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The Association between Knee Osteoarthritis and Changes in the Achilles Tendon: A Cross-sectional Study

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Authors' contributions

This work was carried out in collaboration between all authors. Author TR designed the study, managed the analyses of the study, managed the literature searches and performed data collection. Author OR managed the analyses of the study and managed the literature searches. Author TTL managed the analyses of the study and performed data collection. Author LK designed the study, wrote the first draft of the manuscript and managed the analyses of the study. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aim: To explore the association between knee osteoarthritis (OA) and morphological changes in the Achilles tendon.
Study Design: Pilot cross-sectional study.
Place and Duration of the Study: Rheumatology Unit, Barzilai Medical Center, Ashkelon, Israel. Study took place during 2014.
Methodology: A sample of 56 knee OA patients was recruited. Demographic data, sonographic evaluation of the femoral cartilage thickness, Achilles tendon thickness and Western Ontario and McMaster Osteoarthritis (WOMAC) scores, were collected. The associations between the femoral

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cartilage thickness, WOMAC parameters, and Achilles tendon thickness were tested by Pearson's correlation and linear regression analyses.
Results: The Achilles tendon thickness of the non-(or less)-symptomatic side, significantly negatively correlated with the cartilage thickness of the symptomatic (r=-0.292, *P*=0.029) or non-(or less)-symptomatic (r=-0.319, *P* =0.017) side. These associations remained significant after adjustment for age and BMI in the linear regression analyses (β=-0.284, *P* =0.049 and β=-0.309, *P* =0.026, correspondingly). The WOMAC total score showed a significant positive correlation with the Achilles tendon thickness of the symptomatic side (r=0.389, *P* =0.003), remaining significant after adjustment for age, BMI and cartilage thickness (β=0.400, *P* =0.007).
Conclusions: Previous studies have shown that soleus and gastrocnemius muscles contribute to knee stabilization. Stress on the muscles used to stabilize the osteoarthritic knee may cause structural changes in the Achilles tendon. Further studies are needed to corroborate the association between the Achilles tendon thickness and knee OA. We suggest considering an assessment of the Achilles tendon as part of the knee OA evaluation.

Keywords: Knee; osteoarthritis; Achilles tendon; WOMAC; sonographic evaluation.

1. INTRODUCTION

Osteoarthritis (OA) is the most common joint disease in adults worldwide [1]. The prevalence of painful disabling knee OA in people >55 years old is 10%, of whom 25% are severely disabled [2]. The number of people affected with symptomatic OA is likely to increase due to an aging population and the obesity epidemic. Several studies have highlighted mechanical factors in the etiopathogenesis of this disease [3,4].

In our clinical experience, we observed that individuals with knee OA frequently complained of pain over the Achilles tendon. We found no studies in the literature that evaluated the association between knee OA and Achilles tendon pathology. We hypothesize that knee OA risk factors are similar to Achilles tendon degenerative changes (age, obesity, muscle weakness, sports participation) and that individuals with knee OA develop an altered gate pattern [5], which may be potentially damaging to the Achilles tendon. Several studies have found that quadriceps muscle weakness is associated with knee OA [6,7]. It is possible that changes in the gastrocnemius, the muscle whose attachment is also proximate to the knee joint and contributes to knee stabilization, may be associated with the development of knee OA. The Achilles tendon, a distal part of the gastrocnemius, may also be involved in the process.

Our objectives were to explore the association between knee cartilage thickness and Achilles tendon thickness in patients with knee OA and evaluate the association of knee cartilage thickness and Achilles tendon thickness with pain and disability due to knee OA. We hypothesized that individuals with a decreased cartilage thickness would have a thicker ipsilateral Achilles tendon and that the WOMAC score would be associated with the symptomatic side of the Achilles tendon thickness.

2. METHODS

2.1 Design

Pilot cross-sectional study.

2.2 Setting

Rheumatology Unit, Barzilai Medical Center, Ashkelon, Israel.

2.3 Sample

All individuals with knee pain referred to the Rheumatology Unit during 2014 were scanned for inclusion and exclusion criteria. Inclusion criteria comprised individuals aged ≥ 50 years old, signs of radiographic knee OA (Kellgen-Lawrence (K-L) score ≥ 2) and chronic (>3 months) unilateral or bilateral knee pain. Exclusion criteria comprised traumatic knee pain, previous trauma or surgery to the knee joint, previous trauma or surgery to the Achilles tendon, peritendinous injections within the past six months, a co-existing inflammatory (e.g. enthesopathy) or systemic disease (e.g. rheumatoid arthritis), ulceration or skin pathologies in the area of knee or Achilles tendon.

In total, 56 patients fit the criteria and were asked to participate in the study.

2.4 Ethical Considerations

Participation in the study was voluntary. Each study participant received an explanation as to the aims of the study and methods of data collection. Only after signing an informed consent form was the participant included in the study. The clinical and imaging evaluation of the subjects, including the ultrasound evaluation of knee cartilage thickness, was the standard evaluation routinely performed in the rheumatology unit on patients with chronic knee pain. The only procedure performed specifically for this study was an ultrasound evaluation of the Achilles tendon thickness. It was performed for free (no additional charges were required from the patient or the health plan). This procedure is non-invasive and carries no risk to the patient. The study was approved by the Ethics (Helsinki) Committee of the Barzilai Medical Center.

2.5 Knee OA Evaluation

2.5.1 The Kellgren and Lawrence (K-L) score

All subjects referred to the Rheumatology Unit for a knee OA evaluation, routinely underwent a weight-bearing posteroanterior (PA) radiography of the knee, using Buckland-Wright et al's protocol [8]. Knee OA in tibiofemoral joints was evaluated using the K-L grading scheme [9]. K-L evaluation was used to assess the inclusion criterion.

2.5.2 OA pain and disability evaluation

All participants were asked to fill out the Western Ontario and McMaster (WOMAC) Osteoarthritis Index questionnaire which has been extensively validated, recommended by the Osteoarthritis Research Society and has been widely used in OA clinical trials. The WOMAC encompasses three components: pain, stiffness, and physical function. All scales have high test-retest reliability and validity [10]. Patients were asked to concentrate on the most painful knee when filling out the questionnaire.

2.5.3 Ultrasound evaluation

Ultrasound of both knees and Achilles tendons of all subjects was performed by an experienced rheumatologist (T.R.) blinded to the side of symptoms using the SonoSite M-Turbo Ultrasound System (SonoSite, Inc. USA) with a SLAx (13-6MHz, 36-mm broadband linear array, 6 cm scan depth) transducer. The femoral cartilage thickness at the femoral notch was assessed according to the guidelines of the European League Against Rheumatism (EULAR) [11].

2.5.3.1 Evaluation of changes in the Achilles tendon

Ultrasound is a valid and reliable tool for measuring structure and thickness of the Achilles tendon, with a sensitivity of 0.94, a specificity of 1.00 and an overall accuracy of 0.95 [12,13]. The normal tendon in adults is 3-6 mm thick and 6 cm long with well-defined echogenic margins and fine parallel internal echoes, similar in appearance to the patellar tendon [14].

Subjects lay prone with their feet hanging over the edge of the examination bed. Ankle joints were held at 90°. Tendon and paratendinous structures were routinely imaged in the sagittal (PA) plane [15]. A water-based gel was applied to the transducer head to insure sound wave transmission. The Achilles tendon thickness (maximum anteroposterior diameter) was measured at the midpoint between the musculotendinous junction and the calcaneal insertion. To obtain the transverse section images, the ultrasound beam had to be positioned exactly orthogonal to the tendon, since obliquity of the scanned plane could cause an overestimation of the tendon thickness thereby, resulting in an artifactually hypoechoic pattern [14].

2.6 Additional Data Collection

Demographic data (age, sex, occupation, and leisure physical activity), health history, dominant side, and data as to the present disease were collected. The patient's height (m) and weight (kg) were recorded and body mass index (BMI) calculated. Patients were asked to indicate the painful knee or in the event of bilateral symptoms, the more symptomatic side.

2.7 Statistical Analyses

All statistical computations were performed using the SPSS 17.0 for Windows (SPSS, Chicago, IL, USA). Descriptive statistics were used to characterize the sample. To compare the cartilage thickness and Achilles tendon thickness in symptomatic and non-(or less)-symptomatic sides, the paired t-test was used. To evaluate the association between knee OA parameters (femoral cartilage thickness, pain, and disability (WOMAC) in a knee joint) and Achilles tendon thickness, the univariate Pearson correlations and multivariate linear regression analyses, with adjustment for age and BMI were performed. Statistical analyses were conducted at a 95% confidence level. A p-value of <0.05 was considered significant.

3. RESULTS

Table 1 presents descriptive statistics of the 56 patients (54 females and 2 males) who participated in the study. The mean age of the participants was 64.20±9.04 years, mean BMI 30.85±4.88 kg/m^2 and mean WOMAC -total was 50.39±16.58. The more symptomatic knee in 30 (53.6%) participants was the left leg (Table 1).

Table 1. Descriptive statistics (N=56)

Characteristic	Mean ± SD
Age (years)	64.20±9.04
BMI (kg/m^2)	30.85±4.88
WOMAC - total	50.39±16.58
WOMAC - pain	8.91±3.35
WOMAC - stiffness	3.54±2.04
WOMAC - function	33.07±12.14
	N (%)
Sex (females)	54 (96.4%)
Symptomatic knee (left)	30 (53.6%)

BMI body mass index, SD standard deviation

Data on cartilage thickness and Achilles tendon thickness in symptomatic and non-(or less)-symptomatic sides are presented in Table 2. A moderate significant correlation in cartilage thickness (r=.47, *P* <.001) and Achilles tendon thickness (r=.32, *P* =.018) was found between the symptomatic and non-(or less)-symptomatic side. On the other hand, the differences between sides were not statistically significant (t=-.572, p=.570 and t=-.255, *P* =.800, correspondingly) (Table 2).

Univariate Pearson correlations between cartilage thickness, Achilles tendon thickness, and WOMAC scores are presented in Table 3. The Achilles tendon thickness of the non-(or less)-symptomatic side significantly negatively correlated with the cartilage thickness of the symptomatic (r=-.29, *P* =.029) or non-(or less)-symptomatic (r=-.32, *P* =.017) side. It means that individuals with thinner cartilage had thicker Achilles tendon. Among WOMAC scores, only WOMAC-total showed a significant positive correlation with the Achilles tendon thickness of the symptomatic side (r=.39, *P* =.003) (Table 3).

After adjustment for age, BMI and cartilage thickness in the linear regression analysis, the association between WOMAC-total and Achilles tendon thickness of the symptomatic side, remained significant (β=.400, *P* =.007). Similarly, after adjustment for age and BMI in the linear regression analysis, a negative association between Achilles tendon thickness of the non-(or less)-symptomatic side and cartilage thickness of the symptomatic (β=-.284, *P* =.049) or non-(or less)-symptomatic (β=-.309, *P* =.026) side, remained significant (not presented as a table).

4. DISCUSSION

OA is the most common cause of pain in adults, and the knee is among most common sites of OA [1]. In recent years, much effort has been devoted to the exploration of the pain source of knee OA. However, correlations of knee pain with radiographic severity of knee OA or with the cartilage volume on MRI, were not as strong, as expected [16,17]. On the other hand, some studies have shown that changes in hip muscle strength during the course of knee OA is associated with knee pain [18,19]. We did not find any studies that had examined the association of knee cartilage thickness or knee pain with changes in the Achilles tendon width.

Results of our study support the hypothesis that in individuals with symptomatic knee OA, the WOMAC score is associated not only with knee disease but also with the ipsilateral Achilles tendon thickness. This finding may have significant value in the management of knee OA pain and loss of function. In addition, when treating knee OA, we have to take into consideration all the structures of the same leg.

Table 2. Data on cartilage thickness and Achilles tendon width in symptomatic and non-(or less)-symptomatic sides

Characteristics	Symptomatic side	Non-(or less)-symptomatic side	Pearson correlation (r, p-value)	Comparison (t, p-value)
Cartilage thickness	1.96±0.62	2.01±0.55	r=0.466, *P* <.001	t=-0.572, *P* =.570
Achilles width	3.16±0.61	3.19±0.55	r=0.316, *P* =.018	t=-0.255, *P* =.800

Table 3. Pearson correlations between cartilage thickness, Achilles tendon width and WOMAC scores

			Achilles width		WOMAC			
			Symptomatic side	**Non-(or less)-symptomatic side**	**Total**	**Pain**	**Function**	**Stiffness**
Cartilage thickness	Symptomatic side	r	-.127	**-.292**	0.089	0.108	-0.001	.008
		P-value	.355	**.029**	0.515	0.427	0.992	.952
	Non-(or less)-symptomatic side	r	.007	**-.319**	0.072	0.074	-0.035	.086
		P-value	.962	**.017**	0.598	0.589	0.795	.528
Achilles width	Symptomatic side	r			**0.389**	-0.060	0.027	.042
		P-value			**0.003**	0.658	0.844	.758
	Non-(or less)-symptomatic side	r			0.099	-0.253	-0.068	-.137
		P-value			0.468	0.060	0.617	.312

Statistically significant correlations marked bold

A negative association was found between Achilles tendon thickness of the non-(or less)-symptomatic side and cartilage thickness in both knees. In our study most patients had bilateral symptoms or signs of knee OA. Lack of significant association between cartilage thickness and Achilles tendon thickness of the symptomatic side is surprising. We believe that this association should be tested in additional samples.

Recently, we investigated a different, smaller (n=30) sample as to the association between the Achilles tendon and knee OA [20]. The Achilles tendon side-to-side width was measured by a skinfold caliper (a method found reliable and valid [21]), but can potentially reflect changes in the peritendon tissues. A significant difference was found in Achilles tendon width between subjects with knee OA and healthy controls (17.1±3.4 mm compared to 15.1±3.1 mm, P =.009). Significant correlations were found between Achilles tendon width and knee OA severity.

Previous studies have shown that soleus and gastrocnemius muscles contribute to knee stabilization [22,23]. Stress forces applied to the muscle to stabilize the osteoarthritic knee may cause structural changes in the Achilles tendon. In our study, the thickness of the Achilles tendon of both legs was similar, but a significant correlation was found only between the cartilage size of both knees and the Achilles tendon thickness of the less symptomatic leg. We suggest that both knees were affected by knee OA and that the patients transferred their weight from the symptomatic to the less symptomatic leg. This additional weight bearing in an osteoarthritic knee may cause additional stress on stabilizing muscles, primarily, the gastrocnemius and soleus, thus causing hypertrophic changes to the Achilles tendon. It is also possible that our findings reflect a simple coexistence of two pathological processes: knee OA and Achilles tendinopathy.

A previous study [24] showed that risk factors of Achilles tendinopathy are similar to knee OA. Nevertheless, the association between the Achilles tendon thickness and knee OA should be further investigated, with a larger sample size and a different study design. We suggest considering an assessment of the Achilles tendon as part of the knee OA evaluation.

There are limitations that should be acknowledged. First, is a cross-sectional design of the study, which not allows testing the causal relationships between the Achilles tendon thickness and knee OA features. Our study provides a background for further longitudinal research. Second, in our sample majority of patients were suffering from bilateral knee OA and pain. This can be a reason for the unexpected stronger association between cartilage thickness and contralateral Achilles thickness.

5. CONCLUSION

Results of our study support the hypothesis that in individuals with symptomatic knee OA, the WOMAC score is associated not only with knee disease but also with the ipsilateral Achilles tendon thickness. Stress on the muscles used to stabilize the osteoarthritic knee may cause structural changes in the Achilles tendon. Further studies are needed to corroborate the association between the Achilles tendon thickness and knee OA. We suggest considering an assessment of the Achilles tendon as part of the knee OA evaluation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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