Comparison of ADC Values and MR Breast Densities in a Normal Population

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Introduction: Mammographic breast density has been shown to be a strong marker for breast cancer risk. However mammography suffers from many limitations including limited effectiveness in dense breast tissue, need for compression and radiation to patients. We are interested in quantifying breast density from Magnetic Resonance Imaging (MRI) data. Breast MRI presents high soft-tissue contrast and allows the three-dimensional characterization of fibroglandular tissue ('breast tissue') [1]. MR diffusion-weighted imaging (DWI) measures apparent diffusion coefficient (ADC) values, providing information about the biophysical properties of tissue organization, at the cellular level [2-3]. ADC values translate the magnitude of microscopic translational motions that occur in each image voxel during an MR acquisition. This motion in tissue directly reflects intrinsic tissue properties such as tissue microstructure, the degree of water compartmentalization and the concentration of proteins and macromolecules [2]. We are interested in MRI measurement methods to evaluate the composition of healthy breast (fat, fibroglandular tissue) and ultimately increase our understanding of the relationship between certain breast composition and breast cancer risk. The overall goal of this study is to develop noninvasive quantitative imaging tools on normal volunteers that would be used for future studies to monitor potential changes in breast tissue composition with breast cancer treatments. Our study involves two quantitative MRI assessments, A) quantification of breast density or breast tissue index (BTI) using Fuzzy C-Means technique (FCM) [1] and B) quantification of mean ADC values. Our goal was to compare how ADC values differ depending on breast density in normal volunteers.

Materials and Methods: Our study involved MRI data from 10 healthy volunteers. These were women between 24 and 50 years, (average 36 years). All exams were performed on a 1.5T Signa system (General Electric Medical Systems, Milwaukee, WI) using a bilateral phased array breast coil. We acquired a fat suppressed high resolution T1-weighted sequence using the following (MR parameters: TR = 8.4ms, TE= 4.2ms, NEX=2, FOV=20 cm, 2 mm slice thickness, no gap between slices and 256x 256 acquisition matrix). The resulting in-plane resolution was approximately 0.78x0.78 mm. We also acquired a diffusion weighted sequence, (b=600, TR/TE = 6.2/6.1, FOV 35cm, 5mm thickness) and calculated ADC maps for all volunteers. We applied a Fuzzy C-Means segmentation technique [1] on T1-weighted images (figure 1) to quantify MR breast tissue volume (figure 2) and fat volume. Breast density was calculated for each volunteer as the ratio of breast tissue volume over total breast volume. We then mapped the FCM output image to the ADC images to quantify the ADC values corresponding to breast tissue regions (figure 4 and 5). From the final ADC extracted region (figure 5) we quantified the average ADC values for the complete breast. We compared the values of breast density and ADC values for each volunteer.

Results: A comparison of the semi-automated MR breast density quantification and ADC values is presented in figure 6. This shows a Pearson correlation of 0.80. In the low and high breast density ranges, we found a very good correlation with ADC values, explained by the fact that ADC values carry less partial voluming (breast tissue and fat) for these categories. In the lower breast density category, fat is more prevalent in the breast, therefore reducing the average ADC values. In the high breast density category, breast tissue is less infiltrated by fat, therefore producing higher values of ADC. The larger range of ADC values found for the medium breast density category translates the differences in breast tissue composition in volunteers. In this breast density category, fat involvement in breast tissue will generate lower values of ADC than for volunteers with less fat involvement [3]. We studied the intra-user variations in the definition of breast density and found a low coefficient of variation of 1% using our semi-automated fuzzy C means segmentation technique.

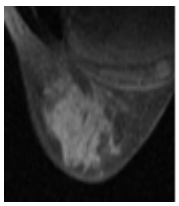
figure 1
T1-weighted image


figure 2
FCM Output


figure 3
FCM Binary Mask

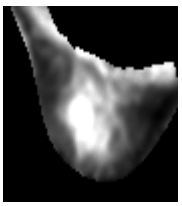
figure 4
ADC Map


figure 5
Resulting ADC ROI

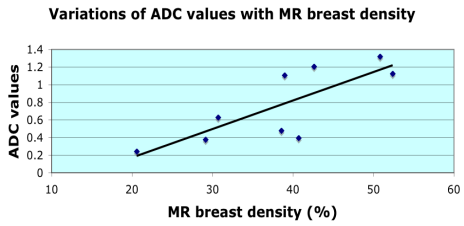

figure 6
ADC values (10^{-3} mm^2/sec) vs. MR breast density

Conclusion: We showed that ADC values strongly correlate with MR breast density, and that our quantitative tools were robust. These measures could therefore become markers for breast tissue composition, to monitor potential changes of breast tissue composition with treatment and eventually help assess breast cancer risk. This pilot study enabled us to develop our quantitative tools providing breast density and ADC values in specific regions of the breast. We expect to study breast tissue composition using our MR breast density and ADC quantitative tools on cancer patients before and after treatment, to monitor changes in breast tissue composition due to treatment.

References: [1] C. Klifa et al, IEEE EMBS 1667-1670, 2004, 16 – 16, [2] Lucas-Quesada FL et al, Radiology; 209 (Suppl):468, 1998 [3] S. Partridge et al, Journal of MRI 14:433-438 (2001).