

Femoroacetabular Impingement: FAI

FAI

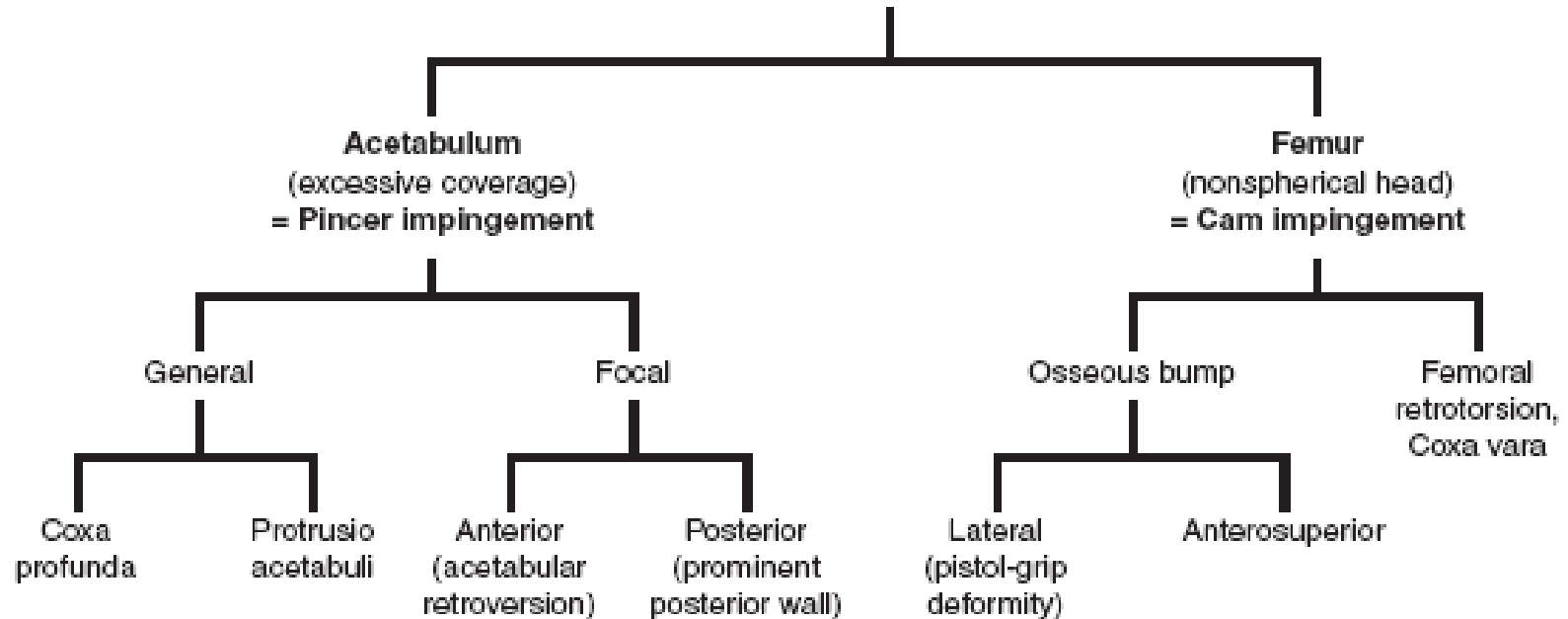
- Cause of early osteoarthritis of the hip especially in young and active people
- Early pathologic contact between skeletal prominences of the acetabulum and femur that limits physiologic hip range of motion.
- Occurs typically during flexion and internal rotation.

FAI

- Pincer impingement: acetabular cause of FAI
 - Focal or generalized over coverage of the femoral head.
- CAM impingement: femoral cause of FAI
 - Due to an aspherical portion of the femoral head-neck junction.

Mixed: 86% - Beck et al JBJS Br 2005

Femoroacetabular Impingement



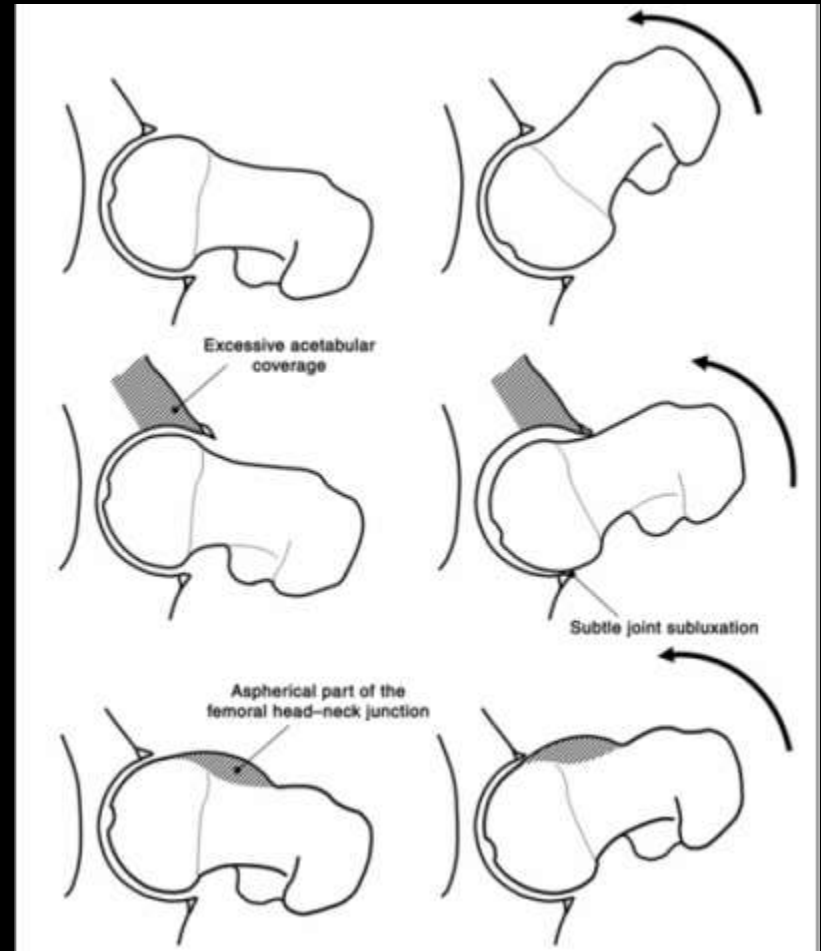
Predisposing factors

- Some predisposing factors to FAI

- Legg-Calve-Perthes disease
- Congenital hip dysplasia
- Slipped capital femoral epiphysis
- Avascular necrosis
- Malunited fractures
- Acetabular protrusion
- Elliptical femoral head
- Retroverted acetabulum
- Prominent femoral head-neck junction

- Proposed etiologies

- Abnormal anatomy
 - Prominent femoral head neck junction
 - Acetabular overcoverage
- Unusual stresses
 - Carpet layers – repeated flexion, adduction, internal rotation



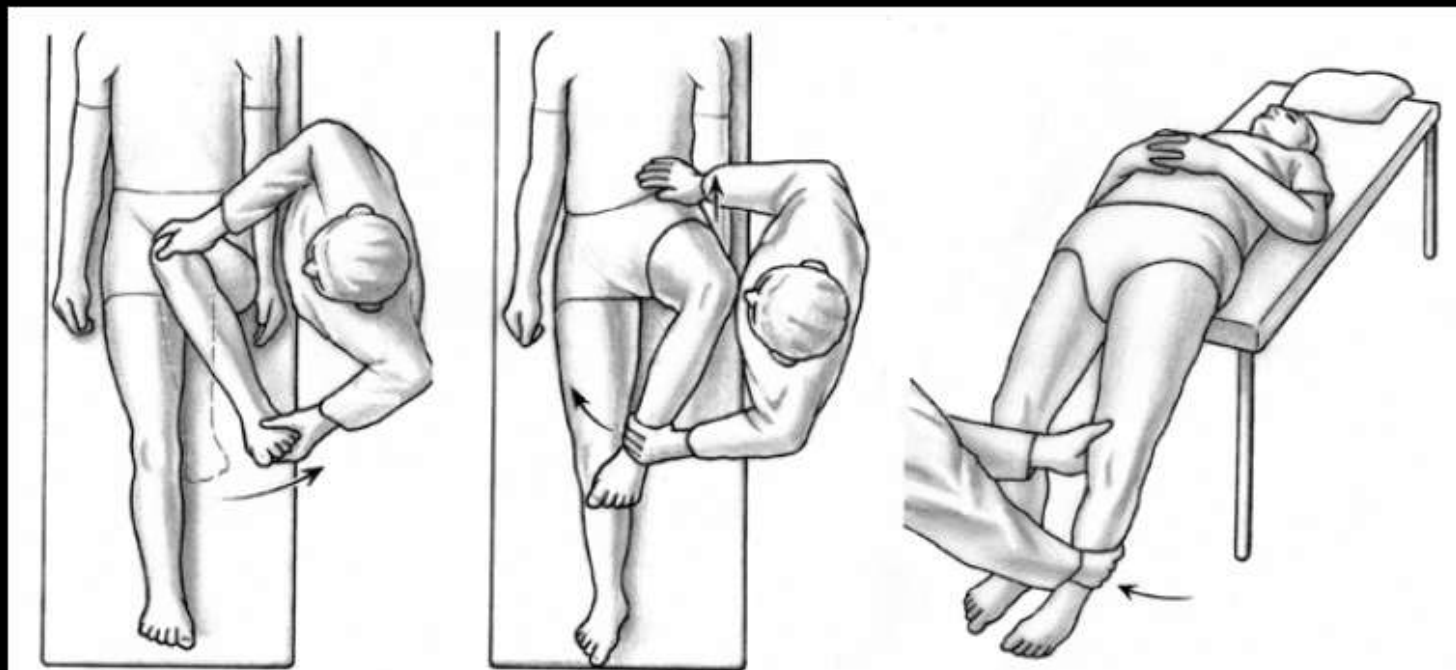
Clinical Findings of FAI

- Young: usually in 20-40's
- CAM type: M:F 14:1 (avg age: 32).
- Pincer typer: M:F 1:3 and usually middle age women (avg age: 40)
- Estimated prevalence: 10-15%
- Present with groin pain with hip rotation, in sitting position, or during/after sports
- Typically aware of limited hip mobility long before sx.

Clinical Findings FAI

- Clinical exam:
 - Restricted range of motion, particularly flexion and internal rotation
 - Positive impingement test: for anterior femoroacetabular impingement if forced internal rotation/adduction in 90° of flexion reproduces pain. For posterior impingement: painful forced external rotation in full extension.
 - Drehmann's sign: unavoidable passive external rotation while performing hip flexion.

Fig. 3—Clinical tests to assess femoroacetabular impingement. Anterior impingement sign (*left*) is positive, with painful forced internal rotation in 90° of flexion. In extreme forms, there is unavoidable passive external rotation of hip during hip flexion (“Drehmann’s” sign, *center*). “Posterior impingement” sign is positive when there is painful forced external rotation in maximal extension (*right*).



RESULTS: Physical Exam

- **Positive impingement test: ALL**
 - Unilateral
- **Limited Flexion**
 - mean **95** degrees (90-110)
 - *Mean 105 degrees: Tannast et al JOR 07*
- **Limited internal rotation in flexion**
 - **17** degrees (mean symptomatic hip) *VS*
 - **24** degrees (mean asymptomatic hip)
 - *11 vs. 35 degrees: Tannast et al JOR 07*

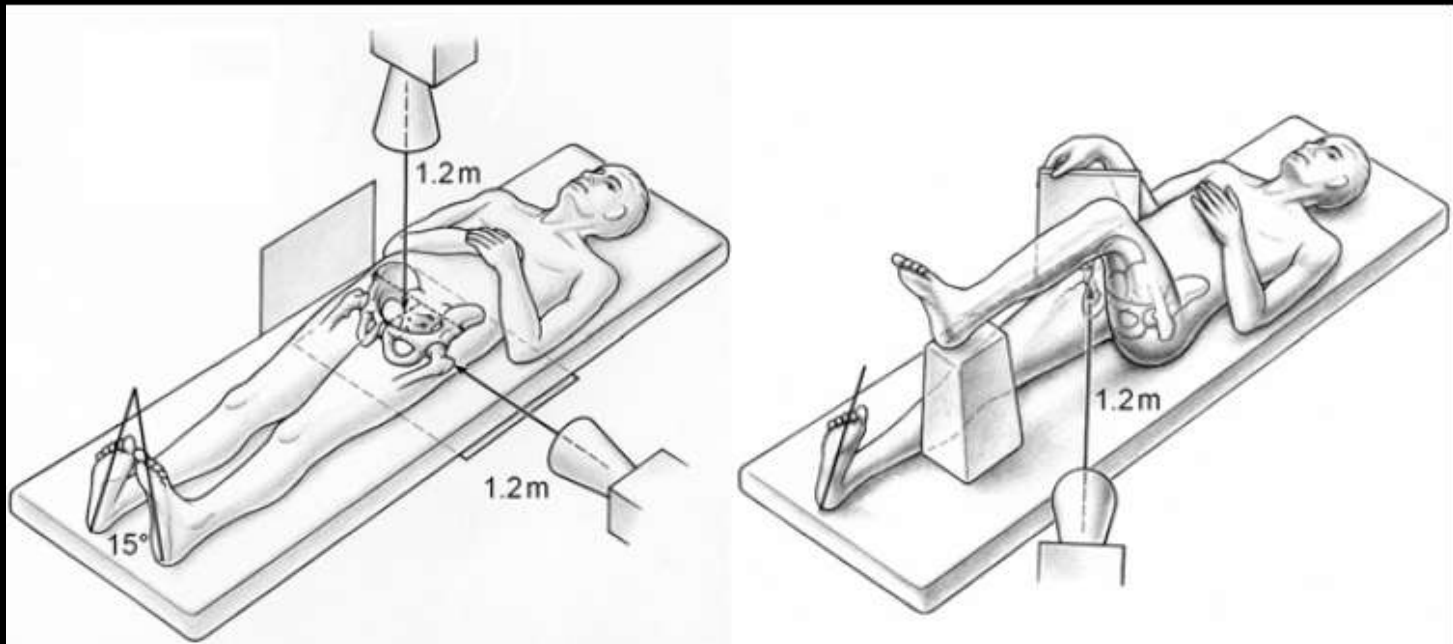


Imaging Evaluation of FAI: MR Arthrography

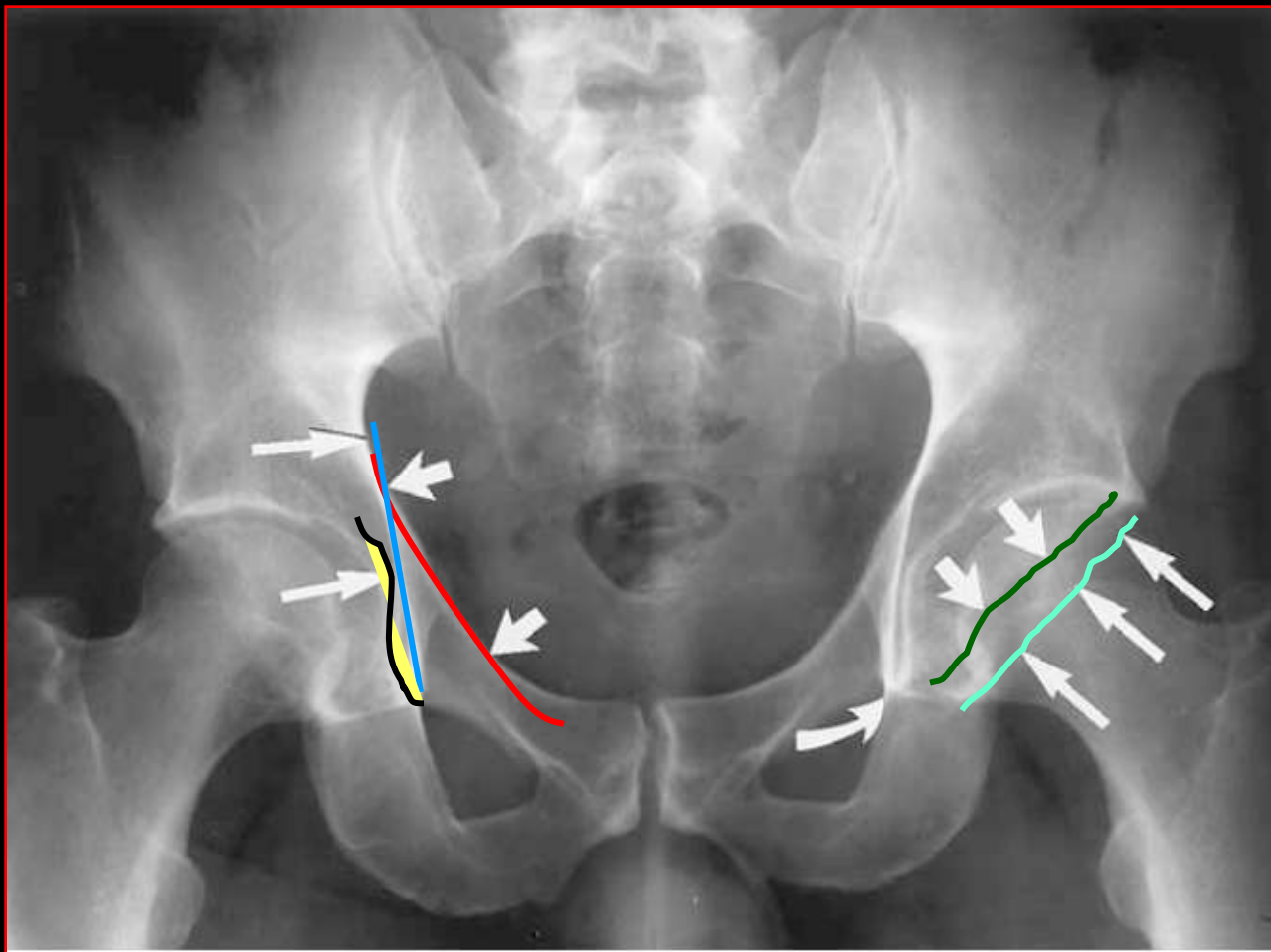
- 14-16 cm FOV, slice thickness 3-5 mm FSE or 1.5-2mm GRE and matrix at least 256 x 256
- T1 FSE FS or GRE FS in all three standard orthogonal planes after 10-15 ml intra-articular GAD
- Coronal and axial FS PD or Coronal STIR or FS T2.
- Axial oblique T1 FS IA Gad: parallel to the axis of the femoral neck

Imaging Evaluation of FAI: Radiographs: AP and Cross table lateral

Correct setting for anteroposterior (*left*) and Cross-table axial radiograph of hip (*right*) is needed to visualize anatomy of anterior femoral head–neck junction, which is not visible on anteroposterior pelvic radiograph.



Normal Anatomy of AP Hip Radiograph



Ilioischial line: posterior column

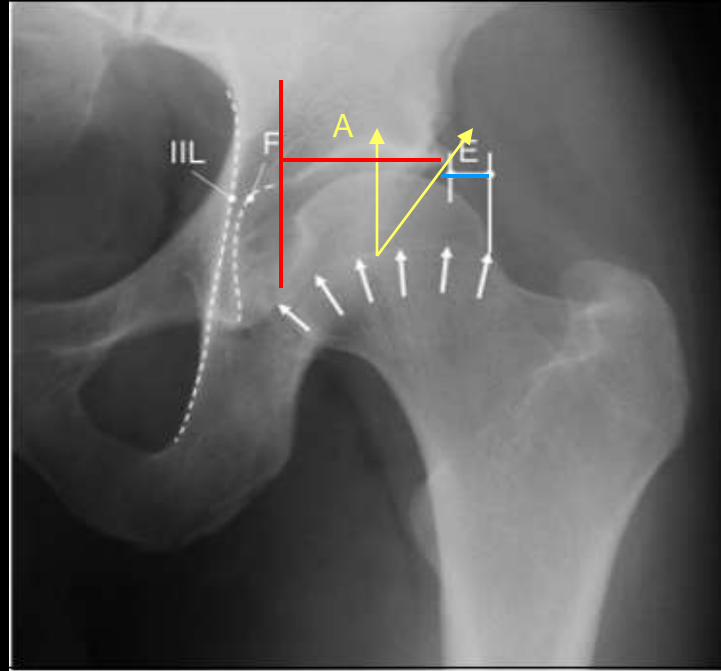
Iliopubic line: anterior column.

Tear drop: medial acetabular wall

Anterior Acetabular Wall

Posterior Acetabular Wall

Normal Anatomy of AP Hip Radiograph.



-Acetabular Fossa lying lateral to ilioischial line.

-Center edge angle: angle formed from vertical line from the center of femoral head and line drawn to the lateral edge of the acetabulum. Normal: $25-39^{\circ}$ ($20-25$ =borderline dysplasia, >39 suggesting acetabular overcoverage).

-**Extrusion Index**: portion of uncovered femoral head divided by total covered + uncovered $E/(A+E)$: Normal $>.25$, $<.18$ =consistent with acetabular overcoverage.

AP View of the Pelvis and Hip

A



B



C



Fig. 14—Influence of individual pelvic orientation on appearance of acetabular rim.
A, Normal acetabular configuration is shown in this cadaveric pelvis with wire marking acetabular rims. a = vertical distance between upper border of symphysis and sacrococcygeal joint.
B, Increased pelvic tilt (visible on increased distance between symphysis and sacrococcygeal joint, a') leads to apparent retroversion of acetabular rim on both sides. Arrows indicate apparent bilateral retroversion due to increased pelvic tilt.
C, Rotation to right (with consecutive increased horizontal distance between middle of symphysis and sacrococcygeal joint, b (horizontal distance between mid of symphysis and mid of sacrococcygeal joint) leads to apparent retroversion of right hip and to pronounced anteversion of left hip. Arrow indicates creation of apparent retroversion on right side due to rotation on right.

AP View of the Pelvis and Hip

Fig. 13—Retroversion sign can be missed if central X-ray beam is not directed correctly. **A**, In this cadaveric pelvis with wire marking acetabular rims, cranial acetabular retroversion is visible on left side on anteroposterior pelvic radiograph. Center of X-ray beam is marked with radiopaque marker. **B**, On anteroposterior hip view, retroversion sign disappears.



-Acetabular version is generally overestimated on AP centered over the hip and figure 8 or cross over sign can be missed or falsely positive depending on degree of angulation of beam.

-Increased pelvic tilt or rotation can lead to more pronounced or false cross over sign.

-Neutral pelvic rotation: tip of coccyx pointing toward symphysis.

-Neutral pelvic tilt: distance between upper border of symphysis and mid portion of the sacrococcygeal joint: Male: 3.2 cm and Female: 4.7 cm.

Pincer Impingement

- Generalized acetabular overcoverage
 - Coxa profunda
 - Protrusio
- Focal acetabular overcoverage
 - Anteriorly: acetabular retroversion
 - Posteriorly: prominent posterior wall vs deficient posterior wall



Acetabular Protrusion: Both medial acetabular wall and femoral head project medial to ilioischial line.

Coxa profunda: medial wall of acetabulum projects medial to the ilioischial line, femoral head remains lateral to it.



General Acetabular Overcoverage

Measuring acetabular depth:

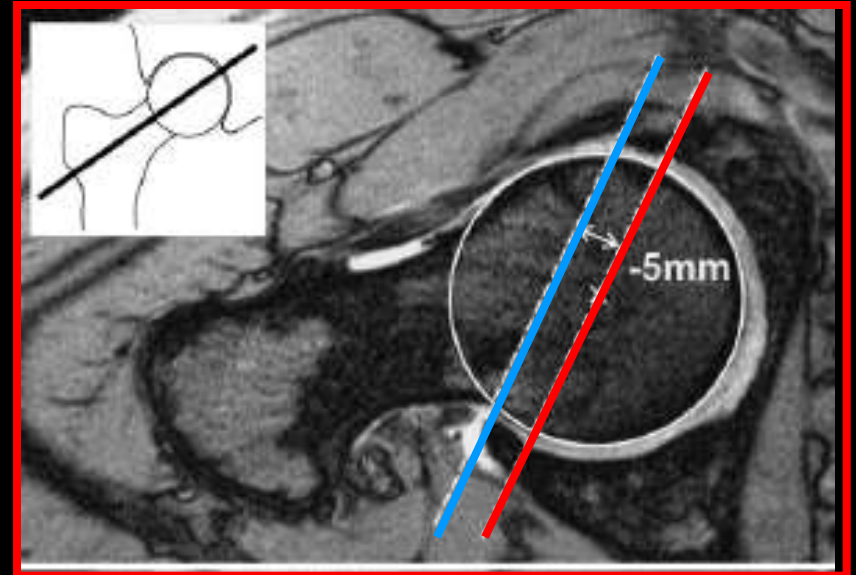
Axial oblique MR:

line connecting the anterior and posterior acetabular margins

line through the center of the femoral head

Depth of acetabulum defined by distance between the two: 0 to +5mm normal.

Neg=increased acetabular depth: -5mm high correlation with Pincer FAI



3



4



1



2



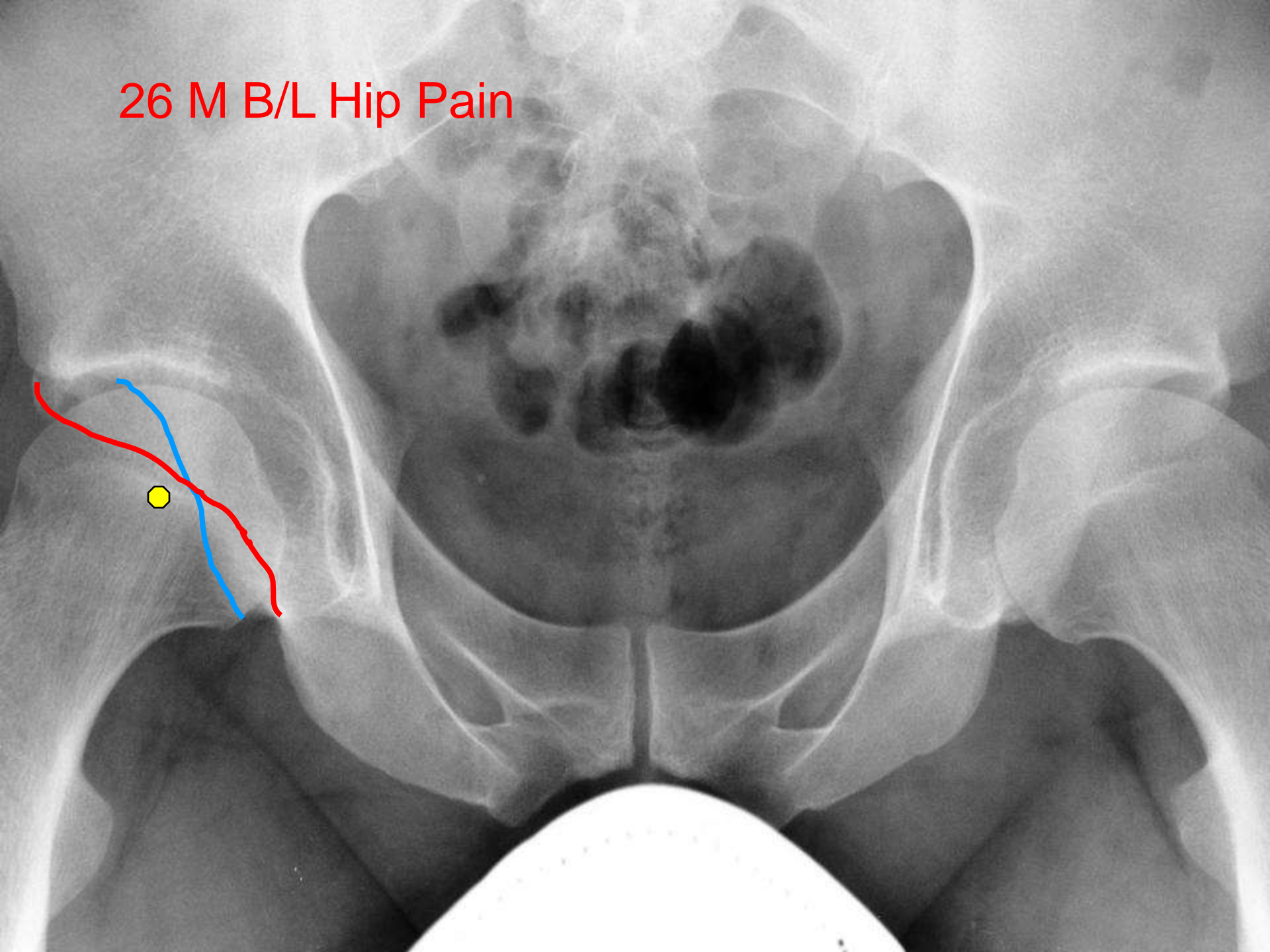
Focal Acetabular overcoverage

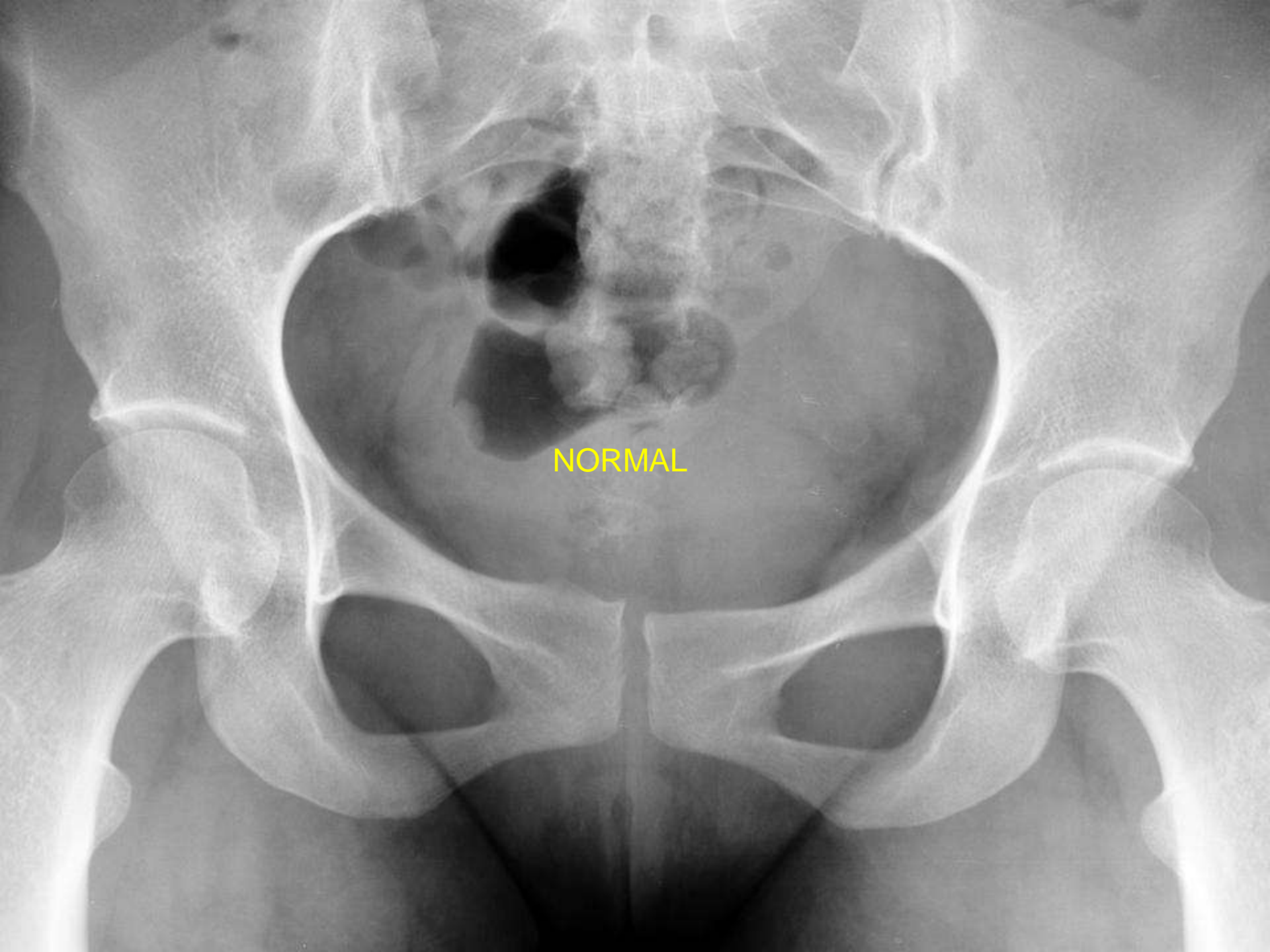
- Anterior: Cranial Acetabular Retroversion
 - Can be reproduced clinically with painful flexion and internal rotation.
 - Normal acetabulum is anteverted
 - Anterior Rim projects medial to posterior wall line.
 - Cranial Acetabular Retroversion the anterior rim line becomes lateral to the posterior rim in the cranial part of the acetabulum and crosses medial in the inferior part making a figure 8 or crossover sign.





26 M B/L Hip Pain

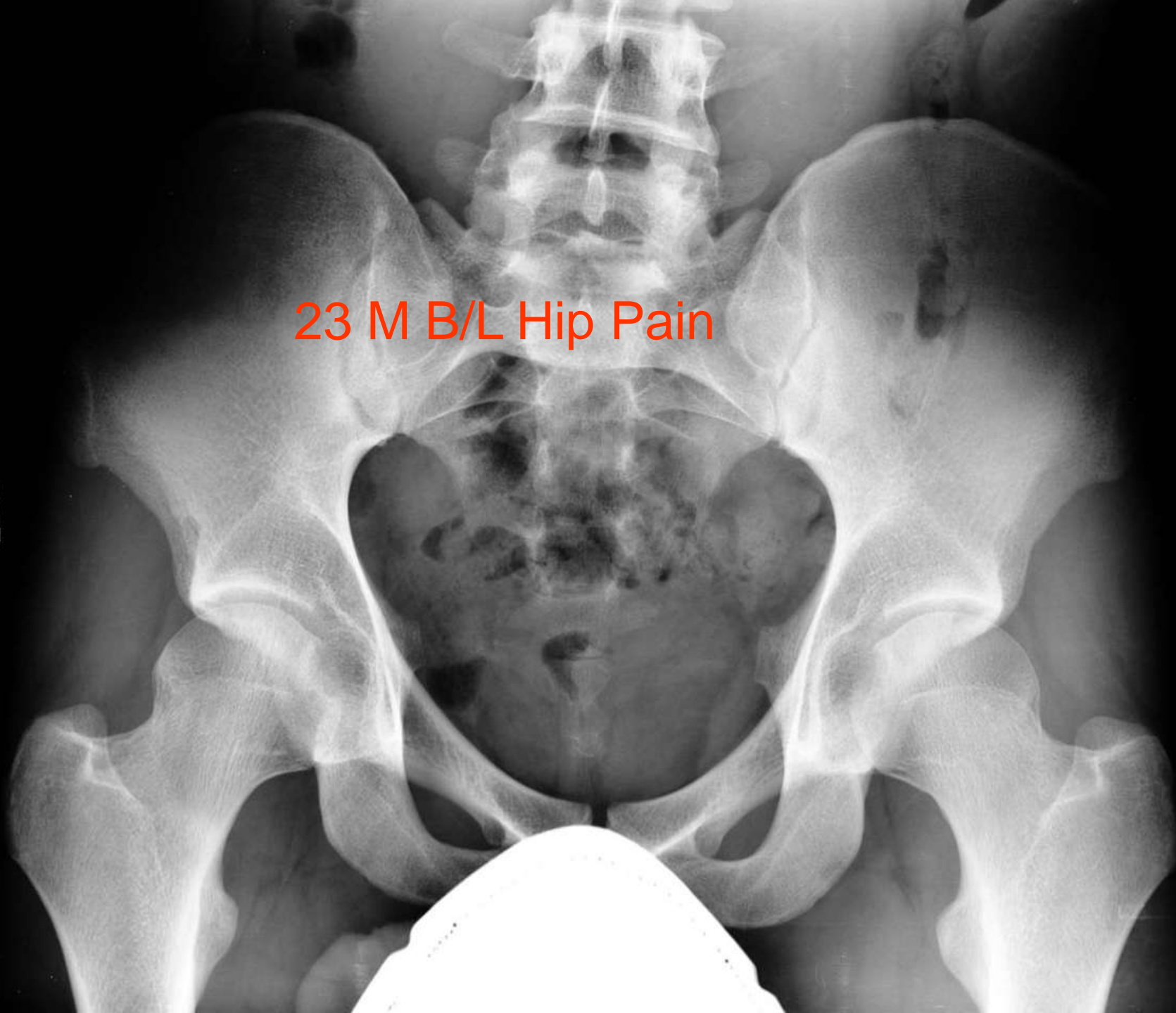




NORMAL

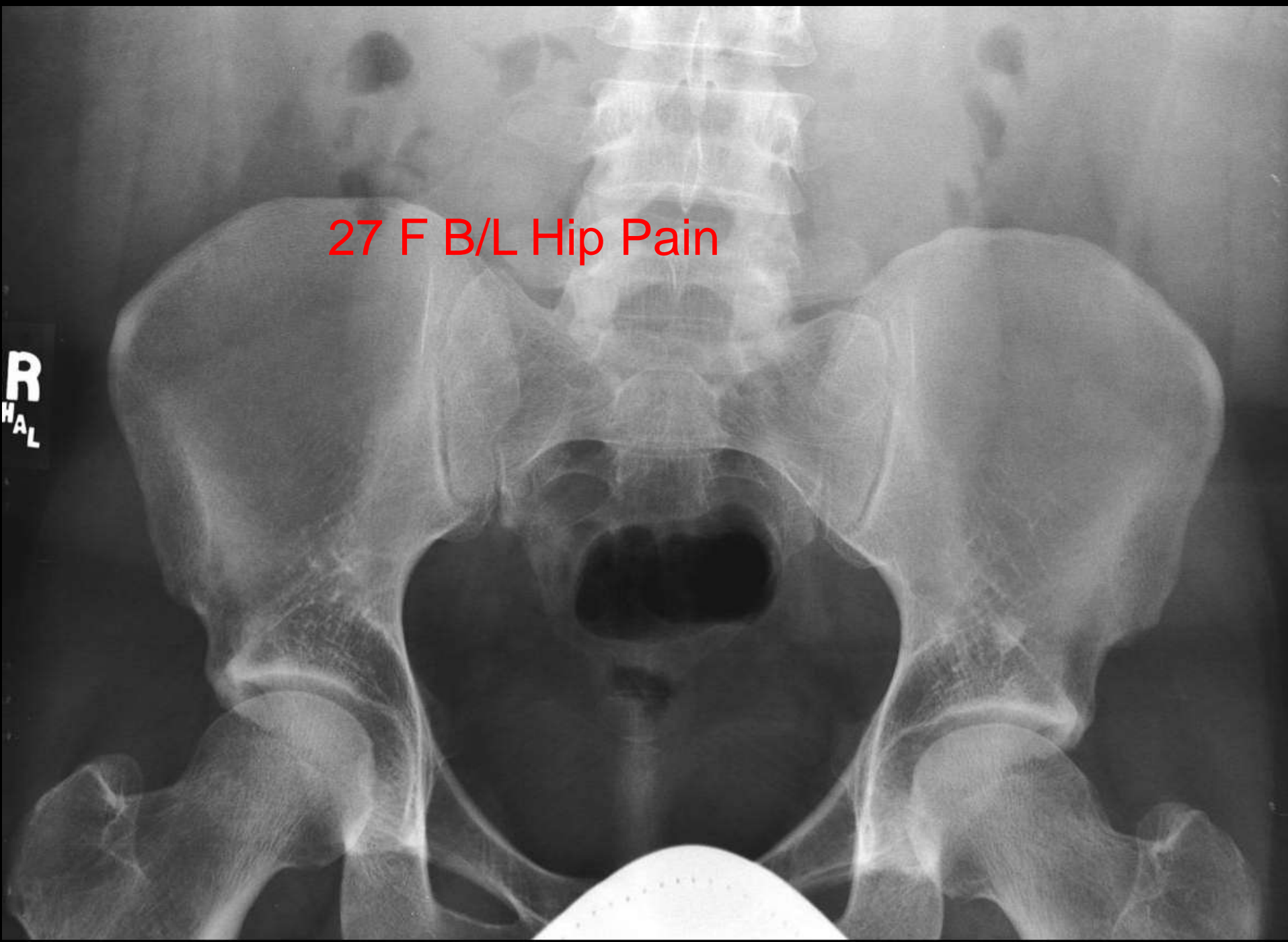
23 M B/L Hip Pain

R



27 F B/L Hip Pain

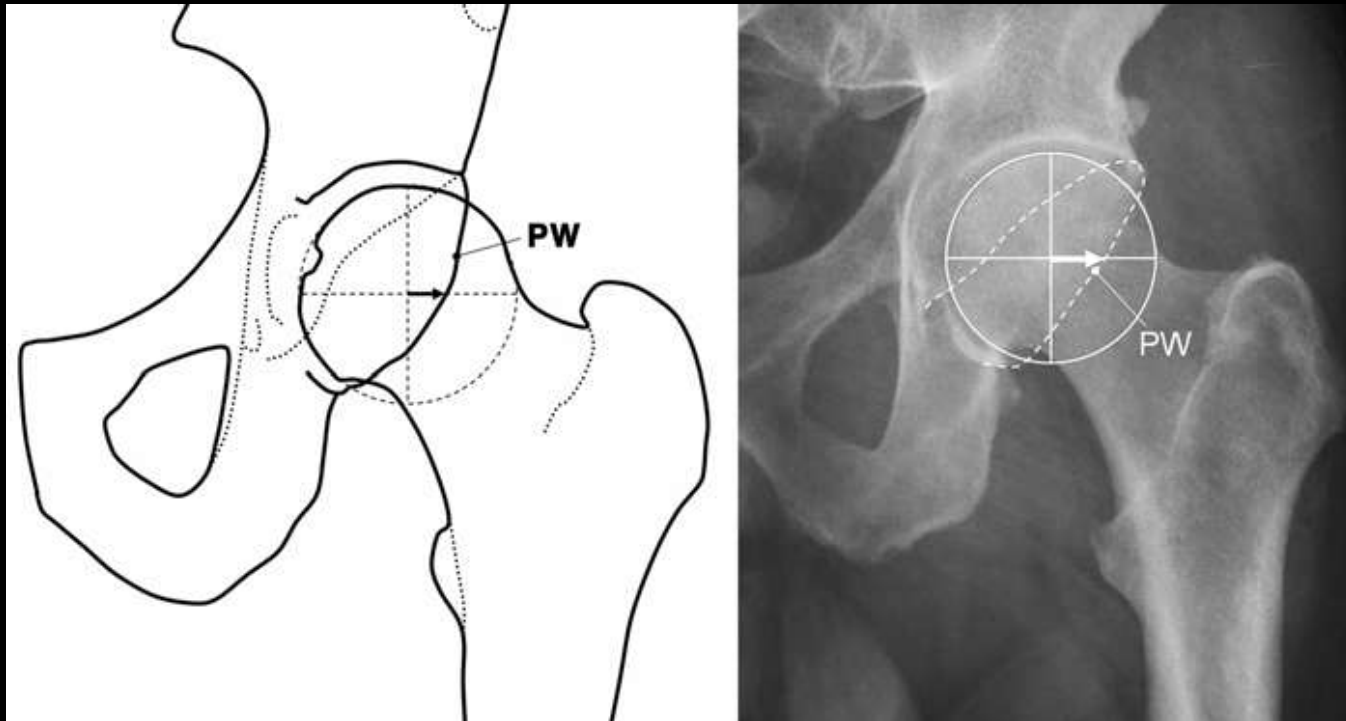
R
MAL



Focal Acetabular overcoverage

- Posterior: Prominent or Deficient Posterior Wall
 - Distinguish between anterior cranial acetabular retroversion and a deficient posterior wall
 - Posterior wall sign: outline of posterior rim passes approximately through the center of the femoral head.
 - If posterior wall is lateral to the center: **More Prominent Posterior Wall.**
 - If posterior wall is medial to the center: **Deficient Posterior Wall.**
 - **Deficient** posterior wall is associated with retroversion or dysplasia.
 - **Prominent** posterior wall associated with coxa profunda/protrusio

Prominent Posterior Wall

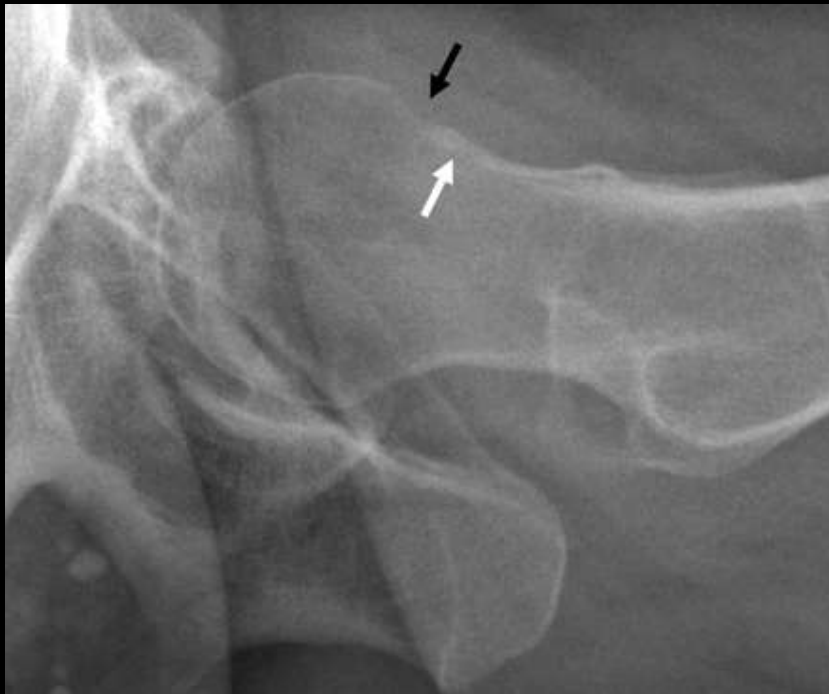


42 M B/L Hip Pain



Linear indentation sign

- Radiographic sign on cross table lateral radiograph or MRI.
- Linear indentation sign – pincer type FAI
- Occurs due to mechanical injury and reactive change



Os acetabuli

- Associated with pincer type
- Os acetabuli

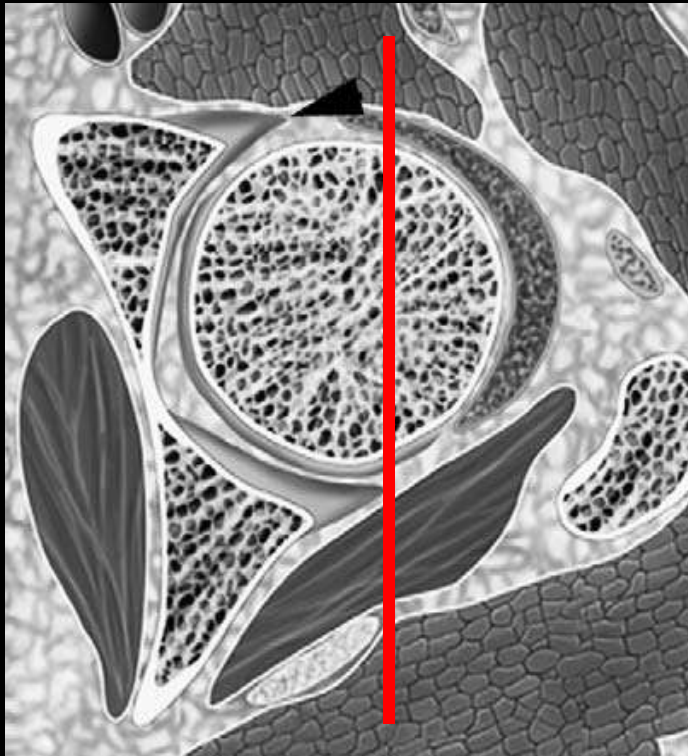




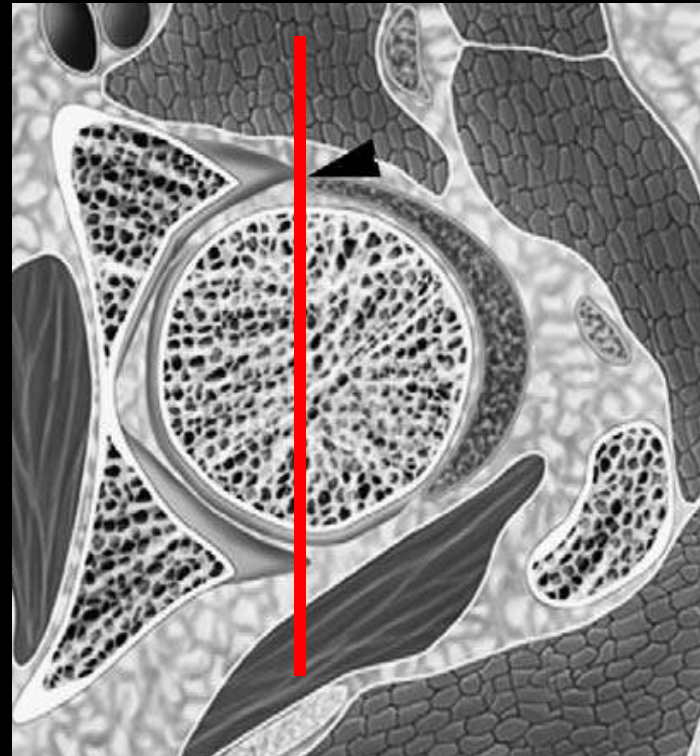
MRI: Pincer type FAI

- Normal alpha angle
- Anterosuperior acetabular labral tearing
- Articular surface defects (typically smaller and more focal than those seen in cam impingement)
- Evidence of osseous impaction along the anterosuperior or superior femoral neck
- Spherical femoral head

Acetabular Retroversion on axial CT and MR



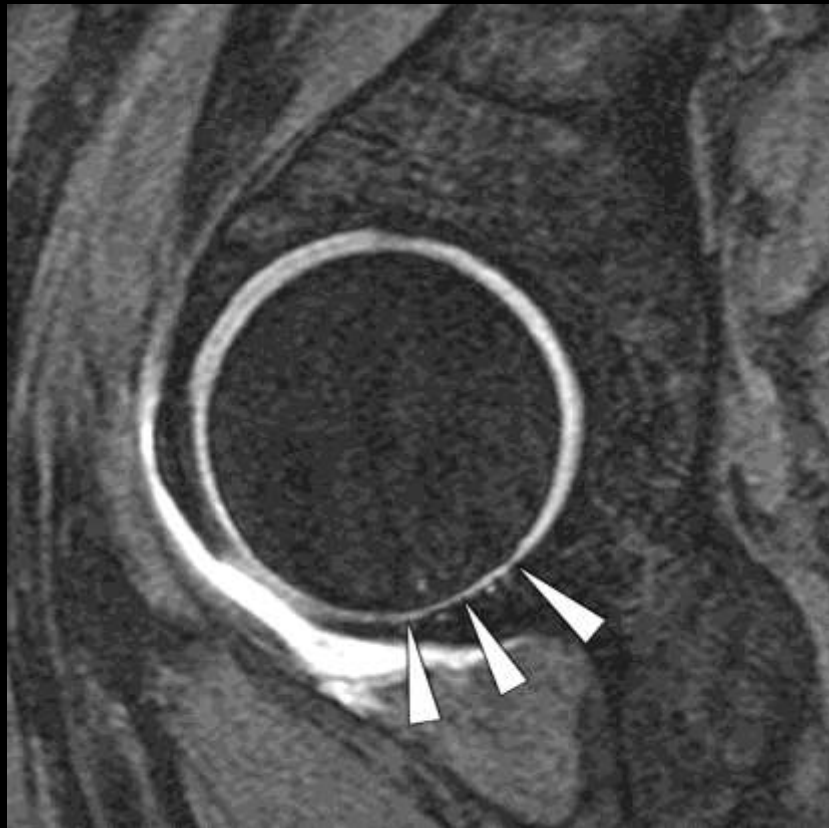
Normal: anterior labrum more medial than the posterior labrum in the sagittal plane.



Retroversion: anterior labrum even with or lateral to the posterior acetabulum in the sagittal plane.

MRI: Pincer type FAI

- Persistent abutment in the anterior hip can lead to a slight subluxation posteroinferiorly increasing pressure between the posteroinferior acetabulum and the posteromedial aspect of the femoral head.
- Causes “contre coup” cartilage lesions more severe posterior and posteroinferior acetabulum.
- Can lead to anterior superior labral tears and subchondral cyst.



Chondral loss in posteroinferior acetabulum seen in pincer impingement.

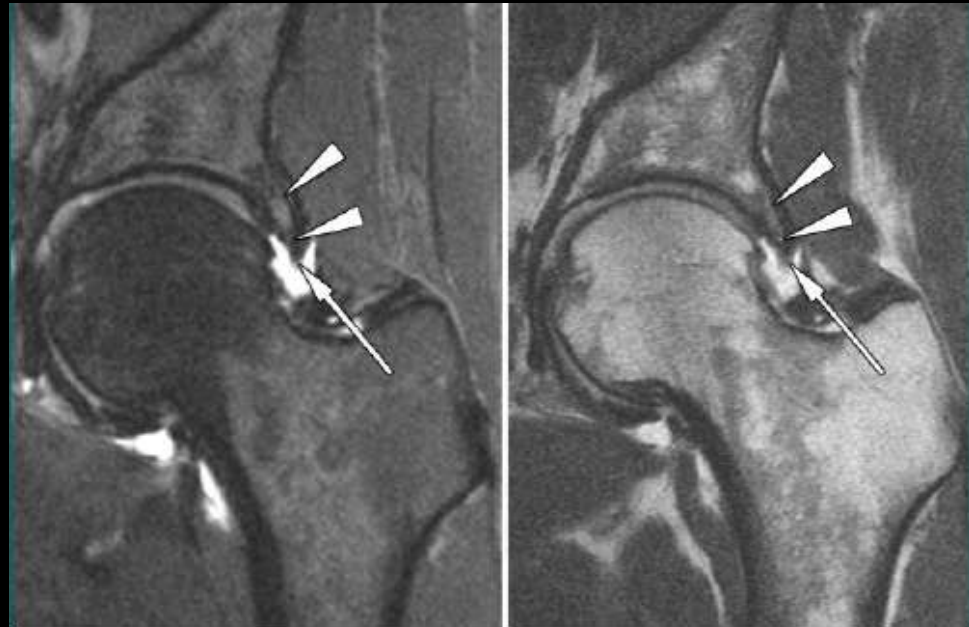
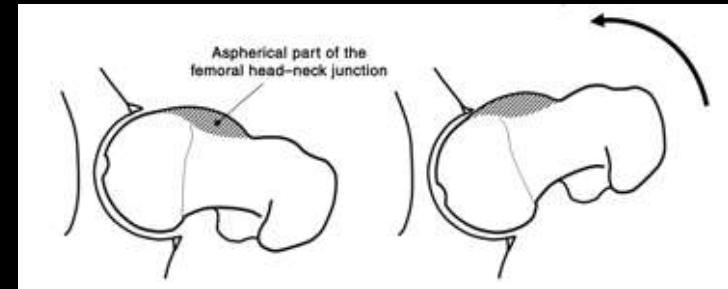


Figure 7: Coronal MR images obtained with an intermediate-weighted fast spin-echo sequence with fat saturation (2500/42) (left) and a T1-weighted spin-echo sequence (524/14) (right) show ossification of the acetabular labrum in a patient with pincer FAI. Bone marrow signal (arrowheads) extends into the substance of the acetabular labrum (arrow).

Cam type FAI

- Cam type of FAI

- Young males (32 years)
- Primary femoral abnormality
- Aspherical femoral head
- Femoral head jams into acetabular rim
 - Shear forces on labrum and cartilage
 - Diffuse articular damage
- Primary radiographic signs
 - Pistol grip deformity
 - CCD angle less than 125 degrees
 - Horizontal growth plate sign
 - Alpha angle greater than 55 degrees
 - Femoral head-neck offset less than 8 mm
 - Femoral retrotorsion



Pistol grip deformity

- Pistol grip deformity - Cam type FAI
 - Stulberg et al. 1975
- Loss of normal concavity seen on AP
- Etiology
 - SCFE
 - LCPD
 - Fracture healing
 - Growth abnormality of the femoral epiphysis

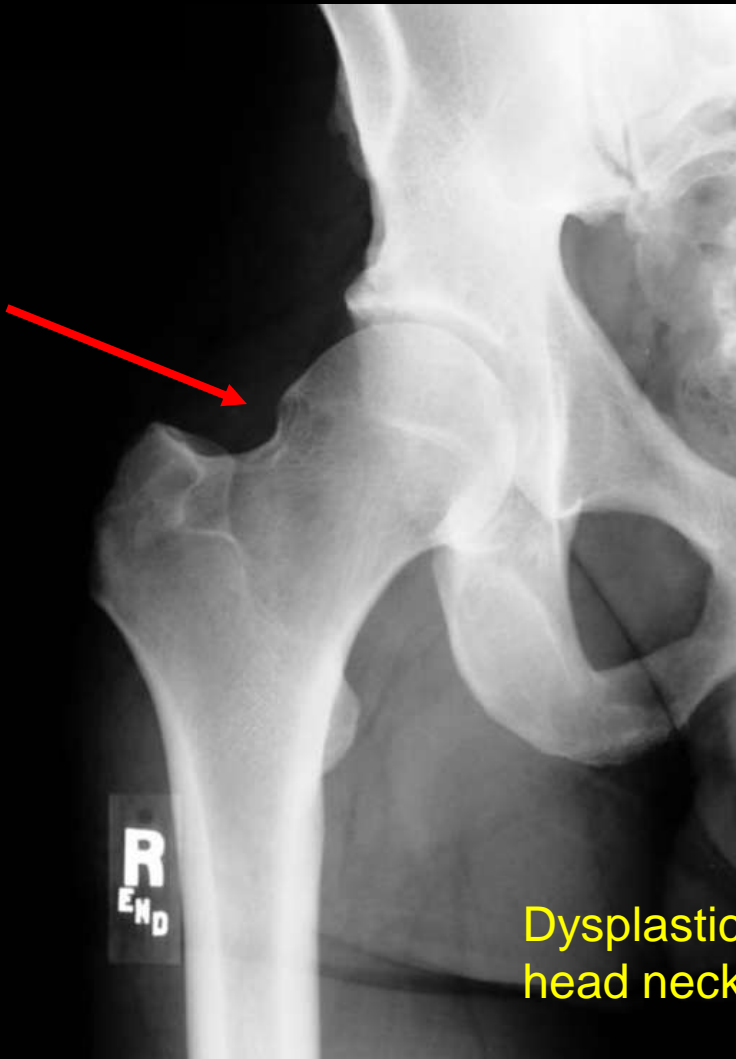


Horizontal growth plate sign

- Horizontal growth plate sign - Cam type FAI
- Physeal scar projects lateral to a best fit circle of the femoral head.



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Dysplastic Bump Anterosuperior or lateral femoral head neck junction



MRI CAM IMPINGEMENT



Axial Oblique

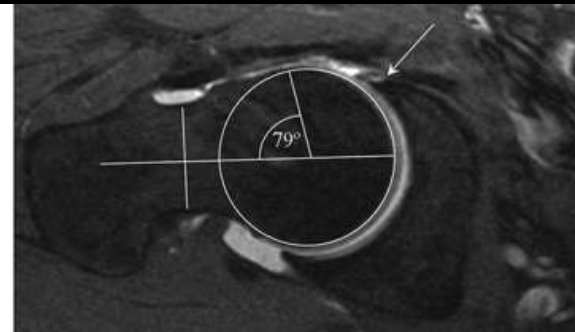
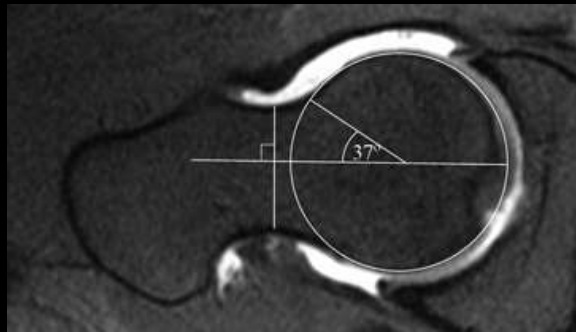
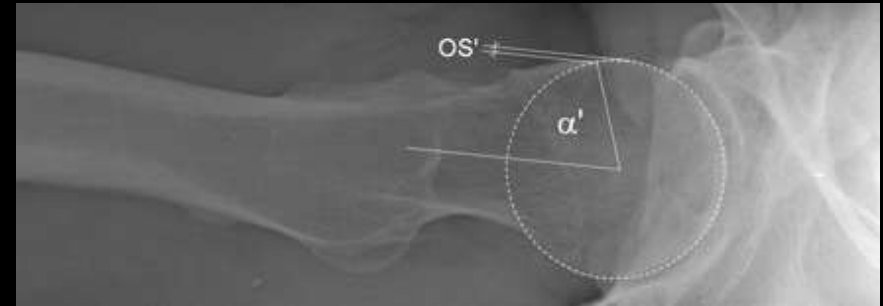
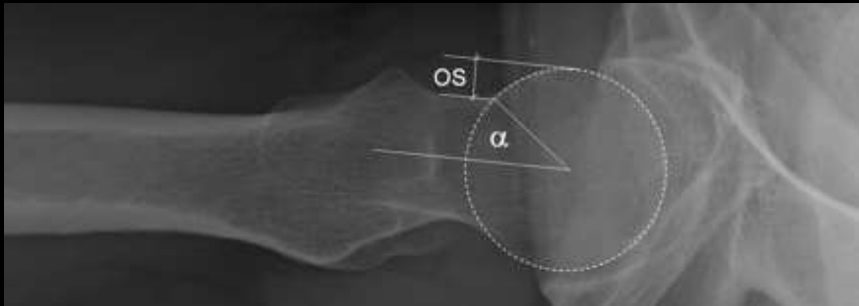
Alpha Angle

Figure 1. Oblique sagittal fat-saturated T1-weighted MR arthrographic image (450/8) shows method of measuring the α angle in a normal hip. A line (*a*) is drawn perpendicular to the femoral neck at its narrowest point. A second line (*b*) is then drawn perpendicular to this point, bisecting the femoral neck. A best-fit circle is drawn, outlining the femoral head. The α angle is calculated as the angle formed between line *b* and the point where the femoral head protrudes anterior to the circle. An angle of 55° or more is considered abnormal.



Alpha angle

- Alpha angle – Cam type FAI
- Used as an objective representation of the prominence of the anterior femoral head-neck junction.
- Abnormal is greater than 55 degrees (mean angle = 70 in sx patients)



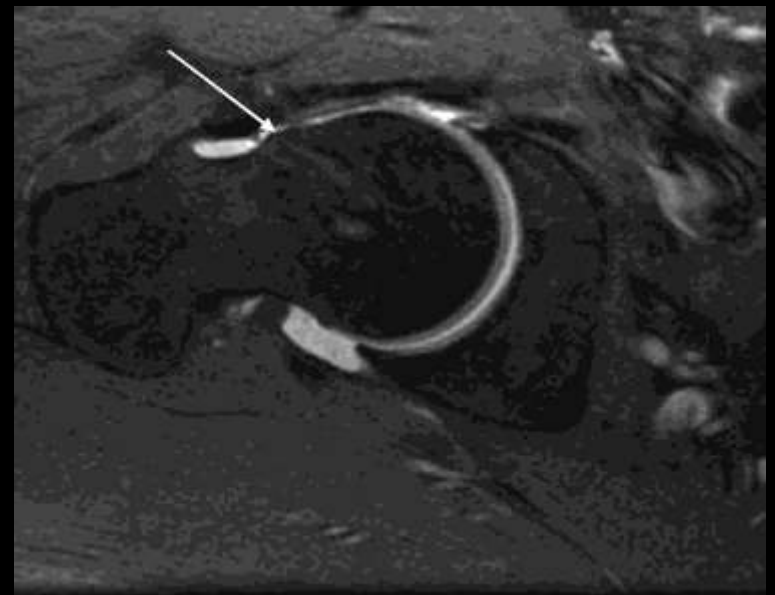
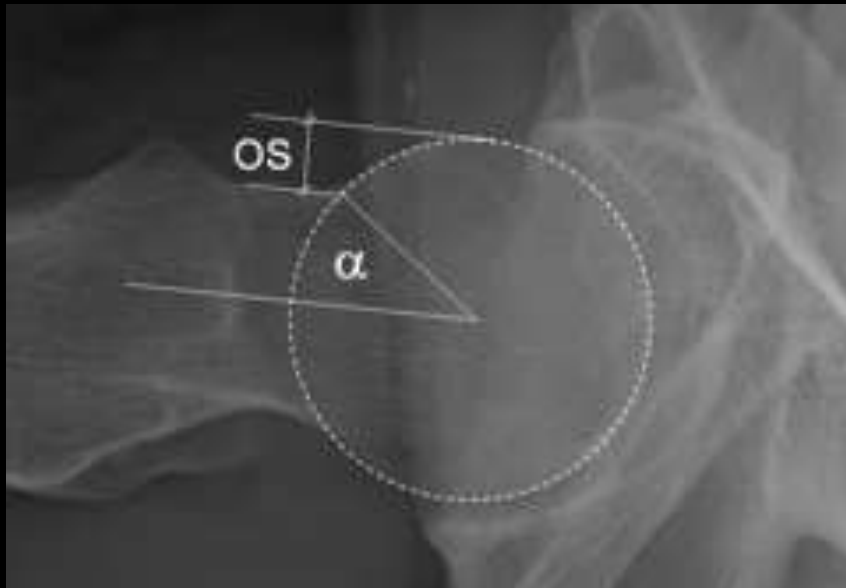
Classic MR findings of CAM Impingement:



- Dysplastic Femoral Bump @ head/neck jxn resulting in abnormal alpha angle.
- Anterosuperior Cartilage Abnormality
- Anterosuperior Labral Tear.

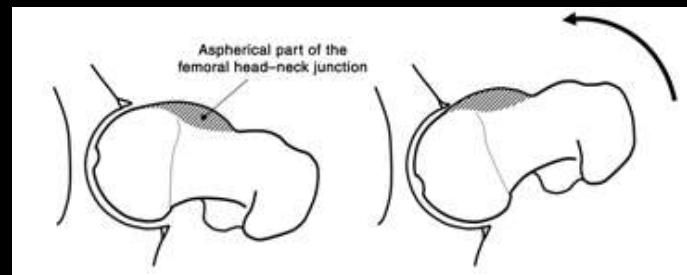
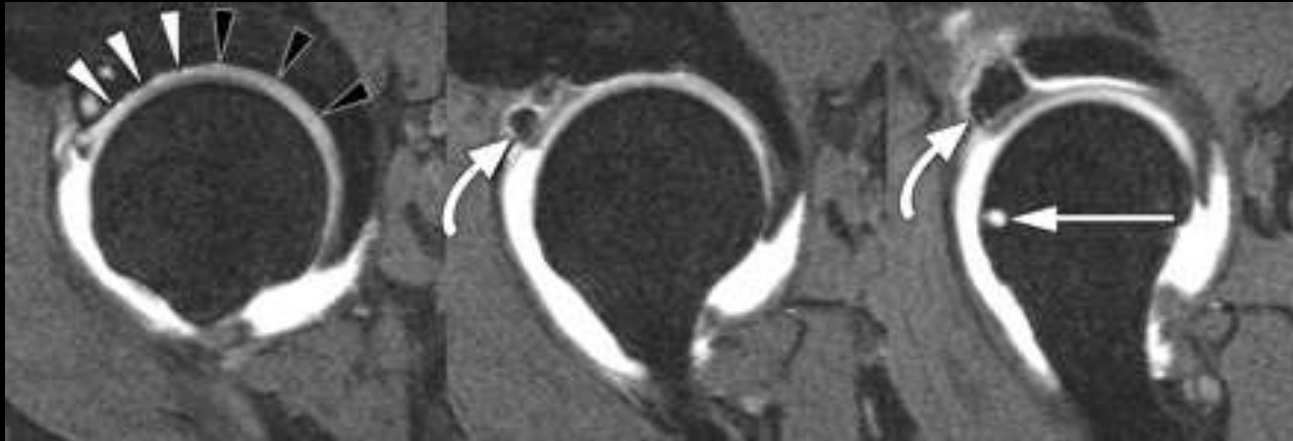
Femoral head-neck offset

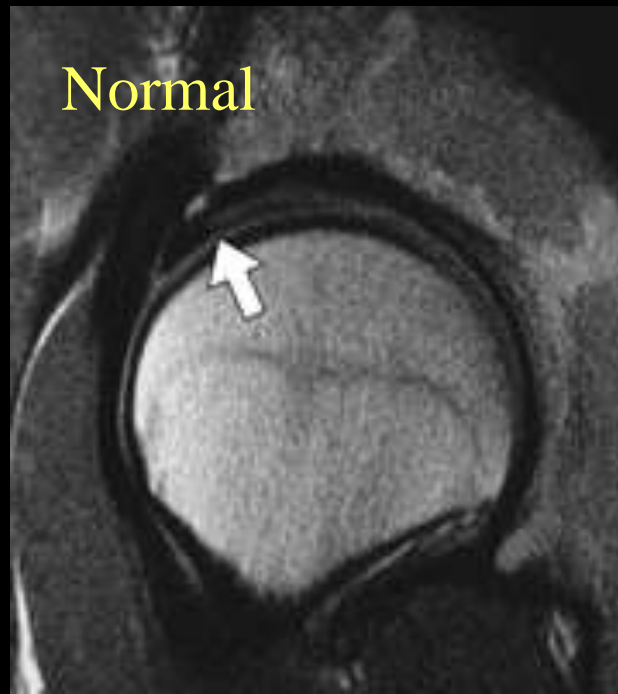
- Femoral head-neck offset (OS) – Cam type FAI
- Abnormal if less than 10 mm



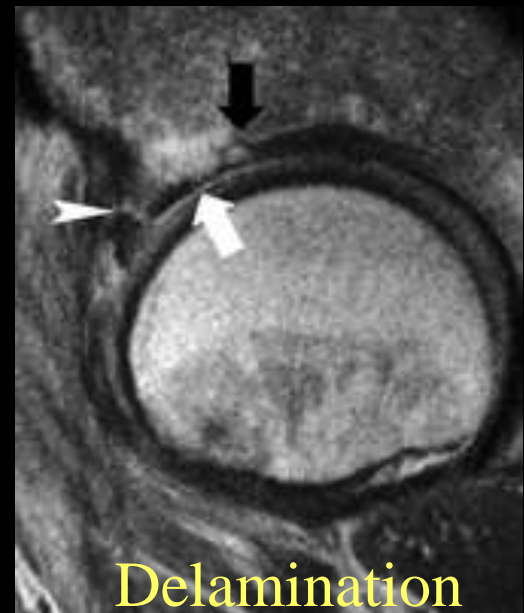
Secondary MR signs

- Synovial Herniation Pit
- Edema anteriorlateral femoral head neck/dysplastic bump and anterosuperior acetabulum
- Os acetabuli

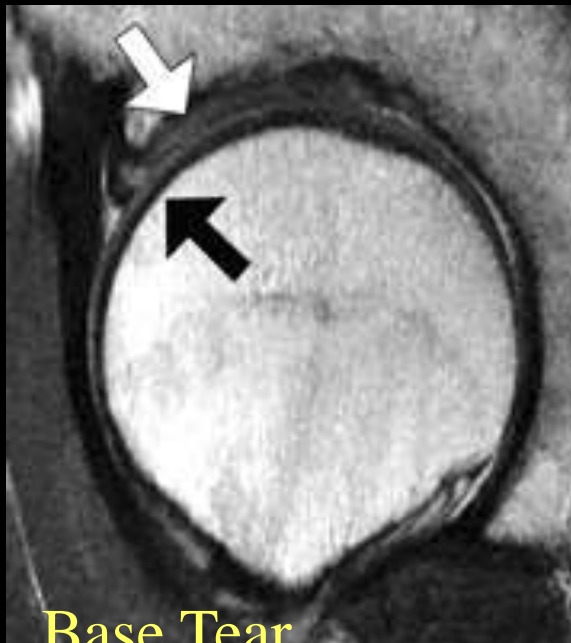




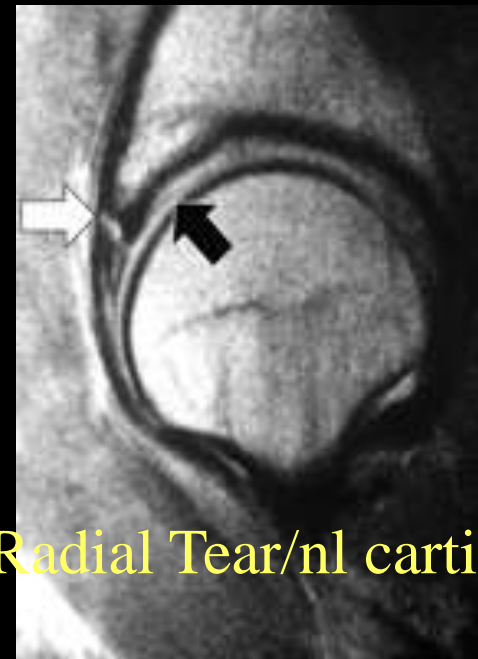
Normal



Delamination

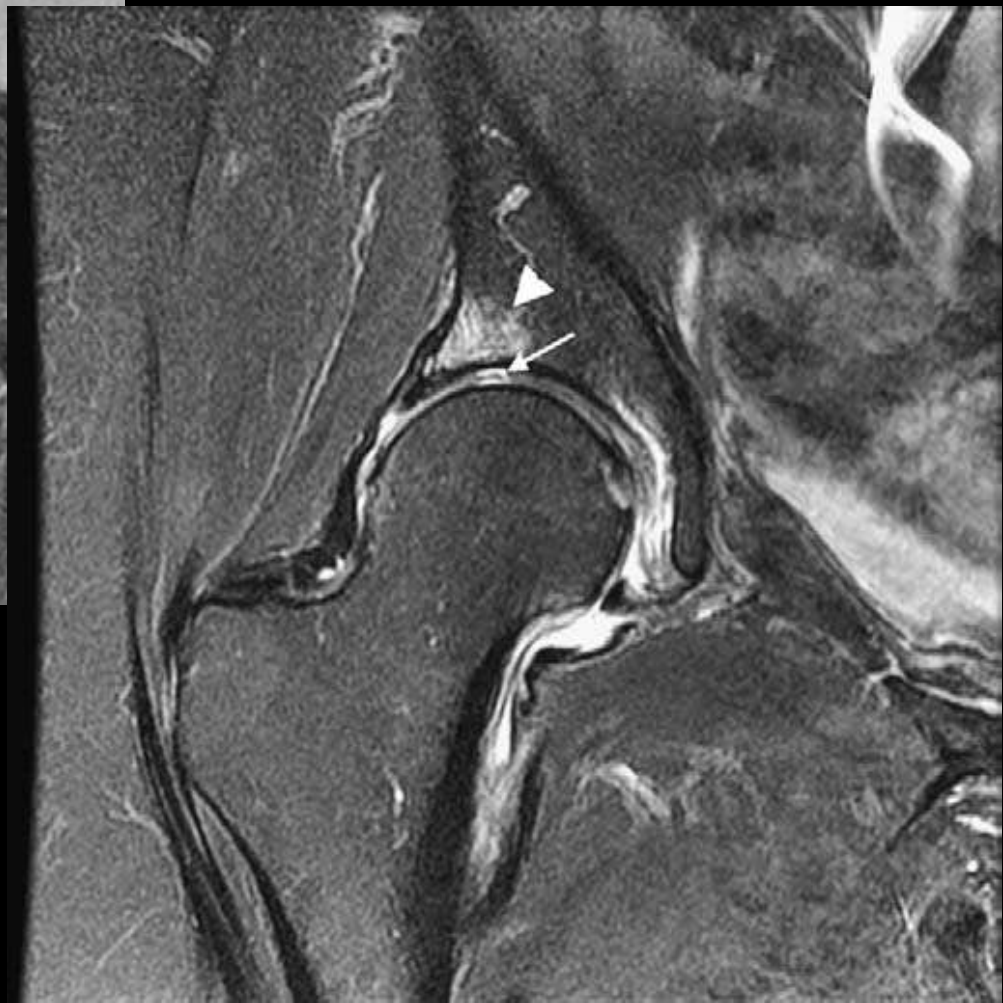
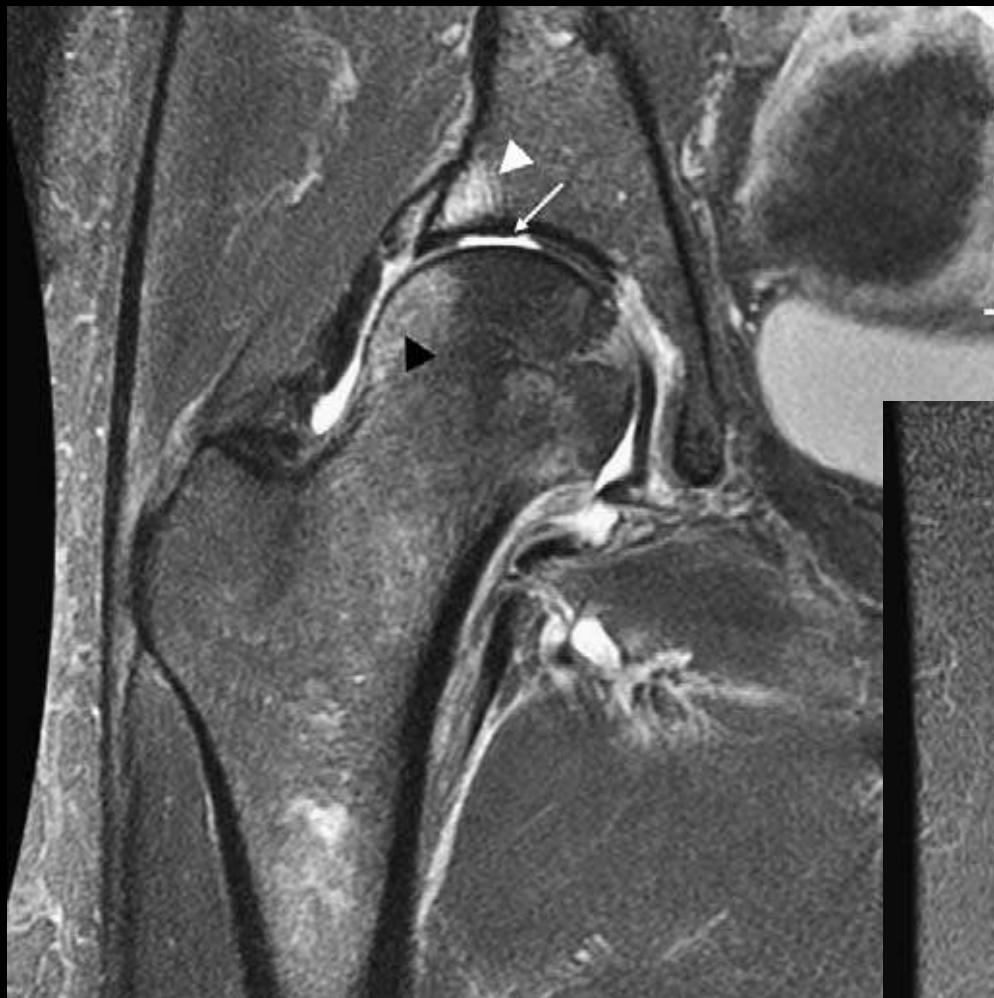


Base Tear



Radial Tear/nl cartilage

CAM type FAI



- edema superolateral acetabulum
- edema dysplastic femoral bump adjacent to physeal scar
- high grade chondral defect superior acetabulum

27 M Right Hip Pain



W 365 - L 130



W 304 - L 125



W 180 - L 140

Coxa vara

- Coxa vara - Cam type FAI
 - Abnormally located femoral neck
 - Decreased caput collum diaphysis (CCD) angle
 - Normal is 125 to 135
 - <115 highly associated with CAM FAI

The varus position gives rise to an abnormally located femoral neck that is situated more superiorly than normal.

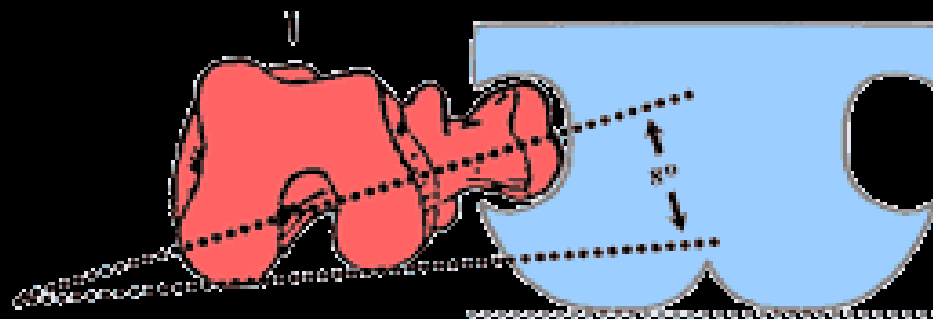
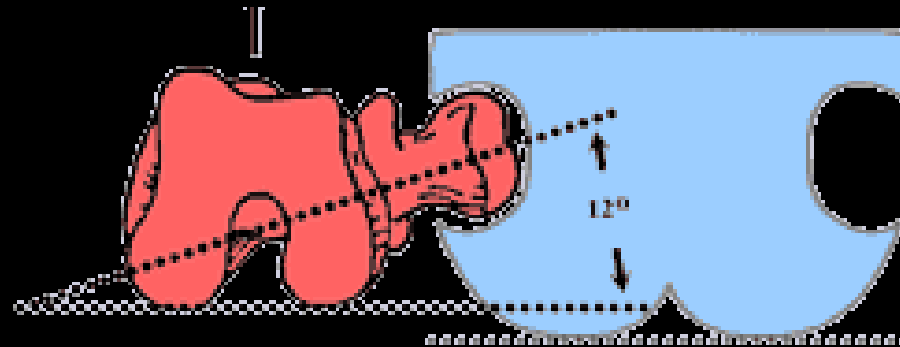


Femoral retrotorsion

- Femoral retrotorsion – Cam type FAI
- Congenital or post traumatic
- Calc by CT

TORSION : head and neck of the femur are measured relative to the condyles of the femur.

VERSION: head and neck are measured relative to the frontal plane of the body.



General radiographic signs

- Conventional radiographic findings

- Pincer

- “Deep” acetabulum

- Focal acetabular retroversion or posterior wall sign

- Cam

- Pistol grip deformity

- Coxa vara deformity

- Misshapen femoral head

- Prior trauma or deformity

- Secondary degenerative changes

- MR imaging

- Labral damage with corresponding damage to femoral head/neck junction

- Chondromalacia

- Superolateral in cam type

- Posteroinferior in pincer type

- CT imaging

- Similar to radiographic findings

Criteria	Pincer Impingement	Cam Impingement
Cause	Focal or general overcoverage	Aspherical head
Mechanism	Linear contact between overcovering rim and head–neck junction	Jamming of aspherical head portion into acetabulum
Sex distribution (M:F)	1:3	14:1
Average age (range) (y)	40 (40–57)	32 (21–51)
Typical location of cartilage damage	Circumferential with contrecoup	11- to 3-o'clock position
Average depth of cartilage damage (mm)	4	11
Associated disorders	Bladder extrophy Proximal femoral focal deficiency Posttraumatic dysplasia Chronic residual dysplasia of acetabulum Legg-Calvé-Perthes disease Slipped capital femoral epiphysis After acetabular reorientation procedures Idiopathic retroversion	Slipped capital femoral epiphysis Legg-Calvé-Perthes disease Posttraumatic retrotorsion of femoral head Coxa vara Pistol-grip deformity Head-tilt deformity Post-slip deformity Femoral retroversion Growth abnormality of femoral epiphysis
Radiographic signs on anteroposterior radiographs	Coxa profunda Protrusio acetabuli Focal acetabular retroversion (figure-8 configuration) Lateral center edge angle > 39° Reduced extrusion index Acetabular index ≤ 0° Posterior wall sign	Pistol-grip deformity CCD angle < 125° Horizontal growth plate sign
Radiographic signs on cross-table radiographs	Linear indentation sign	Alpha angle > 50° Femoral head–neck offset < 8 mm Offset ratio < 0.18 Femoral retrotorsion
Secondary changes	Herniation pits Ossification of labrum Appositional bone sign Os acetabuli Posterior inferior joint space loss (on faux profile in pincer hips) Late: classic signs of osteoarthritis	

Treatment

- Treatment
 - Intertrochanteric flexion-valgus osteotomy
 - Arthroscopic debridement
 - Remove any nonspherical portion of femoral head
 - Reduce size of acetabular rim in pincer type
 - Total arthroplasty in end stage disease



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