Novel Dynamic Contrast Enhanced Breast MRI with High Spatiotemporal Resolution and Fat Separation: Image Quality Compared to the Clinical Standard-of-Care MRI

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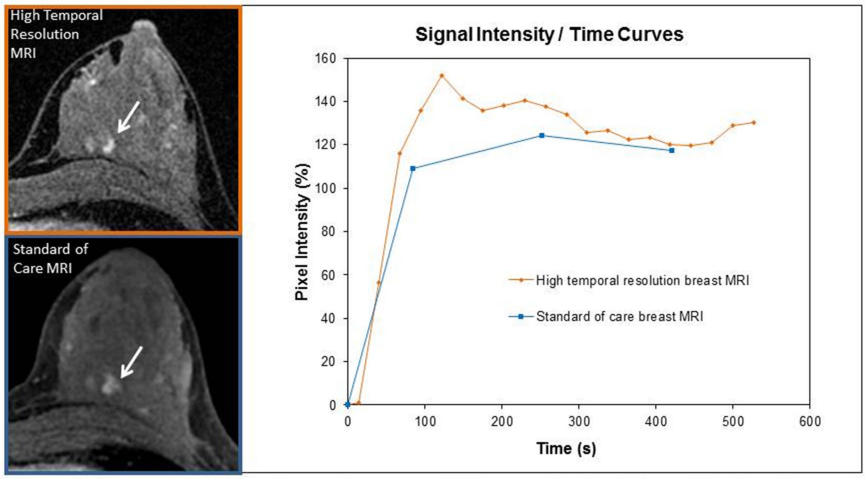
Target Audience: Breast imaging radiologists; medical physicists studying high spatiotemporal resolution MRI, advanced reconstruction techniques.

Purpose: Current clinical dynamic contrast enhanced (DCE) breast MRI prioritizes high spatial over temporal resolution given limitations of acquisition techniques. High temporal resolution MRI with preserved high spatial resolution offers the potential to improve diagnostic accuracy and characterization of breast cancer using multiple DCE time points. The potential advantages of high temporal resolution for DCE breast MRI have been well described[1,2]. The purpose of this pilot study was to assess the subjective intra-patient image quality of a novel high spatiotemporal resolution (STR) DCE breast MRI technique[3] with fat separation compared to the clinical standard-of-care (SOC) DCE breast MRI technique to assess image quality of the novel technique given its higher temporal resolution.

Methods: The records of all patients undergoing routine clinical SOC breast MRI from 9/2013 to 5/2014 were reviewed for this IRB approved, HIPAA compliant study. Thirty patients each demonstrating a focal area of enhancement consented to return for a research high STR breast MRI exam on a second date. SOC T1-Weighted (T1W) FSPGR MRI was performed with one pre- and three post-contrast time-points with 168 second (s) spacing, parallel imaging (PI) factor 2 × 1, and intermittent fat saturation. High STR T1W MRI was achieved by pseudo-random k-space sampling[3] with one pre-and 20 post-contrast time-points with 27 s spacing and 2 × 2 PI factor; images were reconstructed using backwards view-sharing and removal of fat signal was achieved with a 2-point (pt.) Dixon method[4]. Both protocols were performed at 1.5T (GE Healthcare, Waukesha, WI) with an 8 channel breast coil, matched spatial resolution of 0.8 x 0.8 x 1.6 mm^3, and 0.1 mmol/kg gadobenate dimeglumine contrast injected intraveneously at 2 cc/s followed by a 20 cc saline flush. SOC and high STR MRI exams were independently scored for image quality by three breast imaging radiologists. Images were scored on a scale of 1 (worst) to 10 (best) in the following categories: image distortion/artifacts, resolution/ detail, quality/uniformity of fat suppression, lesion conspicuity, noise/graininess, and overall image quality. Adequate diagnostic image quality was scored yes/no. Statistical analysis of the pooled reader scores was performed with a generalized estimating equation model accounting for sequence (independence working correlation matrix with a robust sandwich covariance estimate); the model omitted explicit modeling of potential reader or reader-by-sequence interaction terms.

Results: Thirty women with an average age of 45 (range 28 to 65) years underwent both SOC MRI and high STR MRI. Clinical indications were high risk screening in 24/30 (80%) and diagnostic in 6/30 (20%) (short-term follow-up, newly diagnosed breast cancer, problem solving). High STR MRI achieved a temporal resolution that was six-times faster than the SOC MRI. Representative signal intensity time curves in Figure 1 demonstrate the additional time points captured with high STR MRI. For the pooled reader scores, differences between image quality scores for SOC MRI versus high STR MRI were small and never greater than 0.8 on the 10 pt. scale. Both SOC and high STR MRI were scored as providing adequate diagnostic image quality in all 30 cases. High STR MRI performed better for quality/uniformity of fat suppression (8.8 vs. 8.0; $p<0.01$). Image distortion/artifacts was similar between protocols (7.8; $p=0.91$). SOC MRI performed better than high STR MRI for resolution/detail (mean 8.2 vs. 7.9; $p<0.01$), lesion conspicuity (8.0 vs. 7.5; $p=0.02$), noise/graininess (8.2 vs. 7.4; $p<0.01$), and overall image quality (8.1 vs. 7.7; $p<0.01$).

Discussion: We utilized a novel approach to k-space sampling and image reconstruction with view-sharing to provide breast MRI with a temporal resolution of 27 s, six-times faster than the clinical SOC, while matching the SOC high spatial resolution. Despite this increase in temporal resolution, differences in image quality between protocols were small (0.8 or less on the 10 pt. scale) and adequate diagnostic image quality was maintained in all high STR cases. The 2-pt. Dixon method provided improved fat suppression for high STR MRI. The subjective small decrease in image quality of high STR compared with SOC MRI is expected given the higher 2x2 parallel imaging factor used to accelerate imaging in combination with an 8-channel coil.



High spatiotemporal resolution (orange box; upper left) versus standard of care (blue box; lower left) dynamic contrast enhanced breast MRI demonstrating preserved image quality for the high spatiotemporal resolution protocol. Plot of the signal intensity time curve of the lesion (white arrow) in the left breast demonstrates more time points and greater curve detail using the high spatiotemporal resolution MRI (orange curve) versus standard of care MRI (blue curve).

Conclusion: We successfully performed high STR breast MRI, matching the high spatial resolution of the SOC breast MRI while imaging six-times faster, providing improved fat suppression and maintaining subjective adequate diagnostic image quality. This technique is promising for allowing advanced analysis of perfusion, including semi-quantitative and quantitative pharmacokinetic measurements. Further study is needed to determine if this approach can improve diagnostic accuracy.

References: [1]Li et. al. Radiology 2011;260(1), [2]Yankeelov et. al. Semin Oncol 2011;38(1) [3]Saranathan et. al. JMRI 2014;40(6), [4]Ma J. Magn Reson Med 2004;52(2).

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