Eliminating the Impact of Myocardial Lipid Content on Myocardial T1 Mapping Using a Spectrally-Selective Inversion Pulse

Maryam Nezafat[1,2], Sébastien Roujol[2], Jihye Jang[2], Tamer Basha[2], and René M. Botnar[1]

[1]King's College London, London, UK, United Kingdom, [2]Beth Israel Deacons Medical Center and Harvard Medical School, Boston, MA, United States

Introduction: Quantitative T_1 mapping provides myocardial tissue characterization for assessment of interstitial diffuse fibrosis in cardiomyopathies. Various T_1 mapping methods with different acquisition scheme have been proposed to sample the magnetization recovery curve. Presence of fatty infiltration is common in many patients with cardiomyopathies. However, current T_1 measurements are influenced by lipid contents in the myocardium. The aim of our study is to develop a T_1 mapping sequence which eliminates the impact of fat presence on T_1 measurements.

Methods: Fig. 1 shows the schematic of the proposed imaging sequence, which combines Slice-interleaved T_1 (STONE) mapping sequence [1] with a spectrally selective inversion pulse [2]. The spectrally selective inversion pulse inverts only the water spins, while maintaining high signal of fat. Therefore, fat signal is not disturbed during magnetization preparation with an inversion pulse. The fat signal will results in constant bias of the signal in different images with different inversion time, therefore will not impact the T_1 measurements. The proposed imaging sequence was implemented on a 1.5T Philips Achieva scanner equipped with a 32-element cardiac coil. To evaluate the proposed imaging sequence, a phantom was performed using 14 $NiCl_2$ doped agarose vials with different T_1/T_2 times and a bottle of oil. Images were using a typical STONE sequence, first with adiabatic inversion pulse and second with a spectrally-selective inversion pulse. In both acquisitions, gradient-echo imaging was used for the readout. The water selective inversion pulse tuned to the resonance frequency of water. Imaging parameters included: TR/TE/α=2.5/1.29ms/20˚, FOV=240×200 mm^2, voxel size=2×2 mm^2, SENSE factor= 2. In-vivo images were also acquired in patients undergoing clinical cardiac MR. A respiratory navigator, positioned on the right-hemi-diaphragm was used for tracking of respiratory motion. An in-plane motion correction was used to simultaneously estimate a non-rigid motion field and intensity variations, and employs an additional regularization term to constrain the deformation field using automatic feature tracking [3]. Upon registration, voxel-wise curve-fitting using a 2-parameter fit model was used to generate voxel-wise T_2 maps.

Results: Fig. 2 shows example T_1 maps of the phantom acquired with both techniques. **Fig. 3** shows the regression analysis of T_1 of the vials measurements from STONE and STONE+WS pulse. There was no significant difference between the measured T_1 with both methods (p=0.2). **Fig. 4** shows the T_1 maps that were acquires in a patient and the corresponding fat image. The fat on T_1 map appears to have infinity T_1 due to the use of the water selective inversion pulse.

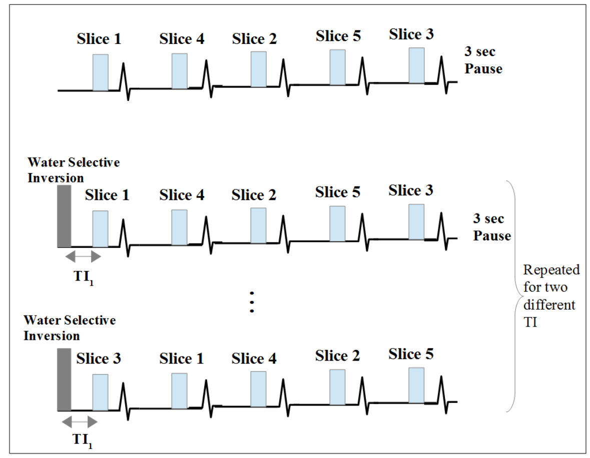

Figure 1: Sequence diagram: First five slices are sampled without an inversion pulse. After a water selective inversion pulse with inversion time TI_1 the same 5 slices are acquired. Subsequently, the slice order is changed to sampling of all 5 heartbeats for each slice. The same experiment then is repeated with an inversion time TI_2. The sequence results in 11 images for each slice with two different inversion times.

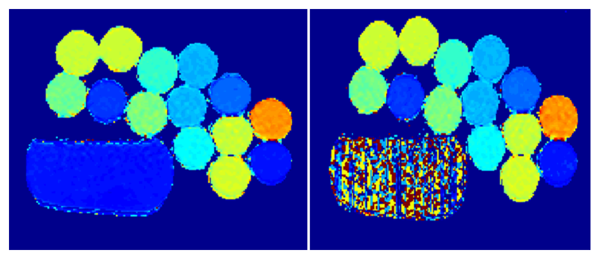

Figure 2: T_1 map of the STONE and STONE with water selective, showing differences in fat vial (the large component).

Conclusions: We demonstrated the feasibility of combining STONE with a water selective inversion pulse to generate T_1 mapping of 5 slices to evaluate the myocardium with minimal SNR penalty. Further studies are needed to evaluate the performance of a water-selective inversion RF pulse on T_1 measurements.

References: [1] Weingartner, MRM, 2014, [2] Havla, JMRI, 2013 ,[3] Roujol, MRM, 2014

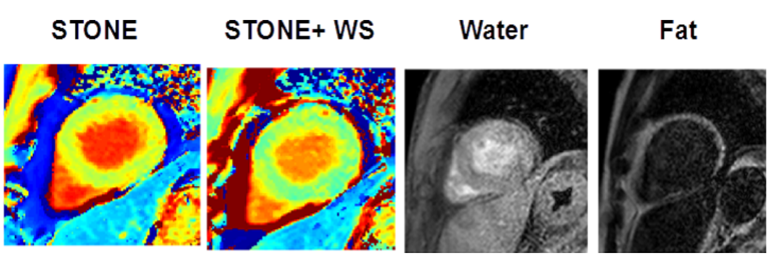

Figure 4: T_1 maps acquired with STONE with adiabatic inversion pulse and with water-selective inversion (STONE+WS). Water and fat images acquired using a conventional Dixon technique are shows as a comparison to demonstrate the regions where T_1 values shows differences due to fat signal.

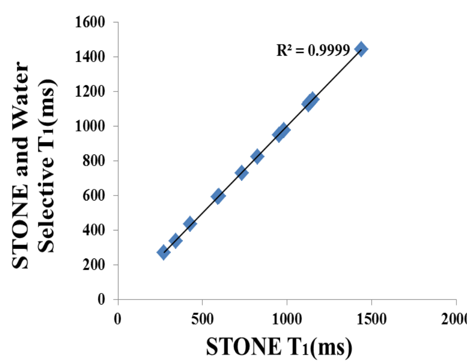

Figure 3: The regression analysis between STONE T_1 with water-selective excitation and conventional adiabatic inversion in phantoms with different T_1.