Revista Brasileira de Física Médica. 2011;5(2):165-70.

Daily quality control in computed radiography mammography using the manufacturer phantom

Controle de qualidade diário em mamografia radiográfica computadorizada usando o simulador do fabricante

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Abstract

The quality control (QC) in mammography system involves a large amount of test tools, which implies a large space for storage and a high number of exposure. This work describes a QC system using a phantom, Fuji Computed Radiography (FCR) One Shot Phantom M Plus, that evaluates several parameters with just one exposure. The software offers tests with annual, semi-annual, quarterly, weekly and daily periodicity, and analyzes the conformities of the mammography equipment, image plate and cassettes. Because of the high number of tests, it was evaluated the daily test only for seven months in two mammography equipments. The test, through the software and its image, allows the analysis of ten parameters in QC. The evaluation of these parameters was realized by the average of the values provided by the software. Only one of the evaluated items showed not conformity, but this was observed and the necessary corrections were realized. The monitoring of use of FCR Mammography QC software with the FCR One Shot Phantom M Plus was realized and through this we could investigate that the quality program provided by the system is appropriate for the radiology services that has the Fuji Computed Radiography system.

Keywords: mammography, quality control, computed radiography.

Resumo

O controle de qualidade no sistema de mamografia envolve uma grande quantidade de ferramentas em teste, o que sugere um amplo espaço para armazenamento e um alto número de exposição. Este trabalho descreve um sistema de controle de qualidade utilizando um simulador para Radiografia Computadorizada Fuji, *One Shot Phantom M Plus*, que avalia diversos parâmetros com apenas uma exposição. O *software* oferece testes de periodicidade anual, semianual, trimestral, semanal e diária, e analisa as conformidades do equipamento de mamografia, da chapa de imagem e dos cassetes. Por causa do elevado número de testes, avaliou-se o teste diário somente por sete meses em dois equipamentos de mamografia. O teste, por meio do *software* e de sua imagem, permite a análise de dez parâmetros no controle de qualidade. A avaliação de tais parâmetros foi realizada pela média dos valores fornecidos pelo *software*. Somente um dos itens avaliados mostrou não conformidade, mas isso foi acompanhado, sendo realizadas as correções necessárias. O monitoramento do uso do *software* de controle de qualidade da mamografia de radiografia computadorizada da Fuji com o *One Shot Phantom M Plus* foi realizado e, por meio dele, foi possível observar que o programa de qualidade fornecido pelo sistema é adequado para serviços radiológicos que possuem o sistema de radiografia computadorizada da Fuji.

Palavras-chave: mamografia, controle de qualidade, radiografia computadorizada.

Introduction

Breast cancer is the second most frequent type in the world and the most common among women, corresponding to the 22% of the new cases per year. When it is diagnosed and treated properly, the prognostic is relatively good[1]. To obtain images that allow a reliable diagnostic, the radio diagnostic services must submit a guarantee quality program for their equipments, containing tests and measurements[2].

It has been habitual in private services the installation in Brazil of digital radiography (DR) and computed radiography (CR) systems for mammography[3]. These technologies require new quality standards and test procedures specifically for digital systems[4].

Considering the installation of CR systems, originally called digital radiography with photostimulable phosphor (PSP)[5], we recommend to check the proper functioning of the system according to the manufacturer specification.

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The manufacturer should provide a quality control phantom and evaluation program with the PSP system[6].

The Brazilian College of Radiology approved the phantom called FCR One Shot Phantom M Plus with Fujifilm FCR Mammography QC Software, based on international standards[3]. In this work, we'll evaluate the daily test results using the phantom and, through them, analyze the application in the practices realized and in the image quality.

Materials and methods

Two mammography equipments Lorad Affinity-Hologic were used in this study, realized at the Advanced Diagnostic Imaging Clinic (DAPI) located in Curitiba, in state of Paraná, which were provided with Fujifilm Computed Radiography system. As additional tests of daily routine for quality control of these equipments, it was adopted the FCR Mammography QC Software system associated to One Shot Phantom M Plus. The software provides the realization of tests with different frequencies (annual, semi-annual, quarterly, weekly and daily). The results obtained are acquired through calculations performed by the software each time that their images are registered and filed. Because of the large number of tests, it will be presented just the evaluation of the daily test in a limited period between January and July of 2010, a total of seven months[7].

The software allows just one diary exposure. For this reason, the survey was accomplished using the phantom in alternate days in each equipment of mammography. These equipments will be identified as the equipments Room 1 and Room 2. The reports are manually issued, because the software does not differentiate the data of both equipments.

FCR Mammography QC Software

The software has as function to carry out tests based on a quality control program and in this way to manage the quality of the FCR Mammography system. The tests can be used for evaluation of the mammography equipment, cassettes, imaging plate (IP) and image reader[7], that compose the system.

Daily test

The daily test is performed to evaluate the image quality, with one exposure only, using the FCR One Shot Phantom M Plus, and to check if the X-ray equipment, IP's and cassettes used in clinic practice are according to this[7]. For this test, it is used an exclusive cassette to the quality control. After the exposure, are included, with the acquired image, ten quality control parameters, specified in Figure 1, which show a diagram of FCR One Shot Phantom M Plus.

To perform the exposure, the cassette is inserted and the FCR One Shot Phantom M Plus is positioned under the bucky of the mammographic equipment. The compression tray should be four centimeters from the bucky. The baseline values are followed as a reference, according to the stipulated through the installation test. For the baseline survey, were performed two exposure with 28 kVp in the mode auto time, the second indication from the manufacturer[7]. The technique achieved is of 28 kVp and 60 mAs, the target/filter of Mo/Mo is selected and the photocell must be in the position 1. The survey considered the two mammographic equipments.

In the image, showed by Figure 2, are analized the patterns: missed tissue at the chest wall edge, in which must appear at least three bars; of geometric distortion, in which the checkered pattern visualized on the images edges should not indicate distortion, therefore all the lines must appear straight and with an aspect off grid; of uniformity, in which must appear four circles in each corner of the image, without cutting, and, if it happens, is indicative that the FCR One Shot Phantom M Plus is not correct centralized and, so, a new exposure must be realized; the image must not present artifacts[7].

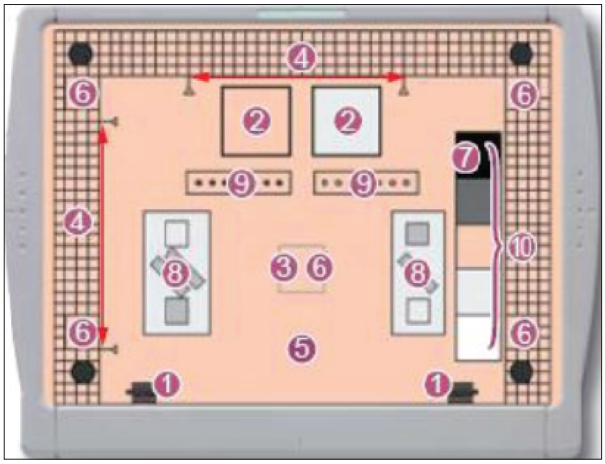

Figure 1. Diagram of FCR One Shot Phantom M Plus[8]. The corresponding components to diagram and their respective parameters analyzed are: 1. Missed tissue at chest wall edge (right and left); 2. Contrast to noise ratio; 3. One Shot Phantom sensitivity constancy; 4.Geometric distortion; 5. Artifacts; 6. Uniformity; 7. Dynamic range; 8. Spatial resolution; 9.Low contrast detectability; 10. Linearity/Beam quality constancy.

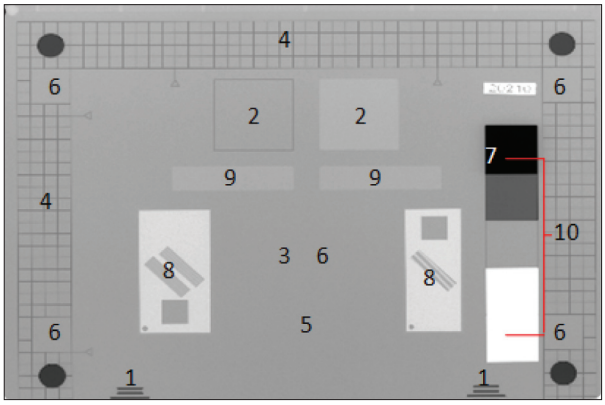

Figure 2. Image acquired after the exposure using the FCR One Shot M Plus.

Results

With the realization of the test using the FCR One Shot Phantom M Plus in equipment, it was possible analyzing the average values of each month for each parameter. The values obtained directly reflect the mammography image quality in the practice of the examinations realized in the room, and in the condition of the equipment. The data of the respective reference of Room 1 and Room 2 follow in Table 1. The values obtained in the equipments of the Room 1 and Room 2 will be shown in Table 2 and 3, respectively.

From the data above, we can observe that the results are within the upper and lower limits, therefore are in accordance with the recommendation of the manufacturer and in agreement with the standard EUREF (European Reference Organization for Quality Assured Breast Screening and Diagnostic Services)[9]. During some days, the linearity/beam QL in steps 3-4 and 4-5 presented no conformity in both rooms, with values below the lower limit, indicating bad positioning of the detector in relation to the sensor, but the problem was corrected putting centralized markers in the bucky. When it was found no conformity of any criterion, surpassing the upper and lower limit stipulated, a request of maintenance of equipments is indicated.

Conclusions

The application of FCR Mammography QC system with the FCR One Shot Phantom M Plus occurs quickly and safely. The results of several quality standards are achieved and accompanied with just one daily exposure. The quality control through the analysis of the test and its image demonstrates the conformity of image standards and the system analyzed, as well as clinical practice. The results obtained with One Shot Phantom M Plus, when compared to others achieved with different test tools, are corresponding. The equipment in study presents reliable answers and its implementation must be strongly encouraged, because identifies the conformity standards of several parameters with just one exposure. The tests with this type of tool do not replace the quality control tests recommended by other reports adopted and carried out with independent equipment manufacturer, but the cost of the system is justified by the benefits.

Table 1. Reference data from Room 1 and Room 2

Content (C)	Parameters (Par)	Lower limit	Upperlimit	Baseline
1. Missed tissue at chest wall edge	1.1 Thoracic edge - right	5		
	1.2 Thoracic edge - left	5		
2. CNR	2.1 CNR	8.634	12.952	10.79
3. Sensitivity	3.1 System sensitivity	72	150	111
4. Geometric distortion [mm]	4.1 Dimension (Scan direction)	101.6	105.8	103.7
	4.1 Dimension (Scan direction)	101.8	106	103.9
6. Uniformity	6.1 Pixel value ratio (Top Right)	-38.05	-8.05	-23.1
	6.2 Pixel value ratio (Top Left)	-34.48	-4.48	-19.5
	6.3 Pixel value ratio (Bottow Right)	-19.35	10.65	-4.35
	6.4 Pixel value ratio (Bottow Left)	-17.15	12.85	-2.15
	6.5 SNR ratio (Top Right)	-27.89	2.11	-12.9
	6.6 SNR ratio (Top Left)	-27.83	2.17	-12.8
	6.7 SNR ratio (Bottom Right)	-18.6	11.4	-3.6
	6.8 SNR ratio (Bottom Left)	-19.72	10.28	-4.72
7. SNR ratio (Bottom Left)	7.1 Average QL at thinnest step wedge	3175	3375	3275
8. Spatial resolution [%]	8.1 2 lp/mm	50.23	56.65	53.44
	8.2 4 lp/mm	18.27	24.71	21.49
9. Low contrast detectability	9.1 Light [%]		40	
	9.2 Dark [%]		40	
10. Linearity/ Beam quality constancy	10.1 QL gap step 1-2	676	716	696
	10.2 QL gap step 2-3	508	548	528
	10.3 QL gap step 3-4	790	830	810
	10.4 QL gap step 4-5	722	762	742

Table 2. Results obtained on equipment from Room 1

Mean values		Jan	Feb	Mar	Apr	May	Jun	Jul
C	Par							
1.	1.1	4.3	4.3	3.9	3.7	3.7	3.7	3.7
	1.2	4.8	4.7	4.4	4	4	4	4.1
2.	2.1	10.42	10.37	10.24	10.12	10.09	10.1	10.11
3.	3.1	114.5	116.8	120	124.4	125.2	126.1	126.1
4.	4.1	103.7	103.7	103.6	103.6	103.6	103.6	103.6
	4.2	103.9	103.9	103.9	103.9	103.9	103.9	103.9
6.	5.1	-19.93	-20.1	-21.43	-22.63	-22.69	-22.84	-22.8
	5.2	-20.03	-20.04	-21.39	-22.63	-22.63	-22.53	-22.45
	5.3	-3.8	-3.9	-3.9	-4.11	-4.28	-4.45	-4.33
	5.4	-4.7	-4.5	-5.9	-7.33	-7.38	-7.28	-6.87
	5.5	-11.17	-11.29	-12.24	-13.08	-13.39	-13.55	-13.67
	5.6	-13.08	-13.32	-14.23	-15.28	-15.35	-15.7	-15.46
	5.7	-3.3	-3.3	-3.31	-3.31	-3.79	-4.05	-4.2
	5.8	-5.3	-5.1	-6.07	-7.18	-7.29	-7.53	-7.4
7.	6.1	3260	3250	3239	3224	3219	3214	3212
8.	7.1	53.78	53.71	53.49	53.19	53.19	53.11	53.37
	7.2	21.54	21.56	21.51	21.58	21.52	21.59	21.56
9.	8.1	66.24	65.65	65.77	66.11	65.32	65.87	64.15
	8.2	65.31	64.68	67.02	65.22	66	64.45	64
10.	8.3	691.1	692.4	689.6	689.6	688.8	687.9	687.4
	8.4	520	521	523.8	525.8	525.7	525.2	524.2
	8.5	803.9	805.8	806.5	808.2	807.3	806.9	805.1
	8.6	737	737.3	736.4	737.2	736.8	736.7	736.5

Table 3. Results obtained on equipment from Room 2

Mean values		Jan	Feb	Mar	Apr	Mai	Jun	Jul
C	Par							
1.	1.1	3.7	3.7	3.8	3.9	3.8	3.8	3.9
	1.2	4.5	4.5	4.5	4.5	4.5	4.6	4.5
2.	2.1	10.28	10.55	10.32	10.50	10.51	10.57	10.40
3.	3.1	115.7	113.3	115.2	112.2	113.3	115.1	119.6
4.	4.1	103.6	103.6	103.6	103.6	103.6	103.6	101.6
	4.2	103.9	103.8	103.9	103.9	103.9	103.9	101.8
6.	5.1	-21.60	-21.71	-21.28	-20.77	-21.26	-21.54	-21.86
	5.2	-20.60	-20.29	-20.42	-20.29	-20.22	-19.89	-20.49
	5.3	-2.48	-2.50	-2.67	-2.75	-2.99	-3.26	-3.45
	5.4	-2.95	-2.80	-3.25	-3.36	-3.49	-3.19	-4.04
	5.5	-12.05	-12.36	-11.81	-11.55	-11.59	-12.00	-12.50
	5.6	-13.43	-13.47	-13.46	-13.67	-13.14	-12.96	-13.69
	5.7	-2.8	-2.9	-3.1	-3.0	-2.8	-2.9	-3.4
	5.8	-4.41	-4.74	-4.49	-4.38	-4.62	-4.27	-5.29
7.	6.1	3243	3257	3249	3264	3258	3250	3234
8.	7.1	53.77	53.67	53.80	53.87	53.84	53.63	53.49
	7.2	21.63	21.64	21.56	21.61	21.61	21.66	21.65
9.	8.1	67.46	67.68	67.88	67.15	68.15	67.37	67.44
	8.2	63.69	62.72	63.99	62.94	64.45	63.97	63.45
10.	8.3	683.2	684.3	683.5	684.4	684.5	684.5	685.1
	8.4	520.6	521.1	520.1	521.1	520.4	520.3	521.1
	8.5	793	794.5	795	795.8	795.5	794.9	796.1
	8.6	733.6	737.3	733.2	726.8	738.1	739.9	732.9

Acknowledgment

Advanced Diagnostic Imaging Clinic (DAPI) and Technological Federal University of Paraná.

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