30 channel unilateral breast coil for ultra high resolution MRI at 7T

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Introduction

Dynamic contrast enhanced MRI provides a sensitivity of up to 100% in detecting breast cancer, however at limited specificity. Although detailed information of morphology has been shown to improve specificity, detection at high spatial resolution is time consuming and suffers from low signal to noise ratio (SNR). At 7T however, SNR can be substantially improved, particularly with dedicated SNR optimized breast coils [1]. Therefore spatial resolution can be improved while maintaining sufficient SNR. On the other hand, dynamic contrast enhancement curves are required to distinguish malignant from benign tissue, therefore limiting the scan time to the temporal resolution required for these curves (typically around 90 sec). In order to combine high spatial resolution MRI within the required temporal resolution, substantial acceleration is required. We therefore propose the use of a 30 element receiver coil for unilateral breast MRI at 7T with high acceleration performances while maintaining optimal SNR.

Methods

A 30 element receiver coil was designed combined with a local RF transmit coil (details in fig 1). The setup was compared to a volume optimized quadrature surface transceiver coil with similar geometric distances to test additional noise contribution of the used electronics. Optimal coil sensitivity weighting was determined using a reference scan that obtained low resolution MRI either with the transmit coil in receive mode or with each of the 30 elements. Both phantom measurements and in vivo measurement were obtained with the two coil setups. FFE sequences were applied with a nominal flip angle of 10° (adjusted for the center of the breast), TR 8.8ms, TE 2.3ms). For the coil comparison no SENSE was applied, whereas for the high resolution MRI obtained with the 30 channel coil, a sense factor of 4 was applied in left right direction.

Figure 1: Schematic and photograph of the 30 channel receiver coil combined with a local transmit coil and integrated in a commercially available mechanical breast coil setup (Machnet BV, Maarn, the Netherlands). The receiver coil elements have an elliptical size of 5 by 2 cm and are decoupled using preamplifier decoupling. The entire setup is interfaced to a 7T whole body MR system (Philips, Cleveland)

Results and discussion

The unloaded versus loaded ratios range from 10 to 1.8. with the highest value for the elements that were positioned closest to the chest and the smallest observed for the elements 27-30 at small breast sizes (i.e. a male volunteer). Therefore, the average element resembles tissue load dominance, hence effects of noise contributions are minimal. This is illustrated in the in vivo results in figure 2, where at the largest distance from the elements (i.e. glandular tissue at the chest wall) the SNR of the 30 channel setup was still similar to the SNR optimized RF coil. As of such, high SENSE accellerations can be applied without artifacts nor additional SNR penalties.

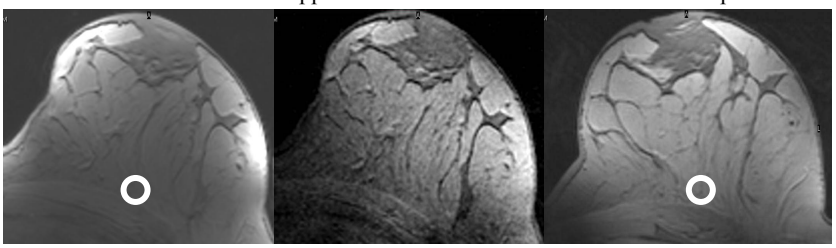

Figure 2 : MRI images from the same breast of a healthy volunteer obtained with the 30 channel surface array (a), the enlarged transmit coil integrated in the 30 channel array (b), and an SNR optimized 2 channel transceiver (c). At the worst case location in the breast (white circle), the SNR of the MRI in a is comparable to c.

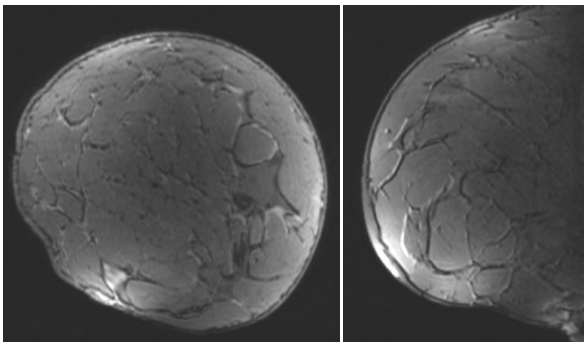

Figure 3: 3D high resolution (0.5 mm isotropic) MRI obtained from the breast using the 30 channel array coil. A sense factor of 4 was applied in the unilateral breast resulting in an acquisition time of only 1.5 minutes.

Conclusion

In this work we demonstrate the feasibility of implementing a 30 channel RF coil array optimized for a single breast. Even with the small size of the elements of 5 by 2 cm, tissue noise remains dominant. We have shown that high resolution MRI can be obtained at 7T within the time frame required for dynamic contrast enhanced studies. Therefore with this setup, functional physiologic information can be obtained from the human breast with a resolution that enables visualization of high morphological details.

References

[1] Klomp et al. High Resolution MR Imaging and Spectroscopy of the Human Breast at 7T Using a Focused Field RF Coil Setup, ISMRM 2010