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Research Article

Measurement Changes Used for Femoroacetabular Impingement Diagnosis in Hip Pain

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Abstract

Objectives: We aimed to determine, the mean values of the hip angles at Magnetic Resonance Imaging(MRI) of Turkish patients, gender variances and to demonstrate the difference in measurements between the painless and painful sides of the same case.

Methods: Retrospectively, 182 patients who underwent hip MRI for hip pain were included in the study. In MRI, Collo-diaphyseal angle (CDA), Acetabular angle (AA), Tönnis angle (T-angle), acetabular depth (AD), anteversion angle (AnA), protrusio acetabuli (PA) and alpha angle (AF) were measured.

Results: The mean CDA, AA, T-angle, AD, PA, AnA, AF was 131.90º, 35.90º, 7.20º, 21 mm, (-4.9) mm, 17.90º, 50º respectively. CDA, T-angle and AD values were lower at women ($p<0.05$). In the right hip angle measurements, CDA and AF values were found high ($p<0.05$) in the painful group. AnA observed higher, at right hip pain than bilateral, in the group with unilateral pain ($p<0.05$); but there was no difference on the left side. In unilateral and bilateral hip pain, there was no difference in the angle measurements.

Conclusion: CDA, T and AD were found lower at women than men. CDA and AnA increase in the group with pain. We think that grasp of the femur head by acetabulum changes due to pain. The measurements on the right side differ from the left, may depend on loading. Prolongation of the process may cause labrum damage and osteoarthritis.

Keywords: Angle measurements, hip, pain

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Acetabulum consists of ilium, iskum and pubis. The delays in the development or damage to any of these bones lead to deformaties.[1] Acetabular impingement, due to global or focal overlay of acetabulum on the femoral head is the most commonly encountered one (5%) among joint deformities. In cases with idiopathic osteoarthritis, the rate of acetabular retroversion is 20%. FAI (femoroacetabular impingement) and acetabular retroversion cause labrum damage, cartilage lesions and subsequent osteoarthritis if left untreated. Therefore, chronic hip pain that is not caused by arthritis is becoming increasingly important.[2]

Parameters used in the assessment of hip dysplasia on Pelvis anterior posterior (AP) radiograph are; centre-edge angle (CEA), the acetabular angle (AA) with acetabulum inclination in the frontal plane, the acetabular index defined by Tönnis for the inclination of the acetabulum roof, and the acetabulum head index, which is the percentage of the acetabulum covering the femur head.[3]

Magnetic Resonance Imaging (MRI) facilitates the differential diagnosis of persistent pain, since it gives information on the hip soft tissues such as labrum, tendon, and bursa. In young cases, the possibility that the etiology of hip pain

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is of soft tissue origin, is higher. For this reason, it is possible to achieve rapid and early diagnosis with MRI without exposing the pelvis to radiation by radiographs, in young patients with persistent hip pain.

In our study, it was aimed to determine the mean values of the hip angles defined in direct radiographs of the Turkish patients in hip MRI examinations, the presence of variance between the genders, and to demonstrate whether there is a difference in angle values between the painless and the painful sides of the same case.

Methods

The study was initiated with 97 cases younger than 60 years of age and having MRI due to hip pain, retrospectively, April-June 2016. The cases with Tönnis grade 2 and above osteoarthritis, lumbar fusion, hip surgery, and scans which were not suitable for evaluation were excluded. One patient with a partial hip prosthesis and a lumbar spondylolisthesis operation, one patient with scoliosis and three patient with a scan that is not suitable for evaluation were excluded from the study and 91 cases, 182 hips were evaluated. The study was approved by the Fatih Sultan Mehmet Training and Research Hospital Research Ethics Board.

Pelvic AP radiograph can be taken in standing or lying position. Correct pelvic AP radiograph should be in standing position, neutral pelvic tilt and rotation according to the definition of Tannast et al.[5] Tönnis criteria were used in the evaluation of osteoarthritis on pelvis radiograph.[3]

Acetabular inclination (Acetabular Angle, Sharp angle, AA) is the angle between the line drawn between the sclerotic corner of the acetabulum in the inferior aspect of the acetabulum and the sclerotic corner of the acetabulum lateral aspect of acetabulum in the AP graph of the pelvis; and the horizontal line.[4]

Acetabular depth (AD) is used to assess the relation of acetabular ceiling to femur head according to ilioiskial line on AP pelvis graph. If the medial corner of the femur head is in the medial region of the ilioiskial line, it is called protrusio, if it is not, it is called profundo. There is a risk in terms of FAI in both cases.[4]

The Tönnis angle (T-angle) measures the relationship between the acetabulum gradient and the weight bearing surface. The angle is between the medial and lateral corner of the acetabulum and the horizontal line. The downside is that it is affected by rotation and inclination of the pelvis.[5–7]

The alpha angle (AF) is the angle between the line drawn from the center of the femur neck to the center of the femur head and the line drawn from the center of the femur head to the point where the femur head sphericity deteriorates in the anterior direction. AF, increases with FAI, and as the value of alpha angle increases, the rate of damage to cartilage and labrum increases. AF does not correlate with age[8] (Fig. 1).

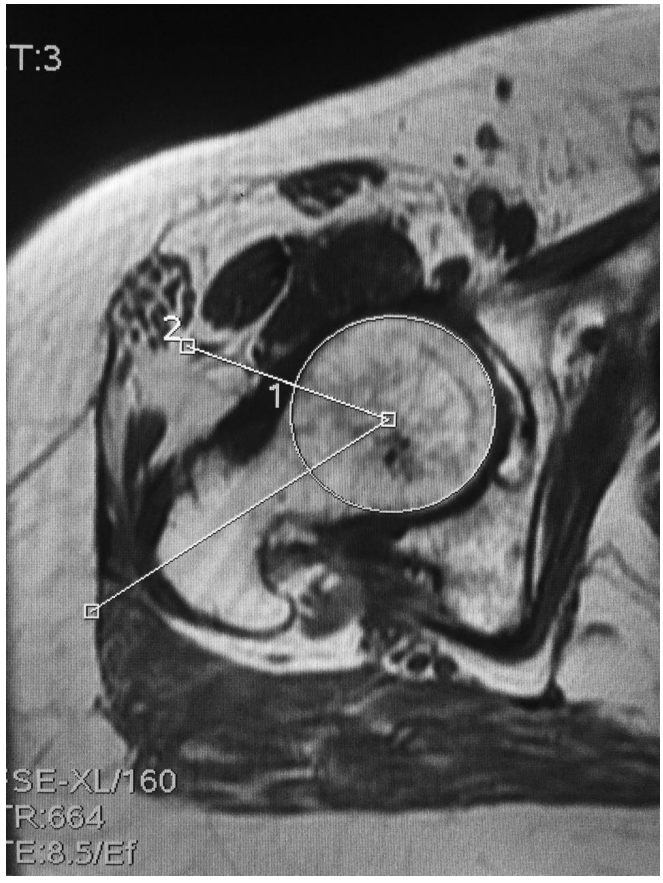

Figure 1. Alpha angle measurement in T1 MR examination in axial plane.

The collodiaphyseal angle (CDA) is the angle between the femur neck and its body. In adults, it is normally 120-130° and it decreases with weight increased on the joint[9] (Fig. 2).

All patients were scanned with a 1.5 Tesla MR device (General Electric, WI, USA) and with superficial coilled straps. Patients were placed in the device, lying on their back, with adequate internal rotation of the feet and legs parallel to each other. Bilateral crista ilia anterior superior and femur proximal metaphyseal diaphysis region were included in the study. The images taken on the coronal and axial plane were taken into consideration. The imaging protocol was performed with axial plane T1 (TR: 740, TE: 8.6-25.7) and T2 fat sat (TR: 4564, TE: 85), coronal plane T1 (TR: 401, TE: 8.6-25.7), STIR: 4765, TE: 42 TI: 150) (cross sectional thickness:4mm, spacing: 1 mm, FOV: 32-35 cm and NEX: 2). Sagittal plane PD (TR: 2000, TE: 30) (cross-sectional thickness 4 mm, spacing 0.5 mm, FOV: 28 cm) was added when deemed necessary in some cases.

Figure 2. Collo-diaphyseal angle measurement in T1 MR examination in coronal plane.

In MRI, on coronal plane; CDA, AA, T-angle and in axial plane, AD, ante-version angle (AnA), PA (protrusio acetabuli), and AF were measured.

Hip MRI scans were evaluated as double blind by two radiologists with at least 10 years of experience.

Statistics

SPSS (Statistical Package for Social Sciences) version 15.0 for Windows (SPSS Inc., Chicago, IL) was used for statistical evaluations. It was assessed whether the data exhibited normal distribution according to Kolmogorov-Smirnov and Shapiro-Wilk and whether it can be subjected to parametric tests. Although the data do not show a normal distribution, since the Skewness and Curtosis values are within ± 2, it was concluded that parametric tests can be used.

A paired sample T-test was used to compare bilateral hip measurements of the patients with unilateral and bilateral pain. Independent sample T-test was used to compare the angle measurements of hips according to gender and right/left hip of patients with bilateral hip pain and the measurements of right or left hip, in those who have pain only on one side.

Results

In our study, 91 cases, 61 women and 30 men, were included. Of the cases, 28 (8 males, 20 females) felt pain in the right hip and 26 (6 males and 20 females) felt pain in the left hip, totally 54 (14 males, 40 females) felt pain in one hip only and 37 (16 males and 21 females) complained of pain on both hips. The average age is 54.6±16.54years (21-60) for women, 47.1±21.33 (9-60) years for men and 52.2±18.42 (9-60) years in general.

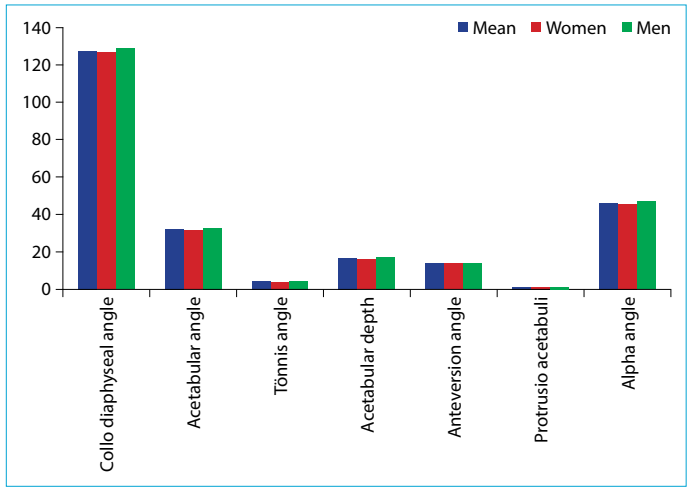

Figure 3. Mean hip measurements in men and women.

In MRI, mean CDA±SD is 131.9±4.57° (120-148.7), mean AA±SD is 35.9±2.66° (33.7-39.9), mean T-angle±SD is 9.1±1.94° (8-11.9), mean AD±SD is 21±3.08 mm (12.8-29.4), mean PA±SD is (-4.9±2.91) mm [(-12)-(-8.1)], mean AnA angle±SD is 17.9±9.57° (8.4-37), mean AF angle ±SD is 50±6.95° (37-54). There was no statistically significant difference between the measurements of the two radiologists except for the alpha angle.

Mean CDA angle for women is 131.3±3.95°; mean AA is 35.7±3.19°; mean T-angle is 8±1.45°; in axial plane, mean AD is 20.6±2.36 mm; mean AnA is 18.0±3.19°; mean AF is 49.4±0.56°, mean PA is (-4.8)±2.58 mm.

CDA angle in males is 133.2±0.61°; mean AA is 36,4±4.49°; mean T-angle is 8.6±0.32°, mean AD is 21.7±0.49 mm; mean AnA is 17.6±2.13°; mean AF is 51.1±1.07°, and the mean PA is (-5.0)±0.39 mm (Fig. 3).

When we look at the genders, CDA, T and AD values were statistically significantly lower in women ($p<0.05$).

In 54 cases with unilateral hip pain, there was no statistically significant difference in the angle measurements of the painful and painless hips were compared.

In cases with pain complaints on both sides; there was no statistically significant difference between the two sides when we compared the right and left hip measurements.

When angle measurements were compared between painful and painless hips, only CDA increased statistically significantly in the group with pain ($p<0.05$) (Table 1).

Table 1. Measurements on painful and painless hip

	Collodiaphyseal angle (°) Mean (±SD)	Acetabular angle (°) Mean (±SD)	Tönnis angle (°) Mean (±SD)	Acetabular depth (mm) Mean (±SD)	Protrusio acetabuli (mm) Mean (±SD)	Alpha angle (°) Mean (±SD)
Right painless	131.06±0.61	21.39±0.39	7.37±0.28	21.16±0.37	-5.02±0.44	50.25±1.02
Left painless	131.71±0.57	21.10±0.37	7.22±0.24	20.80±0.38	-4.62±0.35	51.42±1.01
Right hip pain	131.93±1.26	21.55±1.08	8.39±0.75	21.16±0.37	-5.73±0.88	50.25±1.02
Left hip pain	132.34±1.08	21.18±1.03	7.70±0.60	24.76±0.79	-5.13±0.65	53.30±2.13
Bilateral hip pain	132.83±0.80	20.67±0.42	7.20±0. .32	21.39±0.56	-5.34±0.43	48.91±1.05

SD: Standard deviation.

When the right hip angle measurements of the patients with bilateral hip pain were compared with the right hip of those with complaint of pain only on the right hip, AnA was found to be statistically significantly higher in those patients with unilateral pain ($p<0.05$).

When the left hip angle measurements of the cases with bilateral pain were compared with the left hip angle measurements of the cases with pain on their left hip only, no statistically significant difference was observed.

In the right hip angle measurements, CDA and AF values were found to be statistically significantly higher ($p<0.05$) in the group with pain than the group without pain.

In left hip angle measurements, when the patients with pain and without pain were compared, no statistically significant difference was observed.

Discussion

Hip angle measurements are defined on the direct radiography. Direct radiographs are usually taken in standing position, while hip MRI are performed in lying position. In a study comparing Computerized tomography (CT) in lying position and pelvic radiographs in standing position, there was no significant difference between two shots, in crossover, ischial spine and posterior wall findings.[10, 11] In another study, it was observed that crossover and ischial spine findings were reduced in the horizontal position, when pelvis AP radiographs taken in the standing and lying positions were compared. CEA does not change depending on the position.[10] In a study comparing Dunn 45° and 90° direct X-rays, axial oblique MRI and alpha angle measurements at CT, there was no significant difference between values in other modalities except Dunn 45° radiography. Dunn 45° was found to have higher alpha angle than the others.[12]

In our study, one of our aims was to determine the average of the measurements used in the routine assessment of FAI in routine hip MRI scans in Turkish patients. Mean angle measurements in women were 131.3° for CDA; 35.7° for AA; 8° for T, 20.6 mm for AD, 18.0° for AnA; 49.4° for AF, (-4.8) mm for PA. In the case of men, mean angle measurements were 133.2° for CDA; 36.4° for AA; 8.6° for T, 21.7 mm for AD; 17.6° for AnA; 51.1° for the AF, and (-5.0) mm for the PA. When we look at gender, CDA, T and AD values were found to be lower in women.

The majority of CDA-related studies report average value without specifying gender discrimination. In the study, in which CDA and anteversion were evaluated by pelvic radiographs, it was reported that when genders were compared, no significant difference between the groups was observed in terms of CDA. However, a significant correlation between femur length and CDA is reported in women. In the same study, the mean value of anteversion was higher in females than males, and both genders, it was found to be higher in the right side than in the left side.[9]

Similary, in a study conducted on healthy young individuals in Turkish patients by direct radiography, the average value of Sharp angle in males was 37.9±2.5° and in females it was 38.5±2.1°. Although, the difference between the genders was significant.[13]

In another study comparing CEA and acetabular angle in two hips in Turkish patients, the CEA angle was found to be higher at the left and the acetabular angle was higher at the right. Although both angle values were higher in males than females, the difference was not statistically significant. It was also found that the CEA angle increased with increasing weight and acetabular angle decreased with age.[14]

Preoperative axial MRI and direct radiographic examinations of adolescent FAI cases were evaluated. No significant difference was found between genders in terms of T- angles and CEA. However, it has been demonstrated that AF is higher in males.[8]

There are studies in the literature that show an increase in AF in cases with high BMI. In the same study, it was stated that the acetabular morphology did not change depending on BMI.[15]

Hip joint morphology may vary in different ethnic groups

and populations.[16–19] The normal values of radiographic measurements used in the evaluation of adult hip dysplasia in Turkish population have been reported by Özçelik et al.[20] When CEA angle was evaluated in terms of right-left and gender, different interpretations of different populations were encountered.[14, 16, 20]

In a study conducted on volunteers, the minimum range of joint space, CEA, acetabular depth-to-width ratio (ADR) and acetabular head index (AHI) were measured. Joint width, CEA, ADR, and AHI measurements were found to be associated with hip pain.[21]

Sagittal spinopelvic angle and acetabulum angle were compared with radiographs in asymptomatic adolescents. There was no correlation between CEA and T-angle and sagittal spinopelvic angle. However, the increase in pelvic tilt and lumbar lordosis does not cause an increase in AA.[7]

In our study, in cases with pain on both sides, no significant difference was found between the sides. When the left hip angle measurements of the left side of the patients with bilateral pain and the left hip of the patients with pain only on the left side were compared, no statistically significant difference was observed. When the right hip angle measurements of the patients with bilateral hip pain were compared with those of the right one who felt pain only on the right side, AnA was found to be higher in the group with unilateral pain complaints. This was thought to be secondary to the acetabulum adaptation to optimally grasp the femoral head, due to pain.

In a study by Watarai et al., where acetabulum was assessed three-dimensionally by CT for various reasons, complete peripheral bone extension was found to be rare but if there was, it was generally bilateral and accompanied a very small proportion of pain.[22]

In the follow-up patients with pathologic CEA between the ages of 13 and 60, it was observed that they developed osteoarthritis within 4 to 28 years.[2, 23] Another study of 20-year follow-up of cases with a CEA value of less than 20 showed that osteoarthritis developed.[2, 24]

In a study consisting of athletes with a restriction of hip joint motion (internal rotation <10 degrees) and a control group, the progressive degenerative changes in young athletes were observed to be more than the control group, in their five year MRI and direct radiography follow-up.[25]

In a two-year follow-up of cases with CEA>40 degrees and profunda acetabuli, when the group in which acetabulum covered the femur head normally, was compared with the group in which it covered excessively, it was demonstrated that the group with excessive covering was likely to develop labral tears and pain.[26]

In a study evaluating acetabular rim cartilage in cases with Tönnis grade 0 and 1 coxarthrosis, cartilage damage was detected in 70.3% of 152 cases. The fact that the Tegner activity scale is greater than 6 times increases the risk of cartilage damage, as the alpha angle is more than 55 degrees and the complaints are 20 months or longer.[27]

Femur head-neck offset reduction and cam deformity are common in developmental hip dysplasia.[28] In acetabular FAI cases, there are studies showing that cartilage and labral damage increased and the range of motion decreased as the anterior offset and alpha angle of the head and neck increased.[29]

There are many studies in the literature indicating that some selected hip measurements show inter and intraobserver variation.[4, 30–35]

In a study evaluating FAI-like features in CT, FAI-like features were seen at a high frequency in a young asymptomatic population. Accordingly, it has been reported that the cut off values for defining the morphological abnormalities associated with FAI may be set too low in the current literature. In the same study, it was concluded that axial plane AF measurements could be more accurate than axial oblique plane.[36]

In a study by Wynne-Davies, associates the difference in CEA angle between the right and left hip with the difference in load on the hips.[37]

The limitation of our study is the fact that it is retrospective. For this reason, routine hip examinations of the cases were taken into consideration. Labrum evaluation is not optimal. Lack of long-term follow-up is our other limitation. Previous researches in the Turkish patients have usually been made on direct radiography. In the Turkish patients, these measurements have never been performed on MRI. This is the advantage of our study. In addition, the cases in the previous studies belong to the young population. In our study, the fact that our case group consists of a wide range of age and different age groups, has the advantage of giving an idea about the general population. This is the advantage of our study.

Conclusions

In our study, which has a wide range of age in our society, the incidence of CDA, T and AD was found to be lower in women than in men. The angle of the CDA was higher in painful hips than painless hips. AnA was higher in cases with unilateral pain on the right side, than those with bilateral pain. CDA and AF values increased in cases with pain on the right side, compared to those without pain on the right side. We think that this is due to the fact that acetabulum changes its grasp of the femur head due to pain. The

fact that the measurements on the right side differ significantly from the left, may depend on the weight applied on the hip.

CDA and acetabular anteversion increase in patients with chronic hip pain. For these reason chronic pain may lay the ground for joint limitation. However, further studies are needed to demonstrate long-term follow-up and its association with labrum injury.

Disclosures

Ethics Committee Approval: The study was approved by the Fatih Sultan Mehmet Training and Research Hospital Research Ethics Board (2016/4 meeting, 2016/16 research, document number:17073117-050.99).

Peer-review: Externally peer-reviewed.

Conflict of Interest: The Authors declares that there is no conflict of interest.

Authorship Contributions: Construction idea for research were found by HCC and EDC. Planning methodology, organising and supervising the course of the project were done by HCC and EDC. HCC wrote all the manuscript. HCC and EDC reviewing the article before submission not only for spelling an grammar but also for its intellectual content.

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