Examiner Variability of T2 of Cartilage in Subjects with Osteoarthritis

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INTRODUCTION

MRI provides a non-invasive method to diagnose pathologies of diarthrodial joints. T_2-weighted images have been shown to identify late stage chondromalacia to a high level of sensitivity and specificity [2], but T_2-weighted images also tend to underestimate the presence of surface fibrillation and surface defects [3,4]. As a result, the use of T_2-weighted images alone are unlikely to show early degeneration of cartilage [5].

Recently, investigators have examined the intrinsic MRI T_2 value of articular cartilage to diagnose early stages of OA [6]. T_2 values are dependent upon local water content and collagen fiber orientation. Disruption of collagen fibers and an increase of water content of cartilage is seen during OA [7]. These physiological changes have been detected using T_2 mapping of cartilage. Previous T_2 mapping studies have typically depended on a single examiner to segment cartilage from surrounding structures for T_2 analysis. The effect of different individuals segmenting the same cartilage images is unknown. In addition, the repeatability of T_2 calculations has not been reported in the literature. The purpose of this study was to evaluate inter-examiner and intra-examiner variability of T_2 values of patello-femoral (PF) cartilage in a clinical setting.

METHODS

Data Acquisition: Following IRB approval with informed consent, 20 consecutive subjects with PF OA were enrolled in the study. 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 slice 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 x 12cm, in-plane resolution = 0.49mm x 0.49mm.

Data Analysis: Two examiners independently processed each MR image twice, once on two different days. Custom written software was used to analyze the MR images. Segmented cartilage from the central slice of each patella was used for repeatability 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: $SI(TE)=S_0 \cdot exp(-TE/T_2)$. Data from the first echo was discarded in calculating T_2 values to increase T_2 accuracy [8]. Pixels with T_2 values greater than 200 ms were considered outliers and were excluded from statistical analysis [9]. An average T_2 value generated from all analyzed pixels of each patella was used for statistical analysis. Bland and Altman plots [1] were created to evaluate the intra- and inter-examiner differences of T_2 values. These plots display the average T_2 value of the slice calculated for the two data processors on the ordinate and the difference of the average T_2 values on the abscissa. Repeatability of T_2 measurements was evaluated as the root mean square (RMS) of the T_2 difference. In addition, the mean of the absolute differences of average T_2 values was calculated.

RESULTS

The intra-examiner reliability was high, with a mean T_2 difference of only 0.6 ± 2.4 ms (mean ± std. dev., Figure 1A). Similarly, the inter-examiner reliability was high, with a mean T_2 difference of 0.7 ± 3.1 ms (Figure 1B, Table 1). The mean absolute difference of T_2 values was 2.4 ms for intra- and inter-examiner analysis.

DISCUSSION

This preliminary study found excellent repeatability of T_2 measurements from two examiners using a single data set. The average intra-examiner and inter-examiner T_2 difference was below 1 ms. Two aspects of the results are encouraging for applying T_2 mapping in a clinical setting. First, a subsequent radiographic analysis found the PF OA stage of subjects to be evenly distributed among Kellgren-Lawrence OA stages 0 to 3. Thus, our results indicate that the inter-examiner calculation of average patellar cartilage T_2 value is repeatable and may be independent of the stage of PF OA. Second, the training of the data processors varied greatly prior to data analysis for this study. One processor had significant experience (prior processing of >100 subjects) while the second processor had limited experience, training on several PF image sets with little to no OA. Although the inter-examiner reliability was high, the range of differences may be further reduced by using a rule-based method [10] for selecting pixels for T_2 analysis. Further analysis will benefit from data currently being collected to determine the between-day variability of T_2 analyses. The results of this study will aid in determining the applicability of T_2 mapping in a clinical setting.

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ACKNOWLEDGEMENTS

NIH: R01AR048768-04, 5T32HD007447-13, Kathie Bernhardt and Chris Hughes for assistance in subject recruitment.

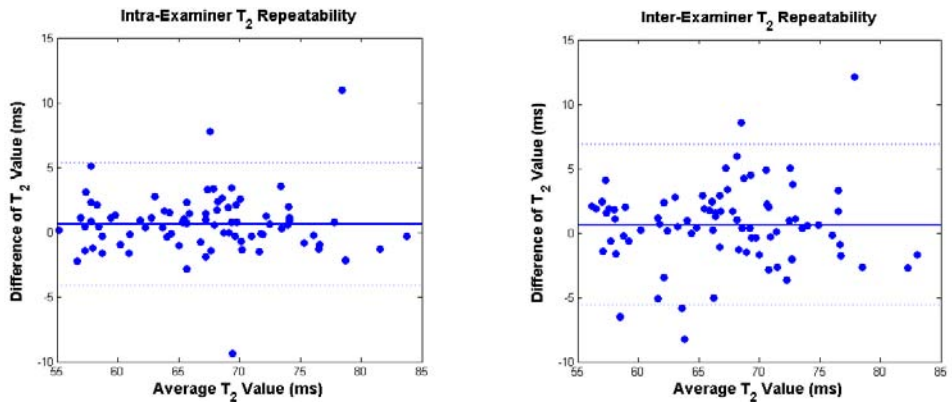

Figure 1a,b. Bland and Altman plots for intra-examiner (A) and inter-examiner repeatability (B). The solid line indicates the mean difference and the dotted lines indicate the limits of agreement [1].

Table 1. Measurement of Reproducibility

Analysis	Difference of T_2 Values (Ave.± St. Dev.)	Mean of Absolute T_2 Value Differences (ms)	Reproducibility Coefficient (ms)
Intra-examiner	0.6 ± 2.4	2.4	1.6
Inter-examiner	0.7 ± 3.1	2.4	2.5