Assessment of Regional Strain in Myocardial Infarction Using 3T Tagged and Late Enhancement MRI

Yuma Inoue¹, Michinobu Nagao¹, Kouhei Hosokawa¹, Teruhito Kido¹, Akira Kurata¹, Hiroshi Higashino¹, Teruhito Mochizuki¹, Hideki Okayama², Jitsuo Higaki², Xiaomei Yang³, Kenya Murase³

1. Department of Diagnostic and Therapeutic Radiology, Ehime University Graduate School of Medicine
2. Department of Integrated Medicine and Informatics, Ehime University Graduate School of Medicine
3. Department of Medical Physics and Engineering, Division of Medical Technology and Science, Course of Health Science, Graduate School of Medicine, Osaka University
Background

Tagged MRI at 3.0T

ED (first phase)  ES  ED (last phase)
Characterization of the Peri-Infarct Zone by Contrast-Enhanced Cardiac Magnetic Resonance Imaging Is a Powerful Predictor of Post-Myocardial Infarction Mortality

Andrew T. et al Circulation 2006; 114

Figure 2. Kaplan-Meier survival curves for all-cause mortality, stratified by median %MDE_{Periphery}. 

%MDE_{periphery} < 50^{th} percentile

%MDE_{periphery} ≥ 50^{th} percentile

P = 0.009

Follow-up Period (Years)
Purpose

To assess regional myocardial movement in myocardial infarction using tagged MRI combined with late enhancement.
Methods

Patient characteristics

• 21 patients with old myocardial infarction

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Age (years)</th>
<th>66.9±13.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male gender</td>
<td>13 (62%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>16 (76%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>10 (48%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>10 (48%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family history</td>
<td>5 (24%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>9 (43%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• 5 volunteers with no prior heart disease

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Age (years)</th>
<th>56.2±19.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male gender</td>
<td>3 (60%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MRI scanner

- Achieva 3.0T Quarser Dual (Philips Medical system)
- 6ch or 32ch cardiac phased array coil.
# MRI scan sequence

<table>
<thead>
<tr>
<th></th>
<th>LGE</th>
<th>Tagging</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sequence</strong></td>
<td>3D</td>
<td>2D</td>
</tr>
<tr>
<td>TR / TE / FA</td>
<td>IR-T1-TFE</td>
<td>TFE</td>
</tr>
<tr>
<td><strong>Matrix</strong></td>
<td>256 x 166</td>
<td>256 x 179</td>
</tr>
<tr>
<td>Thickness/Gap(mm)</td>
<td>12 / -6</td>
<td>10 / 10</td>
</tr>
<tr>
<td><strong>Slice</strong></td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td><strong>FOV (mm)</strong></td>
<td>380</td>
<td>380</td>
</tr>
<tr>
<td><strong>NEX</strong></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>K-space ordering</td>
<td>Linear</td>
<td>Linear</td>
</tr>
<tr>
<td>Trigger or Retrospective</td>
<td>Trigger</td>
<td>Trigger</td>
</tr>
<tr>
<td><strong>SENSE factor</strong></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Scan time (sec)</strong></td>
<td>20sec</td>
<td>19sec</td>
</tr>
<tr>
<td><strong>Gd-DTPA</strong></td>
<td>(0.15mmol/kg)</td>
<td>Tag grid 6.6mm</td>
</tr>
<tr>
<td><strong>Tagging</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>20phase</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tag grid 6.6mm</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Classify the segments

- Infarcted tissue: hyper-enhanced myocardium on LE images

Infarct (transmularity $\geq 25\%$)

Border ($< 25\%$)

Adjacent

Remote

Ant: anterior
AS: antroseptal
IS: inferoseptal
Inf: inferior
IL: inferolateral
AL: anterolateral
Analysis

- The short-axis image of mid left ventricle
- The modified harmonic phase method using Gabor filter
- Measurement of strains for 6 myocardial segments (based on AHA 17-segment model)
Regional strain measurements

1. The peak value of two strain
2. The time to peak value
Statistical analysis

We compared differences in the strain measurements between the segments using the one-way ANOVA with Tukey-Kramer’s post hoc test. A probability value of less than 0.05 was considered statistically significant.
Results

Peak strain value of healthy volunteers

Radial strain

Circumferential strain

n.s.
Time to peak strain of healthy volunteers

radial strain

circumferential strain

Phase

Ant  AS  IS  Inf  PL  AL

Phase

Ant  AS  IS  Inf  PL  AL

n.s.

n.s.
Peak strain value of MI patients

**Radial Strain**

- Remote: 
- Adjacent: 
- Border: 
- Infarct: 

**Circumferential Strain**

- Remote: 
- Adjacent: 
- Border: 
- Infarct: 

P-values:
- P<0.05
- P<0.001
Time to peak strain of MI patients

radial strain

P<0.001

P<0.05

remote adjacent border infarct

circumferential strain

P<0.05

remote adjacent border infarct
Summary of results
Healthy volunteers

There was no significant difference for peak value of strain and time to peak strain between each segments.
Summary of results

Peak value of strain

- The peak value of radial strain for infarct and adjacent segment were significantly lower than those for remote segment.

- The peak value of circumferential strain for infarct segment was significantly lower than those for border and remote segment.
Summary of results
Time to peak strain

● In MI patients, the time to peak radial strain for infarct segment was significantly longer than those for remote and border segment.

● The time to peak circumferential strain for infarct segment was significantly longer than those for border segment.
## Discussion

### Comparison of previous studies

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pervious studies</th>
<th>Our study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanner:</td>
<td>1.5T</td>
<td>3.0T</td>
</tr>
<tr>
<td>Strain analysis:</td>
<td>HARP</td>
<td>Gabor-HARP</td>
</tr>
<tr>
<td>(Diagnosoft)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter:</td>
<td>Peak strain value</td>
<td>Peak strain value</td>
</tr>
<tr>
<td>time to peak value</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Infarct Tissue Heterogeneity by Magnetic Resonance Imaging Identifies Enhanced Cardiac Arrhythmia Susceptibility in Patients With Left Ventricular Dysfunction

Schmidt A. et al Circulation 2007; 115
Enhanced Infarct Border Zone Function and Altered Mechanical Activation Predict Inducibility of Monomorphic Ventricular Tachycardia in Patients with Ischemic Cardiomyopathy

Fernandes V. et al Radiology 2007; 245
Conclusion

- Tagged MRI with late enhancement can assess regional dysfunction in the location at different distances from infarct. Peak strain value was correlated with myocardial viability, which was demonstrated by late enhancement transmularity.

- The contract impairment demonstrated by reduced peak strains was seen not only infarct but border and adjacent.