Digital Breast Tomosynthesis and Mammography

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Abstract

Breast cancer is an inevitable disease that has been successfully screened, diagnosed and treated through technology advancements. The demand for accurate detection has increased, forcing the demand for more advances in technology. Digital breast tomosynthesis (DBT) has provided the necessary advancements in breast imaging. Breast cancer can now be seen more readily than ever before because of the 3D tomosynthesis images. The collaboration of multiple modalities now provides increasing detection and survival rates.
Digital Breast Tomosynthesis and Mammography

Breast cancer is the most prevalent cancer in women in the United States and "remains one of the leading causes of death in women over the age of 40 years" (Hakim et al., 2010, p. W172). Helvie (2010) discusses the importance and value that digital mammography (DM) possesses. With controlled, random trials, DM has proven over and over again the survival benefits for patients. DM is the only imaging modality that has shown these benefits consistently. Digital Breast Tomosynthesis (DBT) is an advancement in mammography that can continue to prove survival benefits. Because DBT is consistent with DM, the superiority of this modality in relation to the detection of breast cancer will continue to surpass Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and Ultrasound.

As mammography continues to be a great way for breast cancer detection, the amount of patients experiencing requested recall imaging is high. The amount of missed breast cancers is also a concern for many patients because of the delay in treatment and more aggressive approach necessary due to the delay. Each woman's breast configuration varies greatly causing the diagnosis of breast cancer to be more difficult than one may think. By using large sensor size and high resolution detectors Hakim et al. (2010) discuss that they "offer not only better contrast sensitivity but also great opportunities to develop advanced digital imaging techniques that could improve conspicuity of breast lesions by enabling better tissue visualization through the provision of 3D nonoverlapped tissue information" (p. W172).

DBT is designed to create 3D images in order to have the best image quality. "Its main advantages are the improvement of the conspicuity of structures, the possibility of depth localization, and the smaller dynamic range required for each reconstructed slice" (Vecchio et
DBT equipment retrieves multiple projection exposures obtained over a limited arc angle. (See Fig. 1) These images will then be reconstructed using unique algorithms.

Chan et al. (2010) discuss two different ways to obtain the 3D images. The first is to combine the information obtained from the image analysis of multiple 2D projection view (PV) images. This approach can be beneficial because the projection view images are independent of the method of reconstruction. The reduction of noise and false positives when using the PV approach is due in part to the correlation between the images after the union of information obtained from the multiple views. The second way to obtain the 3D images is to perform the image analysis of the obtained slices after the tomosynthesis reconstruction of the projection views. "This approach takes advantage of the image reconstruction technique in combining the spatial information accurately before image analysis" (Chan et al., 2010, p. 3577).

Williams, Judy, Gunn, and Majewski (2010) discuss the discomfort that a patient is in when receiving a mammogram because of the compressive force. With DBT the compressive force is reduced, providing more comfort to the patient during the exam. Less force is needed to be used because of the multiple sections that are formed into 3D images.

With DBT, breast masses will be seen more readily as compared to digital mammography alone. "It is considered a possible solution to overcome the main shortcoming in two-
dimensional (2D) conventional mammography: the overlap of anatomical structures on pathologies of interest" (Shaheen et al., 2010, p. 108). The images are presented to the radiologists much like a CT or MRI study. The reconstructed slices can vary in thickness, being as thin as .5 mm. Thin slices will project masses that are often times superimposed with breast tissue when retrieving 2D breast images. As radiologists become familiar with the creation of the DBT 3D images, the detection rate and treatment of DBT patients will greatly increase.

According to Gennaro et al. (2010) designing the equipment for tomosynthesis has been in the works since the 1930s but has been transformed and used more readily in the past ten years because of the advancements in technology. The design of the DBT machine has progressed rapidly in the past 5 years. The Food and Drug Administration (FDA) approved the Holigic Selenia Dimensions 3D System on February 11, 2011. (See Fig. 2) The Affirm upright breast biopsy guidance system and the ImageChecker 3D Calc computer-aided detection are two new products that are specifically created for the new Selenia machine. Currently Affirm is approved for sale in the United States while Image Checker is still in the works. There are opportunities for radiologists to addend conferences and experience firsthand what reading 3D breast images are like. If imaging departments receive proper education on the advantages of DBT, patients will soon see the benefits of this advancing modality.
Algorithm Reconstruction

Now that DBT is emerging at a fast pace, many details are being explored in order to have the most efficient imaging equipment and techniques. The algorithm reconstruction that takes place after the multiple images have been captured is a crucial area for the creation of the 3D images. According to Sidky et. al (2009) iterative reconstruction is most advantageous for DBT. The incomplete data that is originally obtained from a tomographic system lacks the projection data that is much needed.

As a result, regularization of the image takes on two roles: (1) Selection of a unique image among those that agree with the projection data and (2) the traditional role where the image is regularized while relaxing consistency with the available data. In the first role, the image regularization is lowered while the image is constrained to a given data agreement. In the second role the data constraint on the image is relaxed, allowing for further minimization of the image regularization (Sidkey et. al, 2009, p. 4921).

In order to obtain data consistency as well as physical consistency, the reconstructed algorithm uses projection onto convex sets (POCS). Because the algorithm has steep descent components and the POCS step sizes needed to be more easily controlled, another element was added to the POCS to ensure quality images. The adaptive steepest decent-POCS (ASC-POCS) algorithm "allows for the separation of the two roles for the regularizer in tomographic image reconstruction from incomplete projection..."
Now that ASC-POCS has been adopted as a new algorithm, the imaging of microcalcifications will be greatly affected. (See Fig. 3) The contrast of images will increase, showing better quality images as well as more diagnostic images. The most significant part of this advancement is the concept of decreasing patient dose as well as reducing the x-ray intensity. There is hope that an even more efficient algorithm can be produced based off of the ASC-POCS algorithm.

**Imaging Dense Breast Tissue**

Women with dense breast tissue are the most difficult patients to image. There are many opportunities for dense breast tissue to overlap on itself, hiding tumors and lesions. With DBT, not only are cancers shown more readily, the margins of the cancers are shown giving the radiologist more information without additional mammography views. Because the number of women with dense breast tissue is rapidly increasing; finding a way to accurately image these patients is a priority. According to Helvie (2010) "The primary benefit of DBT would be expected to be for

**Fig. 4** (A) Mediolateral oblique (MLO) DM (B) MLO DBT (C) Cranial caudal (CC) DM (D) CC DBT. This patient has invasive ductal cancer.

noncalcified mammographic findings such as masses, asymmetries, and distortion" (p. 919). By improving sensitivity, more cancers will be detected in dense breast tissue and the number of callbacks will decrease. (See Fig. 4)

**Imaging Non-Dense Breast Tissue**

Women with non-dense breast tissue, or fatty tissue, are ideal patients for mammography. Although fatty tissue can be imaged with digital mammography with higher detection rates compared to dense tissue, the detection of smaller lesions is greater with DBT. "This is a variant of improved sensitivity as a decrease in size at time of detection may be associated with improvement in clinical outcome" (Helvie, 2010, p. 919). Another advantage of DBT compared to DM when imaging fatty tissue is the obvious border of the lesion. (See Fig. 5) The diagnostic differences between DM and DBT are clear.

**Radiation Dose**

When new radiology equipment is introduced into the medical field, many patients, technologists and physicians question the dose the patient will receive. The balance between image quality and patient dose is always a major concern. The FDA has set a limit of 300 mrad per exposure for breast imaging; 150 to 250 mrad being the usual range for 2D mammography. Although DBT does not exceed the FDA limit, it is a slightly higher initial dose to patients compared to conventional mammography.

**Fig. 5 DM vs DBT on a patient who has a mass**

Hendrick (2010) discusses the radiation doses received from screen-film mammography (SFM), digital mammography (DM) and DBT. A two view DM exam administers a lower dose to the breast compared to that of a SFM exam while a single view DBT exam administers a comparable dose as a two view DM exam. Depending on the DBT image acquisition strategy, the number of images requested can vary between a single view DBT, two view DBT or DBT and DM combined.

Each patient needs to evaluate their individual risks and benefits when evaluating breast imaging. According to Hendrick (2010) "on average, approximately 10% of women in the United States are recalled on the basis of screening mammography findings" (p. 250). Recall imaging usually involves two or three additional views with a higher dose. Things to consider before receiving breast imaging include previous recall image rate, previous radiation exposure and breast tissue density. "If DBT leads to reduction in recall rate or improvement in sensitivity and specificity, a minimally higher dose may be acceptable" (Helvie, 2010, p. 919).

**Case Study**

Bertolini et al. (2010) conducted a study comparing DBT and Full-field digital mammography (FFDM) using images from both breast modalities having a contrast detail phantom as a guiding tool. A pixel pitch size of 10µm was used with a 24 cm x 29 cm dimension. The same pixel pitch size was used for the FFDM images, while the DBT had a pixel pitch size of 88 µm after reconstruction. According to Bertolini et al. "The DBT images were reconstructed at 1-mm in-plane spacing (between slices)" (p. 59). As the machine was in motion, it obtained 15 slices across the arc.

The contrast detail (CD) phantom was designed to detect masses and calcifications. To decipher between the two, multiple holes of different depths and diameters were included on the
phantom. (See Fig. 6) If the object diameter was greater than 0.5mm, the classification would be a mass, if the object diameter was less than 0.5mm, the classification would be a calcification. "The CD phantom was positioned between two thick layers containing a breast-simulation material. This confounding layer was obtained by properly treating surgical breast specimens. The phantom contained a set of radiopaque markers for image registration" (Bertolini, 2010, p.59).

Both FFDM and DBT used automatic exposure control (AEC) when producing images. The acquisition pattern for both imaging modalities was equal, having acquired images from 0°, 90°, 180°, 270° of CD phantom rotation. A technique of 29 kilovoltage peak (kVp) with an anti-scatter grid was used for FFDM using AEC and a technique of 32 kVp with no grid was selected for DBT. (See Fig. 7) "Two different representations of the same object were obtained with the two techniques" (Bertolini, 2010, p.59).
The comparison of the FFDM image and the DBT image is outstanding. The differences in noise, contrast and spacial system resolution seen on the FFDM and DBT images is exceptional.

**Conclusion**

With the advances taking place in medical imaging, particularly breast imaging, breast cancer victims will have a much greater survival rate. Now that DBT has been approved by the FDA, better breast image quality is available. Patients with different breast size, shape and density are now able to be at ease knowing that better breast imaging options are obtainable. DBT is the future of breast imaging and is going to surpass current mammography expectations.
BREAST TOMOSYNTHESIS

References


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