Development of Micro-Strip Coils for Breast Imaging

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Introduction: In some multiple coil MRI applications, RF coils are necessarily strongly coupled. One such example can be configured for breast MRI where a possible coil geometry would use two coils on parallel surfaces surrounding each breast (Figure 1). In this geometry, the medial coils tend to be highly coupled as their separation, D, may be small for some patients. A number of coil decoupling methods have been proposed, such as capacitive decoupling, transformer decoupling, low impedance pre-amplifier decoupling and active decoupling [1]. However, these systems either require hardware modifications to the RF section of the MR system, or are dependent on the coil geometry and thus require retuning for each patient. In order to overcome this problem, Wang [2] proposed a position-independent decoupling method by using a shielding coil composed of a multi-turn, open loop floating coil mounted on the back of the surface coil. When the surface coil detects the NMR signal, currents are set up in the shield which oppose this in the surface coil and serve to cancel out the magnetic field remote from the shielded side of the coil. However, due to the energy loss in the shielding coil, the SNR was found to be reduced by ~20% compared to an unshielded coil.

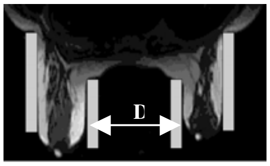

***Figure 1** Breast imaging using parallel surface coil. Inner surface coils are strongly*

In this work, we present a position-independent decoupling method using micro-strip transmission line coils. Micro-strip transmission line receiving coils have been reported to have good SNR and stability [3-6]. They consist of a grounded back plane together with the conductive strip bonded to either side of a low-loss, high permittivity material such as Teflon. This two-part structure is very similar to that of the virtual shielding coil proposed by [2] and therefore should exhibit similar decoupling properties. Furthermore, the signal receiving strip and the grounded plane together form the resonance coil structure. Unlike the virtual shielding coil, in which the energy stored in the shielding coil is lossy, there is no signal loss for the micro-strip coil case. The results of our work showed that pairs of micro-strip coils placed back-to-back exhibit excellent decoupling over a range of geometries without need for individual adjustment, as well as good isolation properties. Due to this shielding affect, a micro-strip coil should exhibit asymmetric signal response resulting in a large signal from spins adjacent to the strip side compared to spins adjacent to the shielded side of the coil. We use this feature to provide decoupling from closely mounted medial coils in the four coil geometry of Figure 1. This allows the signals from each individual breast to be detected primarily from the coil facing the breast. Thus bilateral imaging based on TR interleaving can be achieved without the need for active coil decoupling [1].

Method: The breast micro-strip coils are shown in Figure 2. The Teflon substrate has a thickness of 1/4" (6.35 mm). The top coil strip is 1/2" (12.7 mm) wide with an overall size of 4.0" x 6.0" (10 cm x 15 cm). The coils are tuned to 63.86 MHz and matched to 50 ohms. The shielding effect of ground side was measured with a sense coil and by MR image profile on two phantoms placed on either side of the coil. All images were scanned with GE 1.5T scanner (fSPGR, TE/TR/flip=4.2ms/18ms/30°). Phantoms were made by adding 7.5g NaCl and 0.04g MnCl to each liter of de-ionized water. To quantify the decoupling performance, a phantom was place beside a coil and another coil was placed at distance D, with the grounding sides placed back-to-back. The distance between two coils, D, was varied from 2.5 cm to 12.5 cm. For comparison, the same experiment was conducted with two conventional coils. For the image isolation experiment, two phantoms were positioned to represent the two breasts as in Figure 1. Two micro-strip coils were placed back-to-back between phantoms as medial coils. The field of view (FOV) was prescribed to cover only one phantom.

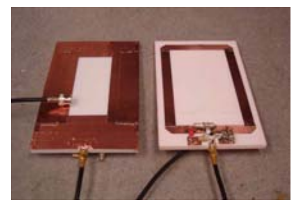

***Figure 2** Prototype Micro-strip coils for breast MR imaging.*

Results: The result showed that the back-to-back placed micro-strip coils are well self decoupled from each other. The signal intensity and SNR are essentially constant over a wide range of coil separation distance D (Figure 3). In the case of the conventional coils, the SNR demonstrated substantial degradation with reduced coil separation. Figure 4 shows the signal profile on either side of the micro-strip coil. Signal from the strip side is well received and similar to conventional loop coil, while the signal from the ground side is much attenuated. Figure 5 shows the isolation property of the micro-strip coil. The left and right coil received signal only from the facing phantom. Ghost images due to detected spins from the phantom adjacent to the shielded side of the coils are <1% of the signal from the strip side of the coil.

Discussion and Conclusion: This preliminary work demonstrates that the micro-strip coils perform well as decoupled medial coils for breast imaging. This allows these coils to be used in TR interleaved bilateral breast MRI without the need for active coil detuning. Alternatively, the isolation property of the coil pair may open a possibility for fast direct bilateral breast imaging techniques.

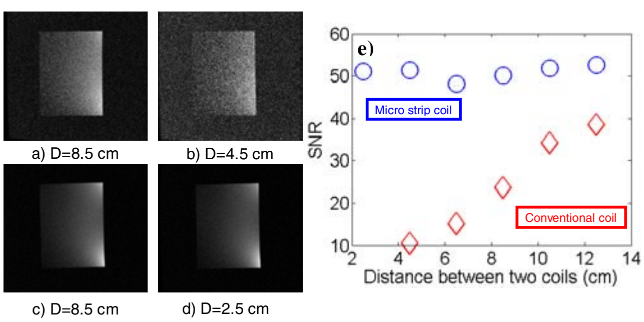

***Figure 3** Decoupling property results of the micro-strip coil pair.*
***(a, b):** conventional coil images in presence of another coil;*
***(c, d):** Images from micro-strip coil in presence of another coil;*
***(e):** SNR vs D of conventional coil and micro-strip coil.*

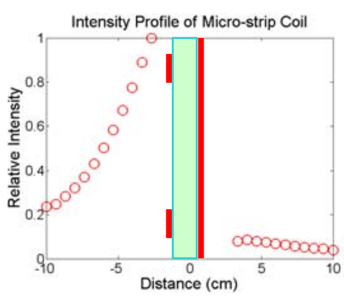

***Figure 4** Signal intensity profiles of the Micro-strip coils. Left: coil loop.*

***Figure 5** Isolation property of the micro-strip coil. Images are from left and right coils respectively. Aliasing ghost is <1%.*

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