Effect of B_1 Inhomogeneity-Correction on T_1-uniformity in breast MRI at 1.5 Tesla: Preliminary results

R. H. El Khouli[1], D. M. Thomasson[1], Y. Pang[2], and D. Bluemke[1]

[1]Radiology and Imaging Sciences, National Institutes of Health, Bethesda, Maryland, United States, [2]Philips Healthcare, Cleveland, Ohio, United States

Introduction:

B_1 inhomogeneity has been shown to affect quantitative evaluation of dynamic contrast enhanced MR images of the breast at high fields [1] but this may be important at all field strengths. Previous work demonstrates that in-vivo B_1 field maps can correct for spatially varying flip angles and consequently improve T_1 maps and subsequent Gd concentrations that are calculated from the baseline T_1 maps in brain and abdomen [2, 3]. In addition, unlike simple signal intensity maps, calculated measures of T_1 or Gadolinium concentrations would correct for non-uniform receive coil inhomogeneities as well. Since B_1 can vary significantly the use of field maps in calculating the T_1 map and in the subsequent calculation of Gd concentration may be more robust in determining simple enhancement ratios as well as the more sophisticated pharmaco-kinetic based permeability maps.

For T_1 based dynamic contrast-enhanced (DCE) Magnetic resonance imaging (MRI) applications, a three-Dimensional (3D) or volumetric spoiled gradient recalled echo (SPGRE) is one of the most efficient methods to acquire high SNR data in a short imaging time. Consequently, B_1 and T_1 mapping techniques that employ a 3D SPGRE acquisition similar to the DCE-MRI acquisition strategy are a very appealing way to produce gadolinium concentration maps. The dual flip angle T_1 mapping technique [4] has been shown to produce errors within 10%, which should be acceptable in an error matched system.

In this work, a B_1 map was generated using a dual TR 3D SPGRE sequence that is less sensitive to T_1 effects ([5]. These B_1 maps were then incorporated into the T_1 based calculation algorithm to produce corrected T_1 maps which could be converted to [Gd] for more accurate enhancement ratio calculations.

Methods: Axial T_1 maps (figure 1b) were acquired using a dual flip angle 3D Fast Filed Echo (FFE) SPGRE protocol with the following parameters: TR/TE/FA_1/FA_2= 6/4/5/15, FOV=450, and slice thickness=5 mm. Axial B_1 maps (Figure 1a) were generated from a dual TR technique 50/250 ms with a reduced acquisition matrix. Maps were produced with lower base matrix resolution and were then re-sampled to matrices similar to the DCE-MRI acquisition. This protocol was applied to 9 patients on a 1.5T Intera whole body MR system (Philips Healthcare, Best, The Netherlands). Patients were scanned in the prone position using a 4 channel SENSE breast coil. Using these B_1 maps of actual flip angles, we were able to produce correction maps (figure 1c) based on the difference between expected and actual flip angle. This correction ratio was then applied to the equations for calculation of T_1. Regions of interest (ROIs) were placed on the non-corrected T_1 map on matched fat portions of each breast (right medial and left medial or right Lateral and left lateral) to quantitatively compare T_1 values of both breasts (figure 1b & 1c). This quantitative assessment was repeated using the B_1-corrected T_1-map using the same slice and location. Paired T-test was used for comparing the right-to-left T_1 values difference between the B_1-corrcted and B_1-non-corrected T_1-maps.

Results: In 87.5% (7/8) of patients, the difference in T_1 time between the right and left breasts was significantly reduced after performing B_1 correction (mean 13 $\pm$ 17) compared to the non- B_1-corrected differences in T_1 times (mean 78.5 $\pm$ 39.3, paired t-test, $p< 0.001$) (figure 1). In one case, the difference in T_1 time between the right and left sides increased after the B1 correction was applied.

Conclusion: B_1 maps that were incorporated into the T_1 based calculation algorithm to produce corrected T_1 maps resulted in significant improvement in T_1 uniformity at 1.5 T compared to the non- B_1-corrected results. This approach would improve quantitative analysis of DCE-MRI of the breast.

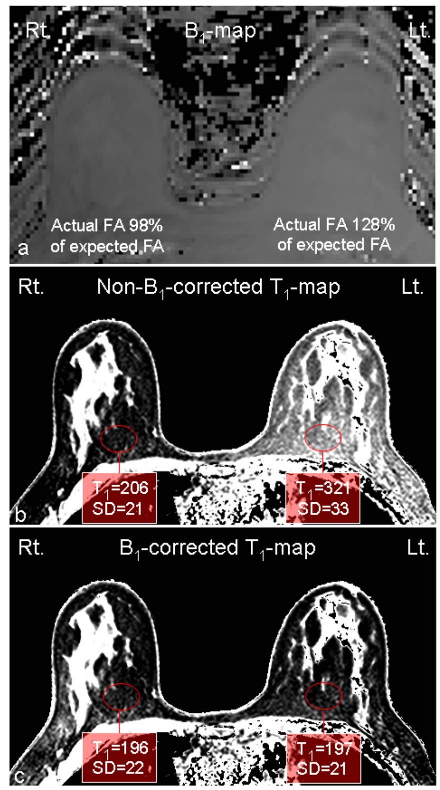

Figure 1, B_1 correction method. A. B1-map demonstrating the right to left difference in actual flip angle in reference to the expected flip angle. B. T1-map before performing B1-correction showing the ROI (red circles) and the corresponding T1-values and standard deviation (SD) and demonstrating the difference of T1-values between right and left side (115). C. T1-map after performing B1-correction showing the ROI (red circles) and the corresponding T1-values and SD demonstrated significant improvement in the T_1 uniformity with negligible T1-value difference between right and left.

References:

1) Effect of B1 inhomogeneity on breast MR imaging at 3.0 T. Kuhl CK, Kooijman H, Gieseke J, Schild HH., Radiology. 2007 Sep;244(3):929-30.

2) T1 mapping with B1 field and motion correction in brain MRI images: Application to brain DCE-MRI, Marcelo Castro, Jianhua Yao, Christabel Lee, Yuxi Pang, Eva Baker, John Butman, David Thomasson, Proceedings of the First Workshop on Analysis of Functional Medical Images, New York, NY, USA September 10th, 2008

3) Optimized and Combined T1 and B1 Mapping Technique for Fast and Accurate T1 Quantification in Contrast-Enhanced Abdominal MRI, Reto Treier, Andreas Steingoetter, Michael Fried,2Werner Schwizer, and Peter Boesiger Magnetic Resonance in Medicine **57**:568–576 (2007)

4) Rapid Combined T1 and T2 Mapping Using Gradient Recalled Acquisition in the Steady State, Sean C.L. Deoni, Brian K. Rutt, and Terry M. Peters, Magnetic Resonance in Medicine 49:515–526 (2003)

5) Actual Flip-Angle Imaging in the Pulsed Steady State: A Method for Rapid Three-Dimensional Mapping of the Transmitted Radiofrequency Field, Vasily L. Yarnykh, Magnetic Resonance in Medicine 57:192–200 (2007)