Original Investigation

Breast Density Estimation with Fully Automated Volumetric Method: Comparison to Radiologists' Assessment by BI-RADS Categories

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Rationale and Objectives: The objective of our study was to calculate mammographic breast density with a fully automated volumetric breast density measurement method and to compare it to breast imaging reporting and data system (BI-RADS) breast density categories assigned by two radiologists.

Materials and Methods: A total of 476 full-field digital mammography examinations with standard mediolateral oblique and craniocaudal views were evaluated by two blinded radiologists and BI-RADS density categories were assigned. Using a fully automated software, mean fibroglandular tissue volume, mean breast volume, and mean volumetric breast density were calculated. Based on percentage volumetric breast density, a volumetric density grade was assigned from 1 to 4.

Results: The weighted overall kappa was 0.895 (almost perfect agreement) for the two radiologists' BI-RADS density estimates. A statistically significant difference was seen in mean volumetric breast density among the BI-RADS density categories. With increased BI-RADS density category, increase in mean volumetric breast density was also seen ($P < 0.001$). A significant positive correlation was found between BI-RADS categories and volumetric density grading by fully automated software ($\rho = 0.728$, $P < 0.001$ for first radiologist and $\rho = 0.725$, $P < 0.001$ for second radiologist). Pairwise estimates of the weighted kappa between Volpara density grade and BI-RADS density category by two observers showed fair agreement ($\kappa = 0.398$ and 0.388, respectively).

Conclusions: In our study, a good correlation was seen between density grading using fully automated volumetric method and density grading using BI-RADS density categories assigned by the two radiologists. Thus, the fully automated volumetric method may be used to quantify breast density on routine mammography.

Key Words: Automated; BI-RADS; Breast density; Mammography; Volumetric method.

INTRODUCTION

Mammography is the recommended screening method for breast cancer in the general population (1). However, the sensitivity of screening mammography is reduced in women with dense breasts because of obscuration of underlying lesion by dense and heterogenous breast tissue. Because of this, chances of missing breast cancer are increased (2–4). At the same time, increased breast density has been considered as an independent risk factor for the development of breast cancer. Various studies have shown that women with high breast density compared to women with low breast density are four to six times more likely to get breast cancer (5–7). Bertrand et al. reported that women with breast density more than 50% have approximately twofold risk of developing breast cancer than women with breast density of 11–23%. The authors also reported a positive correlation between breast density and larger tumor size, positive lymph nodes, and negative estrogen receptor status (8).

The American College of Radiology (ACR) recommends annual screening mammography in women more than 40 years of age. However, in a subset of population having increased risk for breast cancer, ACR not only recommends screening at earlier age but also emphasizes the need of supplemental screening methods like ultrasound and magnetic resonance imaging (1). ACR has also recommended supplemental screening in women with genetic predisposition to the disease and in women with dense breasts (1). Thus, breast density determines the need for supplemental screening and can prove to be an important factor in risk stratification.

Various qualitative and quantitative methods have been devised for measurement of breast density on mammography. Breast imaging reporting and data system (BI-RADS) classification system is the commonest method in practice for measurement of breast density (9). The system is qualitative

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and based on visual analysis. Increased score implies increased breast density. However, this method is not reliably reproducible. Various studies done in the past have shown variable interobserver agreement among the radiologists ($\kappa = 0.43–0.76$) (10–12). In one large cohort study, wide variability was found among community radiologists in measurement of breast density and only 18% had moderate to substantial agreement (12). To overcome this problem, various quantitative methods for breast density measurement have been developed: visual computer assisted (semiautomated) or fully automated. These methods can be area based or volume based. Area-based method estimates breast density from area segmentation of two-dimensional image of compressed breast (13,14). The semiautomated method is based upon user-defined threshold thereby increasing subjectivity of the method and the results are highly user dependent, with substantial inter- and intraobserver variability (11,15). In addition, both qualitative and area-based methods have certain other limitations, including two-dimensional measurements, variability with breast compression, and no consideration of breast thickness (16). Because of these limitations, various volumetric methods have been developed for measuring breast density (17,18).

Fully automated volumetric methods for density measurement are based upon physical model that assumes that the breast is composed of fibroglandular parenchyma and fat. Tissue composition in a given pixel can be calculated from x-ray attenuation properties of these tissues, and fibroglandular density can thus be estimated (18,19). Volumetric method takes breast thickness into account and is more reproducible. Limited number of studies has been carried out in the past to compare various methods of breast density estimation. The purpose of our study was to compare qualitative method of breast density grading using BI-RADS to breast density estimates from fully automated volumetric software. Moreover, most of the previous studies have been done on a Korean population. The objective of our study was to validate the results of fully automated volumetric method on an Indian cohort.

MATERIALS AND METHODS

Patients and Mammography

This was a retrospective study approved by our institutional ethical committee. Informed written consent was obtained from all the patients. From March 2013 to April 2014, a total of 715 full-field digital mammography (FFDM) examinations with standard views (mediolateral oblique and craniocaudal) were performed. All examinations performed on asymptomatic females more than 35 years of age were included in this study. Patients with age less than 35 years, with breast symptoms, and with previous history of any breast surgery were excluded from the study. A total of 239 patients were excluded from the study. All digital mammographic examinations were performed on an FFDM unit: MicroDose SI, Philips (Amsterdam, Netherlands). The system employs crystalline silicon photon counting chamber type of detector and has spatial resolution of 50 µm and image data matrix size of 4800×5200 pixels.

BI-RADS Density Classification

The mammography images were analyzed independently by two blinded radiologists who specialize in breast imaging and had 5–10 years of experience in interpreting mammography. All the images were reviewed in Digital imaging and communication (DICOM) in medicine format at the review workstation. The images were read as a batch at the end of the study.

The radiologists assessed breast density in each mammogram according to the BI-RADS breast density categories. Mediolateral oblique and craniocaudal views were read simultaneously to assess the breast density. The following BI-RADS categories for breast density were used for mammographic interpretations: category 1, almost fatty; category 2, scattered fibroglandular densities; category 3, heterogeneously dense; and category 4, extremely dense (20).

Mammographic Density Analysis by Fully Automated Volumetric Software

For fully automated volumetric analysis, Volpara software (version 1.4.5, Mātakina Technology, LTD, Wellington, New Zealand) was used. The Volpara software processes the image data generated by the digital mammography system and calculates the breast density. The measurement starts with finding a reference point in the breast having known composition (usually near the chest wall containing all fatty tissue). Then x-ray attenuation is calculated in each pixel. From degree of attenuation in a pixel, composition of tissue located between the pixel and the x-ray source is estimated and density maps are created. By analyzing values in density maps, the software computes the fibroglandular tissue volume, the breast volume (both in cubic centimetres), and the volumetric breast density. The volumetric density is then computed from these data, which range from 0% to 40%. Mediolateral oblique and craniocaudal views are averaged and the density information is provided per breast. A Volpara density grade (VDG) is also given to each patient. Total fibroglandular tissue volume is divided by total breast volume to obtain a percentage per patient. The resultant percentage is graded as VDG as follows: 0–4.7% volumetric density, VDG 1; 4.8–7.9%, VDG 2; 8.0–15.0%, VDG 3; and 15.1% and above, VDG 4. After completion of the study, Volpara automatically processes data and sends DICOM secondary capture images containing the breast density information (Fig. 1).

Data and Statistical Analysis

Interobserver agreement in measurement of breast density using BI-RADS was calculated using weighted kappa. The kappa values were interpreted as suggested by Landis and Koch (21) as follows: a kappa value equal to or less than 0.20 indicates