

Komunikasi Pendek/Short Communication

**Image Quality of Two Full Field Digital
Mammography Using A Female Breast Phantom
(Kualiti Imej Dua Sistem Mammografi Berbidang Penuh
dengan Menggunakan Fantom Payudara Wanita)**

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ABSTRACT

Digital mammography has been progressively introduced in screening centers and the concern is to achieve an image of diagnostic value which would be able to detect early changes in the breast tissue. The aim of this study was to evaluate the image quality of mammograms using quantitative and qualitative methods of two FFDM systems with variations in breast thickness and anode/filter combination. This study was done from January to April 2008 with two FFDM systems; Siemens Mammomat Novation^{DR} at Diagnostic Imaging Department, Hospital Kuala Lumpur and Hologic Lorad Selenia at Breast Clinic, National Cancer Society. A CIRS012A tissue equivalent breast phantom (4, 5 and 6 cm) thickness was used to obtain images in the craniocaudal plane with 26-32 kVp and a combination of molybdenum/molybdenum (Mo/Mo) and molybdenum/rhodium (Mo/Rh) anode/filter. For the qualitative evaluation, two independent radiologist with a minimum of five years experience was used to score the images. Wilcoxon Sign Rank Test showed that there are no significant differences ($p > 0.05$) in image quality between both the FFDM systems. Kappa analysis had a poor agreement between the scores given by the two radiologists. The quantitative analysis using Mann-Whitney test showed that there are significant differences ($p < 0.05$) between the SNR values of both FFDM systems. Although the qualitative evaluation was similar, the study showed that Lorad Selenia had a significantly superior SNR value, hence would be a better tool to detect early changes in the breast tissue. This study also demonstrated that a lower kVp is more suitable with molybdenum filter and as the breast thickness is increased rhodium filter with higher kVp displayed better quality images.

Key words: Full field digital mammography, Image quality, Exposure parameters

ABSTRAK

Mamografi digital telah diperkenalkan dengan progresif di pusat penyaringan dan keutamaan yang perlu dicapai adalah kualiti imej yang bernilai diagnostik untuk mengesan perubahan awal pada payudara. Objektif kajian ini adalah untuk menilai kualiti imej mamogram antara dua sistem mamografi digital berbidang penuh (FFDM) dengan variasi ketebalan fantom dan kombinasi anod/penuras. Kajian ini dijalankan sepanjang Januari hingga April 2008 dengan dua sistem FFDM; Siemens Mammomat Novation^{DR} di Jabatan Radiologi, Hospital Kuala Lumpur dan Hologic Lorad Selenia di Klinik Payudara, Persatuan Kebangsaan Kanser. Fantom payudara kesetaraan tisu CIRS 012A (4, 5 dan 6 cm) digunakan untuk memperolehi imej pada planar kraniokaudal dengan 26-32 kVp dan kombinasi anod/penuras molibdenum/molibdenum (Mo/Mo) dan molibdenum/rhodium (Mo/Rh). Bagi penilaian kualitatif, dua pakar radiologi bebas dengan pengalaman minimum lima tahun telah digunakan untuk penskoran imej. Ujian Wilcoxon Sign Rank menunjukkan tiada perbezaan kualiti imej yang signifikan ($p > 0.05$) di antara kedua-dua sistem FFDM. Analisis Kappa menunjukkan persetujuan yang lemah di antara skor imej dua pakar radiologi untuk bintik, fiber dan jisim. Analisis kuantitatif menggunakan ujian Mann-Whitney telah menunjukkan perbezaan yang signifikan ($p < 0.05$) antara SNR yang dihasilkan oleh kedua-dua sistem FFDM. Walaupun penilaian kualitatif menunjukkan sama pada kedua-dua sistem, Lorad Selenia menunjukkan nilai SNR yang lebih tinggi namun boleh mengesan perubahan awal pada tisu payudara. Kajian ini juga menunjukkan kVp yang rendah lebih sesuai untuk penuras molibdenum dan bagi payudara yang tebal penuras rhodium dengan kVp yang tinggi mempamerkan kualiti imej yang lebih tinggi.

Kata kunci: Mamografi digital berbidang penuh, Kualiti imej, Parameter dedahan

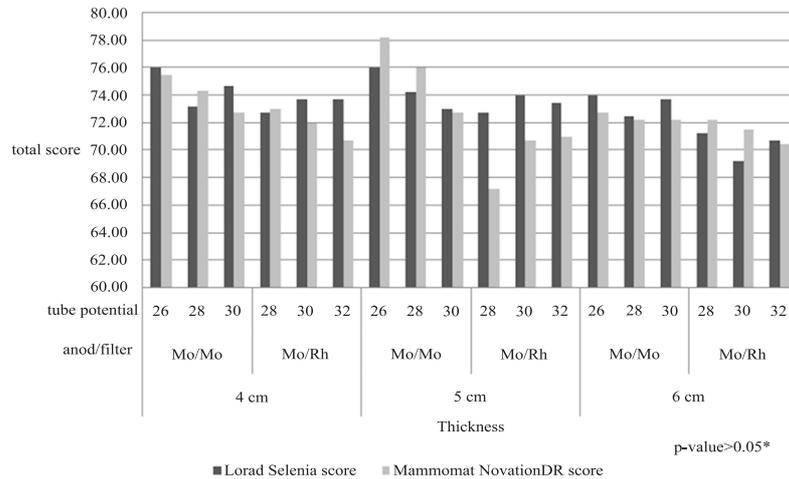
In general radiology, the transition to film-less radiography acted as a catalyst for the conversion of screen film mammography to digital mammography. The currently available systems are computed radiography systems using photostimulable phosphor plates and, digital flat-panel detector radiography. Direct flat-panel detectors offer the advantages of a higher quantum efficiency because X-ray conversion takes place in just one step using amorphous selenium (Yorker et al. 2002). Digital detector offers a better resolution to characterize microcalcifications in the breast and a broad dynamic range to enable simultaneous visualization of structures such as calcifications and fatty tissue (Marshall 2006). Digital acquisition has the advantage of eliminating the need for retakes and allows for electronic enhancement of the image. A previous study with direct flat-panel mammography stated it was superior to the analog screen-film method (Schulz et al. 2002). The aim of this study was to evaluate the

image quality of mammograms using quantitative and qualitative methods of two FFDM systems with variations in breast thickness and anode/filter combination.

The mammography units used for this study were Siemens Mammomat Novation^{DR} (Germany) at the Diagnostic Imaging Department, Hospital Kuala Lumpur and Lorad Selenia (Hologic Inc., Bedford, MA, USA) at the Breast Clinic, National Cancer Society done for a duration of four months from January till April 2008. The Lorad Selenia had an active field of view of the flat-panel detector of 24 × 29 cm, the matrix had an array of 3328 × 4096 pixels, and the pixel edge length was 70 × 70 μm, which is equivalent to a nominal local resolution of 7.2 lp/mm. However, the Mammomat Novation^{DR} had an active field of view of the flat-panel detector of 17 × 24 cm (24 × 30 cm option) the matrix had an array of 2016 × 2816 pixels, and the pixel edge length was 85 × 85 μm, which is equivalent to a nominal local resolution of 6 lp/mm. For both systems data was acquired in an 18 × 24 cm format with a source image distance of 65 cm. The digital system for Lorad Selenia was connected to a workstation (Secur View) that was equipped with soft-copy reading software (Selenia) and a monitor (Barco NView) with a 35 × 45 dimension and resolution of 1600 × 1200 pixels. The Siemens system was connected to workstation (Mammo Report) that was equipped with soft-copy reading software (Window NT) and a monitor (Planar) with a 34 × 27 dimension and a resolution of 1280 × 1024 pixels. A tissue equivalent breast phantom research set model 012A manufactured by Computerized Imaging Reference Systems, Inc. was used in this study. The phantom used consisted of 4 cm, 5 cm and 6 cm thickness with 50/50 glandularity. The phantom had 25 objects: 20 (lp/mm) of line pair target, 12 CaCO₃ specks, 5 nylon fibers and 7 hemispheric masses. These features closely mimic the radiographic properties and shapes of normal and pathological features used for image quality evaluations (Fatouros & Skubic 1985). The position of the phantom and compression paddle were in craniocaudal plane with the same parameters setting used for both systems. The voltage settings were systematically changed between 26 and 32 kVp using the automatic exposure control (AEC) and anode/filter used was molybdenum/molybdenum (Mo/Mo) and molybdenum/rhodium (Mo/Rh) A weighted scoring protocol (Food and Drug Administration, USA), in which scores of higher value are assigned to the detection of less invisible details was used (Gray et al. 1995). Two independent radiologists with a minimum of 5 years experience in interpreting diagnostic mammograms scored the images on the softcopy reporting station. The two radiologist were blinded on the exposure parameters but were provided with diagram displaying the positions of the details. The smallest microcalcification group visible on the images was taken as the smallest size seen by all two radiologist. Use of a single image at each tube potential setting was judged acceptable, as we found a very high experimental reproducibility in scoring mammogram images acquired under

similar conditions (Huda et al. 1997; Caldwell et al. 1992). The image quality was also evaluated using quantitative methods the signal to noise ratio (SNR). The average pixel value from the region of interest was obtained and mathematical calculation was done to obtain the SNR.

Figure 1 showed the visibility of speck, fibre and masses on the image of the CIRS Model 012A using variable tube voltage, thickness and filter of both FFDM systems. The Mammomat Novation^{DR} showed the highest score for Mo/Mo using 5 cm phantom at 26 kVp, however for Mo/Rh filter the highest score was at 30 kVp. For Lorad Selenia, the highest score was at 26 kVp for 4 cm and 5 cm phantom for Mo/Mo combination and for Mo/Rh, the highest score was at 30 kVp for the 6cm thickness. Wilcoxon Signed rank test showed no significant ($p < 0.05$) differences between Lorad Selenia and Mammomat Novation^{DR}. According to the manufacturer's guideline the image should demonstrate; speck bigger than 0.196 mm which are 9 specks, 4 fiber, 4 bigger mass and 15-16 lp/mm line pairs (CIRS 2004). Better quality images were obtained when less thickness phantom was used with lower tube potential due to minimization of scattered radiation (Chida et al. 2005). To achieve better quality images for mammography it is recommended to use lower tube voltage with higher mAs and for thicker breast as demonstrated in this study it is better to use Mo/Rh filter with higher kVp (Tunker & Ng 2001). However, both the FFDM systems met the minimum criteria and would be useful for identification of microcalcifications (specks) and masses for early detection of breast cancer (Kunio et al. 1996). The monitor used for viewing the images had a slightly different specification, Lorad Selenia used Barco monitor and Mammomat Novation^{DR} used Planar monitor which may have contributed to the slight differences in the scores (Evertsz et al. 2002).



*Wilcoxon Sign Rank Test

FIGURE 1. Total image evaluation score for Lorad Selenia and Mammomat Novation^{DR}

However Kappa analysis showed poor agreement between the two radiologist for the scores of image quality as shown in Table 1. The experiences of the radiologist in interpretation of mammogram may had an influence as stated by Carney et al. (2004) as one radiologist had 20 years whilst the other had five years experience. Another variation in scoring may have been attributed due to the origin of one radiologist from hospital and the other from screening centre (Leung et al. 2007).

TABLE 1. Kappa test for image quality

	Value	Asymp. Std. Error ^a	Approx. T ^b	Approx. Sig.
Measure of Agreement Kappa	0.131	0.064	1.888	0.059
N of Valid Cases	51			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Both the FFDM system achieved the minimum level of SNR as recommended by FDA guidelines. Table 2 showed the signal to noise ratio at all the variable exposure parameters. Lorad Selenia displayed a significantly better SNR value in comparison to Mammomat Novation^{DR} using Mann-Whitney test as shown in Table 3. The exposure parameter resulting in the highest SNR value was system specific, dependent on both the tube voltage, anode/filter combinations and on the thickness of the phantom (Dellis et al. 2007). Baldelli et al. (2008) in his study showed as the tube voltage is increased the SNR decreased for both filters. The Mo filter displayed a better SNR in comparison to Rh filter as showed by William et al. (2006). The Lorad Selenia detector was better than the Mammomat Novation^{DR} which may be the factor for the significantly higher SNR at similar parameters.

In conclusion, the study showed there is no significant difference between the images obtained using Mammomat Novation^{DR} and Lorad Selenia for all variable parameters and achieved the criteria as required by Food and Drugs Administration. Although the qualitative evaluation was similar in both systems, the study showed that Lorad Selenia had a significantly superior SNR value, hence would be a better tool to detect early changes in the breast tissue. This study also demonstrated that a lower kVp is more suitable with molybdenum filter, as the breast thickness is increased rhodium filter with higher kVp displayed better quality images.

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TABLE 2. Signal Noise Ratio of Lorad Selenia and Mammomat Novation^{DR} at various parameters

Phantom	Anode/ filter	Tube potential (with AEC)	Signal to Noise Ratio (SNR)	
			Lorad Selenia	Mammomat Novation ^{DR}
4 cm	Mo/Mo	26	51.77 ± 8.87	18.59 ± 17.13
		28	48.77 ± 9.07	8.75 ± 17.33
		30	46.89 ± 8.97	14.85 ± 17.67
	Mo/Rh	28	48.14 ± 8.90	15.63 ± 16.30
		30	46.77 ± 9.03	9.19 ± 16.70
		32	45.28 ± 9.07	73.30 ± 15.27
5 cm	Mo/Mo	26	45.74 ± 9.30	9.34 ± 16.63
		28	46.16 ± 9.10	47.82 ± 16.93
		30	44.49 ± 9.23	12.89 ± 16.93
	Mo/Rh	28	45.45 ± 9.23	23.34 ± 15.93
		30	44.85 ± 9.17	17.59 ± 16.10
		32	44.80 ± 9.27	74.43 ± 15.97
6 cm	Mo/Mo	26	48.01 ± 9.93	17.63 ± 17.40
		28	46.59 ± 9.93	45.89 ± 17.13
		30	44.56 ± 9.57	31.83 ± 17.63
	Mo/Rh	28	46.57 ± 9.73	37.95 ± 16.67
		30	45.50 ± 9.60	28.62 ± 16.50
		32	44.00 ± 9.73	76.21 ± 16.17

TABLE 3. SNR analysis statistic of Lorad Selenia and Mammomat Novation^{DR}

Systems	N	Mean Rank	Sum of Rank	Test statistic*
Lorad Selenia	18	13.78	248	Z-2.689
Mammomat Novation ^{DR}	18	23.22	418	Asymp. Sig. (2-tailed) 0.007
Total	36			

*Significant difference at p-value < 0.05 (Mann-Whitney Test)

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