

Technical Evaluation of Foam Pads in Mammography

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Purpose:

To measure the effect of foam pads on image quality and patient dose with commercially available screen-film mammography (SFM) and full-field digital mammography (FFDM) units across the full clinical range of compressed breast thickness.

Method/Materials:

Four contrast-detail (CD) images at 2, 4, 6, and 8 cm thickness (Figure 1) and one ACR phantom image were acquired on each of 12 commercially available SFM and 4 different manufacturer's FFDM units (Table 1). Images were acquired using no pads (Figures 6), and 1 pad (bottom plate) (Figures 7), and 2 pads (Figures 8) using the BioLucent Woman's Touch[®] MammoPad[®] Foam Pads. Images were acquired using the sites clinical technique factors for each breast thickness using 10 decanewtons of compression force for all images.

Contrast-detail (CD) images were acquired at 2, 4, 6, and 8 cm breast thicknesses. A D-shaped uniform CD phantom made of 2 cm slabs of tissue-equivalent material was used, one section of which contained a 9 x 9 contrast-detail pattern for assessment of simulated low-contrast lesions (Figures 1 & 2). Each row of the CD pattern contained 9 circular objects at a fixed level of contrast with object diameters ranging from 0.25 mm to 4.0 mm with each of the

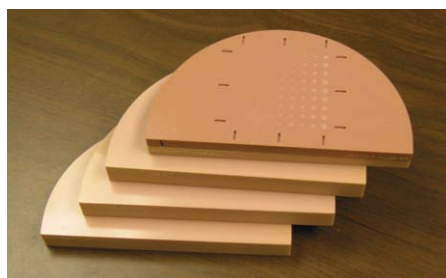


Figure 1. Contrast-detail phantoms.

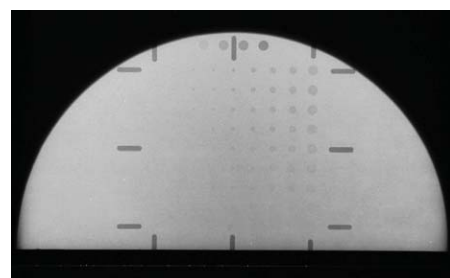


Figure 2. Contrast-detail phantom image.

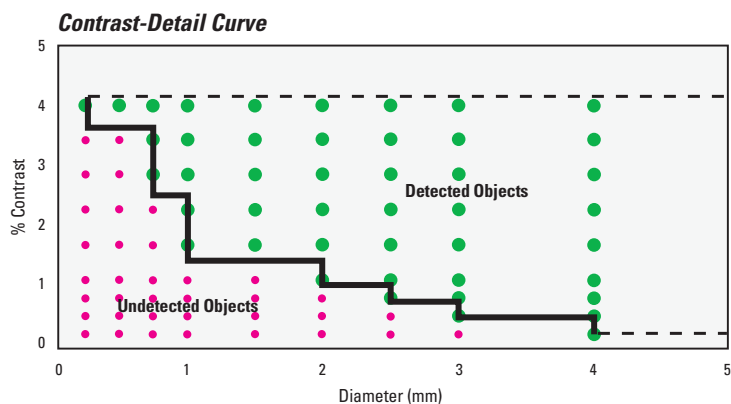


Figure 3. Contrast-detail phantom image scoring pattern.

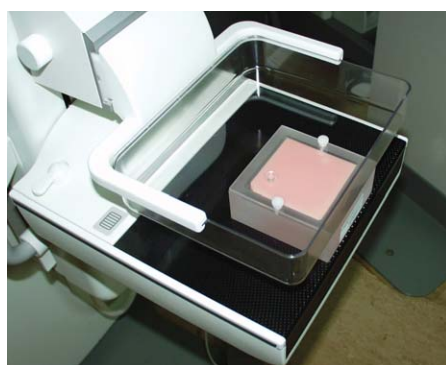


Figure 4. ACR phantom setup.

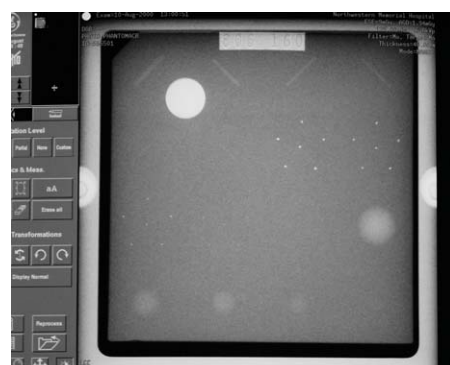


Figure 5. ACR phantom image.

nine rows ranging from 0.3% to 4.0% subject contrast, resulting in 81 total test objects. CD images were scored by counting the number of visible objects in each row. The reader then moved to the next row repeating the scoring technique until all 9 rows were scored. The CD score of each image was determined by calculating the area of detected objects in CD space (Figure 3). The more low-contrast objects detected, the higher the CD score. If no objects were seen, a minimum score of zero would result; if all 81 objects were detected, a maximum score of 17.34 would result.

For each image, average glandular dose (AGD) and optical density (OD) (for SFM images only) were measured, along with contrast-detail (CD) and ACR phantom scores. The AGD for each image was calculated based on HVL and entrance exposure measurements on each individual mammography unit (Figures 9 & 10). Results were analyzed for significance of differences in AGD, OD, CD and ACR phantom scores using 0, 1, and 2 pads at each breast thickness.

Results:

Mean AGD using 0, 1, and 2 foam pads, respectively, for 2 cm breasts were 0.49, 0.51, and 0.51 milliGray (mGy), for 4 cm breasts were 1.43, 1.48, and 1.49 mGy, for 6 cm breasts were 2.89, 2.96, and 2.95 mGy, and for 8 cm breasts were 4.59, 4.59, and 4.72 (Figure 11). The AGD difference was significant between no pads and 1 or 2 pads for 2 cm breasts and 4 cm breasts ($p < 0.01$) (Table 2). Mean AGD for the ACR phantom using 0, 1, and



Figure 6. Contrast-detail phantom set-up: no foam pads.



Figure 7. Contrast-detail phantom set-up: 1 foam pad.



Figure 8. Contrast detail phantom set-up: 2 foam pads.

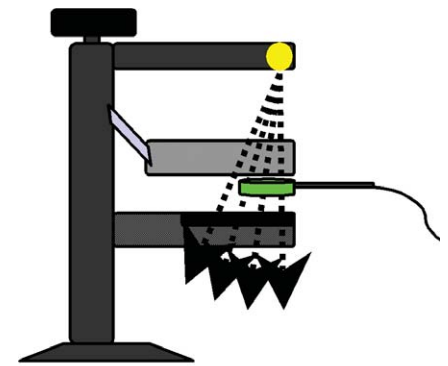


Figure 9. Dosimetry setup for 0 and 1 foam pads.

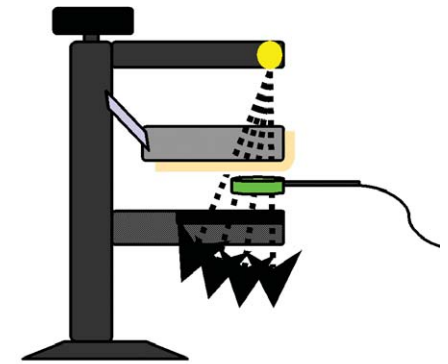


Figure 10. Dosimetry setup for 2 foam pads.

Screen-Film Mammography Units	
General Electric	800T, DMR, DMR+
Instrumentarium	Performa, Alpha RT, Alpha IQ, Diamond
Lorad	M-III, M-IV
Planmed	Sophie Classic
Siemens	Mammomat 3000, Nova
Full-Field Digital Mammography Units	
General Electric	Senographe 2000D
Fischer	Senoscan
Fuji	CR
Lorad	M-IV Platinum Selenia

Table 1. List of SFM and FFDM units used in study.

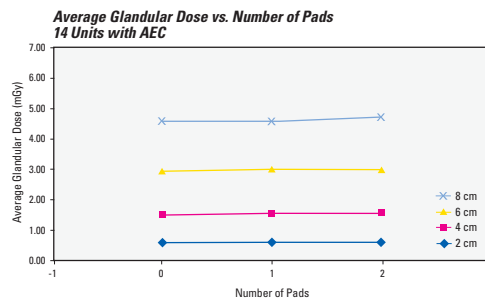


Figure 11. Average glandular doses vs. number of foam pads for 2, 4, 6 and 8 cm breast thickness.

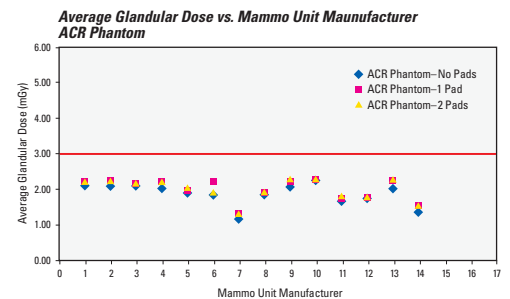


Figure 12. Average glandular doses vs. mammography unit manufacturers that use AEC systems (SFM & FFDM) for the ACR Phantom.

2 foam pads were 1.89, 1.99, 1.99 mGy, respectively, with a significant difference between no pads and 1 or 2 pads ($p < 0.0001$) (Figure 12 & Table 2).

Mean OD using 0, 1, and 2 foam pads, respectively, for 2 cm breasts were 1.74, 1.72, and 1.73, for 4 cm breasts were 1.74, 1.73, and 1.72, for 6 cm breasts were 1.66, 1.66, and 1.61, and for 8 cm breasts were 1.64, 1.58, and 1.58 (Figure 13). Mean OD using 0, 1, and 2 pads for the ACR phantom were 1.67, 1.69, and 1.67 (Figure 14), respectively, and contrast measurements were 0.55, 0.56, and 0.55 (Figure 15), respectively. For different numbers of pads, there was no significant difference in OD for any breast thickness, nor was there a significant difference in contrast across the acrylic disc on the ACR phantom (Table 3).

Mean CD scores using 0, 1, and 2 pads, respectively, for 2 cm breasts were 14.1, 14.0, and 13.8, for 4 cm breasts were 13.5, 13.3, and 13.3, for 6 cm breasts were 12.5, 12.1, and 11.8, and for 8 cm breasts were 10.9, 10.9, and 10.7 (Figure 16). The CD score difference was significant between no pad or 1 and 2 pads for 2 cm breasts ($p < 0.05$) and between no pad and 1 or 2 pads for 6 cm breasts ($p < 0.008$) (Table 4).

The mean ACR phantom fiber scores using 0, 1, and 2 pads were 4.88, 4.94, and 4.87, speck groups were 4.38, 4.47, and 4.25, and masses were 3.53, 3.38, and 3.41 respectively (Figures 17, 18, & 19). Only the speck group score between using 1 and 2 pads had a significant difference ($p = 0.0032$) (Table 5).

Average Glandular Dose (mGy)

# of Pads	2 cm	4 cm	ACR	6 cm	8 cm
0	0.49	1.43	1.89	2.89	4.59
1	0.51 4.1%	1.48 3.4%	1.99 5.3%	2.96 2.4%	4.59 0%
2	0.51 4.1%	1.49 4.2%	1.99 5.3%	2.95 2.1%	4.72 2.8%
Significant $p < 0.05$	0 & 1 0 & 2	0 & 1 0 & 2	0 & 1 0 & 2	0 & 1	**

Table 2. Average glandular doses for 0, 1 and 2 foam pads at 2, 4, 6, 8, and the ACR Phantom images. Percent increase from 0 pads are in magenta.

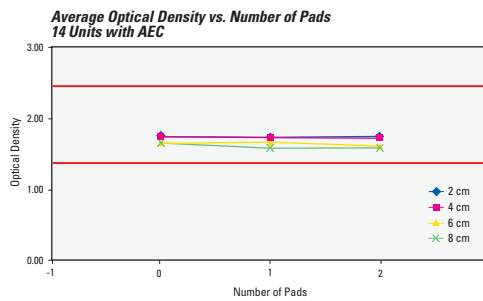


Figure 13. Average optical density vs. number of foam pads for 2, 4, 6 and 8 cm breast thickness. Average OD between 1.4 and 2.5 is recommended for best contrast in the breast.

Average Optical Density

# of Pads	2 cm	4 cm	ACR	6 cm	8 cm
0	1.74	1.74	1.67	1.66	1.64
1	1.72	1.73	1.69	1.66	1.58
2	1.73	1.72	1.67	1.61	1.58
Significant $p < 0.05$	**	**	**	**	**

Table 3. Average optical densities for 0, 1 and 2 foam pads at 2, 4, 6, 8, and the ACR Phantom images.

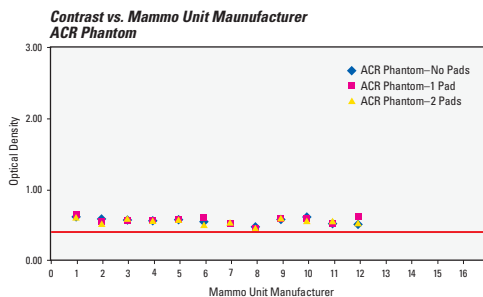


Figure 14. Contrast optical density (across the acrylic disc) vs. SFM mammography unit manufacturers for ACR Phantom. Contrast OD > 0.4 is recommended.

Optical Density vs. Mammo Unit Manufacturer ACR Phantom

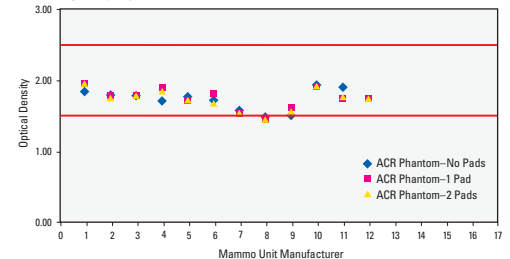


Figure 15. Background optical density vs. SFM mammography unit manufacturers for ACR Phantom. Background OD between 1.4 and 2.5 is recommended.

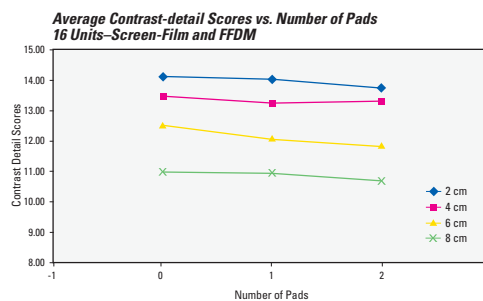


Figure 16. Average contrast detail scores vs. number of foam pads for 2, 4, 6 and 8 cm breast thickness. Compressed breast thickness makes a much greater difference than the number of foam pads.

Average Contrast-Detail Scores

# of Pads	2 cm	4 cm	6 cm	8 cm
0	14.12	13.47	12.51	10.94
1	14.0 -0.7%	13.25 -1.6%	12.05 -3.6%	10.92 -0.1%
2	13.7 -2.5%	13.30 -1.2%	11.82 -5.5%	10.65 -2.6%
Significant $p < 0.05$	0 & 2 1 & 2	0 & 1	0 & 1 0 & 2	0 & 2

Table 4. Average contrast detail scores for 0, 1 and 2 foam pads at 2, 4, 6, 8, and the ACR Phantom images. Percent increase from 0 pads are in magenta.

Conclusions

These results indicate that the use of foam pads has no effect on optical density or contrast at all breast thicknesses, and a minimal, clinically insignificant effect on average glandular dose, contrast-detail scores, and ACR phantom scores. Variability across units and breast thickness was often greater than differences caused by the foam pads. The few statistically significant differences between 0, 1, and 2 foam pads yielded no clinically significant differences in image quality or dose from the use of foam pads to increase the comfort of mammography.

Acknowledgements

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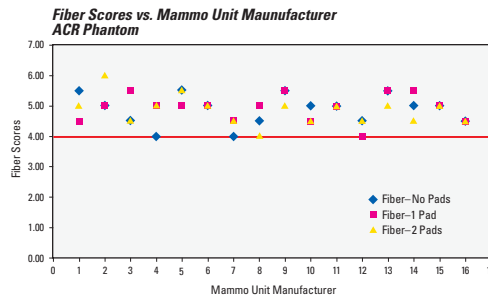


Figure 17. Average fiber scores vs. SFM and FFDM mammography unit manufacturers. A minimum score of 4 is needed to pass ACR accreditation.

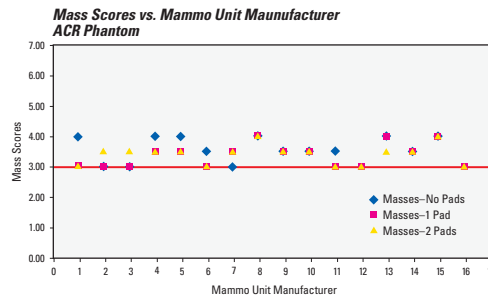


Figure 18. Average mass scores vs. SFM and FFDM mammography unit manufacturers. A minimum score of 3 passes ACR accreditation.

Average ACR Phantom Scores

# of Pads	Fibers	Specks	Masses
0	4.88	4.38	3.53
1	4.94	4.47	3.38
2	4.84	4.25	3.41
Significant p<0.05	**	1 & 2	**

Table 5. Average ACR phantom scores for fibers, specks and masses.

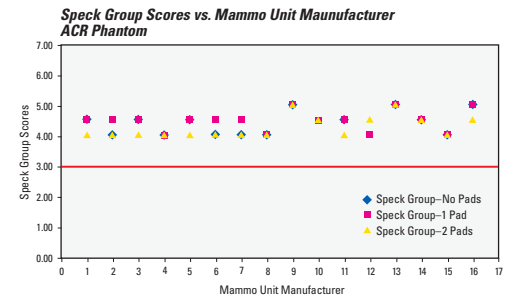


Figure 19. Average speck group scores vs. SFM and FFDM mammography unit manufacturers. A minimum score of 3 passes ACR accreditation.