Consistency of Breast Density Measured from the Same Women Using Different MR Scanners at 1.5T and 3.0T

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Background and Purposes:

Evidence from many screening mammography studies, with up to millions of women, has proven that mammographic density is a risk factor for development of breast cancer. The Breast Cancer Prevention Collaborative Group has recommended that mammographic density should be incorporated into the risk prediction model. However, so far there is limited success. Due to its 2 dimensional nature, mammographic density bears the intrinsic limitation of tissue overlapping, and it cannot provide a true volumetric measure. Also, the measured density is susceptible to many sources of variations. Other methods that can measure quantitative breast density, e.g. based on 3D MRI, have been developed, and it is believed that a more reliable measure of density will help develop an improved risk prediction model. However, MRI is more expensive than mammography, and currently only women with lifetime risk greater than 20% are recommended to receive breast MRI for screening. The cases that can be collected from a single institution are limited. Combining MRI from multiple centers is the only feasible way to obtain a large dataset for assessing the association between MRI-based density and cancer risk. As the first step, whether or how the densities measured from different centers can be combined needs to be investigated. The purpose of this work is to compare the measurement consistency of fibroglandular tissue volume and percent density using 4 different MR scanners.

Materials and Methods:

Thirty healthy female subjects without any history of breast disease were recruited for this study. Each subject was consented to receive 4 non-contrast breast MRI studies using 4 different MR scanners, including GE 1.5T and 3T, Siemens 1.5T and Philips 3T. The four scan sessions were completed within 2 days. Four sets of images, including both fat-sat and non-fat-sat T1-weighted and T2-weighted, were acquired. The sequences were optimized with the assistance of clinical application scientists from each vendor, to make the image quality across the 4 scanners as consistent as possible. The parameters for spatial resolution (acquisition matrix and slice thickness) and coverage field of view (FOV) were kept the same. The breast and fibroglandular tissue segmentation method was based on a published method [Med. Phys. 35:5253–5262 (2008)]. First, an initial cut was made to separate the breast from the thoracic region. This is done using each individual subject's sternum as the landmark, so the breast region analyzed from 4 scanners can be made consistent. Then the chest wall muscle was excluded using b-spline surface fitting. Since the skin showed different contrasts on these 4 different images, it was excluded in the breast volume for comparison. The quantitative breast volume (BV), fibroglandular tissue volume (FV) and the percent density (PD) were obtained. The reproducibility of the measured parameter from the same breast on 4 scanners was compared based on the coefficient of variation (CV), which is the standard deviation from the 4 measurements divided by their mean.

Results:

The results analyzed from non-fat-sat T1 weighted images of 5 subjects are presented here. Overall, these four scanners provided satisfactory image quality for density analysis. The contrast between fibroglandular tissue and the fatty tissue is clear for segmentation. Overall, the images acquired by the Philips 3T scanner had the brightest signal intensity, followed by Siemens 1.5T, then GE 3T and GE 1.5T. Siemens 1.5T showed the best contrast between fibroglandular and fatty tissues. **Figure 1** shows the MR images of four cases that present different amount of dense tissues and the breast parenchymal morphological patterns. **Table 1** summarizes the breast volume (BV), fibroglandular tissue volume (FV), and percent density (PD) measured from these 4 subjects shown in Figure 1. The averaged measurements from the left and the right breasts are listed. The protruding depth of the breast into the coil appeared shallower on the 2 GE scanners than on the Siemens 1.5T and Philips 3T scanners; however, the measured breast volumes were not consistently smaller on GE. This is possibly due to the different shape of the breast coils. Although the volume of the breast on GE appeared smaller on these presented images, overall the entire breast tissues were covered in the 3D imaging slab. The coefficient of variation for each parameter analyzed from these 4 different scanners is also listed in the table. **Table 2** shows the range, mean and standard deviation of CV from 10 analyzed breasts of 5 subjects. The mean CV is 4.0% for breast volume, 6.2% for fibroglandular tissue volume; and 6.0% for the percent density.

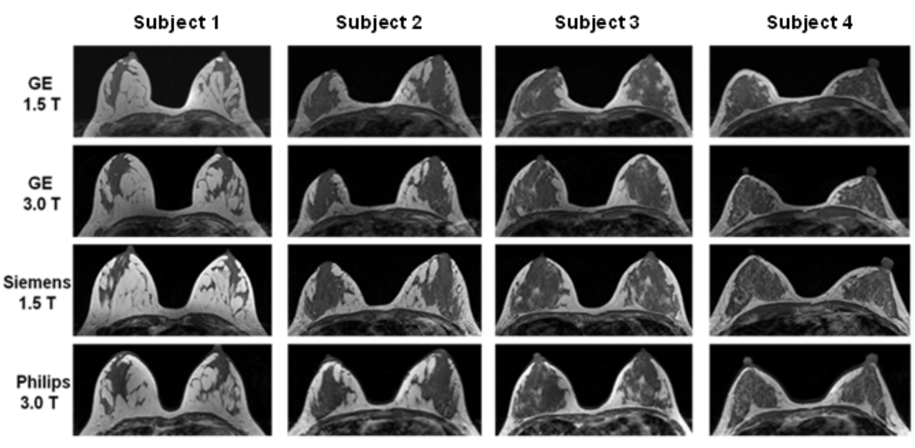

Figure 1. Representative images of breast MRI from four subjects acquired using four MR scanners. They present different amount of dense tissues and different breast parenchymal morphological patterns. The measurement of BV, FV, and PD are listed in Table 1. The coefficient of variation is in the range of 2%-9%.

Table 1: The BV, FV, and PD from 4 subjects shown in Figure 1.

	Sub #1	Sub #2	Sub #3	Sub #4
	Breast Volume (BV, cc)			
GE 1.5	421	216	272	234
GE 3.0	463	224	291	227
Siemens 1.5	441	219	287	238
Philips 3.0	451	226	290	247
Variation	**4.0 (%)**	**2.1 (%)**	**3.0 (%)**	**3.5 (%)**
	Fibroglandular Tissue Volume (FV, cc)			
GE 1.5	62.9	56.1	80.7	67.6
GE 3.0	65.4	53.0	89.8	70.0
Siemens1.5	65.7	49.3	84.6	60.8
Philips 3.0	71.5	57.0	94.8	64.6
Variation	**5.5 (%)**	**6.5 (%)**	**7.0 (%)**	**6.0 (%)**
	Percent Density (%)			
GE 1.5	15.0	26.1	29.6	28.9
GE 3.0	14.1	23.8	30.7	30.8
Siemens1.5	14.9	22.5	29.5	25.6
Philips 3.0	15.8	25.2	32.6	26.1
Variation	**4.0 (%)**	**6.6 (%)**	**4.7 (%)**	**8.8 (%)**

Table 2: The coefficient of variation (CV) among 4 measurements from 4 different scanners, from 10 analyzed breasts

	BV	FV	PD
Range	1.8 ~ 6.1 (%)	2.8~ 10.7 (%)	3.1 ~ 10.4 (%)
Mean ± stdev	4.0 ± 1.3 (%)	6.2 ± 2.3 (%)	6.0 ± 2.2 (%)

Discussion:

The results obtained so far in 5 subjects are very encouraging. As seen on the images shown in Figure 1, the shape of the breast inside different scanners appears very different, which is expected. We used 4 different scanners from 3 vendors, at 2 different field strengths; yet overall the mean variation from 10 analyzed breasts is 4% for BV, 6.2% for FV, and 6.0% for PD. The results indicated that since the breast density is analyzed based on 3D images, as long as the entire breast is covered, and that the analysis is based on each individual woman's own body landmark, the measure density parameters from multiple centers using different imaging protocols are very likely suitable for combined analysis. When all datasets are analyzed, we will further investigate the variation in different types of breasts, in terms of size and the morphological pattern.