Fat water ratio and diffusion-weighted MRI applied to the measure of breast density as a cancer risk biomarker

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Introduction

Retention of radiographically dense areas in the breast as women age has been consistently associated with elevated risk of breast cancer. Decreases in mammographic breast density have been linked with beneficial effects of tamoxifen in chemoprevention trials. However, the low precision, sensitivity and accuracy, and poor reproducibility of mammography have limited the use of mammographic density as a risk biomarker. Exposure to ionizing radiation is also a concern for using mammography in longitudinal studies. In this study we used Fat Water Ratio (FWR) MRI and diffusion-weighted (DW) MRI for assessment of breast density and compared the results to conventional mammography. FWR-MRI should be directly related to the mass density measured by mammography while DW-MRI should yield information about the cellular density of the parenchymal/stromal tissue of the breast.

Methods

All experiments were in approved by the institutional review board at the University of Arizona. A total of 29 women were included in this study including 18 with a history of previous breast cancer. All subjects were ascribed a BI-RAD score [1] and % density score by two radiologists based on recently obtained mammograms. MRI was carried out on a 1.5T GE Signa NV-CVi scanner. A radial gradient and spin-echo (radial-GRASE) MRI pulse sequence was used to obtain fat and water images within a single axial scan without artifacts caused by magnetic field inhomogeneities and/or misregistration [2]. In addition, DW-MRI was carried out to compute apparent diffusion coefficient (ADC) maps of the breast. ADC maps were calculated from the exponential decay of signal between two single-shot echo-planar imaging (SSEPI) images, one obtained without diffusion weighting (b = 0 s/mm^2) and one with diffusion weighting (b = 400 s/mm^2). FWR and DW-MRI data for the entire breast region (12-16 7mm sections, 1 mm gap) were acquired in less than 5 minutes.

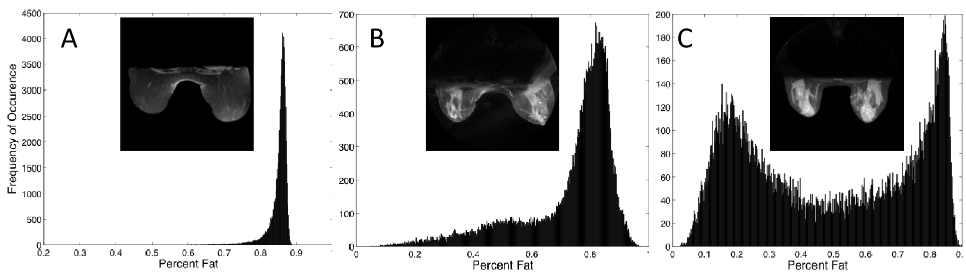

Fig 1. FWR histograms from the entire volume (all slices) of the left breast of representative subjects. Water images of each corresponding subject are included for reference. Histograms of subjects with less dense breasts (BIRADS 1) are single-peaked (A), whereas histograms from subjects with more dense breasts are dual-peaked (B, BIRADS 2 and C, BIRADS 3).

Results

Example FWR-MRI images and resulting FWR histograms are shown in Fig. 1. The fraction of pixel values below 50% fat (Frc50) was used to quantify FWR-MRI for comparison to mammography and DW-MRI. Highly significant correlations ($p < 0.001$) were observed between Frc50 and % density obtained by mammography as well as between Frc50 and mammographic BI-RADS score. Analysis of data obtained over the entire breast was more predictive than assessment of only the largest single slice. Menopausal status (post versus pre/peri) was strongly related to the FWR-MRI values ($p < 0.001$). Interestingly, there was a significant correlation between Frc50 and the mean ADC of the breast ($p < 0.001$), i.e. the higher the overall breast density, the higher the mean diffusivity of the parenchymal/stromal tissue.

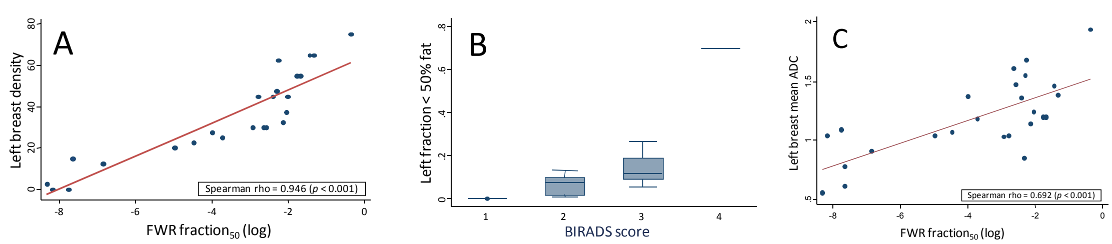

Fig.2 Plots of the log of Frc50 obtained in the left breast vs. mammographic density (A) BIRADS score (B) and mean ADC (C). Red lines in A and C are linear regressions of the data.

Conclusions

Results of FWR-MRI strongly correlate with breast density as measured by standard mammography. The advantage of FW-MRI over mammography is that it provides quantitative information on breast density and does not require exposure to ionizing radiation. ADC values, measured in the same short MRI exam, can provide a quantitative measure of breast composition that is fundamentally different than fat water ratios and/or mammographic density and may provide complimentary information for risk assessment.

References

1) Yaffe, Breast Cancer Res 10:209 (2008) 2) Li et al., MRM 61:1415 (2009)

Acknowledgements

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