Multiple animal TEM RF coil with cylindrical cavity configuration

H. Y. Heo[1], S. Y. Lee[1], K. N. Kim[1], M. H. Cho[1], I. H. Kim[1], T. S. Park[1]
[1]Dept. of Biomedical Engineering, Kyung Hee University, Yongin, Kyungki, Korea, Republic of

Introduction

High throughput imaging is very essential in small animal imaging with MRI since a large number of animal subjects are to be scanned in most animal studies. Many kinds of multiple animal RF coils have been introduced to improve the throughput in small animal imaging. Multiple animal RF coil is very desirable for small animal imaging with a clinical MRI system since the large bore magnet has enough space to scan multiple animals simultaneously [1]. Recently, a multiple animal RF coil based on the transverse electromagnetic (TEM) RF coil configuration has been introduced [2]. The multiple RF coil consists of rectangular cavities placed hexagonally. To improve the sensitivity of the multiple animal RF coil we propose a multiple animal TEM RF coil which consists of cylindrical cavities. The multiple RF coil has been developed as a receive RF coil to facilitate the good homogeneity of the large volume transmit RF coil.

Methods

The multiple RF coil design was based on the TEM RF coil configuration to be used in 3.0 Tesla whole body MRI system. To improve the sensitivity of the RF coil by increasing the fill factor, cylindrical cavities with the diameter of 4cm, rather than rectangular cavities, were used as shown in Fig. 1. Using the commercial electromagnetic field analysis software (XFDTD, Remcom, Inc., USA), we have confirmed that the cylindrical cavity structure has better sensitivity and homogeneity than the rectangular cavity structure. To maximize the number of animals in one scan, each cavity was designed to have enough length to adopt two animals together face-to-face. Therefore, we can image up to 8 animals simultaneously with four cavities. The cavities were placed to form a coaxial cavity as a whole. The RF coil consists of eight pairs of parallel copper plate (3.5cm x 3.5cm, window angle 60°) conforming into the cylindrical cavity geometry. The inner conductor is made of a continuous copper plate, while the outer conductor is made of separate plates connected with wires at each end, forming a complete end ring. Each inner plate is connected to the corresponding outer plate with four capacitors at the four corners. In the MRI scan, a quadrature birdcage coil with the diameter of 30cm is used as the transmit coil. To minimize electromagnetic coupling between the birdcage RF coil and the multiple animal coil, the dynamic tuning and detuning with PIN diodes were used. The spin echo imaging sequence was used to acquire T_1-weighted images of the eight rat brains in vivo (TR/TE=800/15ms, FOV= 90mm x 90mm, NEX=1, 256 x 256 imaging matrix size).

Results

The Q values with and without loading 10mM $CuSO_4$ are given in Table 1. The single animal coil is a reference coil with the same configuration as a quarter of the multiple animal coil, and all the performance measurements on the multiple animal coil has been compared with those of the single animal coil. The Q value of the multiple animal coil is a little lower than that of the reference single animal coil. Table 2 shows that the SNR obtained with the single animal coil was 6~7% higher than that obtained with the multiple animal coil. RF field homogeneity of the multiple animal coil is a little poorer than the single animal coil due to the couplings among the cylindrical cavities. The SNR and homogeneity have been measured with cylindrical phantoms filled with 15cc $CuSO_4$ solution. Axial T_1-weighted images of eight rats obtained with the multiple animal coil are shown in Fig. 2 together with an image obtained with the single animal coil.

Conclusions

The proposed cylindrical multiple animal coil has better RF field homogeneity and higher SNR than that of the rectangular multiple animal coil. Based on the phantom and rat brain imaging results, we expect that the proposed multiple animal coil can be greatly used in rat imaging studies.

References

[1] Bock NA, et al., *Magn Reson Med*, 2003; **49**:158-67
[2] Lazovic J, et al., *Magn Reson Med*, 2005; **53**:1150-7

Table 1. The Q-values of the RF coils

	Without loading	With loading (15cc $CuSO_4$)
Single animal coil	294	213
Multiple animal coil	290	191

Table 2. The SNR and B_1 homogeneity of RF coils

	Single animal coil	Multiple animal coil
SNR	281	262
Homogeneity	96%	88%

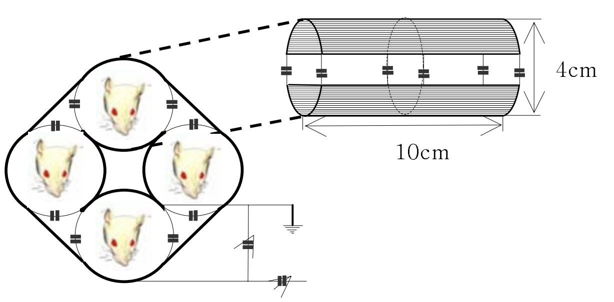

Fig. 1. The structure of multiple RF coil

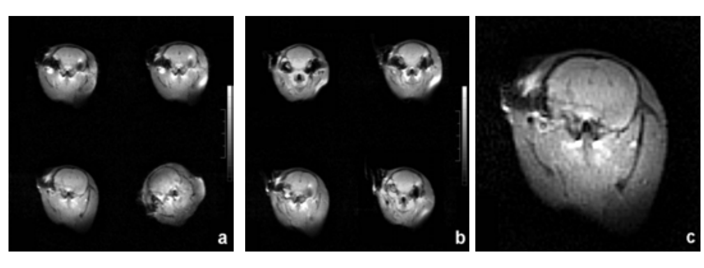

Fig. 2. (a) (b)Axial T_1-weighted images of eight rat brains, and (c) an enlarged view of a single rat brain.