Simultaneous Multi-Slice (SMS) cardiac T1 mapping at 3T using FLASH-MOLLI

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Final Version

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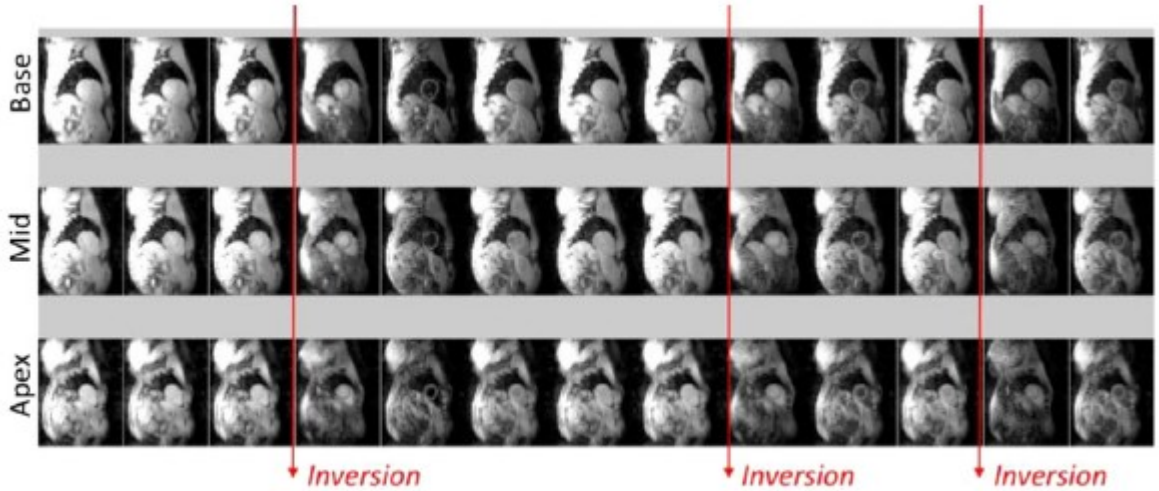
Purpose/Introduction:

Cardiac T1 mapping is increasingly demon- strating clinical value for the diagnosis and follow-up of cardiac diseases (MoonJCMR13), either from native T1 mapping, or from extra-cellular volume (ECV) fraction mapping using an exogeneous contrast injection. Nevertheless, T1 mapping is typically performed over a single slice throughout a *10–15 s breath-hold, which limits the coverage of the entire left ventricule. However, the advent of high density coil arrays allows for the acceleration of acquisition using parallel imaging techniques, notably thanks to novel techniques such as simultaneously multi-slices (SMS) (BarthMRM2016). We propose here to integrate SMS acceleration into the Modified Inversion recovery Look-Locker (MOLLI) T1 mapping sequence (Messrogh- liMRM2004) with a fast low angle shot (FLASH) readout and the Bloch-equations based T1 mapping algorithm (BLESSPC, ShaoMRM2016).



SMS3-FLASH-MOLLI acquisition optimized to [3]5(0)3(0)2 for BLESSPC algorithm using Monte Carlo simulations. The accelerated acquisition allows to cover the 3 levels of the heart.

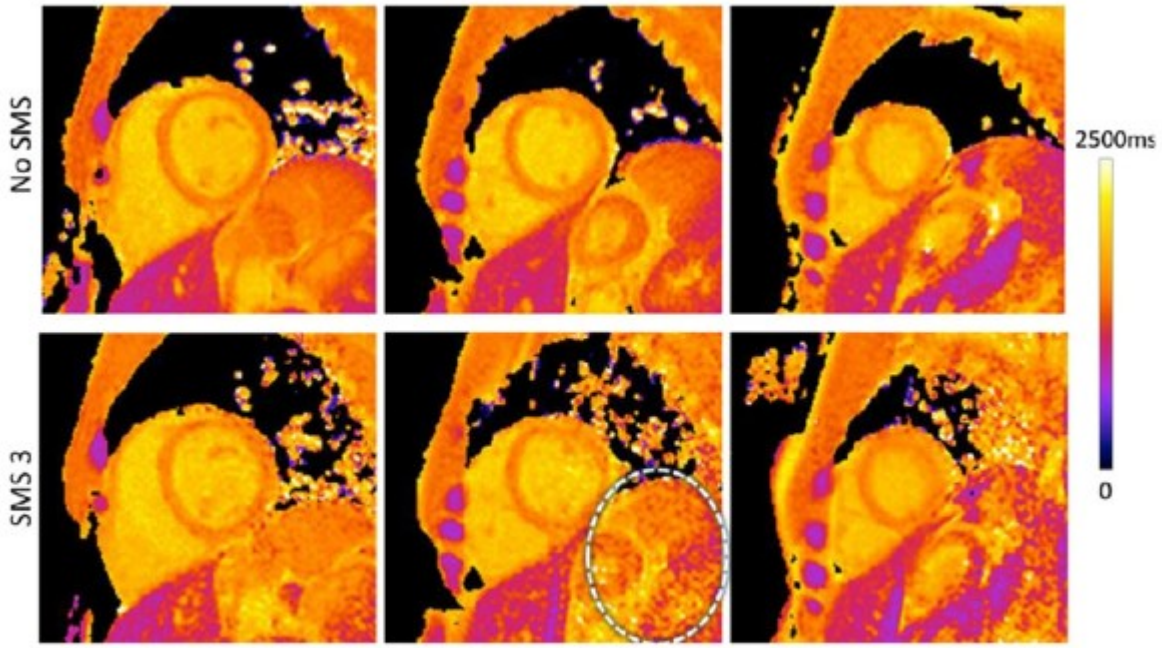
Subjects and Methods:

All acquisitions were performed on a 3T MRI scanner (Siemens Verio) equipped with a 32Rx dedicated car- diac coil. A calibrated relaxometry phantom was imaged to validate T1 quantification and evaluate noise amplification. 4 volunteers have been enrolled so far after written consent was obtained. Imaging protocol included the standard MOLLI sequence (5(3)3 scheme with bSSFP readout (Kellman JCMR2014)) and the FLASH-MOLLI sequence with and without SMS acceleration (SMS3). Acquisition 3parameters were: 160 9 130

matrix, 2 9 2 9 6 mm resolution, 400 Hz/px, 20# excitation, GRAPPA2. For FLASH-MOLLI, refer- ence lines (N = 32) were acquired separately, without SMS acceleration, and MOLLI scheme was optimized (Fig. 1) using Monte-Carlo simulation to be [3]5(0)3(0)2 where the first 3 heartbeats are acquired prior to the first inversion. A variable flip angle FLASH readout was defined to compensate signal decay and improve reso- lution (ZhaoMRM1996). Image reconstruction (with split-slice- GRAPPA) was implemented online using Gadgetron(HansenMRM2013) and BLESSPC was implemented offline using Matlab.

Results:

The point spread function width was reduced by 45% using variable flip angle FLASH. The phantom T1 values correlated well 2with calibration (R = 0.98) and standard MOLLI. T1 standard deviations were increased by 2.4 ± 1.3x between single band and SMS3-FLASH-MOLLI. Excellent slice separation was observed in vivo with no visible slice leakage (Fig. 2). SNR in the myocardium was 16.0 with SMS3 and 17.1 without SMS. FLASH-MOLLI T1 values in the myocardium (1296 ± 101 ms) were slightly higher than the values obtained by standard MOLLI-bSSFP (1121 ± 60 ms) known to underestimate long T1.



T1 maps from FLASH-MOLLI without (top) and with (bottom) Simultaneous Multi-Slices (SMS-3x) acceleration. Noise amplification can be observed (white round) but remains tolerable.

Discussion/Conclusion:

The implementation of SMS MOLLI allows for an exploration of 3 slices simultaneously (e.g. base, mid and apex) within a single 13 heartbeats breath-hold. The noise amplification due to the acceleration remains tolerable using SMS-FLASH-MOLLI. In vivo recruitment in ongoing and clinical applications are war- rented. The simultaneous B1 + measurement is an interesting bonus.

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