ZOOM-PROPELLER-EPI: non-axial imaging at small FOV with PROPELLER-EPI

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Introduction

The PROPELLER-EPI (periodically rotated overlapping parallel lines with enhanced reconstruction using EPI as signal readout) has been shown useful for diffusion applications with reduced geometric distortion [1]. A modified reversed gradient (RG) EPI geometric distortion correction method helps further reducing image blurring for PROPELLER-EPI acquisition [2]. Current implementation of PROPELLER-EPI exhibits difficulty in small FOV or non-axial acquisition due to the aliasing artifact along the phase-encoding direction of each blade. In this work, we propose a ZOOM-PROPELLER-EPI technique, which combines the reducing-FOV (rFOV) EPI [3, 4] to obtain sagittal images with a small FOV.

Material and method

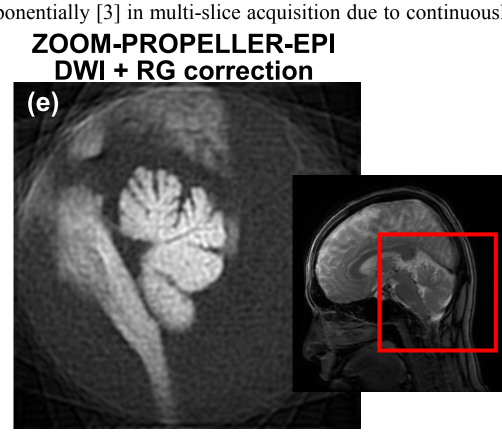
We combined PROPELLER-EPI with three types of rFOV EPI technique based on inner volume excitation, which consisted of single spin echo (SSE) cross excitation (90°z-180°y, slice thickness of 180° = 55mm), dual spin echo (DSE) cross excitation (90°z-180°y-180°y, slice thickness of 180° = 55mm), and SSE with a small tip angle between 90° and 180° slice selection gradient along phase encoding direction (tip angle = 8°, slice thickness of 180° = 10mm), where the subscript of RF flip angle represents the slice selection gradient direction along with this RF. We first collected the ZOOM-PROPELLER-EPI data of phantom on a 1.5T MRI scanner (Signa HDx, GE) with sagittal images and 8.5x8.5cm FOV. The three types of rFOV EPI techniques used for excitation in each rotating blade consisted of the following parameters: blade size 32*128 (ETL=32), rotating angle 15°, NEX 1, SSE/DSE TE 99.7ms/135.1ms, TR 4000ms, slice thickness 5mm, 12 blades for 180° k-space coverage. To verify the compatibility of ZOOM-PROPELLER-EPI and RG correction method, the rotating angles of the blades covered a total of 360°, which fills the entire circular k-space and with a pair of opposite phase gradient polarity of each blade for processing RG correction. A sagittal cerebellum image was acquired using tip angle excitation ZOOM-PROPELLER-EPI technique with diffusion weighting (b-factor 800 s/mm^2) on a 3.0T MRI scanner (Signa HDx, GE): FOV 12x12cm, blade size 32*128 (ETL=32), rotating angle 15°, NEX 1, TE 76.8ms, TR 5000ms, slice thickness 4mm, gap 0.4mm, 24 blades for 360° k-space coverage (which became 12 after applying the RG correction method).

Results

The results of phantom study using ZOOM-PROPELLER-EPI to acquire sagittal small FOV image with different rFOV EPI techniques are shown in Figs.1a-1c. The full FOV of the phantom is shown in Fig.1d, where an image acquired using conventional EPI with reduced FOV shows severe aliasing artifact from objects outside the rFOV along the phase encoding direction. The results of sagittal cerebellum image using a combination of ZOOM-PROPELLER-EPI and RG correction is shown in Fig.1e, and a localizer image is also shown on the right side. Both phantom and in vivo results demonstrated effectiveness of ZOOM-PROPELLER-EPI.

Discussion & Conclusion

Although PROPELLER-EPI is compatible with different rFOV EPI techniques, these rFOV techniques have different effects on the slice profile and different capabilities of multi-slice acquisition. For rFOV using SSE cross excitation, the signal intensity decays exponentially [3] in multi-slice acquisition due to continuously inversion of 180° RF for inner volume excitation. In theory, rFOV using DSE cross excitation contains double inversion with two 180° RF and can be used for multi-slice acquisition, but the signal decay still exists due to imperfect slice profile of the 180° RF used for refocusing a thick inner volume (e.g., 50mm thickness). In addition, DSE shows a decreased SNR due to prolonged TE for double refocusing. For rFOV using SSE with a small tip angle between 90° and 180° slice selection gradient, the signal decay in multi-slice acquisition can be controlled by the tip angle, slice gap, and the refocusing thickness [4], allowing the users to reduce the inter-slice interference in inner volume excitation by appropriately adjusting these parameters. However, the final excited slice profile of tip refocusing in SSE is in the shape of a parallelogram, which shows more signal decay near the edge of FOV comparing to the other two rFOV techniques (Fig.1c; white arrow). In conclusion, ZOOM-PROPELLER-EPI is applicable to small FOV acquisition and compatible with the RG correction method, while the slice profile of inner volume excitation and multi-slice capability are affected by different rFOV techniques, both of which lead to signal loss near edge of FOV. The proposed method may find applications in non-axial high-resolution scans such as diffusion-weighted imaging of the cerebellum.



Reference

[1] Wang FN, et al. MRM 54:1232 (2005). [2] Chang HC, et al, ISMRM #1506 (2006). [3] Jeong EK, et al. MRM 54:1575 (2005). [4] Symms MR, et al, Proc ISMRM, #160 (2000).

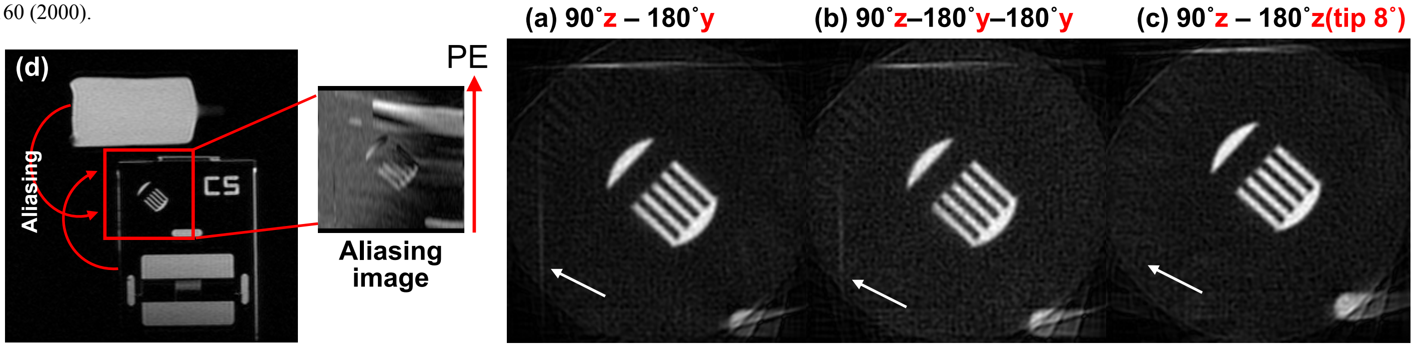


Fig. 1. (a)-(c), showing the phantom images acquired by ZOOM-PROPELLER-EPI with different rFOV techniques. (d) An example image showing the aliasing artifact of conventional EPI acquisition with rFOV. (e) A sagittal cerebellum image acquired by ZOOM-PROPELLER-EPI with RG correction method.