Optimization of Viewing Conditions and Phantom Image Quality Evaluations on GE DMR and Full-Field Digital Mammography System

K. Chakrabarti, J.A. Thomas, R.V. Kaczmarek, R.W. Waynant, and M.F. Loscocco

WE HAVE BEEN STUDYING^{1,2} optimal viewing conditions and effects of luminance, display non-uniformity, and room illumination conditions on phantom image evaluations. As a part of our continued research in this area, we extended our study to evaluate phantom images from GE 2000 D Senographe full-field digital Imaging (FFDM) and GE screen film (SF) DMR systems. We have used a Med Optics Rose phantom for evaluations of both GE DMR and FFDM phantom images. Phantom images were viewed using a SmartLight view box at three different luminance levels, as well as a view box with a scotopic source. For the FFDM system, laser-printed hard-copy images were used.

The Med Optics phantom is a rectangular block of acrylic with hollow vertical cylinders interior to the block laid out in 7×7 matrix format. The depths of the cylinders vary with the matrix row, with groove depth decreasing in millimeters as 0.73, 0.51, 0.36, 0.24, 0.16, 0.11, and 0.06. The diameter of the objects decreases in each column in millimeters as 4.82, 3.50, 2.32, 1.60, 0.70, 0.30, and 0.18. In addition, running horizontally between different rows, the phantom has a pair of 50- μ m diameter gold wires with 150- μ m separation between them, a wire-like linear groove of 150 μ m and another 50- μ m diameter aluminum wire. Under optimal viewing conditions, a system's contrast and spatial resolution, as well as its ability to detect low-contrast objects, can be assessed using this phantom.

RESULTS AND DISCUSSION

Phantom images were acquired using techniques for both SF DMR and FFDM systems. The average

phantom image scores of three reviewers for four different technique factors with molybdenum target and molybdenum filter are provided in Table 1. The phantom images were reviewed in the same ambient room light condition, but with different view box luminance levels designated as 1, 2, and 3, which were measured as 1, 2, and 6 knits (kilo nits), respectively. However, the transmitted light through the films reaching observer eyes was different because of the density differences between the SF images and the processed images from the FFDM.

For all technique factors used, the processed phantom images from the FFDM received higher scores than the SF images. The objects in the seventh row could not be detected by either system with the molybdenum target and molybdenum filter used for this study. For technique factors 26 kVp and 40 mA, ideal for SF images as recommended by the phantom manufacturer, FFDM still fared better. Up to the fourth masses in the sixth row could be read, compared with only one mass for that row in the case of SF images. As exposure level was increased, the film became denser, and the SF system recorded increasingly less information. For overexposed films, a higher luminance level provided some assistance in retrieving some information, particularly for SF images. At 26 kVp, 63 mA, scores in all rows decreased for the SF image, where as that for the FFDM counterpart increased. As the exposure was increased to 100 mA for the same 26 kVp, the SF could not record discernable information beyond the third row. When the luminance level was increased to 6 knit, up to two masses for the fourth and the fifth rows could be read. For the technique factors 28 kVp and 100 mA, virtually no information could be extracted from the SF phantom image. Only a few masses in the first two rows could be seen at the highest luminance level of the view box. However, with this high exposure level, the processed FFDM images showed either the same or higher scores, and the difference in luminance from the view box did not play a significant role.

From the CDRH/Food and Drug Administration, Rockville, MD; and Uniformed Services University of Health Sciences, Bethesda, MD.

Address reprint requests to K. Chakrabarti, PhD, Division of Mammography Quality and Radiation Programs, CDRH/FDA, HFZ-240, 1350 Piccard Dr, Rockville, MD 20850.

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Table 1.

Row	Luminance Level 1		Luminance Level 2		Luminance Level 3	
	SF Score	FFDM Score	SF Score	FFDM Score	SF Score	FFDM Score
Technique factors 26						
kVp, 40 mA						
1	6	6	6	6	6	6
2	6	6	6	6	6	6
3	5	6	3	6	3	6
4	4	5	4	5	4	5
5	2	4	2	4	2	4
6	1	3	1	3	0	3
7	0	0	0	0	0	0
Technique factors 26						
kVp, 63 mA						
1	5	6	5	6	6	7
2	5	6	5	6	6	7
3	4	6	5	6	5	6
4	3	6	4	6	4	6
5	2	4	2	4	4	4
6	0	3	0	4	1	4
7	0	0	0	0	0	0
Technique factors 26						
kVp, 100 mA						
1	4	7	5	7	5	7
2	2	6	3	6	4	6
3	2	6	2	6	4	6
4	0	6	0	6	2	6
5	0	5	0	5	1	5
6	0	4	0	4	0	4
7	0	4	0	0	0	0
Technique factors 28						
kVp, 100 mA						
1	0	7	0	7	4	7
2	0	7	0	7	2	7
3	0	6	0	6	0	6
4	0	6	0	6	0	6
5	0	5	0	5	0	5
6	0	4	0	4	0	4
7	0	0	0	0	0	0

The 150- μ m linear object with 1% subject contrast placed between the fifth and the sixth row could not be detected by any system, whereas the 50- μ m diameter aluminum wire with 10% subject

contrast was detected by the FFDM system, but not by the SF DMR system. The 50- μ m diameter gold wires with 150- μ m separation were detected by both the FFDM and SF systems. However, the wires were clearly resolved by the naked eye in the case of SF images, whereas in case of FFDM images, this could be resolved only with increased magnification.

For all technique factors used, the phantom image scores remained the same for the FFDM-produced images. Most importantly, increasing view box luminance did not change phantom image scores. In fact, increased luminance produced a higher transmission of view box light to the observers' eyes, disrupting eye adaptability. We also scored these phantom images using a view box with a scotopic source of 1-knit luminance that has a spectral output in the blue region. While it was difficult to read SF phantom images, particularly those with high optical density, no change in the FFDM score was noted. This scotopic source or the SmartLight view box with low-level luminance provided better eye adaptability and appears to be less tiring to the observer's eyes, indicating that it may be more suitable for readers who interpret a large number of images. We plan to investigate this further with additional images from two systems using several other phantom images.

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