A Simple Method Of Improving MPRAGE Inversion Coverage at 7T

C. J. Wiggins[1]
[1]Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, United States

Background: MRI at higher fields is characterized by both benefits (e.g. higher SNR) and drawbacks (e.g. RF homogeneity). One particular problem in imaging the brain is the strong susceptibility gradients that arise from air/tissue/bone interfaces above the sinuses and ear canals. At higher fields these can cause a variety of artefacts including signal drop outs in 2D gradient echo imaging and distortions in EPI imaging. In anatomical imaging, and in particular inversion recover (IR) techniques, the strong gradients and frequency offsets can also cause artefacts.

MPRAGE [1, 2] scans at 3T and higher can often suffer from bright artefacts above the sinuses. These arise from a mismatch of the bandwidth of the IR pulse and the frequency offset of the tissue above the sinuses. The simple approach that has generally been applied is to increase the inversion pulse bandwidth to cover the additional offset frequencies required to properly invert this tissue. Unfortunately increasing the pulse bandwidth is generally achieved by shortening the time duration of the pulse. This results in a pulse of higher peak power which may be difficult to achieve at higher fields. It also increases the SAR of the sequence, which can be a limiting factor at higher field.

Method: A simple approach that does not affect the SAR of the sequence comes from the observation that the frequency offsets generated in the brain are generally in the same direction, i.e. the frequency spectrum of the brain has become asymmetric. Better inversion coverage can then be achieved by simply shifting the inversion pulse frequency slightly in this direction.

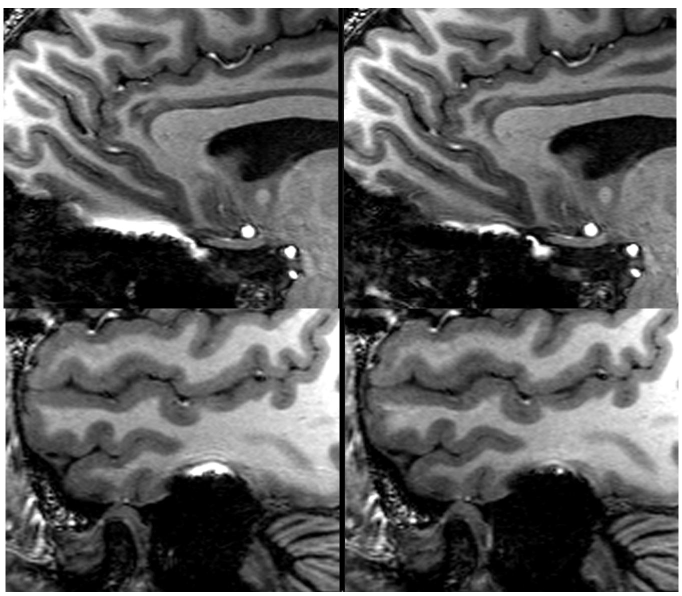

Figure 1: Imperfect inversion due to susceptibility-induced frequency offset can be seen when the inversion pulse frequency is on-resonance (left column). This effect can be seen both above the sinuses (upper row) and ear canals (lower row). Shifting the frequency by 200Hz results in a more uniform inversion (right column).

Results: Experiments were conducted on a Siemens-based 7T MRI system using a 32channel receive coil [3]. An MPRAGE sequence was altered to allow the operator to set the frequency of the inversion pulse to a desired offset from the system frequency. Imaging parameters were: FOV 206x240mm, Matrix 326x448, slice thickness 1.05mm, 160 slices, TR 2.6s, TE 3ms, TI 1.2s, Flip Angle 9, bandwidth 200Hz/pixel. An initial image was acquired with the inversion pulse at 0Hz offset. This sequence was then repeated with the offset set to 200Hz. As can be seen in Figure 1, a significant improvement in inversion performance was evident.

Conclusions: A simple shift of the inversion pulse frequency can improve the inversion coverage of MPRAGE sequences without affecting the RF power requirements or SAR load. While the results do show some remaining artefact, adjustment of both frequency shift and pulse bandwidth for the inversion pulse should result in optimal inversion coverage with minimal RF power and SAR loading.

Acknowledgements: This work was supported by the National Center for Research Resources (NCRR) grant P41RR14075, and the MIND Institute.

[1] J.P. Mugler and J.R. Brookeman *Three-dimensional magnetization-prepared rapid gradient-echo imaging (3D MP RAGE)*. Magn Reson Med. Jul;15(1):152-7 (1990)
[2] J.P. Mugler and J.R. Brookeman *Rapid three-dimensional T1-weighted MR imaging with the MP-RAGE sequence.* J Magn Reson Imaging. Sep-Oct;1(5):561-7 (1991)
[3] G. C. Wiggins, C. J. Wiggins, A. Potthast, V. Alagappan, O. Kraff, A. Reykowski, L. L. Wald, *A 32 Channel Receive-only Head Coil And Detunable Transmit Birdcage Coil For 7 Tesla Brain Imaging*, Proceedings: 14th Annual Meeting ISMRM, Seattle, USA (2006)