Myocardial Motion Tracking with MRI SPOTs

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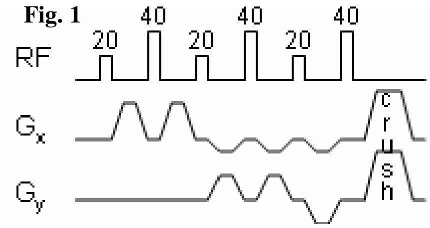
Introduction

Echocardiographic speckle tracking is emerging as a clinically viable technology for tracking the motion of the LV myocardium, with potential application in cardiac resynchronization therapy [1]. The competing technology of MRI tag tracking [2] offers some potential advantages over speckle tracking such as unrestricted viewing geometries, resolution that does not vary spatially, and precise localization of image planes. However, methods for MRI tag tracking are not as robust. One of the advantages of speckle tracking is the punctate texture of speckle, which provides unambiguous information on the direction of motion in the image plane. The clearly defined motion, coupled with a texture matching approach, enables speckle tracking algorithms to automatically compute in-plane motion. In this investigation, we hypothesized that a novel MRI tag pattern that also generates distinct points in the image would enable a texture matching approach to succeed for evaluating tagged MRI.

Methods

MRI Scanning. We programmed a 3T MRI scanner (Philips Achieva) to produce a single point tag (SPOT) grid, based on a pulse sequence (Fig. 1) previously proposed in a theoretical analysis of MR tagging [3]. This tagging sequence generates a hexagonal grid of dark spots and was applied within a 2D, CINE, cardiac triggered, breath-hold, turbo field echo acquisition (TR= 5.6; TE= 2.7; thickness= 8mm; FOV= 320cm; matrix=144x108; turbo factor = 4) in four volunteer subjects. A short axis slice geometry was used in all.

Fig. 1



Data Analysis. For each short axis image series, the approximate middle of the myocardium was identified using 6-8 points placed around the circumference of the LV at end-diastole. These points were then used to compute a B-spline curve at the LV midwall, along which perpendicular spokes of length 9mm were placed at 1 pixel intervals. For each successive image in the sequence, the B-spline was allowed to deform and the spokes were allowed to elongate and rotate until the underlying texture best matched the texture from the previous time frame. The tracking performance was evaluated by manually identifying corresponding SPOTs in each image in the sequence. The same B-spline framework was then fit to these corresponding features and the mean absolute difference between motion estimates was computed.

Results

Fig. 2 shows imaging results using the SPOT grid (top row) and the corresponding motion tracking results (bottom row, zoomed). Visually, the tracking results were excellent through mid-diastole. Beyond this point some instability in the orientation of the spokes was observed and attributed to tag fading. Circumferential shortening and elongation was well represented throughout the cardiac cycle. Fig. 3 summarizes the quantitative behavior of the tag tracking, showing differences generally on the order of 1mm or less throughout the cardiac cycle. It is notable that manual identification contributed substantially to this error and in blinded comparisons, the automatic tracking results were preferred.

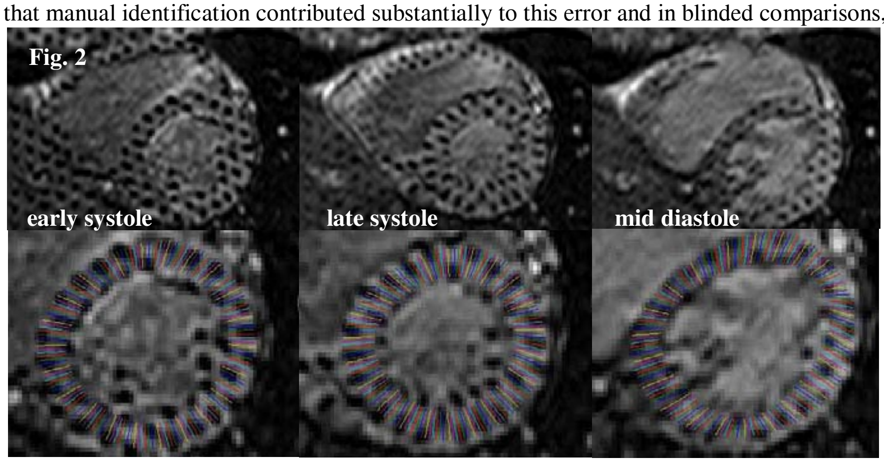
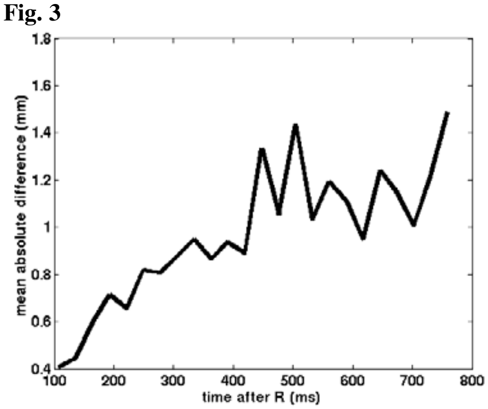


Fig. 3



Conclusions

This study shows that myocardial motion tracking commensurate with the performance of echocardiographic speckle tracking is possible using tagged MRI with a novel tagging pattern. The SPOT pattern was successfully implemented and shown to produce individually definable features that could be robustly tracked. Compared to other tagging approaches that typically feature tag lines, SPOTs do not suffer from ambiguity of motion along the tag line. Tag line grids have previously been used to generate unambiguous motion at the crossing points of tag lines, but do so at the expense of considerable amounts of the myocardium being obscured by the tags. Also, the hexagonal geometry of the SPOTs yields denser packing of the feature points than the Cartesian geometry of tag grids. Compared to speckle tracking, which is less reliable in the long axis, SPOT tracking should be robust in any orientation. Also, the speckle pattern changes randomly with through-plane motion of the myocardium, whereas SPOTs are predictable and unaffected by through-plane motion. This fact is helpful for both noise rejection and visual confirmation of the tracking results. Further investigation will determine whether MRI SPOT tracking is effective for assessing cardiac dyssynchrony.

References

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