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Digital Breast Tomosynthesis

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Digital Breast Tomosynthesis

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Digital breast tomosynthesis (DBT) is a new breast imaging technology that uses tomography and 3-D reconstruction to improve lesion visibility. The U.S. Food and Drug Administration recently approved DBT equipment, and research on its effectiveness continues around the world. This Directed Reading describes the current state of tomosynthesis technology and addresses the issues faced by DBT researchers and manufacturers, as well as potential challenges for radiologists and technologists working with DBT.

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After completing this article, readers should be able to:

- *Describe breast density and its role in digital mammography.*
- *Explain the origins of tomography and tomosynthesis.*
- *Discuss digital acquisition and data storage as they relate to DBT.*
- *Describe projections, compression and patient positioning used in DBT.*
- *Explain the effect of DBT on digital mammography.*
- *Discuss research on and future possibilities for DBT.*

Breast cancer remains one of the most common cancers among women despite early detection methods such as breast self-examination, annual mammograms and clinical breast exams. The chance of developing breast cancer during a woman's life span is estimated by the American Cancer Society (ACS) to be 12%, or 1 woman in 8. Approximately 230 480 new invasive breast cancer cases are likely to occur in the United States in 2011, along with 57 650 cases of noninvasive carcinoma in situ. A woman's estimated chance of death from breast cancer is about 3% or 1 of every 36 women. The ACS also estimated that 39 520 women will die from breast cancer in 2011.[1]

Breast Density and Detection Challenges

The objective of screening mammography is to identify cancers while they are small and localized.[1] However, some breast cancers still are missed while in their earliest stages, and it is widely agreed that imaging of dense breasts can be improved. The results of the Digital Mammographic Imaging Screening Trial (DMIST) stated that full-field digital mammography (FFDM) improves cancer detection in certain populations of women, especially those who are younger than age 50 years, have heterogeneously dense breast tissue or extremely dense breasts and are perimenopausal.[2,3]

The American College of Radiology (ACR) Breast Imaging Reporting and Data System (BI-RADS) lexicon for mammographic breast composition categorizes breast tissue as:

- 1 – predominantly fat (less than 25% glandular tissue).
- 2 – fat with some fibroglandular tissue or scattered glandular breast tissue (25% to 50% glandular tissue).
- 3 – heterogeneously dense (50% to 75% glandular tissue).
- 4 – extremely dense (more than 75% glandular tissue).[4-6]

Categorizing breast composition depends to some extent on the type of imaging performed; breasts categorized one way on a film-screen mammogram may be categorized differently on digital mammograms. For example, radiologists viewing images produced with film-screen mammography may classify the breast as 1 (predominantly fat) but on a digital image more glandular tissue is visible and the breast is classified as 2 (fat with some fibroglandular tissue). The reverse also has occurred; a category 4 (extremely dense) film-screen image may appear digitally as a category 3, a less heterogeneously dense composition. Digital images can be manipulated after exposure to adjust contrast and brightness.

As women age and their hormone levels change, the glandular tissue in their breasts tends to become replaced by fatty tissue. For reasons not fully understood, not all women go through this process after menopause. However, most women's breasts are not totally replaced with fat. For these breasts, there remains the possibility of occult lesions or calcifications because of overlying breast tissues or structures. Younger women and women undergoing postmenopausal hormone replacement therapy also typically have dense breast tissue.[2] Approximately 40% of women who fall within the screening mammography eligibility requirements have dense breast tissue.[7]

The most challenging aspect of using mammography to detect breast cancer is producing diagnostic-quality images of patients with dense breasts. It is easier to observe lesions and calcifications in predominantly fatty breasts because less breast parenchyma obscure the radiologist's view, assuming the images are properly positioned and exposed.[8] Because of the development of FFDM, new techniques have followed to improve breast imaging. One such technique is digital breast tomosynthesis (DBT),[9] also referred to as digital tomosynthesis mammography. A report following release of the DMIST results retrospectively confirmed that diagnostic accuracy improved with use of FFDM compared with film-screen mammography for women younger than age 50 years with dense breasts. The contrary also was true; for women older than age 65 years with fatty breasts, film-screen mammography outperformed FFDM.[8]

FFDM offers potential image manipulation and better visualization through dense tissue. However, overlying and underlying tissues and structures still can mimic or hide breast cancers. Researchers hope that DBT will facilitate visualization of these lesions by removing overlying and underlying structures from view.[10,11]

The Technology Behind Tomosynthesis

DBT is a complex imaging technique that uses computer algorithms and digital images of the breast to create what is in essence 3-D viewing of mammograms. This section reviews the key technologies that make DBT possible, including FFDM and different types of digital imaging detectors, tomosynthesis and computer algorithms.

Film-screen vs Digital Breast Imaging

In mammography, the breast is compressed and the x-ray source is stationary. The x-rays pass through the breast and a movable grid, and are captured by either a stationary phosphor screen and film (analog mammography) or a digital image detector (digital mammography) to create an image. Film-screen systems provide excellent detail resolution, which is crucial for imaging microcalcifications and very small abnormalities that may indicate early breast cancer. Because the narrow dynamic range is balanced against wide latitude, many masses may be hard to visualize in very dense breast tissue. Advantages of FFDM over film-screen mammography include a wider dynamic range, ability to manipulate the image after examination and improved contrast between dense and fatty tissues.[12]

Types of Digital Detectors

Digital radiography began in the 1980s with the introduction of digital subtraction imaging. The era also saw the introduction of computed radiography (CR), a form of digital radiography that uses photostimulable storage phosphors. Next were systems that used charge-coupled devices (CCDs).[4]

CCD Detectors

CCD detectors commonly are used for stereotactic applications and could be considered the first digital mammography application. The field of view afforded by CCD detectors is limited and therefore not considered FFDM. Some manufacturers have marketed CCD detector technology as digital spot mammography imaging.

CCD devices have high spatial resolution, wide dynamic range and a high degree of linearity. Because of the size limitation of CCD technology, a slot scan digital mammographic system was created.[12] The slot scan system used multiple CCDs to create the entire FFDM image. However, the manufacturer since has gone out of business.

CR Detectors

CR initially had limited detective quantum efficiency (DQE) and low spatial resolution.[4] Mammography CR uses a photostimulable phosphor plate within a cassette and can be adapted for use with film-screen mammography equipment. CR mammography is considered indirect conversion imaging[9] FFDM but is not applicable for DBT at this time because it does not use a digital detector. A high-quality FFDM detector is required for DBT.[10,13]