Investigating Parallel Imaging Performance of the 8-Channel Transceiver Array With Tilted Microstrip Elements

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Introduction: Parallel imaging techniques [1-3] require specialized multi-channel coil array with excellent decoupling performance. In previous studies, receiver array and transceiver array with tilted elements have been introduced to improve decoupling performance, enhance RF coil efficiency and reduce the power deposition [4-6]. In this work, parallel imaging performance of the tilted microstrip array [5,6] was investigated in terms of reconstructed image quality, noise correlation matrix and g-factor. Two of the commonly used parallel imaging methods – SENSE [2] and GRAPPA [3] – were applied for in vivo human knee image reconstruction at 7T. Noise correlation between the tilted array elements and the g-factors for two-dimensional SENSE reconstruction were also calculated.

Methods: In our previous studies, an 8-channel transceiver array with tilted microstrip elements has been proposed to improve the decoupling and enhance RF coil efficiency [5,6] and the prototype of this array is shown in Fig.1. To evaluate its parallel imaging performance, each element was tilted by around 30^o (optimized decoupling can be achieved at 30^o tilted angle according to previous study) and MR imaging experiments were performed on a General Electric (GE) 7 Tesla whole body MR scanner. This scanner is equipped with two quadrature transmit channels and two T/R switches. To test the transceiver arrays on this scanner, continuous scans were performed by connecting two coil elements into the transmit channels each time, and combined all sub-images offline. Human knee images from a healthy volunteer were acquired with this array by using gradient echo sequences.

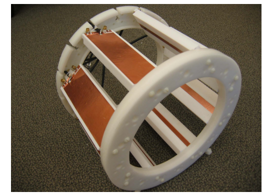

Fig. 1 Prototype of 8-channel array with tilted microstrip elements.

To demonstrate the performance of the tilted array in parallel accelerated imaging, SENSE and GRAPPA were used for human knee image reconstruction. In SENSE imaging the acceleration was applied to phase encoding direction and SENSE reconstruction with acceleration factors of 2 to 8 was demonstrated. The noise matrix was calculated to demonstrate the noise correlation between array elements. The spatial varying g-factors were calculated and the average and maximum g-factors were plotted as functions of acceleration factor to demonstrate the performance of the tilted array in SENSE accelerated imaging. For GRAPPA accelerated imaging, the acceleration was in the phase encoding direction and 32 Auto-Calibration Signal (ACS) lines were acquired in the center of the *k*-space to estimate the missing lines. The GRAPPA reconstruction with acceleration factor from 2 to 8 was performed and compared with the reference image reconstructed using the sum of square method from full *k*-space data.

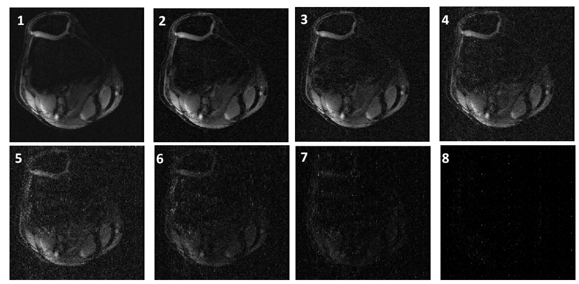

Fig. 2 Image 1 is the reference image reconstructed using sum of square; Image 2 to 8 are reconstructed using SENSE at acceleration factor of 2 to 8.

Results: Fig. 2 shows the reconstructed images of the in vivo human knee using SENSE method at the acceleration factors from 2 to 8 (corresponding to the image number of 2 to 8 assigned in Fig.2). The first image is the reference image reconstructed from full *k*-space using the sum of squares method. Fig.3 demonstrates the noise matrix which describes the noise correlation in the channels of the tilted array. Small noise correlation between array channels is desired because the SNR is inverse proportional to the noise correlation. In Fig.4, the average and maximum g-factors are plotted as functions of acceleration factor. The exact values of g-factors are listed in Tab.1. It is shown that, at acceleration factor below 4, the average g-factor is no greater than 1.41, demonstrating good parallel imaging performance of the proposed tilted microstrip array.

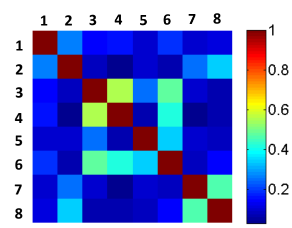

Fig. 3 Noise correlation between tilted array elements.

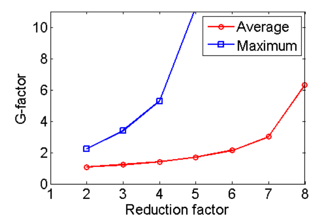

Fig. 4 Average and maximum g-factor vary with acceleration factor.

R	2	3	4	5	6	7	8
Ave	1.08	1.21	1.41	1.70	2.14	3.01	6.32
Max	2.23	3.39	5.27	11.26	15.05	53	457

Tab. 1 Average and maximum g-factor at acceleration R=2 to 8.

Fig.5 shows the reconstructed images of human knee using GRAPPA. The first image is a reference image which was reconstructed from full *k*-space. The images from the second to the eighth in Fig.5 were reconstructed using GRAPPA method at acceleration factors of 2 to 8. It is clearly shown that with the increase of acceleration factor the imaging speed was enhanced while the SNR decreased. When the acceleration factor was smaller than 4, there was not obvious distortion to the image and the image quality was acceptable. For higher acceleration factor up to 8, obvious distortion can be observed in the reconstructed image.

Conclusions: The parallel imaging performance of the 8-channel tilted microstrip array has been investigated using two of the commonly used parallel imaging methods: SENSE and GRAPPA. In vivo human knee MR imaging was performed and images at different acceleration factors were reconstructed. The reconstructed images, noise correlation matrix and g-factor plot demonstrated excellent parallel imaging performance of the tilted microstrip transceiver array. High decoupling performance helps to decrease noise correlation among array elements, which decreases the g-factor and increases the parallel imaging performance.

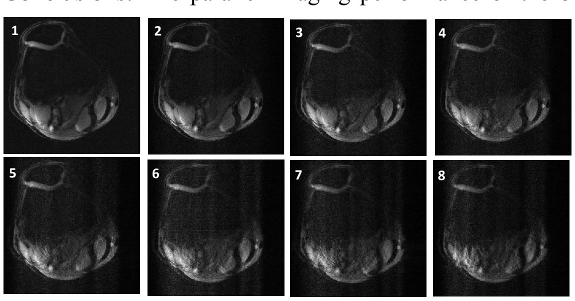

Fig. 5 Images reconstructed using GRAPPA at acceleration factor of 2 to 8 (corresponding to the number 2 to 8 assigned in the images. The first image is reconstructed from sum of square.

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References: [1] D.K. Sodickson, et al, Magn Reson Med 1997;38(4):591-603. [2] K.P. Pruessmann, et al, Magn Reson Med 1999;42(5):952-962. [3] M.A. Griswold, et al, Magn Reson Med 2002;47(6):1202-1210. [4] C. J. Hardy, et al. ISMRM 13th 2005 pp 677. [5] B. Wu, et al. ISMRM 18th 2010 pp 3825. [6] Y. Pang, et al. ISMRM 18th 2010 pp 47.