Clinical evaluation of accelerated cardiac cine imaging using iterative k-t-sparse SENSE

Bradley D Allen[1*], Maria Carr[1], Michael O Zenge[2], Michaela Schmidt[2], Mariappan S Nadar[3], Bruce S Spottiswoode[4], Jeremy D Collins[1], James C Carr[1]

Background
We sought to quantitatively and qualitatively evaluate a clinical implementation of accelerated MR acquisitions using iterative segmented k-t-sparse Cartesian SENSE balanced steady-state free-precession (SSFP) cinegraphic imaging.

Methods
IRB approval was obtained. Twenty patients (age: 54.8 ± 14 years, M:F = 15:5) undergoing non-emergent CMR assessment for myocardial pathology were consecutively recruited. Nine healthy volunteers (age: 44.3 ± 14 years, M:F = 6:3) were also imaged. CMR was performed at 1.5T (MAGNETOM Aera, Siemens Healthcare, Erlangen, Germany). The examination included acquisition of standard segmented SSFP (iPAT2) (GRAPPA accel factor 2, TR 40 msec, $2.1 \times 2.1 \times 10$ mm^3) cine and two accelerated segmented SSFP acquisitions (TPAT accel factor 4, TR 37.7 msec, $2.1 \times 2.1 \times 6$ mm^3), one with an investigational prototype inline iterative k-t-sparse SENSE reconstruction with L1 regularization along one spatial and temporal dimension (TPAT4$_i$) (1)and the other with conventional SENSE reconstruction (TPAT4). Each technique was used to acquire a three-(3Ch), four-chamber (4Ch), and short axis (SA) series in identical slice positions (Figure 1), with SA coverage of the entire left ventricle (LV) with 10 mm interslice gaps. Individual slice scan times were recorded. Quantitative LV functional analysis was performed. A reviewer blinded to acquisition type scored images for overall image quality, noise, and artifacts using a 5-point Likert scale. Continuous variables were compared between groups using a paired t-test, and ordinal variables were compared using a Wilcoxon signed-rank test.

Results
In a combined analysis of patients and volunteers, there was no significant difference between LV ejection fraction between iPAT2 and TPAT4$_i$ (p = 0.48) or TPAT4 (p = 0.34). The iPAT2 technique found marginally lower end-diastolic volume (159 ± 54 ml vs. 169 ± 54 ml, p = 0.01), end-systolic volume (75 ± 33 ml vs. 80 ± 31 ml, p = 0.04), stroke volume (80 ± 35 ml vs. 89 ± 31 ml, p = 0.03) compared to TPAT4$_i$. Single-slice scan times in both TPAT4$_i$(3.29 ± 0.6 sec) and TPAT4 (3.0 ± 0.6 sec) acquisitions were significantly shorter relative to iPAT2 (8.4 ± 1.7 sec, p < 0.001 for both). Qualitative review showed significantly higher image quality and lower noise using both iPAT2 and TPAT4$_i$ acquisitions relative to TPAT4 (quality: p < 0.001, noise: p < 0.001). The iPAT2 acquisition was scored higher than TPAT4$_i$ in quality (4.8 ± 0.4 vs. 4.6 ± 0.6, p = 0.005), noise (4.9 ± 0.3 vs. 4.6 ± 0.6, p < 0.001), and artifact (4.8 ± 0.4 vs. 4.6 ± 0.6, p = 0.04), although the magnitude of difference is relatively small. (Figure 2)

Conclusions
Acceleration using iterative k-t-sparse SENSE techniques can be successfully applied in CMR to reduce scan times by > 50% while maintaining diagnostic image quality and quantitative accuracy in LV systolic function assessment.

[1]Radiology, Northwestern University, Chicago, Illinois, USA
Full list of author information is available at the end of the article
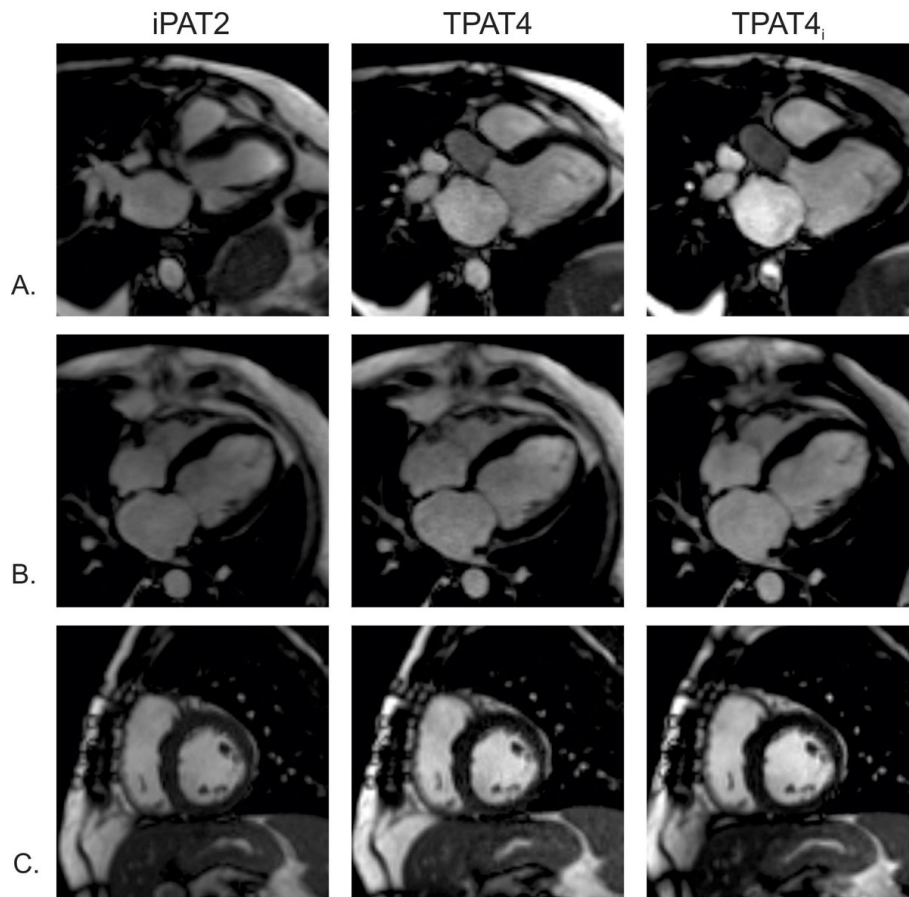
Figure 1 Example A) three-chamber, B) four-chamber, and C) mid-chamber short axis images in a patient undergoing CMR for aortic valve assessment using each acquisition technique.
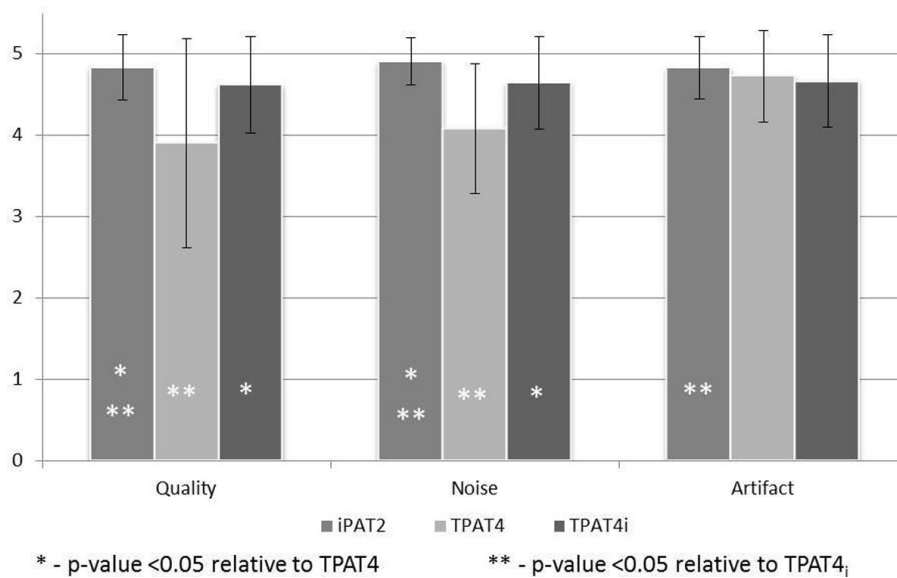

* - p-value <0.05 relative to TPAT4   ** - p-value <0.05 relative to TPAT4$_i$

Figure 2 Qualitative scoring in the combined cohort of patients and volunteers.

Authors' details
[1]Radiology, Northwestern University, Chicago, Illinois, USA. [2]Siemens AG Healthcare Sector, Erlangen, Germany. [3]Siemens Corporate Technology, Princeton, New Jersey, USA. [4]Siemens Healthcare USA, Inc., Chicago, Illinois, USA.

Reference
1. Liu J, *et al*: *ISMRM 20th Annual Meeting* Melbourne, Australia; 2012, 4249.