

Breast Tomosynthesis (DBT) & Tomosynthesis guided Biopsy (TVAB)



Dr. Christian Waldherr
Breast Center Bern

Switzerland

No financial disclosures

Radiology Breast Center Bern at Engeried Hospital

Breast tomosynthesis (DBT) since 2008

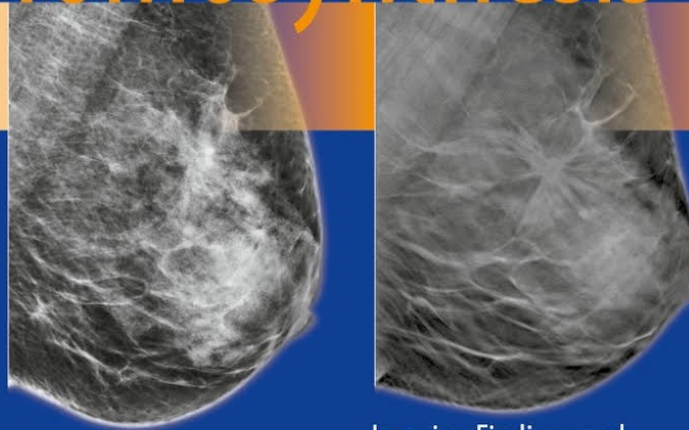
C-View (synthetic 2D) all-in-one since 2011

TVAB since December 2012

FFDM, US, MRI, US + MRI-VAB, SPECT/CT

Martin Sonnenschein
Christian Waldherr

Atlas of Breast Tomosynthesis



Imaging Findings and
Image-Guided Interventions

 Springer

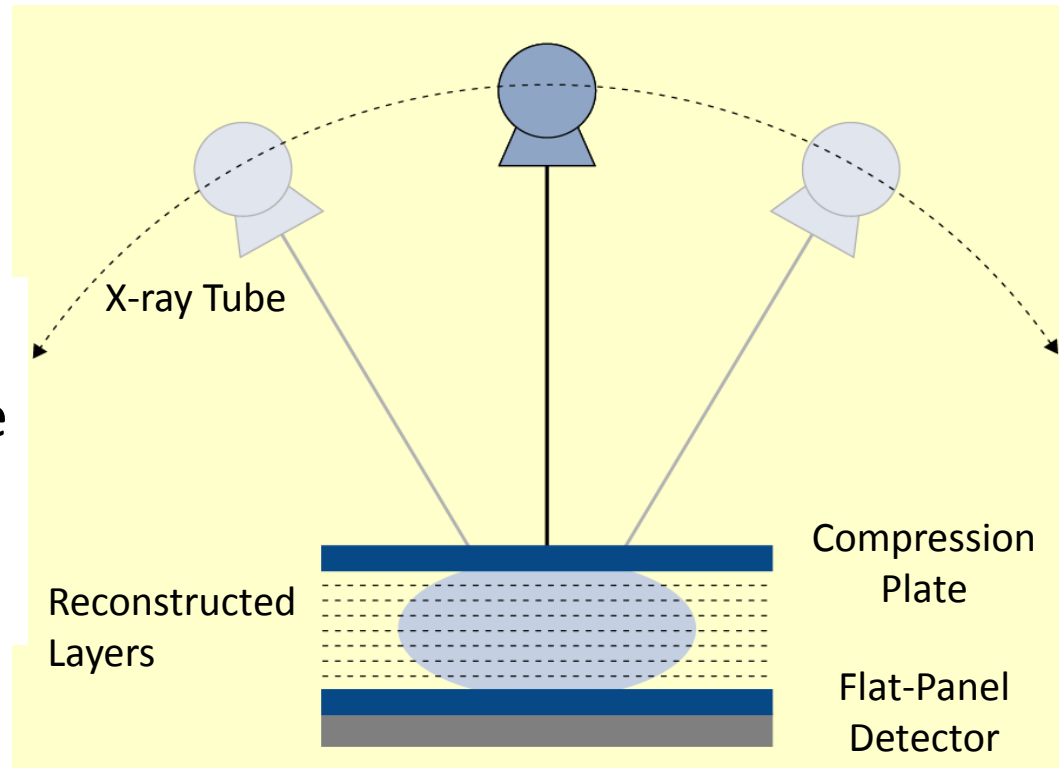
4 Topics

1. Why is DBT (3D) so much better than 2D?
 - Issue 3D imaging unmasks/ highlights
 - Increased cancer detection/ less recalls/ less stress
2. Why DBT needed years to convince the medical community?
 - Issue radiation exposure. Lack of reliable data?
3. Why radiation exposure is no issue anymore?
 - C-view software. Synthetic 2D + 3D images
4. Why is TVAB so much better than SVAB?
 - No miscalculation of target depth, verification possible

What is Breast Tomosynthesis (DBT)?



- DBT is a 3-D-imaging technology
- Only difference to regular mammography is movement of the x-ray-tube



- Takes multiple images from different angles with low dose
- 3-D data set, reconstructed
- Page through CC/ MLO layers like CT

Workflow Mammography/ DBT system



- Start 2D-FFDM (CC, MLO)
- Add DBT views (CC, MLO) after review of 2D by the radiologist
(2 settings. Compression and positioning different)
- Add DBT views direct after acquisition of 2D.
(1 Setting. Same compression + positioning, **Combo mode**)

Why is DBT so much better than 2D?

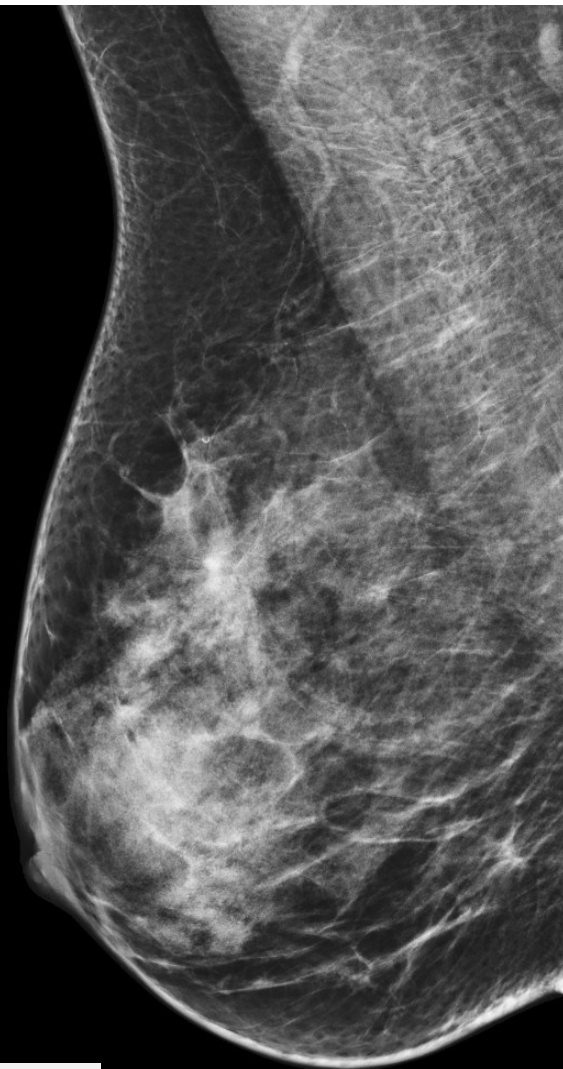


Advantage 3D imaging vs. 2D:

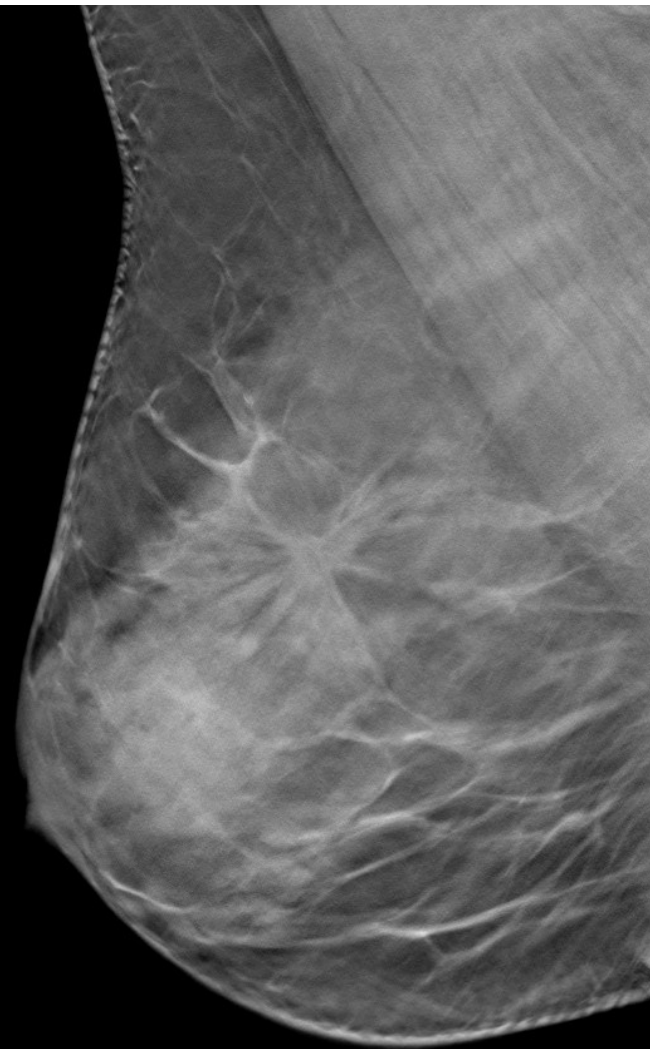
- Reduction/ elimination of tissue overlap
- Unmasks/ highlights masses
- Unmasks / highlights distortions
- Unmasks / highlights micro-calcifications

3D unmask / highlights masses

See, judge, measure



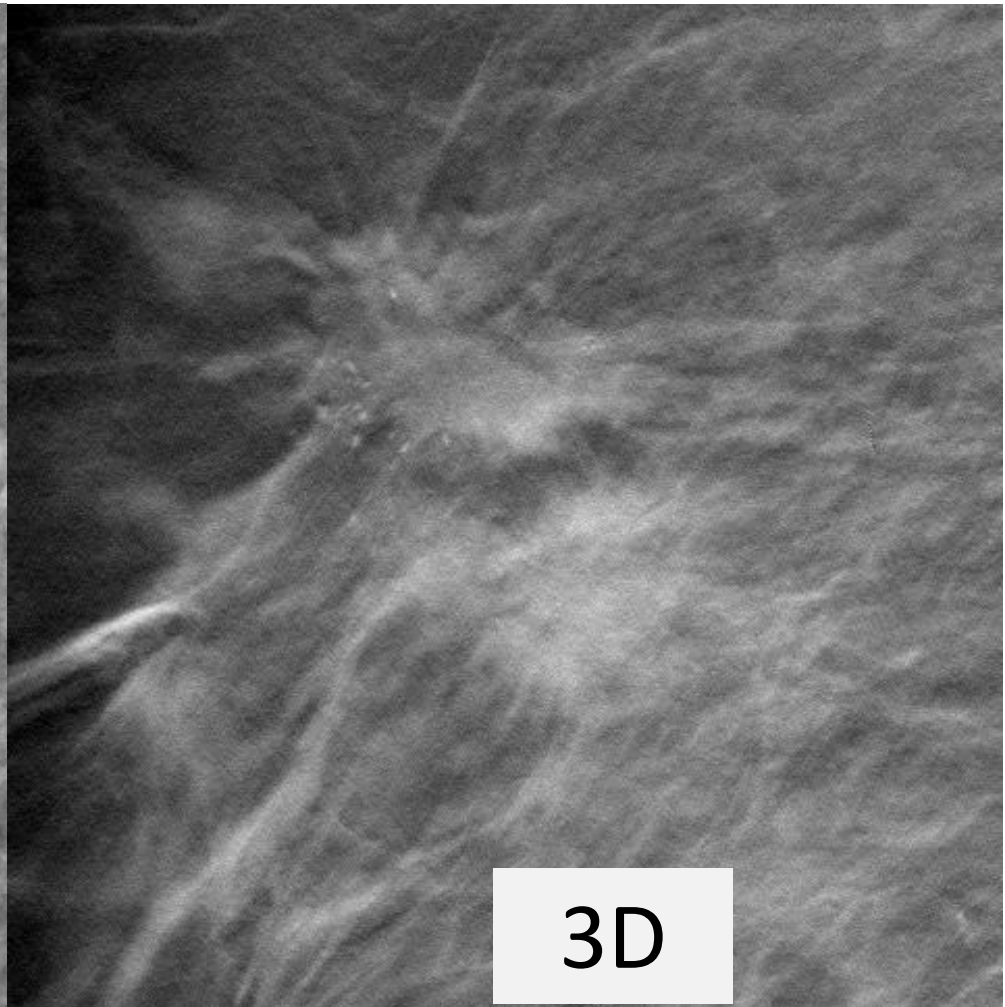
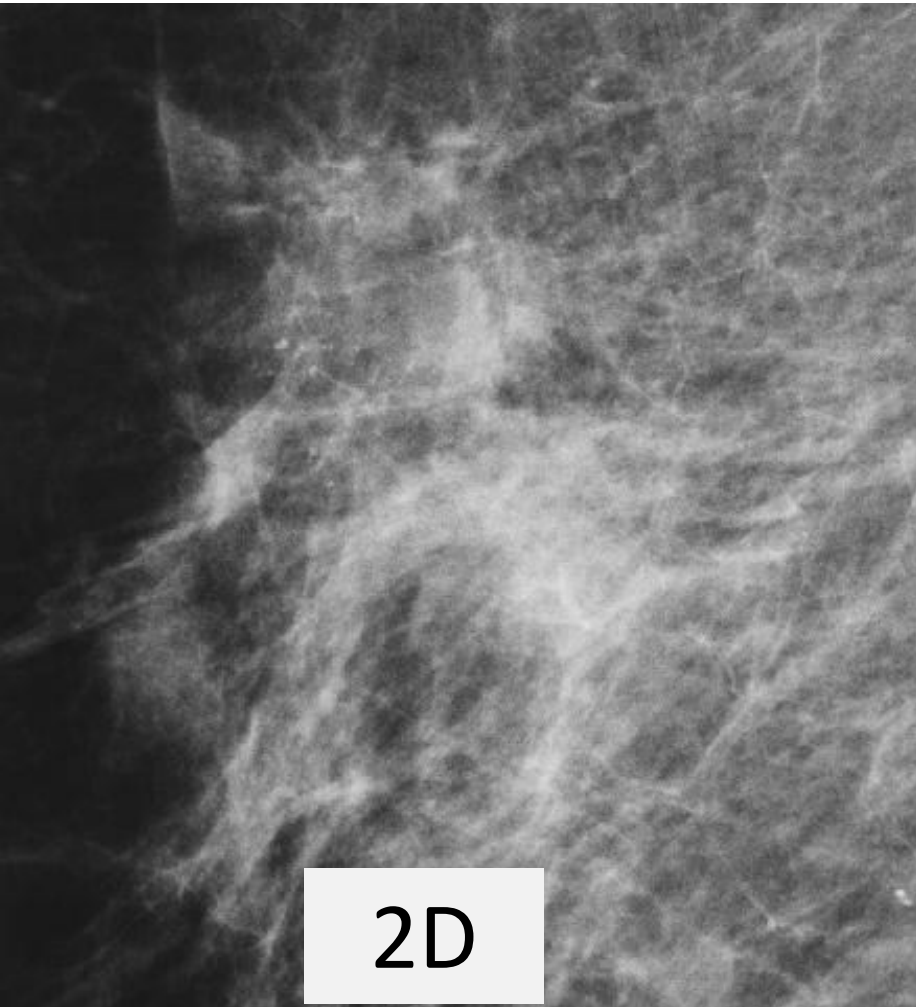
2D



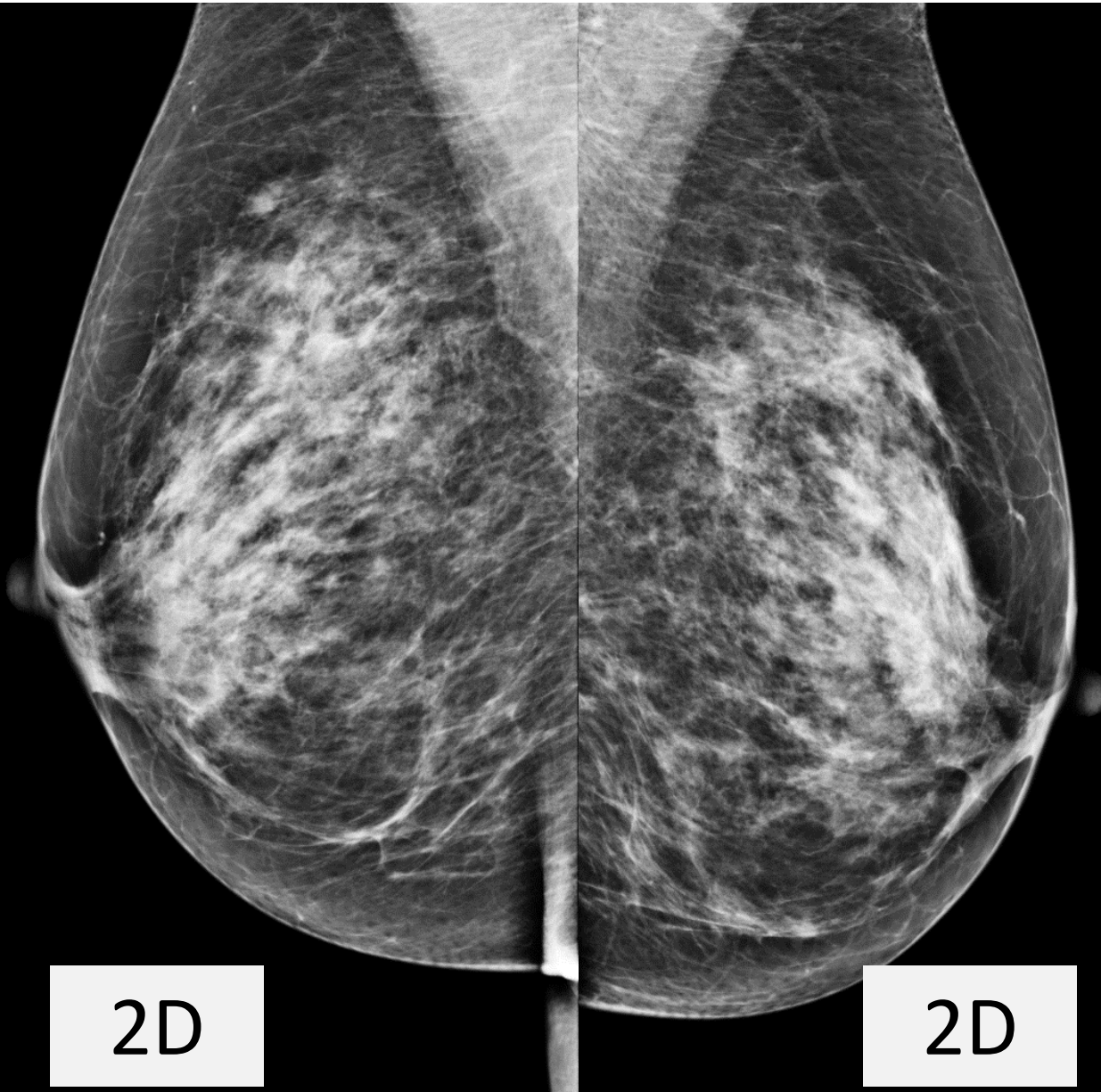
3D

3D unmask / highlights margins + mc

Won't overlook mc and indistinct mass



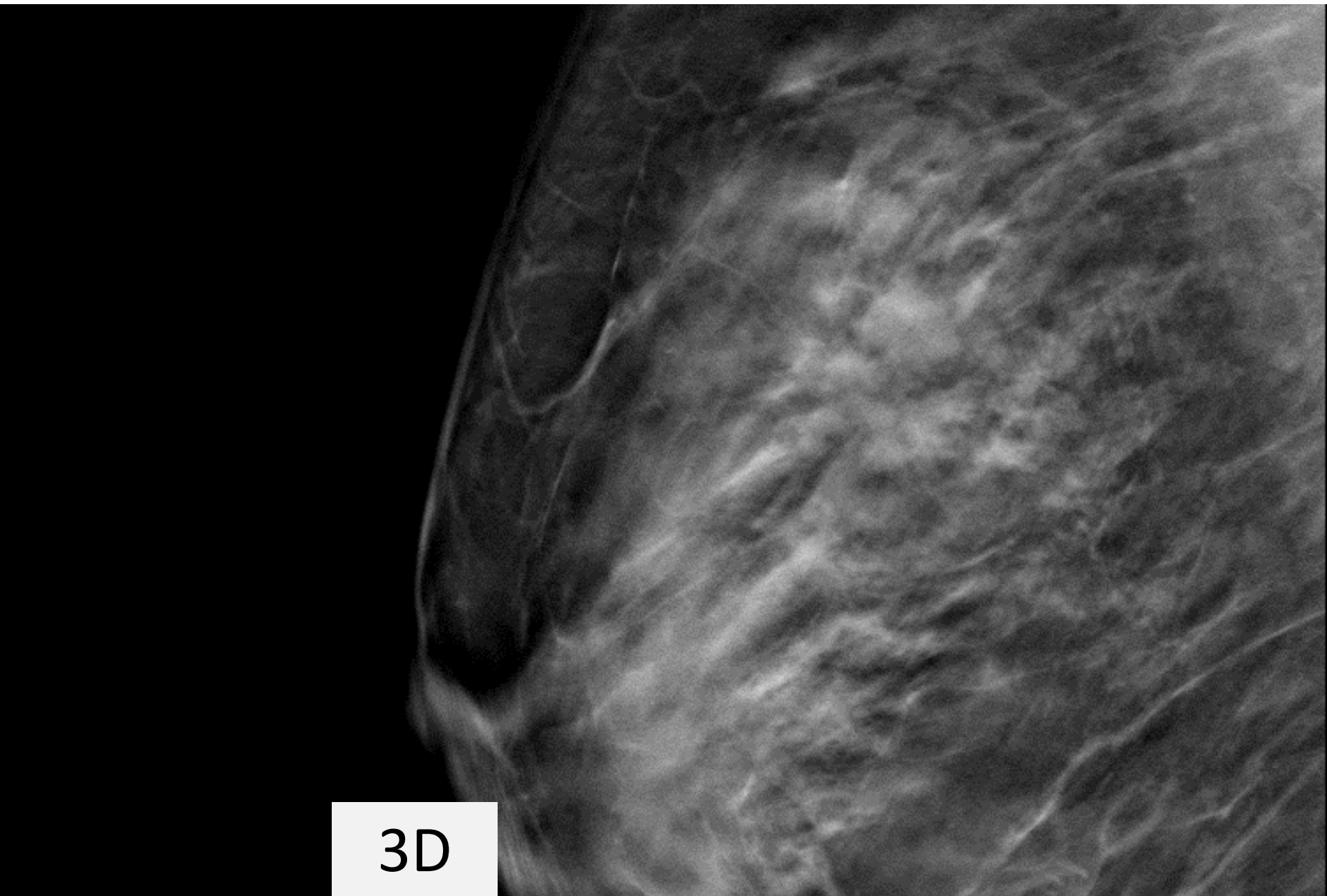
3D unmask / highlights masses in dense tissue



2D

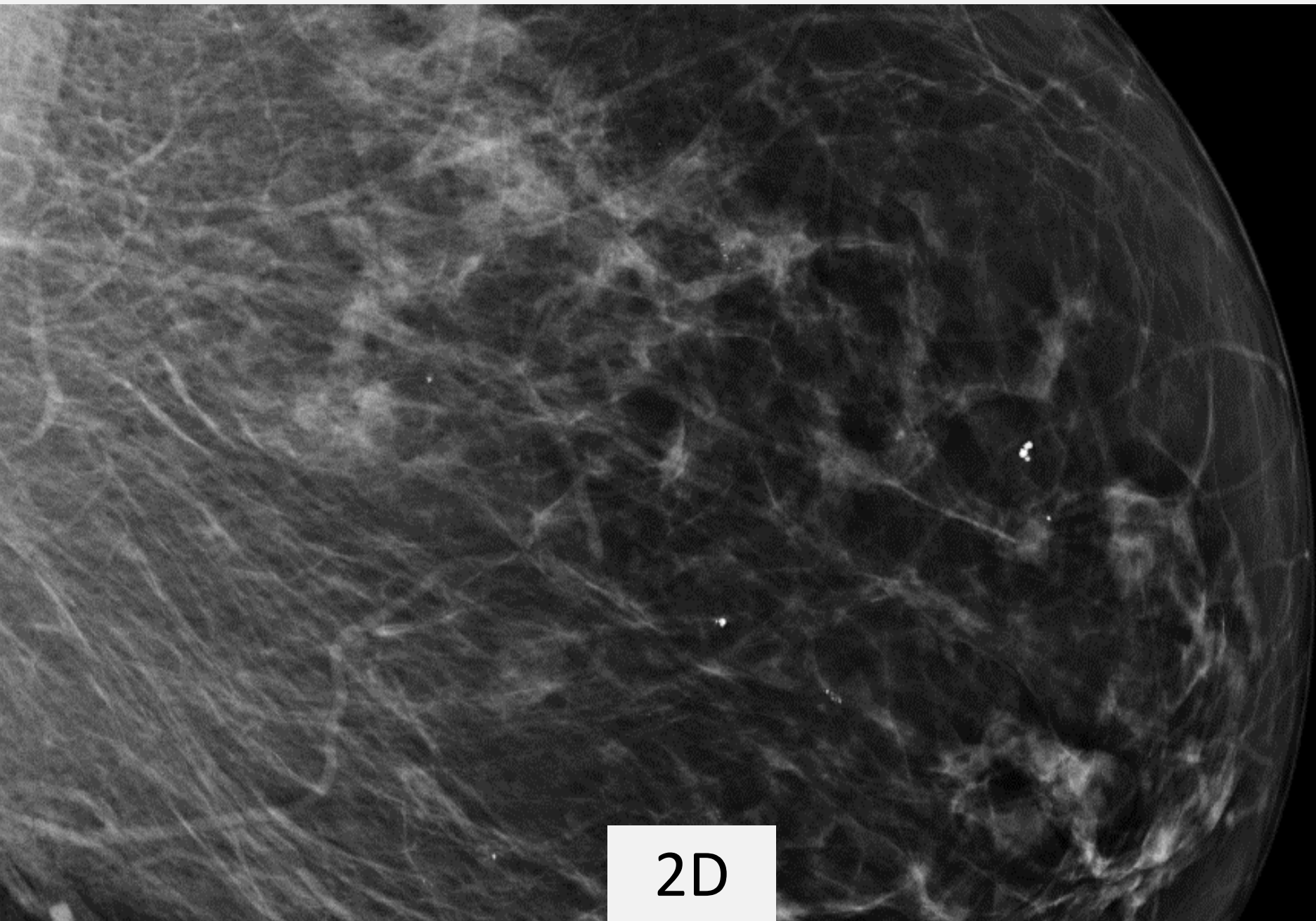
2D

3D unmask / highlights in dense tissue



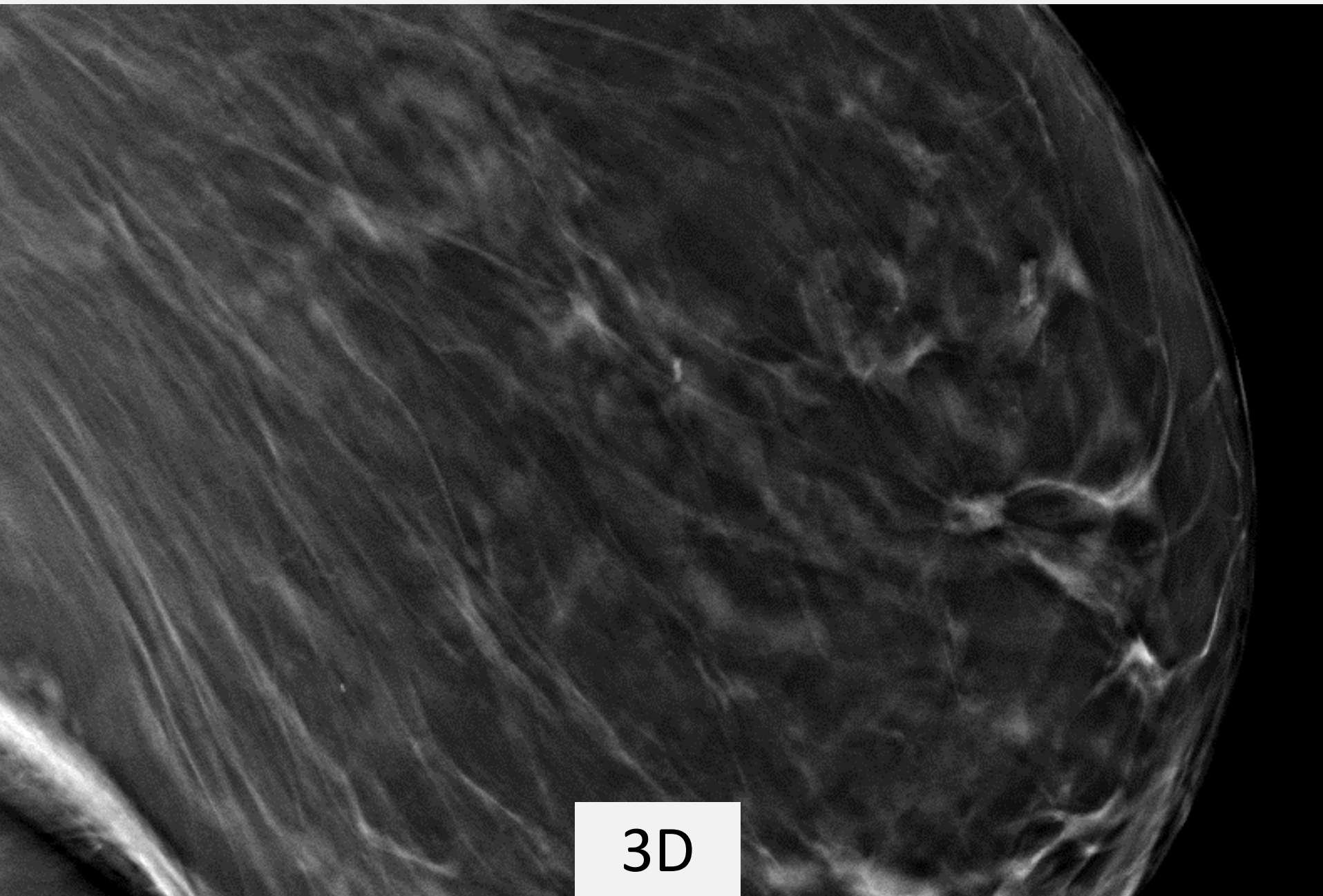
3D

3D unmask / highlights in low dense tissue



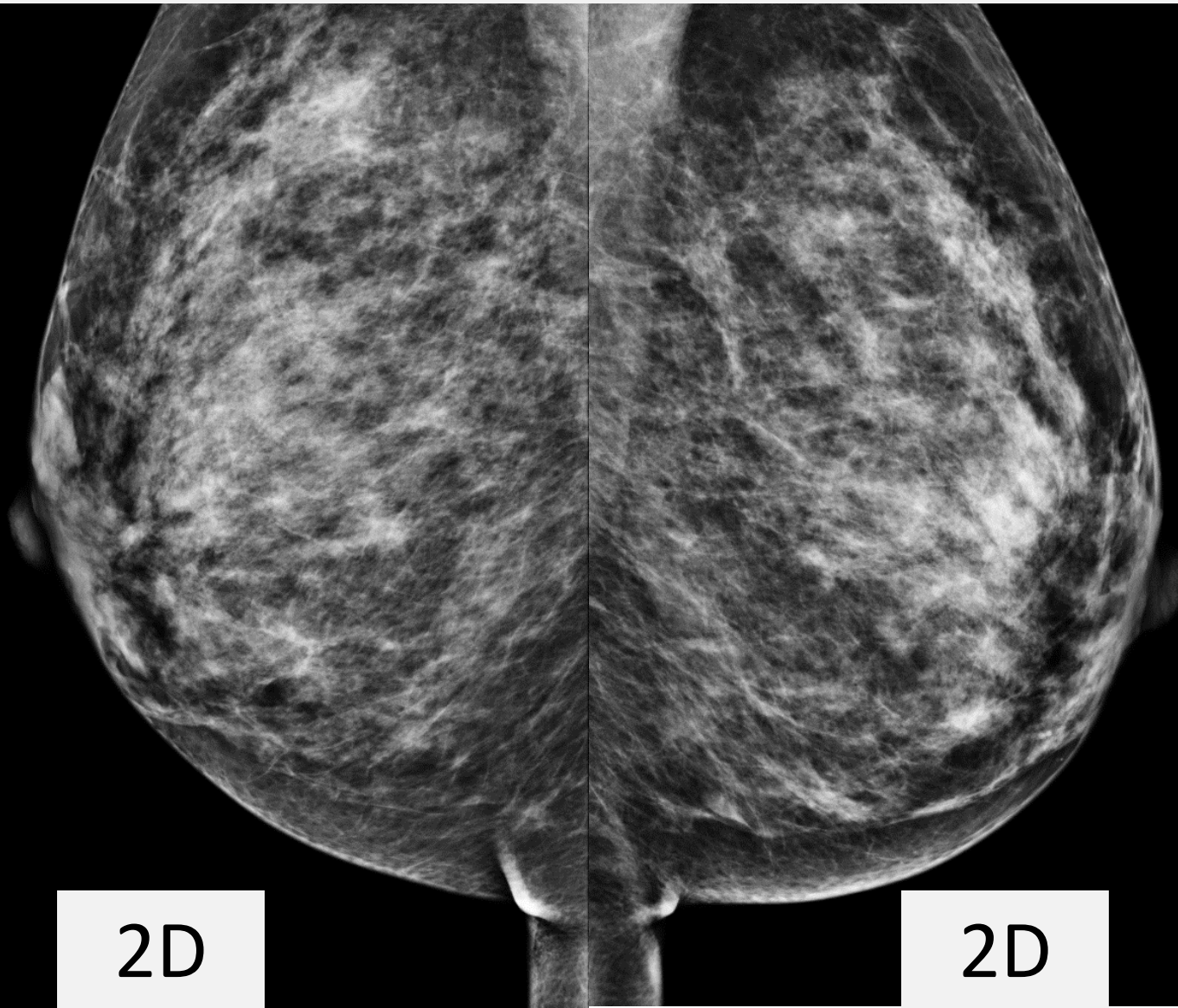
2D

3D unmask / highlights in low dense tissue

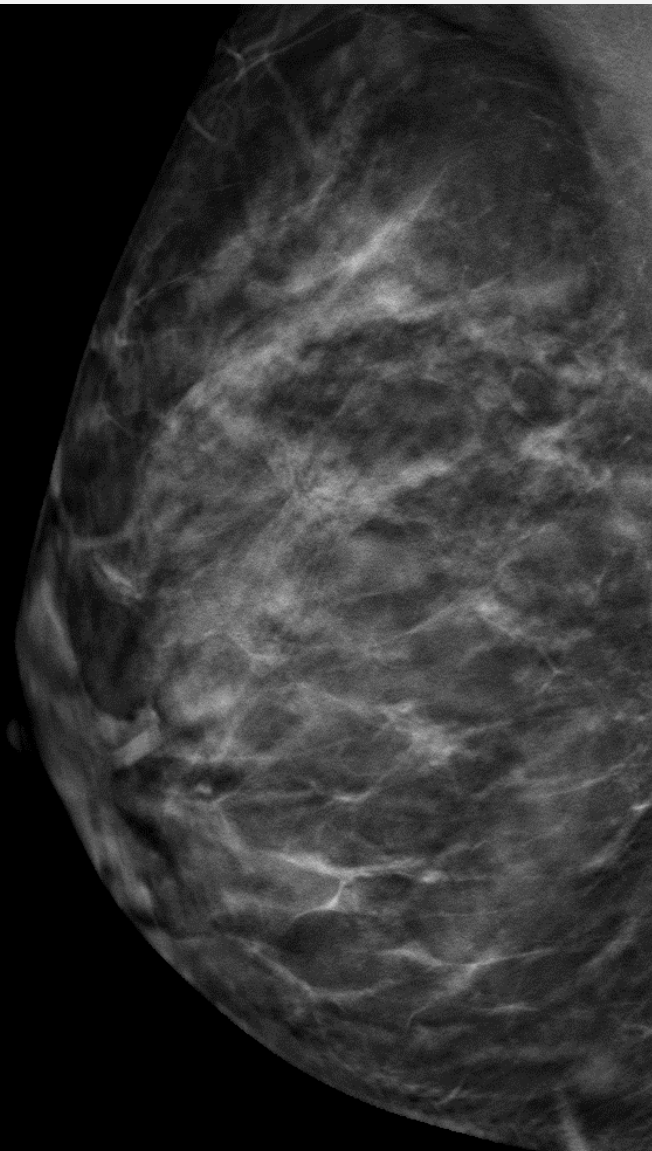


3D

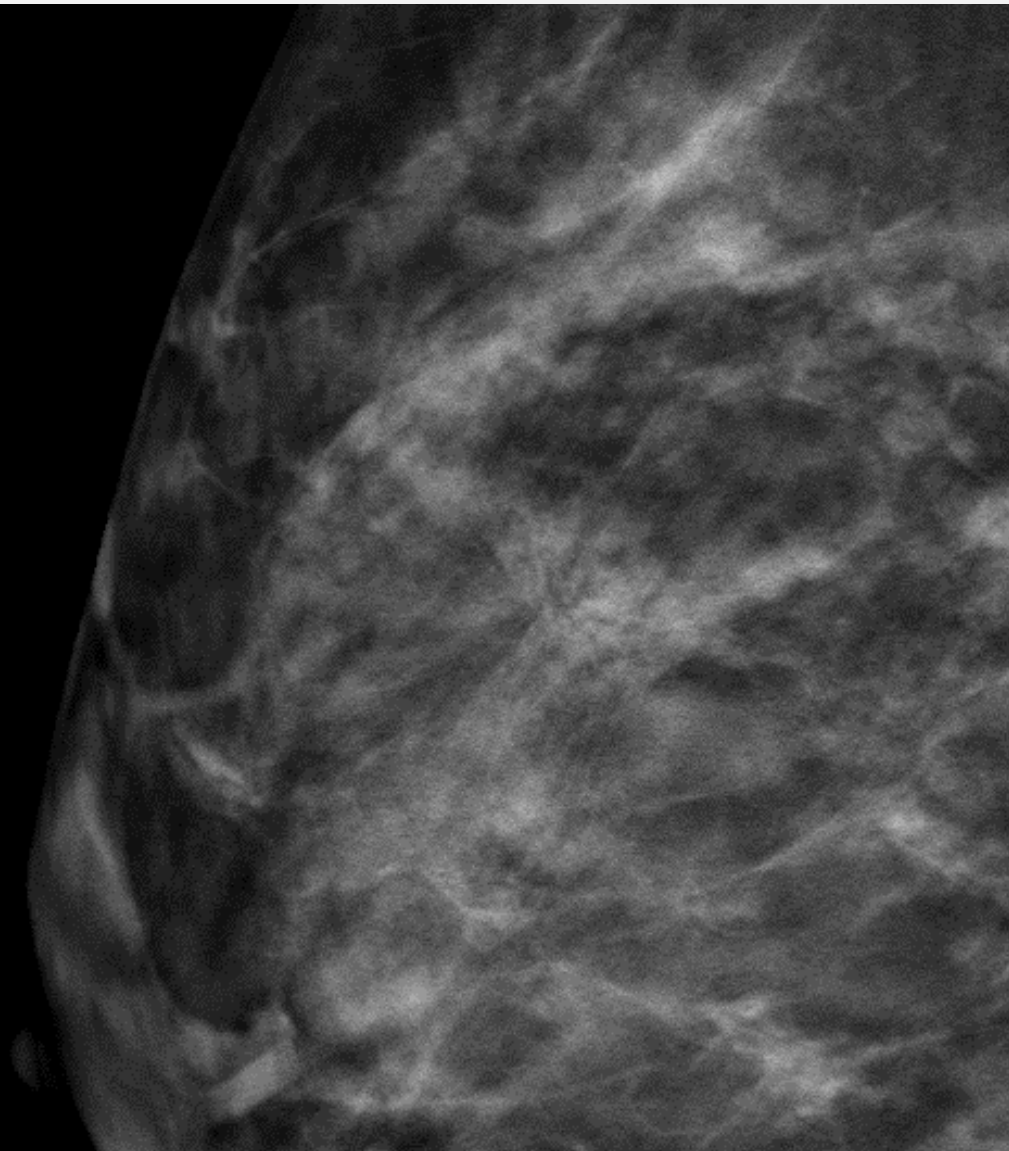
3D unmask / highlights distortions!!,
not visible on 2D-FFDM



3D unmask / highlights distortions

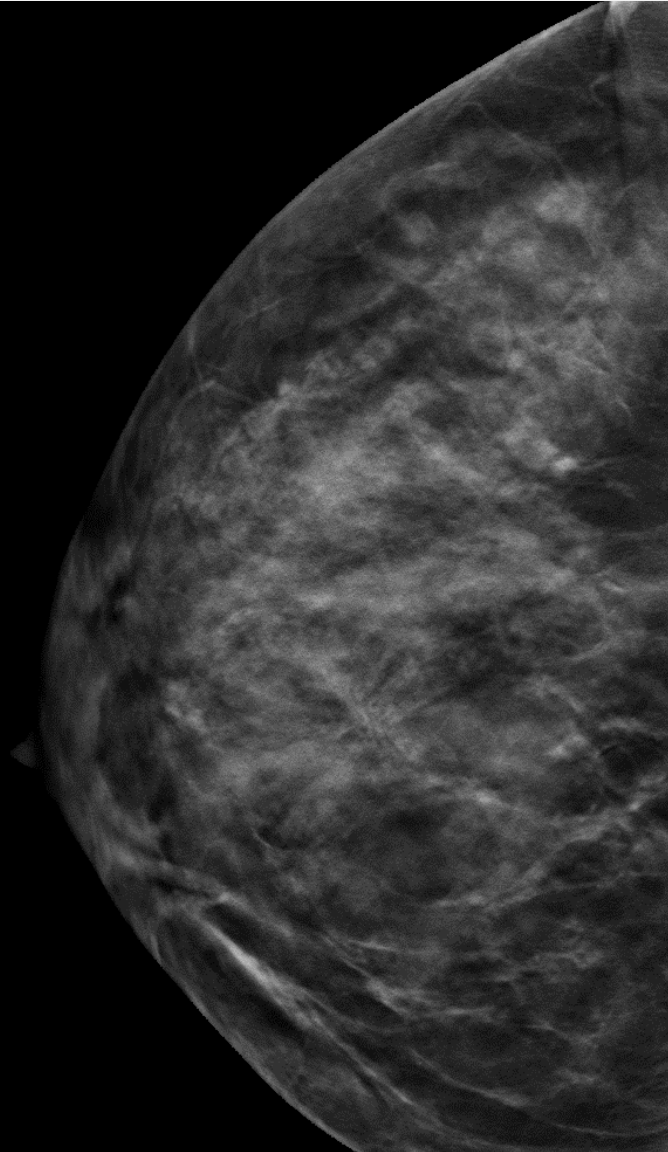


3D-MLO



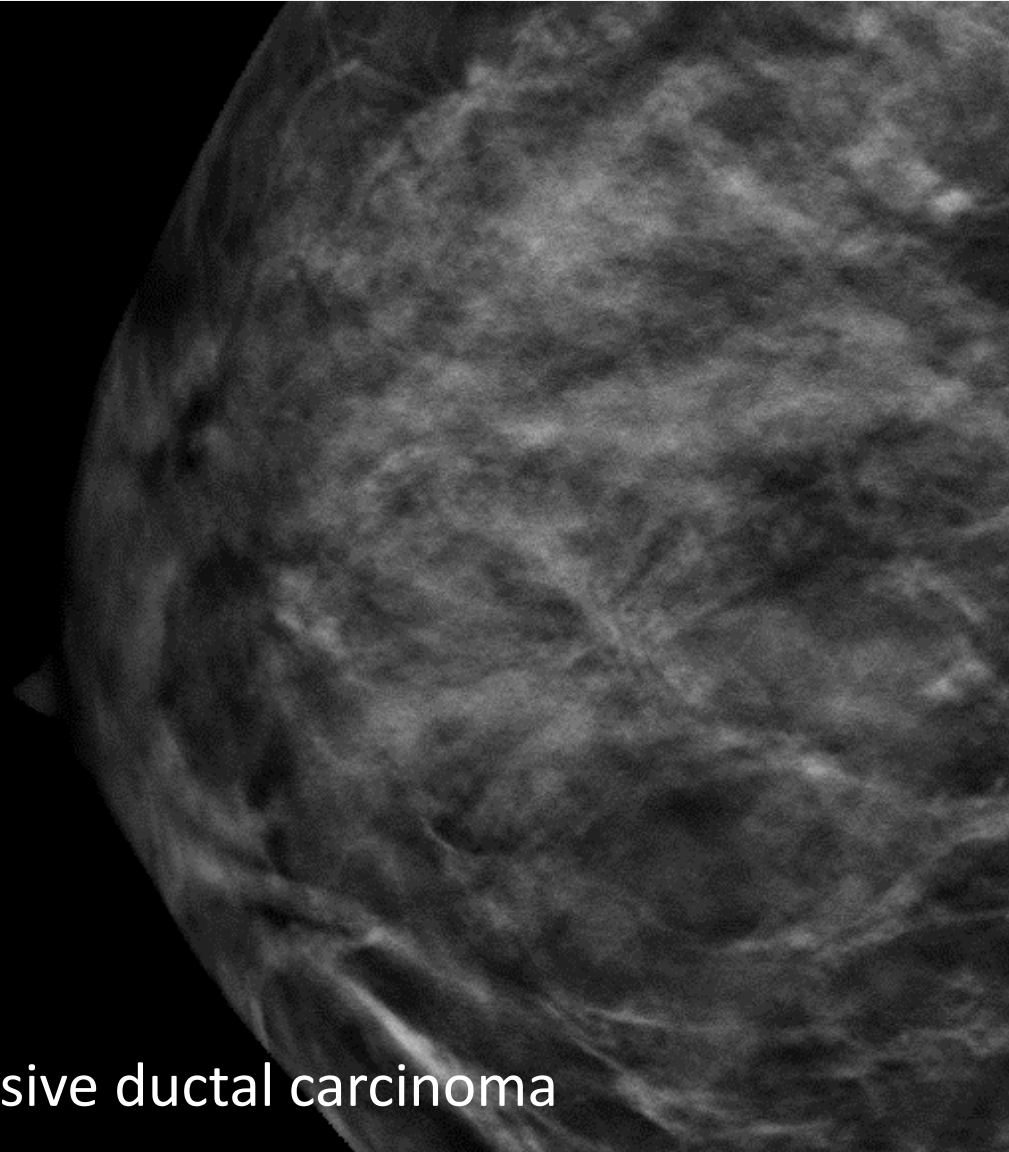
3D-MLO

3D unmask/ highlights distortions



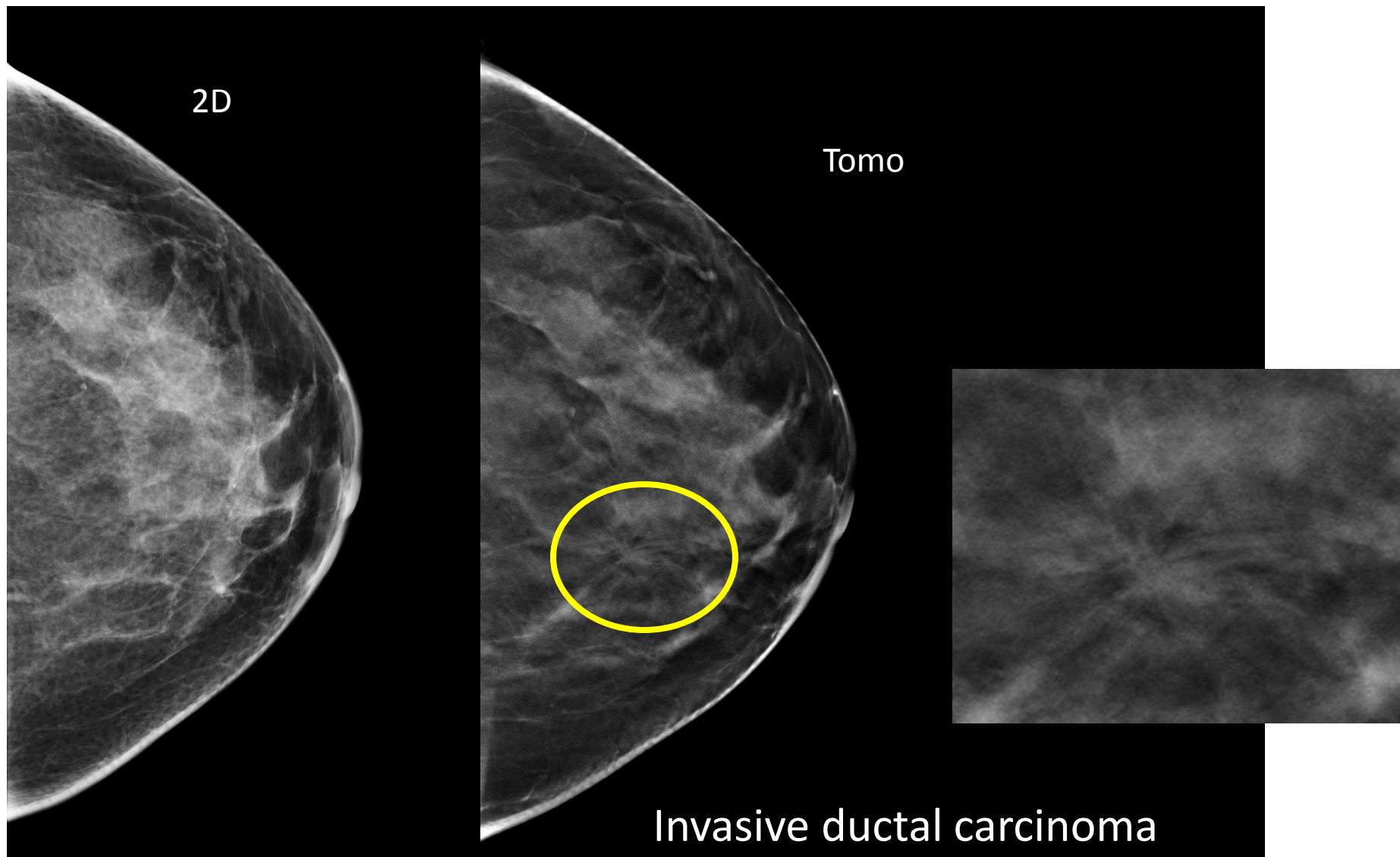
3D-CC

Invasive ductal carcinoma



3D-CC

3D unmask/ highlights distortions



Nice images, reliable data in screening and assessment?

- Significantly increases cancer detection:¹ (12,631 pts)
 - 40% increase in invasive cancer detection
 - 27% increase in cancer detection
- Significant reduction of recalls:¹⁻⁴
 - 20-40% reduction of recall rates
- Patients across all age groups and breast densities benefit ^{2,4}

1. Skaane P. et. al.. Comparison of Digital Mammography Alone and Digital Mammography Plus Tomosynthesis in a Population-based Screening Program. Radiology. 2013 Jan 7.

2. Rafferty EA et al.. Assessing radiologist performance using combined digital mammography and breast tomosynthesis compared with digital mammography alone: results of a multicenter, multireader trial. Radiology. 2013 Jan;266(1):104-13. (1192 pts)

3. Haas BM et al.. Comparison of Tomosynthesis Plus Digital Mammography and Digital Mammography Alone for Breast Cancer Screening. Radiology. 2013 Apr;267(1):47-56. (13 158 pts)

4. Waldherr C et. al.. Value of one-view breast tomosynthesis versus two-view mammography in diagnostic workup of women with clinical signs and symptoms and in women recalled from screening. AJR Am J Roentgenol. 2013 Jan;200(1):226-31.

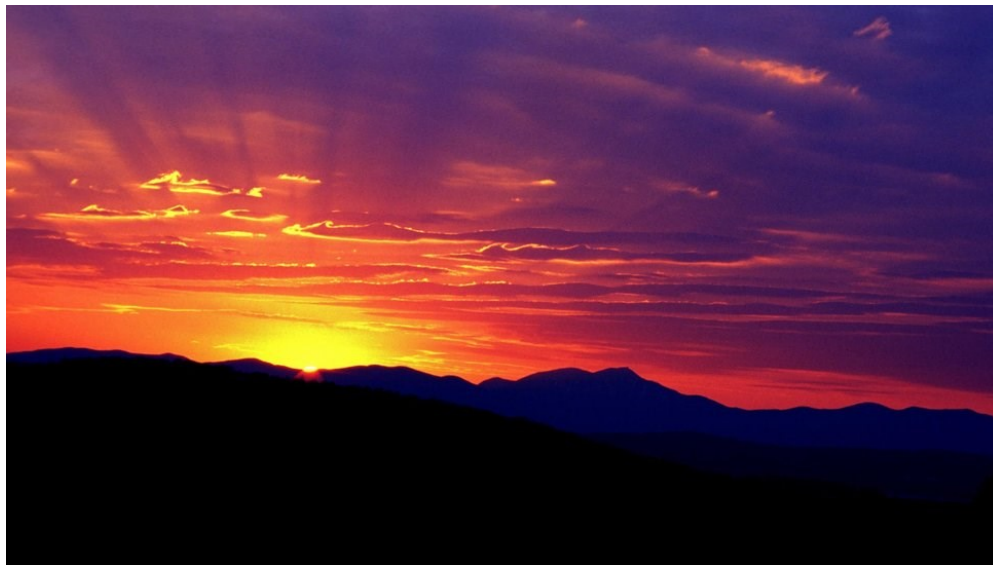
Integration of tomosynthesis for population breast-cancer screening (STORM): a prospective comparison study

- **7292 women** were screened
- 59 breast cancers (including 52 invasive cancers) in 57 women.
- Both 2D and integrated 2D and 3D screening detected 39 cancers.
- **20/ 59 cancers with integrated 2D and 3D only** versus none with 2D screening only ($p < 0.0001$).
- 2D + 3D mammography could have **reduced false positive recalls by 17.2%** without missing any of the cancers detected in the study population.



Nice reliable data, **but** 2D + 3D doubles the dose

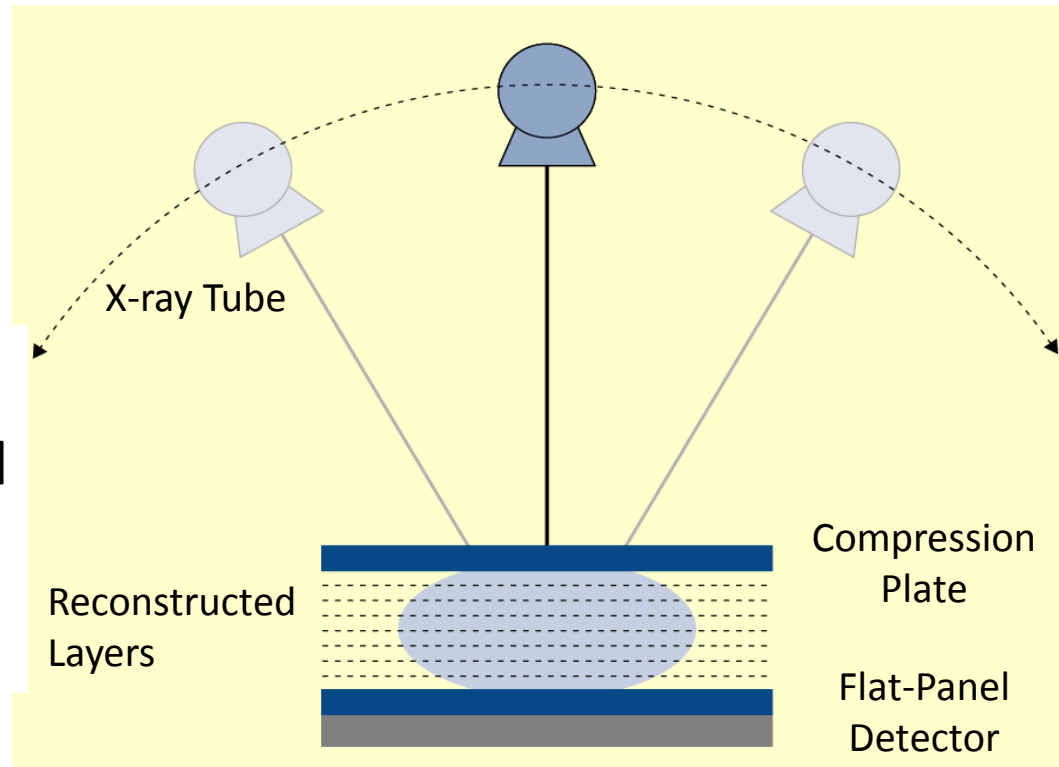
Not anymore!,
since DBT C-view software (synthetic 2D)



What is Synthetic 2D?

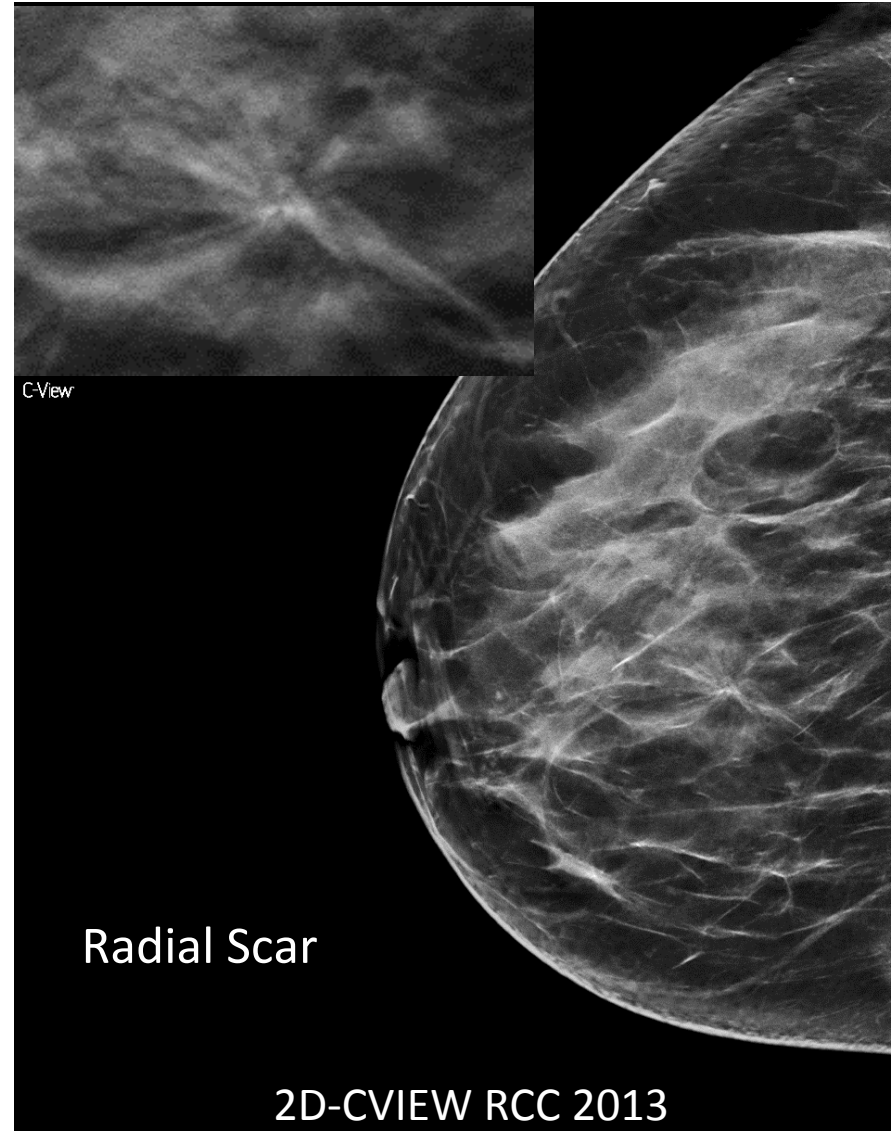
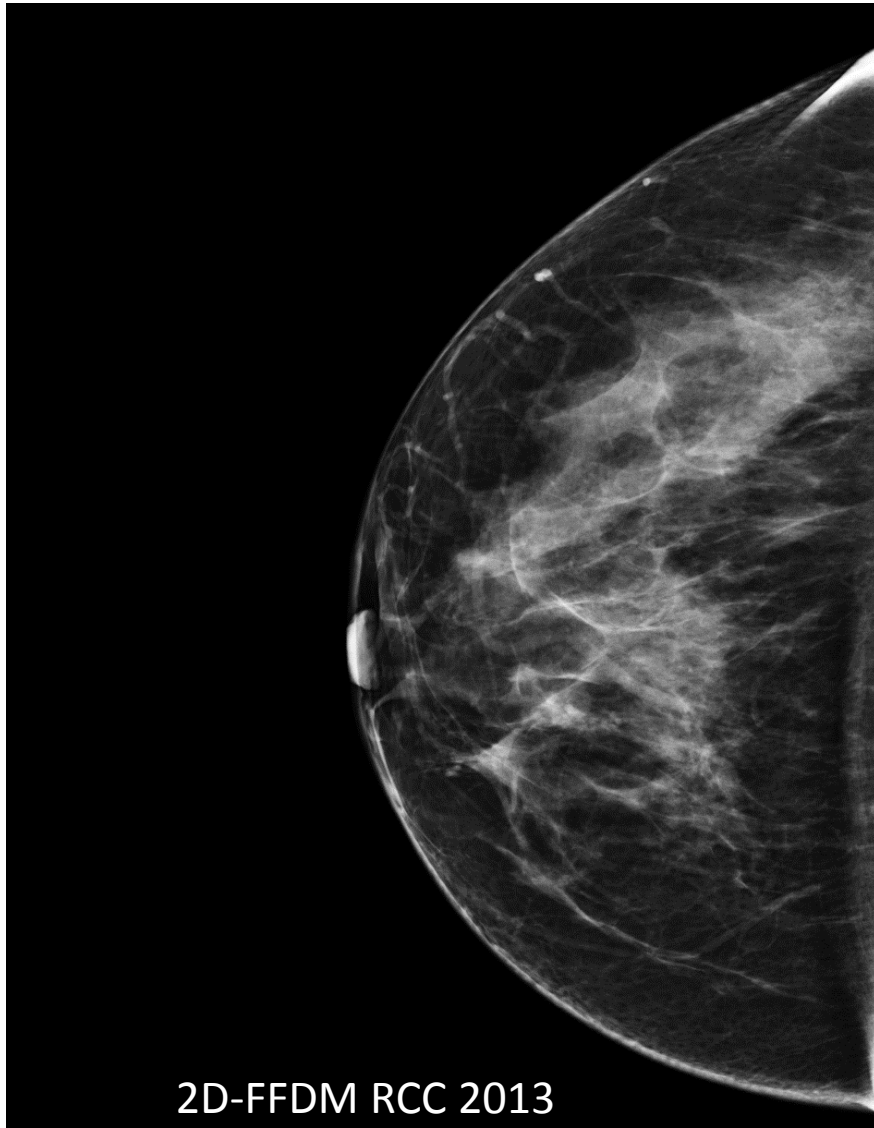


- C-View is a reconstruction software added to your DBT system
- Just once the regular 3D acquisition, no additional 2D acquisition



- C-view software reconstructs out of CC/ MLO 3D data set all 3D and 2D images
- dose almost equivalent to 2D only

Synthetic 2D (2D C-view), better!



Synthetic Mammography versus FFDM

SM Strengths

- Increased conspicuity of calcifications
- Increased definition of spiculated margins
- Better visualization of architectural distortion

SM Weaknesses

- Missed findings in the subcutaneous tissue
- Increased callback for pseudo-calcifications
- Harder to detect motion

Ratanaprasatporn L, Chikarmane SA, Giess CS. RadioGraphics. 2017 Nov-Dec;37(7):1913-1927.

Can we use Synthetic 2D (C-view) as replacement of 2D-FFDM?

Yes

FDA approved since May 21, 2013

December 3, 2013 -- CHICAGO –

The Oslo Tomosynthesis Screening Trial showed (12,271 pts):

Cancer detection rate of 2D and synthetic 2D at least the same (each 100 of 12,271)

Conclusion:

1. Synthetic 2D plus 3D is acceptable for routine in mammography screening,
2. and may (will) replace 2D-FFDM in clinical practice.

STUDY	YEAR	CONCLUSION
Zuley, et al.	2014	SM alone or SM + DBT= performance to FFDM alone or FFDM + DBT
Skaane, et al.	2014	SM + DBT = FFDM + DBT
Bernardi, et al.	2014	SM + DBT = FFDM+ DBT
Durand, et al.	2015	SM+DBT shows majority of mammo findings equal or better than FFDM+DBT, regardless of breast density or age, with equivalent recall rates and CDR
Mariscotti, et al.	2015	SM alone = FFDM, with similar sensitivity, specificity and area under ROC curve
Woo, et al.	2015	SM showed = diagnostic value compared with FFDM. SM superior for spiculated margins and architectural distortion.
Zuckerman, et al	2016	SM + DBT screening maintains CDR while reducing recall rates and radiation dose compared with FFDM + DBT.
Aujero, et al.	2017	Screening with SM/DBT improved recall rate and positive predictive values without loss of cancer detection rate when compared with FFDM/DBT and FFDM alone

Ratanaprasatporn L, Chikamane SA, Giess CS. RadioGraphics. 2017 Nov-Dec;37(7):1913-1927.

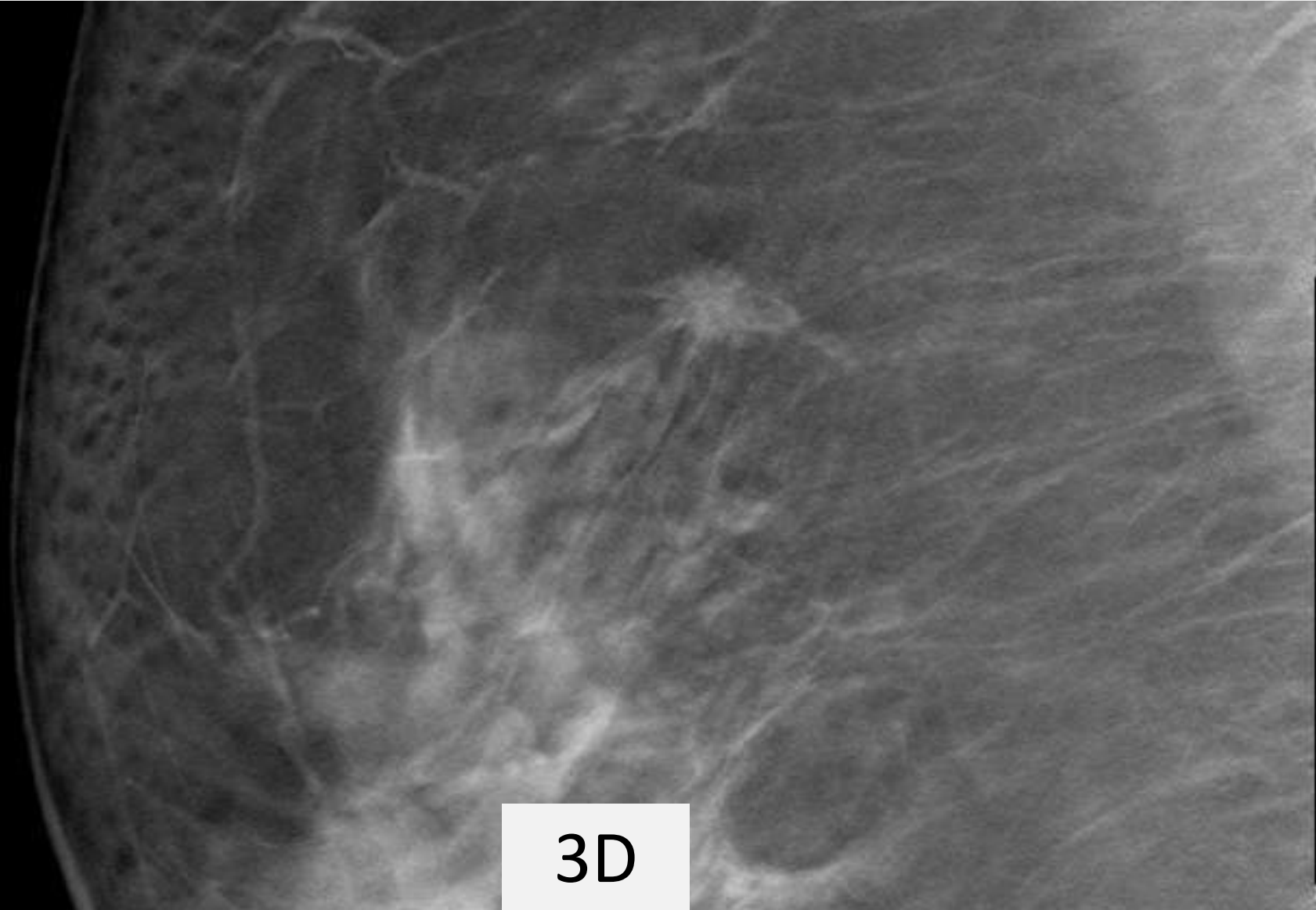
Synthetic 2D + DBT

- **Now we got it all!,
both 2D and 3D with almost the
same radiation exposure of a 2D-FFDM alone**
- One setting, same compression, same positioning
- Higher cancer detection, less recalls, less stress, heaven...

But (Why but?)

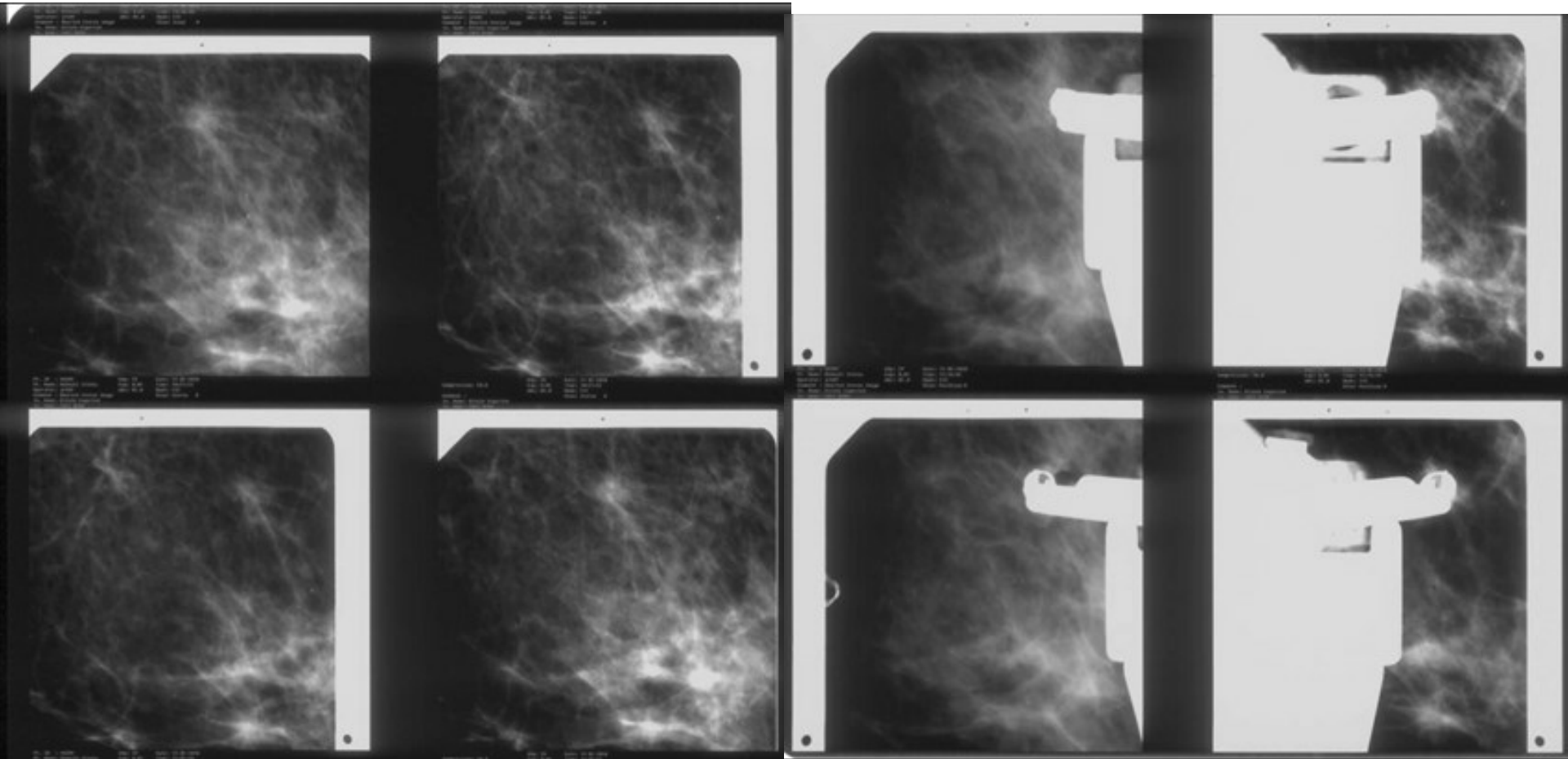
- 3D detects more frequently small US occult lesions,
not detected by 2D-FFDM before
- How to biopsy that?
- Clear! Use the method that showed the lesion: **T-VAB**

Do not use SVAB in
US occult masses and distortions



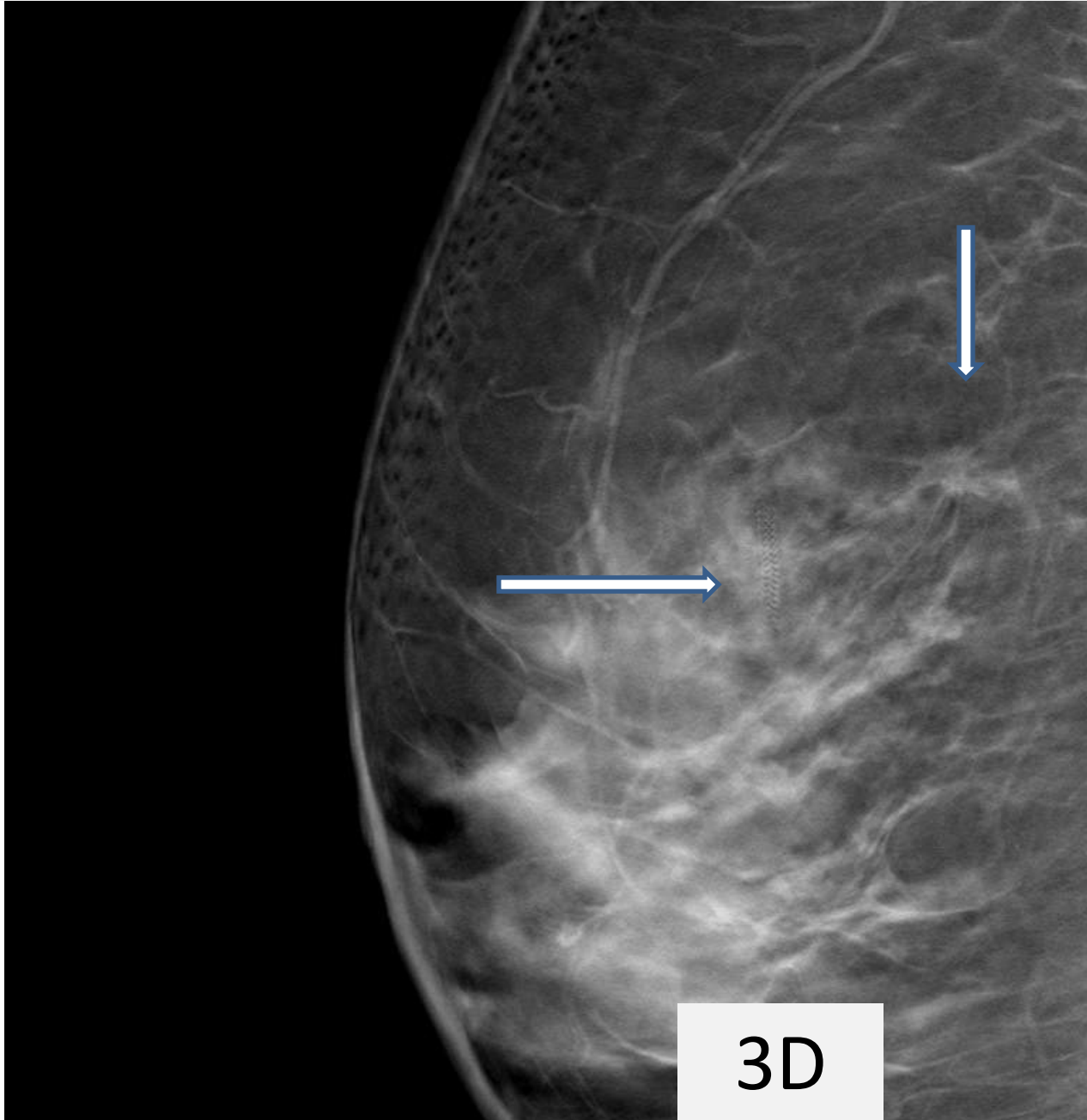
3D

Difficult to identify identical X, Y
Not identical X-, Y- targeting = Z wrong

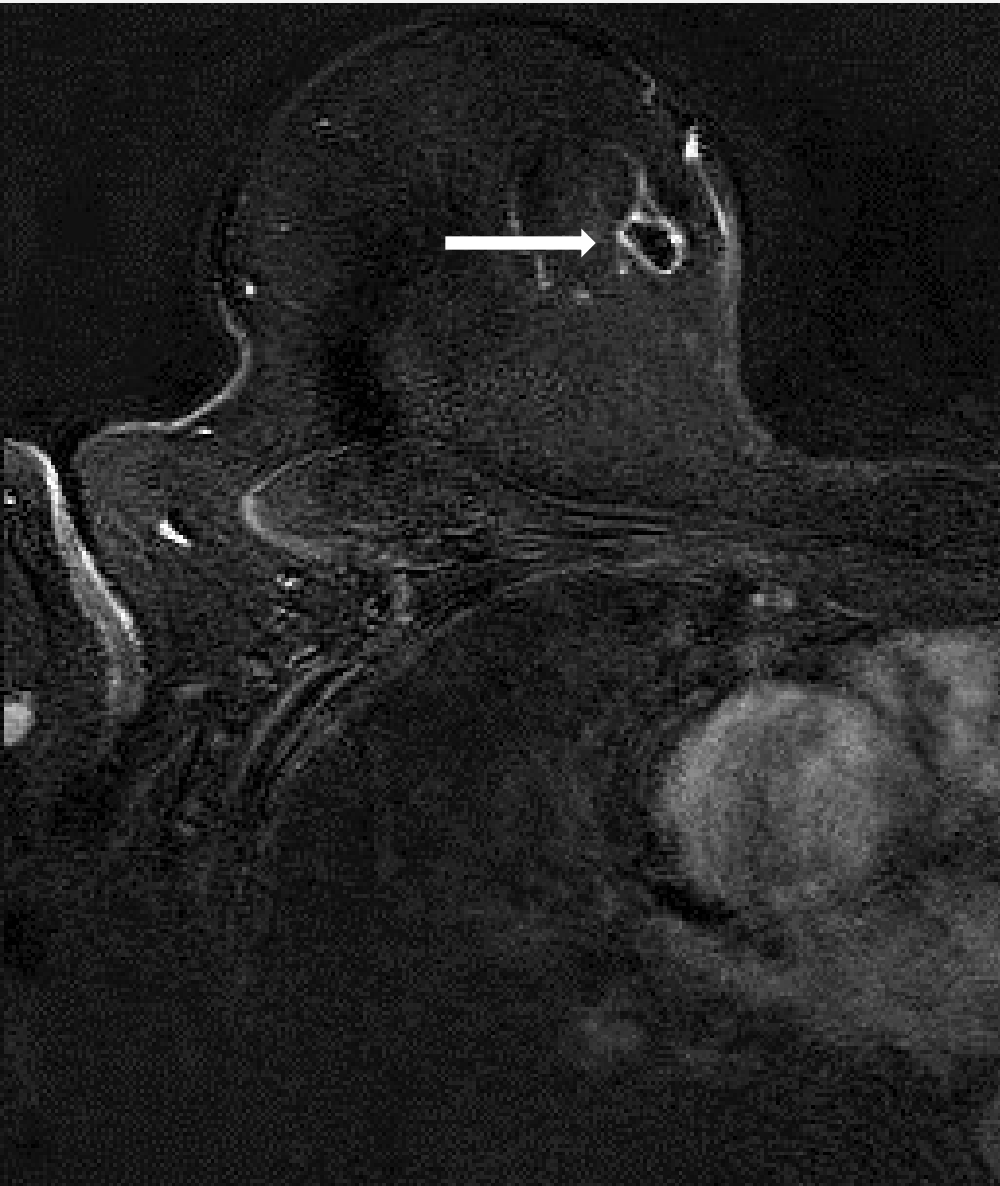


No chance to verify, have to believe your eye

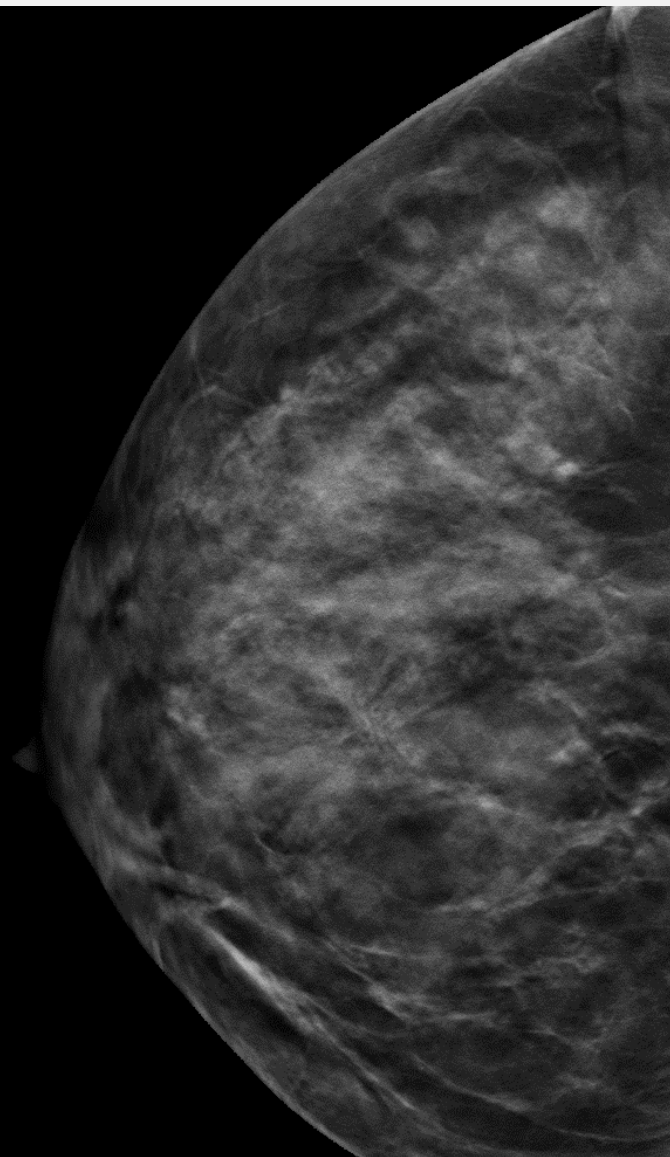
DBT proved SVAB miscalculation



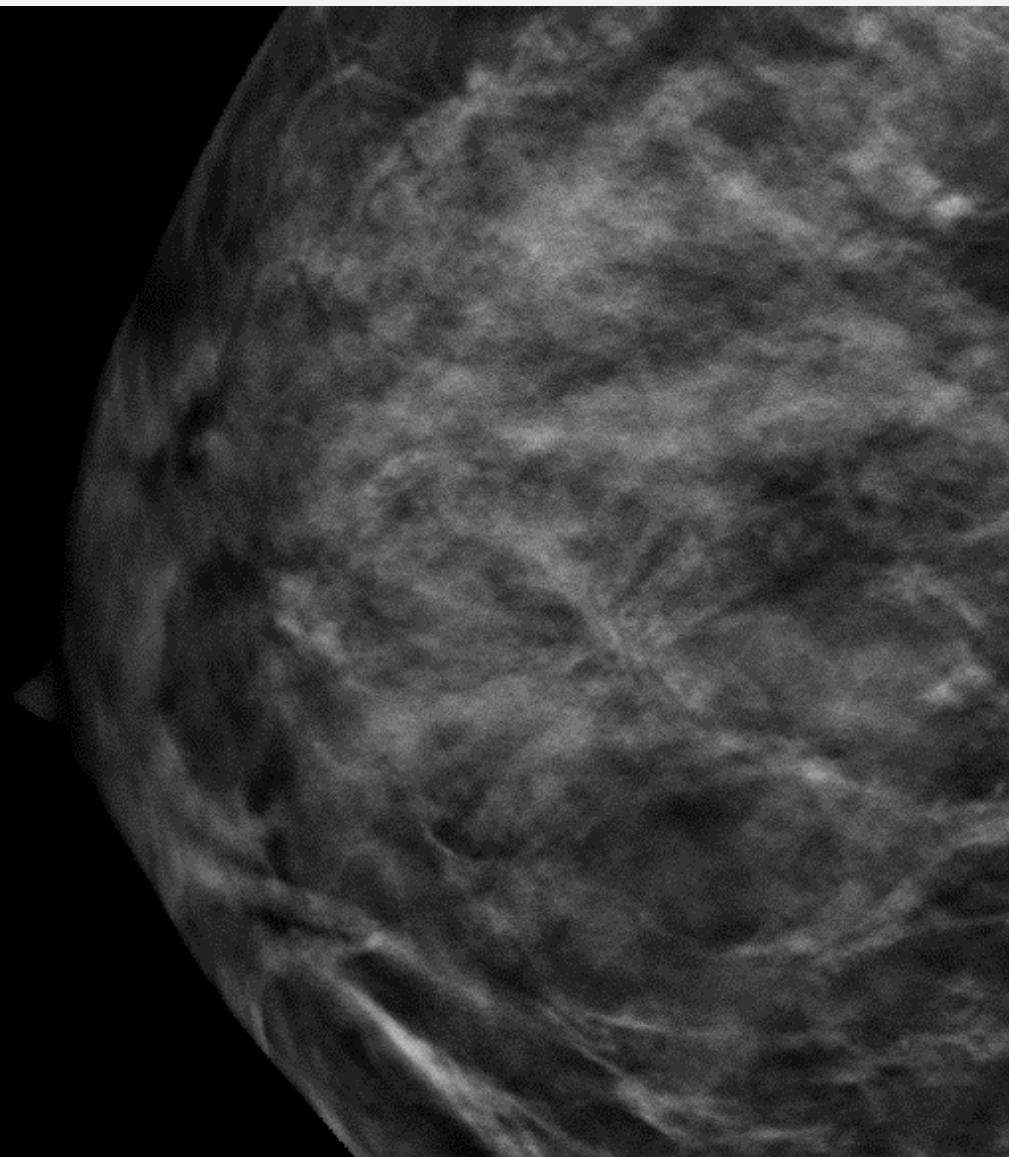
Miscalculation by one quadrant



3D detects US occult distortions. SVAB?



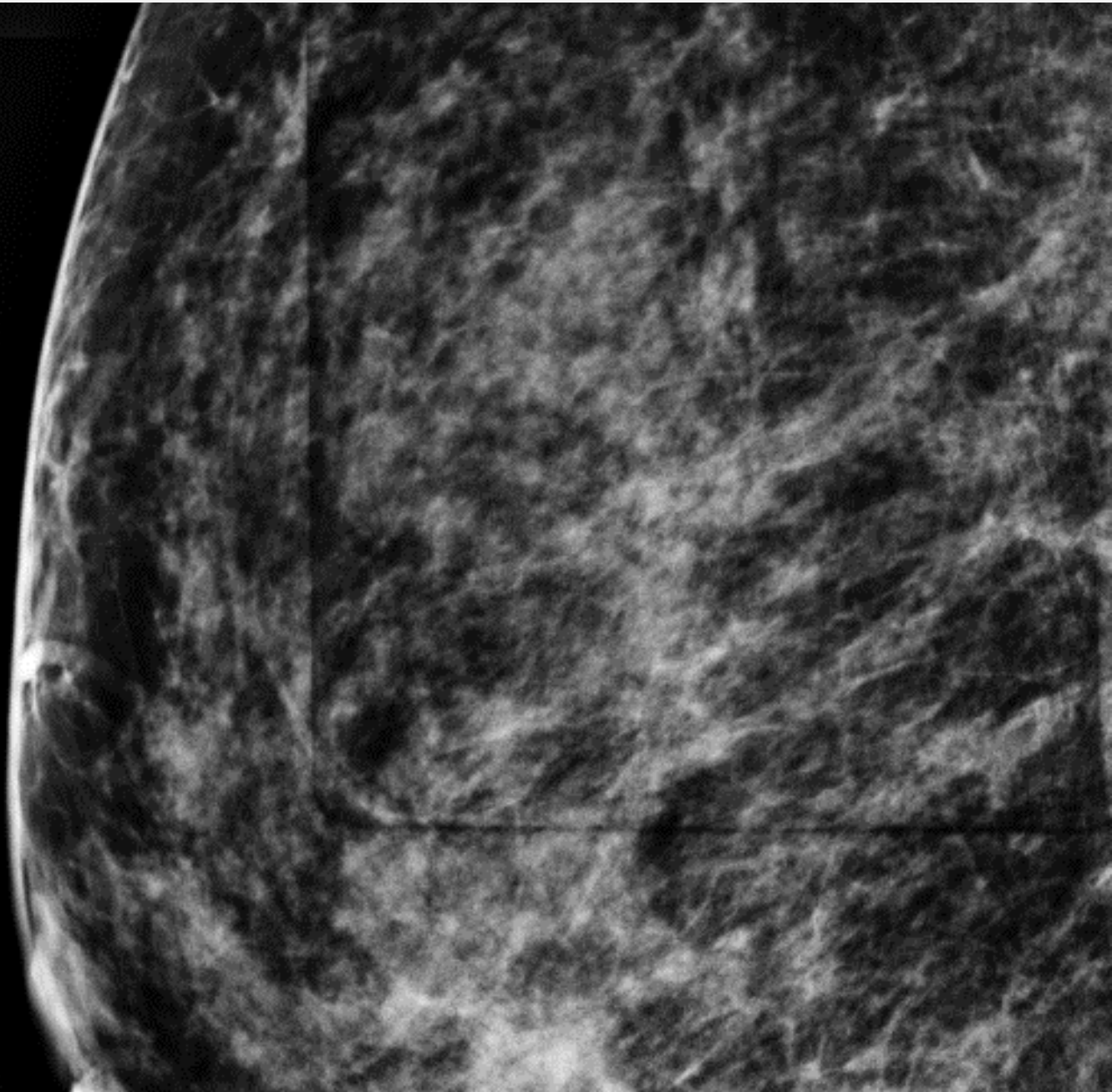
3D-CC



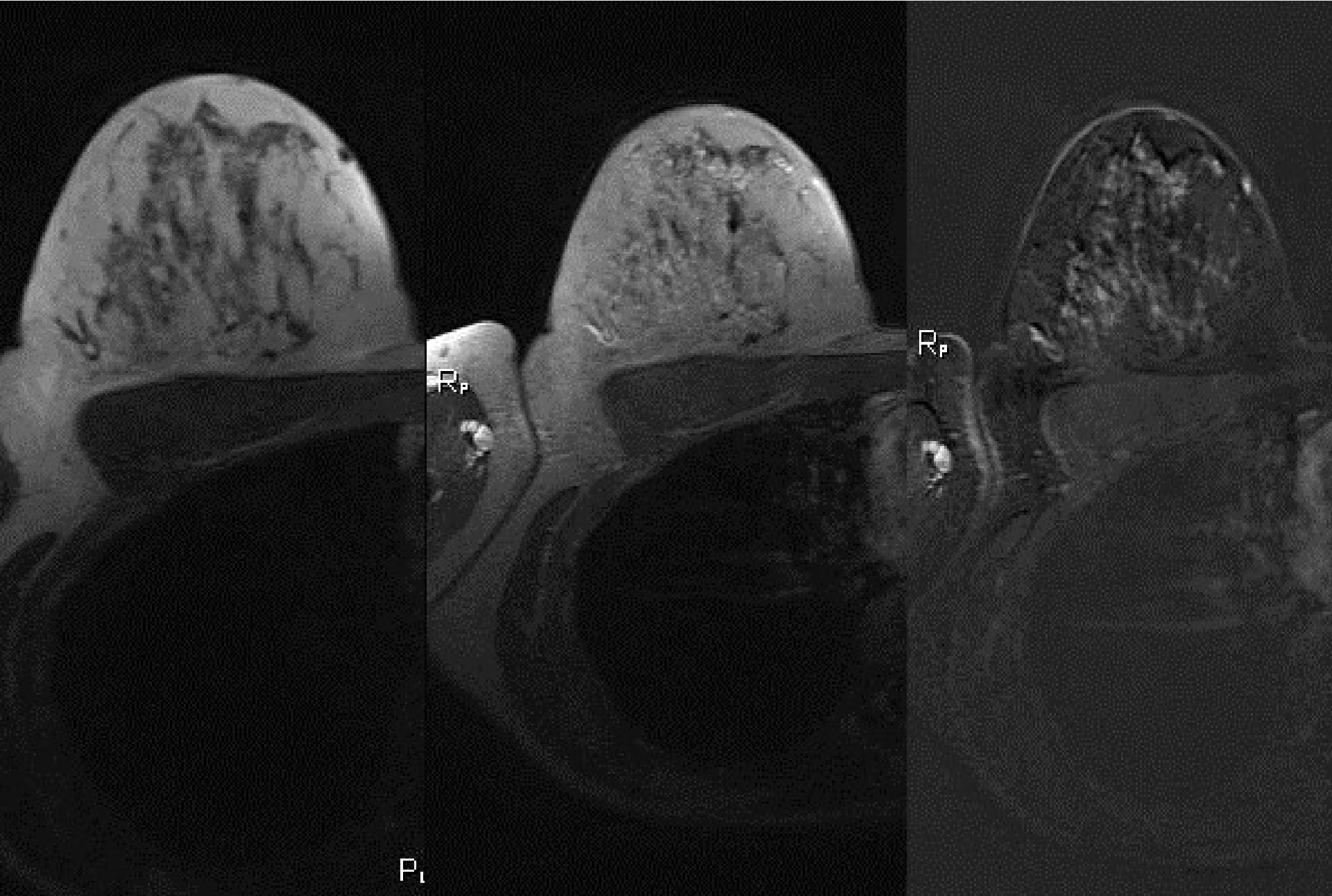
3D-CC

Distortions occult on SVAB. MRI?

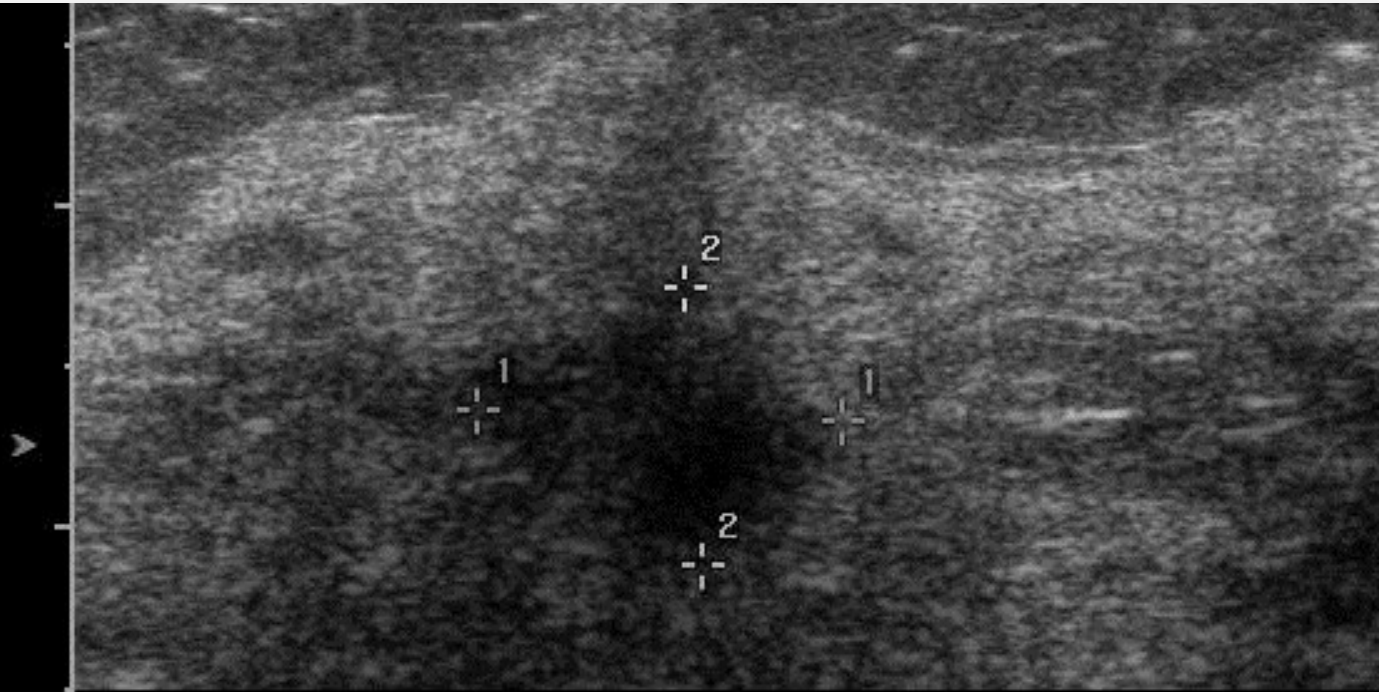
2D-MLO



MRI? Activated fibroglandular tissue



US? Equivocal. Maybe this?



Breast
General

85dB S1/+1/3/4
Gain= 5dB $\Delta=2$

Store in progress



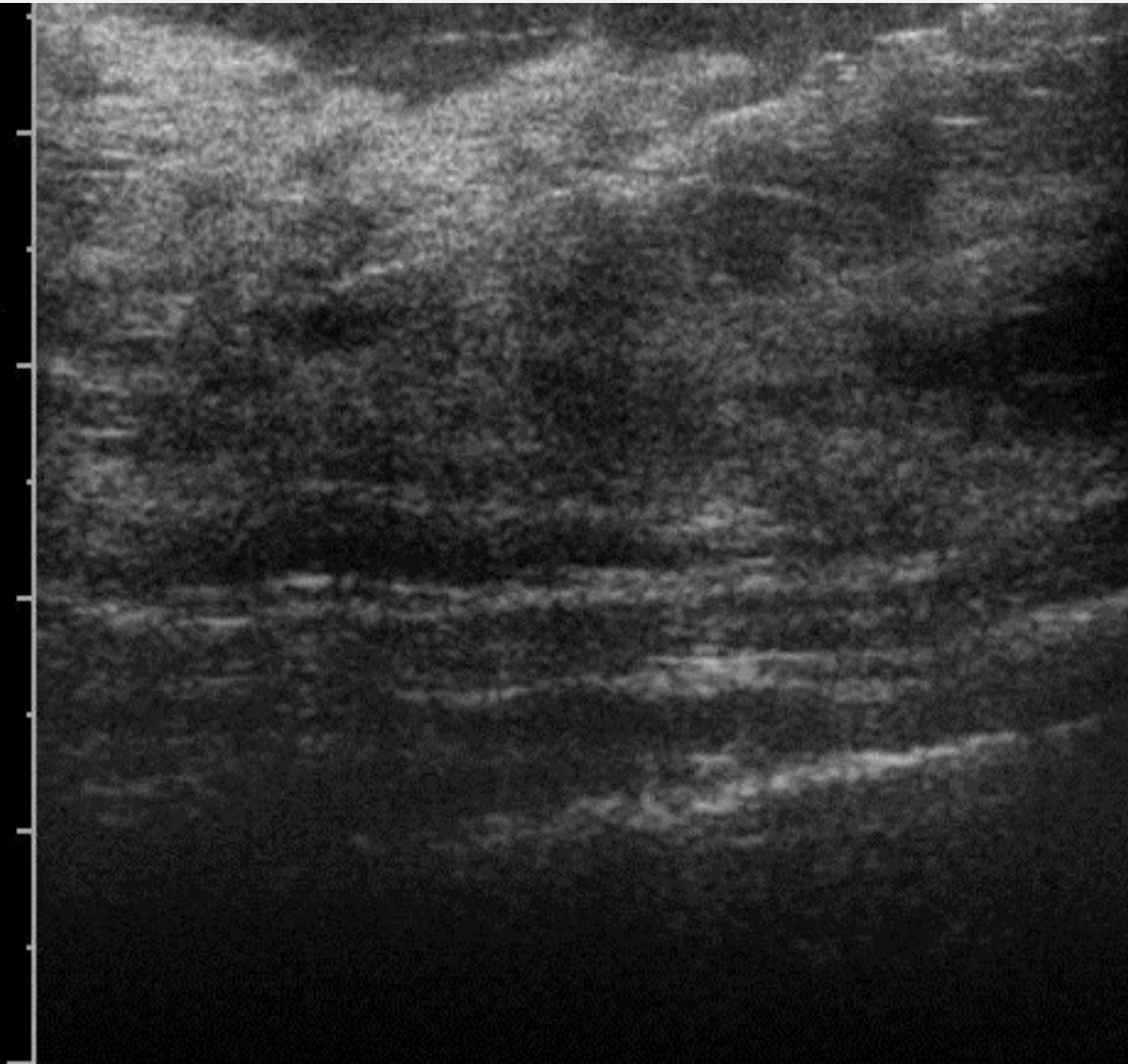
-----1-----
Dist = 1.233cm
-----2-----
Dist = 0.863cm

Delete Set

Lock Set

Select Set

Martin was brave. Needle & clip



Breast
General

85dB S1/+1/3/4
Gain= 9dB $\Delta=2$

Store in progress

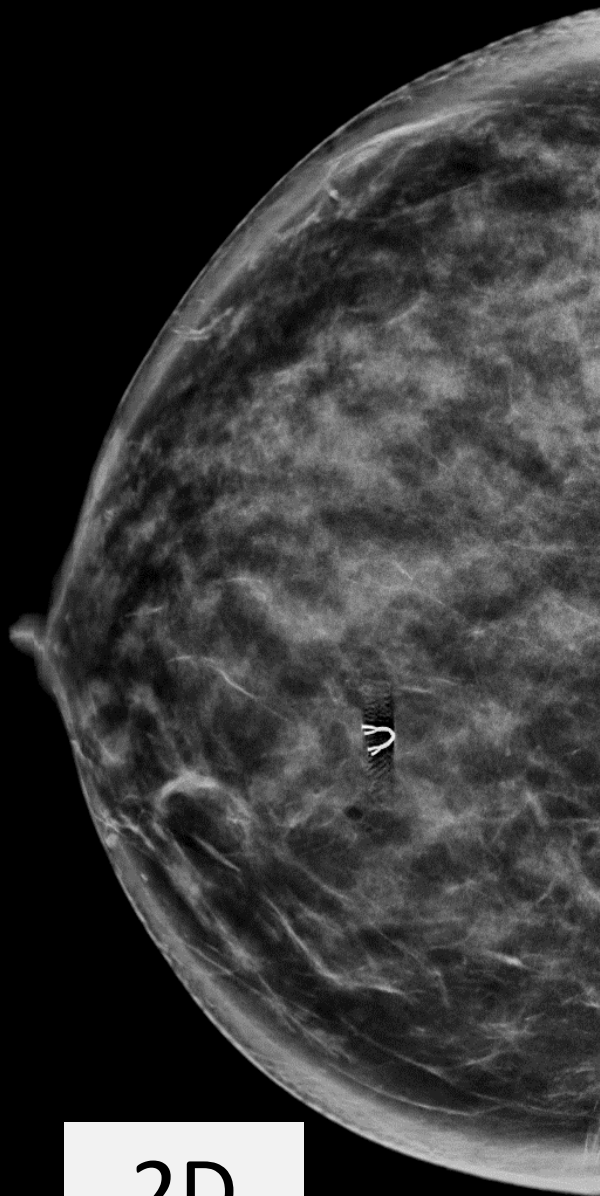


Right AP

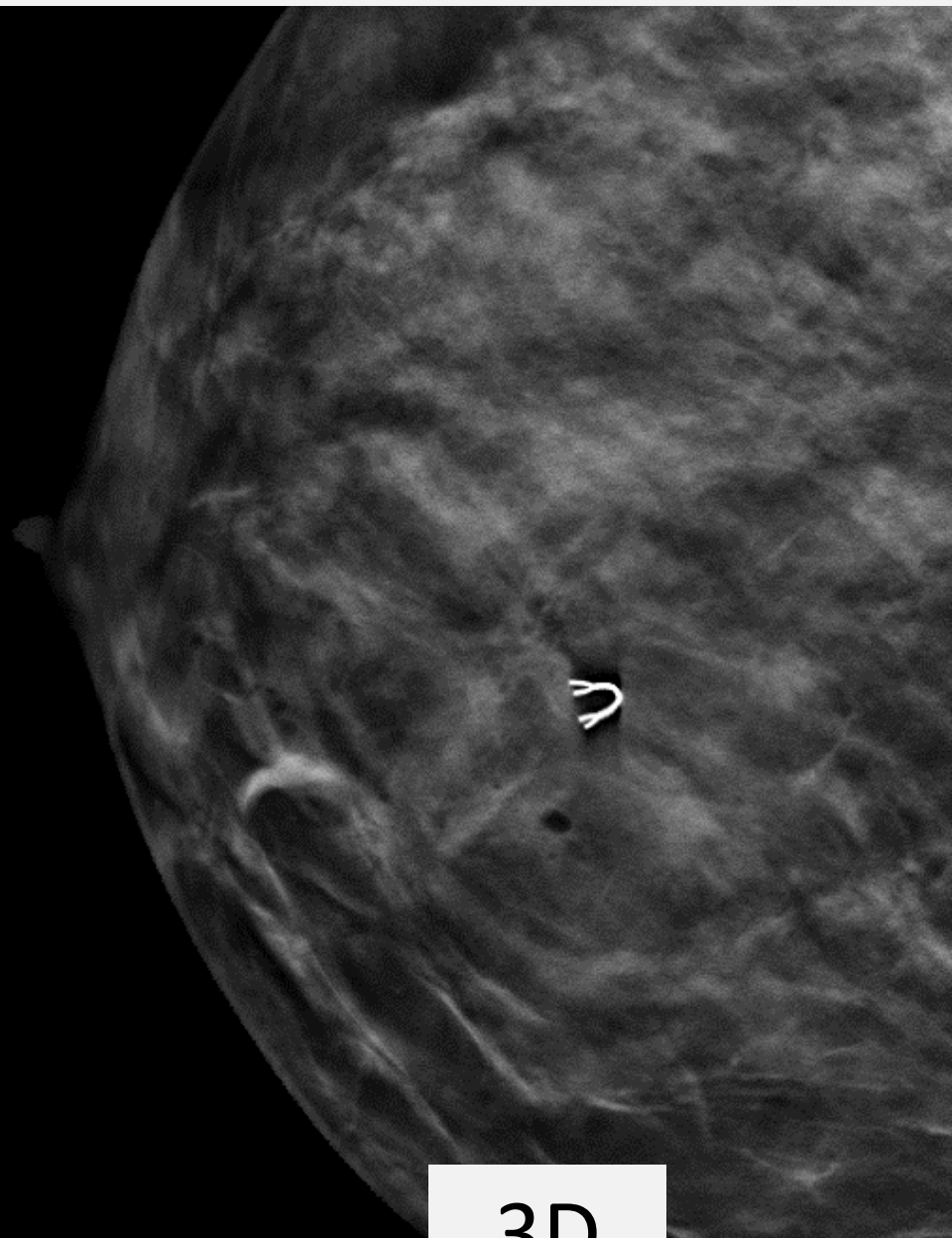
XDCR:Rotate/Move

Move Marker

In 3D clip correct, carcinoma, happy

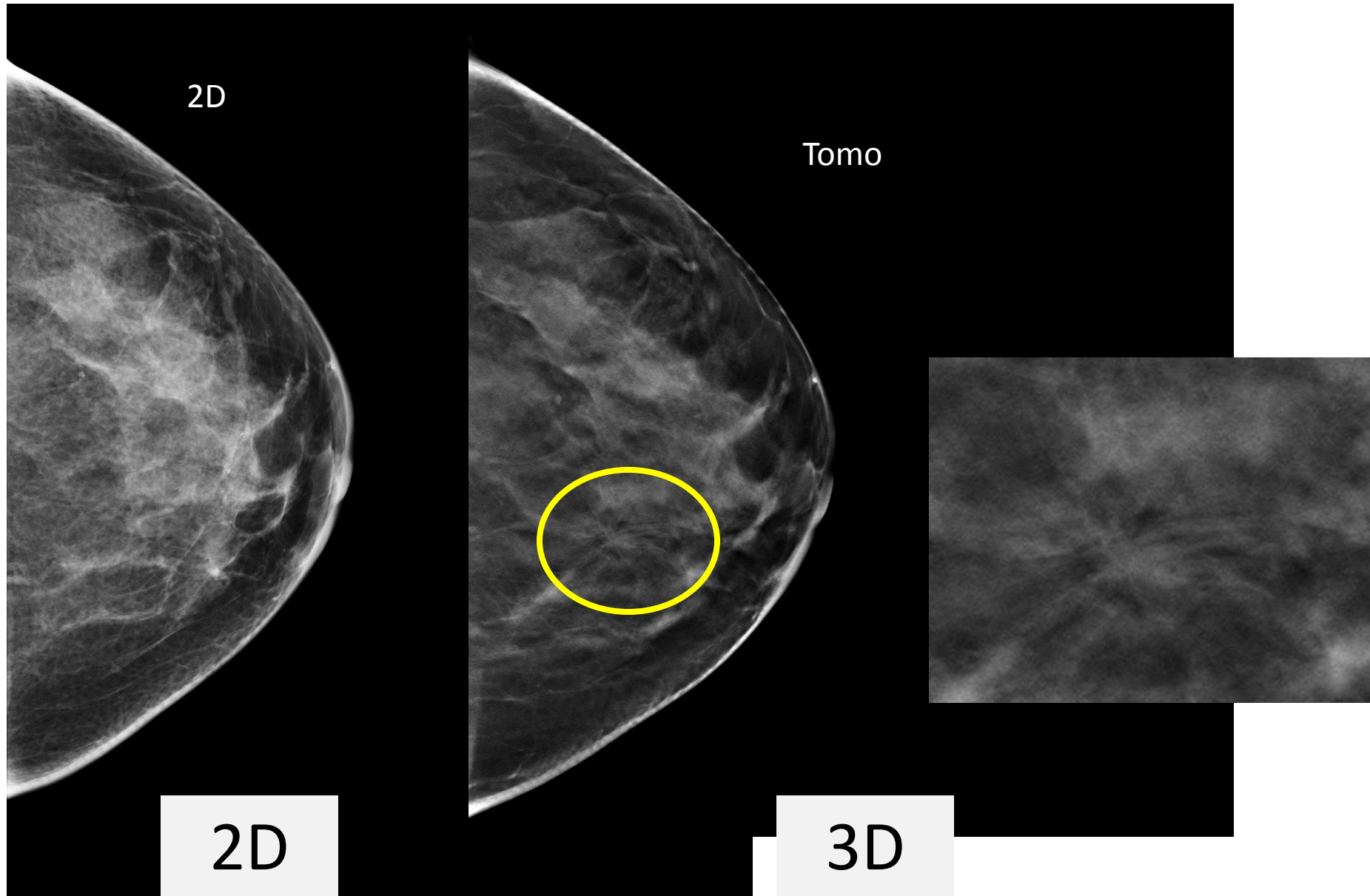


2D



3D

Next distortion visible only on 3D.
Really need to biopsy? Wait and see?



Tomosynthesis-guided vacuum-assisted breast biopsy: A feasibility study.

Purpose:

.....

Materials and Methods:

....**The first 141 biopsies** on 141 patients admitted for stereotaxy.....

Results:

.... **Of the 24 radial distortions, 13 were breast carcinomas** (11 invasive carcinomas, 2 ductal carcinomas in situ). The mean lead time for TVAB was 15.4 minutes (range 7-28 min).....

Conclusions:

.... **Architectural distortions were found to be malignant in 54%** of patients and thus need to be histopathologically evaluated if detected.....

How to biopsy lesions NOT seen on US???

- ~~US => Lesion???~~

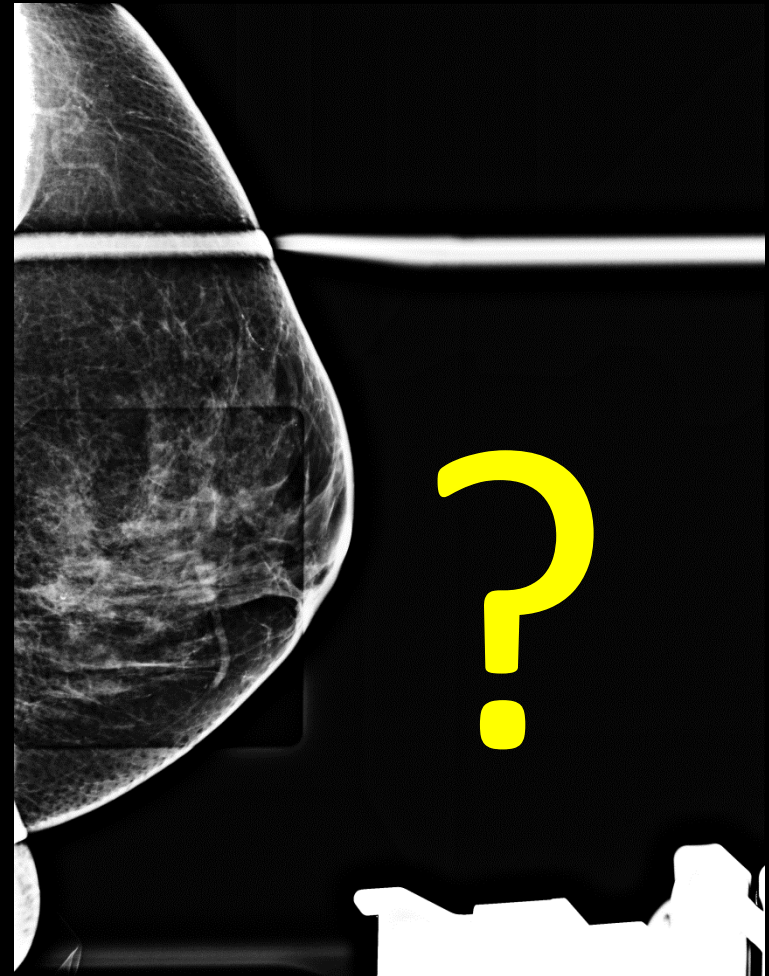


Stereotaxy

in US occult lesions and distortions???

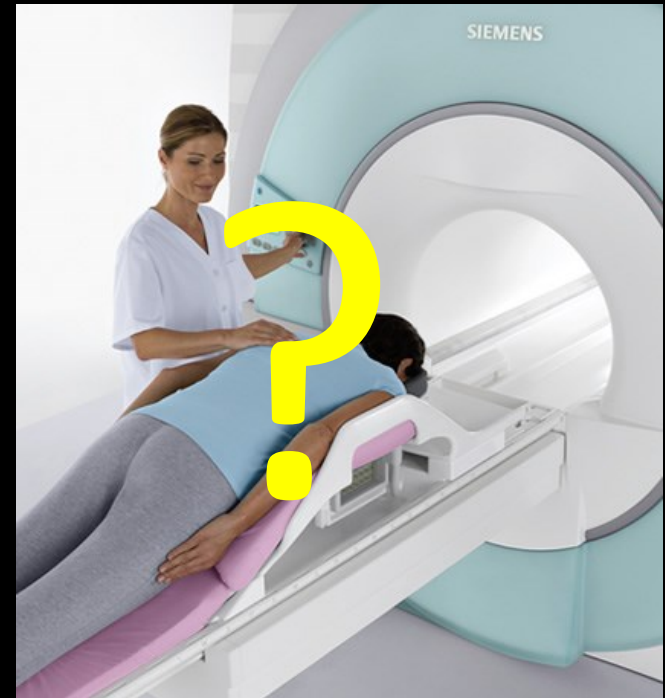
- ~~US => Lesion???~~
- ~~Stereotactic => Lesion???~~

- Distortions mostly not visible on stereo images
- No clear target at least on one stereo image
- Visual needle verification only pretends correct needle depth, danger!



How to biopsy lesions NOT seen on US???

- ~~US => Lesion???~~
- ~~Stereotactic => Lesion???~~
- MRI =>
 - Availability???
 - Will we find lesion???
 - High cost
 - Time
 - Contra-indications: contrast, claustrophobia



How to biopsy such lesions?

Tomosynthesis guided Biopsy (Affirm™)



T-VAB upright/ lateral decubitus position



easy, less time, less space, cheaper, never had problems..

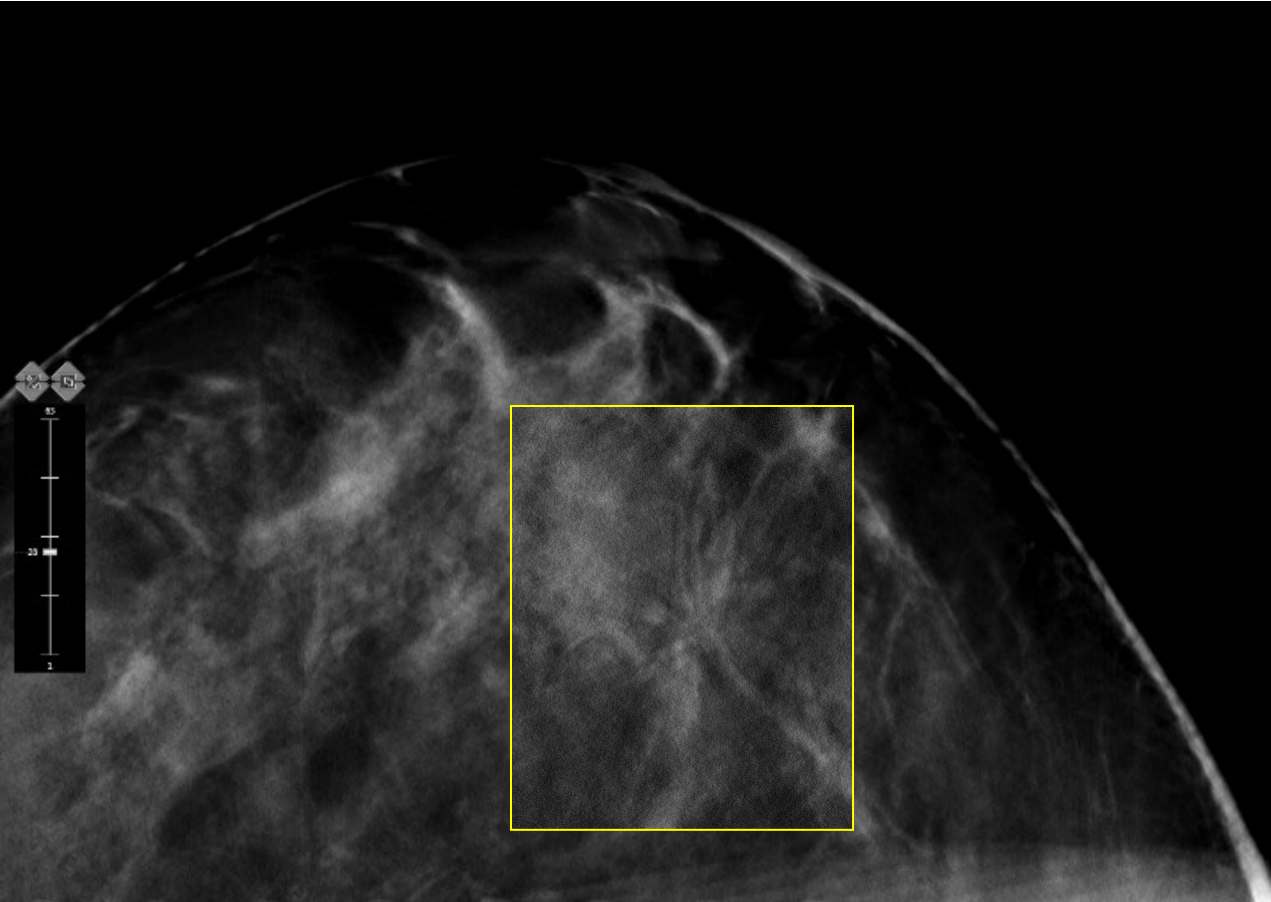
T-VAB procedure - Case 1

Target



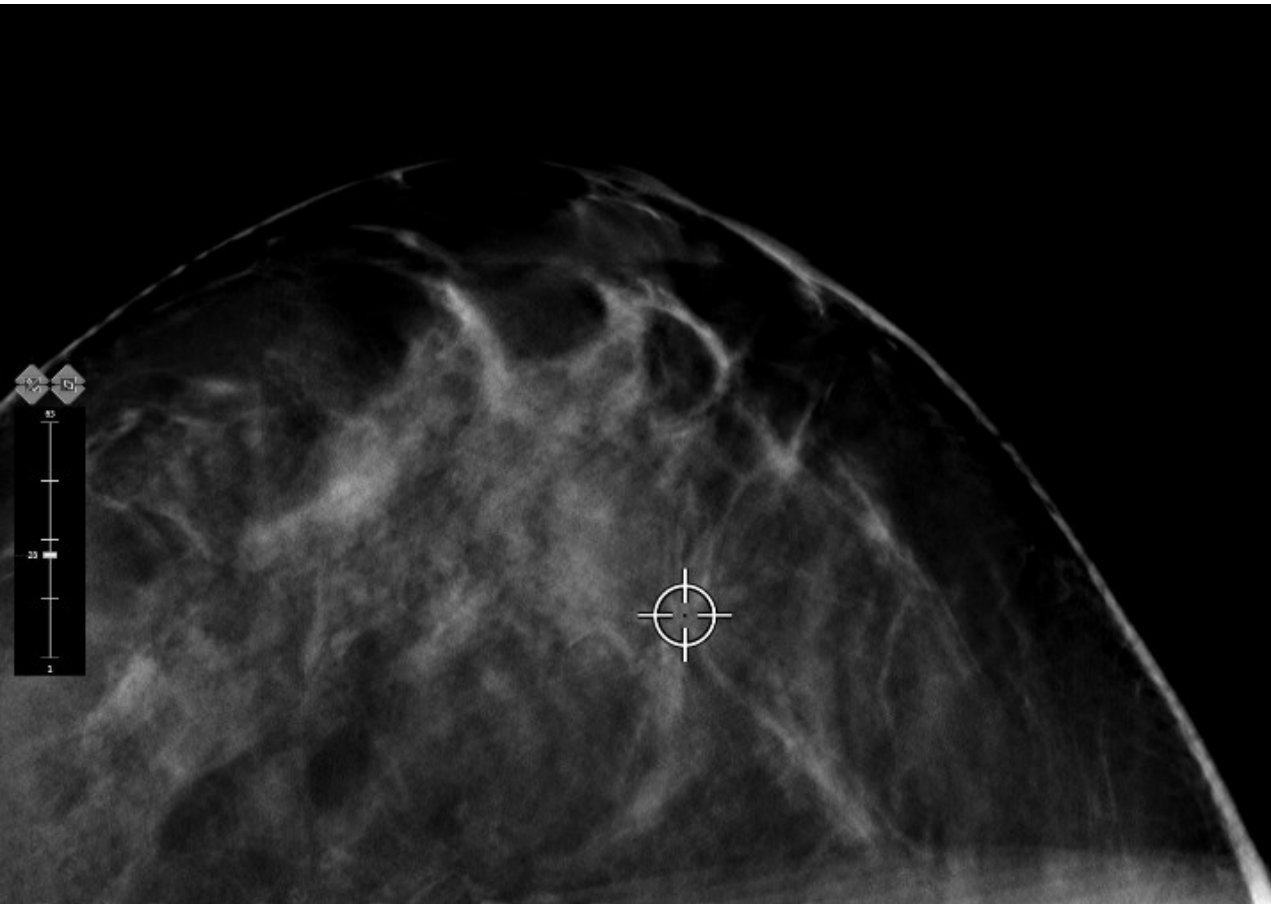
Tomosynthesis procedure - Case 1

Target



Tomosynthesis procedure - Case 1

Target



Vorrichtung
Eviva 9gx13cm, 20mm

Ziele
1: X:0,3 Y:33,9 Z:27,0

Biopsiebereich

20,25mm

15,0mm

0mm

9,61mm

3,0mm

The diagram shows a cross-section of a breast with a biopsy needle inserted. The needle is shown in a vertical orientation. A yellow highlight is placed on the needle shaft at a depth of 15,0mm. The needle is shown to be 20,25mm long. The target area is located at a depth of 9,61mm. The needle is shown to be 3,0mm from the skin surface. The diagram also shows the needle's trajectory and the target area's location relative to the skin surface.

Verification of correct target depth with diagnostic or screening 3D

Tomosynthesis procedure - Case 1

Target

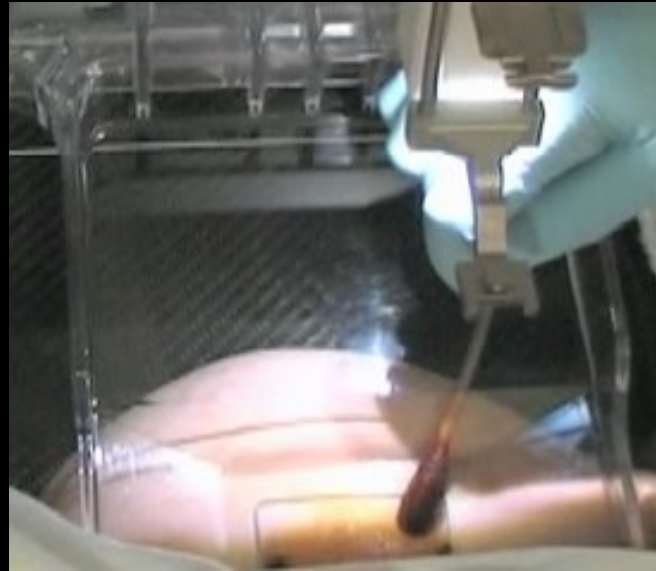
- Prepare biopsy device (Eviva)



Tomosynthesis procedure - Case 1

Target

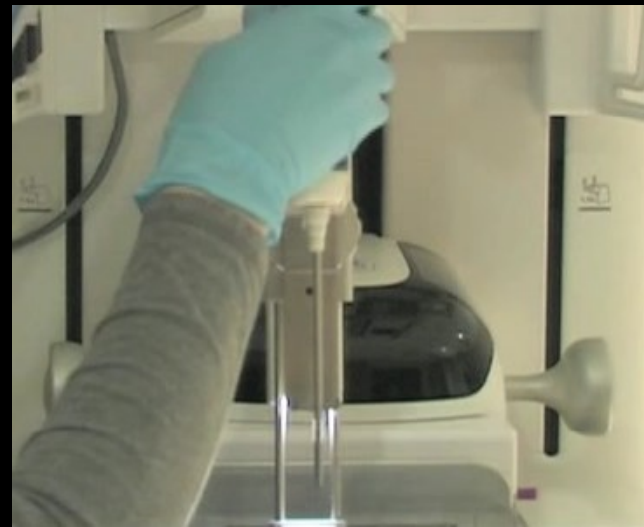
- Prepare Eviva
- Desinfection



Tomosynthesis procedure - Case 1

Target

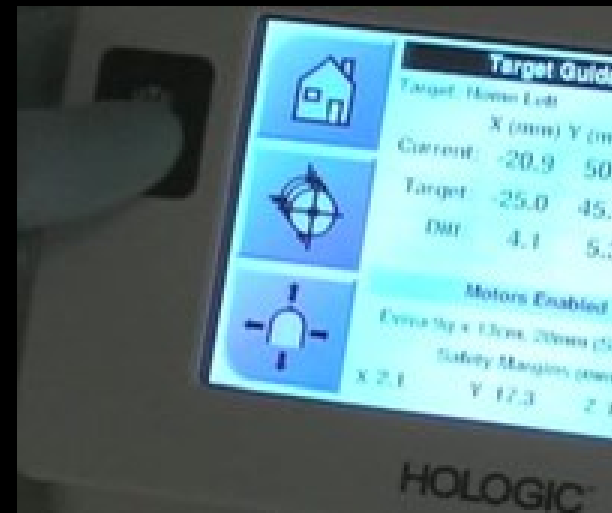
- Prepare Eviva
- Desinfection
- Install needle guide and handpiece



Tomosynthesis procedure - Case 1

Target

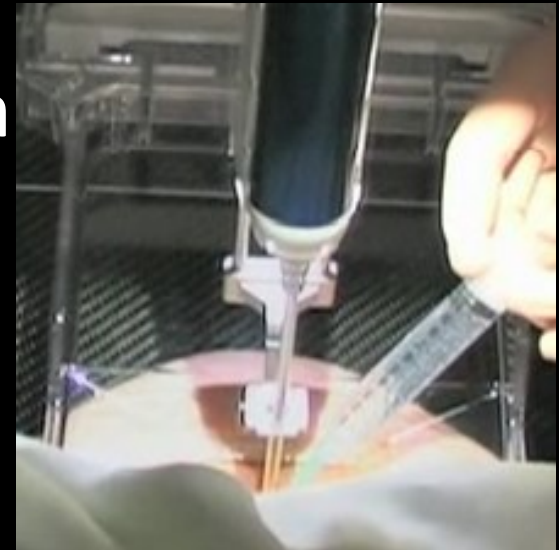
- Prepare Eviva
- Desinfection
- Install needle guide and handpiece
- Go to target



Tomosynthesis procedure - Case 1

Target

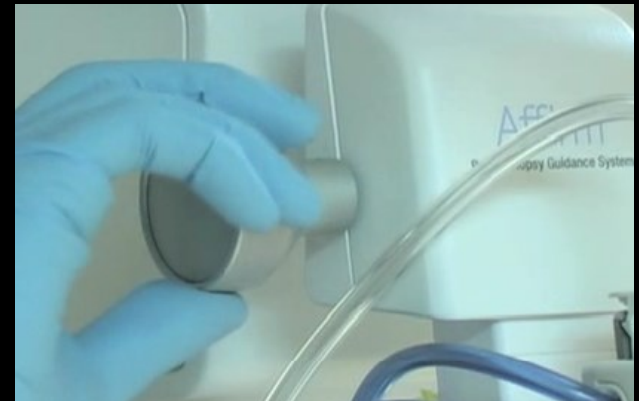
- Prepare Eviva
- Desinfection
- Install needle guide and handpiece
- Go to target
- Local anesthetic + skin incision



Tomosynthesis procedure - Case 1

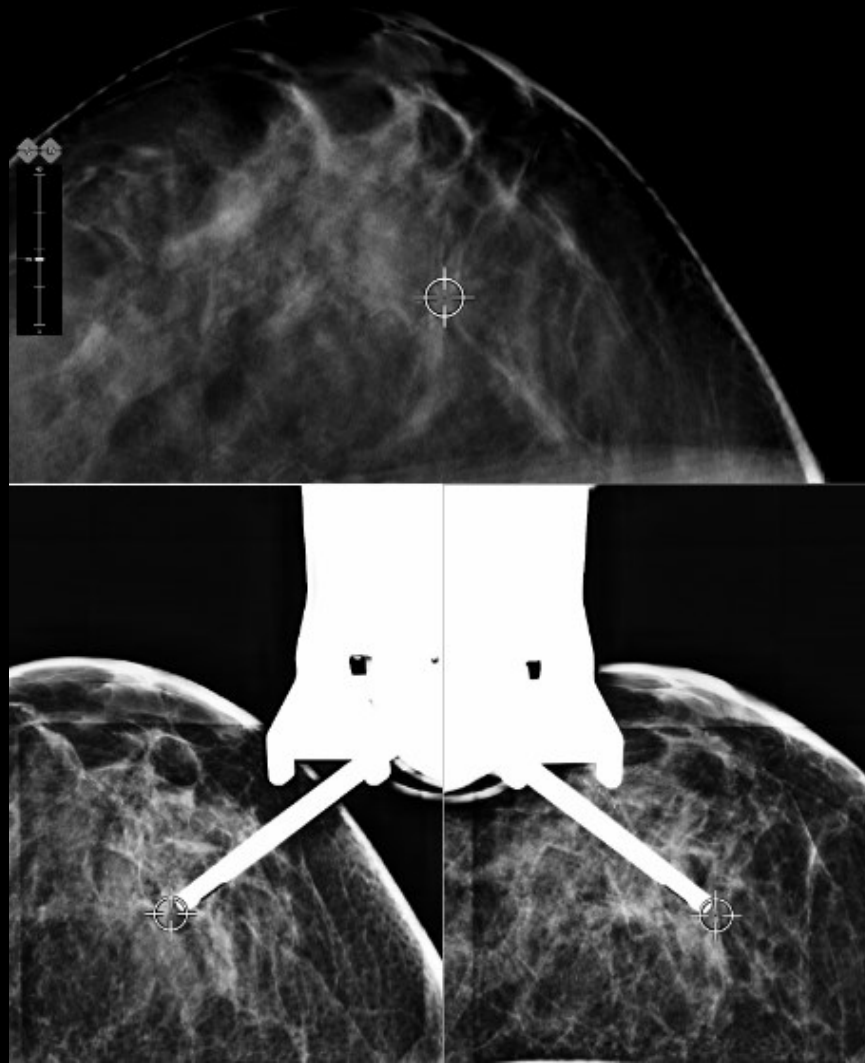
Target

- Prepare Eviva
- Desinfection
- Install needle guide and handpiece
- Go to Target
- Local anesthetic + skin incision
- Dial Z down to zero



Tomosynthesis procedure - Case 1

Pre-Fire – Post-Fire (optional)



Pre-fire images

+ Fire

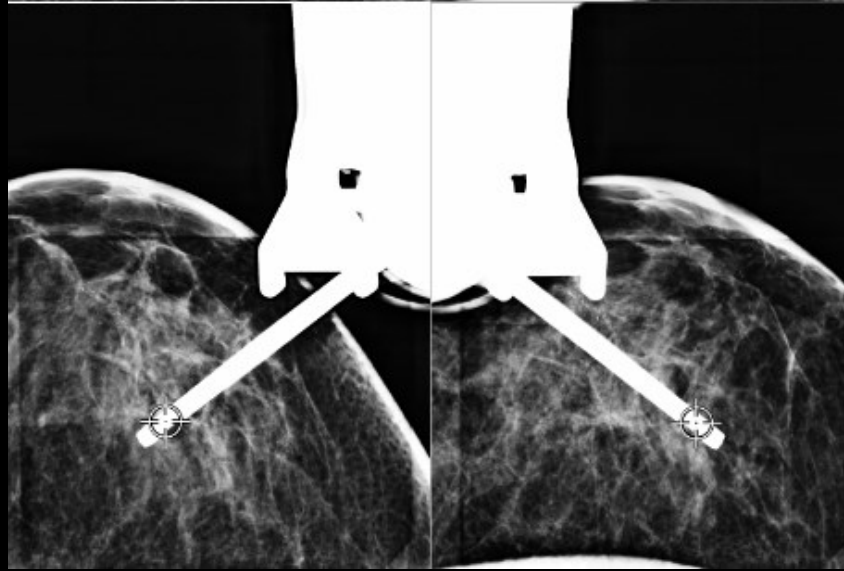
Tomosynthesis Procedure - Case 1

Pre-Fire – Post-Fire (optional)

Pre-fire



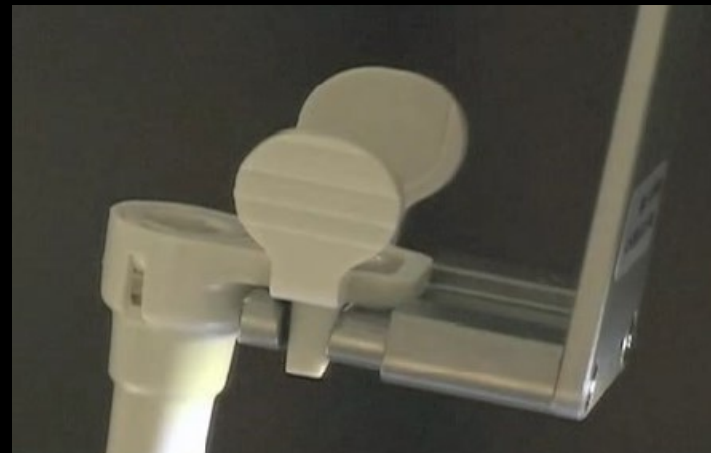
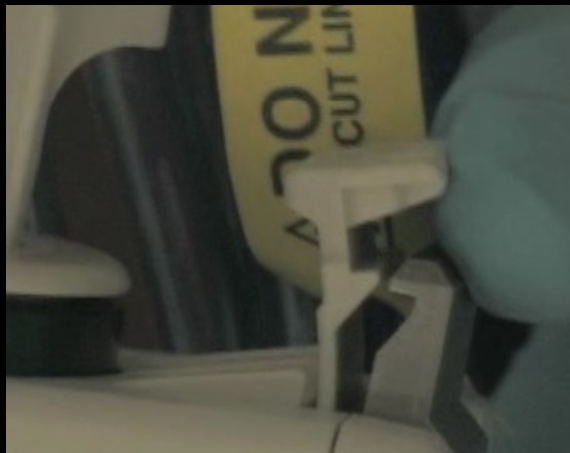
Post-fire



Tomosynthesis procedure - Case 1


Specimen retrieval

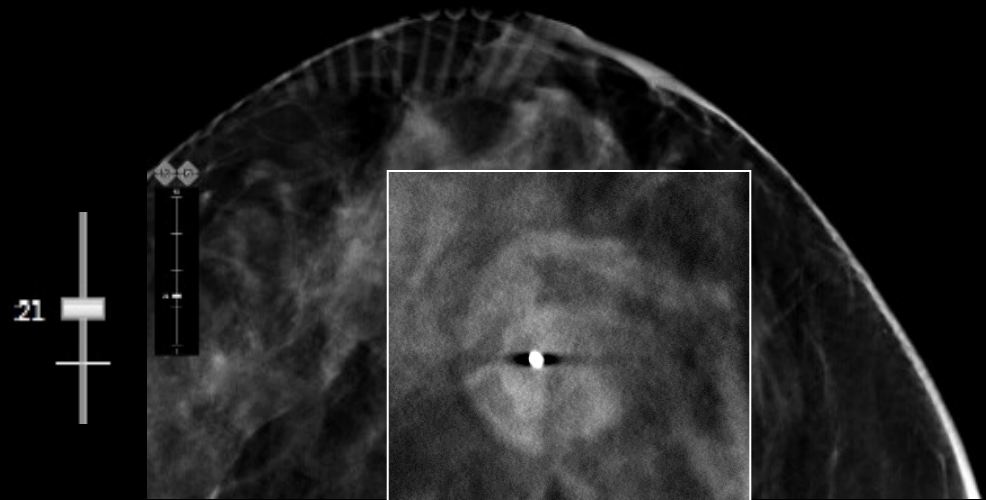
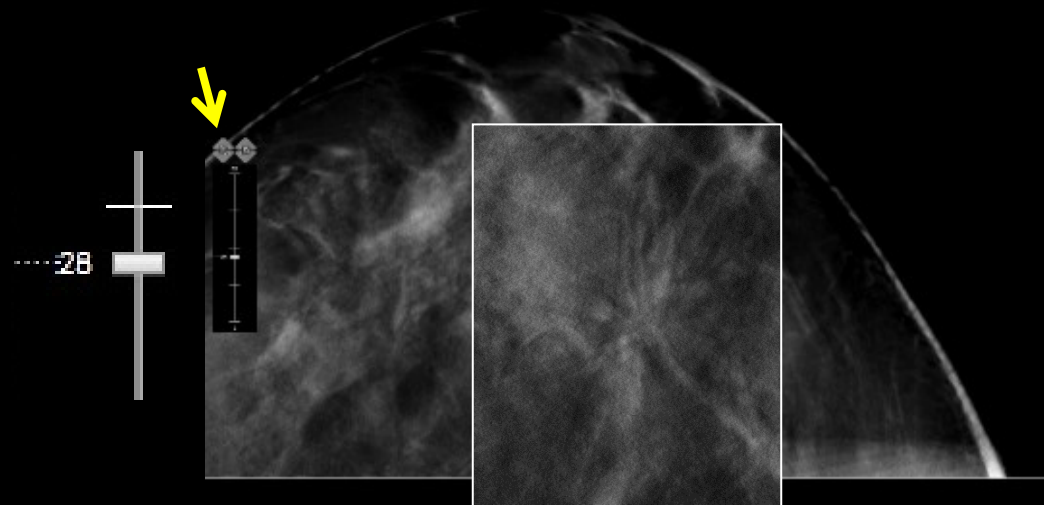
- Specimen retrieval
- Lavage + back to biopsy
- Slide out Eviva handpiece leaving plastic cannula in place for clip insertion



Tomosynthesis procedure - Case 1

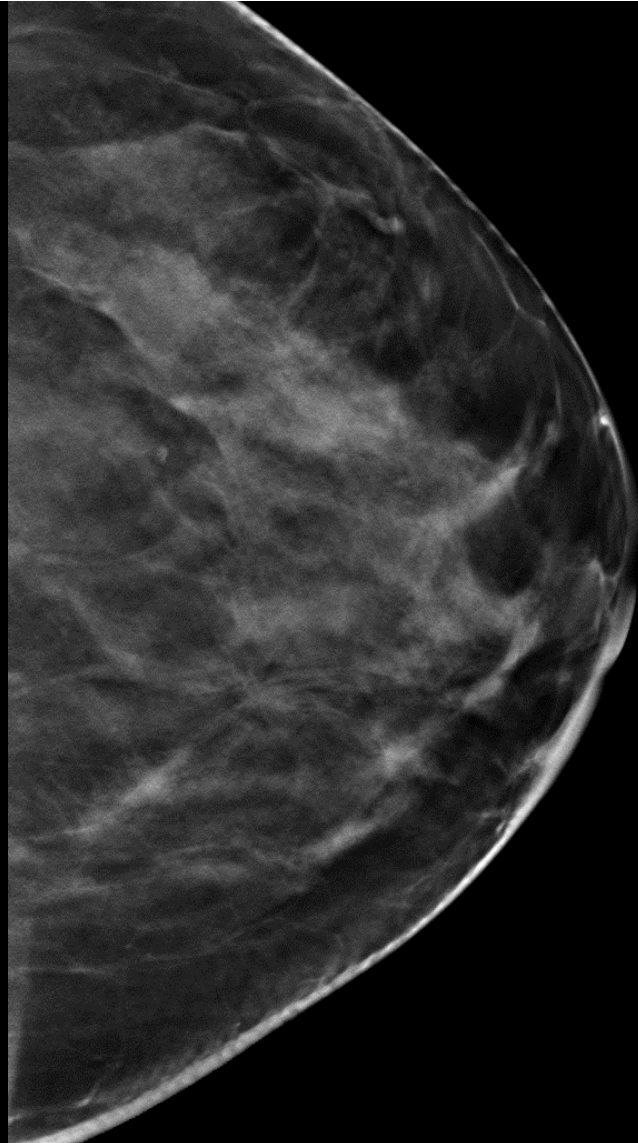
Post Biopsy - Clip

- Post Biopsy Tomo
 - Go to target on target slice →
 - Display target on post biopsy tomo 
- Post Biopsy Tomo
 - Scroll up and down on post biopsy tomo
 - Check if lesion is gone
 - Compare depth hematoma/cavity ↔ lesion on target
- Clip



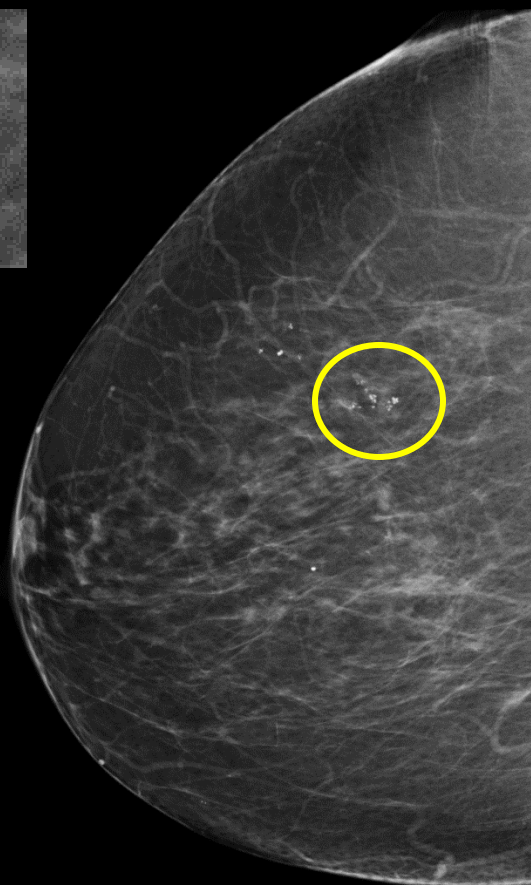
Tomosynthesis procedure - Case 1

- Total lead time: 10 min
- Invasive ductal carcinoma

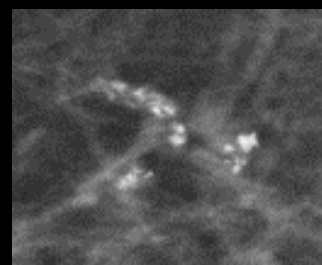


Tomosynthesis procedure - Case 2

Patient 66 y, macro-calcifications



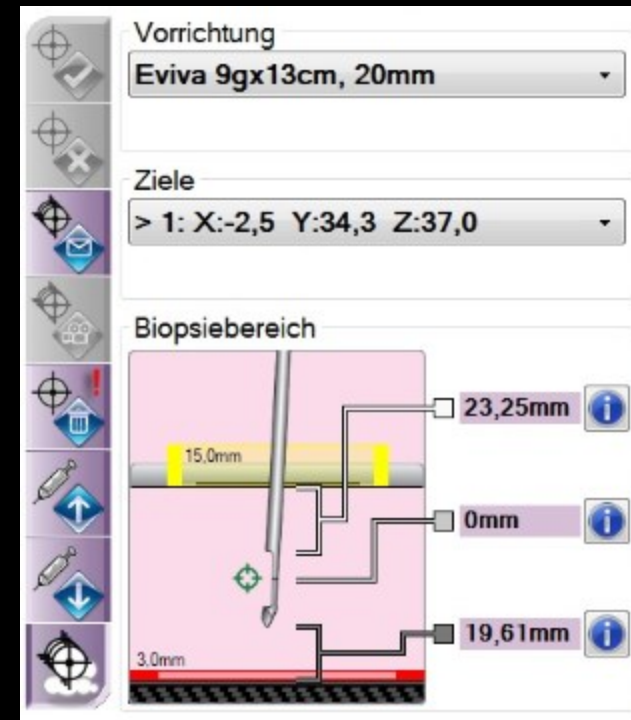
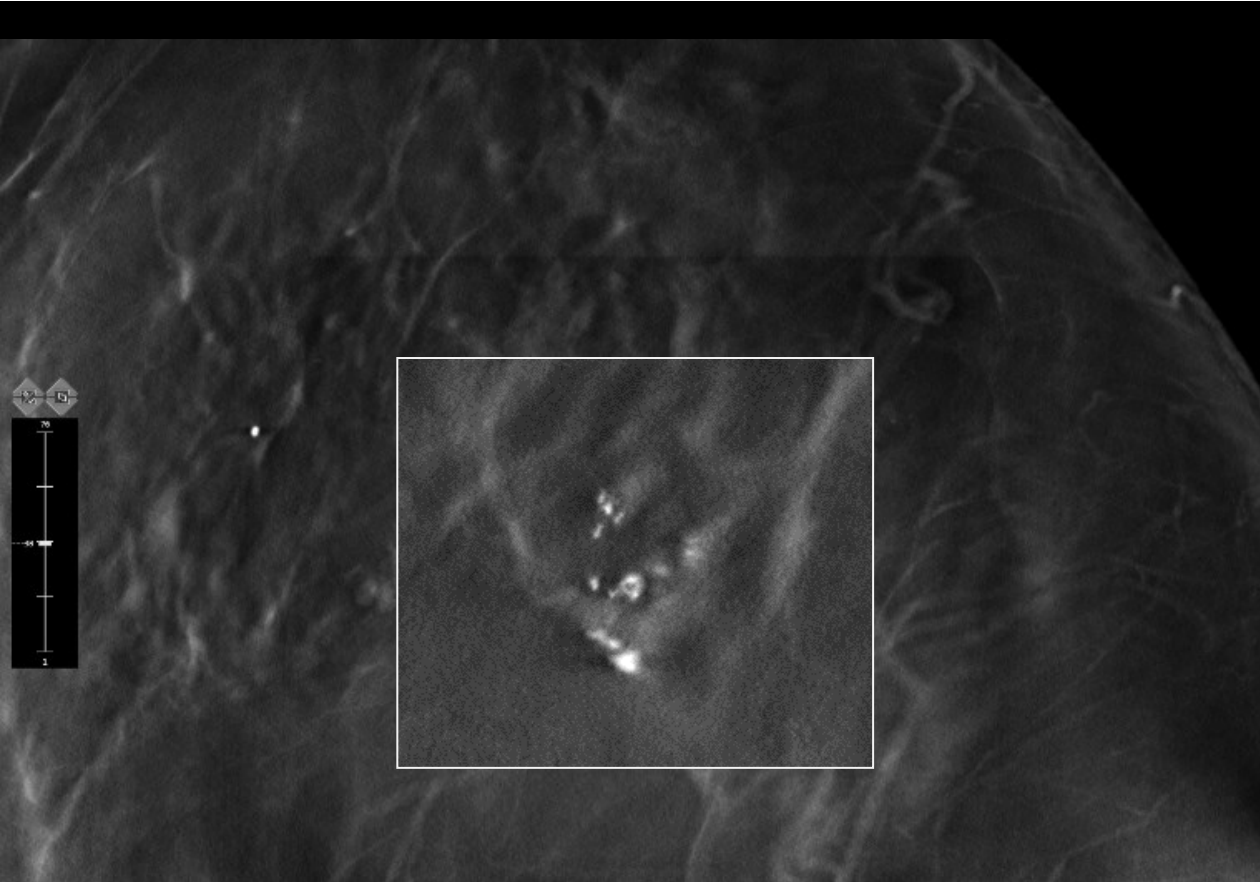
2D RCC



2D RMLO

Tomosynthesis procedure - Case 2

Target



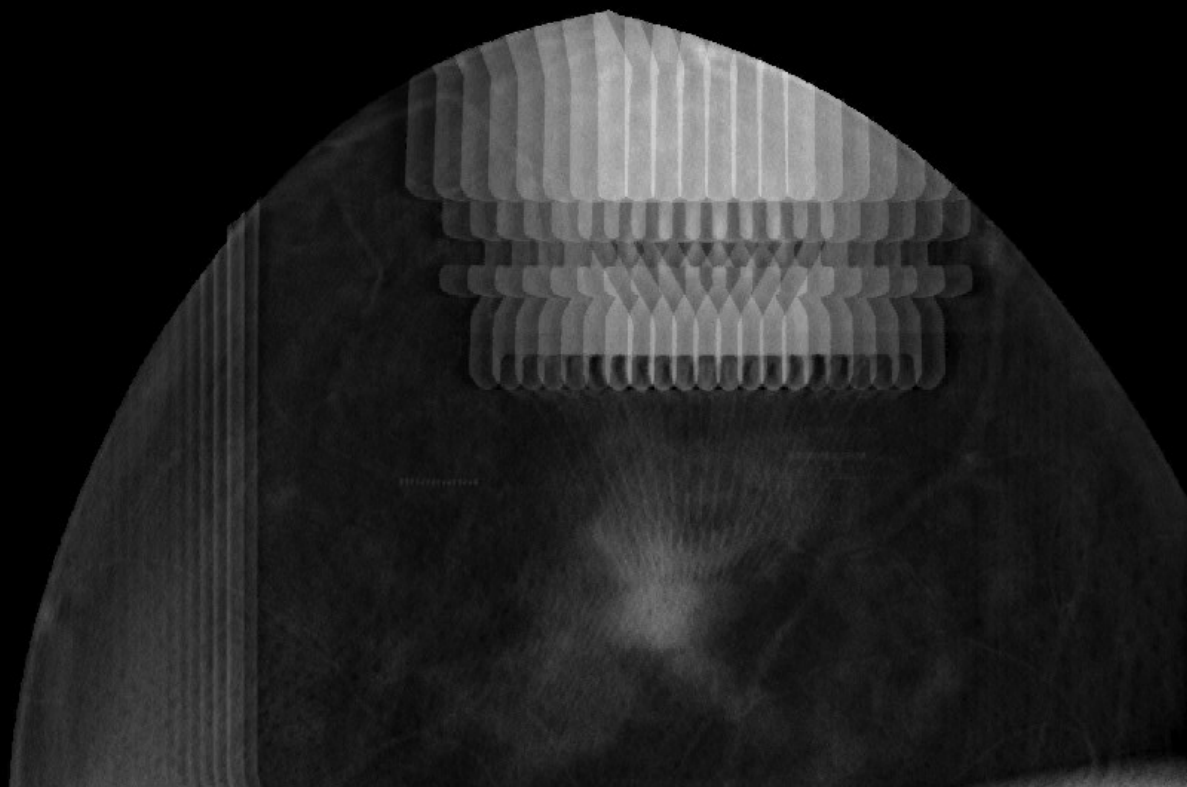
Advantage TVAB (3D) vs. 2 D: separation of several targets in several Z (depth) possible.

Tomosynthesis procedure - Case 2

Specimen Retrieval – Post Biopsy

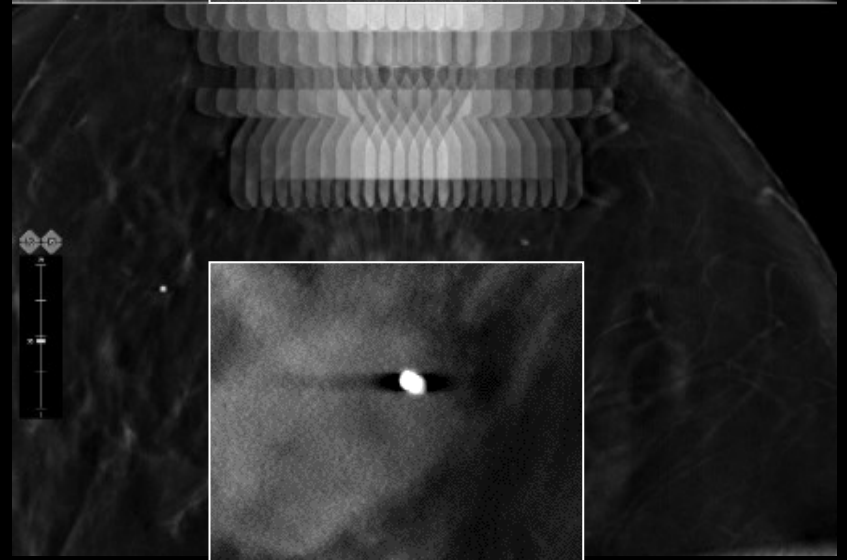
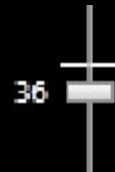
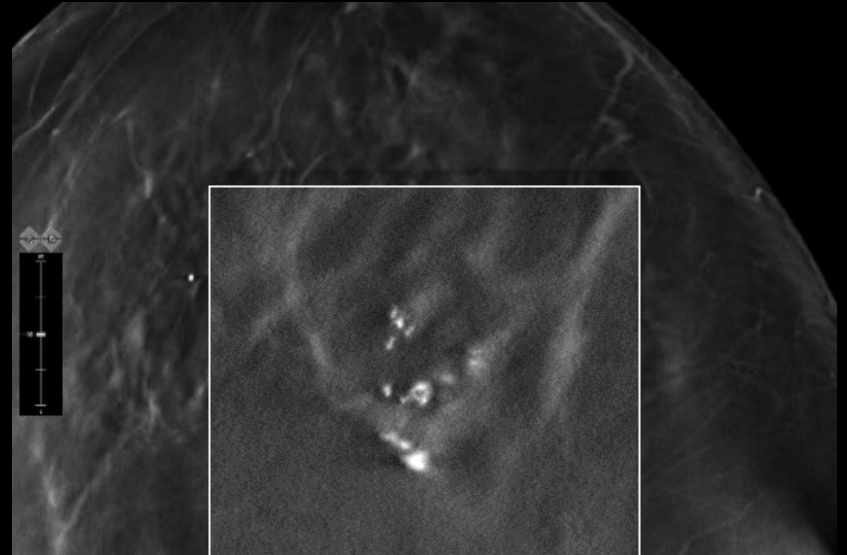
- Specimen retrieval
- Lavage
- Slide out Eviva handpiece leaving plastic cannula in place
- Post Tomo Biopsy

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Tomosynthesis procedure - Case 2 Clip

Fibroadenoma



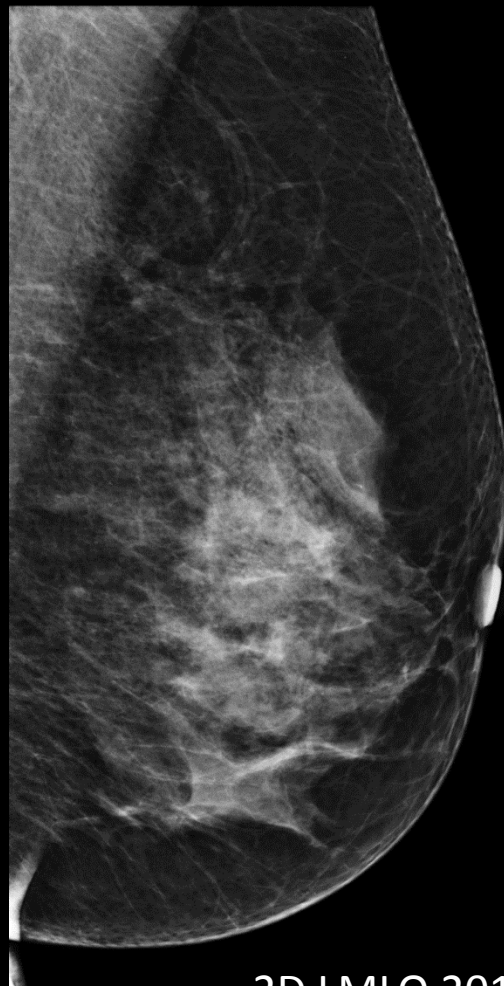
Tomosynthesis procedure - Case 3

Patient 49 y



2D LMLO 2011

LMLO

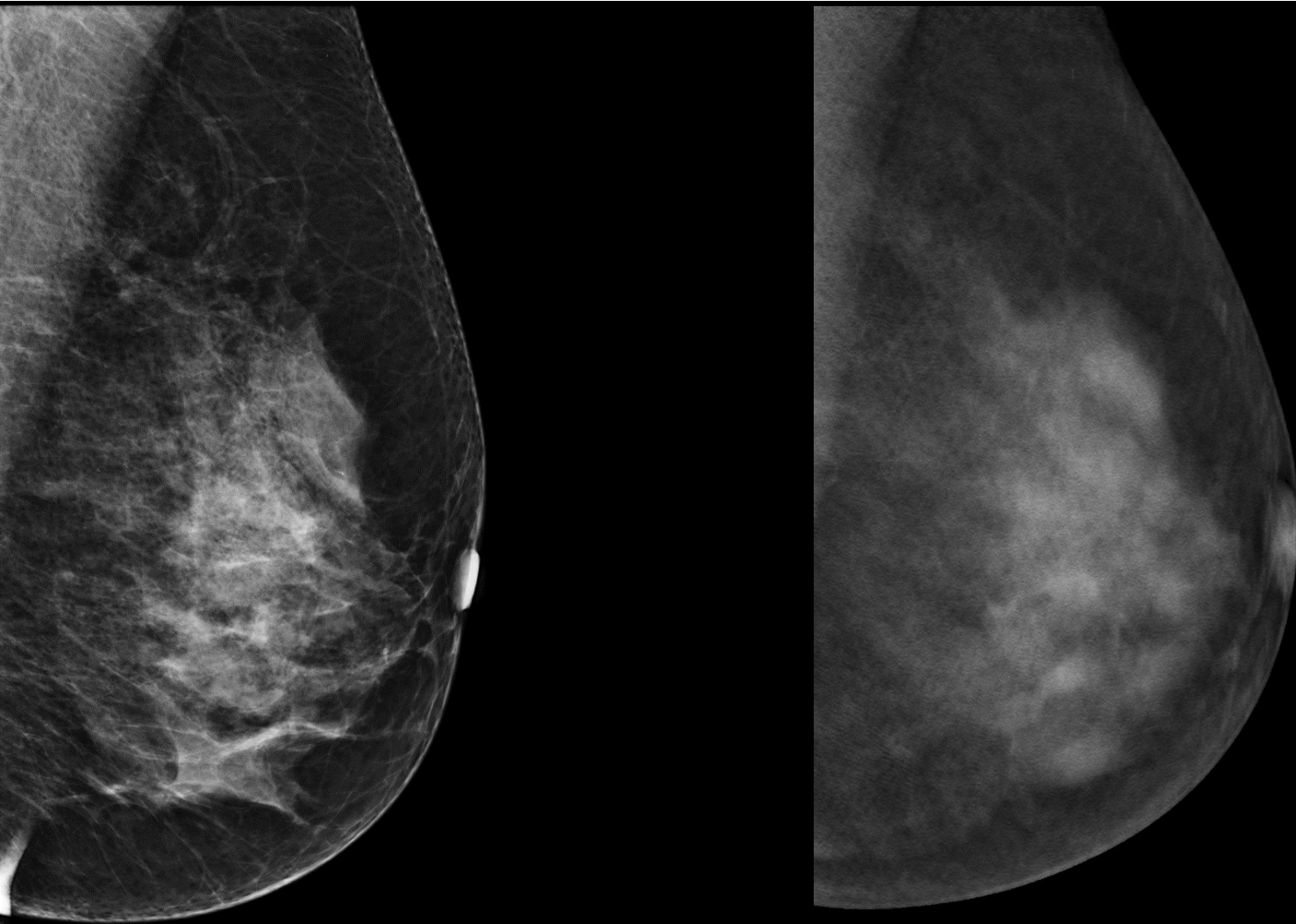


2D LMLO 2013



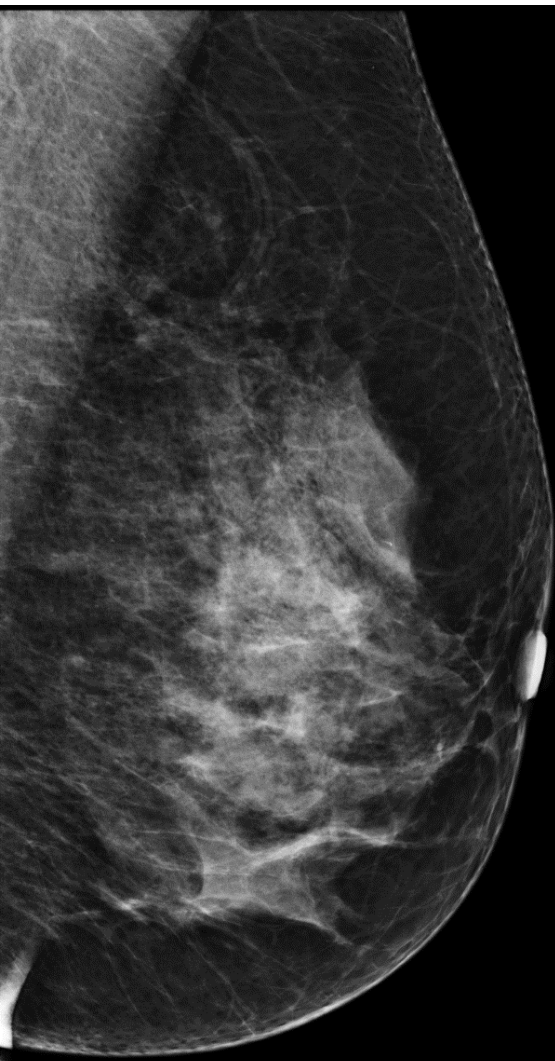
CVIEW LMLO 2013

Tomosynthesis procedure - Case 3

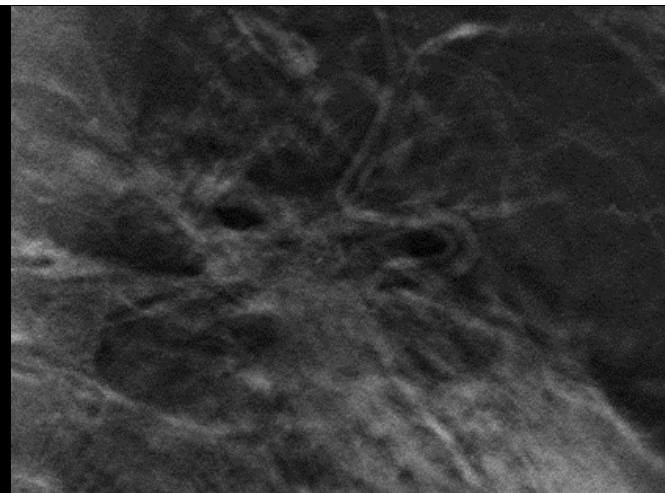
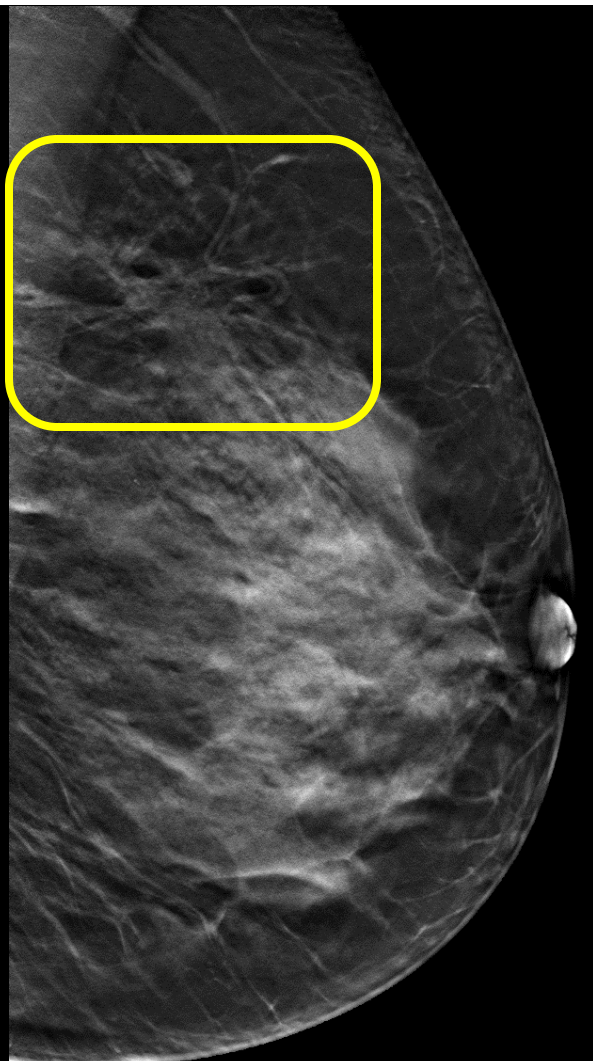


2D LMLO 2013

Tomosynthesis procedure - Case 3



2D LMLO 2013



3D LMLO 2013

Tomosynthesis procedure - Case 3

Patient 49 y



2D LCC 2011



C-VIEW LCC
2013



3D LCC 2013

Tomosynthesis procedure - Case 3

Patient 49 y



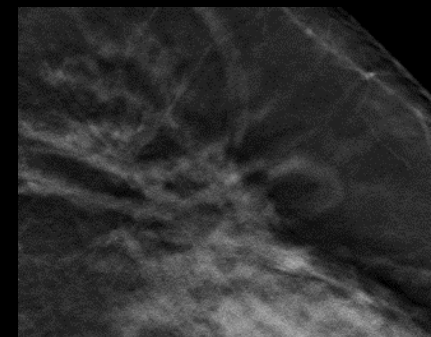
2D LCC 2011



C-VIEW LCC
2013

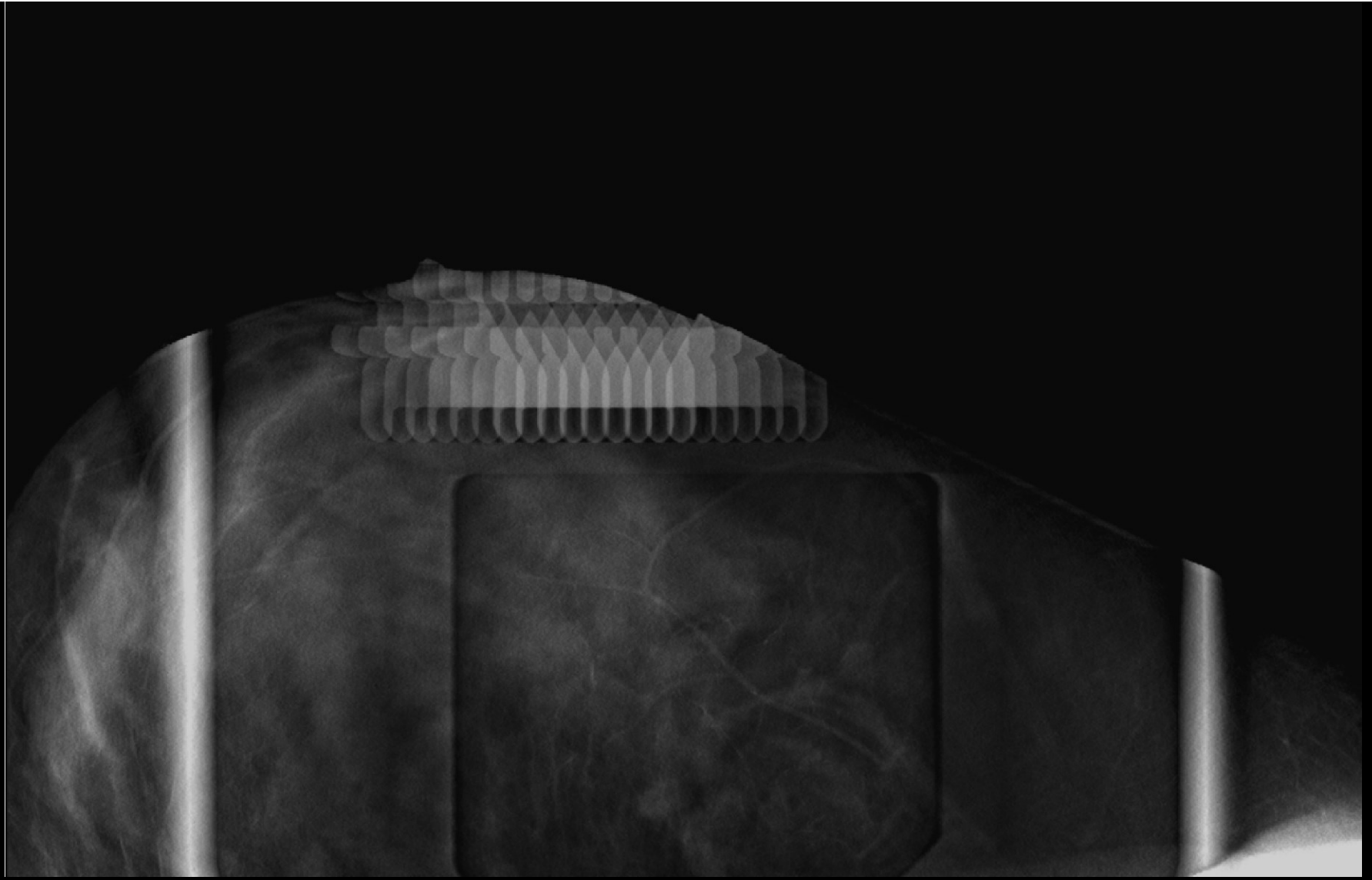


3D LCC 2013



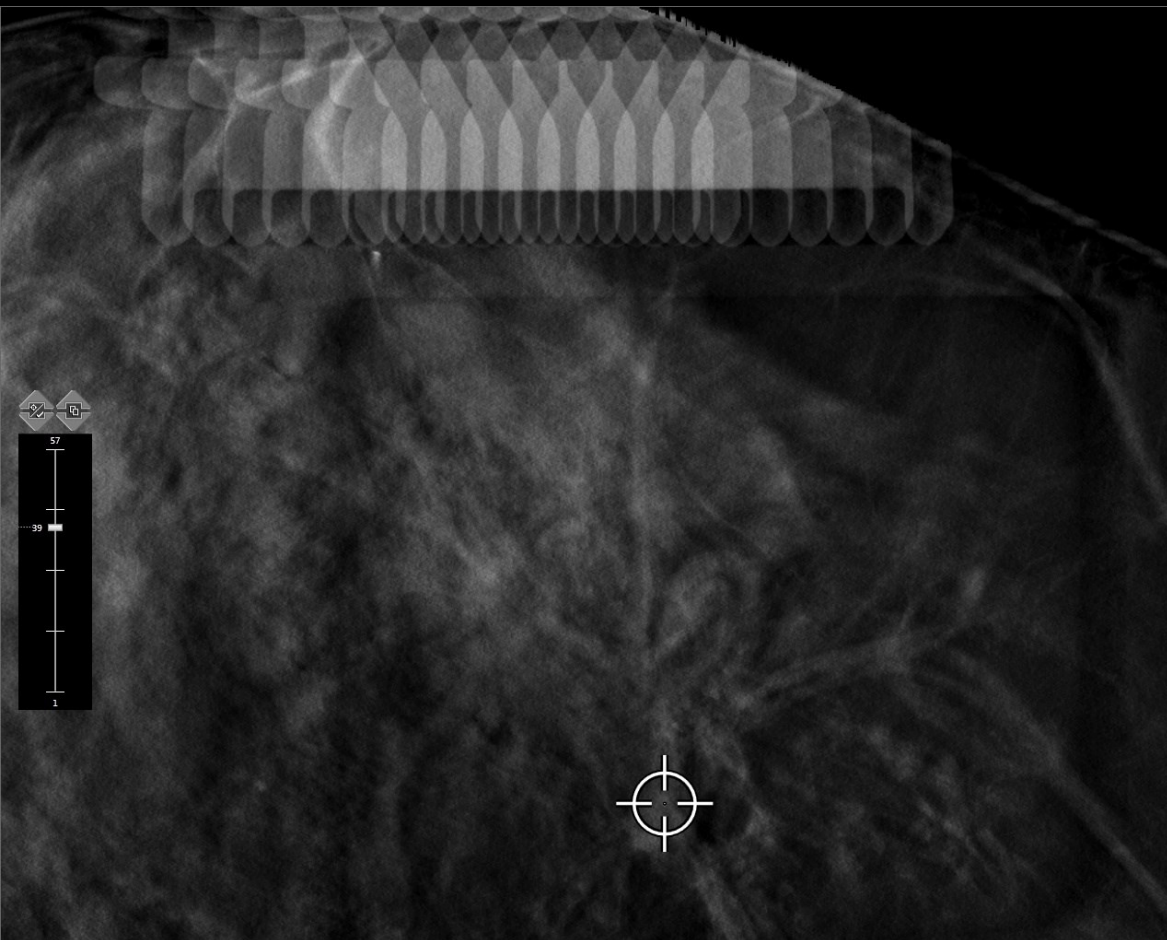
Tomosynthesis procedure - Case 3

Target



Tomosynthesis procedure - Case 3

Target



Device
Eviva 9gx13cm, 12mm (Trocar Pt)

Targets
1: X:-4.0 Y:18.5 Z:38.0

Biopsy Area

6.18mm

15.0mm

0mm

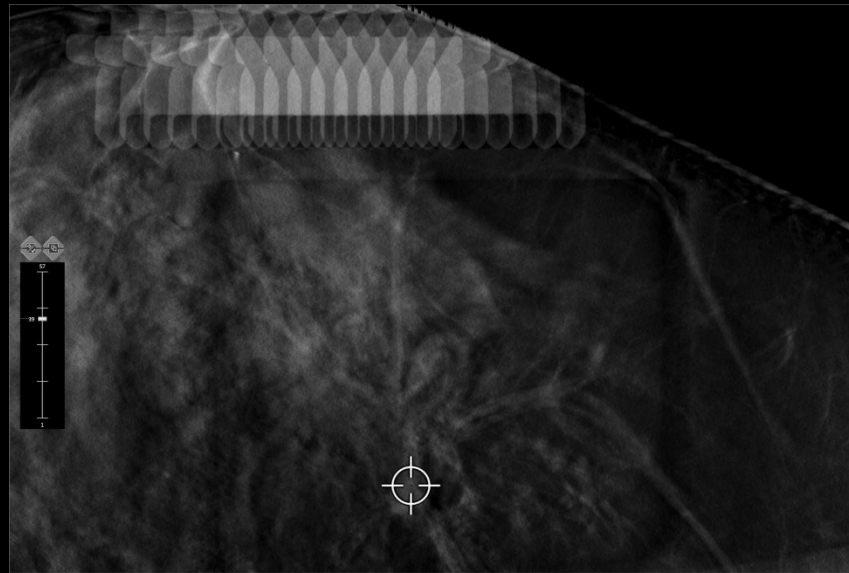
24.55mm

3.0mm

The Biopsy Area diagram shows a cross-section of a breast with a needle path. The needle is shown entering from the top and reaching a target area. The target area is highlighted in yellow. The depth of the target area is 0mm. The depth of the needle tip is 24.55mm. The length of the needle is 15.0mm. The depth of the needle tip is 3.0mm. The diagram also shows a 6.18mm depth marker.

Tomosynthesis procedure - Case 3

Pre-Fire (optional)



Pre-fire images

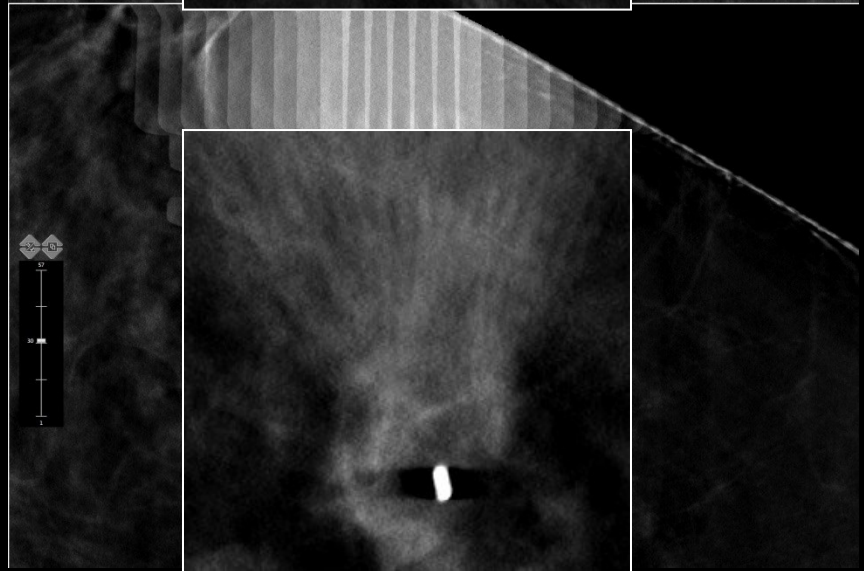
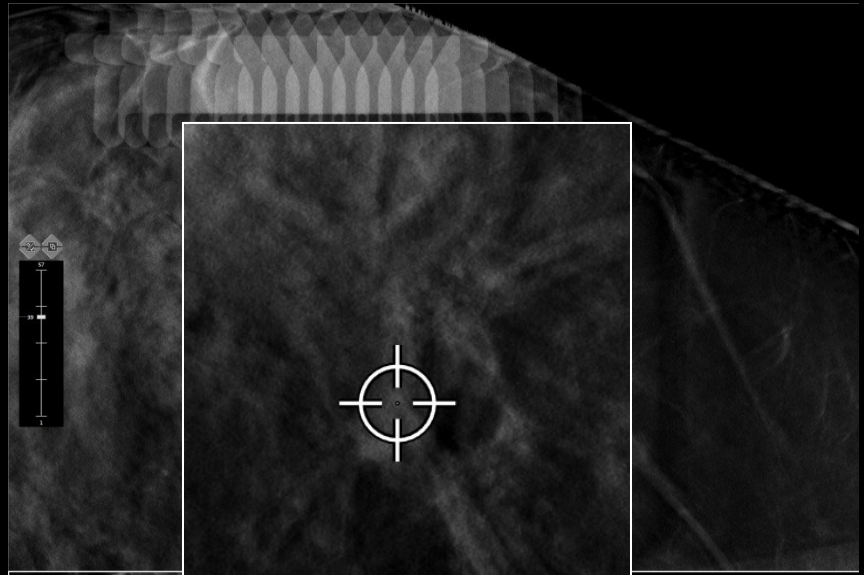
Option to bring
cursor back with



+ fire

Tomosynthesis procedure - Case 3 Clip

Invasive ductal
carcinoma



Advantages of TVAB

- TVAB shows targets not detectable on stereotaxy
- TVAB shows distortions
- TVAB offers distances for verification
target to skin (CC, ML)
- TVAB offers distances for planning best access path (upright (CC, MLO or lateral recumbent)
- TVAB can separate target lesions & calcifications within disseminated lesions/ calcifications

Take home

1. Why will 3D replace Digital Mammography?

- 3D unmask masses, distortions, mc in low and dense tissue
- Increased cancer detection/ less recalls/ less stress

2. Why is radiation exposure of 3D no issue anymore?

- C-View: synthetic 2D + 3D, no additional radiation
- Do it!, tumor size matters, distortions = interval Ca, do not harm your patient....

3. Why is TVAB so much better than SVAB?

- Get solid lesions and distortions you don't get with stereotaxy. Take distortions out. No miscalculations. Faster. ***Use the time for the real important things in life.....***