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INTRODUCTION

- Conventional breast protocols rely on contrast-enhanced fat-suppressed VIBE images. Problems: limited temporal resolution, inhomogeneous fat suppression  
- Golden-angle Radial Sparse Parallel MRI (GRASP) enables dynamic contrast enhanced (DCE) MR imaging with high temporal resolution [1,2]. Problem with inhomogeneous fat suppression remains  

METHODS

- Dixon-RAVE data acquisition  
  3D stack-of-stars sequence | blipped bipolar multi-echo readout  
  
  Continuous acquisition of 400 projections (scan time = 3:10 min, TR = 6.54 ms, spatial resolution = 1.0x1.0x1.2 mm³), contrast injection after 2 minutes

- Dixon-RAVE reconstruction  
  Model-based approach | Deblurring | Compressed Sensing | Parallel Imaging  
  Grouping of 13 consecutive radial spokes  
  Temporal resolution = 6.1 s/volume, 3D dynamic frames

  Signal model
  
  \[ E(W, F, \Phi)_{c,t} = FT \left( C_c \cdot e^{2\pi i \Phi t_o} \cdot W \right) + D(t) \cdot FT \left( C_c \cdot e^{2\pi i \Phi t_o} \cdot F \right) \]

  \( W = \text{water}, \ F = \text{fat}, \ \Phi = B_0 \text{ field map}, \ C_c = \text{coil sensitivities}, \ D(t) = \text{sampling operator}, \ FT = \text{NUFFT operator} \)

  Optimization problem
  
  \[ \arg \min_{c,t} \sum ||E(W, F, \Phi)_{c,t} - y_{c,t}||^2 + \lambda_w ||S(W)|| + \lambda_f ||S(F)|| + \lambda_p ||S(\Phi)|| \]

  \( y_{c,t} = 4\text{-dimensional } k\text{-space data } (N_{\text{raud}}N_{\text{proj}}N_{\text{phase}}), \ S = \text{temporal total variation} \)

  Solved with iterative Gauss-Newton algorithm, initialized with precomputed field map [4]

- Patient study  
  9 patients (age 47.6 ± 15.8 years), 3T Trio (Siemens Healthineers, Erlangen)  
  Diagnostic bilateral breast DCE-MRI

RESULTS

- Dixon-RAVE and fatsat VIBE results from two cancer patient scans. In some areas, fat suppression for conventional VIBE fails due to \( B_0 \) inhomogeneities (arrows), while Dixon-RAVE achieves uniform cancellation of fat.

  Dixon-RAVE

  Fatsat VIBE

  Images scored by two radiologists  
  5-point scale and Wilcoxon signed ranked test

<table>
<thead>
<tr>
<th>Degree of fat suppression</th>
<th>4.44±0.62</th>
<th>3.83±0.62</th>
<th>&lt;0.005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conspicuity of fibroglandular tissue from fat</td>
<td>4.33±0.69</td>
<td>3.61±0.61</td>
<td>&lt;0.003</td>
</tr>
<tr>
<td>Overall image quality</td>
<td>3.67±0.49</td>
<td>3.67±0.59</td>
<td>1.00</td>
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</tbody>
</table>

CONCLUSION

- Dixon-RAVE enables 3D DCE fat/water separated breast imaging with high spatiotemporal resolution  
- Improved fat suppression and higher conspicuity of fibroglandular tissue compared to conventional fat-suppressed VIBE  
- Extraction of both water images ("fat-suppressed") and fat images ("non-fat-suppressed"), combines entire \( T_1 \)-weighted exam into single scan  
- Possible extensions: Fat quantification, \( T_2^* \)-mapping

REFERENCES


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