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IMAGING

The effect of foot position on Power Doppler Ultrasound grading of Achilles enthesitis

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Abstract The aim of this study was to determine whether foot position could modify power Doppler grading in evaluation of the Achilles enthesis. Eighteen patients with clinical Achilles enthesitis were studied with power Doppler ultrasound (PDUS) in five different positions of the foot: active and passive dorsiflexion, neutral position, active and passive plantar flexion. The Doppler signal was graded in any position and compared with the others. The Doppler signal was higher with the foot in plantar flexion and decreased gradually, sometimes till to disappear, while increasing dorsiflexion. The Doppler signal was always less during the active keeping of the position of the joint, than during the passive. The PDUS examination of the Achilles enthesis should be performed also with the foot in passive plantar flexion, in order not to underestimate the degree of vascularization.

Keywords Achilles enthesitis · Power Doppler Ultrasound PDUS · Spondyloarthritis (SpA)

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Introduction

Enthesopathy is a pathological condition of the origin and insertion of ligaments, tendon, fascia, annulus fibrosis and joint capsules. It may have a mechanical or inflammatory origin.

There is no doubt that power Doppler ultrasound (PDUS) modalities are currently considered an integral part of the sonographic assessment [1].

Semiquantitative evaluation of PD signal is the most commonly used method in clinical practice, and it has been used in several clinical studies to define the increased vascularization [2].

Few studies have been published about the variation of Doppler signal of the tendon in different joints position [3–5] but as far as we know no studies have been published about the relationship between the PD grade of Achilles enthesis and foot position.

The aim of this study was to determine the differences of PD grade in patients affected by Achilles enthesitis in neutral position, active and passive dorsal flexion and active and passive plantar flexion of the foot.

Materials and methods

The study was performed following the Declaration of Helsinki principles, and informed consent was obtained from all patients, and the study was approved by Scientific Committee Board of Department.

Between July 2013 and July 2014, eighteen patients (6 male and 12 female) were consecutively studied at Department Medicine, University of Campobasso; age range was from 34 to 69 years.

The inclusion criteria were the following: clinical Achilles enthesitis, of mechanical or inflammatory origin; no previous macrotrauma; no previous tendon's surgery; one or more spots Doppler in the Achilles enthesis at PDUS. At same time, 18 healthy control, matched for sex, age and BMI recruited from our Department were studied.

The ultrasound examination of the Achilles tendon was performed using an Aplio 500 scanner (Toshiba) with 7.2–18 MHz liner array transducer, by two radiologists not independently with 2 and 10 years of experience in musculoskeletal sonography.

Images were obtained in short and long axis of tendon at level of its insertion.

Power Doppler settings were frequency of 7.5–12 MHz, pulse repetition frequency (PRF) of 0.8 kHz, gain just below the level causes the appearance of noise artefacts and low wall filter, as described in literature [6].

Patients were placed in a prone position with their foot hanging over the edge of the table; the transducer pressure was minimized to avoid compression of the small vessels; the tendon was studied in five positions of foot: active dorsiflexion, passive dorsiflexion, neutral position (90° dorsiflexion), active plantar flexion and passive plantar flexion (Fig. 1a–e).

The degrees of PD signal were assessed at enthesis (<2 mm from the bone) [7] in all positions. The Doppler signal was scored 0 if absent, 1 if minimal (only 1 colour spot detected), 2 if moderate (2 spots) or 3 if severe (≥3 spots) [2].

When possible, some anatomical references (e.g., erosions, osteophytes) were identified in the first position and searched again in all the other positions of the foot.

Results

The results are shown in Table 1.

Table 1 PD grade of 18 patients

Patient	PD grade Passive Plantar flexion	PD grade Active Plantar flexion	PD grade Neutral Position	PD grade Passive Dorsiflexion	PD grade Active Dorsiflexion
1	III	III	I	0	0
2	III	III	I	0	0
3	III	II	0	0	0
4	II	II	II	I	I
5	II	I	I	I	I
6	II	II	I	I	0
7	III	II	II	0	0
8	II	II	I	0	0
9	II	II	II	I	0
10	II	II	III	0	0
11	III	II	II	I	0
12	II	I	I	I	I
13	I	0	0	0	0
14	I	I	I	0	0
15	II	II	II	0	0
16	III	III	I	0	0
17	II	II	II	I	I
18	III	II	II	I	0

In passive plantar flexion, we find 2 patients with grade I PD; 9 patients with grade II PD; 7 patients with grade III PD. In active plantar flexion, we find 1 patient with grade 0 PD; 3 patients with grade I PD; 11 patients with grade II PD; 3 patients with grade III PD. In neutral position, we find 2 patient with grade 0 PD; 8 patients with grade I PD; 7 patients with grade II PD; 1 patients with grade III PD. In passive dorsiflexion, we find 10 patient with grade 0 PD; 8 patients with grade I PD. In active dorsiflexion, we find 14 patient with grade 0 PD; 4 patients with grade I PD. See Fig. 2a–e. No sonographic sign was found in the healthy controls.

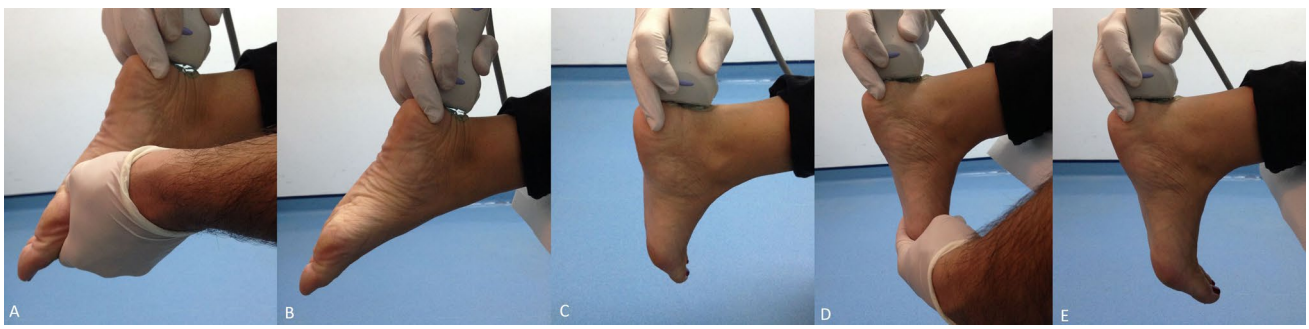

Fig. 1 Female; 36 years old patient with SpA and Achilles enthesitis. The photographs of the foot during the examination and corresponding PDUS images (Fig. 2) in the five positions: passive plantar flexion (**a**); active plantar flexion (**b**); neutral position (**c**); passive dorsiflexion (**d**); active dorsiflexion (**e**)

Fig. 2 More than two spots Doppler (grade III) were detected during PDUS with foot in passive and active plantar flexion (**a**–**b**); two spots Doppler (grade II) were detected at enthesis with foot in neutral position (**c**); no Doppler signal (grade 0) was detected with foot in passive and active dorsiflexion (**d**, **e**). The erosion of the calcaneus was considered an anatomical reference during the change of position

Discussion

The main findings of this study demonstrate that the degree of PD signal of the Achilles enthesis varies significantly by changing the position of the foot, and that PDUS examination should be performed on the foot in passive plantar flexion, in order not to underestimate the inflammation.

The PDUS examination is a fundamental tool in the study of the diseases of the tendons and enthesis. Both in the case of mechanical and inflammatory diseases, it has been extensively demonstrated that the degree of enthesis vascularization is closely related to disease activity, and therefore, the PDUS examination should be an helpful tool both during the diagnostic phase and the monitoring phase of the pathology [8, 9].

Several PDUS grading systems have been proposed in this study of the tendons and enthesis [2, 10–13].

The main limitation of the PDUS is the difficulty of standardizing the method. Some studies have been performed in order to standardize the machine settings and the exact portion of the tendon to be evaluated, but few studies have been made to standardize the position of the patient during the PDUS examination of the enthesis [14].

The first point of our work is that the dorsiflexion (active or passive) of the foot results in a significant decrease or disappearance in the blood supply of the tendon. The reduction in the PD signal with the foot in dorsiflexion may be interpreted as a consequence of a higher tension of the tendon, resulting in the compression of the vessels.

This finding was also previously recognized by Ohberg et al. [15, 16] and Gutierrez et al. [5, 17], although their studies were focused on the tendon and not on the enthesis.

Similar data were obtained from Koenig et al. [3] studying the patellar tendon.

In all our patients, the highest grade of PD signal was obtained with the foot in plantar flexion; in the neutral position (90° of dorsiflexion), we has found a reduction in the PD signal, variable from 0° to 2° with respect to the plantar flexion.

By holding the foot in the same position (plantar or dorsal flexion), in half of the cases there was a little difference between the active and the passive position.

In all these cases, the muscle contraction resulted in a decrease of 1° of the signal DP. Particularly, in 7 of these patients, the reduction in the PD signal was evident between passive and active plantar flexion; while in three cases, the difference was evident between the passive and active dorsiflexion.

The reduction in PD signal from the passive plantar flexion to the active plantar flexion is justified by a possible increase of the tension of the tendon and then by the compression of the vessels. Differently, the reduction in PD signal from the passive plantar flexion to the active plantar flexion, detected in 3 cases, could not be fully understood because the tension of the tendon should not vary.

The results of this study showed a difference variable from 1 to 3 Doppler degrees depending on the position of the joint; this concept is important for the choice of the position of the patient during the PDUS examination of the Achilles tendon insertion.

The European League Against Rheumatism work group Guidelines has already developed guidelines for the use of grey-scale USA in the musculoskeletal system [18]. On the contrary, no guidelines have been created for PDUS assessment. When the foot is in plantar flexion position, in grey-scale USA the deflected Achilles tendon may create the anisotropy artefacts; therefore, some degree of dorsiflexion is correct for grey-scale evaluation, as several articles indicate [14, 19]. Differently, in PDUS examination, the neutral position or the dorsiflexion of foot could generate false negative results.

Few previous studies have investigated the change in the signal of the PD related to the position of the joints, and they have reported individual cases; as far as we know no perspective work on a greater number of patients has been carried out [5, 8]. Furthermore, no work has assessed the exactly difference of PD degree between the positions of the foot and no work has evaluated the difference related to muscle contraction.

The limits of this study are the following: no patient was clinically classified, and therefore, the difference between mechanical and inflammatory enthesitis was not evaluated;

the PDUS was performed by two operators not independently and the interobserver and intraobserver agreements between them could not be calculated; eventual drug therapy was not considered as a criterion for exclusion.

In conclusion, the degree of PD signal is usually highest with the foot in passive plantar flexion, while it tends to decrease with increasing dorsiflexion and/or with increasing of gastrocnemius muscular activity.

Therefore, the authors suggest to evaluate the Achilles enthesis not only with the foot in slight dorsiflexion, but also with the foot in plantar flexion, in order not to underestimate its vascularization.

Author's contribution All authors actively participated in conducting the study, contributed to the critical revisions to the manuscript and approved the article for publication.

Compliance with ethical standards

Conflict of interest Marcello Zappia, Giovanna Cuomo, Maria Teresa Martino, Alfonso Reginelli and Luca Brunese declare that they have no conflict of interest.

Informed consent Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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