Anterior and Posterior Femoral Head-Neck Offset Ratio in the Cam Impingement

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Abstract

Purpose: The purpose of this study was to determine if the anterior-posterior offset ratio is altered in patients with symptomatic cam impingement. **Study Design:** Preoperative radiographs of 15 symptomatic patients with isolated cam-type impingement diagnosed by physical examination and magnetic resonance imaging arthrogram (MRIA) and confirmed by hip arthroscopy findings were assessed. Fifteen asymptomatic volunteers made up the control group. The anterior offset (AO), posterior offset (PO), and AO/PO ratio were calculated. **Results:** The mean $\pm$ SD AO/PO ratio was 0.56 ± 0.1 for the symptomatic group and 0.9 ± 0.2 for the asymptomatic group. This difference was statistically significant. Intra- and interobserver correlation factor for calculating the AO/PO ratio was 0.8 and 0.5, respectively, and differences were not statistically different. **Conclusions:** The AO/PO ratio in this study was a useful radiological parameter for the assessment of patients with a cam-type impingement.

Keywords

femoroacetabular impingement, offset, cross table lateral radiograph

Introduction

The development of new imaging studies, such as magnetic resonance imaging (MRI), and the improvement of the quality of those already available have made it possible to identify new potential etiologies for degenerative arthritis of the hip.¹ Femoroacetabular impingement (FAI) has been increasingly recognized as a cause for hip pain and degenerative hip arthritis with an estimated prevalence of 10% to 15%.²

Initially described as a complication of hip osteotomies, FAI corresponds to an anatomical alteration either in the femoral head-neck junction (cam-type impingement) or in the acetabular rim (pincer-type impingement), which causes a conflict between the two corresponding anatomical structures during articular motion.

The third and most common form of femoroacetabular impingement is the combination of cam and pincer types, which is found in around 86% of cases.³

Either type of impingement causes pain and abnormal hip biomechanics with high pressure points at extreme range of motion. It has been described as a common cause for hip pain in young patients.^{3,4}

It has been demonstrated that these biomechanical alterations cause lesions of the labrum and/or the articular cartilage. This repetitive trauma has been associated with the development of degenerative joint disease.³⁻⁵

Cam impingement occurs when the femoral head has an oversized radius, resulting in an insufficient head-neck

offset. A widening of the femoral neck reduces its concavity, creating an anterior impingement between a triangular-shaped extension of bone and articular cartilage and the anterior undersurface of the acetabular rim, resulting in delamination of cartilage secondary to a shearing injury.

The cross-table lateral view allows quantifying the anterior femoral head-neck offset (AO). The method described by Eijer et al.⁶ is performed as follows: a line bisecting the longitudinal axis of the femoral neck, using the narrowest portion of the neck, is drawn; then, parallel lines tangent to the anterior border of the femoral head and neck are drawn. The perpendicular distance between these 2 lines is the AO (**Fig. 1**).

A value under 9 mm for the AO is considered abnormal according to Eijer et al.⁶ These authors described the offset ratio as well, which is the AO divided by the diameter of the femoral head. This ratio was established as 0.21 ± 0.03 in asymptomatic patients and 0.13 ± 0.05 in symptomatic patients with cam impingement.

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Figure 1. (A) Anterior head border. (B) Anterior neck border. (C) Posterior neck border. (D) Posterior head border.

Goodman et al.⁷ consider that the main deformity in the head-neck junction, secondary to slipped capital femoral epiphysis (SCFE), is in the sagittal plane. Considering this, the deformity might not be seen at all in the anteroposterior (AP) views of the hip and pelvis. Even if the bump is seen, it is only a partial impression and cannot be precisely measured unless a lateral view is assessed.

MRI has been employed to assess the AO with great accuracy.⁸⁻¹¹ Notzli et al.⁹ described the α angle, which evaluates the femoral head-neck junction considering the angle at which the femoral head reduces its convexity. Kassirjian¹² reported abnormal α angles in 39 of 42 patients with FAI (mean of 69.7 degrees).

A minimal slipped capital femoral epiphysis is recognized as one of the main etiologies for cam-type femoroacetabular impingement. In this pathology, a minimal posterior displacement of the femoral head epiphysis would exist, altering the AO. We believe that this phenomenon should increase the posterior femoral head-neck offset (PO) as well, creating an inverse relation between the AO and the PO.

We are not aware of any reports regarding the normal values for the posterior offset; the purpose of this article is to determine if the PO and the AO/PO ratio may be additional parameters for the evaluation of radiographs of patients with suspected cam impingement.

Methods

Preoperative radiographs of 15 symptomatic patients (6 women, 9 men) with a mean age of 41 years (range, 30-62) with a diagnosis of isolated cam-type FAI were assessed. Inclusion criteria for the cases were a positive impingement

test during the physical examination and an altered α angle (greater than 55 degrees in all cases) measured on magnetic resonance imaging arthrogram (MRIA). More important, hip arthroscopy was performed in all the cases, and findings were supposed to be compatible with cam impingement lesions to be included in this study.

Exclusion criteria included radiographic findings compatible with a pincer-type impingement such as coxa profunda, protrusio acetabuli, and acetabular retroversion (suggested by a positive crossover sign and/or posterior wall sign); a center-edge angle less than 25 degrees or greater than 35 degrees; and patients with hip pain suspected of being from any other source than a cam impingement.

The control group consisted of 15 asymptomatic volunteers, age and gender matched with the symptomatic group. None of the patients included in the control group recalled any form of pain related to the hip; on the physical examination, all of them had a negative impingement test. For obvious reasons, the control group did not undergo surgical confirmation.

The radiographic evaluation included an AP view of the pelvis, as well as an AP view and a cross-table lateral view of the involved hip. The AP views were used mainly to rule out a pincer-type impingement, dysplasia, and/or osteoarthritis.

The cross-table lateral radiographs were certified as technically correct by members of the radiology department. In the cross-table view, the AO was measured with the method described by Eijer et al.⁶ (described above) and the PO in the same fashion, considering the posterior border of the femoral neck and the posterior border of the femoral head. The AO/PO ratio was calculated (**Fig. 1**).

Differences between groups were tested using the *t* test or Wilcoxon Mann-Whitney *U* test according to data distribution. Significant tests were all 2-tailed ($P < 0.05$). For all statistical analyses, Sigma Stat 3.0 software (SPSS Science, an IBM Company) was used. A normal distribution was found for the AO and the AO/PO ratio; as a result, the Student *t* test was applied. For the PO values, the Wilcoxon Mann-Whitney *U* test was used.

The individuals interpreting the radiographs were blinded to the groups of the study. Intraobserver and interobserver reliability for calculating the AO/PO ratio was measured with the intraclass correlation coefficient test. Time between observations was 1 week.

Results

The median α angle for the cases was 68 (range, 55-81). The mean $\pm$ SD AO in the symptomatic group was 7 ± 1.7 mm, which is comparable to the values reported by Eijer et al.⁶ for symptomatic patients. The control group presented a mean $\pm$ SD AO of 9.5 ± 1.8 , which was comparable to the 11 mm (mean) reported by Eijer et al.⁶ for asymptomatic patients, and showed no statistical difference. The values of the AO between both groups of our study were statistically significant. Four

Table 1. Anterior Offset, Posterior Offset, and Offset Ratio

	Symptomatic Group	Control Group	PValue
Anterior offset (AO), mm, mean $\pm$ SD (range)	7 $\pm$ 1.7 (4-11)	9.5 $\pm$ 1.8 (6.5-12)	0.02
Posterior offset (PO), mm (range)	13.5 (9-18)	12 (8-16)	0.37
AO/PO ratio, mean $\pm$ SD	0.56 $\pm$ 0.1	0.9 $\pm$ 0.2	<0.001

Table 2. Results of Anterior Offset (AO), Posterior Offset (PO), and AO/PO Ratio According to Eijer et al.⁶ and Nemtala et al. (Current Study)

	AO, mm	PO, mm	AO/PO	According to Nemtala et al.	According to Eijer et al. ⁶
Case 1 (control)	7.21	8.9	0.8	Normal	Abnormal
Case 2 (case)	11	18	0.56	Abnormal	Normal

Note how the AO/PO relationship is altered in the femoroacetabular impingement in the presence of a normal AO according to Ganz et al.³

asymptomatic volunteers presented AO values under 9 mm and would be considered abnormal according to Eijer et al.⁶ The symptomatic group had a median PO of 13.5 mm (range, 9-18), whereas the control group median PO was 12 mm (range, 8-16). The difference between both groups was not statistically significant for the PO values. The mean $\pm$ SD AO/PO ratio was 0.56 $\pm$ 0.1 for the symptomatic group and 0.9 $\pm$ 0.2 for the asymptomatic group; this difference was statistically significant ($P < 0.01$; **Table 1**).

Intraobserver correlation coefficient for AO/PO ratio was 0.8. Interobserver correlation coefficient for the AO/PO ratio was 0.5.

Discussion

Primary or idiopathic degenerative arthritis is still the most common etiological classification for hip osteoarthritis.¹³ Evidence has been mounting in the past few years that point toward subtle undetected and underdiagnosed femoroacetabular pathologies and that in fact primary idiopathic osteoarthritis would be rare.^{7,13-15} Among them, FAI has been increasingly recognized as a cause for hip pain and degenerative hip arthritis.

Tanzer and Noiseux¹³ studied a group of 125 patients with hip osteoarthritis (formerly classified as idiopathic by classic radiographic standards) who presented signs of FAI in 100% of the cases. In this group of patients, 22% showed anterolateral signs of degenerative joint disease, and the rest presented a diffuse compromise of the joint.

In the series analyzed by Tanzer and Noiseux,¹³ 62% were classified as having a pistol grip deformity and FAI, 5% had developmental hip dysplasia, and 2% had protrusio acetabuli. A total of 69% of these patients presented femoroacetabular anatomical alterations.

The α angle measured on MRI has been very helpful since its introduction by Notzli et al.⁹ for the identification of bony

abnormalities in the proximal femur suggestive of a cam impingement. Nevertheless, MRI arthrograms are not always available, and its costs may sometimes be a matter of concern; more affordable and available methods for the screening and diagnosis of patients with a suspected FAI are valued.

Eijer et al.⁶ defined the values for AO in symptomatic patients with cam impingement and the normal values for asymptomatic people.

Absolute values for AO are potentially dependent on the anthropometric variations of the patients, and thus normal values may vary according to the population being assessed.

In our study, a volunteer in the control group presented an AO of 7.2 mm, which is abnormal according to values published by Ganz et al.,³ and a PO of 8.9 mm, also considered small by us. This patient's AO/PO ratio was 0.8, within the normal limits according to our results, and compatible with an individual from the control group. A symptomatic patient presented an AO of 11 mm, which is normal according to Eijer et al.,⁶ and a large PO of 18 mm (according to us), which results in an AO/PO ratio of 0.56, which is altered and compatible with cam femoroacetabular impingement according to our study (**Table 2**).

Eijer et al.⁶ also described the offset ratio (defined in the introduction) to prevent anthropometrical variations. For this method, the AO and the femoral head diameter are measured. From our point of view, the correct identification of the femoral head center sometimes can be difficult, especially in the presence of pathologies grossly compromising the femoral head contour, such as a SCFE or a Legg-Calvé-Perthes disease, making the offset ratio somehow difficult to estimate. Moreover, the intra- and interobserver difference has not been established for this parameter.

The PO in our study showed no statistical difference between the cases and the control subjects, which may reflect that this parameter tends to remain without significant variations in the presence of a cam impingement.

Furthermore, if the cam impingement was due to a minimal SCFE, which has been postulated as a common cause for this disease, the displacement of the epiphysis posteriorly would tend to increase the posterior offset instead of reducing it, thus reducing even more the AO/PO ratio.

The AO/PO ratio is a parameter independent from anthropometry that, according to our study, is altered in the presence of a cam impingement.

Although the intraobserver correlation is very good, the interobserver variations may be an issue, requiring the results of the AO/PO ratio to be interpreted with caution.

A potential bias of our study is the limited number of cases and controls; however, the study in which the AO and the offset ratio were described had even fewer patients.

Conclusions

On the basis of the results obtained in our study, we conclude that the anterior/posterior offset ratio can be effectively used as a new parameter in the screening of patients with suspected cam-type FAI; it is independent from anthropometry and has a fair intra-/interobserver correlation. Nevertheless, many other factors must be considered when assessing these patients, including more sophisticated imaging studies (i.e., MRIA).

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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