Improved Reconstruction of Free-Breathing Abdominal PROPELLER MRI: A Preliminary Study

Dallas C Turley[1], Michael Schär[2], and James G Pipe[1]
[1]*Neuroimaging Research, Barrow Neurological Institute, Phoenix, AZ, United States,* [2]*Philips Healthcare, Cleveland, OH, United States*

Introduction: The goal of this work is to improve the reconstruction of free-breathing multi-slice PROPELLER data of the abdomen to maximize patient comfort while enabling fast data collection and accurate reconstruction.

Imaging Methods: Two healthy volunteers were scanned using a T2-weighted PROPELLER sequence on a Philips 3T Ingenia MR scanner to image the liver during end-exhalation. For each scan, 30 5-mm thick slices were acquired with an in-plane field of view of 50 cm and TE/TR = 100ms/3000ms. Slices were interleaved and blade acquisition order was pseudo-randomized. Four image volumes were acquired for each volunteer, one for each breath-hold scheme detailed in **Table 1**. Volunteers were instructed to breath normally during Free Breathing and Respiratory Gating. During the Delayed Free Breathing (DFB) scheme, volunteers were instructed to pause for 2-3 seconds after exhalation. Physiological monitoring (**Figure 1**) tracked the patient's breathing and recorded when data were being acquired.

Reconstruction Methods: Standard PROPELLER reconstruction [1] correlates individual blades to the average blade (B_{avg}) of a given slice; correlation scores precondition an iterative sample density correction algorithm (SDC) [2] to reduce the contribution of poorly-correlated blades while maintaining uniform sampling density. Ideally, SDC will tend to reject data collected during inspiration, but reconstruction can be biased if multiple blades in a given slice are collected during inspiration. By using delayed inspiration (i.e. DFB) or nonuniformly weighting blades used to calculate B_{avg}, one can substantially bias the slice average in favor of end-exhalation, resulting in more consistent slices and blades which are better correlated to the average blade. Blade data are nonuniformly weighted by multiplying blades by a weighting function based on relative position in the respiratory cycle at which they were collected. Images were reconstructed using 3 methods: (1) standard PROPELLER, (2) preconditioning SDC with a function derived from the respiratory bellows instead of PROPELLER correlation scores and (3) nonuniformly weighting blade data used to calculate B_{avg} before standard PROPELLER reconstruction.

Results & Conclusions: The effect the different reconstruction methods have on SDC weights is shown in **Figure 2**. Results from Method 2 (not shown) were inconsistent, sharpening some areas but also caused additional blurring, especially in adipose tissues and in the chest wall. Pausing after exhalation (DFB) reduced motion-related blurring in both volunteers when compared to normal free breathing as shown in **Table 2**. Method 3 further improved image sharpness in DFB, though images were not as sharp as images from respiratory gated acquisitions. Nonuniformly weighting blade data to calculate B_{avg} enhances PROPELLER reconstruction by preventing errant blades from corrupting the slice average blade. This method presents a promising new method to supplement standard PROPELLER compensation for respiratory motion in abdominal MRI.

Table 1: A summary of relevant parameters for each of the four image volumes collected for each volunteer

Breathing Scheme	Resolution (in-plane)	Data Avgs	Total Scan Time
Breath Hold	1.3 mm	1x	54 seconds
Respiratory Gated	1.0 mm	2x	Varies. Low: 4 min 27 s High: 5 min 2 s
Free Breathing	1.0 mm	3x	3 min 22 s
Delayed Free Breathing	1.0 mm	3x	3 min 22 s

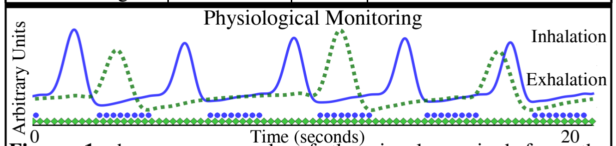


Figure 1 shows an example of the signal acquired from the respiratory bellows during Respiratory Gating (solid line) and Delayed Free Breathing (dashed line). Acquisition marks show when blades are acquired during Respiratory Gating (circles) and Delayed Free Breathing (diamonds).

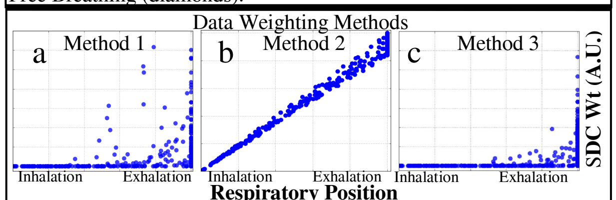
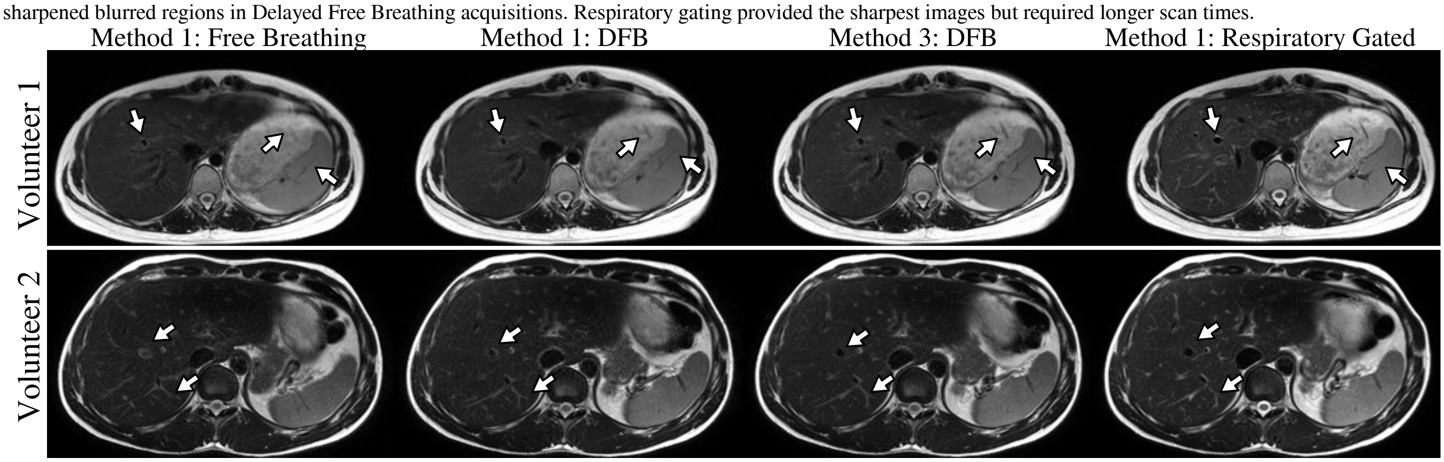


Figure 2 shows the effect data weighting methods have on the relative weight calculated for blades acquired in the Free Breathing scheme. Standard PROPELLER (a) can be biased by multiple blades collected during inspiration. Preconditioning SDC with only the respiratory waveform (b) does not capture enough motion information to appropriately weight the blades. By nonuniformly weighting blades used to calculate B_{avg} (c), blades collected during inspiration are weighted lower than those collected during exhalation.

Table 2: Representative slices from Volunteers 1 and 2. Standard PROPELLER reconstruction showed blurring around some vessels and organ walls (arrows). Modifying the breathing pattern (i.e. DFB) sharpened the images without any other processing necessary. Nonuniformly weighting blade data (Method 3) further sharpened blurred regions in Delayed Free Breathing acquisitions. Respiratory gating provided the sharpest images but required longer scan times.



REFERENCES: [1] Pipe. MRM 43:963-969 (1999). [2] Pipe. MRM 41:179-186 (1999) ACKNOWLEDGEMENTS: This work was funded by Philips Healthcare.