Collagen in native, undigested human patella cartilage is predicted by a combination of T2 and T1ρ relaxation times

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Introduction: Several quantitative MRI techniques [1-6] have been proposed to detect proteoglycan and collagen in cartilage. In several studies the efficacy of a quantitative MRI method was demonstrated by intentional chemical digestion of proteoglycans or collagen. Studies that chemically degraded collagen with collagenase found both increased [1] and decreased [2] T2 relaxation times. In spite of extensive research the clinical utility of quantitative MRI methods in the physiological assessment of native cartilage remains unclear [7]. In this study, we make a preliminary evaluation of the clinical potential of two quantitative MRI methods: T2 and T1ρ. Our goal is to determine if T2 and T1ρ correlate with collagen content across the spectrum of native, undigested human cartilage.

Methods: Native patellae from 19 human cadavers ranging in age from 20 to 90 years (median = 56) were used in this study. Specimens were stored in PBS with protease-inhibitors to minimize the natural degradation process. The specimens were not subjected to intentional chemical digestion of the proteoglycans or collagen. Specimens were imaged in a transmit/receive wrist coil at 3T. A multi-slice, multi-echo 3D sequence was used to acquire T1ρ (spin locking frequency 500Hz) [8] and T2 images with 3.0mm thick slices, 0mm spacing, 10cm field of view and five identical echo/spin-lock times: 7, 21, 36, 65 and 124ms. The fifth echo was not used to determine the T2 relaxation time because the signal in the cartilage was not significantly different from the noise. After imaging, 3mm plugs were removed from across the cartilage surface and an hydroxyproline assay was used to measure the collagen content [9]. If an ROI contained an air bubble or other artifact, the data point was removed from the data set; this resulted in a total of 67 data points.

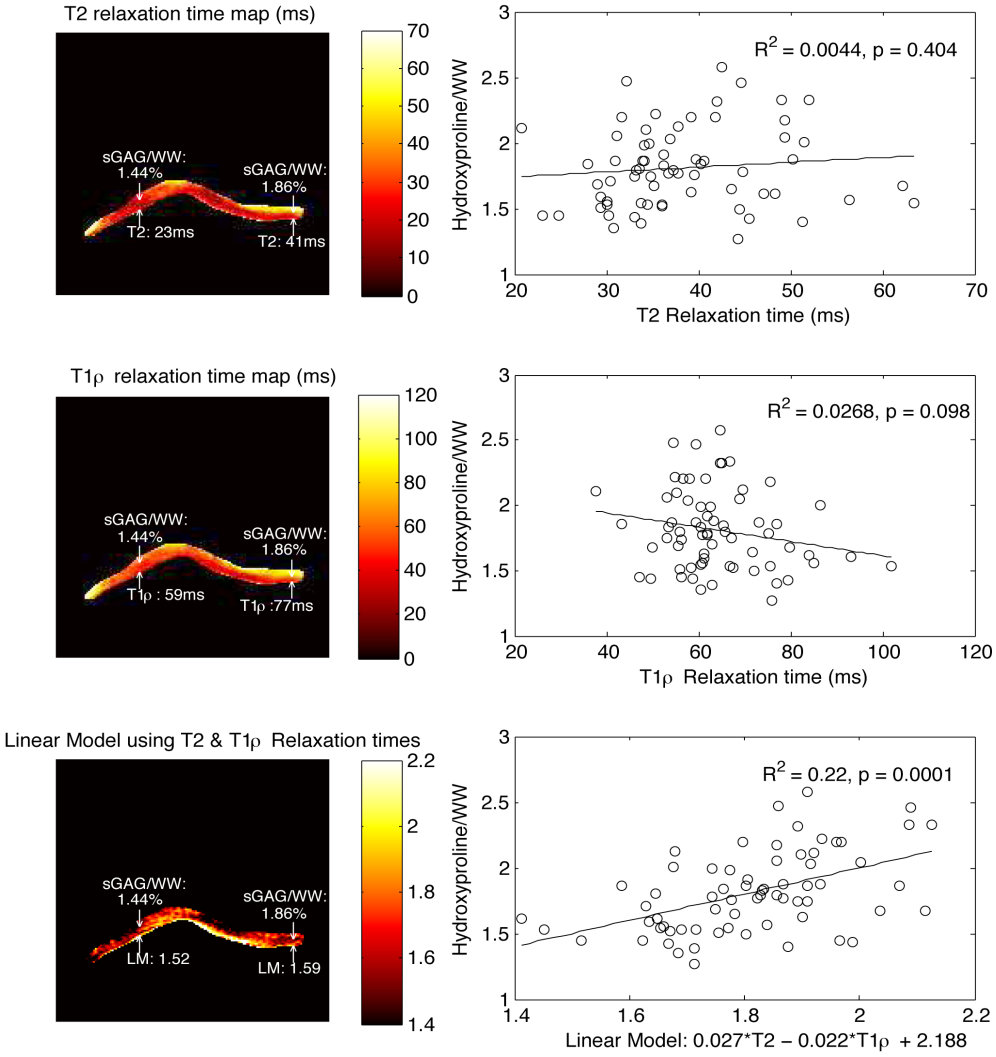

Figure 1: T2, T1ρ and combined maps from a single slice of a natural, undigested human patella specimen (left). Scatter plots showing the correlations between T2, T1ρ and combined model with hydroxyproline/WW, a measure of collagen content (right). The combined linear model (0.027*T2 – 0.022*T1ρ + 2.188) has the strongest correlation with collagen content.

Results: On the left side of Figure 1 are the T2, T1ρ and combined model images from a single slice of a patella specimen. On the right side of Figure 1 are the scatter plots showing the correlation between imaging parameter and hydroxyproline normalized by wet weight. The correlation coefficients are given on the plots; the linear combination model of T2 and T1ρ had the strongest correlation (r^2=0.22; p=0.0001).

Discussion: Combining T2 and T1ρ relaxation time in a linear regression model allowed us to predict the naturally occurring collagen content variation of these human patella cartilage specimens. The correlation values shown here are lower than those determined in studies that used chemical methods to deplete collagen. In order to assess the clinical potential of quantitative MRI, it is important to determine the efficacy of these methods when predicting the variation of cartilage macromolecules in native human cartilage.

References: [1] Wayne JS et al, Radiology 2003. [2] Nieminen MT et al, MRM 2000. [3] Wheaton AJ et al, MRM 2005. [4] Bashir A et al, MRM 1999. [5] Shapiro EM et al, MRM 2002. [6] Ling W, et al, PNAS 2008. [7] Gray ML, JBJS 2009. [8] Li et al, MRM 2008. [9] Bergman I et al, Clin Chim Acta 1970.