MR-Based Computer-Aided Breast Density Measurement Compared with Mammographic Measurement

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Purpose:

Breast density has been traditionally estimated from mammographic images. The American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) criteria classifies breast parenchyma into four categories based on the ratio of fibroglandular (dense) to fatty tissue as 1: < 25%, 2: 25-50%, 3: 50-75%, 4: > 75%. However, there are limitations to this classification, as well as to any estimate of breast density based on mammography. These include: 1). high intra- and inter-observer variability in assigning a BI-RADS category; 2). frequent mixtures of fatty and fibroglandular tissues in the same breast quadrant; 3). inaccuracy in assessment of fibroglandular tissue volume because of the 2-D projectional nature of mammography; 4). differences in breast positioning, compression, and imaging technique among different mammograms. Since breast density is an independent risk factor for the development of breast cancer, accurate measurement of breast density is clinically important. There are several reasons why MRI may be preferable to mammography for assessment of breast density. MRI provides a 3-dimensional image of the breast without compression, also it demonstrates strong contrast to distinguish fatty from fibroglandular tissues. In this study, we seek to compare estimates of breast density provided by radiologists evaluating film mammography with those measured using our quantitative MR-based method.

Methods:

MR images and conventional film mammograms were compared in 20 breast cancer patients (33-76 years old, median 56). The MR images were acquired with a 1.5 T Phillips Eclipse MR scanner with a standard bilateral breast coil. MR breast density calculation was carried out on a personal computer using Image J and Matlab on T1-weighted, non-fat saturated axial MR images (**Fig. 1**). The computer-aided MRI breast density calculation has 2 steps: the segmentation of breast from body, and the segmentation of fibroglandular tissue within the breast. The breast and chest cavity are separated from other body structures by taking a “V-shape” cut at the level of the aortic arch; two lines are drawn from the spinous process of the vertebrae lateral to the pectoralis major muscles. The fuzzy C-means (FCM) algorithm was applied to further separate regions based on the contrast between different tissue clusters (e.g. air – darkest, fibroglandular tissue and chest wall – medium intensity, adipose tissue – brightest). Additional manual segmentation corrects for any mistakes made during automatic segmentation. To calculate the breast density, again FCM is applied to assign tissue classifications as adipose or fibroglandular tissues. Breast density was calculated as fibroglandular tissue volume divided by total breast volume. All patients in this study had been diagnosed with unilateral breast cancer and only the contralateral normal breast images were analyzed. Conventional film mammograms of the same patients were analyzed by four radiologists. The radiologists estimated breast density from both craniocaudal and mediolateral oblique views according to BI-RADS, and also by deciles (0-10%, 10-20%, … density, etc). Each radiologist estimated the density independently and was blinded to the results of the other radiologists. Pearson correlation was used to compare MR versus mammographic breast density measurements, using the average of the four readers’ estimates for each patient according to deciles and also BI-RADS methods. Inter-observer agreement between the four radiologists was computed using the Fleiss Kappa test.

Results:

The averaged breast density from 20 patients was 10.2 ± 1.9% based on quantitative MRI. On mammogram, the mean BI-RADS density category evaluated by 4 radiologists was 2.5 ± 0.98, and the mean mammographic density percentage was 49.0 ± 23.6% based on deciles estimates. The inter-operator variability for computer-aided MRI calculations of breast density was less than 5%. The inter-reader agreement among radiologists for the BI-RADS estimates, as computed by the Fleiss Kappa test was at the border line of poor to fair with κ = 0.22 ± 0.06. The strength of agreement according to κ values are as follows: < 0.20, poor; 0.21 – 0.40, fair; 0.41 – 0.60, moderate; 0.61 – 0.8, good; 0.81 – 1.00, very good. **Fig. 2** shows Pearson correlations of the radiologists’ deciles and BI-RADS estimates of breast density vs. that calculated by computer-aided MRI, yielding loose positive correlations with R^2 values of 0.473 and 0.420, respectively. It is clear that the positive correlation was mainly driven by 4 cases with the highest density on MRI. Two case examples are shown in **Fig.1** to illustrate the lack of correlation between MRI-based and mammography-based density measurements. It was clearly noted that these two patients have very different densities (5.2 vs. 11.8% on MRI). However, a small amount of scattered dense tissues within the breast could yield a moderate density on the projection mammogram, which made it difficult to differentiate the density coming from scattered projection versus that from a much higher amount of dense tissues.

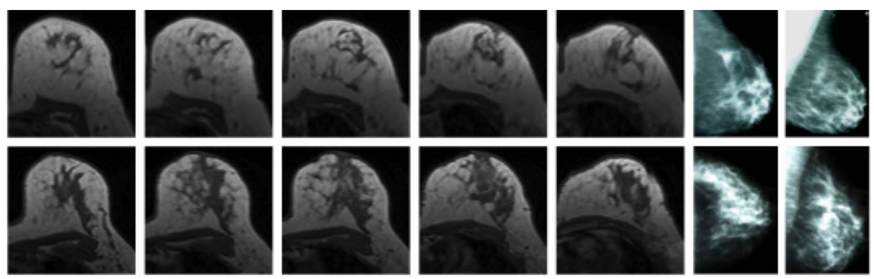

Fig. 1 Two case examples demonstrating the discrepancy between the breast density measured by MRI and mammogram. It is clearly noted that the top patient has smaller content of fibroglandular tissues (5.2% density on MRI), but because of the scattered distribution it shows a moderate density on the projection mammogram. The BI-RADS was 3, 2, 2, 3 by 4 radiologists with a mean deciles percentage of 42.5%. The bottom patient has much denser breast (11.8% on MRI), with dense tissue more confined at the center. The BI-RADS was 3, 2, 2, 2 with a mean deciles percentage of 47.5%.

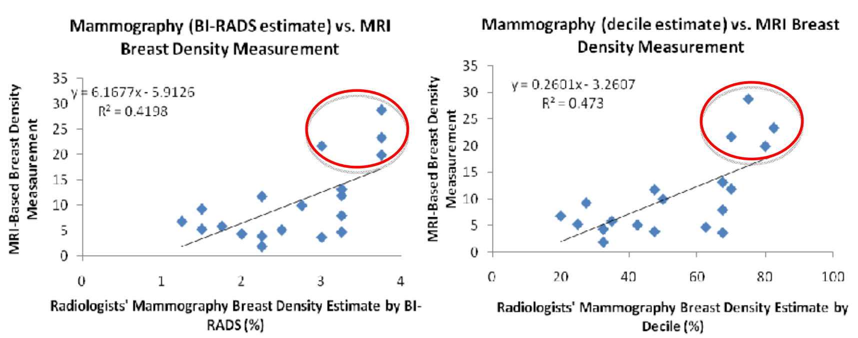

Fig. 2 The correlation between the density measured by MRI and the mean density evaluated by 4 radiologists using BI-RADS category of 1-4 (left) and the deciles percentage of 10-90% (right). It is clear that the positive correlation is mainly driven by 4 cases with the highest density on MRI. If these 4 cases are excluded, the positive correlation between MRI vs. mammography no longer exists.

Discussion:

The results show that subjective assessment of breast density, based upon evaluation of mammographic images by radiologists, was highly variable. Due to the nature of projection image, the measured density was much greater than MRI-based calculations. Correlation of the MR breast density measurement vs. both the deciles and BI-RADS estimates by the radiologists yielded a loose positive correlation. As in a recent paper by Kopans published in Radiology [246:348-353, 2008], the author suggested that the density needs to be measured based on 3D images. Our MRI-based method for density measurement has been demonstrated to have a small variation from intra-, inter-operator analysis, as well as different positions of woman inside the scanner [Nie et al. Medical Physics 2008, in press]. The MRI-based method warrants further investigation to determine whether it may provide a more accurate way of estimating breast cancer risk.