Susceptibility Weighted Imaging of the Human Brain at 9.4T

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Introduction

Susceptibility weighted imaging (SWI) benefits from ultra-high field in terms of increased contrast-to-noise ratio and SNR.
The enhanced sensitivity to susceptibility differences of venous structures gives rise to a novel image contrast [1], making small venous structures visible that are not distinguishable at 3T. This information can be used to investigate diseases like multiple sclerosis, or to assess the spatial sensitivity of the BOLD contrast, the most commonly used mechanism in functional mapping of the brain.

Subjects/Methods

Experiments were performed on a 9.4 T scanner (Siemens, Erlangen, Germany) using a homebuilt, elliptical 16 channel transmit/receive array head coil (diameter 25cm × 20cm). Signal drop-outs were reduced by B_1-shimming. For comparison, 3T images were acquired on a Tim Trio (Siemens, Erlangen, Germany) with a 12 channel head coil for receive and the body coil for transmit. A 3D velocity compensated gradient echo sequence was used on both scanners.

Results

On the 9.4T scanner, we acquired 56 slices within 19 min (TE/TR=16.1ms/26ms, 3 averages, resolution 0.175mm × 0.175mm × 1.3mm, GRAPPA reduction factor 2, bandwidth 160 Hz/pixel, flip angle 10°). On the 3T scanner, data sets consisted of 40 slices, acquired within 22 min and with parameters taken from [2] (TE/TR=25ms/45ms, 4 averages, resolution 0.45mm × 0.50mm × 2mm, 140 Hz/pixel, 20° flip angle). For the 9.4T data, images from each coil element were reconstructed separately and phase unwrapping was done by filtering with a Gaussian filter. Images were masked before combining and magnitude images were intensity corrected. Susceptibility weighted images were constructed using GUIbold [3] (number of multiplications: 4) and several different projections were generated. Figure 2a,b shows a 40mm mIP of images acquired at 3T, figure 2b,c shows a 39mm mIP of images acquired at 9.4T. Both zoomed regions show great detail, however, many more and smaller venous structures can be distinguished in the images at 9.4T. An approximate comparison of the SNR of the magnitude images at both fields gives a ratio of 0.83 with the voxel size at 9.4T amounting to only 9% of the voxel size of 3T, resulting in a total SNR gain of a factor of 9.2 due to the higher field strength.

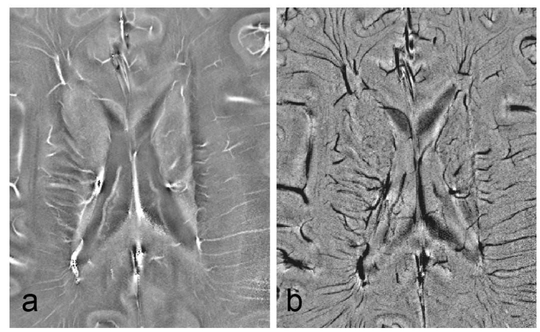

Figure 1: a) Zoomed phase image and b) SWI

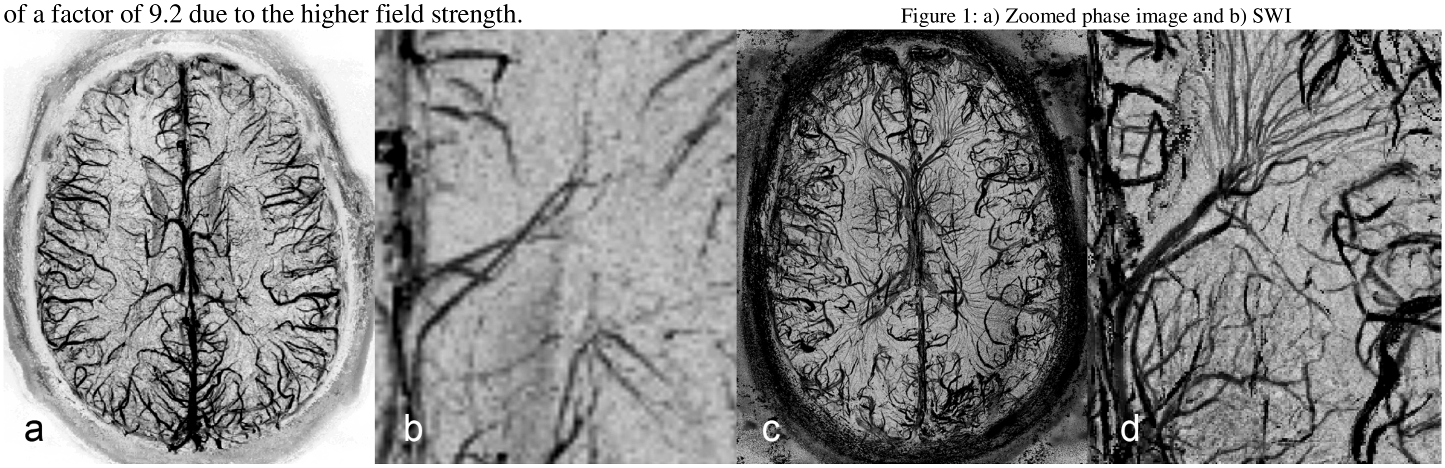

Figure 2: a,b) 3T SWI mIP of 40mm c,d) 9.4T SWI mIP of 39mm, with more than 4x the in-plane resolution of the 3T images in comparable scan time.

Conclusion

Using SWI at ultra-high field, it is possible to obtain very high resolution images at 9.4T in acceptable scan time over almost the entire brain volume. These images exhibit excellent susceptibility weighted contrast, showing significantly more small venous structures than can be distinguished in 3T images acquired in roughly the same scan time with a similar technique.

References

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