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Meeting abstract

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2134 Validation of the spiral Fourier velocity encoding method

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Introduction

Phase-contrast (PC) is the current "gold standard" for MR flow quantitation, despite suffering from partial volume effects. Fourier velocity encoding (FVE) resolves the distribution of velocities within each voxel, allowing larger voxels to be used. In 1995, Frayne et al. [1] proposed 2DFT FVE as a method for non-invasively measuring fluid shear rate and hence vascular wall shear stress, an important factor implicated in atherogenesis. Although the scan-time of this method was prohibitively long, the recently introduced spiral FVE method [2] shows promise as it is substantially faster. In this work, we provide an initial validation of spiral FVE in a carotid artery flow phantom, using high-resolution PC as the gold standard.

Theory

The spiral FVE method acquires a stack-of-spirals in k_x, k_y, k_v space [2], where k_v is the Fourier variable associated with the velocity distribution. Truncation in k-space follows a cylindrical shape, i.e. circular along k_x, k_y (with diameter $1/xy_{res}$), and rectangular along k_v (with width $1/v_{res}$). The associated object-domain blurring can be modeled as convolution of $m(x, y, v)$ with $jinc(sqrt(x^2+y^2)/xy_{res})$ and $sinc(v/v_{res})$.

Methods

Experiments were performed on a GE Signa Excite HD 3 T scanner with a pulsatile carotid flow phantom (Phantoms by Design, Inc.). A slice perpendicular to the carotid bifurcation was prescribed, and through-plane velocities were measured. A gradient-echo 2DFT phase-contrast sequence (0.33 mm resolution, 10 NEX) was used as a gold standard reference. Spiral FVE data with 3 mm resolution was obtained from the same scan plane. Both PC and FVE acquisitions were prospectively gated. The total scan time was 22 minutes for PC, and 24 seconds for FVE.

A simulated FVE dataset was derived from PC using the convolution model described above. For each temporal phase, the images $m(x, y)$ and $pc(x, y)$ (magnitude and phase difference, respectively) were used as follows:

$$fve(x, y, v) = [m(x, y).sinc\ (v-pc(x, y))/v_{res}] * jinc(sqrt(x^2+y^2)/xy_{res})$$

Spatial registration between PC-derived and measured FVE data was performed by visual inspection.

Results

For reference, magnitude and phase-difference images obtained from the first temporal phase of the phase-contrast data are shown in Figure 1. Simulated and measured time-velocity FVE distributions from representative voxels (circles in Figure 1) are shown in Figure 2.

Despite differences in temporal resolution, SNR, TR, flip angle and slice profile, good agreement was observed between simulated and measured FVE distributions. These results suggest that spiral FVE is capable of providing velocity histograms equivalent to those obtained with high-resolution 2DFT phase-contrast, in considerably shorter scan time.

Discussion

Spiral FVE is a time-efficient flow measurement method that provides spatially and temporally resolved velocity

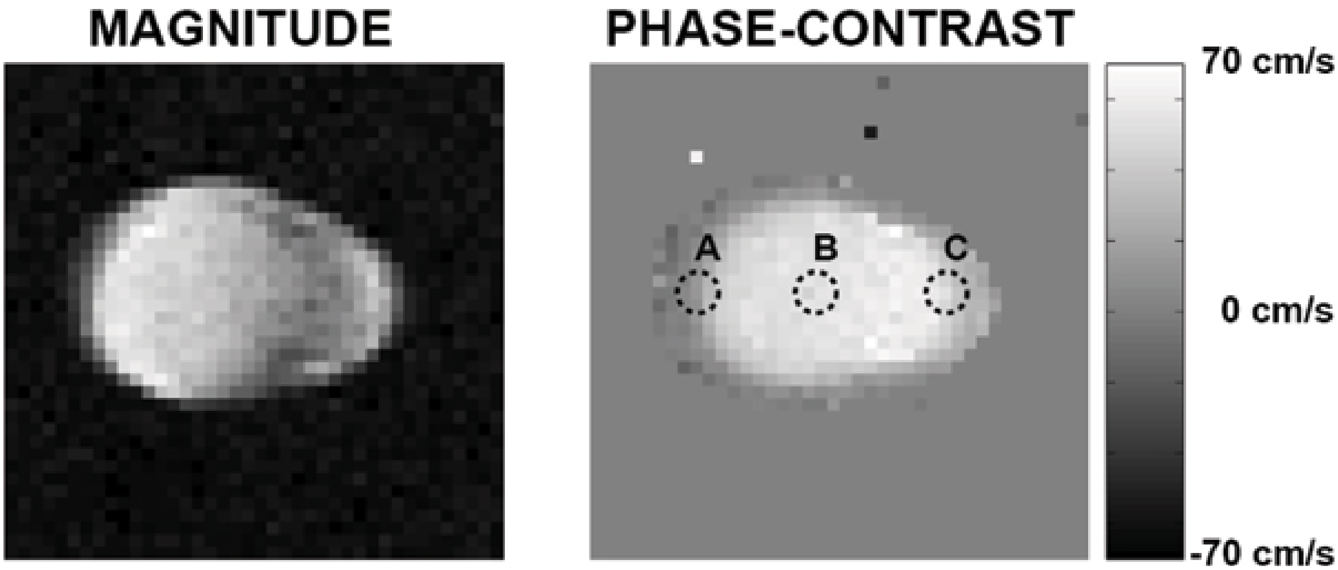

Figure 1
Magnitude and phase-difference images obtained from the first temporal phase of the PC data.

distributions in short acquisitions. It has been shown to work well *in vivo* [2], and has great potential for acceleration [3]. Velocity histograms obtained with spiral FVE showed good visual agreement with those obtained using high-resolution PC, even though acquired in a scan time 50 times shorter. We plan to repeat this study using identical TR, flip angle, and slice profile to quantify the level of agreement, and explore the use of spiral FVE for non-invasive measurement of wall shear rate with reasonable scan-times.

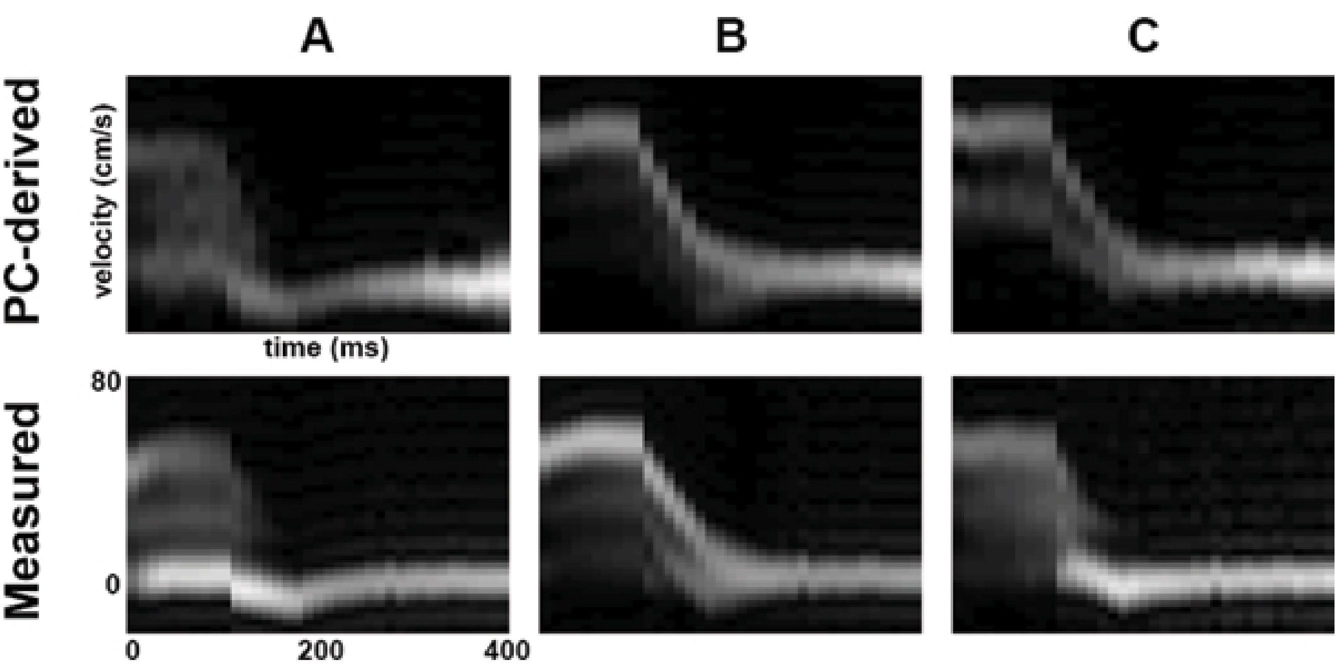

Figure 2
PC-derived (top row) and spiral FVE (bottom row) time-velocity distributions from voxels at the indicated positions in Fig. 1.

References

1. Frayne R, *et al.*: *MRM* 1995, **34:**378.
2. Carvalho JLA, *et al.*: *MRM* 2007, **57:**639.
3. Carvalho JLA, *et al.*: *Proc ISMRM* 2007, **15:**588.