SWI using Different k-Space Undersampling Mechanisms

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Introduction

SWI combines phase and magnitude information and its contrast is different from other acquisition schemes, as it relies on signal loss due to partial volume effects near venous vessels [1]. With typical clinical magnetic field strength of 1.5 T long echo times are needed to obtain sufficient susceptibility weighting. This leads to acquisition times of about 10 min or longer. In this work two different methods were investigated for saving scan time by undersampling k-space: Partial k-space sampling by omitting higher phase encoding lines, elliptical scanning; and parallel imaging combined with a reconstruction algorithm (GRAPPA [2]). The quality of the obtained SW images was evaluated by computing contrast-to-noise ratios (CNR) of different susceptibility inhomogeneities, such as veins. Simulation of the effects of different undersampling schemes may help to determine the optimal method for saving acquisition time.

Methods

T2*-weighted, high resolution images of a healthy volunteer were acquired on a 1.5 T system with a 3D, velocity compensated gradient echo sequence, using a receive-only 8 channel head coil. The sequence parameters were: TR = 57 ms, TE = 40 ms, α= 20° and FOV = 25.6 x 19.2 x 8.0 cm³ with matrix of 512 x 256 x 48. The measured raw data was completely dumped without any processing to an offline workstation and included the full k-space data for each channel.

Denotation	part of k-space measured	scan time / sec	SNR of WM	CNR of V.v. cerebri interior	CNR of Small vein	CNR of tiny vein
Full	1	688	24.5	5.81	3.24	2.81
Elliptical	0.78	538	27.2	5.77	2.79	2.62
Partial	0.58	400	30.5	5.83	2.78	1.52
GRAPPA 2/12	0.55	376	22.9	4.27	2.04	1.32

Table 1: Results of investigated k-space undersampling schemes.

K-space undersampling was simulated by setting the corresponding rows of the full k-space to zero. For elliptical and for partial k-space scanning the edges and the last quarter of each phase encoding direction was set to zero, respectively. For the GRAPPA reconstruction every second row was eliminated except the 12 auto calibrating signals (ACS rows) in the k-space center of each slice. The reconstruction was carried out for each channel. The single channel images were combined by the sum of squares for the magnitude images and complex addition for the phase images. Both images were then used to produce SWI images [1]. SNR was calculated as the mean value of a ROI divided by the standard derivation of background noise. CNR was calculated by the signal difference (contrast) in the SWI of the venous vessel and its surroundings divided by the standard derivation of the background noise.

Results / Discussion

An increased SNR in white matter was observed for the partially sampled zero filled k-space, whereas a decreased CNR was obtained, especially for smaller veins (Tab.1), which is due to the reduced spatial resolution. The reconstructed parallel images yielded lower SNR than the images reconstructed from fully sampled k-space. The decrease in CNR of the former was dominated by the increased noise. These results are also reflected in SW images (Fig.1). Combining zero filling and parallel imaging will help to speed up the acquisition. CNR, however, decreases, especially for small structures.

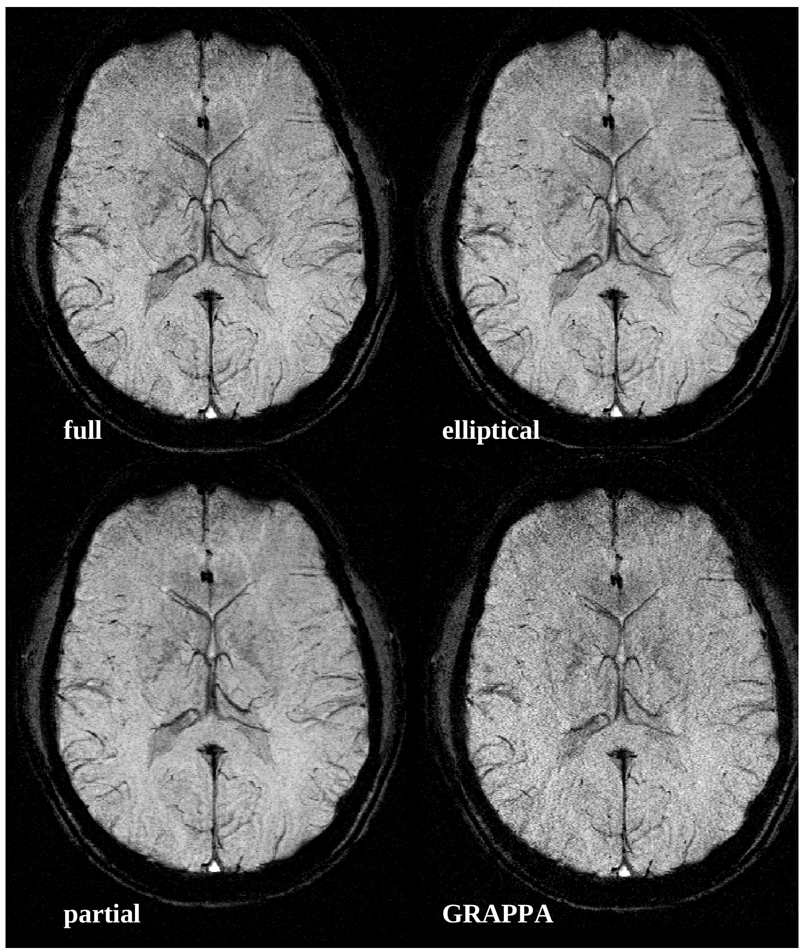

Fig. 1: mIP SWI of all k-space under sampling methods

References

[1] Haacke EM *et al*. MRM 2004 52: 612-8.
[2] Griswold MA *et al*. MRM 2002 47: 1202-10