Measurements and Signs in Femoro-acetabular Impingement (FAI): a Radiological Survival Guide

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Learning objectives

This presentation intends to familiarise the reader with the radiological signs and measurements that can be elicited to support a diagnosis of femoro-acetabular impingement (FAI).
Background

Femoro-acetabular impingement (FAI) is an established cause of premature osteoarthritis (1-5). The natural history of the disease is still largely unknown, but early diagnosis and surgical intervention has been shown to reduce symptoms and improve function at least in the short term (6, 7). Early treatment may also reduce the risk of significant degenerative changes in later life (4). Two types of FAI have been described although mixed types do exist (8). In the Cam lesion there is asphericity at the femoral head-neck junction. In the Pincer-type lesion there is focal or generalised over-coverage of the acetabulum. These anatomical variances are thought to predispose to early pathological contact between the femoral head and acetabular articular and labral surfaces during movement of the hip joint. Although FAI remains a clinical diagnosis, there are a number of imaging findings established in the literature that can support the diagnosis.
a) **Alpha angle**

A measure of asphericity of the femoral head-neck junction. It is measured in the axial oblique plane with conventional radiography, CT or MRI. The angle is measured between a line drawn from the centre of the femoral head through the central axis of the femoral neck and a second line drawn from the centre of the femoral head to the point anteriorly where the distance from the centre of the head exceeds the radius of the femoral head (Figure 1). It has been proposed that an alpha angle >55° predisposes a patient to cam FAI (9).

Recent research (10) suggests that alpha angles calculated from radial reformatted CT or MR image slices may provide a more accurate assessment of asphericity at the femoral head-neck junction (Figure 2). In this way alpha angles can be calculated along the whole circumference of the femoral head-neck junction, whereas measurement in the traditional axial oblique plane will define asphericity in the anterior plane only. Defining the anterosuperior quadrant (12 to 3 o’clock positions) of the femoral head-neck is particularly relevant to cam FAI.

b) **Femoral head-neck offset** (Figure 3)

This is measured in the axial oblique plane with conventional radiography, CT or MR. The anterior offset is the distance (d) which lies between lines (b) and (c), which lie parallel to the anterior aspect of the femoral neck cortex and the anterior cortex of the femoral head respectively. Lines (b) and (c) lie parallel to the mid-point of the femoral neck at its narrowest dimension (line a). A reduced offset is defined as <8mm (1).

c) **Pistol grip deformity** (Figure 4)

Flattening of the usual concave surface of the lateral femoral head due to abnormal extension of horizontally oriented femoral epiphysis (11).

d) **Lateral centre edge angle** (Figure 5)

The angle is formed by a line drawn from the centre of the femoral head to the outer edge of the acetabular roof, and a vertical line drawn through the centre of the femoral head (12). >39° implies acetabular over-coverage.
e) **Angle of acetabular version** (Figure 6)

This can be calculated from an axial CT/MR slice that corresponds to the deepest portion of the acetabular cup. It is the angle that is formed between a line that is perpendicular to a tangent that runs between the posterior corners of the acetabuli, and a line that joins the anterior and posterior corners of the acetabulum. An angle <15° is indicative of acetabular retroversion (13).

f) **Acetabular index** (Figure 7)

This is the angle that forms between a line running tangentially between the points that represent the edges of the medial sclerotic rims of the acetabuli, and a line which adjoins the point that marks the medial edge of the sclerotic rim of the acetabulum and the lateral edge of the acetabulum. The angle is positive or negative depending on its relationship to the former line (13). A negative acetabular index implies overcoverage of the acetabulum.

g) **Cross-over sign** (Figure 8)

A sign of acetabular retroversion. The anterior wall overlaps the posterior wall (lies lateral to the posterior wall superiorly) of the acetabulum (1).

h) **Posterior wall sign** (Figure 9)

Associated with posterior impingement. The posterior wall of the acetabulum lies lateral to the centre of the femoral head (1).
Fig. 1: Alpha angle calculated in the axial oblique pain. An angle >55 degrees implies asphericity of the femoral head-neck junction.

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Fig. 2: Alpha angles calculated in the radial plane are reported to be more accurate. The 12-3 o'clock positions will reflect the anterosuperior quadrant of the femoral head-neck.

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Fig. 3: Femoral head-neck offset: A reduced offset is defined as
Fig. 4: Pistol grip deformity. Note asphericity and the typical horizontally appearing epiphyseal line.

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Fig. 5: Lateral Centre Edge Angle: An angle >39° is indicative of acetabular over-coverage.

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Fig. 6: Angle of Acetabular Version: An angle

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Fig. 7: Acetabular Index: A negative acetabular index is associated with pincer FAI.

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Fig. 8: Positive acetabular cross-over sign.

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Fig. 9: Prominent posterior wall sign.

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Conclusion

Although FAI is a clinical diagnosis, imaging has a key role to play in identifying the anatomical risk factors that predispose the young individual to the condition. Awareness of the radiological parameters that are associated with FAI, as presented in this survival guide, may help to halt the development of premature osteoarthritis of the hip.
References


