Calculation of E-M Field Intensity and SAR for 3.0 Tesla TX/RX Spine RF Coils

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E-M field and SAR values for spine (C-, T/L- Spine) quadrature TX/RX RF Coils have been calculated for 3.0 Tesla MRI systems. Although the need of imaging other than the brain area in the high field MRI system has increased, the combination of the receive-only RF coil and the TX body coil cannot be implemented easily because of the difficulties of constructing the body RF coil and the requirement of high power RF transmission. C- and L/T- spine RF coils have been developed for 3.0 T MRI system for both TX and RX purposes and their performance and safety checked by calculating the SAR and field map. We have found that even RF pulses for some conventional pulse sequences may cause SAR above the limit and the imaging parameters should be selected carefully for this kind of TX/RX RF coils for localized volume imaging.

Introduction

The purpose of this study is to calculate E-M field and SAR for spine (C-, T/L- Spine) quadrature TX/RX RF Coils for a 3.0 Tesla MRI system. Although the need of imaging other than the brain area in the high field MRI system has increased, the combination of the receive-only RF coil and TX body coil cannot be implemented easily due to the difficulties in constructing the body RF coil and the requirement of high-power RF transmission. We have developed C- and L/T- spine RF coils for a 3.0 T MRI system for both TX and RX purposes and check their performance and safety by calculating the SAR and field map.

Materials and Methods

Imaging

Both T/L and C spine RF coils have been developed to generate quadrature field in the target areas and tuned to 127.74 MHz. All images were acquired on a 3.0 Tesla clinical MRI system at CMC in Seoul (Medinus, Ltd., korea). Various imaging methods have been tried and Fig. 1 and 2 show some examples of the imaging results.

SAR Calculation

Most of numerical simulations were performed with the XFDTD 5.3 program (REMCOM, Inc., State College, PA 16805). A digital body phantom with the mesh size of 5mm×5mm×5mm has been used. The intensity of a 1-msec square RF pulse was adjusted to have the 90° flip angle at the target area. Then, the average and maximum SAR values in one gram of tissue are calculated for various widths of the 90° pulse assuming 10% duty cycle. The maximum pulse intensity or minimum pulse width for a given flip angle is calculated for a given RF coil[1][2].

Result and Discussion

Based on the 8 W/kg limit, about 1.8 msec is the minimum applicable 90° RF pulse width for the C-spine RF coil and 1.6 msec for T/L spine coil assuming 10% duty cycle. The average SAR values in the brain and spine were calculated for all the cells in the volume of interest. The peak SAR value has been obtained by finding the maximum value among the sums of 8-neighboring cells (each with about 0.125 gram weight).

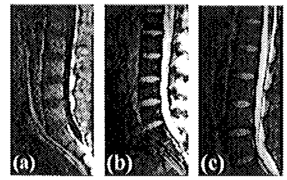

Figure 1. T/L Spine images. (a) Spin echo T1, (b) Gradient echo T2, (c) Fast spin echo image.

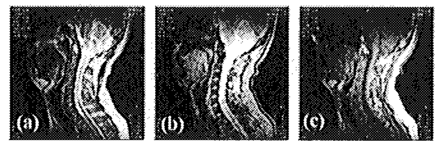

Figure 2. C Spine images. (a) Fast spin echo T2, (b) Gradient echo T2, (c) Spin echo T1.

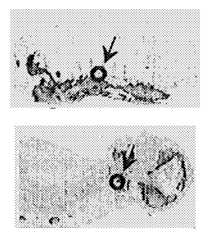

Figure 3. The calculated SAR map. The circle is target position with 90° flip angle (a) T/L spine coil, (b) C spine coil

SAR (3 msec, 90°, 100 % duty cycle)	T/L (W/kg)	C (W/kg)
Average	0.58	0.87
Peak in one gram of tissue	23.34	29.82

Table 1. The Calculated SAR in body mesh. The used RF pulse is 90° flip angle, 100 % duty cycle, 3 ms duration time, and rectangular pulse.

By using the RF coils, cervical, lumbar and thoracic spine images have been obtained without using the body RF coil. The SNR at the spinal cord was higher than 95. The SAR of both coil is lower than the standard limits (local or average SAR level) (601-2-33 © IEC:1995).

References

[1] Collins C.M., S. Li, Smith M.B., Mag. Res. Med., 40, 847-856, 1998
[2] Collins C.M., Smith M.B., Mag. Res. Med., 45, 692-699, 2001.

Acknowledgment

This study has been supported by Medinus, Ltd. and San-Ki-Ban Project from the Ministry of Commerce, Industry, and Energy.