Performance evaluation of parallel travelling wave MRI using microstrip transceiver arrays

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Introduction:

Travelling Wave MRI (TWM) [1] is an emerging method for large FOV imaging at ultrahigh fields, where the design of traditional large volume coils faces a great challenge due to the required high operating frequency. Recently, the ideas for implementing parallel imaging in TWM have been explored using patch antenna arrays [2] and multiple propagating modes of waveguides by dielectric loading [3]. In this work, we investigate the parallel imaging capability and performance of the traveling wave MRI implemented by using simple microstrip transceiver arrays for signal transmit and receive. Parallel MR imaging experiments were performed to validate this technique.

Material and method:

As shown in Fig 1, at the patient end of the bore of a 7 Tesla whole body MR scanner, two microstrip transceiver elements were placed orthogonally for excitation and reception. This orthogonal microstrip arrangement provides excellent decoupling performance and diverse field distribution from each element which could benefit parallel imaging. The imaging sample was a cylindrical phantom (11.5 cm in diameter and 27cm in length) containing dimethyl silicone fluid and gadolinium colorant, placed 50 cm away from the coil. The magnet bore has a diameter of ~63 cm, corresponding to a cutoff frequency of 278.9 MHz for the lowest TE waveguide mode, which supports the wave propagation at the Larmor frequency of protons at 7 Tesla (298.2 MHz). Images of the phantom in the axial planes were acquired using gradient echo sequences. The acquisition parameters used were TE = 3.2 ms, TR = 250 ms, matrix size = 256 × 256, FOV = 22 cm, slice thickness = 5 mm, slice spacing = 10 mm, average number = 3, totally 10 axial slices were obtained. In parallel imaging performance tests, accelerated images were reconstructed using the GRAPPA algorithm. Matlab code was written to calculate the g-factors for 1D SENSE and residual errors.

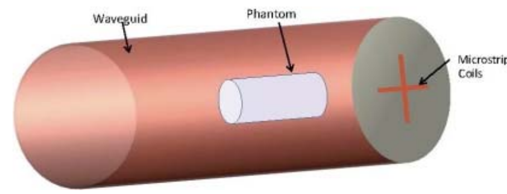

Fig 1. 2-element microstrip coil array set up on the 7T MR scanner loaded with a cylindrical phantom.

Table 1 The Average g-factors for 1D SENSE for 5 Slices at reduction factor R of 2.

Slice	1	2	3	4	5
Average g-factor	2.44	2.53	3.01	2.72	2.70

Results:

As shown in the first and second column of Fig 2, the images with full-sampled k-space data from each channel have distinct sensitivity map, which indicates the potential of parallel imaging. The fourth column of Fig 2 shows the GRAPPA reconstruction images with acceleration factor = 2. Compared with the sum-of-square combination of full-sampled images shown in column 3, the GRAPPA accelerated images have a relatively lower residual error, as shown in column 5. To better display the residual error and make it visible, the amplitude of residual error in each slice was multiplied by the factor of 3. The average g-factors for 1D SENSE for each slice are shown in the Table 1. The g-factor varied with the distance between targeted slice and coil arrays due to the variation of the B1 field diversity along propagation direction. Images with more background noise have bigger g-factors due to the amplification of noise in background in SENSE reconstruction.

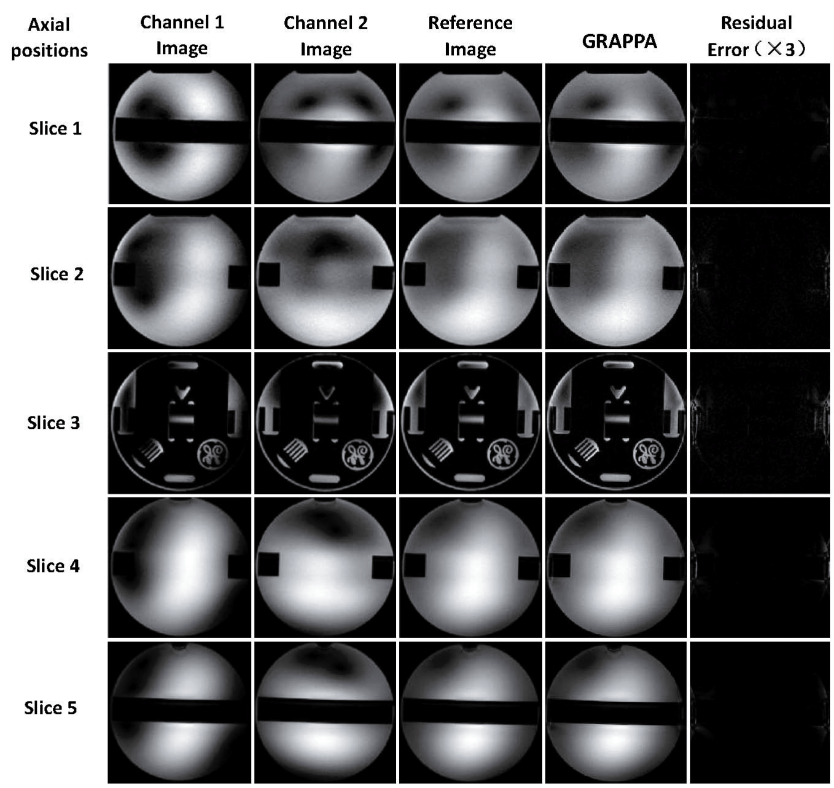

Fig 2. GRAPPA reconstruction of axial images in TWM, acceleration factor 2, with 32 ACS lines. Columns from 1 to 5 denote images of each channel with full-sampled k-space, the combination of images using a sum of squares method, GRAPPA reconstruction image and the residual error maps multiplied by 3 for visualization.

Discussion and Conclusion:

The parallel imaging performance of the traveling wave MRI using microstrip transceiver arrays was investigated. Considering coil arrays with only two elements used in the experiment, the excellent quality of the accelerated images at an acceleration factor of 2 was obtained. The study also demonstrates the sufficient spatial diversity of B1 fields of each transceiver channel and superior electromagnetic decoupling between the transceiver elements. These merits are essential to high quality parallel imaging. The proposed method suggests a simple way to perform parallel imaging in traveling wave MRI. The next step is to investigate the parallel traveling wave MRI performance at higher acceleration rates when the microstrip transceiver arrays with more element counts become available.

References:

1. Brunner DO, et al, Nature 2009;457: 994 – 998. 2. Pang Y, et al, MRM 2011;67:965 – 978. 3. Brunner DO, et al, MRM 2011;66:290 – 300.

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