Microcalcification Detection Using Susceptibility Weighted Phase Imaging: Cross-correlation and Relative Magnetic Susceptibility Difference Methods

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INTRODUCTION

The feasibility of detecting calcium deposits in the breast has been investigated by simulation and experimentally. Calcium deposits in the breast can be early indicators of cancer. Calcium has a different magnetic susceptibility than water and tissue, so susceptibility weighted imaging (SWI) can be used to detect calcium (1). It is possible that combining SWI with other functional MRI measures such as diffusion and dynamic contrast enhanced MRI may increase the sensitivity and specificity of diagnostic breast MRI as all three of these can be assessed in the same imaging session. Here we evaluate the conditions under which realistic microcalcifications can be detected in practice.

METHODS

Simulations. SWI phase images were generated as previously described (2). We first construct a "template" that consists of a (3 mm)^3 phase image that would be obtained for a 1 mm^3 calcification with infinite SNR. A series of simulated 3D phase image "data" sets with values between $[-\pi, \pi]$ (to prevent phase wrapping) are then constructed using different voxel sizes, TEs, and SNR. We then compute the cross correlation matrix between the template and simulated data sets. The cross correlation matrix maximum value (CCMV) was used to identify the calcification signature. We also computed the relative magnetic susceptibility difference map, $\Delta\chi_r$, using the Salomir method (3). The ability of the CCMV and the $\Delta\chi_r$ map to correctly identify areas of susceptibility difference due to calcium were obtained for different SNRs and spatial resolution.

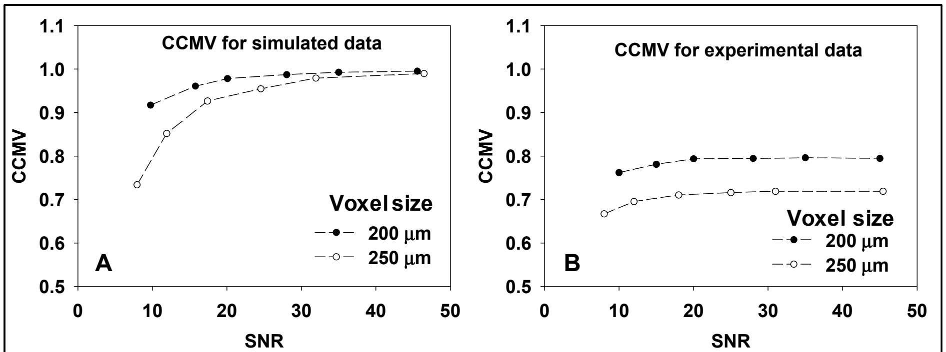

Fig. 1 CCMV as function of simulated (panel A) and experimental (panel B) data. The experimental results appear to follow the response predicted by the simulations showing little CCMV change for SNR values above 20.

Phantom studies. Phantoms were constructed using a 1 mm glass bead with χ = -11 ppm, immersed in agar gel with χ = -9 ppm; thus, $|\Delta\chi_r|$= 2 ppm, just as for calcium and water. A 4.7T Varian MRI scanner obtained 3D gradient echo images with fixed TR\α= 10ms\7^o and different values for TE, acquisition matrix, and NEX to obtain similar phase shifts, resolutions (200µm^3 and 250µm^3), and SNR values to those employed in the simulations. After phase images were acquired the CCMV and the $\Delta\chi_r$ values were computed so that a comparison to the simulations could be made.

RESULTS

Fig. 1a and 1b depict the CCMV as a function of SNR, for simulated and experimental data, respectively. The $\Delta\chi_r$ mean and standard deviation for simulated and experimental data are presented in Fig 2a and 2b, respectively. For both the CCMV and $\Delta\chi_r$, the experimental results appear to follow the response predicted by the simulations. These results suggest little change in $\Delta\chi_r$ and CCMV are to be expected for SNR values above 20.

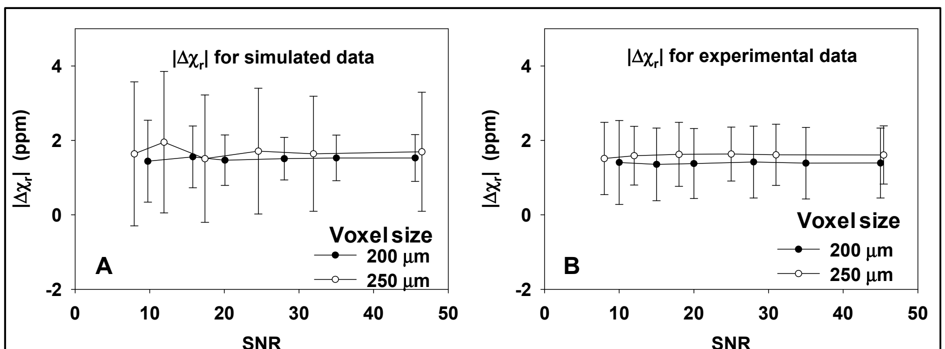

Fig. 2 $|\Delta\chi_r|$ as function of simulated (panel A) and experimental (panel B) data. The experimental results appear to follow the response predicted by the simulations suggesting little changes on $|\Delta\chi_r|$ are expected for SNR values above 20.

DISCUSSION and CONCLUSION

We have compared two different techniques to locate the susceptibility induced signature of a 1 mm object by computing the $\Delta\chi_r$ values and the cross-correlation between phase data and a template. The results suggest a SNR ≥ 20 and a voxel size ≤ 0.25 mm (isotropic) are required for both methods to work. Ongoing studies are exploring the SNR and resolution needed to locate calcium like objects as small as 0.5 mm.

REFERENCES 1. Haacke et al. Magn Reson Med 2004;52:612-618. 2. Baheza et al. Proc ISMRM 18;1996:4467. 3. Salomir et al. Conc in Magn Reson B 2003;19B:26-34.

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