A MULTI ELEMENT RF COIL AND GAMMA RAY RADIATION SHIELDING ASSEMBLY FOR MRSPECT SYSTEM

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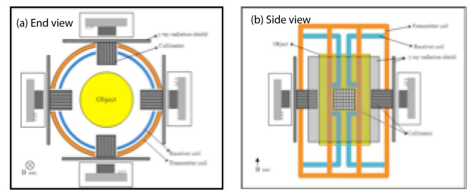
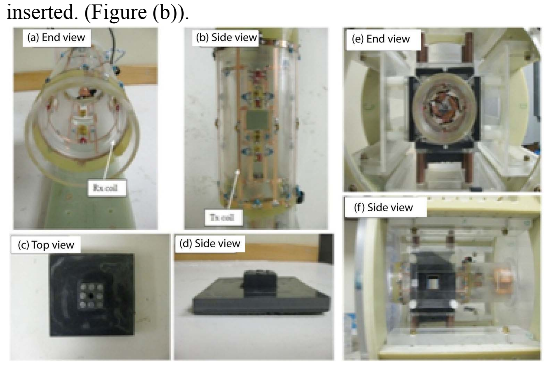
Introduction: A previous combined MRI and SPECT (MRSPECT) setup proposed by Chen *et al*, Meng *et al* and Hamamura *et al* consists of pinhole collimators embedded into a cylindrical, hollow γ-ray radiation shield covering the RF coil that maintains a certain distance from the coil to avoid degradations caused by the shielding material [1-3]. IN this work since the nuclear detector is placed behind the shielding assembly, the configuration limits how close the detector can be placed to the subject. In ISMRM 2010, we proposed a new assembly for RF coil and γ-ray radiation shield to avoid degradation of MR image quality by maximizing the shielding-RF coil (and shielding-subject) distance and optimizing SPECT image quality by minimizing the detector-subject distance [4]. In this study, we introduce a universal setup for MRSPECT and investigate its efficiency in a combined MR and SPECT study.

Figure 1 (a-b) Combination of the Tx/Rx coil and four γ-ray radiation shielding. The γ-ray radiation shielding was designed to fit within the windows between the neighboring RF segments. It is suitable to use with both pinhole and parallel-hole collimators (figures are shown for parallel-hole collimators). The CZT detector is shielded by a copper mesh box to suppress the RF interference.



Method: A newly designed receive- only array coil consists of four decoupled coil elements. Each element has a rectangular shape that can cover a cylindrical acrylic tube. Neighboring coils are kept 1cm apart, except for the place where the collimators sit. The designed RF transmitter also has windows with identical dimension and position as that produced by the array coil. Multi-pinhole collimators and parallel-hole collimators can be mounted on four windows of both RF coils (figure 1 and 2). The Tx coil has a 82mm diameter and 140mm length The high pass birdcage type transmitter coil has eight elements and is driven as a quadrature type. The receive-only array coil was made up of four rectangular shaped elements (width = 45mm length =100mm) that were printed at 90º apart around the hollow cylindrical acrylic pipe that has 70mm diameter and 160mm length. Coil shapes were modified as shown in Fig 1b and 2b for mounting collimators. The passive detuning method was utilized to decouple the array coil from the RF transmitter while high power RF energy was transmitting. Coupling between the neighboring segments was reduced using the inductive decoupling method. Isolations among neighbor channels were -18.7 dB, -20.0 dB, 19.8dB and -19.5 dB. The outputs of the four-channel receive-only coils were plugged into low noise amplifiers (LNA) with low input impedance (below 3~4Ω) to reduce mutual coupling between the opposite neighbor coils.

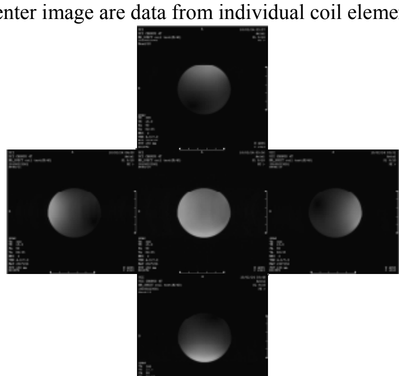
Figure 2 (a-b) Assembly of the transmitter coil and receiver array coils. The shape of the receiver coil is shown in the transmitter coil at the end view (a). (c~d) 9 Pin hole collimators and γ-ray radiation shields which are made of composite lead**.** (e-f) The experimental setup of with the transmitter coil, receiver array coils, and γ-ray radiation shields. The window of γ-ray radiation shield is the position at which a collimator is inserted. (Figure (b)).



Results: As expected from the experimental setup, (figure 2) the variation of the Q factor with and without the composite lead shielding on the Tx coil and Rx array coil demonstrated little difference. When four composite lead shields surrounded both RF coils, Q factors dropped 10.3% (transmitter coil) and 6.5% (receiver coil) relative to measurements taken without γ-ray radiation shielding. Additionally, the resonance frequencies were shifted by less than 200 kHz, which meant that RF coils could be operational without additional fine frequency tuning. The constructed four-channel array coil generated a uniform B1 field as shown at the center image of Fig 3.

Discussion and Conclusion: In this study, we reported on the successful implementation of an advanced multi-element RF coil designed for a MRSPECT system. Although the proposed RF coil had only four receiver channels because it was designed for a small animal SPECT system with four detectors, this concept can easily be expanded to human imaging by increasing the number of RF receiver coils and SPECT detector modules. Besides the improvement in the MR image SNR and SPECT sensitivity/spatial resolution, the proposed RF coil array offers parallel imaging possibilities such as SENSE imaging [5]. Multiple SPECT detectors can also be used to rapidly acquire dynamic data or to increase the count levels in noisy images without lengthening the imaging time, or to acquire transmission images for attenuation correction concurrently with an emission study [6].

Figure 3. Image of cylindrical shaped phantoms using the 4-channel array coil without γ-ray radiation shielding. The center image is the data combined from all four channels using sum of squares technique. The four images around the center image are data from individual coil elements.



References : [1] *Chen S, et al IEEE Nuc. Sci. Sym.* pp 3250-5 (2007). [2] *Meng LJ, et al IEEE Nuc. Sci. Sym.* pp 2956-60 (2007).[3] *Hamamura M J, et al* 2010 *Technol. Cancer Res. Treat.* 9 21-27(2010). [4] *Ha SH, et al Proc. ISMRM* pp 1517 (2010). [5] *Pruessmann KP, et al., Magn. Reson. Med.* 42 952-62 (1992). [6] *Buscombe JR et al.,* Clin Nucl Med. 20(1):13-7(1995).