Comparison of Breast Density Measured on Fat-suppressed versus Non-fat-suppressed MRI

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Purpose: Mammographic density is known to be strongly associated with the risk of breast cancer development. Since the measurement is made from 2D projection images, it is susceptible to different positioning of patients. Furthermore, it does not provide true volumetric information, an issue pointed out by Kopans [1]. MRI acquires 3-dimensional images, and thus provides a promising alternative for characterizing volumetric breast density as well as relative tissue distribution patterns. Although it is no longer sensitive to positioning issues, the question of whether the measurement is affected by technical factors, such as the choice of pulse sequences, needs to be investigated. Two commonly used pulse sequences in breast MRI are fat-suppressed (fat-sat) and non-fat-suppressed (non-fat-sat) T1-weighted sequences, and both demonstrate distinct contrast between the background, fatty tissue, and fibroglandular tissue. The purpose of this work is to compare the segmentation of breast and dense tissue based on T1 fat-sat and non-fat-sat images.

Methods: A total of 21 women were scanned using a 3T Phillips MRI scanner. Fat-sat and non-fat-sat images were acquired before injection of contrast agents. Example images taken from the same woman are shown in Fig.1. For the non-fat-sat image, the fat is bright, and for the fat-sat image the fat is dark. The breast density was analyzed with a software package previously developed by our group [2], which uses a fuzzy c-means segmentation algorithm with b-spline curve fitting to first segment the breast from the rest of the body and then to segment fibroglandular tissue from breast adipose tissue (Fig.1). The percent density is then calculated to be the total volume of fibroglandular tissue divided by the total volume of the breast. Because the segmentation for fatty breast is not reliable, for the purpose of this work, the fatty cases (n=8), which had less than 8% calculated breast density for both sequences, were excluded from the comparison. An additional 5 breasts were excluded due to severe fat inhomogeneity issues that could not be corrected for in the segmentation. The intra-rater reproducibility was evaluated by performing the segmentation three times on both sets of images, with a two week interval in between each analysis session.

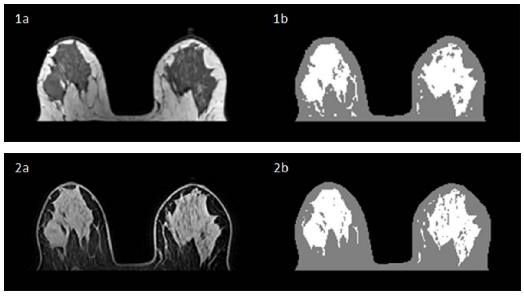

Figure 1. (a) non-fat-sat image (b) segmentation result.
Figure 2. (a) fat-sat image (b) segmentation result.

Results: The results averaged over three different analysis sessions are shown in Table 1. The correlation between the measurements based on fat-sat and non-fat-sat sequence was determined by Pearson's correlation (Fig.2), and the coefficients for breast volume, fibroglandular volume, and the percent breast density were r=0.997, r=0.930, and r=0.952, respectively, signifying strong linear correlation. These correlations were also very close to the unity slope (Fig.3). For non-fat-sat images, it was noted that the operator's selection of the cluster/mask number used in the segmentation algorithm had to be 6/3 to attain visually satisfactory segmentation results, whereas for fat-sat images, a range of cluster/mask values would still lead to visually reasonable segmentation results, though with differing volumetric results for each. This is most likely the result of the relative differences in tissue contrast between the two pulse sequences. Despite this interesting feature, a standard cluster/mask of 6/3 achieved visually acceptable segmentation results and was used for all subjects for both sequences in this study, and high intra-rater reproducibility was achieved for both sequences.

Table 1. Mean values across three analyses. Intra-rater reproducibility expressed as average percent standard deviation. Significant differences expressed as *p* values.

	Non-fat-sat	Fat-sat	*p* Value
BV mean ± stdev (avg stdev)	629 ± 336ml (3.5%)	683 ± 366 ml (2.2%)	p<0.000
FV mean ± stdev (avg stdev)	93.3 ± 55.1ml (2.5%)	100.0 ± 50.0ml (2.5%)	p<0.022
BD mean ± stdev (avg stdev)	16.6% ± 8.2% (2.8%)	16.4% ± 7.9% (2.7%)	p<0.920

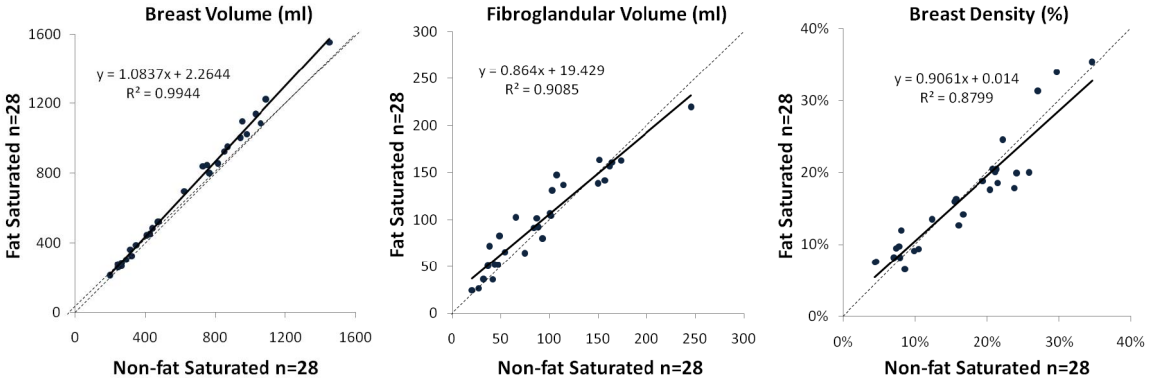

Figure 3. Correlation of breast volume, fibro-glandular volume, and breast density measured based on non-fat-sat and fat-sat pulse sequences. The dashed line shows the unity line as a reference point.

Conclusions: We have demonstrated that the measurement of breast volume, fibroglandular tissue volume, and percent density based on fat-sat and non-fat-sat sequences are highly correlated, though not at a 1:1 ratio, most likely due to relative tissue contrast differences between the two sequences. It is well known that segmentation is dependent on the contrast between different tissues, and our results show that the breast and fibroglandular tissue volume analyzed from the fat-sat images tend to be higher than those from non-fat-sat images, but maintain comparable percent density. This may be in part be due to the larger relative tissue contrast in fat-sat images, which allows for the selection of a much wider range of cluster/mask values that lead to acceptable segmentation results. For both sequences, the intra-operator variability was small, with less than 3.5% variation for all three volumetric measurements. Thus in practice, the findings suggest that images acquired using either pulse sequence can be used for MR-based density calculations; however, if the changes from the same woman are to be evaluated, breast density should be assessed from images acquired using the same sequence. The evidence also suggests that fat-sat images, with their stronger relative tissue contrast, may possibly produce more accurate segmentation results; once a ground truth can be established for 3-dimensional-based methods of volumetric assessment, this topic can be assessed in greater detail.

References: [1] Kopans. Radiology 2008; 98(17):1204-14. [2] Nie K, et al. Medical Physics 2008; 35(12):5253-5262.
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