Diagnostic Imaging in Sports

Module 2: Imaging Modalities (continued)

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Fluoroscopy

- Motion picture x-ray
- Good for the evaluation of mid-range instabilities
- Image quality is poor
  - Must have minimal radiographs of the area
  - Radiation dose for a cervical ~7 view Cspine x-ray
- Small office units
  - Underpowered
  - CSpine and extremities only
- Owning/ordering VERY dependent – check your board

MRI: Magnetic Resonance Imaging

MRI

PROS

- Excellent tissue contrast
- High resolution imaging
- Imaging in any plane
- Lack of ionizing radiation
  - Limited MRI of
    - Pregnant pts
    - Infants/children
- Relatively non-invasive
- Can add contrast for more information

CONS

- Availability
- Implanted metal
  - Absolute vs. relative contraindications
- Claustrophobia
- Obese patients
- Contrast reactions
- Expense
  - $500-4000

MRI Contraindications

- ABSOLUTE CONTRAINDICATIONS
  - Heart pacemaker
  - Metallic foreign body in the eye
  - Cochlear implants
  - Ferromagnetic surgical clips
- This only represents a partial list. Additional data at MRISafety.com

MRI Contraindications

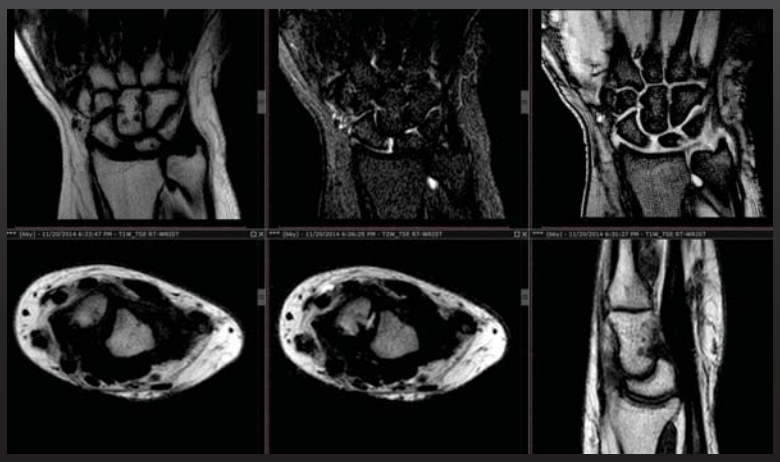
- RELATIVE CONTRAINDICATIONS / COMPLICATING FACTORS
  - Metallic devices in the area of interest that severely alter the resolution of the scan
  - Pregnant females: not a contraindication, however informed consent is a must
    - No evidence of fetal effect from MRI
  - Severe claustrophobia (Open MRI may be an option)
  - Morbid obesity (Open MRI may be an option)
- This only represents a partial list. Additional data at MRISafety.com

MRI Sequences

- MRI come with different “weightings”
  - aka “pulse sequences”
  - Allows MRI to highlight different tissues
- You don’t need to specify sequences with the imaging center
  - Make sure the center protocols are what you want
    - e.g. sagittal STIR in the spine

Pulse Sequences

- T1
- T2
- Proton Density
- Gradient Echo
- Fat suppression techniques



- Diffusion weighted images
  - Primarily a brain sequence, not MSK

The T1 Weighted Image

- "Short TR, Short TE"
  - TR<1000, TE<60
- This is a FAT image
- Fatty structures have HIGH signal (whiter)
  - Subcutaneous fat
  - Fatty marrow
  - Epidural fat

What is T1 Good For?

PROS

- Good anatomic detail (fast scan)
- Loss of epidural fat
- Evaluation of marrow pathology
- Hemorrhage

CONS

- Poor evaluation of edema
- STIR and FatSat T2 are more sensitive for marrow pathology

The T2 Weighted Image

- "Long TR, Long TE"
  - TR>2000, TE>60
- This is a WATER image
  - T2=H2O
- Watery structures have HIGH signal (whiter)
  - Synovial fluid
  - Edema
  - CSF

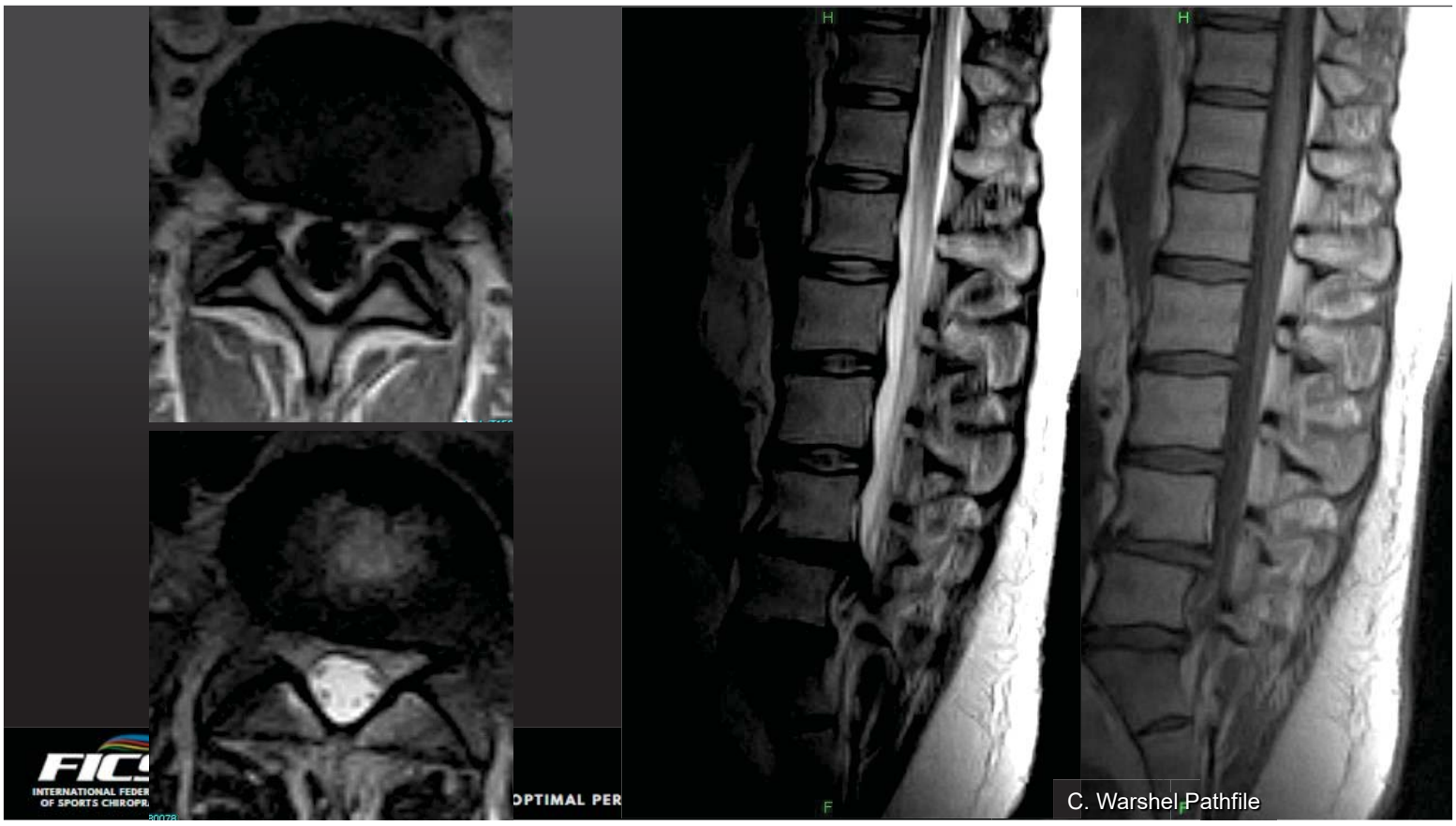
What is T2 Good For?

PROS

- Detecting fluid, edema
- Many marrow pathologies are "watery"
  - Malignancies
  - Infections

CONS

- Longer imaging times
  - Motion artifact
- Can miss marrow pathology without FatSat

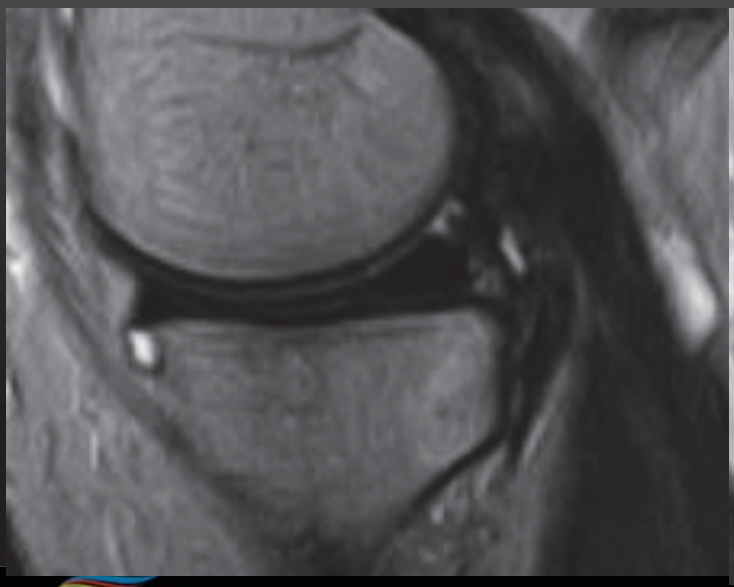


Other Image Sequences

- Proton Density
  - "Long TR, Short TE"
    - Really intermediate TR
    - TR>1000, TE<60
    - Signal relative to # of protons per unit volume

PROS	CONS
High anatomic detail	Poor tissue contrast
Excellent for fibrocartilage	Poor evaluation of edema
Meniscus	
TFCC in wrist	

T2, PD



C. Warshel Pathfile

T2, PD

C. Warshel Pathfile

Other Image Sequences

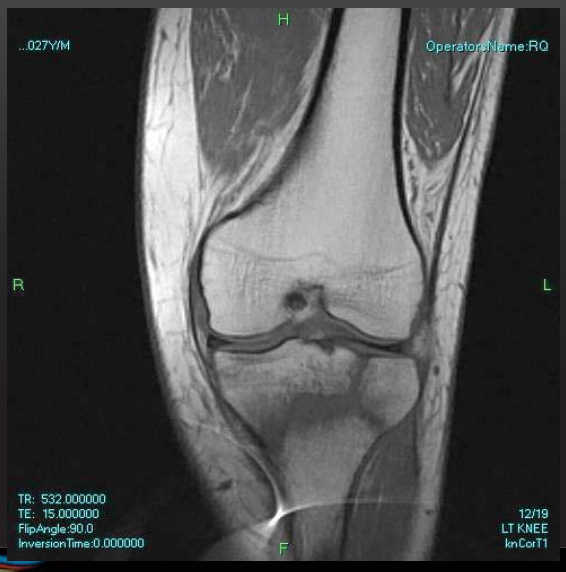
- Gradient Echo
  - Variable TR, TE, but has a FLIP ANGLE
  - Creates a T2 effect, with less time
    - If it looks like a T2, but the numbers are not consistent, look for a flip angle, it is probably a GRE T2

PROS	CONS
T2 effect, faster scan time, less motion	Reduced tissue contrast for muscle, fat
Excellent for small ligaments	Susceptibility effect
Usually cervical axial series	Loss of signal at tissue interfaces
Wrist and ankle	Edema in marrow and marrow fat
Excellent for cartilage	Bone and marrow replacement disease
Menisci, TFCC	
Loose bodies	

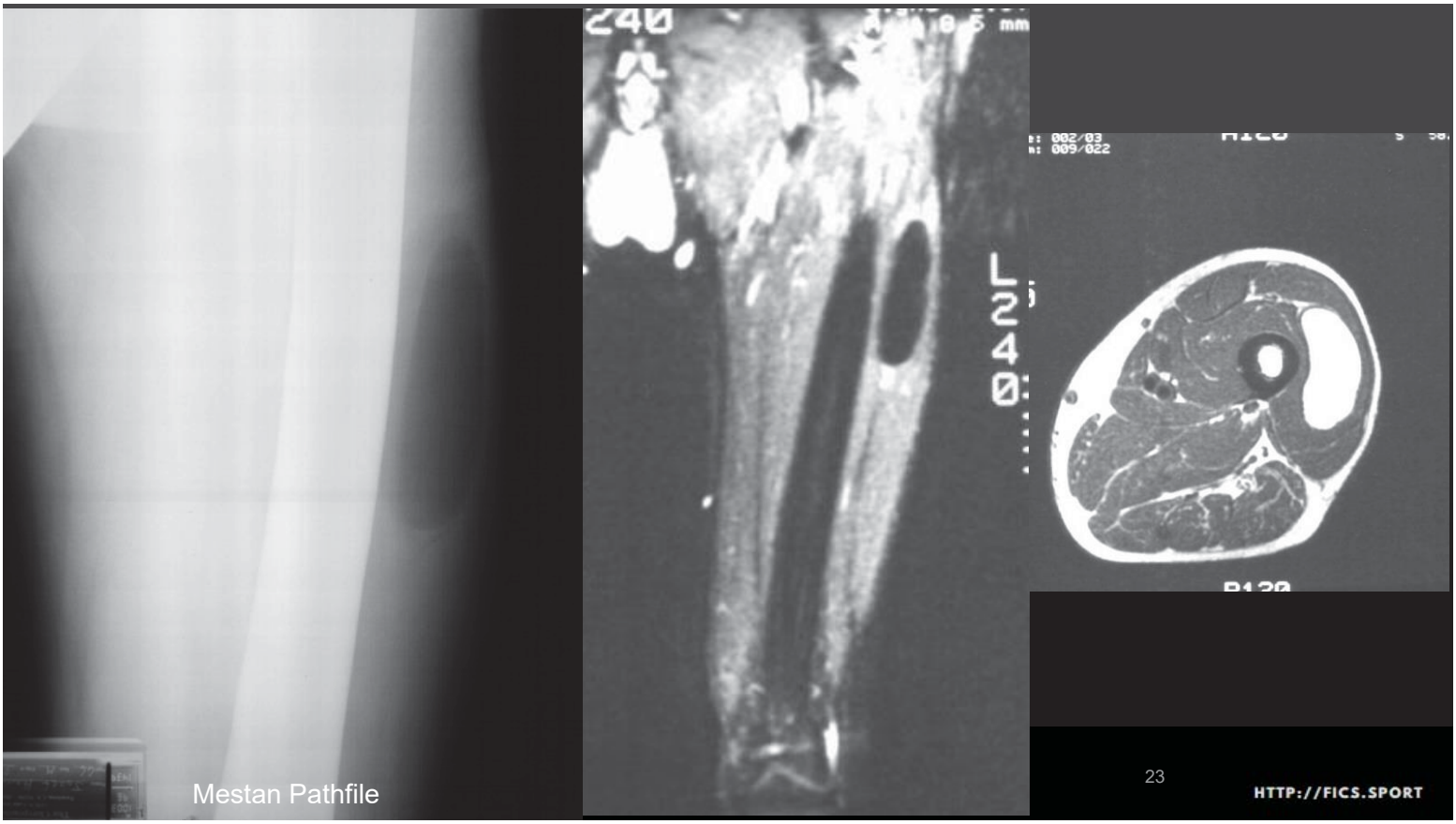
Fat Suppression Techniques

- Can be added to multiple types of pulse sequences to high light tissues
- STIR
  - Low field strength magnets
- FatSat
  - High field strength magnets

T1, STIR



C. Warshel Pathfile



Live DICOM Demonstration

- 00: Lumbar spine sequences
- 01: Cervical spine sequences (gradient echo)
- 02: Knee sequence (proton density and fat sat)

MRI Contrast

- The MRI contrast is Gadolinium
  - aka Gad, Gado
- Contrast is used to highlight particular structures
  - IV
  - Arthrography

MRI Contrast Indications

- IV: highlights vascular tissue
  - "Contrast goes where blood flows"
  - Malignancy / tumor mass
  - Infection
  - Post-surgical back
    - Distinguish scar vs. recurrent disc herniation
- Arthrography
  - Increases sensitivity for cartilage defects
    - Shoulder and hip labrum

IV: Precon and Postcon

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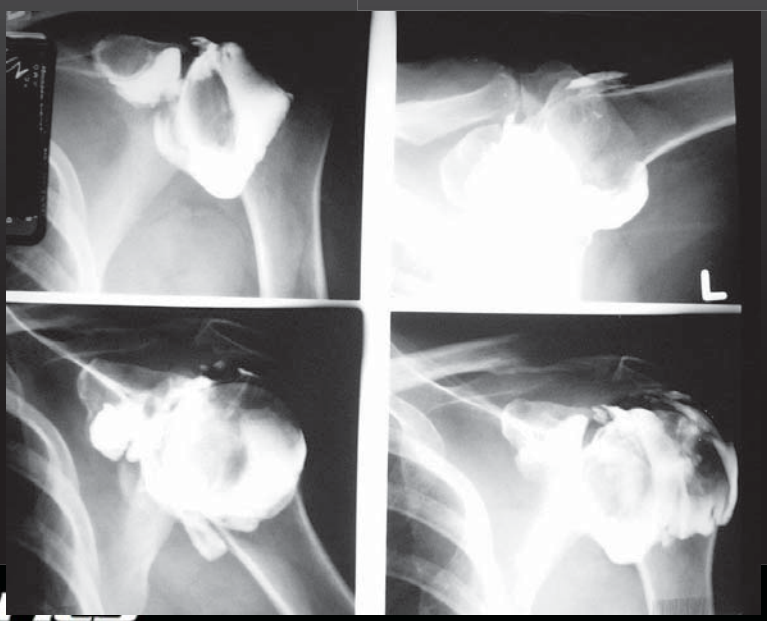
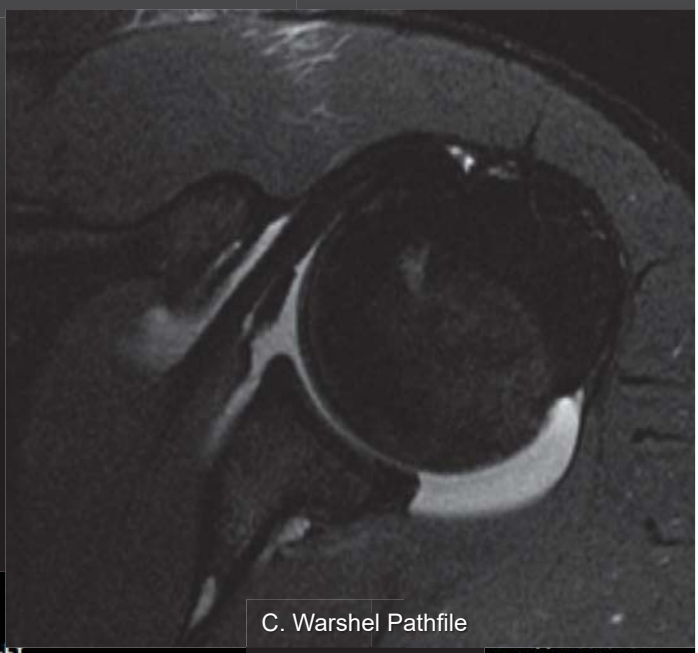
Shoulder Arthrogram





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MRI Contrast CONTRAINDICATIONS

- Generally very safe
- Renal insufficiency (Creatinine of 2.0+)
- Nephrogenic Systemic Fibrosis
  - AKA Nephrogenic Fibrosing Dermopathy
  - ~2.4% of patients undergoing MRI w/ Gado
  - Occurs in patients with renal insufficiency
    - Mostly dialysis patients, but not always
  - 20-48% 2 year mortality rates
  - Most pts wheelchair bound within weeks of onset

MRI Contrast CONTRAINDICATIONS

- Not used on pregnant patients unless absolutely necessary
- History of previous MRI contrast reactions

MSK MRI Quirks

- Metallic structures
  - Create signal voids
  - Interferes with seeing adjacent structure
  - Cannot visualize metal parts well
    - Can be used to evaluate a spine around fusion hardware
    - NOT useful for imaging joint replacements

CT: Computed Tomography

Image credit: University of Leicester

CT

PROS

- VERY available
- High resolution of minute structures
- Useful for MRI contraindicated patients
- Can add contrast for more information

CONS

- Very high dose study
- Has demonstrated overutilization (ER)
- Contrast reactions
- Expense
  - $500-2000

CT

- Computed Tomography
  - Formerly Computed Axial Tomography
- Radiation using modality
  - Substantially higher dose than radiographs
- No claustrophobia or obesity issues
- Excellent bony resolution
  - Much finer bony detail than radiographs
  - Great for difficult to visualize areas or complex anatomy

Live DICOM Demonstration

- 03: CT Cspine (bone detail)
- 04: CT Lspine (bone and disc)
- 05: CT Shoulder (bone, soft tissue, lung)

CT

- Imaging for acute head/brain
  - Stroke, epi/sub dural hematoma
- Gold standard for imaging
  - Chest
  - Abdomen
- Can also be used with contrast
  - IV: excellent vascular detail
  - Arthrography: where MRI arthrograms are contraindicated

CT IV Contrast Indications

- Highlights vascular tissue
  - Chest studies
    - Highlights the mediastinum, lung vasculature
  - Abdomen studies
    - Almost all abdomen CT
      - Except when evaluating for calculi (stones)
  - Malignancy / tumor mass
  - Infection

CT IV Contrast Contraindications

- Renal insufficiency (Creatinine of 2.0+)
- Renal failure
- Pregnancy
- Allergy to iodine or shellfish
- Thyroid diseases/cancers
- Previous contrast reactions

Diagnostic Ultrasound

Diagnostic Ultrasound

- Allows live time imaging, no ionizing radiation, no claustrophobia
  - Great for sideline usage
- VERY STEEP learning curve!

MSK Ultrasound Applications

- Spine
  - Limited application
- Extremities
  - Much broader application than the spine
    - Rotator cuff tears
    - Superficial tendons and ligaments
    - Evaluation of inflammatory arthritis and response to treatment
      - Rheumatoid arthritis
  - Not good for deep anatomy
    - ACL, glenoid labrum

Scintigraphy

Scintigraphy

- a.k.a. nuclear medicine
  - Most common used in MSK is bone scan
- Utilizes a radioactive pharmaceutical that is injected intravenously
  - Technetium 99MDP is M/C
  - Also gallium, indium or radiolabeled white cells for infection
    - Increased sensitivity and specificity for osteomyelitis vs. Tech
- The radiopharmaceutical is taken up by osteoblasts and its distribution is documented by a camera
  - Produces a physiologic skeletal survey based upon the local metabolic activity of the bone

Bone Scan

- Planar bone scan or a 3 phase bone scan
  - Planar bone scan is for metastasis, stress Fx, polyostotic bone lesions, avascular necrosis
  - 3 phase bone scan is useful in complex regional pain syndrome, and soft tissue infection vs osteomyelitis determinations
    - Angiographic phase
    - Blood pool phase
    - Bone scan phase

Bone Scan

- Indications
  - Early detection or high sensitivity is needed
    - Infection, malignancy
    - Stress injury
    - Avascular necrosis
    - Monostotic vs polyostotic bone disease, e.g. Pagets
    - Acute pars stress fracture
    - RSDS/CRPS
    - Prosthetic joint loosening

Bone Scan

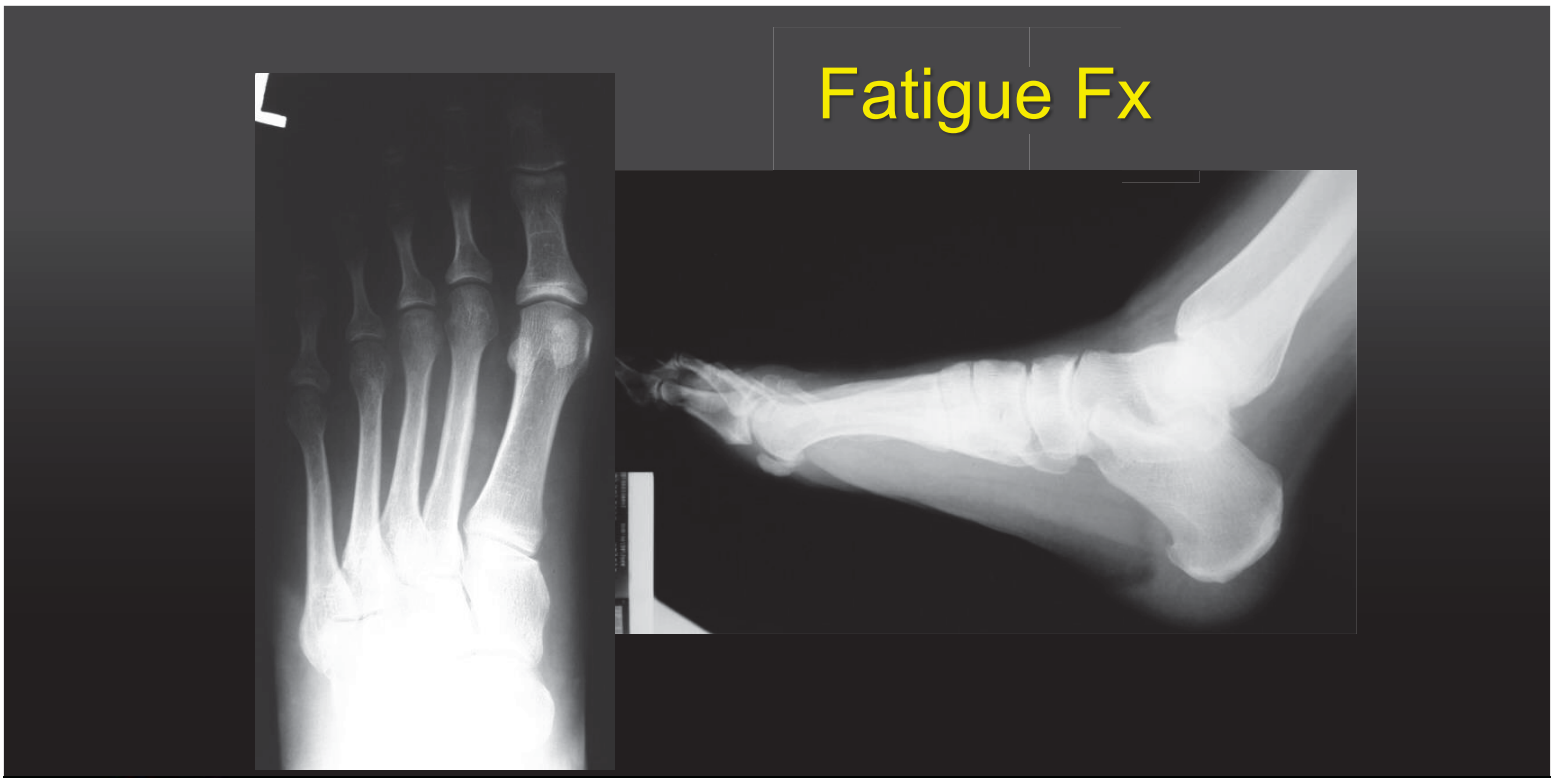
PROS

- Very sensitive
  - Only requires 3-5% change in bone density to detect
- Can be sectional
  - SPECT
- Low dose study
  - Highest dose is to the urinary system

CONS

- Poor specificity
- Still involves radiation
  - Very low whole person dose, high renal and bladder dose


R
Metastatic Disease
Image Source: C Warshel Path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Fatigue Fx
Image Source: M. Mestan Pathfile

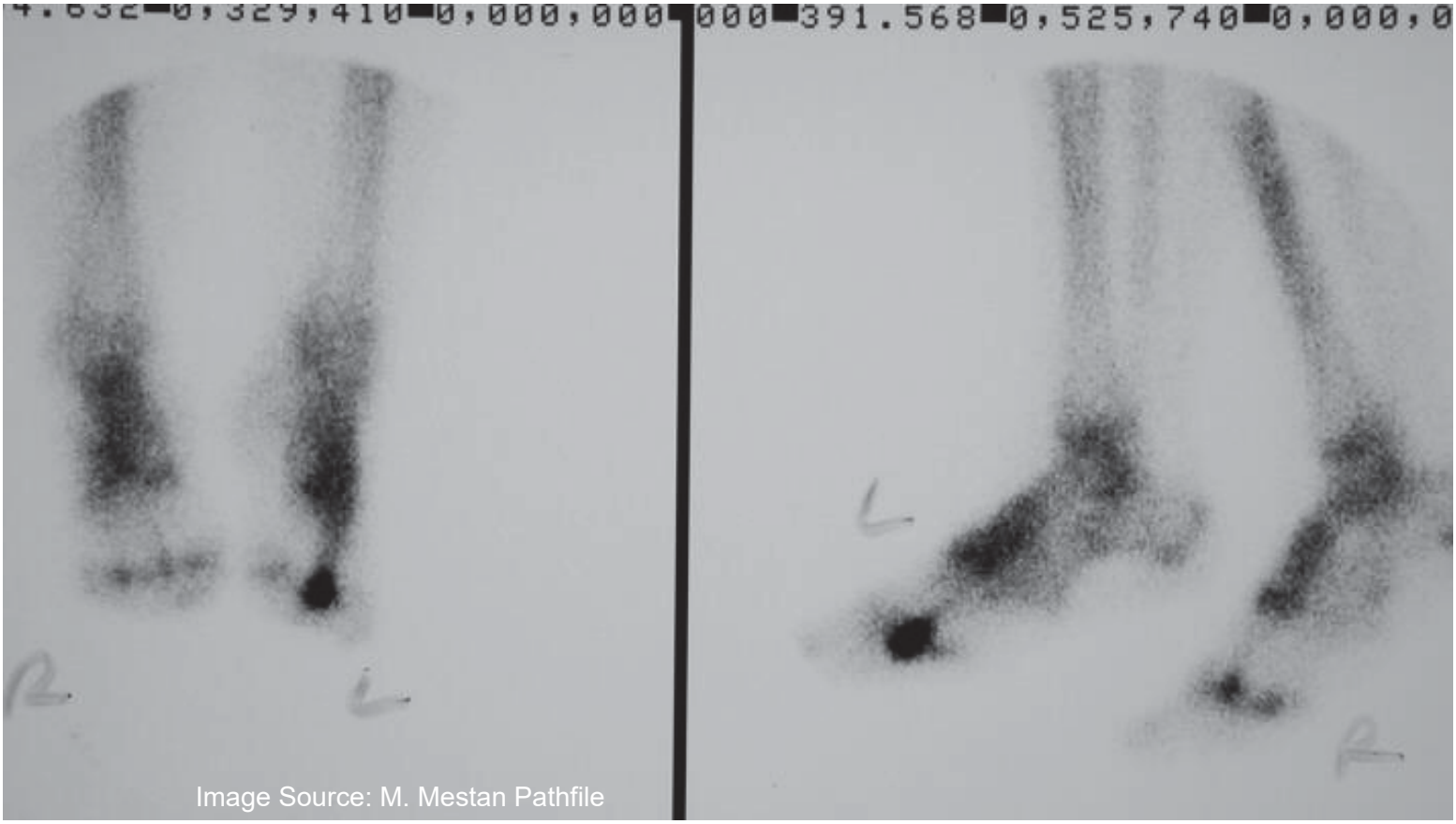


Image Source: M. Mestan Pathfile


Image Source: M. Mestan Pathfile

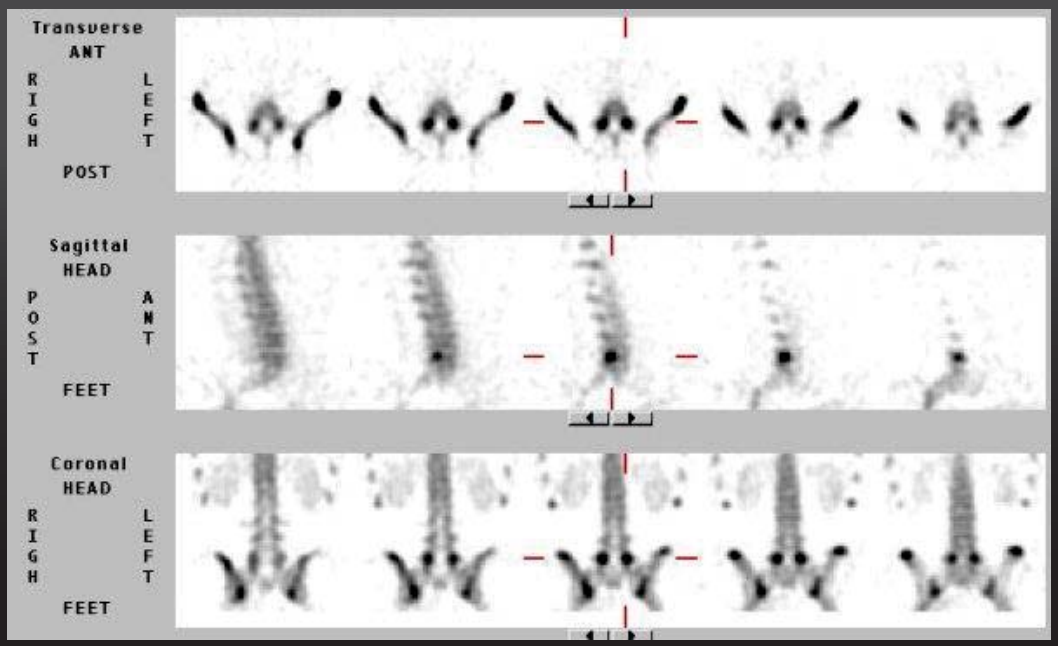
SPECT

SPECT

- Single Photon Emission Computed Tomography
  - Bone scan coupled with sectional imaging
  - Allows for 3D localization of lesions
  - Some “normal” findings can be warm on bone scans and hide pathologic findings on a planar scan
    - Degenerative changes, neuropathic joints
  - This allows us to see what is “normal” and what is pathologic

SPECT Applications

- Most commonly used for spinal imaging
  - Concern for active pars fractures
    - Or re-injury of old pars defects
    - SPECT has 10-20x better contrast than planar bone scan for pars defects
    - ***Has been supplanted by MRI with sagittal plane fat suppression (STIR or FatSat) techniques***



SPECT Scan

DEXA

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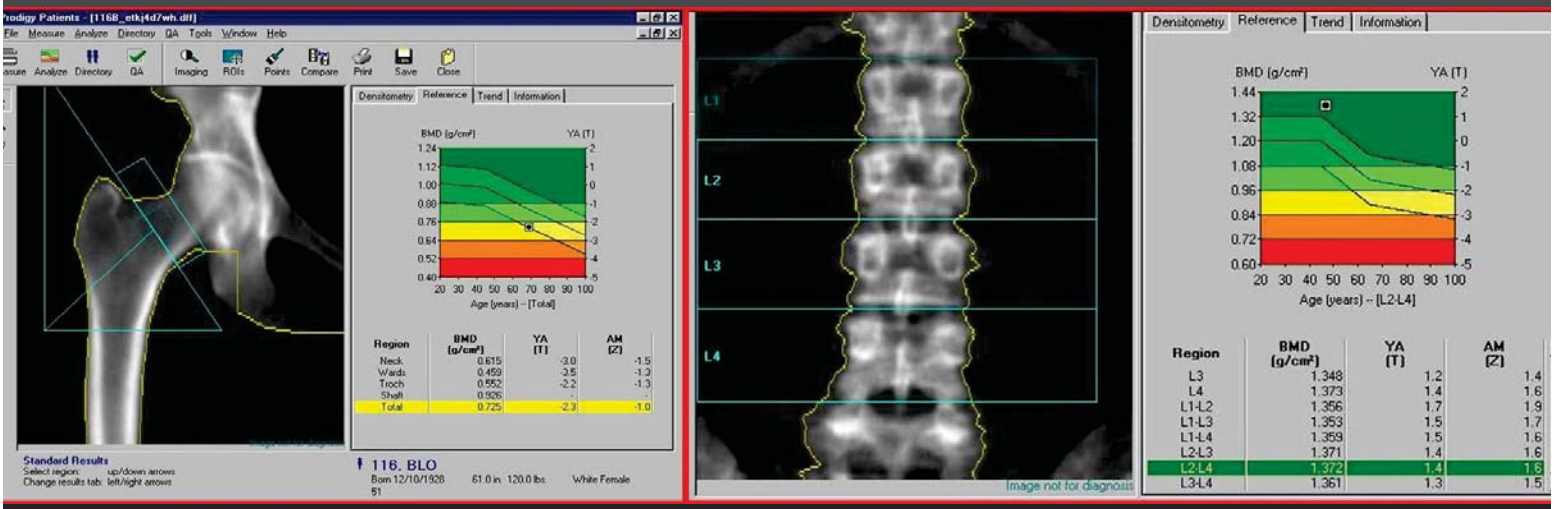
DEXA

- Dual Energy X-ray Absorptiometry
- Allows for quantification of bone density with accuracy and reproducibility
- Scans should be of the spine and hip
  - Extremity scans are of lower value, and have much more variability due to regional osteopenia situations, e.g. disuse post fracture
  - Exception being hyperparathyroidism
    - Distal forearm is the preferred region for evaluation

DEXA

- Other methods, e.g. QCT, QUS are not widely available
- Radiation dose = ~1/10 of a chest x-ray
- Images obtained are NOT diagnostic for bony pathology
- Other use of DEXA
  - Also used for determination of BMI



DEXA

- Diagnostic criteria laid out by the WHO
- 2 scores given as a standard deviation
  - T score: compares patient to 18-25yo gender and race match
    - This is used for risk of fracture in older populations
    - See next slide for criteria
  - Z score: compares patient to age, gender, and race match
    - This is used in men < 50, children, premenopausal women
    - In these populations, < -2.0 are below the expected range

DEXA Scoring

- WHO Criteria (T score)
  - >+1.0 = increased bone density
    - Can be a result of DJD, fluorosis, hyper vitaminosis D, osteopetrosis, etc
  - +1.0 to -1.0 = normal bone density
  - -1.0 to -2.5 = osteopenia
  - < -2.5 = osteoporosis
  - < -2.5 w/ Hx of fragility Fx = severe osteoporosis

DEXA and Fracture Risk

- T score predicts fracture risk
  - As you go down each whole number value
  - Double the risk of fracture
- If the T score is
  - -1.0 = 2x the risk of a “normal” density patient
  - -2.0 = 4x the risk
  - -3.0 = 8x the risk

End of Modalities