Ultrasonographic features of tibialis posterior tendon in rheumatoid arthritis patients with pes planovalgus

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Aim
The aim of this study was to assess the relationship between ultrasonographic features of tibialis posterior (TP) tendon in rheumatoid arthritis (RA) patients and associated pes planovalgus (PPV) foot deformity.

Patients and methods
This study included 20 (40 feet) RA patients with PPV and ultrasound-proven TP tenosynovitis. The following variables were recorded for patients: the number of tender and swollen foot joints count, foot posture index (FPI), Health Assessment Questionnaire, and Disease Activity Score 28 (DAS28). FPI is a clinical tool used to quantify the degree to which a foot is pronated, neutral, or supinated using the set criteria. Patients underwent high-resolution ultrasound of the TP tendon. Measurement of tendon diameter was recorded in the retromalleolar region. The presence of fluid around the TP tendon and levels of power Doppler signal (PDS) were assessed.

Results
High disease activity was detected in patients (mean DAS28 of 5.89). Eighteen (45%) feet had thickened transverse diameter and 15 (37.5%) feet had thickened longitudinal diameter. Twenty-three feet showed PDS. Nineteen feet had fluid around the tendon, detected only in the retromalleolar region. Regarding FPI, 14 feet were mild to moderate pronated feet and 26 feet were highly pronated feet. There were direct correlation between FPI and both DAS28 ($p=0.05$) and transverse diameter thickness ($p=0.01$). Highly pronated feet had higher DAS28 ($p=0.03$), increased transverse diameter thickness ($p=0.04$), more detection of fluid around the TP tendon ($p=0.005$) as well as higher incidence of PDS around the TP tendon ($p=0.002$).

Conclusion
Higher degree of pronation in RA feet with PPV is associated with ultrasonographic increased tendon thickness, PDS, and fluid around TP tendon. Early diagnosis and intervention for TP tenosynovitis may prevent progressive PPV foot deformity.

Keywords:
foot posture index, pes planovalgus, rheumatoid arthritis, tenosynovitis, tibialis posterior

Introduction

Rheumatoid arthritis (RA) is the most common inflammatory arthritis, affecting ∼1% of the world's population [1]. Approximately 90% of patients with RA will report foot-related symptoms at some time during the disease course [2]. Tenosynovitis is one of the key features of the clinical pattern in these patients [3]. The most common ankle tendons affected by tenosynovitis is the tibialis anterior followed by the tibialis posterior (TP) [4]. Tibial posterior tendon stabilizes the hindfoot against valgus and eversion forces. It is a powerful subtalar joint supinator and acts as a support of the medial longitudinal arch (MLA). Dysfunction of the TP tendon following degeneration and rupture results in progressive destabilization of the hindfoot and the midfoot [5]. However, lesser degrees of TP tendon dysfunction is

considered as a factor contributing to heel valgus and flatfoot deformities in RA patients. This condition results in significant foot pain and walking disability [6]. Flat feet are also associated with knee pain and cartilage damage [7]. Furthermore, tenosynovitis and associated flat feet could result in the occurrence of tarsal tunnel syndrome [8].

Both mechanical and inflammatory factors are believed to be involved in the development of pes planovalgus (PPV) foot deformity and TP tenosynovitis in RA patients [9]. However, there is still a controversy

around whether the planovalgus deformity is due to TP tenosynovitis and /or subtalar and midfoot arthritis and synovitis [10].

Musculoskeletal ultrasound (US) is important for the diagnosis and monitoring treatment efficiency in patients with inflammatory rheumatic diseases [11]. It is a reproducible tool for evaluating and monitoring tenosynovitis in RA. US can assess tendon features, detect synovitis and power Doppler signal (PDS) can detect the presence of hyperemia suggestive of active inflammation [12,13]. It can also identify residual subclinical inflammation in clinically silent patients [14]. Accordingly, this work aimed at assessing the US features of TP tenosynovitis, in RA patients having PPV foot deformity, and studying their relationship to pes planus foot posture.

Aim
The aim of this study was to study US features of TP tendon in RA patients having PPV foot deformity using high-resolution US and assess the relationship of these US features to pes planus foot posture.

Patients and methods
The study included 20 RA patients (diagnosed based on the 2010 American College of Rheumatology criteria [15]) with PPV foot deformity and US features of TP tenosynovitis. Inclusion criteria for patients included: passively correctable PPV deformity (valgus rearfoot alignment, MLA collapse, and medial bulging of the talonavicular joint) [16,17], in conjunction with abduction of the forefoot in relaxed standing [18] and US-confirmed tenosynovitis 'defined as hypoechoic or anechoic thickened tissue with or without fluid within the tendon sheath which may or may not exhibit Doppler signal' [19]. The nature of this study was explained to all studied patients. Informed consents were obtained from all patients. Research protocol was approved by the local ethics committee.

Demographic data and clinical assessment
The studied patients' age, sex, and disease duration were also assessed. The following clinical variables were recorded: tender and swollen foot joint count and global disability using the Health Assessment Questionnaire (HAQ) [20]. Disease activity was recorded using the Disease Activity Score in 28 joints (DAS28) [21], including erythrocyte sedimentation rate within 2 weeks of assessment. Visual analog scale (100 mm) was used to record foot pain, general health, and arthritis pain. Foot posture was recorded using the foot posture index (FPI) [22,23].

The FPI [22–24] is a diagnostic clinical tool for quantifying the degree to which a foot can be considered to be in a pronated, supinated, or neutral position. The FPI is a six-item foot posture assessment with the patient standing relaxed in a bipedal position. The six items of the FPI include talar head palpation, supra and infra lateral malleolar curvature, calcaneal frontal plane angle, prominence in the region of the talonavicular joint, congruence of the MLA, and abduction/adduction of the forefoot on the rearfoot alignment. Each item is scored on a five-point scale of between –2 and +2 and provides a total sum of all items between –12 (highly supinated) and +12 (highly pronated). Accordingly, positive score values [24] indicate a pronated posture (+6 to +9 is pronated, ≥+10 is highly pronated), negative score values indicate a supinated overall foot posture, while for a neutral foot the final FPI score should lie somewhere around 0 (0 to +5) [24].

Ultrasound assessment of tenosynovitis
For the assessment of tenosynovitis, high-resolution US was performed by a single experienced sonographer (experienced radiologist) in a governmental institution using Toshiba Xario 200 Ultrasound machine with dedicated US linear musculoskeletal US probe 14–18 MHz (Toshiba, Tokyo, Japan). The TP tendon was viewed bilaterally and images were recorded along the length of the tendon at three locations: medial malleolus, navicular insertion, and midway between the two points. Measurement of tendon diameter was recorded in the retromalleolar region and compared with normative data published in the literature [25,26]. Presence of fluid around TP tendon, which is suggestive of active inflammation, was also recorded. In addition, PDS [27] was recorded and graded using a four-point semiquantitative scale (absent/minor/moderate/major) [28].

Statistical analysis
Statistical analyses were performed using IBM SPSS software package, version 20.0 (IBM Corp., Armonk, NY) [29]. Qualitative data were described using number and percent. Quantitative data were described using mean, SD, and range.

The distributions of quantitative variables were tested for normality using Kolmogorov–Smirnov test.

The raw data were compared between patients and control groups using Student's t-test for normally distributed variables and Mann–Whitney test for abnormally distributed variables. The

statistical significance level was set at p value less than 0.05.

Comparison between different groups regarding categorical variables was tested using the χ^2-test. When more than 20% of the cells have an expected count of less than 5, correction for χ^2 was conducted using Monte Carlo correction and Fisher's exact test. Correlation between two quantitative variables were assessed using Spearman's coefficient.

Results

Clinical characteristics

The study included 20 female patients, with a mean age of 47.67±12.45 years and a median of 53. The duration of the disease ranged between 2 and 25 years with a mean duration of 10.93±7.66 years.

All the studied patients (100%) received medications with one (5%) patient receiving corticosteroids only, one (5%) patient receiving disease-modifying antirheumatic drugs only, and 18 (90%) patients receiving a combination of these medications (corticosteroids and disease-modifying antirheumatic drugs). No of the studied patients was on biologic therapy. Regarding foot joint examination, the number of tender foot joints ranged between four and 12 joints with a mean of 6.20±2.93 joints. The number of swollen foot joints ranged between two and six joints with a mean of 4.0±1.41 joints.

Table 1 demonstrates demographic data and the studied clinical variables. High disease activity state was present in the studied RA cohort with a mean DAS28 score of 5.89±1.03. Three (15.0%) patients had moderate disease activity and 17 (85.0%) patients had high disease activity. Regarding the HAQ, it ranged between 0.50 and 2.75 with a mean HAQ of 1.89 ±0.63. Overall, 60% of the patients had moderate functional disability and 35% of patients had severe functional disability. FPI of the studied patients had a mean of 9.93±2.53; 14 (35%) feet were pronated, and 26 (65%) feet were highly pronated.

Ultrasonographic features of tibialis posterior tendon

Measurement of TP tendon diameter was recorded in the transverse and longitudinal views at the medial malleolus level, and the longitudinal : transverse ratio was calculated. All data were normally distributed and values are summarized in Table 2. This study results were compared with normal values from the literature [25,26]. Eighteen (45%) feet had thickened transverse diameter. Fifteen (37.5%) feet had thickened longitudinal diameter of the tendon. Thirty-five (87.5%) feet showed increased longitudinal : transverse ratio. Figure 1 shows the thickened longitudinal diameter of the TP tendon in one of the studied patients. Figure 1 show thickened hypoechoic TP tendons (5.8 mm thickness) with anechoic rim (edema along the tendon sheath).

Table 1 Demographic and clinical data of the studied patients

| Variables	RA patients (*n*=40)[mean±SD (range)]
Age (years)	47.67±12.45 (27–65)
Disease duration (years)	11.7±7.42 (2–25)
BMI	32.04±5.69 (17.56–40.48)
DAS28 score	5.89±1.03 (3.9–7.73)
HAQ score	1.89±0.63 (0.5–2.75)
Foot pain VAS (0–100 mm)	6.53±1.19
General health VAS (0–100 mm)	6.60±1.12
Arthritis VAS (0–100 mm)	6.60±1.12
Swollen foot joint count (range 0–14)	4.0±1.41
Tender foot joint count (range 0–14)	6.20±2.93
ESR	51.8± 33.89
FPI (range −12–12)	9.77±2.53

DAS28, disease; activity score in 28 joints; ESR, erythrocyte sedimentation rate; FPI, foot posture index; HAQ, Health Assessment Questionnaire; n, number of feet; RA, rheumatoid arthritis; VAS, visual analog scale.

Table 2 Ultrasonographic measurements of tibialis posterior tendon diameter in the studied rheumatoid arthritis patients

| Tendon diameter	Patients feet (*n*=40)	Published normal values
Transverse diameter (mm)		
Minimum–maximum	1.8–5.80	3.1–14.1
Mean±SD	3.53±1.33	8.4±4.2
Longitudinal diameter (mm)		
Minimum–maximum	2.1–5.6	1.3–6.0
Mean±SD	3.31±0.88	2.8±1.8
Longitudinal : transverse ratio		
Minimum–maximum	0.5–2.33	0.20–0.46
Mean±SD	1.07±0.47	0.30±0.14

n, number of feet; mm, millimeter

Figure 1
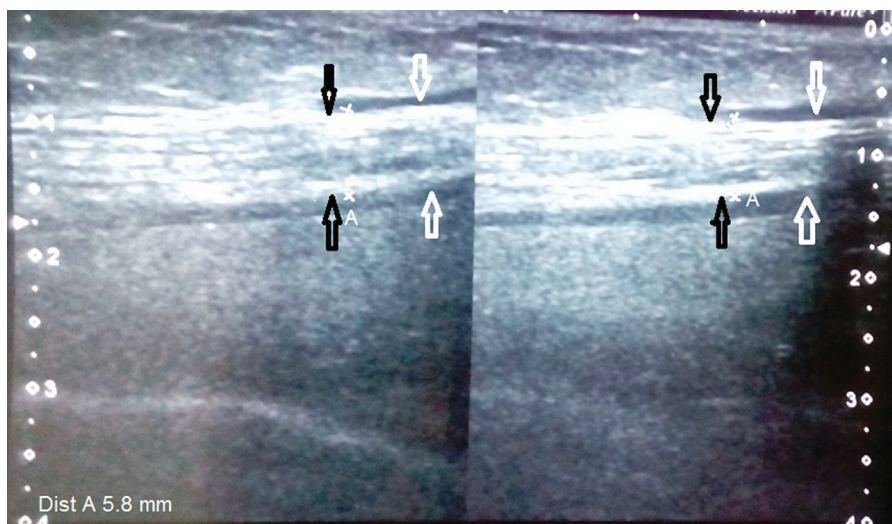
Thickened longitudinal diameter of tibialis posterior tendon in one of the studied patients. It shows thickened hypoechoic tibialis posterior tendon (longitudinal diameter thickness, 5.8 mm) with anechoic rim (edema along the tendon sheath). Black arrows point to the tendon and white arrows point to the edema along the sheath.

Figure 2
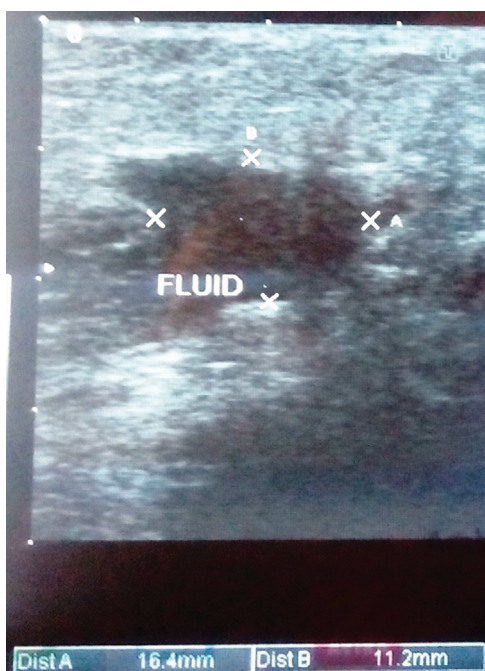
Transverse ultrasound view of anechoic fluid accumulation (16.4×11.2 mm dimensions) around tibialis posterior tendon in one of the studied patients.

Regarding the presence of fluid around TP tendon in both views, 19 (47.5%) feet had fluid in the transverse view. Eighteen (45%) feet had fluid longitudinally around the tendon. Fluid was detected only in the retromalleolar region. Figure 2 demonstrates transverse US view of anechoic fluid accumulation around TP tendon in one of the studied patients.

Table 3 Distribution of the studied patients regarding power Doppler signal

PDS	TP tendon (n=40) [n (%)]
PDS retromalleolar	
Absent	15 (37.5)
Mild	9 (22.5)
Moderate	16 (40)
PDS midway	
Absent	18 (45)
Mild	9 (22.5)
Moderate	13 (32.5)
PDS navicular insertion	
Absent	18 (45)
Mild	4 (10)
Moderate	18 (45)

PDS, power Doppler signal; n, number of feet; TP, tibialis posterior.

Regarding PDS, eight feet had absent PDS, 10 had mild PDS, and 22 had moderate PDS. The levels of PDS were also recorded at three sites, the greatest level of pathology was recorded at the navicular insertion region, where 18 feet out of 40 scored as moderate, four out of 40 as mild, and 18 out of 40 as absent (Table 3).

Table 4 demonstrates the correlation between FPI and the studied clinical parameters as well as US features of TP tendon. FPI was not significantly correlated with disease duration, BMI, or HAQ. In contrast, there was weak positive correlation between FPI and disease activity (DAS28) (r=0.3, p=0.05) as well as moderate positive correlation between FPI and transverse diameter thickness of the TP tendon (r=0.04, p=0.01).

FPI of the studied patients was divided into two groups: pronated and highly pronated groups. The two groups were compared with each other regarding the different clinical and sonographic parameters (Table 5). There was a trend toward longer disease duration (>10 years) in the highly pronated group despite absence of statistical significance. The highly pronated group had significantly higher disease activity (DAS28) ($p=0.03$). Regarding sonographic features of TP tendon, the highly pronated group had significantly higher transverse diameter thickness and lower longitudinal/transverse diameter ratio. There was a statistically significant relationship between the degree of foot pronation and fluid around TP tendon ($p=0.005$) as well as PDS around the tendon ($p=0.002$). The majority of the highly pronated group

had fluid around the TP tendon (18 out of 26 feet) and moderate PDS around TP tendon (20 out of 26 feet) (Table 5).

Discussion

Up to 80% of RA patients report foot problems during the course of the disease [30]. Pes planovalgus associated with involvement of the TP tendon is common [1]. Treatment requires early diagnosis and intervention to prevent further deformity and disability. Accordingly, if clinical suspicion exists, imaging studies are most useful to determine pathology and help in management [25]. This work assessed TP tendon pathology using high-resolution US and PDS was graded. Relationship of TP tendon pathology to foot posture was studied.

The studied patients had high DAS28 (5.89±1.03) and high visual analog scale for pain indicating high disease activity with increased pain impairing functional activities.

TP tendon often has superficial and deep fibers. It divides into two sets of fibers proximal to the navicular tuberosity. The deep fibers insert directly into the navicular. The superficial fibers cross the navicular and insert into the cuneiforms, cuboid, and metatarsal bones [31–34]. This study showed evidence of abnormal TP tendon thickening in US and increased levels of fluid in the retromalleolar region indicating TP tendon inflammation. The vulnerability of the retromalleolar area to tenosynovitis is related to the presence of fibrocartilage component in this region

Table 4 Correlation between foot posture index and the studied parameters (clinical parameters and sonographic features of tibialis posterior tendon)

Variables	FPI *r*	FPI *p*
Disease duration	0.02	0.96
BMI	0.13	0.41
ESR	−0.28	0.23
DAS28	0.3	0.05*
HAQ	0.06	0.8
US of TP tendon (transverse diameter thickness)	0.4	0.01*
US of TP tendon (longitudinal diameter thickness)	−0.12	0.48
US of TP tendon (longitudinal/transverse ratio)	−0.35	0.03*

DAS28, disease activity score in 28 joints; ESR, erythrocyte sedimentation rate; FPI, foot posture index; HAQ, Health Assessment Questionnaire; *r*, Spearman's coefficient; TP, tibialis posterior. *$p \leq 0.05$, statistically significant.

Table 5 Comparison between pronated and highly pronated feet regarding the studied parameters (clinical and sonographic features of tibialis posterior tendon)

Variables	FPI Pronated feet (6–9) (*n*=14)	FPI Highly pronated feet (10–12) (*n*=26)	*p*
Duration	11.38±7.82	11.92±7.49	0.79
BMI	30.67±6.84	32.77±4.95	0.51
HAQ	1.8±0.72	1.95±0.59	0.91
ESR	67.63±46.02	41.25±18.24	0.22
DAS28	6.27±1.54	5.68±0.56	0.03*
US of TP tendon (longitudinal diameter thickness)	3.47±0.87	3.22±0.9	0.34
US of TP tendon (transverse diameter thickness)	2.94±1.18	3.85±1.27	0.04*
US of TP tendon (longitudinal/transverse ratio)	1.35±0.55	0.92±0.34	0.03*
US-detected fluid around TP tendon			
Present (*n*=18)	–	18	0.005*
Absent (*n*=22)	14	8	
PDS			
Absent (*n*=8)	2	6	$^{MC}p=0.002*$
Mild (*n*=10)	10	–	
Moderate (*n*=22)	2	20	

ESR, erythrocyte sedimentation rate; FPI, foot posture index; HAQ, Health Assessment Questionnaire; MC, Monte Carlo test; n, number of feet; PDS, power Doppler signal; TP, tibialis posterior; US, ultrasound. *$p \leq 0.05$, statistically significant.

same as in the tendon insertion. In addition, TP tendon changes direction at this region and is consequently subjected to compressive stress leading to inflammation [35,36]. Regarding PDS around TP tendon, it was found that the majority of patients had PDS and the greatest level of PDS was recorded in navicular insertion region. The navicular insertion of TP is a known site for stress dissipation [33]. A significant portion of the polytrimethylene terephthalate fibers continue to the distal sites of insertion, contacting the fibrocartilage covering the navicular, making the navicular region an area for potential involvement by inflammation in RA patients [33,34]. Accordingly, mild-to-moderate PDS in the navicular insertion region indicates active inflammation.

In agreement with these results, Barn *et al.* [10] studied 10 patients with moderately active RA and found abnormal thickening and increased levels of fluid in the navicular region. In addition, they reported that seven patients had PDS at the polytrimethylene terephthalate enthesis, indicating active inflammation [8]. In addition, Ward *et al.* [2] studied 21 patients with RA and reported higher rates of thickened TP tendon approaching the enthesis as well as TP tenosynovial effusion at the enthesis, indicating active inflammation. PDS was detected in more than 15% of RA patients compared with the control participants. They concluded that the TP tendon enthesis was frequently affected in RA patients than in healthy controls or psoriatic arthritis patients [2]. Harman and Tekeoglu [11] studied 142 inflammatory rheumatic disease patients including 69 RA patients and assessed ankles ultrasonographically. They stated that TP tenosynovitis was significantly more common in the RA group than in the other groups.

In this study, FPI was not significantly related to disease duration; however, the highly pronated feet group had longer disease duration than the pronated group. A larger number of patients are needed to properly assess the relation of disease duration to PPV foot deformity in arthritis patients. Bouysset *et al.* [37] stated that the PPV deformity increases with increasing disease duration, where patients with long-standing disease duration had highly pronated feet. This could be explained by the fact that RA is a progressive disease; therefore, it is expected that the number and the severity of deformities increase with the duration of the disease especially with poor control and increasing flares. In this study, there was a statistically significant relationship between the FPI

and the DAS28. The role of inflammatory mediators cannot be ignored due to the high disease activity in the studied patients. The degree of pronation increases with increasing disease activity. This runs in agreement with several studies [38,39] that reported PPV as a commonly seen deformity in the active stage of RA. In the active stage of RA, there is weakening of the muscles, increased edema, and softening of the ligaments; thus full weight-bearing in this stage may be followed by various deformities, depending on the direction of the influencing forces [40]. The absence of statistically significant relationship between HAQ and the FPI was most probably because FPI indicated the patient current degree of pronation that had already progressed at different points of time and with flares during the course of the disease regardless of the current functional disability status of the patients. There was a statistically significant positive correlation between US transverse diameter thickness of TP tenosynovitis and the FPI. The more the transverse diameter thickness of the TP tendon, the higher the degree of pronation. In addition, detection of PDS and fluid around the TP tendon was more in the highly pronated feet. This suggests that TP tenosynovitis might be a factor contributing to the development of PPV foot deformity. Several authors recognized this condition as a disabling cause of progressive flatfoot deformity [41,42]. Posterior tibialis tendon dysfunction is a primary soft tissue tendinopathy of the posterior tibialis that leads to altered foot biomechanics [43]. Complete tendon rupture is not essential for the development of flatfoot due to the short excursion of the tendon, accordingly less degree of tendon damage may render it ineffective leading to the condition known as TP dysfunction. As the tendon becomes dysfunctional due to inflammatory or mechanical causes, the MLA of the foot collapses causing a relative internal rotation of the tibia and talus. There is eversion of the subtalar joint, which forces the heel into valgus alignment, and abduction at the talonavicular joint [44].

Conclusion

This study demonstrated that a higher degree of foot pronation (PPV) in RA patients is associated with US-detected increase in tendon thickness, PDS, and fluid around TP tendon. TP tenosynovitis and high disease activity state might be important factors related to foot impairment and PPV deformity. Accordingly, early management may be needed to reduce TP tendon inflammation and improve foot posture. It is recommended that a larger sample size be studied

for robust conclusions to be drawn and to determine the sensitivity and specificity of different US features in early detection of TP tenosynovitis associated with PPV deformity.

Limitation of the study
The assessment of tarsal tunnel syndrome was beyond the scope of this study and it is recommended to extend this study to include electrodiagnosis of this condition and to examine its incidence to the degree of PPV and US findings.

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Conflicts of interest
There are no conflicts of interest.

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