A NEW SIMPLE HIGH FIELD TRANSMIT COIL DESIGN: OPEN CAVITY RESONATOR

O. Ipek[1], B. van den Bergen[1], J. J. Lagendijk[1], and C. A. van den Berg[1]
[1]Department of Radiotherapy & Radiology, University Medical Center Utrecht, Utrecht, Utrecht, Netherlands

Introduction

The concept of a body coil is not eligible anymore for high field MRI (> 7 T). Due to waveguide action of the cavity formed by the RF shield, the field tends to spread much further than the length of the coil elements [1]. In this study we investigated whether we can make a body coil actually exploiting this effect. We inserted a tubular dielectric inset to the RF shield which will tune a part of the RF cavity above the cut-off frequency. This facilitates efficient wave propagation in this inset region. Wave reflections at the end of the inset will result in a standing wave in the inset region. This should create a open cavity resonator which provides the RF excitation. In this study, we will compare by means of electromagnetic simulations the excitation efficiency of such a concept for body applications with a traditional TEM body coil.

Methods

The cavity resonator consists of an RF shield (58 cm diameter, 122 cm length) with a tightly fitting tubular dielectric inset (50 cm inner diameter, 4 cm thickness, 60 cm length). We chose a dielectric constant of 30 and a loss tangent of 0.003 which corresponds to commercially available dielectric materials. The cavity is excited by four electric dipole antennas having 7.5 cm length and 5 mm thickness copper which are integrated in the dielectric inset. The conventional 7 T body coil consists of 12 TEM elements each connected with two tunable capacitors (top and bottom) to the RF shield to tune each element to resonance [2]. FDTD simulations were used to compute and compare the electric and magnetic fields of both designs. The response of each antenna was separately calculated and matched and tuned to 300 MHz in an iterative fashion. The dipole antennas were tuned by changing the length of copper part. The FDTD simulations were performed with a patient model from the virtual family member [3] without arms to emulate arm in upright position (see Figure 1). The patient was positioned with the pelvic region central in the coil.

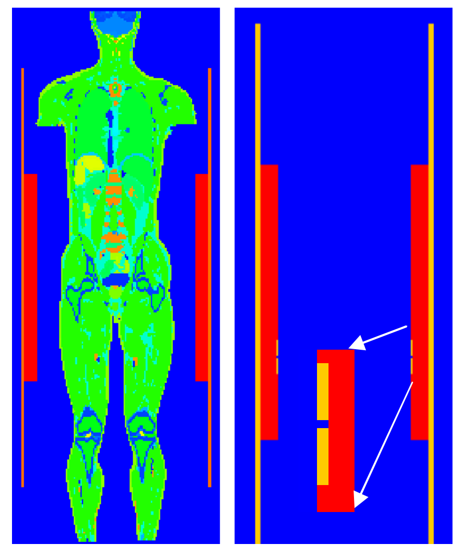

Figure 1:Coronal image of the dielectric layer attached to the RF shield with the patient model (left) and dipole sources stacked to the dipole antenna. Inset depicts the magnified dipole antenna.

Results & Discussion

In Figure 2, the B_1^+ fields are shown for the open cavity resonator (left) and the conventional 7 T body coil. We used in both case quadrature drive. The average B_1^+ in a central elliptic normalization ROI for equal RF power was slightly higher (8.5 %) for open cavity resonator than the conventional body coil. The B_1^+ homogeneity of the cavity resonator was better (std/mean=43 %) than the body coil (std/mean = 69 %). However, the SAR values of the body coil are less than that of the cavity resonator in Figure 2.

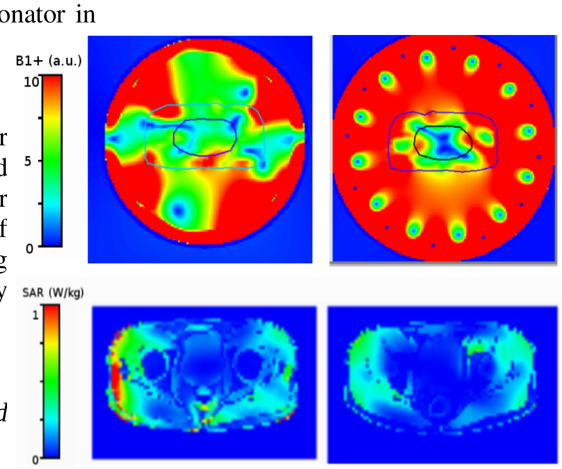

Figure 2: Transverse B_1^+ field and SAR for cavity resonator (left) and that for body coil(right). For upper images, outer contour depicts the patient model; inner contour depicts normalization ROI. SAR is normalized to B_1^+ field of 0.7 μT and duty cycle of 0.05.

Conclusions

Our study demonstrates that the RF shield with a dielectric inset excited by four simple dipole antennas can achieve comparable excitation efficiency and homogeneity as a conventional 12 element 7 T body coil. However, it is a far more simple design and the field in the patient is mostly contained to the extent of the dielectric inset. In the near future, we will examine the RF shimming capability of the open cavity resonator and compare it with the 12 elements body coil.

References

1. J. T. Vaughan et al., Body Imaging at 7 T, ISMRM Workshop High Field Systems & Applications, Rome, 2008.
2. B. van den Bergen et al., Phys. Med Biol., 52 (2007) 5429-5441.
3. A. Christ et al., The Virtual Family – Development of anatomical CAD models of two adults and two children for dosimetric simulations, in preparation.