Sensitivity Encoded Multi-Echo Spectroscopic Imaging

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INTRODUCTION

Reducing the scan time in spectroscopic imaging (SI) with high spatial resolution is one of the milestones towards the usage of SI in clinical routine. It has been shown that sensitivity encoding (SENSE) [1] permits reducing the acquisition time of conventional SI by a factor of four [2]. In this work we combine the concept with fast multi-echo SI [3], achieving a scan time of only 3 minutes for *in vivo* spectroscopic imaging with a spatial resolution of 7 mm.

METHODS & MATERIALS

Sensitivity encoding utilizes spatial information related to the coil sensitivities of a receiver array for signal localization. In a multi-echo SI experiment, often referred to as Turbo Spectroscopic Imaging (TSI), it may permit a further increase in acquisition speed. Sampling only every fourth point in k-space in a circular area and acquiring two echoes per repetition time enables a net ten-fold scan time reduction with respect to conventional SI.

Spectroscopic brain imaging experiments were performed on a Philips Gyroscan ACS NT 1.5 Tesla whole-body scanner using an array of 6 surface coils, surrounding a healthy volunteer's head. Conventional SI and TSI experiments, using a 32x32 matrix, were compared with SENSE-SI and SENSE-TSI. For SENSE acquisition a 16x16 matrix and half the field-of-view were used, thus maintaining the spatial resolution while reducing the scan time by a factor of 4. The reconstruction of the undersampled data set to a full 32 x 32 metabolite map is done using knowledge of the sensitivities of the individual receiver coils [1].

PRESS volume selection was combined with CHESS water suppression and polygonal outer volume presaturation. The parameters for the SI measurements were TR=1500 ms, TE=136 ms, bandwidth = 750 Hz, 512 samples. For TSI the parameters were TR = 1500 ms, TE = echo spacing = 272 ms, bandwidth = 1125 Hz and 256 samples, using a turbo-factor of 2.

Signal processing of the spectra included Lorentz spectral and cosine k-space filtering, a digital shift algorithm for improved water suppression and polynomial baseline correction. Furthermore, spectra were corrected for B_0 inhomogeneities by referencing to a low resolution scan without water suppression, which preceded the actual measurement. The metabolic images of N-Acetylaspartat (NAA), Choline and Creatine, obtained by modulus integration of the respective peaks, were Fourier interpolated to 256x256 pixels.

RESULTS

Significant savings in scan time were achieved: SENSE-SI was completed within 7.5 minutes while conventional SI took 30 minutes. In SENSE-TSI the scan time was reduced to 3 min, while normal TSI with a turbo factor of 2 took 11 min. Fig.1 shows NAA maps of a transverse slice of the brain, acquired with the four techniques.

In agreement with theoretical considerations, SENSE metabolite maps differ from conventional maps in their signal-to-noise-ratio (SNR). The SNR in the SENSE spectra is reduced essentially by a factor of 2, namely the square-root of the reduction factor, with respect to their fully Fourier encoded counterparts. Sample spectra corresponding to the single voxel indicated in Fig.1 are shown in Fig.2.

CONCLUSION

The findings of this work demonstrate that sensitivity encoding can be combined with the multi-echo approach for fast spectroscopic imaging. Using the hybrid technique, metabolite maps can be obtained substantially faster than with either of the two principles alone and ten times faster than with conventional SI.. This improvement is particularly promising as it adds to the potential value of metabolite imaging as a clinical tool.

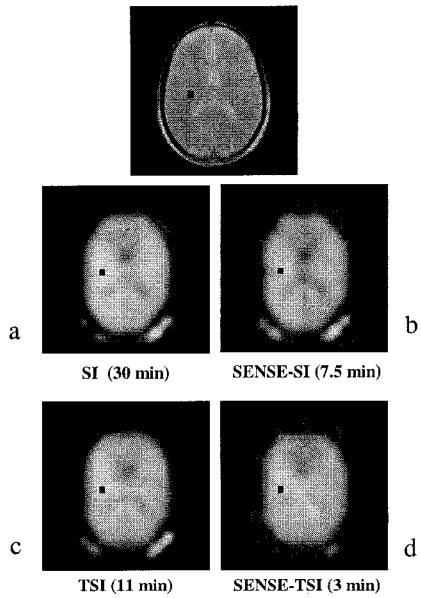

Figure 1. NAA-maps acquired in 30 min with conventional SI (a), in 7.5 min with SENSE-SI (b), in 11 min with TSI (c) and in 3 min with SENSE-TSI (d).

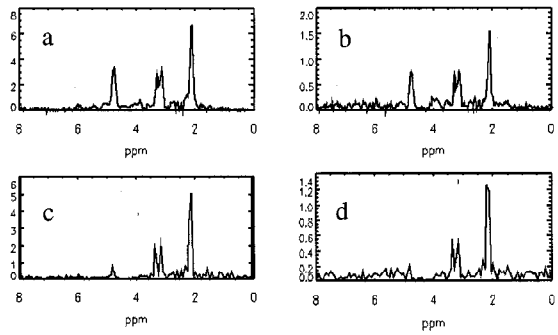

Figure 2. 1H spectra from the voxel marked in Fig. 1, showing (from left to right) the residual water peak, the Choline and Creatine peaks and the NAA peak: (a) acquired with normal SI, (b) with SENSE-SI, (c) with TSI and (d) with SENSE-TSI.

REFERENCES

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