Reducing SAR and Enhancing SNR with High Permittivity Dielectrics (ε) at 3T

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INTRODUCTION The recent experiences on ultra high-field human imaging systems demonstrated that high dielectric constant of human body plays an important role for RF field behavior in human body in high field. In this context, studies at 4T [1,2] and 7T [3] showed that the RF field distribution in human head can be altered by changing dielectric loading. Dielectric shimming and focusing of RF field are, thus, proposed [3]. In this study we show experimental results of human head imaging at 3T that the RF power for an 180° excitation pulse can be reduced by as much as 50% while enhancing image SNR by 20-40% with padding around the human head containing appropriate amount of high dielectric material (70). Our experiemntal results suggested that the efficiency of a given RF coil can be potentially enhanced by incorporating dielectric materials into the RF coil design.

METHODS Human brain images were acquired on a 3T whole body system (Bruker, Biospin, Ettlingen, Germany) using a quadrature birdcage coil with slice thickness = 5 mm, matrix = 128 x 128, FA = 180°, and FOV = 30 mm. Fast spin-echo (RARE) human brain images were acquired with identical parameters before and after a water pad was placed around the head and after the coil was tuned and matched for each condition. The subjects remained in the magnet during the process of placing the water pad, re-tuning the coil and adjustment of RF power for 90°/180° flip angle.

RESULTS
Figure 2 shows a set of axial brain images acquired with identical acquisition parameters under three conditions: a) before; b) after placement of the water pad and re-adjustment of tuning/matching, and c) after subsequent adjustment of RF power for 90º/180º flip angles. The center bright region typically seen in 3T image in Fig. 1a turned darker than the peripheral regions after the pad was placed as seen in Fig. 1b, suggesting that the excessive RF power for 90º/180º flip angles. Subsequently, re-adjusting the RF power by 3-dB reduction yielded 90º/180º flip angles and images acquired as such shown in Fig. 1c. The image signal to noise ratios for each condition were listed under the corresponding images, showing that overall SNR was increased by 20-40% with placement of the dielectric pad.

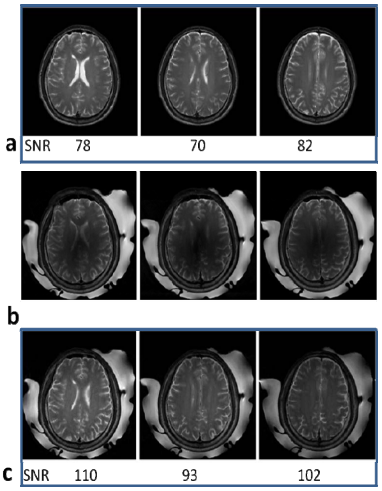

Fig. 1. (a) Axial RARE image at 3T without water pad. **(b)** The same image slices acquired with identical parameters after placing a 6L water bag around the head and tuning/matching the coil. **(c)** Same image slices acquired with a 3-dB reduction of the input power used for **(a)** and **(b).**

DISCUSSION The remarkable enhancement of RF field by the dielectric pad demonstrated in this simple experiment has an important significance in RF engineering. First, our experiment shows a simple and effective approach for enhancing RF field performance of a given coil. In practice, dielectric pad can be used to enhance RF coil performance while simultaneously provides comfort and reduction of motion for the patients. Secondly, our results suggest a novel approach of incorporating dielectric material directly into RF coil designs. Further implementation of this approach requires a systematic study to determine optimal dimensions and permeability values of low lossy dielectric materials of various configurations for optimal RF field performance. Lastly, the RF field engineering has taken the center stage for high field MRI research mainly because of the limitations in SAR and inhomogeneity. In light of the new data presented at 3T, the potential utilization of high dielectric material for SAR reduction could have profound impact on high field MRI research.

CONCLUSIONS We have shown that the performance of RF coil can be improve significantly in term of image SNR increase and RF power reduction with water pads around the head at 3T. This phenomenon deserves careful theoretical and experimental investigations. The thorough understanding of this phenomenon may offer an effective approach of RF field engineering.

REFERENCE
1. Alsop *et al.*, MRM, 40, 49, 1998
2. Foo *et al.*, MRM, 23, 287, 1992
3. Q.X.Yang *et al.*, J Magn Reson Imag, 24, 197, 2006

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