The prevalence of cam-type femoroacetabular deformity in asymptomatic adults

K. A. Jung, C. Restrepo, M. Hellman, H. AbdelSalam, W. Morrison, J. Parvizi

From The Rothman Institute, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania, United States

We performed a retrospective examination of the anteroposterior pelvic CT scout views of 419 randomly selected patients between April 2004 and August 2009 in order to determine the prevalence of cam-type femoroacetabular deformity in the asymptomatic population. The CT scans had all been undertaken for conditions unrelated to disorders of the hip. The frequency of cam-type femoroacetabular deformity was assessed by measuring the α-angle of each hip on the anteroposterior images. The α-angles were classified according to the Copenhagen Osteoarthritis Study. Among 215 male hips (108 patients) the mean α-angle was 59.12° (37.75° to 103.50°). Of these, a total of 30 hips (13.95%) were defined as pathological, 32 (14.88%) as borderline and 153 (71.16%) as normal. Among 540 female hips (272 patients) the mean α-angle was 45.47° (34.75° to 87.00°), with 30 hips (5.56%) defined as pathological, 33 (6.11%) as borderline and 477 (88.33%) as normal. It appears that the cam-type femoroacetabular deformity is not rare among the asymptomatic population. These anatomical abnormalities, as determined by an increased α-angle, appear to be twice as frequent in men as in women. Although an association between osteoarthritis and femoroacetabular impingement is believed to exist, a long-term epidemiological study is needed to determine the natural history of these anatomical abnormalities.

Femoroacetabular impingement (FAI) is regarded by some as a precursor to osteoarthritis (OA) of the hip. FAI includes two subtypes: cam impingement and pincer impingement, with abnormalities of the femoral head-neck junction or of the acetabulum, respectively, causing abnormal contact within the hip joint. To date, most investigators have focused on the clinical diagnosis, imaging modality, structural characteristics, mechanisms and treatment options for patients with FAI. A combination of findings at imaging and the surgeon’s clinical judgement is necessary for the diagnosis and treatment of cam-type FAI. The α-angle is commonly used as a quantitative evaluation for the degree of femoral deformity in cam-type FAI, and can be measured using a variety of imaging modalities. Hips with deformity of the femoral head-neck junction have a large α-angle, which may lead to symptomatic impingement. However, not all hips with a large α-angle are symptomatic. Therefore, the frequency of cam-type deformity and the range of α-angles in asymptomatic adults remain unknown.

We believe that identifying the frequency of cam-type FAI deformity associated with a large α-angle in asymptomatic as well as symptomatic hips might lead to a better understanding of FAI and more appropriate management of the condition. We felt that a cohort of patients having pelvic imaging by anteroposterior (AP) CT scout images for non-hip related problems would be a suitable asymptomatic group. Previous studies have shown that many hips with increased α-angles and cam-type FAI are able to be detected on AP radiographs. Our study was designed to determine the range of α-angles in a patients without symptoms in the hip and to establish the prevalence of cam-type femoroacetabular deformity within the general population.

Patients and Methods
A total of 838 hips in 419 randomly selected patients who underwent abdominal or pelvic CT at our institution for other medical diseases from April 2004 to August 2009 were examined for this study. AP scout images taken during CT scanning were used to measure the α-angle of each hip, as described by Nötzli et al. The centre of the femoral head, the central axis of the femoral neck and the resultant α-angle were determined using the measurement tools available in the Stentor Picture Archive Communication System (PACS) software (Philips, Andover, Massachusetts). The α-angle was determined as the angle between a...
line drawn from the centre of the femoral head through the central axis of the femoral neck, and a line drawn from the centre of the femoral head to a point laterally where the sphericity of the femoral head is lost (e.g. the lateral point where the distance from the centre of the femoral head is increased) (Fig. 1). All images were measured by two investigators (KAJ and CR) and the final readings were determined by consensus. Radiological exclusion criteria were applied to 34 hips imaged in external rotation, 15 hips with ill-defined femoral head margins, 12 hips with definitive evidence of osteoarthritis, and 12 dysplastic hips. A total of ten hips were excluded due to previous surgery in that hip or contralateral hip, which was seen from the radiological study. Additionally, patients whose radiological or medical records mentioned a symptom relating to the hip or suggested hip pathology were excluded. In all, 755 hips were potentially eligible for analysis.

In order to evaluate the prevalence of cam-type FAI deformity, all participants were classified according to criteria defined by Gosvig et al.\(^1\) based on the Copenhagen Osteoarthritis Study. For men, three ranges of values were defined for the \(\alpha\)-angle: pathological (\(\geq 83^\circ\)), borderline (\(69^\circ \text{ to } 82^\circ\)) and normal (\(\leq 68^\circ\)). For women these values were: pathological (\(\geq 57^\circ\)), borderline (\(51^\circ \text{ to } 56^\circ\)) and normal (\(\leq 50^\circ\)). Cam-type FAI is a common disorder in young adults, therefore all participants were further grouped based on age 50 years and older and those below the age of 50.

**Statistical analysis.** \(\alpha\)-angles for both gender and age groups were directly compared using an independent \(t\)-test. The frequencies of pathological, borderline and normal for both gender and age groups were also compared using a chi-squared test. Finally, correlations between \(\alpha\)-angle and age, gender and body mass index (BMI) were also analysed using Pearson’s correlation test. A \(p\)-value < 0.05 was considered statistically significant.

Lesions were also classified as unilateral or bilateral in all participants. Asymmetrical hips were defined as those with \(\geq 10^\circ\) difference in their \(\alpha\)-angles.

The reliability of the \(\alpha\)-angle measurements was determined by calculating the inter-class correlation coefficient (ICC), which is a test of agreement for continuous data and ranges from 0 to 1. An ICC > 0.75 indicates excellent reliability. The ICC for the \(\alpha\)-angle measurements was 0.952, indicating excellent agreement among raters. All analyses were performed using SPSS v12.0 (SPSS Inc., Chicago, Illinois).

**Results**

A total of 215 hips in 108 men with a mean age of 62.5 years (26.6 to 92.6), and 540 hips in 272 women with a mean age of 59.5 years (25.5 to 90.9), were included in the study. The mean \(\alpha\)-angle among the 755 hips was 49.3\(^\circ\) (SD 12.8\(^\circ\)). The mean BMI was 28.6 kg/m\(^2\) (13.2 to 45.4): 26.6 kg/m\(^2\) (13.2 to 39.7) in men and 29.5 kg/m\(^2\) (15.6 to 45.4) in women. Statistically significant gender differences were found, with men having a higher \(\alpha\)-angle than women (\(p < 0.001\)). Men also had a statistically significant higher frequency of pathological and borderline \(\alpha\)-angles than women (chi-squared test, \(p < 0.001\)) (Table I). The latter was true regardless of age. Men had statistically significant higher \(\alpha\)-angles than women in the corresponding age groups (both \(p < 0.001\)).
There were no significant differences in α-angles between the age groups within each gender group (p = 0.789 and p = 0.780 for men and women, respectively).

With regard to bilaterality, five women (1.8%) out of 272 with bilateral hip AP scout views showed asymmetry. These women had normal ranges of α-angle in one hip and pathological ranges of α-angle in the other hip. Asymmetry was present in five women (12.8%) out of 39 with borderline and pathological ranges of FAI. Two men (1.8%) out of 108 with bilateral hip views showed asymmetry. One man had a normal range of α-angles in both hips. One man had a normal range of the α-angle in one hip and a pathological range of the α-angle in the other. Asymmetry was present in two men (5.8%) out of 34 with borderline and pathological ranges of FAI. Age, bilaterality and BMI were not found to have a statistically significant relationship with the α-angles (p = 0.786, p = 0.681 and p = 0.601, respectively) (Table II).

Discussion

Femoroacetabular impingement is a pathological condition that was recently highlighted by Ganz et al.² The hallmark of this condition is an abnormal contact between the femoral head-neck junction and the acetabular rim that leads to labral tearing and the development of a subsequent chondral lesion. The majority of patients with symptomatic FAI present with hip (groin) pain and some degree of functional disability. The presence of FAI and an associated labral tear is detected using routine AP radiographs, specialised radiological images (Dunn’s view¹³) and cross-sectional images such as MR arthrography.³,¹¹-¹⁷ Patients with sufficient symptoms are usually subjected to arthroscopic or open surgical intervention aimed at removing the abnormal mechanics of impingement and repair or resection of the labrum.⁴,¹⁸-²⁰ Although it seems intuitive that the presence of an abnormal bony lesion at the femoral head-neck junction may lead to chondral damage and subsequent arthritis, the incidence of asymptomatic FAI in the general population is largely unknown.

The cam-type impingement is characterised by the presence of an osseous bump at the femoral head-neck junction, which can usually be detected on routine radiographs and leads to an abnormal α-angle.¹¹,¹² Although measurement of the α-angle is believed to be best performed on a radial MRI and/or 3D CT view of the femoral neck, recent studies have demonstrated that the bump is usually present on the AP view of the hip.¹¹ We used the AP scout images of the

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Table I. The mean (sd) α-angles in men and women and the distribution of the α-angle classes

<table>
<thead>
<tr>
<th>Classification (α-angle)</th>
<th>Number (%)</th>
<th>Mean α-angle (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (≤ 58°)</td>
<td>153 (71.16)</td>
<td>59.12 (17.61)</td>
</tr>
<tr>
<td>Borderline (59° to 68°)</td>
<td>32 (14.88)</td>
<td></td>
</tr>
<tr>
<td>Pathological (≥ 69°)</td>
<td>30 (13.95)</td>
<td></td>
</tr>
</tbody>
</table>

Table II. The distribution of mean (sd) α-angles based on age: greater than 50 years of age and 50 years and less, and distribution of the classes in these age ranges

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean α-angle (sd)</th>
<th>Classification (α-angle)</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men &gt; 50 years old</td>
<td>59.59 (17.87)</td>
<td>Normal (≤ 58°)</td>
<td>117 (70.48)</td>
</tr>
<tr>
<td>(n = 166)</td>
<td></td>
<td>Borderline (59° to 68°)</td>
<td>36 (23.47)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pathological (≥ 69°)</td>
<td>6 (4.07)</td>
</tr>
<tr>
<td>≤ 50 years old</td>
<td>57.21 (16.95)</td>
<td>Normal (≤ 58°)</td>
<td>117 (70.48)</td>
</tr>
<tr>
<td>(n = 49)</td>
<td></td>
<td>Borderline (59° to 68°)</td>
<td>36 (23.47)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pathological (≥ 69°)</td>
<td>6 (4.07)</td>
</tr>
<tr>
<td>Women &gt; 50 years</td>
<td>45.52 (7.40)</td>
<td>Normal (≤ 58°)</td>
<td>383 (88.45)</td>
</tr>
<tr>
<td>(n = 433)</td>
<td></td>
<td>Borderline (59° to 68°)</td>
<td>36 (8.42)</td>
</tr>
<tr>
<td>≤ 50 years old</td>
<td>45.31 (7.46)</td>
<td>Pathological (≥ 69°)</td>
<td>6 (1.41)</td>
</tr>
<tr>
<td>(n = 107)</td>
<td></td>
<td>Normal (≤ 58°)</td>
<td>94 (8.76)</td>
</tr>
</tbody>
</table>

*indicates that men in their respective age group had a statistically higher incidence of pathological and borderline α-angles compared to women in the same age group by the chi-squared test (p < 0.001)
hip, followed by CT scans of the pelvis for conditions unrelated to the hip, to determine the prevalence of an increased α-angle.

This is the first study to report on the frequency of cam-type FAI deformity in a large cohort of asymptomatic patients in the United States. The frequency of cam-type FAI deformity in men was about twice that in women (13.95% vs 5.56%). The incidence of FAI in our cohort appears to be higher than that in the Danish population as reported by Gosvig et al.,11 which detected cam-type deformity in approximately 6% of men and 2% of women, based on AP radiographs. The higher frequency of FAI deformity in the USA population was found despite adhering to the same definition of FAI used by Gosvig et al.11 We are uncertain about the cause of this difference. One possible explanation might be that our cohort consisted of slightly older patients. If one assumes that FAI deformity develops over time, then the prevalence of this condition should be higher in an older patient population.

One of the limitations of this study relates to the fact that we assumed all participants to be asymptomatic. The clinical records of these patients at our institution were checked to ensure that none of them had symptoms from the hip or associated pathology. However, it is plausible that some patients may have been receiving treatment for hip problems at other institutions without our knowledge. The other limitation of this study and the Copenhagen Osteoarthritis Study11 is that some believe that AP radiographs are not suitable for determination of the α-angle. Gosvig et al.11 reported that most bump malformations at the femoral head-neck junction can be identified at acceptable levels on standard AP radiographs, especially when combined with the triangular index. In contrast, Dudda et al.21 reported that the impingement site at the anterolateral quadrant of the femoral head-neck junction is a common blind zone radiologically, and the absence of a bump at this spherical junction would lead to missed cam lesions and an underestimation of FAI deformity. If the latter is true, the incidence of FAI in the general population is likely to be even higher than was detected in this study. In addition, these limitations might mean that the lower prevalence of cam-type deformity in women is erroneous because of the possibility of missing more such deformities in women when using AP radiographs. By using radial MRI and/or 3D CT, a more accurate assessment of FAI deformity could be made. Another limitation is the fact that none of these patients were contacted after the radiological study to assess the veracity of their asymptomatic status. Finally, the AP scout views used in this cohort were not taken for the investigation of hip disorders and hence were not standardised. This explains why some patients from the original cohort had to be excluded to prevent bias that might have been introduced by the variability in imaging techniques.

We recognise that our findings might not be generalisable to the entire United States population. However, this study highlights an important finding. It appears that asymptomatic possible cam-type FAI deformity is not a rare condition, so patients presenting with pain around the hip who may have evidence of FAI should be subjected to strict diagnostic scrutiny, as the presence of an abnormal α-angle does not appear to hold an absolute relationship with the presence of symptomatic disease. The other issue raised by this study relates to the natural history of this condition. There did not appear to be a difference between the older and younger patients in the study with regard to the prevalence of abnormal α-angles, considering the factor that cam-type FAI is known to be common among young adults. Therefore, we need to examine whether an abnormal α-angle does indeed lead to the development of osteoarthritis in all patients. There is some recent evidence to suggest that asymptomatic patients with impingement may not necessarily develop significant osteoarthritis.22,23

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


