Tomosynthesis Imaging of the Breast: Literature Review and Case Study

November 13, 2012
Abstract

Digital breast tomosynthesis uses low dose images of the breast to view the tissue. Tomosynthesis has been around since the 1930s. The use of lower radiation exposure to the tissue and the ability to remove background densities around tissues of concern, allow for clearer images. Comparing the benefits and disadvantages of digital mammography and DBT, hospitals can use this new technology to perform breast tissue exams. Factors such as radiation dose to patient, comfort for the patient during exam, and the ability of the radiologist to interpret the exam all conclude that DBT is beneficial in all aspects.
**Introduction**

Mammography has recently been evolving to increase the quality of images and quality of care for the patients. From traditional mammography to digital mammography and lastly to digital breast tomosynthesis (DBT), this evolving field is changing how radiologists can view and read breast images. This new exam allows for images to be taken at one angle unlike the digital mammography. By limiting the angle, the images acquired reduce the background and tissue variance in the breast allowing for clearer images (Svane et al., 2011). Another concern for using x-rays to image breast tissue is how much radiation dose the patient is receiving. Digital mammography gives a higher dose of radiation to the breast tissue than DBT.

Tomosynthesis is now being used to achieve images for other parts of the body. Some images are compromised when using computed tomography for imaging due to artifacts from metal prosthetics. Tomosynthesis imaging is allowing clearer images to be obtained by removing the artifact caused by the radiation coming into contact with metal which creates scatter and streaking. This newer technology can improve the images taken. Images of hip prosthetics and the chest are compared using computed tomography (CT) and tomosynthesis.

**Literature Review**

**Breast Examinations and Radiation Dose**

In Svane et al., (2011) using DBT for breast imaging and digital mammography is compared. The study consisted of 144. Protocol 2 views were obtained alongside the DBT images for each patient during the study. Cranial caudal and medio lateral oblique positions for the digital mammography images compared to just the 1 view medio lateral oblique obtained by DBT. Size of lesion detection had no significant difference between the 2 types of exams.
Results of radiation dose to the patient showed that in the study by Svane et al., (2011), 63% of the radiation digital mammography produced, was produced by DBT imaging. In the study done by Tagliafico, A., Tagliafico, G. et al., (2012) the mean glandular dose the patient received were increased, but within the acceptable limits. Spot compression was used to spread out breast tissue if an area of concern was apparent. Using DBT alone had lower radiation dose for the patient then using mammography and spot compression to image tissues (Tagliafico, Astengo et al., 2011).

Full field digital mammography (FFDM) shows less lesions compared to DBT even when 1 view is obtained compared to the 2 views taken in digital mammography is shown in Gennaro et al., (2009). Also, the mean accuracy shown by radiologists who were asked to read both and rate each one, showed that there was no diagnostic difference between FFDM and DBT. In the study done by Vecchio (2010), DBT has higher sensitivity for breast tissue then FFDM. A phantom was used in this study for each participating radiologist. The same 28 kilo voltage was used for FFDM and DBT to obtain images. Comparing CT and DBT the radiation dose the patient receives is less with DBT. (Sunaguchi et al., 2011).

Exam Times and Compression

Each diagnostic unit for DBT had its own angle and time for the images to be taken. The rotation used by the DBT imaging allows for less compression of the breast tissue since it is at an angle (Gennaro et al., 2009). Also shown in the study by Tagliafico A. Tagliafico, G. et al., (2012), 15 images were obtained without having to move the patient to compress the breast tissue multiple times. In Vecchio (2010), it took around 19 seconds to acquire images while it took 18 seconds in the Svane study. This makes DBT less time consuming.
One study performed by Svane (2010), gave participating patients a survey and rate from 1 to 10 on their comfort level. Ninety-seven percent answered that DBT was more comfortable than traditional digital mammography; three percent were unbiased between the two. Some breast tissue is dense causing the surrounding tissue to overlap upon each other making it hard for radiologists to observe. Spot compression is used to spread tissue out and take additional images of an area of interest. Most often masses and micro calcifications need to be viewed under spot compression. Tomosynthesis did not appear to obtain better images for calcifications in breast tissue (Spangler, 2011, as cited in Tagliafico, A., Tagliafico G. et al., 2011). Contrary to this, Svane et al., (2011), found that single calcifications were easily seen with DBT.

### Algorithms

Algorithms are used to move background tissue in a DBT study to focus on a specific spot or slice. Three algorithms are currently available for tomosynthesis: a) backprojection, b) filtered back projection, and c) iterative (Gomi, et al., 2011). Filtered back projection (FBP) is used to blur surrounding tissue around a particular slice or piece of the images obtained (Sunaguchi, 2011). Protocols must be used for obtaining multiple images for DBT to use for reconstruction. Once the images have been taken, they must be reconstructed before the radiologist can examine the images in a 3 dimensional plane. These images can be viewed by scrolling through a series of three dimensional images to look at a particular plane.

As previously discussed, in digital mammography 2 images are obtained of each breast. The medio lateral oblique and cranio caudal views are obtained, limiting the view of the exam. DBT allows a 3 dimensional representation of the breast tissue readily available. Two views can cause a false positive, with the addition of DBT the call back percentage on these false positives is reduced (Svane et al., 2010). With reduction of false call backs, the patient receives less
radiation dose with unnecessary images not being taken. This relates back to the previous topic of reducing radiation dose for the patient by using DBT.

**Tomosynthesis vs. other modalities**

Tomosynthesis may be used for other imaging such as chest, joints in the hands, lungs, and teeth (Gomi, Hirano, Nakajima, & Umeda, 2011). FBP algorithms are also used in computed tomography (CT). This allows for two dimensional acquired images to be 3 dimensional reconstructions. Many artifacts can occur with CT imaging. Metal artifacts found within the body or on the person’s clothing can contain these. When scanned with CT, it causes refraction of the metal object in the images. Streaking, scatter radiation, and bright images can be seen after a CT scan. If the point of interest is located closely around the metal artifact contained in the body, the images become non-diagnostic.

Prosthetics account for many images containing artifact. Using tomosynthesis and FBP to acquire these images instead of CT can greatly reduce the streaking and scatter radiation. Different algorithms may be used to focus on soft tissue or bone in a particular area. Imaging of the temporomadibular joint can be obtained using CT, magnetic resonance imaging, and conventional radiographs. This joint in the jaw is very hard to image. Each one of these modalities poses difficulties in certain aspects. Tomosynthesis was used to obtain images and compared with these modalities. In every aspect the images acquired from tomosynthesis were clearer. This was dependent on the angle chosen, thickness of the slices, and number of views. These manipulations of image parameters are the same with CT.

Another artifact that can occur when using tomosynthesis, is the ripple effect. Rippling of an image occurs because of quantum noise. Quantum noise increases when lower radiation doses are used for an exposure. This affects the contrast of the images. If any of the detectors are
misaligned when taking an image this artifact can occur. Filtration can decrease this effect and decrease the radiation dose to the patient (Gomi et al., 2011).

Imaging of the chest is done with conventional radiography and CT. Helical scanning for disease process in the chest is the standard. An issue with imaging the chest, as in the breast, is overlapping anatomy. This makes it hard to see the chest completely. Two-dimensional radiography is less sensitive than CT making it hard to see disease processes. The downfall of CT is the increased radiation the patient receives and the cost compared to radiography. Tomosynthesis can be used to image the chest. This reduces the amount of radiation as related to CT and increases the sensitivity compared with radiography. Another advantage is the tomosynthesis images are in slices just as in CT. This allows for the radiologists to look section by section into the tissues.

Case Report

Fifty-two patients were included for, “…evaluation of masses, focal asymmetries or architectural distortion.” (Tagliafico, Astengo et al., 2011, p. 541). Each patient had undergone digital spot compression and DBT. This study was conducted in March 2010 until June 2010. Three consistent technologists were used to do each digital spot compression and DBT exam. This would give more uniform images by using the same positioning for each patient and similar techniques for each acquired image. Cranio caudal and medio lateral oblique images were used for digital spot compression. DBT images were taken at a fifteen degree angle while the breast is compressed. (See Figure 1)

The digital image was placed on one monitor and next to it the DBT images were on the adjacent monitor for comparison. A system was put into place to allow the radiologists involved a way to rate each image for the same patient with digital spot compression and DBT. This rating
system is called BI-RADS. Numbers one through five were used to rate each image. One to two was negative findings and three to five was positive findings. This allowed for the data set to be graphed and evaluated. The breast tissue was also rated on its readily visible masses, asymmetries or architectural distortion: one is no visible finding, two is low visibility, three is medium visibility, four is high visibility, and lastly five is very high visibility (Tagliafico, Astengo et al., 2011). Data was also taken for the radiation dose the patient received for these procedures.

Another study was completed by Ikejimba, Kontos, and Maidment, (2009), comparing digital mammography and DBT. The digital mammography images were obtained using cranio cadual and medio lateral oblique positions. DBT used 0.1mm² slices achieved by taking the images on an angle. FBP was used for the DBT images creating 1 mm slices to be viewed. (See Figure 2) The images were rated on: coarseness, contrast, energy, homogeneity, skewness, and fractal dimension. The contrast allows for textures, abnormalities, and calcifications to be seen. Energy and homogeneity allow for the image to be consistent. Skewness shows the adipose tissue within the breast. Fractal dimension measures how a like the tissue in regards to the entire tissue of the breast. Seventy-one women were included in this study. Their digital mammography and DBT images were compared with each other and given a rating.

**Discussion**

As shown in the first case study, in regards to sensitive breast tissue, the mean glandular dose for tomosynthesis was less than digital spot compression. Lesion prediction scored higher with DBT images. Sensitivity of the images for DBT and digital spot compression scored equally. Two false positives were found with digital spot compression. They were positive
findings with digital spot compression. The suspicious breast tissue was biopsied and cleared for malignancies (Tagliafico, Astengo et al., 2011).

In the second case study, besides coarseness, DBT scored higher in all other categories. Correlation coefficients were computed using mathematical formulas for each section. Texture of the breast tissue and breast percent density was compared with high findings of: coarseness, contrast, energy, homogeneity, skewness, and fractal dimension. A significant correlation found in this study was DBT images had higher breast percent density in relation to texture of the breast tissue (Ikejimba, Kontos, & Maidment, 2009).

Tomosynthesis may be a great improvement for imaging, but it still has limitations. When tomosynthesis is used the angle at which each image is taken must be set correctly to obtain diagnostic images. This is dependent on which area of the body is being imaged. The body part must also be perpendicular to the imaging receptor to obtain unvarying images. Outlying structures that are blurred to highlight a specific spot in the image are not completely removed because they are in the same plane of the image taken. For the patient aspect, sometimes it is hard for the patient to remain in the same position for a longer period of time to obtain sliced images using tomosynthesis; though it may be a few seconds longer than a CT or regular digital mammography exam. Using compression in mammography almost eliminates this motion artifact, when doing images of the chest, temporomadibular joint, or hip it may be harder to remain in the exact same position.

In conclusion, tomosynthesis can be used in many ways to acquire better diagnostic images. Research is still being done to test its limitations. For breast imaging this optional way of taking images is beneficial. This could be added with regular digital mammography to improve the diagnostic quality. In regards to imaging of the hip, temporomadibular joint, and chest, the
quality is still being tested to compare with CT. Tomosynthesis is a valuable tool to reduce artifact for diagnostic imaging.
Figures

Figure 1. From left to right, figure one and two are obtained as digital images using the cranio caudal and medio lateral oblique views. Figure three is obtained using one view medio lateral oblique using DBT. Clarity is noted more prominently on figure three.


Figure 2. X-ray tube design is shown to obtain DBT images on an angle. A filter is used to allow filtered-back projection. The images now can be scrolled through and surrounding tissue blurred.

References


Tagliafico, A., Astengo, D., Cavagnetto, F., Rosasco, R., Rescinito, G., Monetti, F., & Calabrese, M. (2011). One-to-one comparison between digital spot compression view and digital...