RESEARCH ARTICLE

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A New Breast Density Assessment Method Using Portable Document Format

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Abstract

Purpose: Breast density assessment is an essential component of risk-stratified and supplemental breast cancer screenings for the future generation. International collaborative research and cooperation are required to determine global trends and differences in mammographic breast density. Due to the cost and energy associated with the use of film or digital mammograms, international breast density assessment studies tend to be challenging. A novel breast density assessment method using portable document format (PDF) is currently explored and the justification is needed. This study aimed to investigate the inter-method agreement between two viewing platforms – mammograms on PDF and mammograms on a workstation – for a subjective breast density assessment. **Methods:** Three radiologists assessed 100 cases with 200 normal bilateral mediolateral oblique view images twice at 1-month interval using mammograms on PDF and mammograms on a workstation. Further, to assess intra-reader agreement, one reader performed two readings of the PDF set at 1-month interval. The reading order of the images was changed each time. Weighted kappa coefficient (κw) was used to assess inter-method and intra-observer agreements. **Results:** The average inter-method agreement was substantial (κw = 0.74, range = 0.73–0.76) on a four-grade scale (fatty, scattered, heterogeneously dense, or extremely dense) and almost perfect (κw = 0.81, range = 0.78–0.84) on a two-grade scale (non-dense or dense). The intra-observer agreement was almost perfect on a four-grade scale (κw = 0.85) and two-grade scale (κw = 0.90). **Conclusion:** The PDF and mammography workstation readings for breast density assessment had almost perfect inter-method agreements. Moreover, the intra-observer agreement of PDF reading was almost perfect.

Keywords: Breast density-assessment- mammography- methods

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Introduction

Risk-stratified and supplemental breast cancer screenings for women with dense breasts are hot topics worldwide [1-4]. Efficient and effective approaches for controlling breast cancer worldwide via risk-stratified and supplemental breast cancer screenings can be established with international collaborative research and cooperation. Breast density assessment is an essential component of these approaches [5, 6]. Visually subjective breast density assessment is the most common strategy; however, it is susceptible to inter-reader and intra-reader variabilities and previous studies have reported about racial/ethnic differences in breast density [7,8]. Therefore, a multi-international analysis of breast density assessment is important. Nevertheless, there is only one report on the multi-international inter-observer variability of breast density assessment [9]. To decrease the cost and energy associated with the use of film or digital mammograms, it used a method for reading mammograms on portable document format (PDF) for breast density assessments. In addition, a recent report on the multi-institutional inter-observer variability of breast density assessment using PDF has been published [10].

Digital mammograms are typically reviewed by experts using specialized equipment and software. The Digital Imaging and Communications in Medicine (DICOM) format, which is standard for these images, demands high-speed data transfer and significant storage capacity. Consequently, online mammographic density evaluation systems face difficulties due to the extensive size of DICOM mammograms and users' limited bandwidth for uploading images. In contrast, PDF files are versatile documents that maintain consistent formatting across different devices and software. They are compressed, making them smaller than their source files,

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which facilitates quick sharing and downloading [11]. Although it has been speculated that the quality of PDF images is inadequate for diagnostic interpretation, recent studies concluded that breast density assessment using mammograms on PDF reading is clinically acceptable [9, 10]. These studies have revealed that high-resolution images are not required for density assessment comparison. However, they had a limitation because the new breast density assessment method using mammograms on PDF reading on standard monitors was not certified. Hence, we need studies to clarify the justification.

This study aimed to investigate the inter-method agreement between two viewing platforms – mammograms on PDF and DICOM mammograms on a workstation – for visually subjective breast density assessments. Further, the intra-observer agreement of PDF reading was evaluated.

Materials and Methods

The institutional review board approved this retrospective, multi-reader, multi-case study. The need for informed consent was waived (approval number: J2022-242-2022-1-3). All mammogram images taken between January 2021 and June 2021 at our institution were obtained using a commercially available digital mammography system (Selenia Dimensions; Hologic, Bedford, MA). In total, 200 normal mammograms from 100 consecutive cases were acquired. The findings were considered normal based on the breast cancer screening program. We believe that breast lesions may impact the adjacent breast tissue and potentially alter mammographic density [12]. Thus, we have omitted examinations from women diagnosed with breast lesions to avoid skewed results. All cases involved Japanese women. The mean and median ages of the patients were 57.6 and 57.0 (range: 41–69) years, respectively. Three Japanese radiologists who were ranked as having an "A" certification from the Japan Central Organization on Quality Assurance of Breast Cancer Screening assessed the normal bilateral mediolateral oblique view images twice at 1-month interval using two viewing platforms: mammograms on PDF and DICOM mammograms on a workstation. The PDF set involved was produced using the DICOM viewing workstation software to save each mammogram in the Joint Photographic Experts Group (JPEG) format with 96-dpi and 24 bits, embedding JPEG images in a PowerPoint file fitting on the screen and converting it to a PDF file (Figure 1). The optimal resolution for web usage (screen resolution) is 96-dpi. This study is intended to be conducted on personal computer monitors, hence the adoption of 96 dpi. If the image was converted to the PDF format, the readers could not adjust the image brightness (windows/widths). The PDF, with its 300-dpi resolution and 24 bits color depth, offers vivid images, perfect for professional displays on standard monitors. Each reader viewed the PDF images at 100% scale without zooming in or out.

To investigate the intra-reader agreement, one reader read the PDF set twice at 1-month interval. The reading order of the images was changed each time.

Workstation reading was performed on a commercially available mammography workstation (Climb-Mammography WS; Climb Medical Systems, Japan), with a 5-MP digital mammography-certified diagnostic color display (CCL-S500; JVCKENWOOD, Japan) calibrated to the DICOM grayscale standard display function. The reader did not use an option of scrolling and zooming and altering the window level of the images for breast density assessment.

PDF reading was performed on the commercially available personal computer of each reader, with a screen size of 15.6–19 inches and a resolution of 1,280 × 720 and 1,280 × 1,024, under a well-lit room. Each reader independently and subjectively assessed breast density according to the Breast Imaging Reporting & Data System 5th edition, published by the American College of Radiology, using a four-grade scale (category A: almost completely fatty, category B: scattered areas of fibroglandular density, category C: heterogeneously dense, which can obscure small masses, and category D: extremely dense, which lowers mammography sensitivity) [13]. Then, the breast density categories were further divided into non-dense (fatty and scattered) and dense (heterogeneously and extremely dense).

When evaluating reading sessions related to this study, note the following points: observer 1 and observer 2 each performed one interpretive reading of mammograms on PDF and DICOM mammograms on a workstation. Observer 3 performed two readings each of mammograms on PDF and DICOM mammograms on a workstation, totaling four readings.

Kappa coefficient and its 95% confidence interval were calculated to measure inter-method and intra-observer agreements for breast density assessment. The variables were ordinal scales. Hence, weighted kappa coefficient (κw) was used with weights proposed by Cicchetti and Allison [14]. R version 4.1.2 (R Core Team, November 2021; www.r-project.org) was used in all statistical analyses. Based on the Landis and Koch guidelines [15], the κw values were interpreted as follows: <0.01, poor agreement; 0.01–0.20, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0. 80, substantial agreement; and 0.81–1.00, almost perfect agreement. The cross-tabulations of each four-grade scale analysis were also performed.

Results

Table 1 shows the inter-method agreement for breast density assessment in each observer cohort. The average inter-method agreement was substantial (κw = 0.74, range: 0.73–0.76) on a four-grade scale (fatty, scattered, heterogeneously dense, or extremely dense) and almost perfect (κw = 0.81, range: 0.78–0.84) on a two-grade scale (non-dense: fatty and scattered or dense: heterogeneously dense and extremely dense). The intra-observer agreement of PDF reading was almost perfect on a four-grade scale (κw = 0.85) and two-grade scale (κw = 0.90) (Table 1,2). Supplementary tables show there is a good correlation and hardly any bias in each four-grade scale analysis.

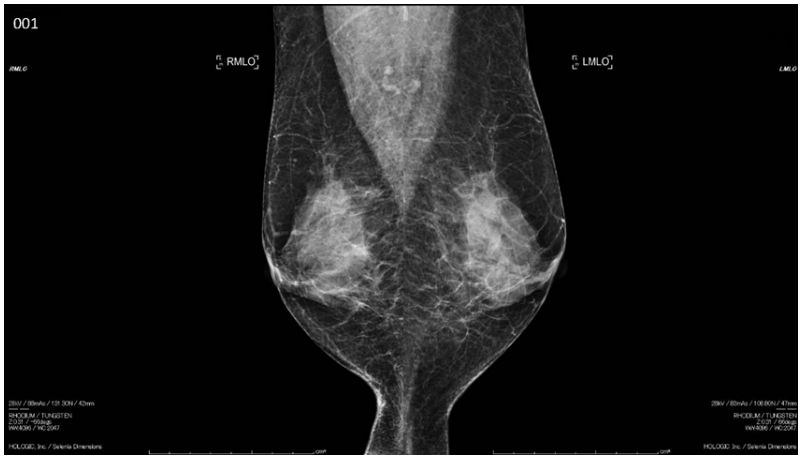

Figure 1. Mammograms on a PDF File. The case was categorized as heterogeneously dense with a perfect agreement among the three readers.

Table 1. Overall Inter-Method Agreement (95% confidence interval) for each Cohort of Observers.

Scale	Inter-method agreement		
	Observer 1	Observer 2	Observer 3
Four-grade scale	0.74 (0.62– 0.85)	0.73 (0.63 – 0.83)	0.76 (0.65 – 0.87)
Two-grade scale	0.81 (0.69 – 0.93)	0.78 (0.66 – 0.90)	0.84 (0.73 – 0.95)

Table 2. Overall Intra-Observer Agreement (95% confidence interval) for One Observer.

Scale	Intra-observer agreement
Four-grade scale	0.85 (0.76 – 0.94)
Two-grade scale	0.90 (0.81 – 0.99)

Discussion

The inter-method agreement of two viewing platforms – mammograms on PDF and DICOM mammograms on a workstation – for visually subjective breast density assessments was investigated. Results showed a near-perfect agreement for breast density assessment between PDF and mammography workstation reading. Further, the intra-observer agreement of PDF reading was almost perfect. Thus, based on these results, reading mammograms on PDF and reading on a workstation for visually subjective breast density assessments are both reliable. Unlike mammography interpretations that look for any pathological findings in the breast, breast density assessment is based on the overall view of the volume of fibroglandular tissue relative to the fatty tissue. We hypothesized that the performance of visually subjective breast density assessments via reading mammograms on PDF cannot be impaired compared with that via reading standard DICOM mammograms on a workstation. This study showed there were no problems encountered while reading mammograms on PDF for breast density assessment and confirmed that mammograms on PDF had an evident visual contrast between the fibroglandular and adipose background tissues. Hence, each reader can evaluate breast density on PDF easily and accurately. Breast density assessment, without interpretations that look for any pathological findings in the breast, does not require a reading dual-monitor workstation with 5-MP digital mammography-certified diagnostic displays with high resolution. To the best of our knowledge, this study first reported that there were no issues encountered in reading mammograms on PDF for breast density assessment using commercially available personal computers. This then takes one step forward to establishing a global consensus on mammographic breast density, and global trends and differences in mammographic breast density can be identified because environmental, equipment, storage, and delivery issues related to breast density assessment using mammograms on a workstation can be eliminated.

A multi-international analysis of breast density assessment is important for establishing efficient and effective approaches for breast cancer control worldwide via risk-stratified and supplemental breast cancer screening. Hence, identifying an alternative, low-cost, efficient, and resourceful method for breast density assessment worldwide can guarantee international multicenter collaborative research. A previous study has established a cornerstone for the global trends and differences in mammographic breast density. However, this study only included four countries. Among these countries, two had a small number of readers, and they did not have national screening mammography programs and did not perform sample-size calculations [9]. Therefore, further studies should be performed to clarify the truth. If there is a large gap in inter-observer variabilities in international breast density assessments with a visually subjective method, discussing risk-stratified and supplemental breast cancer screening with a similar concept internationally can be challenging. In such as case, cross-national studies on breast density will require quantitative software assessments of breast density [16].

PDF files can keep the original look of a document, including fonts, images, colors, and layout, no matter what software or device was used to make it. This means that if you can open a PDF, you'll see the document just as it was intended to look, with the design and information staying true to the original. The result is that the image used to evaluate breast density can be viewed on various personal computer monitors without differences in reading conditions, offering the advantage of consistent imaging across different readers.

Reading mammograms on PDF for breast density assessment using commercially available personal computers can bring another benefit. That is, international standardized breast density assessment education and training can be easily conducted for global readers to reduce variability and subjectivity.

This study had some limitations. First, it was retrospective in nature and had a relatively small population. Further large-scale studies on this strategy may be need. Second, this study showed that regarding breast density assessment reading mammograms on PDF is as accurate as reading digital mammograms on a dedicate workstation. However, global consensus of the standardization for establishing the PDF might be helpful.

In conclusion, the almost perfect inter-method agreements between PDF and mammography workstation readings can justify the use of reading mammograms on PDF for visually subjective breast density assessments. Moreover, the intra-observer agreement of PDF reading was almost perfect. The study results can promote an international analysis of breast density assessment, which improves breast cancer control worldwide via risk-stratified and supplemental breast cancer screening.

Author Contribution Statement

All authors contributed equally in this study.

Acknowledgements

Ethical statement

Our Institutional Review Board approval was obtained with No. J2022-242-2022-1-3.

Written informed consent was waived by our Institutional Review Board.

Data Availability

The datasets used and/or analyzed during the current study are available from the first author (Takayoshi Uematsu) on reasonable request.

Competing interest

The authors state that this work has no financial and non-financial competing interests.

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