Phase Sensitive Fat Suppression SSFP With Phase Correction

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Introduction

Steady State Free Precession (SSFP) imaging provides high contrast and high SNR images. However, SSFP is limited by the fact that fat appears bright, possibly obscuring underlying pathology. Several techniques about fat suppression for SSFP sequences were proposed so far [1-3], but they doubled the acquisition time. Hargreaves et al. [4] have proposed a method for fat suppression which uses the single-acquisition phase-sensitive method. In the method, a simple phase correction technique was applied to remove system phase errors, while spatially dependent phase shift caused by RF receiver coil when surface coil was used can not be removed [5]. The aim of this study was to acquire fat suppression SSFP images using phase sensitive SSFP with the correction of system and spatially dependent phase errors.

Methods

Experiments were performed on a Siemens Symphony 1.5T scanner (Siemens, Erlangen, Germany) using a TrueFISP pulse sequence and a six-channel phased-array coil. The imaging parameters were a 60-degree flip angle, TR/TE = 4.6/2.3 ms, 256×256 matrix, 30×30-cm^2 field of view (FOV) and 5 mm slice thickness. Appropriate selection of TR and the center frequency results in water and fat signal having opposite signs. A fully automated algorithm provided by Ma [6] was used to correct phase errors including system and spatially dependent phase shift. This algorithm corrects phase errors by region-growing, employing both the magnitude and the phase information of image pixels. Slowly varying phase errors which are assumed to be caused by RF receiver coil can be removed while phase shift between fat and water is preserved. The algorithm was implemented in Matlab 6.5 (The Math Works, Natick, Ma). By removing these phase errors an image with positive and negative pixels can be achieved. The image pixels were then separated into water and fat images based on the sign of the signal.

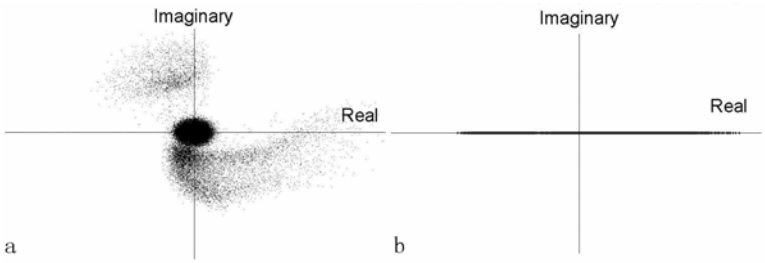

Fig.1. Scatter plot of complex image pixels. a) before phase correction, b) after phase correction.

Result and Discussion

Data of a phantom of water and fat were acquired. The complex image data from one channel are scatter-plotted in Figure 1. The phase of the image data deviates greatly in figure 1a, while the points are well distributed along the real axis in figure 1b. Figure 2 shows the phantom images reconstructed from data acquired with 6 channels. Failed separation of fat and water can be seen from figure 1a and 1b, while fat signal in figure 2c is separated from water in figure d successfully. By removing the system and spatially dependent phase errors, phase sensitive SSFP provides excellent fat suppression image.

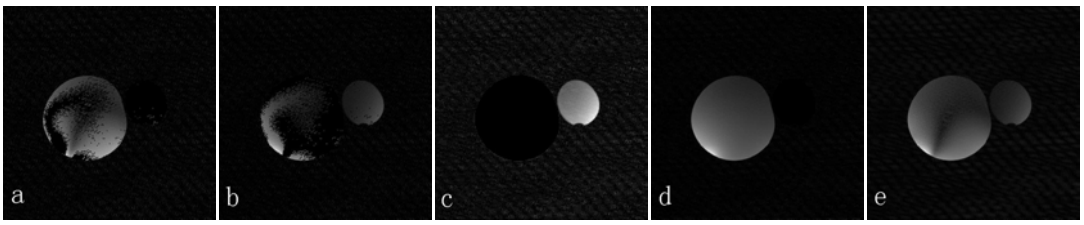

Fig.2. Phantom images; a) fat image before correction, b) water image before correction, c) fat image after correction, d) water image after correction, e) combined image.

References

[1] *Vasanawala et al.* MRM 42:876-883 (1999); [2] *Scheffler et al.* MRM 45:1075-1080 (2001); [3] *Reeder et al.* Am . J. Roentg. 180:357-362 (2003); [4] *Hargreaves et al.* MRM 50:210-213 (2003); [5] *McVeigh et al.* Med. Phys. 13:806-814 (1986); [6] *Ma.* MRM 53:904-910 (2005)