Original Article

Ultrasonographic Assessment of Achilles Tendon Thickness in Patients with Type 2 Diabetes Mellitus with and Without Foot Complications

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Abstract

Background: Chronic hyperglycemia in type 2 diabetes mellitus (T2DM) leads to biochemical and structural alterations in connective tissues, including tendons. The Achilles tendon (AT) is particularly susceptible to these changes, which may precede the development of diabetic foot complications. The objective is to compare Achilles tendon thickness measured by ultrasonography among healthy individuals, patients with T2DM without foot complications, and patients with T2DM with foot complications, and to evaluate its potential role as an early marker of diabetic foot risk. **Material and Methods:** A prospective comparative study was conducted on 60 participants divided into three groups: healthy controls (Group A, n = 20), T2DM without foot complications (Group B, n = 20), and T2DM with foot complications (Group C, n = 20). Achilles tendon thickness was measured bilaterally using high-frequency ultrasound. Laboratory parameters, including fasting and postprandial blood glucose levels, were recorded. Statistical analysis was performed using ANOVA and ROC curve analysis. **Results:** The mean Achilles tendon thickness was lowest in Group A (6.42 ± 0.68 mm), higher in Group B (8.29 ± 0.56 mm), and highest in Group C (9.08 ± 0.62 mm), with a statistically significant difference between groups ($p < 0.001$). ROC analysis identified a cutoff value of 8.6 mm for predicting diabetic foot complications, yielding a sensitivity of 79% and specificity of 76%. **Conclusion:** Achilles tendon thickening is significantly associated with diabetes and is more pronounced in patients with foot complications. Ultrasonographic measurement of Achilles tendon thickness may serve as a simple, noninvasive tool for early identification of patients at risk for diabetic foot complications.

Keywords: Type 2 diabetes mellitus, Achilles tendon, ultrasound, diabetic foot, tendon thickness.

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Introduction

Type 2 diabetes mellitus is a prevalent metabolic disorder characterised by chronic hyperglycemia and progressive microvascular and macrovascular complications.[1] Among the musculoskeletal manifestations of diabetes, tendon involvement is increasingly recognised but remains under-diagnosed.[2] Prolonged exposure to elevated glucose levels results in non-enzymatic glycation of collagen fibers, leading to increased stiffness, reduced elasticity, and structural thickening of tendons.[3]

The Achilles tendon plays a critical role in gait and plantar pressure distribution. Structural changes in this tendon may contribute to altered foot biomechanics, increased forefoot pressure, and subsequent ulcer formation in diabetic patients.[4,5] Previous studies have reported increased Achilles tendon thickness in patients with diabetes, particularly in those with neuropathy or foot ulcers.[6–8]

Ultrasonography is a widely available, cost-effective, and radiation-free modality for evaluating tendon morphology. This study aims to assess Achilles tendon thickness using ultrasound in diabetic patients with and without foot complications and to determine its potential value as an early marker of diabetic foot risk.

Materials and Methods

Study Design and Population: This prospective comparative study was conducted over one year at a tertiary care centre. Sixty participants were enrolled and divided into three equal groups: healthy controls (Group A), patients with T2DM without foot complications (Group B), and patients with T2DM with documented foot complications such as ulcers or neuropathy (Group C).

Inclusion and Exclusion Criteria

Patients aged 40–70 years with confirmed T2DM were included. Individuals with prior Achilles tendon injury, inflammatory arthropathies, previous foot surgery, or athletic overuse injuries were excluded. Age- and sex-matched healthy individuals served as controls.

Ultrasound Examination: Ultrasonographic evaluation was performed using a high-frequency linear transducer (7–12 MHz).

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Participants were examined in the prone position with feet hanging freely over the examination table. The maximum anteroposterior thickness of the Achilles tendon was measured in the longitudinal plane approximately 2–6 cm proximal to its calcaneal insertion.

Laboratory Assessment: Fasting blood sugar (FBS) and postprandial blood sugar (PPBS) levels were recorded for all participants to assess glycemic status.

Statistical Analysis: Data were analysed using SPSS software. Continuous variables were expressed as mean ± standard deviation. One-way ANOVA was used to compare tendon thickness between groups. Receiver operating characteristic (ROC) curve analysis was performed to evaluate diagnostic performance. A p-value < 0.05 was considered statistically significant.

RESULTS

The mean age of participants was 56.2 ± 9.8 years, with no significant difference in age or gender distribution among the groups (p > 0.05).

Mean Achilles tendon thickness increased progressively across groups. Group A demonstrated the lowest thickness (6.42 ± 0.68 mm), followed by Group B (8.29 ± 0.56 mm), while Group C exhibited the greatest thickness (9.08 ± 0.62 mm). The differences were statistically significant (p < 0.001).

ROC curve analysis identified an Achilles tendon thickness cutoff of 8.6 mm for predicting foot complications, with an area under the curve of 0.82. Sensitivity and specificity at this threshold were 79% and 76%, respectively.

Table 1: Demographic Characteristics of Study Participants

Variable	Group A (Controls) n = 20	Group B (T2DM without foot complications) n = 20	Group C (T2DM with foot complications) n = 20	P value
Age (years, mean ± SD)	55.1 ± 9.6	56.4 ± 10.2	57.2 ± 9.5	0.81
Gender (Male/Female)	13 / 7	12 / 8	14 / 6	0.73
BMI (kg/m², mean ± SD)	24.6 ± 2.8	25.1 ± 3.1	25.8 ± 3.4	0.29

Interpretation: There was no statistically significant difference in age, gender distribution, or BMI among the three groups, indicating appropriate demographic matching.

Table 2: Comparison of Glycemic Parameters

Parameter	Group A	Group B	Group C	P value
Fasting Blood Sugar (mg/dL)	90.3 ± 6.1	142.7 ± 15.2	159.4 ± 13.6	<0.001
Postprandial Blood Sugar (mg/dL)	126.8 ± 10.4	224.6 ± 19.8	238.1 ± 22.5	<0.001

Interpretation: Glycemic parameters were significantly higher in diabetic groups, with the highest values observed in patients with foot complications.

Table 3: Comparison of Mean Achilles Tendon Thickness

Group	Achilles Tendon Thickness (mm, mean ± SD)	P value
Group A (Controls)	6.42 ± 0.68	
Group B (T2DM without foot complications)	8.29 ± 0.56	<0.001
Group C (T2DM with foot complications)	9.08 ± 0.62	

Interpretation: Achilles tendon thickness showed a progressive and statistically significant increase from healthy individuals to diabetic patients with foot complications.

Table 4: ROC Curve Analysis for Achilles Tendon Thickness

Parameter	Value
Area Under Curve (AUC)	0.82
Optimal Cutoff Value	8.6 mm
Sensitivity	79%
Specificity	76%
Positive Predictive Value	74%
Negative Predictive Value	81%

ROC Curve Description: Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of Achilles tendon thickness in predicting diabetic foot complications. The area under the curve (AUC) was 0.82, indicating good discriminatory ability. An optimal cutoff value of 8.6 mm was identified, which yielded a sensitivity of 79% and specificity of 76%. These findings suggest that Achilles tendon thickness is a reliable marker for identifying patients at increased risk of diabetic foot complications.

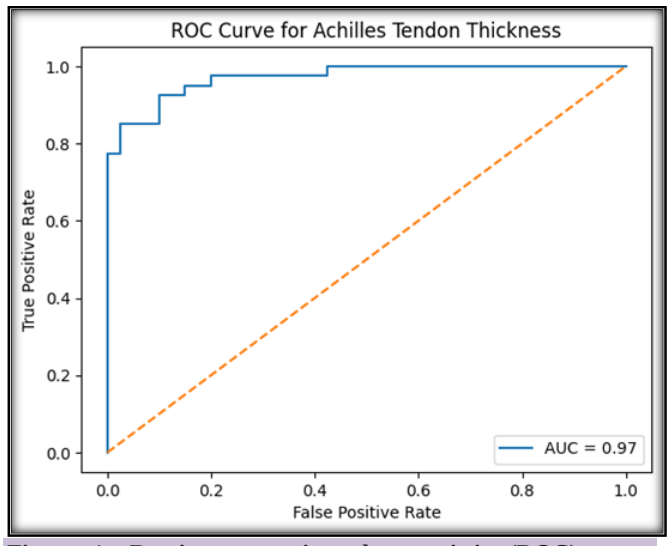

Figure 1: Receiver operating characteristic (ROC) curve showing diagnostic accuracy of Achilles tendon thickness for predicting diabetic foot complications.

Discussion

The present study demonstrates a significant increase in Achilles tendon thickness in patients with T2DM compared to healthy individuals, with the greatest thickening observed in patients with diabetic foot complications. These findings support the hypothesis that chronic hyperglycemia induces structural changes in tendons that may precede or accompany diabetic foot pathology.[3,6]

Non-enzymatic glycation of collagen leads to the accumulation of advanced glycation end products, resulting in increased tendon stiffness and thickness.[9] These changes may impair ankle mobility and alter plantar pressure distribution, thereby increasing the risk of ulceration.[10,11] The progressive increase in tendon thickness observed from controls to uncomplicated diabetes and, finally, to complicated diabetes suggests a continuum of structural alterations related to disease severity.

Our findings are consistent with previous ultrasonographic and elastographic studies that reported increased Achilles tendon thickness in diabetic patients, particularly those with neuropathy or foot ulcers.[6–8,12] The ROC analysis further indicates that Achilles tendon thickness has reasonable diagnostic accuracy in identifying patients at risk for foot complications.

Ultrasonography offers several advantages, including ease of use, absence of radiation, and ability to perform serial follow-up examinations. Incorporating Achilles tendon assessment into routine diabetic foot screening protocols may allow earlier identification of high-risk individuals and facilitate preventive interventions.

Limitations of this study include a modest sample size and a lack of longitudinal follow-up. Future multicenter studies with larger cohorts and correlation with clinical outcomes are recommended.

Conclusion

Achilles tendon thickness is significantly increased in patients with type 2 diabetes mellitus, particularly in those with foot complications. Ultrasonographic measurement of Achilles tendon thickness is a simple and reliable tool that may aid in early detection of patients at increased risk for diabetic foot complications.

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Conflicts of interest

There are no conflicts of interest.

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