INTRODUCTION

Although articular cartilage thickness has previously been quantified using B-mode ultrasonography (US) [1, 2], thicknesses in those studies were measured 2-dimensionally using B-mode slice images. Cartilage thickness has also been quantified by creation of 3-dimensional (3D) models from MRI data [3, 4], but this approach has not been adapted to US. The purpose of this study was to develop a method to measure 3D articular cartilage thickness at the femoral condyle using B-mode US and to compare results with 3D measurements using MRI to clarify the feasibility of US in clinical evaluations of articular cartilage.

OBJECTIVES AND METHODS

US B-mode image acquisition

Subjects comprised 2 healthy male volunteers (age, 37 and 59 years) and 2 male patients with knee osteoarthritis (age, 73 and 81 years) who provided written informed consent prior to participation in the study. The study protocol was approved by the ethics committee of our institution. A B-mode 10.0-MHz linear ultrasonic probe (UST 5411; Aloka, Tokyo, Japan) connected to an ultrasound device (Prosound ALPHA 10; Aloka) was attached to a probe scanner stabilized by a holding arm, allowing the ultrasound probe to move along the surface of the flexed knee (Fig. 1A). The base of the holding arm was rotated by a gear and data on angle of rotation of the arm was transferred to the ultrasound device by an encoder. Scans with angle data were recorded. The medial surface of the right knee of each participant was scanned using the ultrasound probe with the knee flexed at 120° (Fig. 1B) so the cartilage surface of the femoral medial condyle could be visualized by US. The US probe was attached to the arm so the US imaging plane was parallel to the arm plane, allowing the imaging plane to rotate around the center axis of the encoder, which was coaxial with the medial-lateral axis of the femoral condyle. The range of the angle of rotation for the arm was 0-80° and the US B-mode images (total, 101 images) were acquired every 0.8° (Fig. 2A). System settings were optimized to image the cartilage surface (tissue harmonic, 420 pixels × 468 pixels; pixel size, 0.0855 mm × 0.0855 mm).

Measurement of Articular Cartilage Thickness Using a 3D Image Reconstructed from B-mode Ultrasonography

Mechanical Scans - Comparison with MRI-derived Data-

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PEARSON’S COEFFICIENT OF CORRELATION WAS USED TO COMPARE TC-US WITH TC-MRI. A CORRELATION WAS CONSIDERED SIGNIFICANT FOR VALUES OF p<0.05.

RESULTS

With color mapping of articular cartilage thickness, the US model exhibited relatively good similarity to the MRI model in thickness distribution (Fig. 3A, B). TC-US correlated significantly with TC-MRI in all participants (p<0.0001, each) (Fig. 4). Pearson’s coefficient of correlation tended to be slightly higher in volunteers than in patients with osteoarthritis.

DISCUSSION

This is the first study to clinically measure Tc using a 3D US cartilage model, although 3D US has been adopted for evaluating other tissues, such as the Achilles tendon [6] and rotator cuff [7]. Considering the high accuracy of Tc measurement using MRI [8], our results show that, like MRI, TC-US measurement using 3D models also allow accurate measurement of Tc, in both healthy individuals and patients with osteoarthritis.

REFERENCES


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