3D Mammography

- The FDA recently approved 3D mammography (breast tomosynthesis) for both screening and diagnostic mammography
- In 3D mammography, multiple low-dose exposures are acquired by a digital detector as the x-ray tube moves in an arc over the patient
- The images are presented as a series of slices, avoiding the problem of overlapping structures that are seen in conventional 2D mammography
- Both the sensitivity and specificity of 3D mammography are better than that of conventional mammography, with fewer false positive and false negative findings
- The radiation dose from 3D mammography is well within recommended guideline limits for mammography

Figure 1. (A) shows an asymmetry on 2D mammography. On 3D imaging (B), the "asymmetry" is clearly seen to be a spiculated mass. Invasive ductal carcinoma.

Multiple international clinical trials have provided indisputable evidence that screening mammography has led to a significant and substantial decrease in the death rate from breast cancer. However, mammography is not perfect. The major limitation of conventional mammography is that it depicts the three-dimensional (3D) breast as a two-dimensional (2D) projection image. The resulting overlap of normal structures can obscure cancers, rendering them more difficult for radiologists to perceive. In addition, this "structure noise" can actually mimic mammographic abnormality, generating false positive findings that result in unnecessary additional imaging, patient inconvenience, anxiety and financial expense. These limitations of mammography have led investigators to evaluate other imaging modalities such as ultrasound and MRI in an effort to maximize breast cancer detection while minimizing unnecessary studies.
Figure 2. (A) shows no abnormality on 2D mammography. On 3D Imaging (B), an area of architectural distortion is clearly seen. Invasive ductal carcinoma.

3D Mammography

3D mammography (breast tomosynthesis), the breast is compressed as in conventional 2D mammography. Then the breast is imaged in a series of exposures as the x-ray tube moves through a limited arc. Each individual exposure is only a fraction of the dose utilized in a conventional mammographic exposure, such that the total dose from 3D mammography is similar to a single conventional digital mammographic image.

The raw data projection sets are then reconstructed using algorithms similar to those used in other 3D imaging techniques to produce thin (typically 1 mm) slices of tissue. Because the overlap of tissues is minimized in the 3D mammography studies, the characteristic margins of a tumor can be seen more clearly (Figure 1) and it is possible to positively identify a tumor that is otherwise obscured by overlying tissue (Figure 2) or to recognize normal or benign structures that appear suspicious on conventional mammographic imaging (Figure 3).

The final approval of 3D mammography for clinical use by the Food and Drug Administration (FDA) comes after two clinical trials demonstrating its safety and efficacy. In these clinical trials, 27 different radiologists demonstrated significantly improved clinical performance when using 3D in addition to 2D digital mammography when compared with using 2D digital mammography alone, as demonstrated by significant gains in the area under the curve (AUC) using receiver operator characteristic (ROC) methodology. The use of the combination examination (2D plus 3D) facilitates comparison to prior examinations and eases the transition as radiologists adapt to the interpretation of a new imaging modality. The combination mammography can be obtained in a single breast compression at a radiation dose below the FDA limit for a single conventional mammographic exposure.

In general, superimposition of normal breast structures does not degrade the visibility of calcifications in the breast, whereas it does affect the visibility of masses, architectural distortion and asymmetries. Accordingly, radiologist performance in the detection and analysis of calcifications was not significantly enhanced by the addition of 3D mammography. In non-calcified lesions, however, radiologists achieved substantial improvements in performance through the use of 3D imaging (difference in AUC of .10; p=.0008); by minimizing the impact of overlapping structures in the breast, the addition of 3D mammography resulted in improvements in sensitivity, specificity, positive and negative predictive value when compared with 2D mammography alone (Table 1).

As might be expected, the addition of 3D mammography to conventional mammography results in more significant gains when utilized in women with dense breast tissue. In fact, although 3D mammography significantly improved the performance of radiologists in women with fatty breasts (AUC .925 vs .880; p=.0004), the gains in performance were three times greater in women with dense breast tissue (AUC .880 vs .786; p=.0001).

| Table 1. Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value for Reader Study 2 using BIRADS scores comparing 2D and 3D mammography |
|---------------------------------|--------|--------|
|                                | 2D     | 2D plus 3D |
| Sensitivity                    | 65.5%  | 76.2%  |
| Specificity                    | 84.2%  | 89.3%  |
| Positive Predictive Value      | 43.0%  | 56.4%  |
| Negative Predictive Value      | 93.0%  | 95.4%  |
Figure 3. (A) shows a possible mass behind the nipple on 2D mammography. On 3D imaging, only normal structures are seen behind the nipple (B, C, D); the normal structures combine to give the appearance of a mass on 2D mammography. This false positive finding on 2D is resolved using 3D.

The FDA gave its approval for the use of 3D mammography in both the screening and diagnostic settings. In diagnostic breast imaging, the 3D mammography acquisition can function as an additional view for the radiologist, with the potential to give similar information as would be gained through several additional standard projection images. Other studies indicate that 3D mammography may also play a role in the diagnostic work-up of patients with known masses. For example, one study indicated that the availability of 3D mammography would reduce the need for ultrasound by 12%. Because it is much easier to characterize the margins of a lesion as malignant or benign, the use of 3D mammography has the potential to reduce the number of biopsies. Furthermore, surgical oncologists anticipate that they will be able to improve surgical treatment of breast cancer by using 3D mammography to better inform them on the extent of disease.

The greatest potential of the imaging technique, however, will likely be achieved in the screening setting, where the removal of the impact of overlapping structures in the breast is expected to maximize mammographic breast cancer detection while reducing the number of women recalled for additional imaging evaluation, which causes unnecessary anxiety and expense in false positive cases. In addition to improvements in diagnostic clinical performance, all 27 radiologists in the two clinical studies evaluated by the FDA decreased their recall rate from screening; relative reductions in radiologist recall rate ranged from 38-70%. In a separate study of screening and the potential impact of 3D mammography, one group of radiologists read the standard 2D mammography while a second group of radiologists read the 3D mammography images of 1957 patients, with resultant recall rates of 7.5% and 4.3% respectively. These results have been confirmed by other similar studies and suggest that the implementation of 3D mammography in the setting of screening mammography has the potential to decrease recall rates while maintaining high levels of cancer detection. Similar reductions in screening recall rate in clinical practice could translate to millions of women not being recalled from screening mammography for unnecessary studies.

**Limitations of 3D Mammography**

To date, all investigation of 3D mammography has taken place in research settings and, while the results have been generally favorable, implementation of the technology in the working clinical environment will reveal its true potential and define its optimal role in breast imaging evaluation. Extensive training of technologists and radiologists will be necessary for proper image acquisition and interpretation.

Another potential limitation of the technology is the ability to adequately detect calcifications. It is notable that calcifications can be difficult to analyze on cross-sectional display, where their distribution can sometimes fail to be appreciated. Current imaging strategies utilizing both 2D and 3D imaging optimize review of calcifications, but other approaches, such as maximum intensity projection (MIP) images that show slices that are 1-2 cm thick are under investigation for the purpose of optimizing review of 3D mammography images for microcalcifications.

**Scheduling**

3D mammography (breast tomosynthesis) is now available at Mass General Hospital. Screening examinations may be ordered on ROE for appointment times in the evening and on weekends. During daytime hours, priority will be given to diagnostic examinations with 3D mammography. During these times, access to the 3D mammography resource will be more limited for screening examinations.
**Further Information**

For further questions on 3D mammography (DBT), please contact Elizabeth A. Rafferty, MD, Director of Breast Imaging, or Phoebe E. Freer, MD, Director of Breast Imaging Education and Program Development, at **617-726-3093**.

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**References**


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