Lesion Visibility in Low Dose Tomosynthesis

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Abstract. Visibility of lesions in mammography are significantly reduced by the presence of anatomical, or structure, noise. Breast tomosynthesis offers the possibility of reducing this noise. We have compared the detection of low contrast and microcalcification objects with tomosynthesis imaging as a function of dose to full field digital mammography (FFDM) performed at a standard screening dose. The measurements were performed with a variety of phantoms and complex backgrounds. The complex backgrounds greatly reduced object visibility using FFDM; much less so for the tomosynthesis images. In summary, visibility of low contrast objects using tomosynthesis was superior to visibility of these objects in FFDM, even when the tomosynthesis imaging was performed at 1/4 or less of a FFDM dose. Tomosynthesis also showed superior visibility to FFDM for 160-180 micron microcalcifications at 1/2 the FFDM dose.

1 Background

The sensitivity of conventional two-dimensional mammography can be limited by the presence of structures in the breast, which obscure detection of pathologies of interest[1]. Three dimensional imaging techniques reduce tissue overlap and improve visibility of low contrast details. Tomosynthesis is a method of performing high resolution limited angle tomography, at mammographic dose levels. Because the intrinsic contrast of tomosynthesis slices is very high, through the reduction of tissue overlap, it is of interest to estimate what tomosynthesis dose levels might provide equivalent detection efficiency compared to FFDM.

2 Method

Object visibility was measured using phantoms. Three types of phantoms were used. Two were contrast detail phantoms: the CDMAM phantom[2] and RMI-180 mammography contrast detail phantom[3]. The CDMAM phantom has gold discs with diameters from 0.06 to 2 mm and thickness 0.03 to 2 microns. The RMI-180 phantom has holes in acrylic with diameters from approximately 0.3 to 7 mm and depths from 0.06 to 1 mm. A third phantom contained calcifications grouped into sizes 160, 180 and 250 microns.

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These phantoms were imaged on top of complex backgrounds of varying types. The backgrounds were cadaverous 4.5 cm thick breast tissue and a piece of 2.5 cm thick beef.

The phantom/background combinations were imaged with a FFDM system at conventional U.S. screening dose (~1.7 mGy for 4.2 cm standard breast), and with a tomosynthesis system at a variety of doses (1.45, 0.73, 0.36, and 0.18 mGy for 4.2 cm standard breast).

Tomosynthesis acquisitions on a prototype system were performed, the raw data reconstructed, and the reconstructed slice at the appropriate height for the phantom objects was identified. Four experienced readers viewed all the images. For the microcalcification targets, the number of visible specks at each microcalcification size was totaled for each image and used as a scoring metric. For the contrast detail phantom, contrast detail curves were generated for the FFDM and the tomosynthesis images at the different doses.

2.1 Acquisition Method

The FFDM images were acquired on a standard digital mammography system (Selenia, Hologic, Inc.). The tomosynthesis images were acquired using a digital tomosynthesis prototype[4], which is a Selenia FFDM system modified to accommodate tomosynthesis acquisitions. This system acquired 11 views over a 15-degree scan. The phantoms were imaged twice at each dose level, moving the phantom relative to the background between exposures to avoid biasing the results by inadvertent arrangements between the objects and the obscuring background structures.

2.2 Reconstructions

The data acquired using the tomosynthesis systems were reconstructed using a filtered back projection algorithm. The images were reconstructed in a matrix with pixel spacing of 100 microns and a slice separation of 1 mm.

2.3 Reading and Scoring

Four experienced readers evaluated the images in a darkened room using a softcopy workstation with dual 3 MP flat panel monitors. Readers were free to magnify and window/level, and to spend as much time as desired on every image. In the case of the tomosynthesis images, only one slice was scored- the in-focus slice where the objects were visible with the greatest sharpness.

Contrast detail phantoms were scored using the following criteria. For each disc diameter, the score was the thinnest visible disc, not allowing skipping over larger sized invisible discs. No other corrections were made to these scores. With the CDMAM phantom, only the central disc in each square was evaluated. The contrast detail results were averaged over the four observers and over the two sets of acquisitions for each phantom and background combination.

The microcalcification scoring proceeded differently. The phantom consisted of groups of microcalcifications of differing sizes. The number of microcalcifications in