Towards Practical Breast Diffusion Tensor Imaging at 3.0T in the Clinical Setting

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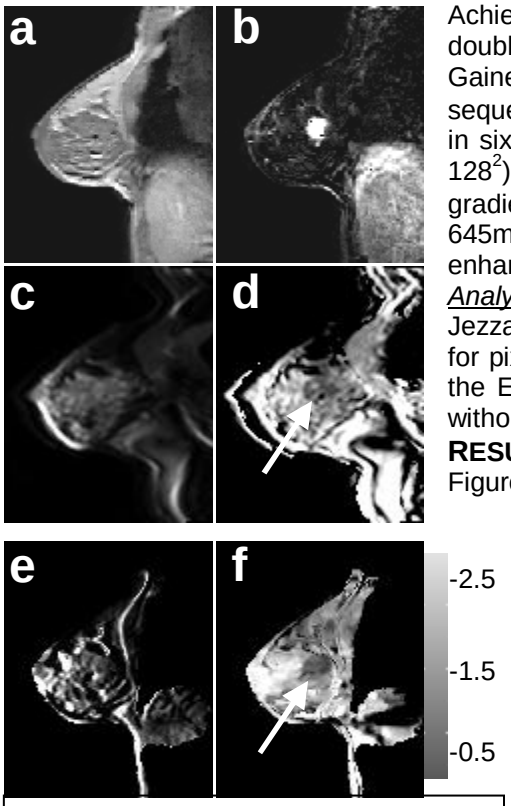
INTRODUCTION

Diffusion weighted MRI (DW-MRI) is a promising surrogate biomarker for the characterization of human breast cancer (1-4). Unfortunately, the quality of DW-MRI data is frequently compromised, especially in the breast, by the presence of main magnetic field ($\boldsymbol{B}_0$) inhomogeneities which can lead to geometric distortion in the echo planar imaging (EPI) techniques typically used to acquire such data. As the demand for higher temporal and spatial resolution increases in breast imaging, there is some motivation to move to higher (≥ 3.0T) fields (5) and this will increase the difficulty of acquiring quality DW-MRI data of the breast. Thus, we have begun investigating the ability of $\boldsymbol{B}_0$ field map corrections to reduce geometric distortion in diffusion tensor imaging (DTI) data obtained at 3.0T in a clinically relevant time period.

METHODS

Acquisition Data from six patients has thus far been analyzed. Patients were ≥ 18 years of age with biopsy-proven infiltrating breast cancer, stages IIA to IIIB and ECOG performance status 0 to 1. MRI was performed on a Philips 3.0 T Achieva scanner (Philips Healthcare, Best, The Netherlands) prior to all therapy. A double-breast 4-channel receive coil was used for all imaging (In vivo Inc., Gainesville, FL). The DTI acquisition employed a fat-suppressed, single shot EPI sequence with TR\TE\α\NSA = 2500ms\45ms\90°\10, b-values of 0 and 500 s/mm^2 in six directions (applied sequentially), and an imaging matrix of 80^2 (zero-filled to 128^2) acquired over sagitally over a $(25.6\ \text{cm})^2$ FOV. Just prior to DTI, a double gradient echo was acquired to produce a $\boldsymbol{B}_0$ field map with $TR\backslash TE_1\backslash TE_2\backslash\alpha$\NSA= 645ms\2.3ms\4.6ms\40°\1. The MR session, including a dynamic contrast enhanced (DCE) study, is approximately 25 minutes.

Analysis Matlab (Mathworks, Natick, MA) was used to implement the method of Jezzard and Balaban (6) in which field maps were constructed and used to correct for pixel shifts in the phase encode direction due to $\boldsymbol{B}_0$ inhomogeneities present in the EPI data. DW images through the central slice of the tumors both with and without $\boldsymbol{B}_0$ correction were compared to anatomical and DCE images.



a displays a sagittal T_1-weighted pre-contrast image, while **b** shows a subtraction image to localize the tumor. Panels **c** and **d** display the b=500s/mm^2 uncorrected EPI data and corresponding ADC map (units of 10^{-3} s^2/mm), respectively, while panels **e** and **f** present the $\boldsymbol{B}_0$ corrected data.

RESULTS

Figure 1a depicts a sagittal, pre-contrast T_1-weighted image, while panel b is a post-contrast subtraction image showing the localization of the lesion. The original b=500 s/mm^2 image is shown in panel c and displays significant geometric distortions; panel d is the corresponding ADC map in which the tumor is visible (white arrow) as an area of decreased intensity most likely due to increased cellularity resulting in decreased water diffusion. Panels e and f present the corresponding post-correction data of panels c and d, respectively. The post-correction data display significantly less distortion as evidenced by the better matching of the contour of the breast seen in panel a. The lesion is also more easily seen on the corrected ADC map (panel f). (Due to space limitations, we have only considered the ADC maps and not the fractional anisotropy maps.)

CONCLUSION and DISCUSSION

We have presented preliminary evidence suggesting that correcting DTI data *via* a $\boldsymbol{B}_0$ map can lead to superior quality DTI data in terms of less distortion and better tumor localization when compared to anatomical and DCE data. Reducing geometric distortion in DTI data facilitates the comparison of derived DTI parameters with those obtained from, for example, DCE pharmacokinetic parameters. Furthermore, just as Jezzard and Balaban noted (6), collecting data for quality field maps requires only a minimum amount of additional scan time and may be easily incorporated into existing protocols. Thus, we conclude that this straightforward method be further explored to potentially improve the quality of breast DTI data obtained at high fields in clinically relevant scan times.

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