T2 Values of Patellar Cartilage in Subjects with Osteoarthritis

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INTRODUCTION

Standard in-vivo assessment of osteoarthritis (OA) is routinely performed by examining radiographic and magnetic resonance images (MRI). On radiographs, the grade of OA is assigned by examining the joint space width, presence and size of osteophytes and the gross joint morphology. Analysis of MRI can localize cartilage lesions that are not seen on radiographs. To date, limited quantitative analysis of MRI images has been performed to diagnose OA in human joints.

Recently, MRI T_2 values of articular cartilage have been proposed as a biomarker for OA [1]. T_2 values are dependent upon local water content and collagen fiber orientation in cartilage – both indicative of the presence of OA. Limited studies have been performed in-vivo comparing cartilage T_2 values across varying degrees of OA [2]. Relating T_2 values of cartilage to a standard clinical OA staging method would be beneficial for determining the clinical applicability of this new technique. The purpose of this study was to quantify differences of T_2 values of patellar cartilage across different stages of OA as defined by radiological examination.

METHODS

Subjects: Following IRB approval with informed consent, 110 consecutive subjects (55.8 ± 11 y.o., 29 M, 81 F) were enrolled in the study. The height and weight of subjects were recorded to calculate body mass index (BMI).

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. 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 x 12cm, in-plane resolution = 0.49mm x 0.49mm.

Data Analysis: Individuals were grouped as Normal (BMI=19-25), Overweight (BMI=25-30), Obese (BMI=30-40) and Morbidly Obese (BMI=40+). Radiographs were graded for patello-femoral 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. Patellar cartilage was manually segmented on each image. 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 image was discarded in calculating T_2 values to increase T_2 accuracy [3]. Pixels with T_2 values greater than 200 ms were considered outliers and were excluded from statistical analysis [4]. An average T_2 value generated from all analyzed pixels of each patella was used for statistical analysis. One-way ANOVAs were performed to determine any differences of patellar cartilage T_2 values across the KL stages of OA and by level of BMI. Statistical significance was set at $p<0.05$.

RESULTS

No significant differences of T_2 values were found across KL stages of OA ($p=0.35$, Table 1). T_2 values did differ by BMI classification ($p<0.0001$, Figure 1). T_2 values of Normal subjects were significantly lower than other BMI groups. Obese subjects had T_2 values similar to Overweight and Morbidly Obese subjects, but Morbidly Obese subjects had higher T_2 values than Overweight subjects. A weak but significant correlation ($r=0.304$, $p<0.0001$) was found between average T_2 value and BMI.

DISCUSSION

This study demonstrated a lack of differences of T_2 values across OA stages. This finding is primarily due to two factors. First, the KL staging of a joint assigns an OA stage based on the overall radiographic appearance of a joint. Therefore, the KL staging will detect advanced stages of OA rather than the onset of the disease. If there is a rapid change of T_2 values during the onset of OA and not at later stages, then we would not expect to find differences using a KL protocol for staging OA. Second, an average T_2 value of each patella was used for statistical analysis. This would diminish the effect of focal increases of T_2 values on the total patella T_2 value. Thus, while T_2 values have been shown to correlate very well with histological examination of degraded cartilage [2], enough of the articular surface might need to be fibrillated during OA to increase the average patellar T_2 value.

Also of interest is the positive correlation of T_2 with BMI. Previous investigators have studied the gait characteristics of subjects with knee OA and a high BMI [5]. The individuals made *functional* changes during their gait cycle to compensate for the symptoms of OA. The results of this present study indicate that individuals with high BMI also have *structural* changes occurring at the joint as indicated by the increased T_2 values [1].

T_2 mapping of patellar cartilage may provide a non-invasive method for accurate staging of OA within the knee. However, additional studies evaluating different methods of T_2 mapping may highlight the benefits and sensitivity of T_2 mapping in a clinical setting.

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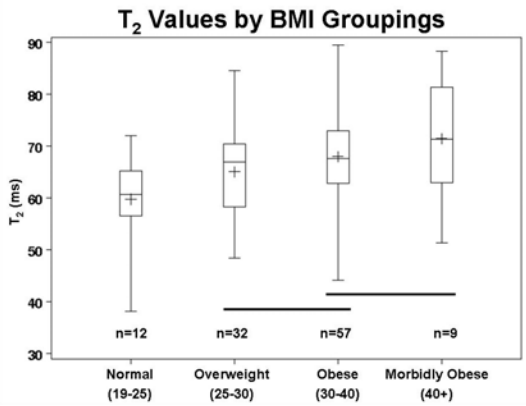

Figure 1. Box-plot of T_2 values of patellar cartilage by BMI classification. Bars indicate similar groups.

Table 1. T_2 Values of Patellar Cartilage at Each Stage of OA

Kellgren-Lawrence OA Stage	n	T2 Values (ms) (Ave. ± Std.Dev.)
0	39	65.5 ± 6.1
1	87	66.2 ± 9.4
2	62	67.8 ± 10.0
3	25	65.5 ± 8.8
4	4	73.1 ± 2.6