T2 relaxation time reveals early cartilage changes after one-year and two-year follow-up in subjects at risk for osteoarthritis: data from Osteoarthritis Initiative

A. Herronen[1], E. Lammentausta[2], R. O. Ojala[3], and M. T. Nieminen[1,2]

[1]Department of Medical Technology, University of Oulu, Oulu, Finland, [2]Department of Diagnostic Radiology, Oulu University Hospital, [3]Deaconess Institute of Oulu

INTRODUCTION

Osteoarthritis (OA) is a chronic, slowly progressing musculoskeletal disorder characterized by loss of articular cartilage. Several factors increase the risk of OA, including age, overweight, knee injury, race, sex, and genome [1]. Currently OA is diagnosed based on clinical symptoms and joint space narrowing (JSN) assessed from X-ray images. Unfortunately, at the point of JSN, the development of the disease is already at an advanced, irreversible stage. Therefore it is justifiable to search for biomarkers capable of detecting OA at an early stage. T2 relaxation time of cartilage is reported to provide indirect information about the integrity of the collagen network and water content [2, 3]. T2 relaxation could serve as a sensitive biomarker to detect early degenerative changes in cartilage prior to symptoms or JSN, and aid in understanding the disease development. The aim of this study was to investigate the longitudinal change in T2 relaxation time in femoral cartilage of subjects without radiographic changes but at risk for OA.

MATERIALS AND METHODS

From the OAI incidence cohort, caucasian subjects with data from baseline, 1-year follow-up and 2-years follow-up time points were selected. This totaled to forty-one subjects (17 male, 24 female; mean age 58±9 years; body mass index (BMI) 25.7±3.7 kg/m²). By definition, the subjects of the incidence cohort did not have radiographic changes (Kellgren-Lawrence (KL) grade 0) or regular knee pain at baseline, and had one or more of the following risk factors for knee OA: knee symptoms in a native knee in the past 12 months, overweight, knee injury, knee surgery, family history, Heberben's nodes, work or free time activity including repetitive knee bending and age 70-79 [4]. It was confirmed that KL grade remained zero at all time points, leading to the exclusion of two subjects. For T2 relaxation time measurements, multi-echo spin-echo measurements were conducted (TR 2700 ms, 7 TE's between 10 and 70 ms, FOV 12 cm, matrix size 384x384) obtained at 3T (Siemens Magnetom Trio, Siemens Medical Imaging, Erlangen, Germany) from right knees at baseline, 1-year follow-up and 2-years follow-up. T2 relaxation maps were computed and further analyzed with an in-house Matlab application. A single slice from the center of each condyle was selected. Three regions from the primary weight-bearing cartilage and surrounding areas were manually segmented and further divided into deep, superficial and bulk (full-thickness) ROIs to determine the mean T2 values for each ROI. The non-parametric Wilcoxon-test was used to compare unilateral femoral T2 values at different time points (baseline, 1-year and 2-year follow-up).

RESULTS

Compared to baseline, a statistically significant elongation of T2 relaxation time was observed at 1-year and 2-year follow-up in both lateral and medial condyles. In particular, T2 was elevated at the primary weight-bearing cartilage (pCF, Figure 1). An increasing trend of elevated T2 was observed at most ROIs, although the change was not statistically significant at all ROIs. The most pronounced changes occurred from baseline to 1-year follow-up. Between the 1-year and 2-year follow-up time-point there was an increasing trend, however, the changes were statistically significant only at two regions of interest.

DISCUSSION

Previously, an elevation of T2 relaxation time has been associated with cartilage degeneration [2, 3]. For the first time, the present results show an increase in T2 relaxation time in subjects without radiographic joint changes but with known risks for OA development. Particularly in the primary weight-bearing region of the femur, T2 relaxation time increased significantly in all ROIs. The present results suggest that T2 mapping can serve as a sensitive tool to detect early osteoarthritic cartilage changes that occur prior to the onset of the clinical symptoms. Since the KL-grade of study subjects remained unchanged T2 relaxation time mapping appears more sensitive than radiography to reveal changes in cartilage status. Furthermore, T2 mapping provides information on the biochemical status of articular cartilage while radiography or MR morphometry are merely measures of cartilage quantity. The present results are very promising in view of predicting OA in subjects at risk for the disease.

REFERENCES

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Table 1. T2 relaxation times at three time points and p-values separately for each ROI (**p<0.01, *p<0.05). Prefixes "b", "s" and "d" refer to bulk, superficial and deep T2 values, respectively.

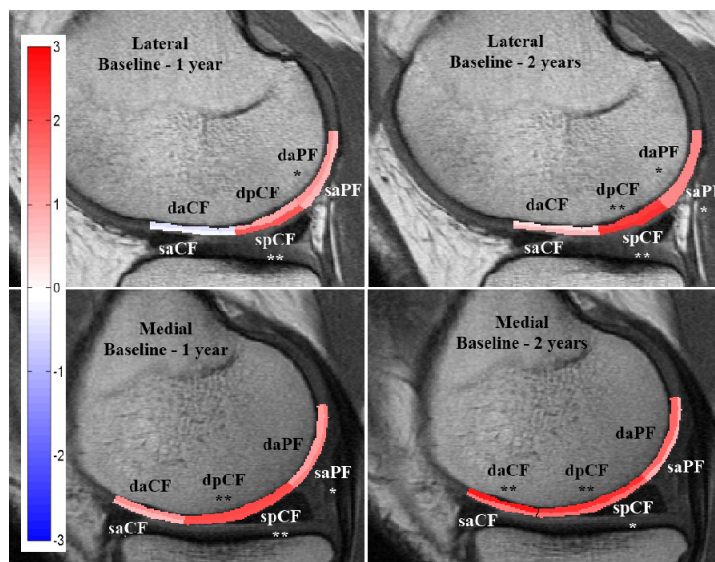|		T2 relaxation times			p-values		
		Baseline	1-year	2-year	BL-1y	BL-2y	1y-2y
Lateral	baCF	41.1±3.6	41.0±3.2	41.9±3.6	0.707	0.162	0.066
	bpCF	47.5±5.0	48.8±5.0	49.5±5.6	0.004**	0.002**	0.197
	baPF	47.1±4.0	48.3±2.8	48.8±3.8	0.023*	0.003**	0.405
	saCF	48.7±4.7	48.5±4.4	49.6±4.5	0.741	0.254	0.216
	spCF	55.1±5.5	57.2±5.0	57.6±5.8	0.008**	0.002**	0.591
	saPF	52.4±4.9	53.2±4.3	53.9±5.0	0.188	0.04*	0.354
	daCF	34.2±4.2	33.8±4.1	34.6±4.7	0.334	0.707	0.216
	dpCF	40.4±5.7	41.4±5.9	42.7±6.6	0.17	0.002**	0.047*
	daPF	42.4±4.2	43.7±3.3	43.9±3.8	0.018*	0.011*	0.545
Medial	baCF	43.4±4.3	44.6±5.0	45.5±4.5	0.082	0.007**	0.226
	bpCF	48.1±4.8	50.3±4.8	50.1±5.0	0.002**	0.014*	0.717
	baPF	53.7±4.7	55.1±4.3	55.1±4.0	0.032*	0.136	0.925
	saCF	49.9±5.9	50.8±6.3	51.5±6.2	0.425	0.147	0.809
	spCF	56.4±5.1	58.6±4.6	58.2±5.7	0.002**	0.045*	0.519
	saPF	58.7±6.5	60.2±5.2	59.7±5.2	0.034*	0.411	0.638
	daCF	36.8±4.7	38.2±5.6	39.7±4.9	0.197	0.002**	0.047*
	dpCF	40.1±5.4	42.3±6.1	42.6±6.1	0.009**	0.01**	0.610
	daPF	48.9±4.5	50.2±5.0	50.8±4.9	0.176	0.053	0.436

Fig.1. Change in T2 relaxation time (ms) from baseline to one/two-year follow-up at various ROIs. Statistical significance of change is indicated (**p<0.01, *p<0.05).