

A Fast Clinically Viable 3D T2 Mapping Technique

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Introduction: Though T2 mapping is desirable in many clinical applications it is not preferred due to the long acquisition times associated with the conventional Spin Echo (SE) sequence. Turbo or fast SE sequences though considerably faster than spin echo sequences are not suitable for T2 mapping due to the stimulated echoes associated with them. Here we present an alternative technique based on DESS (Double echo steady state) to produce T2 maps.

Background: In a conventional DESS sequence the FISP and PSIF components are combined to create a unique contrast (1, 2) that is found to be desirable for orthopedic applications, however in this experiment the contrast in the individual echoes has been leveraged differently by creating a ratio of the echoes to develop a T2 map based on the following relationship:

$$T_2 = \frac{2T_R}{\ln\left(\frac{PSIF}{FISP}\right)}$$

This relationship is only valid at flip-angles close to 90°. For flip-angles less than 90° the calculated T2 has a dependence upon the flip-angle and the T1 of the voxel.

Method: Eight vials were filled with varying concentrations (0.01-1%) of MION-47 (Center for Molecular Imaging Research, Boston MA). These vials were taped around a standard water phantom to isolate them from each other so that their susceptibilities do not interfere with each other and imaged on a 3T clinical scanner with a 12 channel head array coil both with a 2D SE sequence with 6 echoes (TR=3s, TE= 13-92 ms) and with a 3D DESS sequence (TR=40-20ms, TE=4.6-25ms and FA=90°). The size of the acquired volume was maintained to be identical (8 slices, 5mm slice thickness, 200x200 FOV) for both sequences. Two averages were acquired to reduce the noise in the calculated maps.

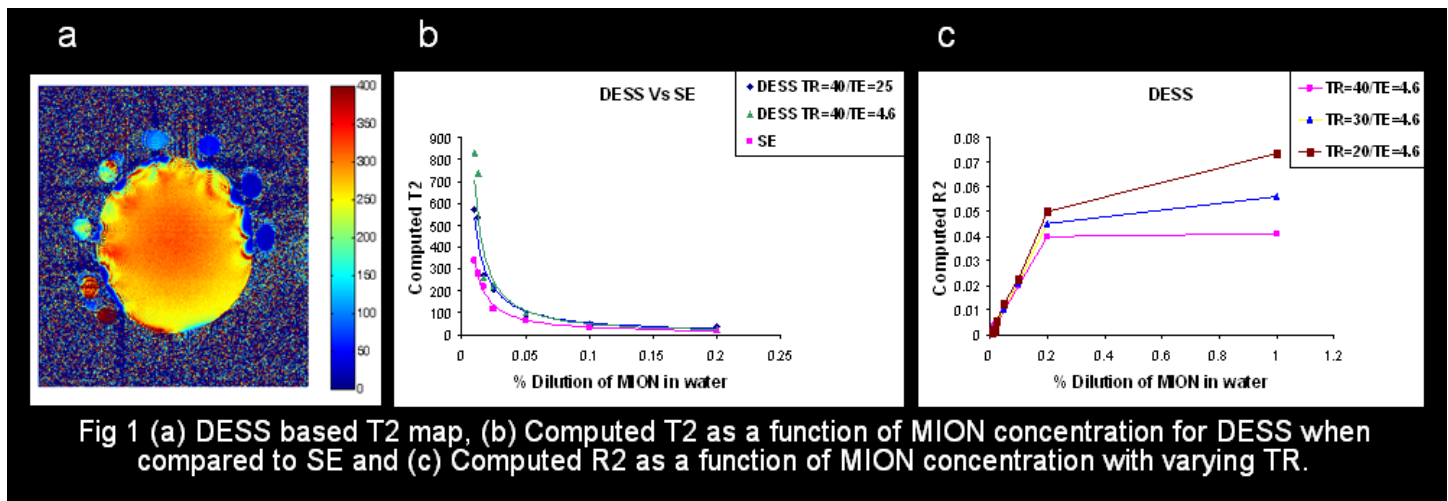


Fig 1 (a) DESS based T2 map, (b) Computed T2 as a function of MION concentration for DESS when compared to SE and (c) Computed R2 as a function of MION concentration with varying TR.

Discussion and Results: The total acquisition time for the SE sequence was around 16 minutes while that of the DESS was around 2 minutes for the two averages. The computed T2 map for the DESS is shown in fig 1a. The apparent T2 values as a function of MION dilution is shown in the two graphs (fig 1b and fig 1c). From fig 1b it can be seen that while the decays are identical with both sequences the apparent T2 values seem to be amplified at lower concentrations of MION with the DESS sequence. The amplification increases with decreased TE (factor of 1.5). From fig 1c it can be seen that apparent R2 increases (T2 decreases) with decreasing TR, hence when imaging with a long TR and low TE it would be possible to increase the sensitivity of susceptibility agents like MION considerably. Also from fig 1.c it can be seen that the linear relationship for R2 is only valid at lower concentrations of MION (<2%). Saturation occurs beyond 1% MION concentration. This property was also found to be valid for the SE sequence.

Conclusion: We have demonstrated here that by leveraging a 3D DESS sequence it is not only possible to reduce the acquisition time for T2 mapping by a factor of 8, but also increase T2 sensitivity by a factor of 1.6, especially at lower concentrations of MION which can be useful in many applications like stem cell tracking or lymph node imaging with susceptibility agents.

References:

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2. P. A. Hardy, M. P. Recht, D. Piraino, D. Thomasson, Optimization of a Dual Echo in the Steady State (DESS) Free-Precession Sequence for Imaging Cartilage, JMIR 1996 6:321&335