White Paper

Study to Demonstrate Efficacy of 8MP Color Display - Mammography

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Product & Business Development Dept.

Product Technology section

1. Introduction

EIZO proposes the RadiForce RX850, an 8MP color diagnostic display, as being equivalent to dual 5MP displays for mammography use despite its smaller matrix size (2 x 2048 x 2160 for the RadiForce RX850 vs. 2 x 2048 x 2560 for the dual 5MP displays).

In order to compare the diagnostic performance of the single 8MP display to that of the dual 5MP displays, we asked Elizabeth A. Krupinski, PhD, a Professor at the University of Arizona in the Departments of Medical Imaging, Psychology and Public Health, to conduct a clinical evaluation.

One of the evaluation results was that there were significant improvements in reader efficiency with the single 8MP display compared to the dual 5MP displays. This white paper shows the details of the clinical evaluation including the advantages of the 8MP display. For more details, please see the report written by Dr. Krupinski.

2. Purpose

The goal of this study was to assess diagnostic accuracy and reader efficiency as a function of display and display layout. This study had 2 reading conditions: a single EIZO 8MP display (without central bezel) vs dual-5MP EIZO displays (with bezels between the two screens). There were three aspects of reader performance that were studied: diagnostic accuracy as measured by Receiver Operating Characteristic (ROC) analysis, reading time, and number of times the readers zoomed/panned the images.

3. Methods

The study was carried out using displays (Figure 1) that were equivalent except for the parameter of interest (8MP without bezel vs dual 5MP with bezel). They were set up by EIZO with as equivalent as possible white points, maximum/minimum luminance, and black levels, and were calibrated to the DICOM GSDF. For details, please see the report written by Dr. Krupinski.

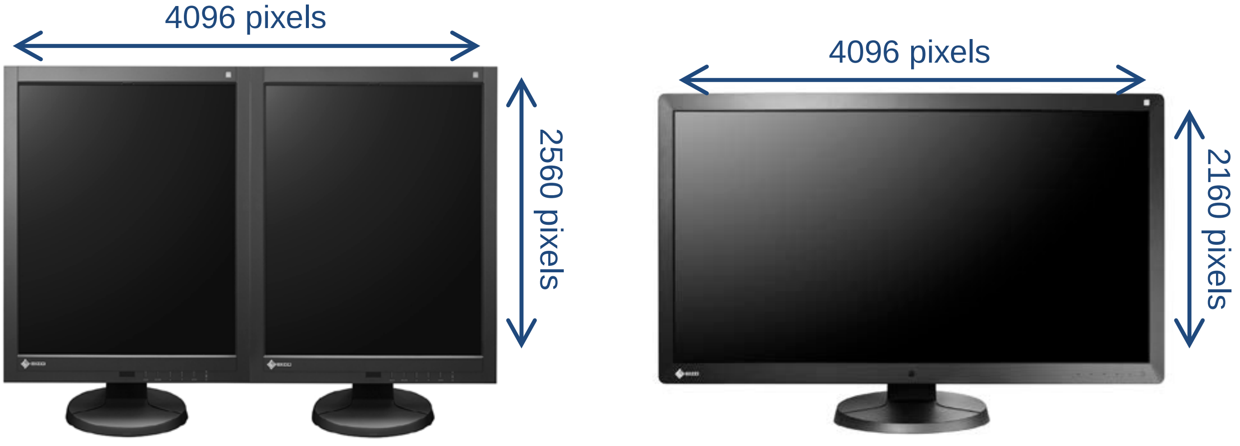


Figure 1. The two display configurations.

4. Results

This section shows three advantages we found of the single 8MP display. For details, please see the report written by Dr. Krupinski.

For viewing time, there was a significant difference between the two reading conditions, with the single 8MP display taking less time on average than with the dual 5MP displays. The single 8MP display is superior to the dual 5MP displays by 10 percent.

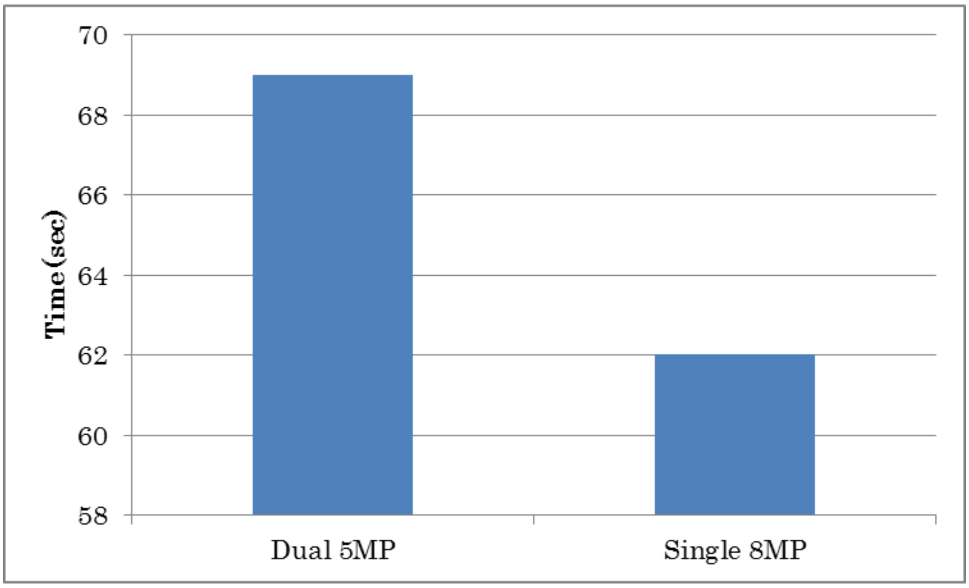


Figure 2. Average viewing time in each reading condition.

The total number of fixations generated with the single display was also significantly fewer than with the dual displays. The single 8MP display is superior to the dual 5MP displays by 13 percent.

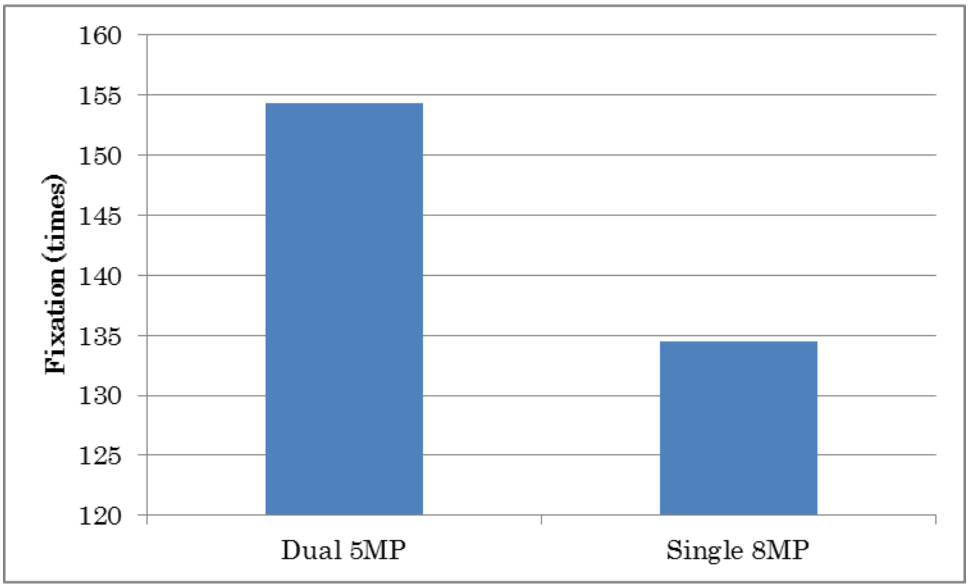


Figure 3. Average of total number of fixations.

The number of times they scanned from one image to the other was significantly fewer with the single display than with the dual displays. The single 8MP display is superior to the dual 5MP displays by 17 percent.

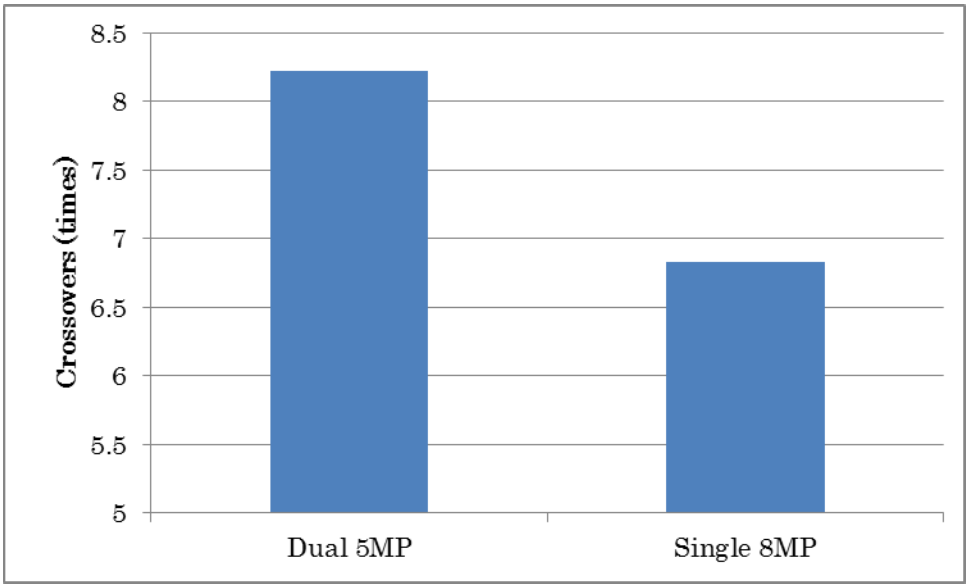
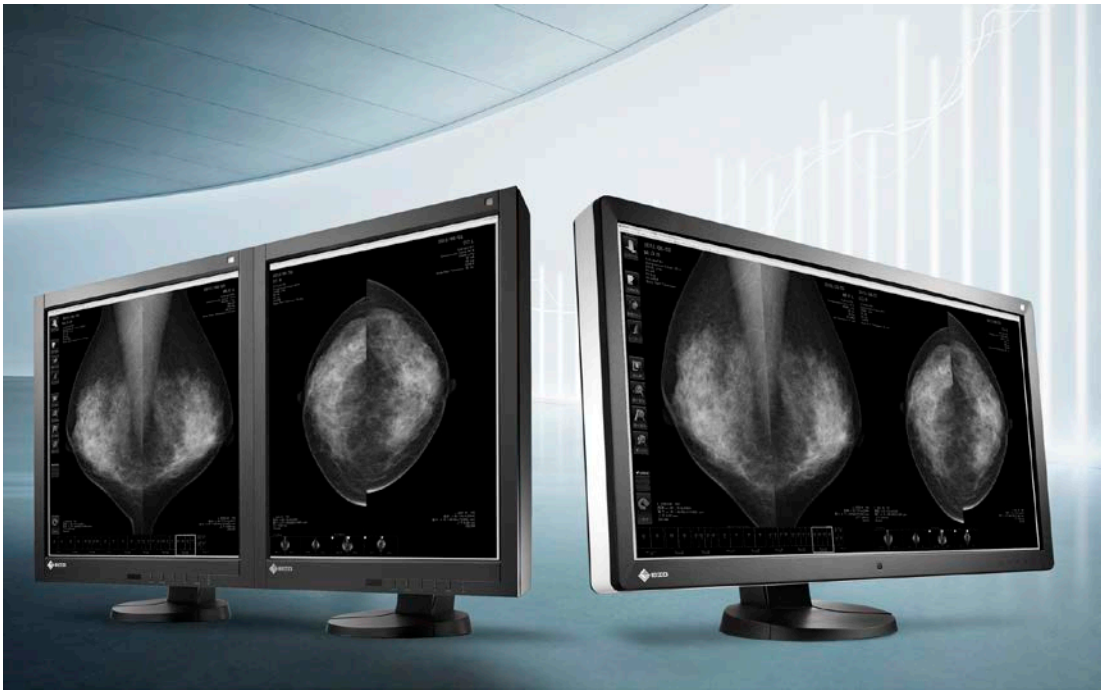


Figure 4. Average of number of times scanned from one image to the other for each of the readers in each reading condition.

5. Conclusions

Our conclusion is that the single 8MP display yielded the same diagnostic accuracy as the dual 5MP displays. In addition, we found advantages in viewing time, total number of fixations and number of times readers scanned from one image to the other. Therefore, the single 8MP display can substitute for the dual 5MP displays.



Note: All figures are not based on the measurement result but simplified images.

6. Report from Dr. Krupinski, University of Arizona

Study to Demonstrate Efficacy of 8MP Color Display - Mammography

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1. PURPOSE

The goal of this study was to assess diagnostic accuracy and reader efficiency as a function of display and display layout. This study had 2 reading conditions: single Eizo 8MP display (without central bezel) vs dual-5MP Eizo displays (with bezels between the two screens). There were three aspects of reader performance that were studied: diagnostic accuracy as measured by Receiver Operating Characteristic (ROC) analysis, reading time, and number of times the readers zoomed/panned the images.

2. METHODS

The study was carried out using display monitors (Figure 1) that were as equivalent except for the parameter of interest (8MP without bezel vs dual 5MP with bezel). They were set up by Eizo with as equivalent as possible white points, maximum/minimum luminance, and black levels, and were calibrated to the DICOM GSDF.

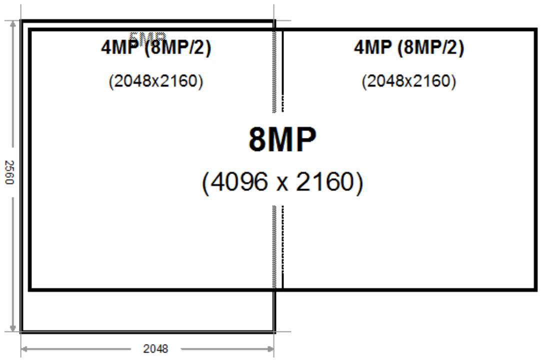

Figure 1. The two display configurations.

The study protocol was approved by the University of Arizona's Human Subjects office for IRB approval prior to the start of the study. Six mammographers were recruited as observers – four Board-Certified mammographers, 1 mammography Fellow, and one senior resident about to enter a mammography Fellowship.

Each observer viewed a set of 60 mammographic cases, once on each reading condition using a counterbalanced design in which half of the observers viewed the cases in one condition first and the other half viewed them on the alternative condition first. At least 3 weeks passed between sessions to promote forgetting of the cases. Forty of the cases contained a single malignant lesion (20 masses and 20 microcalcification clusters) and 20 were lesion free. All cases with lesions had been verified by biopsy regarding lesion status, and the lesion-free cases had at least 2-years follow-up without change in status. Lesions ranged from subtle to moderately subtle and were located throughout the breast.

The images were displayed using specialized display software (ImprocRAD) for image presentation and recording of observer response data. The software was originally developed by Bill Dallas, PhD and was modified under the contract for use in this study to incorporate the specific needs of the design and reporting procedures. Standard observer performance study protocols were observed, such as having the ambient room lights set to 40 lux and noise levels were minimized.

The task of the readers was to determine for each case if a lesion was present or absent. They then reported their confidence in that decision using a 6-point scale: lesion present definite; lesion present probable; lesion present possible; lesion absent possible; lesion absent probable; lesion absent definite. They indicated the location using the mouse and a cursor. Reading time (time from when the images first appear until a decision is rendered) was recorded as was the number of times they zoomed/panned per case presentation.

The confidence data were analyzed for statistically significant differences in reader accuracy using the Multi-Reader Multi-Case (MRMC) Receiver Operating Characteristic (ROC) technique and software from the University of Iowaz (http://perception.radiology.uiowa.edu/Software/ReceiverOperatingCharacteristicROC/MRMCAnalysis/tabid/116/Default.aspx). The timing and zoom/pan use data were analyzed using a repeated measures Analysis of Variance with time (sec) and zoom/pan use as the dependent variables and display condition and lesion type as independent variables.

An additional study with eye-position recording, using a sub-set of 15 cases (5 mass, 5calcification, 5 normal), was also conducted. The ASL SU4000 Eye-Tracker system (Applied Science Labs, Bedford, MA) was used to record eye-position. The eye-position data were analyzed using standard methods. Parameters analyzed were: total viewing time, number of fixations generated, time to first hit lesion (in either image), total time on lesion (sum for both views, MLO and CC), and number of times scanned from one image to the other.

3. RESULTS

Diagnostic Accuracy

The MRMC ROC analysis revealed no statistically significant difference in diagnostic accuracy between the two display conditions (F = 4.43, p = 0.0891). The average and individual area under the curve (Az) results are shown in Table 1.

Reader	Dual 5MP	Single 8MP
1	0.869	0.840
2	0.819	0.779
3	0.816	0.767
4	0.817	0.825
5	0.894	0.849
6	0.876	0.890
Mean	0.849	0.823

Table 1. ROC Az values for each of the readers in each reading condition with means for the conditions at the bottom.

Viewing Time

For viewing time, there was a significant difference (F = 13.901, p = 0.0002) between the two reading conditions, with the single 8MP display taking less time on average than with the dual 5MP displays. On average, viewing time with the single display was 62.04 sec (sd = 24.09) and that with the dual displays was 68.99 (sd = 25.87). There were no significant differences as a function of type of lesion (F = 0.144, p = 0.8657). Figure 2 shows the average reading time for each of the 6 readers in the two reading conditions.

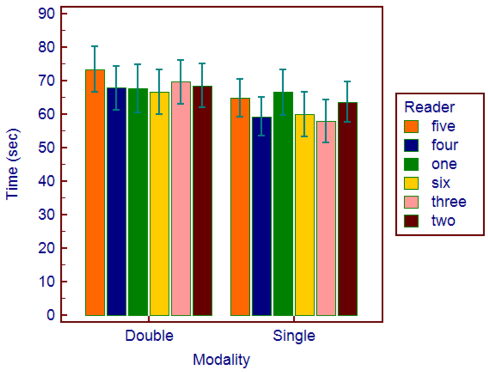

Figure 2. Viewing times for each of the readers in each reading condition.

Zoom/Pan Use

There was no significant difference (F = 0.254, p = 0.6145) in the number of times zoom/pan was used by the readers as a function of single display vs dual displays. On average, frequency of zoom/pan use with the single display was 1.94 times per case (sd = 1.40) and that with the dual format was 1.89 times per case (sd = 1.38). There was no significant difference as a function of lesion type (F = 0.292, p = 0.7467). Figure 3 shows the average zoom/pan use for each of the 6 readers in the two reading conditions.

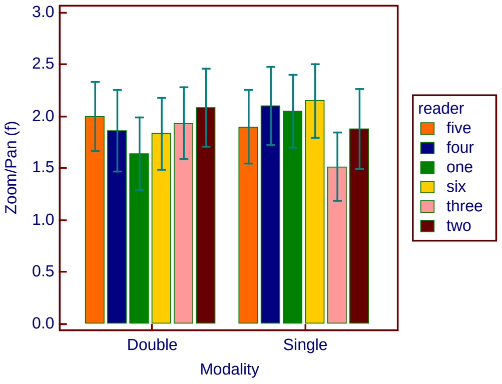

Figure 3. Frequency of use of zoom/pan for each of the readers in each reading condition.

Eye-Position Study

As in the main study, the total viewing time was significantly shorter (F = 4.372, p = 0.0394) with the single display (mean = 54.65, sd = 24.09) than with the dual displays (mean = 62.86, sd = 27.58). The total number of fixations generated with the single display was also significantly (F = 4.073, p = 0.0466) shorter (mean = 134.47, sd = 65.14) than with the dual displays (mean = 154.29, sd = 65.09). The number of times they scanned from one image to the other (Figure 4) was significantly fewer (F = 10.305, p = 0.0018) with the single display (mean = 6.83, sd = 2.58) than with the dual displays (mean = 8.22, sd = 2.99).

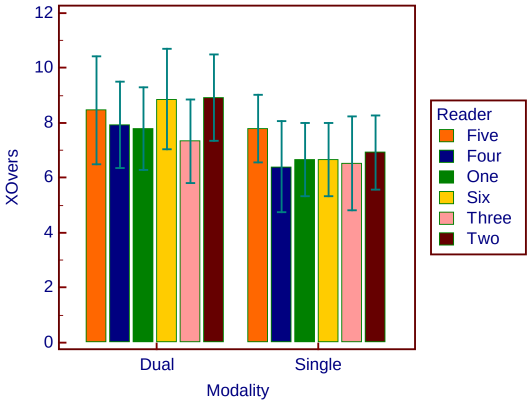

Figure 4. Number of times scanned from one image to the other for each of the readers in each reading condition.

The time to first fixate the lesion (in either image) did not differ significantly (F = 0.126, p = 0.7240) between the single display (mean = 6.83, sd = 3.47) and dual displays (mean = 6.63, sd = 3.64). In other words, it did not take any longer to detect the lesion as a function of the display configuration. The total time spent on the lesion (in both views) did not differ significantly (F = 0.097, p = 0.7567) between the single display (mean = 8.59, sd = 4.43) and dual displays (mean = 8.39, sd = 4.18).

4. CONCLUSIONS

Overall the single 8MP display yielded the same diagnostic accuracy as the dual 5MP displays. The lower resolution did not appear to influence the readers' ability to detect and view the lesion details, as the eye-position study showed no significant differences in time to first fixate or in total time on the lesions. Nor did the lower resolution result in significant differences in the number of times the readers zoomed/panned the images while viewing the cases.

There were however significant improvements in reader efficiency with the single 8MP display compared to the dual 5MP displays. This was seen in terms of reduced overall time spent viewing the images in both the main and eye-position studies. From the eye-position study it appears that the gain in efficiency is not due to detecting or spending any different time on the lesions, but in terms of not scanning back-and-forth from image to image as much. The reason for this may be the presence of the bezels between the two screens of the dual 5MP displays – creating a physical separation between the two images, while the single 8MP display has the two images abutting each other without anything between them.