Implementation of STR body coil for high field MRI

S-T. Chung[1], I-K. Hong[1], K-N. Kim[2], Y-C. Ryu[3], J-H. Yi[4]

[1]Korea Polytecnic University, Sihung-si, Kyoungi-Do, Korea, Republic of, [2]Neuroscience Research Institute, Gachon Medical School, Incheon, Incheon-si, Korea, Republic of, [3]Korea University, Ahnam, Seoul, Korea, Republic of, [4]Konkuk University, Chunju, ChungBuk, Korea, Republic of

INTRODUCTION

Clinical imaging of patient is becoming as routine study in 3.0T whole-body MRI system as in 1.5T MRI system. Whole-body 3.0T MRI system becomes an important to provide significant increase in high resolution images such as cardiac, spine and extremity imaging using a receive-only surface coils. Therefore, whole-body coil becomes more important for such high quality images in 3.0T MRI system. In this preliminary study we consider homogeneous volume excitation for high signal to noise ratio at 3.0T MRI with STR (Slotted Tube Resonator) [1-3]. The aim of this study is to design an optimized 3.0T whole-body coil (Tx/Rx) to produce a high sensitivity and quality images and confirm the safety of the coil by SAR calculation.

METHODS

The basic formula for SAR calculation can be written as follows $SAR=\sigma|E|^2/\rho$, where σ is tissue density and ρ is tissue conductivity. Most of numerical simulations were performed using the XFDTD 6.2 program(REMCOM, Inc., State College, PA). The used digital body phantom has been modified to standard Korean body scale (70% of original size). The amplitude of the 1msec square RF pulse was adjusted to the 90° flip angle. The average and maximum SAR values deposited in one gram of tissue were calculated to find the 90° RF pulse width assuming 10% duty cycle. The maximum pulse amplitude or minimum pulse width for a desired flip angle is calculated for a given RF coil. Figure 1 shows the coil geometry file which used in simulation

Figure 1 Coil geometries for simulation model (left) and the real coil (right) (Diameter: 50 cm)

Each orthogonal resonant mode is independently excited by two coupling coils and feeding port are matched to 50Ω. Generated quadrature field is the superposition of two orthogonal fields, which are oscillating linear field generated by two electrically and geometrically orthogonal co-frequency resonant modes of the coil. The width of each horizontal band covers approximately 40°, therefore, optimized window angle for the slotted tube resonator is 50°.

RESULTS AND DISCUSSION

Figure 2 shows the magnitude of B1 field in axial and coronary plane using the proposed body RF coil. All planes were selected to include the center of the coil. This shows that proposed coil generates homogeneous B1 field over the large area.

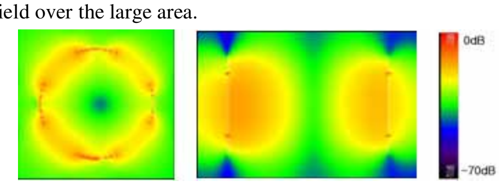

Figure 2. Simulated B1 field (Right: Axial plane, Left: Coronal plane)

Table 1 shows the calculated SAR effects. To satisfy 8 W/kg local limit of FDA, 1.6 msec is the maximum duration for the applicable rectangular 90° RF pulse for the proposed body RF coil. The average SAR values in the body was calculated for all cells in the volume of interest.

	SAR (W/kg)
Average SAR in one gram tissue	0.8
Peak in one gram tissue	28

Table 1. The calculated SAR values in the body mesh. The RF pulse has 90° flip angle, 10% duty cycle, 3ms RF duration, and rectangular pulse.

The SAR levels induced during a pulse with flip angle α and duration τ would be $SAR_{\tau/\alpha}=f(3ms/\tau)^2(\alpha/90°)^2SAR_{3ms/90°}$ where f is a factor determined by the type of pulse used[4].

Figure 3. T1 axial (left), T2 axial (center) and T1 Coronal (right) images.

Figure 3 shows volunteer body images obtained by using the STR body RF coil with MAGNUM 3.0T MR system. We have observed a reduction in required transmitter power approximately by a factor of two and an improvement in received signal-to-noise ratio approximately by $\sqrt{2}$. The use of a proposed body coil will enable full utilization of the inherent increased SNR of the high field MR system for whole body imaging.

ACKNOWLEDGEMENT

This research was supported by a grant (M103KV010017 04K2201 01730) from Brain Research Center of the 21st Century Frontier Research Program funded by the Ministry of Science and Technology, the Republic of Korea.

REFERENCES

1. Alderman D.W., et al. J. Magn.Reson.36:447-451, 1979.
2. Yoda, K., et al. J. Magn.Reson., 81, 284-287, 1989.
3. Nijhof, E.J., Magn. Reson. Imaging, 8, 345-349, 1990.
4. Christopher M.C., et al Magn. Reson. Med., 40, 847-856, 1998.