Doubled Scan Efficiency in Multi-slice Real-time Cine TrueFISP Cardiac Imaging by Pseudo-Continuous Sliding Slice Acquisition

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Introduction: Real-time TrueFisp cardiac imaging allows multiple slice cine acquisitions within a single breathhold. Typically, the steady state preparation is established utilizing a full heartbeat per slice. Hence, only every other heartbeat is used to collect data. A simple elimination of the preparation heartbeats to increase scan efficiency compromises the contrast between blood and myocardium and signal dynamics for the first few cardiac phases. This work presents a novel method that shifts the slice position between consecutive phases by a distance small compared to slice thickness. High contrast is maintained throughout all cardiac phases providing whole heart coverage within a single breathhold. This approach was compared to to a clinically established real-time cine protocol with and without dummy heartbeats for steady state preparation

Material and Methods: A TrueFISP real-time cine sequence was implemented that covers the left ventricle (LV) using a pseudo-continuous shift of the slice position (slideRT) for each cardiac phase. The required shift per phase (pitch p) was calculated using the desired coverage in slice selection direction (Z), temporal resolution T and clinically acceptable breathhold TA duration resulting in $p = Z \times T / TA$. In order to guarantee a dense spatial sampling across the cardiac cycle, total shift of the slice within each cardiac cycle was less than the slice thickness. The slideRT technique was evaluated in an initial volunteer study (n=5) and compared to a well established multi slice real-time cine TrueFisp protocol using a full heartbeat per slice for steady state preparation (prepRT) or no steady state preparation (noprepRT), respectively providing the same scan efficiency as slideRT. Fig. 1 shows the scan strategy for slideRT, prepRT, and noprepRT acquisition. All scans were acquired with a 1.5T clinical scanner (MAGNETOM Avanto, Siemens Healthcare, Erlangen) and had identical scan parameters (acq time 70 ms, slice thickness 8 mm, iPAT x2, 72 phase encoding lines, echo spacing 1.9 ms, FoV 400 x 283 mm).

Results: The slideRT acquisition resulted in equivalent diagnostic image quality and yielded the same excellent blood-myocardium contrast in comparison to prepRT but at doubled scan efficiency. NoprepRT method showed the expected artifacts (reduced contrast and transient artifacts) for typically the half of RR interval in every slice. Fig. 2 presents representative short axis images in different slice positions. Regions of artifatcs and reduced contrast in the noprepRT images are marked with arrows. Image quality of prepRT and slideRT acquisitions showed comparable image quality and contrast: Fig. 3 shows the relative blood-myocardium contrast $2(SI(blood)-SI(myo))/ (SI(blood)-SI(myo))$. There is a significant contrast drop during the first half of the noprepRT acquisition for every slice position.

Discussion: The sliding slide technique presents a novel approach to cover the heart in a single breathhold scan with highest scan efficiency. Recent advances in scan acceleration enable significant acceleration of real-time cine. However, the acceleration of 2D multi slice methods is limited by the requirement of steady state preparation per slice and 3D acquisitions put additional boundary conditions on imaging parameters and the blood-myocardium contrast is reduced due to saturation. This limitation is overcome with the sliding slice method. slideRT enables visual evaluation of the data in a continuous cine loop rather than toggling across different slice positions. SlideRT poses new requirements on the evaluation for function analysis due to the continuous change of slice position with every cardiac phase. However, a model-based analysis should even profit from the more continuous spatial coverage.

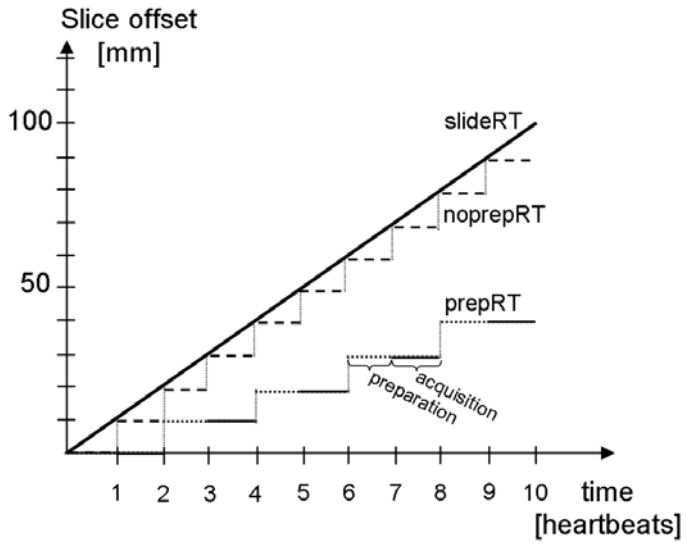

***Figure 1**: Slice position as a function of heartbeat. The sliding slice method (SlideRT) covers a substantially larger slab than an established multi slice protocol with fixed slice positions (prepRT) in the same breathhold duration. The noprepRT shows the same scan efficiency as the slideRT, but at the expense of image quality and contrast.*

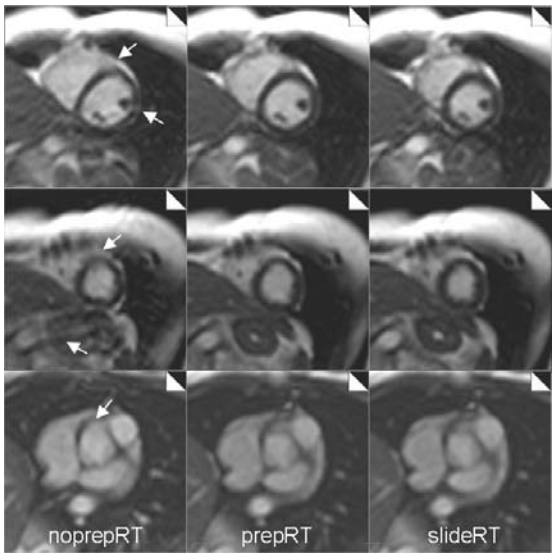

***Figure2**: Short axis images at different positions: Left column: conventional sampling with no steady state preparation, center column: conventional sampling including preparation heartbeat; right column: sliding slice acquisition.*

***Figure3** Relative contrast between septum and blood pool of the left ventricle as a function of cardiac phase for a mid-ventricular short axis slice. Sliding slice (slideRT) and conventional (prepRT) data acquisition method show similar contrast. Images acquired with fixed position without steady state preparation (noprepRT) show significant contrast drop of initially 50% in the first cardiac phase.*