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Review Article

Femoroacetabular Impingement Radiographic Diagnosis: A Current Concept Review

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Abstract

Femoroacetabular impingement (FAI) could cause early osteoarthritis in patients. It is important to diagnosis this condition in the early stages to avoid osteoarthritis. The radiological x-ray is one of the main methods to diagnose FAI. There are many radiological signs which help orthopedic surgeons to diagnose FAI in the pelvic x-ray. Recent studies revealed many new signs for diagnosis and in the present concept article, we try to review all the radiological signs of the FAI in the pelvic and hip x-ray.

Keywords: Femur; Acetabulum; Hip; Radiography

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Background

Femoroacetabular impingement (FAI) could cause early osteoarthritis in patients (1, 2). A pathologic contact of the skeleton prominence of the hip acetabulum and the femur is responsible for the occurrence of FAI, which impairs flexion and internal rotation movements (3, 4). Although FAI is based on clinical diagnosis, radiographic imaging and modalities will assess the FAI and distinguish a better treatment approach by categorizing them. Based on the radiology assessment, FAI is described in 3 types, pincer, cam, and a combination of them (5, 6). Plain radiography and magnetic resonance arthrography (MRA) are the two gold standards for preoperative assessment, which have made their way to clinical practice in the past decades (1). Herein, we provide a recent update of the radiographic diagnosis of FAI.

Radiographic Views

The primary imaging of FAI is plain radiography which is cheap, quick, and widely available. The majority of underlying hip disorders, such as Perthes disease, developmental dysplasia of the hip, and also advanced osteoarthritis, could be diagnosed with only one plain radiography (7). In order to have a good and correct understanding of a 3D structure with only a 2D image, standard acquisition techniques should be used (8). In the common plain radiography, a conical beam is projected from a point-shaped source which could be influenced by the distance between the film-tube and patient-film, centering at the direction of the x-ray beam and pelvic orientation during image acquisition. Hence, a standardized imaging is required to evaluate hip pathology accurately. The distance between the film-tube and patient-film play a major factor in the acuity of the imaging. The alteration of these distances will lead to the impaired magnification of the object, and the projection of the desired limb will be influenced. Another important factor to have good quality imaging is centering the x-ray beam between a line connecting both anterior superior iliac spines (ASIS) and the upper border of the symphysis. If the central beam orientation changes, the imaging is suitable for other purposes, not for FAI, which varies from low-centered projections (common for hip arthroplasty) or hip-centered projection (Figure 1). It has been shown that the anteroposterior (AP) pelvis radiograph is the best view to project in terms of the lateral center edge (LCE) angle, acetabular index (AI), acetabular center (ACM) angle, Sharp's angle, and total femoral coverage (9-11). The cross-table lateral is another radiographic view, which is the best to project and measure alpha angle sign (12, 13).

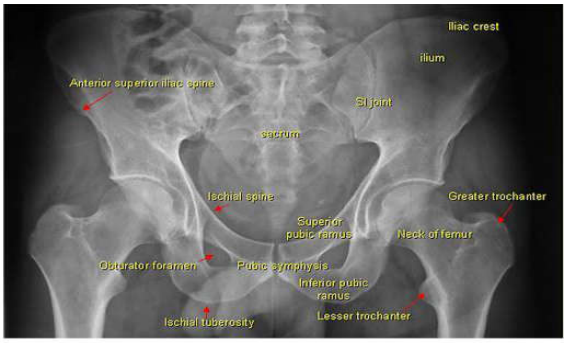

Figure 1. Normal pelvic anteroposterior (AP) view x-ray

Types of FAI

Pincer Type: Middle-aged women are more common to suffer from pincer impingement and could have comorbidities. Over-coverage of hip occurs this type of FAI, which could accelerate osteoarthritis. It leads to a linear contact between the acetabular rim and the femoral head-neck junction, causing scrub of the bone in the contact point. Compared to cam impingement, pincer impingement damages a lesser proportion of cartilage (Figure 2A) (3, 14).

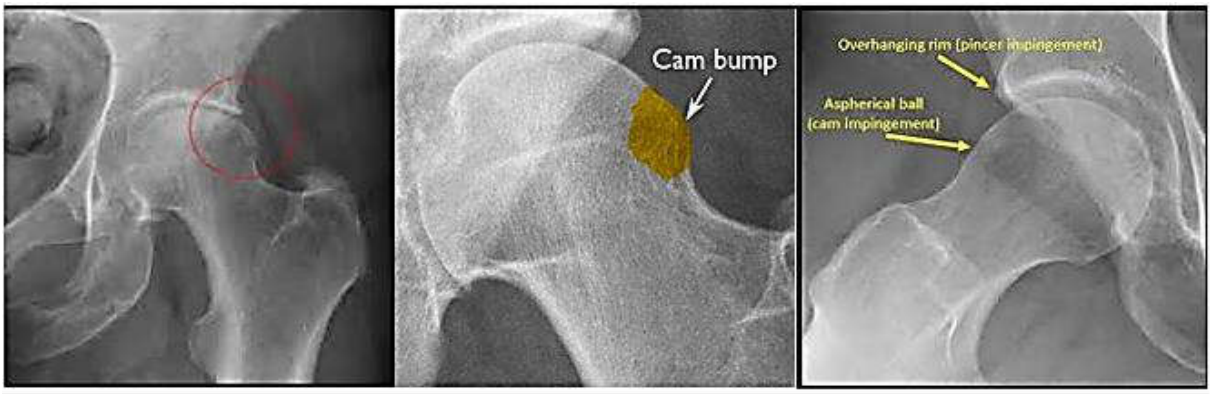

Figure 2. Pincer impingement type (A), Cam impingement type (B), Combined CAM-Pincer type (C)

Cam Type: Young men are more prone to be diagnosed with cam impingement. Herein, the femur is the cause of impingement, as femur has an aspherical head jammed into the acetabulum. This process decreases femoral head-neck offset, and the larger proportion of cartilage is injured (Figure 2B) (12, 15, 16).

Combined Pincer/Cam Type: Most patients have a combination of both cam and pincer (Figure 2C).

Radiographic Signs and Findings

Pistol Grip Deformity: A pistol grip is an osseous bump in the lateral of the femoral head-neck junction, which is seen on the AP pelvic radiograph. This sign is identified on radiographs when the lateral aspect of the femoral head is flattening instead of the usual concave surface of the aspect (Figure 3) (17-19).

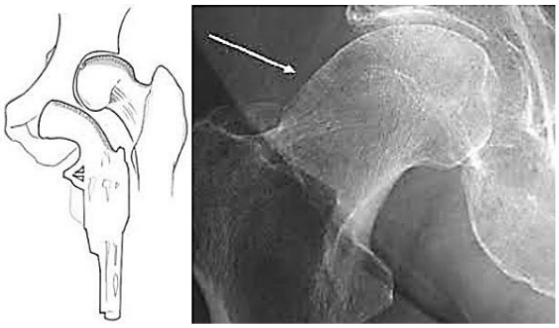

Figure 3. Pistol grip deformity as a radiologic sign of femoroacetabular impingement

Cross-Over Sign: The acetabulum is usually anteverted, and an anterior rim line (Red line, Figure 4A) crosses medially towards the posterior wall line (Blue line, Figure 4A). Whenever there is a focal over-coverage, the acetabulum is cranially retroverted. Hence, the anterior rim line projection will be changed to lateral to the posterior rim in the cranial parts of the acetabulum, and it will cross the latter in the distal part of the acetabulum. This description provides a good understanding of the cross-over sign (Figure 4A) (20).

Posterior Wall Sign: Usually, the acetabulum is anteverted, and the anterior rim line goes toward the posterior wall line, which will form a cross-over sign in FAI. The posterior wall sign is defined as the center of the femoral head that is lateral to the posterior rim line, in global retroversion (Figure 4B) (21).

Hip Ptosis Sign: Hip ptosis is a very recent sign of FAI appearing on AP radiographs, which appears due to a reverse breakdown in Shenton's line. Previously, Sutton et al. revealed that in the cases with FAI, the lower border of the femoral head is in a lower position than the inter-teardrop line (Figure 5) (22).

Radiographic Measurements

Alpha Angle: A line that connects the center of the femoral head to the point the anterior head-neck contour exceeds the femoral head radius. If the alpha angle exceeds 50°, it is associated with a cam-type FAI. The best projection of alpha angle is on the cross-table view; however, it could be measured in other projections as well (Figure 6A) (12, 23).

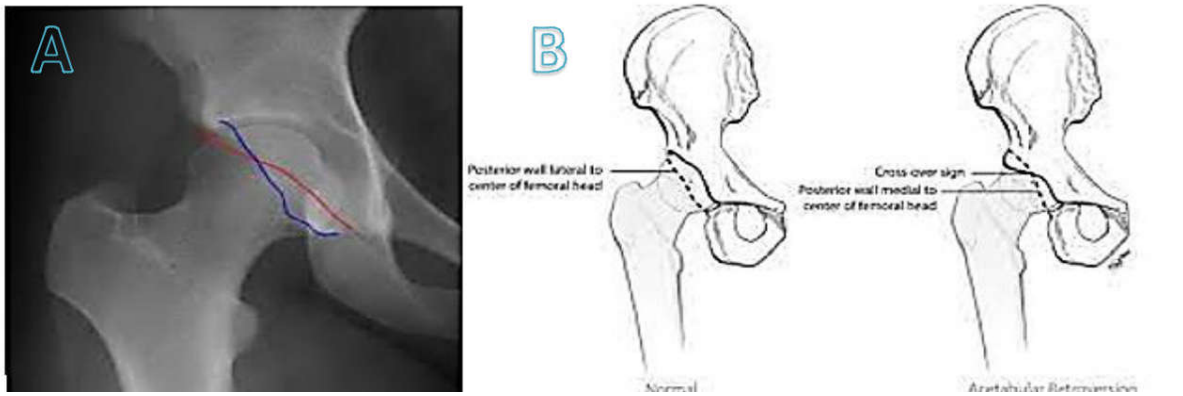

Figure 4. Crossover sign, The anterior wall of the acetabulum (Red line, A) crosses the posterior wall of the acetabulum (Blue line, A); when the posterior wall of the acetabulum is placed medial to the femoral head, it is named posterior wall sign (B).

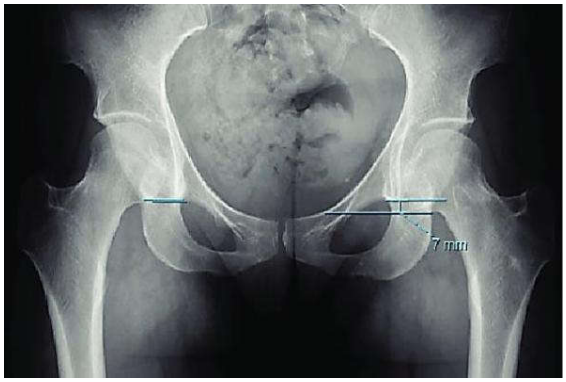

Figure 5. Hip ptosis sign, when the lower border of the femoral head is placed lower than teardrop sign.

Head/neck Offset Ratio (HNOR): The osseous bump in cam impingement decreases femoral head-neck offset. The femoral head-neck offset is the distance between the widest diameter of the femoral head and the most prominent part of the femoral neck. An offset less than 10 mm is usually associated with cam impingement; the offset ratio is calculated by division of the offset by the diameter of the femoral head (Figure 6E) (12, 15).

Lateral Center-edge Angle (Wiberg Angle): The angle between a line connecting the femoral head center with the lateral edge of the acetabulum and the vertical line is the lateral center-edge angle (Wiberg angle) that is usually in a range between 25 and 39°. An angle of Wiberg above 39° is an indicator of over-coverage (Figure 6C) (24, 25).

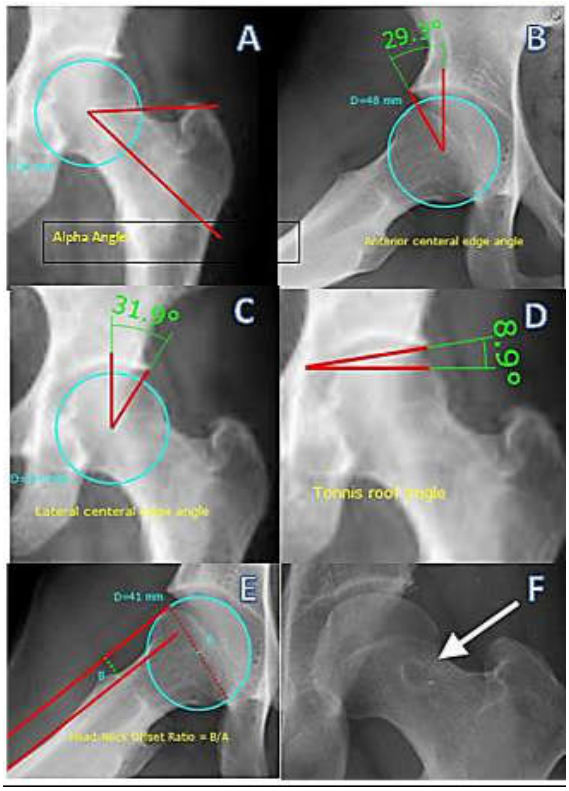

Figure 6. Radiologic measurements of the femoroacetabular impingement (FAI), alpha angle (A), anterior central edge angle (B), lateral central edge angle (C), Tonnis roof angle (D), head/neck offset ratio (E), herniation pit (F)

Anterior Center-edge Angle: The angle between a line connecting the femoral head center with the anterior edge of the acetabulum and the vertical line is the anterior center-edge angle in the frog-leg x-ray that is usually in a range between 25 and 39°. An anterior center-edge angle above 39° is an indicator of over-coverage, the same as the Wiberg angle (Figure 6B) (26).

Acetabular Index or Tonnis Roof Angle: The horizontal line and a connection line between the medial point of the sclerotic zone and the lateral center of the acetabulum make an angle called the acetabular index (Figure 6D) (5).

Herniation Pit: The radiolucencies with sclerotic margins located in the anterior proximal superior quadrant of the femoral neck are called herniation pits. Herniation pits occur in some of the patients (Figure 6F) (5, 27, 28).

Conclusion

It is important to diagnosis FAI in the early stages to avoid osteoarthritis. The radiological x-ray is one of the main methods to diagnosis FAI. There are many radiological signs which help orthopedic surgeons to diagnosis FAI in the pelvic x-ray. Recent studies revealed many new signs for diagnosis. We reviewed all the radiological sign of the FAI based on the recent studies.

Conflict of Interest

The authors declare no conflict of interest in this study.

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