Comparison of EPI and Double Angle B_1 Maps at 7T

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INTRODUCTION The acquisition of B_1 field maps is particularly important at field strengths of 7T and above in setting the flip angle correctly for a particular region of interest, for designing compensating pulses to produce a uniform excitation over a given region, and for comparing the efficiency of different transmitter coil designs. While the double angle method [1] is conceptually the simplest, care must be taken in selecting the repetition time to avoid partial saturation effects which can substantially alter both the estimated B_1 amplitude and distribution of amplitudes throughout the object. The following study examines this dependency in comparison to an echo planar imaging based method. B_1 maps from high and low permittivity phantoms, bracketing the properties of human tissue, are examined, along with volunteer data.

METHODS All data were acquired on a GE Signa 7T Human MR Research System (GE Healthcare, Waukesha WI), an investigational device, using a Nova (North Andover, MA) 2 channel shielded birdcage transmitter with an 8 channel receiver insert. Two phantoms were examined: a 17 cm diameter sphere containing water and metabolites doped with Gadolinium to reduce the T_1 to roughly 400 ms at 7T, and a similar sphere filled with polydimethylsiloxane doped with a nonionic gadolinium chelate. Gradient recalled echo planar images were collected using a spectral-spatial excitation pulse with 4 interleaves and a 15 second repetition time, for an acquisition time of 1 minute per dataset, on a field of view of 20 cm with a 64 by 64 nominal matrix (with oversampling in the read direction to allow sampling under the ramps). 5 mm slices were collected with a 5 mm slice gap at each of 5 nominal flip angles (10°, 15°, 30°, 60°, and 75°). A separate reference dataset was acquired without phase encoding gradients at a nominal flip angle of 60°.

Conventional gradient recalled images were acquired on a 64 by 64 matrix with a 20 cm field of view from the same locations with repetition times of 125 ms, 250 ms, 500 ms, 1 s, 2 s, 4 s, and 15 s at nominal flip angles of 20° and 40°. All datasets were then transferred offline for reconstruction and analysis. Total acquisition time for the EPI data was 6 minutes; for the conventional gradient echo, total acquisition time ranged from 16 seconds (125 ms TR) to 34 minutes (15 s TR). The volunteer study was conducted with informed consent under a protocol approved by the institutional Committee on Human Research; 32 slices were acquired with no gap, covering the same total volume of tissue but with twice as many slices.

A nonlinear phase correction [2] was applied to the EPI data by multiplying each line from each receiver by the phase of the corresponding line and receiver from the reference dataset. The corrected raw data were then Fourier transformed and interpolated and downsampled to correct for the sampling under the ramps of the readout gradient. Images from each receiver were then combined by root sum of squares. A mask was constructed by thresholding the 60 degree dataset, and for each pixel with the mask, the amplitudes from the five images were fit to a*sin(b*x)+c, where x is the nominal flip angle in radians. Maps of b then correspond to the local scaling of the nominal flip angle. Fitting was performed using Matlab's nonlinear trust-region algorithm.

For the conventional gradient echo data, images were reconstructed by Fermi filtering followed by Fourier transformation and root sum of squares combination. Magnitude masks were constructed from the 40° dataset, and B_1 maps calculated as acos(0.5*im40/im20)*9.0/π for each pixel in the mask. The resulting maps should then correspond directly to the maps derived from the EPI datasets.

RESULTS & DISCUSSION Volume histograms of the different field maps reveal that for repetition times less than three times the T_1, there is substantial alteration of the measured B_1 distribution as shown in Figures 1 and 2. While the maps all appear to provide expected results (the low permittivity phantom providing a fairly uniform field throughout, while the high permittivity phantom shows substantial inhomogeneity within individual slices and from slice to slice), care must be taken in interpreting the double angle data unless the repetition time is sufficiently long. Both phantoms are doped with gadolinium compounds and have T_1 relaxation of approximately 400 ms. For the volunteer, a 5 second repetition time, yielding a 10 minute total acquisition (vs 6 minutes for the EPI acquisition), gave equivalent results to the EPI method. The vertical scale difference is due to the greater number of slices for the EPI dataset. *This work was supported by a UC Discovery academic-industry partnership grant Itl-bio-04-10108 with GE Healthcare .*

REFERENCES [1] Stollberger R and Wach P MRM **35** 246-51. 1996.

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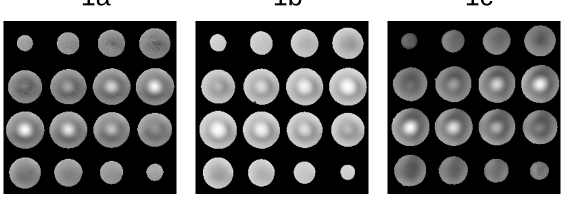

Figures at left show B1 maps acquired with conventional gradient echo at 15 seconds (a) and 125 ms (b), and EPI (c) for the MRS phantom, and at right for 15 s (d) and 125 ms (e) for the silicone phantom. Below are the three sets of histograms for the 2 phantoms and a volunteer (right)

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