A new technique for phase susceptibility-weighted imaging of iron in the brain

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Introduction

Magnetic resonance (MR) imaging may be an effective method to detect the distribution of iron in the brain. Although attempts have been made to take advantage of the high sensitivity of the MR phase signal to the susceptibility effects of iron *(1,2)*, these signals are often hidden by the phase changes due to an inhomogeneous field. A new technique for susceptibility-weighted imaging (SWI) of iron using phase-based SWI is presented. To determine whether this method is advantageous for iron imaging in the brain, sensitivity and contrast-to-noise ratio (CNR) of magnitude-based and phase-based SWI were compared.

Materials and methods

Brain imaging was performed on two normal volunteers under IRB approval. GRE-EPI magnitude and phase images were acquired on a Philips 3.0 Tesla system (Philips Medical Systems, Best, NL) using a Philips head SENSE coil. A series of images were acquired with multiple TEs from 5 to 29 ms in 2 ms increments. Each image was acquired with TR 150, FOV 250, matrix 256x256, and slice thickness 3 mm. R_2* mapping of the magnitude data was calculated using a linearized two-point fit. Phase shift ($\Delta\phi$) maps were calculated using a pairwise subtraction algorithm similar to that in *(3,4)*, which calculates the phase shift induced by a dynamic change in contrast agent concentration. For our purpose, the concentration is constant, and thus a change in TE (ΔTE) was employed to show a susceptibility-induced phase shift. A low-pass filtered $\Delta\phi$ image was subtracted from the $\Delta\phi$ image to remove the slowly varying phase rolls produced from an inhomogeneous field. After processing, an ROI was placed to measure the R_2* and $\Delta\phi$ of the substantia nigra, an iron-containing structure, and of a white matter area in the posterior part of the brain. The CNR was measured for both methods between these two areas.

Results

Figure 1 shows the processed R_2* (a) and $\Delta\phi$ (b) SWI images. Co-registered arrows have been placed to identify iron-containing structures, the substantia nigra and red nucleus. These gray matter structures can be clearly seen on the $\Delta\phi$ SWI image, even with a small change in TE (16 ms). The R_2* SWI image does not appear to have the amount of sensitivity to these structures. A measurement of the CNR for the $\Delta\phi$ SWI images was 1.54 +/- 0.38, while a measurement of the same area on the R_2* SWI image was -0.51 +/- 0.72, demonstrating the CNR stability and advantage of the MR phase signal which has previously been reported in *(4,5)* for dynamically changing concentrations of contrast agent.

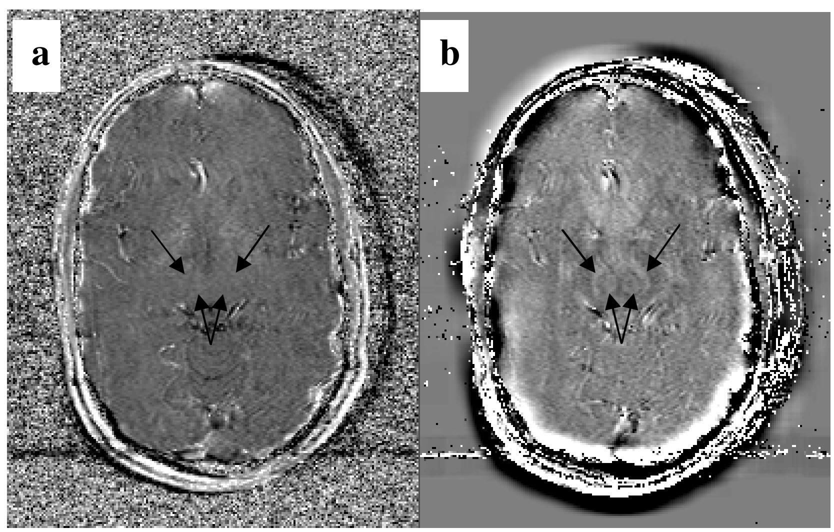

Figure 1. *R_2* (a) and $\Delta\phi$ (b) susceptibility-weighted images of human brain. Both images were processed from TE = 5 ms to TE = 21 ms.*

Discussion

A new technique for phase-based susceptibility weighted imaging has been shown to have greater sensitivity and a 6:1 higher CNR than a typical magnitude-based method. This improved sensitivity was shown to be significant even with a very small change in TE, thus minimizing the effects of susceptibility due to an inhomogeneous field.

References:

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