A 28 Channel Bi-lateral Breast Array for Accelerated MR Imaging

R. O. Giaquinto[1], C. McKenzie[2], D. K. Sodickson[2], A. K. Grant[2], G. E. Murtagh[1], R. L. Furman[1], L. J. Swider[1], C. J. Hardy[1], C. L. Dumoulin[1]
[1]GE Global Research, Niskayuna, NY, United States, [2]Department of Radiology, Beth Israel Deaconess Medical Center, Boston, MA, United States

Introduction:

Despite the excellent sensitivity and good specificity of breast MRI, several technical limitations are hindering wider clinical acceptance. One of the most significant of these limitations is the relatively long acquisition time needed to acquire diagnostically useful images. To address this problem a breast imaging table with a built-in 28-channel breast coil array was constructed. The performance of the coil array was evaluated in phantoms and human volunteers.

Methods:

A breast imaging table (Figure 1) was constructed and evaluated with a 32-channel 1.5 Tesla MR scanner (GE Healthcare, Waukesha, WI). The main component of the table is a 28-element breast receiver coil array built on four lightweight Lexan™ plates (two lateral and two medial), with seven 6.9 cm diameter hexagonal rings mounted on each plate. The support frame is sunk into the table and is designed to accommodate a prone patient. The design allows for the breasts to hang between each lateral and medial plate. The medial plates are fixed to the support frame and are angled 20 degrees so that the plates are closer together at the chest wall. The lateral plates can be slid and locked in the lateral direction to provide mild compression of the breasts. If desired, the lateral plates can be removed to enable lateral access to the breast for biopsy. The coil elements are placed in a hexagonal lattice and are overlapped so as to decouple nearest neighbors, as shown in Figure 2. The coils were cut from 0.81 mm thick copper sheet using a computerized water jet and are grouped into three layers separated by 1.5 mm thick Lexan™ sheets. Grooves cut in the Lexan™ sheets hold the rings in place. Transmit blocking circuits and baluns are incorporated in each coil.

Signal-to-Noise Ratio (SNR) phantoms were constructed by filling trapezoidal Lexan™ containers with $CuSO_4$-doped water (1.0 g/l). MR images of the phantoms were obtained with both the new 28-channel breast imaging table and a conventional 4-coil breast array (MRI Devices, Gainesville, FL) using identical protocols: TR=4.6, TE=1.8ms, FOV=32cm. Additional phantom images were obtained with the new breast array using three-dimensional acquisitions with acceleration factors of 4 (i.e. 2x2) and 12 (i.e. 4x3). SNR measurements were made in the center of the phantom in a position corresponding to deep breast tissue.

Performance of the new breast array was also evaluated in volunteers using a number of different protocols. These protocols included large acceleration factors (>6x) in combination with traditional three-dimensional fat suppressed spoiled gradient recalled echo (SPGR) images and Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares estimation (IDEAL) for dynamic contrast enhanced breast MRI (1).

Results:

The 28-channel breast array was found to have 2.8 times the SNR of the conventional 4-coil array in phantoms. Even with a 4-fold acceleration (i.e. 2x2), the 28-channel coil array was found to have greater SNR than the equivalent unaccelerated scan using the conventional array (184 *vs.* 138). Cross coupling between coil elements was found to be minimal and coil detuning during body coil transmit was found to be adequate for all coils in the array. The SNR advantage, and the large number of coil elements permitted volunteer studies to be performed with acceleration factors as high as 7.6. Sample images are shown in Figure 3. Volunteers reported only minor comfort issues associated with the cushions.

Discussion:

The excellent sensitivity of the rf coils in the breast imaging table and the large number of independent elements permit MR imaging with substantial acceleration factors. This in turn affords greater flexibility in reducing scan times, increasing resolution and choice of protocol. Exams such as multi-phase, high-resolution 3D IDEAL imaging after Gd contrast injection, which have been impractical in the past, can now be performed in clinically realistic scan times.

References

1. Reeder et al, MRM, 2004;51:35-45.

Figure 1. Photograph of the breast table (cushions removed).

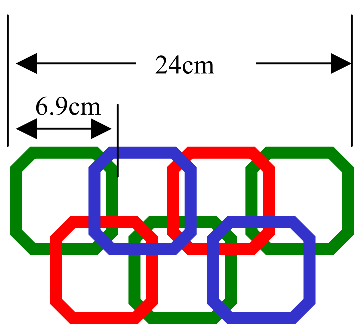

Figure 2. Layout of the seven coil elements for each plate. Coils of the same color are embedded in the same layer of Lexan™.

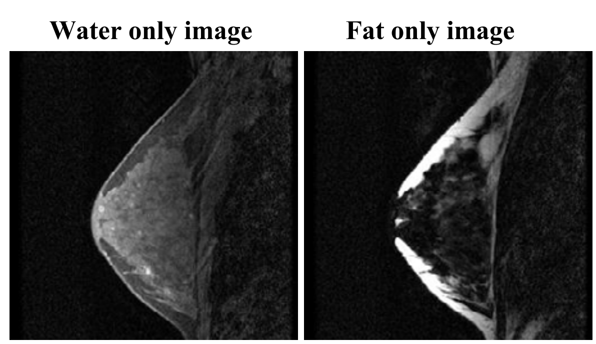

Figure 3. Sample images of a volunteer: 3D IDEAL with a factor of 7.6 acceleration. Voxel size is less than 1μl.