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Original research

A soft patellar tendon on ultrasound elastography is associated with pain and functional deficit in volleyball players

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ABSTRACT

Objectives: To investigate the diagnostic performance of grey scale Ultrasound (US), power Doppler (PD) and US elastography for diagnosing painful patellar tendinopathy, and to establish their relationship with Victorian Institute of Sport Assessment-Patella (VISA-P) scores in a group of volleyball players with and without symptoms of patellar tendinopathy.
Design: Cross-sectional study.
Methods: Thirty-five volleyball players (70 patellar tendons) were recruited during a national university volleyball competition. Players were imaged with conventional US followed by elastography. The clinical findings of painful patellar tendons were used as the reference standard for diagnosing patellar tendinopathy. In addition, all participants completed the VISA-P questionnaires.
Results: Of the 70 patellar tendons, 40 (57.1%) were clinically painful. The diagnostic accuracy of grey scale US, PD and elastography were 60%, 50%, 62.9%, respectively, with sensitivity/specificity of 72.5%/43.3%, 12.5%/100%, and 70%/53.3%, respectively. Combined US elastography and grey scale imaging achieved 82.5% sensitivity, 33.3% specificity and 61.4% accuracy while routine combination technique of PD and grey scale imaging revealed 72.5% sensitivity, 43.3% specificity and 60.0% accuracy. Tendons in players categorized as soft on elastography had statistically significantly greater AP thickness ($p < 0.001$) and lower VISA-P scores ($p = 0.004$) than those categorized as hard. There was no significant association between grey scale US abnormalities (hypoechogenicities and/or fusiform swelling) and VISA-P scores ($p = 0.098$).
Conclusions: Soft tendon properties depicted by US elastography may be more related to patellar tendon symptoms compared to grey scale US abnormalities. The supplementation of US elastography to conventional US may enhance the sensitivity for diagnosing patellar tendinopathy in routine clinical practice.

1. Introduction

Patellar tendinopathy is common among active athletes particularly those involved in jumping sports such as basketball and volleyball.[1] A failed healing response of the tendon at histology, clinically patients with patellar tendinopathy present with localized pain and tenderness in the patellar tendon that is aggravated by high load stretch-shortening cycle (running, sprinting, and jumping).[2,3] The condition is difficult to treat effectively and can significantly limit or even prevent sporting activity.

Ultrasound (US) and magnetic resonance imaging (MRI) are commonly used to confirm a clinical diagnosis of patellar tendinopathy. Both imaging modalities can reveal morphological changes in tendon such as tendon swelling and collagen fibres

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disorganization. However, such morphological changes are not necessarily associated to symptoms, as athletes can have painful tendons without structural change or structural change without pain.[4] For example, Cook et al. found that 22% of asymptomatic elite athletes had structural hypoechoic changes of the patellar tendon. The authors concluded that the presence of an US hypoechoic change in an elite athlete with anterior knee pain does not confirm a diagnosis of patellar tendinopathy.[4] The presence of Doppler US signals in the degenerated tendon has been suggested as a clue to symptomatology but in other studies, Doppler signal has been identified among active, asymptomatic athletes such as volleyball players.[5,6] There is a need to better understand the relationship between US imaging findings and pain, while exploring imaging methods that may yield more clinically useful data.

Real-time US elastography is a relatively new US based technique that evaluates the elastic properties of tendons.[7] To date, several studies applying US elastography to assess Achilles tendinopathy and common extensor tendinopathy have been published with promising results.[8,9] De Zordo et al. compared 25 patients who presented with Achilles tendinopathy and 25 gender-matched controls using a clinical diagnosis of "pain" as the reference standard. The research team found that US elastography and grey-scale US achieved accuracy of 97% and 93%, respectively, in diagnosing clinically symptomatic Achilles tendinopathy.[9] To our knowledge however, no studies have investigated the clinical feasibility of US elastography in the assessment of patellar tendinopathy. The primary aim of this study was to investigate the diagnostic performance of US elastography, grey scale, power Doppler (PD) US and combination techniques in confirming clinically painful patellar tendon in a cohort of high risk athletes. We set out to explore whether the supplement of US elastography to conventional US improve the routine sonographic diagnosis of patellar tendinopathy, which may in turn, impact on early diagnosis, management and rehabilitation of patients with tendinopathy. The secondary aim was to investigate the relationship between elastographic measures, grey scale US, PD imaging, and Victorian Institute of Sport Assessment-Patella (VISA-P) scores.

2. Methods

The Queen Mary University of London Research Ethics Committee approved the study and written informed consent was obtained from each participant. The inclusion criterion was participation in the 2011 British University Volleyball Championships. A convenience sample of men and women with and without symptoms of patellar tendon pain was recruited from the cohort of volleyball players participating in the tournament. Fifty of the 150 players were approached between games in the championship. The exclusion criteria were prior patellar tendon surgery, injury (partial or complete rupture) of the patellar tendon in the past two years, on-going infection near the tendon, earlier treatment with steroid injection in the vicinity of the tendon, diabetes or systemic inflammatory disease. Participants completed a VISA-P questionnaire for each patellar tendon. The VISA-P questionnaire is a valid and reliable disease specific measure for assessing the severity of symptoms and functional ability in patients with patellar tendinopathy.[10] Results can range from 0 to 100, where 100 represent the perfect score with full function. The clinical examination of the patellar tendon in all participants was performed by a specialist physiotherapist (D.E.) who was also one of the co-authors of the present study. A diagnosis of a painful patellar tendon was made when localized pain was induced in the region of the patellar tendon with loading activities such as squatting and jumping.[11] Additionally, the eligible participants completed a self-administered questionnaire in which the demographic information (age, gender, height), smoking history,[12] volleyball activity (minutes of volleyball) prior to US, possible history of patellar tendon injury or surgery, and pain at presentation were obtained. All participants were asked not to disclose any knee injury history to the radiologist performing the US scans.

All participants were examined with grey-scale US and PD imaging using the Philips iU22 US scanner (Eindhoven, Philips Healthcare, Netherlands) that was equipped with a high resolution L17-5 MHz linear transducer. A single radiologist (P.J.R.) with over 16 years musculoskeletal experience evaluated and imaged the right and left patellar tendons of each participant. The radiologist was blinded to the players' VISA-P scores, history of patellar tendon pathology and pain at presentation. The patellar tendon was initially examined in the longitudinal and transverse planes using conventional B-mode (grey scale) and Doppler US. A standardized, preprogrammed grey scale US scanning protocol (with optimized scanning parameters such as depth, frequency, focal zone) was used to ensure consistency of results obtained between patients. The patellar tendon was examined with the knee in 20–30° flexion (with a wedge immobilizer placed under the knee) in order to stretch the extensor mechanism and avoid possible anisotropy related to the concave profile that the patellar tendon assume in full extension. A viscous scanning gel at room temperature (Aquasonic 100; Parker Laboratories Inc, Fairfield, New Jersey) was used to improve contact between the transducer and the skin. The maximum antero-posterior (AP) thickness of the patellar tendon was measured in the transverse plane. The absence or presence of grey scale abnormality (normal/abnormal) was graded according to the criteria suggested previously by Cook et al..[13] A grey-scale US abnormality was defined as either (i) the presence of discrete hypoechoic area > 2 mm (reproducible in both the longitudinal and transverse planes), and/or (ii) fusiform swelling without hypoechoic regions.[13] The patellar tendon was classified as normal if both of these features were absent, or abnormal if any one or both were present (Fig. 1).

Each patellar tendon was examined for presence of intratendinous vasculature using PD imaging with slow perfusion settings (pulse repetition frequency of 1000 Hz, low wall filter settings of 75 Hz).[14] The participant was positioned with the knee fully extended and relaxed. Care was taken to minimize tendon compression and therefore obliteration of small vessels whilst scanning. The colour intensity was set marginally below the artefact threshold. A standard 15 mm sampling box was placed on the longitudinal image with the greatest vascular density centred over the patellar tendon. The Doppler signal of the patellar tendon was dichotomized as either absent or present. Patellar tendons were designated as "vascular" if they demonstrated a vessel within the sampling box in the sagittal plane that was estimated to be greater than 1 mm in length.[15]

After recording the grey scale and PD US images, real-time US elastography was performed with a linear L12-5 MHz transducer on the same US machine. Light repetitive compression was applied over the patellar tendon with the hand-held transducer. Transducer pressure was applied vertically, perpendicular to the patellar tendon and was adjusted according to the real-time visual indicator for compression on the right side of the screen. The visual compression bar has two colour indicators: green and grey. A green compression bar indicates quality elastogram with appropriate tissue deformation while a grey bar denotes excessive or too little pressure. Care was taken to hold the probe perpendicular to the patellar tendon to avoid anisotropy when performing grey-scale US and to avoid "tissue shifting" artefact (occurs when the region of interest moves out of plane) when performing US elastography.[9] In the present study, we used a graduated colour strain map (red–yellow–green–blue) to categorize the elastographic findings. The presence of a "blue