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Dedicated 3D Breast CT: A Novel Approach to Breast Cancer Detection

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Introduction

The goal of mammography is to detect breast cancers. Mammography is the current gold standard for screening asymptomatic women for breast cancer, and has been proven to decrease mortality (Fracheboud et al. 2004; Coburn et al. 2004; Jatoi et al. 2007). However, this technology does have some limitations. In women with dense breasts, mammography is not as sensitive as in the population of women with non-dense breasts. In reaction to this problem, various researchers have investigated digital breast tomosynthesis (DBT) as a way to eliminate the lesion obscurity or ‘masking’ resulting from overlapping tissue prevalent in women with dense breasts. DBT was made feasible with digital mammography technology and fast computer processors. DBT in combination with a conventional digital mammogram has demonstrated improved mass detection (Michell et al. 2009; Gennaro et al. 2010; Svahn et al. 2010), decreased recall rates and increased cancer detection (Michell et al. 2009; Gennaro et al. 2010; Svahn et al. 2010; Skaane et al. 2013). However, DBT is a ‘pseudo’ 3D technique, since the images of the breast are acquired in a range of angles usually limited to 15 -30 degrees and mammographic breast compression is still utilised.

Dedicated breast CT (DBCT) is a new imaging modality that provides 3D data that can be reconstructed into multiple imaging planes, similar to breast magnetic resonance imaging (MRI). DBCT is performed without breast compression and is not limited by breast density or breast implants. The radiation dose level is similar to the dose of a conventional twoview digital mammogram. Recently, research in the field has focused on the development of low radiation dose scanners with fast image acquisition times and with improved spatial resolution (Boone et al. 2001; Lindfors et al. 2008; McKinley et al. 2012).

DBCT: How Does It Work?

One breast at a time is imaged, as with mammography. Unlike mammography, the patient lies prone, with the breast to be imaged placed through a hole in the DBCT scanning table. The breast to be imaged is pendent (not compressed) in the scanner. Some DBCT systems can stabilise the pendent breast to decrease any patient motion, but there is still no ‘mammographic type’ compression. From below the table, the technologist can observe that the subject’s hanging breast is centred in the device. Some DBCT systems have open access to the breast for patient positioning or biopsy access. The imaging hardware is beneath the scanning table and does not touch the patient.

The basic imaging hardware of a cone-beam DBCT system consists of a flat panel detector, x-ray tube and generator and drive motors to move the system 360 degrees around the pendent breast while the patient is breath-holding (Lindfors et al. 2008; McKinley et al. 2012). During the acquisition of the images, the technologist has access to the system position and real-time projection images of the breast.

The acquired image data of the breast is used to reconstruct a volume dataset for image display. Since DBCT is true 3D imaging and does not compress the breast, it allows for registered orthogonal views of the breast in any projection for viewing (see Figure 1). The viewing software allows the radiologist to review images in multiple planes, window and level the images, and magnify and adjust slice thickness of the images for interpretation. Areas of concern can also be measured and annotated. In addition, multi-intensity projection image can also be visualised as part of the software display also seen in Figure 1.

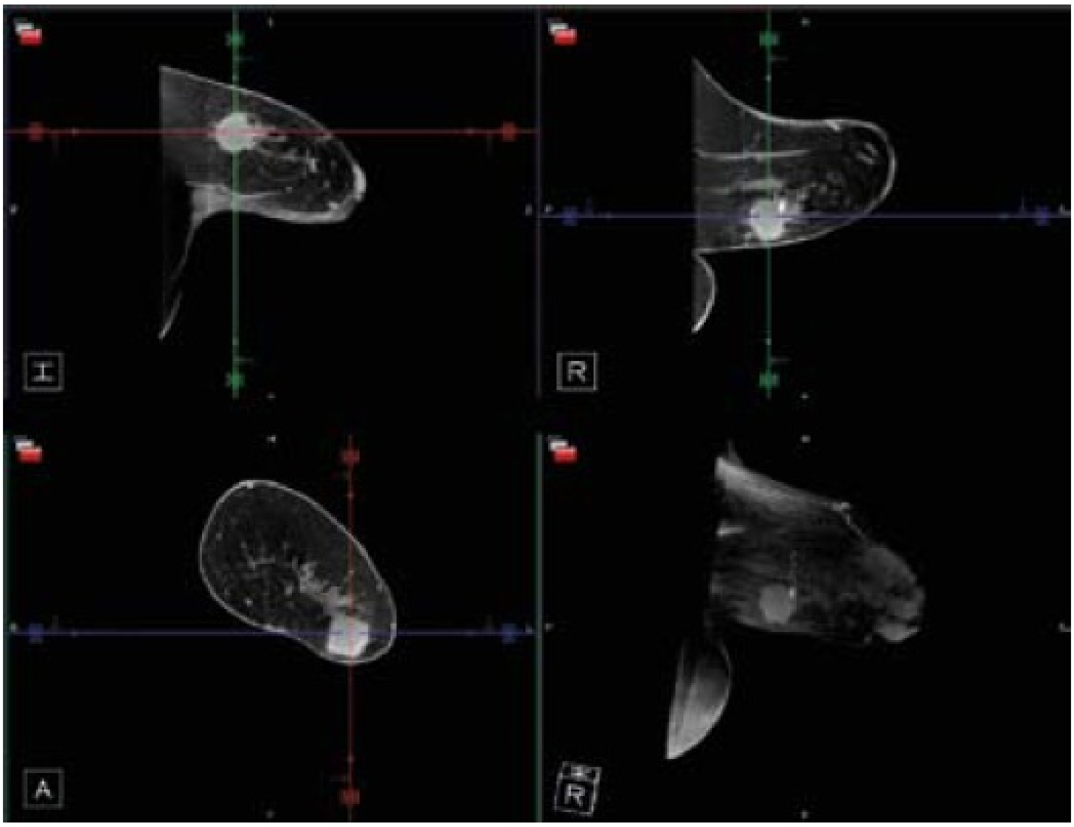

Figure 1.
Dedicated Breast Computed Tomography representative slice in three projection views (sagittal,

transverse, and coronal) with multi-intensity projection image (MIP), lower right-hand image. A mass is seen in the cross-hair of the reference marker.

DBCT Performance

Clinical trials with DBCT have shown promising results when compared to 2D mammography and MRI. Lindfors et al. demonstrated in 69 women with BI-RADSR 4 and 5 lesions that noncontrast DBCT showed a significant increase (p<.002) in visualisation of masses; however, mammography was better for visualisation of calcifications (p<.006) (McKinley et al. 2012). In 2014, Kuzmiak et al. evaluated 20 women with a total of 23 BI-RADSR 4 and 5 lesions initially detected with diagnostic 2D fullfield digital mammography (dxDM). Noncontrast DBCT imaging of these lesions showed an increase in radiologist reader visualisation confidence of the evaluation of mass shape (p<.010) and margin (p<.020) (see Figure 2). However, there was a significant decrease in reader visualisation confidence for calcification morphology (p<.001) and distribution (p<.002) (Kuzmiak et al. 2014). Thus, improvements in detector resolution of different DBCT systems continue, as well as exploration of other methods of increasing lesion conspicuity and characterisation.

One such method of increasing lesion conspicuity and characterisation is to use intravenous contrast in with DBCT. Zuley and colleagues compared contrastenhanced DBCT to contrast-enhanced (CE) breast MRI in the characterisation of 24 cancers and 33 benign lesions. They reported CE-DBCT to be equivalent to MRI in diagnostic performance. With CE-DBCT, five radiologists classified 94.2% of the malignant lesions and 83.6% of the benign lesions correctly, versus MRI where 93.3 % of the malignant lesions and 86.1% of the benign lesions were correctly classified (p >.63) (Zuley et al. 2011).

Currently, there is no FDA-approved DBCT system in the United States. However, investigators from the Wende Logan Breast Center and the University of Rochester, Rochester, NY, in conjunction with the Medical University of South Carolina, Charleston, SC, are evaluating the Koning Breast Computed Tomography (KBCT) (Koning Corporation, West Henrietta, NY, USA) system for premarket approval. The goal of their study is to evaluate if 3D KBCT can improve the clinical performance of diagnostic workup for breast cancer detection and diagnosis compared to conventional 2D diagnostic mammography (Koning Corporation).

Conclusion

Although still in development, dedicated breast computed tomography is a novel imaging device of the breast that allows for a full 360 degree scan of the breast without compression. DBCT is currently under clinical investigation for patients who have suspicious findings from screening or diagnostic mammography. Initial studies demonstrate that this technology can help resolve the issue of overlapping tissue possibly obscuring a breast cancer, and may provide physiologic information when intravenous contrast is used. In addition, this technology may provide more flexiblity to our patients, since it has faster scanner times and possibly more availablity in our clinics than MRI.

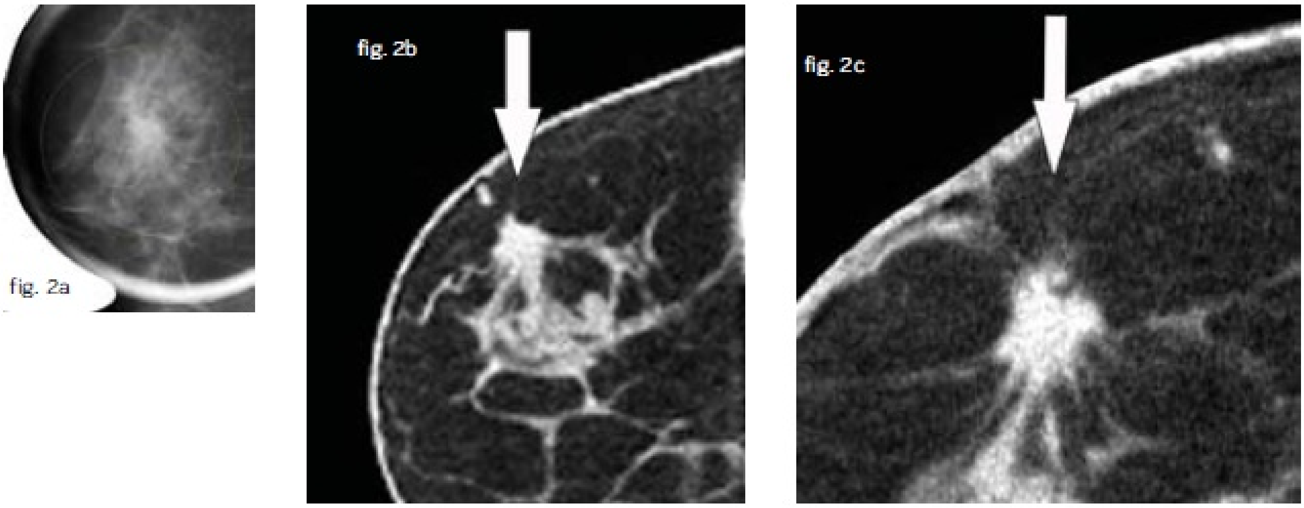

Figure 2.
57-year-old woman.
a) Medial lateral oblique spot compression magnification view of the right breast shows a possible mass (circle), but it is obscured by breast tissue.
b) Increased lesion conspicuity on this single sagittal non-contrast DBCT image demonstrates a 1.5 cm spiculated, high-density mass (arrow).
c) Close-up DBCT image. Core biopsy revealed invasive ductal carcinoma.

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