The Correlation Between Ultrasonographic Measurements of Femoral Cartilage Thickness and Physical Function in Patients with Primary Kknee Osteoarthritis

Mona Abdullah El Sebaie Aly[1], Hany Naji Ahmed Hamada[2], Reem Mohamed Ezz Eldean El Mallah[3] and Abdelrhman Mohamed Mohamed Hassan1[2]

Original Article

[1]*Departments of Physical Medicine, Rheumatology and Rehabilitation, Armed Forces College of Medicine*

[2]*Physical Medicine, Rheumatology and Rehabilitation, Military Medical Academy*

[3]*Physical Medicine, Rheumatology and Rehabilitation, Faculty of Medicine, Ain Shams University*

ABSTRACT

Background: Osteoarthritis (OA) of the knee joint is one of the most common degenerative disorders that affects the synovial joints, which can cause severe pain and disability**.**

Objective: To assess the association between femoral cartilage thicknesses as measured by US with WOMAC score & 6 min walk test and find out other ultrasonographic findings in cases with primary knee OA**.**

Patients and methods: This cross-sectional study was conducted on 35 patients diagnosed with primary knee OA clinically and imaging by X-ray who recruited from ARRC and 6th October military hospital from February 2023 to June 2023.

Results: On performing correlation between disease duration and US assessment of the patients, there was a negative correlation between disease duration and each of medial femoral thickness (r = -0.46 and *P* <0.05), Intercondylar thickness (r = -0.46 and *P* <0.05) and, lateral femoral thickness (r = -0.69 and *P* <0.05).

On performing correlation between WOMAC Score and US assessment of our patients, there was a negative correlation between WOMAC Score and each of medial femoral thickness (r = -0.739 and *P* <0.001), Intercondylar thickness (r = -0.561 and *P* <0.001), and Lateral femoral thickness where (r = -0.731 and *P* <0.001)

On performing correlation between 6-minute walk test and each of disease duration and WOMAC score there was a negative correlation (r = -0.629 *p*<0.001) and (r = -0.838 *p*<0.001) respectively. But there was a positive correlation between 6 min walk test and each of medial femoral thickness (r = 0.609 and *P* <0.001), Intercondylar thickness (r = 0.551 and *P* <0.001), and Lateral femoral thickness where (r = 0.667 and *P* <0.001).

Conclusion: Disease duration was closely related in the prediction of hyaline cartilage thickness and there was a significant correlation between femoral cartilage thickness assessed by US and physical function assessed by each of WOMAC score and 6 min walk test in patients with primary knee OA.

Key Words: FEMORAL Cartilage Thickness,Physical Function, primary knee osteoarthritis,Ultrasonography

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Corresponding Author: Abdelrhman Mohamed Mohamed Hassan, Departments of Physical Medicine and Rehabilitation, Armed Forces College of Medicine, Cairo, Egypt. **Tel.:** +2 010 2226 0121, **E-mail**:bodimmh@gmail.com

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INTRODUCTION

Osteoarthritis (OA) of the knee joint is one of the most common degenerative disorders that affects the synovial joints, which can cause severe pain and disability. OA also can affect the functional status of the patient. In addition, it can cause health problems and monetary losses, especially among the elderly[1].The articular cartilage in the knee progressively deteriorates and develops localized degeneration in OA. The articular cartilage of the femur is a hyaline kind and is made up of chondrocytes and extracellular matrix. Finding an appropriate method for measuring cartilage thickness is crucial for evaluating disease progression & therapy response[2].Using plain knee X-rays was the main radiological tool for diagnosing knee OA. When the joint space in the knee narrows, physicians can diagnose knee OA. Because the cartilage surface is not clearly visible on a standard radiograph, the correlation

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between clinical complaints as well as joint space width may be inaccurate. Although CT is another option for detecting knee OA, it carries risks associated with large doses of ionizing radiation and relatively high price. Magnetic resonance imaging (MRI) is another safe imaging method that can detect any focal cartilage abnormalities[3]. There are a number of issues for patients who have claustrophobia or noncompatible metallic prosthesis that make MRI a prohibitively expensive and inconvenient modality[4]. Ultrasonography (US), on the other hand, is a harmless method that individuals generally accept that can detect cartilage abnormalities as well as bone erosions in the early first stages of knee OA[5].

PATIENTS AND METHODS

This cross-sectional study was conducted on 35 patients diagnosed as primary knee OA clinically and imaging by X-ray who recruited from ARRC and 6th October military hospital from February 2023 to June 2023.

Inclusion criteria

Patients diagnosed as primary knee OA according to ACR 1991 criteria.

Exclusion criteria

Patients with secondary Knee OA, BMI is more 35, infection or malignancy, Patients with history of systemic steroids in the previous 3 months or intraarticular injection of hyaluronic acid or steroids in the past six months, Balance impairment and Use of a gait aid.

Method

Initial assessment

All patients were subjected to full history taking including

Personal history, Complain in the patient own words and Present history with special attention to articular manifestations and full clinical examination.

Activity and physical function Assessments

Six-min walk test

All patients were assessed by a Six-min walk test; they were told to walk as far as possible in 6 minutes at a self-selected intensity[6]. Six min walk test was conducted in a well-ventilated, quiet, and flat surface hallway with at least 20 m distance. In healthy individuals, the 6-min walk distance ranges from 400 to 700 m. Two cones were placed 20 m apart, and the patients walked and tried to cover the maximum distance in 6 min.

WOMAC score A questionnaire consists of 24 items divided into 3 subscales: The pain subscale (P subscale) includes 5 questions about pain, Stiffness subscale (S subscale) 2 questions, S1 as well as S2, measure how stiff you feel immediately upon waking and again after prolonged periods of sitting, lying, or resting during the day, respectively. The physical function subscale (PF subscale) includes 17 questions about the degree of difficulty when 'descending stairs'. All 24 items were answered using a 0–4 Likert scale (none, mild, moderate, sever, and extreme), higher scores on WOMAC indicate worse pain, stiffness, and functional limitation[7].

Radiological assessment of affected knee joint

The radiological severity of knee OA was evaluated using the kellgren and lawrence global scale, as well as a plain X-ray was taken of both knees in a standing AP orientation[8]

Sonographic assessment

The subject was positioned supine with full flexion of the knee. Medial, intercondylar sulcus and lateral femoral articular cartilages was scanned in a transversal plane to assess the cartilage. According to the criterion provided by Outcome Measures in Arthritis Clinical Trials (OMERACT), it was determined to be deteriorated when there was a loss of surface sharpness, increased inner echogenicity, local thinning, and overall loss of cartilage thickness[9]. The patient was instructed to bend his knees as far as possible, after which the femoral hyaline cartilage was evaluated in a transverse plane, and categorized into one of five degrees: 0, normal; 1, loss of normal sharpness level interfaces or increased echogenicity cartilage; 2 A, modification from degree 1 with reducing the cartilage thickness by less than fifty percent of the size; 2B, decreasing the cartilage thickness by more than fifty percent but less than one hundred percent; & 3, complete loss of cartilage thickness in a localized area[10]. Patients were then instructed to fully extend their knees, at which point an anterior-posterior scan was performed from both the medial and lateral sides of the joint space to obtain longitudinal images of the femoral and tibial osteophytes and medial and lateral menisci. Osteophytes were graded as follows: grade 0 = no osteophytes, grade 1 = minimal osteophytes, grade 2 = medium osteophytes, and grade 3 = substantial osteophytes, all based on established grading standards. If the meniscus stuck out more than 3 mm in a direction perpendicular to the joint line where the ends of the tibia and femur meet, it was considered to be extruded[11]

Administrative and Ethical Desig

NInformed written consent was gotten from all cases before enrolment. Study details, the nature of the investigations, and interventions were explained to all

patients. Approval of the Research Ethics Committee of Armed Forces College of Medicine, Egypt, was obtained, & the trial was performed in accordance with the Declaration of Helsinki. Policy of data confidentiality was strictly followed.

RESULTS

Demographic data among the studied population are shown in (Table 1). The Age ranged from 38 to 73, male patients were 11 and female were 24. BMI ranged from 25.39 to 35.

Table 1: Demographic data among the study population (n = 35)

Age (Years)	
Mean ± SD.	56.23 ± 10.97
Median (IQR)	35 (47 - 65)
Range (Min-Max)	38 - 73
Sex	
Male	11 (31.43%)
Female	24 (68.57%)
BMI	
Mean ± SD.	32.39 ± 2.64
Median (IQR)	33 (31.12 - 34.28)
Range (Min-Max)	25.39 - 35

SD: standard deviation **IQR**: interquartile range

On taking history, all patients had mechanical knee pain, while those with Stiffness were 25. Duration of the disease (months) ranged from 3 to 180 month as shown in (Table2)

Table 2: Clinical history results among the study population (n = 35)

Mechanical knee pain (n. and % of patients)	35 (100%)
Stiffness (n. and % of patients)	25 (71.43%)
Disease duration (months)	
Mean ± SD.	72.97 ± 57.58
Median (IQR)	60 (30 - 120)
Range (Min-Max)	3 – 180

SD: standard deviation **IQR**: interquartile range

Regarding the clinical examination, patients with antalgic Gait were 18 (51.43%). Those with soft tissue swelling were 12 (34.29%), 10 (28.57%) had Deformities due to OA, 14 (40%) had effusion, none of patients had hotness, while all of them 100% had Tenderness and Crepitus. As regard ROM, patients with limited flexion were 17 (48.57%) but those with extension lag were 6 (17.14%) as shown in (Table 3)

Table 3: clinical examination among the study population

	Study population (n = 35)
Antalgic Gait (n. & % of patients	18 (51.43%)
Soft tissue swelling (n. & %)	12 (34.29%)
Deformities (n. & %)	10 (28.57%)
Hotness (n. & %)	
- Normal	35 (100%)
- Abnormal	0 (0%)
Tenderness (n. & %)	35 (100%)
Crepitus (n. & %)	35 (100%)
Effusion(n. & %)	14 (40%)
Flexion(n. & %)	
- Normal	18 (51.43%)
- Limited	17 (48.57%)
Extension lag (n. & %)	
- Normal	29 (82.86%)
- Limited	6 (17.14%)

WOMAC Score test among the study populations was ranged from 10 to 63 with mean ± SD 39.4 ± 13.92. the mean distance of 6-minute walk test, was ranged from 200 to 377 m with mean ± SD = 293.43 ± 44.11 m

Radiological assessment of patients was done by X-ray KL scale, Grade zero was 1 (2.86%), first grade was 7 (20%), second grade was 9 (25.71%), Third grade were 14 (40%), Fourth grade was 4 (11.43%).

Ultrasonographic evaluation showed patients with Grade 1 Femoral hyaline cartilage were 8 (22.86%), Grade 2 A were 7 (20%), Grade 2 B were 17 (48.57%), Grade 3 were 3 (8.57%)

Ultrasonographic assessment of the Medial femoral cartilage thickness, osteophytes, medial and lateral meniscal extrusion are shown in (Table 4,5)

Table 4 : Ultrasonographic measurement of the Femoral hyaline cartilage thickness among the study population

	Study population (n = 35)
Medial thickness	femoral
Mean ± SD.	0.23 ± 0.05
Median (IQR)	0.23 (0.2 - 0.27)
Range (Min-Max)	0.12 - 0.3
Intercondylar thickness	
Mean ± SD.	0.33 ± 0.07
Median (IQR)	0.33 (0.29 - 0.38)
Range (Min-Max)	0.18 - 0.44
Lateral thickness	femoral
Mean ± SD.	0.3 ± 0.06
Median (IQR)	0.3 (0.26 - 0.34)
Range (Min-Max)	0.18 - 0.43

Table 5: Sonographic assessment results among the study population (n = 35)

Femoral osteophytes grade	
-0	5(14.29%)
-1	9(25.71%)
-2	15(42.86%)
-3	6(17.14%)
Tibial osteophytes grade	
-0	6(17.14%)
-1	9(25.71%)
-2	14(40%)
-3	6(17.14%)
Medial menisci extrusion	24(68.57%)
Lateral menisci extrusion	9(25.71%)

Correlation between the disease duration (months) and US assessment of the patients, showed negative correlation between disease duration and each of medial femoral thickness (r= -0.46 and *P* <0.05), Intercondylar thickness (r= -0.46 and *P* <0.05) and, lateral femoral thickness (r= -0.69 and *P* <0.05).

Correlation between 6 minute walk test and each of the clinical and US parameters are shown in (Table 6)

On performing ROC curve; WOMAC Score (>40) used to predict Medial femoral thickness, Intercondylar thickness and Lateral femoral thickness. (AUC, Cutoff value, sensitivity, specificity, *PPV*, N*P*V are shown in (Table 7)

Table 6: Spearman's correlation coefficients (rho) between 6-minute walk test and each of disease duration, WOMAC score and femoral cartilage thickness

Disease duration	Spearman's correlation coefficients P (rho)
-0.629	<0.001
WOMAC score	
-0.838	<0.001
Medial femoral thickness	
0.609	<0.001
Intercondylar thickness	
0.551	<0.001
Lateral femoral thickness	
0.667	<0.001

P < 0.05 significant, *P*>0.05 non-significant, *P*<0.001 highly significant.

Table 7: ROC curve analysis with cut-off value, sensitivity, specificity, PPV and NPV of WOMAC Score (>40) to predict hyaline cartilage thickness

	Diagnostic parameters					
	AUC	Cutoff value	Sensitivity	Specificity	PPV	NPV
Medial femoral thickness	0.521	0.225	70.6%	44.4%	54.55%	61.54%
Intercondylar thickness	0.520	0.255	100.0%	33.3%	58.62%	100%
Lateral femoral thickness						

DISCUSSION

The mean age of the studied group was 56.23 ± 10.97 years with female predominance 24 (68.57%) and their BMI ranged from 25.39 to 35 with mean ± SD = 32.39 ± 2.64. Comparable with the current study Razek & El-Basyouni., showed that the mean age of patients with primary OA of knee joint was 57 years with female predominance 56/80 (70%)[12].

As well as, Refaat *et al*., showed that 62% of patients with knee OA were female. The mean age was 57.1 years and the majority of the patients were overweight[13].

Regarding WOMAC Score test, in our study results ranged from 10 to 63 with mean ± SD = 39.4 ± 13.92. In agreement with our study Mortada *et al*., and Seifeldein *et al*., showed that the mean WOMAC score among knee OA patients was 59.2 ±11.2, 39.68 ± 12.83 respectively[14,15].

Regarding plain X-ray grading by KL scale, only one patient was grade zero, 7 (20%) were first grade, 9 (25.71%) patients were second grade, 14 (40%) were third grade, while 4 (11.43%) patients were fourth grade. While, Abd Elrazik *et al*., & Khalil *et al*., showed that the most common grades based on X-ray were grade II (38%, 45% respectively) and grade III (38%, 40% respectively)[16,17].

On performing ultrasonographic evaluation, medial femoral cartilage thickness ranged from 0.12 to 0.3 cm with mean ± SD = 0.23 ± 0.05, the intercondylar cartilage thickness ranged from 0.18 to 0.44 cm with mean ± SD= 0.33 ± 0.07, while lateral femoral cartilage thickness ranged from 0.18 to 0.43 cm with mean ± SD 0.3 ± 0.06. Similar to our results Refaat *et al*., reported that all of the knee OA

individuals included in their study had reduced cartilage thickness, with varying degrees, along different parts of the femur. At the medial epicondyle, the average cartilage thickness was 0.16 cm and ranged from 0.14 to 0.19 cm. At the intercondylar notch, the average cartilage thickness was 0.21±0.02 cm & ranged from 0.18 to 0.25 cm. The average cartilage thickness at the lateral epicondyle was 0.18±0.03 cm and ranged from 0.12 to 0.2[13].

Our results for the femoral hyaline cartilage grading, 8 patients (22.86%) were grade 1, 7 patients (20%) grade 2A, 17 patients (48.57%) were grade 2B, while only 3 patients (8.57%) were grade 3. Similar to the results that are reported by Khalil *et al*., The femoral cartilage grading revealed that 40 % of those examined patients were grade 2B, and 30% were grade 2A[17].

Regarding US evaluation for osteophytes, patients with Grade 0 femoral osteophytes were 5 (14.29%), Grade 1 femoral osteophytes were 9 (25.71%), Grade 2 femoral osteophytes were 15 (42.86%), Grade 3 femoral osteophytes were 6 (17.14%).

Number of patients with Grade 0 tibial osteophytes were 6 (17.14%). Grade 1 tibial osteophytes were 9 (25.71%), Grade 2 tibial osteophytes were 14 (40%), Grade 3 tibial osteophytes were 6 (17.14%). While, Podlipská J *et al*., have found that number of patients with global grade osteophytes grade 0 was 31.7%, grade 1 was 32.4%, grade 2 was 16.2%, and grade 3 was 19.7% Patients with medial menisci extrusion were 24 (68.57%) while those with lateral menisci extrusion were 9 (25.71%) [11], the difference in the number and percentage may be due to different sample size.

On performing correlation between disease duration (months) and US assessment of the patients, there was a significant negative correlation between disease duration and each of medial femoral thickness (r -0.46 and P <0.05), Intercondylar thickness (r -0.46 and P <0.05) and, lateral femoral thickness (r -0.69 and P <0.05). Similarly, Khalil *et al*., & Abd El Monaem *et al*., revealed that there were significant correlations between patients' disease duration and US measurements concerning osteophyte length, lateral femoral cartilage thickness, medial femoral cartilage thickness, and thickness of the quadriceps tendon[17,18].

On performing correlation between WOMAC Score and US assessment of our patients, there was a significant negative correlation between WOMAC Score and each of medial femoral thickness (r -0.739 and P <0.001), Intercondylar thickness (r -0.561 and P <0.001), and Lateral femoral thickness where (r -0.731 and P <0.001).

In line with the current study Razek & El-Basyouni., showed that there was a significant association of WOMAC with cartilage changes (P = 0.001), osteophytes (P=0.001), and synovial effusion (P=0.05)[12].

Moreover, Khalil *et al*., showed that there was significant correlation between knee OA severity assessed by US grading and WOMAC total scores (p=< 0.001)[17].

On performing correlation between 6-minute walk test and each of disease duration and WOMAC score there was a significant negative correlation (r -0.629 p<0.001), (r -0.838 p<0.001) respectively.

But there was a significant positive correlation between 6 min walk test and each of medial femoral thickness (r 0.609 and P <0.001), Intercondylar thickness (r 0.551 and P <0.001), and Lateral femoral thickness where (r 0.667 and P <0.001). Similarly, Ateef *et al*., have found that 6 min walk test had a negative correlation with each of symptom's subscales including pain subscales, with quality-of-life subscales, and with disease severity[19].

On performing ROC curve; WOMAC Score (>40) used to predict Medial femoral thickness at a cutoff level of 0.225, AUC of 0.521, with 70.6% sensitivity, 44.4% specificity, 54.55% *PPV* and 61.54% N*P*V. Our result showed that WOMAC score (>40) can be used to predict Intercondylar thickness at a cutoff level of 0.255, AUC of 0.520, with 100.0% sensitivity, 33.3% specificity, 58.62% *PPV* and 100% NPV. Furthermore, it was shown that WOMAC score (>40) can be used to predict lateral femoral thickness at a cutoff level of 0.27, AUC of 0.709, with 94.1% sensitivity, 55.6% specificity, 66.67% *PP*V and 90.91% N*P*V.

Our results were supported by Razek & El-Basyouni. (12) & Khalil *et al*.,[17] showed that there was significant association of WOMAC with cartilage Thickness (P = 0.001)[12,17].

CONCLUSION

Disease duration was closely related to the hyaline cartilage thickness and there was a significant correlation between femoral cartilage thickness assessed by US and physical function assessed by each of WOMAC score and 6 min walk test in patients with primary knee OA.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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