T2-weighted body imaging with PROPELLER using parallel imaging with across blade calibration

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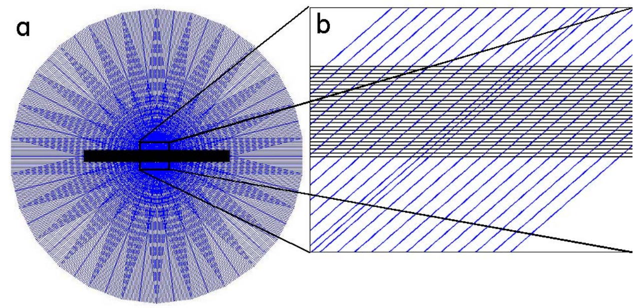
Introduction: Multi-slice T2-weighted fast spin echo (FSE) imaging is one of the most important abdominal sequences in routine clinical use for detection and characterization of disease. Respiratory gating is commonly used to minimize artifacts from respiratory motion. However, gating can be ineffective in subjects with rapid or irregular respiration, particularly in patients with ascites. PROPELLER has been shown to correct for rigid body motion as well as to distribute non-rigid motion into less coherent artifacts than Cartesian acquisitions [1], and parallel imaging has been used to achieve greater PROPELLER blade widths for improved motion correction in T2-weighted body imaging [2]. In this work, we demonstrate the application of a shared calibration scheme for autocalibrated parallel imaging, previously used in the head [3], to enable greater blade acceleration achieving wider blades and reducing the number of blades required to produce full angular sampling for T2-weighted abdominal imaging.

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



Methods: Healthy normal subjects were imaged on a 3T clinical MR system (MR750, GE Healthcare, Waukesha, WI) using an 8 channel phased array coil (GE Healthcare, Waukesha, WI). A PROPELLER FSE acquisition was performed with a calibration blade acquired during the first repetition (in place of a 'dummy' repetitions ordinarily used to bring magnetization to the steady state) followed by acquisition of the accelerated blades. A diagram of the acquisition scheme is shown in Figure 1. Calibration data was oversampled by 2× in the frequency and 1.5× in the phase encoding directions. Accelerated blades were undersampled by 2× in the phase encoding direction with 2 additional internal calibration lines. Acquisition parameters included FOV 34 × 34 cm, 384 readout, 8mm slices, 1 mm gap, ETL 25, BW ±50kHz, TE / TR = 95.8 ms / 9 s, 1 average, 10 slices, and scan time of 2:17. Calibration coefficients were calculated using a combination of both the internal blade calibration lines as well as data interpolated from the calibration blade onto the undersampled blade using the APPEAR algorithm [4]. Translation and rotation corrections were applied to the PROPELLER blade data to maximize the correlation of the individual blades during respiration. For comparison, two conventional acquisitions were also performed. The first was a respiratory-gated acquisition with FOV = 34cm × 26 cm, 384 × 384 matrix, 24 ETL, 384 phase encodes, TE = 91 ms, TR = 5 respiratory cycle (~10 s), BW = ±50kHz, 1 average, 10 slices, scan time of ~2:50. The second was a non-gated acquisition with 4 averages, TR = 4 s, and scan time of 3:17.

Figure 2. Example axial images from (a) respiratory gated, (b) free-breathing 4 NEX, and (c) free-breathing PROPELLER acquisitions. Respiratory motion artifact visible in images from the conventional acquisitions (arrows) is not visible in the image from the PROPELLER acquisition.

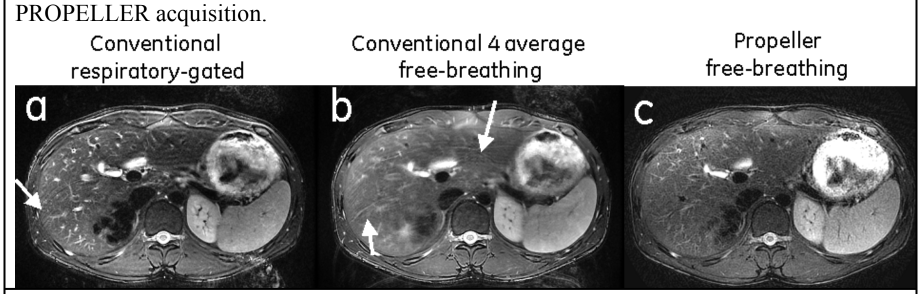
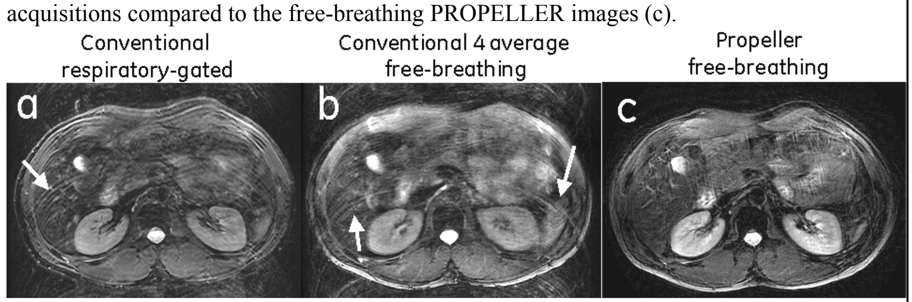


Figure 3. Axial images from a volunteer with irregular breathing pattern. Note artifacts in both the conventional respiratory-gated (a, arrow) and 4 average free-breathing (b, arrows) acquisitions compared to the free-breathing PROPELLER images (c).



Results: Images acquired using a conventional respiratory gated acquisition (Fig. 2a) demonstrate crisp depiction of liver vessels and other small structures while motion artifact and blurring are visible in the ungated 4 average acquisition (Fig 2b, arrows), the ungated PROPELLER acquisition with shared calibration shows reduced blurring and correction of motion (Fig. 2c). Examples of images from a volunteer with an irregular breathing pattern show aliasing artifacts in the conventional acquisitions (Fig. 3a-b) while the free-breathing PROPELLER technique allowed improved image quality (Fig 3c).

Discussion: PROPELLER with shared calibration parallel imaging enables robust free-breathing T2-weighted abdominal imaging. Image quality was compared to a conventional respiratory gated acquisition in volunteers with regular breathing, and also compared to a 4 average free-breathing acquisition, a common 'fall back' for patients who can not be well imaged with respiratory gating. Potential work-flow related time savings are possible using the PROPELLER acquisition, as there is no need to set-up and utilize the respiratory bellows, and no need to repeat with a long 'fall back' acquisition if the gated acquisition fails. For identical readout train lengths, a fully sampled PROPELLER acquisition requires a greater number of repetitions than a Cartesian acquisition, which does contribute to improved SNR in the PROPELLER data due to signal averaging.

References: [1] Pipe et al. MRM 1999;42:963-969. [2] Hirokawa et al. MRM 2009;28:957-962 [3] Beatty et al. ISMRM 2008 A1464. [4] Beatty et al..ISMRM 2007 A335.