Beam Optimization for Digital Mammography – II

Mark B. Williams[1], Priya Raghunathan[1], Anthony Seibert[2], Alex Kwan[2], Joseph Lo[3], Ehsan Samei[3], Laurie Fajardo[4], Andrew D.A. Maidment[5], Martin Yaffe[6], and Aili Bloomquist[6]

[1] University of Virginia
[2] University of California-Davis
[3] Duke University
[4] University of Iowa
[5] University of Pennsylvania
[6] University of Toronto

Abstract. Optimization of acquisition technique factors (target, filter, and kVp) in digital mammography is required for maximization of the image SNR, while minimizing patient dose. The goal of this study is to compare, for each of the major commercially available FFDM systems, the effect of various technique factors on image SNR and radiation dose for a range of breast thickness and tissue types. This phantom study follows the approach of an earlier investigation [1], and includes measurements on recent versions of two of the FFDM systems discussed in that paper, as well as on three FFDM systems not available at that time. The five commercial FFDM systems tested are located at five different university test sites and include all FFDM systems that are currently FDA approved. Performance was assessed using 9 different phantom types (three compressed thicknesses, and three tissue composition types) using all available x-ray target and filter combinations. The figure of merit (FOM) used to compare technique factors is the ratio of the square of the image SNR to the mean glandular dose (MGD). This FOM has been used previously by others in mammographic beam optimization studies [2],[3]. For selected examples, data are presented describing the change in SNR, MGD, and FOM with changing kVp, as well as with changing target and/or filter type. For all nine breast types the target/filter/kVp combination resulting in the highest FOM value is presented. Our results suggest that in general, technique combinations resulting in higher energy beams resulted in higher FOM values, for nearly all breast types.

1 Introduction

The criteria for optimization of tube voltage and external filtration in full field digital mammography (FFDM) differ from those used in screen-film mammography. This is in part because the separation of the processes of acquisition and display in the former permits the contrast of individual structures to be adjusted when the image is viewed. Thus, rather than maximization of contrast within the constraint of acceptable film darkening and patient dose, beam optimization in digital mammography requires maximization of the image SNR, constrained by acceptable patient dose [4]. In recent

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years, four FFDM systems have gained FDA approval, with others soon to follow. Most of those systems are equipped with mechanisms for automatic selection of at least some technique factors including mAs and in some cases kVp, filtration, and target material. In some units, different acquisition modes are available in which different look-up-tables are utilized to emphasize either subject contrast (with lower kVp and higher mAs) or low dose (with higher kVp and lower mAs). It is the goal of this study to examine, for three simulated breast compositions, and three simulated breast thicknesses, the effect on the image SNR and the mean glandular dose (MGD) of varying kVp, and target and filter type.

2 Methods

Five different FFDM systems, the GE Healthcare Senographe 2000D, the Siemens Mammomat Novation, the Lorad Selenia, the Fischer/Hologic Senoscan, and Fuji's mammographic storage phosphor system, were used to image a common set of phantoms made of blocks of breast equivalent material (CIRS, Inc., Norfolk, VA). Nine different phantoms were assembled and imaged, simulating breasts of three different thicknesses (3 cm, 5 cm, and 7 cm), and three different attenuation equivalent adipose/fibroglandular mass ratios (30/70, 50/50, and 70/30). Two 5 mm thick blocks were placed on the top and bottom of each stack, to simulate skin (Fig. 1). The skin blocks were 100% adipose equivalent material.

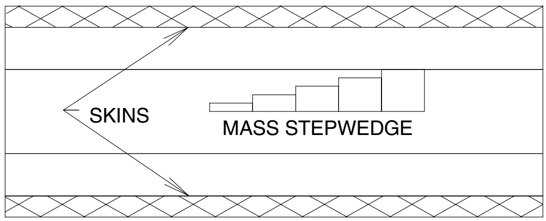

Fig. 1. Side view of a 5 cm phantom with a 2 cm signal block at the center, two 1 cm blank blocks and two 0.5 cm skins on the surface

In each phantom stack assembled, the centrally located block in the stack (the signal block) contained two stepwedges, one each of calcification equivalent and mass equivalent material. The mass equivalent stepwedge has the same x-ray attenuation as 100% glandular equivalent material, and the microcalcification equivalent step wedge is composed of calcium carbonate (Fig. 2). The thickness of all signal blocks is 2 cm.

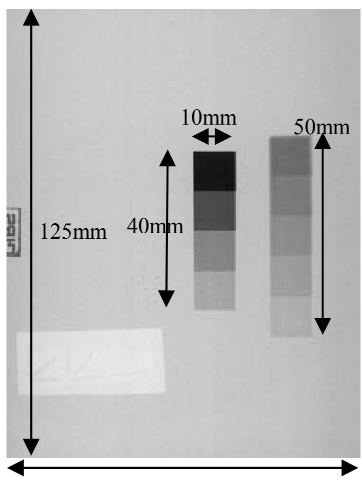

Fig. 2. Image of the phantom showing calcification (left) and mass equivalent step wedges.