Quantitative susceptibility based Susceptibility Weighted Imaging (QSWI) for Venography

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Introduction

Susceptibility Weighted Imaging (SWI) uses susceptibility differences between tissues, (i.e. phase image) to enhance the contrast of the magnitude image, such as venography [1]. However, quantitative value of image phase is hard to estimate due to its non-local and orientation dependent properties. Limitations such as restriction of resolution to achieve optimum phase shift in SWI [2] arise from these reasons.

In this abstract, therefore, we propose a new SWI method (QSWI) for venography using quantitative susceptibility mapping (QSM) which allows reliable quantification of magnetic susceptibility (i.e. intrinsic property of tissue) to improve the contrast and mitigate above limitations.

Materials and Methods

To obtain the high-pass filtered phase for SWI, we applied 64 x 64 size hamming window to the k-space data and these low-pass filtered phase images were subtracted from the original phase images using complex division [3]. And to obtain the QSWI, we used laplacian method for phase unwrapping [4], sphere mean filtering to remove the background phase [5] and advanced truncated k-space division method [4] for QSM.

Since vein has negative phase in the transverse plane and positive susceptibility due to deoxy-hemoglobin, we used negative phase mask for SWI and positive susceptibility mask for QSWI to improve the contrast of the magnitude image as shown in Fig. 1., respectively. The number of phase mask or susceptibility mask multiplications was 4.

To illustrate the usefulness of the QSWI, we compared the reconstructed minimum intensity projection (mIP) images at the upper brain regions (35 slices) that have acute B0 inhomogeneity artifacts caused by air.

In vivo data were collected using 3D spoiled gradient echo sequence (TR = 49 ms, TE = 40 ms, Flip angle = 15°, FOV = 256 x 256 mm^2, Number of slices = 96, Voxel size = 1.0 x 1.0 x 1.0 mm^3, 3T Siemens Tim Trio MRI scanner). Data reconstruction was performed using MATLAB R2009b.

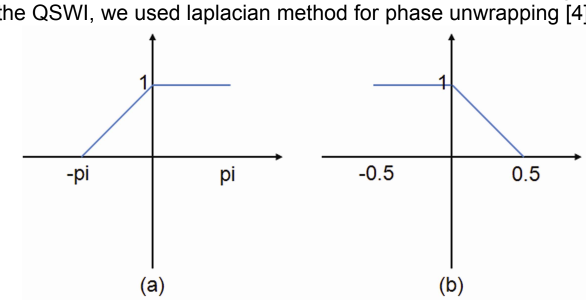

Figure 1: (a) Negative phase mask and (b) Positive susceptibility mask.

Results

In Fig. 2, reconstructed magnitude image, SWI, and QSWI are shown. As expected, SWI and QSWI enhance the contrast of the vein. QSWI, however, enhance the contrast of not only vein but also lateral ventricle and some white matter regions.

Fig.3. shows the mIP images using magnitude image, SWI, and QSWI. Reconstruction using the QSWI method shows better resolved images compared to the magnitude image and SWI, for example at the enlarged regions. Globus pallidus, a region with high iron concentration, is also emphasized.

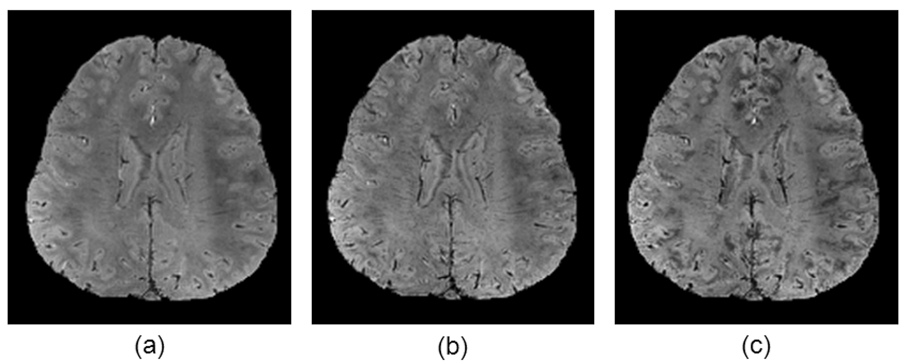

Figure 2: Reconstructed (a) magnitude image, (b) SWI, and (c) QSWI.

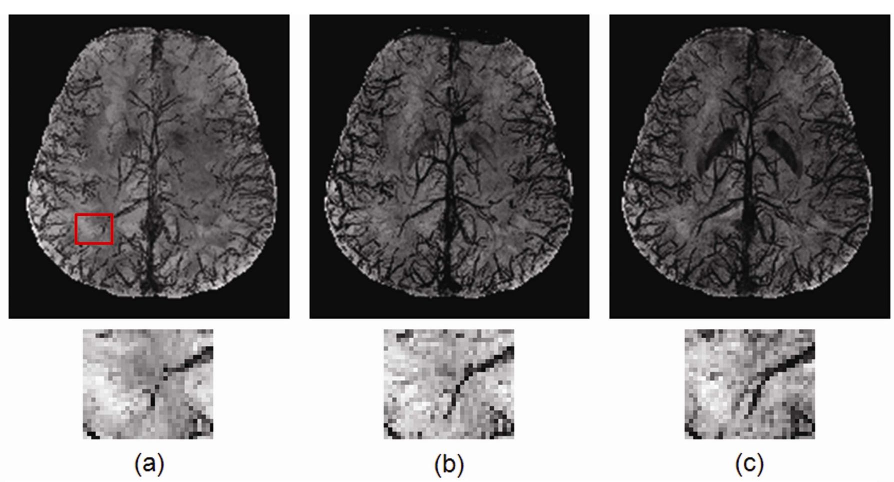

Figure 3: Reconstructed mIP images by (a) Magnitude image, (b) SWI, and (c) QSWI.

Conclusion

QSM can overcome the limitations of the phase image. Therefore, using QSM as the weighting factors rather than phase image can be useful in enhancing the contrast in the SWI process.

In this work, we propose the QSWI to emphasize the contrast of the vein rather than SWI. The method can be useful for other applications such as finding the Meyer's loop.

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References

[1] EM Haacke, et al. Magn Reson Med. 52, 612-618, 2004. [2] Y Xu, et al. Magn Reson Imag. 24, 155-160, 2006. [3] JR Reichenbach, et al. J Comp Assit Tomo. 24, 949-957, 2000. [4] W Li, et al. Neuroimage. 55, 1645-1656, 2011. [5] F Schweser, et al. Neuroimage, 54, 2789-2807, 2010.