7T Breast Imaging with a 2-Channel Bilateral Loop Design

L. L. Warmington[1], G. Adriany[1], C. Snyder[1], E. J. Auerbach[1], and P. J. Bolan[1]

[1]Center for Magnetic Resonance Research, Radiology/University of Minnesota Medical School, Minneapolis, MN, United States

Introduction

High-field MR imaging in the body is complicated by the high non-uniformity of the transmit RF field. Initial studies have shown that it is possible to image the breast at 7T with dedicated unilateral breast coil designs using solenoidal (1,2), quadrature, and TEM strip designs (3,4). These studies were limited to single breast, and generally did not have sufficient penetration to evaluate the chest wall and auxiliary region. Alternatively, it is possible to image the breasts using full-body or torso arrays in combination with multi-channel transmit RF systems (5). Such RF systems are currently being developed, but they are very expensive and not widely available. Our goal for this project was to develop a simple bilateral coil design that could be used without a parallel transmit RF system, and to determine if this configuration would be suitable for use in MRI/MRS investigations of patient populations.

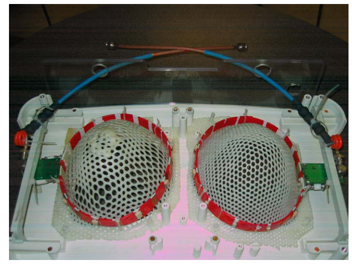

Figure 1 – Picture of the dual-coil design.

Methods

Images were acquired using a 7T Siemens scanner equipped with an 8kW RF broadband amplifier (Communications Power Corporation). A Siemens 4-channel CP breast coil housing was modified and fitted with forms for a sized D-cup breast, as shown in Fig 1. The loop was created from copper tape mounted on PTFE and had dimensions of 16 cm diameter, 2.5 cm height and 2 mm thickness. Sheath currents were minimized using with a sleeve balun. Decoupling circuitry was not employed. A single RF channel was split using a quadrature hybrid splitter and two high-power T/R switches (Varian), as shown in Fig. 2 and described previously (6). The relative transmit phase between the channels was modified by adjusting the cable length between the hybrid and one of the T/R switches. Several phantoms were imaged, along with three subjects of breast size A, B and DD. Imaging included 3D gradient echo sequences with and without fat-suppression, and RF mapping using the manufacturer's *rf_map* sequence.

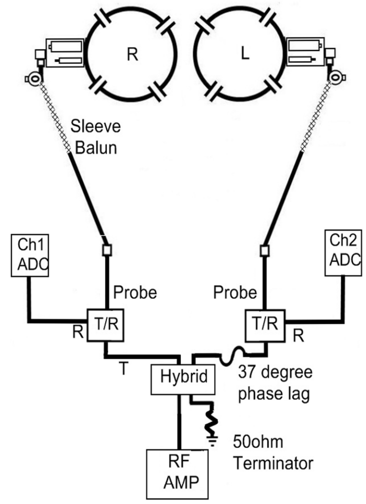

Figure 2 – Schematic of coil and RF configuration

Results and Discussion

Phantom experiments were used to select a fixed relative phase between the two channels that moved the dark band of destructive interference out of the breasts and into the torso. The best solution used a 53° phase lag on the left channel. Using this fixed phase, three human subjects were imaged. Example images from these studies are shown in figure 3. The receive coupling measured in one subject was 10%, measured *in vivo* which supported our decision to ignore decoupling. Fat suppression using the manufacturer's chemically-selective presaturation worked acceptably well for unilateral imaging, but was not sufficient for bilateral imaging. Parallel imaging was possible up to R=2 in the left-right direction with no evidence of reconstruction artifacts. B1+ mapping was performed in 2 subjects, and a representative slice is shown in fig 4. The map shows max B1+ to be 60μT (γB1=2.6 kHz), measured in the center of the breast in the B-cup subject. Much of the breast has B1+greater than 35μT, demonstrating that it is sufficient for single-voxel spectroscopy.

Conclusion:

This simple approach for 7T breast coil design produced images of better than expected quality and acceptable performance for single-voxel spectroscopy. This design is not suitable for general clinical imaging but does illustrate the feasibility of use in research studies in patients.

As expected, the transmit efficiency was best in the DD cup. Future work would include 1) making a second coil for A-B cup breasts, and 2) adding axilla coils for more uniform transmit coverage, and 3) optimizing the fat-suppression to account for the large B1+ and B0 inhomogeneities.

References:

(1) Lee RF et al, ISMRM 2006, (2) Hecht EM, et al. MR Clinics of North America 2007, (3) Bolan PJ et al., ISMRM 2006 (4) Haddadin et al., NMR Biomed 2007 (5) Vaughan JT et al., ISMRM 2008, (6) Glover GH et al., JMRI 1985

Acknowledgements:

NIH grants R01CA120509, P41RR008079 and The Keck Foundation

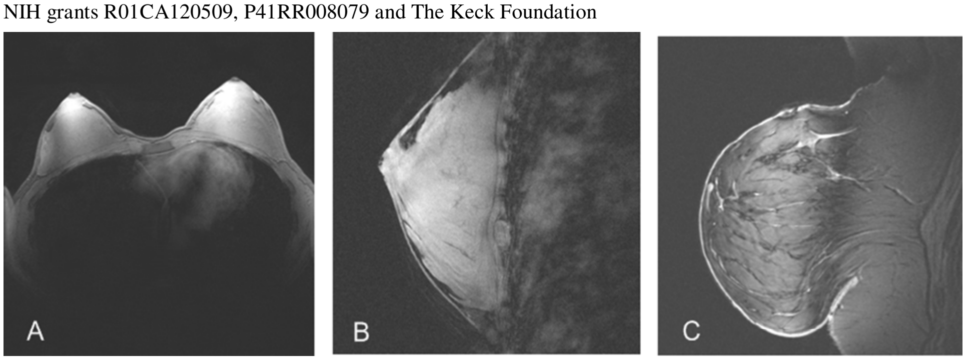

Figure 3 – a) a slice from bilateral 3D GRE (TR/TE = 10/3.1 ms, resolution 0.5 x 0.5 x 2mm); b) sag high-res FS 3D GRE (TR/TE = 8.3/3.6 ms fat-sat, resolution 0.3 x 0.3 x 0.15 mm) from same subject; c) sag high-res FS 3D GRE (TR/TE = 8.3/3 ms, fat-sat, resolution 0.5 x 0.5 x 2mm)

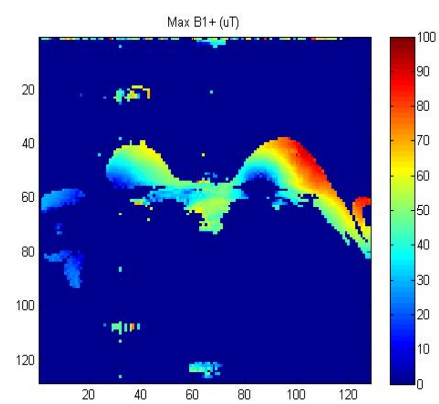

Figure 4 – B1+ map of subject with size A-cup in μT.