

## Distortion of MOLLI Estimates of Myocardial T1 from Fatty Infiltration

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**PURPOSE:** To characterize the response of the modified Look-Locker inversion recovery (MOLLI) T1 mapping technique to the presence of off resonant protons in fat. MOLLI has been shown to be useful in characterizing changes in the myocardium resulting from myocardial infarction<sup>3</sup>. A response to a myocardial infarction is fatty replacement of infarcted myocardium

**METHODS:** All patients were scanned after providing informed consent in this IRB-approved study. We developed a phantom consisting of vials containing 5 mL of saline doped with Gd-DTPA designed to alter the T1 relaxation time between approximately 2000 to 200 ms. On top of each sample we added 5 mL of peanut oil as a mimic for visceral fat. The phantom was imaged on a 1.5T system (MAGNETOM Aera, Siemens Healthcare, Germany) using a manufacturer-supplied prototype T1 mapping sequence based on MOLLI<sup>2</sup>. We used a 5(3)3 MOLLI protocol with a 1000 ms simulated heart rate for measuring T1. When imaging the phantom we progressively shifted the slice position in the slice select direction to alter the relative proportions of oil and water included in the image. We used the MOLLI T1 values to estimate the effect of fat on the calculation of the extracellular volume (ECV). For this we assumed the Hct = 45%. For comparison, we measured the T1 for each vial using an inversion recovery – fast spin echo technique with TR=7500 ms and T1 ranging from 100 ms to 5000 ms. This data was fit to the standard inversion recovery equation to estimate T1.

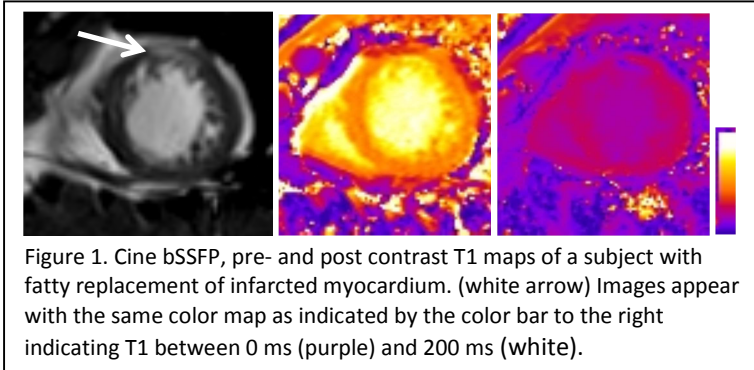


Figure 1. Cine bSSFP, pre- and post contrast T1 maps of a subject with fatty replacement of infarcted myocardium. (white arrow) Images appear with the same color map as indicated by the color bar to the right indicating T1 between 0 ms (purple) and 200 ms (white).

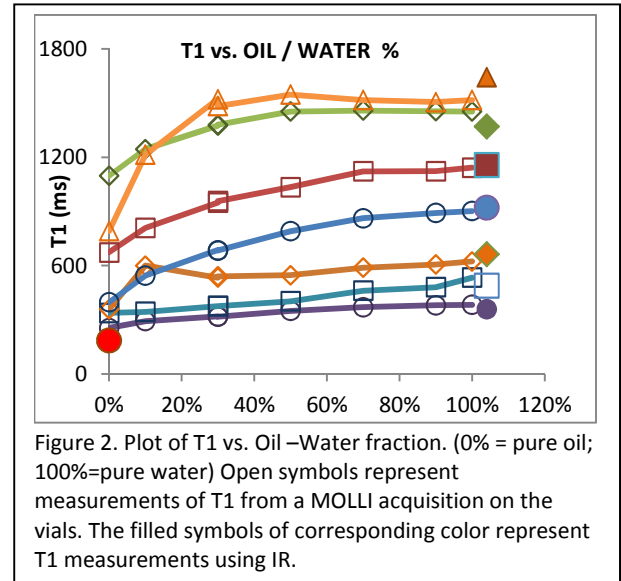


Figure 2. Plot of T1 vs. Oil –Water fraction. (0% = pure oil; 100%=pure water) Open symbols represent measurements of T1 from a MOLLI acquisition on the vials. The filled symbols of corresponding color represent T1 measurements using IR.

**RESULTS:** Figure 1 demonstrates a case of fatty remodeling of the anterior wall of the LV myocardium following myocardial infarction. Notice the significantly reduced T1 (red replacing orange) in this area in the pre-contrast calculated T1 images. Figure 2 shows, in open symbols, the variation of the T1 values in the vials, measured by the MOLLI 5(3)3 acquisition, as a function of the relative amount of oil and water. Figure 2 also shows, using filled symbols, the T1 value for each vial measured by the IR technique. The T1 of the oil measured with the IR technique was 185 ms (red dot on Figure 2). The T1 measured by MOLLI was approximately equal to that derived from IR. As expected, the measured T1 declined as the relative oil concentration increased although the values never reach the T1 value for oil measured by IR. The reduction in T1 is surprisingly modest for water-oil mixtures above 50% and is especially the case for aqueous samples with long T1. The reduction in T1 is more significant in samples with shorter T1 and at lower concentrations of water. Using these values to estimate an extracellular volume fraction we found, with 0% oil, the ECV=39% and it progressively decreased to 24% at 100% oil.

**DISCUSSION:** The dependence of the T1 measured by MOLLI as a function of the relative amount of oil is not surprising given the admixture of tissues with dissimilar T1. Additionally, others have demonstrated the dependence of the measured T1 in MOLLI on off resonance conditions<sup>1</sup>. However, the dependence of the measured T1 on the relative concentrations is dissimilar to how it would be in the case of blending two tissues with similar resonant frequencies but different T1. The effect on a measurement of the ECV with increasing fat concentration is predicted to lead to a progressive and significant underestimate of ECV.

**CONCLUSION:** The infiltration of the myocardium with fat alters the measured T1 through both changes in the average relaxation time and by the effect of including off resonance protons. This distortion in MOLLI measured T1 will significantly underestimate the extracellular space volume.

### REFERENCES:

1) Kellman P. et al JCMR 15 63 (2013) ; 2) Messroghli DR et al JMIRI 26(4) 1081-6 (2007) ; 3) Lee JJ et al JCMR 13:75 (2011)