Original Investigation

Shear Wave Elastography (SWE) for Monitoring of Treatment of Tendinopathies: A Double-blinded, Longitudinal Clinical Study

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Rationale and Objectives: We aimed to investigate the diagnostic accuracy with which shear wave elastography (SWE) can be used to monitor response to treatment of tendinopathies, and to compare it to conventional ultrasound (US)-imaging methods (B-mode US (B-US) and power Doppler US (PD-US)).

Materials and Methods: A prospective Institutional Review Board-approved longitudinal study on 35 patients with 47 symptomatic tendons (17 Achilles-, 15 patellar-, and 15 humeral-epicondylar) who underwent standardized multimodal US and standardized clinical assessment before and after 6 months of treatment (tailored stretching exercise, sport break, and local Polidocanol) was carried out. All US studies were performed by radiologists blinded to the clinical symptoms on both tendon sides to avoid biased interpretations, by B-US, PD-US, and SWE, conducted in the same order, using a high-resolution linear 15 MHz probe (Aixplorer). Orthopedic surgeons who were in turn blinded to US imaging results used established orthopedic scores (Victorian Institute of Sports Assessment questionnaire for Achilles, Victorian Institute of Sports Assessment questionnaire for patellar tendons, and Disability Arm Shoulder Hand scoring system) to rate presence, degree, and possible resolution of symptoms. We analyzed the diagnostic accuracy with which the different US imaging methods were able to detect symptomatic tendons at baseline as well as treatment effects, with orthopedic scores serving as reference standard.

Results: B-US, PD-US, and SWE detected symptomatic tendons with a sensitivity of 66% (31 of 47), 72% (34 of 47), and 87.5% (41 of 47), respectively. Positive predictive value was 0.67 for B-US, 0.87 for PD-US, and 1 for SWE. After treatment, clinical scores improved in 68% (32 of 47) of tendons. Treatment effects were observable by B-US, PD-US, and SWE with a sensitivity of 3.1% (1 of 32), 28.1% (9 of 32), and 81.3% (26 of 32), respectively. B-US was false-positive in 68.8% (20 of 32), PD-US in 46.9% (15 of 32), and SWE in 12.5% (4 of 32) (SWE). Clinical scores and B-US, PD-US, and SWE findings correlated poorly ($r = 0.24$), moderately ($r = 0.59$), and strongly ($r = 0.80$).

Conclusion: Unlike B-US or PD-US, SWE is able to depict processes associated with tendon healing and may be a useful tool to monitor treatment effects.

Key Words: Shear wave elastography; sonography; tendon; tendinopathy.

INTRODUCTION

Tendinopathies of Achilles, patellar, or epicondylar tendons, characterized by pain, swelling, or function, are some of the most common orthopedic conditions, not only in sportsmen or athletes (1) (2), but also in individuals with sedentary lifestyle (3).

To date, B-mode ultrasound (B-US), power Doppler ultrasound (PD-US), and magnetic resonance imaging (MRI) are the main diagnostic tools in detecting and monitoring

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tendinopathies (4,5). Typical US detectable changes, such as tendon thickening, inhomogeneous tendon structure, loss of echogenicity, and hypervascularization are known to be imaging signs associated with or indicative of tendinopathy (6–9).

However, sensitivity, specificity, and inter-reader agreement of B-US or PD-US assessment are limited. This is in part because symptomatic tendons may not exhibit US-detectable morphologic changes and may not always be associated with PD-US detectable hypervascularization (10) due to false-positive findings that can be caused by subtle US abnormalities that can be found in asymptomatic individuals, especially among athletes (11). Accordingly, the role of B-US and PD-US for detection of tendon pathology remains controversial (12–16).

Recent studies suggest that shear wave elastography (SWE) provides semiquantitative (color-map) and quantitative (absolute SWE values) imaging biomarkers that are useful to assess tendon integrity (8). By assessing tendon elasticity, SWE can help distinguish between asymptomatic and symptomatic tendons (17), with diseased tendons being significantly softer than healthy, asymptomatic tendons (18,19). Tendon softening, as visualized by SWE, correlates closely with the degree of clinical symptoms as assessed by clinical scoring systems such as the Victorian Institute of Sports Assessment (VISA) or Disability Arm Shoulder Hand (DASH) (18), that is, with pain and with functional deficits (20).

The aim of this study was to investigate, through a longitudinal, double-blinded, randomized intraindividual comparative study, the diagnostic accuracy of SWE, compared to conventional US (B-mode and Doppler), for the assessment of treatment effects in patients undergoing treatment for tendinopathies. Because depiction of treatment effects requires the demonstration of abnormal imaging findings at baseline, that is, prior to treatment, the secondary aim was to investigate the diagnostic accuracy with which the three different US imaging methods are able to demonstrate presence of tendinopathy.

MATERIALS AND METHODS

Study Design and Population

A prospective, longitudinal, intraindividual clinical study including 35 symptomatic participants (mean age 43 ± 10.4 years, 20 male, 15 female) with unilateral or bilateral tendinopathies of the Achilles, patellar, or humeral radial/ulnar epicondylar tendon was carried out between December 2013 and November 2014. Every participant underwent a standardized clinical and multimodal US protocol twice: at baseline, that is, prior to therapy, and after 6 months of treatment (mean: 183 ± 7 days).

Inclusion Criteria

We included patients with chronic (>6 months duration) pain of the Achilles, patellar, or humeral epicondylar (radialis/ulnaris) tendon(s), regardless of whether the symptoms were unilateral or bilateral.

Pain, diffused or localized swelling, reduced force, and reduced flexibility of the tendon were defined to be signs of tendinopathy. Participants with history of tendon rupture and tendon surgery were excluded from participation.

Clinical Assessment

At the first clinical visit, every participant completed a standardized questionnaire concerning general medical history, sports activity, and current tendon pain (rest, movement, or pressure pain).

At each visit, presence and degree of tendon pain was established by standardized questionnaires and standardized clinical examination by an orthopedic surgeon. Results of the questionnaire as well as results of the clinical examinations were documented in a dedicated database.

The degree of Achilles and patellar tendon pain was established using the standardized VISA scoring system: VISA-A questionnaire for Achilles and VISA-P questionnaire for patellar tendons (21). The VISA-A and VISA-P scoring systems range from 0 to 100: a score of 100 means "no pain or impairment of physical activity"; a score of 0 means "maximum pain or impairment of physical activity."

The degree of epicondylar tendon pain was obtained using the standardized DASH scoring system (22). The DASH scoring system ranges from 100 to 0: a score of 100 means "highest pain"; a score of 0 means "no pain." DASH score scale was later on mathematically inverted (100–DASH) for data analysis, to make it comparable to VISA-A and VISA-P scores.

Tendinopathy Treatment

Every patient underwent a standardized tendinopathy treatment protocol according to current orthopedic guidelines (23,24) consisting of concentric stretching exercises, sports break, and topical application of polidocanol ointment (Polidocanol Thesit Gel, 3%, gepepharm). At clinical visits, self-reported compliance rates were 100% for stretching exercises and ointment application, respectively.

At the first visit, participants were instructed by an orthopedic surgeon on how to perform static stretching exercises. Participants were asked to perform these exercises at least once a day (and up to three times per day). Participants with extensive sporting activity (>3 times per week) were asked to interrupt this activity throughout the study duration (6 months).

Polidocanol has been proven to be a useful sclerosing agent when injected in affected tendon areas. Patients were encouraged to locally apply Thesit Gel three times a day in the first 2 weeks and whenever required in the remaining period of time. Patients were guided to apply the ointment at least 15 minutes before dressing the treated area.

Imaging Protocol

Every participant underwent bilateral multimodal US on a dedicated sonography unit (Aixplorer, Supersonic Imagine, Aix-