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Assessment of mammography quality in İstanbul

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PURPOSE
We aimed to evaluate the mammography image quality in İstanbul and to survey the awareness of mammography quality.

MATERIALS AND METHODS
Fifty-five mammography units in İstanbul were visited. The mammography image quality was evaluated using a standard American College of Radiology (ACR) accreditation phantom. The phantom contained 16 objects, and a score of at least 10 of 16 was accepted as the optimum level for image quality according to ACR recommendations. Mediolateral oblique (MLO) and craniocaudal (CC) best views obtained from 48 units were evaluated for proper positioning. The technologist for each unit completed a questionnaire designed to determine the equipment properties and quality awareness. Finally, the technologist was asked to evaluate the quality of mammograms at that site. All phantom images and best views were evaluated and scored by two blinded radiologists.

RESULTS
Of the 55 units visited, 50 completed both the phantom imaging and questionnaire. Images from 19 of 50 units (38%) did not meet quality standards. Positioning for MLO view was not correct in 72% of the units, and 39% of the units had improper positioning for the CC view. However, 90% of these units reported that they had excellent image quality and positioning.

CONCLUSION
The mammography image quality is poor in İstanbul, and mammography units are not aware of the image quality.

Key words: • mammography • image quality • breast ultrasonography

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Mammography is the only proven effective method for breast cancer screening (1). Image quality in mammography plays an important role in detecting small lesions and microcalcifications. Low quality images lead to underdiagnosis of *in situ* and early cancers (2). Quality standards for mammography are established in Western countries, and breast imaging units are accredited and strictly monitored (3–5). Unfortunately, Turkey has no established standards. The Manual for Quality Standards of Conventional Mammography prepared by the Turkish Radiological Society (TRS) contains the only guidelines published in Turkey (6), and the manual has not been used in an accreditation program. A volunteer accreditation program has been developed by the Society for Conventional Mammography but, to our knowledge, no applications have been made to date. The only obligatory inspection for mammography machines occurs in the application for a license during the registration process conducted by the Turkish Atomic Energy Authority. However, this process does not take the image quality into account.

The aim of the present study was to assess the image quality of mammography units in İstanbul.

Materials and methods

A total of 55 mammography units in İstanbul were visited between November 2010 and March 2011. The list of the mammography units was obtained from the health authorities. Four centers refused to enter the study. Twenty-four of the units belonged to public healthcare facilities, and 27 were private centers. The public health care facilities included three university hospitals, one military research hospital, 11 public educational research hospitals, and nine public hospitals or clinics. The private centers included three private university hospitals, 18 private hospitals, and eight private centers. Full-field digital mammography (FFDM) equipment was used in 18 units, 24 units used computed radiology (CR) for digital imaging, and an analog mammography system was used in nine units. Two machines did not have an automatic exposure control (AEC) system. An American College of Radiology (ACR) accreditation phantom was used to assess image quality. We used a phantom (Computerized Imaging Reference Systems Model 015 [Z 673], Norfolk, Virginia, USA) made of acrylic that contained 16 structures mimicking masses such as calcifications and fibers that was the equivalent of 4.5 cm thickness of compressed breast tissue. Each unit exposed the phantom according to its own protocol for a craniocaudal (CC) view of a standard size (B cup) breast. All exposures were performed using the AEC system with the exception of those made by the two units that did not have AEC systems. In these units the technologists were asked to use the same protocol they used to take a CC view of a standard size breast. The phantom images were obtained by the first author (B.G.) with the help of the responsible technologist on site.

For phantom image evaluation, we obtained soft copy images made using the DICOM format from the centers that had FFDM systems and radiograms from the centers that used an analog mammography system. In the centers that used CR systems, we evaluated the type of copy the unit reader preferred for interpreting the film, i.e., we evaluated soft copies if that is what the unit reader preferred, and we evaluated both the hard and soft copy in cases where the reader preferred the hardcopy. In units where hardcopies were used for film interpretation, the printers used to produce the hardcopy were noted. All CR devices and printers were checked with the manufacturer for compatibility with breast imaging. Furthermore, the film processor and film screen combinations used in the analog mammography systems and the screens used in the CR systems were noted.

The units were asked to provide a copy of their best CC and mediolateral oblique (MLO) view mammograms for an analysis of the quality of their breast positioning technique. The technologists in each unit were asked to complete a 10-item questionnaire concerning the type of mammography equipment they used and the care given to meet quality control standards. The questionnaire was administered during a one-to-one interview by the first author on the day of visit. The questions were designed to determine the number and type of mammography machines in the unit and whether they had AEC; the number and type (diagnostic, screening, or both) of mammograms taken; the types of processors, printers, film screen combinations, and film storage used; the presence of densitometry, sensitometer, phantom, and thermometer for processor checks; and the use of routine processor, screen, and phantom image checks. In the last question, the technologist was asked to score the quality of the mammograms in their facility from 1 to 5, with 5 as excellent and 1 as poor.

Analysis of image quality

The phantom images and best mammograms were evaluated by two radiologists blinded to the site and type of equipment used. The images were evaluated after the visits were completed and all the data were compiled. The best mammograms and phantom images did not contain any sign or label indicating the name of the site. All the labels were covered on the hard copies and hidden on the soft copies. One of the readers had more than 10 years experience in breast imaging and read more than 3000 mammograms per year. The second reader had one year of experience in mammography. The hard copies were evaluated by a view box used only to read mammograms, and soft copies were evaluated using the same five megapixel medical monitor dedicated for mammography reading, which was routinely calibrated. All images were evaluated in a separate darkroom.

The image quality was assessed by the total score of resolved phantom structures incorporated in the phantom. The ACR and TRS recommendations were used for image analysis. The phantom contained 16 objects representing fibers (speculations), speck groups (microcalcifications), and masses. A score of at least 10 out of 16 was the accepted optimum level for image quality. The artifacts were noted separately. The best mammograms were evaluated according to the recommendations of TRS. The scoring system for image position in the CC view was two points each for imaging of the medial endpoint of the mammogram, the correct position of the nipple, and if the difference in the distance from the nipple to the pectoral muscle in the MLO view was less than 1 cm. Scoring in the MLO view was two points each for the correct position of pectoral muscle, imaging the fatty tissue posterior to the fibroglandular tissue, showing the inframamarian fold, a clear image with no movement artifacts, and an effective compression. As these were the best mammograms, a total of 16 points was expected and defined as excellent. The results of two readers were compared, and in case of inconsistency, the film was re-evaluated, and a consensus was formed.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois, USA) was used to perform the statistical tests. The phantom findings for the three mammography systems were evaluated using a one-way analysis of variance (ANOVA), and the differences were evaluated using a Tukey-Kramer multiple comparisons test. P values < 0.05 were deemed to be statistically significant. The difference between different units was evaluated using an unpaired t test with the Welch correction. The best mammogram was evaluated using a Mann-Whitney U test.

This study was approved by the Ethics Committee of the Marmara University School of Medicine.

Results

Of the 55 breast imaging units visited, four refused to enter the study, and one unit completed the questionnaire, but did not allow us to see the phantom images and best mammograms. Thus, 50 units completed both the phantom imaging and questionnaire. Of those, we were unable to obtain the best mammograms from two units because of poor archiving. Thus, the best mammograms were evaluated in 48 units.

Image analysis

Nineteen of the 50 units (38%) scored less than 10 points (Table 1). A significant difference in image quality was found between the analog, FFDM, and CR systems ($P < 0.01$; Table 2, Fig.). No statistical difference in image quality was found between private and public facilities ($P > 0.05$).

Nine of the 48 units (18.7%) scored the full 10 points for best MLO mammograms (Table 3), and 31 (64.5%) of the units scored at the full 6 points for the best CC mammograms (Table 4).

Questionnaire

Six (12%) of the units reported that they performed screening mammography solely, and the remaining 45 (88%) reported performing both screening and diagnostic mammography. The analog film processors in the conventional mammography units were for general use and none were suitable for mammography. The CR systems in five units were not suitable for mammography, but were suitable for general radiography. However, all the CR screens and analog mammography film screen combinations were suitable for mammography.

Each site was asked if they followed routine daily, monthly, or yearly protocols for quality control. Fourteen (27%) of the 51 units reported that

Table 1. Frequency distribution for phantom lesion variables

		Frequency	All (%)	Evaluated (%)	Cumulative (%)
Number of lesions detected	0.00	2	3.9	4.0	4.0
	1.00	1	2.0	2.0	6.0
	2.00	1	2.0	2.0	8.0
	3.50	1	2.0	2.0	10.0
	5.00	1	2.0	2.0	12.0
	5.50	1	2.0	2.0	14.0
	7.50	3	5.9	6.0	20.0
	8.50	5	9.8	10.0	30.0
	9.00	2	3.9	4.0	34.0
	9.50	2	3.9	4.0	38.0
	10.00	2	3.9	4.0	42.0
	10.50	4	7.8	8.0	50.0
	11.00	4	7.8	8.0	58.0
	11.50	7	13.7	14.0	72.0
	12.00	5	9.8	10.0	82.0
	12.50	2	3.9	4.0	86.0
	13.00	5	9.8	10.0	96.0
	14.00	2	3.9	4.0	100.0
	Total	50	98.0	100.0	
No phantom		1	2.0		
Total		51	100.0		

Table 2. Comparison of the systems

	Mean odds	q	*P*
Film vs. CR	-2.7	3.5	< 0.05
Film vs. DR	-5.8	7.1	< 0.001
CR vs. DR	-3.2	5	< 0.01

CR, computed radiography system; DR, digital radiography system.

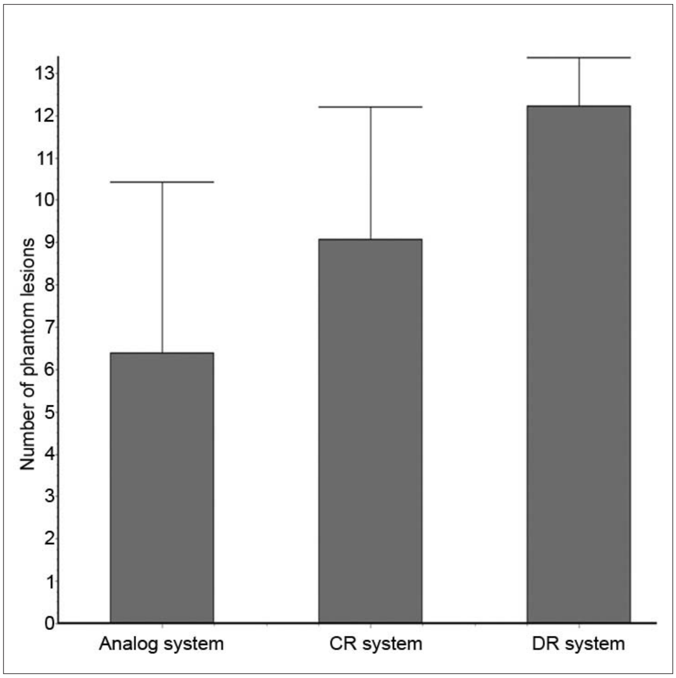

Figure. The mean accuracy of the analog, computed radiography (CR), and digital radiography (DR) systems in detecting phantom lesions. Error bars indicate standard deviation.

Table 3. Frequency distribution for MLO views

		Frequency	All (%)	Evaluated (%)	Cumulative (%)
Score	0.00	3	5.9	6.3	6.3
	3.00	1	2.0	2.1	8.3
	4.00	1	2.0	2.1	10.4
	5.00	8	15.7	16.7	27.1
	6.00	5	9.8	10.4	37.5
	7.00	5	9.8	10.4	47.9
	8.00	9	17.6	18.8	66.7
	9.00	7	13.7	14.6	81.3
	10.00	9	17.6	18.8	100.0
	Total	48	94.1	100.0	
No film		3	5.9		
Total		51	100.0		

Table 4. Frequency distribution for CC views

		Frequency	All (%)	Evaluated (%)	Cumulative (%)
Score	0.00	2	3.9	4.2	4.2
	2.00	2	3.9	4.2	8.3
	3.00	1	2.0	2.1	10.4
	4.00	3	5.9	6.3	16.7
	5.00	9	17.6	18.8	35.4
	6.00	31	60.8	64.6	100.0
	Total	48	94.1	100.0	
No film		3	5.9		
Total		51	100.0		

they did not follow any quality control protocols, 11 (21%) reported that they followed a protocol sometimes, 26 of 51 units (51%) reported that they routinely followed a protocol. Two sites using an analog mammography machine reported that the raw films were exposed to daylight and radiation in storage.

We found artifacts on the phantom images from eight units (16%) owing to the absence of routine cleaning and quality control, although three of these units reported that they conducted routine quality control procedures and two reported that they sometimes performed quality control procedures. In eight of the CR units the readers evaluated mammograms on hardcopies, but none of these facilities had printers suitable for mammography printing.

During the self-assessment, 43 technologists (84.3%) gave themselves a score of 5 (excellent).

Discussion

The present study showed that the quality was poor in 38% of the mammograms performed in the mammography units in İstanbul. Quality is indispensible in screening mammograms in which microcalcifications and lesions less than 1 cm need to be detected (1, 2). Poor quality mammography may result in failure to detect these lesions and may cause adverse consequences such as missed cancers, an increase in false positive examinations, increased costs, and anxiety and discomfort for the women who must undergo additional procedures (2). The implementation of screening programs and recognition of the importance of quality control in mammography screening examinations have led to the development and promotion of quality assurance standards. Guidelines and accreditation programs are common in the Europe and USA where screening is widely performed (3–5). The Mammography Quality Standards Act (MQSA) in the USA required all mammography facilities to become accredited and certified in 1994 (5). This Act has led to a significant improvement in mammogram quality in the USA over the last 10 years (5). Turkey has no mandatory mammogram accreditation program. The only manual for quality assurance in mammography is that published by the TRS, and it contains guidelines for analog mammography systems only (6). Although the TRS has called for volunteer applications for accreditation of analog mammography systems on its website, to our knowledge, no application has been made to date. The only obligatory inspection for mammography machines is made by the Turkish Atomic Energy Authority during the registration process, and that inspection does not take image quality into account. A recent study by Voyvoda et al. (7) surveyed the quality of mammography systems in Turkey using a questionnaire. Their results showed that some of the machines were not registered by the Turkish Atomic Energy Authority, and the responses showed a lack of quality across the country. At the introduction of the MQSA, 30% of the facilities failed to meet the standards; however, that number dropped to 11.7% in 2003 (5). Although our results are similar to those in the USA in 1994, the requirements of the MQSA are stricter than the criteria in the present study.

Positioning was not satisfactory in either the CC or MLO view. Only 28% of the units showed the correct MLO view. The results for the CC view were better, with a 61% success rate. The MLO view appears to be a more difficult and less well understood position for technologists than the CC view. Although 72% of the technologists failed to obtain a perfect MLO view, 90% rated their images as excellent in their self-assessment. Thus, our study demonstrated a lack of awareness of quality and knowledge of mammography positioning among the technologists. Voyvoda et al. (7) reported similar findings, showing that, despite insufficient mammography quality, 71.5% of the participants indicated high satisfaction with the quality of the mammograms in their facility. Comparably, 16% of the units had artifacts in their images but 62.5% of these units reported that they had routine or irregular quality control programs. Both studies showed a severe lack of awareness and knowledge of mammography quality.

The present study showed a significant difference in the quality of images taken by FFDM, CR, and analog machines. All of the phantom images made with FFDM machines scored 10 or more, whereas we found failures in both the CR and analog systems. This finding may give a false impression of the superiority of FFDM compared with CR and analog equipment. The Digital Mammographic Imaging Screening Trial (DMIST) showed that the overall diagnostic accuracy of digital and film mammography screening for breast cancer was similar (8). The DMIST compared analog mammography and FFDM, including a CR system. The only difference found in favor of FFDM was in women under the age of 50 years and for dense breasts. Further analysis of the data did not show a difference between individual FFDM units, including the CR system (8). The results of the DMIST study conflict with our findings. The centers that participated in the DMIST met the quality control standards for both digital and analog mammography (9). Other studies comparing conventional and digital mammography have shown similar results to the DMIST (10–11). In the present study, lack of quality control in the image processing can explain the poor quality in the CR and analog systems. We found that storage was not adequate and films were exposed to light and radiation in two centers. The analog film processors were not suitable for mammography, although they were suitable for general radiographic use. Some of the CR systems were not suitable for mammography. In eight of the units that had CR systems, the radiologists evaluated hardcopies that were printed by general use radiography printers that were not mammography compatible. The analog and CR mammography systems have multiple components such as the mammography machine, film screen combination, film processor, CR device, and CR screens for which quality requirements should be in place. In contrast, the FFDM equipment is installed and maintained by the manufacturer as a closed system where it is not possible to use a low resolution, inexpensive, poor-quality detector or medical monitor. It is well documented that quality imaging cannot be obtained in a conventional mammogram without a correct film screen combination and dedicated film processor (3). Similarly, for CR systems, it is not possible to produce good quality images without mammography-compatible CR devices or CR screens.

The present study had some limitations. We did not use detailed inspection criteria such as optical density or mean glandular dose. Our goal was to evaluate the end result of the process, the image, which indicates the quality of the entire process.

As a conclusion, the quality of the mammography is poor in a significant proportion of the breast imaging units in İstanbul. Although İstanbul is just one city in the entire country, it is the biggest city in Turkey, and home to one-fifth of the population. Thus, we believe that our results can be generalized to the entire country. According to our data, deficiencies in the quality of image processing and lack of knowledge and awareness of quality in mammography are the main sources of the problem. Quality control steps such as a mandatory accreditation program, continued education, and information on quality for health administrators should be taken immediately.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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