Evaluation of Cartilage Repair with T2 and dGEMRIC Up to Two Years After Autologous Chondrocyte Transplantation

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INTRODUCTION

Autologous chondrocyte transplantation (ACT) is a method for repairing focal chondral defects. Clinical MRI has not been able to predict the histological features of grafts [1]. It is important to find a non-invasive means to assess the graft tissue after an operation. Previously, dGEMRIC [2-4] and dGEMRIC combined with T2 relaxation time mapping [5] have been used to characterize the tissue after ACT. In the present study, combined dGEMRIC and T2 mapping were used to follow ACT repair up to two years after the operation.

METHODS

A total of 11 patients (7 male, 4 female) underwent ACT surgery, one of the patients having two separate lesions repaired. The study was approved by the local ethics committee. MRI measurements of the femoral joint surfaces were conducted at three timepoints (5±1, 12±2 and 23±1 months) for each patient at 1.5 T. For T2 measurements, 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 measured in the sagittal and coronal planes. 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 single slice 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) at sagittal and coronal planes. Regions of interest (ROIs) were manually segmented at the graft and control site. The mean dGEMRIC index and T2 was determined for the superficial and deep halves of the tissue as well as for full thickness of cartilage, i.e. bulk value. In the sagittal direction the control ROIs were measured from adjacent cartilage with signal intensity resembling normal cartilage. If the graft was in the posterior part of the joint the control was on its anterior side and *vice versa*. In the coronal plane the control ROIs were located at the opposite condyle.

The relationships between graft and control tissue, the difference between superficial and deep ROIs in the two imaging planes were analyzed using the Wilcoxon Signed Ranks test. The trends between the three time points were analyzed using the Friedman test.

RESULTS

T2 relaxation time showed a trend towards longer values at the graft as compared to control (Table 1). This was true for all graft ROIs (superficial, deep, bulk) at all timepoints in the sagittal plane and for bulk and superficial T2 values in the coronal plane at 5 months.

Superficial and deep graft T2 values showed no statistical difference at any timepoint or plane. The T2 values of the superficial control tissue were significantly higher than those of the deep control tissue at 5 months in the sagittal planes and 12 months in both planes.

Differences between graft and control dGEMRIC values were observed in superficial values at 5 months and superficial and bulk values at 23 months, all measured in the coronal plane.

Superficial graft dGEMRIC values were significantly shorter than deep values at the 5 month measurement in both planes and at 23 month measurement in the sagittal plane. No difference in dGEMRIC values was shown between superficial and deep control tissue.

A decreasing trend in the deep graft T2 relaxation time was observed from 5 to 23 months in the coronal plane ($p = 0.04$). No other temporal trends were found in either T2 or dGEMRIC.

Table 1: T2 and dGEMRIC relaxation time values at different time-points for graft and control tissue in sagittal and coronal views.

		ROI Depth	T2 (ms)		dGEMRIC (ms)	
			Graft	Control	Graft	Control
5±1 months	**Sagittal**	Deep	64± 9 [a]	44±10 [b]	473± 73 [b]	429±137
		Superficial	66±15 [a]	52± 9 [b]	411± 94 [b]	387± 96
		Bulk	65±12 [a]	48±10	442± 88	408±118
	Coronal	Deep	65±11	50±19	448± 61 [b]	463± 89
		Superficial	70±12 [a]	52±14	401± 52 [a, b]	461± 71
		Bulk	67±11 [a]	51±16	425± 60	462± 78
12±2 months	**Sagittal**	Deep	59±10 [a]	41± 6 [b]	464±119	464±102
		Superficial	62±11 [a]	49±10 [b]	414±100	437±105
		Bulk	60±10 [a]	45± 9	439±110	451±102
	Coronal	Deep	57±11	47±14 [b]	397±100	432±127
		Superficial	61± 8	57±11 [b]	416± 63	434± 48
		Bulk	59±10	52±13	406± 82	433± 93
23±1 months	**Sagittal**	Deep	59±16 [a]	44± 9	487±117 [b]	427± 96
		Superficial	63±12 [a]	49±10	422± 96 [b]	414± 94
		Bulk	61±14 [a]	47±10	455±110	421± 93
	Coronal	Deep	54± 9	51±10	430± 97	497± 40
		Superficial	54±11	56±18	390± 36 [a]	484±103
		Bulk	54±10	53±14	410± 73 [a]	490± 76

[a] Statistically significant difference when compared to control at the same time point ($p \leq 0.05$).
[b] Statistically significant difference between deep and superficial ROI tissue at the same time point ($p \leq 0.05$).

DISCUSSION

T2 relaxation time of the ACT grafts was typically higher than that of control tissue at all timepoints. Further, superficial and deep graft T2 values were similar up to 23 months. The higher T2 values for superficial control tissue are in line with findings reported previously [6]. Present findings suggest that up to 23 months ACT repair tissue has a general lack of the preferential collagen arrangement that is observed in normal adult cartilage. However, the shortening trend in deep cartilage T2 in one imaging plane suggests that some maturational changes in ACT grafts occur in the course of time.

The dGEMRIC values at the grafts were frequently similar to normal-appearing control tissue. These findings are in agreement with a previous study reporting that five out of six grafts regained normal (>80% of control) T1 values under a 12 month period [2]. Differences between superficial and deep graft dGEMRIC values were observed at 5 and 23 months suggesting depth-wise variations in the PG content of ACT grafts.

The present results suggest that the collagen orientation of ACT graft tissue has not regained the 3-D architecture typical to articular cartilage at two years, and that PG replenishment to normal levels may take place during the first six months after the operation and significant changes in PG levels may not occur thereafter.

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