Hip anthropometry measurements related to femoroacetabular impingement: normal ranges of alpha angle, anterior femoral distance and acetabular depth

Poster No.: C-1798
Congress: ECR 2011
Type: Scientific Paper
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Keywords: Musculoskeletal joint, Anatomy, CT
DOI: 10.1594/ecr2011/C-1798

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Purpose

Femoroacetabular impingement (FAI) is a pathologic entity which can lead to chronic symptoms of pain, reduced range of motion in flexion and internal rotation (1). Femoroacetabular impingement refers to abnormal contact between the femoral head-neck and acetabulum. It occurs as a result of morphological deformity of one or either structure, and has increasingly been recognised as a significant contributor to labral tear and premature osteoarthritis (2, 3).

Two subtypes of this entity have been described, 'Pincer-FAI' related to an abnormality of the acetabulum that results in over-coverage of the femoral head, and 'Cam-FAI' relating to overgrowth of the femoral head-neck junction (4). It is generally accepted that while isolated Pincer-FAI or Cam-FAI may be present in any one individual, a combination of both subtypes is usually present (5).

Although the majority of patients with FAI demonstrate radiologic abnormalities that support the clinical diagnosis, identical abnormalities can be seen in patients without the symptoms and signs of impingement syndrome (6).

The purpose of the study is to designate normal ranges of alpha angle (AA), anterior femoral distance (AFD) and acetabular depth (AD) which are helpful in the assessment of the femoral head-neck morphology and femoral head-acetabulum relationship in normal population using CT data.

Methods and Materials

Thirty-three consecutive patients (66 hips) (14 female, 19 male) with a mean age of 31.8 years who underwent abdominopelvic CT for a variety of reasons other than hip problems and who are agreed to undergo this study constituted the study population. All patients underwent FAI test.

Inclusion criteria:

- Negative FAI test
- Age between 18-45 years
- No known hip or spine surgery history
- Not having musculoskeletal disease history

Exclusion criteria:
• Positive FAI test
• Degenerative or congenital pathological changes in CT images
• Known hip pain
• Having hip and/or vertebral disorders including pain and previous surgery

Raw data from the abdominopelvic CT scans were used and a region starting from the superior iliac wing down to the level of femoral neck was reconstructed with 2 mm from the 5-mm source of CT images. An axial oblique image parallel to the long axis of the femoral neck for each hip were reconstructed in a workstation by one radiologist and sent to PACS for measurements. Alpha angle, AFD and AD measurements for each hip were performed from the reconstructed image in a workstation by two radiologist with a consensus technique. Pearson correlation test was performed for the presence of correlation between AA and AFD and AD.

1. Measurement of alpha angle (AA):

The AA is a parameter used to quantify the contour abnormality of the femoral head-neck junction in FAI. The AA is measured on an oblique image through the center of the femoral neck (figure 1) that is previously described by Nötzli et al (7). A line is drawn along the long axis of the femoral neck bisecting a circle which outlines the femoral head. A second line is then drawn from the center of the circle to the point at which the femoral head or neck protrudes beyond the confines of the circle anteriorly. The angle formed by these two lines comprised the AA (figure 2).


The AFD is described as the greatest perpendicular depth of epiphyseal overgrowth at the anterior femoral head-neck junction (2), and measured as the perpendicular distance between a line drawn along the cortex of the anterior aspect of the greater trochanter/ anterior femoral neck and the point of maximal femoral head-neck overgrowth (figure 3).

3. Measurement of acetabular depth (AD):

The AD was measured on the axial oblique image obtained through the center of the femoral neck (figure 4). The depth of the acetabulum is previously defined as the distance between the center of the femoral neck and the line connecting the anterior acetabular rim to the posterior acetabular rim (8). The value considered as 'positive' if the center of the femoral neck was lateral to the line connecting the acetabular rim.
Images for this section:

Fig. 1: An oblique image through the center of the femoral neck, reference plane for measuring alpha angle, acetabular depth and anterior femoral distance.
**Fig. 2:** Alpha angle—the angle measured between the line crossing the center of the femoral neck and the line joining the center of the femoral head and the point where the radius femoral head exceeds the circle.
Fig. 3: The AFD, the perpendicular distance between a line drawn along the cortex of the anterior aspect of the greater trochanter/anterior femoral neck and the point of maximal femoral head-neck overgrowth.
**Fig. 4:** AD was measured on the axial oblique image obtained through the center of the femoral neck. The depth of the acetabulum was defined as the distance between the center of the femoral neck and the line connecting the anterior acetabular rim to the posterior acetabular rim.
Results

In our patient series the AA values varied between, 29-53° (mean, 39) SD±4.74, and AFD values varied -2,6-2,8mm (mean, 0,87) SD±0,99. There was a low positive correlation between AA and AFD (r=0,303, p<0,05).

On the other hand, AD values varied between 0-8,5mm (mean, 4,5) SD±2,6. We found a low positive correlation between AA and AFD (r=0,303, p<0,05). No positive or negative correlation was found between AD and AA or AFD.

Conclusion

It is important to identify the type of FAI because surgical treatment differs for each type. The clinical aspects are then correlated with radiologic findings to confirm or exclude the diagnosis. Imaging-based diagnosis is possible with conventional radiography, MR imaging, and computed tomography (CT). In clinical radiology practices the diagnosis of FAI as an entity is not well established.

Several imaging findings have been described for diagnosing the cam type of femoroacetabular impingement (2, 7-9). The AA is being used as an objective representation of the prominence of the anterior femoral head-neck junction. It has been known that angles greater than 55° is closely associated with cam-FAI (7). One of the other alternative measurements for epiphyseal overgrowth is the AFD measurement. Lohan et al demonstrated that values greater than 3.6mm should be considered abnormal and might be used for the indicator for Cam-FAI (2). The AD on the other hand has been previously described by Pfirrmann et al and demonstrated that the depth of the acetabulum is relatively deeper in Pincer-type compared to Cam-type (8).

To our knowledge normal ranges of AFD and AD which are used in the assesment of femoral head-neck juction and femoral head-acetabulum relationship has not been previously designated. We aimed to determine the normal limits of those measurements and compare with widely utilized AA. These values appeared to be not related so that one might need to measure each of these values in the assesment of FAI.

References


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