High-resolution DWI for Characterizing Breast Tumor Response to Treatment

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Background: Diffusion-weighted imaging (DWI) provides information about tissue microstructure and has shown promise as a potential biomarker of early treatment response in breast cancer [1,2]. However, the spatial resolution of DWI is typically not as high as other conventional sequences such as T1-w acquisitions used for DCE-MRI, a limitation that may affect the ability of DWI to detect treatment-related changes. Our group has optimized a high-resolution single-shot echo planar reduced-FOV DWI (HR-DWI) acquisition for breast imaging. The sequence utilizes a 2D spatially-selective echo-planar RF excitation pulse and a 180-degree refocusing pulse to reduce the FOV in the phase-encode (PE) direction [3]. The shortened readout allows a high in-plane resolution images to be acquired with fewer k-space lines and also reduces off resonance effects. In earlier work we demonstrated that the HR-DWI had improved image quality compared to standard DWI and that the tumor ADC distributions of the two techniques were different [4]. Therefore, we hypothesized that HR-DWI measurements of tumor response to neoadjuvant treatment would differ from standard (STD-DWI) measurements and might better correlate with treatment response.

Methods: Patients with invasive breast cancer were scanned with both HR-DWI and STD-DWI before (pre-treatment) and after one cycle (early-treatment) of neoadjuvant taxane based treatment as part of an ongoing IRB approved study at our institution. All patients gave informed consent. Imaging was performed on a 1.5T GE Signa scanner LX (GE Healthcare) using an 8 channel bilateral phased array breast coil (Sentinelle Medical, Toronto, Canada).
HR-DWI sequence: TR/TE: 4000ms/64.8ms, FOV: 140x70 mm, matrix: 128x64, NEX: 16, b=0,600 s/mm^2, voxel size: 4.8mm^3.
STD-DWI sequence: TR/TE: 6000ms/69.6ms, FOV: 400x400 mm, matrix: 128x128, NEX: 6, b=0,600 s/mm^2, voxel size: 29.3mm^3.
One tumor region of interest (ROI) was defined on the HR-DWI slice estimated to contain the largest tumor area and then applied to the corresponding slice and location on the STD-DWI and HR-DWI ADC maps. Mean tumor ADC as well as 15th, 25th, 50th, 75th, and 90th percentile ADCs were calculated for both DWI acquisitions. Differences between ADC metrics calculated from the two sequences were compared using a Wilcoxon-signed rank test. For this preliminary study, DCE-MRI tumor volume change between the pre-treatment MRI and a post-taxane MRI was used as an indicator of response. The relationship between ADC metrics and tumor volume change was evaluated using a Pearson's correlation.

Results: Nine patients were evaluated with the HR- and STD-DWI sequences. Mean tumor ADC was not significantly different between the two DWI acquisitions. Figure 1 shows the tumor pre- and early-treatment ADC percentile values averaged over the group. The lower percentile HR-DWI ADCs were smaller than STD-DWI values, reaching significance at the early treatment time point for the 15th (p=0.0117) and 25th (p=0.0391) percentile. Comparing ADC metrics to tumor volume change, the strongest correlations were found for the pre-treatment HR-DWI acquisition 15th percentile ADC (r^2=0.71, p=.0043, Fig. 2a) and mean ADC (r^2=0.68, p=.0061). Weaker correlations were found for the pre-treatment STD-DWI 15th percentile ADC (r^2=0.57, p=.0189, Fig. 2b) and mean ADC (r^2=0.62, p=0.0113). Similar, but weaker, correlations were found between tumor volume change and the early treatment 15th percentile and mean ADCs.

Figure 1a HR-DWI vs STD DWI Pre-Treatment

Figure 1b HR-DWI vs STD DWI Early Treatment

Figure 2a

Figure 2b

Conclusions: The differences between the HR- and STD-DWI tumor ADCs were greatest in the lower percentiles, consistent with our previous work [4]. This difference was larger at the early treatment visit. A higher correlation was found between the pre-treatment HR-ADC and the tumor volume change than with the STD-ADC, and was greatest for the lowest ADC percentile. The results are consistent with the hypothesis that the HR-DWI technique is more sensitive to characterizing low tumor ADC values, and suggest that the HR-DWI and may be of value in evaluating tumor change with treatment. Studies are ongoing to evaluate the ability of HR-DWI to predict clinical outcome in a larger population.
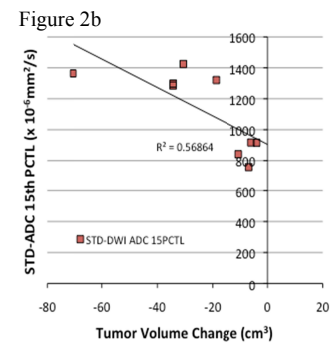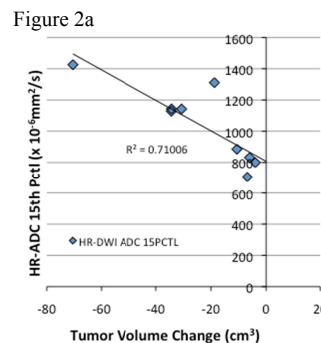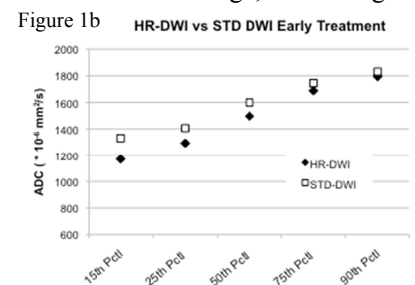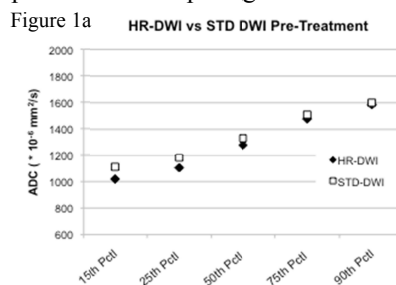
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