EFFECT OF FILM DIGITIZATION ON MAMMOGRAPHIC IMAGE QUALITY

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Abstract. *The modern hospital environment uses PACS (Picture Archiving and Communication System) instrumentation for storing and process digital images. Breast cancer is of the highest causes for women death. Routinely mammography examinations are performed for the early detection of breast cancer and reference purposes. The purpose of this study was to evaluate the image quality of digitized films which might be incorporated in digital hospital environment. The Artinis CDMAM type 3.4 phantom, was placed in contact with 40mm PMMA slabs and irradiated with Mo/Mo and Mo/Rh typical X-ray mammographic spectra. The derived films were digitized with an AGFA Duo Scan medical scanner with 8bit pixel depth and 1000ppi resolution. The optical density of the film was in the linear pat of the scanner transfer curve. For the analysis of the digitized images the Image J software was used. The contrast detail curve to both the analog and the digitized films was calculated according to the CDMAM instructions. It was found that the 25kV mammogram was presented betted contrast detail than the other exposure conditions. If the 28kV is consider the image quality of the film depends upon the position of the phantom with respect to the film. In most cases the digitized film presents worse contrast detail.*

1 INTRODUCTION

Breast cancer is one of the most common presented in women. From early years women were subjected to mammographic screening X-ray examination to determine the possibility of breast cancer. The mammograms are usually stored for reference purposes and for image findings comparison. The storing place was either in the institute where the mammogram was taken, accompanying the patient medical record, or was kept by the examinee. In the early years where the images were analog in the form of a radiographic film, storing problems in a large institution may have occurred. In recent years the advances of digital mammography and the establishment of a digital communication network in a Hospital Information System (HIS) environment allowed easier management of data. In addition, the uses of digital picture archiving techniques, as well as the effective utilization of the Radiology Information System (RIS), have provided the means for small physical storage. Some of the existing medical institutions however may still uses analog screen films technology, and/or may wish to digitize their films in order this information to be incorporated in the RIS and be easily available and accessible by the radiologists. Film digitization however modifies the signal and noise transfer characteristics of the original image since the scanner adds noise in the image. In addition the scanner resolution convolves with the fine details visible on a film leading to degradation of image detectability [1]. Finally the scanning parameters may affect the dynamic range of the image. There is published literature studying the signal and transfer properties of medical scanners, usually through quality acceptance protocols [1-3]. Current literature in film scanning is usually focused on scanner type performance evaluation or objective assessment of scanned SMPTE patterns [4]. In addition the Signal to Noise ratio of different high energy radiographic techniques and their scanned images has been reported [3,5]. Finally the effect of digitization parameters have been studied for dental radiology applications [6]. In this work the effect of the digitization of mammographic films, in image contrast detail has been studied. The studied comprised the irradiation of Artinis CDMAM phantom under different exposure conditions and phantom thickness. The films were scanned with an Agfa Duo Scan medical image scanner. Contrast detail was assessed by 4 observers. It was found that the extent of degradation of the contrast detail, due to the digitization, is affected by the exposure conditions of the original image.

2 MATERIALS AND METHODS

2.1 Exposure Conditions

Mammographic contrast detail was assessed via the Artinis CDMAM phantom, demonstrated in figure 1. The phantom consists of e series of gold disks (99.999…% purity), positioned in square blocks, with thicknesses ranging from 0.03μm to 2μm in 16 exponential steps, corresponding to a contrast range between 0.5-30% under standard conditions. The corresponding diameters, ranges from 0.06mm to 2.0 mm in 16 exponential steps [7]. In each detection area two disks are present, one in the center and the other randomly placed in an edge of the square, as it is demonstrated in Figure 1 [7]. The phantom was placed between slabs of PMMA of 10mm thickness each, resulting in total subject thickness ranging from 10mm (only the phantom) to 50mm (the phantom plus 4 slabs). In addition the position of the phantom between the slabs was varied. The irradiation was performed with a GE Senograph DMR mammographic X-ray unit installed in Euroclinic Hospital of Athens. The tube voltages used were 25, 28 and 32 kVp for both Mo/Mo and Mo/Rh anode filter combinations. The mAs was varied between 6 and 140. The high kVp and mAs values was chosen to counterbalance the additional 0.5mmAl exist in the base of the CDMAM phantom. The optical density of the developed films (Fuji) was measured with a PTW sensodensiX densitometer. Only films with optical densities between 1 OD and 2 OD were chosen for digitization in order to ensure that the final images were in the linear range of the film and the scanner [1].

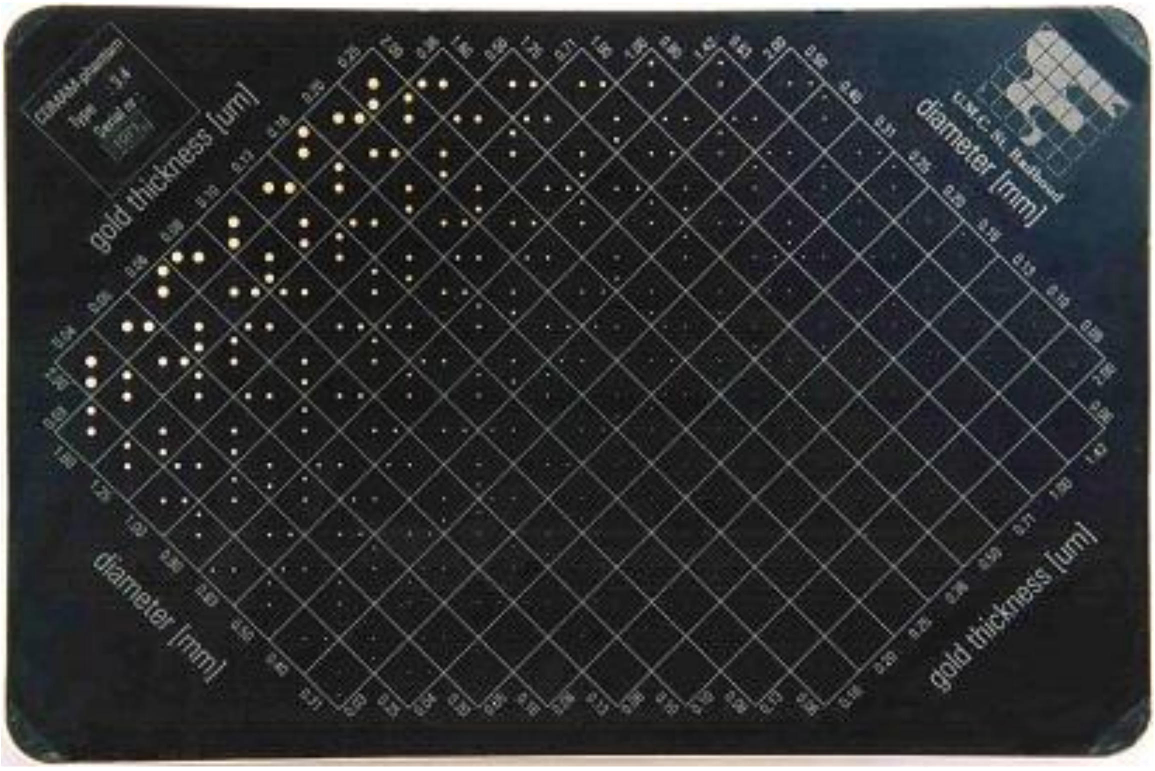

Figure 1. The Artinis CDMAM phantom [7]

2.2 Digitization Process

An Agfa Duo SCAN medical film digitizer was utilized. The scanning parameters were: Original=Transparent, Mode=grayscale, bits per color=8bits, input=1000ppi, scale to:100%, range:densities. All the other scanning parameters: tone curve, sharpness, descreen, flavor and W/B point was chosen as 'none' to minimize any image processing effect by the scanner software. The digitization step of 1000ppi corresponds to 25.6 μm per pixel. This pixel size theoretically allows the detection of microcalcifications of very small dimensions. The color available was 8bit and 16bit, corresponding in image sizes of 50Mb and 70Mb respectively. The choice of the 8bit color was necessitated by reasons of image capacity. However the human eye can hardly detect differences above 12 bit, therefore the 8bit over the 16bit color was a reasonable choice, for a common computer access and storing capabilities.

2.3 Contrast detail assessment

The digitized images as well as the original films were assessed in terms of contrast detail by 4 viewers. The area with the minimum detectability for each film was chosen by common decision provided 75% (3 out of 4) of the viewers agreed. According to the CDMAM manual "true" detection is valid provided both disks are visible in the square, as well as in two of its nearest neighbors. The films were observed in contact with an illumination box to maximize the threshold contrast detectability, as seen in Figure 2. It can be observed from Figure 2, that the illumination box contrast detail curve presents better detectability (lower curve) for disks thicknesses below 0.5 μm and for disks diameters up to 0.8mm than the physical light conditions (red mark). The scanned films were observed in a high resolution, commercially available and for general use, computer monitor with low background light conditions. The digital pictures were handled via Image J software [8]. Digital image manipulation (i.e. zoom) was allowed.

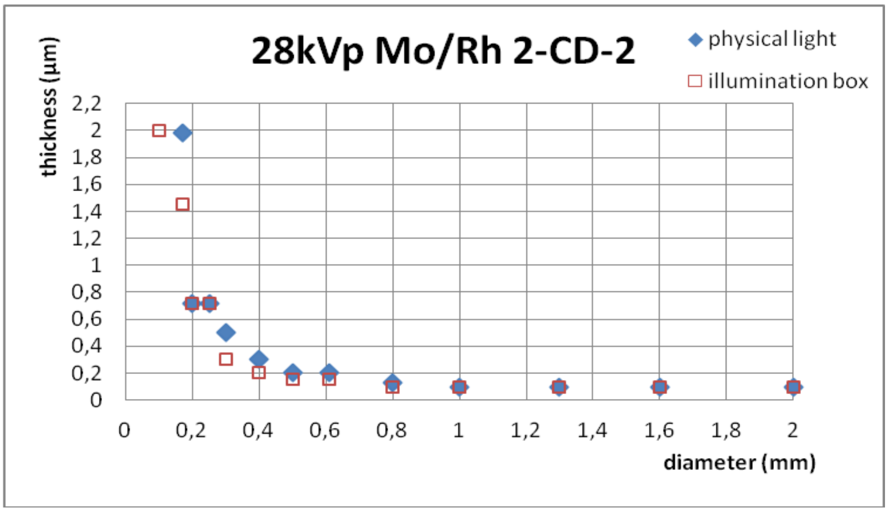

Figure 2. The film contrast detail curve for 28kVp Mo/Rh irradiation spectrum.

3 RESULTS AND DISCUSSION

In Figure 3 the contrast detail curves for irradiation conditions of 28kVp for both target/filter combinations available are demonstrated. The black color marks correspond to the film and the red marks to the digitized images. The irradiation geometry consisted of 4 PMMA slabs followed by the CDMAM phantom on top of the bucky (4-CD-0). This geometry minimizes the effect of image blurring due to scatter X-ray photons prior to the bucky. It can be observed from Figure 3 that for both X-ray spectra the digitized image shows inferior detail detectability, for disk thicknesses up to 1.5 μm and diameters up to 0.6mm. The details visible by the two spectra are practically equivalent for both the original and the digitized images. Despite the fact that the Mo/Mo target/filter combination spectrum presents a lower mean energy [9], resulting in a higher subject contrast, than Mo/Rh, this contrast theoretical superiority is not transferred in the images. This may be attributed to the increased number of X-rays originating from Mo/Rh higher energy that penetrate more efficiently the 0.5 mmAl of the phantom base, thus resulting in an image of lower noise.

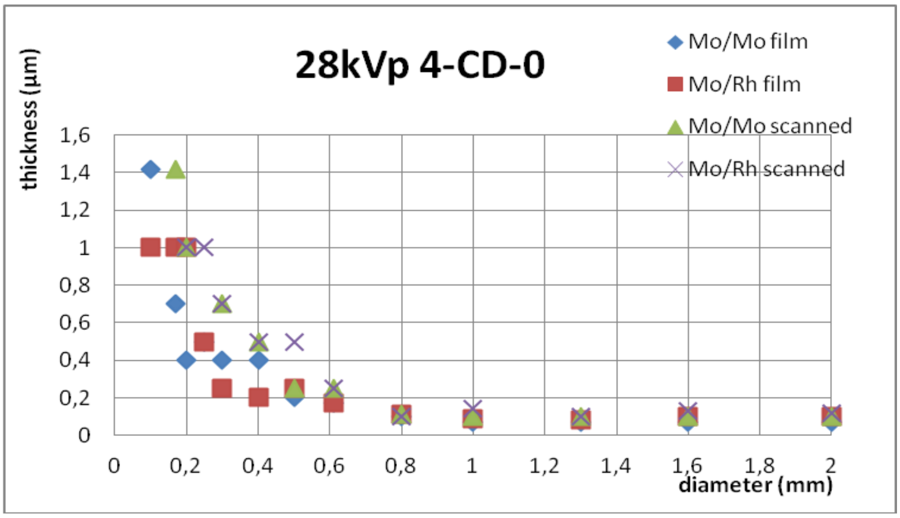

Figure 3. Contrast detail curves of films and their corresponding digitized images, for Mo/Mo and Mo/Rh filter/target combinations at 28kVp.

In Figures 4a, 4b, and 4c, the contrast detail curves for irradiation conditions of 25kVp, 28 kVp and 32kVp respectively are demonstrated. The irradiation geometry consists of 2 PMMA slabs followed by the CDMAM phantom and another 2 PMMA slabs on top of the bucky (2-CD-2). The target/filter combination was Mo/Rh. It can be observed from Figures 4b and 4c that the digitized image detectability is less than the original film for disks thicknesses up to 1.0μm and diameter up to 1.2mm. On the contrary in Figure 4a, corresponding to 25kVp voltage, the contrast detail curves for both images are remarkably the same. An explanation of this should consider that the detectability of images is affected by the Contrast-to-Noise ratio of the subject images. Although the 28kVp and the 32kVp allows more X-ray photons to be detected thus leading to low noise images the subject contrast of the 25kVp images is sufficient enough so as to allow a similar level of human observer detectability. The scanner characteristics: blur due to pixel aperture and noise, as expected, affects all images, which is already demonstrated in figures 3, 4b and 4c. It is of interest however to observe that a high contrast image can retain its visual perception after digitization. The presented results however are biased from the transfer characteristics of the scanner (i.e. linear range) and the quality of the computer monitor. A high resolution medical monitor may demonstrate images of better quality and thus results in a smaller degree of difference between the contrast detectability of films and their corresponding digitized images.

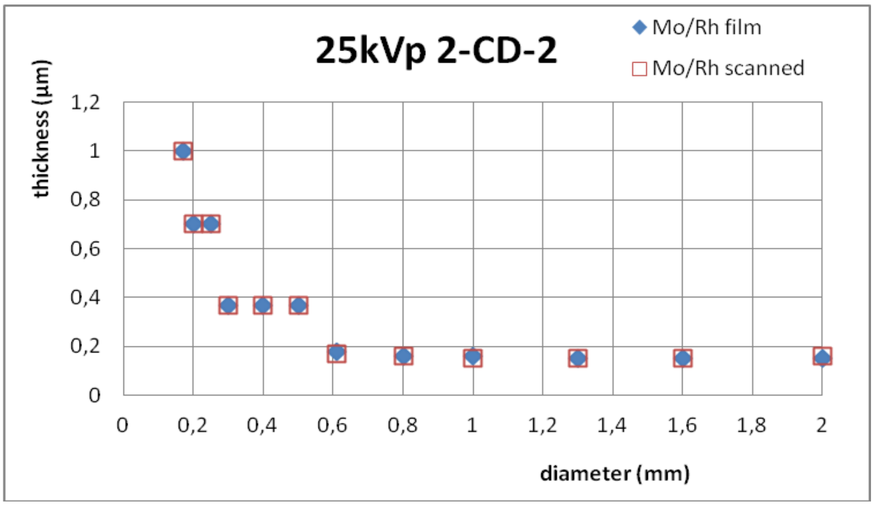

Figure 4a. Contrast detail curves of film and its digitized image, for Mo/Rh filter/target at 25kVp.

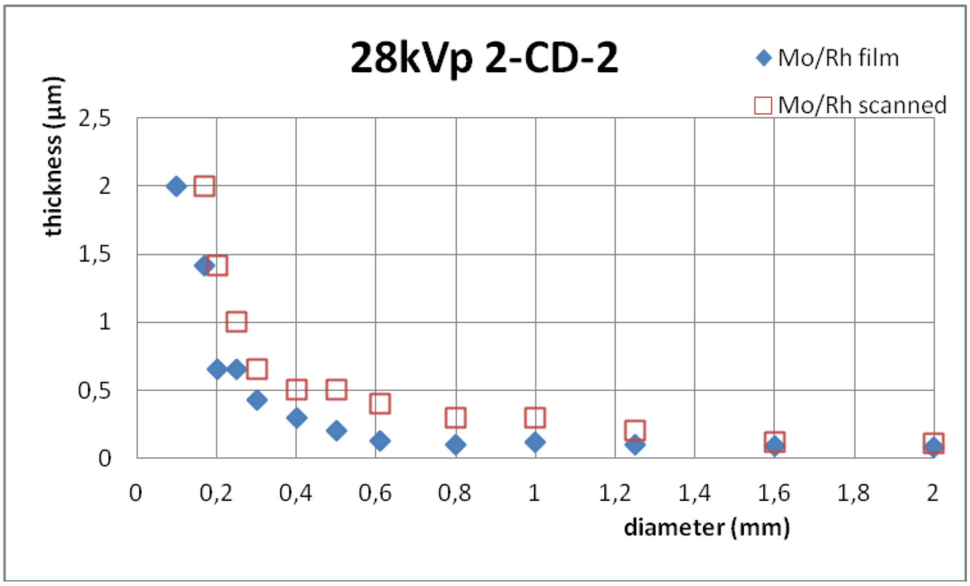

Figure 4b. Contrast detail curves of film and its digitized image, for Mo/Rh filter/target at 28kVp. The y-axis is the disk thickness and the x-axis the disk diameter.

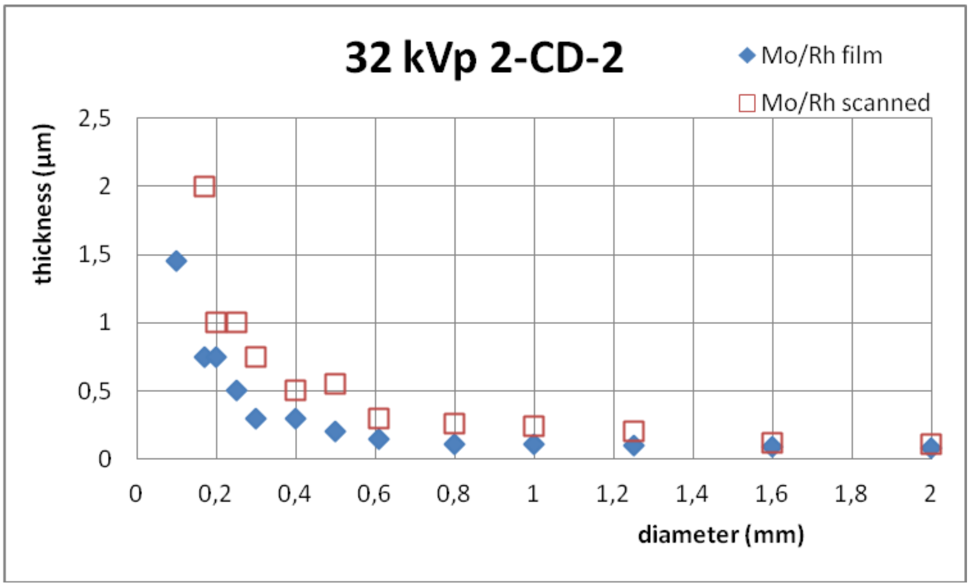

Figure 4c. Contrast detail curves of film and its digitized image, for Mo/Rh filter/target at 32kVp.

4 CONCLUSION

The effect of the digitization on mammographic image quality through contrast detail assessment has been studied. The evaluation was performed via imaging the Artinis CDMAM phantom. The effect of X-ray spectrum and kVp selection was examined. It was found that the digitization process suppress the image detectability for gold disk thicknesses up to 1.5μm and corresponding diameters up to 0.6mm in most of the cases. However images with high contrast managed to sustain their detectability, through human observer assessment even after digitization. The presented results are affected by the transfer characteristics of the scanner, the quality of the computer monitor and the experience of the viewers. Nevertheless they could be of assistance in deciding the digitization of mammograms.

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