Targeted-PROPELLER MRI

J. Deng[1,2], and A. C. Larson[1,2]

[1]Biomedical Engineering, Northwestern University, Chicago, IL, United States, [2]Radiology, Northwestern University, Chicago, IL, United States

INTRODUCTION

Multi-shot TSE-based PROPELLER techniques [1] acquire data segments as concentric rectilinear blades along a propeller-shaped k-space trajectory. PROPELLER imaging has been shown to be less sensitive to motion artifacts. However, PROPELLER imaging requires longer imaging time compared to conventional TSE due to oversampling of *k*-space. Also, it has been demonstrated that regional motions cannot be effectively corrected based on an entire image including both static and moving objects. A recent targeted-HASTE (single-shot TSE) approach [2] employs inner-volume excitation [3] to limit the field-of-view (FOV) in the region of interest (ROI). In this study, we propose a targeted-PROPELLER technique for (i) imaging a small ROI with reduced FOV to shorten imaging time and (ii) targeting the moving objects for robust regional motion correction.

METHODS

Targeted-PROPELLER Pulse Sequence   For TSE train of each blade, slice selection gradients were applied in PE direction for 90° excitation RF pulse and in the slice direction for 180° refocusing RF pulses. The perpendicular slice selection directions of 90° excitation and the first 180° refocusing pulses limited the FOV in the phase encoding direction for each rectangular blade image. Rotation of blade segment acquisitions limited the FOV in the overlapping area of all blade images.

Imaging Studies   All imaging experiments were performed using a 1.5 T clinical scanner (Magnetom Sonata, Siemens Medical Solutions). ***Phantom Study I.*** PROPELLER images with full FOV (200×200 mm^2), ½ FOV (100×100 mm^2) and ¼ FOV (50×50 mm^2) targeted-PROPELLER images were acquired. In all PROPELLER images, spatial resolutions were identical (0.4×0.4×5.0 mm^3), echo train length (ETL) =25, imaging matrix / number of blades (NBL) were 512×512/40 for full FOV, 256×256/20 for ½ FOV and 128×128/10 for ¼ FOV images. Additionally, a ½ FOV targeted-HASTE image with identical spatial resolution was acquired for comparison. ***Phantom Study II.*** We constructed a phantom model consisting of two rigid objects – a moving object and a static object. Images were acquired before and after translation and rotation of the moving object. Three *k*-space datasets (i.e. before movement, after two separate movements) were interleaved and combined in one *k*-space to reconstruct image mimicking motion artifacts. Full FOV PROPELLER images and ½ FOV targeted-PROPELLER image targeting the moving object were acquired. Images mimicking motions were reconstructed from both datasets and motion corrections were performed. ***In vivo Imaging Study.*** Full FOV and ½ FOV targeted-PROPELLER images of the brain were acquired in one volunteer with the following imaging parameters: FOV=200×200/100×100 mm^2, matrix =256×256/128×128 (full FOV/½ FOV), TR/TE=3000/117ms, ETL=25, NBL=20 and spatial resolutions = 0.8×0.8×5.0 mm^3.

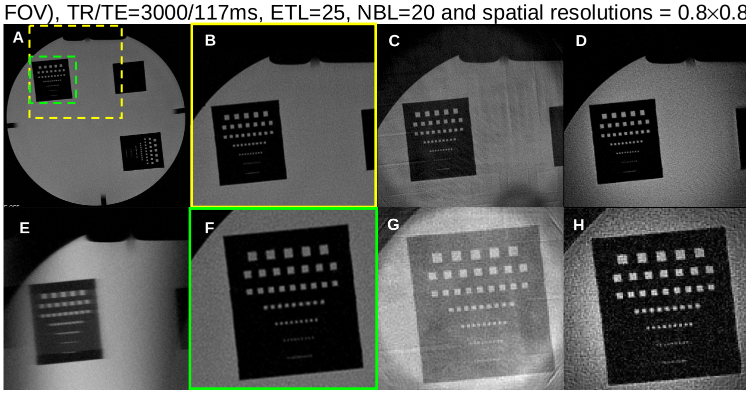

Fig. 1. (**A**) Full FOV PROPELLER image, (**B,F**) corresponding zoom-in images of ROI within **A** (dashed box), (**C**) ½ FOV and (**G**) ¼ FOV conventional PROPELLER images (note streak artifacts), (**D**) ½ FOV and (**H**) ¼ FOV targeted-PROPELLER images. (**E**) ½ FOV targeted-HASTE image.

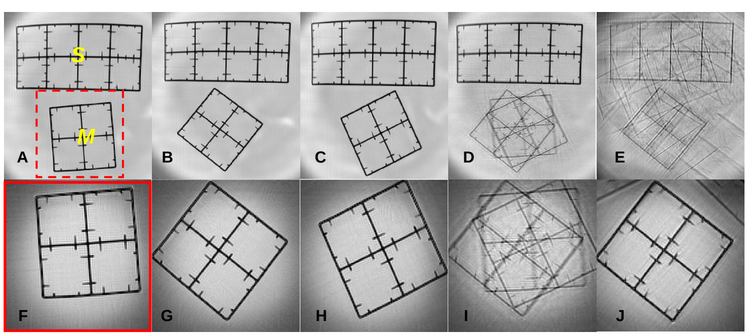

Fig.2. A phantom model consisting of a static object (*S*) and a moving object (*M*). Full FOV (**A-C**) and reduced FOV targeted-PROPELLER images (**F-H**) (red box) acquired before and after moving the lower object (red dashed box). Full FOV image (**D**) and targeted FOV image (**I**) with motion. Motion corrected full FOV image (**E**) and targeted FOV image (**J**).

RESULTS and DISCUSSIONS

In **Fig.1,** reduced FOV images using conventional PROPELLER showed severe streak artifacts (**C,G**). Targeted-PROPELLER images (**D,H**) demonstrated superior image quality with similar image sharpness and contrast compared to the zoom-in full FOV image (**B,F**). Targeted-PROPELLER images achieved same spatial resolution as full FOV image, while using less number of blades and hence less imaging time. Targeted-PROPELLER provided isotropic spatial resolution compared to the targeted-HASTE image (**E**), which was blurred along the phase encoding direction. However, targeted-PROPELLER had decreased signal-to-noise ratio (SNR) compared to full FOV PROPELLER images. In **Fig. 2,** images were acquired before and after each movement using full FOV (**A-C**) and ½ FOV targeted-PROPELLER targeting the moving object (**F-H**). The motions shown in the combined images (**D** and **I**) were effectively corrected in the targeted-PROPELLER image (**J**) but not in the full FOV image (**E**). Regional motion correction within the limited FOV targeting the moving object resulted in more robust motion corrections in PROPELLER. **Fig. 3** shows full FOV (**A**) and zoom-in (**B**) PROPELLER brain images and the corresponding ½ FOV targeted-PROPELLER image (**C**). The targeted-PROPELLER image demonstrated similar image resolution and contrast but less streak artifacts compared to the full FOV image. This finding may be attributed to reduced motion sensitivity of the targeted-PROPELLER approach.

CONCLUSIONS

Targeted-PROPELLER provides a promising method of shortening imaging time and improving spatial resolution compared to conventional PROPELLER. Furthermore, it offers the potential of targeting moving objects for robust regional motion correction, which could otherwise be corrupted by different types or amount of motion present in the entire image volume.

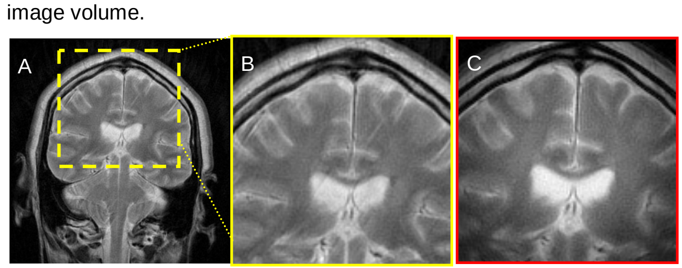

Fig. 3. Full FOV (**A**), zoom-in (**B**) and targeted-FOV (**C**) PROPELLER image of the brain.

References:

[1] Pipe et al. *Magn Reson Med*. 1999;42: 963–969.
[2] Zimmermann et al. *Magn Reson Med*. 2006;56: 481–488.
[3] Feinberg et al. *Radiol.* 1985;156:743-747.