Radial Measurement of T1 and T2 in Normal Patellar Cartilage Using DESPOT1 and DESPOT2

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Introduction: Prior *in vitro* and *in vivo* investigations of the T1 and T2 relaxations times in articular cartilage[1, 2] have associated changes in these parameters with proteoglycan loss and disruption of the collagen framework. Histomorphologically, articular cartilage can be divided into three uncalcified zones. It has been shown that T1 and T2 values vary throughout articular cartilage, however, values have been derived from large regions of interest and profiles are generated from a select number of projections[2,3]. To evaluate variations in relaxation times across depth in the entire tissue, we propose an analysis approach that measures patellar cartilage T1 and T2 values along radial projections (normal to the contour of the patella) in combination with DESPOT1 and DESPOT2.

Methods: High-resolution, three-dimensional T1 and T2 maps of the patellar cartilage were acquired at 1.5T from 6 healthy and asymptomatic volunteers (3 male, 3 female, mean age = 24 years) using the rapid DESPOT1 (TE/TR = 3.1ms/14.4ms, α = 4° and 15°, BW = ±7.14 kHz) and DESPOT2 (TE/TR = 2.4ms/4.8ms, α = 15° and 75°, BW = ±62.5 kHz) methods[4] and a custom built dual element, receive-only coil designed for patellar imaging. To investigate the T1 and T2 profiles along radial projections, the Canny edge detection method[5] was first employed to detect the articular surface of the patellar cartilage and the osteochondral boundary. The vector normal to the boney boundary was then computed at each voxel along the contour and T1 and T2 values were obtained through the tissue depth along this normal trajectory. Using cubic interpolation, the individual profiles were normalized to a common unit length and averaged. This procedure (shown in Figure 1) is repeated over multiple slices through the volume and the results averaged.

Results: Average T1 and T2 profiles through the patellar cartilage of 6 healthy volunteers are shown in Figure 2 with good agreement noted between the individual profiles. The profiles, derived from 50 to 60 projections, represent the average over 20 to 26 contiguous slices from the T1 and T2 map volumes. In both T1 and T2, an overall increase is noted moving from the deep cartilage to the articular surface with three distinct T1 and T2 zones; one with reduced values located adjacent to the patella, a middle region with linearly increasing values, and a superficial zone with increased values. T1 values located in this region also appear to be more variable between subjects in comparison to the other zones. These results clearly indicate the structured inhomogeneity of T1 and T2 throughout the cartilage layer, making it difficult to interpret mean values from large regions of interest.

Discussion / Conclusions: Here we have demonstrated an alternative approach for investigating T1 and T2 values throughout the patellar cartilage by using the combination of DESPOT1/DESPOT2 and radial projections normal to the cartilage surface. Results of this analysis confirm the existence of T1 and T2 gradients through the cartilage and suggest three discrete zones [Figure 2]. Histological comparison is required to determine if these regions correspond to the radial, transitional, and superficial zones. Based on the method's success in evaluating normal cartilage, this technique and the high-resolution, rapid DESPOT methods can be implemented to evaluate osteoarthritic changes in the T1 and T2 gradients across depth throughout the articular cartilage.

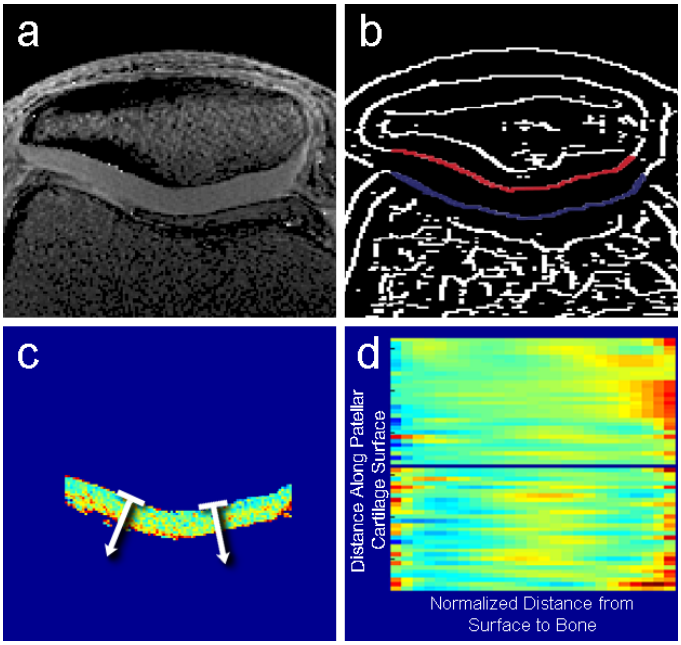

Figure 1: Analysis method for radial projections. From a raw T1 map (a), Canny edge detection is used to determine upper and lower edges of patellar cartilage (b) yielding a segmented cartilage layer (c). T1 and T2 profiles through the cartilage are then calculated through the layer along the trajectory normal to the articular surface and normalized to a standard length (d).

References:

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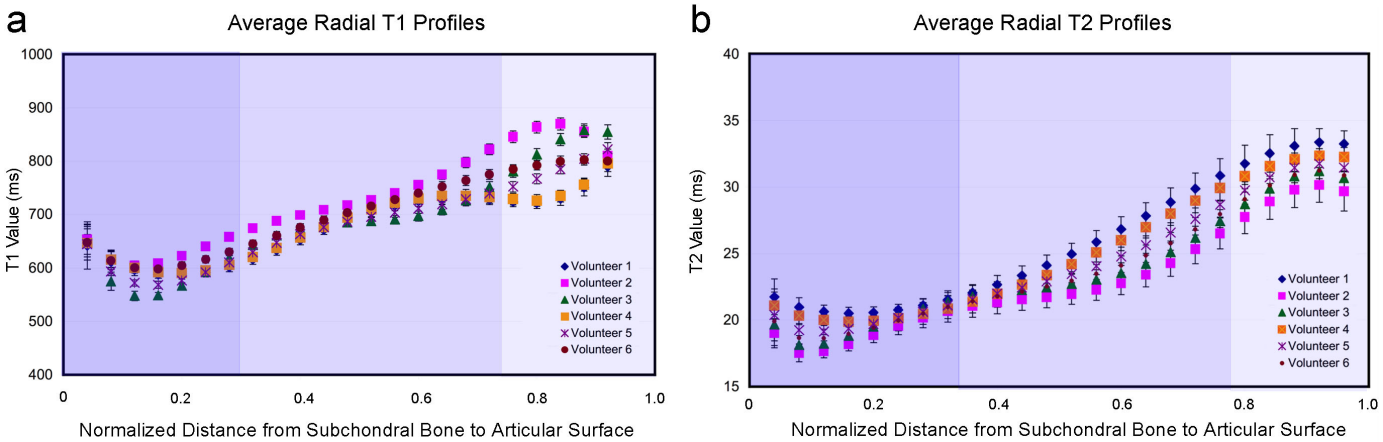

Figure 2: Average T1 (a) and T2 (b) profiles through the patellar cartilage of 6 normal volunteers. Points represent the mean values calculated from 20 to 26 contiguous slices and error bars represent the standard deviation of the measurements. Shaded regions illustrate three discrete zones.