Digital Mammography Imaging: Breast Tomosynthesis and Advanced Applications

Wilmarie Rivera-Hernández, MD DABR
Women's Imaging Specialist
Pavia Breast & Imaging Center
Hospital Oncológico

Breast Cancer Facts...

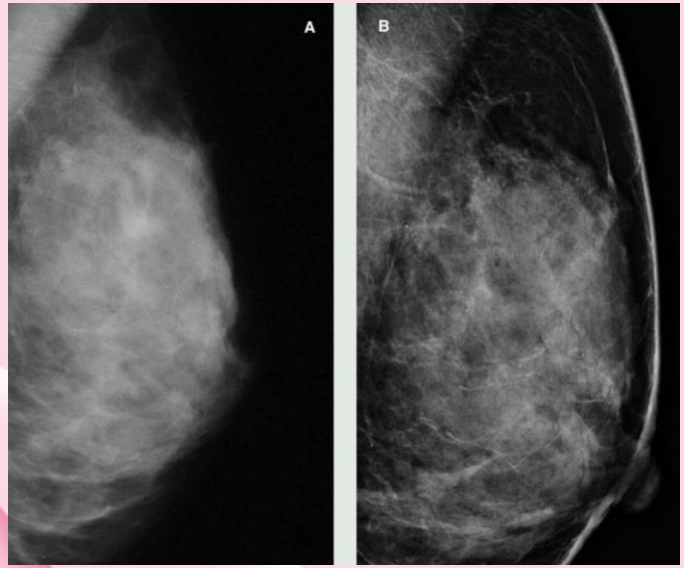
- Breast cancer is the most commonly diagnosed cancer in women.
- One in eight women in the United States will be diagnosed with breast cancer in her lifetime.
- Breast cancer is the second leading cause of cancer death among women.
- Each year it is estimated that over 252,710 women in the United States will be diagnosed with breast cancer and more than 40,500 will die.
- Although breast cancer in men is rare, an estimated 2,470 men will be diagnosed with breast cancer and approximately 460 will die each year.
- On average, every 2 minutes a woman is diagnosed with breast cancer and 1 woman will die of breast cancer every 13 minutes.

Annual Screening Mammogram

- Mammography can reduce breast cancer mortality by 30% or more.
- Early detection of small nonpalpable node-negative cancers.
- Despite its clearly documented benefit, it is well recognized that mammography is imperfect.
    - Overall sensitivity is limited by the presence of dense fibroglandular breast tissue, which can obscure an underlying cancer.
    - Specificity is also reduced by the presence of overlapping fibroglandular tissue, which can mimic the appearance of cancer.

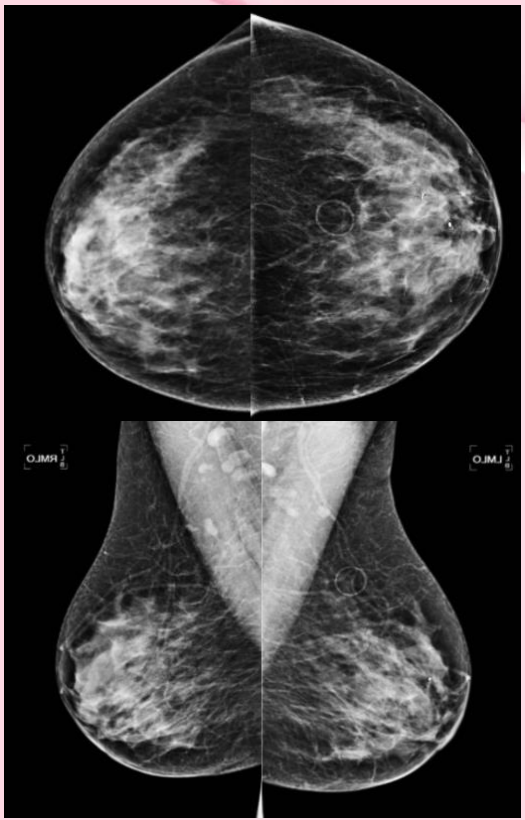
Annual Screening Mammogram

- In the early 2000s, the conversion from analog film-screen mammography to full-field digital mammography (FFDM) improved diagnostic performance, particularly in women with dense breast tissue and women 49 years of age or younger.



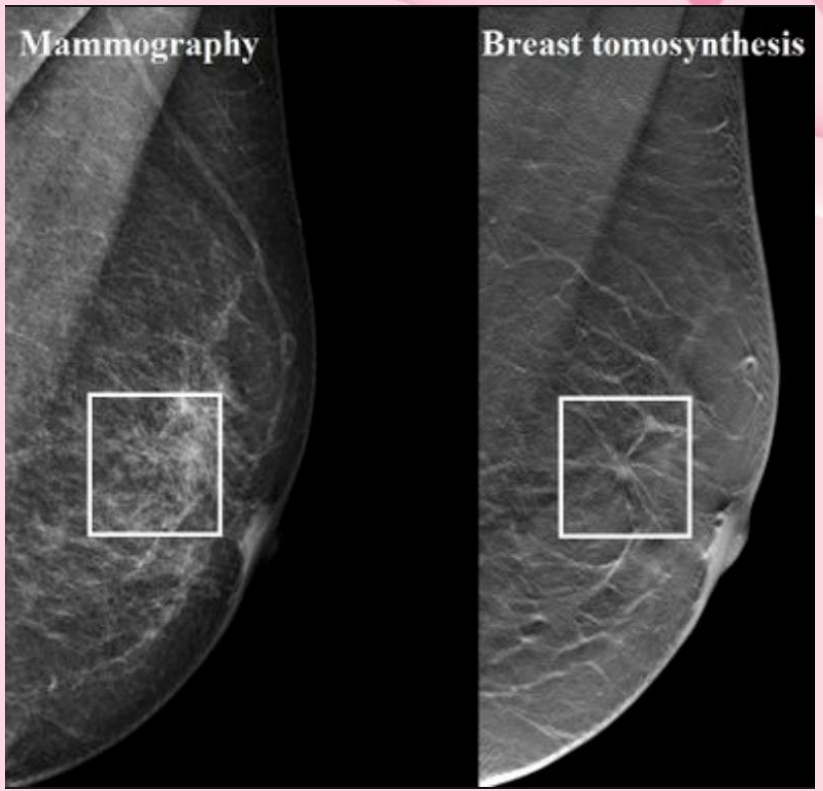
Full-Field Digital Mammogram

- 2D mammograms.Take only one picture, across the entire breast, in two directions.
    - Overlapping breast tissue in 2D mammogram poses a significant challenge to interpretation since breast cancer can be hidden in the overlapping tissue and not show up on the mammogram.
- More callbacks to perform additional imaging causing increasing patient anxiety and increase in health costs.
- The median recall rate is approximately 9.3% in the US.



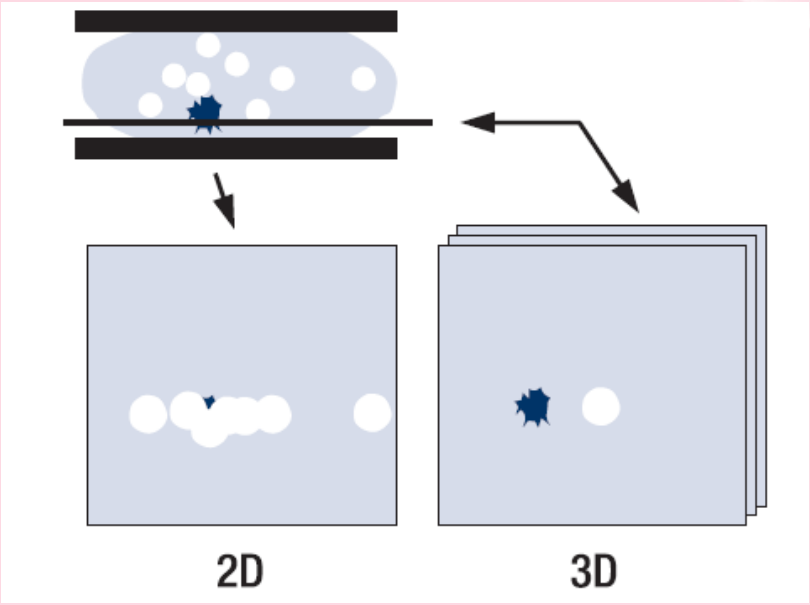
Digital Breast Tomosynthesis (DBT)

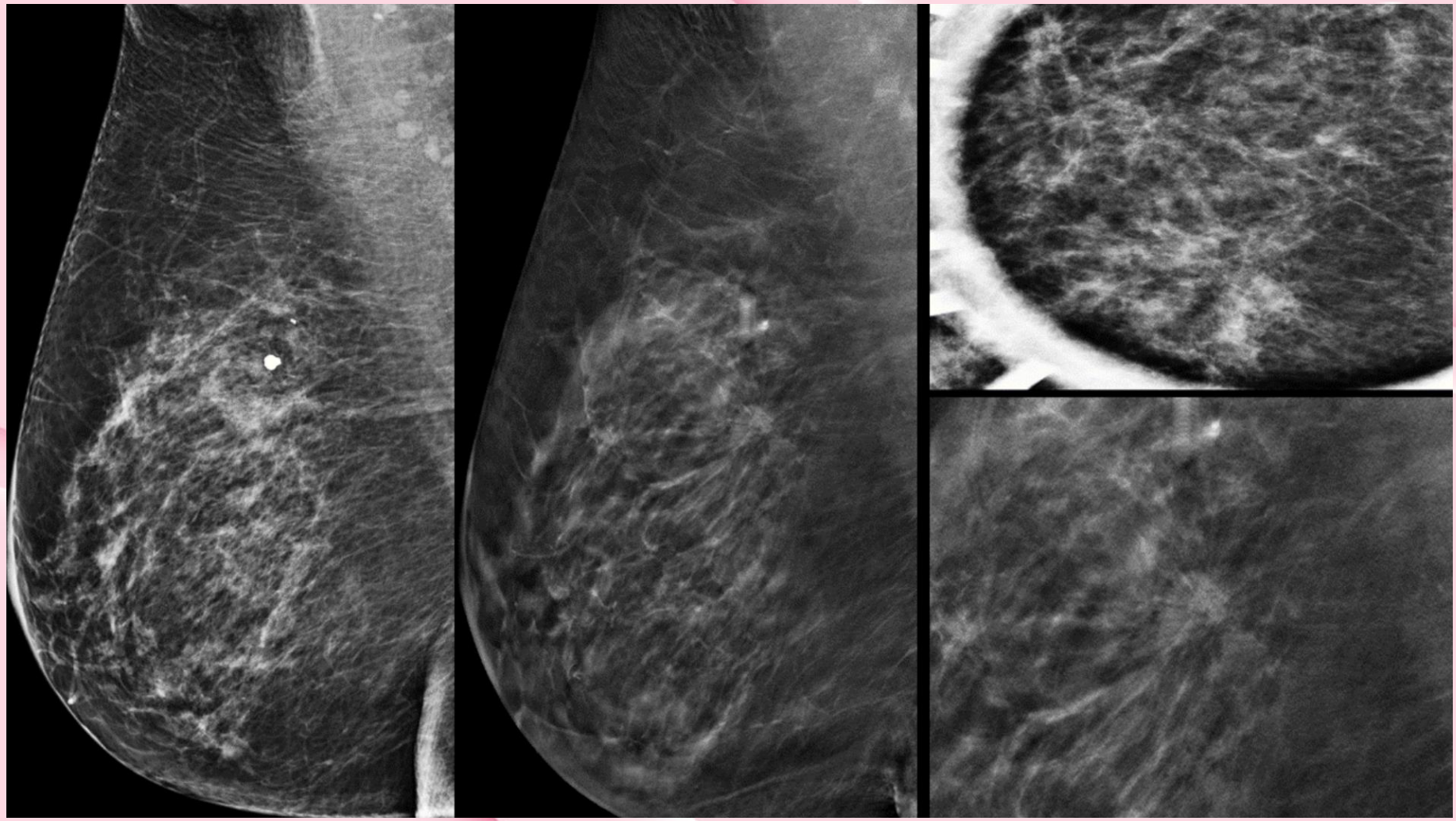
- In 2011, the FDA first approved digital breast tomosynthesis (DBT) which represents another significant advance in mammography technology.
  - Multiple studies have shown that DBT is effective in both screening and diagnostic settings.
  - It was developed to overcome tissue superimposition.

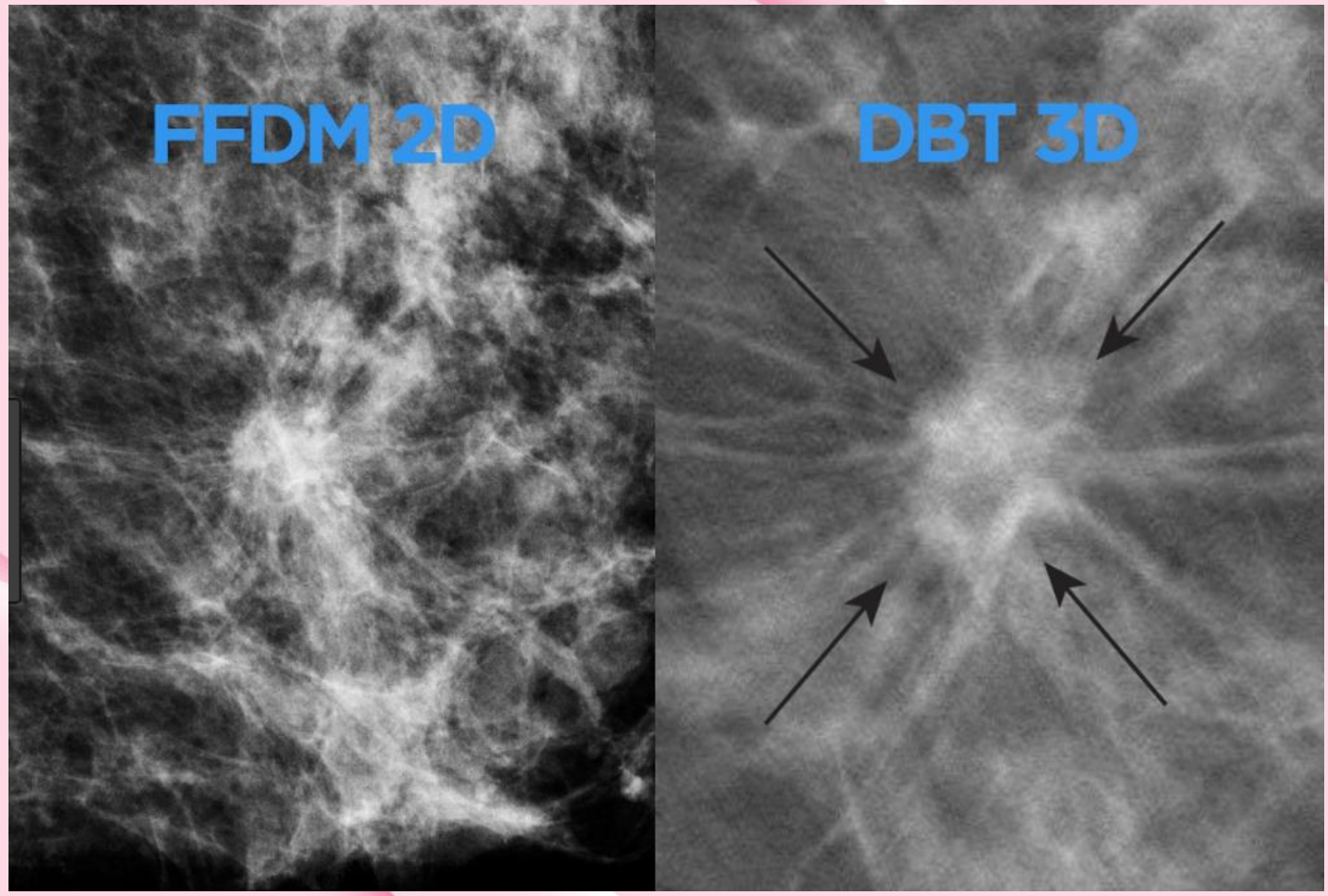


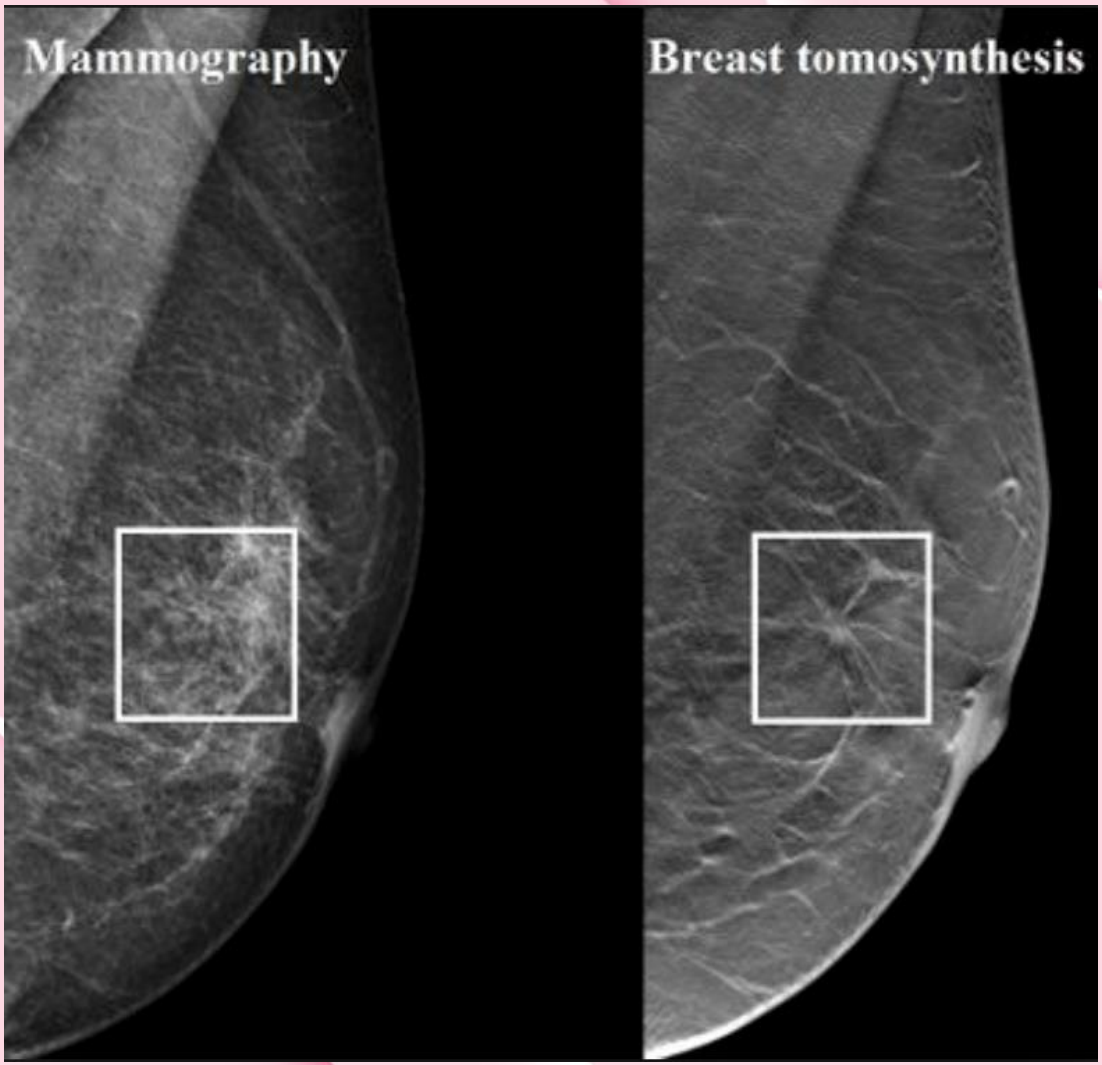
What is Digital Breast Tomosynthesis?

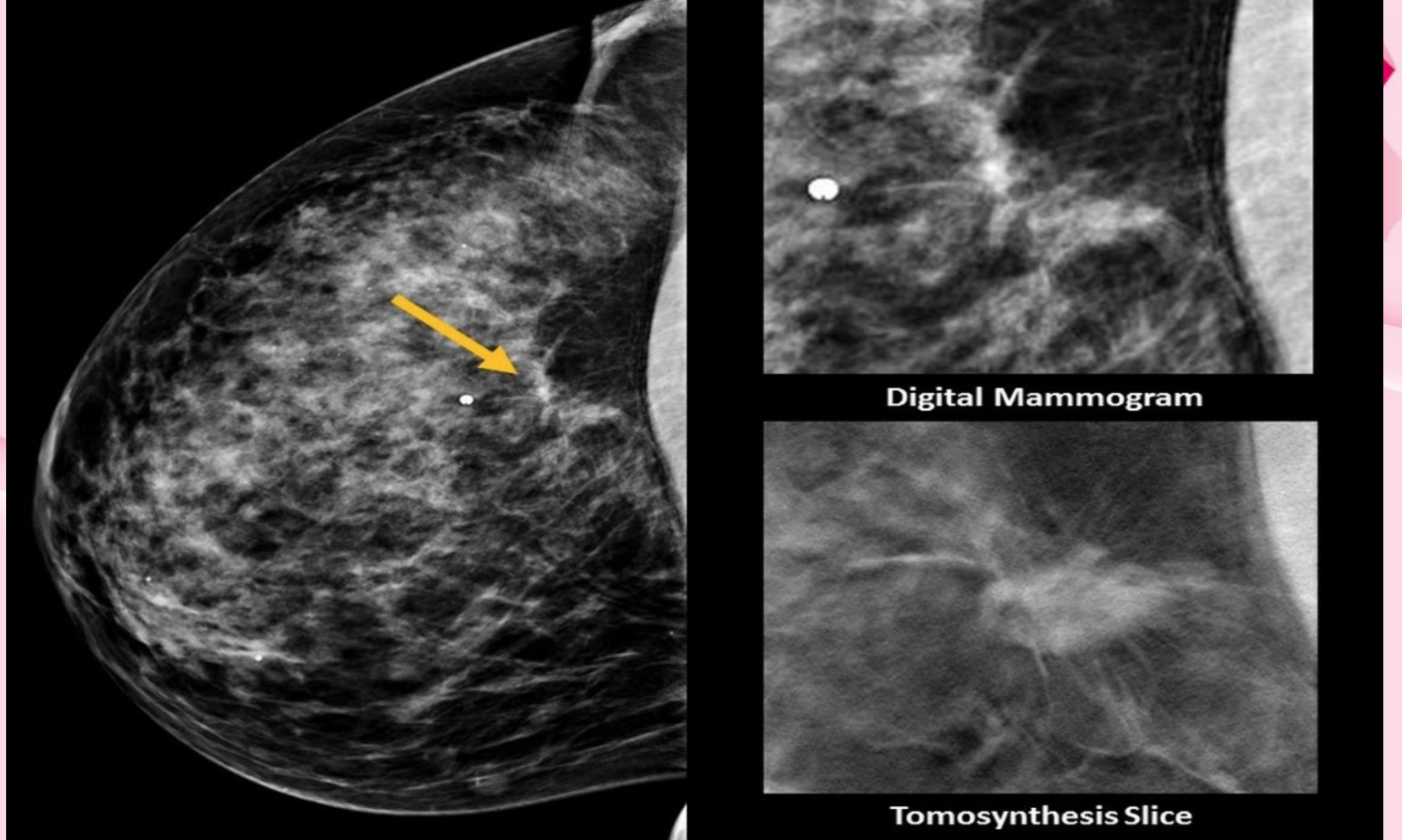
- Also known as 3D mammography.
- It is a digital mammography technique that takes multiple X-ray pictures of the breast from many angles.

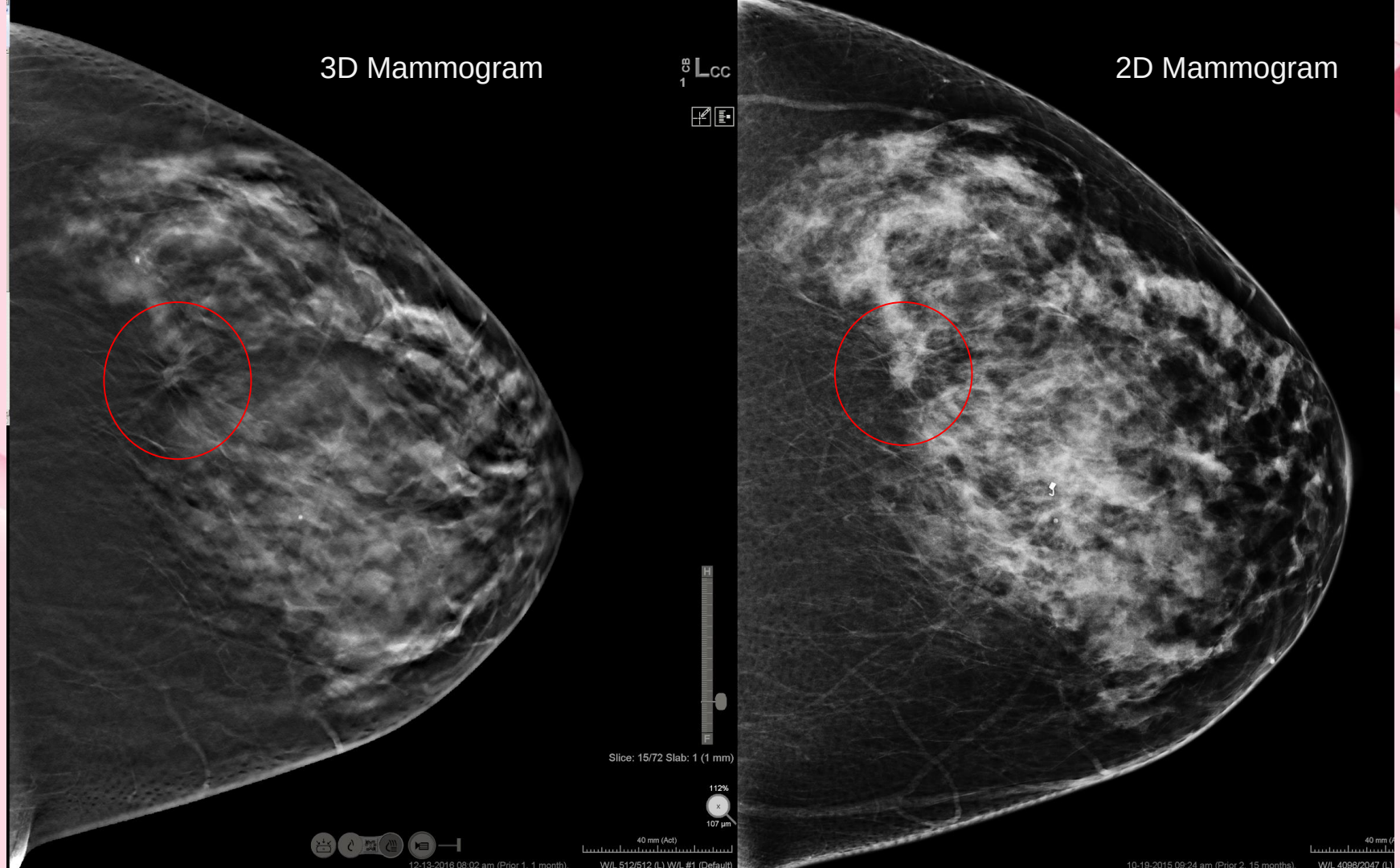


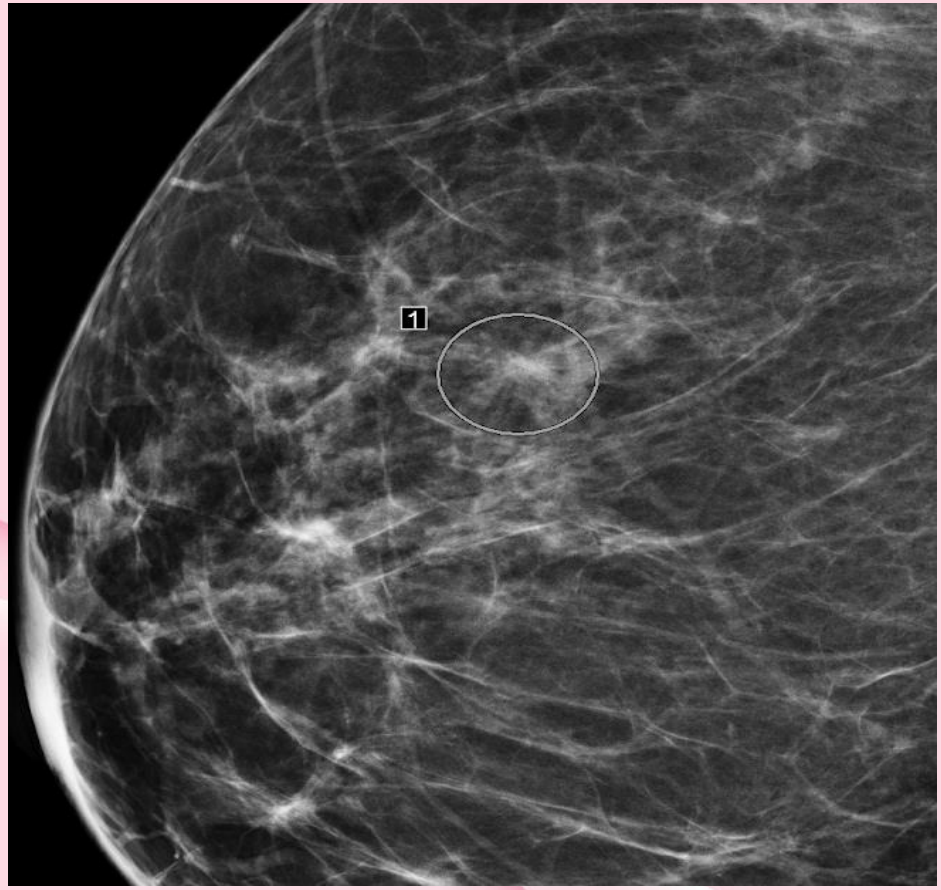



FFDM 2D
DBT 3D


Mammography
Breast tomosynthesis

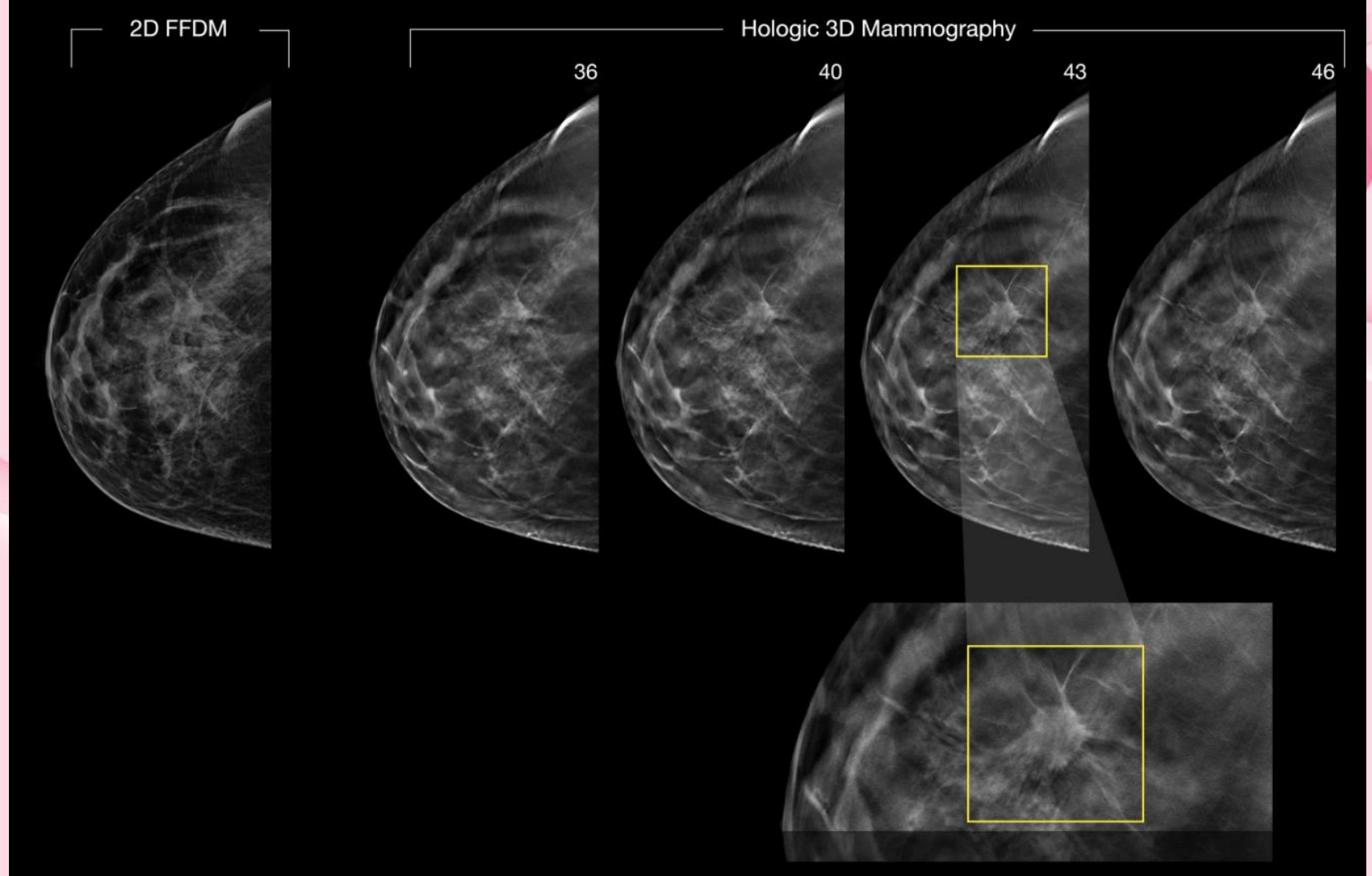

Digital Mammogram
Tomosynthesis Slice


3D Mammogram
CB 1 Lcc
H
F
Slice: 15/72 Slab: 1 (1 mm)
112%
107 µm
40 mm (Act)
12-13-2016 08:02 am (Prior 1, 1 month)
W/L 512/512 (L) W/L #1 (Default)
2D Mammogram
40 mm (
10-19-2015 09:24 am (Prior 2, 15 months)
W/L 4096/2047 (L)



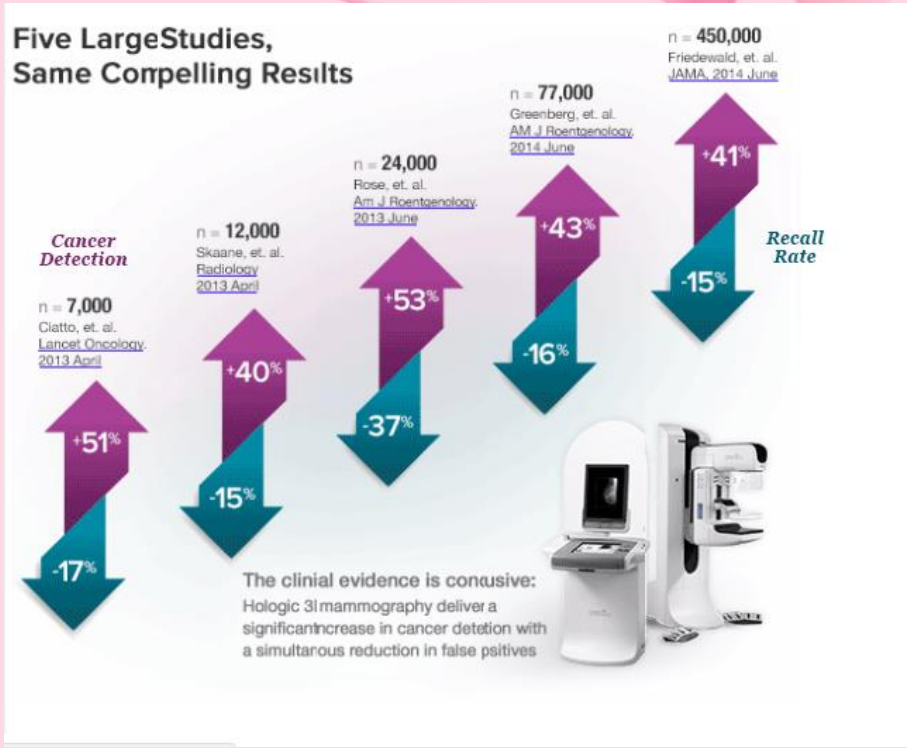
2D Mammogram

3D Mammogram

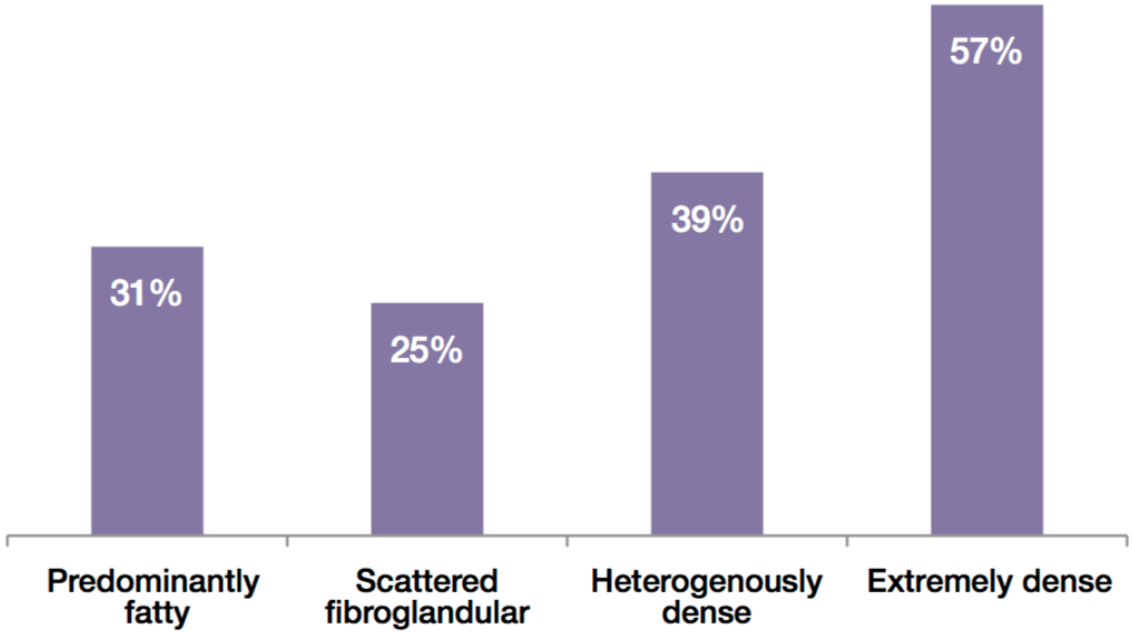

2D FFDM
Hologic 3D Mammography
36
40
43
46

Benefits of Tomosynthesis

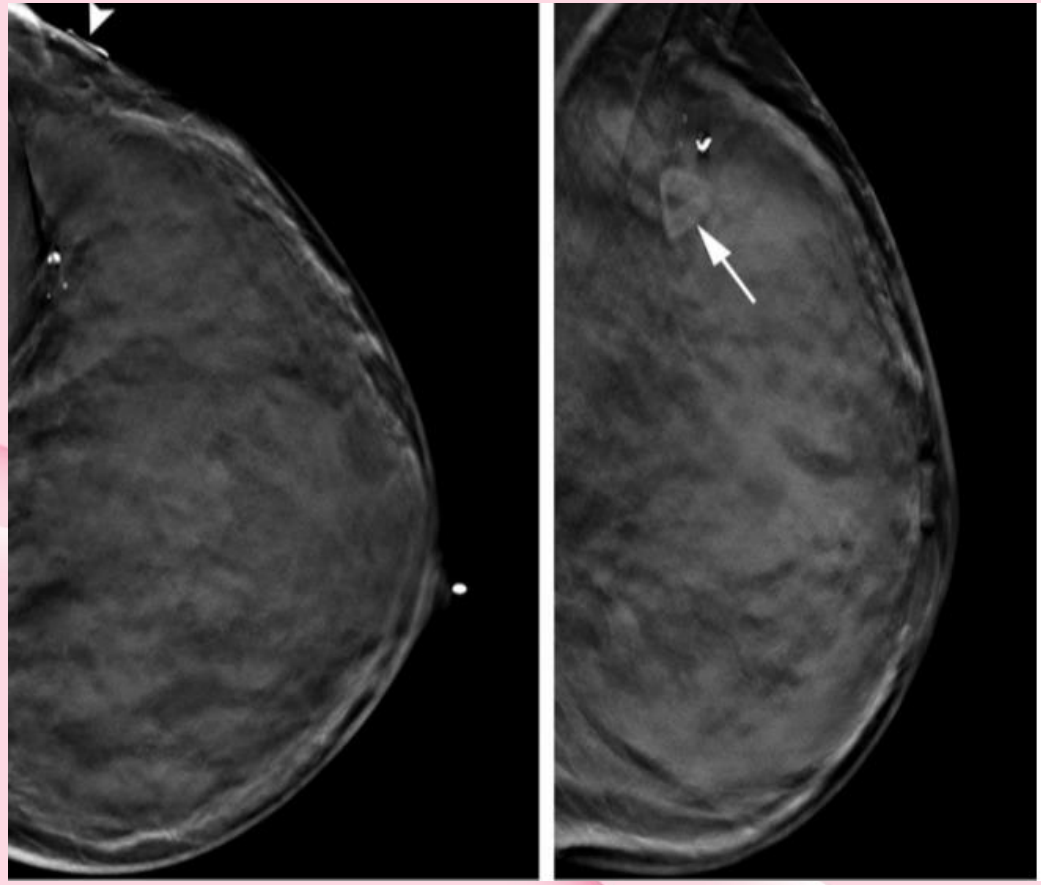
- Increased cancer detection (40-53%).
  - Beneficial to women regardless of breast density.
- Increased conspicuity of invasive cancers.
  - Invasive cancer detection rate relative increase of 41%
- Minimizes the effect of tissue overlap.
  - Marked reduction in recall rates from screening (15-37%).
  - Reduce false-positive results (15-30%).
- Overall - Tomosynthesis enhance both the sensitivity and the specificity of mammography.

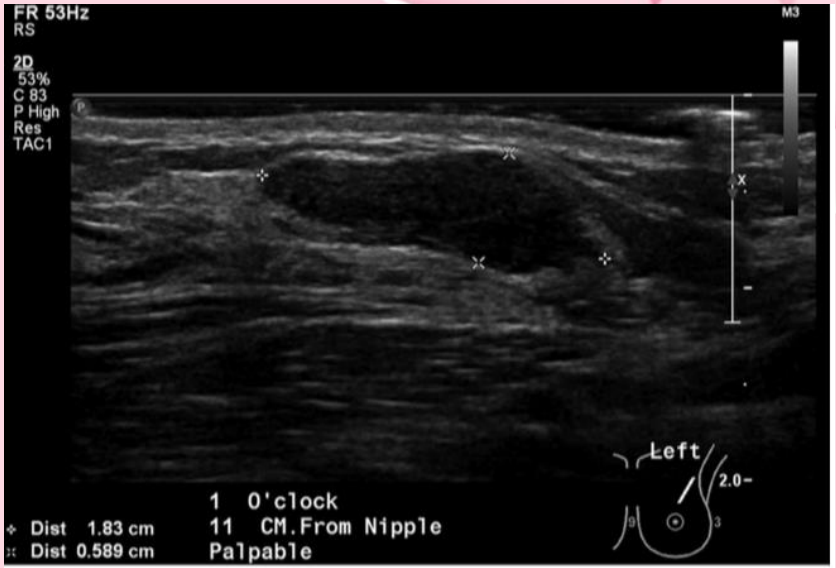


Recall Rate Reduction by Breast Density



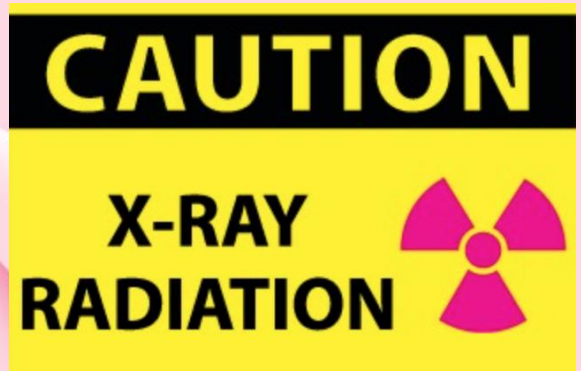
In the study by Haas, et al., the addition of 3D mammography decreased recalls across all breast densities, with significant reductions in denser breasts.




FR 53Hz
RS
M3
2D
53%
C 83
P High
Res
TAC1
Left
2.0
1 O'clock
11 CM.From Nipple
Palpable
Dist 1.83 cm
Dist 0.589 cm

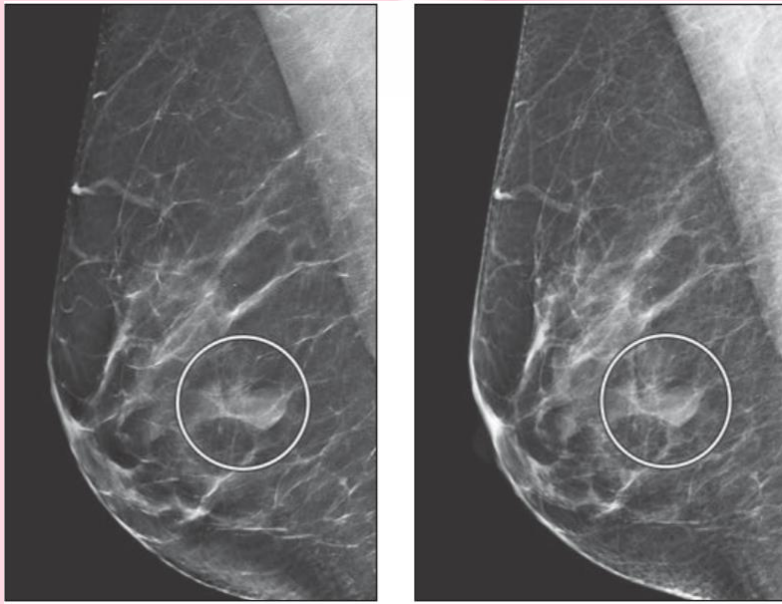
DBT Radiation Dose

- The DBT images are low in dose; however, a combination of 2D and DBT study increases patient radiation exposure by approximately twofold.
- The increased total dose is still below the FDA safety limits of 3 mGy/view.
- The added DBT dose is equivalent to only 1 to 2 months of annual background radiation in the United States.
    - A FFDM is 7 weeks of background radiation
    - versus an abdominopelvic CT which is 3 years of background radiation



Synthesized 2D Mammography

- The data from the DBT images are condensed into a single image.
- Eliminate the need for a conventional 2D image.
- Benefit of a combined 2D plus DBT examination with radiation doses at parity with 2D alone.
    - DBT plus SM can reduce radiation dose by approximately 45% compared with DBT-FFDM.
- FDA approved the use of synthesized 2D in combination with DBT in May 2013.



DBT guided Biopsy

- Inevitably, suspicious lesions will be detected that are only seen on DBT.
- The detection of tomo only findings such as architectural distortions increased with the use of DBT and poses a challenge since biopsy is usually necessary and tomosynthesis guided biopsy is not widely available.

Contrast enhanced mammography

Figure 1. The low energy mammograms pre-injection (a) and post-injection (b) look almost identical, as the contrast uptake is not easily distinguished. The high energy mammogram (c) shows the lesion, as well as the breast parenchyma, but both at low contrast due to the high kV of the exposure. The final dual-energy subtracted image (d) removes most of the parenchyma and clearly shows the iodine uptake in the single isolated lesion.

ACR Appropriateness Criteria

ACR Appropriateness Criteria

Variant 1: **Breast cancer screening. Average-risk women: women with <15% lifetime risk of breast cancer.**

Procedure	Appropriateness Category	Relative Radiation Level
Mammography screening	Usually Appropriate	☢ ☢
Digital breast tomosynthesis screening	Usually Appropriate	☢ ☢
US breast	May Be Appropriate	O
MRI breast without and with IV contrast	Usually Not Appropriate	O
MRI breast without IV contrast	Usually Not Appropriate	O
FDG-PEM	Usually Not Appropriate	☢ ☢ ☢ ☢
Tc-99m sestamibi MBI	Usually Not Appropriate	☢ ☢ ☢

ACR Appropriateness Criteria

Variant 2: **Breast cancer screening. Intermediate-risk women: women with personal history of breast cancer, lobular neoplasia, atypical ductal hyperplasia, or 15% to 20% lifetime risk of breast cancer.**

Procedure	Appropriateness Category	Relative Radiation Level
Mammography screening	Usually Appropriate	☢ ☢
Digital breast tomosynthesis screening	Usually Appropriate	☢ ☢
MRI breast without and with IV contrast	May Be Appropriate	O
US breast	May Be Appropriate	O
FDG-PEM	Usually Not Appropriate	☢ ☢ ☢ ☢
Tc-99m sestamibi MBI	Usually Not Appropriate	☢ ☢ ☢
MRI breast without IV contrast	Usually Not Appropriate	O

ACR Appropriateness Criteria

Variant 3: **Breast cancer screening. High-risk women: women with a BRCA gene mutation and their untested first-degree relatives, women with a history of chest irradiation between 10 to 30 years of age, women with 20% or greater lifetime risk of breast cancer.**

Procedure	Appropriateness Category	Relative Radiation Level
Mammography screening	Usually Appropriate	☢ ☢
Digital breast tomosynthesis screening	Usually Appropriate	☢ ☢
MRI breast without and with IV contrast	Usually Appropriate	O
US breast	May Be Appropriate	O
FDG-PEM	Usually Not Appropriate	☢ ☢ ☢ ☢
Tc-99m sestamibi MBI	Usually Not Appropriate	☢ ☢ ☢
MRI breast without IV contrast	Usually Not Appropriate	O

ACR Appropriateness Criteria

Variant 1: **Breast cancer screening during lactation. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Digital breast tomosynthesis screening	Usually Appropriate	☢ ☢
Mammography screening	Usually Appropriate	☢ ☢
US breast	May Be Appropriate	O
MRI breast without and with IV contrast	Usually Not Appropriate	O
MRI breast without IV contrast	Usually Not Appropriate	O
Tc-99m sestamibi MBI	Usually Not Appropriate	☢ ☢ ☢

Variant 2: **Breast cancer screening during pregnancy. Age younger than 30 at high risk. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Digital breast tomosynthesis screening	Usually Appropriate	☢ ☢
Mammography screening	Usually Appropriate	☢ ☢
US breast	May Be Appropriate	O
MRI breast without and with IV contrast	Usually Not Appropriate	O
MRI breast without IV contrast	Usually Not Appropriate	O
Tc-99m sestamibi MBI	Usually Not Appropriate	☢ ☢ ☢

Variant 3: **Breast cancer screening during pregnancy. Age 30 to 39 years at elevated risk (intermediate or high risk). Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Digital breast tomosynthesis screening	Usually Appropriate	☢ ☢
Mammography screening	Usually Appropriate	☢ ☢
US breast	May Be Appropriate	O
MRI breast without and with IV contrast	Usually Not Appropriate	O
MRI breast without IV contrast	Usually Not Appropriate	O
Tc-99m sestamibi MBI	Usually Not Appropriate	☢ ☢ ☢

ACR Appropriateness Criteria

Variant 4: **Breast cancer screening during pregnancy. Age 40 years or older, any risk level. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Digital breast tomosynthesis screening	Usually Appropriate	☢ ☢
Mammography screening	Usually Appropriate	☢ ☢
US breast	May Be Appropriate	O
MRI breast without and with IV contrast	Usually Not Appropriate	O
MRI breast without IV contrast	Usually Not Appropriate	O
Tc-99m sestamibi MBI	Usually Not Appropriate	☢ ☢ ☢

Conclusion

- Mammographic screening represents one of the major medical advances of the past 50 years.
- Mammography is the only screening imaging technology which has proven itself to show survival benefit.
- DBT is poised to further improve the ability to detect more cases of breast cancer at a smaller size and earlier stage while offering greater screening accuracy.
- 2D mammography plus DBT is superior to 2D mammography for the detection and diagnosis of breast cancer with a concomitant reduction in false positive results.

References

Friedewald, S. M., Rafferty, E. A., Rose, S. L., Durand, M. A., Plecha, D. M., Greenberg, J. S., Conant, E. F. (2014). Breast Cancer Screening Using Tomosynthesis in Combination With Digital Mammography. *Jama, 311*(24), 2499.

Helvie, M. A. (2010). Digital Mammography Imaging: Breast Tomosynthesis and Advanced Applications. *Radiologic Clinics of North America,48*(5), 917-929.

Hooley, R. J., Durand, M. A., & Philpotts, L. E. (2017). Advances in Digital Breast Tomosynthesis. *American Journal of Roentgenology, 208*(2), 256-266. doi:10.2214/ajr.16.17127

Kopans, D. B. (2014). Digital Breast Tomosynthesis From Concept to Clinical Care. *American Journal of Roentgenology, 202*(2), 299-308. doi:10.2214/ajr.13.11520

Park, J. M., Franken, E. A., Garg, M., Fajardo, L. L., & Niklason, L. T. (2007). Breast Tomosynthesis: Present Considerations and Future Applications. *RadioGraphics, 27*(Suppl_1).

Rafferty, E. A., Park, J. M., Philpotts, L. E., Poplack, S. P., Sumkin, J. H., Halpern, E. F., & Niklason, L. T. (2013). Assessing Radiologist Performance Using Combined Digital Mammography and Breast Tomosynthesis Compared with Digital Mammography Alone: Results of a Multicenter, Multireader Trial. *Radiology, 266*(1), 104-113.

Raghu, M., Durand, M. A., Andrejeva, L., Goehler, A., Michalski, M. H., Geisel, J. L., Philpotts, L. E. (2016). Tomosynthesis in the Diagnostic Setting: Changing Rates of BI-RADS Final Assessment over Time. *Radiology, 281*(1), 54-61.

Vedantham, S., Karellas, A., Vijayaraghavan, G. R., & Kopans, D. B. (2015). Digital Breast Tomosynthesis: State of the Art. *Radiology, 277*(3), 663-


EARLY
DETECTION
SAVES
LIVES