

Image quality improvement via phase correction for travelling wave MRI at 3T

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Introduction. Travelling wave magnetic resonance imaging (twMRI) offers an alternative approach to acquire images with larger fields of view at 7 T or greater [1]. However, we have recently demonstrated the feasibility of using twMRI at 3T using a clinical imager [2]. twMR images have two main problems: a) inhomogeneous acquisition due to the physical restriction in coaxial waveguide MRI experiments at 7 T [3] and, b) added noise in parallel plate waveguide (PPWG) MRI at 3 T [2]. We have demonstrated the feasibility of generating images with a PPWG and phantom located outside the magnet [4], and that the MR imager performance is not affected and no image geometric distortion present. We measured the signal phase added by a PPWG in twMR images at 3 T, using a circular coil for transmission and other one for reception, both tuned at 128 MHz. Phantom images were then acquired with the PPWG in clinical scanner at 3 T. Finally, the phase shift information was used to improve the quality of images acquired with the PPWG and results compared.

Method. The experimental setup of Fig. 1 was used to investigate the behaviour of the phase delay of the signal using two circular coils with 16 cm diameter and a parallel-plate waveguide and, a spherical phantom was positioned between them. All experiments were run at 128 MHz with waveguide aluminium plates. The signal phase experiments were performed in a semi-anechoic chamber (7m x 7m x8 m) and using a network analyzer (ZNB8, Rohde & Schwarz, Munich, Germany). A standard gradient echo (GE) sequence was used to generate T1-weighted images of spherical phantom with the acquisition parameters: Flip angle=60°, TR/TE=336.9/16.1ms, FOV=450mmx190mm, matrix size= 500x169, slice thickness=10mm, NEX=5. The embedded whole-body birdcage coil was used for transmission and the circular coils for reception only. All imaging experiments were performed in a 3T clinical imager (Philips Medical Systems, Best, NL). Unlike the homodyne detection method [5], the image phase values were measured directly as described above and no low-pass filter were applied to obtain a reference image. These complex images can be demodulated using a phase factor to generate images of the added noise and without noise.

Results and Discussion. Phase shift measurements were obtained with the network analyzer and plotted in Fig. 2 for a bandwidth of interest. We appreciate that the phase shift is linear inside the PPWG for a frequency range around the resonant frequency of 128 MHz, and resulting an experimental phase shift of 20.2°. Phantom imaging experiments were performed using the PPWG and a spherical phantom where one coil is operated in reception and reception was conducted with the second coil in the opposite side, as shown in Fig. 1.b). We used a phase correction algorithm together with the experimental phase shift value to improve the signal-to-noise ratio (SNR) of the images. A difference image was also computed with the original and the phase shift-processed images. Fig. 3 shows an example of the phantom image and its improved image and the difference image. We used the phantom image data to calculate comparison profiles as shown in Fig. 3.d) and the image SNR, giving: SNR(original)/SNR(phase-shift)=10.44/15.11. The profile comparison and the image SNR show a considerable improvement of the image processed with the phase shift data over the image acquired with the twMRI approach and the PPWG. Fig. 4 show a demodulated image of the added noise using the phase factor. Image histograms were computed and plotted in Fig. 5. Improved image histogram shows that phase-corrected image outperforms the original phantom image. These experimental results demonstrate that the signal phase shift correction can be used to improve the image quality in twMRI experiments at 3 T.

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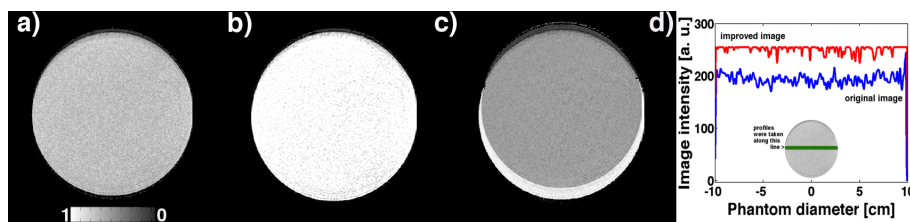


Fig. 3. Original image acquired with the PPWG, b) Improved image and c) Profile comparison of image uniformity.

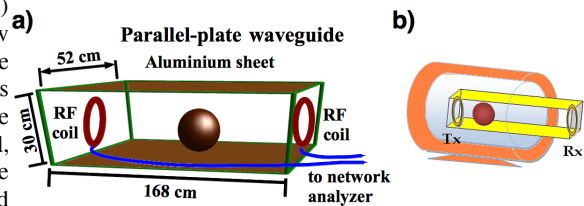


Fig. 1. Experimental setups for signal phase experiments (a) and image acquisition with a PPWG (b).

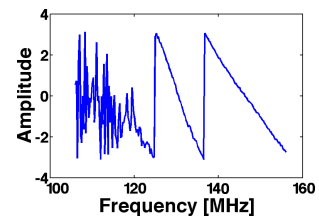


Fig. 2. Signal phase in a PPWG for twMRI at 3 T.

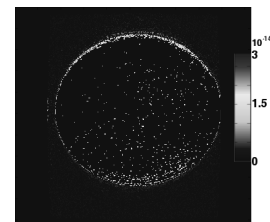


Fig. 4. Added noise image

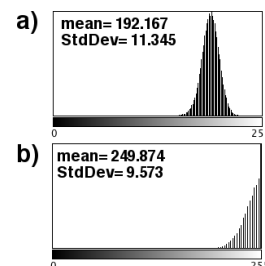


Fig. 5. Histograms of original image (a) and improved image (b) of Fig. 3