Differentiation between Intermingled and Central Type Breast Parenchymal Patterns Using Quantitative Morphological Parameters Based on Segmented Dense Tissue

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***Purpose*:**

The most well-studied breast density parameter is "mammographic density", which measures the percentage of dense tissue area over the total breast area on mammograms. There are numerous studies reporting mammographic density as a significant risk factor; the higher the percentage, the higher the breast cancer risk. There is also evidence suggesting that the relative distribution of adipose and fibroglandular tissue (referred as the breast parenchymal pattern in this work) is involved in cancer development. The adipose tissue that is abundantly present around the ductal epithelium of the mammary gland may function as a slow-release depot for lipid-soluble carcinogenic agents, and thus may affect cancer risk. However, the relationship between parenchymal pattern and cancer risk has never been reported, possibly due to the lack of both the imaging modality necessary to reveal the distribution pattern and the appropriate analysis methods. MRI provides 3D images of the breast, and that allows for the slice-by-slice segmentation of the fibroglandular and the fatty tissues for the evaluation of breast parenchymal pattern. The purpose of this work is to develop quantitative parameters to characterize the different morphological distribution patterns of fibroglandular and fatty tissues.

Methods:

A total of 301 patients, who had unilateral breast disease and for whom age and race information was available, were included in this study. Patients who had fatty breasts with the percent density < 7% (N=71) were classified as the fatty breast group. Since this group could easily be classified based on percent density alone, they were not included in the morphology analysis. The remaining 230 patients were used for the analysis of breast parenchymal pattern. The cases were assigned to Type-I (N=141, the intermingled pattern with mixed fatty and fibroglandular tissue) or Type-C (N=89, the central pattern with confined fibroglandular tissue inside surrounded by fat outside) based on the consensus of a radiologist and a physicist. Four morphological parameters that are sensitive to shape ("Circularity" and "Convexity") and margin (related to the ratio between the surface area and the total volume, "Irregularity" and "Compactness") were used to differentiate between Type-I and Type-C. Circularity is the ratio of the fibroglandular tissue volume within the sphere of effective diameter to the total volume of fibroglandular tissue (Fig.1). Convexity is the ratio of the fibroglandular tissue volume to the volume of the minimum convex hull. The irregularity index compares the total surface area to the surface area of a sphere with effective diameter. Compactness is the ratio of the total surface area to the volume. The histogram and ROC analysis were performed to differentiate these two patterns.

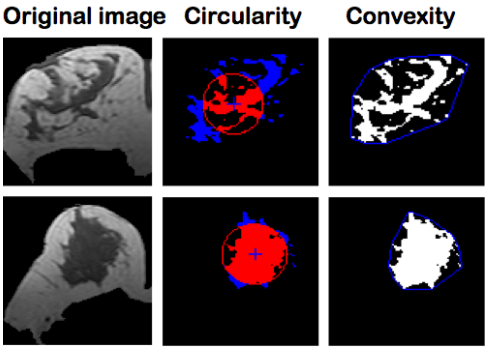

Figure 1: Two parenchymal patterns, Type-I (top): intermingled dense and fatty tissue, Type-C (bottom): confined fibroglandular tissue surrounded by fat.

Results:

Figure 2 shows the histogram of these 4 parameters in Type-I and Type-C. Two cases with comparable densities, one with high index and one with low index were graphically depicted as examples for visual inspection. In ROC analysis, the sensitivity was defined as the ability to correctly classify the intermingled pattern (Type-I), while specificity was defined as the ability to correctly classify the central type (Type-C). Among all four parameters, the "Compactness" index was the best single predictor, which attained the highest area under the ROC curve (AUC) of 0.84. When all 4 parameters were combined, the AUC was further improved to 0.94.

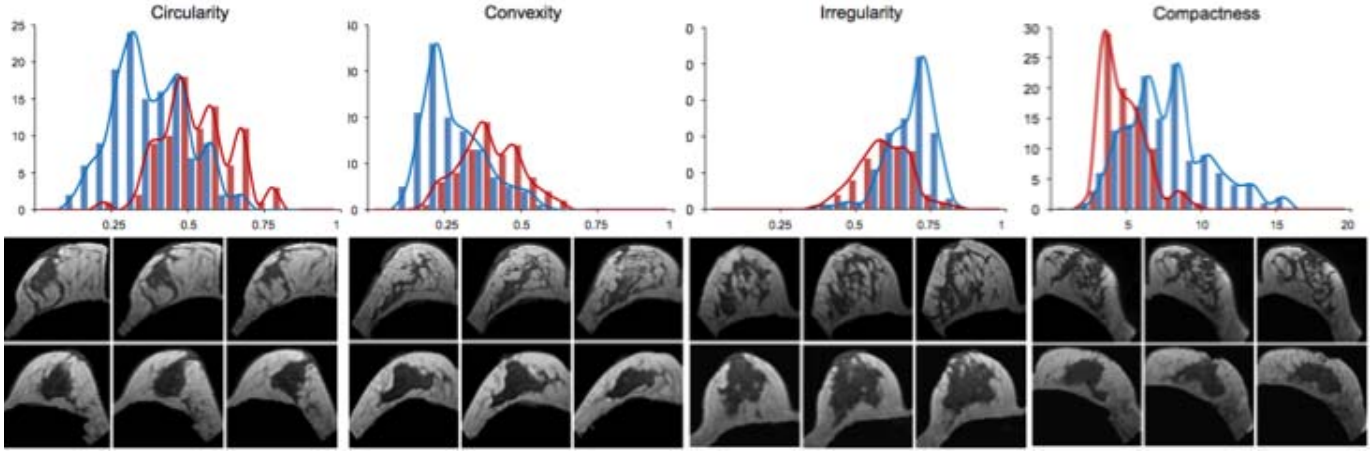

Figure 2: The histogram of these 4 quantitative morphological parameters between Type-I and Type-C cases. The widest separation is by compactness. The cases with high and low index are selected from the neighborhood of #35 and #195 ranking among all 230 cases demonstrate distinct patterns.

***Discussion* :**

We have demonstrated that the parameters (Circularity, Convexity, Irregularity, and Compactness) can be used to characterize dense tissue distribution patterns based on MRI, and they can be used to investigate the relationship between parenchymal pattern and the cancer risk. For example, between two women who have similar percent density but have differing parenchymal patterns (e.g. central type verses mixed type), who will have a higher risk of developing cancer? Our method to characterize the morphology of the fibroglandular tissues provides an essential foundation for such research in the future. Breast density is a well-established risk factor, and a consensus has been reached by the Breast Cancer Prevention Collaborative Group (BCPCG) to incorporate quantitative breast density into risk models. The morphological breast density features may also be incorporated into models to further improve the accuracy in predicting each individual woman's cancer risk.

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