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Evaluation of hip angles with magnetic resonance imaging in early stage femoral head osteonecrosis

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ABSTRACT

Aims: It was aimed to evaluate the alpha and Wiberg angles of patients with clinical and radiological diagnosis of idiopathic femoral head osteonecrosis (FHO) in comparison with the control group.

Methods: Routine hip MRI (Magnetic resonance imaging)s between January 2022 and May 2024 were examined retrospectively. MRI images diagnosed with early stage (stage I, II according to Ficat and Arlet classification), idiopathic FHO were recorded. A control group matched in age and gender was created. Alpha angle was measured as the angle between the parallel line drawn from the center of the femoral head to the femoral neck in axial MRIs and the line drawn from the transition point between the femoral head and neck in the anterior to the center of the femoral head. Wiberg's central corner angle was measured as the angle between the perpendicular line drawn from the center of the femoral head to the acetabulum and the line connecting the outermost point of the acetabulum in coronal images. Measurements were compared statistically in both groups. P<0.05 was considered statistically significant.

Results: A total of 70 hips were examined, including 35 FHO (13 unilateral and 11 bilateral hips) and 35 control groups (3 unilateral and 16 bilateral hips). There was no difference between the groups in terms of age and gender (P>0.05). We found statistically significant differences in alpha and Wiberg angles between the FHO and control groups (P=0.04, P=0.025, respectively). There was no statistically significant difference between stages I and II in terms of alpha and Wiberg angles (P=0.376, P=0.078, respectively).

Conclusion: These changes in hip angle measurements in this study may explain the cause of idiopathic FHO. We can predict FHO early.

Keywords: Hip, femur head, femur head necrosis, MRI, asetabulum

INTRODUCTION

Osteonecrosis, also known as avascular necrosis of bone, is the death of marrow elements and osteocytes due to deterioration of the vascularity of the bone.[1,2] Femoral head osteonecrosis (FHO) is the most common site and is probably caused by the combination of high loading during standing and poor blood supply.[3,4] There are many potential causes of osteonecrosis, including trauma, steroid use (systemic or local), vasculitis, hyperlipidemia, sickle cell anemia, Gaucher disease, pancreatitis, alcoholism, AIDS, radiation, and embolism. Some cases are classified as idiopathic.[1]

Osteonecrosis can be diagnosed based on characteristic radiographic, Computed tomography, MRI (Magnetic resonance imaging), or radionuclide bone scintigraphy findings.[1] The Ficat and Arlet classification uses a combination of plain radiographs, MRI, and clinical features to stage osteonecrosis of the femoral head.[5,6] It consisted of stages I through.[4,5,6] On MRI, edema in stage I, geographic defect, sclerosis and/or subchondral cysts in stage II are observed. Starting from stage III, morphological changes and degeneration begin to develop in the femoral head.

Alpha angle measurement is the best way to evaluate the abnormal morphology of the anterior femoral head-neck connection in the axial oblique plane. This is a widely used method for evaluation. The alpha angle was first described by Notzli et al.[7] in 2002. Angles greater than 55° are thought to be associated with femoroacetabular impingement.

The central edge angle was defined by Wiberg and provides information about the lateral coverage of the femoral head by the acetabulum in the coronal plane. It measures the

femoral head-acetabulum relationship in the coronal plane. While large angle values indicate deep acetabulum, small angle values indicate both protrusion of the femoral head and shallowness of the acetabulum. Here, the angle between the line connecting the center of the femoral head and the lateral edge of the acetabulum and the line drawn perpendicularly from the center of the femoral head is measured.[8]

Hip angle measurements have been frequently examined in femora-acetabular impingement syndromes. To our knowledge, no evaluation has been made on idiopathic FHO. Changes in hip angles (alpha and wieberg angle) are observed in FHO. In this study, we aimed to evaluate the alpha and Wiberg angles of patients with a clinical and radiological diagnosis of stage I-II (which did not cause any change in femoral head morphology) idiopathic femoral head osteonecrosis, in comparison with the control group.

METHODS

This retrospective study was conducted at Gaziantep University. The study was carried out with the permission of the Gaziantep University Clinical Researches Ethics Committee (Date: 12.06.2024, Decision No: 2024/209). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Subjects

Between January 2022 and May 2024, hip MRI examinations were examined. In this study, patients with early stage(stage I, II according to the Ficat and Arlet classification).[5,6] Idiopathic FHO, and clinically and radiologically diagnosed MRI images that did not cause any change in femoral head morphology were included in the study. A control group was created from hip MRI images similar in age and gender, with normal hip MRI examinations.

Exclusion Criteria

Exclusion criteria for the patient and control groups; Patients who were younger than 18 years of age, had distorted hip joint and femoral head configuration on MRI, had stage III and IV osteonecrosis and osteoarthritis in the hip joint, had a history of tumor, trauma, and had surgery were excluded from the study.

Considering similar studies in the literature,[9-11] in order for the volume change between groups to be statistically significant (Cohen's d=0.5), the minimum number of people required in each group should be 35 (α=0.15, 1-β=0.85). In our study, we determined that a total of 70 hip MRI images would be performed, 35 in each group. Power analyses were performed by the Gpower 3.1 program.

MRI Technique and Measurements

All MRI examinations were performed using cranial coil by 3.0 Tesla (T) MRI systems (Ingenia, Philips Healthcare, Best, the Netherlands). The routine hip MRI protocol for the 3.0-T MR machine at Gaziantep University Hospital was as follows:

T1 weighted in the coronal plane (TR ms/TE ms; 500/20, FOV 250x396 mm and matrix 300×421 mm) were obtained using a 4-mm slice thickness and 0,5-mm intersection gap; and 35-40 coronal sections were obtained. T2-SPAIR (Spectral Attenuated Inversion Recovery) weighted in the axial plane (TR ms/TE ms; 700/62, FOV 275x350 mm and matrix 31×310 mm) were obtained using a 4-mm slice thickness and 0,5-mm intersection gap; and 35-40 axial sections were obtained.

The alpha angle was measured on the axial T2-(SPAIR) weighted MRI images by calculating the angle between the parallel line drawn from the center of the femoral head to the femoral neck and the line drawn from the transition point between the femoral head and femoral neck in the anterior to the center of the femoral head (Figure 1).[8,10,12] Central corner angle of Wiberg was measured on the coronal T1-weighted images by calculating the angle between the perpendicular line drawn from the center of the femoral head to the acetabulum and the line connecting the outermost point of the acetabulum (Figure 2).[8,10,12] All measurements were made by one radiologist (D.M.), and MRIs were determined by consensus by two radiologists (Duçem M, Şahan MH).

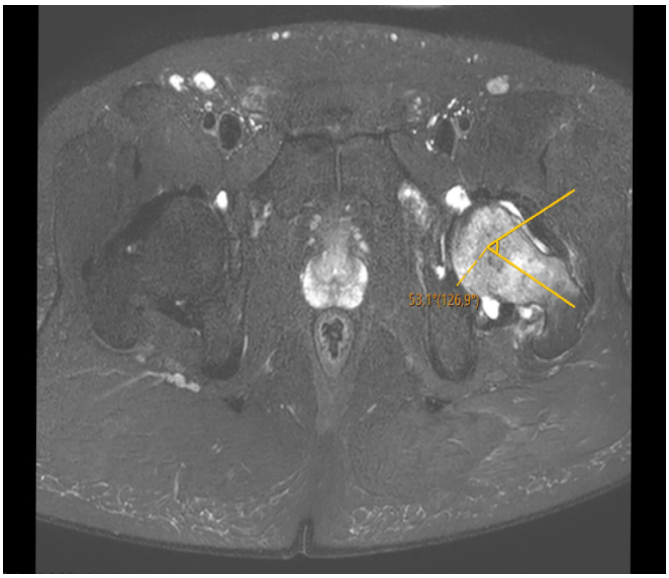

Figure 1. 44-year-old man, stage I osteonecrosis of the left hip, alpha angle measurement on the axial T2 SPAIR weighted image

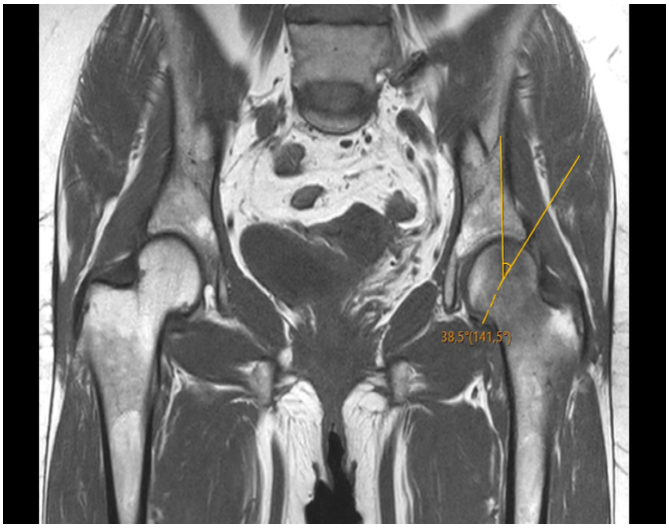

Figure 2. 48-year-old woman, stage I osteonecrosis of the left hip, Wieberg angle measurement on the coronal T1 weighted image

Statistical Analysis

Version 20.0 of the Statistical Package for the Social Sciences (SPSS, INC, an IBM Company, Chicago, Illinois, United States) software was used for the analysis. Descriptive

statistics are presented as mean, standard deviation, minimum and maximum. A chi-square test, independent samples t-test, Mann whitney U test. A p-value < 0.05 was considered as statistical significance.

RESULTS

A total of 70 hips were examined, including 35 FHO (13 unilateral and 11 bilateral hips) and 35 control groups (3 unilateral and 16 bilateral hips). There was no difference between the groups in terms of age and gender (p >0.05), (Table). There was no significant difference between hip directions (right-left). (FHO; 17 right, 18 left and control group; 18 right and 17 left hips). Of the FHO patients, 7 were stage I and 28 were stage II. We found statistically significant differences in alpha and Wiberg angles between the FHO and control groups (p=0.04, p=0.025, respectively), (Table). There was no statistically significant difference between stages I and II in terms of alpha and Wiberg angles (p=0.376, p=0.078, respectively).

Table. Comparison of age, gender, alpha angles and Wiberg angles of femoral head osteonecrosis and control group

	FHO	Control group	p value
Age (years)	46.89±12.3	47.2±13.89	0.939*
Gender: M/F	26/9	23/12	0.434*
Alpha angle mean (min-max)	50.22±6.3	54.1±8.9	0.04**
	(37.9-63.7)	(38-70)	
Wiberg angle mean (min-max)	40.89±7.8	36.87±6.7	0.025**
	(25-58)	(28.1-54.5)	

FHO: Femoral head osteonecrosis, M: Male, F: Female
* P value shows the results of Man Whitney U test
**P value shows the results of Chi-square test
***P value shows the results of independent samples t-test

DISCUSSION

FHO is an increasingly common cause of hip disability and poses a significant diagnostic and treatment challenge.[4] The cause of FHO can be clearly identified in patients with direct damage to the bony vascular system, bone or marrow.[9,13] However, the pathogenesis of FHO remains a matter of debate in many patients as sufficient information is still lacking. In addition to the known identifiable causes of FHO, some cases (30%) are defined as idiopathic because the pathology cannot be precisely determined.[9,13,14]

In our study, we found that the alpha angle was low and the Wieberg angle was significantly high on MRI in stage I and II FHO. Studies in the literature on alpha and Wiberg angle are related to femoroacetabular impingement.[8,10,12] Alpha angle is the angle between the parallel line drawn from the center of the femoral head to the femoral neck and the line drawn from the transition point between the femoral head and neck in the anterior to the center of the femoral head. Above 55° is considered as a cam type femoral acetabular impingement lesion.[10,15,16] Wiberg angle is defined by measuring the angle between the line connecting the lateral edge of the acetabulum to the center of the femoral head and the line drawn perpendicular to the center of the femoral head.[8,10,12] While larger angles indicate a deep acetabulum, smaller angle values indicate both protrusion of the femoral head and shallowness of the acetabulum. The normal range is 25-39°, over 40° indicates excessive coverage, between 25°-17° indicates borderline dysplasia, and below 17° indicates severe dysplasia.[8,10,12]

Hip angles have not been studied with FHO before. It can be assumed that FHO, one third of which have no clear underlying etiology, has a direct correlation with changes in the alpha and Wieberg angles of the Hip. More comprehensive studies can be conducted that include different angle measurements.

Limitations

This study had some limitations. First, the study had a single-center, retrospective design with a relatively small sample size. Second, measurements included routine hip MRI protocols. Finally, the variability of the intraobserver and the interobserver measurements were not evaluated.

CONCLUSION

These changes in angle measurements in this study may explain the cause of idiopathic FHO. In the study results, we found that the alpha angle was low (abnormal morphology of the femoral head-neck connection) and the Wieberg angle was high (associated with the deep acetabulum). Based on these results measured on MRI, we can predict femoral head osteonecrosis early. More multicenter studies with larger series of FHO patients are needed to fully elucidate these findings and their clinical significance.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Gaziantep University Clinical Researches Ethics Committee (Date: 12.06.2024, Decision No: 2024/209).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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