Multimodality Tissue Tracking Algorithm of Myocardial Strain: Initial Validation with Tagged MRI

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Target Audience: Clinicians and researchers who perform cardiovascular MRI studies.

Background: Left ventricular strain is a potentially beneficial biomarker for regional myocardial function, necessitating methods for its quantification. Traditional CMR tagging techniques used to obtain strain information, including complementary spatial modulation of magnetization (CSPAMM) and displacement encoding with stimulated echoes (DENSE), require dedicated acquisition sequences with low signal to noise ratio and lengthy post-processing times[1,2]. A novel Multimodality Tissue Tracking (MTT) algorithm[3] allows for rapid evaluation of MR cine images, which have high spatial/temporal resolution and are obtained clinically. The purpose of this study was to validate the MTT software in the assessment of regional myocardial function in a pool of heart failure and healthy volunteers.

Materials and Methods: Forty-three subjects [15 healthy, 19 systolic heart failure, and 9 diastolic heart failure] underwent CMR examinations on a 3.0T scanner (Verio, Siemens) using a 32-channel cardiac array coil. Short-axis tagged CSPAMM and SSFP cine images were acquired for the base, mid, and apical slices. Tagged and cine images from corresponding slices were analyzed by MTT (Toshiba, v.6.0, Tokyo, Japan) and compared against tagged images analyzed by the reference standard HARP (Diagnosft, v.4.3.1, Morrisville, NC). 16-segment circumferential and radial strain and strain rates as well as mean image analysis times were assessed. Pearson's correlation coefficient and univariate regression analysis were performed for quantitative assessment while intra-class coefficient (ICC) was used for reproducibility (MedCalc Software v12.2.1, MariaKerke, Belgium).

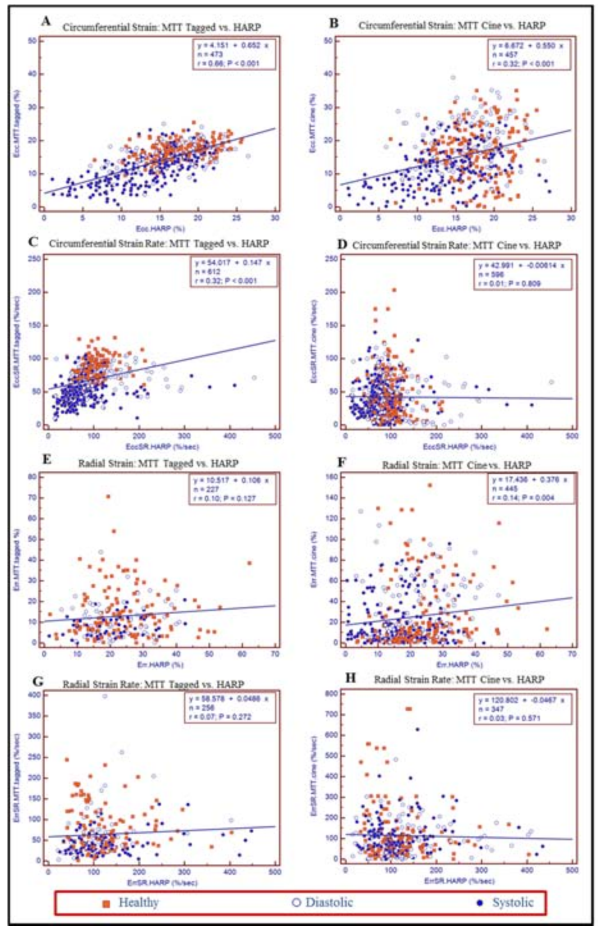
Results: 8,256 strain measurements were collected, of which 25.0% of HARP and 12.4% of MTT values were excluded due to poor tracking. Mean image analysis times were significantly shorter for MTT compared to HARP (5:57 ± 2.3 min vs. 13.26 ± 3.3 min, $p<0.001$). In general, there was a stronger correlation between MTT tagged and HARP strain/strain rate measurements in the circumferential direction ($r=0.66$, $p<0.001$ and $r=0.32$, $p<0.001$, respectively) compared to radial direction ($r=0.10$, $p=0.13$ and $r=0.07$, $p=0.27$, respectively) with similar, yet less prominent trends between MTT cine and HARP values (Figure 1). However, MTT cine images showed higher inter- and intra-observer agreement for radial strain for the mid-slice segment (ICC=0.85 and 0.92, respectively) than either MTT tagged (ICC=0.76 and 0.88) or HARP (ICC=0.80, intra). All three modalities showed excellent agreement for circumferential strain (Table 1).

Discussion: A viable alternative to standard tissue tracking methodologies is presented. MTT allows for rapid strain quantification of cine images, necessitating less than half of the post-processing time as HARP. Superior image quality of cine compared to tagging images diminishes issues with unreadable cases, illustrated by less data being excluded from analysis with MTT than HARP. Quantification of circumferential strain with MTT shows good correlation with HARP. Radial strain analysis by MTT offers high reproducibility despite poor correlation with HARP, suggesting need for better reference standard for radial strain validation.

Conclusion: A novel tissue tracking algorithm allows for rapid, reproducible circumferential strain/strain rate assessment that is well correlated with HARP strain analysis. Further validation is needed for radial strain/strain rate measurements despite high reproducibility to compare against proper reference standard.

References: [1] Ibrahim SH, et al. *JCMR*, 2011;13:36. [2] Tee, M, et. al. *Expert Rev Card Ther*, 2013;11(2):221-231. [3] Helle-Valle TM, et al. *Am J Cardiol*, 2010;54(7):618-624.

Figure 1: Univariate correlation coefficient and regression



Note: Univariate correlation coefficient and regression analysis were performed for base, mid, and apical-slice measurements between HARP and MTT techniques. Significant correlation is defined as $p<0.05$. Overall segments include data from all six segments pooled together for strain and strain rates (SR) in both radial (Err) and circumferential (Ecc) direction.

Table 1: Inter- and intra-observer reproducibility

Intraclass Correlation Coefficient (ICC)					
	HARP tagged	MTT tagged		MTT cine	
Level	Intra-observer	Inter-observer	Intra-observer	Inter-observer	Intra-observer
Circ. Strain					
Anterior	0.86	0.91	0.93	0.96	0.90
Septal Anterior	0.95	0.92	0.87	0.92	0.95
Septal Inferior	0.85	0.89	0.82	0.75	0.96
Inferior	0.83	0.93	0.92	0.66	0.94
Inferior Lateral	0.82	0.88	0.86	0.69	0.93
Anterior Lateral	0.89	0.84	0.83	0.84	0.96
Overall	0.89	0.90	0.88	0.85	0.95
Radial Strain					
Anterior	0.67	0.85	0.79	0.85	0.92
Septal Anterior	0.93	0.78	0.83	0.85	0.88
Septal Inferior	0.79	0.56	0.83	0.82	0.93
Inferior	0.84	0.75	0.91	0.80	0.94
Inferior Lateral	0.63	0.67	0.74	0.79	0.92
Anterior Lateral	0.80	0.75	0.77	0.87	0.93
Overall	0.80	0.76	0.88	0.85	0.92

Note: Intra- and inter-observer agreement are displayed using intraclass correlation coefficient (ICC) with two-way random model (ICC < 0.40 = poor, ICC ≥ 0.40-0.75 = fair to good, ICC > 0.75 = excellent agreement). ICC values are displayed for both circ. (circumferential) and radial strain parameters for mid-slice segment.