Changes of T2 Values of Patellar Cartilage in Subjects With Osteoarthritis Over a One Year Time Period

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INTRODUCTION

Magnetic resonance imaging (MRI) enables non-invasive in-vivo diagnosis of diarthrodial joint pathologies, such as osteoarthritis (OA). Standard T_2-weighted images are capable of identifying late stage chondromalacia [1], but tend to underestimate surface fibrillation and surface defects [2]. As a result, the use of T_2-weighted images alone are unlikely to show early degeneration of cartilage.

Recently, the MRI transverse relaxation time constant (T_2) of articular cartilage has been proposed as a biomarker for OA [3]. Cartilage T_2 values are dependent upon local water content and collagen fiber orientation – both indicative of the presence of OA. Previous investigators have examined the effects of age, gender and location of cartilage on calculated T_2 values. Changes of T_2 resulting from enzymatic degradation have also been examined [4], but enzymatic degeneration of articular cartilage may not be representative of the actual degeneration of the tissue seen during OA.

To the best of our knowledge, no study has evaluated the natural changes of in-vivo T_2 values in response to a person's regular activities of daily living (ADLs). The purpose of this study was to examine changes of T_2 values of cartilage in a cohort of control subjects over a testing period of one year.

METHODS

Subjects: Following local institutional review board approval with informed consent, 15 subjects (10F, 5M, average age 53.4±9.8 y.o.) were enrolled in the study.

Data Acquisition: Bilateral MR images of each subject's patellae were obtained. A series of axial T_2-weighted fast spin-echo (FSE) images were acquired across 10 slices locations spanning the length of the patella. Eight echo images were acquired at each slice location: TR=1000ms, TE=8-76ms, slice thickness=2mm, slice spacing=4mm, FOV=12cm^2, in-plane resolution=0.49mm^2. All images were acquired using a clinical 1.5T scanner with a dedicated transmit-receive knee coil. The entire scanning process was repeated during a return visit, approximately one year from the initial visit. All subjects were asked to continue performing their regular ADLs during the intervening year. Data Analysis: T_2 values of patellar cartilage were calculated on a pixel-by-pixel basis by fitting the echo time (TE) data and the corresponding signal intensity (SI) to a mono-exponential equation: $SI(TE)=S_0 \bullet exp(-TE/T2)$ using a linear least-squares algorithm. Pixels with T_2 values greater than 200 ms were considered outliers and were excluded from statistical analysis [5]. An average bulk T_2 value was generated from all analyzed pixels of each patella. Average T_2 values from the superficial, middle and deep zones of cartilage from the most central patellar image plane were also used for statistical analysis. A paired t-test and a two-factor repeated measures ANOVA was performed to determine the effect of scanning time interval on change of bulk T_2 value and zonal dependent T_2 values, respectively. A post-hoc Student-Neuman-Keuls test was performed when significance was found. Significance was taken at $p<0.05$.

RESULTS

No significant difference in overall bulk T_2 value was found between the two scanning periods (p=0.5, Figure 1). Similarly, no significant differences of corresponding regional T_2 values were found between visits (p=0.63). There was no interaction between the factors of visit and zone of cartilage (p=0.37). However, differences were found between different zones of cartilage (p=0.002). The middle zone had significantly lower T_2 values than the superficial and deep zones of cartilage. All statistical analyses indicated a trend towards higher T_2 values at the return visit. The time of the return visit from the initial visit was 12.4 ± 2.6 months (mean ± std).

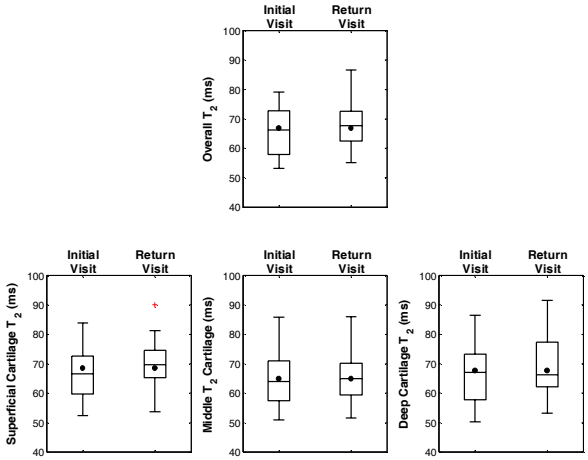

Figure 1. Box plots of T2 values of patellar cartilage at one-year interval for bulk T_2 values (top) and zonal dependent T_2 values (bottom). The box has lines at the median and 25th and 75th quartiles. Whisker lines extend to 10th and 90th percentiles. The mean value is indicated by the (●) in each box. Outliers, if present, are indicated by a (+).

DISCUSSION

This study evaluated the natural progression of bulk and zonal T_2 values of patellar cartilage in control subjects over the time period of one year. All calculations of T_2 values tended to increase between the two time points, however, the increases were insignificant. These findings may be due to several factors. First, the OA stage of subjects' knees were unknown prior to enrollment in the study. Knees with initially low levels of OA may have the potential for a larger change in T_2 value than knees which initially had higher levels of OA due to the relative "health" of the joint. T_2 values from individuals with higher levels of OA may convolute the results of this study. We are currently evaluating radiographs of subjects and enrolling additional subjects to resolve this possibility. Second, changes of patellar cartilage T_2 values may occur over a larger time scale than examined in this study. Calculating T_2 values at regular time intervals would be beneficial for determining the sensitivity of this novel image analysis technique. Finally, it is necessary to confirm any detected differences of T_2 values are from changes in the cartilage and not from drift of the scanning equipment. It would be beneficial to image a T_2 phantom immediately following data acquisition from subjects to quantify scanner repeatability. While additional phantom scanning time was not available in the current study, our clinical practice performs a routine quality control of the MR equipment to ensure consistent SNR and RF transmit power and minimal image distortion from the coil, and an examination of all electronic components of the scanner.

This study will aid in the clinical application of cartilage T_2 mapping. Current studies using T_2 mapping are typically research oriented with occasional clinical use (e.g. tracking integration of autologous chondrocyte transfers to cartilage defects [6]). Understanding the rate change of T_2 values will help determine the sensitivity of T_2 mapping to detecting changes in the cartilage which may otherwise be undetectable with conventional MR imaging techniques.

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