19F-Compressed-Sensing-CISS: Elimination of banding artifacts in 19F bssfp MRI/CSI without sacrificing time

T. C. Basse-Luesebrink[1,2], A. Fischer[1,3], T. Kampf[1], V. Sturm[1], G. Ladewig[2], G. Stoll[2], and P. M. Jakob[1,3]

[1]Experimental Physics 5, University of Wuerzburg, Wuerzburg, Germany, [2]Neurology, University of Wuerzburg, Wuerzburg, Germany, [3]Research Center for Magnetic Resonance Bavaria (MRB), Wuerzburg, Germany

Introduction

The high sensitivity of balanced ssfp (bssfp) sequences makes them important techniques in MRI and CSI. The high sensitivity, however, comes at the cost of banding artifacts in either the image domain (e.g., TrueFISP) or the spectral domain (e.g., bssfp-CSI [1]). Those artifacts can be eliminated using a constructive interference in the steady state (CISS) [2] technique. This, however, results in prolonged measurement times due to the need of additional experiments with different phase cycles. Thus, in particular, the applicability of high resolved bssfp-CSI is limited.

Compressed sensing (CS), a reconstruction method for undersampled MR data, was recently introduced [3]. This method allows a reduction in the time needed for experiments, but requires sparsity in the data. The lack of ^{19}F background signal in living tissue leads to an intrinsically sparse signal distribution in the image domain. This makes ^{19}F MRI/CSI a suitable target for CS. First applications of CS on ^{19}F-CSI have been recently demonstrated [4].

The present study focuses on the application of CS in bssfp ^{19}F-MRI/CSI. The purpose of this application is to gain enough time for the acquisition of additional experiments with different phase cycles. Thus, the goal is to eliminate banding artifacts in the same or less time needed for one phase cycle of a fully sampled bssfp experiment.

Materials and Methods

All measurements were performed using a ^{1}H/^{19}F birdcage coil on a 7T small animal scanner. A fixed mouse labeled with ^{19}F markers served as an *ex-vivo* phantom.

Two fully sampled 3D-bssfp-CSI measurements were performed using alternating and non-alternating pulses. In addition, four undersampled datasets with and four undersampled datasets without alternating pulse phase were acquired. All three spatial dimensions were undersampled with the acceleration factor (af) of ~ 8. Imaging parameters for all experiments: T_{acq}/TR = 10/13.5ms; FOV = 70x30x30mm; Spect. Points = 64; MTX = 70x48x48; NA = 1.

Using the two phase cycles of the fully sampled experiments, sum-of-squares CISS reconstructions were obtained. Regarding the undersampled experiments, for each phase cycle, single, twice, and four times averaged data were generated. Accordingly, each averaged data were CS reconstructed independently for each phase cycle. In a final step, sum-of-squares CISS reconstructions were obtained of the CS reconstructions.

Results

Fig. 1 presents the results of the fully sampled experiments. The same representative slice and spectral point is shown in all images. Non-alternating pulses were used in the experiment shown on the left side of Fig. 1A. The alternating case is shown on the right side of Fig. 1A. In Fig 1B, the CISS reconstruction of both images is shown.

In Fig. 2, the results of the undersampled, averaged, CS and CISS reconstructed experiments are displayed. The same slice and spectral point as in Fig. 1 was used. The calculated CISS images of the differently averaged CS reconstructions show basically the same pattern as the CISS image of the fully sampled case.

Retrospectively undersampled TrueFISP experiments showed similar results (data not shown).

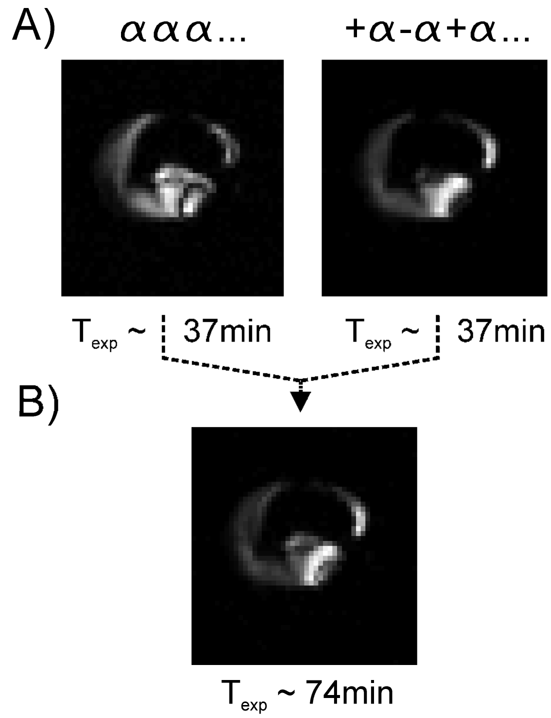

Fig. 1: Results from the fully sampled experiments (NA = 1). A) One slice/spectral point of the non-alternating (left) and alternating (right) data. B) Corresponding CISS reconstruction

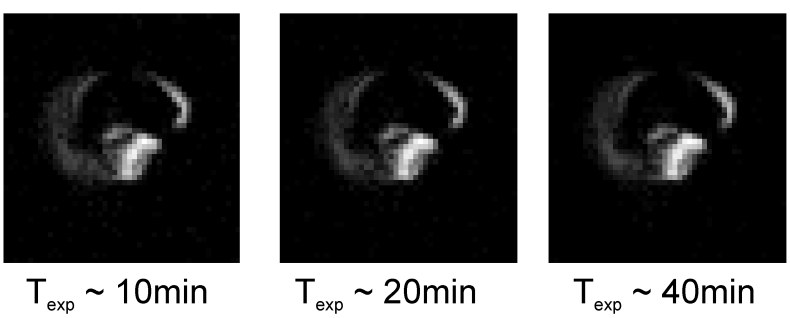

Fig. 2: Results of the undersampled, CS and CISS reconstructed experiments. The same slice/spectral point as in Fig. 1 is shown. From left to right: NA = 1, NA = 2 and NA = 4.

Discussion and Conclusion

CS-CISS experiments could be conducted in up to 1/8 of the time needed for a fully sampled CISS experiment. In this study, the time gained was used to acquire additional undersampled datasets. This was in order to improve CS reconstructions through averaging. However, if the signal is sufficient enough to ensure proper CS reconstructions from only one undersampled average, this time gain can be used to implement additional phase cycles, which would improve CISS reconstruction.

References

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