Data-sharing PROPELLER imaging for increased temporal resolution retaining spatial resolution and image contrast

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Introduction

In PROPELLER MRI (1,2), several blades of k-space data, each exhibiting identical image contrast, were collected to reconstruct one image. The multi-shot nature therefore restricted this technique to static MR imaging. In this study, we propose data-sharing PROPELLER (dsPROPELLER) which combines blades with different contrast using the concept of "keyhole" (3), such that information of edge sharpness is kept refreshing by adjacent blades while the central k-space data dominating image contrast are updated dynamically. With appropriate manipulation of the rotating blades, the reconstructed dsPROPELLER images could exhibit the desired image contrast with high spatial resolution at increased temporal resolution. Simulation results from dynamic contrast-enhanced perfusion imaging and an in vivo T2 estimation experiment based on multi-echo spin-echo are demonstrated.

Materials and Methods

Let N_b be the number of blades to cover the circular k-space and i the index of the acquired blades (which is also taken as the index of dsPROPELLER images). In data combination of the i-th dsPROPELLER image, the central k-space data in an N_b-regular polygon-shaped region were provided by the i-th blade, while the remaining k-space was filled by adjacent N_b blades chosen adequately. Re-gridding, density compensation, and Fourier transform were subsequently applied for reconstruction (1,2).

A simulation was performed using pulmonary contrast-enhanced imaging. The original full-space dynamic data composed of 35 consecutive coronal scans. 35 blades (80 k-lines each) were generated spaced at 30-degree increment. Choosing $N_b = 6$, the i-th dsPROPELLER image was reconstructed using 6 adjacent blades (from i-4-th to i+1-th). After reconstruction, regions of interest (ROIs) were chosen to compare signal-time behaviors on dsPROPELLER and the original full-space images.

The T2 experiments were performed on human brain at 3T (Siemens Trio, Erlangen, Germany) using a multi-echo spin-echo sequence with 16 echoes (TE = 15 to 240 ms stepping 15ms). 6 blades were acquired for every TE, such that PROPELLER and dsPROPELLER T2 maps could both be generated with $N_b = 6$ and 30-degree rotating increment.

Results

Fig.1 exemplifies a series of dynamic images (the 4th, 6th, and 8th) with full-space and dsPROPELLER, respectively, exhibiting similar contrast without prominent artifacts. Signal-time curves from ROIs chosen in the pulmonary artery, descending aorta, and lung parenchyma show great consistency between full k-space and dsPROPELLER images (Fig.2). Difference was found to be less than 2.5%. Fig.3 shows the T2 maps generated from PROPELLER and dsPROPELLER images, respectively. The high agreement between these two T2 maps is clearly seen from pixel-by-pixel correlation shown in Fig.4 (Pearson's correlation coefficient = 0.99).

Discussion

Results from our study demonstrate that dsPROPELLER is feasible for dynamic imaging, with temporal resolution of the blades and the spatial resolution of the PROPELLER images. Consistency with full-k-space images in its contrast suggests that dsPROPELLER has minimal loss of information even with k-space data omission. Compared with the keyhole technique, the edge sharpness is updated continuously in dsPROPELLER without the need of reference scans. dsPROPELLER therefore has potential in dynamic imaging where high spatial resolution is needed at increased temporal resolution.

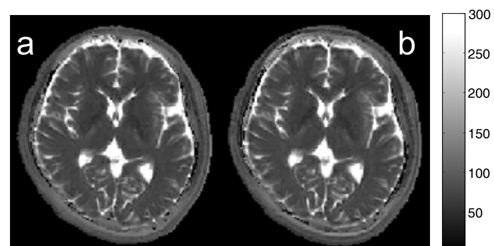

Fig.3 T2 maps of human brain generated from PROPELLER (a) and dsPROPELLER images, showing high similarity.

Reference

1. Pipe JG. MRM 42:963-969, 1999.
2. Wang F-N, et al. MRM 54:1232-1240, 2005.
3. van Vaals JJ, et al. JMRI 3:671-675,1993

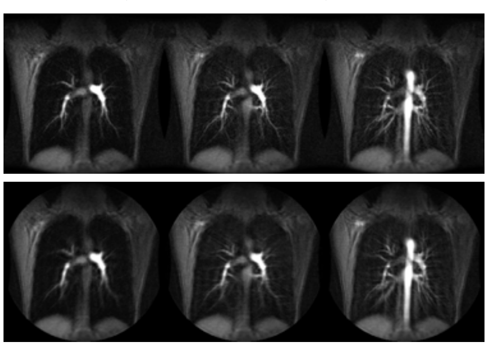

Fig.1 The full k-space (upper row) and dsPROPELLER (lower row) images of the same series of dynamic scan (the 4th, 6th, and 8th), showing high similarity.

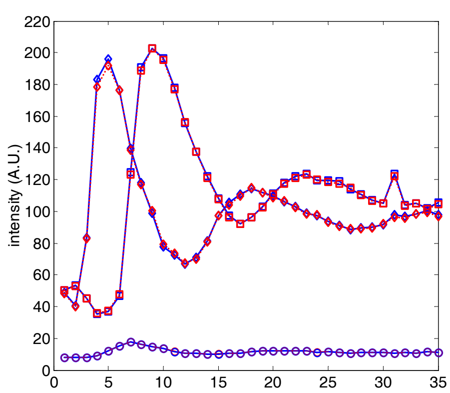

Fig.2 Dynamic signal-time curves of full k-space (blue) and dsPROPELLER (red) images of ROIs chosen from pulmonary artery (diamond), descending aorta (square), and lung parenchyma (circle).

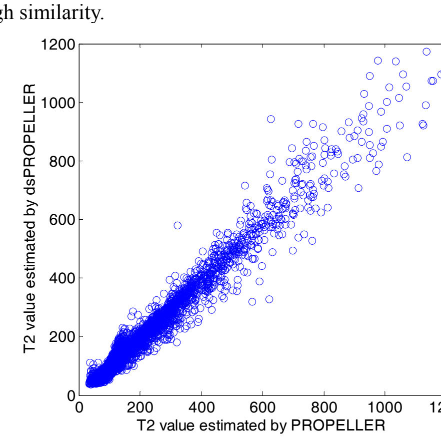

Fig.4 T2 values from dsPROPELLER plotted versus those from PROPELLER reconstruction shows good consistency with R = 0.99.