DIGITAL BREAST TOMOSYNTHESIS (DBT)
A Revolutionary Improvement in Mammography

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MAMMOGRAPHY SCREENING HAS FULFILLED ALL OF THE TESTS OF EFFICACY

BCDDP - Detects cancer earlier
RCT – Invitation to screening decreases mortality relative to control groups
Population screening decreases death rate
  a. Sweden 2 County and 7 counties
  b. Netherlands screening centers come on line death rate decreases
Screening begins 1983-84 (Incidence surges and DCIS begins to be detected) – Death rate down 25% since 1990
Digital mammography may be slightly better at detecting cancer (Oslo II, DMIST), but the main advantages from digital are primarily logistical.
The real benefit that has come with the development of digital detectors is that they provide an opportunity to improve the x-ray evaluation of the breast.
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Once the image is digital it offers the opportunity for important computer manipulation.
Digital mammography and conventional film/screen mammography are both limited in sensitivity and specificity by the problem of the structure noise of normal breast tissues on 2-dimensional x-ray imaging.
In two dimensional x-ray mammography all structures from one side of the breast to the other are superimposed on the projection image obscuring important details.
CONVENTIONAL TWO DIMENSIONAL MAMMOGRAPHY - FILM/SCREEN AND DIGITAL
TWO DIMENSIONAL X-RAY MAMMOGRAPHY

The deleterious effects of normal structure noise are easily seen when the two dimensional mammographic image is compared to the specimen radiograph of the same lesion once it has been removed from the breast.
Cancer on mammography in the breast

Specimen radiograph of excised tissue
IT IS EASIER WHEN THERE IS NO OVERLAP.

IT IS DIFFICULT WHEN EVERYTHING IS OVERLAPPING.
IT IS DIFFICULT
TO READ A MAMMOGRAM
WHEN EVERYTHING IS OVERLAPPING
IT IS EASIER WHEN THERE IS NO OVERLAP
IT IS EASIER
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DIGITAL BREAST TOMOSYNTHESIS

X-ray
DIGITAL BREAST TOMOSYNTHESIS

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X-ray
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DIGITAL BREAST TOMOSYNTHESIS
SHIFT AND ADD

Individual images

Synthesized image

1 + 2 + 3
DIGITAL BREAST TOMOSYNTHESIS
SHIFT AND ADD

Individual images

Synthesized image

1 + 2 + 3

1

2

3
Digital Breast Tomosynthesis produces a 3-dimensional mammogram.

By eliminating the “structure noise” of overlapping normal breast tissue, DBT improves the detection of breast cancer while it decreases false positives created by overlapping structures mimicking lesions.
First GE prototype DBT
Second GE prototype DBT
DIGITAL BREAST TOMOSYNTHESIS

Technique:

1. The x-ray tube is moved through an arc of 50 degrees in 7 seconds
2. 11 exposures are made during the single sweep
3. Each exposure is a fraction of the dose of a conventional film/screen mammogram so that the total dose is less than a two view two dimensional mammographic study.
4. The images are “synthesized” into slices 1mm apart through the entire breast.
In the early trials DBT has been at a disadvantage.

Patients have participated in DBT protocols only if they had a finding on their conventional mammogram. Nevertheless, DBT has already demonstrated 7 cancers that were not evident on the conventional images.
CASE

Patient was referred to the MGH with a subtle area of spiculated architectural distortion on the screening mammogram of her right breast.
Tomosynthesis found the cancer that was barely visible on the standard two view mammogram.

This slice shows the cancer
Tomosynthesis found a second cancer that was not evident on the conventional two view mammogram. This slice shows the second cancer 1 cm. from the first.
VISIBILITY OF MASSES AND ARCHITECTURAL DISTORTION

CASES

0  2  4  6  8  10  12  14  16  18  20

READER 1
(p < .001)

READER 2
(p < .001)

READER 3
(p < .001)

TOMO > FS
TOMO = FS
TOMO < FS
DIGITAL BREAST TOMOSYNTHESIS

Not only does DBT permit a clearer analysis of a lesions margins by removing overlapping structures, but since it is a 3-dimensional technique, the exact 3-dimensional location of any lesion is defined precisely by its slice number (mm. from the detector).
Not only was the lesion worrisome, but since it was only visible in the MLO projection its location in the breast was indeterminate.
The thin capsule of fat-containing mixed lesion is evident.
The lesion is also precisely located by Tomosynthesis on slice 33 making it 33 mm from the detector in the center of the 66 mm thick breast.
An area of architectural asymmetry was noted in the left breast on this patient’s screening mammogram.
POSSIBLE ARCHITECTURAL DISTORTION
Additional mammographic evaluation failed to identify any abnormality. What was seen at screening was a benign superimposition of normal structures. Tomosynthesis eliminates this reason for recall.
CALLBACK RATES FOR 60 BLINDED REVIEWS

- FS: n = 45
- TOMO 1: n = 18
- TOMO 2: n = 24

- BIOPSIED--BENIGN
- BIOPSIED--MALIGNANT
- SIP
- NORMAL

PPV = 39%  PPV = 33%
TOMOSYNTHESIS: REDUCTION OF FALSE POSITIVE STUDIES

• The call-back rate for patients ultimately shown to have superimposed normal structures accounting for the possible abnormality decreased by 87%.

• While the cancer detection rate was maintained at 93%.
1. The conspicuity of cancers is markedly improved increasing sensitivity.

2. The superimposition of normal structures is no longer a problem increasing specificity.

3. Three-dimensional localization is no longer a problem
Digital Breast Tomosynthesis (DBT) — 2nd generation GE prototype

Detector:
- amorphous-Si (CsI) epitaxially grown scintillator
- 300msec readout time
- 23cm × 19.2 cm area
- 100 micron pixel size

Acquisition:
- 15 projections
- 40° arc
- 15s acquisition
- Mo and Rh anodes
- same dose as CC+MLO
- 360° gantry rotation permits all standard views
Here are the standard mammographic projections. A suspicious asymmetry was noted on the CC projection of the right breast. Is it real? Where is it?
CONVENTIONAL MAMMOGRAM

TOMOSYNTHESIS SLICE

INVASIVE CARCINOMA
DIGITAL TOMOSYNTHESIS OF THE BREAST

Blinded Reader Studies Comparing Tomosynthesis to film/screen mammography

1. Greater conspicuity of lesions
   Tomo > F/S 67%

2. Cancer detection rate
   Tomo > F/S 18%

3. False positive rate
   Tomo decreased by 87%
DIGITAL BREAST TOMOSYNTHESIS

PREDICTION

DBT will become the platform for multimodality breast imaging. It will permit perfectly registered whole breast ultrasound and other imaging tests and will replace “conventional” digital mammography.