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Sonoelastographic and High Resolution Gray Scale Evaluation in Clinically Diagnosed Achilles Tendinopathy of Type 2 Diabetic Patients

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Achilles Tendinopathy, Type 2 Diabetes Mellitus, Sonoelastography.

ABSTRACT:

Background: Type 2 diabetes mellitus (T2-DM) often leads to various musculoskeletal changes, including alterations in the structural and mechanical properties of tendons such as the Achilles tendon (AT). This study aims to assess sonoelastographic and high-resolution gray scale sonographic changes in the AT of patients with T2-DM diagnosed with Achilles tendinopathy.

Methods: This cross-sectional study included 110 patients with T2-DM from Shri Sathya Sai Medical College & Research Institute, all of whom provided informed consent. Each subject underwent sonoelastography and high-resolution gray scale ultrasonography using a Mindray DC-80 with a high-frequency linear probe. Parameters measured included AT thickness, echotexture, and shear wave velocity (SWV), comparing those with and without neuropathy.

Results: The study cohort was divided into two groups based on the presence of diabetic neuropathy: Subgroup I (with neuropathy, n=56) and Subgroup II (without neuropathy, n=54). No significant difference in AT thickness was found between the groups ($p \sim 0.99$). However, SWV was significantly lower in Subgroup I than in Subgroup II ($p < 0.001$), indicating reduced tendon stiffness in patients with neuropathy.

Conclusion: Sonoelastography combined with high-resolution gray scale ultrasonography is a valuable tool for assessing changes in the Achilles tendon in patients with T2-DM. This study highlights the importance of monitoring AT properties in diabetic patients to prevent complications such as tendinopathy and ulcers.

INTRODUCTION

The metabolic abnormalities and long-term consequences that are characteristic of diabetes mellitus (DM) are the hallmarks of the endocrine illness known as diabetes. Due to the high prevalence of microangiopathic and macroangiopathic sequelae, type 2 diabetes is a significant contributor to disability. Diabetic foot is a particularly severe condition that causes a significant strain on both society and the economy. [1]

A person's Achilles tendon (AT) is the biggest, thickest, and strongest tendon on their body. As an integral part of foot biomechanics, it works in tandem with the plantar fascia (PF).[2] During propulsion, the AT and PF stabilize the longitudinal arch, preventing its collapse during landing and absorbing mechanical shock. [2] Tendon mechanical characteristics may change with metabolic disorder. Due to chronic hyperglycemia, proteins are non-enzymatically glycated in cartilage, muscles, tendons, and ligaments. [3] This increases stress owing to gait and loading variations. Stress on plantar soft tissue may cause ulcers.[4] Patients with diabetes have thicker AT, according to numerous research studies.[2,4]

A tissue's elasticity determines how well it can withstand changes in form or size caused by an external force. Alterations to the echo pattern and tendon thickness may serve as indirect markers of anomalies with regards to their elastic characteristics. However, sonoelastography uses ultrasound to measure tissue elasticity, including tendons, in response to mechanical stress.[5,6]

There are primarily two types of elastographic techniques: strain imaging and shear wave imaging. Strain imaging measures tissue displacement perpendicular to compression.

An acoustic radiation force pulse is used in the newly developed elastographic technology known as shear wave elastography imaging (SWEI). A "pushing pulse" of brief but intense duration moves perpendicular to the compressive force, displacing tissue and creating shear waves. We then measure the velocity inside the ROI by following these waves using tracking pulses. One measure of a tissue's elasticity is its shear wave velocity (SWV). This study examines the incidence and kind of sonographic anomalies in T2-DM patients' Achilles tendon (AT), including thickness, hypoechogenicity, fibrillar pattern loss, and

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AT flexibility. This method does not need any external compression.[7]

This study aims to assess the range of sonographic changes in the Achilles tendon (AT) of patients with type 2 diabetes mellitus (T2-DM), including thickening, hypoechogenicity, loss of fibrillar pattern, and changes in AT elasticity.

PATIENTS AND METHODS

The Cross-Sectional Study was done after approval by Institutional ethical committee (No: 2022/739) and procuring informed consent from each patient for a total of 110 Type 2 diabetes mellitus patients of Shri Sathya Sai Medical College & Research Institute who were referred to the Department of Radiodiagnosis. Patients (≥30 years) with type 2 diabetes mellitus and diagnosed with nontraumatic Achilles tendinopathy were included in study. Both Achilles tendons were evaluated by mindray DC-80 machine with a high-frequency linear probe (7-10Mz). After explaining the procedure to the patient, the patient was made to lie in a prone position with the patient lying and feet hanging free in a neutral position over the end of the examination table. A coupling gel was applied to the Achilles tendon (AT) area to ensure proper contact between the patient's skin and the ultrasound transducer. The AT was scanned in both longitudinal and transverse planes (B-mode) from the myotendinous junction to its insertion in the calcaneus.

The Achilles tendons were evaluated at 2-6 cm above insertion at the calcaneus and the antero-posterior diameter was measured in transverse scans. Their thicknesses were measured three times consecutively to reduce intra-observer variability, and the average value for each side was recorded in millimeters. Tendon echotexture alterations such as inhomogeneity, and diffuse or focal loss of the normal fibrillar pattern were noted in patients with Diabetes mellitus. The presence or absence of the loss of fibrillary pattern and hypoechoic foci was documented.

SWEI of the AT's of both sides was done on mindray DC- 80 ultrasound system using a 7-10 MHz linear array transducer. The tendons were examined in the sagittal plane by placing the probe longitudinally. After activating the virtual touch quantification (VTQ) mode, the ROI, which is a rectangle with fixed dimensions of 0.5 cm × 0.6 cm, was placed at a point approximately 2-6 cm proximal to the calcaneal insertion of the AT. These shear waves were tracked by tracking pulses, and the SWV was measured and expressed in meters/second. The clinical details of the patients were documented pertinent history such as numbness, tingling, and loss of sensation in the foot indicative of peripheral neuropathy (PN), comorbidities, and complications associated with diabetes mellitus (DM).

RESULTS

Out of 110 cases with type 2 diabetic patients, we divided the subjects into 2 groups - subgroup I 56 (51%)and subgroup II 54 (49%). On evaluating gender, distribution -29(51.7%) of subjects from subgroup I and 28(51.8%) from subgroup II were male, and 28(48.2%) from subgroup I and 26(48.1 %) from subgroup II were female. There was no significant difference was seen between subgroup I and subgroup II in terms of age, gender, and duration of Diabetes Mellitus, which are not statistically significant. The mean FBS and HbA1C were significantly higher in Subgroup I when compared to subgroup II and was statistically significant ($p < 0.05$). In our study Shear wave velocity of AT was significantly lower in patients of subgroup I (with neuropathy), compared with patients of subgroup II (without neuropathy) and was statistically significant ($p < 0.001$). In our study Achilles tendon thicknesses (ATT) was similar between subgroup I and subgroup II and was not statistically significant (p ~0.99).

IMAGES

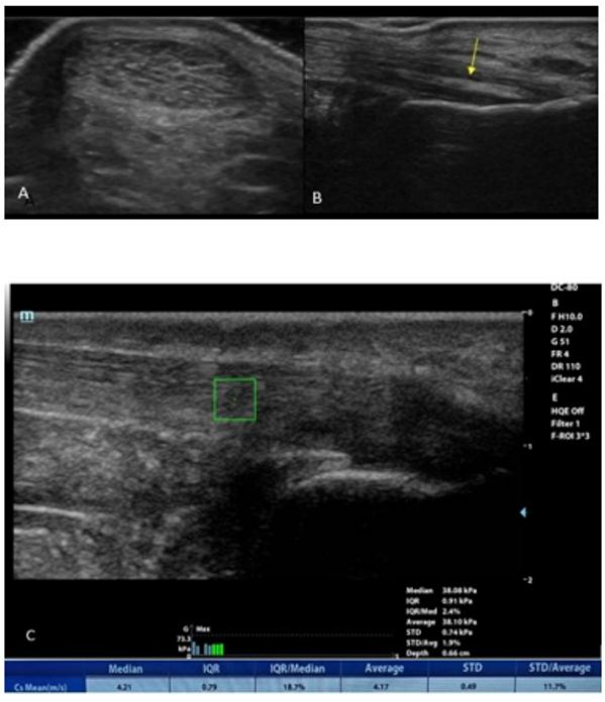

Figure 1: (A) Short axis USG . (B) Long axis USG sections of thickened Achilles tendon showing architectural distortion and hypoechoic changes (yellow arrow), in a diabetic patient with peripheral neuropathy. (C) ARFI imaging of the Achilles tendon, ROI was located approximately 2–6 cm above the insertion on the calcaneus showing mean shear wave modulus of 38.0kPa and mean shear wave velocity of 4.21 m/s suggesting a lower value.

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Table 1: Effect of Type 2 DM on Mean Shear Wave Velocity (SWV) and Achilles Tendon Thickness

Parameter	Subgroup I	Subgroup II	P Value
Rt. SWV (m/s)	4.01 (1.2)	5.4 (1.0)	<0.001*
Lt. SWV (m/s)	4.12 (1.1)	5.5 (1.1)	<0.001*
Right ATT (mm)	5.3 (0.6)	5.1 (0.5)	~0.99
Left ATT (mm)	5.2 (0.2)	5.0 (0.1)	~0.99

The table above shows the effect of type 2 DM on Achilles Tendon Shear Wave Velocity (SWV) and Achilles Tendon Thickness (ATT). The shear wave velocity was significantly lower in patients of Subgroup I (with neuropathy) compared to Subgroup II (without neuropathy) with a statistically significant difference ($p < 0.001$). However, the mean Achilles tendon thickness was similar between the two subgroups and was not statistically significant ($p \sim 0.99$).

* - Significant

DISCUSSION

Achilles tendon (AT) is softer for the patients who are suffering from diabetic neuropathy. In our study, also primary findings were Achilles tendon (AT) stiffness and thickness alterations, notably in diabetic neuropathy patients. The correlation between diabetes mellitus and Achilles tendinopathy was well supported by research.

In our study, we used ultrasonography to assess Achilles tendon thickness. It was noted that AT volume increases with neuropathy severity, which could also impact stiffness. We evaluated the thickness of the Achilles tendon (ATT) and noted a considerable increase in Achilles tendon thickness (ATT) in patients with type 2 diabetes mellitus (T2-DM) 2-6 cm proximal to the insertion site. The mean thicknesses were 5.2 (0.4) mm for those with peripheral neuropathy (PN) and 5.0 (0.3) mm for those without. Peripheral neuropathy (PN) patients had a somewhat thicker middle third tendon, but were not statically significant ($p \sim 0.99$). Comparing subgroups I and II, furthermore, there was no statistically significant difference observed between the average ATT of the left and right sides in both subgroups ($p > 0.05$). Consequently, the tendons from both sides were combined for further analysis. A study by Grant WP *et al.* in 1997 suggested that structural changes might result from long-term non-enzymatic glycation.[8] Giacomozzi *et al.* reported greater Achilles tendon thickness in patients with diabetes mellitus compared to individuals without the condition although the distinction was not noteworthy.[4] According to Reddy GK. *et al.*, this thickening is caused in part by nonenzymatic glycation of the collagenous component, which occurs as a result of high blood sugar.[9] Evarnos *et al.* (2015) discovered that peripheral neuropathy patients had a greater thickness increase. [10]

Our study observed a notable positive correlation between Achilles tendon thickness (ATT) and HbA1c and fasting blood sugar (FBS) levels among all participants. The mean FBS and HbA1c showed significant elevation in Subgroup I compared to Subgroup II, with a statistically significant difference ($p < 0.05$). Achilles tendon thickening may be caused by increased non-enzymatic glycation of the collagenous component, which may be attributed to poor glycemic management, according to Reddy *et al.* [9] Ursini *et al.* (2017) linked plasma glucose to tendinopathy. [11]

In our study, we employed shear wave elastography imaging (SWEI) technology to evaluate the elastic properties of the AT. Our results indicated notably reduced shear wave velocity (SWV) values in diabetic patients with peripheral neuropathy compared to diabetic patients without peripheral neuropathy, measuring 4.0 (1.1) m/s and 5.4 (1.0) m/s for both sides respectively ($p < 0.001$). A study done by R. Dixit *et al.* in 2020 also found significantly lower SWV values in patients compared to healthy volunteers, with measurements of 4.5 (1.71)m/s and 5.5 (1.7) m/s, respectively ($p < 0.001$).[12] Alterations in the Achilles tendon could affect its biomechanical properties, contributing to diabetes mellitus foot issues. Achilles tendons (ATs) are softer and less elastic than non-diabetics.[13] Evranos *et al.* demonstrated a reduction in AT stiffness and elasticity in diabetic foot patients using sonoelastography. [10] Our research found no statistically significant difference between subgroups I and II with respect to gender, age or duration of diabetes mellitus. Similarly study done by by Ugboma *et al.* in 2021 also found no
correlation between Achilles Tendon Thickness and Duration of Disease (DM) among Cases. However, a 2020 research by R. Dixit *et al.* linked tendon hypoechogenicity, fibrillary pattern loss with age, and diabetes.
duration.[12]

Our main findings were changes in Achilles tendon (AT) stiffness and thickness, especially in patients with diabetic neuropathy. These modifications may cause diabetic ulcers. Clinicians may avoid diabetic ulcers in people without symptoms by detecting AT changes early. Elastography and sonography are valuable tools for assessing Achilles Tendons and can be easily used in outpatient settings to evaluate patients with diabetes.

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Some of the flaws in our study were the cross-sectional design and the limited sample size. Additionally, no histological research was conducted to compare ultrasonography results with histopathological changes. Future studies examining the relationship between elastography and Achilles tendon biopsies could further validate the use of elastosonography in monitoring diabetic patients.

CONCLUSION(S)

High-resolution sonography is a simple, safe, quick, accurate, and cost-effective method for assessing the Achilles Tendon (AT) in diabetic patients. High-frequency ultrasound and sonoelastography can study AT thickness and Shear Wave Velocity (SWV) for early detection and evaluation, facilitating timely lifestyle changes to reduce morbidity. Research shows Achilles tendinopathy softens the tendon. Our study found thicker Achilles tendons in those with diabetic peripheral neuropathy, suggesting it worsens tendon thickening. Measuring AT thickness is effective for assessing peripheral neuropathy risk in diabetic patients. No significant corelation was found between AT thickness and diabetes duration. Larger prospective studies are needed to clarify the link between sonoelastographic changes in the AT and diabetic foot ulcers.

CONFLICT OF INTEREST: None.

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