3T Breast Array Optimized for Parallel Imaging

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Introduction

MR breast imaging is becoming more prevalent with advances in hardware and imaging techniques. A 4-channel breast coil was developed for 3T parallel imaging of the breast to incorporate the high SNR of the 3T system with the advantage of parallel imaging to increase the spatial resolution. The coil is g factor optimized for acceleration in the LR as well as the AP direction. The bottom part of the coil contains 2 elements and is electrically independent of the top part. The bottom part could therefore be removed if 2-channel imaging is desired combined with improved patient access, or the 2 bottom elements could be deactivated for imaging small patients. The resulting breast coil has been used for 3T imaging of the breast using a 3D technique with acceleration in the slice direction (LR)

Method

The coil has been constructed on a Lexan former using ¼ inch 3M copper tape. A circuit diagram is shown in Figure 1. The top portion measures 7 by 7 inched for each loop with a 0.75-inch separation between the loops. The bottom portion is 5 inches below the top and the loops here are 7 inches by 7.5 inches (LR) with a 0.75-inch separation. Both top and bottom are concave: the bottom to fit the patient cradle contour, the top for patient comfort and to better fit the adjacent chest wall. All loops are transmit field decoupled by means of a passive blocking network on the inferior end, and an active blocking network on the superior end input ports. The coils are decoupled from each other in the LR direction by means of canceling out the mutual inductance with opposite reactance. In the AP direction the coils are decoupled by means of distance, which is good enough at the loaded Q of 20. Unloaded the Q of the coil is around 140. Cable trap baluns are applied at the input ports of the coil to minimize standing cable shield waves. The patient is cradled by a sloping top, which allows larger individuals to fit into the magnet in the prone position.

Figure 1- Circuit Diagram

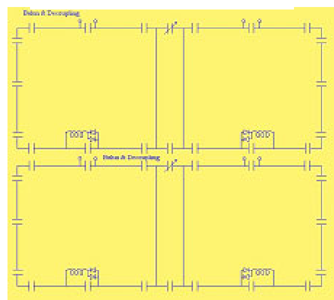
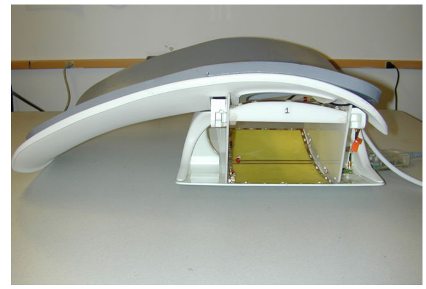


Figure 2 Top view of Array



Results /Discussion

The G factor maps were calculated for a reduction factor of 2 in the AP direction, as well as the LR direction. Fig 4 shows a map for phase encoding in AP. The coil produced theoretical mean g-factors of 1.02 for a spherical phantom and 1.00 for cylindrical phantom, peak g-factors were 1.04 and 1.14 for a sagittal slice. For parallel imaging, the SNR of accelerated imaging is given by $SNR = {SNR_0}/{g\sqrt{R}}$, where R is the acceleration factor and SNR_0 is non-parallel imaging SNR. The coil produced theoretical mean g-factors of 1.02 for a spherical phantom and 1.00 for cylindrical phantom, peak g-factors were 1.04 and 1.14 respectively for a sagittal slice.

$$\frac{SNR_R}{SNR_0} = \left(\frac{g_0}{g_r}\right)\sqrt{\frac{R_0}{R_r}}$$

Therefore, since the g-factors are close to one the SNR ratio will be dependent on the ratio of the square root of the R factors. Clinically this is what has been found. At R=4, the g-factor will become a more predominant factor and foldover will produce significant artifacts in the image as well as extra noise. This is due to the limited number of coils available for un-wrapping the data in the direction of the acceleration (LR). The B field of the coil was calculated and compared to phantom images and is shown in Figure 3 for a sagittal slice. The map shows good homogeneity within the phantom which will in turn produce good fat saturation in the breast images. Finally Figure 5 shows a fat sat sagittal breast image from the coil using a 3D gradient echo technique, 256 x256 matrix, 10 degree flip and 31.25 kHz bandwidth. FOV's for the patients are between 14 and 22cm.

Figure 3- Sagittal B1 map

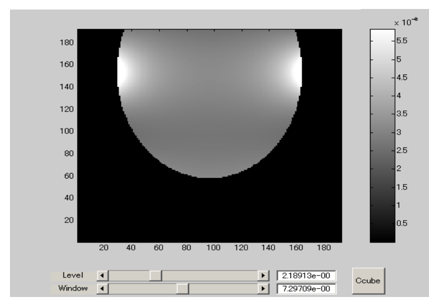


Figure 4 – Phase Encode (AP) Map

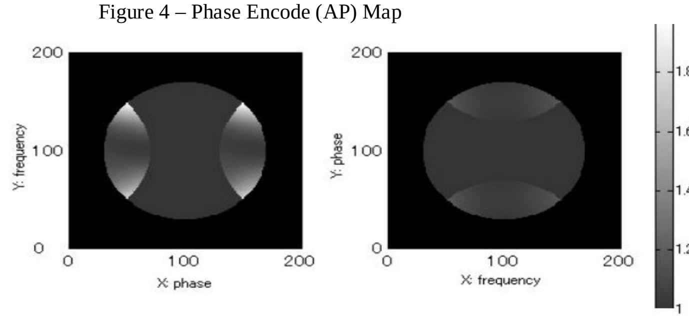
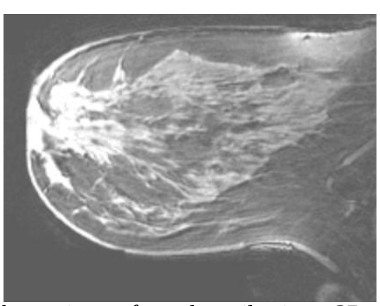


Figure 5 Sagittal Slice at 2X acceleration



Conclusion

MR mammography is dependent upon the use of both high temporal and spatial resolution in dynamic enhancement imaging. The increase in signal from the higher field strength allows us to accelerate the imaging through the use of parallel imaging. Therefore, using the higher acceleration factors will allow us to obtain higher resolution imaging in the same amount of acquisition time. The above coil design takes into account optimization for acceleration factors in the slice direction. Moreover, this design allows for greater access, multiple coil selections as well as easy removal of posterior elements for biopsy procedures.