Fast, Free-breathing 3D T2 mapping at 3T in 5 min for Whole-Heart Myocardial BOLD MRI

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Introduction Myocardial BOLD MRI is an appealing alternative to contrast-enhanced methods for the functional assessment of coronary artery disease. While significant advances have been made in BOLD CMR, some limitations still exist. In particular, the current methods are limited by (a) weighted imaging approaches (T2*-weighted, T2-weighted, or SSFP-based), which are not immune to coil bias; (b) 2D, limiting accurate registration between rest and stress images; (c) LV coverage, particularly during the administration of stress; (d) need for suspension of breathing; and (e) potential contamination from T1 effects. An ideal myocardial BOLD MR method would be able to overcome these existing limitations by permitting acquisition of high quality 3D myocardial BOLD images as maps (T2 or T2*) within 5 minutes, without the need to suspend breathing. In this work, we developed a stack-of-stars k-space acquisition scheme, which permits 100% acquisition efficiency, to construct 3D T2 maps with full LV coverage within 5 minutes. We tested this approach in healthy human volunteers.

Method Data Acquisition**:** Following informed consent, imaging studies were performed in human volunteers (n=5) on a 3T Siemens Verio MRI system (Siemens Medical Solutions, Germany). After localization scans, whole-heart shimming, and scouting to determine the appropriate center frequency,3D hybrid GRE acquisitions were prescribed with respiratory navigator at end diastole along short-axis orientation with the following scan parameters:TR/TE =3.4/1.7 ms, flip angle = 15°, imaging resolution = 2 x 2 x 6 mm^3 with 16 partitions, adiabatic T2 prep pulses with T2prep durations of 0, 24, and 55 mswith T2 preparation in every other heart beat.The acquisition time for a single echo was less than 2 mins with total acquisition time= 5mins.For validation, 2D T2 mapping sequence with breath holds were also applied. Image Reconstruction**:** The acquired data were first separated into 4 different respiratory bins using the navigator signal. Data with different T2 prep durations in each bin were then combined to generate undersampled images for respiratory motion estimation (Fig.1). Respiratory motion correction was prescribed to each bin using an algorithm previously described[1].Motion corrected images from the different echoes were fit to a mono-exponential using least squares approach to derive T2 maps. T2 values of the myocardium weremeasured from the different acquisitionsand were compared using multiple measurement ANOVA.

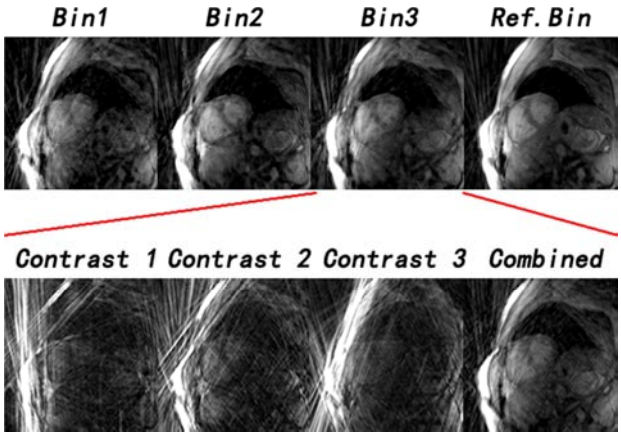

Figure 1 For each bin, images with significantly reduced under sampling artifact was obtained by combining images from different T2prep durations. These images were then used in the motion estimation.

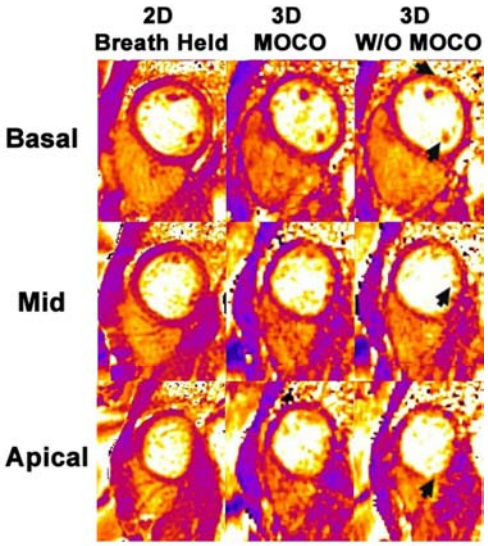

Figure2 T2 maps from standard 2D acquisition (Breath Held), proposed technique with motion corrected reconstruction (3D MOCO) and without motion corrected reconstruction (3D W/O MOCO) are shown for basal, mid and apical slices. The black arrow in the map in the last column point to the artifact caused by respiratory motion, which is corrected in the middle row.

Results Typical motion corrected 3D T2 map are shown in Fig. 2.Comparison between 3D images and the standard 2D images showedgreater similarity after correcting for respiratory motion; T2 values in both cases were: $3D_{non\text{-}moco}$=48.2±14.2, $3D_{moco}$=44.5±7.7, $2D_{BreathHold}$=40.6±7.2. Specifically, results showed significant difference between standard 2D acquisition and non-corrected 3D T2 values ($p<0.05$) but no difference between the T2 values from motion-corrected images and the standard 2D breath-held images ($p=0.58$).

Conclusions The proposed method provides a time-efficient way to obtain 3D T2 map of whole left ventricle. The capability of the proposed technique to provide fast T2 maps of the whole heart within the standard 6 minutes over which adenosine is typically delivered for provocation of stress is expected to enhance the clinical utility of cardiac BOLD MRI. Patient studies are required for clinical translation.

Ref: Bhat MRM 2011;