Two-component T2* mapping on knee patients: Preliminary results

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INTRODUCTION

Two-component T_2* mapping has the capability to separate short-T_2* components from long-T_2* components. The separated components then have two independent characteristic parameters of time constant and intensity fraction, leading to an increase in freedom that may help detect subtle changes of the T_2* components in a two-dimensional space. Short-T_2* relaxation has potential to detect disruption of well-organized collagen fibers in cartilage (1), which is an early sign of cartilage degeneration in the knee (2). Presented here is a preliminary study on a small group of patients with knee injuries, showing the potential of short-T_2* relaxation to be more sensitive to cartilage degeneration than long-T_2* relaxation or the simplified single-component T_2* relaxation.

METHODS AND EXPERIMENTS

Methods. Clinical arthroscopy grading was employed to rank disruption of collagen fibers in cartilage as severity of the collagen fiber disruption correlates with degree of cartilage degeneration (3). Selected cartilage regions were graded arthroscopically and two-component T_2* mapping was performed on matching image regions. The relation between the arthroscopic grades and maps of T_2* relaxation was examined. ***Experiments.*** Six adult patients with ACL injury were selected and assigned into three groups based on the arthroscopic assessment of their cartilage (0-hard, 1-soft, and 2-superficial damage), with two patients in each group. Under an IRB-approved protocol, T_2*-weighted MR images were acquired at 11 echo times (TEs) between 0.6-40 ms, on a 3T clinical MRI scanner (Magnetom Trio Tim, Siemens Medical Solutions, Erlangen, Germany) with an 8-channel knee coil (Invivo Inc., Gainesville, FL). An ultrashort echo time (UTE) pulse sequence AWSOS was used, with the acquisition parameters of TR/θ=80ms/30º, 60 slices at thickness 2mm, FOV= 140mm, matrix size=256, resolution=0.55mm, in-plane spirals=24, and spiral readout Ts=11.52ms. The total acquisition time for the 11 TE-images was 22 min. ***T_2* mapping.*** A customer-developed, NNLS-based, automatic iterative algorithm was employed to perform two-component T_2* mapping on a pixel-by-pixel basis. An averaging in a region of 3×3 pixels was applied to the maps of short-/long-T_2* relaxation time and intensity fraction a_{21} or a_{22}, but not applied to the single-component T_2* map.

RESULTS AND DISCUSSION

In Figure 1 are maps of short- and long-T_2* time (T_2*short or T_2*long) and component intensity fraction (a_{21} or a_{22}), and single-component T_2* time (T_2*single). In firm and relatively healthy cartilage (top row) the layers are clearly visible from cartilage surface to the deep on the maps of short-T_2* relaxation time and intensity fraction. They are also visible on the maps of long-T_2* relaxation and single T_2* relaxation. Progressive degeneration demonstrates greater progressive loss of laminae in short-T_2* relaxation (time and fraction) than in long-T_2* relaxation or single T_2* time, with short-T_2* time decreasing but intensity fraction increasing. Quantification of these changes among the patients studied is shown in Figure 2. Short-T_2* relaxation grouped the cartilages in the order of their arthroscopic grades (G0, G1 or G2) but the long-T_2* relaxation or the single T_2* time did not (i.e., mixing the scope grades). This finding suggests that short-T_2* relaxation may be more sensitive to severity of cartilage degeneration. However, the sample size of this study was too small (only two patients in each grade) to permit assessment of statistical significance of these findings.

REFERENCES [1] Qian Y, *et al*. MRM 2010; 64:1426-31. [2] Blumenkrantz G, *et al*. Eur Cell Mater 2007; 13:75-86. [3] Williams A, *et al*. OC 2010; 18:539-46.

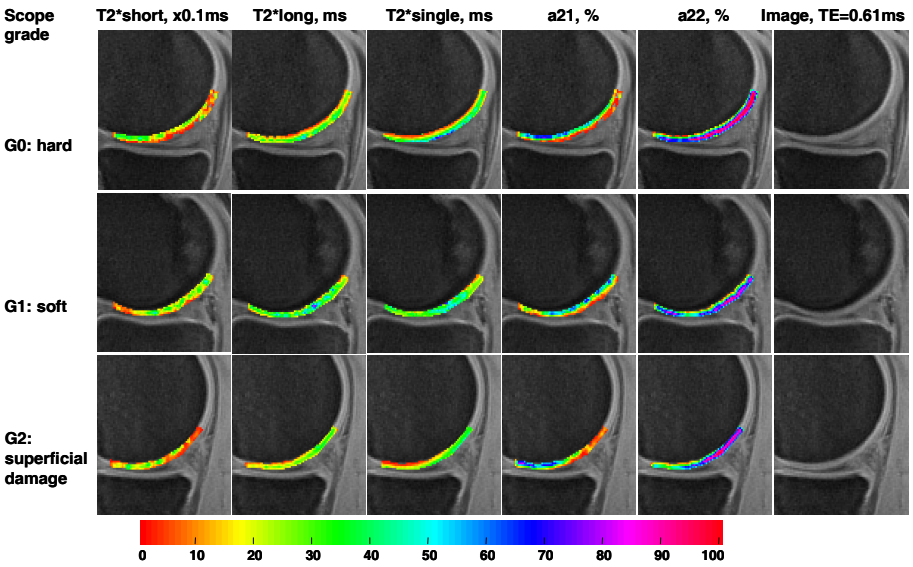

Fig.1. Maps of two-component T_2* relaxation in the knee cartilages of patients.

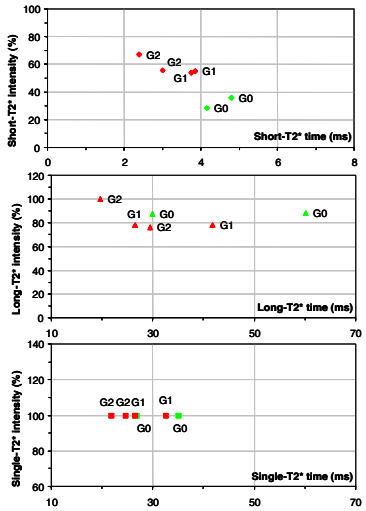

Fig. 2. The mean values of two-component T_2* mapping in the region of interest shown in Fig. 1.