**T2 and T2* Relaxometry in the Meniscus using a Novel, Rapid Multi-Echo Steady State Sequence**

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**Introduction:** Imaging the meniscus is challenging due to its short T2 relaxation time and highly organized collagen architecture. The meniscus plays an important role in osteoarthritis and it is becoming increasingly clear that detecting early degeneration, before gross morphological changes occur, is essential for evaluating disease progression and treatments. T2 and T2* relaxation time can be used to detect early meniscal degeneration1-3; however, lengthy scans are required (10 to 20 minutes per measure). In this work we show that a novel multiecho steady-state sequence can be used to estimate T2 and T2* relaxation times in the meniscus *simultaneously in under 5 minutes.*

**Methods:** A quantitative “DESS” sequence4,5 was modified to include multiple gradient echo readouts (“MEDESS”, Figure 1). In this sequence, the S* signal has the usual T2* decay; however, the S’ signal has T2 decay with rephasing, similar to gradient-echo spin echo methods5,6. In TR1, we have included two S* and two S’ signals. This sequence is then repeated with an offset of ΔTE in TR2. Interleaving TR1 and TR2, we have four S’ and four S’ signals within one acquisition. T2* relaxation time can be estimated by fitting a monoexponential decay curve to the four S’ signals. T2 relaxation time can be estimated using S* and S’ signal pairs (ie: 1 & 8, 2 & 7) and a signal model (T2 = (TE8+1 - (TR + TE8+1)) / log (S8 / S1))1. This signal model does not consider the mixed T2/T2* contrast present in the S* signal which causes an underestimation of T2. Extended phase graph (EPG) simulations can be used to correct the estimate (assuming T2=800 ms, based on previous laboratory measurements).

We compared estimates of T2, corrected T2 and T2* relaxation times obtained using the MEDESS sequence to standard measures in four cadaver knee specimens. All scans were acquired in the sagittal plane (matrix: 256 x 256, field of view: 20 cm, slice thickness: 3 mm). 2D spin echo (SE) was used as the standard measure of T2 (eight scans, TE: 10 to 24 ms, TR: 1 s, total time: 35 minutes). A 3D multi-echo GRE (MEGRE) was the standard measure of T2* (eight echoes, TE: 2 to 20 ms, TR: 100 ms, FA: 30°, time: 19 minutes). Monoexponential curve fits were used for both standard measures. Differences between MEDESS and standard measures were described as the root mean square (RMS) absolute difference for a single slice.

**Results:** T2 and T2* relaxation times estimated using MEDESS were similar to standard measures (Figures 2 and 3); the RMS absolute difference was 3.5, 2.9 and 2.0 ms, for T2, corrected T2 and T2*, respectively. MEDESS consistently underestimated the T2 and T2* relaxation times (Figure 2); this was true for mean differences and pixel-wise differences (Figure 3).

**Discussion:** The EPG-based correction provided a modest improvement to the T2 estimate. However, since the variation within the maps was consistent between the methods, the observed bias is not of great concern; it will still be possible to detect changes over time and between patient groups. This novel sequence, can be used for estimation of meniscal T2 and T2* relaxation times in under 5 minutes, about a 75% time reduction compared to acquiring both of these measures with other techniques.


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