Integration of 2-channel Parallel Transmission with Forced Current Excitation for Improved B_1 Homogeneity in Breast Imaging at 7T

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Introduction

Ultra-high field MR offers the promise of increased SNR and spectral dispersion which should lead to higher spatial/temporal resolutions in imaging, and increased sensitivity and better quantification in MRS [1]. Capitilizing on these advantages however requires resolving the concomitant issues of decreased B_1 and B_0 homogeneity. Several general approaches have been proposed for improving B_1 inhomogeneity, notably the use of the additional parametric freedom of parallel transmission where not only the amplitude but also the phase of the multiple transmission channels can be controlled. An alternative approach, termed forced current excitation (FCE) was proposed [2,3] for addressing the issue of B_1 inhomogeneity in unilateral breast imaging at 7T. This approach offers the advantage of simplified hardware parameter setting and relative insensitivity of coil tuning and matching to coil loading. The large variability in the general population in breast size and composition leads to a large variability in coil loading, and while this argues in favour of utilizing FCE, this technique does not offer the flexibility of independent channel transmission. In this abstract, we report on improved 7T B_1 homogeneity achieved by combining the flexibility of 2-channel parallel transmission with the insensitivity to loading of common-point FCE.

Methods

This study was performed on a 7T whole body scanner (Philips Medical Systems, Cleveland OH) equipped with a vendor-installed dual-channel parallel transmission. A previously reported [4], unilateral breast quadrature coil, capable of FCE excitation was used. The coil consists of a Helmholtz pair (i.d. 16 cm, spacing 8.0 cm) driven in FCE-mode, and, orthogonal to that, a saddle-coil pair (diameter 15.3 cm, length 8.7 cm, aperture 120o) also driven in FCE mode. The FCE uses transmission line properties (quarter wave length distance from the voltage feed point to each FCE coil element) to ensure equal coil element currents irrespective of unequal loading, coupling, or coil sizes. The Helmholtz pair and the saddle pair were driven in parallel by the two independent 4 kW RF amplifiers, such that the additional flexibility of setting individual RF amplitudes and phases was retained. B_1 calibration maps were collected, per individual transmit channel, both from phantoms and normal volunteers using a dual-TR 3D B_1 acquisition [5] with nominal flip angle of 50^0, TR1 / TR2 = 35 / 140 ms, and resolution 2 x 2 x10 mm. Both magnitude and phase data was acquired and used to perform B_1 shimming based on minimization of the standard deviation of the B_1^+ field over a user-selected region (volume selective power optimization [6] was also used in the same region, Figure 1), utilizing the middle slice of the 3D field maps. Comparison of the B_1 maps acquired with the FCE coils either run in quadrature or in 2-channel multi-transmit (Multix) mode was then performed. All human studies were performed under a protocol approved by the local IRB.

Results and Discussion

Figure 1 depicts B_1 maps acquired with the use of quadrature-only FCE excitation (A) vs. Multix-FCE excitation (B). The ACRIN breast phantom was used. The B_1 line profile (horizontal line drawn through the middle of the ROIs) is notably flatter in the Multix-FCE case (Figure 2). The B_1 coefficient of variation (CV) in the multix-FCE case is 3.6%, which is about twice smaller than the CV = 6.1% in the quadrature-FCE excitation. Additionally, the B_1 CV in the ROIs (Figure 1) was 19% in the quad case compared to 11% in the Multix-FCE indicating ~40% transmit field homogeneity improvement. Human volunteer data shows B_1 CV in the ROIs (Figure 3) of 9.2% in the quad case compared to 7.8% in the Multix-FCE indicating approximately 15% field homogeneity improvement.

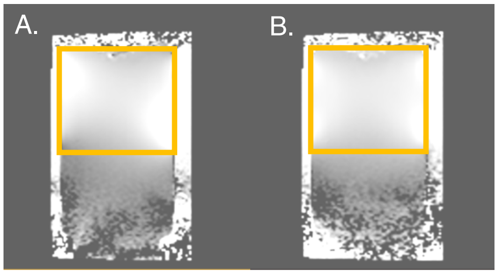

Figure 1. Quadrature-only-FCE (A.) vs. Multix-optimized FCE (B.) B_1 maps. Optimization ROIs are shown in yellow.

Conclusions

Adding 2-channel parallel transmission to FCE breast coil further improves B_1 homogeneity making the overall transmit design even more favorable for high quality breast imaging at high static magnetic field. Additionally, because of its relative insensitivity to coil loading this approach may allow for better patient throughput since breast size and composition vary widely across population.

References

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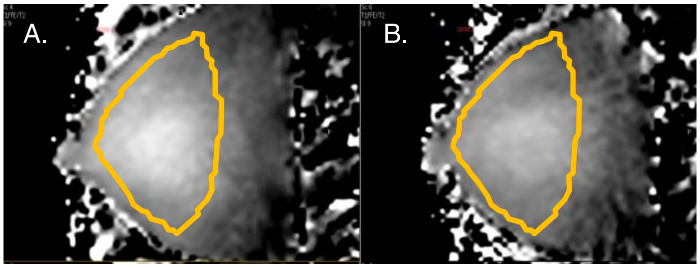

Figure 3. Quadrature-only-FCE (A.) vs. Multix-optimized FCE (B.) B_1 maps in a human breast . ROIs shown are a subset of B_1 shim and power optimization ROIs to exclude regions with insufficient SNR for B_1 estimation.

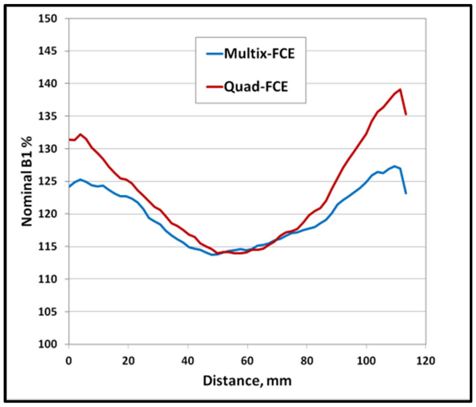

Figure 2. Quadrature-FCE B_1 line profile (in red) vs. Multix-optimized FCE B_1 (in blue).