



**HAL**  
open science

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

Stanislas Rapacchi, Thomas Troalen, Zakaria Bentatou, Maxime Guye, Monique Bernard, Alexis Jacquier, Frank Kober

► **To cite this version:**

Stanislas Rapacchi, Thomas Troalen, Zakaria Bentatou, Maxime Guye, Monique Bernard, et al.. Simultaneous Multi-Slice (SMS) cardiac T1 mapping at 3T using FLASH-MOLLI. ESMRMB: 34th Annual Scientific Meeting, Oct 2017, Barcelona, Spain. pp.302, 10.1007/s10334-017-0633-0 . hal-01784726

**HAL Id: hal-01784726**

**<https://amu.hal.science/hal-01784726>**

Submitted on 16 May 2018

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

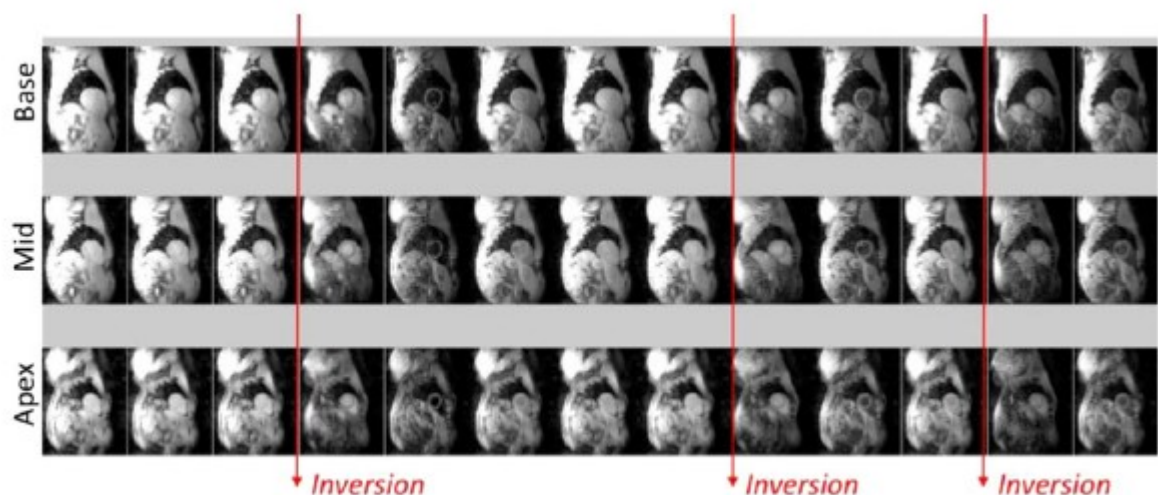
## **Simultaneous Multi-Slice (SMS) cardiac T1 mapping at 3T using SMS-FLASH-MOLLI**

S. Rapacchi<sup>1</sup>, T. Troalen<sup>2</sup>, Z. Bentatou<sup>1</sup>, M. Guye<sup>1</sup>, M. Bernard<sup>1</sup>, A. Jacquier<sup>1</sup>, F. Kober<sup>1</sup>

1-CRMBM/CEMEREM UMR 7339, Aix Marseille University CNRS, Marseille/France, 2-S A S, Siemens Healthcare, Saint Denis/ France

### **Purpose/Introduction:**

Cardiac T1 mapping is increasingly demonstrating 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 exogenous 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 ventricle. 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.

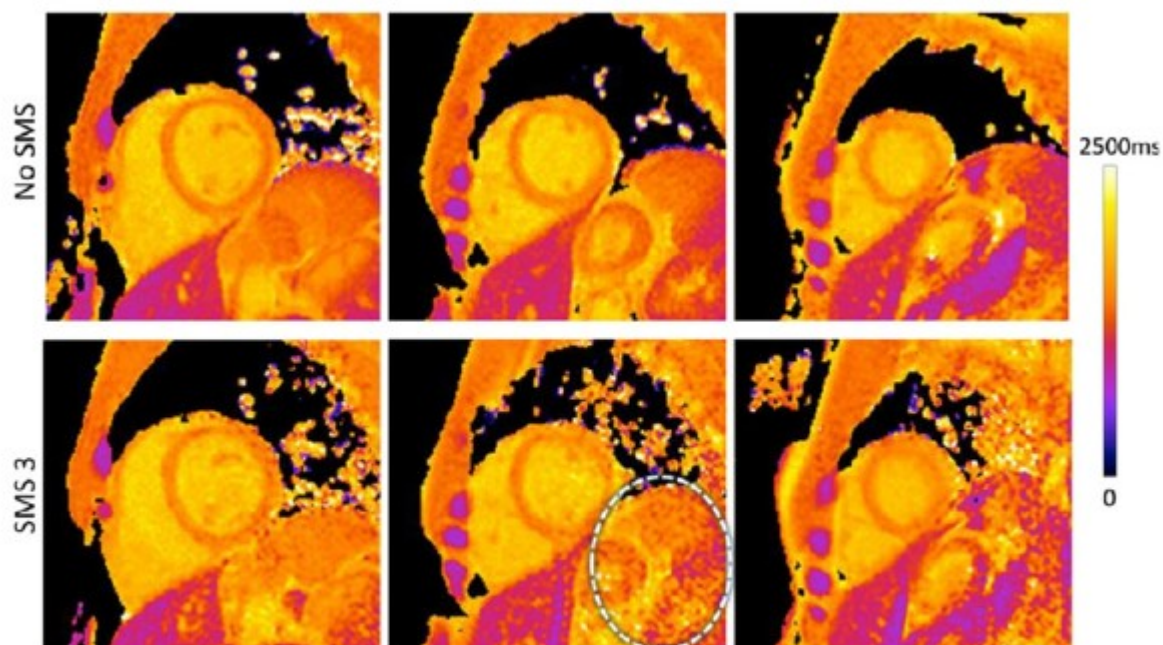
### **Subjects and Methods:**

All acquisitions were performed on a 3T MRI scanner (Siemens Verio) equipped with a 32Rx dedicated cardiac 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, reference 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 resolution (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 with calibration ( $R = 0.98$ ) and standard MOLLI. T1 standard deviations were increased by  $2.4 \pm 1.3x$  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 ( $1296 \pm 101$  ms) were slightly higher than the values obtained by standard MOLLI-bSSFP ( $1121 \pm 60$  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 warranted. The simultaneous B1 + measurement is an interesting bonus.

### References:

Barth, M., Breuer, F., Koopmans, P.J., Norris, D.G., and Poser, B.A. (2016).

Simultaneous multislice (SMS) imaging techniques. *Magn. Reson. Med.* 75, 63–81.

Hansen, M.S., and Sørensen, T.S. (2013). Gadgetron: an open source framework for medical image reconstruction. *Magn. Reson. Med.* 69, 1768–1776.

Kellman, P., and Hansen, M.S. (2014). T1-mapping in the heart: accuracy and precision. *J. Cardiovasc. Magn. Reson. Off. J. Soc. Cardiovasc. Magn. Reson.* 16, 2.

Messroghli, D.R., Radjenovic, A., Kozerke, S., Higgins, D.M., Sivananthan, M.U., and Ridgway, J.P. (2004). Modified Look-Locker inversion recovery (MOLLI) for high-resolution T1 mapping of the heart. *Magn. Reson. Med.* 52, 141–146.

Moon, J.C., Messroghli, D.R., Kellman, P., Piechnik, S.K., Robson, M.D., Ugander, M., Gatehouse, P.D., Arai, A.E., Friedrich, M.G., Neubauer, S., et al. (2013). Myocardial T1 mapping and extracellular volume quantification: a Society for Cardiovascular Magnetic Resonance (SCMR) and CMR Working Group of the European Society of Cardiology consensus statement. *J. Cardiovasc. Magn. Reson. Off. J. Soc. Cardiovasc. Magn. Reson.* 15, 92.

Shao, J., Rapacchi, S., Nguyen, K.-L., and Hu, P. (2016). Myocardial T1 mapping at 3.0 T using an inversion recovery spoiled gradient echo readout and bloch equation simulation with slice profile correction (BLESSPC) T1 estimation algorithm. *J. Magn. Reson. Imaging* 43, 414–425.

Zhao, L., Mulkern, R., Tseng, C.H., Williamson, D., Patz, S., Kraft, R., Walsworth, R.L., Jolesz, F.A., and Albert, M.S. (1996). Gradient-echo imaging considerations for hyperpolarized  $^{129}\text{Xe}$  MR. *J. Magn. Reson. B* 113, 179–183.