Automated and Human Determination of Threshold Contrast for Digital Mammography Systems

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Abstract. European Guidelines for quality control in digital mammography specify minimum and achievable standards of image quality in terms of threshold contrast, based on readings of images of the CDMAM test object by human observers. However this is time-consuming and has large inter-observer error. To overcome these problems a software program (CDCOM) is available to automatically read CDMAM images and can be used to predict the threshold contrast for a typical observer. The results of threshold contrast determination by a panel of 3 human observers was compared in this study to predicted human readings for different types of digital mammography system to determine whether this provides a viable method of automated quality control and comparison with existing European Guidelines.

1 Background

European Guidelines for the quality control of mammography provide quality control procedures and minimum standards of performance for digital mammography [1]. The image quality standard is based on contrast-detail measurements using the CDMAM phantom (version 3.4, UMC St. Radboud, Nijmegen University, Netherlands) [2]. The minimum standards were chosen to ensure that digital systems are as good or better than current film screen systems [3]. Such contrast detail measurements rely on a large number of observer readings and suffer from significant inter-observer error, which undermines the reliability and confidence in the measurements. The use of human observers is also very time consuming. A possible solution to these problems is the use of the CDCOM program, which automatically reads CDMAM images [4,5,6,7]. It has been noted that the threshold contrasts determined using this program are lower than those found by human observers [4,5]. However recently the relationship between automatic and human observer scoring has been explored and a means of predicting typical human threshold contrast described [8]. This method is used here along with a panel of human observers to assess threshold contrasts for a variety of digital mammography systems and to compare these with the standards in European Guidelines.

2 Method

The CDMAM phantom was radiographed on each of the digital systems shown in Table 1. (One of the systems is identified only as Test CR as the manufacturer has

Susan M. Astley et al. (Eds.): IWDM 2006, LNCS 4046, pp. 266 – 272, 2006.

suggested that the system may have been faulty and its performance not representative of normal operation.) The phantom was positioned with a 20 mm thickness of PMMA blocks above and below. This combination has a total attenuation approximately equivalent to 50 mm of PMMA. This has been shown to be equivalent to breasts of typical composition with a compressed thickness of 60 mm [9]. Expanded polystyrene spacers were added at the edges of the phantom to create a total thickness of 60 mm and a standard compression of 100N applied. This arrangement was imaged using the factors automatically selected by the X-ray set and shown in Table 1. Where possible the effect of dose on threshold contrasts was assessed using further sets of 8 CDMAM images obtained on each system by manually selecting mAs values that were approximate multiples of 2 higher or lower than selected using the AEC control. The tube voltage and target/filter combinations were kept the same. (It was not possible to adjust the dose for the Sectra system across a wide range.) The unprocessed CDMAM images were transferred to disk for subsequent analysis at our laboratory.

Table 1. Digital mammography systems tested

Imaging system (pixel size)	X-ray set	kV target filter
Fischer Senoscan	n/a	29kV W Al
Sectra Microdose	n/a	32kV W Al
Siemens Novation	n/a	28kV W Rh
GE Senographe DS	n/a	29kV Rh Rh
Fuji Profect (50 μm)	GE Senographe DMR+	26kV Mo Rh
Kodak Directview CR 850 (50μm)	GE Senographe DMR+	29kV Mo Rh
Test CR	GE Senographe DMR+	27kV Mo Rh

For each exposure the factors used when imaging the CDMAM phantom with the additional PMMA were recorded. The x-ray setting output, half-value layer (in mm of aluminium) and the distance from the focus to table top were measured allowing the entrance surface air kerma at the top of a 50mm thickness of PMMA to be calculated. The method described by Dance et al. was used to calculate the mean glandular dose (MGD) to typical breasts with a 60 mm compressed breast thickness and an attenuation equivalent to a 50 mm thickness of PMMA [9]. The average of these MGD values for each set of similar CDMAM images was then calculated. The maximum acceptable MGD in the European Guidelines is 3 mGy at this thickness.

The CDCOM outputs for the 8 CDMAM images were combined to determine the proportion of correctly identified discs for each detail diameter and thickness. A data smoothing algorithm was applied and a psychometric curve fitted for each detail diameter as described previously [8].

The threshold gold thickness was determined for each diameter as the point on the fitted curve with a probability of detection of 0.625. This probability is used because it lies midway between random guessing at 0.25 and complete accuracy at 1.0. These threshold gold thicknesses were converted to threshold contrast for a nominal 28 kV Mo/Mo combination as described in European Guidelines. A contrast detail curve was then fitted to improve the reproducibility of the measurements. Predicted