A COMPARISON OF T2* MEASURED BY A VARIABLE ECHO TIME SEQUENCE AT 3 AND 7T IN CONNECTIVE TISSUES IN THE EX VIVO KNEES

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Target audience

Musculoskeletal radiologists, physicists developing sequences for imaging of fast relaxing tissues

Introduction

The imaging of short-relaxing tissues in MSK MRI has become very popular recently with improved hardware and software development. Modern sequences, such as 2D-UTE [1], 3D-UTE [2] or AWSOS [3], allow the acquisition of a signal directly from highly organized, rapidly relaxing tissues. A variable echo time sequence (vTE) allows imaging of these tissues with high resolution in a relatively short scan time[4]. The aim of this study was to compare T_2* values from connective tissues in the knee, measured by vTE, in order to validate reproducibility and accuracy of the method.

Materials and Methods Six *ex vivo* human knees were used in the study (mean age, 76 +/- 7 years). The *ex vivo* knees were examined with a 3T whole-body Siemens system (Siemens Medical, Erlangen, Germany) and a 7T investigational whole-body system (Siemens Healthcare, Erlangen Germany) using similar 8-channel knee coils (In vivo, USA). T_2* maps were calculated from an isotropic, 3D, multi-echo vTE-sequence using ten sequentially shifted echo times (TE =0.75, 3.51, 5.87, 8.23, 10.6, 12.96, 15.33, 17.69, 20.06, 22.42 ms), and a mono-exponential fit least-squares analysis performed in IDL 6.3 (Interactive Data Language, Research Systems, Inc, Boulder, CO). The fitting function was $S=S0 \times \exp(-TE/T_2^*)+O$ where O was estimated from the TE=0.75ms image noise. T_2* values were manually evaluated using an ROI analysis in these tissues: lateral (L) and medial (M) meniscus; anterior (A) and posterior (P) horn; patellar tendon; and cartilage (three segments in the femoral cartilage), as depicted in Figure 1. Images were obtained in the sagittal plane, but also, a reconstruction in the coronal plane was performed. Evaluation was done by physicist with seven years of experience, in consensus with radiologist with 25 years of experience. To calculate inter- and intra-observer variability, coefficients of variation (CV, %) were calculated from another evaluation done by a physicist with 15 years of experience. T_2* values were compared between 3 and 7 Tesla using a paired t-test with equal variances. P-values less than 0.05 were considered statistically significant. All statistics were calculated in SPSS v 16.0 for Windows.

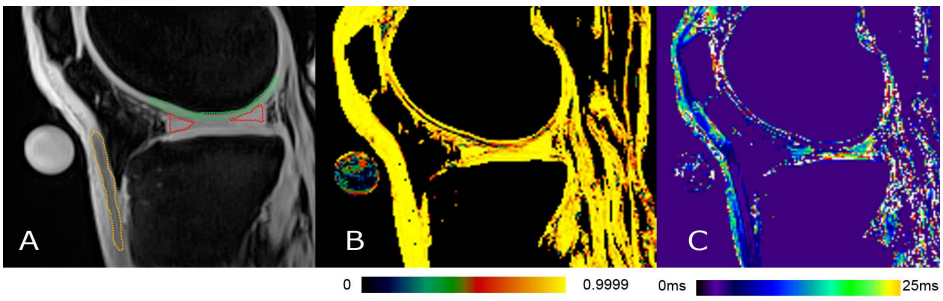

Figure 1. A: vTE image acquired at TE=0.75ms used for the segmentation of menisci, patellar tendon, and cartilage (medial meniscus displayed, lateral meniscus was evaluated on a different slice); B: R^2 map (precision of fit). T_2* map calculated by mono-exponential fitting on a pixel-by-pixel basis; C: corresponding T2* map.

Results Intra-observer variation was in a range of 5.28 to 8.89%. Inter-observer variation was in the range of 6.78 to 13.41%. The summary of all CV is listed in Table 1. The T_2* values were lower at 7T, as expected. Due to increased local inhomogeneities at higher field strength, the dephasing is much faster [5]. The mean T_2* in menisci (total) was 13.18±2.27ms at 3T and 11.22±1.63ms at 7T. The mean T_2* in cartilage (total) was 31.98±8.99ms at 3T and 19.48±3.39 at 7T. The mean T_2* in the patellar tendon was 6.22±1.04 at 3T and 3.01±0.78 at 7 Tesla. However, the statistically different means were observed only for cartilage. The summary of all T_2* values, as well as p-values of statistical differences, are shown in Table 2.

Intra-observer variability CV[%]	
meniscus M	7.84
meniscus L	5.28
cartilage	10.24
tendon	9.70
Inter-observer variability CV[%]	
meniscus M	6.78
meniscus L	8.12
cartilage	13.41
tendon	11.79

Table 1. CV for intra- and inter-observer variability

	3T	7T	p
meniscus MA	13.54	11.95	0.90
meniscus MP	10.67	8.85	0.96
meniscus LA	12.43	12.52	0.77
meniscus LP	16.11	11.55	0.26
cartilage 1	21.77	23.07	0.74
cartilage 2	35.45	19.03	**0.04**
cartilage 3	38.71	16.33	**0.035**
patellar tendon	6.21	3.00	0.15

Table 2.T_2* in ms, p-values from paired t-test with equal variances

Discussion

This study showed the feasibility of vTE images to calculate T_2* maps with superior accuracy (mean R^2 was 0.998) in relatively short scan times (~12 min 16 sec). The advantage of vTE over radial or spiral sequences is the elimination of unwanted artifacts, such as image blurring or sensitivity to incorrect gradient timing. However, it seems that one-stop shopping is still problematic, since the range of echo times did not allow the calculation of T2* maps for all tissues with the same accuracy (especially the cartilage, with a relatively high T_2*).

Conclusion vTE has a great potential in the clinical environment, not only for morphological imaging, but also for quantitative assessment of rapidly relaxing tissues.

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