Detectability of breast cancer and reading time on screening mammography: Comparison between 5-MP and 8-MP LCD monitors.

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Aims and objectives

According to ACR-AAPM-SIIM (the American College of Radiology, the American Association of Physicists in Medicine, and the Society for Imaging Informatics in Medicine) practice guideline for determinants of image quality in digital mammography (MMG), 5-megapixel (MP) monitors are recommended as soft copy devices for digital mammogram [1]. In addition, the guideline recommended that all images should be viewed at 1:1 or 100% size during the image interpretation [1]. Spatial resolution of 5MP monitor is actually 165 µm; therefore we have to use magnification function to match the pixel size between the acquired image and the monitor in viewing minute structures such as microcalcifications or marginal character of mass lesions even with 5MP monitor.

The ACR-AAPM-SIIM practice guideline shows no requirement whether the monitor should be monochrome or color; however, most of 5MP monitor used for screening or diagnostic MMG is monochrome. Thus, the advantage of the 5MP monochrome monitor is high spatial resolution, but the disadvantage is lack of general versatility because it could not be used for other modalities such as color images including [18F]-fluorodeoxyglucose positron emission tomography-computed tomography (18F-FDG-PET/CT), single-photon emission computerized tomography (SPECT-CT), volume rendering images of 3-dimensional CT, and endoscopic images. Additional disadvantage of 5MP monitor is expensiveness. On the other hand, 8MP monitor has been recently used as a medical-use liquid-crystal display (LCD) monitor, and it exhibits two 4MP monitors within one monitor.

Kamitani and colleagues reported that 3MP LCD monitor with magnifying function showed comparable results to 5MP LCD monitor regarding the detectability and characterization of breast cancer on screening MMG, and Yamada and colleagues also showed the similar results [2, 3]. Therefore, we hypothesized that 8MP LCD monitor that is dihedral 4MP LCD monitors could achieve comparable detectability of breast cancer by using the magnification function. In addition, the merit of single plane of an 8MP LCD monitor could clear the border of the dual planes of 5MP LCD monitors, and observers are expected to easily compare the bilateral breasts in a short reading time. Thus, the purpose of this study was to compare detectability of breast imaging reporting and data system (BI-RADS) 3 or more breast lesion and reading time on screening MMG between 5-MP and 8-MP LCD monitors.
Methods and materials

Patient Selection

This retrospective patient study was approved by the institutional review board (No. 22-11), informed consent was waived. One hundred and twenty patients (50 normal cases, 50 cancer cases, and 20 benign cases; age range, 26-85 years; mean ± S.D., 55.0 years ± 11.8) examined between 2012 January and March 2013 were consecutively selected for the assessment of observer performance.

Image Acquisition

All mammograms were performed with AMULET (FUJIFILM, Tokyo, Japan) as the flat panel display (FPD) system. The plate size was 18x24 cm, and the focus size was 0.3 x 0.3mm. Spatial resolution was 50 µm per pixel (pixel dimension: 3,540 x 4,740), and the contrast resolution was 14 bits.

Image Display

The images were displayed on two types of monitor; i) a set of monochrome, 5-MP LCD monitors (RadiForce GX540; 2048 pixels x 2560 pixels, 21.3 inch; pixel size, 165 µm; EIZO, Ishikawa, Japan), and ii) a single plane of color, 8-MP LCD monitor (RadiForce RX850; 4096 pixels x 2160 pixels, 31.1 inch; pixel size, 170.4 µm; EIZO, Ishikawa, Japan). Physical properties of two types of LCD monitors are shown in Table 1. Those monitors run with the PACS software (Synapse 3.2.1, FUJIFILM, Tokyo, Japan) and the viewing software specialized for MMG (Mammoview, FUJIFILM, Tokyo, Japan). The maximum luminance was adjusted to 500 cd/mm², and the output contrast resolution was 8 bits in both sets of monitors.

<table>
<thead>
<tr>
<th>Physical properties of two types of LCD monitors.</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen size</td>
<td>EIZO, Ishikawa, Japan</td>
</tr>
</tbody>
</table>
Image Interpretation

Six board-certified radiologists (6-25 years' experience in breast radiology, mean 15 years) assessed two same sets of 120 bilateral MLO view mammograms (50 normal cases, 20 benign cases, and 50 cancer cases) in each reading test. A total of 480 MMG images (120 patients × 2 sides × 2 types of monitors) were analyzed. Soft copies of all images were displayed on a workstation (Mammoview; FUJIFILM, Tokyo, Japan) with two types of LCD monitors (Table 1). The room luminance at the center of the display was 30 lux, as measured with a calibrated photometer (ANA-F9 Lux Meter; Tokyo Photo-Electric, Tokyo, Japan).

All observers independently assessed 240 images (120 patients × 2 sides) in each reading test using two different monitors without the knowledge of the screening results. The order of used monitor type was also randomized in each observer (three observers used 5MP LCD monitors first, and the rest used 8MP LCD monitor first). The observers were asked to rate the images on a continuous scale of 0 to 100 for the likelihood of the presence of BI-RADS category 3 or more lesion that require further examination [4]. The imaging datasets were randomly ordered in each reading session in each observer, and the interval between the reading tests in each observer was more than 1 month to reduce the learning effect [5].

Statistical Analysis

The detection performance of BI-RADS category 3 or more breast lesion was evaluated using receiver operating characteristic (ROC) analysis [6]. The confidence level results were used to construct ROC curves. For the calculation of the area under the ROC curve (AUC), a statistical program (DBM MRMC 2.2 Build 3; University of Chicago, Chicago, IL, USA) was used. This statistical program was based on the jack-knife method [6]. The mean reading time for six observers was compared between 5MP- and 8MP-LCD monitors using a paired t-test. Statistical software (JMP Pro 9.0.2; SAS, Cary, NC) was
used to analyze the raw data. P values less than 0.05 were considered statistically significant in each statistical analysis.
Results

**ROC Analysis for BI-RADS 3 or more breast lesion detection**

Table 2 and Fig. 1 show the AUC values and the ROC curves for the detection of BI-RADS 3 or more breast lesion using 5MP- and 8MP-LCD monitors, respectively. The mean AUC value in the detection of BI-RADS 3 or more breast lesion using 5MP-LCD monitors and an 8MP-LCD monitor were 0.925 and 0.915, respectively. The difference was not statistically significant ($P = 0.46$).

<table>
<thead>
<tr>
<th>Reader</th>
<th>5MP</th>
<th>8MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reader 1</td>
<td>0.898</td>
<td>0.909</td>
</tr>
<tr>
<td>Reader 2</td>
<td>0.929</td>
<td>0.937</td>
</tr>
<tr>
<td>Reader 3</td>
<td>0.924</td>
<td>0.915</td>
</tr>
<tr>
<td>Reader 4</td>
<td>0.900</td>
<td>0.878</td>
</tr>
<tr>
<td>Reader 5</td>
<td>0.907</td>
<td>0.944</td>
</tr>
<tr>
<td>Reader 6</td>
<td>0.932</td>
<td>0.908</td>
</tr>
<tr>
<td>Mean</td>
<td>0.925</td>
<td>0.915</td>
</tr>
</tbody>
</table>

*Observer performance regarding reading time*
The mean reading time of six readers for 120 bilateral MLO MMGs using 5MP- and 8MP-LCD monitors were 3458 ± 984.9 sec and 3092 ± 337.2 sec, respectively (Table 3). There was no significant difference in mean reading time of MMGs between 5MP- and 8MP-LCD monitors (P = 0.39).

<table>
<thead>
<tr>
<th>Reader</th>
<th>5MP (min, sec)</th>
<th>8MP (min, sec)</th>
<th>P = 0.39</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46:06</td>
<td>48:39</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50:24</td>
<td>50:16</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>81:49</td>
<td>58:07</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>73:38</td>
<td>54:18</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>41:09</td>
<td>42:28</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>53:42</td>
<td>55:23</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>57:48</td>
<td>51:32</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Fig. 1: Receiver operating characteristic (ROC) curves for the detection of BI-RADS category 3 or more lesions. TPF true positive fraction; FPF false positive fraction. The thick line shows the ROC curve for a set of 5-MP monochrome LCD monitors, and the dashed line shows the ROC curve for a 8-MP color LCD monitor. There was no significant difference between the two types of different display modes (P = 0.46).
Conclusion

Our study results showed that there was no significant difference between 5MP- and 8MP-LCD monitors in the detectability of BI-RADS 3 or more breast lesion. The pixel size of 5MP- and 8MP-LCD monitor is 165µm and 170.4 µm, respectively. Thus, 8MP-LCD monitor is inferior to 5MP-LCD monitor in spatial resolution; however, the size of minute calcifications of breast cancer is reported to range from 100 to 500 µm [7-9], it could therefore has a little effect on the detectability.

Regarding the difference between monochrome and color of LCD monitor, this factor did not influence the observer performance in this study. The ACR-AAPM-SIIM practice guideline shows no requirement whether the monitor should be monochrome or color. This critical issue influence on observer’s stress, because radiologists should select properly LCD monitors according to imaging modalities in a reading room. Takahashi and colleagues reported that measured display functions for the 2MP color LCD monitor set at 500 cd/m$^2$ color LCD and 2MP monochrome LCD monitor se at 500 cd/m$^2$ monochrome LCD were almost identical, and that there was no significant difference in detectability of a simple object with low contrast [10]. However, comparison of physical properties using high contrast materials between monochrome and color with resolution of 3MP or more LCD monitor has not yet been reported; therefore a future study is required on this question.

Concerning the reading time, there was also no significant difference between 5MP- and 8MP-LCD monitors. Among the characteristics of the two types of monitors shown in Table 1, the difference of pixel sizes might affect the reading time, especially in the view at the 1:1 of pixel size during the image interpretation. The magnification percentage at the 1:1 of pixel size using 5MP- and 8MP LCD monitor is 330% (165/50) (Fig. 2) and 341% (170.4/50) (Fig. 3), respectively. Therefore, the reading time should prolong when we observe all area of MMG with monitors as we enlarge in a larger percentage using an 8MP LCD monitor. However, in a clinical study, we only have to magnify images to focus the localized lesion such as clustered microcalcifications or marginal character of mass lesion. We speculate that this procedure did not cost a significant difference in prolonged time to magnify the focal lesion on MMG.

There are some limitations in our study. First, our patients group was selected from our reporting database of diagnostic mammograms. That means that it tends to show more obvious findings than screening mammograms. This selection bias might result in relatively high AUC values without a significant difference. If we used the patients selected from the database of screening mammograms with subtle findings, the results might led to a substantial difference. Second, the numbers of cases and observers were relatively small. A future study with a larger screening dataset and multiple observers is warranted to reach a definitive conclusion. Third, the type of monitor being used was readily identifiable by the observers; therefore a potential performance bias could not
be completely eliminated. Forth, we have not evaluated whether the level of observer experience could influence the difference of LCD monitor.

In conclusion, detectability of BI-RADS 3 or more breast lesion and reading time on screening MMG using an 8-MP LCD monitor were comparable to those using a 5-MP LCD monitor.
Fig. 1: Receiver operating characteristic (ROC) curves for the detection of BI-RADS category 3 or more lesions. TPF true positive fraction; FPF false positive fraction. The thick line shows the ROC curve for a set of 5-MP monochrome LCD monitors, and the dashed line shows the ROC curve for a 8-MP color LCD monitor. There was no significant difference between the two types of different display modes (P = 0.46).

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Fig. 2: The magnification percentage at the 1:1 of pixel size using 5MP-LCD monitor is 330% (165/50).

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Fig. 3: The magnification percentage at the 1:1 of pixel size using 8MP-LCD monitor is 341% (170.4/50).

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References


