

Flexible Four Element Phased Array Coil for Supine Breast MRI

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INTRODUCTION

Dynamic contrast enhanced breast MRI shows a high sensitivity for breast cancer [1]. To avoid respiratory motion artifacts, breast MR images are currently acquired with the patient in a prone position. Supine unilateral breast MRI has several applications including scanning of patients with known claustrophobic sensations, as an aid to breast-conserving surgeries and guidance of breast-biopsies. Previously, a feasibility prototype coil system consisting of a custom-designed two-element imaging coil and a fixture to position the coil above the breast was built [2]. A modified imaging sequences [3], which compensate for respiratory motion in accordance to the zonal motion-adapted acquisition and reordering technique (ZMART) [4] was used. ZMART is a combination of gating and k -space reordering based on the respiration pattern. The set-up was designed in a way to allow placement of the coil in close proximity to the breast without touching the breast to leave it in its natural supine configuration.

However, the first supine breast coil prototype was a two coil element rigid design, which allowed only translation of the coil along the three coordinate axis and produced only moderate signal-to-noise (SNR) images. To improve the SNR, a flexible four element coil, which is able to conform better to individual breast geometries, was designed and tested in phantom and volunteer experiments.

MATERIALS AND METHODS

A four-element receive coil for supine breast imaging at 1.5T was built on a flexible Teflon sheet (Fig.1a). The coil was 26cm long and 23cm wide. The coil loops were made of 6.35mm wide copper tape placed on the Teflon sheet. Coupling between neighboring coil loops was minimized by overlapping the loops and decoupling capacitors. Low input impedance pre-amps were also used to increase the coil isolation.

Three lines of gimbaled joints (Loc-Line system, Modular Hose) allow a stable bending of the coil shape (Fig. 1c-d) to conform as closely as possible to different breast geometries. In addition, a gimbaled joint is used to connect the coil to the fixture, which allows arbitrary rotation of the new coil above the patient's breast (Fig. 1c-e).

All experiments were performed on a whole body 1.5T MR scanner (GE Signa Excite).

• SNR measurement:

The coil was positioned over a homogenous agar gel phantom (20g/l, 1ml/l Omniscan), which emulated the geometry of a patient lying in supine position. As with patient scans, an air gap of a minimum of 1cm was kept between the surface of the phantom and the coil. For the SNR calculation [5,6], three data sets were acquired: axial images (fast 3D spoiled gradient echo (SPGR) sequence, $T_E=4.2\text{ms}$, $T_R=6.5\text{ms}$, flip angle=30°, $\text{FOV}=230\times230\times256\text{mm}^3$, matrix=256×256×128), coil sensitivity data (3D SPGR, matrix=64×64×128) and noise samples (2D SPGR, matrix=256×256).

• Volunteer scan:

After obtaining consent, unilateral, oblique coronal scans with a left-right frequency-encoding direction ($T_E=4.2\text{ms}$, $T_R=6.5\text{ms}$, $\text{FOV}=180\times180\times96\text{mm}^3$, matrix=256×256×48, flip angle=30°) of a free-breathing volunteer were acquired with a fast 3D SPGR sequence. The sequence was modified to allow compensation for respiratory motion in accordance to ZMART [4]. The actual position in the respiratory cycle was tracked using a respiratory belt. The gating limit was set to 60% of the maximal displacement between expiration and inspiration and 32 ZMART-zones were used for reordering.

RESULTS

The SNR-scaled images of the supine breast phantom (Fig. 2) showed very high SNR values over a volume which would cover the entire breast tissue of a supine breast.

In the volunteer experiment, the new coil provided good SNR over the entire supine breast tissue (Fig. 3).

DISCUSSION AND CONCLUSIONS

The flexible design is especially useful for multiple element coils, because their SNR advantage requires the coil to be close to the given volume of interest. The increased number of coil elements will give improved parallel imaging performance [7]. In addition, they provide the potential for higher acceleration factors, which would further decrease the relatively long scan-time caused by the ZMART motion compensation. The mechanical fixture allows a close proximity to the body habitus, which ensures a good SNR.

In the future, coils with more elements will be tested as well as different strategies for the arrangement of the lines of gimbaled joints to facilitate positioning of the coil during the preparation of the patient for MRT.

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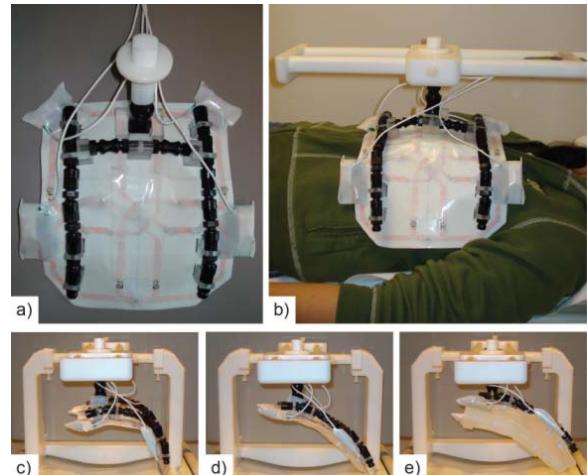


Figure 1: a) Flexible supine breast coil with four elements. The black fixture is bendable to adapt to the breast geometry of each individual. b) Positioning of the coil above the breast of the patient. c,d) Reshape and e) rotation of the flexible

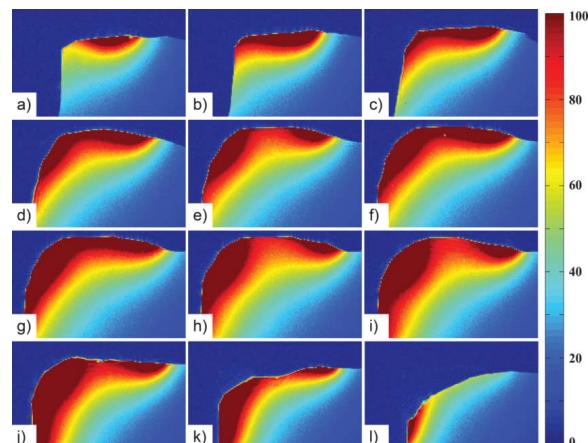


Figure 2: SNR maps of the supine four-element coil. Shown are axial slices (16mm between slices shown) through a supine breast phantom from a) anterior to l) posterior.

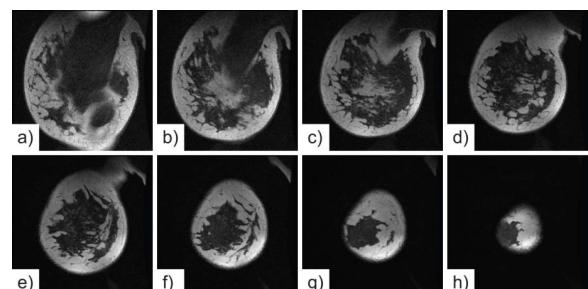


Figure 3: Supine breast images in oblique coronal orientation. Shown are slices (6mm between slices shown) through the supine breast from a) inferior to b) superior.