Differences in T2 values of knee cartilage measured with different scanners

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INTRODUCTION

T2 relaxation time of articular cartilage has been reported to reflect the orientation and concentration of collagen fibrils [1-2], and dGEMRIC (delayed gadolinium-enhanced MRI of cartilage) technique has been developed to assess GAG content of articular cartilage [3]. T2 relaxation time of articular cartilage has been applied in clinical practice using scanners from various manufacturers and using different pulse sequences [4-6]. To be able to compare the results obtained with different scanners and sequences, the variability in T2 of scanners within and across manufacturers should be investigated. The aim for the present study was to evaluate differences in T2 relaxation time quantitation between different scanners using phantoms and a healthy volunteer. Additionally, T1 of the phantoms was measured.

METHODS

A set of phantoms with T2 relaxation times ranging from approximately 40 to 100 ms and T1 relaxation times from 400 to 1200 ms consisting of agarose and nickel nitrate were prepared [7]. For the in vivo part, the right knee of one healthy volunteer was imaged in axial orientation. Four 1.5 T MR devices were used: a Siemens Symphony scanner and three GE HDx scanners, one updated from Echospeed, one updated from TwinSpeed and one was a native HDx installation in a mobile unit. T1 and T2 relaxation times were measured on three scanners using as similar protocol as possible. For T1 measurements single-slice inversion recovery spin echo sequence was used with TR of 3320 ms, TE of 10 ms and TI's of 50, 10, 200, 400, 800, 1600 and 3200 ms and NEX of 1. For T2 measurements, multislice multiecho spin echo sequence was used with TR of 2000 ms, eight TE's between approximately 10 and 80 ms and NEX of 1. A 256x256 matrix and FOV of 12 cm were used for all measurements with GE, and for Siemens, the FOV was 14 cm. This difference was due to the parallel imaging utilized with GE sequence enabling the use of smaller FOV. The same multislice multiecho sequence was used for T2 measurements of the healthy volunteer. Three axial images were obtained with spacing of 6 mm. Regions of interest covering bulk, deep and superficial cartilage were manually segmented. The patellar cartilage was divided into medial and lateral facet from the apex, and both facets were further divided into two equally sized regions (Figure 1). The regions within different slices were treated as independent regions of interest. To evaluate the significance of the differences between the scanners, the Wilcoxon signed rank test was used.

RESULTS

For phantom measurements, T2 relaxation times between the three GE scanners showed no significant differences, whereas T2 values on the Siemens Symphony were significantly different from all of the GE scanners ($p<0.05$). The relaxation times are shown in Figure 2. A statistically significant difference ($p<0.05$) in T1 values was observed between all scanners, except for between GE EchoSpeed HDx and mobile HDx and between GE TwinSpeed HDx and Siemens Symphony.
For patellar cartilage, a statistically significant difference was observed in T2 values between Siemens Symphony and all three GE scanners for bulk ($p<0.01$), superficial ($p<0.05$) and deep ($p<0.002$) regions of interest. There were no significant differences in T2 between different GE scanners.

DISCUSSION

The current results display significant difference in T2 and T1 values obtained between scanners from different manufacturers. Variation in T1 was not dependent on scanner manufacturer, while T2 showed a clear dependence on the manufacturer. The differences in T2s is likely due to differences in pulse sequences rather than manufacturer-dependent reasons. Due to stimulated echoes, multi-echo sequences have been reported to produce higher T2 values than single echo spin echo sequences [3]. The pulse sequence used in GE scanners is optimized for cartilage T2 mapping with modified slice profile [4], whereas the sequence used for Siemens is a conventional spin-echo multi-echo sequence. It has been shown for phantoms that T2 measurement with similar scanners using similar sequences are comparable, but the imaging conditions such as imaging room temperature and RF coil uniformity has to be controlled [8]. In addition, the small variation in patient positioning, slice localization and segmentation add some uncertainty to the measurements.

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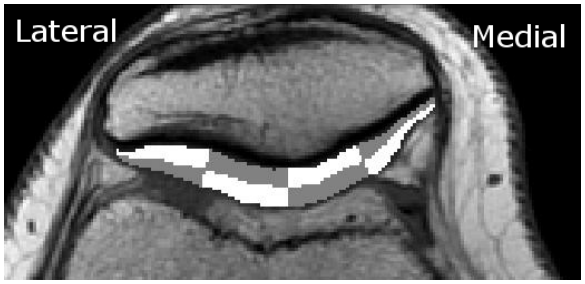

Figure 1. The regions of interest segmented into patellar cartilage.

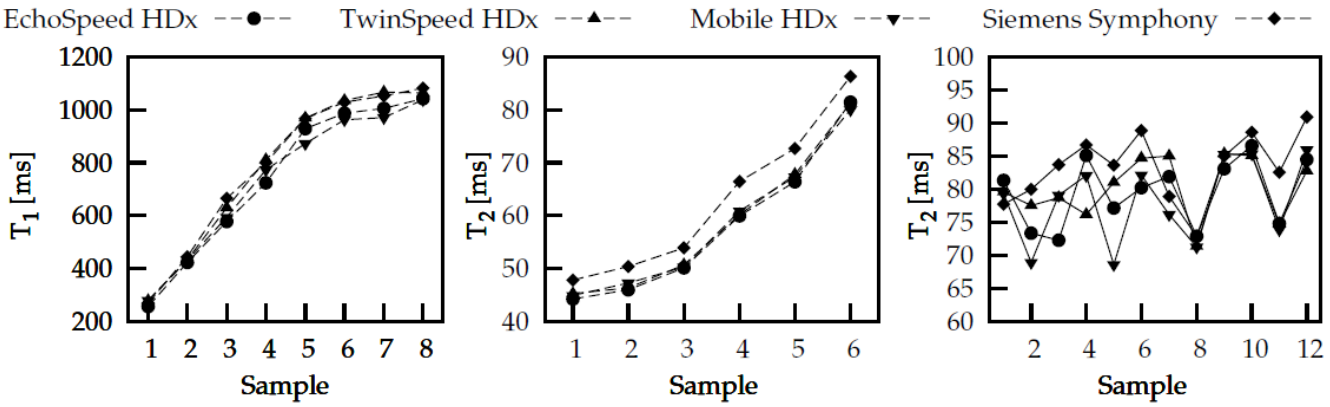

Figure 2. Left: T1 values for the gel phantom set. Middle: T2 values for the gel phantom set. Right: T2 values for patellar cartilage of healthy volunteer, superficial regions of interest. The deep and bulk regions show similar behaviour. All regions in three slices are treated as independent regions of interest.