Comparison of active and passive parallel transmit in 3T breast

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INTRODUCTION: While 3T breast imaging gives a clear benefit over 1.5T in increased SNR, it also has significant problems resulting from B_1 inhomogeneity. Inhomogeneous B_1^+ field is identified as a significant source of SNR loss, image shading, inaccuracy in T_1 and contrast images, artifacts, and improper fat suppression. Both active and passive parallel transmit have been proposed as possible solutions, but neither are clinical standard at this time. Here 'active' parallel transmit refers to the use of multiple RF transmission lines capable of at least independent B_1^+ amplitude and phase adjustment. We use 'passive' parallel transmit to refer to the use of one or more tuned coil elements, inductively coupled to a single active transmit field [1,2]. Here active and passive parallel transmit are compared in RF homogeneity and relative SAR in-vivo over the breast at 3T.

METHODS: All images and B_1 maps were acquired on a 3T GE 8-channel Parallel Transmit scanner with a integrated body transmit coil (MR Instruments). 8 female volunteers were scanned in accordance with local IRB guidelines. B_1 homogeneity for four transmit modes were compared:

Single Channel CP mode: Circularly polarized RF phases were applied to the 8-channels to mimic a typical single channel system. Figure 3a shows a B_1 map for a single-channel circularly polarized field in our scanner. This B_1 distribution is typical in the breast at 3T [3,4].

Passive Parallel Tx: The average left/right B_1 ratio was measured for the Single Channel CP mode to be 1.49±0.2 in five volunteers (weight 62±8 kg),. A simple passive coil was built and experimentally tuned to 151.5 MHz to produce the same, but opposite left/right B_1 ratio in a silicon oil breast phantom. This coil was placed at the base of the right breast in a standard 8-channel receive coil (Figure 1).

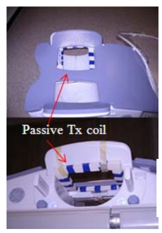

Fig. 1: Passive Tx coil

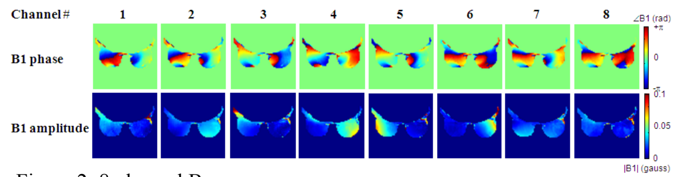

Figure 2: 8-channel B_1 maps

Active Parallel Tx: 8-Channel, spin echo Bloch-Siegert B_1 amplitude and phase maps were acquired for three slices having 64x64 res, 40x40x0.5cm FOV per slice [5] (Figure 2). Optimal B_1 amplitude and phase settings were calculated for each slice to minimize B_1 inhomogeneity inside a mask chosen to include both breasts and axilla. Two configurations of 2-channel parallel transmit system were simulated by combining subsets of the 8 channels as shown in Figure 3b, c. Figure 3b approximated a split birdcage, and Figure 3c was chosen as the optimal two channel configuration for our bimodal 3T breast inhomogeneity. Optimal amplitudes and phases were found for these 2-channel configurations with a circularly polarized phase relationship within each channel set.
A full 8-channel amplitude and phase shim was calculated with a joint optimization to minimize both inhomogeneity and SAR. Two 8-channel cases are compared here- one where the SAR penalty was removed to assess the minimum possible inhomogeneity, and one with a weighted penalty choosing shim solutions for both homogeneity and SAR efficiency.

RESULTS/DISCUSSION: Bloch-Siegert B_1 maps were acquired for 3 axial slices to compare the transmit field homogeneity for each of the cases. B_1 maps and histograms over the masked volume for one slice, in one volunteer are shown in Figure 3 for all configurations except the 8-channel, without SAR penalty. Table 1 shows the standard deviation of the B_1 field over pixels in the masked volume is shown for all configurations. Also shown is relative global B_1 power compared to the CP mode (Eqn. 1). This refers to the squared sum over all channels of B_1 required for a shim case relative to CP mode, to achieve the same average total B_1 field over the mask volume.
Results shown are preliminary, regarding the small population size. B_1 homogeneity in the breast at 3 Tesla improves with increasing channel count, at least up to the 8-channels tested here. However, system complexity and SAR add additional considerations in choosing an optimal configuration. The 2-channel configuration in Figure 3c in particular performs almost as well in B_1 homogeneity as the 8-channel case, and better in SAR efficiency. However, this configuration would not be optimal for all anatomy. Of the parallel transmit configuration option, the passive transmit coil is by far the simplest to implement. One coil tuning was chosen for the population, giving B_1 homogeneity comparable to a 2-channel shim, and 30% less SAR compared to a single channel system.

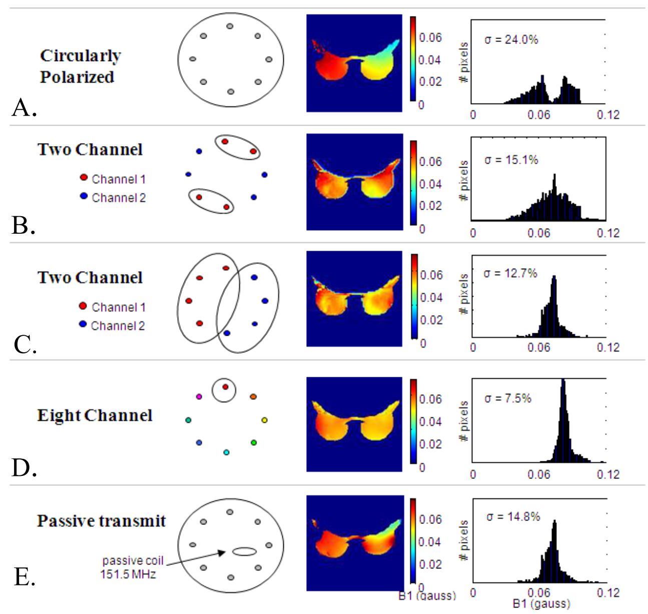

Figure 3: B_1 homogeneity comparison, 1 subject

Mode:	CP	2 Channel (split birdcage)	2 Channel (left/right channels)	8 Channel (no SAR penalty)	8 Channel (with SAR penalty)	Passive Transmit
B_1 standard dev. (% of mean B_1 field)	24.4 ± 4.1	16.0 ± 5.5	13.1 ± 3.6	11.3 ± 4.3	12.8 ± 5.2	14.0 ± 5.7
Relative B_1 Power	1.0	0.92 ± 0.16	0.93 ± 0.08	2.2 ± 1.4	1.2 ± 0.4	0.7 ± 0.08

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