Use of Opposed Shim Currents for Infold Reduction on a UHF MRI System with Head Gradient

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Introduction: The use of a head gradient set within a wholebody magnet can lead to significant artifacts. Signal arising from the shoulders is encoded in such a way that it aliases into the main image (Figure 1). Such artifacts are particularly pronounced at higher field, where B1 effects cause the sensitive region of volume coils to extend out into the chest and shoulder region [1]. Previous approaches have tried to diminish the RF penetration in this area (through the use of RF shielding materials) or to disrupt the local field through using ferromagnetic material shown into a jacket that the subject wears. This study was aimed at determining whether through the use of both the wholebody and head gradient shim sets the signal from the shoulders could be dephased without affecting the signal from the head itself.

Methods: When looking at a plot of field offset vs distance from isocenter (Fig. 2), one can see the expected form of the Z2 shim for the wholebody coil (black line). The Z2 shim for the head gradient coil, however, reaches a plateau around 25cm from isocenter and then inflects (purple line). This is a similar behavior to the Z gradient, and explains the infolding of signal from the chest. However if both shim sets are used in opposition, i.e; if a DC current is applied to one set and corrected for by current applied in the other, one can retain homogeneity in the area of the brain (up to about 15cm from isocenter) while the difference in behavior between the shims causes a field inhomogeneity further from isocenter (green line).

Similarly, use of other shims can be beneficial. Fig. 3 shows a plot of the field developed when the C2 shims are used in opposition, with an overlay of a human torso. Again a uniform field can be maintained over the head while significant changes are made to the field in the region of the shoulders.

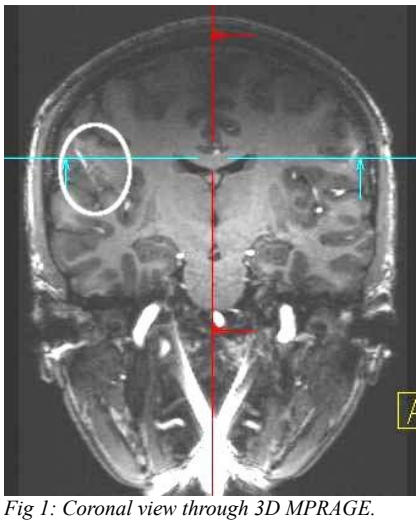

Fig 1: Coronal view through 3D MPRAGE. Note crossed signal in the neck region, with signal extending through the brain (circled).

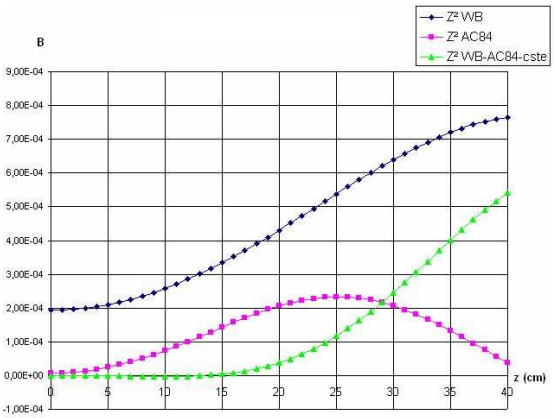

Fig 2: Plots of the Z2 shim from the wholebody shim (black), the head gradient shim (purple) and the result of subtraction. Note that while the head gradient shim alone goes through an inflection, subtracting the two shims can result in a homogeneous area in the region of the brain (up to about 15cm from isocenter) but a inhomogeneous region outside this.

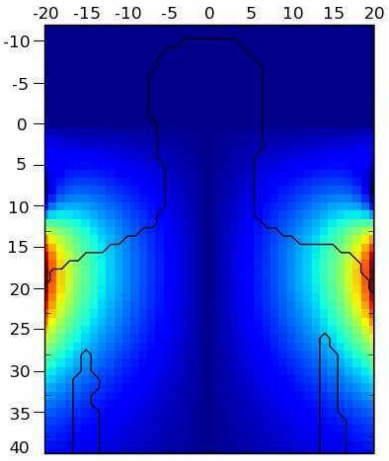

Fig 3: Field plot of opposed C2 shims, with overlaid outline of a human torso. Note the extremes of field in the shoulder regions.

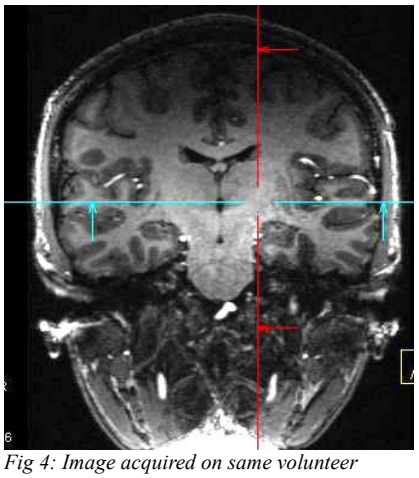

Fig 4: Image acquired on same volunteer without repositioning, but with 4 Amperes of current applied to the head gradient set shim. Note the reduction of infolded signal.

Results: Data shown are from a 7T wholebody system (Siemens Medical Systems, Erlangen, Germany) equipped with an AC84 head gradient set. In this setup the head gradient coils were being used for imaging, but the system was configured to use the wholebody shims. Seperate cabling allowed currents to be applied to the shim coils of the AC84 3D MPRAGE scans [2] were acquired sagitally, with the coronal view presented here. Sequence parameters TE=3.3ms, TR=2640, TI=1100, resolution 1x1x1.5mm. Figure 1 was acquired with no opposed shim current, and shows the typical infolding effects. Figure 4 shows the effect of applying 4 Amperes to the Z2 shim of the head gradient set, without repositioning the subject. The systems automatic procedure for 3D shimming was used to re-establish homogeneity. Note the considerable attenuation of the infolded signal.

Conclusion: Opposed shim currents in the wholebody and head gradient shim sets can be used to reduce the level of signal from shoulder and chest regions. Further work is required to establish the optimal current levels required for a larger subject population.

The concepts and information presented in this paper are based on research and are not commercially available.

1: **L.L. Wald, G.C. Wiggins, A. Potthast, C.J. Wiggins, C. Triantafyllou**, *Design Considerations and Coil Comparisons for 7 Tesla Brain Imaging,* Proc. Intl. Soc. Mag. Reson. Med. 13 (2005), p.921.
2: **John P. Mugler III, James R. Brookeman,** *Rapid three-dimensional T1-weighted MR imaging with the MP-RAGE sequence,* Journal of Magnetic Resonance Imaging, Volume 1, Issue 5, Wiley-Liss, pp.561–567.