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Evaluation of knee cartilage thickness: A comparison between ultrasound and magnetic resonance imaging methods

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ABSTRACT

Background: Establishing clinically accessible measures of cartilage health is critical for assessing effectiveness of protocols to reduce risk of osteoarthritis (OA) development and progression. Cartilage thickness is one important measure in describing both OA development and progression. The objective was to determine the relationship between ultrasound and MRI measures of cartilage thickness in the medial femoral condyle.

Methods: Mean cartilage thicknesses of the left medial femoral cartilage were measured via T1 weighted MRI and ultrasound imaging from transverse, anterior, middle, and posterior medial femoral regions in 10 healthy females (Mean ± Std Dev) (1.66 ± 0.08 m, 59.5 ± 8.3 kg, 21.6 ± 1.4 years) and nine healthy males (1.80 ± 0.08 m, 79.1 ± 6.2 kg, 21.7 ± 1.5 years). Pearson correlations examined relationships between MRI and ultrasound measures. Bland–Altman plots evaluated agreement between the imaging modalities.

Results: Transverse ultrasound thickness measures were significantly positively correlated with MRI middle ($r = .67$, $P \leq .05$) and posterior thicknesses ($r = .49$, $P \leq .05$) while the middle and posterior longitudinal ultrasound measures were significantly correlated to their respective MRI regions ($r = .67$, $P \leq .05$ & $r = .59$ $P \leq .05$, respectively). There was poor absolute agreement between correlated measures with ultrasound thickness measures being between 1.9 and 2.8 mm smaller than MRI measures.

Conclusions: These results suggest that ultrasound may be a viable clinical tool to assess relative cartilage thickness in the middle and posterior medial femoral regions. However, the absolute validity of the ultrasound measure is called into question due to the larger MRI-based thickness measures.

Level of evidence: Level IV.

1. Introduction

Knee osteoarthritis (OA) represents a significant health care burden where irreversible damage to the articular cartilage has occurred [1]. Establishing clinical measures associated with cartilage health and identifying changes in cartilage status are critical

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for evaluating the effectiveness of protocols to reduce risk of knee OA development and progression. Cartilage thickness is an important measure in detecting both OA onset and progression [2,3]. Although the very earliest OA stages may result in an increase in cartilage thickness [4,5], structural changes in the development and progression of clinical OA are commonly understood to be characterized by erosion and loss of articular cartilage. Individuals with established knee OA have less tibiofemoral cartilage compared to healthy subjects [6]. It has been suggested that the central medial femoral cartilage be assessed for changes in cartilage morphology associated with early signs of knee OA [7]. Accurate measurements of cartilage thickness may be clinically useful in detecting and monitoring treatment effects for focal cartilage defects. Thus, effective measurement tools are needed to detect both increases and decreases in medial femoral cartilage thickness.

Magnetic resonance imaging (MRI) has been the gold standard for assessing knee cartilage thickness [8]. However MRI is expensive, not available to all patients at all times and not easily available for serial evaluation of cartilage status. While conventional radiography is more clinically available it reveals only gross joint space narrowing and not the direct cartilage surface, it carries greater risk to the patient, and does not offer MRI's ability to weight MRI sequences for specialized tissue imaging [9]. Diagnostic ultrasound assessment of cartilage thickness offers an alternative measure as a clinically available and more cost-effective source of knee articular cartilage imaging [10]. Due to ease of use and relative low cost of clinical assessment, ultrasound has recently gained favor for its ability to evaluate the status of the femoral cartilage in pathologic OA populations [11,12].

There are few studies reporting the validity of ultrasound measures and are limited in scope to pathologic knees and older populations [10,13,14] Little is understood about the association of knee femoral cartilage thickness measured using ultrasound and MRI in healthy knees. Establishing ultrasound as a valid measurement tool of cartilage thickness in uninjured or healthy knees may allow for the development of a clinical tool to monitor the health of knee cartilage in a relatively young population such as ACL injured individuals that are at high risk of future OA development. Thus as a first step, our purpose was to determine the association and absolute agreements between ultrasound and MRI outcomes of medial femoral condyle cartilage thickness in healthy individuals. We hypothesized that ultrasound and MRI outcomes of medial femoral condyle cartilage thickness would be strongly correlated and would demonstrate a high degree of absolute agreement.

2. Methods and materials

2.1. Experimental protocol

Ten healthy females (Mean ± Std Dev) (1.66 ± 0.08 m, 59.5 ± 8.3 kg, 21.6 ± 1.4 years) and nine healthy males (1.80 ± 0.08 m, 79.1 ± 6.2 kg, 21.7 ± 1.5 years) participated in this cross-sectional observational study. The university's Institutional Review Board approved the study and all participants gave written informed consent. Healthy was defined as no current orthopedic injury or history of significant injury or surgery in left limb. Participants attended two sessions in random order occurring within 48 h of each other in

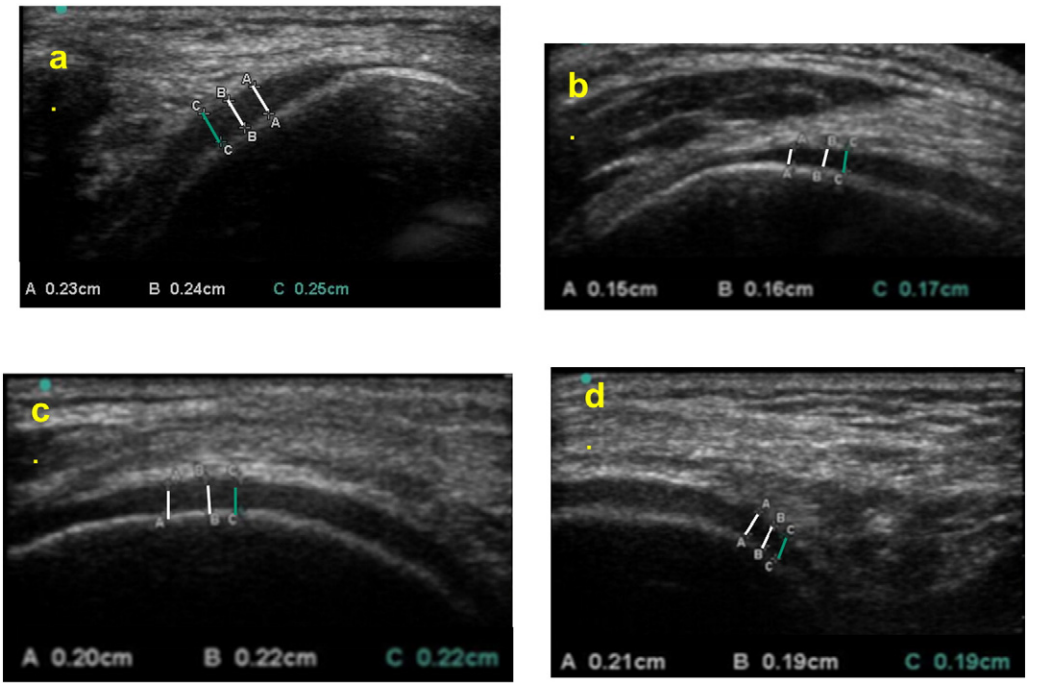

Figure 1. Transverse (a) and longitudinal anterior (b), middle (c), posterior (d) ultrasound images demonstrating three adjacent medial femoral cartilage thicknesses (lines A, B, & C) that were averaged for analyses.