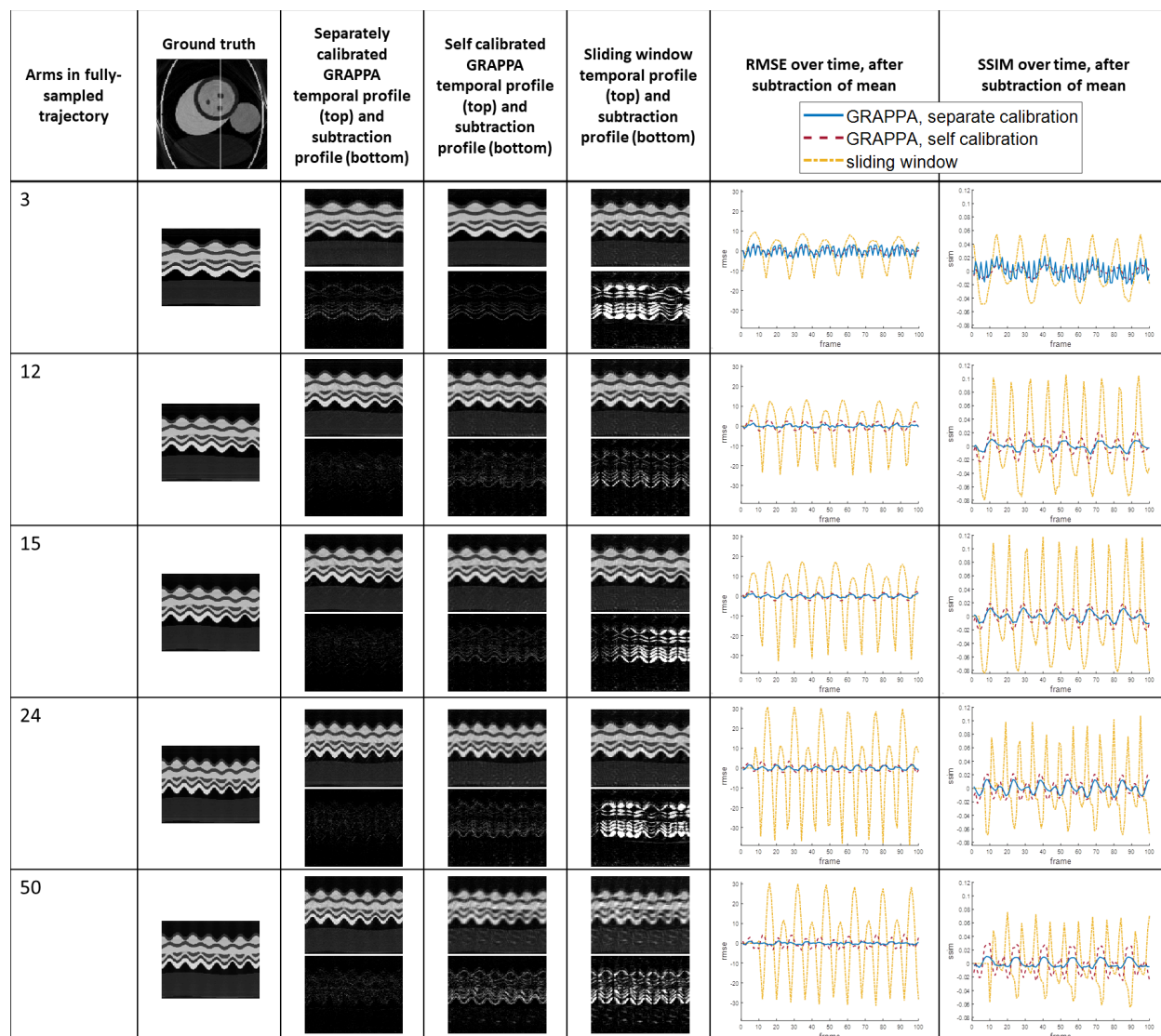
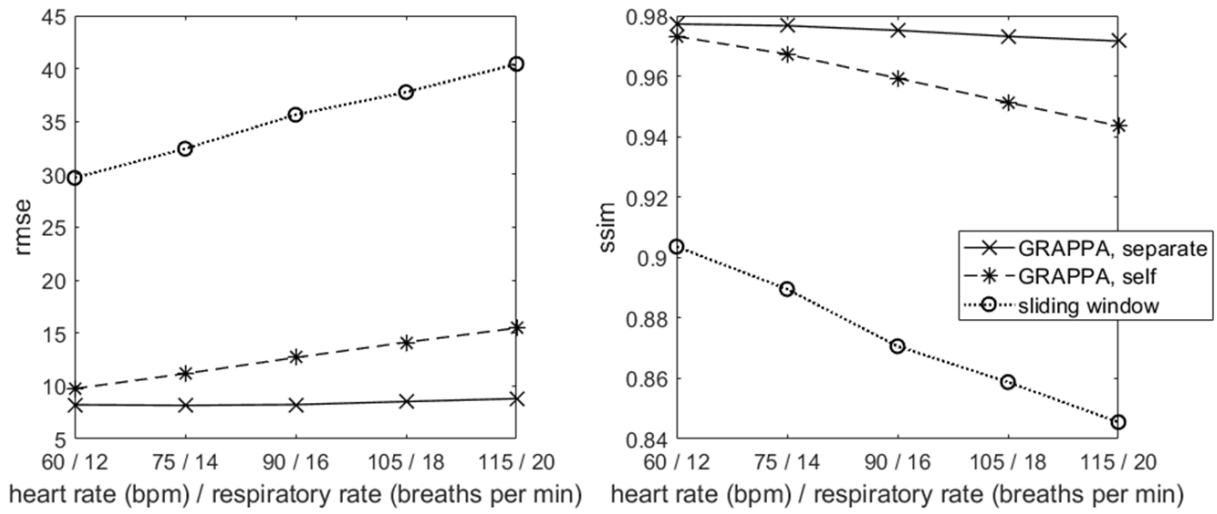


Arms in fully-sampled trajectory	Repetition time (ms)	Acceleration factor	Temporal resolution of accelerated frame (ms/frame)	GRAPPA kernel duration, separately calibrated (ms)	GRAPPA kernel duration, self calibrated (ms)
3	24.58	3	24.58	49.16	49.16
12	8.18	3	32.72	24.54	40.9
15	7.10	3	35.5	21.3	42.6
24	5.46	3	43.68	16.38	49.14
50	4.17	5	41.7	20.85	87.57

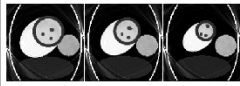
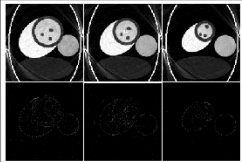
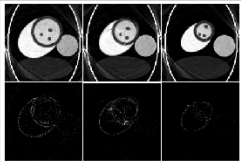
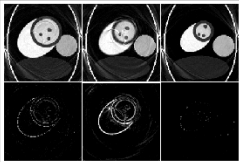
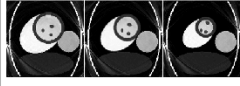
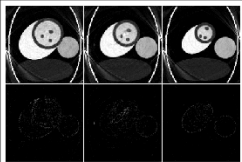
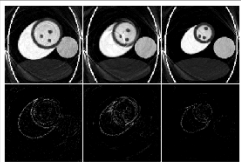
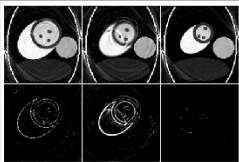
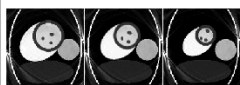
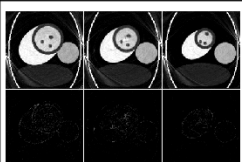
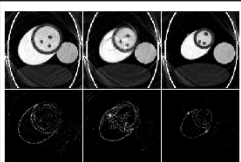
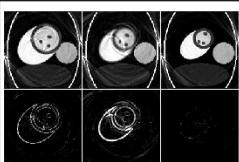
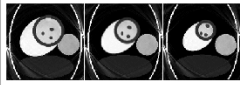
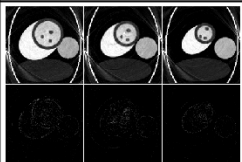
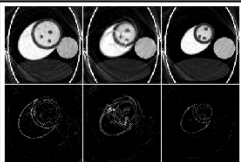
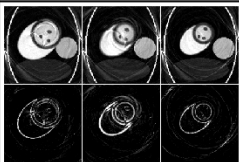
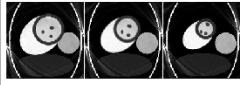
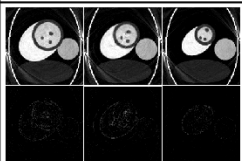
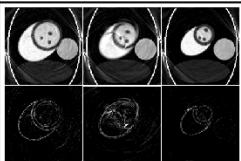
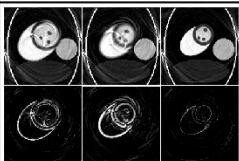
**Supporting Information Table S1:** Characteristics of sample trajectories tested in digital phantom simulations.



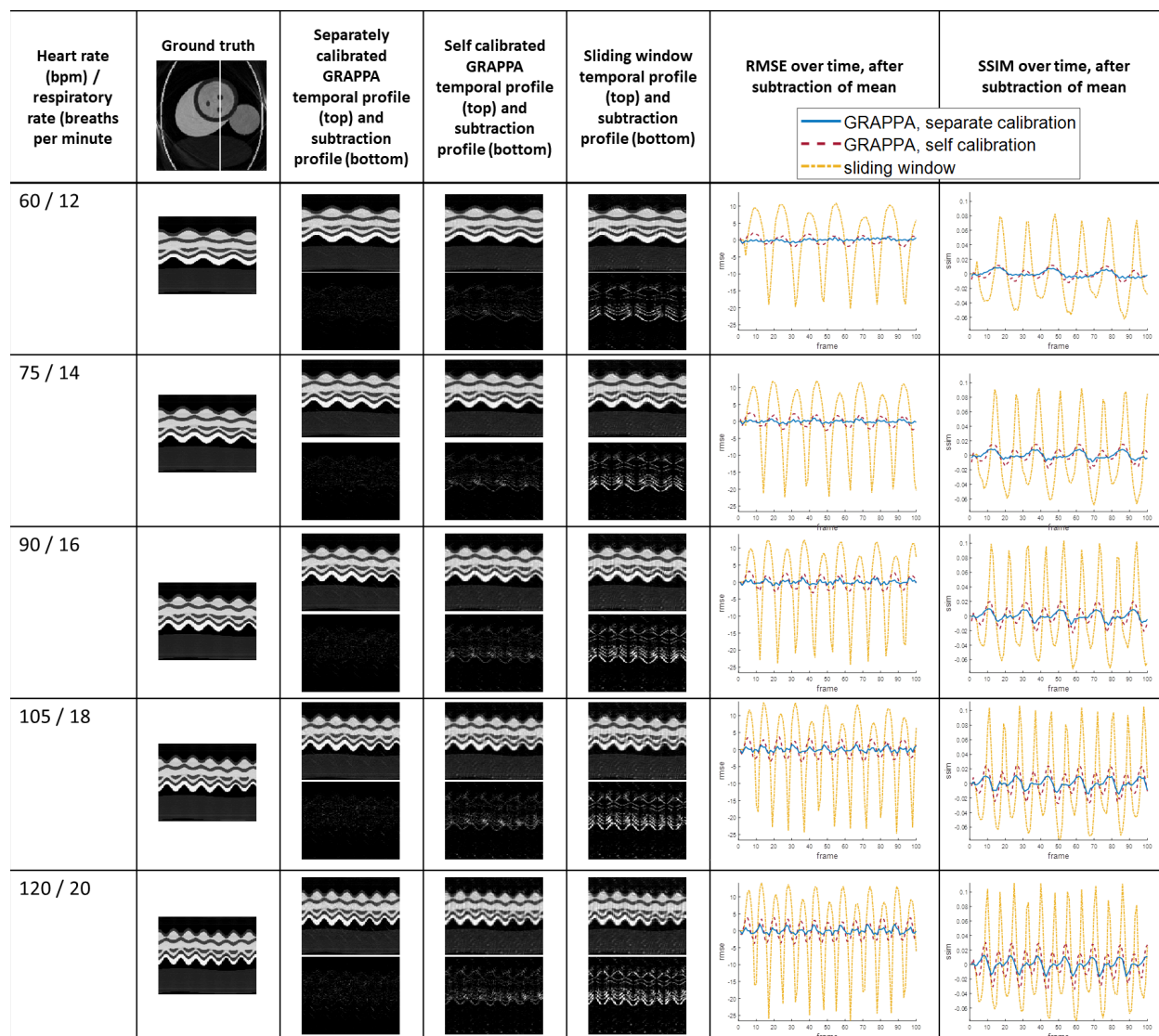
**Supporting Information Figure S1:** Temporal profiles over 100 accelerated images corresponding to the trajectories in Figure 3. The line profiles track the position shown in the simulated heart. Subtraction images are scaled by x2. The right two columns plot RMSE and SSIM by frame for each of the reconstructions. For both values, the mean value over all time frames is subtracted from each time frame such that the three reconstructions can be viewed on the same y-axis.



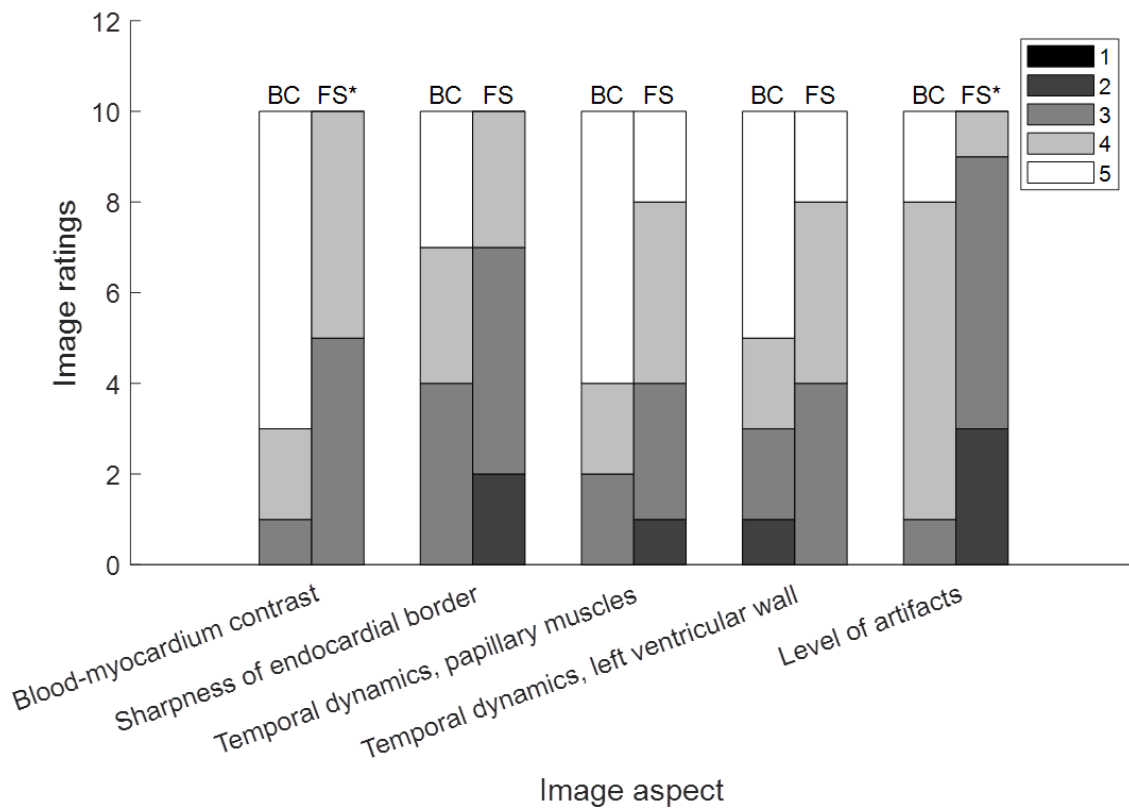
**Supporting Information Figure S2:** Effect of cardiac and respiratory motion on the two through-time spiral GRAPPA implementations and a sliding window reconstruction. Digital phantom simulations were performed using the 12-arm trajectory used for in vivo scanning.

Heart rate (bpm) / respiratory rate (breaths per minute)	Ground truth	Separately calibrated GRAPPA images and subtraction images	Self calibrated GRAPPA images and subtraction images	Sliding window images and subtraction images
60 / 12				
75 / 14				
90 / 16				
105 / 18				
120 / 20				

**Supporting Information Figure S3:** Sample digital phantom images in diastole, mid-cycle, and systole corresponding to different motion conditions. Images from the two spiral GRAPPA implementations and the sliding window reconstruction are given, along with subtraction images compared to the ground truth (x2 scale).



**Supporting Information Figure S4:** Temporal profiles over 100 accelerated images corresponding to different motion conditions. Subtraction images are scaled by x2. The right two columns plot RMSE and SSIM by frame for each of the reconstructions. For both values, the mean value over all time frames is subtracted from each value such that the three reconstructions can be viewed on the same y-axis.



**Supporting Information Figure S5:** Comparison of Likert scale ratings of different image quality aspects for the gold-standard, ECG-gated and breathheld Cartesian scan (BC) and the proposed real-time, free-breathing spiral scan (FS). Asterisk indicates statistical significance to the  $p < 0.05$  level in a Wilcoxon signed rank test between the gold standard and proposed methods.