SHADES OF WHITE
15-18 JANUARY 2014
ENGLEBERG, SWITZERLAND

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THURSDAY 16 JANUARY

0800-1230: SESSION I. THE SPINE AND PELVIS

FRIDAY 17 JANUARY

0800-1230: SESSON III: THE LOWER LIMB

SATURDAY 18 JANUARY

0800-1300: SESSON IV: THE UPPER LIMB

THURSDAY 16 JANUARY

0800-1230: SESSION I. THE SPINE AND PELVIS

IMAGING SEQUENCES

T1
T2
PROTON DENSITY (PD)
STIR
GRADIENT ECHO
FAT SATURATION
GADOLINIUM
MR ANGIOGRAPHY (MRA)

SUMMARY OF SEQUENCE UTILITY

SEQUENCE	STRENGTH	WEAKNESS
T1	Anatomical detail Fat, subacute blood Marrow pathology Use with Gadolinium	Does not show edema Bone detail lacking
T2	Detection of water Detection of edema Longer imaging time Good with hardware	Need Fat Saturation to show marrow edema May not show subtle edema Fast spin echo makes fat bright
PD	Anatomical detail T1 and T2 properties Good for tendons	Edema not always visible Poor tissue contrast (“flat”)
STIR	Enhances edema Inherent fat saturation Long section imaging	Poor anatomical detail Long imaging time
T1 FS GAD	Enhances inflammation Vascular permeability Many conditions enhance-scar, infection, tumour, surgery	Must have normal renal function Risk of systemic nephrogenic fibrosis Must use in combination with fat saturation Enhancement is non-specific
MRA	Show arterial vessels No contrast required Excellent for large to medium vessels	Aneurysm may not fill Slow / turbulent flow artefacts Small vessel detail poor Calcium not well seen

T1 SEQUENCE

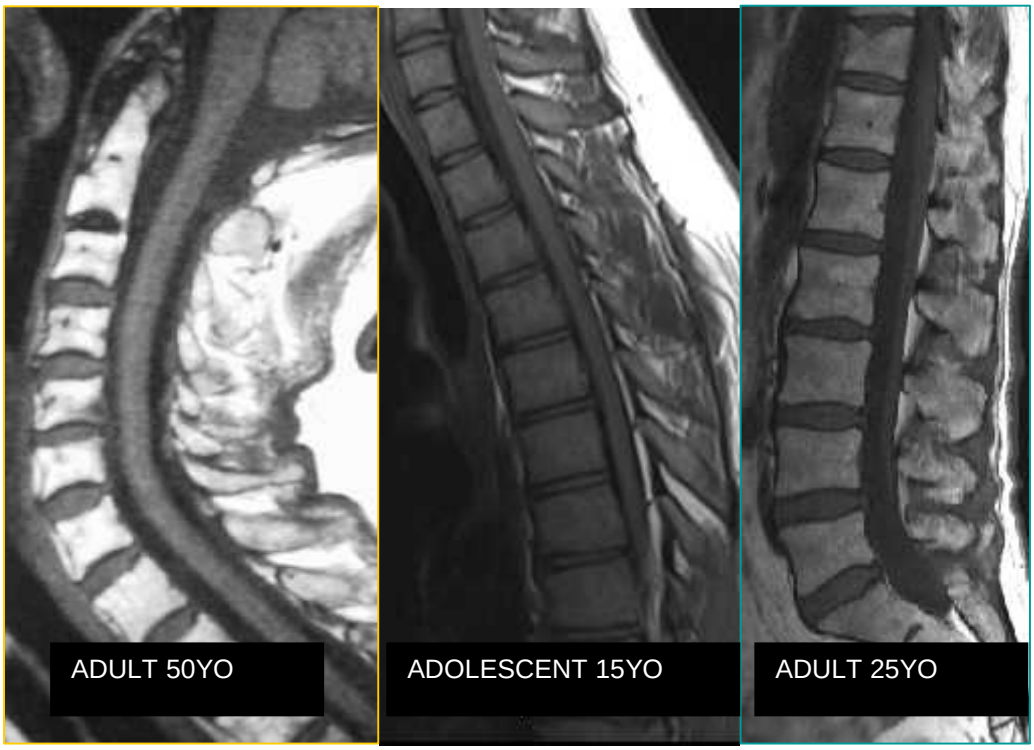
"Short-Short": Short TR (<800msec), Short TE (<30msec)

STRENGTHS

Anatomical detail
Fat, subacute blood
Marrow pathology

WEAKNESS

Does not show edema



Fat will be bright, water intermediate signal. Note fatty (yellow) marrow in 50yo, red marrow in 15 yo, mixed in 25 yo.

T2 SEQUENCE

"Long-Long": Long TR (>2000msec), Long TE (60msec)

STRENGTHS

Detection of water
Detection of edema

WEAKNESS

Longer imaging time
May not show subtle edema

Water will be high signal (T2=H2O), fat remains high signal.

ADULT 50YO ADOLESCENT 15YO ADULT 25YO

PD SEQUENCE

"Short-Long" (internmediate) TR>1000msec, TE<30msec
Use especially in extremities

STRENGTHS

- Anatomical detail
- T1 and T2 properties
- Good for tendons

WEAKNESS

- Edema not always visible
- Poor tissue contrast ("flat")

STIR SEQUENCE

TR>2000msec TE>30msec
Apply an inversion pulse first
- Enhances water signal
- Cancels effects of fat ("fat saturation")

STRENGTHS

- Enhances edema
- Inherent fat saturation
- Long section imaging
- Wide field of view

WEAKNESS

- Poor anatomical detail
- Long imaging time
- Motion artifact

T1 FS GADOLINIUM SEQUENCE

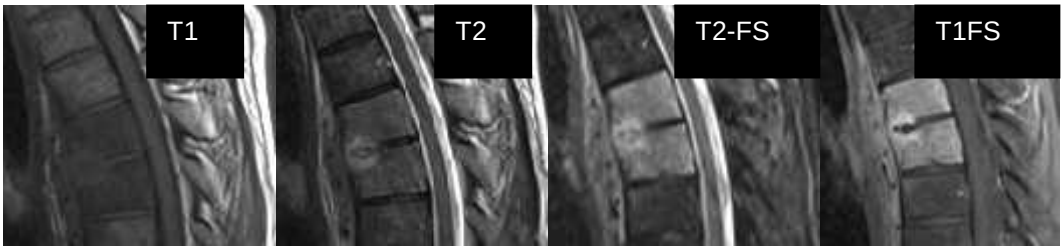
Gadolinium is paramagnetic and best depicted on T1 images
Combine with fat saturation
- Takes away high signal on T1 of normal fat
- Anything bright will be due to gad enhancement

STRENGTHS

Any condition which has vascular permeability will enhance
- Scar, infection, tumour operative sites, trauma

WEAKNESS

- Must have normal renal function
- Risk of systemic nephrogenic fibrosis
- Must use in combination with fat saturation (t1=bright fat)
- Enhancement is non-specific-many causes



MRA

Magnetic Resonance Angiography Use flow void of moving blood ("black blood technique")

STRENGTHS

- Show arterial vessels
- No contrast required
- Excellent for large to medium vessels

WEAKNESS

- Aneurysm may not fill
- Slow / turbulent flow
- Small vessel detail poor
- Calcium not well seen

SUMMARY OF SEQUENCE UTILITY

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PATIENT PREPARATION

- Clear on indications
- Clarify cost
- Take previous studies
- Warnings
    - Exclude contraindications
    - Claustrophobia
    - Noise
    - Length of examination
    - Need for Gadolinium

MRI CONTRAINDICATIONS

- Ferromagnetic material
    - Orbit metallic foreign body
    - Cardiac pacemakers
    - Some heart valves
    - Cochlear implants
    - Jewellery
    - Tattoos
    - Acupuncture needles
- Body habitus
- Claustraphobia

PRINCIPLES OF INTERPRETATION

SEQUENCES

BASIC

SAGITTAL T1
SAGITTAL T2
AXIAL T2

ADDITIONAL

SAGITTAL STIR
SAGITTAL GRADIENT ECHO
T1 FS

METHOD OF INTERPRETATION

1. *IDENTIFY THE PATIENT*
2. *IDENTIFY AND INTERPRET SCOUT IMAGES*

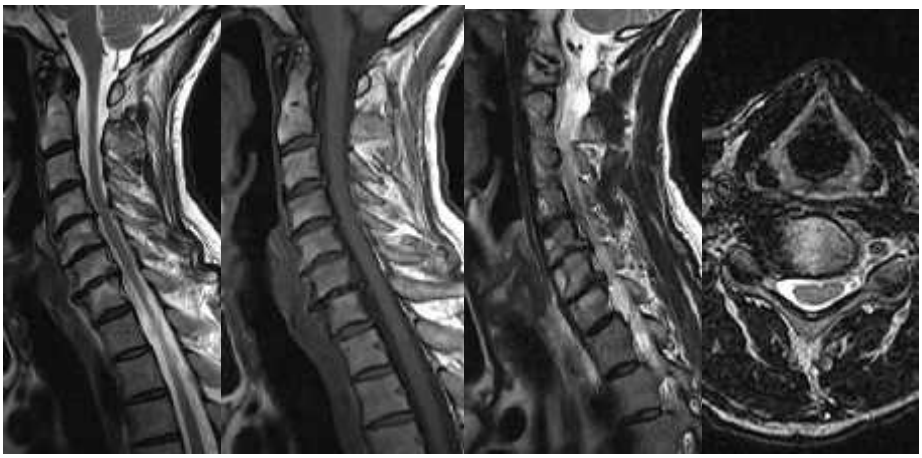
3. *LOCATE SAGITTAL T2*
   - Find mid sagittal image
   - Follow parasagittal images left and right to IVF
   - A: Alignment
   - B: Marrow signal
   - C: Disc spaces, facet joints
   - S: Spinal cord, soft tissues (anterior, posterior)

4. *LOCATE SAGITTAL T1*
   - Repeat as for T2 but look carefully at-
     - Bone marrow signal
     - Ligaments

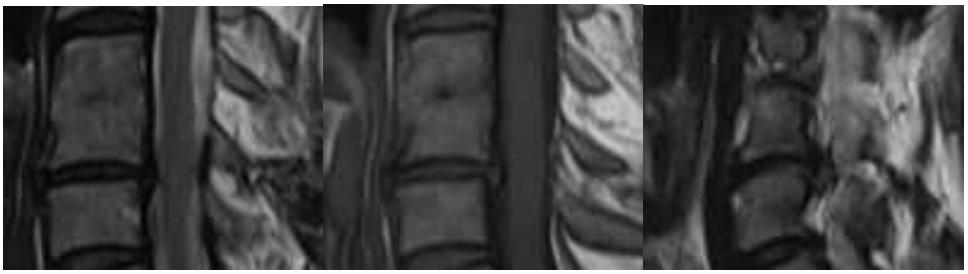
5. *LOCATE AXIAL T2*
   - Start at highest level and identify disc levels
   - Find pedicles, disc space is just above
   - Identify posterior disc margin and note shape and size
   - Identify the spinal cord and subarachnoid space
   - Locate exiting nerve roots

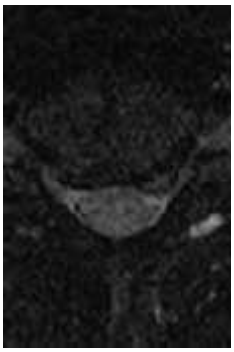
CERVICAL SPINE CASES

CASE 1. A 45 YEAR OLD WITH RIGHT ARM PAIN AND PARESTHESIA TO THE INDEX FINGER

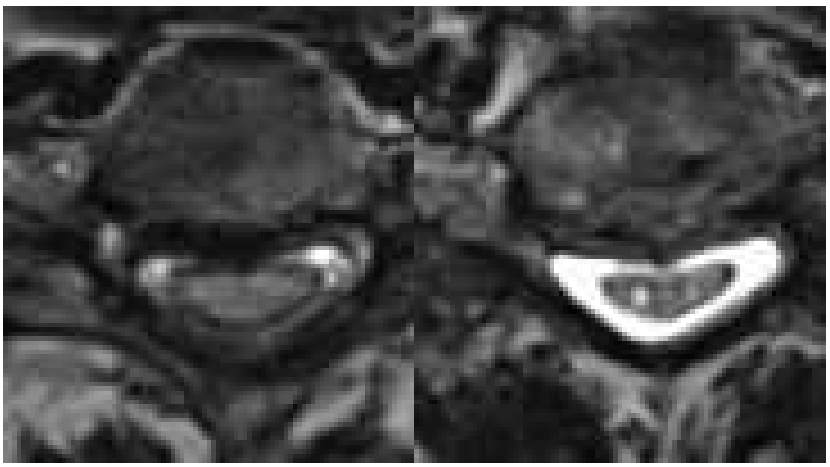


CASE 2. A 32 YEAR OLD MALE RUGBY PLAYER WITH NECK PAIN AND LEFT ARM WEAKNESS.

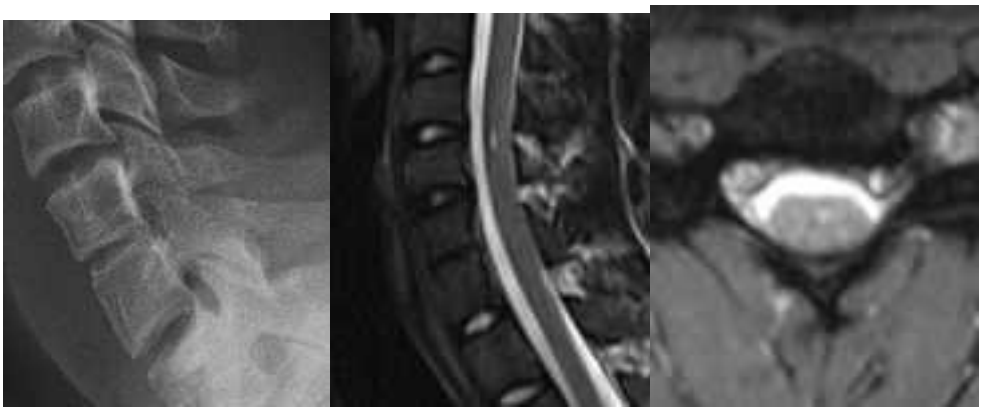




CASE 3. A 65 YEAR OLD MALE WITH BILATERAL ARM WEAKNESS AND PAIN



CASE 4. A 36 YEAR OLD MEDICAL PRACTITIONER WITH HORNER'S SYNDROME AND RIGHT ARM SHOULDER WEAKNESS.

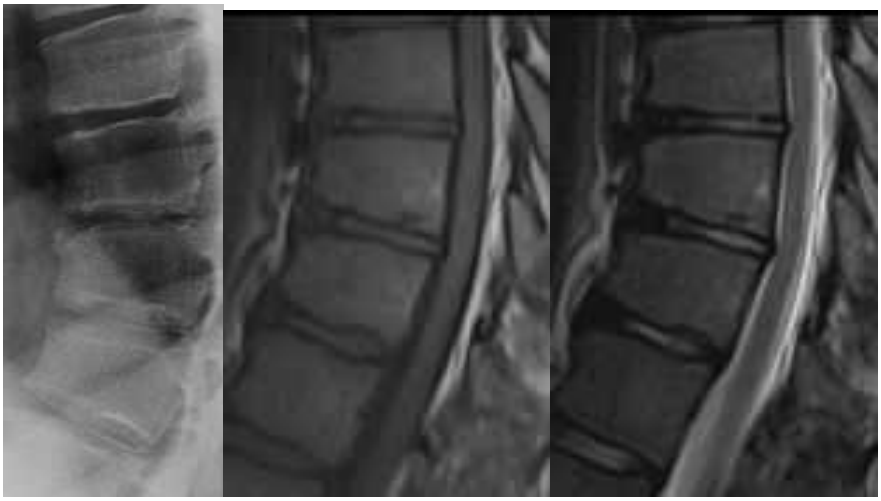


CASE 5. A 45 YEAR OLD MALE WITH NECK PAIN.

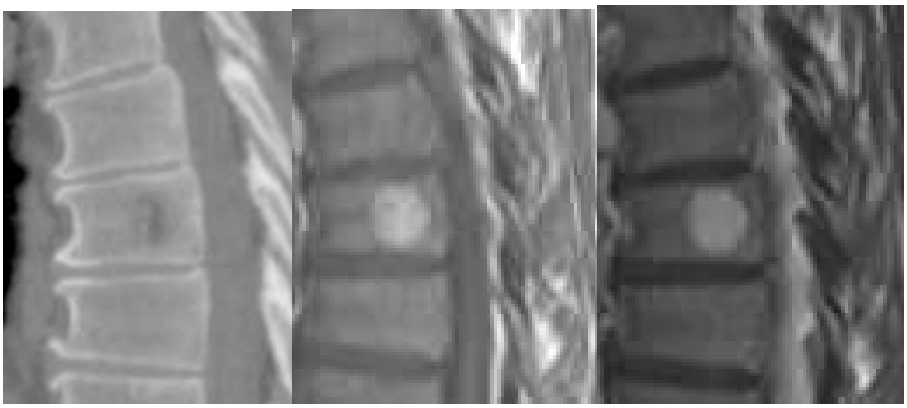
THORACIC SPINE CASES- SHADES OF GREY

CASE 1. A 16 YEAR OLD FEMALE WITH PAIN

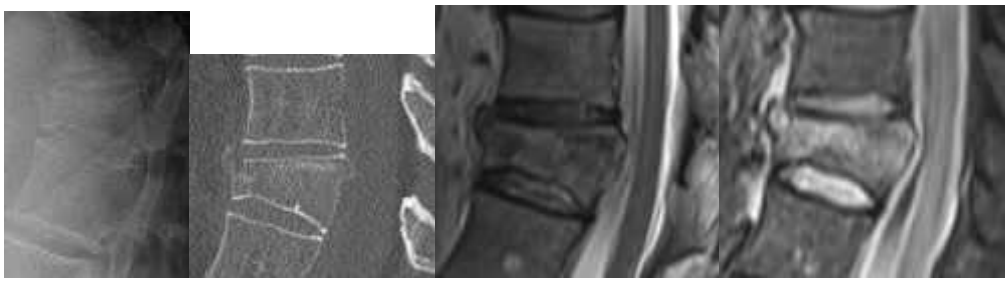
CASE 2. AN 18 YEAR OLD MALE WITH THORACIC SPINE PAIN.



CASE 3. A 62 YEAR OLD FEMALE WITH PREVIOUS BREAST CANCER NOW THORACIC SPINE PAIN.



CASE 4. A 46 YEAR OLD MALE WITH ACUTE BACK PAIN.



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   - C: Disc spaces, facet joints
   - S: Spinal cord, soft tissues (anterior, posterior)
4. *LOCATE SAGITTAL T1*
   - Repeat as for T2 but look carefully at-
     - Bone marrow signal
     - Ligaments
     - Nerve root exits
5. *LOCATE AXIAL T2*
   - Start at highest level and identify disc levels
   - Find pedicles, disc space is just above
   - Identify posterior disc margin and note shape and size
   - Identify the spinal cord and subarachnoid space
   - Locate exiting nerve roots

LIST OF LUMBAR SPINE ANATOMICAL STRUCTURES

L1-L5

Disc
- Hydration
- Height
- Posterior shape

Vertebral body
- Shape
- Marrow signal
- Discovertebral

Facet joints

Spinal cord

Posterior soft tissues
- Multifidus
- Ligamentum flavum
- Facet joint capsule
- Posterior long lig

Anterior soft tissues
- Psoas
- Aorta

I. ANATOMICAL HOUSE

Conceptual approach to understanding disc disease and the relationship to exiting nerves.

The Three Stories

Each vertebral segment can be conceptualized as having three "floors".

A. The First Floor- The Intervertebral Disc Zone

At the level of the intervertebral disc.

Intervertebral disc
Posterior longitudinal ligament
Epidural venous plexus
Epidural fat
Facet joints
Ligamentum flavum
Nerve root
Thecal sac

B. . The Second Floor - The Foraminal Zone

At the level of the intervertebral foramen.

Vertebral body
Epidural venous plexus
Nerve root
Dorsal root ganglion
Epidural fat
Lateral canal divisions
- Lateral recess
- Sub-articular
- Foraminal (sub-pedicular)
- Extra-foraminal ("far-out" zone)

C. The Third Floor- The Pedicle Zone

At the level of the pedicle.

Contents:

Vertebral body
Pedicle
Basi-vertebral vein
Lateral recess
Nerve root
Epidural fat

NB: 1. Up to 15-30 percent of asymptomatic persons have an abnormal disc on CT of the lumbar spine.

2. Up to 50 percent of asymptomatic persons have an abnormal disc on MR of the cervical or lumbar spines.

II. DISC BULGING

Loss of water and proteoglycans; redundant annulus around entire disc

XR: Normal, early osteophytes, loss of disc height
CT: Convex posterior margin
MRI: Convex posterior margin, annulus usually intact
Contributes to central and lateral canal stenosis

III. INTERNAL DISC DISRUPTION

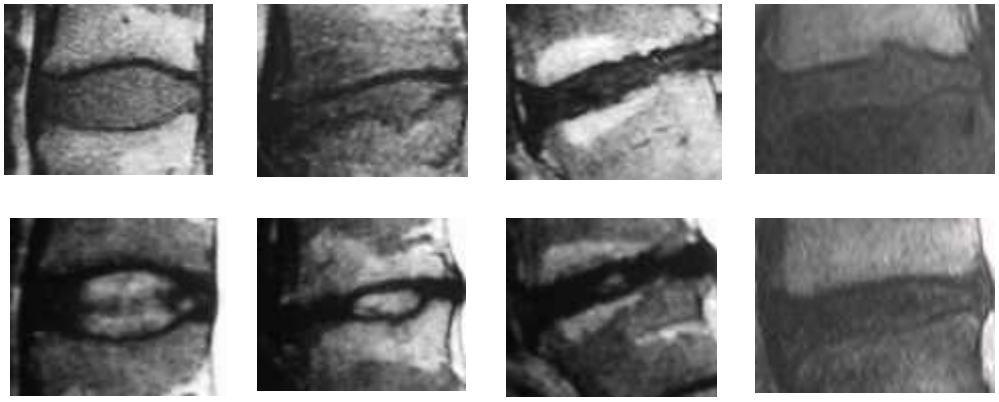
Annular tears exposing nuclear material to the immune system
Pain from outer third of the annulus
CT: Vacuum in outer annulus
Discography and combined with CT- "CT Discography" main method of diagnosis
HIZ- high intensity zone on MR in annulus

IV. DISC RESORPTION

Rapid collapse of the disc, vacuum with few osteophytes

MODIC CHANGES AT THE DISCOVERTEBRAL JUNCTION

NORMAL TYPE 1 TYPE 2 TYPE 3



Normal Edema Fat Sclerosis

V. DISC HERNIATION

Lateral selects a single root/ central more roots
Disc may dissect superiorly or inferiorly
Reduce 30% of initial volume in first year and then less than 5% in following 5 years
Central large herniations can result in cauda equina syndrome (MRI best study)
May be associated with epidural hematoma
Chronic herniation signs: calcification, vacuum, osteophytes

VI. DISC SEQUESTRATION

Free fragment

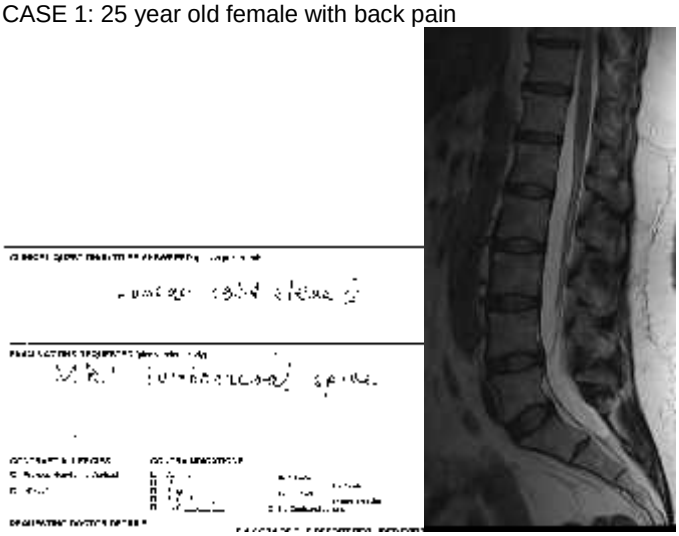
VI. SPONDYLOLISTHESIS

Rare as an isolated acute # -
usually a chronic unhealed stress #
* L5: 90% L4: 8% L1-L3: 2%
* 5% of the Caucasian population,
higher in athletes
i. Unilateral Spondylolysis (Wilkinson's syndrome)
* Contralateral sclerosis of pars and pedicle
* Sclerosis disappears when get second defect
ii. Bilateral Spondylolysis
* Usually between 10-14 years of age
* Slip follows within one year
No slip through adult years is typical
May slip secondary to disc degeneration later

MRI IN SPONDYLOLISTHESIS
T1, T2, STIR or T2FS
Status of the pars defect
Bone
Cartilage
Edema
Nerve compression
Associated disc herniation

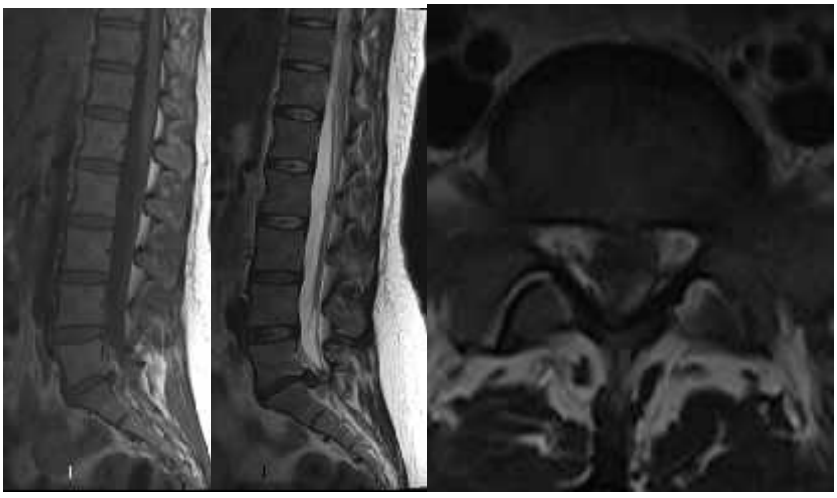
LUMBAR SPINE CASES - “SHADES OF GREY”

CASE 1: 25 year old female with back pain

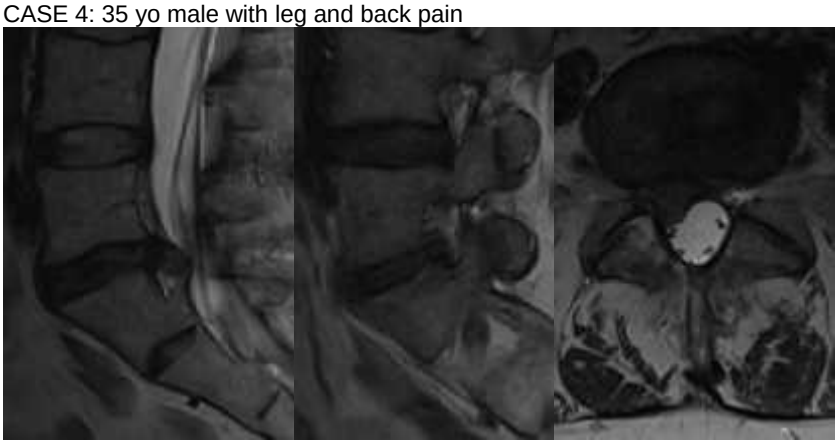


CASE 2: 45 year old nurse with leg pain

CASE 3: 48 year old medical physician with acute back pain



CASE 4: 35 yo male with leg and back pain



CASE 5: 44 year old with back pain after waterskiing. Normal xray.

SACROILIAC JOINT

NORMAL ANATOMY / PRINCIPLES OF INTERPRETATION

JOINT COMPONENTS

- ANTERIOR
  - SYNOVIAL
- POSTERIOR
  - LIGAMENTOUS
- SUPERIOR
- INFERIOR

ARTICULAR CARTILAGE

- SACRAL
- ILIAC

BONE LANDMARKS

- SYNOVIAL SURFACES
- ARTICULAR CREST
- LIGAMENTOUS CREST

MRI SEQUENCES

CORONAL T2FS OR STIR
AXIAL T2 FS

JOINT DISEASE

- OSTEOARTHRITIS

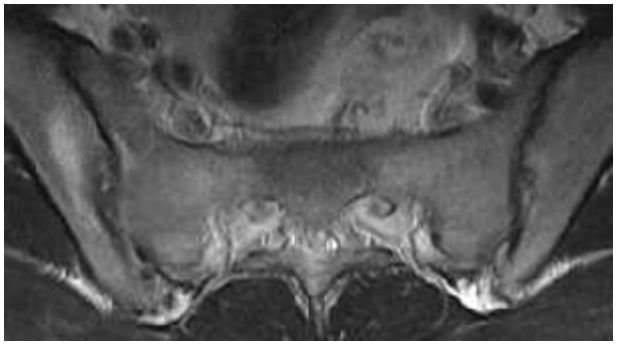
- OCI
- DISH
- SENILE ANKYLOSIS
- INFLAMMATORY
  - GRADING SACROILIITIS
    - 0: NORMAL
    - 1: SUSPISCIOUS - BLURRED JOINT SURFACE
    - 2: ABNORMAL- EROSIONS, ALTERED JOINT SPACE, SCLEROSIS
    - 3: MARKED DISEASE- EROSIONS, SCLEROSIS
    - 4. ANKYLOSIS
- SEPTIC

BONE DISEASE

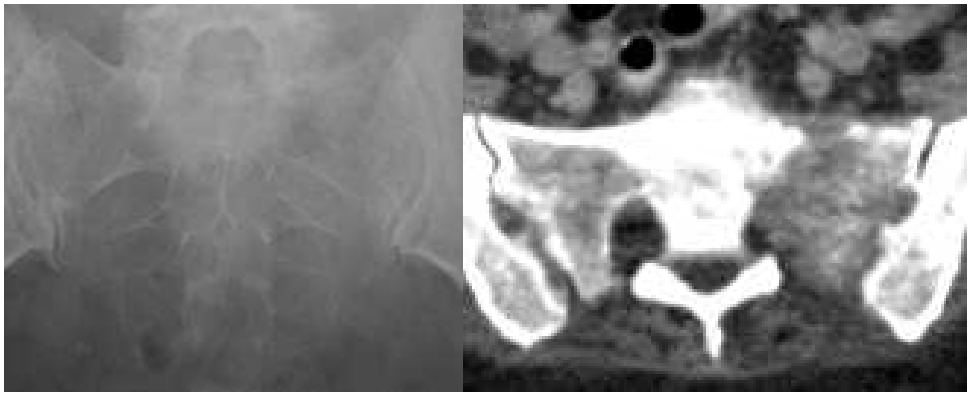
1. INSUFFICIENCY FRACTURE
   - Most common sacral pathology over the age of 65 years of age
   - Osteoporosis with fall or hip replacement
   - Sacral and Groin pain on standing
   - Fractures not evident on X-ray
   - Fractures parallel SIJ and connect across S2-3
   - "H" fractures
2. BONE TUMOUR
   - Sacral foraminal lines key structure
   - Metastatic most common

SIJ AND SACRUM CASES - "SHADES OF GREY"

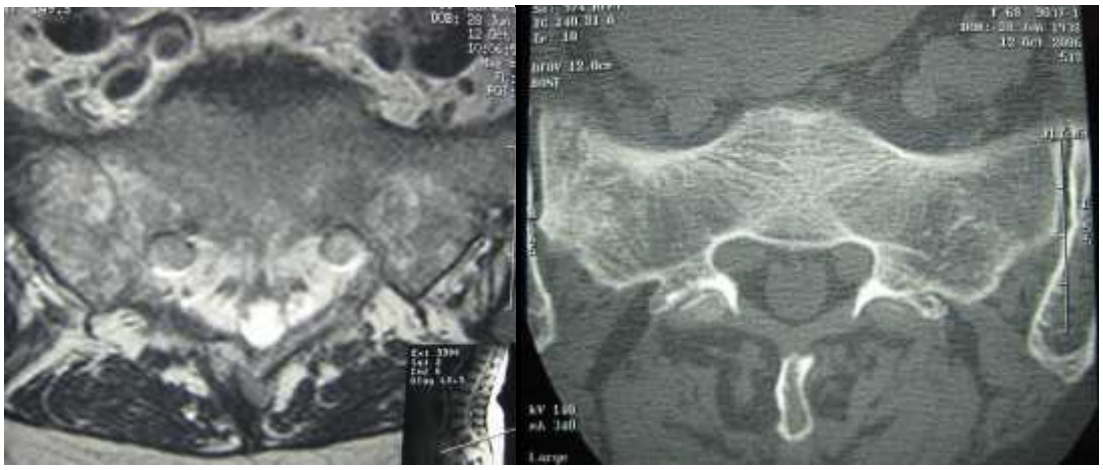
CASE 1: 26 year old male with back pain



CASE 2: 53 year old male with back pain



CASE 3: 68 year old female with back and groin pain.



PUBALGIA

ANATOMY

Symphisis joint

- Solid at birth (amphi-arhrosis)
- Develop a cleft in adolescence *"PRIMARY CLEFT"*
- Degenerative cleft in adults *"SECONDARY CLEFT"*
- Prominent blood supply in body of pubis
  - Many A-V shunts identified
- Innervation prominent
- Adductor longus-rectus abdominus continuous
  - In a sheath which attaches with the anterior pubis

OSTEITIS PUBIS

- Disorder of the joint with inflammation and bone resorption
- XR- bone loss of joint surface
  - Sclerosis
  - Wide joint space
- MR- Bone marrow edema
  - Secondary cleft sign- fluid in joint extending beneath sheath

APONEUROSIS TEAR

- Adductor longus-rectus abdominus continuous
  - In a sheath which attaches with the anterior pubis
  - MR diagnosis- secondary cleft sign
    - Muscle edema
    - Bone marrow edema

MRI Pubic Protocols

Coronal

- STIR
- T1

Axial

- T2 FS

Sagittal

- T2 FS

Axial Oblique

- T2 or PD FS

OTHER CAUSES OF PUBALGIA

- Sub pubic cartilaginous cyst
- Inguinal hernia
- Seronegative arthropathy
- Crystal arthropathy
- Tumour
- Infection

- Zoaga et al. Athletic pubalgia and the "sports hernia": MR imaging findings. Radiology. 247:797-807, 2008.

FRIDAY 17 JANUARY

0800-1230: SESSON III: THE LOWER LIMB

THE HIP

IMAGING PROTOCOLS

PLAIN FILM RADIOGRAPHY
- AP PELVIS
- AP SPOT
- FROGLEG

CT
- MULTISLICE TECHNOLOGY
- MPR- Multi-planar reconstructions (Sagittal, Coronal, other)
- 3D

US
- Joint Effusion
- Tendons
- Bursa

MRI
- **Coronal**
  - T1
  - T2 FS
  - STIR
- **Axial**
  - T1
  - T2 FS
- **Sagittal**
  - T2
  - PD
- **Arthrogram**
  - T1/PD FS
- **Pubic Protocols**
  - **Coronal**
    - STIR
    - T1
  - **Axial**
    - T2 FS
  - **Sagittal**
    - T2 FS
  - **Axial Oblique**
    - T2 or PD FS

PELVIS
AVULSION INJURIES OF THE PELVIS

1. Ischium
- Hamstring attachments
- a. Bony avulsion
  - i. Ischial apophysis avulsion between 12-18 years
  - ii. Apophysis fragments and enlarges post avulsion
  - iii. Hamstrings remain attached to avulsed bone
  - iv "Rider's bone"
- b. Hamstring tendon avulsion

2. ASIS
- Sartorius avulsion

3. AIIS
- Rectus femoris avulsion

4. Iliac Crest
- Erector spinae avulsion

5. Adductor Avulsive Injuries
- a. Adductor longus and brevis, pectineus insertion

b. Irregularity and sclerosis of pubic bone
c. Changes of osteitis pubis

B. FRACTURES OF THE PUBIS

Near symphysis
Superior ramus
Inferior ramus/ischium

C. FRACTURES OF THE ACETABULUM

Displaced and non displaced
Obturator internus fat line displacement

D. HIP ALIGNMENT ASSESSMENT

1. Shenton's line
2. Iliofemoral line
3. Klein's line
4. Skinners line
5. Teardrop distance
6. Femoral angle
7. Acetabular margin.

E. COMMON VARIANTS

1. Acetabular notch
   "Pseudo defect" of acetabulum
2. Os acetabulae
3. Bone island
   Oval and orientated along trabecular lines

F. SLIPPED FEMORAL EPIPHYSIS

Usual age is 11-14 years
Often referred knee pain
Radiographic signs:
Decreased vertical height of epiphysis
Wide, irregular growth plate
Positive Klein's line
Up to 25% can be bilateral

G. LEGG-CALVE-PERTHES DISEASE

Usual age is 6-10 years
Limp; Episodes of "Transient Synovitis"
Sudden onset of pain / hip contracture; self limiting 7-10 days
Radiographic signs
Sclerosis
Fragmentation
Crescent sign- subchondral fracture
Deformity- mushroom deformity

H. MISELLANEOUS BONE LESIONS

1. Simple bone cyst

Thin sclerotic rim, may expand bone, no matrix- prone to fracture

2. Fibrous dysplasia

Thick sclerotic rim, smokey matrix ("ground glass")

3. Fractures

Subcapital / Mid cervical / Basicervical (intra articular)
Intertrochanteric / Subtrochanteric / Trochanteric (extra articular)
Pathological
Neck / shaft
Lesser trochanter
Treatment
Pins
Pin and Plate
Prosthesis- Austin Moore, total hip

I. TRANSIENT SYNOVITIS

4-12 years
Sudden onset of hip pain, refusal to walk
Aseptic joint effusion, relieved by aspiration
Diagnose with ultrasound

J. TROCHANTERIC DISORDERS

Bursitis: MR shows T2 high signal / fluid over trochanter
Tendonitis: High T2 signal within the tendon
Tendon avulsion: Gluteus medius / minimus

K. LABRAL INJURY

Separation of labrum most commonly superiorly
Anterior pain- severe and intermittent with specific movements
XR: NAD
- Os acetabulae
- Cysts

MR Arthrogram
- avulsion, tear or perilabral cysts

L. OSTEOARTHRITIS

Classic features:
- Loss of superior joint space
- Osteophytes at head margin
- Lateral shift of femur
- Geodes- subchondral cysts
- Variable sclerosis
- Complicating avascular necrosis

M. FEMORO-ACETABULAR IMPINGEMENT (FAI)

Over coverage odf the femoral head by the acetabulum
Results in cartilage-bone impaction at superolateral joint

XR-
- failure of acetabular overlap of femoral head
- Osteoarthritis in young
- Femoral neck "bump"

MR:
- Cartilage loss
- Labral tears
- Bone marrow edema at impingement sites head and acetabulum

N. AVASCULAR NECROSIS

Key sign is collapse of the articular cortex- *"step" sign*
Usually only affects upper third in wedge or oval shaped fashion
Over 50% become bilateral
MRI most reliable early and late diagnostic method
FICAT staging
- I. No imaging signs
- II. Bone marrow edema
- III. Collapse
- IV. Cysts
- V. Acetabular changes

THE KNEE

IMAGING PROTOCOLS

XR: Four views—AP (weight bearing), AP intercondylar, Lateral, Tangential (Skyline)
- Bone injuries, effusions, patellofemoral alignment

US: Cysts, effusions, MCL, LCL

CT: Tumors, fractures

MR: Intra articular and ligament derangements, bone marrow edema
- Coronal
  - T2 FS
  - STIR
  - PD/T1
- Axial
  - T2 FS
- Sagittal
  - PD
  - Gradient Echo (3D acquisition)

FRACTURES AND DISLOCATIONS

Fractures less common than dislocations and ligament / meniscal injuries

Tibial plateau: varus-valgus injury

Segond Fracture- avulsion fracture of the lateral tibial condyle

PATELLOFEMORAL DISORDERS

1. Chondromalacia patellae

MRI diagnosis—disease of the retropatellar surface
- Grade 1: Histologic change only
- Grade 2: Fibrillation
- Grade 3: Fibrillation with denudation
- Grade 4: Fibrillation with denudation with bone changes

Grading does not have prognostic value

2. Patella dislocation

Small patella

Femoral trochlear dysplasia (shallow patellofemoral sulcus)

Dislocates laterally and then reduces often spontaneously

Characteristic pattern of bone marrow edema
- Lateral femoral condyle, medial patella

3. Osgood Schlatter's disease

Thick tendon

Edema of subcutaneous tissue and tendon

Bone ossicles at tibia tuberosity

4. Patella tendonitis ("Jumper's knee")

MR diagnosis: US less sensitive

Edema of tendon substance at tibial or femoral attachment

Pre-patellar bursitis often coexists

5. Hoffa's disease

Rare- inflammation of the infra patellar fat

Loss of fat definition

Can occur post trauma

6. Quadraceps / patellar tendon rupture

Patellar Baja: low lying patella (quadriceps)

Patellar Alta: high riding patella (patella tendon)

7. Miscellaneous disorders

Bursitis
Effusion
Plicae syndrome
Iliotibial band friction syndrome

B. MENISCAL INJURIES

Concept of the different zones of the meniscus

"Red" zone: vascularised and able to repair, outer third

"White" zone: non vascularised, no repair

1. Medial meniscus tear

a. Radial

b. Longitudinal ("bucket handle")

c. "Parrot beak"

d. Intrasubstance horizontal tear

e. Mucoid deposition

2. Lateral meniscus tear

a. Radial

b. Longitudinal

c. Cyst

C. LIGAMENTOUS INJURIES

1. Medial Collateral Ligament (MCL)

a. Grade 1

b. Grade 2

c. Grade 3

d. Pelligrini Stieda disease

2. Lateral Collateral Ligament (LCL)

3. Posterior Cruciate Ligament (PCL)

4. Anterior Cruciate Ligament (ACL)

D. MISCELLANEOUS DISORDERS

1. Chondral lesions

2. Osteochondral defects (Osteochondritis dissecans)

3. Synoviochondrometaplasia

4. Osteoarthritis

THE ANKLE AND FOOT

ANKLE

IMAGING PROTOCOLS

XR: Three views- AP, AP oblique and lateral
Fractures, bone lesions
MRI: Stress injuries, ligament – tendon injuries
US: Tendon and ligament injury, joint effusion

MISSED INJURIES OF THE "TWISTED ANKLE"

Always with a twisted ankle check for:
ATF ligament
Talar dome injury
Anterior process of the calcaneus
Base of the fifth metatarsal
Proximal fibula fracture (Maissoneuve)

FRACTURES

Weber Classiifcation
A: Below the joint
B: At the joint
C: Above the joint

1. Lateral malleolus

2. Medial malleolus

3. Talus
   Osteochondritis dissecans
4. Calcaneus
   Anterior process fracture
   Compression fractures- assess with Boehlers angle, CT for subtalar joint

TENDON AND LIGAMENT INJURY

1. Achilles
   Ultrasound or MR (best)
2. Tibialis posterior
   Spontaneous sudden flat foot in female over 50 years of age
3. Impingement syndromes
   Os trigonum

4. Ligament injury
   Anterior talofibular ligament

FOOT

1. Variants
a. Bone island

b. Os tibiale externum

c. Os trigonum

2. Fractures
a. Lis franc injury

b. Navicular

c. Base of fifth metatarsal
   "Jones fracture"

d. Phalanx

"Bedroom fracture"

3. Miscellaneous disorders

a. Osteoarthritis
   Tarso-metatarsal joints
   1st MTP

b. Freiberg's disease

c. Hallux sesamoid necrosis
   Long distance runners

d. Plantar spur – plantar fasciitis

e. Tarsal Coalition

f. Reflex Sympathetic Dystrophy Syndrome (RSDS, Sudek's atrophy)

STRESS FRACTURES

A. IMAGING PROTOCOLS

1. Plain films

a. Always obtained first
b. Radiographic latent period of at least 2-8 weeks
c. Multiple, collimated views

2. Bone Scan

a. Most sensitive method- positive within 24 hours of symptoms
b. Triple phase study:
Flow (0-30 secs: Pool (1-5 mins): Delayed (2-4 hours)

3. CT

a. Good for fracture and early callus depiction
b. Helical scans with reconstructions targeted to the region

4. MRI

a. Very sensitive for bone marrow edema but fracture line often absent
b. Easily interpreted as changes suggesting osteomyelitis or tumor.
c. T1, T2, T1 gad with fat sat

B. LOCATIONS

Hallux sesamoids
Metatarsal neck
Navicular
Calcaneus
Tibia
Fibula
Femoral neck
Pars interarticularis

C. IMAGING SIGNS

1. Plain films

a. Normal appearance, no changes
b. Early subtle veil-like periosteal new bone adjacent fracture site
c. Linear band of sclerosis often perpendicular to the trabeculae
d. Fracture line may be eventually visible
e. Callus later re-organises and becomes thick and confluent

2. Bone Scan

a. On triple phase, detection improved with SPECT
   Flow: Normal- mild increased flow
   Pool: Mild accumulation
   Delayed: Focal, avid uptake

3. CT

a. Localised medullary sclerosis and periosteal new bone
b. Fracture may be visible

4. MRI

a. Sensitive for bone marrow edema at fracture site

UPPER LIMB

THE SHOULDER

1. IMAGING PROTOCOLS

Always plain films: AP with internal and external rotation then supplementals
- AC Joint/clavicle: Angled up 15 degrees, weights
- GH Joint: rotate 45 degrees
- Dislocation: lateral scapula
- Abduction: AC joint, GH instability—always include the apex of the lung

Ultrasound next study in Australia, Canada and Europe

MRI always in the US

MR ARTHROGRAM—placement of contrast (gadolinium) into the joint cavity
- Technique of choice in the assessment of:
  - Subtle rotator cuff tears
  - Previously operated shoulders
  - Labral tears
  - Recurrent dislocation
- Can be done two ways:
  - i. Direct-- injection into the joint
    - Iodinated dye introduced for CT or gadolinium for MRI
  - ii. Indirect-- intravenously and then exercised

2. PRINCIPLES OF INTERPRETATION

ULTRASOUND
- TENDONS
  - Each tendon viewed long and transverse
  - Biceps
    - Present and lies in groove
  - Supraspinatus
    - Long- Anterior, middle, posterior
    - Dynamic assessment
  - Infraspinatus, Subscapularis
- BURSA
  - Subdeltoid- subacromial
- LABRUM

MR
- **CORONAL**
  - **T2 FS (+ OR – STIR)**
  - **PD FS**
- **AXIAL**
  - **PD FS**
- **SAGITTAL**
  - **T1**
  - **T2FS**
- **Method of interpretation**
  - **Coronal**
    - Humerus position
    - Acromial shape
    - Supraspinatus
    - Biceps
    - Labrum
    - AC joint
    - Bones

Axial

AC joint
Labrum
Biceps
Tendons- especially subscap and infraspinatus

3. FRACTURES

a. Humerus
- Greater tuberosity= "flap fracture"; need external rotation view
- Surgical neck
- Comminuted head
- Shaft spiral fractures

b. Clavicle
- Distal may be overlooked; heal with exuberant callus
- Most common birth injury

c. Scapula
- Body, neck

4***. DISLOCATION***

a. Acromioclavicular joint
- i. Grade 1
- ii. Grade II
- iii. Grade III
- **iv. Post Traumatic Osteolysis of the Clavicle (PTOC)**
  - * Resorption of distal clavicle surface
  - * Cysts, surface irregularity; acromion surface is normal
  - * Weight lifters, overhead throwers

b. Glenohumeral joint
- Anterior and inferior
- Associated with:
  - Anterior labral/ bony avulsion- **the "Bankart lesion"**
  - Impaction fracture of the posterior superior humeral head "**Hill- Sachs defect".**

5. LABRAL LESIONS

a. Bankart – anterior inferior separation; plain film and CT for bony lesions

b. SLAP lesion – superior labrum anterior to posterior tear of the labrum
- Needs MR preferably with gadolinium arthrogram

c. Bennett lesion – posterior labral-bony avulsion in high velocity throwers such as baseball pitchers

6. ROTATOR CUFF TEARS

Most commonly the supraspinatus tendon
MRI is the gold standard in imaging;
- MRI: 92% sensitivity for tears
- US: 90% sensitivity for tears but allows dynamic assessment

"CRITICAL ZONE"- watershed area of relative avascularity 1cm from insertion.
Most common site for degeneration and tear

a. Full thickness
- With or without retraction
- XR: Humerus elevated within the glenoid
  - Cysts and roughened greater tuberosity
  - Subacromial osteophytes
- US: Hypoechoic zone
- MRI: Fiber discontinuity
  - Fluid within the tear

b. Partial thickness
Intrasubstance
Undersurface
External surface
c. Tendonitis- inflammation

d. Tendinosis- infiltration with myxoid material; prone to tear

e. Calcific tendonitis

f. Impingement
US diagnosis: on abduction sliding tendons beneath the acromion.
Impingement evident as no sliding and get thicker
Described as “bunching”

6. Biceps Lesions

a. Bursitis
Fluid around the tendon
Pain on compression
b. Dislocation
Usually with subscapularis tears
Show dynamically with ultrasound

THE ELBOW

1. IMAGING PROTOCOLS

Always plain film studies first
AP, AP oblique, Lateral
Need radial head view many times

Radiocapitellar Line

Fat Pad sign- Lateral projection
>90% will have a n intra-articular fracture of the elbow
Most commonly radial head

2. OSTEOLIGAMENTOUS AVULSIONS

a. Medial epicondyle avulsion
Little Leaguers elbow: avulses and displaces inferiorly; then overgrows

b. Collateral ligament avulsions
Throwing sports valgus stress- usually anterior band of lateral collateral
Stress radiographs
MRI—difficult to interpret

3. FRACTURES

a. Fat pad sign
i. Supracondylar fracture

ii. Radial head fracture

4. DISLOCATION

Most commonly posterior dislocation of the olecranon
Prone to post traumatic myositis ossificans

5. SUPRACONDYLAR PROCESS

Two percent of the population
Brachial artery and median nerve pass beneath it
Often a thick ligament (Struther's) going from the process to the medial epicondyle
Prone to fracture—neurovascular injury

6. LATERAL EPICONDYLITIS

Irregular lateral epicondyle on xray; may see dense calcification
US/MR shows fluid and altered muscle signal

7. TRICEPS TENDON INJURIES

Partial tears/ retraction/bursitis

THE WRIST AND HAND

1. IMAGING PROTOCOLS

XR: Minimum of 4 views- PA, PA ulnar flexion, Oblique, lateral
Specific Scaphoid views
US: Tenosynovitis, tendon injury, ganglion
MRI: Occult bone injury, tendons, ligaments
CT: Occult fracture, fracture management, bone tumors

2. FRACTURES

a. Colle's: *Distal radius, dorsal angulation of the distal fragment*
b. Smith's: *Reversed Colle's, volar angulation of the distal segement*
c. Scaphoid: *Usually through the waist*
Proximal pole prone to avascular necrosis
Complications
Avascular necosis, non union, radiocarpal arthritis, median n.
SNAC WRIST
Scaphoid Non union Associated Collapse

d. Scapholunate disassociation
Ruptured interosseous scapolunate ligament
PA view with clenched fist
Widened S-L space *("Terry Thomas" sign)*
Lunate rotates usually dorsally
DISI instability
(Dorsal Intercalated Segemental Instability)
SLAC WRIST
Scapho-lunate associated collapse

e. Boxers and drillers wrists
Degenerative arthropathy of both wrists

f. Hook of hamate
Raquet/ handle sports
Ulnar nerve neuropathy

3. SOFT TISSUES

a. Tendons: Tenosynovitis- US, MRI

b. Swellings: Ganglion- US, MRI

c. Median Nerve: US, MRI

d. Triangular Fibrocartilage (TFCC)
Develop tears
MR best technique

4. ULNAR IMAPACTION SYNDROMES

Positive ulnar variance ; Bone marrow edema of lunate and ulna head or styloid

HAND

1. IMAGING PROTOCOLS

Minimum of 3 views- PA, Oblique, lateral
Specific finger and thumb views

2. THUMB INJURIES

a. Bennett's fracture

Intra articular fracture through the base of the first metacarpal

b. Rolando's fracture

Comminuted Bennett's fracture

c. Game keepers injury

Avulsion of the medial collateral ligament from the proximal phalynx
May be bony- avulsed fragment
May be ligamentous (Stenner lesion)

3. METACARPAL FRACTURES

a. Bar room fracture

Neck of the fifth metacarpal

b. Boxer's fracture

Neck/head of 2-3 metacarpals

c. Dislocation

Usually base of the 4-5

4. PHALANGES

Shaft and Tuft Fractures
Articular plate avulsions
Mallet Finger—avulsed dorsal extensor insertion from the distal phalanx
Dorsal plate bone avulsion – XR
Tendon avulsion—MR
Dislocation

5. TENDONS

US/MRI: Flexor pulley injuries in rock climbers or trauma

Masses
Giant cell tumor of tendon sheath