PROPELLER EPI with Parallel Imaging on High Resolution DTI at 3T

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Introduction

PROPELLER imaging [1] can be used to acquire multi-shot diffusion weighted MRI data by the composition of individual blade image after phase and motion correction. Compared to TSE, PROPELLER by spin-echo EPI [2] also has the advantage of lower SAR. Thus it is more appropriate in high field diffusion imaging. In our previous study [3], we demonstrated that PROPELLER EPI with SENSE [4] can further reduce the number of echo train length (ETL) to obtain less distorted images. In this study, we use PROPELLER EPI with GRAPPA [5] to achieve 4-fold acceleration to obtain *in vivo* fractional anisotropy (FA) maps and diffusion tensor images.

Materials and Methods

Diffusion tensor imaging using diffusion-weighted EPI was implemented with PROPELLER k-space trajectory on a 3T scanner with 8-channel circularly symmetric head array coil (Siemens medical solution, Erlangen Germany). Each PROPELLER blade image was further accelerated using GRAPPA technique. Two subjects were scanned using PROPELLER diffusion-tensor EPI with the following parameters (number of blades: 14, size of each blade: 64×256, rotational angle: 13°, FOV: 220*220mm^2, TR: 2000ms, NEX: 4, 7 diffusion-weighting gradients: (0,0,0), (1,1,0), (1,-1,0), (1,0,1), (1,0,-1), (0,1,1), (0,1,-1) with a b-value of 700 s/mm^2). Each PROPELLER blade image was accelerated at 1, 2, and 4 fold accelerations with corresponding TEs of 135, 89, and 71 ms, respectively. Image reconstruction was implemented by first GRAPPA reconstruction to restore the full k-space data in each blade image, and second PROPELLER reconstruction to combine all blades with phase and motion correction. The final reconstructed image had spatial resolution of 0.86×0.86×5 mm^3. In addition, we also acquired TSE images (TE/TR: 102/3440 ms, ETL: 9, NEX: 1) to compare the PROPELLER EPI images.

Results

Fig.1a, **b**, **c** were PROPELLER EPI images with GRAPPA obtained at acceleration factors R = 1, 2, and 4, which corresponded to the echo train length (ETL) of 64, 32, and 16 k-space lines. In **Fig.1a**, we found that there was obvious blurring artifact due to EPI-related distortion in each blade. At higher acceleration rates, the blurring effect was decreased (**Fig.1b**, **c**). Compared to a TSE image (**Fig.1d**), PROPELLER EPI with 4-fold acceleration was found to be similar with less distortion. Different image contrast in **Fig.1a**, **b**, **c** was due to different TE in each acquisition. High-resolution FA map and color-coded DTI using 4-fold GRAPPA acceleration were shown in **Fig.1e** and **f**. The fine structures of the white matter neuronal fiber bundles, for example, as denoted by the white arrow in **Fig.1f**, the connections between human thalamus and visual cortex, were clearly identified.

Discussions

Using GRAPPA parallel MRI technique, image distortion and susceptibility artifact were reduced because of decreased ETL and increased bandwidth at higher acceleration rates. Applying this technique to PROPELLER blade image yielded final PROPELLER reconstruction with fewer artifacts, including distortion, blurring effect and susceptibility loss, by taking the TSE image as reference. In diffusion weighted imaging, longer TE is generally required due to presence of diffusion weighting gradient. Thus signal may drop significantly when T2* is short. Using PROPELLER with parallel imaging, the ETL can be shortened (16 echoes at R=4 in our study) and TE can be reduced to avoid significant signal loss at the T2* rate. The combination of shortened TE, increased bandwidth in the phase encoding direction in each blade image, and reduced ETL, all contribute to the improved SNR and reduced distortion and minimized susceptibility artifact in diffusion weighted PROPELLER GRAPPA EPI. Using this method, high resolution diffusion tensor imaging was achieved without prominent artifacts, leading to advanced neuronal connectivity studies [6].

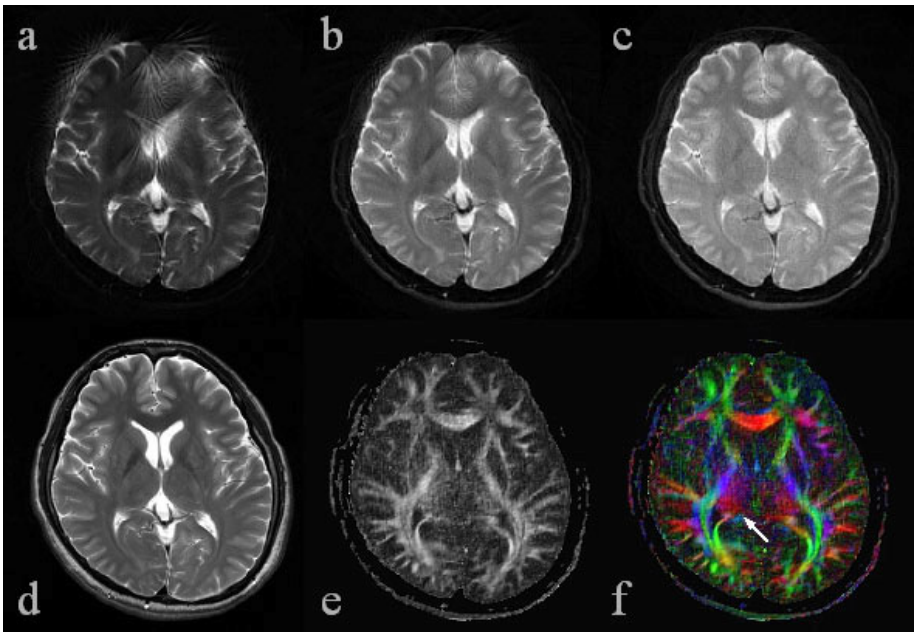

Fig.1a, **b**, and **c** showed PROPELLER EPI images with GRAPPA at acceleration R=1, 2, and 4. **(d)** was TSE image for reference. **(e)** and **(f)** were high resolution (0.86×0.86 mm^2 in-plane resolution) FA map and DTI at R=4.

References

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