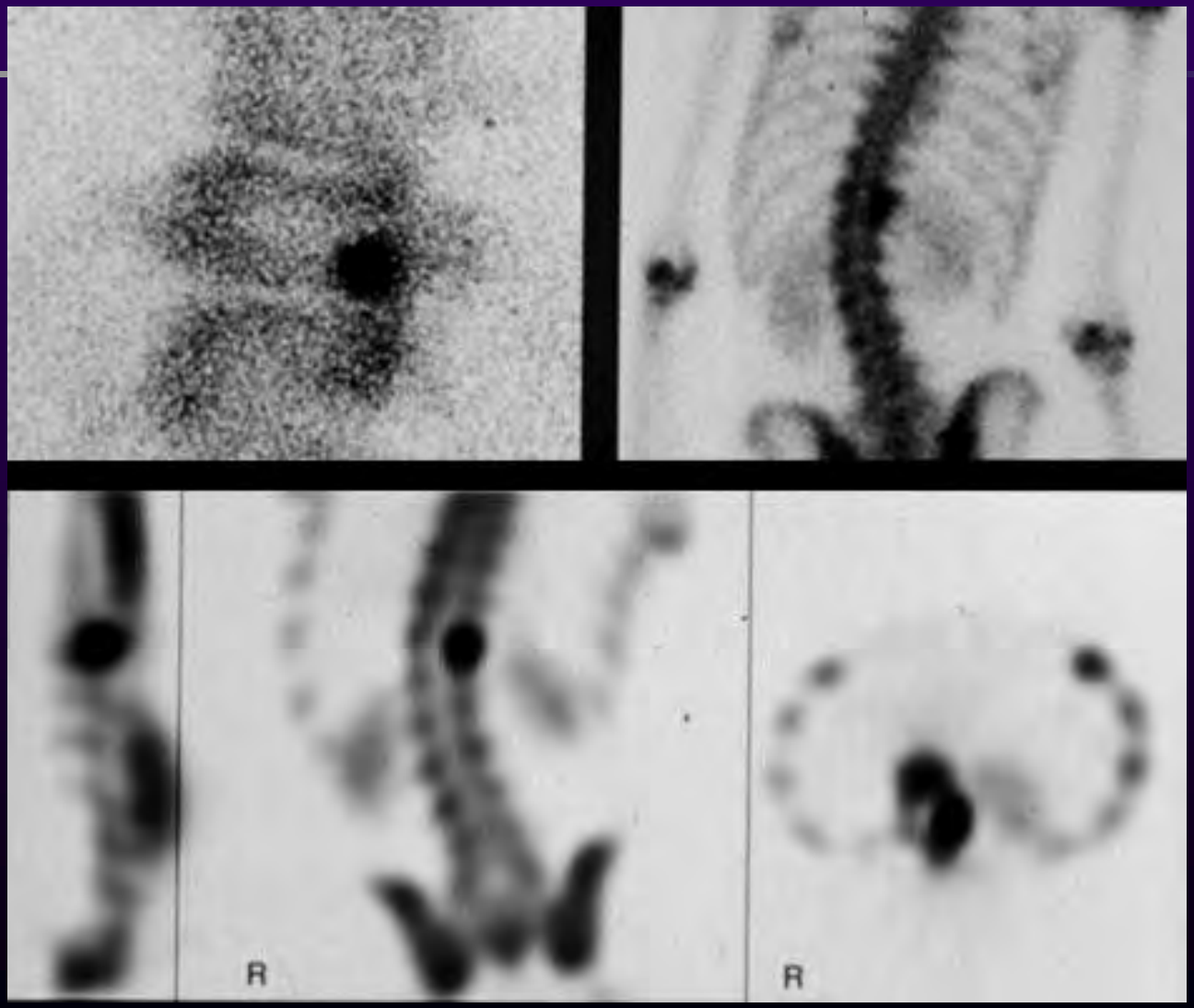
SPECT scanner

SPECT scan

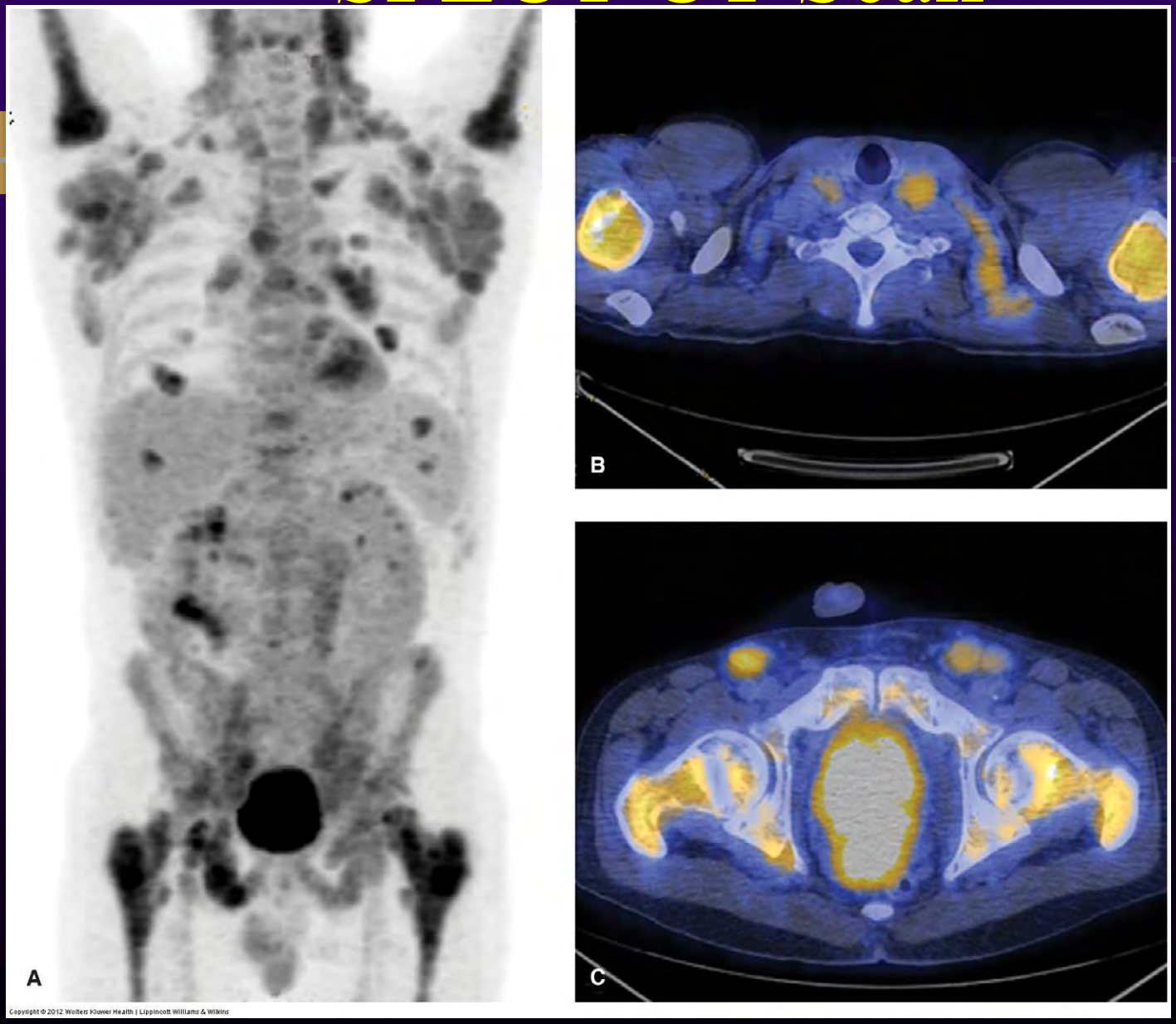


Pars interarticulares stress reaction (fracture?) in young athlete

Osteoid Osteoma



SPECT-CT Scan

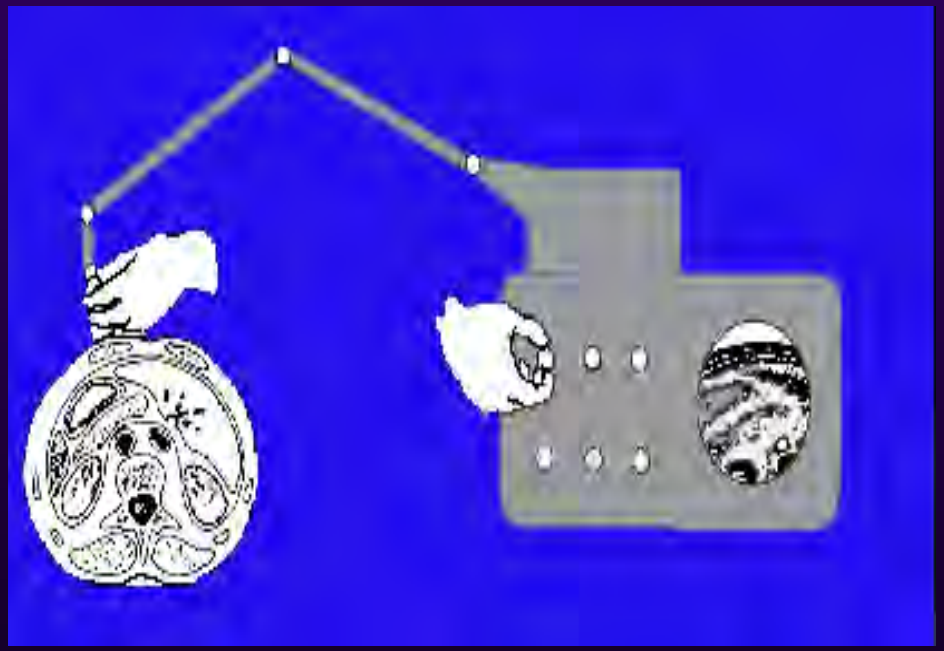


Diagnostic ultrasound

- Soundwaves penetrate surface of patient
  - Waves are reflected back to surface as soundwaves pass through different densities of tissues
  - Reflected waves are recorded and an image constructed

Diagnostic ultrasound

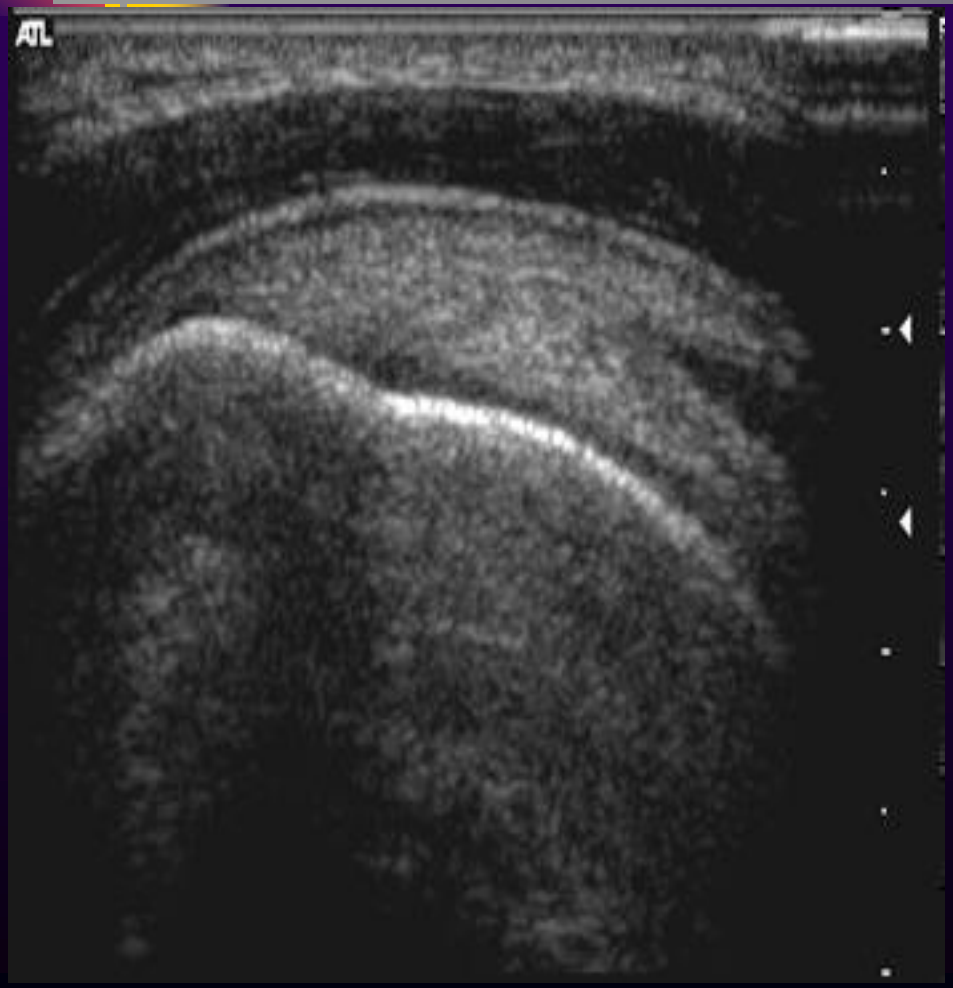
- Soundwaves reflected back based upon changes in densities (interface).
- Allows evaluation of fluid accumulation as well as fibrotic changes in tissue



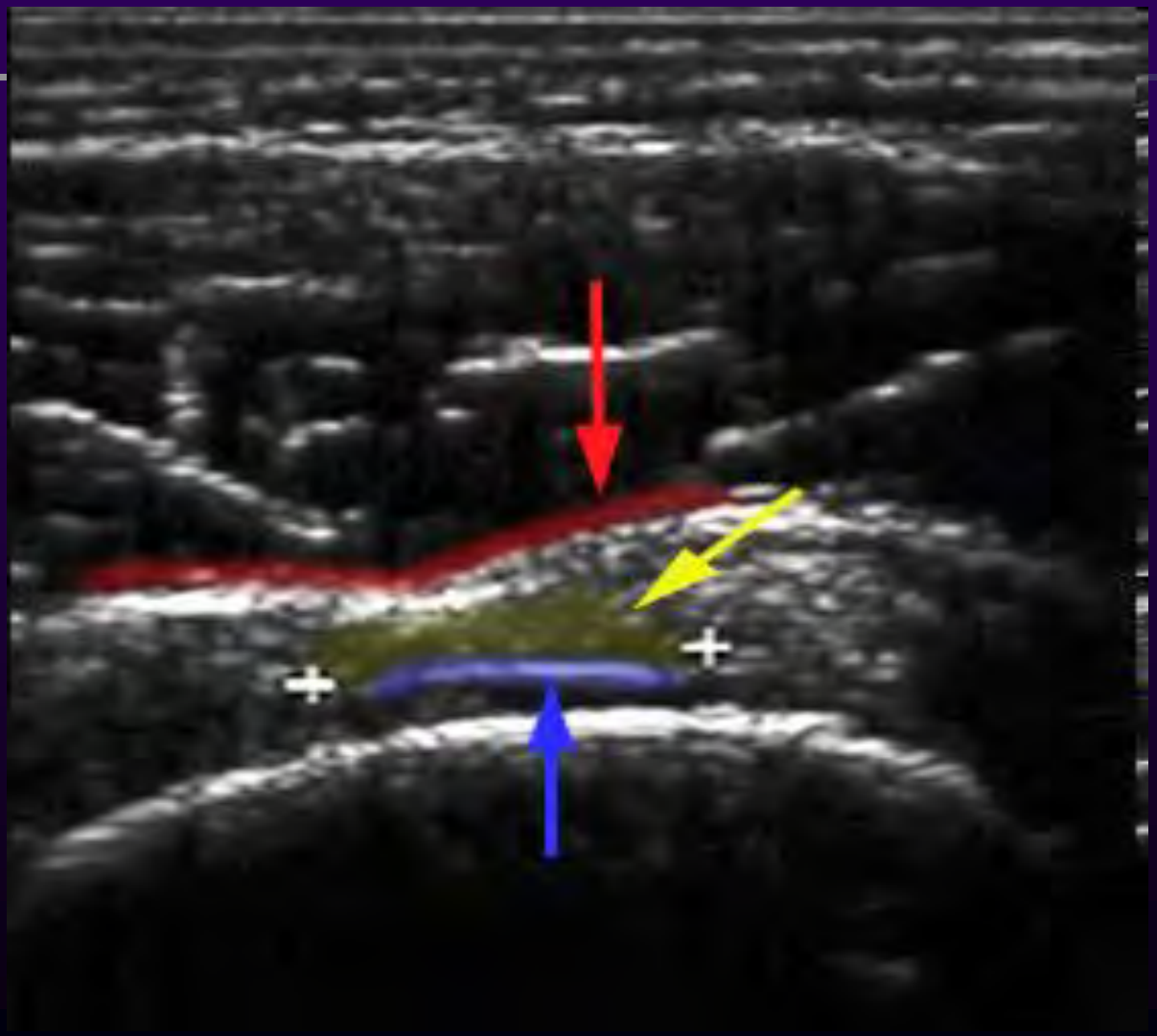
Diagnostic ultrasound

- Realtime images
- Allows multiplanar imaging
- Areas in motion

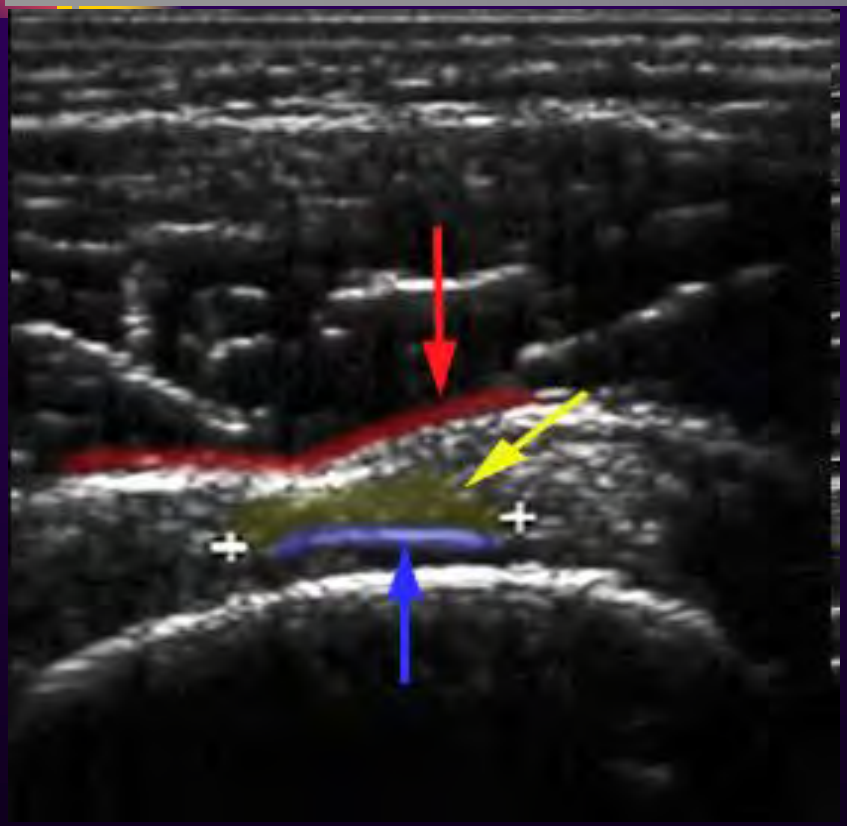
Diagnostic ultrasound



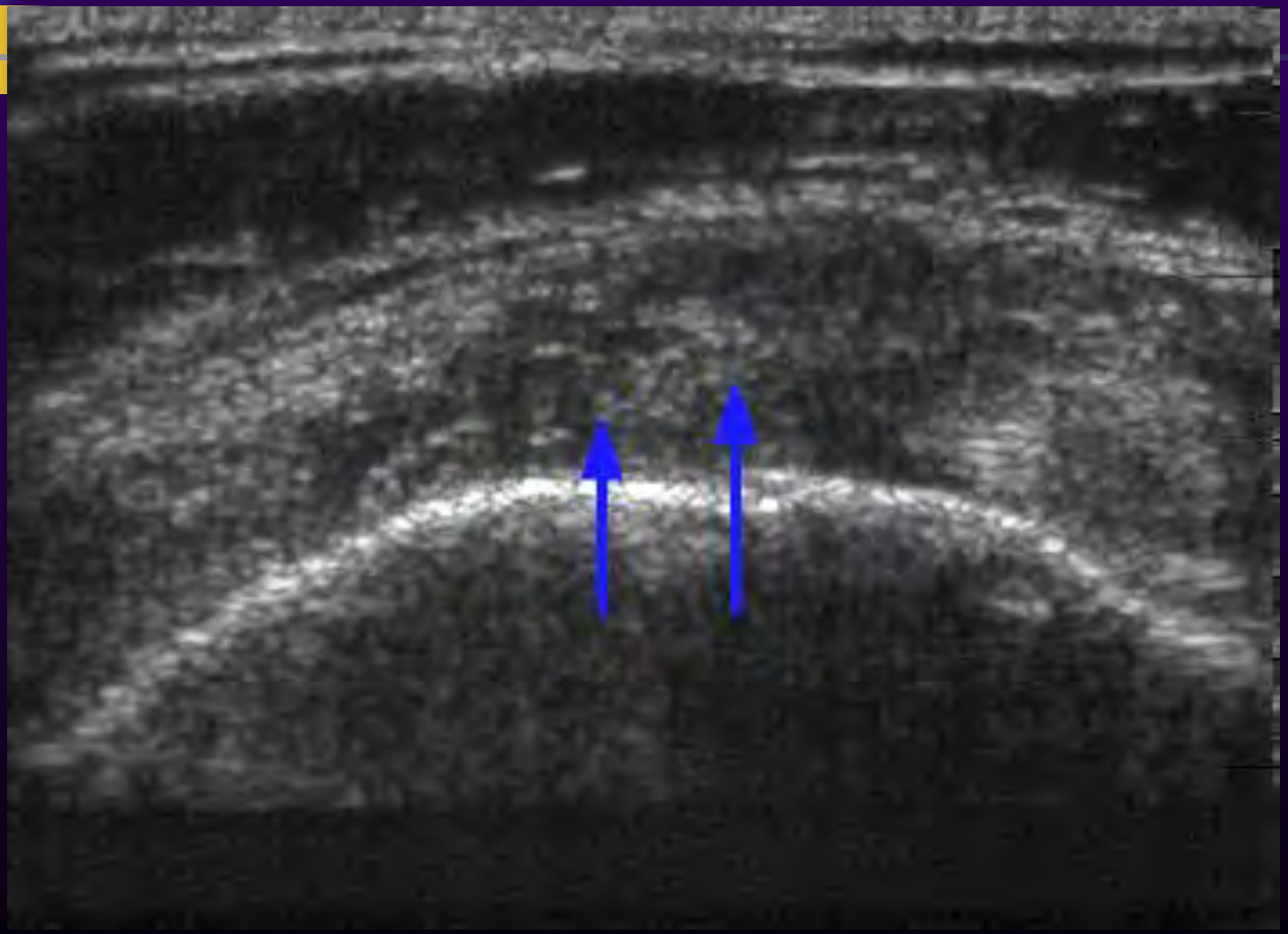
Diagnostic ultrasound



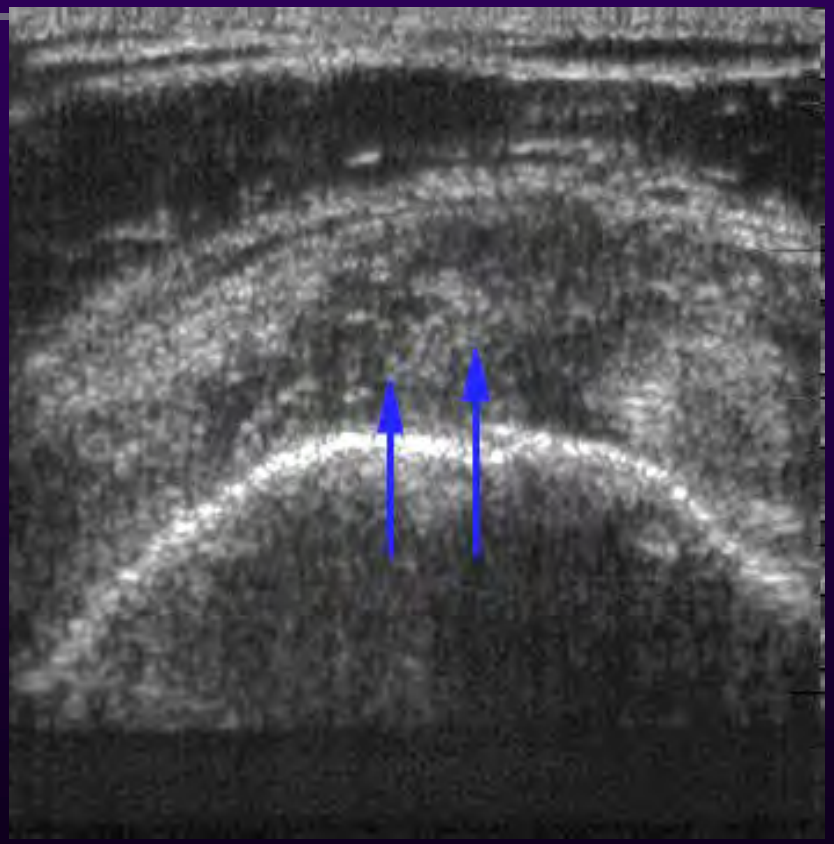
Diagnostic ultrasound



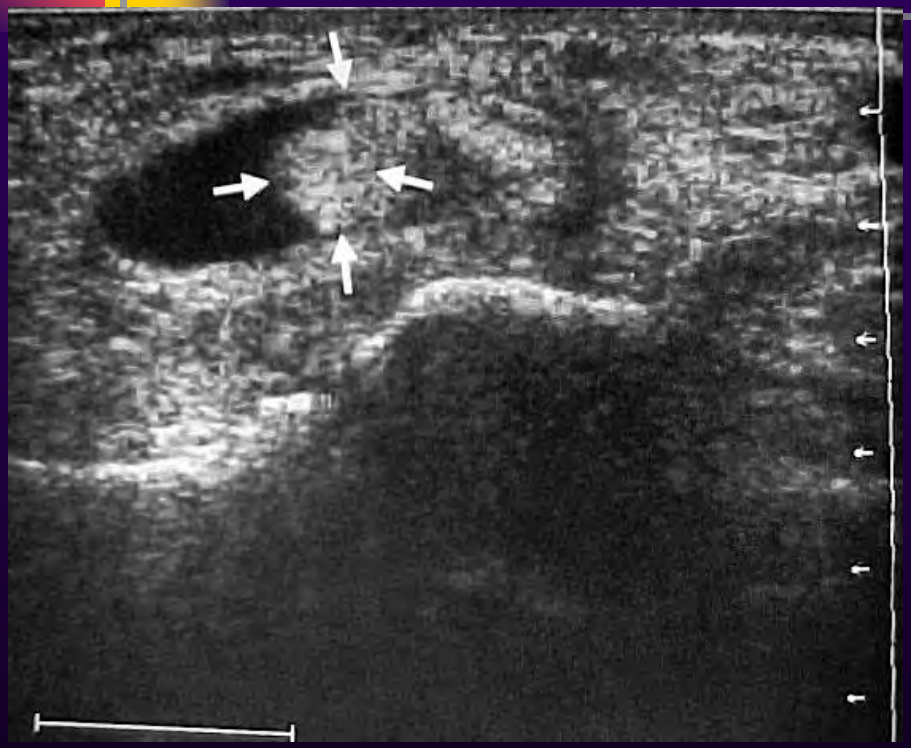
Diagnostic ultrasound

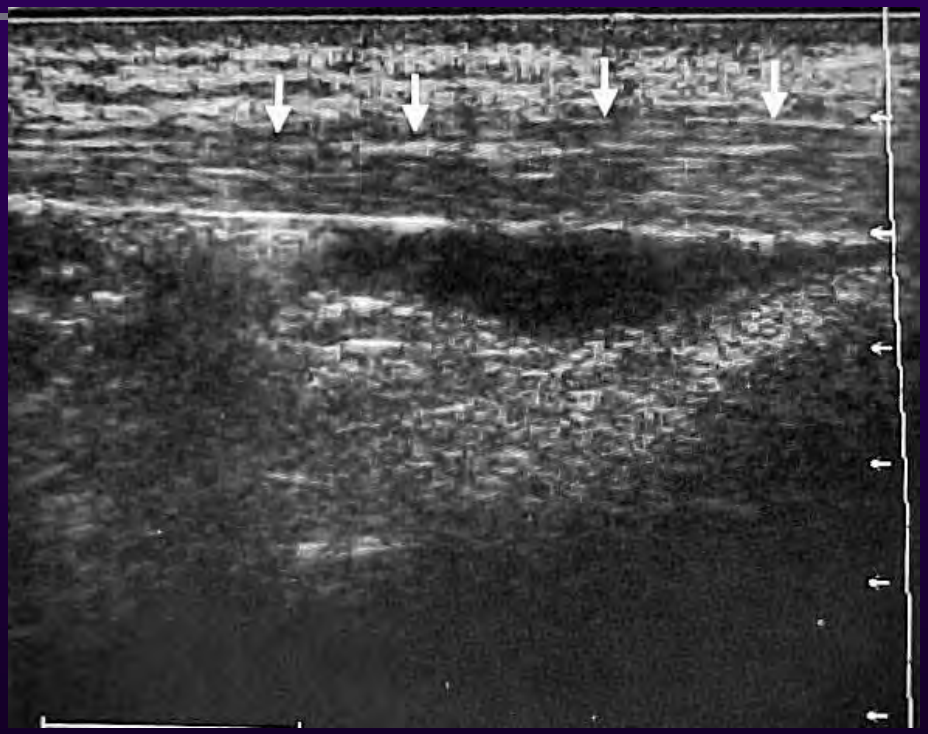


Diagnostic ultrasound



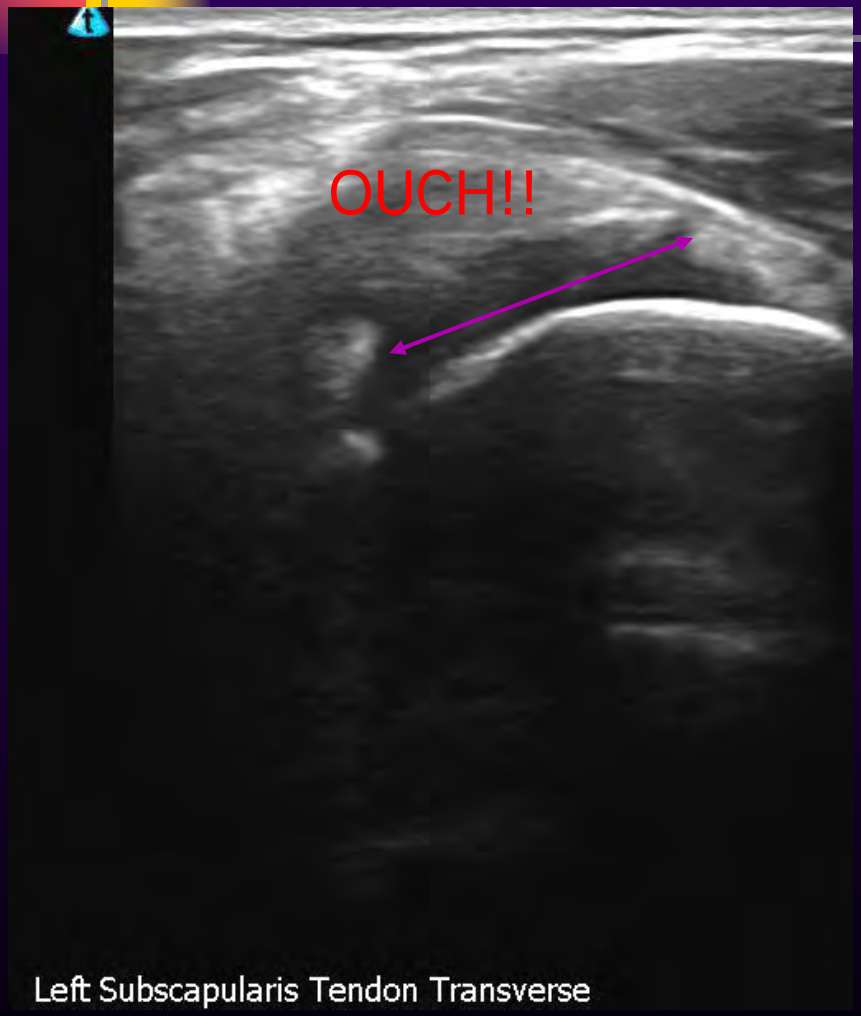
Diagnostic ultrasound

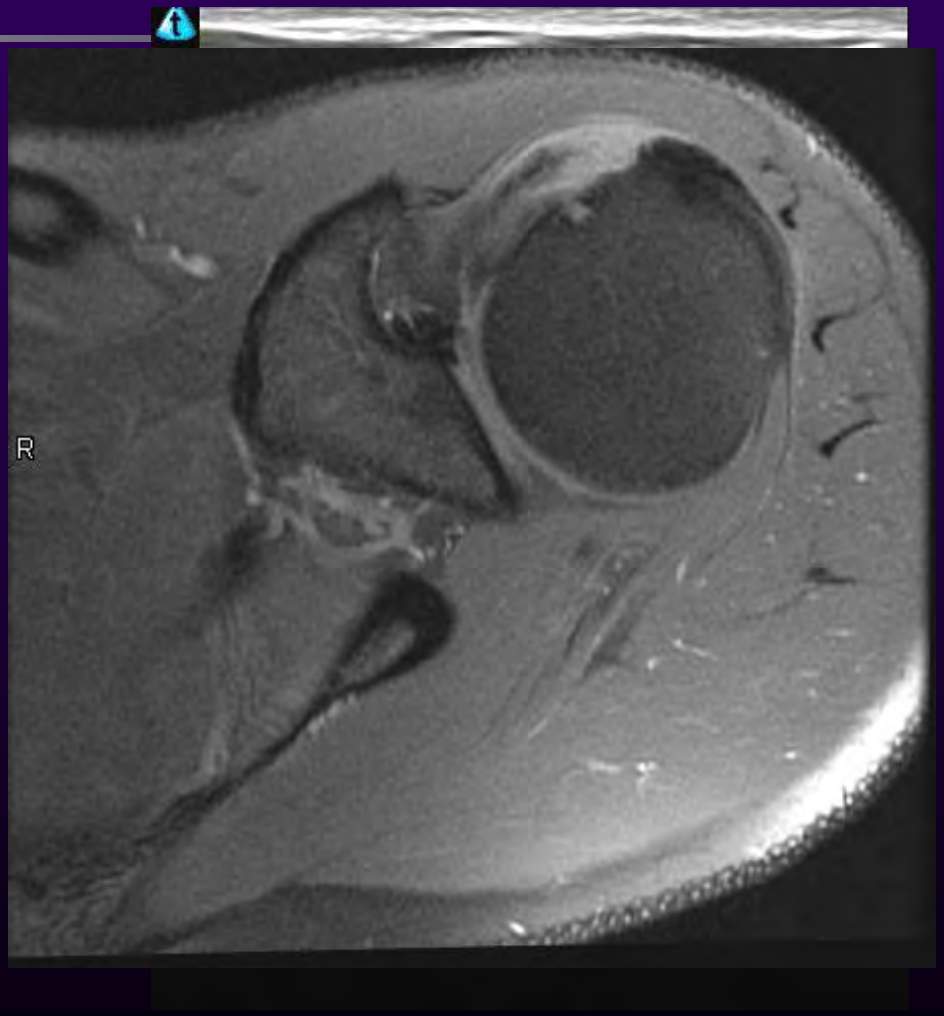




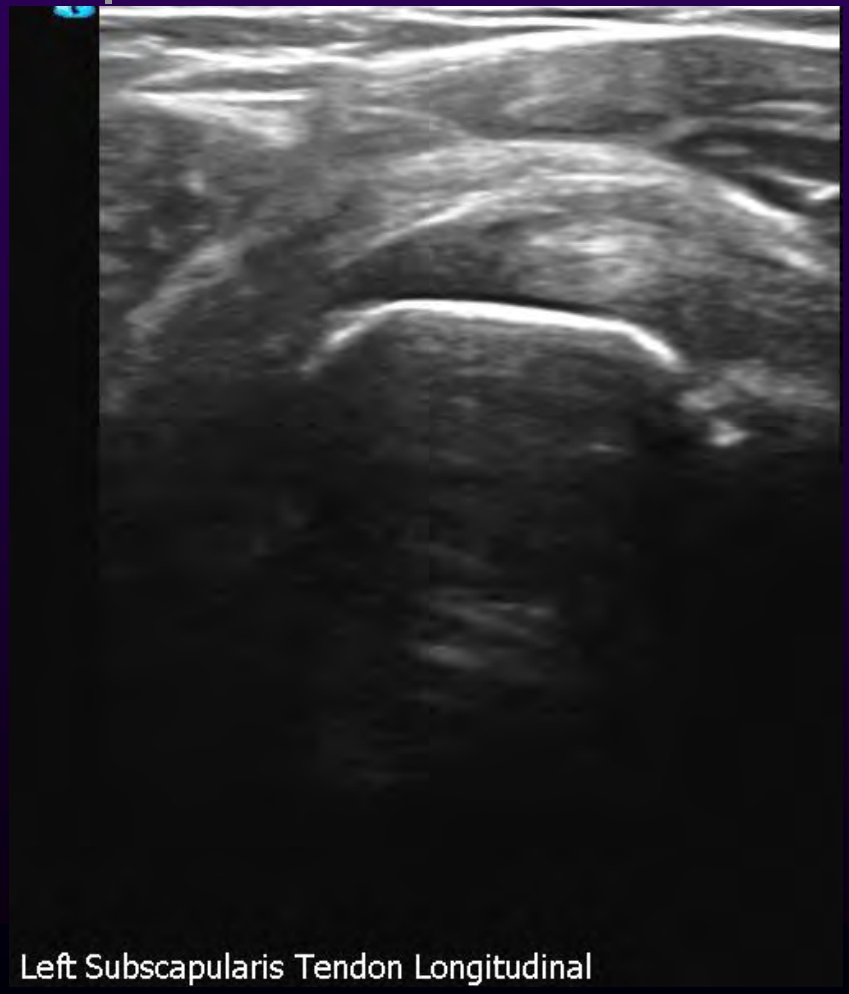
Tenosynovitis of the tibialis posterior tendon

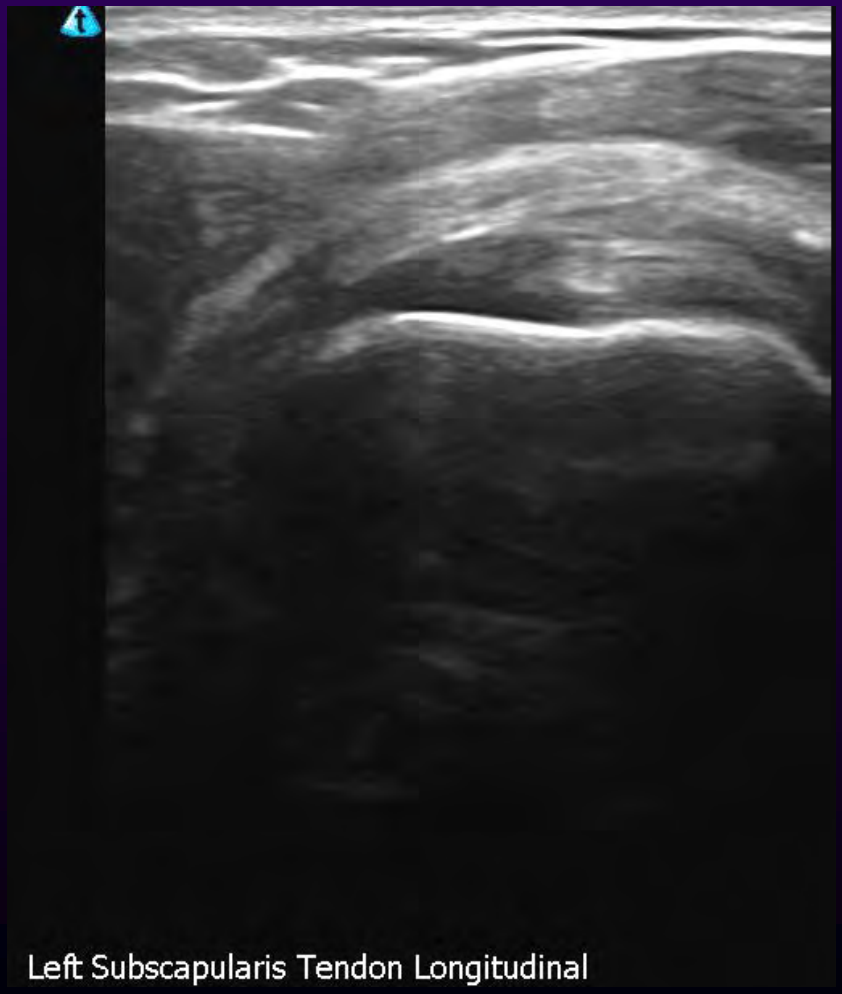
Diagnostic Ultrasound





Diagnostic Ultrasound





Diagnostic ultrasound

- Advantages:
  - Real time imaging
  - Good soft tissue resolution
  - No ionizing radiation
  - Relatively inexpensive
  - Shows early edema, and fibrotic changes
- Disadvantages:
  - Very difficult to interpret
  - Not all areas thoroughly researched (spine)
  - Shadowing effect

This ends our modalities review, thanks your time

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