More Comprehensive Cardiac DENSE MR Imaging by Combination of Short Axis and Long Axis Data

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Introduction: Displacement ENcoding with Stimulated Echoes (DENSE) MRI is a phase contrast method that provides a 3D Lagrangian frame work for particle tracking. This noninvasive method has some advantages over other methods in the area of quantitative analysis of myocardial deformation. In contrast with Tagging which is affected by tag fading and provides only the in-plane Lagrangian displacement, DENSE has a higher spatial and temporal resolution and is able to image the entire cardiac cycle. However it is time consuming and therefore the full potential of this novel method has not been revealed. In this study we have shown the feasibility of the combination of Short Axis (S.A) and Long Axis (L.A) images that provides a more comprehensive data from DENSE MRI in 20 to 40% shorter time.

Methods: Experiments were performed in a Siemens Trio 3T MR whole body scanner at the Caltech brain imaging center with an eight-channel cardiac array coil. Ten S.A as well as three L.A images captured from the heart of a 36 year-old male volunteer. Important parameters are as follows: TR = 3.1 ms, TM = 250 ms, number of averages = 3, number of phases = 3, in-plane resolution = 1.5x1.5 mm^2. Slice thickness of S.A images is 5mm while it is 6 mm for L.A images. S.A slices were spaced every 7.5 mm and the distance of L.A slices is 24 mm. Experiment was performed under free respiration condition. To synchronize the RF pulses with the motion of the heart and chest, respiratory and heart monitoring were achieved using a pneumatic bellow and ECG. Position and direction of images were determined by header information of DICOM files and used to put the slices together as shown in figure 1. The displacement field was smoothed by a moving average filtering. Using displacement of the particles in separated S.A slices and L.A slices, we tried to estimate the motion of the points in the volume surrounded by these planes through a multi-linear interpolation. This estimated displacement field was compared to the original displacement acquired by DENSE MRI for particles over the interleaved S.A layers.

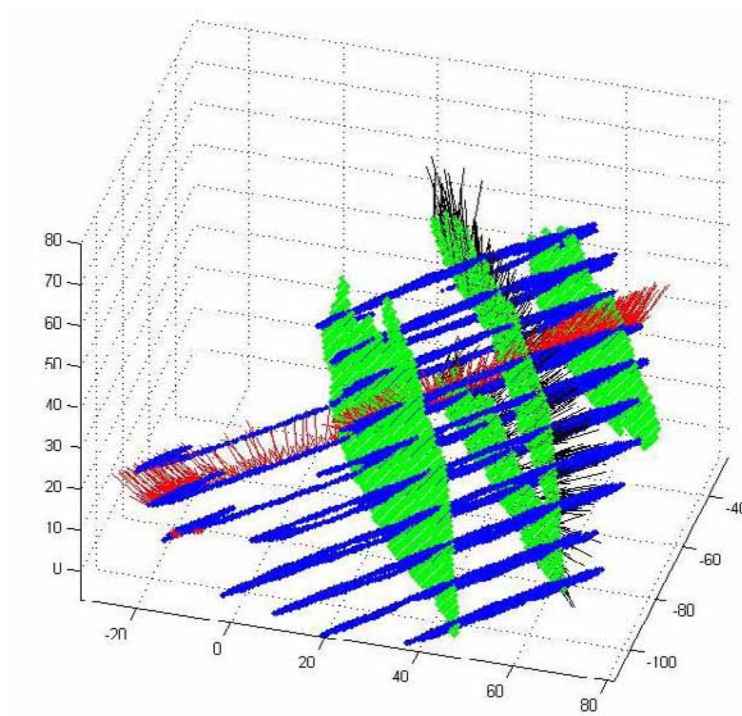

Figure 1. Mounting L.A slices (green) over the S.A structure (Blue) by DICOM information. Red and black arrows show the displacement field acquired by DENSE MRI.

Results: Estimating the magnitude of the displacement field for a region on one of the S.A layers by its adjacent S.A and L.A neighbors resulted in 29% relative root mean squared (rms) error. It is almost equal to the 24% relative rms difference of the same parameter calculated by S.A and L.A acquisitions for the points on the intersection of those layers.

This method also provided the displacement information for other points out of the images and therefore has the potential of resulting in more accurate calculation for the mechanical strain of the myocardium.

Conclusion: This method is able to give more accurate calculation for the mechanical strain of the myocardium by increasing the resolution of data points. This advantage is along with a 20 to 40 percent reduction of the scan time based on the number and position of the selected layers for imaging.