Initial Testing of a Two Region Gradient Coil

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Introduction We report preliminary results with the first two region gradient insert coil. When combined with an overlapping single region gradient insert this will 1) make extended body imaging possible without moving the table or the patient and 2) reduce nerve stimulation (1,2). Construction and testing of a two region gradient coil insert is a necessary intermediate step as a proof of concept for the three region gradient system.

Methods Design/Construction: The dimensions of the two region gradient insert were constrained by the diameter of the homogenous spherical volume (DSV) of the commercial human magnets where the insert might be tested. The maximum DSVs in commercial systems available to us were about 50 cm. The Z extent of the 50 cm DSV was divided into three equal regions rounded to 17cm each. Even though this prototype is only a two region coil it is a necessary step towards designing a three region coil and space was allocated for a future central region. Available plastic pipe for the gradient formers were chosen to be co-insertable and of radii large enough to allow for reasonably large phantoms and RF coils as well as small enough to keep the weight of the insert manageable. We chose 6, 8, 10 inch (15.24, 20.32, 25.4cm) diameter pipe for formers of the X, Y, Z, coil windings and a 12 inch (30.48cm) diameter pipe to enclose the system. Designs for conductor placement for two region X, Y and Z coils were generated by simulated annealing (1,3). Wire patterns for each axis were chosen that gave reasonable homogeneity, efficiency and imaging volume. Copper wire was inserted into wire patterns milled in Teflon sheets and then rolled and bonded to the plastic pipes. Teflon tubing for water cooling and thermocouples were placed between layers. Thermally conductive epoxy was poured into the insert for mechanical stability. **Imaging:** Imaging was performed on a GE 3Tesla imager using the body coil for Tx/Rx as well as a single 3 inch (7.62cm) diameter Tx/Rx RF surface coil. Phantoms were placed in various positions to test gradient homogeneity and cross talk between regions. Spin Echo images displayed used TR/TE 300/30msec GRE images displayed were acquired with TR/TE 5/1msec. Phantoms were constructed to have T_1 of about 100msec at 3T except B in Fig2, which was filled with distilled water.

Results

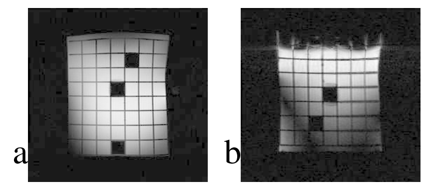

Figure 1. Coronal SE images of the grid phantom in either (a) the front region of gradient insert or (b) back region of gradient insert. Each image was acquired with the body RF coil using a single phantom only. The shading in b results from transmitting RF through the gradient coil (still better than expected).

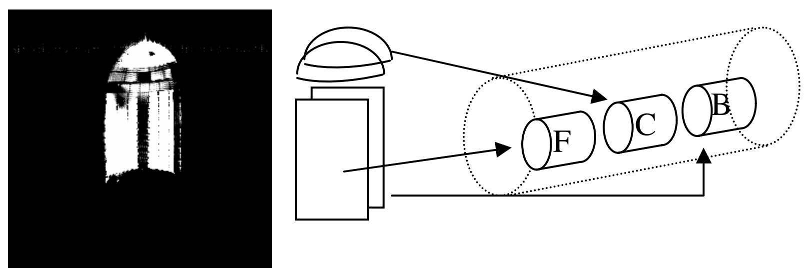

Figure 2 Coronal GRE image with grid phantoms in the front (F), central (C) and back (B) regions acquired with body RF coil and the gradient inserts. Schematic on the right indicates the relationship between signal position in the image and the phantoms physical position within the gradient insert. The image demonstrates the overlapping of signals from the two regions, as well as the extensive distortion of the phantom in the central region.

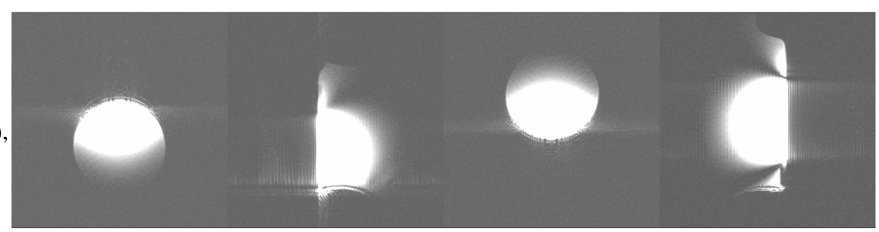

Figure 3 Axial and coronal GRE images acquired with a shielded Tx/Rx RF surface coil. These images were acquired with the surface coil on top of the water bottle while the grid phantom was in the opposite region. Left images are from the front region (correct gradient polarity), Right image pair is from the rear region (reversed polarity images). Window/Level chosen to illustrate lack of cross talk from opposite region.

Conclusion and Discussion We have shown that imaging can be performed in both regions of the gradient insert without measurable cross talk between the two regions when imaged with shielded RF coils internal to the insert. Shielded RF coils within the insert are necessary to isolate received signal to the region of interest. Images acquired with a shielded Tx/Rx RF surface coil did not suffer from signal dropout as in Fig 1b or crosstalk/wrap between front and back imaging regions as in Fig 2. Notice the polarity is reversed in the back region as expected. Body coil RF transmission seems to be significantly hampered in the rear region probably due to the proximity of the gradient insert power distribution cables (Fig1b). Two RF Tx/Rx coils are needed to demonstrate simultaneous imaging of the two regions. Unwanted signal from the central region needs to be addressed in the design of the three region gradient and RF coils. Corrections needed for field non-linearity, eddy currents, and shimming all need to be quantified. These results are preliminary and further testing is on going.

References

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