JVC

White Paper

Advantages of High-Bright and High-Contrast Display on Mammography diagnosis

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1. Preface

Today digital diagnostic imaging is regarded as the standard practice for radiology. In primary mammography diagnosis using digital imaging displays the required resolution is a 5 mega-pixel (5MP) display with a recommended luminance of 500 cd/m^2. Lesion is diagnosed by difference of gradation on grayscale calibrated to DICOM GSDF. Consequently, display wider gradation of grayscale need to be a higher maximum luminance and a lower minimum luminance, which means high brightness and high contrast must be required for reading of digital mammography.

We have developed mammography displays since the cathode-ray tube (CRT) era, always seeking to improve the image quality over many years. In 2019, JVC released the MS-S500 (Fig.1) which improves to render increased reproductive image quality with a much higher contrast and brightness than conventional displays.

In this paper, we describe the advantages of MS-S500, in terms of the current demand for high brightness and high contrast displays.

(Fig.1) 5MP monochrome mammography monitor MS-S500

2. Advantages of High-Bright and High-Contrast Display by the clinical evaluation

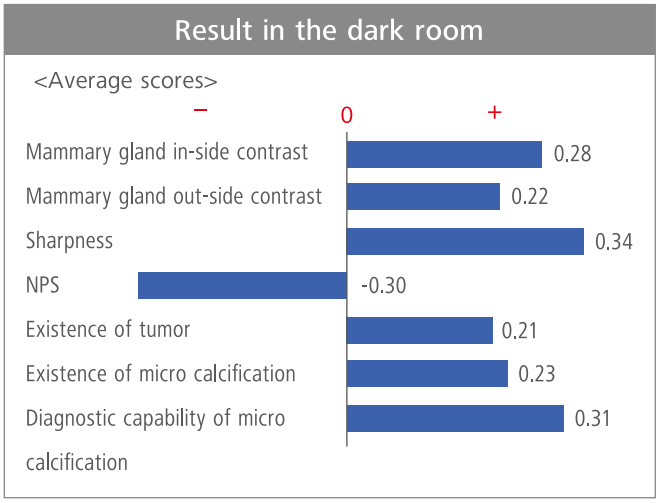
This content was presented by Radiological Technologist Ms. Mochiya (Department of Central Radiology, Kanazawa University Hospital), "Performance evaluation of Super High-bright and High-Contrast LCD displays -visual evaluation on clinical mammography images" held on the 29th Meeting of Japan Association of Breast Cancer Screening. In this evaluation, two Radiologists and five Radiological Technologists diagnosed 40 samples of clinical mammography images which included 20 samples of tumors and 20 samples of micro calcifications under two luminance settings of 500 cd/m^2 and 1,000 cd/m^2 each. They evaluated whether it had an influence on the accuracy of diagnosis, using a 2-point preference method (+2 = very good with 1,000 cd/m^2, +1 = good with 1,000 cd/m^2, 0 = same, -1 = good with 500 cd/m^2, -2 = very good with 500 cd/m^2).

Luminance setting	Evaluated items	Reading environment
• 500 cd/m^2 setting Lmax = 500 cd/m^2 Lmin = 0.5 cd/m^2 • 1,000 cd/m^2 setting Lmax = 1,000 cd/m^2 Lmin = 0.5 cd/m^2	• Mammary gland in-side contrast • Mammary gland out-side contrast • Sharpness • Noise Power Spectrum (NPS) • Existence of tumor • Existence of micro calcification • Diagnostic capability of micro calcification	• A dark room (Illuminance of apx. 3 [lx]) • A high illuminated room (Illuminance of apx.100 [lx])

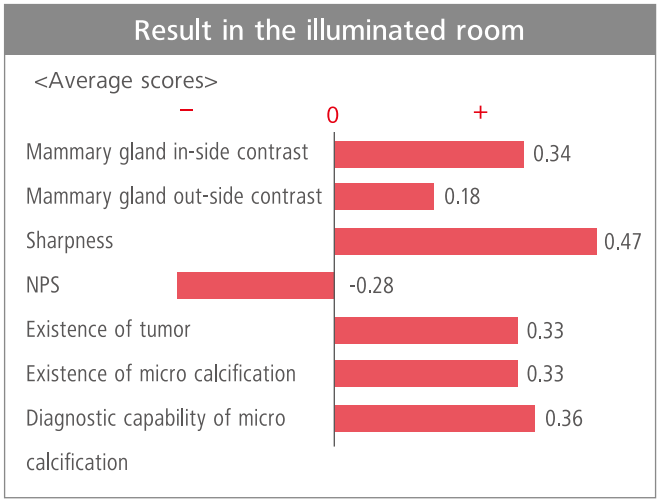
(Table 1) Evaluation conditions for comparative reading

2-1. The comparison results on different luminance settings

We calculated total scores in each evaluated item. As a result, 1,000 cd/m^2 setting was superior in all evaluated items except for NPS (Fig.2, Fig.3) since contrast was improved by the higher luminance while retaining the sufficiently low brightness part. Furthermore, 1,000 cd/m^2 setting also got higher scores both in the dark room and the illuminated room due to the enough darkness in low illuminated areas of images. In other words, NPS showed to the contrary results due to the other evaluated items which had the opposite characteristics such as sharpness.



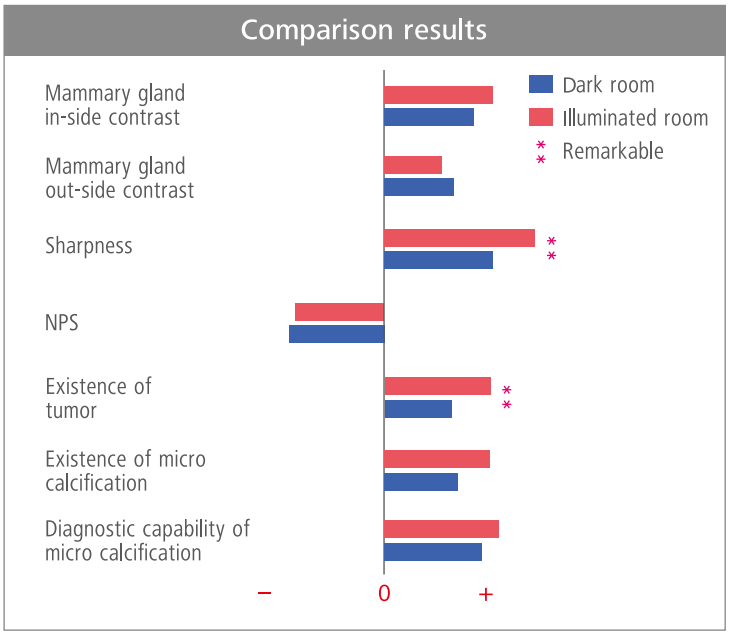
(Fig.2) A dark room (Illuminance of apx. 3 [lx])



(Fig.3) An illuminated room (Illuminance of apx.100 [lx])

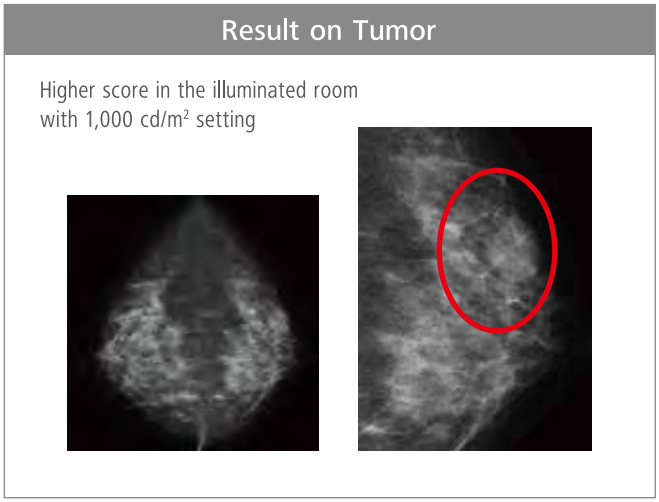
2-2. The comparison results of diagnosis in high illuminated rooms and dark rooms

Next, we calculated total scores in each evaluated item within the two reading environments, and subsequently calculated T-test. Specifically detecting for sharpness and existence of tumor in both the high illuminated room and the dark room showed remarkable results. (Fig.4).

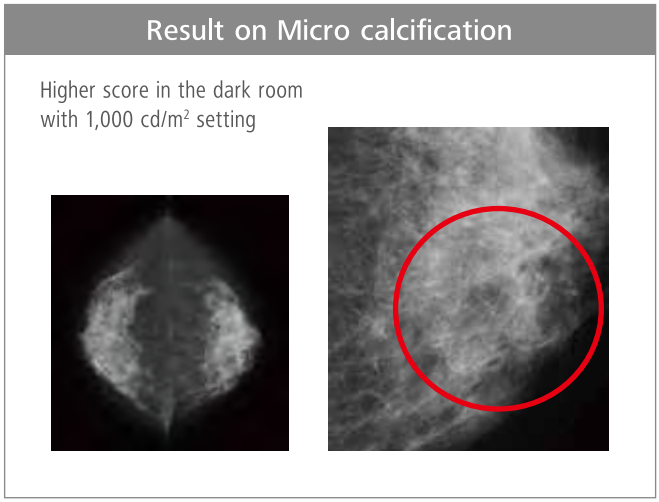


(Fig.4) Average scores in the dark room and the illuminated room

Also, 1,000 cd/m^2 setting in the illuminated room was superior in detecting for both existence of tumor (Fig.5) and thinner microcalcification (Fig.6) even in high density circumstance. It suggests that high-luminance setting enables the readers to diagnose the lesion which is difficult to detect even in high illuminated rooms. That indicates it may be additional advantage of high-bright displays due to the reduction of eye strain caused by reading in dark rooms.



(Fig.5) Tumor

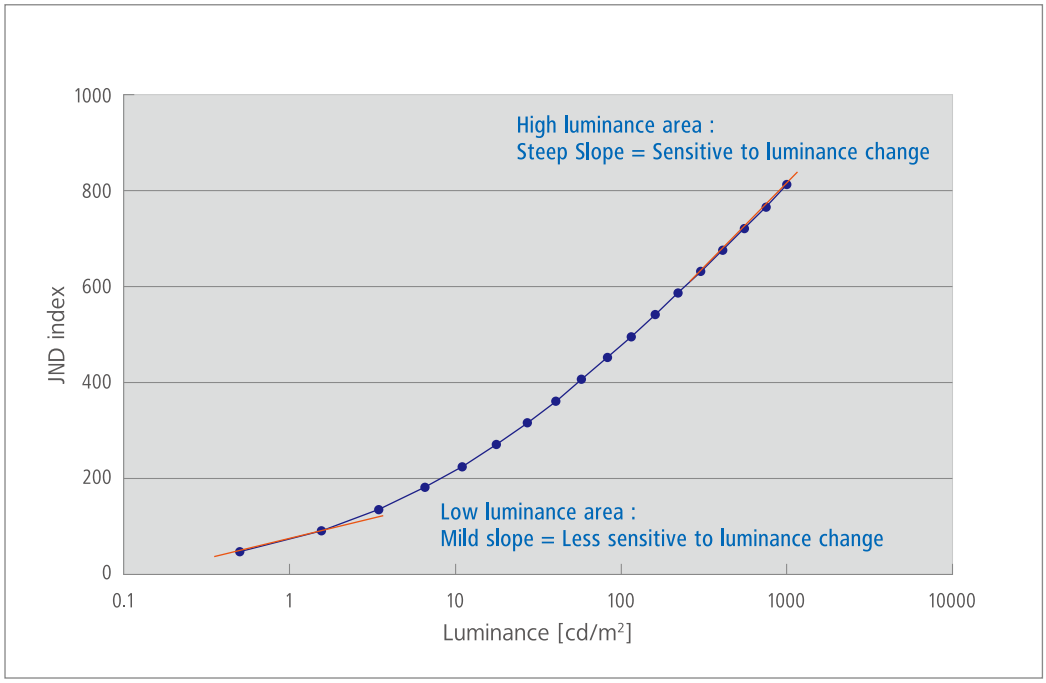


(Fig.6) Micro calcification

3. Advantages of High-Bright and High-Contrast Display by the physical evaluation

Next, we explained the advantages of high brightness and high contrast display based on JND (Just Noticeable Difference) that is defined as the minimum difference of change in luminance for human eyes perceive. However, the JND index calculated from JND has a larger difference as the minimum luminance is lower and the maximum luminance is higher, which increases the visual contrast. For example, a luminance difference of 10% near 1,000 cd/m^2 is equivalent to 15 JND index, and near 1 cd/m^2 is equivalent to 5 JND index, JND at high luminance is quite different from it at low luminance. The correlation graph (Fig.7) shows slope near 1,000 cd/m^2 is steeper than that near 0.5 cd/m^2. In other words human eyes are more sensitive to brightness changes in higher luminance. It means higher luminance leads to higher visual contrast.

The possible lowest luminance of conventional model equipped with 1400:1 contrast ratio would be 0.71 cd/m^2 under the Lmax 1,000 cd/m^2 setting, while the new MS-S500 equipped with 2000:1 contrast ratio would be 0.5 cd/m^2 as lowest luminance. Consequently, overall contrast was improved since the lower luminance afforded the smaller JND index and the higher luminance afforded the larger JND index. Besides, that effectiveness was emphasized since the higher luminance leads to the higher visual contrast. From the above, we conclude that monitors with the minimum luminance is lower and the maximum luminance is higher, extend recognizable grayscale gradations drastically wider than previous, which is an advantage for detecting the lesions at low contrast areas in mammography image.



(Fig.7) The Correlation between JND and Luminance

4. Conclusion

The newly developed 5MP monochrome mammography monitor "MS-S500" has a 1.5 times higher luminance and 1.43 times higher contrast than any other conventional products and increases JND steps to avoid overlooking the lesion even in illuminated rooms. It reduces eye strain and improves the image quality of micro calcification, tumors and structure of lesion. Furthermore, it lifts the sense of depth in the image for dense breast and realizes the much more efficient mammography image diagnosis.

Acknowledgements

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