Parallel RF transmission for breast MRI at 3.0 Tesla: Preliminary Results

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Synopsis

Breast MRI at 3.0T has been shown to suffer from inhomogeneous RF transmission which results in heterogeneous T1-contrast across the field of view, in particular in large field-of-view, bilateral imaging protocols. The heterogeneous T1-contrast translates into variable enhancement of tumors, just depending on their location within the field of view. This has been a major reason why breast MRI at 3.0 T has only reluctantly been used in clinical practice. Breast Parallel RF transmission holds the promise of reducing dielectric resonance effects at high field strengths and enables control of RF distribution to optimize RF deposition. Parallel RF transmission has by now not been used or fully tested on clinical high-field MR systems. Our study demonstrates that parallel RF transmission in MR in breast imaging can effectively avoid B1-inhomogeneities.

Introduction: Breast imaging at current 3.0T MR systems has shown be prone to flip angle variations due to dielectric shading, in 3D imaging as well as in high-resolution 2D imaging (1). Parallel RF transmission (2-4) has the potential to fundamentally address dielectric shading. Up to now, parallel RF transmission has been primarily evaluated in simulation based studies and prototype MR systems (5-7) and not been used or fully tested on routinely used clinical high-field MR systems. In this paper we investigate the first clinical use of a parallel RF transmission in breast examinations.

Materials and Methods: A clinical 3.0T MR imaging system (Philips Achieva 3.0T TX, Philips Healthcare, Best, The Netherlands) equipped with fully flexible multi-source RF transmission (MultiTransmit) was used. The RF power was distributed to the ports of the system body coil using multiple independent RF transmit channels under full software control. With this design it was possible to independently control phase, amplitude and shape of the RF waveforms. Breast imaging was performed using conventional, single source RF transmission, as well as with patient-adaptive multi-source RF transmission (MultiTransmit) which was optimized for RF uniformity. Patient-adaptive image-based B0 shimming was applied for improved fat suppression. B1 maps were acquired using conventional and MultiTransmit 3.0T imaging and analyzed by comparing B1/flip angle in left and right breast (as % of intended B1 / flip angle). A total of 5 healthy pre-menopausal volunteers and two patients with breast cancer were investigated by contrast enhanced breast MRI without and with MultiTransmit. In addition, the two patients with breast cancers were also, on a separate day, investigated by contrast enhanced breast MRI at 1.5T.

Results: B1 maps revealed that the variation of flip angle ranged from 65-96% of the intended flip angle in conventional 3T imaging, confirming previous reports on B1 inhomogeneity at 3.0T (1). With MultiTransmit, the flip angle variations were substantially reduced, ranging between 92-98% of the intended flip angle. Images showed substantially improved signal homogeneity and consistent T1 contrast across the images in all 7 subjects. In the two patients with breast cancer, the enhancement kinetics of breast cancers were equivalent to the kinetics observed at 1.5T.

Conclusion: With flexible multi-source RF transmission, one obstacle to breast MRI at 3.0T in clinical practice – i.e. B1 inhomogeneities – appears to be overcome. Consistent T1 contrast across the entire field of view, with no left-to-right signal intensity variations, was achieved for the first time.

Reference List: 1). Kuhl CK, Kooijman H, Gieseke J, Schild HH. Effect of B1 inhomogeneity on breast MR imaging at 3.0 T. Radiology. 2007;244:929-30 **2)** Katscher U, Bornert P. Parallel RF transmission in MRI. NMR Biomed. 2006;19:393-400. **3.)** Katscher U, Bornert P, Leussler C et al. Transmit SENSE. Magn Reson.Med. 2003;49:144-150. 4**.)** Zhu Y. Parallel excitation with an array of transmit coils. Magn Reson.Med. 2004;51:775-784. **5.)** Graesslin, I, Niemann, M, Harvey, P et al. SAR and RF power reduction with parallel excitation using non-cartesian trajectories. MAGMA 18, S251. 2005. **6.)** Ullmann P, Junge S, Wick M et al. Experimental analysis of parallel excitation using dedicated coil setups and simultaneous RF transmission on multiple channels. Magn Reson.Med. 2005;54:994-1001. **7.)** Zhu, Y, Watkins, R, Giaquinto, R et al. Parallel excitation on an eight transmit-channel MRI system. Proc.Intl.Soc.Mag.Reson.Med. 13, 14. 2005. **8.)** Pruessmann KP, Weiger M, Scheidegger MB et al. SENSE: sensitivity encoding for fast MRI. Magn Reson.Med. 1999;42:952-962.