In Vivo T2 Mapping and dGEMRIC of Human Articular Cartilage Repair after Autologous Chondrocyte Transplantation

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INTRODUCTION

T2 relaxation time mapping and dGEMRIC are promising techniques for assessing the macromolecular status of articular cartilage in disease and after cartilage repair. Previously dGEMRIC has been used to characterize the repair tissue after autologous chondrocyte transplantation (ACT) in human subjects [1,2]. In the present study both T2 mapping and dGEMRIC were used to evaluate cartilage repair after ACT surgery.

METHODS

Ten patients (4 male, 6 female, age 35±9 years) with local cartilage defects in the knee joint underwent ACT surgery [3]. The study plan was approved by the local ethical committee. MRI measurements at 1.5T (GE Signa 1.5T, Milwaukee, WI) were conducted at 10 to 15 months after the surgery. For T2 measurements of the femoral joint surfaces, a single slice fast spin echo sequence (TR=2000ms, ETL=9, six TEs between 18 and 110ms, 3-mm slice, in-plane resolution of 0.31mm) was used in the sagittal plane. For dGEMRIC measurements, an intravenous injection of 0.2mM/kg Gd-DTPA(2-) was given. After a 2-hour delay the T1 relaxation time was determined from a series of inversion recovery fast spin echo measurements (TR=1800ms, ETL=9, TE=17ms, seven TIs between 50 and 1650ms, 3-mm slice, in-plane resolution of 0.31mm). For T1 and T2 maps equal-sized regions of interest (area 6-18mm^2, mean 11±3mm^2) were manually localized at the center of the graft and from two control sites adjacent to the graft (anterior and posterior). The control values were averaged, however, for two patients only one control ROI was defined due to the location of the graft.

RESULTS

The ACT repair tissue filled the lesion sites (Fig. 1). The repair tissue mostly lacked the laminar T2 appearance typical to normal cartilage. The T2 relaxation times for the ACT grafts were significantly higher as compared to control tissue (Wilcoxon signed ranks test, $p<0.01$). The average T2 relaxation time was 60±10ms and 50±7ms for graft and control tissue, respectively. T2 values of the graft ranged between -4% (lower) to +55% (higher) as compared to control tissue (Fig. 2). dGEMRIC values for repair and control tissue were 421±105ms and 468±77ms, respectively, and the difference was not statistically significant ($p<0.17$). dGEMRIC values for grafts ranged between -46% and +44% as compared to control. T2 and dGEMRIC values in repair or control tissue did not show a statistically significant correlation (graft: $r=0.30$, $p<0.39$; control: $r=0.04$, $p<0.92$).

DISCUSSION

Previous studies have shown that ACT repair tissue can reach dGEMRIC values comparable to normal cartilage, indicative of proteoglycan replenishment [1,2]. In the present study, there was considerable variation in the dGEMRIC values for repair and control tissue, however, this difference was not statistically significant. T2 relaxation time values, however, were significantly higher for repair tissue as compared to control. T2 relaxation time of cartilage is typically short due to effective dipolar interaction of collagen-associated water, and alters as a function of the collagen fibril arrangement in the static magnetic field [4]. Earlier, an increase in T2 was found in native bovine cartilage after specific enzymatic degradation of tissue collagen [5]. In the present study, the significantly higher T2 values in ACT repair tissue and the lack of laminar appearance would therefore suggest that the collagen network organization in the repair tissue is different than in normal cartilage.

A recent study using an animal model for spontaneous cartilage repair showed significantly shorter T2 relaxation times for fibrous repair tissue as compared to control tissue [6]. This is contrary to the present findings and gives rise to speculation on the different nature of repair tissue produced by different surgical procedures that may be discerned using T2 mapping. The present results point out that dGEMRIC and T2 can provide complementary information on engineered cartilage, and a more comprehensive characterization is possible by combining these two techniques.

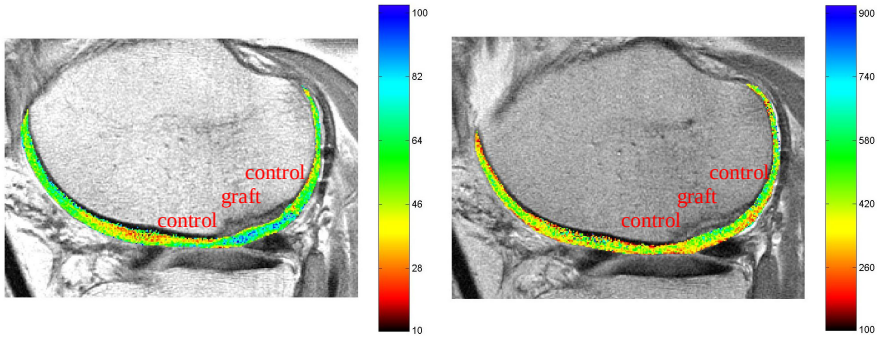

Fig. 1: T2 relaxation time map (left) and dGEMRIC map (right) for a patient at 10 months after autologous chondrocyte transplantation in the medial femoral condyle. The graft shows a higher T2 relaxation time than the surrounding tissue, while the graft has dGEMRIC values comparable to normal cartilage.

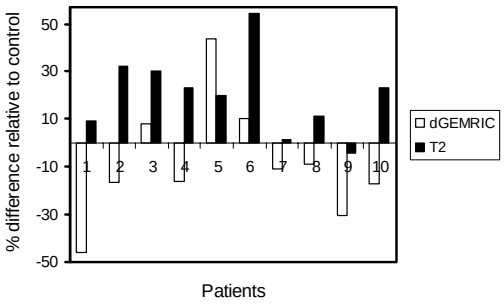

Fig. 2: For 10 patients, the percentual difference of T2 relaxation time and dGEMRIC values in ACT grafts as compared to surrounding cartilage.

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