

IMAGING ATHLETIC INJURIES
24-29 JANUARY 2010
ZERMATT, SWITZERLAND

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SUNDAY 24 JANUARY

0800-0930: SESSION I. THE HIP 2-6

1000-1130: SESSION II. THE KNEE 7-8

TUESDAY 26 JANUARY

0800-0930: SESSON III: THE FOOT AND ANKLE 9-11

1000-1130: SESSION IV: THE SHOULDER 12-14

THURSDAY 28 JANUARY

0800-0930: SESSON V: THE ELBOW 15

1000-1130: SESSION VI: THE WRIST AND HAND 16-17

SUNDAY 24 JANUARY

0800-0930: SESSION I. 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. A/IS

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. MISCELLANEOUS 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 of 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

O. PUBALGIA

ANATOMY

Symphysis joint

Solid at birth (amphiarthrosis)

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

REFERENCES

- Brennan et al. Secondary cleft sign as a marker of injury in athletes with groin pain: MR image appearance and interpretation. *Radiology* 235:162-167, 2005.
- Zoaga et al. Athletic pubalgia and the "sports hernia": MR imaging findings. *Radiology*. 247:797-807, 2008.
- Omar et al. Athletic pubalgia and "sports hernia": Optimal MR imaging technique and findings. *RadioGraphics* 28:1415-1438, 2008.
- Robinson et al. Cadaveric and MRI study of the musculotendinous contributions to the capsule of the symphysis pubis. *AJR* 188:440-445, 2006.
- Carvalho et al. Nutrition pathways to the symphysis pubis. *J Anatomy* 204:209-215, 2004

SUNDAY 24 JANUARY

1000-1130: SESSION II. 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

Second Fracture- avulsion fracture of the lateral tibial condyle

PATELLOFEMORAL DISORDERS

1. *Chondromalacia patellae*

MR 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. *Quadriceps / 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. Mucoïd 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

TUESDAY 26 JANUARY

0800-0930: SESSION III. 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 (Maisonneuve)**

FRACTURES

Weber Classification

- 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
Anterior
Medial
Lateral
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
- b. Isointense on T1, high signal on T2
- c. Enhances with gadolinium

TUESDAY 26 JANUARY

1000-1130: SESSION IV. 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. Tendinitis- 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

THURSDAY 28 JANUARY

0800-0930: SESSION V. 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 an 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

THURSDAY 28 JANUARY

1000-1130: SESSION VI. 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 segment*
- c. Scaphoid:** *Usually through the waist*
 - Proximal pole prone to avascular necrosis*
 - Complications*
 - Avascular necrosis, 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 Segmental 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 IMPACTION 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