Measuring the myocardial angular information through the Radial Tagging

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Introduction: The angular information of the left ventricle, including the twist, shear and circumferential strain, are of fundamental importance to quantify the regional or global myocardial function[1]. Radial tagging facilitates the measurement of this information[2]. In particular when the density of radial taglines are sufficiently high, it was theoretically shown that the circumferential strain can be measured directly from the K-Space data[3]. In this study we present the application of the circumferential encoding method on the actual cardiac MR images which are tightly tagged in the radial direction using our newly developed sequence. We also show the transmural differences in rotational motion of the left ventricle using these images.

Methods:

a) Imaging: A rotating excitation plane with an alternating RF pulse generates a radial pattern for longitudinal magnetization. In this implementation the preparation sequence is followed by a spoiled gradient echo (GRE) cine readout module. Each short axis (SA) image is tagged by radial lines that meet in the center of the left ventricle. The sequence acquires a series of images that contains the diastole and systole phases.

b) K-space process: Since MR images are acquired in the frequency domain (K-space), the compression of the patterned lines may be extracted through the appropriate filtering in K-space. Regions with certain degrees of compression of radial tag lines can be reconstructed through the circular bandpass filtering of K-space. We get the structural image encoded by the level of the compression of radial tag lines through sequential scanning of the whole K-space by these filters and weigh each recovered region with the corresponding frequency. Global circumferential strain can be easily determined by the shift of the circumferential frequency average. Regional strain needs comparison of the frequency between corresponding regions before and after deformation. Having radial tags, corresponding regions can be automatically found without time consuming exact tissue tracking techniques.

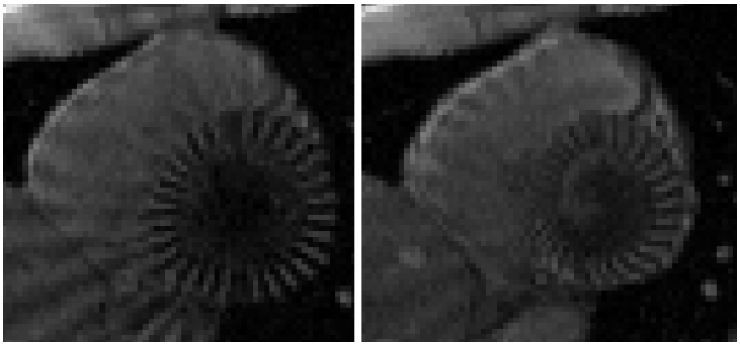

Figure 1. radially tagged images of the short axis view of a healthy volunteer at diastole and systole. The tortional motion of the left ventricle is well pronounced at the posterior wall of the myocardium.

Results: Using the developed sequence short axis images of two healthy volunteer were acquired for the entire cardiac cycle at 1.5 (Avanto) and 3.0T scanner (TIM Trio, Siemens Medical Solutions). Each image has 15 radial taglines in the half circle. Other MR parameters are as follows: 250mm FOV, 5mm slice thickness and TE/TR = 4.6/87ms. Other parameters were different on two scanners: 250 and 400Hz/pixel, 15° and 12° flip angle, 128x128 and 256x246 matrix size respectively for Avanto and Trio (Figures 1 and 2). Comparison of the taglines at diastole and systole demonstrates that the transmural differences in rotational motion and circumferential strain of the ventricle can be obtained from this technique.

The algorithm was implemented using Matlab 7.0.4 scanning the K-space for spatial frequencies between 0.13 to 0.32 cycle/mm. Figure 2 shows the actual images overlaid by the density weighted images. The increase of the spatial frequency is evident from one image to the other.

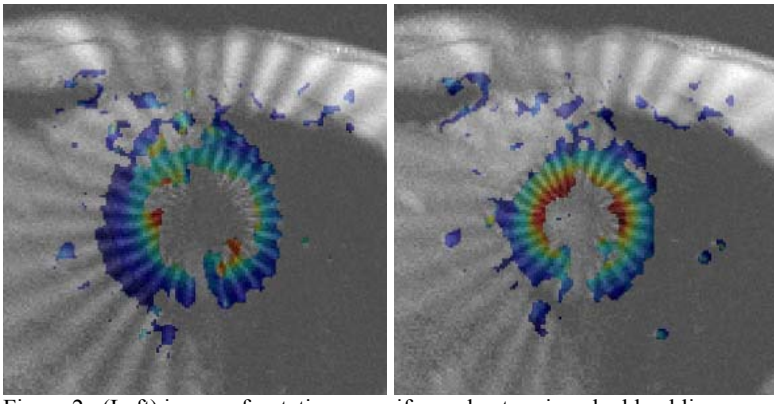

Figure 2. (Left) image of a stationary uniform phantom in a double oblique imaging plane. (Middle and Right) radially tagged images of the short axis view of a healthy volunteer at diastole and systole. The tortional motion of the left ventricle is well pronounced at the posterior wall of the myocardium.

Conclusion: In the new tagging sequence the spatial resolution and density of taglines are considerably higher compared to previous schemes of the radial tagging. This makes the angular information of the LV pronounced and also satisfies the condition for application of a k-space-based method, CIRCOME.

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