Quantitative Assessment of Quadrant Breast Density Using 3D MRI

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Background and Purpose: Mammographic density is an independent risk factor for breast cancer. The biological basis for this increased risk for breast cancer associated with increased mammographic densities is not fully understood. Studies of mammographically dense tissues suggest that density may represent increased epithelial cellular concentration, stromal fibrosis, and epithelial hyperplasia. A fundamental question that has yet to be answered is whether cancers tend to arise in mammographically dense tissue. Among few studies exploring the question, one study did show that DCIS occurs overwhelmingly in the mammographically dense areas of the breast, suggesting that some aspect of stromal tissue comprising the mammographically dense tissue directly influences the carcinogenic process in the local breast glandular tissue [1]. A recent study also noted that tumors arise predominantly within the radiodense breast tissue [2]. Another study, however, found that accounting for overall percentage density, density in the region where the cancer subsequently developed was not a significant risk factor [3]. Many studies have shown the quadrant disparity of cancer risk and noted that the upper outer quadrant (UOQ) of the breast is the most frequent site of carcinoma. An adequate explanation for this asymmetric occurrence of breast cancer within the breast has never been established. This study aimed to use MRI to investigate the density distribution in the four quadrants of the breast and compare between a Western and an Asian cohort.

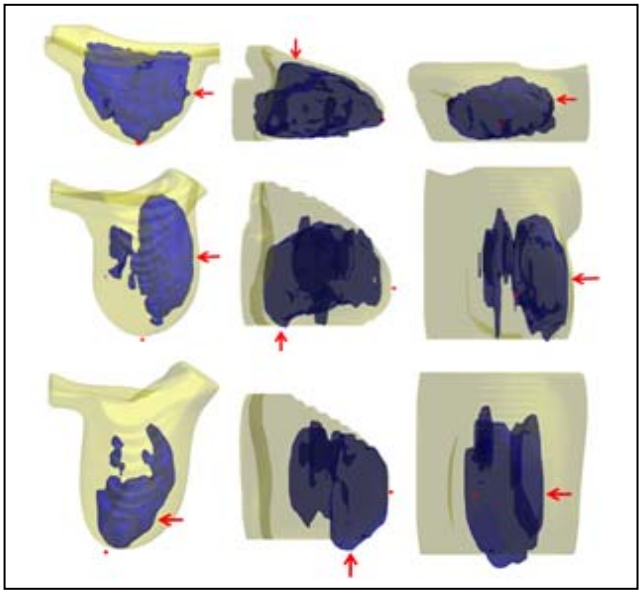
Materials and Methods: Breast MRI from Western women (N=250) and Asian women (N=156) was used for the comparison of regional (quadrant) breast density. The MRI was performed for screening and diagnostic purposes, acquired using 1.5T scanners. Only the normal breasts without cancer were used for imaging analysis. Non-contrast-enhanced T1-weighed MR images were used for the analysis of MR breast density. The 3D MR segmentation was based on our previously developed methods [4]. MRI measures are dependent on accurate and reliable segmentation of breast from background and fibroglandular tissue from fat. A novel method based on nonparametric nonuniformity normalization (N3) and adaptive FCM algorithm was used to remove the strong intensity non-uniformity and correct the bias field for segmentation of fibroglandular tissue and fatty tissue. The standard FCM algorithm is applied to classify all pixels on the image. The default setting is to use a total of 6 clusters, 3 for fibroglandular tissue and 3 for fatty tissues. The segmented breast and fibroglandular tissue from all slices were then reconstructed into 3D volume. The nipple was used as an anatomic landmark to divide the breast into four quadrants. The quadrant density (QD) in each breast was compared between the two cohorts.

Results: In total, 91 right breasts and 65 left breasts from the Asian cohort, and 144 right breasts and 106 left breasts from the Western cohort were analyzed. In the Asian cohort, combining the left and the right breasts, the highest QD was found most frequently in the inner upper, followed by the inner lower, quadrant. In the Western cohort, on the contrary, the highest QD was noted in the outer lower, followed by the outer upper, quadrant. Details of results are shown in **Table 1**. Three case examples showing the difference of QD in the two subject cohorts are also presented **Figure 1**. In Figure 1, the upper panel is the quadrant breast density acquired from three-dimensional reconstruction of the normal right breast of an Asian woman showing that inner upper quadrant had the highest density (42.1%) followed by the outer upper quadrant (31.1%), outer lower quadrant (30.0%), and inner lower quadrant (28.3%). The higher breast density in the inner upper quadrant could be visually noted (indicated by arrows). The middle panel is the quadrant breast density acquired from three-dimensional reconstruction of the normal left breast of a Caucasian woman showing that outer lower quadrant had the highest breast density (28.8%) followed by the outer upper quadrant (6.49%), inner lower quadrant (5.5%), and inner upper quadrant (5.4%). The higher breast density in the outer lower quadrant could be visually noted (indicated by arrows). The lower panel is the quadrant breast density acquired from three-dimensional reconstruction of the normal left breast of another Caucasian woman showing that outer lower quadrant had the highest breast density (15.4%) followed by the outer upper quadrant (11.1%), inner upper quadrant (3.3%), and inner lower quadrant (1.4%). The higher breast density in the outer lower quadrant could be visually noted (indicated by arrows).

Table 1. Frequency of highest quadrant breast density in four quadrants of two cohorts

	Inner Upper	Inner Lower	Outer Upper	Outer Lower
Asian Cohort (N=156)				
Right breast (N=91)	31	26	13	21
Left Breast (N=65)	30	11	5	19
Total	**61**	37	18	40
Western Cohort (N=250)				
Right breast (N=144)	24	32	39	49
Left Breast (N=106)	23	19	30	34
Total	47	51	69	**83**

Figure 1. Case examples of quadrant density in the two study cohorts



Discussion: The results from the preliminary study comparing the quadrant breast density in two subject cohorts have shown that the Asian and Western women have different patterns of regional breast density. While Asian women are most likely to have the highest density in the inner upper quadrant; Western women are mostly likely to have the highest density in the outer lower quadrant. As literature reports have noted that breast cancer most commonly occurs in the outer upper region of the breast, our study suggested that regional breast density cannot fully explain the preference of breast cancer growth in a specific breast location.

References: 1. Ursin G, et al. Breast Cancer Research 2005, 7:R605-R608; 2. Pereira SMP, et al. Cancer Epidemiol Biomarkers Prev; 2011;20(8); 1–8.; 3. Vachon CM, et al. Cancer Epidemiol Biomarkers Prev 2007;16(1):43–9.; 4. Lin M, et al. 2011;38(1):5-14.

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