

COMPARISON AMONG RADIAL, SPIRAL-OUT AND SPIRAL-IN/OUT BSSFP IN REAL TIME CARDIAC IMAGING

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Introduction: Cartesian and radial balanced SSFP (bSSFP) sequences are widely used clinically for real-time cardiac imaging. Spiral bSSFP sequences have been used in several research studies [1], but clinical adoption has been slow. The goal of this study is to compare the performance of radial and spiral bSSFP in real-time cardiac imaging. In addition, we have developed a spiral-in/out bSSFP sequence by putting a symmetrical spiral-in gradient in front of a traditional spiral-out gradient to explore the TE = TR/2 mechanism and realize 0th and 1st gradient moment nulling via symmetry to save time [2]. This sequence is also compared.

Methods: To achieve a fair comparison, the temporal and spatial resolutions are tuned to be similar among three sequences. The temporal resolution is calculated as the number of frames completely updated during one second; the spatial resolution is calculated as the FWHM of the theoretical point spread function. The sequence parameters are 1) radial: FOV = 340 mm, TR/TE = 2.36/1.18 ms, FA = 46°, # of interleaves = 48, spatial resolution = 3.24*3.24*8 mm, temporal resolution = 8.83 Hz; 2) spiral-out: FOV = 340 mm, TR/TE = 3.69/1.84 ms, FA = 50°, # of interleaves = 32, spatial resolution = 3.15*3.15*8 mm, temporal resolution = 8.47 Hz; 3)

spiral-in/out: FOV = 340 mm, TR/TE = 3.76/0.99 ms, FA = 50°, # of interleaves = 32, spatial resolution = 3.20*3.20*8 mm, temporal resolution = 8.31 Hz. Four healthy volunteers with informed consent participated in this study; for each subject, one mid-ventricular short axis and one long axis view of the heart were acquired under breath-hold and non breath-hold conditions on a Siemens 1.5T Avanto scanner. All images were blindly evaluated by two cardiologists on 5 point scale with 5 representing the highest image quality. A paired Wilcoxon signed rank test was performed on the rating scores. SNR of myocardium and blood and CNR between them were measured separately for each image series. SNR and CNR were compared using one way analysis of variance on ranks.

Results: Figure 1 shows long-axis images acquired with the three sequences. Compared with the radial images (top row), both the spiral-out (medium row) and spiral-in/out (bottom row) have lower artifact level. The chest wall is clearest in spiral-in/out images, and is most blurred in radial images. The results of the breath-hold and non breath-hold experiments are similar for all three sequences and two cardiac views, therefore, we combined the result of breath-hold experiment and non breath-hold experiment and get the image rating result as 1) short axis view: a) radial: 3.59±0.61, b) spiral-out: 3.91±0.52, c) spiral-in/out:

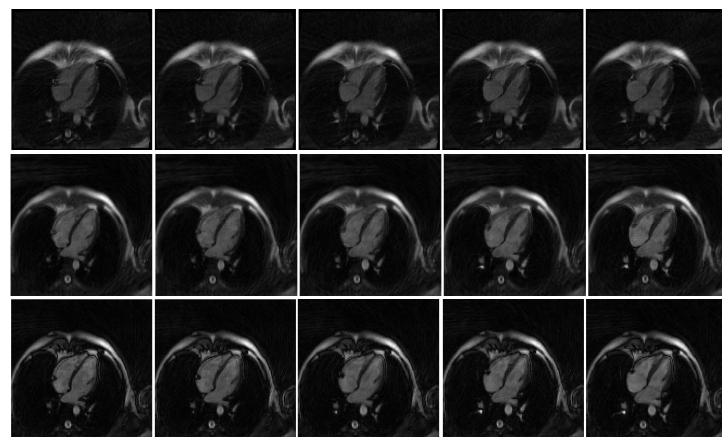


Fig. 1 Long axis real-time cardiac images using radial bSSFP (top row), spiral-out bSSFP (center row) and spiral-in/out bSSFP (bottom row)

spiral-out vs. spiral-in/out: 0.0918, 2) long axis view: a) radial vs. spiral-out: 0.0013, b) radial vs. spiral-in/out: 0.0005, c) spiral-out vs. spiral-in/out: 0.7451. Figure 2 shows the SNR of blood pool and myocardium, and the CNR between them for short-axis and long-axis views. The CNR plots show the spiral-in/out has the highest blood myocardium contrast and spiral-out is the second; the advantage is more obvious in short axis view. The difference of CNR between spiral-in/out and radial is statistically significant (shown by * in figure 2).

Conclusions: The image rating result shows both spiral-out and spiral-in/out bSSFP outperform radial bSSFP. The aliasing level decreases and SNR and CNR increase with spiral-out and spiral-in/out due to the data acquisition efficiency of spiral sequences. The spiral-in/out bSSFP is potentially a better choice compared with spiral-out bSSFP, especially in short axis view.

References: [1] Nayak KS, et al. MRM 53:1468–1473, 2005 [2] Feng X, et al. ISMRM 2010

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4.13±0.39; 2) long axis view: a) radial: 3.28±0.26, b) spiral-out: 3.81±0.57, c) spiral-in/out: 3.88±0.34. The p-values of paired Wilcoxon signed rank test under the null hypothesis that two compared sequences behave the same are 1) short axis view: a) radial vs. spiral-out: 0.090, b) radial vs. spiral-in/out: 0.0024, c)

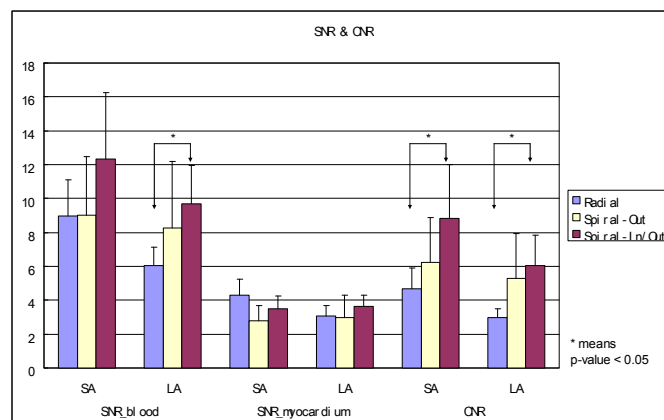


Fig. 2 SNR_{blood}, SNR_{myocardium} and CNR plot for radial, spiral-out and spiral-in/out bSSFP in short axis view (SA) and long axis view (LA)