THE CONTRIBUTION OF CARDIAC MOTION TO DARK RIM ARTIFACTS IN MYOCARDIAL PERFUSION SCANS

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Introduction: Adenosine stress perfusion imaging is a promising method for the evaluation of coronary artery disease, but dark rim artifacts in the myocardium can mimic perfusion defects and thus reduce its accuracy. The causes of dark rim artifacts are not completely understood, with Gibb's ringing and cardiac motion thought to be contributing factors. In this work our experimental data lends strong support to the idea that dark rim artifacts come from motion, and it also shows that these artifacts are more significant in some portions of the cardiac cycle than in others. Furthermore, a 1D motion model is developed and used to predict how dark rim artifacts vary over the cardiac cycle. One goal of this work is to use the 1D motion model to develop non-rigid cardiac motion correction methods.

Methods: To produce dark rim artifacts from experimental data, we collected a gradient-echo cine data set with high temporal resolution and then synthesized images with coarser temporal resolution. 110 *in vivo* images (192×144) were acquired from the same heart slice, but with different cardiac phases. The experiment was performed with breath holding and ECG triggering on a 1.5T Siemens Avanto scanner. Therefore, each initial image was considered to have negligible motion blurring. The data was resampled by combining the initial images, similar to a typical segmented perfusion scan. Each initial image contributed 4 phase encoding lines. Different portions of the image series were used to simulate different cardiac trigger times.

For the 1D motion model, the left ventricle and the myocardium were represented by rectangles with different signal amplitudes. These rectangles were compressed and expanded at different times in the cardiac cycle to match the motion of the experimental data. This motion model was then sampled in k-space, matching the phase encoding collection scheme for the simulated images.

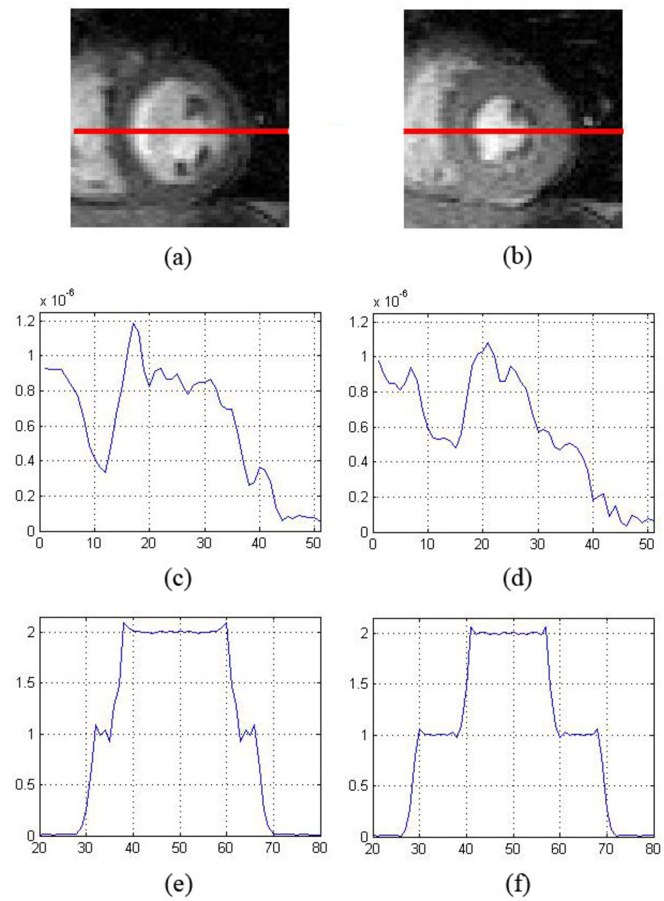

Fig.1: Simulation of dark rim artifacts caused by motion. (a) and (b) show synthetic images at diastole and systole, respectively. c) and (d) are corresponding line plots from (a) and (b); (e) and (f) show the corresponding 1D model.

Result: In Figure 1, (a) and (b) illustrate that the synthetic images show that dark rim artifacts are more significant at different times in the heart cycle. (c) and (d) are 1D plots through (a) and (b) at the position given by the red line. From them, we can observe a significant change in the dark rim artifact. In systole, both the dark edge (at position 12) and bright edge (at position 19) become less intense than in diastole. Similar behavior can be observed in the 1D motion model, as seen in (e) and (f).

Conclusion: These results indicate that cardiac motion alone can generate dark rim artifacts. Moreover, they indicate that dark rim artifacts are more serious in some cardiac phases than in others. This may explain why dark rim artifacts do not appear in all patients or in all slices. In a typical stress perfusion protocol, multiple slices are acquired and the heart rate varies from patient to patient, so there is typically a wide variation in trigger times relative to the underlying heart motion. Further study of this issue may permit more robust perfusion imaging. With improved understanding, it may be possible to avoid portions of the heart cycle likely to result in dark rim artifacts or to use different k-space trajectories to minimize their likelihood. An accurate 1D motion model would permit the study of acquisition alternatives and motion correction methods.

Reference: 1. M. Salerno et al, *SCMR,* 246(2007). 2. Storey P et al. , *Magn Reson Med,*48:1028-1036(2002).