

# Using Dielectrics and RF Shielding to Increase $B_1^+$ Efficiency and Homogeneity

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## OBJECTIVE

To improve  $B_1$  transmission efficiency and homogeneity for 7T human imaging by using dielectric materials and RF shielding in a 16-channel body coil.

## INTRODUCTION

Previous MR experiments have proved 7T body imaging is feasible (1,2). Both theoretical models and experimental images have shown that the reduced wavelengths in the body at 7T create destructive interference patterns which can lead to loss in image homogeneity, RF shading and possible increases in localized SAR. Even the head positioned well outside of the body coil experiences some of the highest  $B_1$  values due to traveling waves or radiation. Dielectric pads have been used to improve body  $B_1$  homogeneity for 3T body imaging (3,4). In order to improve  $B_1^+$  field homogeneity and focus the RF fields into the human torso, theoretical models using RF shielding at different locations and different dielectrics materials, placed between the patient and the coil, were calculated.

## METHOD and MATERIALS

A 16-channel 33cm long co-axial TEM body coil array was modeled with XFDTD (Remcom, State College, PA). The coil i.d. defined by coaxial elements is 57.5 cm; the coil o.d. defined a 1m long cavity is 62.5 cm. The magnet gradient set (id:67.5cm, od:89cm,length:125cm) and the magnetic bore (id: 90cm; length: 300cm) were also included in simulation.

A hollow cylinder dielectric board was placed closely around the human torso, and its relative permittivity was incrementally adjusted to 2, 5,10,20,40 and 80 (Figure 1 a) to test the effect of dielectric in focusing RF fields. RF shielding was placed at the ends of the magnet bore, right above head and around neck (Figure 1 b-c) to observe  $B_1$  variation.

A body model loaded into the coil was derived from the National Library of Medicine (NLM) Visual Human digital atlas whose electrical properties were adjusted to those of 300 MHz. The body model contains 23 bio-tissue materials and has 4.7 million cells with a resolution of 5mm. Each of the body coil's 16 elements were driven independently with phases corresponding to their azimuthal angles (0, 22.5°, 45°, ...).

## RESULTS

Given in Figure 2 is the  $B_1$  distribution within the central sagittal slices for following cases from left to right: 1.) The  $B_1$  fields in body without addition of dielectric material or shielding, 2.)  $B_1$  fields with dielectric material added per Figure 1a and  $\epsilon_r=10$ , 3.)  $\epsilon_r=20$ , 4.)  $\epsilon_r=80$ , 5.) RF shielding added above head per Figure 1b, 6.) RF shielding added per Figure 1c around neck, and case 7.) with both dielectric  $\epsilon_r=20$  and RF shielding added around the neck. Only  $B_1$  fields within human tissues are displayed. The  $B_1$  fields are normalized such that 1W RF power is deposited into the human body. The radiation efficiency of the whole RF coil is also listed in Table 1 for the coil with and without dielectric loading materials. Results with different dielectrics demonstrate that high dielectric materials can help focus to RF fields into the human torso. By reducing fields within the head and other anatomy outside of RF coil or ROI,  $B_1$  transmission efficiency within torso will be improved.

Note that the radiation and the  $B_1$  field strength within the head reach their minimum value with a dielectric loading of  $\epsilon_r=10$ . Increasing the relative permittivity tends to increase radiation and the  $B_1$  field within head (Table 1). The coil without added dielectric material has a 20.55% radiation loss, which drops to 8.52% when a dielectric of  $\epsilon_r=10$  is introduced.

## CONCLUSION

We have shown that increasing the relative permittivity to  $\epsilon_r=10$  in the space between the human and coil elements improves  $B_1$  efficiency in the torso, but minimal gains are had beyond an  $\epsilon_r=20$ . Additionally, shielding the head around neck also increases the transmit efficiency in body coil. But placing RF shielding above the head or further away from human body does not improve the  $B_1$  field uniformity in torso or reduce the  $B_1$  field within head.

## References

[1] Vaughan JT, et. MRM 61:244-48. [2] Vaughan JT, et. ISMRM 2006: 213. [3] Sreenivas M, et. Euro. J. of Rad. 62:143-146. [4] Schmitt M, et. ISMRM 2005:331.

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**Table 1. Radiation efficiency with dielectric of different relative permittivity**

	Original	Epson=2	Epson=5	Epson=10	Epson=20	Epson=40	Epson=80
Radiation efficiency	20.5515%	18.2493%	13.2775%	8.52257%	11.6633%	15.9953%	17.0577%

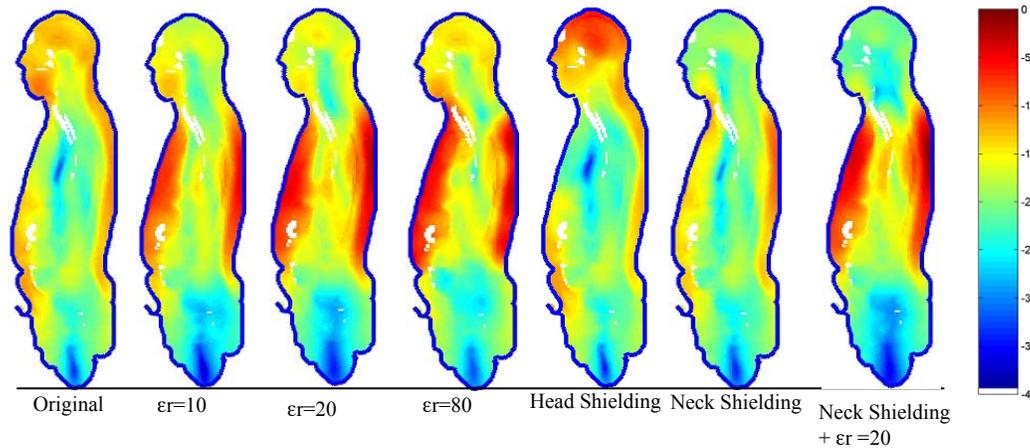


Figure 2.  $B_1$  field distributions for the following cases 1-7, left to right

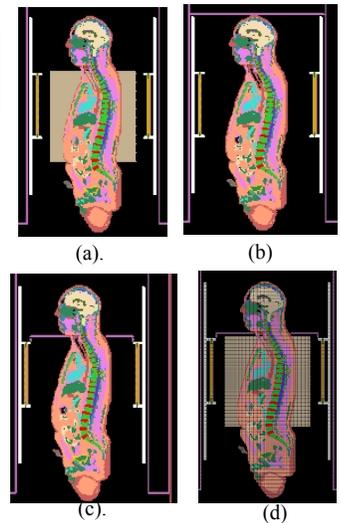


Figure 1. FDTD Models with dielectric (a), RF shielding above head (b), RF shielding around neck (c), and with both dielectric and RF shielding around neck (d).