Relationship of Joint Space Width and Cartilage T2 Values in Subjects with Osteoarthritis

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INTRODUCTION

The MRI image analysis technique of T2 mapping has been developed to investigate osteoarthritis (OA) in diarthrodial joints [1]. T2 values of cartilage are related to the local collagen fiber orientation and water content of the tissue [2,3]. A previous study correlated T2 values and OA using radiographic grading [4]. Relating cartilage T2 values to alternative methods of assessing diarthrodial joint OA would be beneficial for determining the clinical implications of the T2 mapping technique. Standard in-vivo assessment of OA is routinely performed by examination of the joint space width (JSW). JSW is known to change during the progression of OA [5]. The relationship between JSW and the corresponding T2 value of cartilage within the joint is unknown. The purpose of this study was to assess the relationship between patellar cartilage T2 values and JSW measurements to determine if the correlation is dependent upon stage of OA.

METHODS

Subjects: Following IRB approval with informed consent, 113 consecutive subjects (56 ± 11 y.o., 29M, 84 F) were enrolled in the study.

Data Acquisition: Standing lateral radiographs centered on the patella were obtained for each knee. Following the radiological exam, MR images of each subject’s patellae were obtained. For T2 calculations, a series of axial T2-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 x 12cm, in-plane resolution = 0.49mm x 0.49mm. Immediately following, an oblique sagittal spiral fast SPGR sequence was used to acquire images for joint space width calculations: slice thickness = 3mm, slice spacing = 1mm, FOV = 15x15 cm, in-plane resolution: 0.29mm x 0.29 mm, flip angle: 90 degrees. The knee was in approximately 20° flexion for both imaging sequences.

Data Analysis: Radiographs were graded for patello-femoral (PF) OA based on the Kellgren and Lawrence (KL) scale from 0 (no OA) to 4 (end-stage OA). This scale assigns a level of OA based on the evaluation of joint space width and the presence and size of osteophytes. Custom written software was used to analyze the MR images. For T2 calculations, patellar cartilage was manually segmented on each image. T2 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: $SI(TE) = S_0 \cdot \exp(-TE/T2)$. Data from the first echo image was discarded in calculating T2 values to increase T2 accuracy [6]. Pixels with T2 values greater than 200 ms were considered outliers and were excluded from statistical analysis [4]. An average T2 value generated from all analyzed pixels of each patella was used for statistical analysis. Measurement of JSW was made using a semi-automated program which assigned each pixel a value based on the ratio of local signal intensity differences to maximal signal intensity differences in the image [7]. The program then performs a line search on the processed image to determine the edges of the joint space, from which the minimum JSW is calculated. Regression analysis and calculation of the Pearson correlation coefficient (r) was performed between average T2 values and minimum JSW measurements. Regression and correlation analysis was also performed for JSW within each stage of KL OA. Statistical significance was set at p<0.05.

RESULTS

No correlation was found between T2 values and JSW for all combined stages of OA (r=0.0644, p=0.34, Figure 1). In addition, weak correlations and insignificant regressions of T2 values with JSW were found for all stages of OA (Table 1). Regression and correlation analysis for KL OA Stage 4 was not performed due to limited sample size (n=3).

DISCUSSION

This study evaluated the relationship between T2 values of patellar cartilage and measurements of patello-femoral JSW measurements. No relationship was found between these two variables for combined and individual stages of PF OA. This finding is primarily due to two factors. First, changes of T2 values likely occur during the onset of OA, while changes of JSW occur at a later time point. The time difference between changes of T2 values and changes of JSW would result in weak correlation between the two variables. Second, this study evaluated the minimum JSW of the PF joint with an average patellar cartilage T2 value. While we often found focal increases of T2 values on individual image slices, statistical analysis using an average T2 value of the patella diminished the effect of focal increases of T2 values on the total patellar T2 value. A regional specific analysis of T2 values with JSW may result in significant findings. Our results indicate that measurement of patello-femoral minimum JSW may not be used as a surrogate for average patellar cartilage T2 values. Further work is needed to investigate the relationship of patellar cartilage T2 values to standard clinical assessment of PF OA.

REFERENCES


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![Figure 1: Scatter plot of T2 values of patellar cartilage by OA stage verses joint space width measurements of the patello-femoral joint.](image_url)