Supporting Background Information S1:

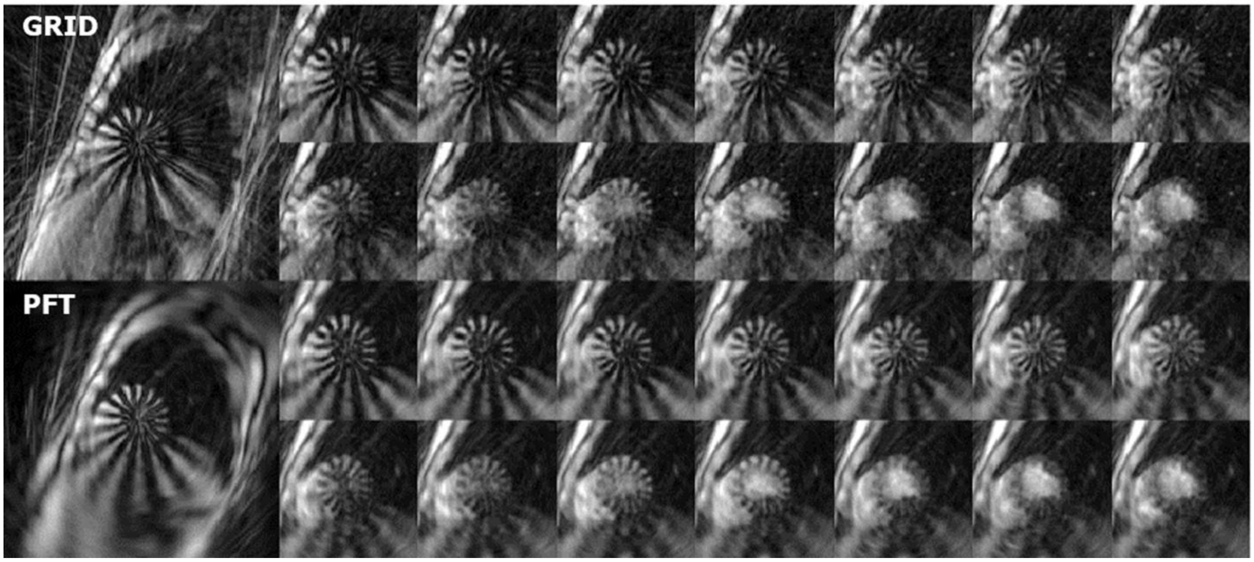
Reduced circular FOV defined by angular undersampling

As mentioned in (1,2), with an angular undersampled polar acquisition, alias-free reconstruction is only possible within a reduced FOV (rFOV), which can be determined by the inverse of the arc length of $\Delta k_{\theta max}$ (the maximum distance between azimuthal samples) as following:

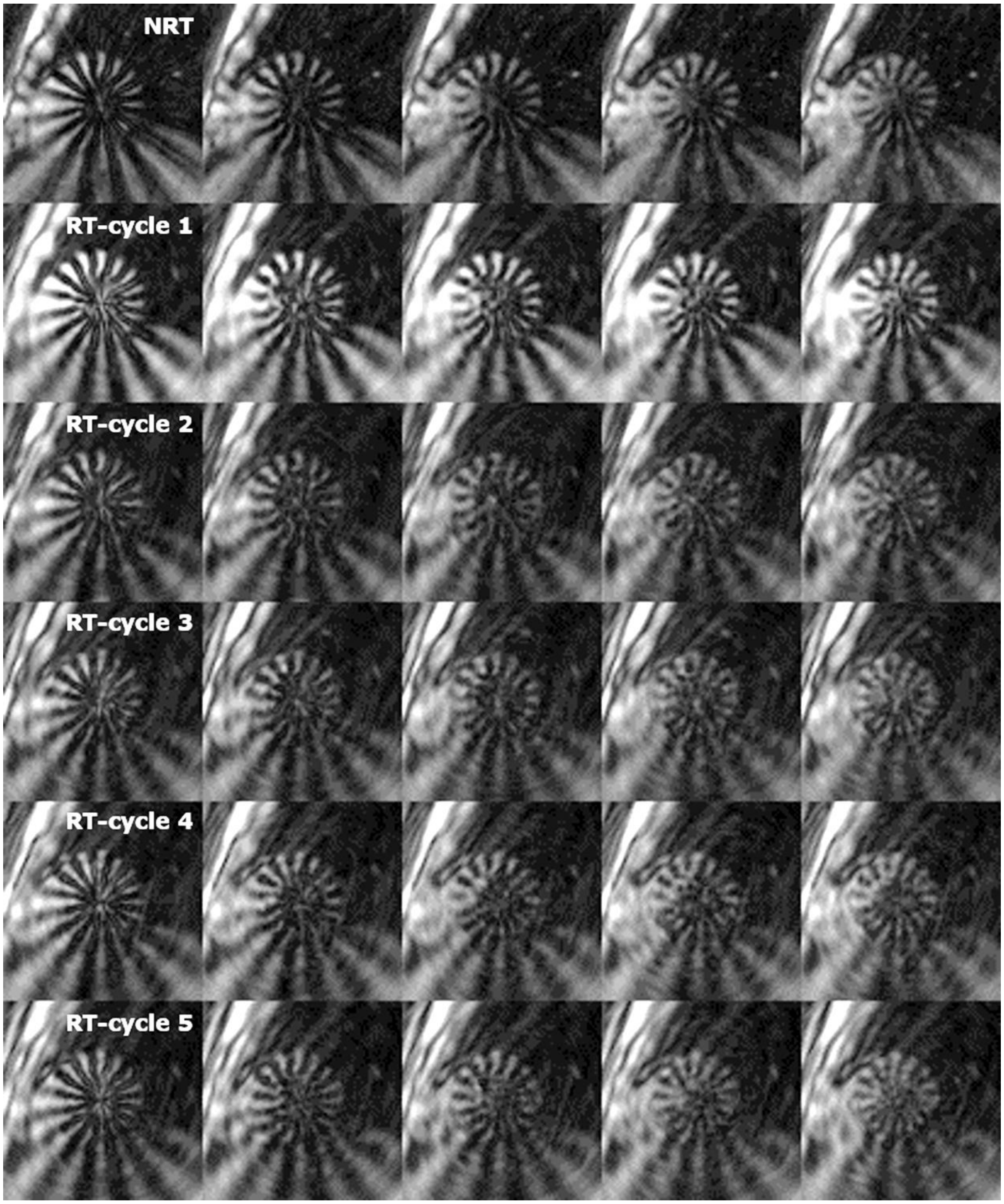
$$rFOV = \frac{1}{\Delta k_{\theta max}} = \left[\left(\frac{\pi}{N_s}\right) \cdot \left(\frac{\Delta k_r N_r}{2}\right)\right]^{-1} = \frac{2N_s}{\pi \Delta k_r N_r} = FOV \times \frac{2N_s}{\pi N_r} \quad (1)$$

In addition, when the Polar Fourier Transform (PFT) is used, the regions located outside the rFOV are affected by more blurring rather than streaking artifacts (3). For our study, undersampled radial acquisition results in an rFOV of 21 mm. However, this rFOV does not encompass the entire LV in short-axis view; an increasing blurring appears, as we get further away from the LV center.

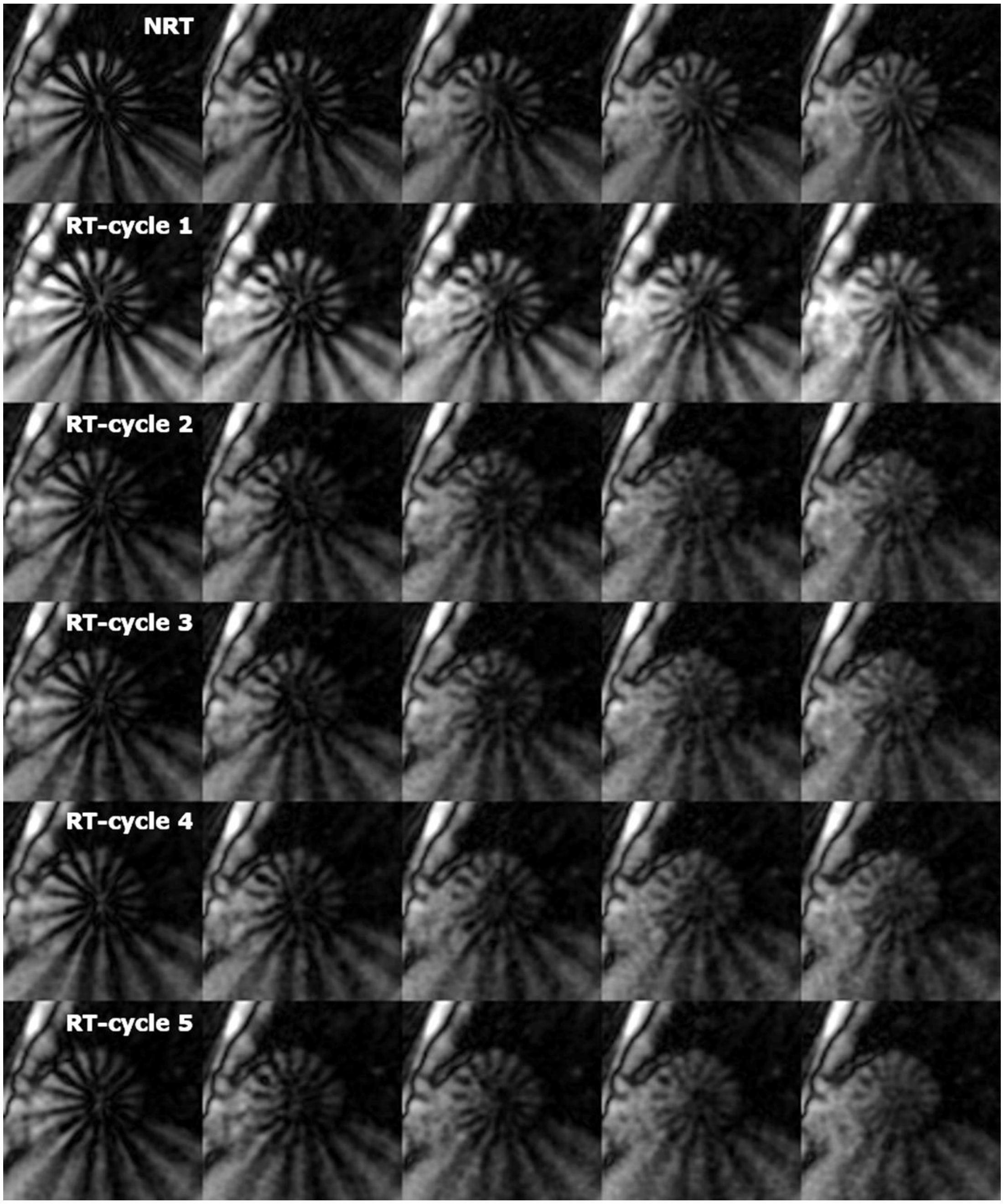
1. Scheffler K, Hennig J. Reduced circular field-of-view imaging. *Magn Reson Med*. 1998;40(3):474-480. doi:10.1002/mrm.1910400319
2. Peters DC, Korosec FR, Grist TM, et al. Undersampled projection reconstruction applied to MR angiography. *Magn Reson Med*. 2000;43(1):91-101.
3. Golshani S, Nasiraei-Moghaddam A. Efficient radial tagging CMR exam: A coherent k-space reading and image reconstruction approach. *Magn Reson Med*. 2017;77(4):1459-1472. doi:10.1002/mrm.26219



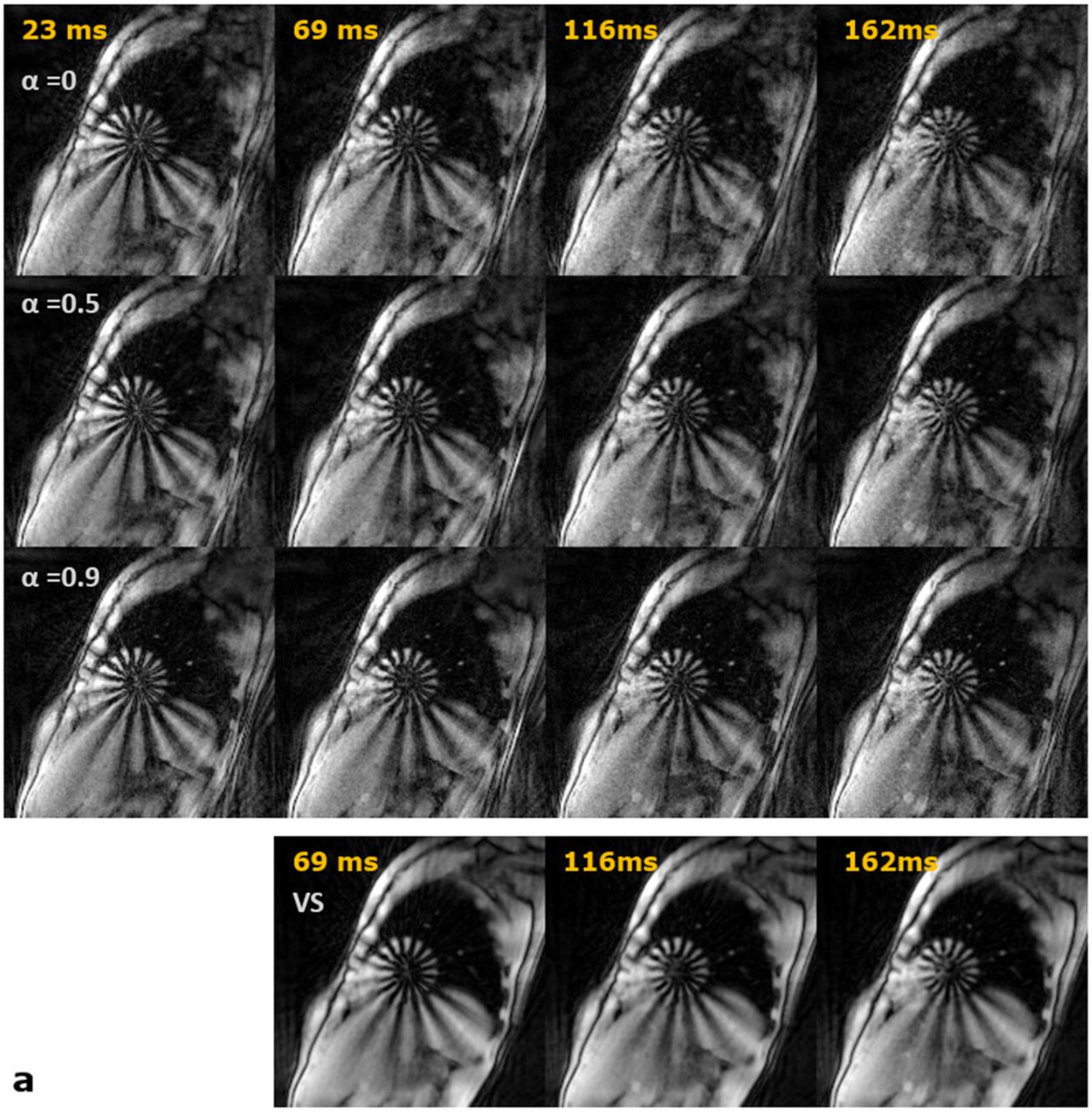
Supporting Information Figure S1. Complete set of RT images for single heartbeat composed of 15 cardiac phases (left to right, top to bottom, covering 23 to 700 ms) reconstructed by re-gridding (GRID) and PFT methods at the mid-LV short-axis level of a healthy volunteer.



Supporting Information Figure S2. The representative short-axis mid-LV images acquired by turned-cycle trajectory with 5-turn arrangement and reconstructed by PFT as an NRT and RT (all cardiac cycles), top to bottom. The images in each raw represent five consecutive frames from one cardiac cycle.

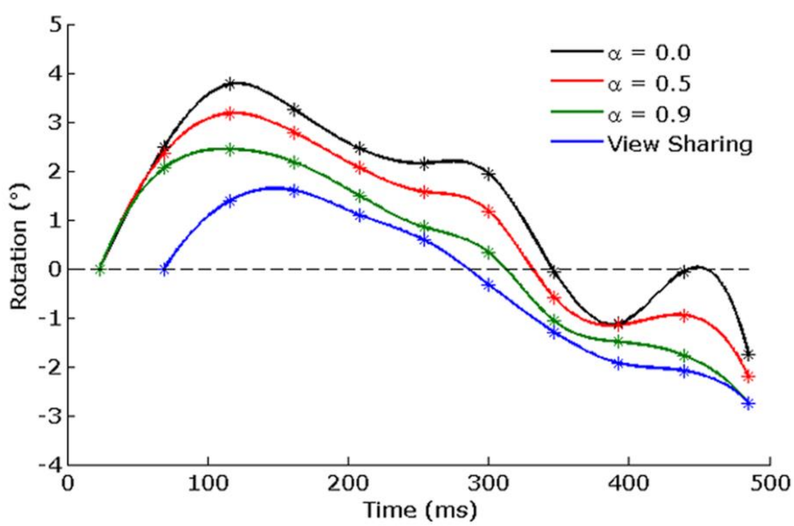


Supporting Information Figure S3. The representative short-axis mid LV images acquired by turned-cycle trajectory with 5-turn arrangement and reconstructed by NLINV as an NRT and RT (all cardiac cycles), top to bottom. The images in each raw represent five consecutive frames from one cardiac cycle.



23 ms
69 ms
116ms
162ms
α =0
α =0.5
α =0.9
69 ms
116ms
162ms
VS

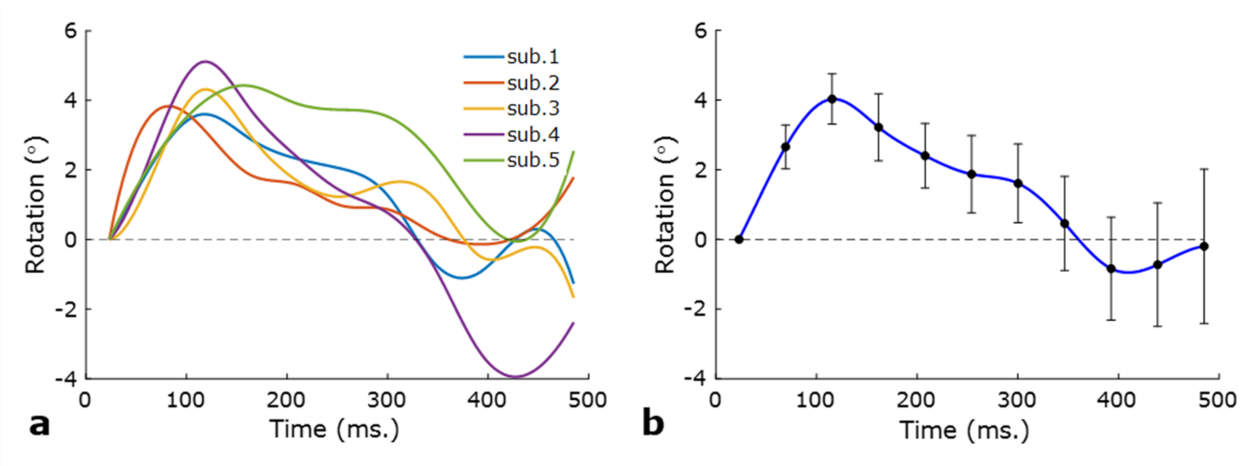
a



α = 0.0
α = 0.5
α = 0.9
View Sharing
Rotation (°)
Time (ms)
5
4
3
2
1
0
-1
-2
-3
-4
0
100
200
300
400
500

b

Supporting Information Figure S4. (a) Tagged LV short-axis images of a healthy volunteer (covering 23 to 162 ms) at the mid-level. The data was acquired using RT MRI with three-turn arrangement acquisition for consecutive frames and reconstructed by NLINV method with $\alpha = 0, 0.5, 0.9$, and also view sharing of three consecutive frames (top to bottom). **(b)** The measured rotational results obtained by different image sets of part **(a)**. As it can be seen, using NLINV reconstruction with a temporal regularization term results in the smoothed rotational motion, or the leakage of the rotational information to following phases, similar to what happens in view sharing of following frames.



Supporting Information Figure S5. (a) The measured global rotation at mid-level of LV for five volunteers. **(b)** The mean (mean ± SD) of mid-LV global rotation averaged over all healthy volunteers. The mean values nicely match with other studies, but with a substantial SD, that reflects the rotation changes from person to person and also its sensitivity to the LV level.