

Correlation between Cine-derived Strain and Late Gadolinium Enhancement in the Left Atrium

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Purpose: Change in left atrial (LA) strain is a potential cause of LA fibrosis, and the presence of fibrosis will impact LA strain. LA strain post-ablation has been analyzed using DENSE tagging (1), but is challenging to quantify due to thin walls that do not permit use of standard tagging techniques. It has been measured in patients prior to ablation, with echocardiographic speckle tracking methods (2), and related to fibrosis using late gadolinium enhancement (LGE) MRI. A newer related method, feature-tracking, claims the possibility of computing circumferential strain based on contours of a cine scan (3-6). We have developed a feature tracking method, and applied it to 2-chamber views of patients to estimate LA strain, and correlate it with LGE estimations of LA fibrosis.

Methods: Nine patients undergoing cardiac MR, with no prior ablation, had 2-chamber cines and late gadolinium enhancement images. All imaging was performed on a 1.5T Siemens Aera (Siemens Healthcare, Erlangen, Germany), and the study was IRB approved. Left atrial LGE was obtained using an ECG-triggered, navigator-gated 3D GRE inversion recovery (IR) sequence obtained 10 minutes after the administration of 0.2 mmol/kg of Gadobutrol, with spatial resolution of 1.5 x 1.4 x 3mm³. 2-chamber cine images were obtained with balanced SSFP, with a 2 x 2 x 8 mm³ spatial resolution, and 30 frames. The LGE images were analyzed blinded to other data, using an 18 segment model (7), resulting in scar scores from 0 to 1 (1 = all segments with scar). The 2-chamber data sets

were segmented to include the LA cavity with BioimageSuite (Figure 1A). The strains were measured using the feature tracking software, which computed a non-rigid grid-point to grid-point displacement field in the segmented region (Figure 1B). The edges of the segmented LA cavities were extracted using Matlab. The edges were then discretized into finite sets of points. The LA contours at begin-systole and end-systole were used; the former was registered to the latter using an affine point cloud registration (3). Next, the circumferential strains were computed as follows: $S_i = [(P_{Ei+1} - P_{Ei}) - (P_{Bi+1} - P_{Bi})] / (P_{Bi+1} - P_{Bi})$, where $i+1$ and i index locations of neighboring points, and E and B index begin and end-systole. Average strain over the contour was estimated, and LA "ejection fraction" (LA EF) was calculated on the 2D images as difference of areas between begin and end-systole, divided by the end-systolic area.

Results: Figure 1 shows results from 1 subject, with Figure 1D showing a slice from the matching LGE image. Figure 2 plots the strain vs. EF, showing a very strong correlation, with a trend towards a significant correlation between scar score and strain, with greater scar score correlating with lower strain.

Conclusions: Feature tracking allows LA strain estimation which was previously unmeasurable. LA average strain exhibits a correlation with measures of LA fibrosis. **References:** 1) Schmidt EJ et al, *Europace* 2013. 2)Kupphaly SS et al., *Circ Cardiovasc Imaging*, 2010; 3(3): 231-9 3) Rangarajan, A. et al, *H. Med Image Anal*, 1997; 1(4): 379-98 4) Bellini, C et al., *J Biomech Eng*, 2012; 134(2). 5)Di Martino et al., *J Biomech*, 2011; 44(16): 2755-60. 6) Imai, M et al, *JCMR (abstract)*, 2013; 15; 266. 7) Shaw JL et al. *MRM* 2013.

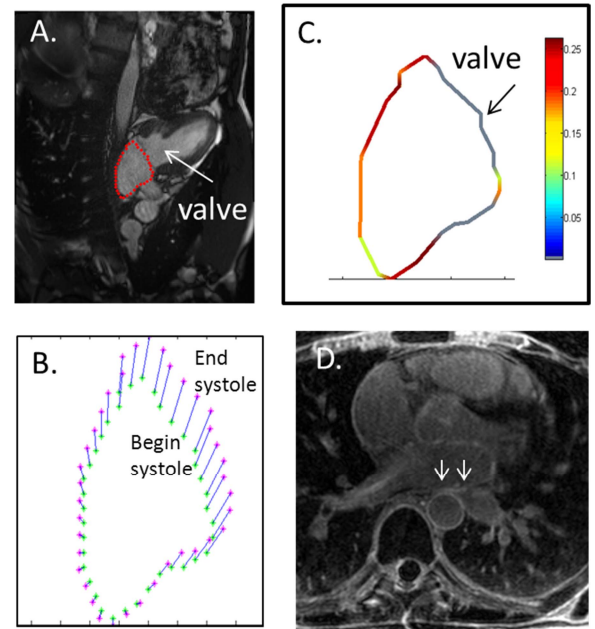


Figure 1: Custom feature-tracking method. A) Contours of the left atrium on a 2-chamber image. B) Contour points are matched between begin and end-systole. C) Strain maps are derived. D) These are compared to LGE images. Arrow indicates enhancement/fibrosis.

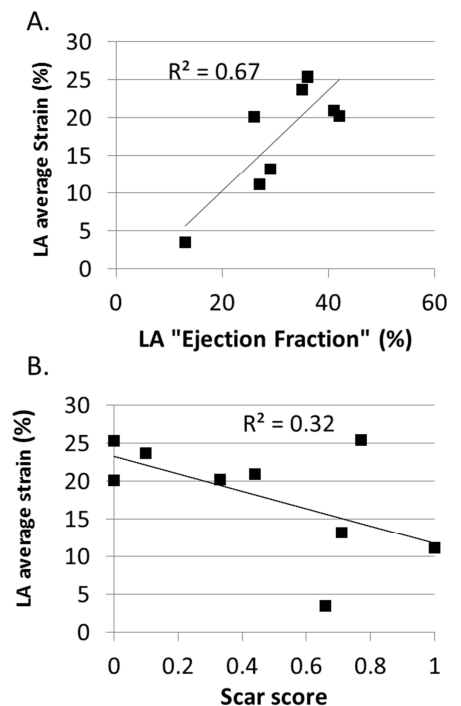


Figure 2: A) LA average strain vs. LA EF (p=0.007). B) Lower strain is correlated with higher scar score. (p=0.1).