Strain Sonoelastography of Knee Tendons in Knee Osteoarthritis

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Abstract

Introduction: Knee Osteoarthritis (KOA) is a prevalent and potentially debilitating degenerative condition affecting an increasing number of people. Early intervention plays a key role in the prevention and effective management of KOA, hence detection of early pathological changes in the knee joint are appealing. Strain sonoelastography (SE) is a widely accessible and affordable point of care imaging technique with expanding clinical roles in the musculoskeletal field. However, there is no gold standard technique for measuring tissue elasticity, and the reliability and validity of the SE technique is not fully established. SE has shown promise in the measurement of tendon stiffness and conceptually, tendon alterations can plausibly influence muscle-tendon performance and neuromuscular control. Patterns and comparison of knee tendon SE within the healthy and KOA population are currently not known. The purpose of this study was to evaluate reliability and clinical application of SE for knee tendon measurements in knee KOA.

Methods: A sequential series   of   five   studies were   performed. Study   1 involved 20 healthy participants. A standardised protocol was developed for quadriceps and patellar tendon SE, and was performed by 3 operators with different levels of experience, to evaluate reliability. Study 2 included 20 healthy participants and 2 different operators and machines to determine inter-machine agreement, repeatability and association. Study 3 included 20 healthy participants and evaluated inter-machine elasticity measurement comparisons, and participant characteristics associated the with the magnitude of difference between repeated measures. Study 4 included 104 participants and evaluated differences between SE measures of individuals with KOA and a control population. Study 5 included 95 older adults, including those with KOA, and explored the associations between quadriceps tendon elasticity and neuromuscular control. Statistical assessment was performed using

percentage of agreement, Cohen's kappa, coefficient of variance, Bland Altman plots, intra-class coefficient's and Pearson/Spearman's correlations. Between group SE differences were evaluated using Kruskal-Wallis and Mann Whitney U tests. Spearman's correlations and regression analysis were performed to evaluate associations between SE measurements and participant characteristics (age, gender, leg circumference and osteoarthritis status) and participant physical and neuromuscular measures.

Results: Study 1 determined that greater intra-operator and inter-operator agreement and repeatability of knee tendon SE was achieved by the most experienced operators. Study 2 found that intra-machine measures were not significantly different and colour score SE was highly agreeable, yet inter-machine elastic ratio's (ER) were not associated. The proximal and distal patellar tendon regions were most reliably measured. Study 3 found that increased participant Body Mass Index (BMI) and body fat % influenced variation of repeated measures, where measurement of the quadriceps and mid-patellar sites were most vulnerable, yet not significant. Study 4 found significant difference between the SE measures of young control, old control and KOA populations. The distal quadriceps and proximal patellar tendon sites were significantly stiffer, and the distal patellar tendon less stiff, in KOA individuals compared to healthy older adults. Significant differences were observed between KOA gender groups where females displayed stiffer tendon at the DQT and DPT, compared to males. Age and gender were associated with SE knee tendon outcomes, particularly in the colour scoring method. Study 5 demonstrated that distal quadriceps tendon SE was significantly associated with KOA group neuromuscular control measures.

Conclusion: A three-point colour scoring system and ER SE measurement can be reliably performed by suitably trained operators, however inter-machine ER should not be carried out. Increased body habitus characteristics contribute to measurement variability, therefore participant selection should be considered for appropriate follow-up. Age and gender are associated with SE knee tendon stiffness and significant differences between healthy controls, and KOA is observed, suggesting opportunity for targeted intervention. SE as an additional US imaging investigation to evaluate tendon alterations could be adopted to inform such interventions, however further work is required to evaluate clinical outcomes following a period of tendon rehabilitation.