Robust method for EPI ghost correction

F. Godenschweger[1], M-H. In[1], and O. Speck[1]
[1]Biomedical Magnetic Resonance, Institute for Experimental Physics, Otto-von-Guericke University, Magdeburg, Germany

Introduction:

An important step in the reconstruction of an EPI scan is the phase correction between the odd and even lines to reduce the Nyquist ghost. Typically, the correction is performed for each channel, slice, and repetition of a data set separately. We propose a phase correction technique, which determines the phase correction differences between channels and slices with high accuracy in a preparation step from a set of navigator echoes. Taking this calibration into account, only one single correction needs to be determined dynamically for all slices and channels during the EPI series, greatly improving stability. Thus, the information in the navigator echoes can be optimally combined favoring strong signals and avoiding correction of low signal region (e.g. away from small receiver coils) with noise navigators.

Methods:

Non-phase encoded navigator echoes prior to the echo train are used to calculate the linear phase correction between the odd and even lines as introduced in [1]. In order to determine the optimal phase correction as a common basis for all later measurement, the linear phase difference for the different channels is calibrated. The residual phase error is identical for all channels and only varies slightly across slices. After this calibration step only one common residual phase correction curve is needed, which can be calculated with high accuracy from the combined navigator signals (see Fig. 1). Data were acquired on a 7T whole body system with the product EPI sequence.

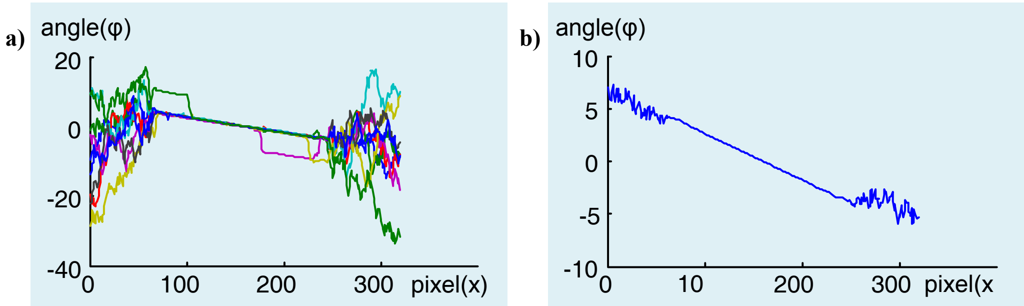

Fig. 1. Phase correction curves calculated from navigator echoes with some residual phase error (a) and after the calibration step (b).

Results:

The robustness of the proposed technique was tested on phantom and in-vivo data. A calibration step is needed in order to calculate the linear and constant phase correction for different slice positions. Therefore, navigator echoes for all slice positions and channels are analyzed.

Fig. 2 shows phantom and in-vivo data reconstructed with the proposed technique compared to the vendor provided correction. The ghost level for the proposed correction is significantly reduced with this new approach.

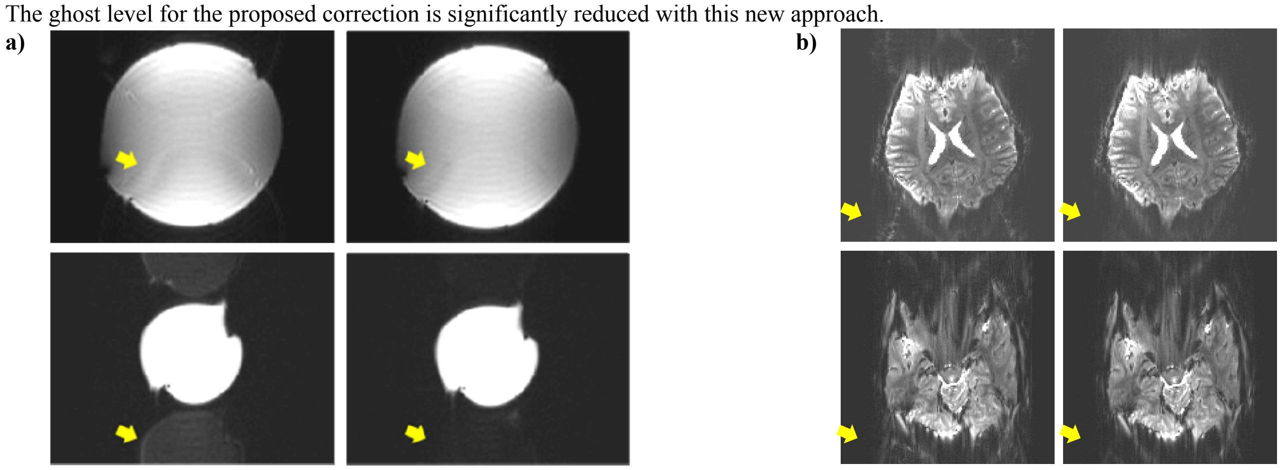

Fig 2. Phantom (a) and in-vivo (b) results where the left column shows the previous and the right column shows the proposed phase correction method. With the proposed method the Nyquist ghost is reduced dramatically, which is depicted with the arrows.

Discussion and Conclusion:

The proposed method combines the available common information provided in the navigator echoes of all slices and channels, thus avoiding a potentially unstable correction that is based on noisy reference data. No modification of the acquisition method is necessary.

A calibration step is used to calculate an optimal phase correction curve from a set of previously acquired navigator echoes. The resulting phase correction curve is used for all following measurements (for example in fMRI) and is updated continuously based on the combination of the navigators of all channels and slices. The proposed technique for EPI ghost correction dramatically improves the image quality.

References:

[1] O. Heid, Robust EPI phase correction, 2014, Proceedings of Sixth Annual Meeting of the International Society and Magnetic Resonance in Medicine, 1997

Acknowledgments

This project is supported by DFG-grant (SP 632/3-1)