

WORKSHOP PRESENTATION

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Joint reconstruction of quantitative T_2 and apparent diffusion coefficient (ADC) maps in the heart

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Background

Myocardial tissue characterization with T_2 -weighted imaging is an established technique for evaluating the presence of myocardial edema or iron overload (Kellman, P. *MRM* 2007, Anderson, LJ. *EHJ* 2001). More recently, both T_2 -mapping and apparent diffusion coefficient (ADC) mapping have emerged as quantitative techniques for characterizing edema (or iron overload) and water mobility. The purpose of this work was to develop a framework for the simultaneous recovery of both T_2 and ADC from a single breath-hold acquisition.

Methods

Spin echo (SE) diffusion weighted imaging (DWI) signals are principally governed by the tissue's apparent diffusion coefficient ($ADC=D$) and T_2 relaxation, as well as the sequence's diffusion encoding b-value (b) and echo time (TE): $S(b,TE) = S_0 e^{-bD} e^{-TE/T_2}$. We propose that acquisition of several signals with varying TEs and b-values permits joint reconstruction of both ADC and T_2 maps.

Bloch equation simulations were used to generate signals for a broad range of T_2 (20-70ms) and ADC ($0.1-2.4 \times 10^{-3} \text{mm}^2/\text{s}$) using 10 TEs (17-100 ms) and $b=500 \text{ s/mm}^2$ (TE=60-68ms) along 3 directions. Complex Gaussian noise was added to each signal such that the signal to noise ratio (SNR) of the minimum TE, $b=0$ signal matched that of acquired data (SNR = 38). Reconstructions were performed using linear least-squares on a subset of the simulated data (TE=17,20,30,50,70,100ms) to reflect a feasible *in vivo* acquisition (scan time:18s). Mapping accuracy and precision were determined by the bias

and standard deviation (SD) of T_2 and ADC compared to programmed values.

Images were acquired on a 3.0 T Siemens Skyra system in an *ex vivo* infarcted porcine heart using single-shot SE EPI with TEs and b-values to match simulated parameters. T_2 and ADC maps were jointly reconstructed using linear least-squares from 6 TEs plus 3 DWI sets and compared to: 1) Best-Available T_2 -maps from all 10 TEs; 2) Best-Available ADC maps from DWI (3 directions, 6 averages); 3) Independent T_2 maps from 6 TEs; and 4) Independent ADC maps from 3 DWI averages.

Results

Joint reconstruction of simulated data recovered T_2 and ADC values with bias<1% and SD<10% for a broad range of tissues and even lower for healthy and infarcted myocardium (Table 1).

Reconstructed ADC and T_2 maps from the *ex vivo* acquisition are shown in Figure 1. Joint estimation maps were closer to the Best-Available T_2 or ADC maps than the Independent T_2 or ADC maps alone (Joint Estimation Maps: T_2 -bias=-0.5 %, ADC-bias=-4.8%; Independent Maps: T_2 -bias=-4.1%, ADC-bias=-14.1%).

Conclusions

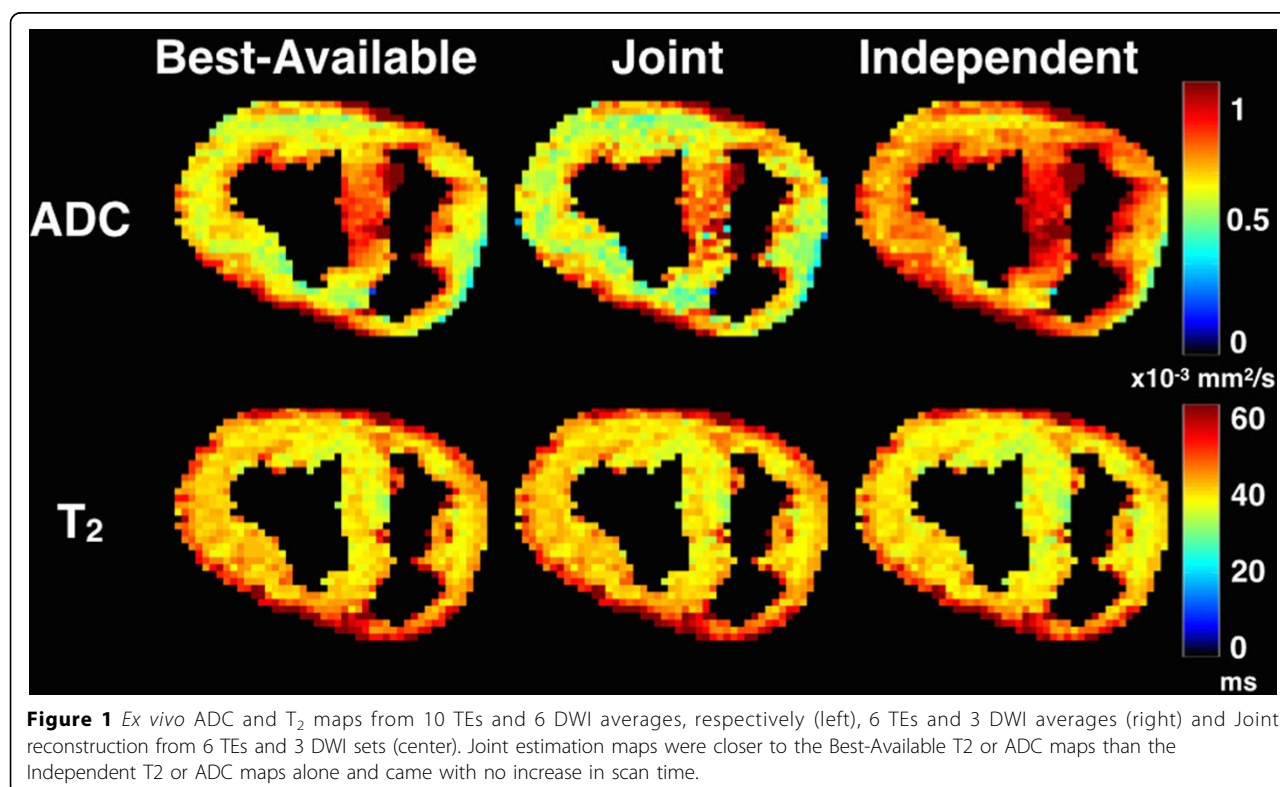
Joint acquisition and estimation of T_2 and ADC maps is feasible in a breath hold and improves quantitative accuracy and precision compared to independent T_2 or ADC mapping. DWI acquisitions typically require multiple averages to improve SNR. Here, varying TE takes the place of signal averaging and permits the reconstruction of a perfectly registered T_2 map.

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Table 1 Simulation results

	T2 Bias	T2 SD	ADC Bias	ADC SD
Healthy (T ₂ =56ms, ADC=1.69x10 ⁻³ mm ² /s)	0.3 %	4.5 %	-0.3 %	7.0 %
Infarction (T ₂ =69ms, ADC=2.4x10 ⁻³ mm ² /s)	0.2 %	4.6 %	0.2 %	5.6 %



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