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Prevalence of radiographic markers of femoroacetabular impingement in asymptomatic adults

Prevalência dos achados radiográficos de impacto femoroacetabular em adultos assintomáticos

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A B S T R A C T

Objective: to determine the prevalence of radiographic signs of femoroacetabular impingement (FAI) in asymptomatic adults and correlate them with data from physical examinations. **Methods**: We conducted a cross-sectional study with 82 asymptomatic volunteers, 164 hips, between 40 and 60 years of age, selected by convenience. They were submitted to anamnesis and clinical examination of the hip, anteroposterior (AP) pelvis radiographs with three incidences, Dunn 45° and Lequesne false profile of each hip, to measure the variables. We measured the alpha angle, anterior offset of the femoral neck, cervical diaphyseal angle, CE angle of Wiberg, acetabular index, Sharp angle, and the crossing, ischial spine and posterior wall signs. **Results**: our sample consisted of 66% women, mean age of 50.4 years. The average alpha angle was 45.10°, SD=8.6. One quarter of the hips showed alpha angle greater than or equal to 50°; among men the prevalence was 34%, and among women, 11%. We found indicative radiographic signs of femoroacetabular impingement in 42.6% of hips, whether femoral or acetabular, and the increased alpha angle was related to the decrease in hip internal rotation (p<0.001). **Conclusion:** the radiographic findings of femoroacetabular impingement in asymptomatic patients were frequent in the studied sample. The increase in alpha angle was associated with decreased internal rotation.

Key words: Femoroacetabular impingement. Hip. Radiography. Cross-sectional studies. Prevalence.

INTRODUCTION

Primary or idiopathic Osteoarthritis (OA) of the hip accounts for approximately 30% to 40% of cases 1, and the secondary, resulting from proximal femur epiphysiolysis, Legg-Calvé-Perthes disease, avascular necrosis among others, the remaining[1,2].

Factors related to OA etiology are genetic, structural, morphological and biomechanical. Since 1976, Solomon had reported that hip OA was always associated with an abnormality, even if subtle, of the joint[3]. However, until today the exact pathogenesis of primary OA has not been established[4-8]. According to Bardakos *et al.*, the etiology of osteoarthritis of the hip remains an enigma[9].

In the last decade there was an increase in the scientific literature regarding the etiology of primary osteoarthritis, supporting the hypothesis that small changes in the morphology of the hip could cause mechanical damage to the joint, resulting in its wear over time[1,10]. A spinal deformity in the anterolateral head neck junction of the femur and excessive anterior acetabular coverage correspond to those deformities. The term Femoroacetabular Impingement (FAI) would therefore translate the mechanism by which these morphological changes could cause damage to the hip joint, culminating in OA.

The FAI is puzzling because the mere presence of an sole lesion, whether Came or Pincer type, is not sufficient for the development of OA of the hip, which has been observed in patients who have these deformities bilaterally, but with only one symptomatic hip[1,11]. What is reported on the findings of many papers on FAI is that follow-up studies are needed to provide information about its natural history[3,12,13]. The most renowned authors on the subject state that there is no information about the natural course of the more subtle femoral and acetabular deformities, such as those present in FAI, and that only with investments, studies and cohorts it will be possible to determine the real impingement of FAI[12]. The knowledge about the etiology and natural history of primary OA of the hip is still controversial[1,13].

This uncertainty about the prevalence of these "deformities" related to the FAI in the general population, as well as the natural history of Came and Pincer types alterations in asymptomatic patients, and the real contribution of these changes to the development of hip OA led us to the realization this work.

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This research aims to assess the prevalence of radiographic findings of femoroacetabular impingement in asymptomatic adult patients.

METHODS

This was a descriptive, cross-sectional study, conducted in the outpatient clinic of the Department of Orthopaedics, Clinics Hospital of Porto Alegre (HCPA). The sample consisted of 82 volunteers (164 hips), aged between 40 and 60 years, asymptomatic as for the hip joints and lumbar spine, with no history of any disease in this region. The sample was selected for convenience, after the dissemination of the research in the HCPA. This study was approved by the Ethics Committee of the HCPA - Protocol number 09-137.

We excluded Individuals with a history of disease or previous treatment on the hips or the lumbar spine, history of rheumatic diseases and those with inadequate radiographs. Radiographs were strictly controlled by the obturator foramen index (OFI) of Tönnis, and the pelvic tilt, by the symphysis-sacrococcygeal joint distance[14]. Women of childbearing potential who were not using any contraceptive method and who did not know the date of the last menstrual period were also excluded to avoid radiation exposure in possible pregnant women. Those who did not agree with the Terms of the Free and Informed Consent did not participate in the study either.

All participants underwent an interview and physical examination, performed by the same doctor. Range of motion of both hips was assessed and then applied the FAI maneuver or provocative test, with flexion, adduction and internal rotation[15]. The maneuvers were performed with the patient in supine position, with special attention to the pelvic movement, the degree of amplitude being determined at the first hint of mobilization of the hip. The examination respected the following sequence: flexion, internal and external rotation with the hip and knee flexed at 90 degrees, abduction and adduction with the hip in a neutral position. The hip extension was measured with the participant in the prone position, with a resident of the Orthopedics Service stabilizing the pelvis and the researcher applying the extension. The measurements were performed with a universal, double-angled goniometer, millimetered in transparent plastic.

After clinical examination, participants underwent anterior posterior (AP) pelvis radiography in the standing position, Lequesne false profile and Dunn 45° incidence.

Radiographs were performed by the same X-ray technician, who received specific training in a referral center in musculoskeletal radiology prior to the commencement of the research.

The anterior posterior radiograph was performed in the standing position, with the X-ray tube positioned at a distance of 120 cm from the film, centered at the intersection of an imaginary line between the anterior superior iliac spines and a vertical line through the center of, about two centimeters proximal to, the pubic symphysis[5].

In this same incidence we controlled the quality of radiographs as for the rotation through the obturator foramen index (OFI) described by Tönnis, where the greatest horizontal axis of the right obturator foramen is divided by the left- most horizontal axis, having an acceptable result between 0.56 and 1.8 for measurement of the acetabular landmarks[14]. We adopted a less tolerant range, and included only those radiographs with OFI between 0.8 and 1.2. To control pelvic tilt, we observed the distance from the top surface of the pubic symphysis to the sacrococcygeal joint, considered ideal between one and three centimeters[4]. In this incidence, when the quality criteria were not fulfilled, we discarded the measures relating to the analysis of the acetabulum and pelvis; however, the findings regarding the proximal femur were not discarded because they are not influenced by pelvic rotation or tilt.

The false profile incidence of Lequesne and Sezé was performed according to the description of Lequesne[16]. Radiographs considered appropriate were those showing a distance corresponding to the diameter of a femoral head between the two hips.

The profile of Dunn at 45° was obtained with the patient supine with the hips to be x-rayed at 45° flexion and 20° abduction in neutral rotation, with the X-ray tube directed at the inguinal crease, perpendicular to table, at a distance of 100cm[8] (Figure 1).

The variables analyzed in the AP radiographs were as follows: cervical-diaphyseal angle, sphericity of the femoral head, angle of Sharp, center edge angle of Wiberg, acetabular index, index of extrusion of the femoral head, acetabular depth and minimum joint space. We also investigated the presence of the crossing sign, suggesting a partial overcoverage, the ischial spine signal, denoting

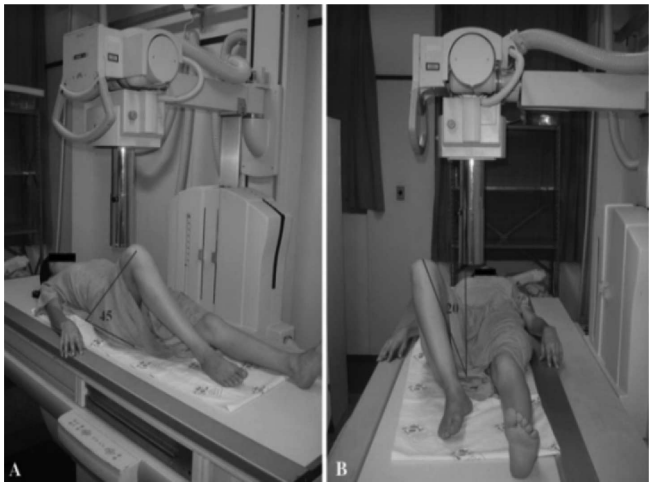

Figure 1 - *Positioning the patient for the Dunn 45° radiographic incidence.*

acetabular retroversion, and the posterior wall sign, suggesting posterior coverage disability.

In the false profile incidence of Lequesne, we measured the anterior cover angle to assess a possible reduction of the joint posterior-inferior space or also the countercoup injury, present in the Pincer-type FAI[16,17].

In the Dunn 45° incidence we measured the alpha angle as described by Nötzli, to ascertain the anterior concavity of the head-neck junction. The measure was obtained by the intersection of two lines: the first runs along the axis of the femoral neck and the second connecting the center of the femoral head to the point where the anterior cortex of the head-neck junction diverges from the perfect circle that the femoral head should form following the concentric angles of Moose[18]. Another measure in this incidence was performed the anterior offset of the femoral neck, which is the distance between a line parallel to the anterior cortex of the femoral neck and another drawn parallel to the first, at the foremost part of the femoral head in the Dunn 45° incidence.

The measurements were performed using a transparent millimetered ruler, with the center of the femoral head being determined by following the concentric angles of Moose.

Qualitative variables were described as frequency and percentage. Quantitative ones were describe as minimum, maximum, mean and standard deviation. We used The Kolmogorov-Smirnoff test to analyze the distribution of variables. We use the Pearson linear correlation for variables with normal or symmetrical distribution, and the Spearman method for the asymmetric. For independent samples we used the Student's t test to compare means. Statistical significance was considered at p value <0.05.

RESULTS

The study included 82 subjects (164 hips), of which 28 (34%) were men and 54 (66%) women. Ages ranged from 40 to 60 years, with a mean of 50.4. Three patients (3.7%) had inadequate AP radiographs, according to the applied criteria[14].

The alpha angle ranged from 32 to 74 degrees, the most frequent values ranging between 35 and 50 degrees (Figure 2).

The average alpha was 45 degrees, with SD=8.6. Alpha angles greater than or equal to 50 degrees were found in 41 hips (25%). Among men the average was 47.52 degrees, and 43.85 in women. This difference was statistically significant (p=0.028). Of the 56 male hips, 19 (34%) had alpha angles greater than or equal to 50 degrees, and among the 108 women, only 12 (11.11%) had the alpha in this range.

Increasing the alpha angle was associated with a decrease in internal rotation (RI) of the hip, (r= -0355, p<0.001). The internal rotation in those with alpha angles greater than or equal to 50° was significantly lower than those who had alpha <50° (p=0.002).

When analyzing the radiographs as for the deformity presented, 42.6% had some sort of deformity suggestive of FAI. The deformity characterizing the Came-type impingement was found in 41 hips (25%), the Pincer deformity in 20 cases (12.65%), and mixed type in six cases (3.7%). The remaining 96 hips (58.5%) showed no radiographic changes suggestive of FAI.

The prevalence of variables denoting Pincer-type impingement and acetabular retroversion are shown in table 1.

The femoral anterior head-neck offset, the angle of anterior acetabular coverage (AAC) and further measures analyzed are described in Table 2.

On physical examination, variables of range of motion (ROM), mean and standard deviation are shown in Table 3.

Hip flexion was not related to the angle of the anterior acetabular coverage (AAC) (p=0.243) nor with the sign of the cross (p=0.822). The femoral anterior head-neck offset showed a negative correlation with the hip internal rotation, though not statistically significant (p=0.889).

DISCUSSION

We present results from 82 individuals, 164 hips, two thirds of the sample being female (66%). This disparity probably occurred because the samples have been selected for convenience, and we know that women are more concerned and seeking more health services than men.

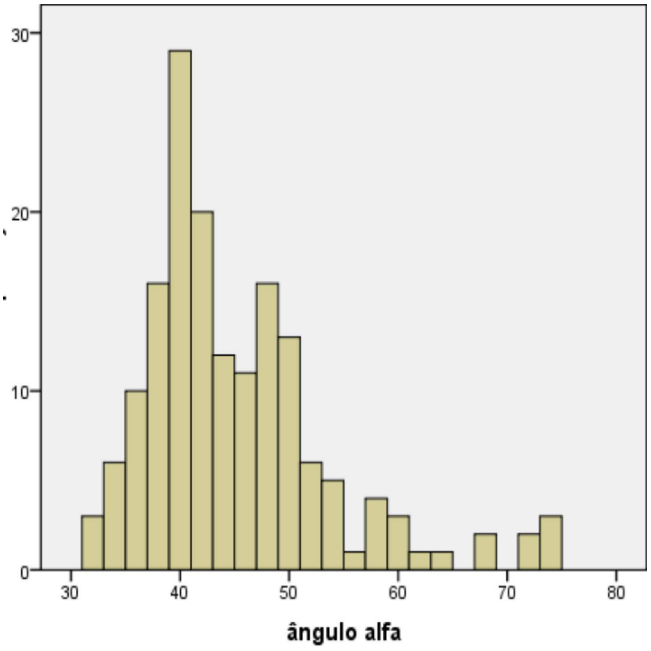

Figure 2 - *Distribution of the alpha angle values according to frequency.*

Table 1 - Radiographic findings of Pincer-type impingement and acetabular retroversion in the evaluated hips.

Radiographic Alteration	Absolute number of hips	Prevalence (%)
Deep thigh	120	76,0
Crossing sign	20	12,6
Posterior wall Sign	58	36,7
Ischial spine Sign	47	29,7

Note: In the radiographic assessments of the pelvis and acetabulum only 158 hips were considered because six of them were excluded due to image rotation.

Table 2 - Values of measures of acetabular and femoral angles.

Variable	Minimum/Maximum	Average	SD
Cervical-diaphyseal angle	116/146	131.00	6.45
Center edge angle	20/56	33.85	7.10
Acetabular index	-11/14	2.27	5.28
Femoral head extrusion index	-6/27	11.11	6.15
Angle of anterior acetabular coverage	12/56	34.25	8.3
Sharp angle	28/49	39.43	4.08
Acetabular depth	25/44	33.86	3.75
Anterior offset	1/16	9.22	2.46
Minimum articular space	2/7	3.8	-

SD: Standard Deviation.

Table 3 - Values of range of motion (ROM) of the hip.

Movement	ROM minimum-maximam (degrees)	Average (degrees)	SD
Flexion	90/150	115.3	9.21
Internal rotation	5/45	25.90	7.07
External rotation	15/45	29.16	5.95
Abduction	20/55	35.63	5.80
Abduction	20/40	35.63	3.94
Extension	10/30	17.14	4.71

SD: Standard Deviation

We had losses due to the rotation of the AP pelvis radiographs (OFI <0.8 and/or >1.2) in 3.7% of cases (three individuals). However, the measures concerning the proximal femur were maintained because they are not influenced by the pelvic rotation, as described by Siebenrock[19]. Our loss was lower than the larger cohort followed up on the subject in Copenhagen, with radiographic loss of 4.5% due to pelvic rotation[20].

The average alpha angle of the sample was 45.10 degrees. Despite the large variation found, 32-72°, we believe that the average found was not higher only because two thirds of the sample were women, and it is known that these have an average alpha lower than men do. Nötzli found an average of 42 degrees in the control group and in 74 cases, determining a cutoff point of 50 degrees. Other authors describe averages between 42 and 52[10,13,21]. However, due to the large variation of alpha in normal, asymptomatic patients, there are few studies that have described a normal alpha up to 60 to 62 degrees[11,13,22], others even[9] to 67, ie, there has been no consensus as for the normal alpha angle in the general population. Pollard *et al*. questioned the study of Nötzli, putting in doubt whether hips with alpha greater than 50 degrees should be considered pathological, and suggest an alpha threshold of 63 degrees[13]. Others describe the normal alpha as 60°[11]. Our suggestion is that the alpha angle, mostly in men, have increased their cutoff value proposed by Nötzli. Going against the trend of increase of the alpha angle's upper limit, Neumann *et al*. published an interesting article where they measured the average alpha angle necessary to avoid bone impingement and obtain an internal rotation from 20 to 25° at 90° flexion, and found that an alpha of 43° would be required[23].

The mean alpha angle among men was 47.52 and 43.85 degrees among women, similar to the averages found by Toogood *et al*. in his work analyzing 375 femurs

stored at the Museum of Natural History of Cleveland in the United States[21]. This difference was statistically significant (p=0.028). The average alpha in men was significantly higher, since the Came-type deformity is more common in male patients[1,10,13,21,22].

Of the 164 hips analyzed, 25% (41 hips) had alpha higher than 50°, and about 34% of men showed alpha in that range. Hack *et al*. observed increased alpha in 24% of men. However, they considered an abnormal alpha when greater than 68 degrees 24. Gosvig *et al*. reported prevalence of increased alpha by approximately 20% of men[25]. This high prevalence of cases with alpha greater than 50° in our study corroborates the questioning of Pollard in his study of the suitable value of the alpha angle of 50° proposed by Nötzli, the former suggesting an acceptable alpha to 62°[13,18].

Increasing the alpha angle was related to decreasing of internal rotation of the hip (IR), (r = -0355, p<0.001).

Despite the correlation between the alpha angle and the internal rotation present is of low intensity, there are reports of a marked decrease in internal rotation in patients with FAI[18]. Langer *et al*. described that the resection of the "bump" increased RI by 8°, resection of the "Pincer" by 5° and when the impingement was mixed, the increase in internal rotation was greater, on average 15°[26]. In a case-control study, Wyss *et al*. found a RI average of 4° in the cases compared with 28° in the control group, using dynamic MRI study, concluding that the main cause of limitation of internal rotation is the bone impingement, diminishing the importance of soft tissue retraction in limiting the movement[27].

The average of the anterior femoral head-neck offset was 9.22mm, SD = 2.46, in agreement with the reference value for normality largest 9mm[28].

Inclusion cysts or herniation pits, reported as indirect signs of Pincer-type impingement, were found in seven hips (8.6%) in the Dunn 45°incidence, slightly below the 12% reported by Ecker in a review of normal contralateral hips in patients who underwent total hip arthroplasty[10].

We found Came- or Pincer-type radiographic abnormalities in 42.6% of tests. Acetabular abnormalities were less frequent, accounting for 14%, and the femoral (bulging), were found in 25% of cases (41 hips). The mixed type impingement was found in six cases (3.7%).

The prevalence of Came-type deformity found among men was 34% higher than the figures reported in the literature. Doherty *et al*. observed a prevalence of 3.6% 29 in a case-control study with over a thousand participants in each group. Another author described prevalence of 12% in asymptomatic hips[10]. Other authors found a prevalence of 8% of the Came-type in more than 2,600 skeletons, suggesting that this deformity is considered a normal variation due to the high prevalence in the male population and due to the fact that it alone will not be responsible for the development of hip OA[11].

Radiographic changes in the acetabulum which translate Pincer-type impingement, such as the cross sign, were found in 20 hips (12%), whereas 7% displayed it bilaterally. The signs of the posterior wall and the of ischial spine were found in 37% and 30% of cases, respectively[30]. Hartofilakidis *et al*. found an even higher prevalence, of 42.7%, in their retrospective series[31]. The prevalence of radiographic signs of acetabular retroversion in the general population cited by Giori *et al*. was 5%, reaching 20% in patients with OA[32]. In a study with symptomatic patients, Allen *et al*. found signs of acetabular retroversion in 24% of the sample, in agreement with the study cited above[11,32]. Barros *et al*. observed a greater number of the crossing sign in controls than in patients, 8.1 and 7.1%, respectively[33].

The radiographic alteration that caught our attention for its high prevalence was the thigh deep, found in 76% of cases. Some articles reported a prevalence of 15-19%[11,25]. Due to the differences found between our results and those in the literature, all radiographs were reassessed six months after collection, following the exact definition of the alteration described extensively in the literature[11], and the results coincided with the previous findings. We found no justification for this disparity, since our methods for radiographs control were strict.

The average internal rotation was found to be 26°, consistent with normal standards of physical examination of the hip and the work described in the literature, reporting averages of 18-32°[13,15,27]. However, the rotation in those with alpha greater than or equal to 50° was significantly lower than in subjects with alpha lower than 50° (p=0.002). This corroborates the findings of Wyss *et al.*, where the average internal rotation in cases was 4° and 28° in controls[27].

Although Wyss *et al*. al argue that a hindering of internal rotation is limited by bone structure[27], we did not find this relationship in the flexion analysis of with the anterior center edge angle (AAC). The expected would be that the greater the AAC, the higher the anterior cover and the lower the hip flexion. Nevertheless, our results did not find this association, nor correlated with the cross sign.

Our study has some limitations. The fact that the sample was obtained by convenience, with people linked in some way to the HCPA, cannot compose a representative sample of the normal population. The strong point of this work consists in the systematization and standardization of radiographs, and one of the few studies that used the 45° Dunn incidence, recommended by Meyers as the most significant way to detect abnormalities in Came-type impingement[34].

R E S U M O

Objetivo: *determinar a prevalência dos sinais radiográficos de impacto femoroacetabular (IFA) em adultos assintomáticos e correlacionar com dados do exame físico.* ***Métodos:*** *estudo transversal, com 82 voluntários, 164 quadris, selecionados por conveniência, assintomáticos, entre 40 e 60 anos de idade. Esses foram submetidos à anamnese e exame clínico do quadril, exame radiográfico com três incidências, antero-posterior (AP) de bacia, Dunn a 45° e falso perfil de Lequesne de cada quadril, para mensuração das variáveis. Aferimos o ângulo alfa,* offset *anterior do colo femoral, ângulo cérvico diafisário, ângulo CE de Wiberg, índice acetabular, ângulo de Sharp, além dos sinais do cruzamento, da espinha isquiática e da parede posterior.* ***Resultados:*** *nossa amostra foi formada por 66% de mulheres, com média de idade de 50,4 anos. O ângulo alfa médio foi de 45.10º, DP = 8.6. 25% dos quadris apresentaram ângulo alfa maior ou igual a 50°; entre os homens a prevalência foi 34% e entre as mulheres 11%. Encontramos sinais radiográficos indicativos de impacto femoroacetabular em 42,6% dos quadris, sejam eles femorais ou acetabulares, e o aumento do ângulo alfa esteve relacionado com o decréscimo na rotação interna do quadril (p < 0,001).* ***Conclusão:*** *Os achados radiográficos de impacto femoroacetabular em pacientes assintomáticos foram frequentes na amostra estudada. O aumento do ângulo alfa esteve relacionado com o decréscimo da rotação interna.*

Descritores*: Impacto femoroacetabular. Quadril. Radiografia. Estudos transversais. Prevalência.*

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