MR experiment validation of parallel traveling-wave with quadrature patch antenna transceiver array

Y. Pang[1], D. Vigneron[1,2], and X. Zhang[1,2]
[1]Radiology & Biomedical Imaging, University of California San Francisco, San Francisco, CA, United States, [2]UCSF/UC Berkeley Joint Graduate Group in Bioengineering, San Francisco & Berkeley, CA, United States

Introduction: Traveling-wave MRI uses far-fields of an antenna to cover large size imaging samples [1,2]. Recently, studies developing parallel accelerated imaging [3-5] with traveling-wave by using different strategies have been reported [6-9]. In this work, the method of implementing parallel traveling-wave using single-feed quadrature patch antenna transceiver array [9] was investigated and validated through MR experiments using a 7T whole body MR scanner. A human head shaped phantom was positioned 85 cm away from the patch antenna array, and SENSE and GRAPPA reconstructed images were acquired.

Methods: In this work, the parallel traveling wave MR imaging was performed using the two element patch antenna array shown in figure 1 [9] on a General Electric (GE) 7 Tesla whole body MR scanner. The 7T MR scanner was equipped with two quadrature transmit channels and two T/R switchers which were connected to our transceiver patch antenna array. Figure 2 shows the detailed experiment setup. The patch antenna array was positioned at the patient end of the magnetic bore. The imaging sample was a human head shaped water phantom which was placed approximately 85 cm away from the patch antenna array. Images of the head phantom in both axial and sagittal planes were acquired with the travelling-wave patch array by using gradient echo sequences. The acquisition parameters were TE=3.2ms, TR=1000ms, matrix size =256×128, field of view (FOV) =24cm, slice thickness =5mm, NEX=10, and phase encoding direction is A/P.

In parallel imaging performance tests, two of the commonly used parallel imaging methods – SENSE [3] and GRAPPA [5] – were used for image reconstruction, and the acceleration was applied to phase encoding direction in both methods. In SENSE imaging the acceleration factor was 2 for each slice. The g-factors for 1-D SENSE were calculated to demonstrate the parallel imaging performance. In GRAPPA imaging, 48 Auto-Calibration Signal (ACS) lines in the center of the *k*-space were used to estimate the missing lines. The GRAPPA reconstruction with acceleration factor of 2 was performed to all the slices in both axial and sagittal planes. In addition, the reference image of each slice reconstructed from the sum of squares method from full *k*-space data were also calculated for comparison.

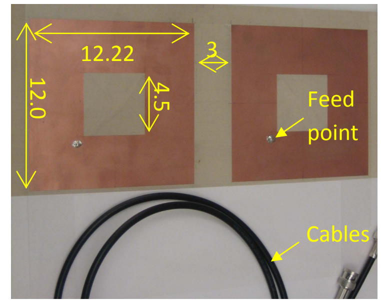

Fig. 1 Prototype of the two-channel quadrature patch antenna array. The decoupling is better than -26 dB.

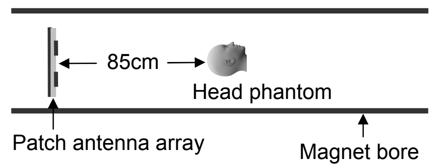

Fig. 2 MR experiment setup. Patch antenna was placed 85 cm from phantom.

Results: Figure 3 shows the axial images of 5 slices at different position within the phantom. The first column images are reference images which were reconstructed by using the sum of squares method from the full *k*-space data. The second column images are SENSE reconstructed images at acceleration factor of 2. It is shown that some noise and aliasing artifacts appears in the phase encoding direction on the reconstructed image, this may be because the acceleration rate has reached the maximum value of 2 for this two element patch array. The average g-factors of each image are also presented. The images in the third column are GRAPPA reconstructed images with 48 ACS lines at acceleration factor of 2. From these parallel imaging performance results it is illustrated that parallel travelling-wave MR imaging based on the proposed microstrip patch antenna array is feasible.

Figure 4 shows the 5 slices of head phantom images in the sagittal orientation. The three column images from left to right are the reference images reconstructed from sum of squares method, SENSE reconstructed images and GRAPPA images respectively. The average g-factors for 1-D SENSE reconstruction at acceleration factor of 2 are also listed. The promising results verify that the proposed parallel traveling-wave imaging method is suitable for not only one direction but other directions as well.

Conclusions: These MR experiments using a 7T MR scanner have validated that it is feasible to implement parallel traveling-wave MRI using the proposed single-feed quadrature transceiver patch antenna array. Excellent parallel imaging performance in both axial and sagittal planes has been demonstrated in both SENSE and GRAPPA imaging. Although a 2-element array was used in this experiment, the approach can be potentially performed with more array elements/channels based on the proposed patch antenna array design. This patch antenna array was used as both transmitter and receiver, showing its potential for performing parallel transmit.

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References: [1] Brunner DO, et al, Nature 2009; 457: 994-998. [2] A.G. Webb, et al., MRM 2010;63(2):297-302. [3] D.K. Sodickson, et al, MRM 1997;38(4):591-603. [4] K.P. Pruessmann, et al, MRM 1999;42(5):952-962. [5] M.A. Griswold, et al, Magn Reson Med 2002;47(6):1202-1210. [6] D.O. Brunner, et al. ISMRM 18th 2010 pp 646. [7] J. Paska, et al. ISMRM 18th 2010 pp 3793. [8] A.G. Webb, et al. ISMRM 18th 2010 pp 3798. [9] Y. Pang, et al. ISMRM 18th 2010 pp 3794.

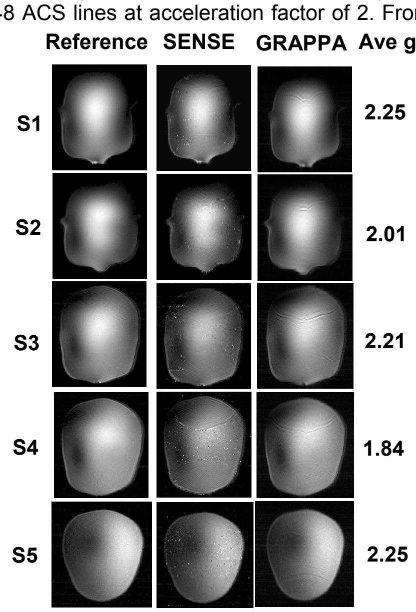

Fig. 3 Axial images of the phantom from MR experiments. First column: the images reconstructed from the sum of squares method; Second column: SENSE reconstructed images at acceleration factor of 2; Third column: GRAPPA reconstructed images with 48 ACS lines at acceleration factor of 2; Fourth column: average g-factor for each slice. Although there is some noise and artifacts in the accelerated images, the parallel imaging performance is still good by using the travelling-wave patch array.

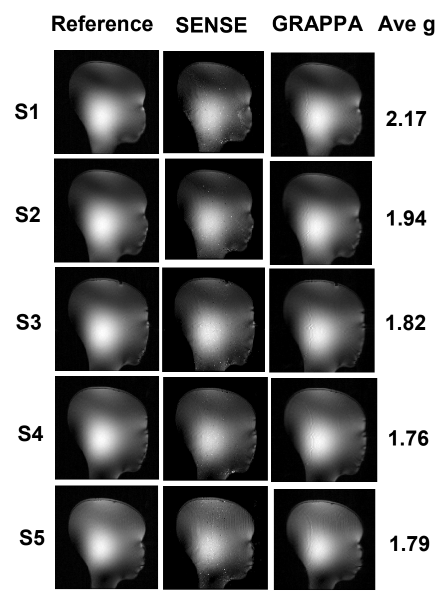

Fig. 4 Sagittal images of the phantom from MR experiments. First column: the images reconstructed from the sum of squares method of full k-space; Second column: SENSE reconstructed images at acceleration factor of 2; Third column: GRAPPA reconstructed images with 48 ACS lines at acceleration factor of 2; Fourth column: average g-factor for each slice. It is shown that the parallel imaging can be applied to different anatomical planes, and the performance is nearly the same.