Myocardial $T_{1\rho}$ Mapping at 3T Using a Novel Spin-Locking Technique

B. E. Northrup[1,2], X. He[1], K. S. McCommis[1], and J. Zheng[1]

[1]Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri, United States, [2]Dartmouth Medical School, Hanover / Lebanon, New Hampshire, United States

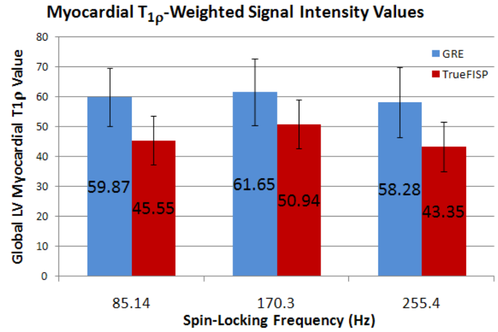

Figure 1. Myocardial $T_{1\rho}$ values from GRE and TrueFISP sequences at varying spin-locking frequencies.

Purpose

Recent studies have shown that T_1 relaxation in the rotating frame of reference ($T_{1\rho}$) can be used to differentiate normal myocardium from that which has suffered irreversible ischemic damage [1,2]. Additionally, $T_{1\rho}$-weighted imaging has been used to measure cerebral blood flow and oxygenation with contrast agents, such as $H_2{}^{17}O$, via $T_{1\rho}$ mapping techniques [3,4]. However, the application of $T_{1\rho}$ mapping techniques to *in vivo* cardiac MR imaging has been limited by sequence lengths that render acquisition in a single breath-hold impractical. The purpose of this study is to develop and evaluate a new spin-locking technique on a clinical 3T MRI system capable of acquiring myocardial $T_{1\rho}$-maps in a single breath-hold.

Methods

Five volunteer subjects between the ages of 20 and 30 with no known history of cardiovascular disease were imaged on a 3.0-T (Siemens, Trio) MRI system with a phased-array cardiac coil. The sequence consisted of spin-locking preparation pulses and either segmented gradient-recalled echo (GRE) or segmented balanced gradient-echo (TrueFISP) acquisitions. In order to compensate for B0 and B1 field imperfections [5,6], the spin-locking preparation pulse consisted of a hard excitation pulse (x axis), followed by a half duration of spin-locking pulse (y axis), a refocusing pulse (y axis), another half duration of spin-locking pulse (-y axis), and a hard pulse (-x axis) to return magnetizations to the z-axis. A composite refocusing pulse was used to reduce the artifacts from the imperfect 180° flip. Images corresponding to different spin-locking durations were acquired in an interleaved fashion. All 5 subjects completed three ECG-gated GRE sequences (with spin-lock frequencies of 85.14, 170.3, and 255.4 Hz) during uninterrupted breath-hold (~ 20 sec). Four subjects also completed three ECG-gated TrueFISP sequences (with identical spin-lock frequencies) during a breath-hold. Four spin-locking durations (TSL), 20, 45, 70, and 90 msec, were used in a single scan. A mid-ventricular short-axis section was imaged with an in-plane resolution of 2 x 1 mm^2 and a section thickness of 8 mm. A ring-shaped ROI was drawn on the entire myocardial ring of the left ventricle (LV). This was used to calculate $T_{1\rho}$ -weighted signal intensity and signal-to-noise ratio (SNR). $T_{1\rho}$ mapping was then obtained [3].

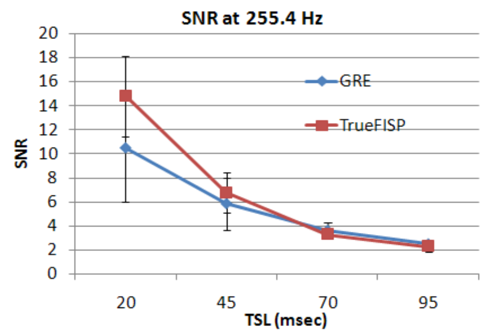

Figure 2. Myocardial SNR at increasing TSL times.

Results

The $T_{1\rho}$ values for the two sequences are shown in Figure 1. A comparison of the myocardial $T_{1\rho}$ values between GRE and TrueFISP sequences at spin-lock frequencies of 85.14, 170.3, and 255.4 Hz (*P* values of 0.05, 0.15, and 0.07, respectively) suggested a trend towards a significant difference. Additionally, no differences were observed among the three spin-locking frequencies, which is consistent with other reports [7]. A typical signal decay curve with increasing TSL duration is shown in Figure 2. Figure 3 demonstrates calculated myocardial $T_{1\rho}$ maps that show relatively uniform $T_{1\rho}$ distributions.

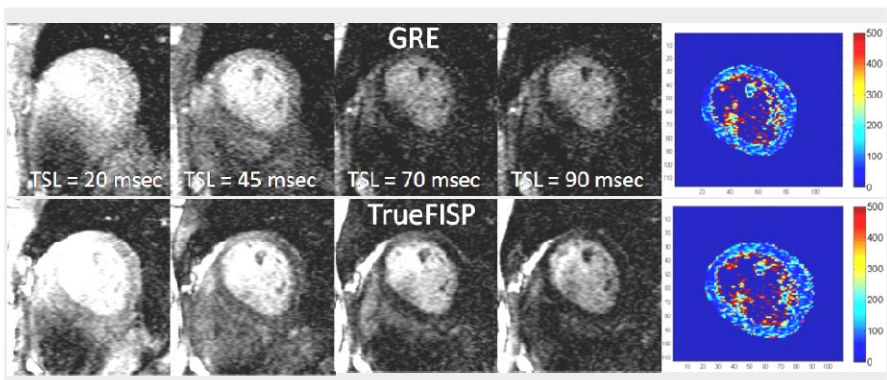

Figure 3. $T_{1\rho}$-weighted GRE (top) and TrueFISP (bottom) images and corresponding T1p maps. Little intra scan motion artifacts were observed. Higher SNR was shown in TrueFISP images, but slightly lower $T_{1\rho}$ was obtained. The scale bar unit is msec.

Conclusions

Using this spin-locking pulse sequence, a series of $T_{1\rho}$-weighted images can be acquired in a single breath-hold, allowing for single-section $T_{1\rho}$ mapping. The difference in the myocardial $T_{1\rho}$ values between the GRE and TrueFISP sequences may be due to the sensitivity of TrueFISP sequence to the residual field inhomogeneity of the 3T system. This study provided baseline myocardial $T_{1\rho}$ data in normal subjects, which will be useful for the evaluation of myocardial function in various disease states with $T_{1\rho}$ techniques in the future.

References

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