

Correlation of percent breast density with background parenchymal enhancement measured in MRI

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Background and Purpose: Background parenchymal enhancement (BPE) is commonly observed in dynamic contrast enhanced (DCE)-MRI. BPE can be affected by age and hormonal status. BPE may influence the diagnostic performance of breast MRI. BPE is most commonly measured qualitatively by visually evaluating the degree of enhancement. Alternatively, BPE can be measured precisely based on segmented fibroglandular tissue (FT) in the breast, by averaging the enhancements from all pixels [1]. Like percent breast density (PD), recently, BPE was found to be a risk factor for breast cancer [2]. Since both PD and BPE can be affected by hormonal status, it is reasonable to postulate that both parameters will correlate each other to a certain degree. Few studies have investigated the correlation between PD and BPE. A significant correlation between qualitative assessment of MR density and enhancement levels was noted [3], while other studies did not find a strong correlation [4, 5]. The different results may be attributed to different analysis methods that were used to assess density and tissue enhancement in these studies. In this study we aimed to correlate PD and BPE in the contralateral normal breast (CNB) of patients who was diagnosed with breast cancer. For BPE, two measurements were investigated, the mean enhancement measured from the entire FT and the hot spot enhancement based on an automatic search.

Materials and Methods: Breast MRI of the CNB of 117 female patients (age range 30-76, mean 50.3 y/o) diagnosed with breast cancer were studied. 67 patients had MRI at 3.0T MR, and 50 patients had MRI at 1.5T MR. The non-enhanced non-fat-saturated T1W images were used for breast segmentation. The quantification of the fibroglandular tissue volume (FV) was based on a computer-assisted algorithm [6]. In this study we did not apply any imaging co-registration algorithm to fuse the segmented FT with the contrast-enhanced images. The degree of misalignment that may be present within the dynamic series was assessed using a least squares approach and a rigid body spatial transformation with respect to the first dynamic frame. The misalignment of the different frames of DCE-MRI, compared to the non-enhanced images, was very minimal (usually less than one half of pixel shift) and deemed negligible. An example was shown in **Figure 1**. For hot spot measurement, only the 50 patients acquired at 1.5T MR were studied. After the segmentation, the largest connecting piece was identified for the search of hot spot. Using this criterion can ensure that the hot spot is within the FT, not from isolated vessels. A kernel of 3 x 3 pixel was applied to search through the largest connecting piece on the subtraction image taken at 5 min after contrast injection (frame #12), and the box that has the highest signal enhancement is identified as the hot spot. A mean signal enhancement time course was obtained by averaging over all pixels contained in the segmented FT, also the hot spot enhancement time course was obtained by averaging over the 9 pixels contained in the hot spot box. The percent enhancement is calculated as the signal intensities difference measured between post-contrast frame (#12) and pre-contrast frame (#3) divided by pre-contrast intensity (x100%). The mean background enhancement and the hot spot enhancement were correlated with age, and also with FV and PD.

Results: Overall, there was a weak negative correlation between age and PD ($r=-0.34$), and age and FV ($r=-0.35$). For the correlation of PD or FV with BPE or hot spot, it was also noted that only very weak correlation was shown. Nevertheless, hot spot measurement did correlate better with PD or FV, compared to BPE measurement (PD vs. BPE, $r=0.09$; FV vs. BPE, $r=0.22$; PD vs. hot spot, $r=0.24$; FV vs. hot spot, $r=0.33$) (**Figure 2**). **Figures 3-5** (upper, middle and lower panel respectively) are three case examples of pre-menopausal women illustrating the correlation of background enhancement with FV and PD. **Figure 3** is a 32 y/o woman with a 9.1cm ER-negative/Her-2 negative (triple negative) invasive ductal cancer (IDC) in the right breast. Note the strong background enhancement in the left breast. The FV was 178.7ml, and PD was 33.2%. The BPE was 80.0% and hot spot measure was 140.0%. **Figure 4** is a 45 y/o woman with a 7.1cm ER-positive/Her-2 negative IDC in the left breast was noted. Note the scarce background enhancement in the right breast. The FV was 111.4ml, and PD was 7.5%. The BPE was 7.7% and hot spot measure was 14.3%. **Figure 5** is a 41 y/o woman with a 3.1cm ER-positive/Her-2 positive IDC in the left breast. Note the strong background enhancement in the right breast. The FV was 119.2ml, and PD was 13.4%. The BPE was 66.7% and hot spot measure was 166.2%. Compared to **Figure 4**, **Figure 5** had similar FV but with much higher BPE and hot spot measures.

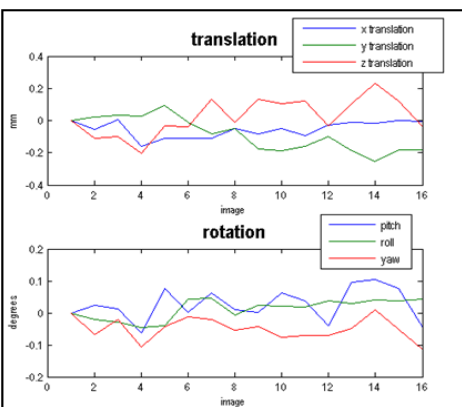


Figure 1. A representative case showing the misalignment. As noted, the misalignment was <0.2 mm for translation and < 0.1mm for rotation.

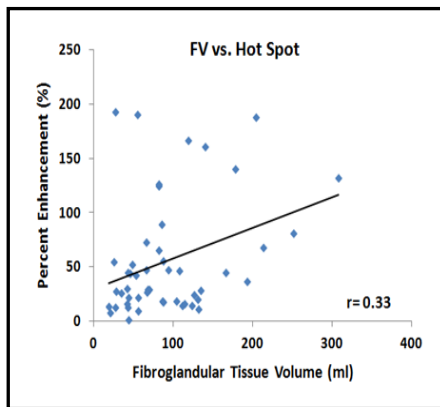
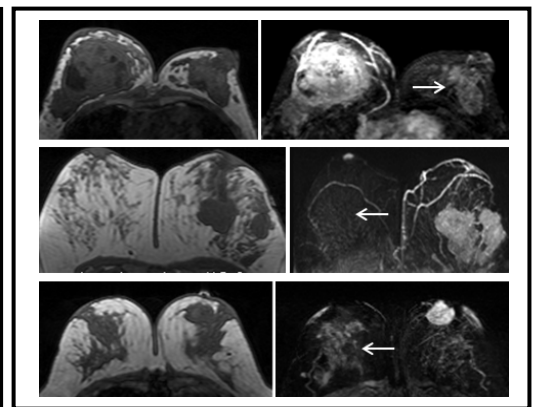


Figure 2. Correlation of FV with hot spot measure of the DCE-MRI.



Figures 3-5. The correlation of BPE and hot spot with FV and PD.

Conclusions: The results from our study showed that BPE, measured by the averaged enhancement of the whole FV or by hot spot, did not correlate well with quantitative measurement of PD and FV. The results agreed with findings from other studies [4, 5]. Despite PD and BPE are proven risk factors for breast cancer and are affected by endogenous hormonal levels, mainly ovarian function, our results indicated that the mechanisms of action of these two risk factors related to cancer occurrence may be different.

References: 1. Chen JH, et al. Magn Reson Imaging. 2013;31(9):1465-71; 2. King V, et al. Radiology. 2011;260:50-60; 3. Arkani S, et al. San Antonio Breast Cancer Research Conference 2006; 4. Cubuk R, et al. Radiol Med. 2010;115(3):434-41; 5. Klifa C, et al. JMRI. 2011;33:1229-34; 6. Nie K, et al. Med Phys. 2008;35(12):5253-62.

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