

FEMOROACETABULAR IMPINGEMENT, PART 2

Prior to the 1990s, radiology reports described cystic change at the anterosuperior femoral neck with the innocuous term “Pitt’s pits,” summarily dismissing them as normal variants. But subsequent understanding of hip pathology has shown these pseudocysts to be footprints of impingement. This issue of *The WCC Note* reviews the imaging diagnosis and findings of femoroacetabular impingement (FAI).

FAI DIAGNOSIS

How is FAI diagnosed?

1. The hallmark of cam FAI is asphericity of the femoral head. This becomes apparent at the head/neck junction (see image at right). Cam FAI jams an aberrantly shaped femoral head into the acetabulum.
2. Pincer FAI contacts an overcovered deep hip socket or retroverted acetabulum into the femoral head-neck junction.
3. These osseous collisions of FAI are worst in hip flexion and/or internal rotation. (1)
4. The diagnostic features of FAI reflect these predisposing anatomic risk factors and their consequences.

RIGHT: Coronal MRI image showing CAM FAI (arrow).

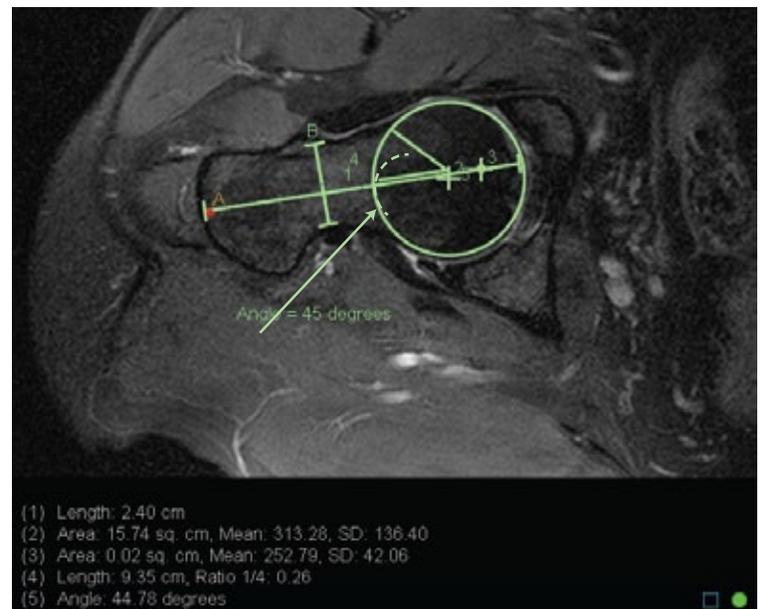


FAI BONE FEATURES

What are FAI bone features?

1. Femoral head and neck:

- a. The diagnosis of cam FAI hinges on discovery of femoral head asphericity.
- b. Measurements to assess femoral head asphericity include the alpha angle.
 - i. This measurement places a point in the center of the femoral head about which a compass draws a circle.



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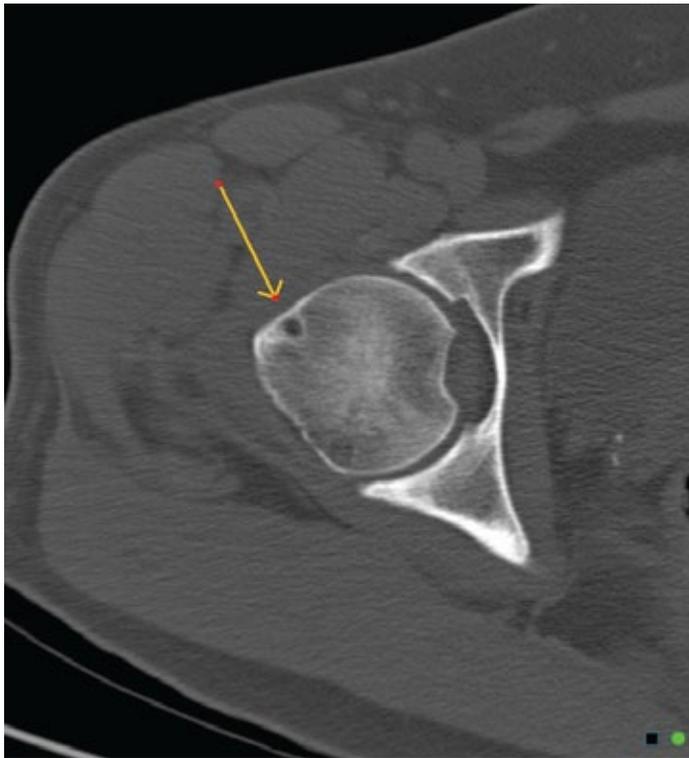
ABOVE: MRI showing normal alpha angle of 45 degrees.



ABOVE LEFT: MRI images showing abnormal alpha angle of 59 degrees. ABOVE RIGHT: Coronal image of cam FAI showing asphericity of the femoral head (arrow).

- ii. A line is drawn perpendicular to the femoral neck at its most narrow region. A perpendicular line is then drawn down the center of the femoral neck; this line is used to form an angle with a third line which is drawn from the center of the circle to the point where the femoral head protrudes anterior to the circle. An abnormal alpha angle is 55 degrees or more. (13)
- iii. In a normal femoral head, the anterior head/neck junction will become concave at the edge of this circle.
- iv. In a hip with cam FAI, the anterior head/neck junction does not become concave at this circle. Rather, the femoral head has an anterior convex bump, is “pistol grip” in morphology, or is otherwise wide rather than narrowing into a concavity.
- v. Conflicting utility of this measurement is reported. Authors from UCLA found it to be capricious. They noted interobserver variability, concluding that it held no statistical value in suggesting presence or absence of cam FAI. These authors deemed the clinical impingement test as the most reliable predictor. (2)
- vi. However, subjective analysis of the alpha angle has also been reported as suboptimal unless the bone abnormality is confidently identified. In a study of 50 patients, more than half the abnormal alpha angles were subjectively assessed as possibly or probably normal. In those hips with normal angles, slightly fewer than half were incorrectly placed in abnormal categories. (3)

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ABOVE LEFT: CT (bone window) image showing anterior femoral neck pseudocyst. ABOVE RIGHT: MRI (T2) image showing anterior femoral neck pseudocyst.

2. Femoral neck:

- a. The anterosuperior femoral neck showed high prevalence of juxtaarticular fibrocystic changes in FAI hips compared to hips with developmental dysplasia in a study of pelvic radiographs and MRI arthrography. (1) These changes were formerly misnamed “herniation pits” or “Pitt’s pits.”
- b. Histologically, the fibrocysts (pseudocysts) range from gelatinous to fibrous. (1)
- c. The pits need to be distinguished from other cystic lesions to avoid overestimating FAI. “Herniation pit” features include subchondral/subcortical location, completely surrounding sclerosis, sharp demarcation, and round to oval shape by CT. (4) The overlying capsule may become swollen.
- d. In the younger patient, cysts that convert to fat signal indicate attempted healing. (5)
- e. In contrast to FAI, hips affected by developmental dysplasia (DD) display deficient acetabular coverage anterosuperiorly only.
 - i. The femoral head of a DD hip can migrate in that direction and the instability can result in shear forces that are worst in hip full extension and external rotation. (1)
 - ii. In one study, no DD-affected hips had juxtaarticular cysts at the anterosuperior femoral head-neck junction compared to their presence in 33 percent of FAI-affected hips. (1)
- f. In a study of 85 patients with “herniation pits”, association was found with increased alpha angle indicating cam-type FAI but not morphologic indicators of pincer FAI. The pits were predominantly located in the superior proximal anterior femoral neck, but were also discovered inferiorly. (6)

3. Acetabular:

- a. Pincer FAI, in contradistinction to cam FAI, shows abnormal acetabular morphology, like acetabular retroversion or coxa profunda. Since pincer FAI results in abnormal contact between the acetabulum and the femoral head-neck junction, the labrum sustains the primary injury with only minimal cartilage damage of the acetabular rim. However, the posteroinferior acetabulum can receive contrecoup injury in the setting of persistent impingement. (7)
- b. Retroversion is diagnosed by assessing for the crossover sign, when the superior anterior acetabulum projects lateral to the posterior wall on axial imaging. (8)
- c. An os acetabulum suggests FAI, often occurs with the femoral neck bump and can be seen with cam FAI. (9)
- d. The acetabular cup may be too deep (“protrusio”) contributing to femoral overcoverage.



ABOVE: Three MRI images from the same patient showing abnormal alpha angle of 61 degrees (LEFT), cam FAI labral tear (CENTER), and acetabular cartilage delamination (RIGHT).

FAI CARTILAGE FEATURES

What are FAI cartilage features?

1. Cam FAI commonly shows acetabular cartilage delamination at MR arthrography. In one series of patients undergoing surgery for it, the prevalence was 52 percent. Helpful criteria appeared as hypointensity in the acetabular cartilage on intermediate-weighted fat-saturated or T1-weighted images. (10)
2. At MR arthrography, acetabular cartilage showing hypointensity on intermediate weighted fat-saturated and T-1 weighted images helps diagnose delamination. Fluid under the delaminated cartilage is specific for cartilage delamination but occurs uncommonly. (10)
3. Patients undergoing hip surgery for cam FAI showed acetabular cartilage delamination in 44 percent (28 of 64 hips), strongly associated with male sex and femoral sided signs of impingement. Delamination was identified best on the sagittal T1 and PD SPIR images. (11)
4. Distribution of cartilage abnormality proved unique for the sub-groups of FAI in a study of 26 symptomatic FAI patients. Cam-type involved the anterior to superior location; pincer-type showed generalized circumferential decrease. (12)

FAI LABRAL CHANGES

What FAI labral changes occur?

1. In cam FAI, labral pathology happens at the articular region and usually after preceding cartilage damage. Labral detachments are reported as more common than tears in cam FAI. (9)
2. In pincer FAI, labral tears are said to occur earlier in the manifestations of that diagnosis. (9)

CAM-FAI FINDINGS

Summary of CAM FAI findings:

1. The dominant finding is asphericity of the femoral head at the head/neck junction.
2. Surgical evidence supports that cartilage injury occurs as the principal damage in cam FAI and that the labrum is initially uninvolved. (9)
3. Labral pathology tends to be detachment. Labral tears or detachments happen at the articular margin, not the capsular side. (9)
4. A triad of abnormal head-neck junction morphology, anterosuperior cartilage abnormality, and anterosuperior labral abnormality was reported in 37 of 42 patients. (13)
5. Characteristic MRI arthrogram findings are a large alpha angle greater than 55 degrees, anterosuperior cartilage lesions, and osseous bump formation at the femoral neck. (14)

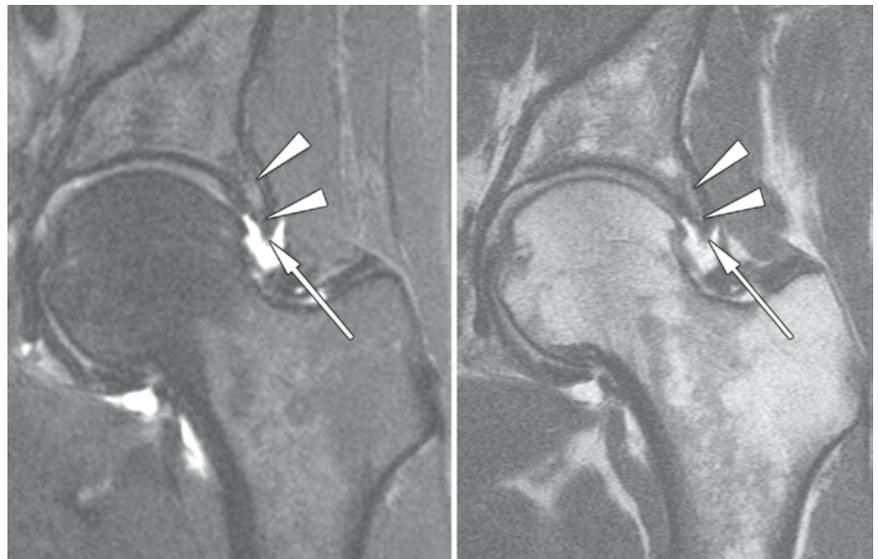


ABOVE: Hip MRI showing bilateral os acetabuli.

PINCHER-FAI FINDINGS

Summary of PINCHER FAI findings:

1. Increased coverage of the anterosuperior femoral head, leading to contact of the normal anterolateral femoral neck with the prominent acetabulum. (9)
2. The impingement causes primarily labral tears and acetabular bone proliferation. Labral pathology tends to be a tear. (9)
3. Cartilage abnormality is secondary. With chronicity, cartilage injury with contrecoup cartilage damage at the posteroinferior acetabulum may occur. (9)
4. Characteristic MRI arthrogram features are a deep acetabulum (“protrusio”) and posteroinferior cartilage lesions. (14)
5. Acetabular cup retroversion may be present.



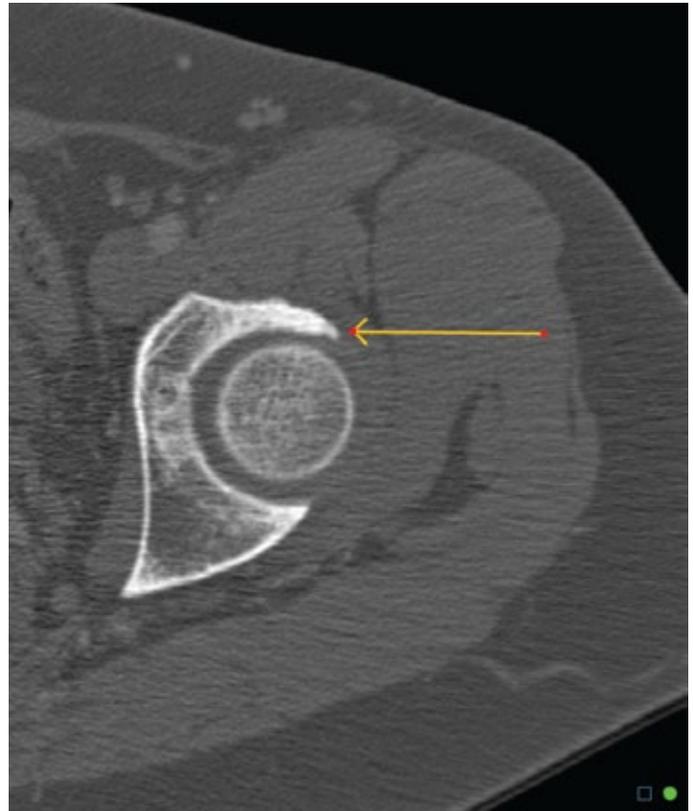
ABOVE: Coronal MR images obtained with an intermediate-weighted fast spin-echo sequence with fat saturation (2500/42) (left) and a T1-weighted spin-echo sequence (524/14) (right) show ossification of the acetabular labrum in a patient with pincher FAI. Bone marrow signal (arrowheads) extends into the substance of the acetabular labrum (arrow). (17)

Discussion of mixed cam and pincer FAI.

1. Both cam and pincer FAI may coexist. (15) While acetabular retroversion, a nonspherical femoral head at the femoral head-neck junction and decreased depth of the femoral waist may occur in combination, a predominant form of FAI is reported as usually present. (15)

How does developmental dysplasia of the hip (DDH) differ from FAI?

1. Since DDH and FAI share clinical symptoms and early osteoarthritis, distinguishing between these entities proves important, but findings may be extremely subtle. (9)
2. Assessment for DDH requires evaluating for deficient acetabular coverage of the femoral head by evaluating the acetabulum anteriorly and laterally.
 - a. Lateral coverage: The center-edge angle of Wiberg is evaluated on weight-bearing AP radiographs. This angle should be greater than 25 degrees. It is measured by making a point in the center of the femoral head and then drawing two lines. One line extends vertically. The other line goes to the lateral acetabular margin. (9)
 - b. Anterior coverage: This is assessed on the Lequesne's false profile view. A standing radiograph, ipsilateral posterior oblique, is performed. Two lines extend from the center of the femoral head. One is vertical; the other, goes to the anterior acetabular rim. The angle should be at least 25 degrees. (9)
3. Ligamentum teres and pulvinar hypertrophy are typical findings in DDH. (9)
4. A check for sphericity of the head and whether retroversion is present should be made. In DDH, focal retroversion of the anterosuperior acetabulum exists in a large number of patients. (9) Retroversion may also be found in pincer impingement.
5. Microinstability can occur in DDH because of the deficient acetabulum, with anterolateral femoral head migration leading to acetabular rim shear stress. This is often accompanied by labral hypertrophy, which eventually fails and tears.
6. Labral pathology differs in DDH and FAI.
 - a. While the labrum may be abnormal anterosuperiorly in both DDH and FAI, the labral changes differ.
 - b. In DDH, the labrum tends to have myxoid degeneration and increased volume, not present in FAI.
 - c. Paralabral cysts are common in DDH and less common in FAI. (9,16)



ABOVE: Hip MRI showing focal retroversion of the anterosuperior acetabulum.

CONCLUSION

Conclusion: The emblematic MRI findings of cam FAI are asphericity of the femoral head, enlarged alpha angle, proximal femoral neck pitting, and labral pathology, which typically precedes anterolateral cartilage damage and often is a detachment injury. Pincer FAI features include acetabular overcoverage, earlier labral tears, and a generalized secondary cartilage loss with possible contrecoup cartilage disease posteroinferiorly. Careful distinction between FAI and DDH is important and can be very subtle.

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