PROPELLER using parallel imaging with across blade calibration for T1 FLAIR

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Introduction: T1-weighted FLAIR is used to suppress CSF and improve detection of enhancing lesions. PROPELLER allows correction for patient motion, including rotational correction if the blade widths are sufficient [1]. However, short echo train lengths are optimal for T1-weighted imaging, limiting the blade width, and thus making it difficult to acquire motion-corrected PROPELLER images with T1 FLAIR contrast. Parallel imaging provides the opportunity to increase the blade width, but conventional auto-calibration limits the amount of effective acceleration possible on each blade. Reducing the number of internal calibration lines using data from a shared external calibration blade enables higher acceleration for each blade [2]. Here, we demonstrate that the shared calibration technique enables an increase in the effective blade width that is sufficient for rotational correction, improving image quality in T1 FLAIR imaging.

Figure 1. a) Acquisition trajectory with an over-sampled calibration blade (black) and accelerated blades (blue). b) enlargement of the calibration blade and a single accelerated blade.

Methods: Figure 1 shows the k-space readout lines for the proposed technique. A single calibration blade (black lines) is acquired that is oversampled by 2× in the frequency and 1.5× in the phase encoding directions. Accelerated blades (blue lines) are undersampled by 3× in the phase encoding direction with only 2 additional internal calibration lines. With an ETL of 13, an effective blade width of 33 encodes is achieved. Healthy normal subjects were imaged on a 1.5 T clinical MR system (Signa HDx, GE Healthcare, Waukesha, WI) using an 8 channel brain coil (MRI Devices, Waukesha, WI). Acquisition parameters included FOV 23 cm × 23cm , 384 readout, 5 mm slices, 2 mm gap, 10 slices, ETL 13, BW ±50kHz, TE 51.5 ms, TR 3 s, TI 920 ms. 54 blades were acquired to maintain sufficient angular sampling following the rejection of some blades due to extreme head motion. Total scan time was 2:52. Calibration coefficients were calculated using a combination of the internal blade calibration lines as well as data interpolated from the calibration blade onto the undersampled blade using the APPEAR algorithm [3]. Images were reconstructed with and without rotation correction to evaluate the utility of the correction, correction for translational motion was applied to both image sets. Individual imaging blades were rejected if their correlation with the mean of all blades was found to be significantly low [1], a limit of 0.96 was used for this work.

Results: Figure 2 compares images acquired when the volunteer was stationary to images acquired during modest head movement. The data were reconstructed with and without rotational correction showing significant reduction in blurring with the application of rotational correction (arrows). Figure 3 demonstrates correction in a case of severe motion. In this case, 70% of the blades could be utilized when correcting for rotation, while only 45% of the imaging blades could be used without rotational correction.

Figure 2. Example axial images from an across blade calibration PROPELLER T1 FLAIR acquisition with no motion. (stationary), motion with correction for rotation and with no correction for rotation. Top row shows enlargements of the frontal lobes and 2 example slices are shown in the middle and lower rows. Note blurring evident in images with no rotational correction while high image quality is maintained with rotation correction that is comparable to images acquired while the subject was stationary.

Figure 3. Example of subject with (a) severe motion with correction rotation and (b) no correction for rotation. Note significant blurring evident in image with no rotational correction.
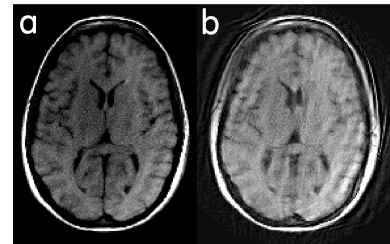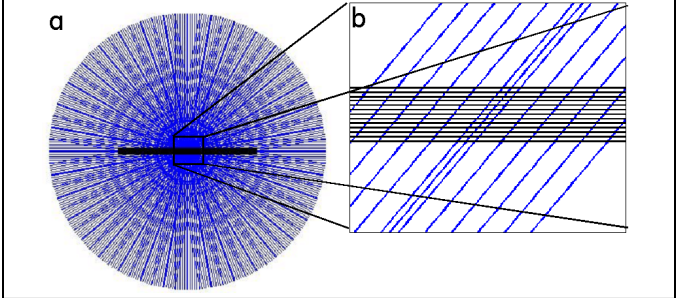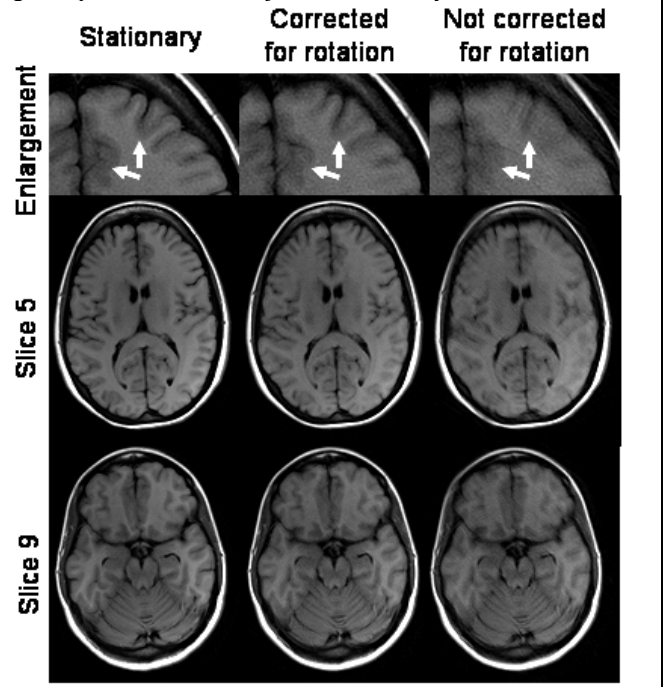

Conclusions: Shared calibration enables PROPELLER images to be acquired with T1 FLAIR contrast. Despite short ETLs, high acceleration increases the effective blade width significantly, enabling rotational motion correction and improving robustness to subject motion. The current implementation was optimized for greater blade width and improved rotation correction however the technique may also be used to reduce the TE and acquired ETL to improve the T1 contrast.

References: [1] Pipe et al. MRM 1999;42:963-969. [2] Beatty et al. ISMRM 2008 A1464. [3] Beatty et al..ISMRM 2007 A335.