Shading Reduction at 3.0T using an Elliptical Drive

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INTRODUCTION

An inherent problem among clinical 3.0T MR scanners concern the B1 homogeneity of the RF transmit field inside the body. Dielectric related artifacts are commonly present at 3.0T during spin echo sequences in patients having an elliptical crosssectional area. Frequently, this dielectric resonance pheneomenon is prevalent in small patients, usually female, with a flat or concave abdomen. The energy propogation through one axis of the body cooresponds to less phase shift, less signal cancellation, and better homogeneity. An elliptical drive can be used as an alternative to dielectric pads to overcome shading in the trunk and improve B1 homogeneity over a diverse patient population.

METHOD

A 3.0T RF birdcage coil was created and fields were simulated using FDTD. The birdcage coil had a 610 mm inside diameter and the RF shield had a diameter of 650 mm. Sources in the model were driven to produce a circularly polarized B1 field and an elliptically polarized B1 field in free space. Fields were calculated inside the human model and homogeneity improvements are shown in fig. 1. A GE 3.0T MR system was reconfigured to drive two 3T RF body coil ports independently, fig. 2. The new transmit chain consisted of a small signal quadrature power splitter following the excitation from the system. These quadrature signals drove two RF power amplifiers with gains of 75.44dBm. The outputs of the power amplifiers were attached to directional couplers to monitor the forward and reflected power absorbed by the body. A T/R switch allowed body coil signals to be received into two receive channels and variable matching networks were used to match the ports of an RF body coil to 50 Ohms for all body sizes. The system's prescan was used to optimize the power required to achieve the desired flip angle inside the patient. The receive signals were combined using the systems sum of squares, phased array combination. A 0dB to 10dB variable attenuator was placed between the 90degree port of the power splitter and the 2nd RF amplifier, capable of 0.1dB attenuation steps. The attenuator was increased in order to reduce the B1 field produced in the short axis of the body while the SNR and left to right shading were measured. SNR was measured using the average signal over 90% of the body, and the left to right signal ratio was measured in similar tissue on the left and right sides of the body.

RESULTS

Attenuation values of 0dB, 1dB, 2dB, 2.5dB, 3dB and 3.5dB were used to compare images from a small female, as seen in fig. 3. Measurements using 3dB of attenuation showed about 45% reduction in left to right shading, shown graphically in fig. 4, compared to equal power using 0dB of attenuation. A 5% increase in body SNR was seen and total power from the system stayed relatively constant. Measurements from additional volunteers showed similar SNR and shading improvements.

DISCUSSION and CONCLUSION

A system methodology was introduced for controlling shading in the body at 3.0T. This study confirmed that a unique elliptical drive was required for each independent body shape. Simulation results show whole body SAR as well as local SAR peaks inside the body can be minimized using an elliptical drive.

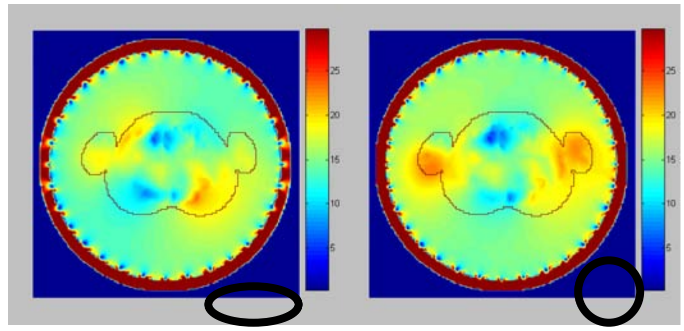

Figure 1: Elliptical and Circular B1 Fields

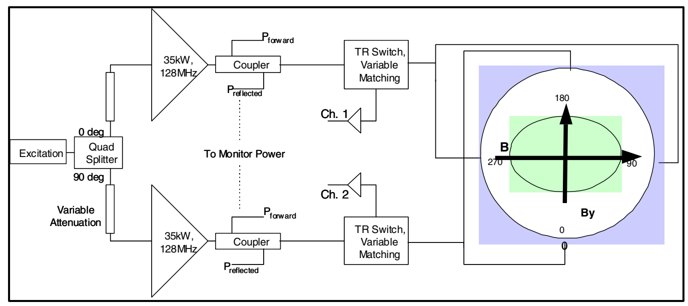

Figure 2: Block Diagram of the New Transmit Chain

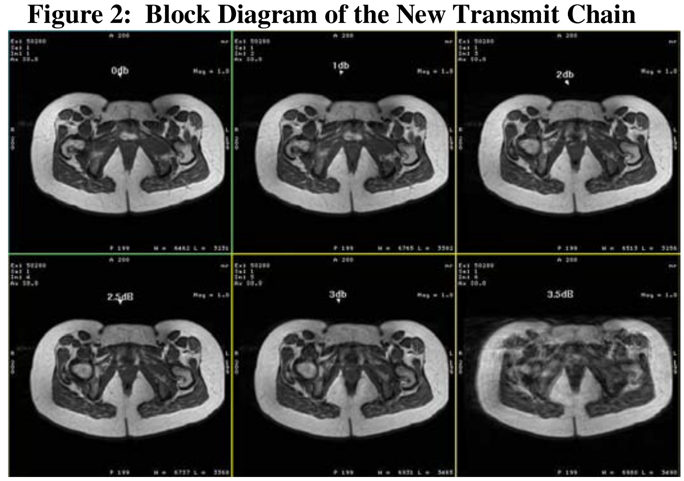

Figure 3: Female Abdomen vs. Attenuation

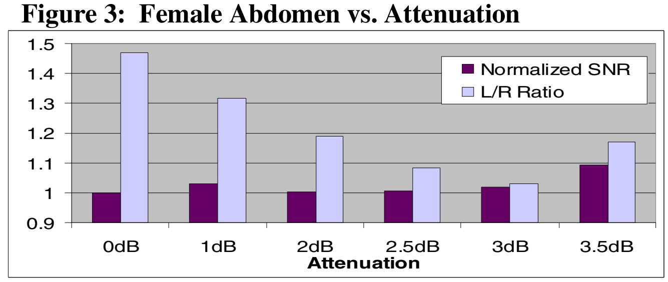

Figure 4: SNR & L/R Shading Results vs. Attenuation