PROPELLER EPI: Application to Diffusion Tensor Imaging

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Purpose

The feasibility and application of Propeller MRI (1) have been demonstrated with a fast spin-echo (FSE) implementation. Compared with Propeller FSE, Propeller EPI alleviates the problem inherent in the CPMG echoes (1,2) and has the potential advantage of less SAR, an important consideration at high field strength. In this study we present a successful implementation of Propeller EPI, with appropriate phase correction and echo weighting for effective artifact removal. Applications to diffusion tensor imaging (DTI) with little geometric distortion are demonstrated for human brain near the skull base.

Materials and Methods

Three normal subjects were scanned for DTI using PROPELLER EPI method on a 3T scanner (Siemens Allegra). The imaging parameters were TE/TR=65/1500 ms, Matrix size 128x128, FOV=220 mm, b-factor 700 s/mm^2, slice thickness 2mm, 16 slices, and the total scanning time was 4'54''. A total of 26 "blades" was acquired for one image, and each blade had 24 phase encoding lines. The angle between the consecutive blades was 7 degree to cover the k space. After applying the motion and phase correction (1), each blade was multiplied by a triangular weighting window. Within each blade, the inner echoes with less phase error were thus overweighed to reduce both the susceptibility-induced signal loss and the blur effect, which was caused by averaging various geometry distortions (2). Afterwards, conventional DTI images using single-shot EPI were also acquired for comparison. The TE/TR was set to the shortest limit of 113/2700 ms, 15 NEX, scan time 4'40'', and all other parameters were identical to the PROPELLER scan.

Results

Fig.1 (a) and (b) compare the spin echo images (b-factor=0) by single-shot and PROPELLER EPI respectively, with overlaid contours from a FSE image shown in (c). Note the warped eyeballs in (a) caused by off-resonance whereas the shape of eyeballs in (b) are dramatically undistorted. The SNR at (a) by single shot EPI is 35.7, while the SNR at (b) by PROPELLER has a comparable value of 39.1. The diffusion tensor images by single-shot EPI (d) and PROPELLER EPI (e) are also shown.

Discussion and Conclusion

The PROPELLER EPI can be used to acquire images with reduced susceptibility and motion artifacts. The weakness of this technique is the extra time required for acquiring multiple blades. Nonetheless, by the nature of PROPELLER technique, the oversampling of k-space center increases the SNR and can be utilized for phase correction of each blade. For application to DTI, the benefits of SNR shortens the total scan time by applying fewer NEX, and the feasibility of phase correction is prerequisite before combining the blades with diverse phases by applying diffusion gradients. Using the PROPELLER EPI also does not have the CPMG and SAR problems of conventional PROPELLER by FSE. Therefore, with the SNR and scan time comparable to a conventional DTI sequence, this technique is able to achieve undistorted images at high field scanners.

References

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2.Pipe J, et al., MRM 47(1): 42-53,2002.

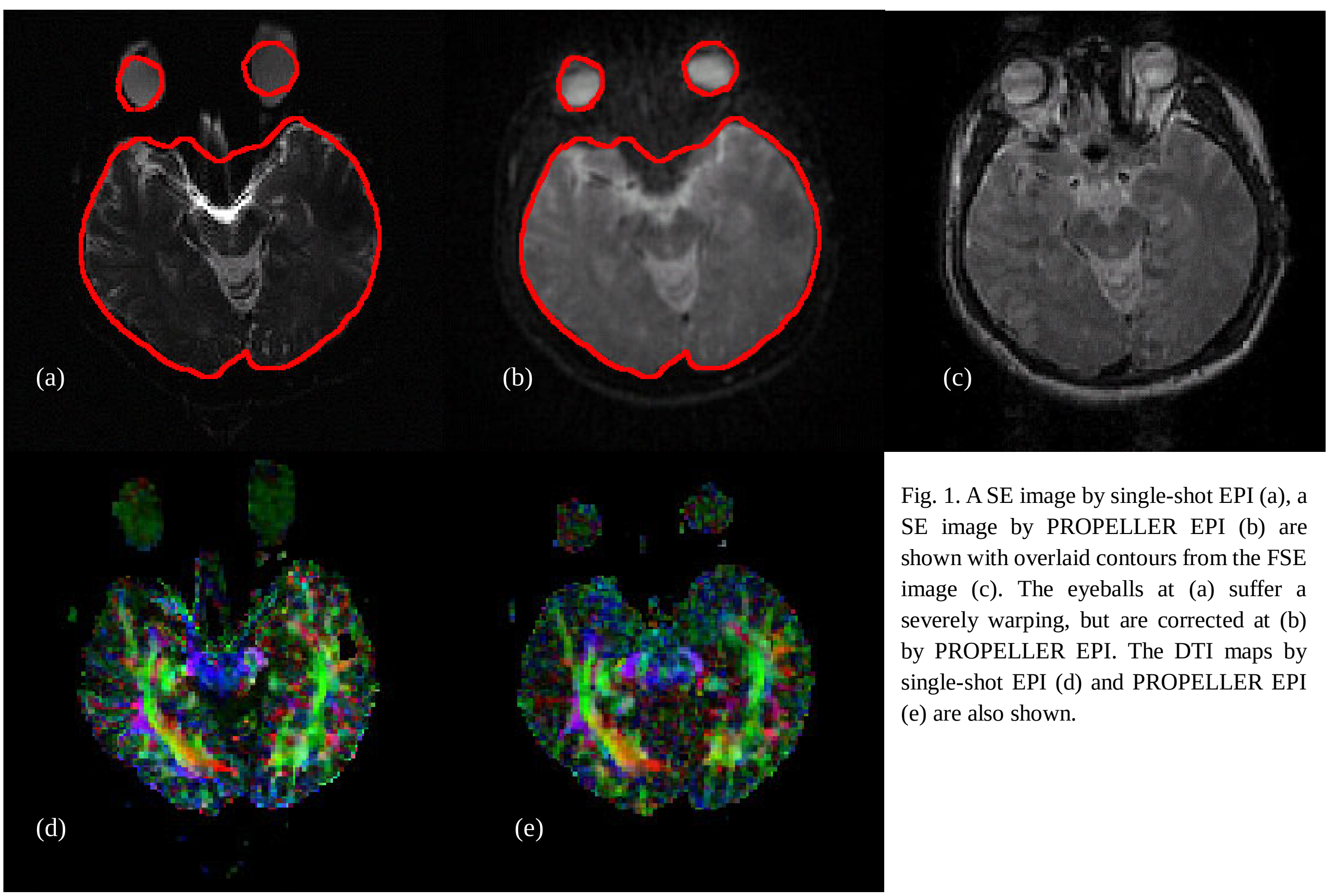

Fig. 1. A SE image by single-shot EPI (a), a SE image by PROPELLER EPI (b) are shown with overlaid contours from the FSE image (c). The eyeballs at (a) suffer a severely warping, but are corrected at (b) by PROPELLER EPI. The DTI maps by single-shot EPI (d) and PROPELLER EPI (e) are also shown.