MRI of the HIP
Normal osseous anatomy

- Hip is ball and socket joint stabilized by its intrinsic anatomy
Normal osseous anatomy
Acetabular labrum: ring closed by transverse ligament
Ligaments

- Pubofemoral ligament
- Ant. inf. iliac spine
- Iliofemoral ligament
- Ischiofemoral ligament
- Greater trochanter
- Lesser trochanter
Normal marrow

- Yellow / fatty marrow
  - T1 hyperintens
  - T2 intermediate

- Red / hematopoietic marrow
  - T1 and T2 intermediate because of higher water content

- Conversion to yellow marrow in apo- / epiphysis of the femur in 1st year
Normal marrow

• Next conversion to yellow marrow in femoral diaphysis
• In adults, some red marrow may be present in the proximal femoral metaphysis
• In the pelvis there is often patchy red marrow present
Beenmergoedeem t2
Avascular necrosis (AVN)

- Diminished / disrupted blood supply $\rightarrow$ necrosis of subchondral bone
- Causes:
  - Trauma
  - Corticosteroid use
  - Alcoholism
  - Hemoglobinopathies
- Wedge-shaped subchondral ischemic focus
- Anterolateral weightbearing femoral head
- Non-traumatic AVN is bilateral in 50-80% of cases
- Trauma may lead to unilateral AVN
- MRI most sensitive and specific imaging modality
- Involvement of $>50\%$ of the weight bearing surface $\rightarrow$ poorer prognosis
Avascular necrosis (AVN)

- **T1**
  - Hypointense peripheral band = reactive interface
  - ± Hypointense bone marrow edema
  - ± Hypointense joint effusion

- **T2**
  - Characteristic ‘double line’ sign in 80%

- **T1 C+**
  - Early stage - decreased enhancement
  - Nonviable trabeculae + marrow – no enhancement
  - Enhancement corresponds to reparative zone
Fig. 7 MR arthrography findings in avascular necrosis of the femoral head. a On the T1-weighted spin echo image a serpiginous line of low signal (arrowheads) surrounding an area of fatty marrow (curved arrow) is seen anterosuperiorly. b On the fat-suppressed T2-weighted turbo spin echo image a hypodense serpiginous line (arrows) is paralleled by an inner and outer hyperintense line (arrowheads). These lines represent granulation tissue at the interface of necrotic and viable bone.
# MR Staging

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th>T1 SIGNAL INTENSITY</th>
<th>T2 SIGNAL INTENSITY</th>
<th>HISTOPATHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>High</td>
<td>Intermediate</td>
<td>Fat</td>
</tr>
<tr>
<td>B.</td>
<td>High</td>
<td>High</td>
<td>Subacute Blood</td>
</tr>
<tr>
<td>C.</td>
<td>Low</td>
<td>High</td>
<td>Fluid and/or Edema</td>
</tr>
<tr>
<td>D.</td>
<td>Low</td>
<td>Low</td>
<td>Fibrosis</td>
</tr>
</tbody>
</table>
Ficat and Arlet Staging

- Stage 0: normal imaging
- Stage 1: Positive bone scan / MR
- Stage 2: Mottled femoral head / sclerosis / cyst / osteopenia
- Stage 3: Crescent sign lesions + depression femoral head
- Stage 4: Flattening articular surface

Joint space narrowing
Secondary acetabular changes
Transient osteoporosis of the hip

- Progressive hip pain

- Middle-aged men and during third trimester pregnancy

- Self-limiting

- Resolution of symptoms after 6 to 10 months

- Osteoporosis can be severe enough to cause an insufficiency fracture
Transient osteoporosis of the hip

• **T1WI**
  – Large areas of hypointensity
  – May spare medial and/or lateral margins of femoral head +/- greater trochanter
  – Homogenous and well-margined edema
  – ± joint effusion

• **T2WI**
  – Hyperintensity most conspicuous on STIR
  – Edema interface well-defined (no double-line sign)
  – Normal cortex, subchondral plate and adjacent soft tissue

• **T1 C+**
  – Prominent heterogenous enhancement
Transient osteoporosis of the hip
Acetabular Labrum

- Fibrocartilaginous tissue
- Contiguous with acetabular (hyaline) articular cartilage
- Synovial recess between labrum and capsule
Figure 1. Coronal $T_1$ weighted MR arthrogram demonstrating normal anatomy. The triangular shaped superior labrum (white arrow) and inferior labrum (black arrow) are surrounded by contrast and therefore well visualized. The transverse acetabular ligament (arrowheads) blends with the hip capsule.
Figure 2. Axial oblique $T_2$ gradient echo MR arthrogram demonstrating the anterior and posterior portions of the acetabular labrum. Note that there is some heterogeneous signal within the intact labrum which may represent myxoid degeneration.
Labral tears

• Part of continuum of changes associated with hip deformities
  – Labral tears
  – Delamination of adjacent cartilage
  – Finally, early osteoarthritis

• Mechanism
  – Twisting or pivoting motion
  – Femoroacetabular impingement

• Risk factors
  – Athletes
  – Hypermobile individuals
Labral tears

• Acute, traumatic tears – young athletes
• Femoroacetabular impingement – middle-aged
• Degenerative tears – older patients

• Hip pain
• Snapping, clicking and locking
- MRI accurate in detecting labral tears
Labral tear classification

- Traumatic vs degenerative
- Intrasubstance vs detachment
- Staging 0 – 3

**Stage 0**
Normal triangular labrum
Normal recess
- **Stage 1A**
  - Increased intralabral signal

- **Stage 2A**
  - Contrast material extends into labrum

- **Stage 3A**
  - Labral detachment

- **B subtypes**
  - Hypertrophied labrum without perilabral recess
Labrum

- Triangular 69.2%
- Round 15.8%
- Flat 12.5%
- Absent 2.5%
Anatomical variant of the labrum

- Sublabral sulcus
  - Anterosuperiorly
  - Posteroinferiorly
  - Anteroinferiorly
  - Posterosuperiorly
Paralabral cysts

- Hyperintens cyst adjacent to labrum
- Communicates with labral tear
- Anterosuperior → posterosuperior → inferior
- Associated with impingement
- ± Septated + lobulated
- T1
  - Hypo to intermediate
- T2
  - Hyperintens
- T1 C+
  - Peripheral enhancement
Typical

(Left) Axial FS PD FSE MR shows posterior paralabral cyst (arrow) in association with a posterosuperior labral tear. (Right) Coronal FS PD FSE MR shows extension of paralabral cyst lateral to the joint capsule (lateral to the iliofemoral ligament).
Herniation pit

Figure 6. Herniation pit. (a) AP radiograph of the right hip shows a well-circumscribed, round lucent area (arrow) in the superolateral portion of the femoral neck. (b) Lateral radiograph of the groin shows the anterior location of this area (arrow). (c) Axial T1-weighted fat-saturated magnetic resonance (MR) arthrogram shows fluid signal intensity within the herniation pit.
Femoroacetabular Impingement

Definition

• Abnormal contact between acetabular rim and femur

Causes

• Abnormal morphology of the proximal femur
• Abnormal morphology of the acetabulum
• the patient, subjecting the hip to excessive and supraphysiologic range of motion

Result

• Early osteoarthritis of the hip
Types of FAI

**Cam Impingement:**
- Femoral cause: Femoral waist deficiency

**Pincer Impingement:**
- Acetabular cause: Overcoverage

**Often:** Mixed Impingement
Cam Impingement

Cam = kruk
Cam Impingement

Mechanism: Femoral cause
• Jamming of an abnormal femoral head into the acetabulum during forceful motion, especially flexion and internal rotation

„Classic“ Imaging finding
• abnormal femoral head with a laterally increasing radius
• femoral waist deficiency

„Classic“ Patient
• young and athletic male
Cam Impingement: Pistol Grip Deformity
Cam Impingement: Pistol Grip Deformity
Cam Impingement

Normal

Cam Impingement
Cam Impingement

Normal

Cam Impingement
Cam Impingement

Normal femoral neck

Waist deficiency of ant. femoral neck

Anterosuperior labral degeneration / tear and cartilage damage
Cartilage Lesions Location

Anterior: 54%
Superior: 22%
Posterior: 23%
Cartilage Lesions: Localization

• Acetabulum >> Femur

• Antero - superior

• Labral tears often associated

• Junction of labrum and cartilage
Delamination of acetabular cartilage (Flaps):
Very common in FAI CAM Type
Difficult to visualize with MR-Arthography
Pincer Impingement

Pincer = Tang
Pincer Impingement

Mechanism: Acetabular cause
• Contact between acetabular rim and femoral head-neck junction

„Classic“ Imaging finding
• General ‘overcoverage’ (coxa profunda / protrusio)
• Local anterior ‘overvoverage’ (acetabular retroversion)

„Classic“ Patient
• Middle-aged women
Pincer Impingement: deep acetabulum

Protrusio acetabuli: “the deep acetabulum”
Relative prominence of anterior acetabular wall
Pincer Impingement: deep acetabulum

Normal

Protrusio acetabuli: “the deep acetabulum”
Relative prominence of anterior acetabular wall

Pincer FAI
Pincer Impingement: deep acetabulum

Protrusio acetabuli: “the deep acetabulum”
Relative prominence of anterior acetabular wall
Pincer Impingement: acetabular retroversion

Normal

Acetabular retroversion
Acetabular retroversion

- Crossover (or 8) sign

- The anterior rim of the acetabulum is lateral to the posterior rim on the first axial image that includes the femoral head
Pincer impingement

- Overcoverage
- Cartilage rarely affected
- Contre-coup injury to posteroinferior labrum
Occult, stress and insufficiency fractures

- **Stress fracture**
  - Repetitive, prolonged muscle action
  - Normal bone
  - Compression type
  - Medial inferior femoral neck
  - Young and middle-aged, military recruits and athletes

- **Insufficiency fracture**
  - Bone failure
  - Normal muscle activity
  - Distraction type
  - Transverse fracture, with defect in superolateral cortex
Occult, stress and insufficiency fractures

- **T1**
  - Low signal fracture line

- **STIR**
  - High signal edema and haemorrhage
Occult, stress and insufficiency fractures

- **TI**
  - Low signal fracture line

- **STIR**
  - High signal edema and haemorrhage
Avulsion fractures

- Ischial tuberosity - Hamstrings
- ASIS - Sartorius
- AIIS – Rectus femoris

- Usually in athletes
- Excessive eccentric contraction
- Adults, bone usually not involved
- In children, avulsion of apophysis

- T1WI – involved tendon often lax
- T2WI – hyperintense edema and fluid
Insufficienty fractuur sacrum
Avulsie os pubis
Muscle strain

• Musculotendinious junction typical
• Rectus femoris and hamstrings most common

• First degree – minor fiber disruption
  – Interstitial edema, with or without hemorrhage
• Second degree – partial tear without retraction
  – Hematoma with intra- and extramuscular fluid
• Third degree – complete tear

• T1WI: often no abnormality
• T2WI: Hyperintense edema and hemorrhage within muscle
Osteitis pubis, adductor dysfunctie
Hockey, myotendineus
Complete tear of the rectus femoris with edema at the musculotendinous junction (arrows)

- **T1WI**: often no abnormality
- **T2WI**: Hyperintense edema and hemorrhage within muscle
Hamstring tendinosis

Biceps femoris, semitendinosus and semimembranosus
Hamstring tendinosis

- Biceps femoris, semitendinosus and semimembranosus

- Young athletes

- T1WI: hypointens tendon
- T2WI: Proximal hyperintensity
- Thickening of tendon ± splaying
- Adjacent bone marrow edema
Bursitis

- Inflammation secondary to
  - Friction
  - Infection
  - Trauma

- Trochanteric, iliopsoas and ischiogluteal bursitis

- **T1**
  - Hypointense to intermediate

- **T2**
  - Hyperintensity with bursal distension
  - Heterogenous = hemorrhage or proteinaceous debris

- **T1 C+**
  - Peripheral enhancement
Trochanteric bursitis

- STIR demonstrating high signal adjacent to the greater trochanter indicating trochanteric bursitis.
Iliopsoas bursitis

- Hyperintense iliopsoas bursal distension medial to the right iliopsoas tendon.
- Anterior convexity
- Tear-drop morphology
MRI of the HIP – Imaging checklist

- Femur – osteonecrosis, fractures or edema
- Cartilage surfaces – fissures, fraying, thinning or defects
- Joint recesses – chondral debris or corpora aliena
- Labrum – tears, detachment, fraying or degeneration
- Acetabulum – shallow contour?
- Muscles and tendons – tears or strains
- Trochanteric or iliopsoas bursitis?

- Check the symphysis pubis, superior / inferior pubic rami, ilium, sacroiliac joints and sacrum on large FOV coronal images