Quantification of Delayed Enhancement Image Contrast at 3T using Serial T1 Measurements

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Introduction: The spin-lattice relaxation time (T1) is known to increase from 1.5T to 3T, which may cause changes in image contrast in delayed contrast enhancement (DCE) imaging. DCE exploits the large difference in myocardium and infarct T1 values post-contrast to distinguish non-viable tissue. The difference in T1's at 1.5T is significant, but it is not certain whether the difference is similar at 3T. Current experience at 3T has revealed a significant increase in image contrast between infarct tissue and normal myocardium [1], but the underlying T1 effects have not been studied fully. Since the relationship between tissue T1s at both field strengths (B_0) lends insight into the utility of specific pulse sequences, it is feasible to predict the potential change in image contrast at 3T, and determine the advantages or disadvantages of delayed enhancement imaging at high field.

Purpose: Using known T1 values of myocardium and infarct tissue at 1.5T and 3T, the focus of this study was to determine the theoretical signal difference (contrast) expected at 3T as a function of time after contrast injection.

Methods: The study protocol was approved by the institution's internal review board, and informed consent was obtained from all 7 subjects. T1 measurements were performed post-contrast (0.2mmol/kg Gd-DTPA-BMA) every 5mins for 30mins at 1.5T (Philips Intera) and 3T (Philips Intera, or Siemens Trio) on seven individuals with known myocardial infarction [2]. The measurement technique was a single-breath hold (<17s) FLASH-EPI "Look-Locker" (LL) technique programmed to acquire at least 46 cardiac frames over 2 heartbeats using a temporal resolution of approximately 40ms. An additional heartbeat was skipped to ensure full T1 relaxation. Each image frame was acquired with 128x96 pixels (recon to 256) over a 300mm^2 FOV, using TR/TE/flip = 7.6/4.1/10 with 5 EPI lines per TR and 5 TRs per temporal frame. T1 was determined from a multi-parameter fit to the LL data [3] using manually drawn ROIs placed in myocardium and infarct tissue. Using the average measured T1 data for each time point at 1.5T and 3T, a "T1-contrast" metric was mathematically determined by *calculating the absolute difference between myocardium and infarct longitudinal magnetizations (M_z) in a simulated inversion recovery (IR) experiment*, at the point where myocardium M_z is zero (nulled). The simulated IR experiment accounted for common imaging parameters (M_0=1, TR=5ms, flip=25deg, RR interval=1700ms, phase encodings/RR=25, linear ordering). The simulated parameters were kept consistent between B_0, except for M_0, which was estimated in this study to be higher at 3T by 33% relative to 1.5T (M_0=1.33). All results for T1-contrast were normalized relative to M_0 at 1.5T, and compared against time post-contrast.

Results: An example of the simulated IR experiment for calculating T1-contrast is shown in Figure 1. The measured T1 values were consistently longer at 3T for both normal myocardium and infarct tissue [2], which caused increased signal saturation. However,since M_0 was greater at 3T, the calculated T1-contrast was generally greater at 3T. This trend was consistent over time post-contrast, as shown in Figure 2, except for one time point (t=15min) that exhibited less T1-contrast at 3T (this was likely due to a low T1-ratio between myocardium and infarct at 3T at this time point). Another point illustrated in Figure 2 is that the time to peak T1 contrast is delayed at 3T compared to 1.5T. The peak contrast at 1.5T is in the 15-25 minute range with a drop-off occurring at 30 minutes post-contrast. The peak contrast at 3T appears to be 20-30 minutes post contrast, suggesting that imaging at 3T should occur later after contrast injection compared to 1.5T.

Conclusions: Despite longer T1 values at 3T, a greater equilibrium magnetization (M_0) at 3T is a significant reason there may be higher image contrast in 3T delayed enhancement imaging, as seen with current in-vivo results.

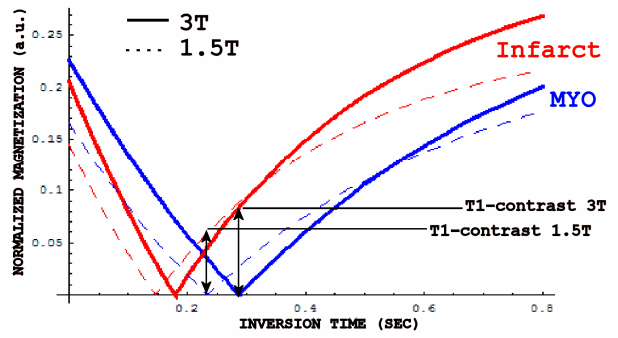

Figure 1. Simulated T1-contrast at t=30min post based on a set of T1 measurements in normal and infracted tissue.

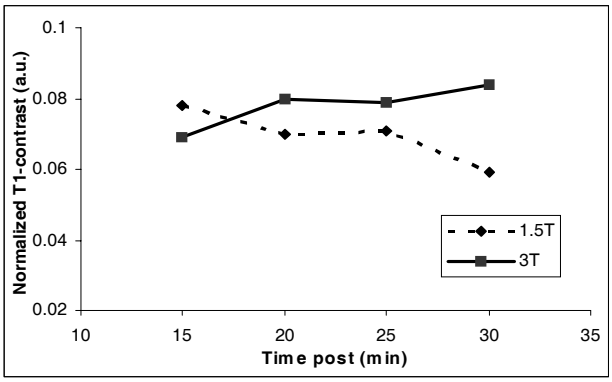

Figure 2. T1-contrast over time post-contrast (15-30min shown only)

References

1. Klumpp et al. Invest Rad 2006:41;661-67
2. Sharma P, et al Proc ISMRM 13
3. Pickup S, et al. JMRI 2004;19:508-512