

Mammographic Calcifications

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Primary Signs of Malignancy

- Mass
- Calcifications
- Asymmetry
- Architectural distortion

Primary Signs of Malignancy

- Mass
- Calcifications
- Asymmetry
- Architectural distortion

Calcifications

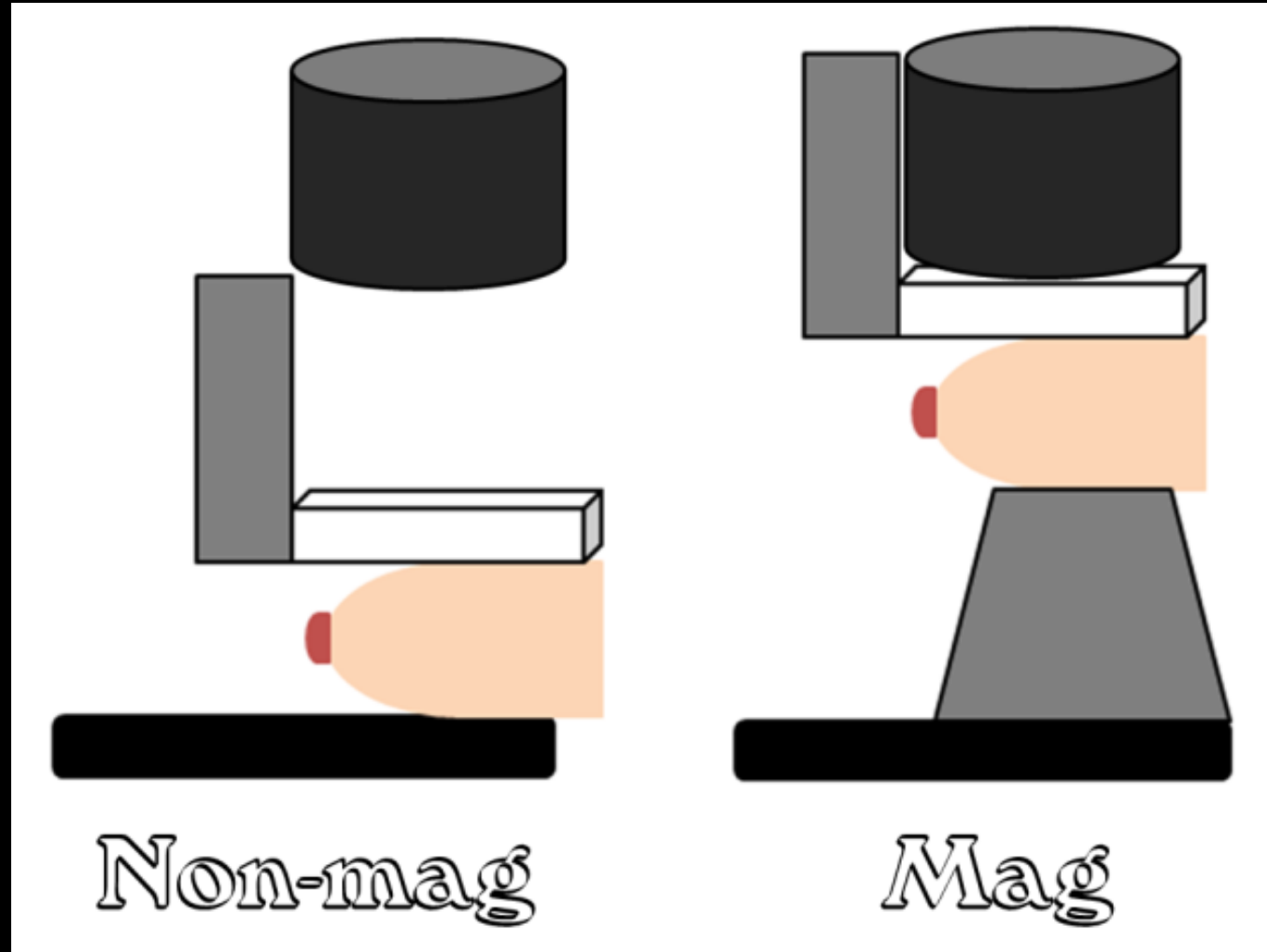
- Morphology
- Distribution

Spot Compression Magnification

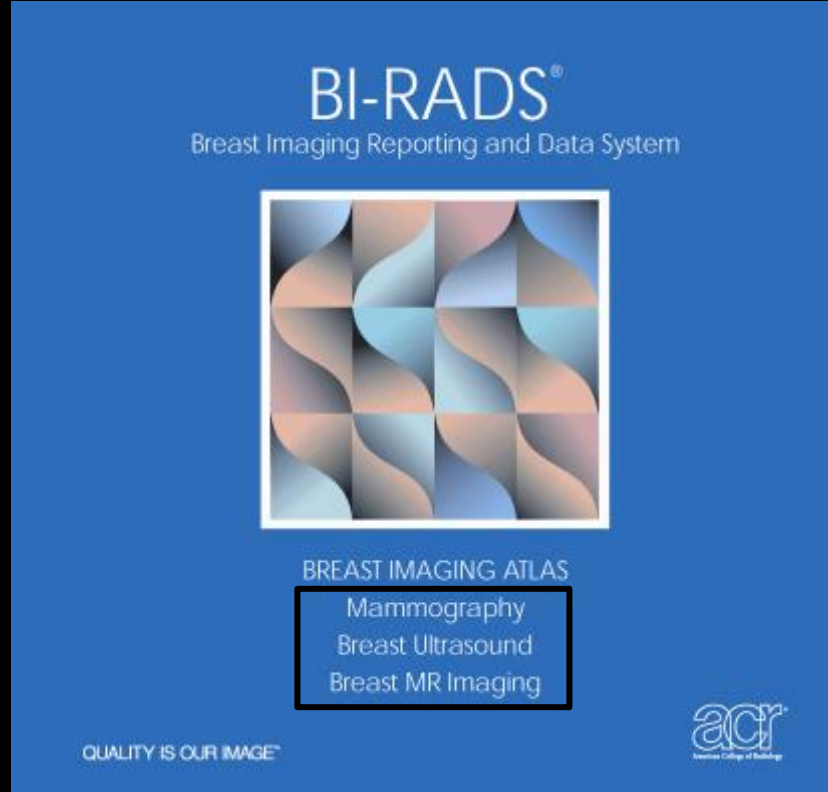
CC

90-degree
lateral

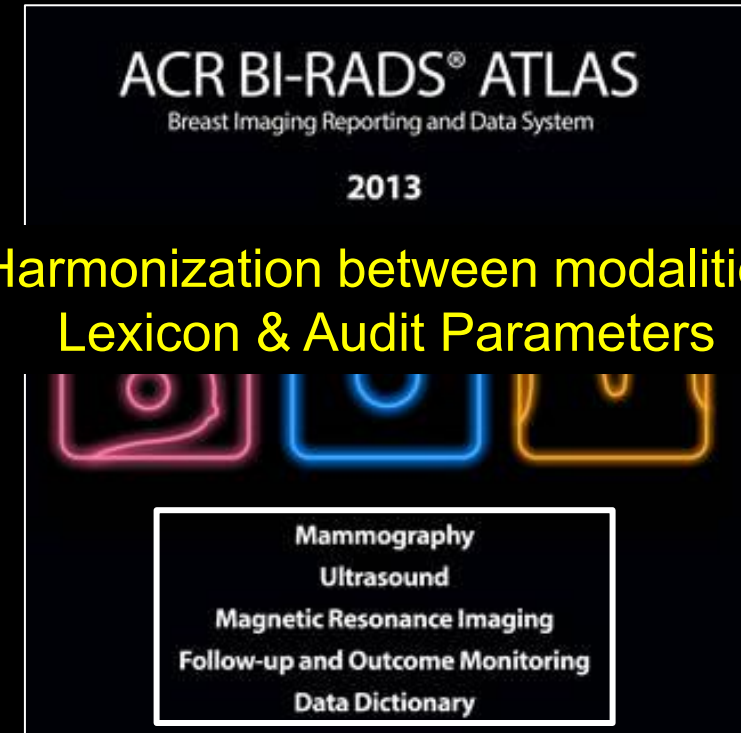
Oblique?



Breast Imaging Reporting and Data System BI-RADS



4th Edition
2003



5th Edition
2013

Harmonization between modalities
Lexicon & Audit Parameters

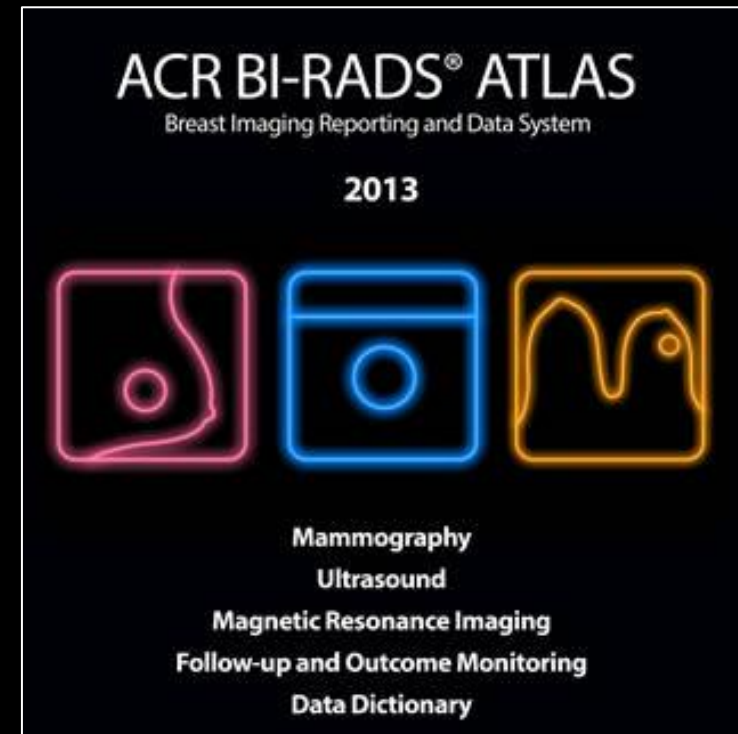
Breast Imaging Reporting and Data System

BI-RADS

Organizational Changes

- No longer called 6th edition, but 2025 edition
- No longer called “lexicon and atlas”, but “manual”
- **BI-RADS v2025 Manual**

6th Edition
2025

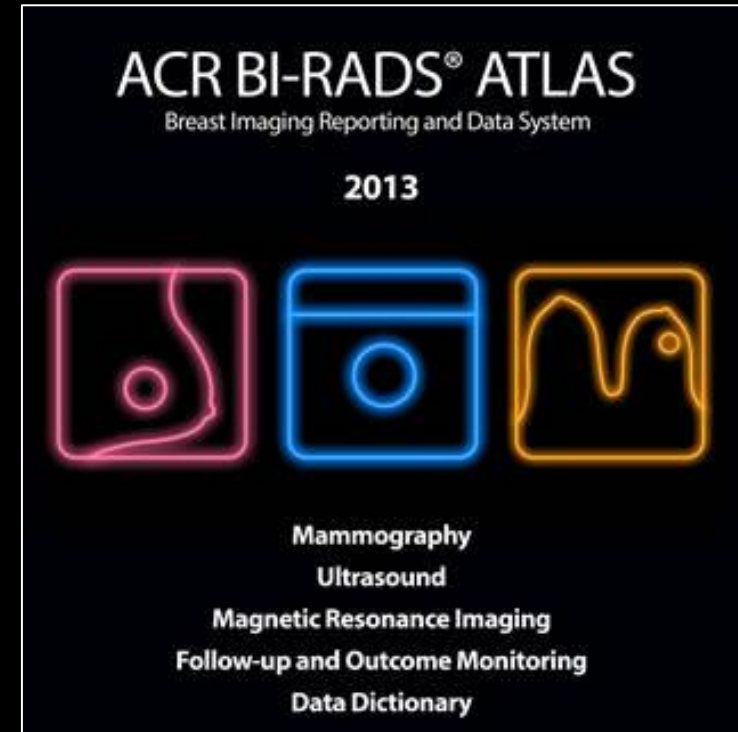


5th Edition
2013

Breast Imaging Reporting and Data System BI-RADS

- **BI-RADS v2025 Manual**
- Mammography
- Ultrasound
- MRI
- **CEM**
- Audit and Outcomes Monitoring

6th Edition
2025



5th Edition
2013



American College
of Radiology™

BI-RADS® v2025 Manual

Breast Imaging Reporting
and Data System



BI-RADS v2025

- Lexicon terms re-ordered from **least to most suspicious**, where practical
- **Harmonization** across modalities

ACR BI-RADS® Atlas Fifth Edition

QUICK REFERENCE



ULTRASOUND

Tissue composition (screening only)	a. Homogeneous background echotexture – fat b. Homogeneous background echotexture – fibroglandular c. Heterogeneous background echotexture	
Masses	Shape	Oval Round Irregular
	Orientation	Parallel Not parallel
	Margin	Circumscribed Not circumscribed - Indistinct - Angular - Microlobulated - Spiculated
	Echo pattern	Anechoic Hyperechoic Complex cystic and solid Hypoechoic Isoechoic Heterogeneous
	Posterior features	No posterior features Enhancement Shadowing Combined pattern
Calcifications	Calcifications in a mass	
	Calcifications outside of a mass Intraductal calcifications	
Associated features	Architectural distortion	
	Duct changes	Skin thickening Skin retraction
	Edema	
	Vascularity	Absent Internal vascularity Vessels in rim
	Elasticity assessment	Soft Intermediate Hard
Special cases	Simple cyst	
	Clustered microcysts	
	Complicated cyst	
	Mass in or on skin	
	Foreign body including implants	
	Lymph nodes – intramammary	
	Lymph nodes – axillary	
	Vascular abnormalities	
	AVMs (arteriovenous malformations/pseudoaneurysms) Mondor disease	
	Postsurgical fluid collection	
	Fat necrosis	



MAMMOGRAPHY

Breast composition	a. The breasts are almost entirely fatty b. There are scattered areas of fibroglandular density c. The breasts are heterogeneously dense, which may obscure small masses d. The breasts are extremely dense, which lowers the sensitivity of mammography		
Masses	Shape	Oval Round Irregular	
	Margin	Circumscribed Obscured Microlobulated Indistinct Spiculated	
	Density	High density Equal density Low density Fat-containing	
	Calcifications	Typically benign	Skin Vascular Coarse or "popcorn-like" Large rod-like Round Rim Dystrophic Milk of calcium Suture
		Suspicious morphology	Amorphous Coarse heterogeneous Fine pleomorphic Fine linear or fine-linear branching
Distribution		Diffuse Regional Grouped Linear Segmental	
Architectural distortion			
Asymmetries		Asymmetry	Global asymmetry Focal asymmetry Developing asymmetry
	Intramammary lymph node		
Skin lesion			
Solitary dilated duct			
Associated features	Skin retraction		
	Nipple retraction		
	Skin thickening		
	Trabecular thickening		
	Axillary adenopathy		
	Architectural distortion		
	Calcifications		
Location of lesion	Laterality		
	Quadrant and clock face		
	Depth		
	Distance from the nipple		



MAGNETIC RESONANCE IMAGING

Amount of fibroglandular tissue (FGT)	a. Almost entirely fat b. Scattered fibroglandular tissue c. Heterogeneous fibroglandular tissue d. Extreme fibroglandular tissue		Associated features	Nipple retraction		
Background parenchymal enhancement (BPE)	Level	Minimal Mild Moderate Marked		Nipple invasion		
	Symmetric or asymmetric	Symmetric Asymmetric		Skin retraction		
				Skin thickening		
				Skin invasion		
Focus			Direct invasion Inflammatory cancer			
Masses	Shape	Oval Round Irregular	Fat containing lesions	Axillary adenopathy		
	Margin	Circumscribed Not circumscribed - Irregular - Spiculated		Pectoralis muscle invasion		
	Internal enhancement characteristics	Homogeneous Heterogeneous Rim enhancement Dark internal septations		Chest wall invasion		
				Architectural distortion		
				Lymph nodes		
Non-mass enhancement (NME)	Distribution	Focal Linear Segmental Regional Multiple regions Diffuse	Location of lesion	Normal Abnormal		
	Internal enhancement patterns	Homogeneous Heterogeneous Clumped Clustered ring		Fat necrosis Hamartoma Postoperative seroma/hematoma with fat		
				Location		
				Depth		
				Kinetic curve assessment		
Intramammary lymph node			Implants	Initial phase		
Skin lesion	Ductal precontrast high signal on T1W			Slow Medium Fast		
	Non-enhancing findings	Cyst		Kinetic curve assessment Signal intensity (SI)/time curve description	Delayed phase	
		Postoperative collections (hematoma/seroma)			Persistent Plateau Washout	
		Post-therapy skin thickening and trabecular thickening			Implant material and lumen type	
		Non-enhancing mass	Saline Silicone - Intact - Ruptured Other implant material			
Architectural distortion			Lumen type			
Signal void from foreign bodies, clips, etc.			- Single - Double - Other			
			Implant location			
			Retroglandular Retropectoral			
			Abnormal implant contour			
			Focal bulge			
			Intracapsular silicone findings			
			Radial folds Subcapsular line Keyhole sign (teardrop, noose) Lingule sign			
			Extracapsular silicone			
			Breast Lymph nodes			
			Water droplets			
			Peri-implant fluid			

BI-RADS® ASSESSMENT CATEGORIES

Category 0: Mammography: Incomplete – Need Additional Imaging Evaluation and/or Prior Mammograms for Comparison
Ultrasound & MRI: Incomplete – Need Additional Imaging Evaluation

Category 1: Negative

Category 2: Benign

Category 3: Probably Benign

Category 4: Suspicious

Mammography & Ultrasound: Category 4A: Low suspicion for malignancy
Category 4B: Moderate suspicion for malignancy
Category 4C: High suspicion for malignancy

Category 5: Highly Suggestive of Malignancy

Category 6: Known Biopsy-Proven Malignancy

ACR BI-RADS® Atlas Fifth Edition

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Architectural distortion		
Asymmetries	Asymmetry	
	Global asymmetry	
	Focal asymmetry	
	Developing asymmetry	
Intramammary lymph node		
Skin lesion		
Solitary dilated duct		
Associated features	Skin retraction	
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		Mild		Skin retraction	
	Symmetric or asymmetric	Moderate Marked		Skin thickening	
Focus	Symmetric or asymmetric	Symmetric	Fat containing lesions	Skin invasion	Direct invasion Inflammatory cancer
		Asymmetric		Axillary adenopathy	
				Pectoralis muscle invasion	
				Chest wall invasion	
Masses	Shape	Oval	Location of lesion	Lymph nodes	Normal Abnormal
		Round Irregular		Fat necrosis	
	Margin	Circumscribed		Hamartoma	
		Not circumscribed - Irregular - Spiculated		Postoperative seroma/hematoma with fat	
Internal enhancement characteristics	Internal enhancement characteristics	Homogeneous	Kinetic curve assessment Signal intensity (SI)/time curve description	Initial phase	Slow Medium Fast
		Heterogeneous		Delayed phase	Persistent
		Rim enhancement			Plateau
		Dark internal septations			Washout
Non-mass enhancement (NME)	Distribution	Focal	Implants	Implant material and lumen type	Saline Silicone - Intact - Ruptured Other implant material
		Linear		Lumen type - Single - Double - Other	
		Segmental			
		Regional			
Internal enhancement patterns	Internal enhancement patterns	Multiple regions	Implant location	Retroglandular	
		Diffuse		Retropectoral	
		Homogeneous		Focal bulge	
		Heterogeneous			
Intramammary lymph node			Intracapsular silicone findings	Radial folds	
Skin lesion	Ductal precontrast high signal on T1W	Cyst Postoperative collections (hematoma/seroma) Post-therapy skin thickening and trabecular thickening Non-enhancing mass Architectural distortion Signal void from foreign bodies, clips, etc.		Subcapsular line	
				Keyhole sign (teardrop, noose)	
				Lingule sign	
			Extracapsular silicone	Breast	
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Masses	Shape	Oval		Pectoralis muscle invasion			
		Round		Chest wall invasion			
	Irregular	Architectural distortion					
	Margin	Circumscribed		Lymph nodes			
		Not circumscribed	Normal				
		- Irregular	Abnormal				
		- Spiculated	Fat necrosis				
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		Rim enhancement	Location				
		Dark internal septations	Depth				
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		Linear		Slow			
	Segmental	Signal intensity (SI)/time curve description	Medium				
	Regional		Fast				
	Multiple regions	Delayed phase	Persistent				
	Diffuse		Plateau				
	Internal enhancement patterns	Homogeneous	Washout				
		Heterogeneous	Implant material and lumen type				
		Clumped	Saline				
		Clustered ring	Silicone				
Intramammary lymph node			Implants	- Intact			
Skin lesion	Non-enhancing findings	Ductal precontrast high signal on T1W		- Ruptured			
		Cyst		Postoperative collections (hematoma/seroma)		Other implant material	
				Post-therapy skin thickening and trabecular thickening		Lumen type	
			Non-enhancing mass		- Single		
			Architectural distortion		- Double		
		Signal void from foreign bodies, clips, etc.		- Other			
				Implant location	Retroglandular		
					Retropectoral		
		Abnormal implant contour	Focal bulge				
		Intracapsular silicone findings	Radial folds				
			Subcapsular line				
		Extracapsular silicone	Keyhole sign (teardrop, noose)				
			Linguine sign				
		Water droplets	Breast				
			Lymph nodes				
		Peri-implant fluid					

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Category 5: Highly Suggestive of Malignancy

Category 6: Definitive of Malignancy

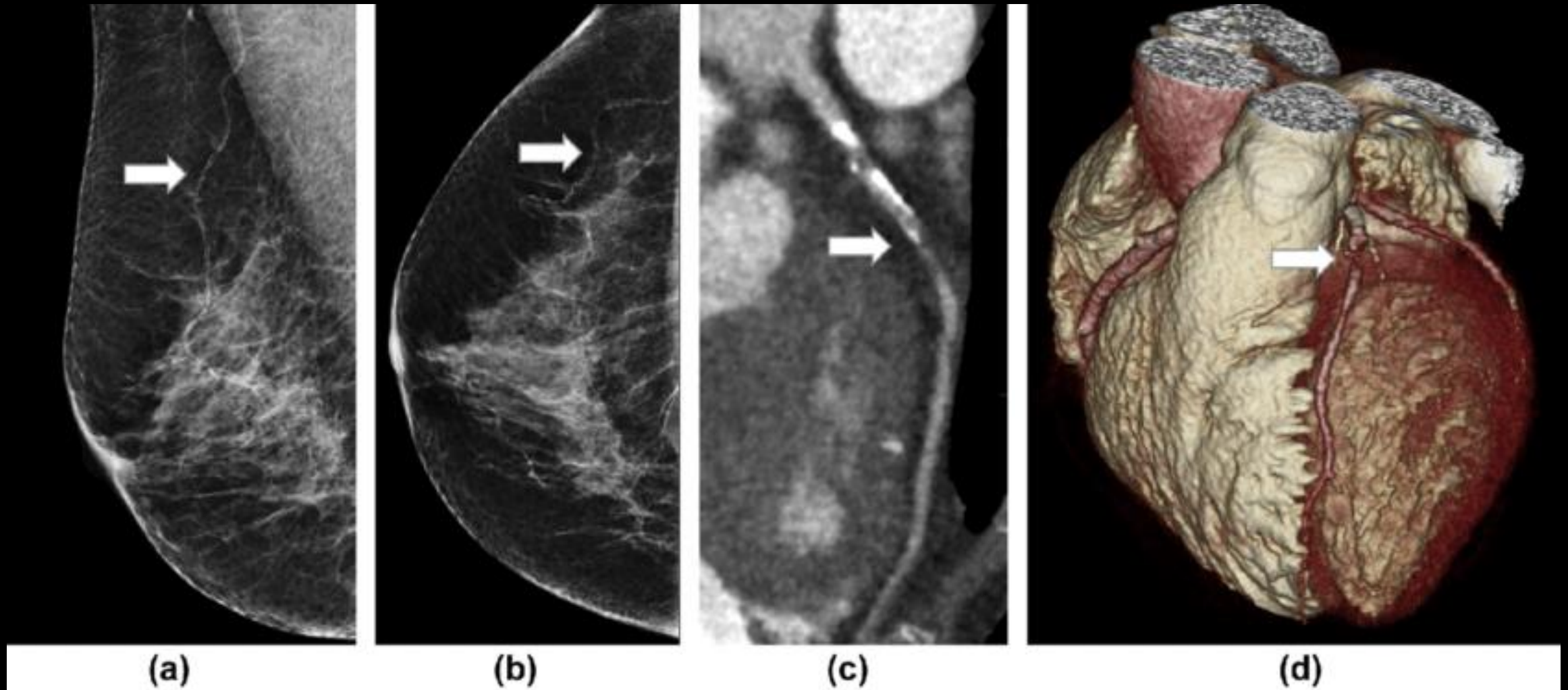
Calcifications: BI-RADS v2025

- Typically benign
 - Skin, vascular, coarse, large rod-like, round, rim, layering, suture (~~popcorn-like, dystrophic, punctate~~)
- Suspicious morphology
 - Amorphous, coarse heterogeneous, fine pleomorphic, fine linear or fine-linear branching
- Distribution
 - Diffuse, regional, grouped, linear, segmental

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Breast arterial calcifications (BAC) as a marker of risk for cardiovascular disease



Source: McLenachan S, et al. Clin Radiol 2019; 74:421-428

Assessment Categories

Category

Degree of Abnormality

1

Lowest

2

3

6

0

4

5

Highest



Source: BI-RADS 2013 ; Table 7. Abnormality Hierarchy

BI-RADS 1 Negative & 2 Benign

- Same management recommendation → routine mammography screening
- Category 2 used when at least one benign finding described (not only visualized)
- Recommend consensus in particular facility to describe finding or not

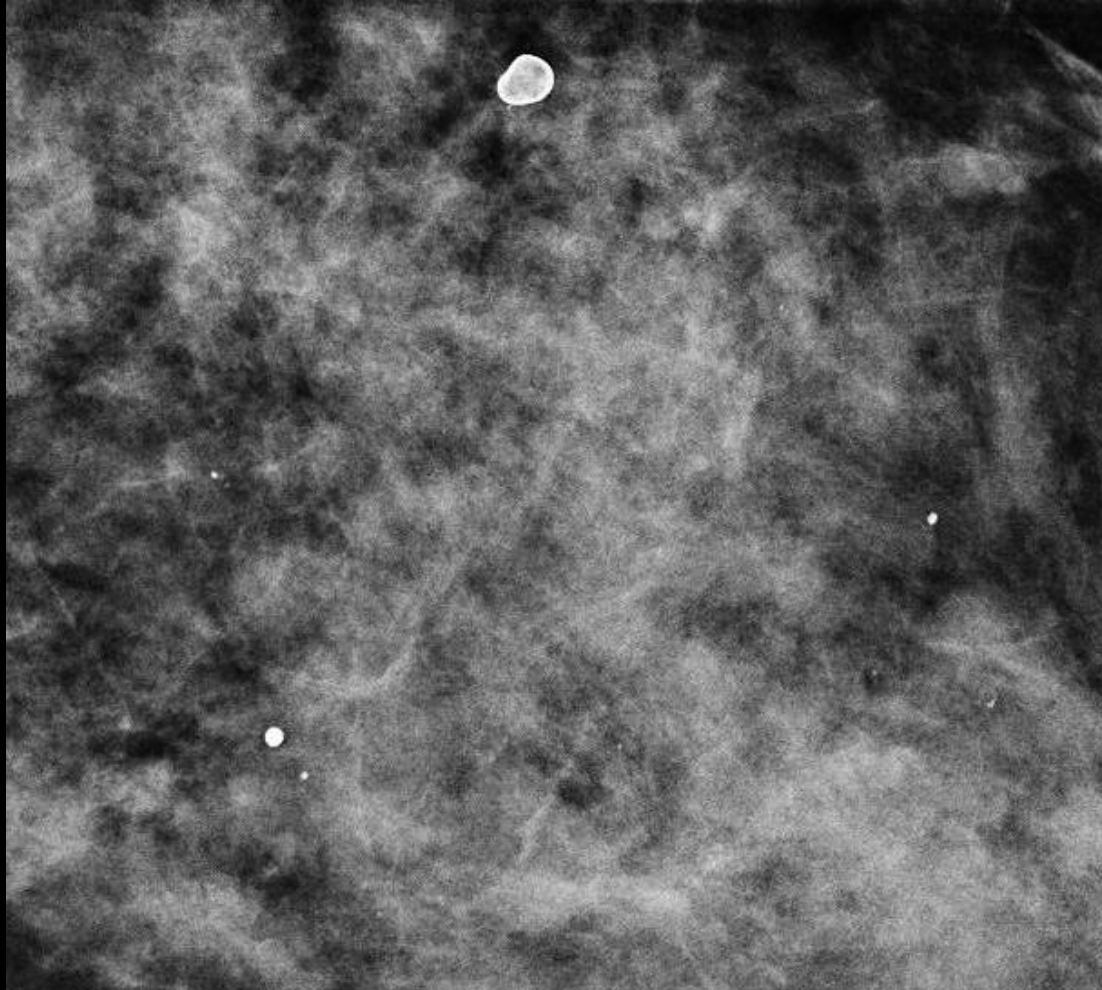
BI-RADS Assessment 2 Benign

- Typically benign morphology
 - Skin, vascular, coarse or “popcorn-like”, large rod-like
 - Round
 - If isolated group of punctate = BI-RADS 3
 - If new, increasing, linear or segmental = BI-RADS 4
 - Rim, lucent-centered
 - Dystrophic, milk-of-calcium, suture

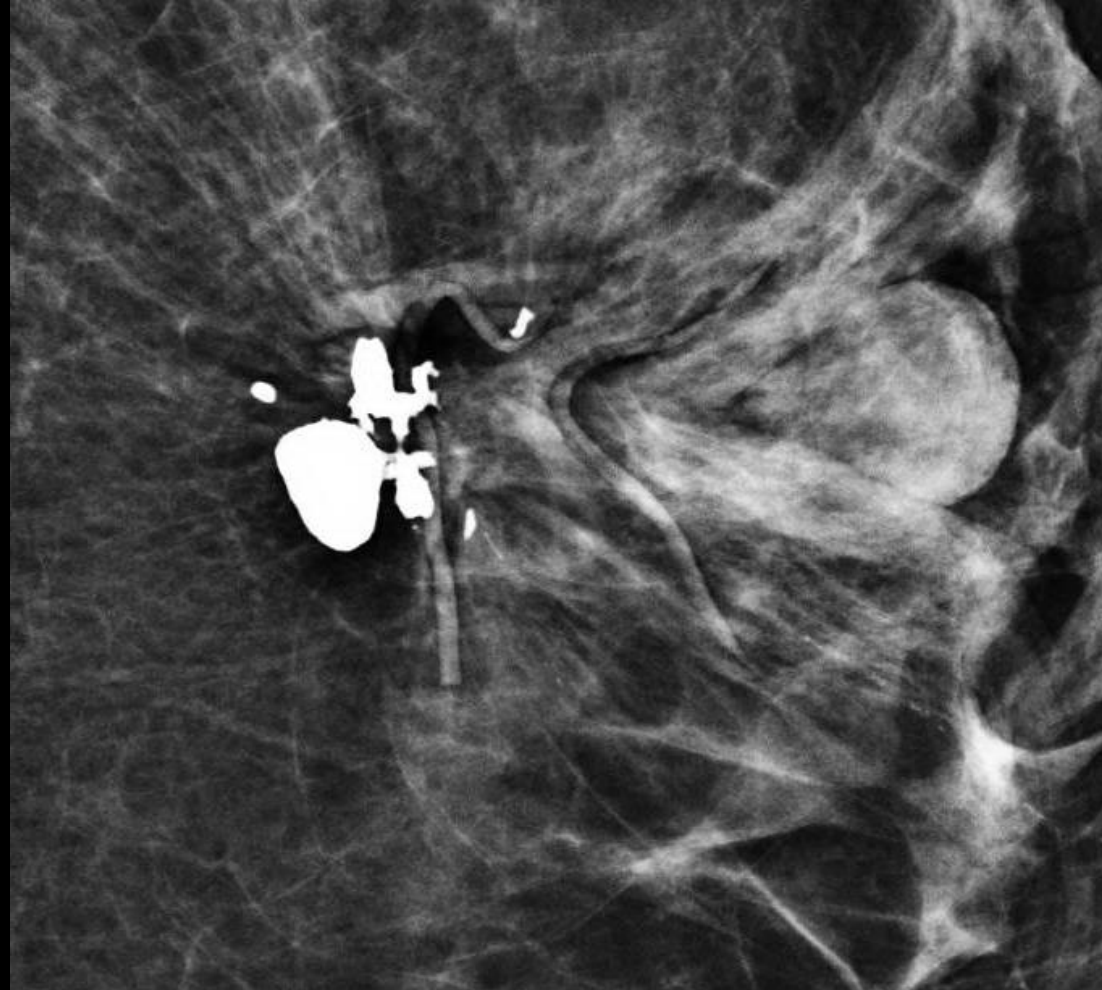
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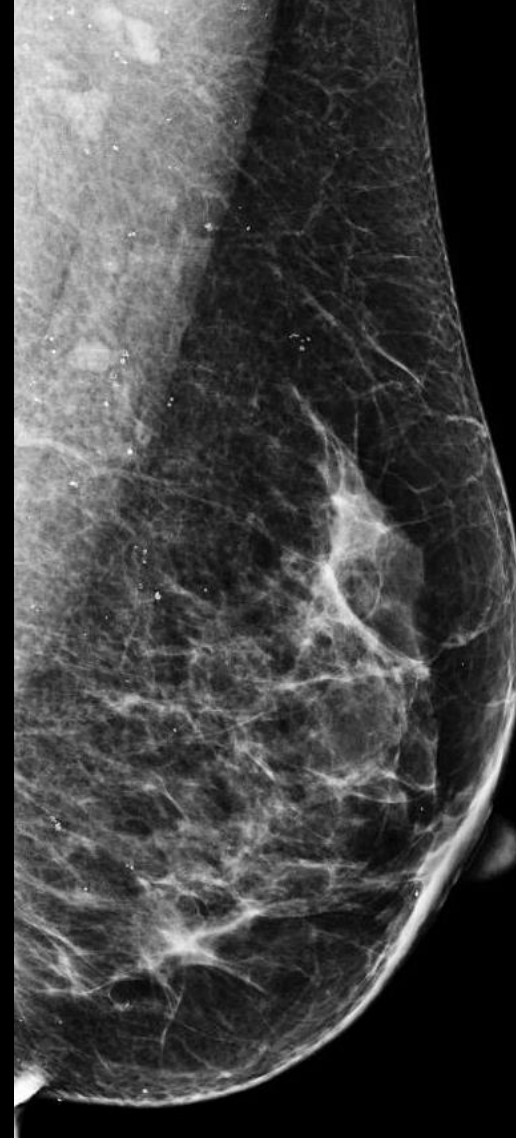
Round/punctate/rim



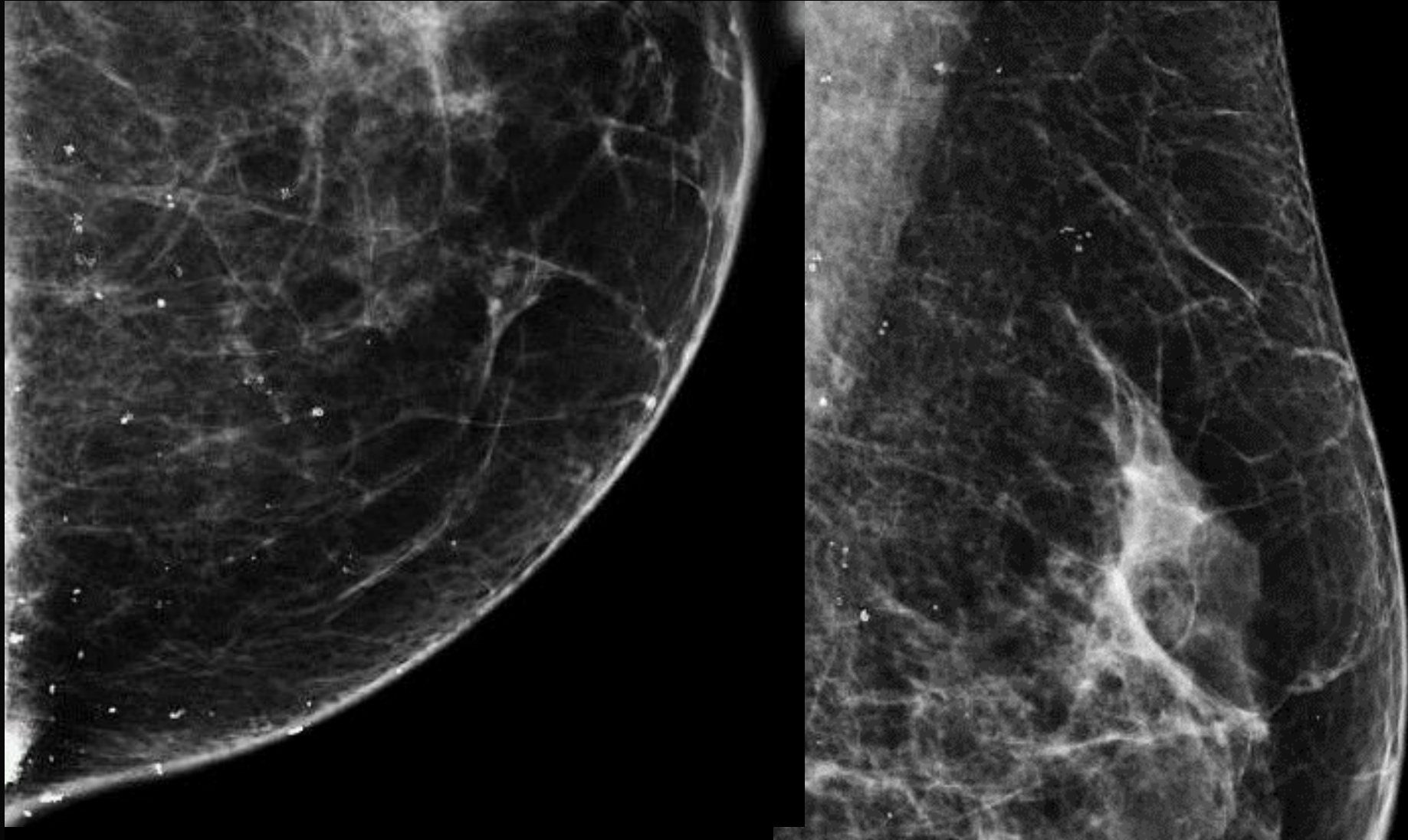
Dystrophic Coarse



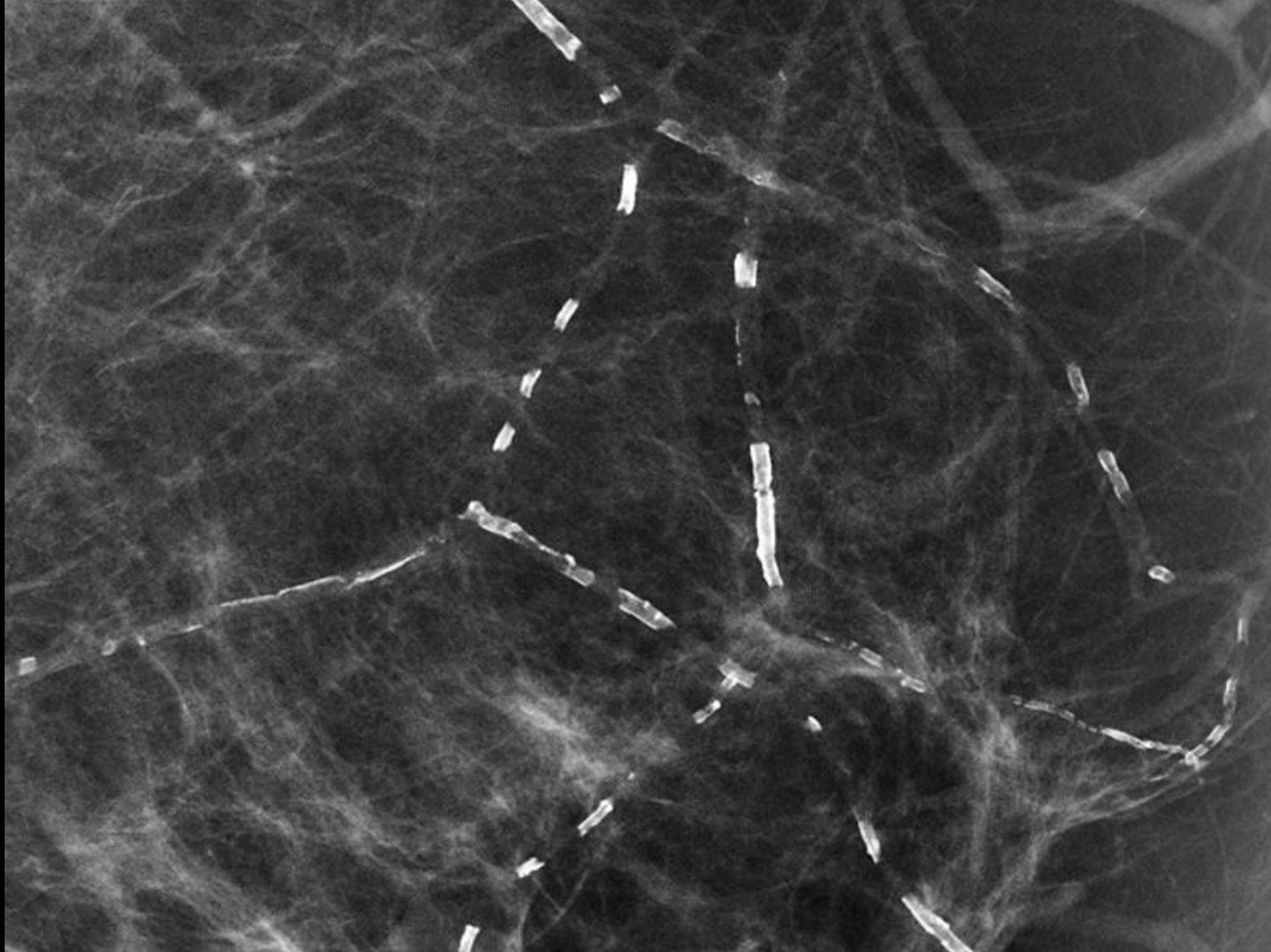
Skin Calcifications



Skin Calcifications



Vascular Calcifications



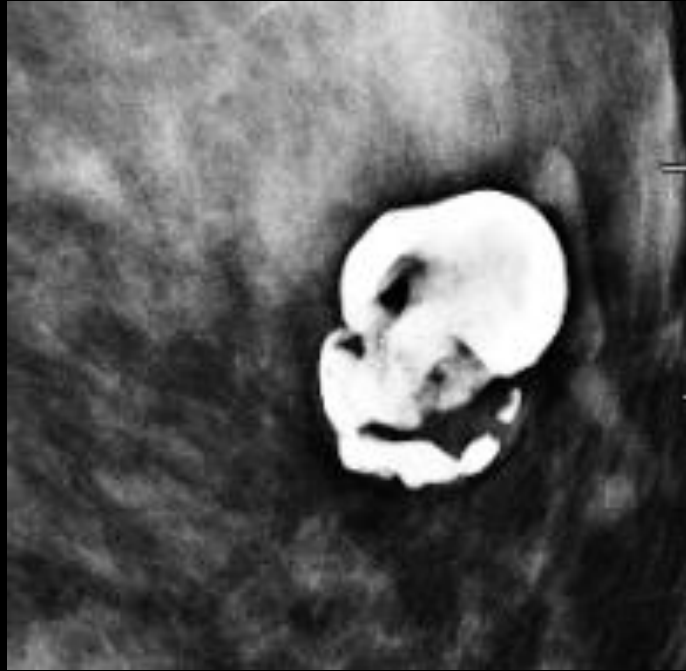
Secretory Calcifications



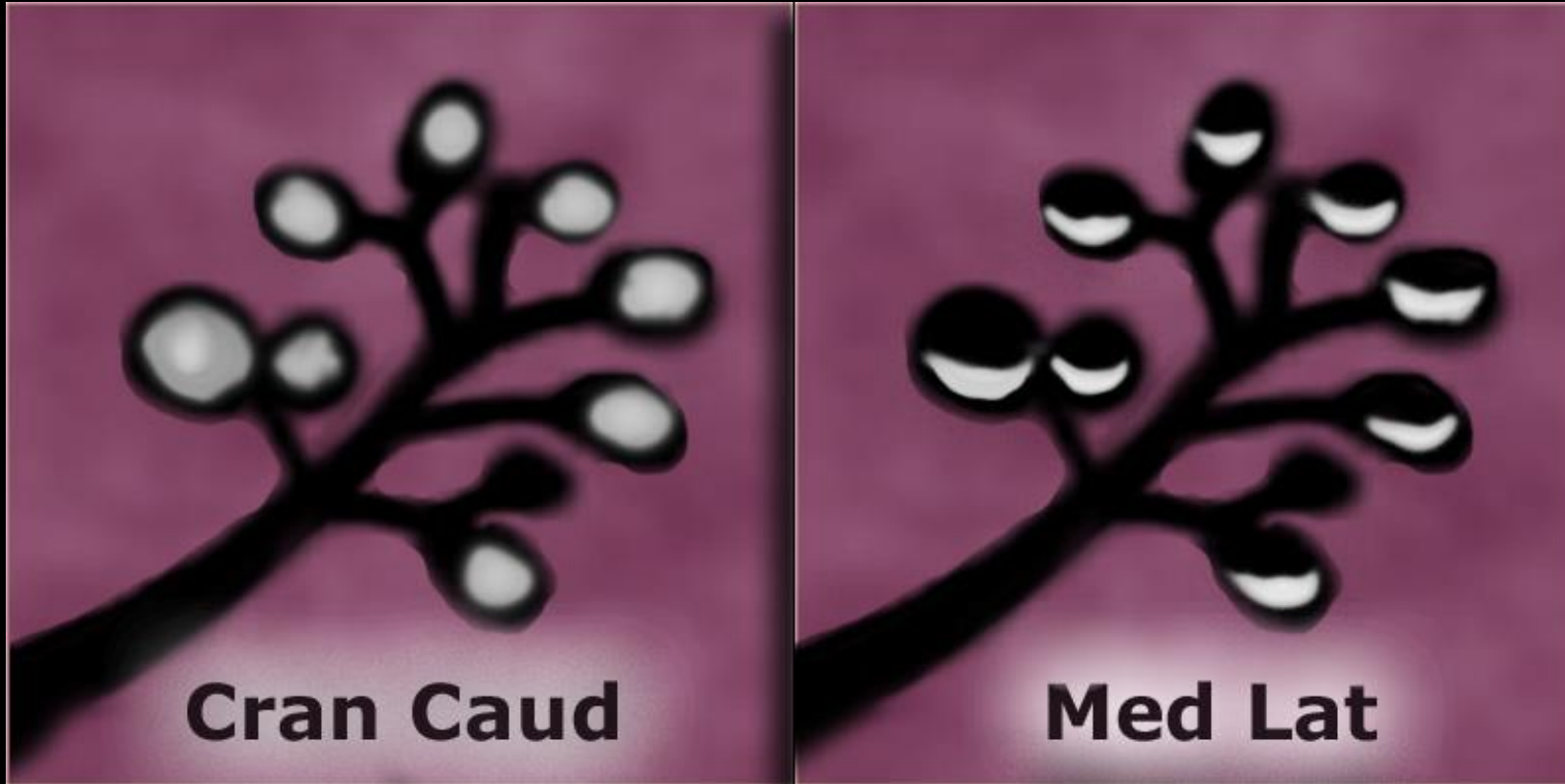
Musician Prince → changed his name to Love Symbol



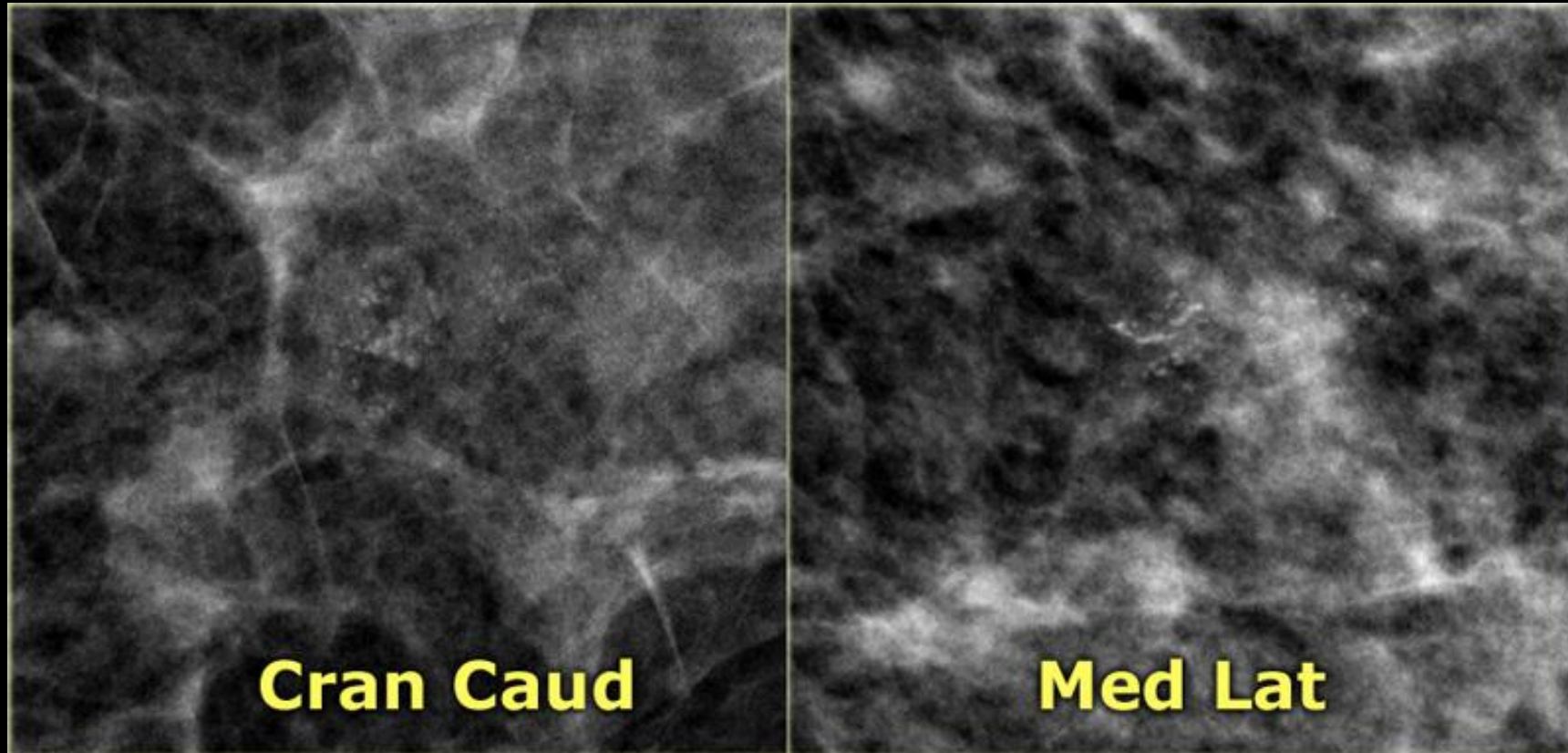
Coarse or “popcorn-like”



Milk-of-Calcium



~~Milk-of-Calcium~~



Milk-of-Calcium

Milk-of-calcium → Layering



Lateral



CC

BI-RAS Assessment 3 Probably Benign

- NOT indeterminate category when not sure benign (2) or suspicious (4)
- Specific imaging finding with known PPV of $> 0\%$ but $\leq 2\%$
 - Noncalcified circumscribed solid mass
 - Focal asymmetry
 - Solitary group of punctate (round) calcifications

BI-RADS Assessment 3 Probably Benign

- Only use after complete diagnostic evaluation (not at screening)
- Interval change → if not BI-RADS 2 → then recommend biopsy

Calcifications (BI-RADS 4, 5)

Level of Suspicion

Lowest

- Morphology

- Amorphous (10%)
- Coarse heterogeneous (13%)
- Fine pleomorphic (29%)
- Fine linear (70%)
- Fine linear branching (70%)

Highest



Table 3. Positive Predictive Value of Malignancy of Breast Calcifications Based on Morphology

Morphology Descriptor	Choi et al. 2020 [21]	Park et al. 2019 [22]	Kim et al. 2015 [23]	Bent et al. 2010 [24]	Burnside et al. 2007 [25]
Amorphous	9.1%	15.9%	7.9%	20%	13%
Coarse Heterogeneous	16.1%	31.7%	17.8%	20%	7%
Fine Pleomorphic	78.8%	58.2%	63.2%	28%	29%
Fine Linear or Fine Linear-Branching	78.6%	90.6%	100%	70%	53%

Source: BI-RADS v2025

Calcifications (BI-RADS 2, 3, 4, 5)

Level of Suspicion

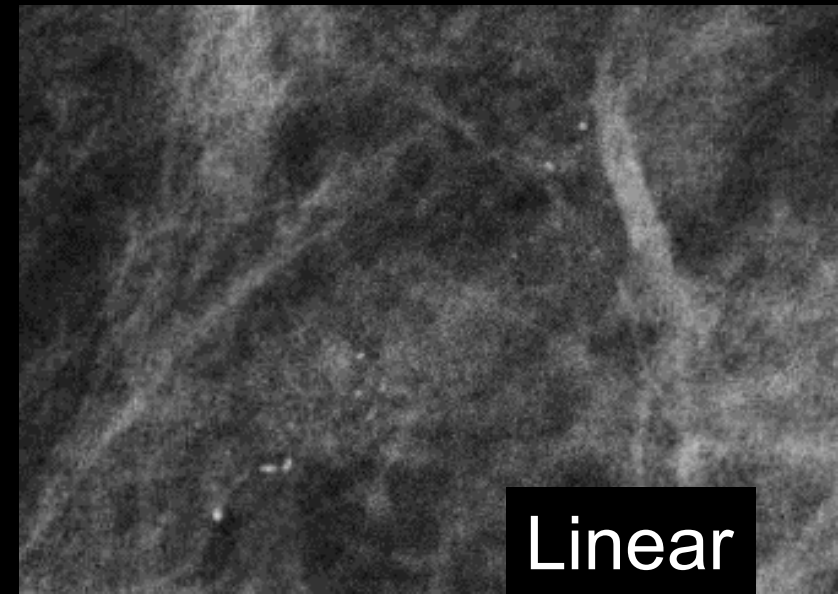
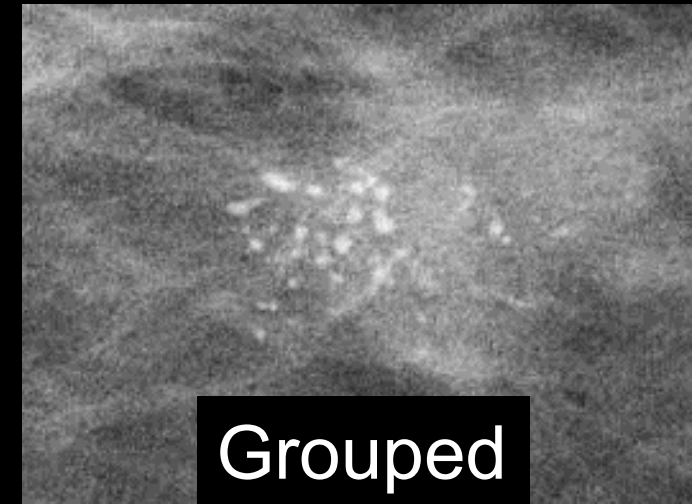
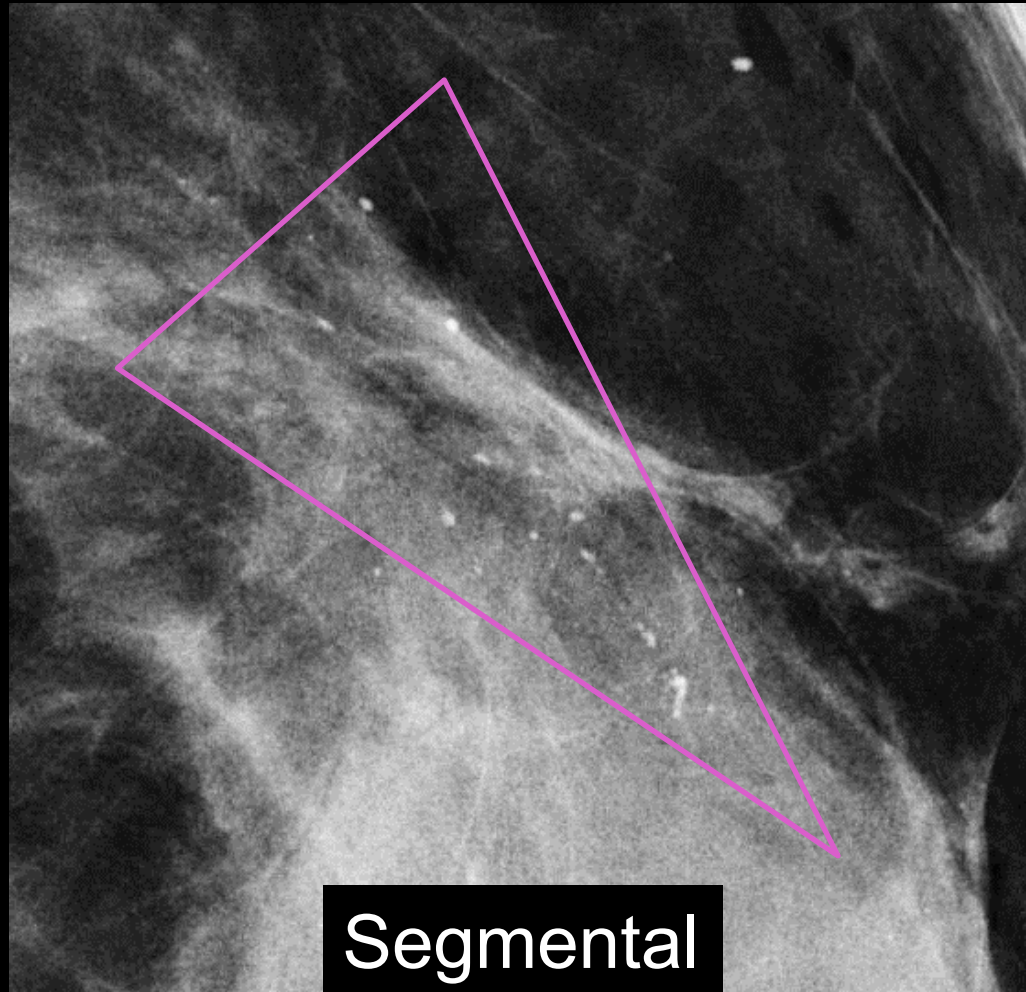
Lowest



Highest

- Distribution
 - Diffuse
 - Regional
 - Grouped, clustered
 - Linear
 - Segmental

Calcifications: Morphology & Distribution

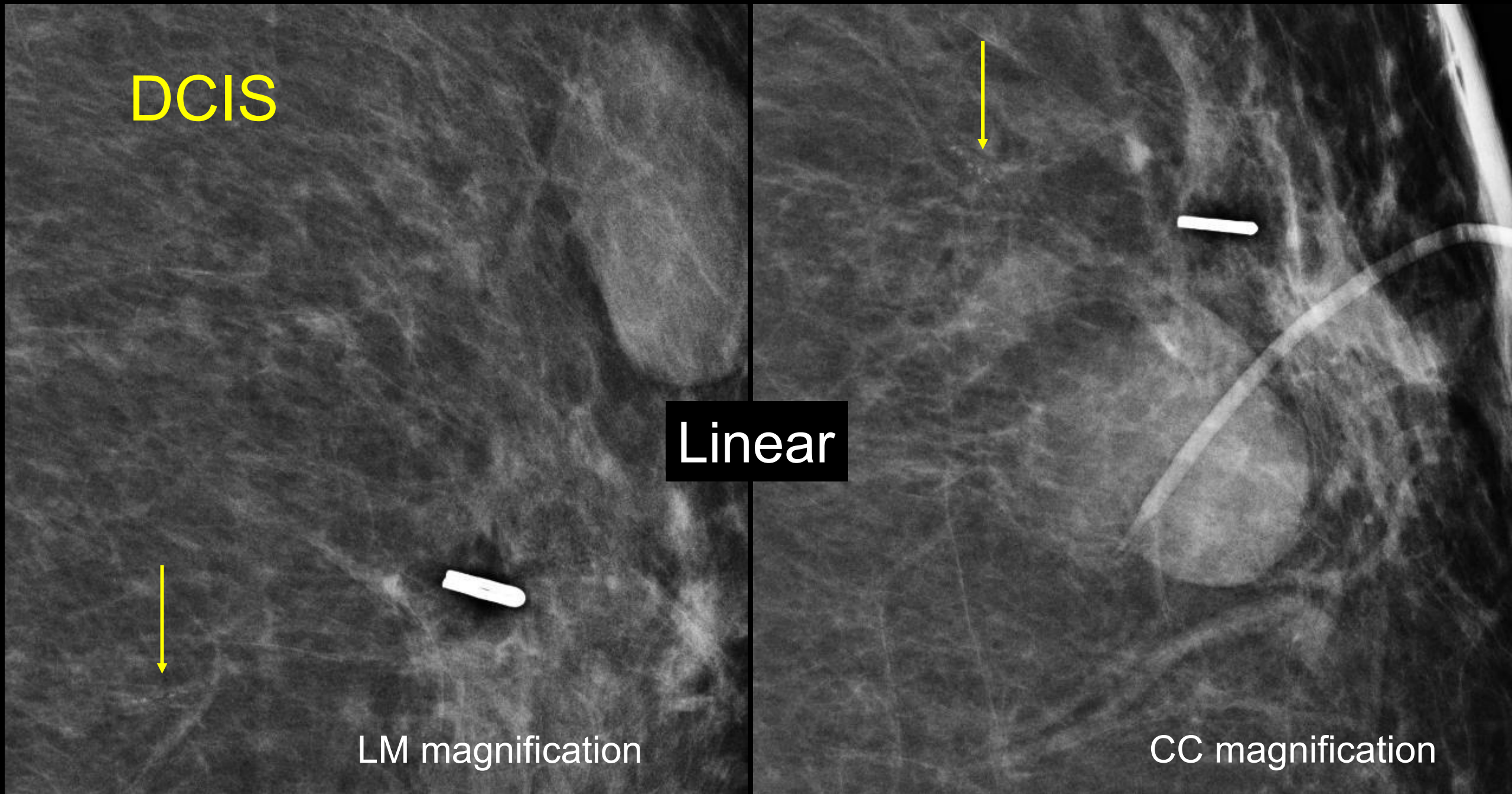


DCIS

Linear

LM magnification

CC magnification



BI-RADS Assessments 4, 5

- BI-RADS 4 = suspicious (>2 to $<95\%$ PPV)
- BI-RADS 5 = highly suggestive of malignancy ($\geq 95\%$ PPV)
- Both recommend tissue diagnosis

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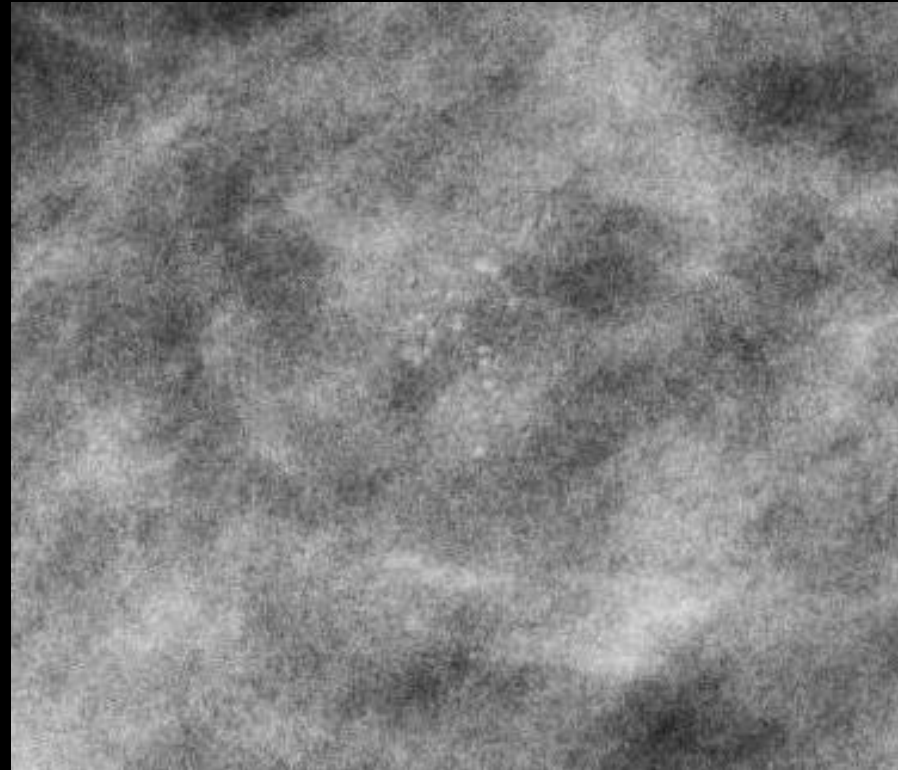
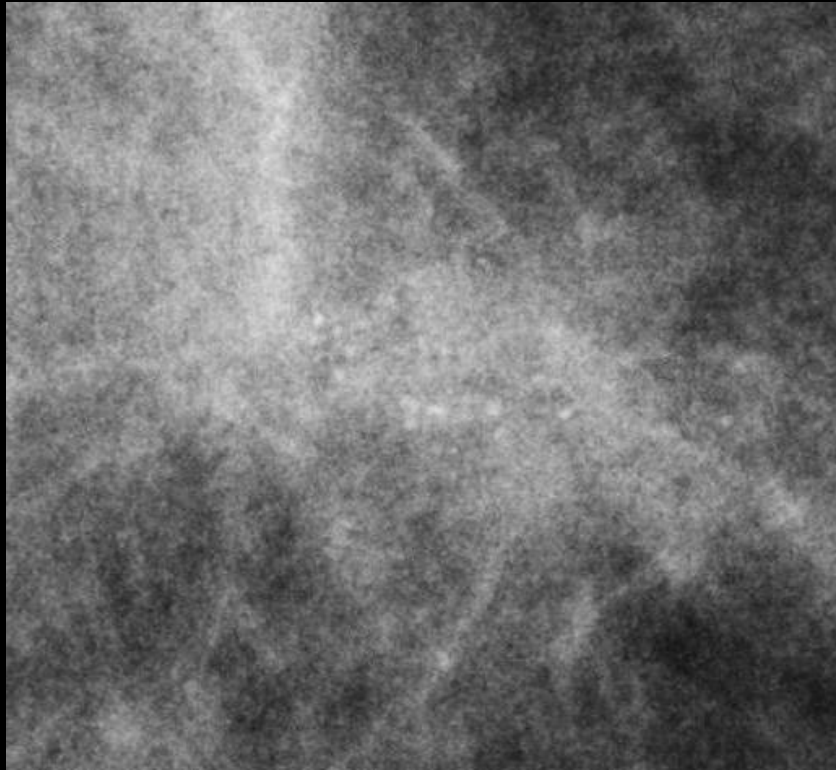
Calcifications (BI-RADS 4, 5)

- Amorphous
- Coarse heterogeneous
- Fine pleomorphic
- Fine linear or fine-linear branching

BI-RADS Assessments 4A, 4B, 4C

- 4A – low suspicion for malignancy ($>2\%$ to $\leq 10\%$)

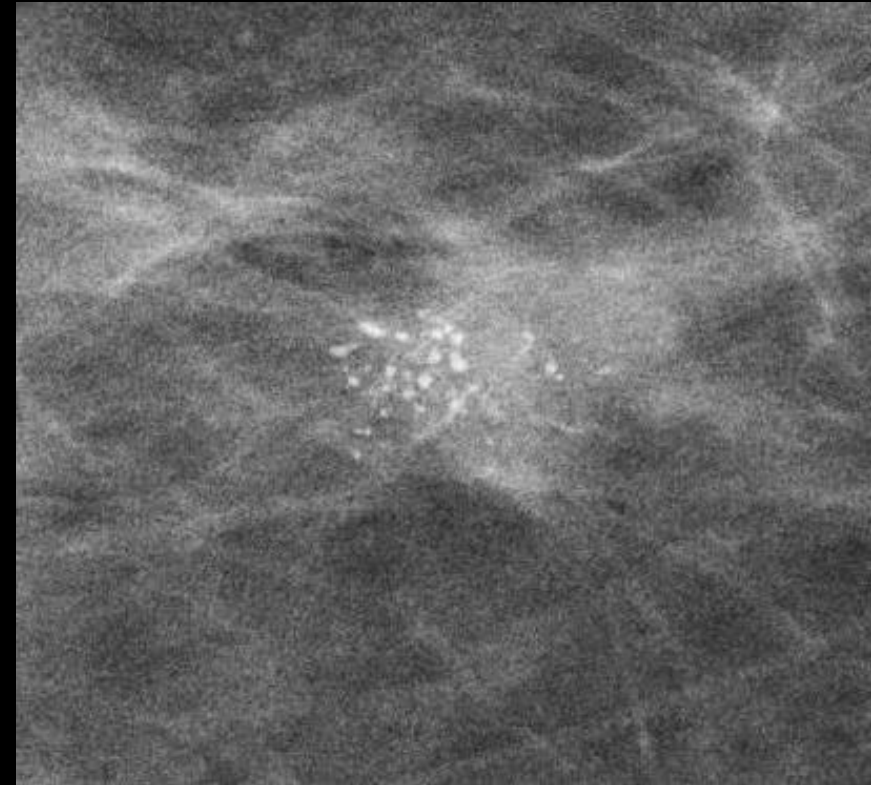
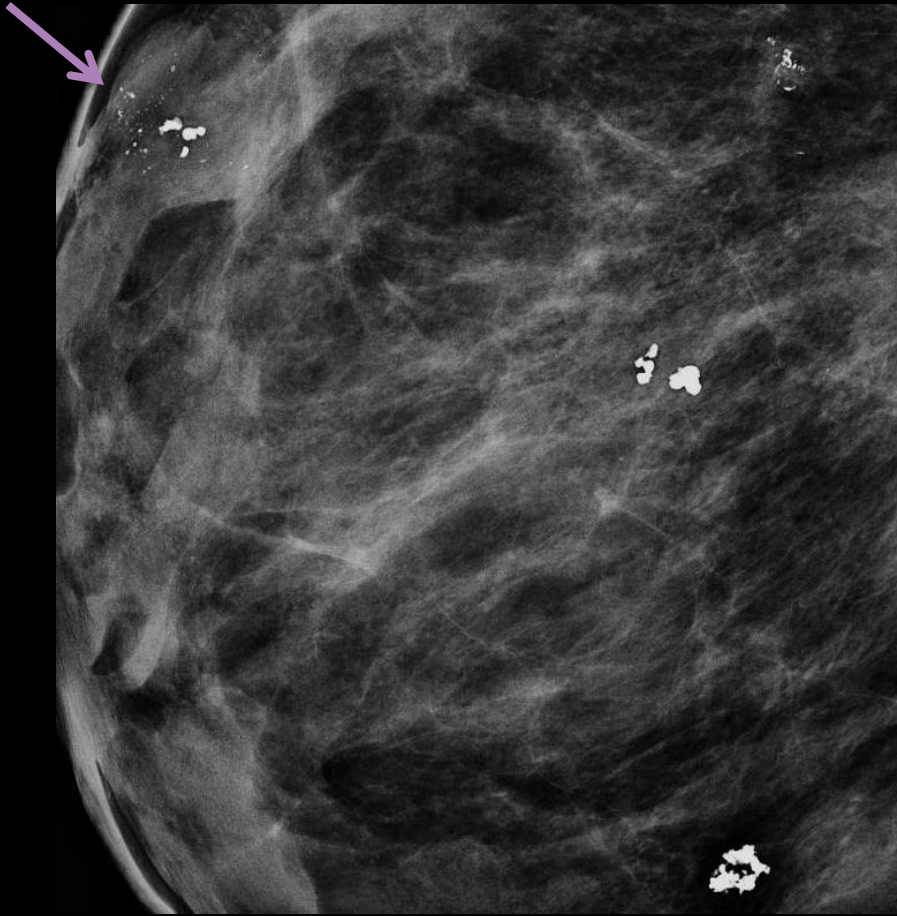
Amorphous (4A)



BI-RADS Assessments 4A, 4B, 4C

- 4A – low suspicion for malignancy ($>2\%$ to $\leq 10\%$)
- 4B – moderate suspicion for malignancy ($>10\%$ to $\leq 50\%$)

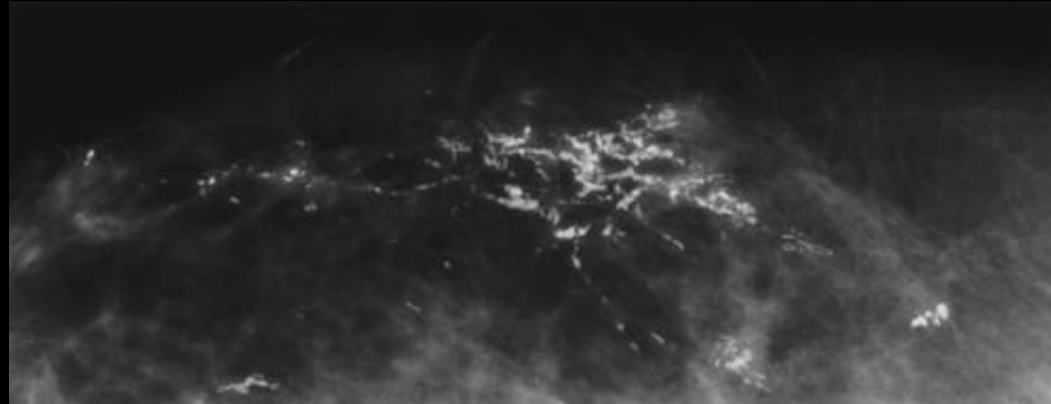
Coarse heterogeneous (4B)



BI-RADS Assessments 4A, 4B, 4C

- 4A – low suspicion for malignancy ($>2\%$ to $\leq 10\%$)
- 4B – moderate suspicion for malignancy ($>10\%$ to $\leq 50\%$)
- 4C – high suspicion for malignancy (but not classic) ($>50\%$ to $<95\%$)

Linear Branching Calcs (4C)



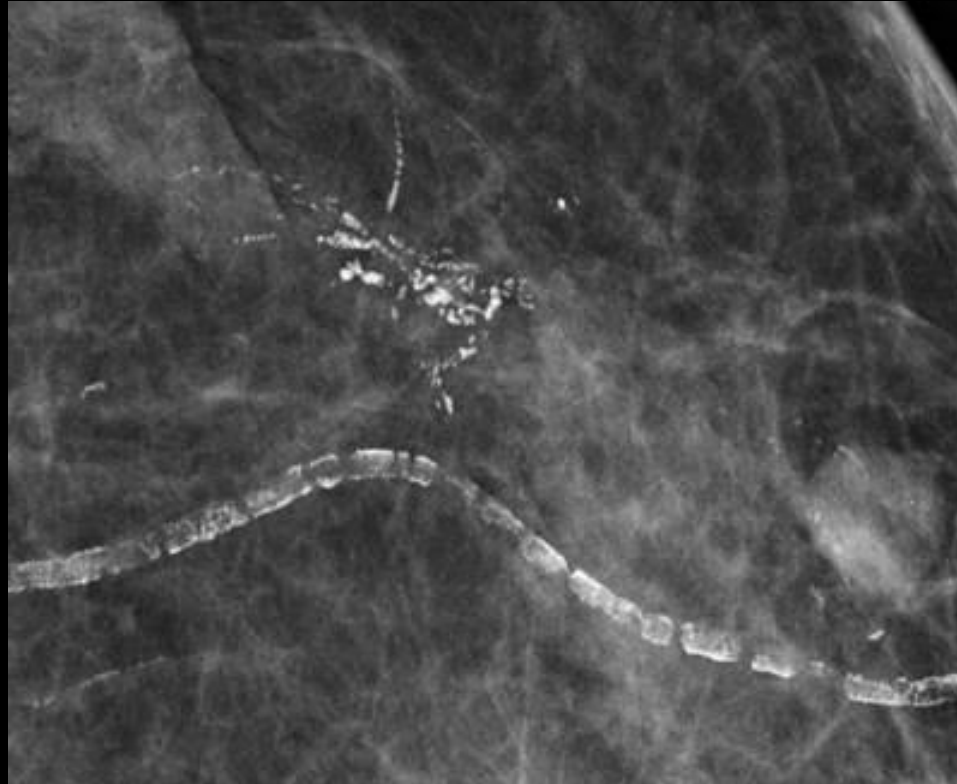
BI-RADS Assessments 4A, 4B, 4C

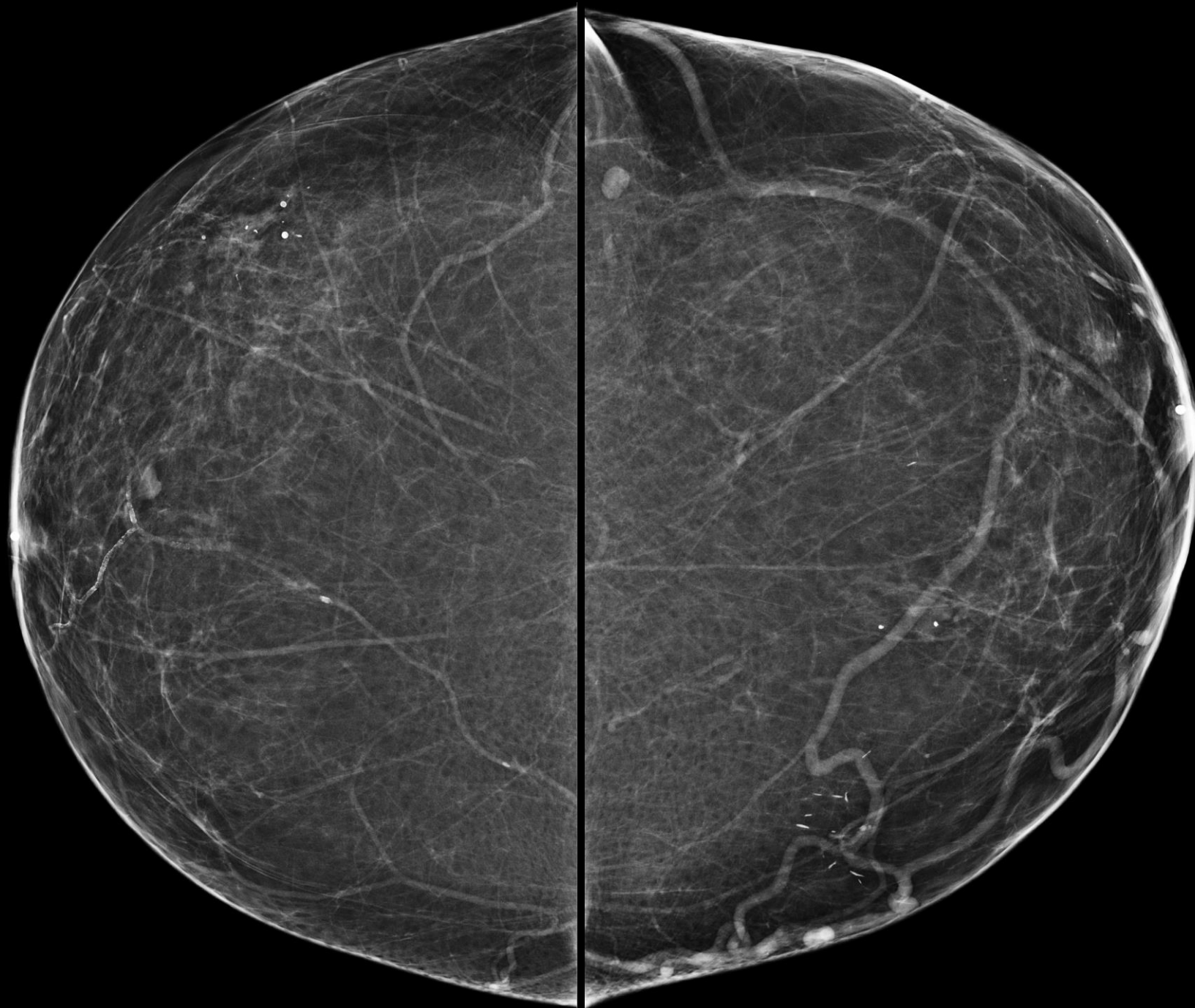
- More meaningful audit
- Clinical research
- Information to clinicians, pathologists
- NOT approved for MQSA as final assessment

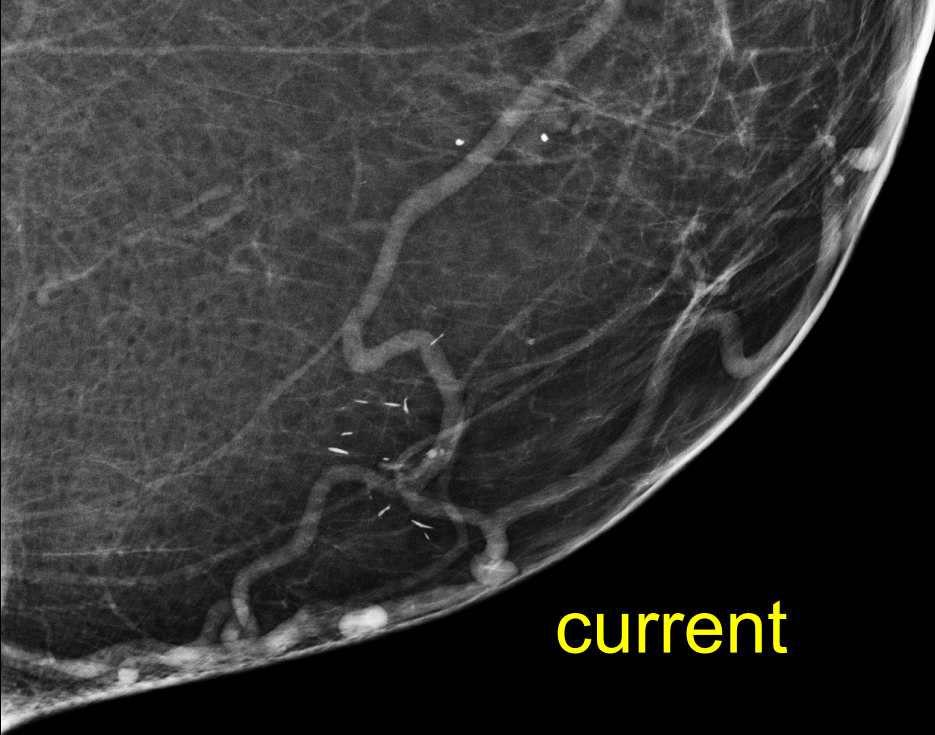
Multiple Etiologies



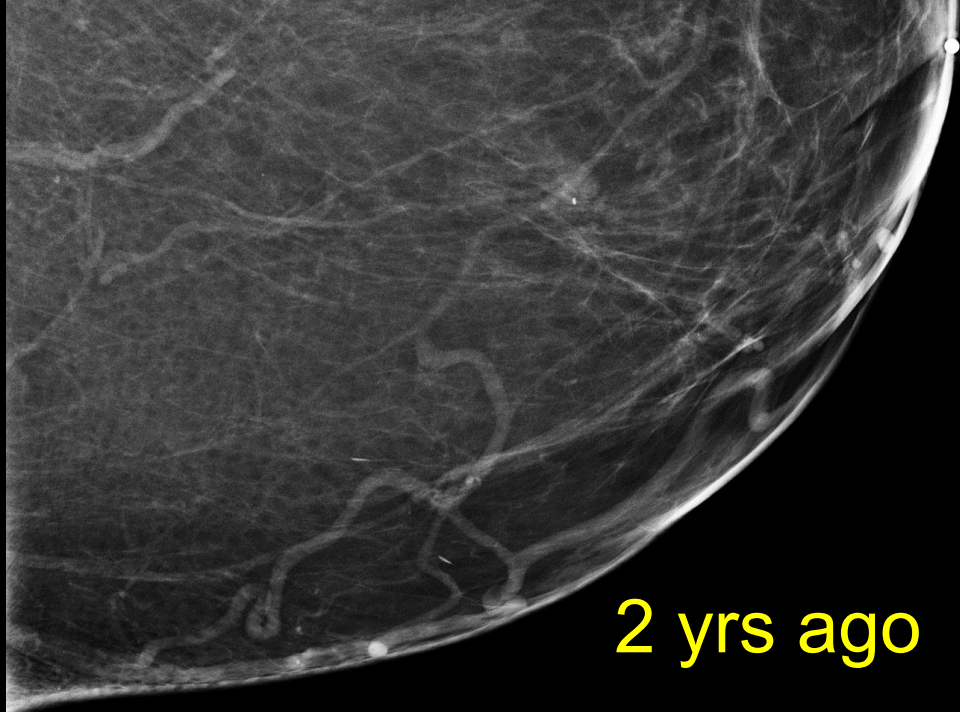
Multiple Etiologies





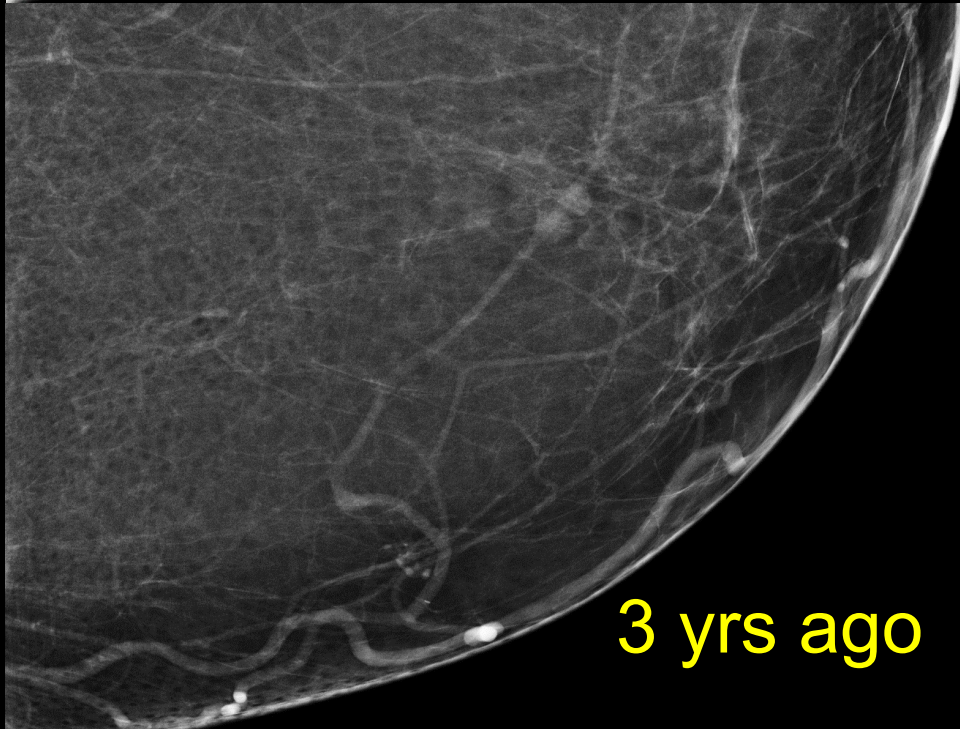


current



2 yrs ago

Interval increase may be seen in typical evolution of benign calcifications



3 yrs ago

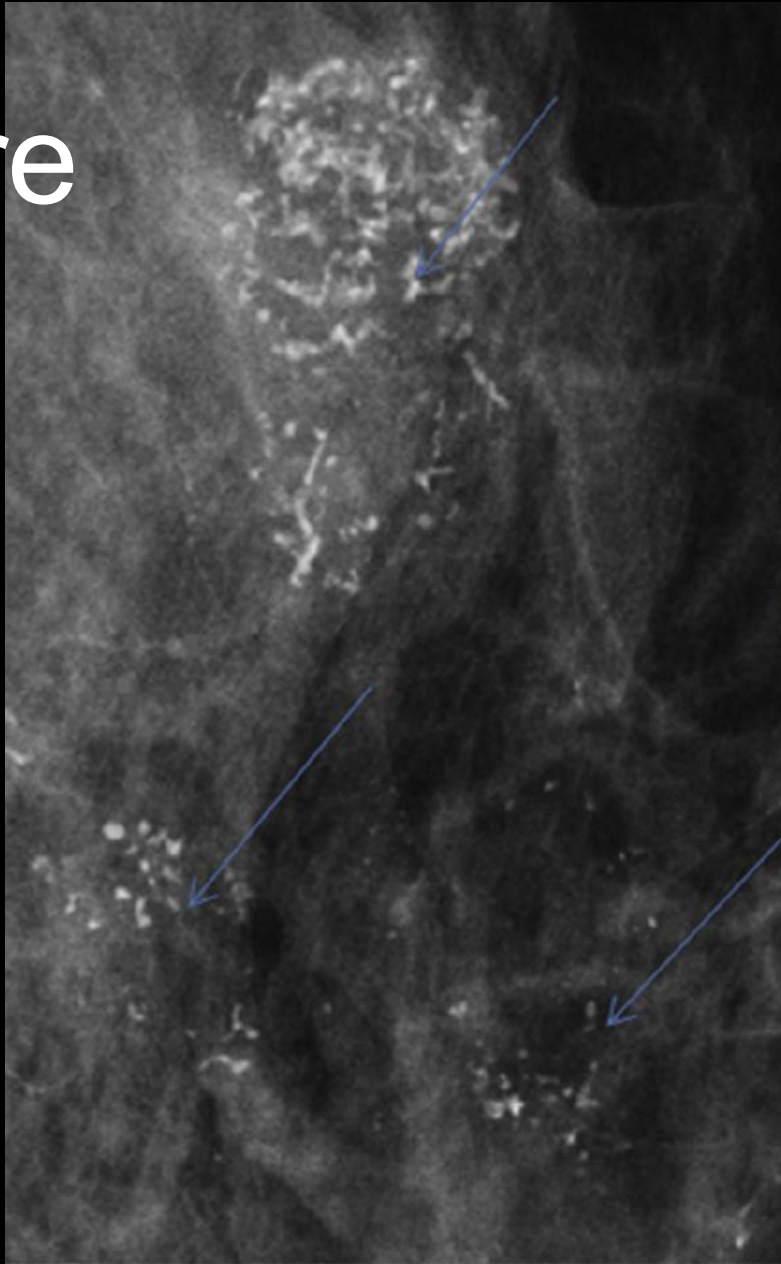
BI-RADS Assessment 6

- BI-RADS 6 = known biopsy-proven malignancy
 - “Clinical follow-up with surgeon and/or oncologist, and definitive local therapy (usually surgery) when clinically appropriate”
 - Replaced ~~“surgical excision when clinically appropriate”~~
 - Replaced ~~“appropriate action”~~
 - Biopsy proven cancer requiring more imaging prior to definitive treatment
 - Second opinion
 - Neoadjuvant chemotherapy monitoring

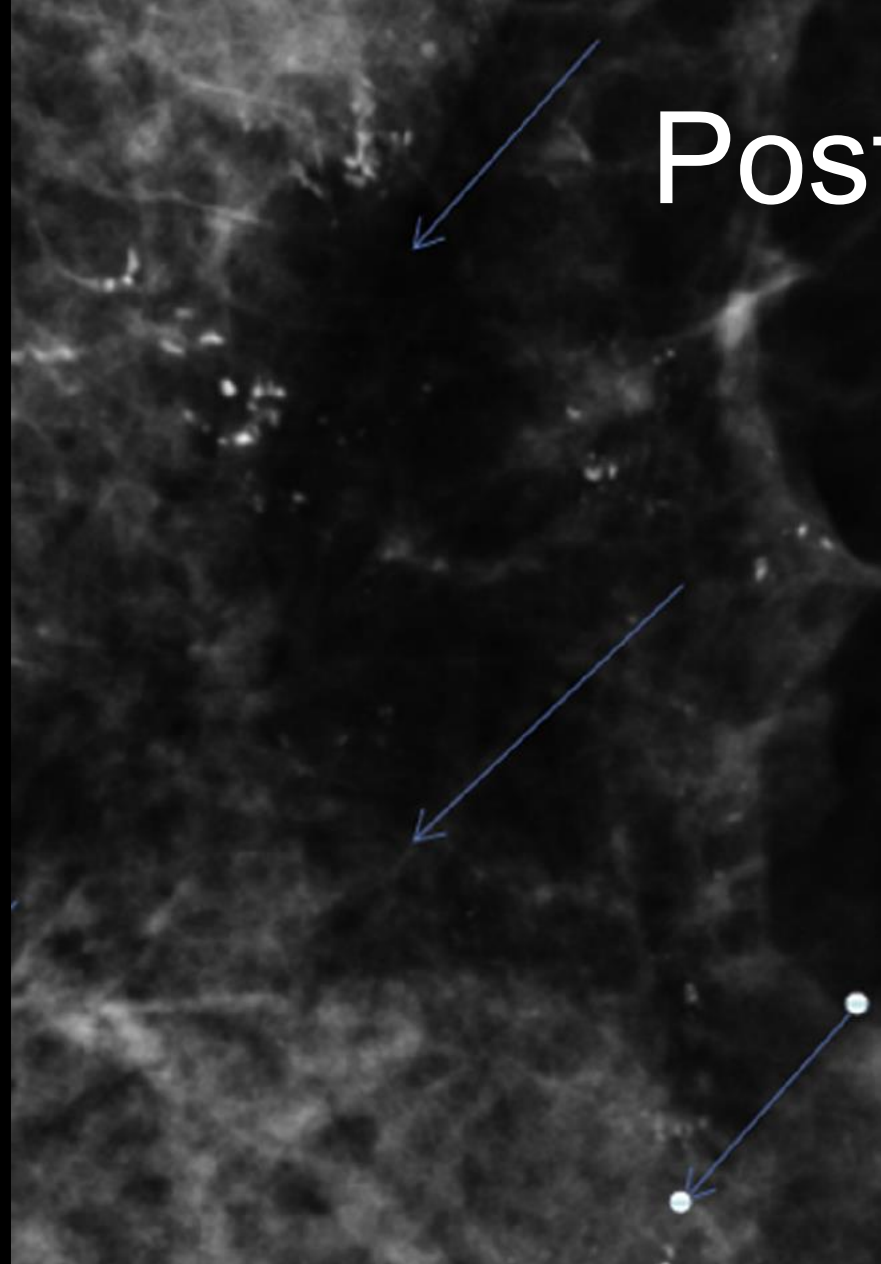
Mammography

- Calcifications correlated poorly with residual tumor burden*
- Calcifications may increase in setting of response

Pre

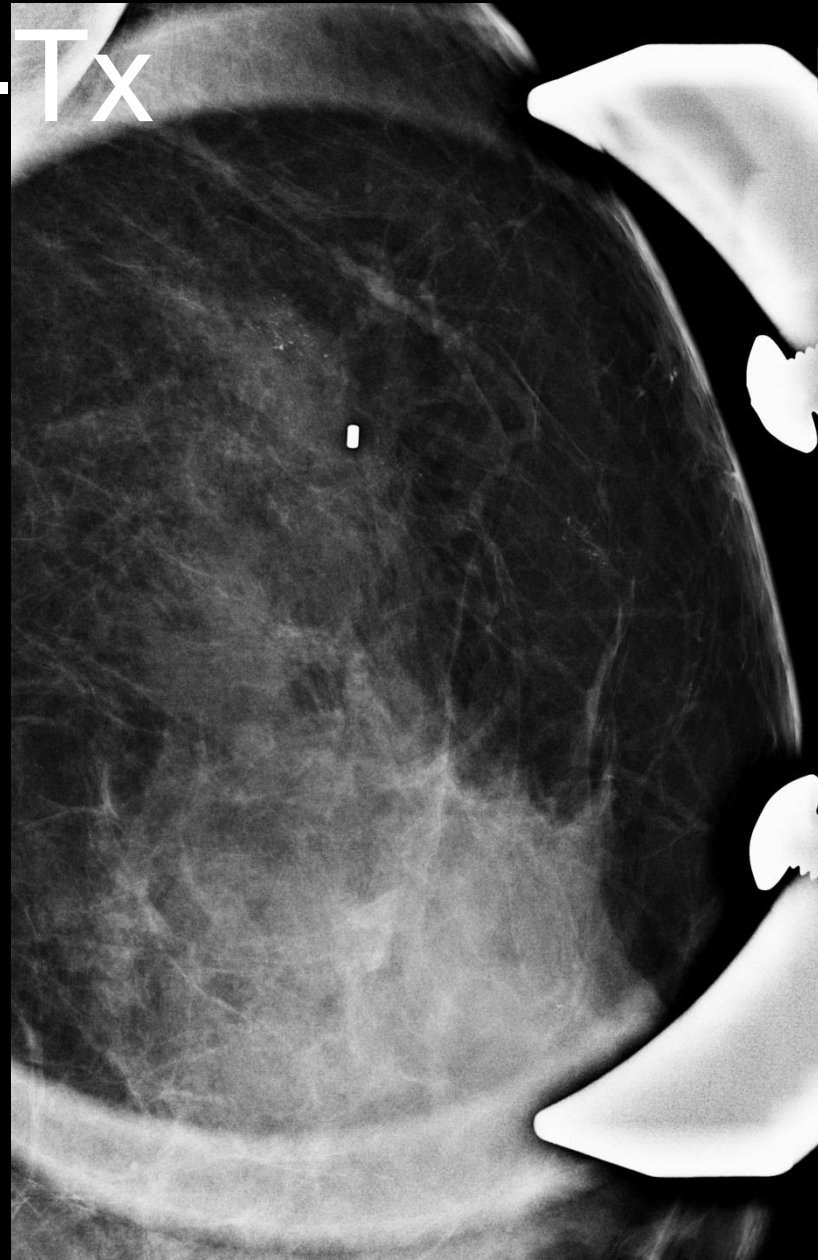
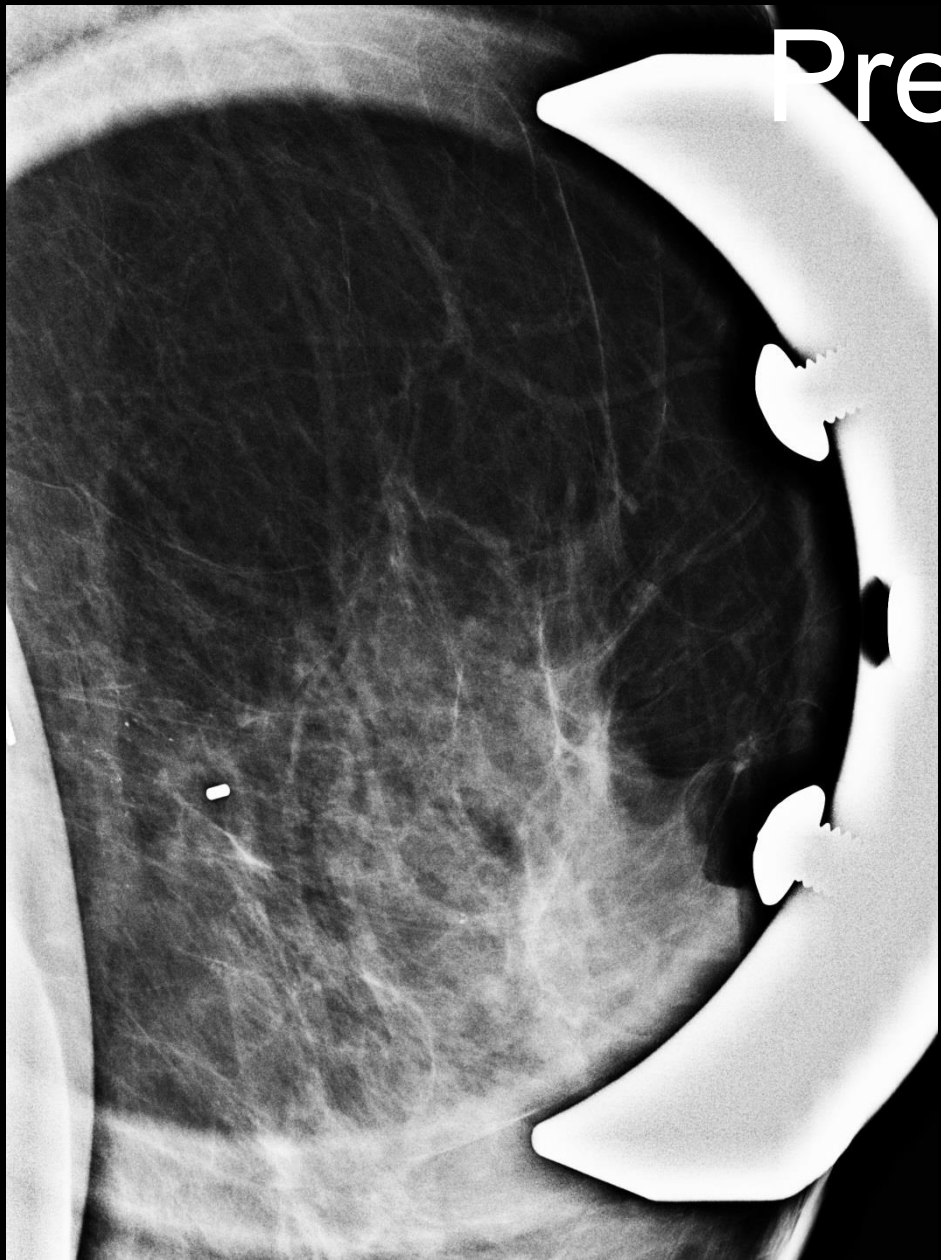


Post

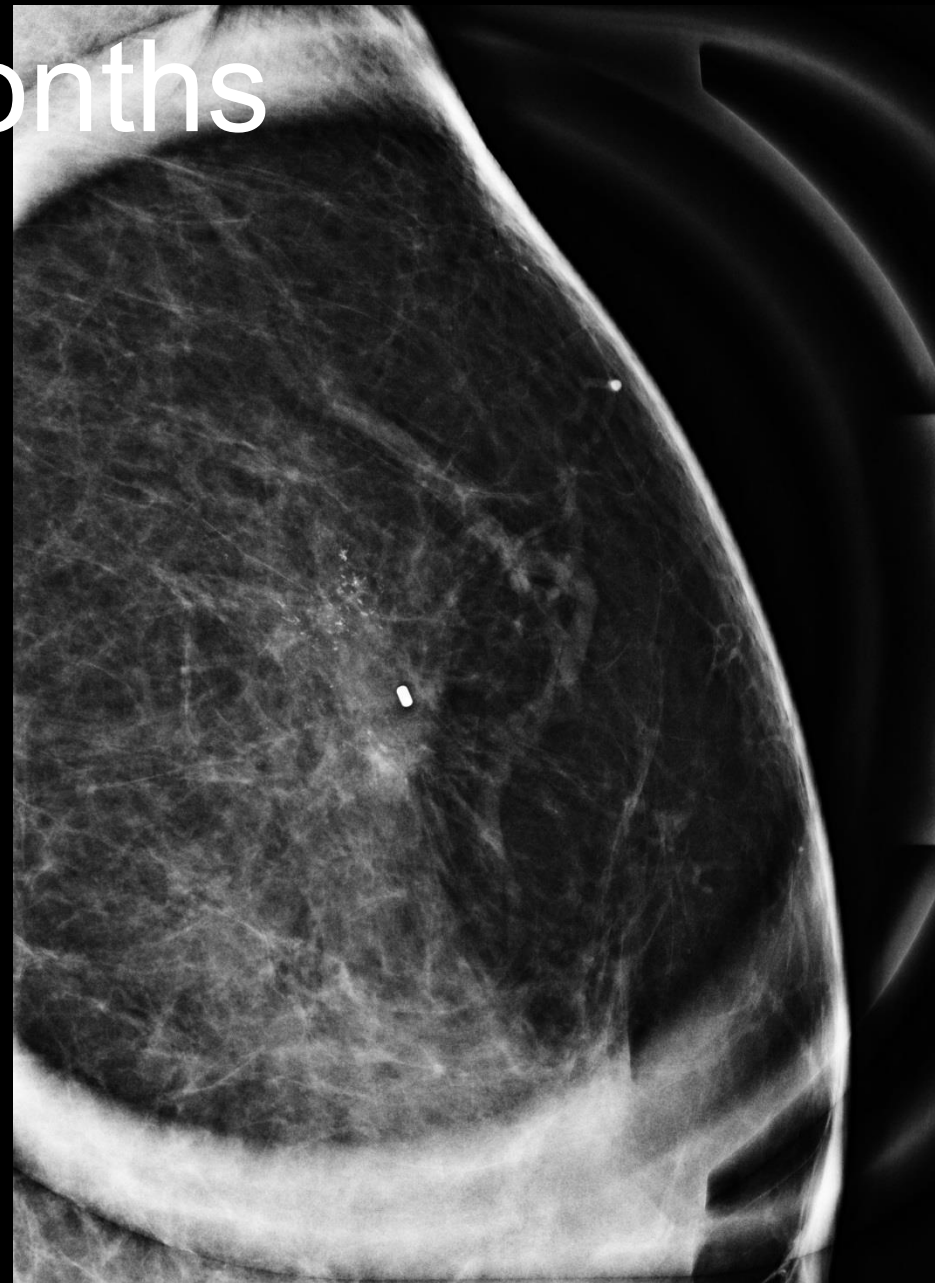


Source: Golan O, et al. Clin Radiol 2016; 71:458

Pre-Tx



3 months



6 months

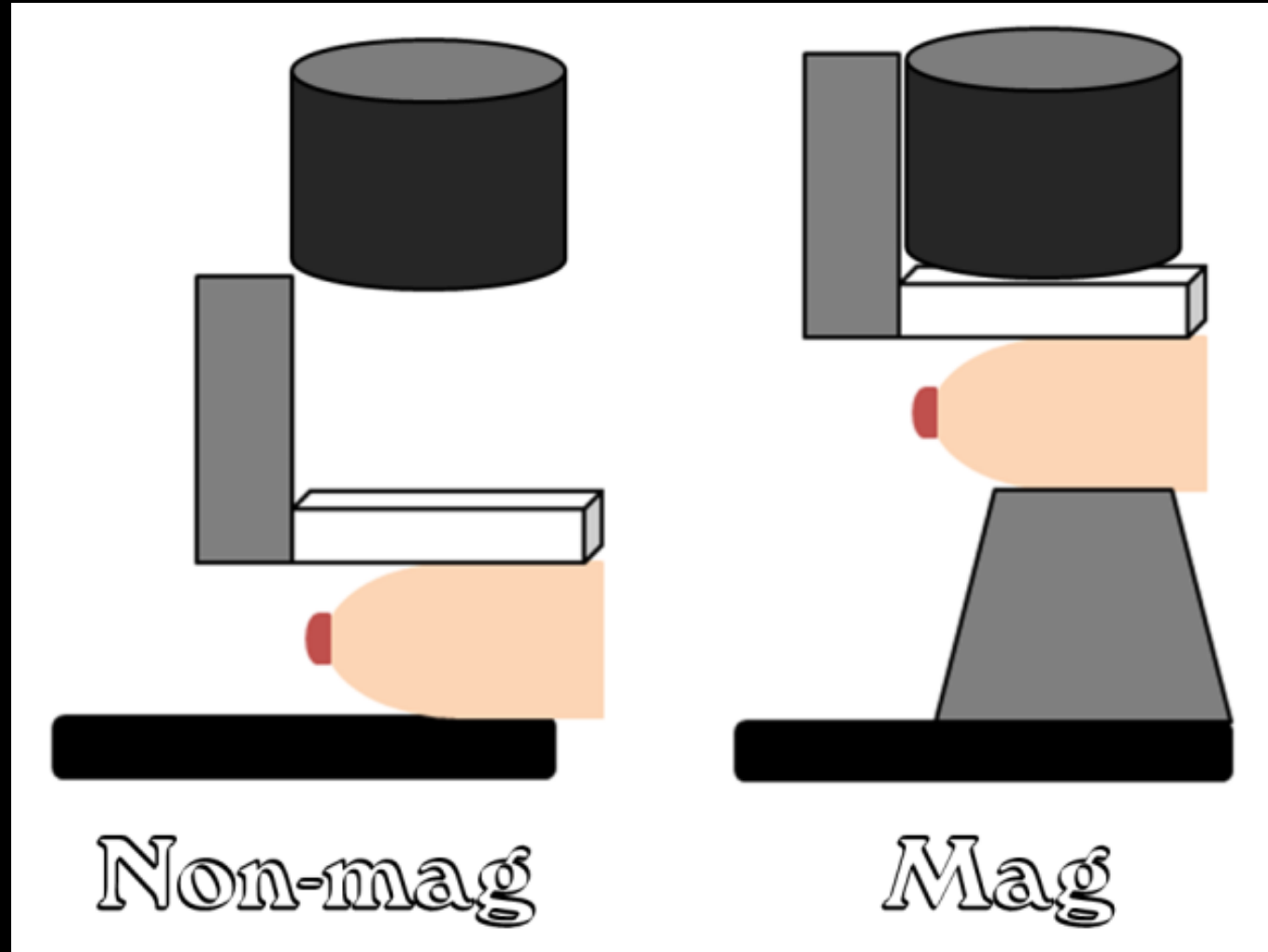


Spot Compression Magnification

CC

90-degree
lateral

Oblique?



Sonographic Detection and Sonographically Guided Biopsy of Breast Microcalcifications

Mary Scott Soo¹
Jay A. Baker
Eric L. Rosen

OBJECTIVE. The purpose of this study was to evaluate the ability of sonography to depict and guide biopsies of mammographically suspicious microcalcifications and to reveal the mammographic features and histologic outcomes of lesions amenable to sonographically guided biopsy.

SUBJECTS AND METHODS. Suspicious clusters of microcalcifications without other mammographic abnormalities were evaluated on sonography before biopsy and divided into two groups: those with and those without microcalcifications seen on sonography. Sonographically detected lesions underwent sonographically guided biopsy; lesions not seen on sonography underwent mammographically guided biopsy. Imaging features and histologies were correlated, and the positive predictive value of sonography was determined.

RESULTS. Of 111 lesions (105 patients), 26 lesions (23%) were identified and underwent sonographically guided biopsy; 85 lesions (77%) were not identified sonographically. The diameters of microcalcification clusters in the sonographically identified group were significantly larger ($p = 0.0005$) and contained larger numbers of microcalcification particles ($p = 0.038$) compared with clusters not identified sonographically. Sonographically identified lesions were seen as masses (77%) or dilated ducts (23%) with echogenic foci. Sonographically identified lesions were more likely to be malignant than those not seen on sonography (69% vs 21%, respectively; $p < 0.00002$). Of 38 malignant lesions, those visible on sonography were more likely to be invasive than those not seen on sonography (72% vs 28%, respectively; $p = 0.018$). In malignant lesions undergoing core biopsy and surgical excision, the extent of disease was underestimated less with sonographically guided biopsy (7%, 1/15) than with stereotactic biopsy (33%, 5/15).

CONCLUSION. Suspicious microcalcifications are seen infrequently on sonography (23%) but, when detected, can be successfully biopsied with sonographic guidance and more frequently are malignant and represent invasive cancer than those seen on mammography alone.

Mammographically revealed, suspicious clustered microcalcifications that have no associated mammographic features are usually diagnosed by either percutaneous core needle biopsy with stereotactic guidance or at surgical excision after mammographically guided wire localization. Although both techniques are successful for aiding in diagnosis of these lesions [1], the techniques require mammographic compression of the breast that is uncomfortable for the patient, and they expose the breast to ionizing radiation. Many stereotactic biopsies are performed with the patient in a prone position, which is often considered uncomfortable and in some cases is difficult or impossible for patients to tolerate. In addition, mammographic

compression can make the breast too thin to allow successful core needle biopsy of a lesion. Finally, stereotactic biopsy equipment is expensive and not universally available.

Sonography is frequently used to guide percutaneous core biopsy or wire localization before excisional biopsy of breast masses [1]. In general, sonographically guided procedures are preferred by patients over mammographically guided procedures because patients are more comfortable supine, the breast is not compressed, and the procedures are often performed faster [1, 2]. In addition, no ionizing radiation is used, the needle insertion site is more flexible, and the needle can be observed in real time with sonographically guided procedures [1, 2].

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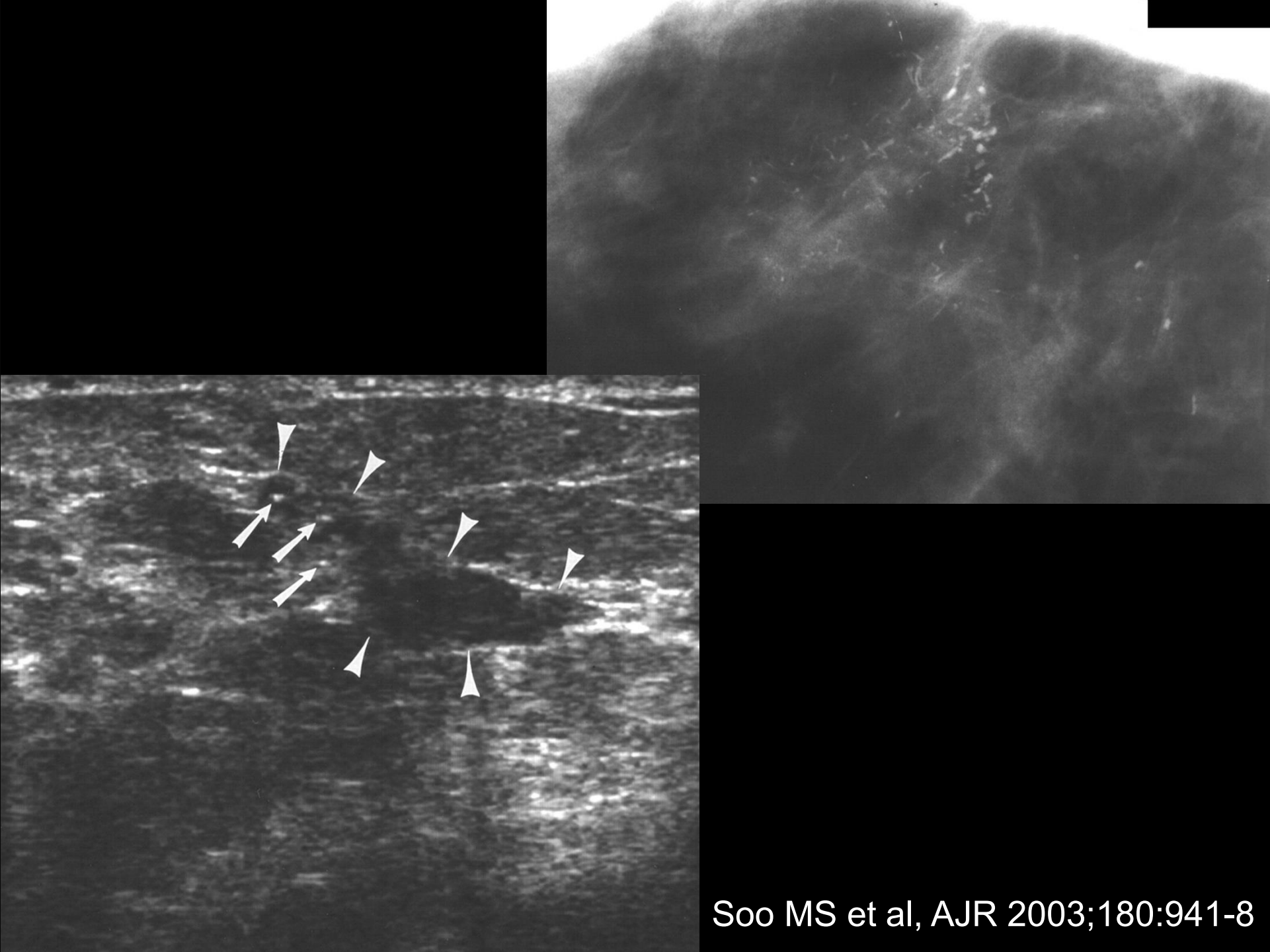
AJR 2003;180:941–948

0361–803X/03/1804–941

© American Roentgen Ray Society

US in Evaluating Calcifications

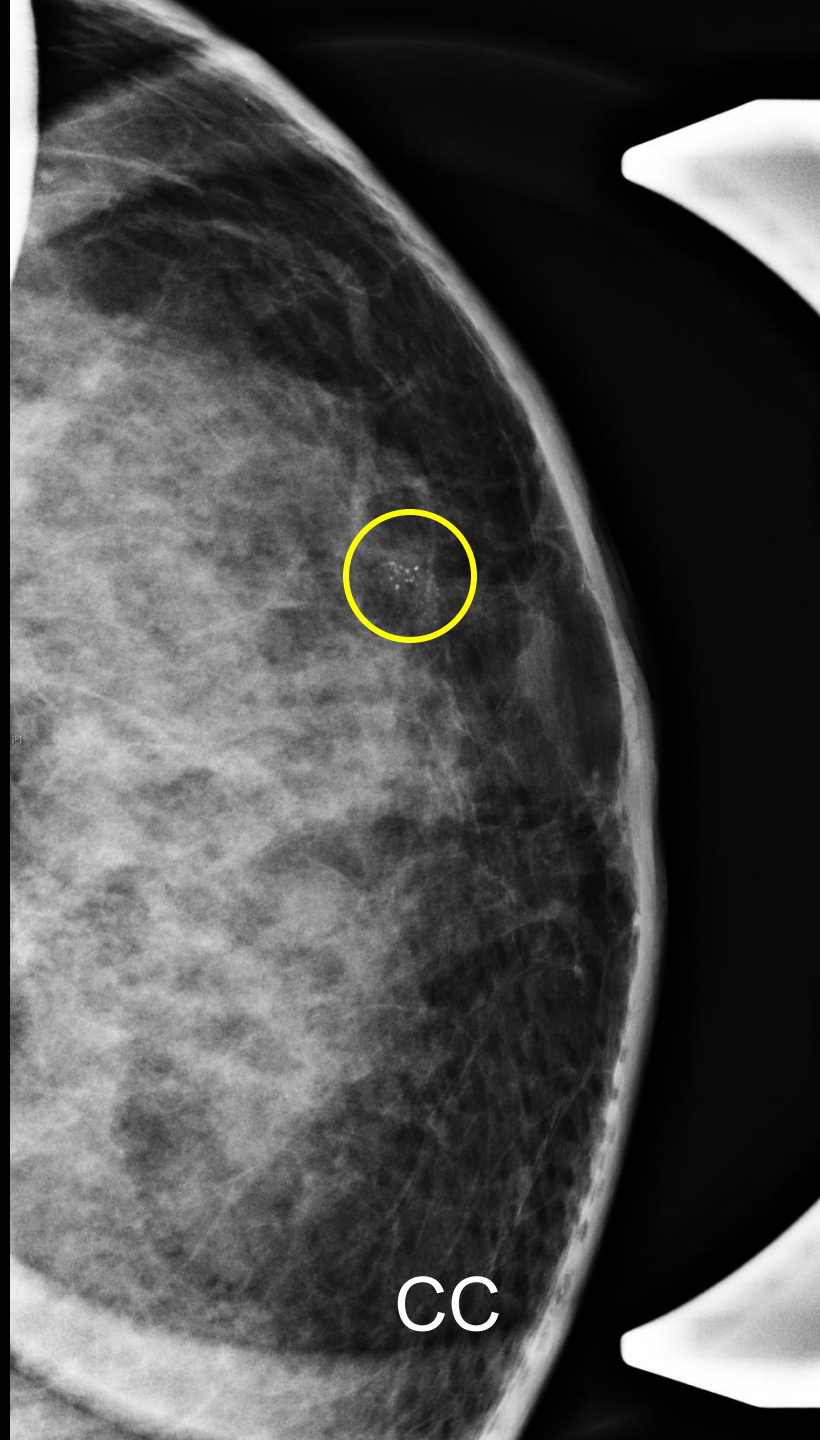
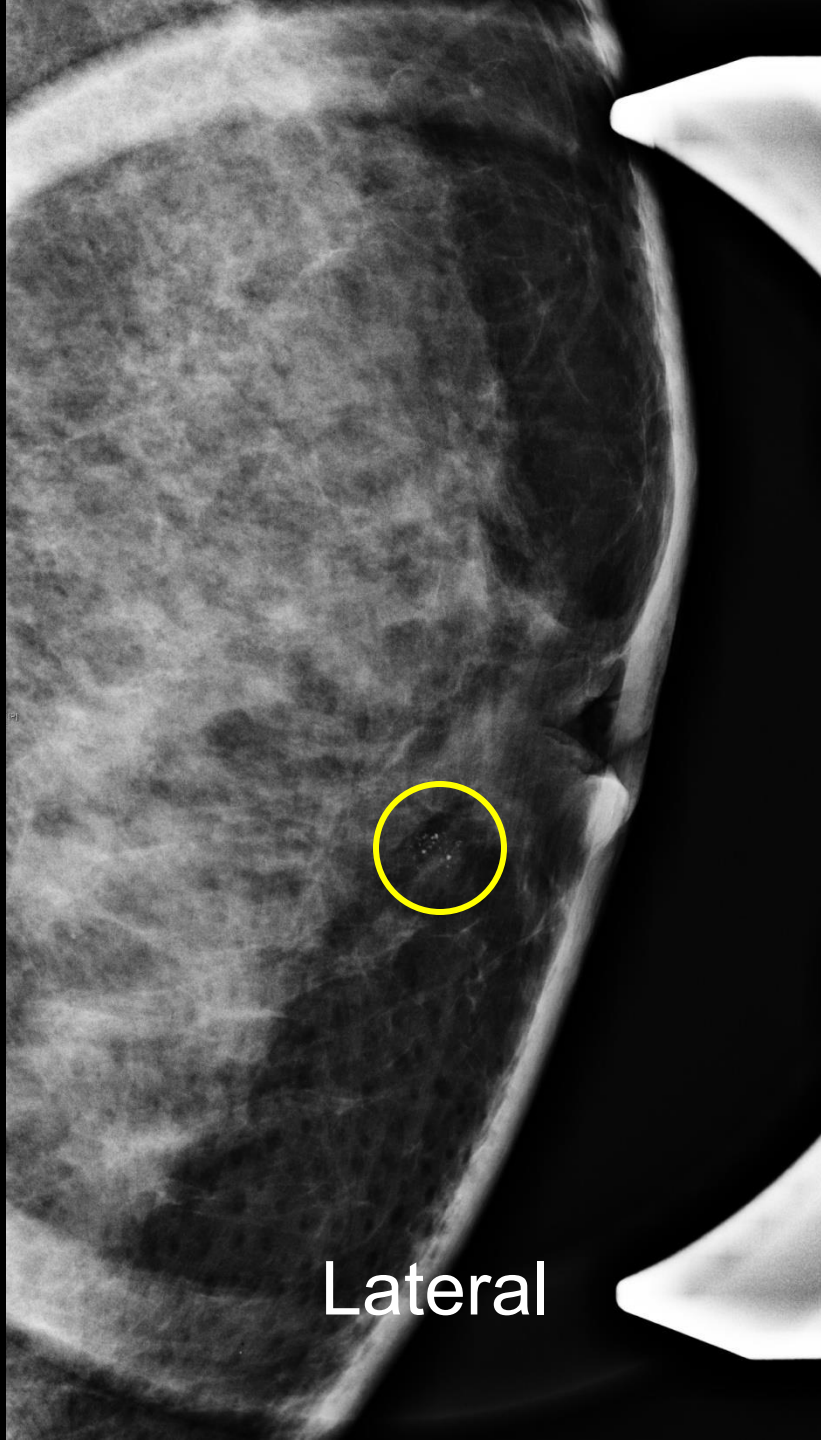
- N=111 cases
- 23% seen; 77% not seen
- 77% mass; 23% dilated duct + echogenic foci

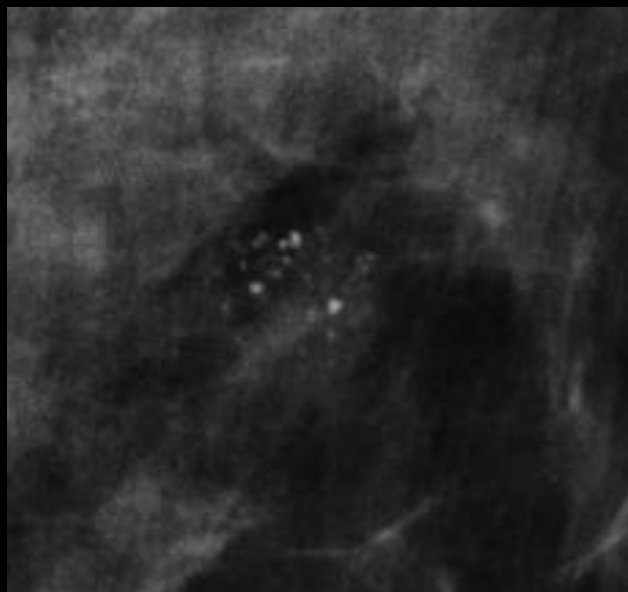


US in Evaluating Calcifications

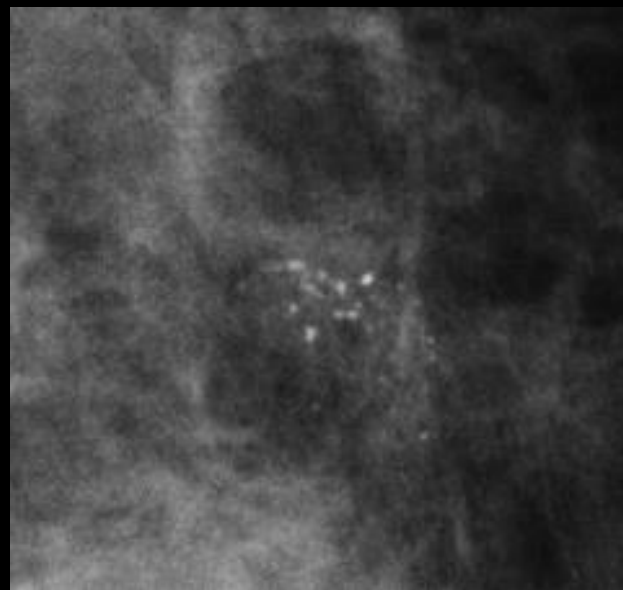
	+ US Correlate	No US Correlate
PPV	69%	21%
Invasive	72%	28%
Underestimation	7%	33%

* Soo MS et al. AJR 2003; 180:941-8



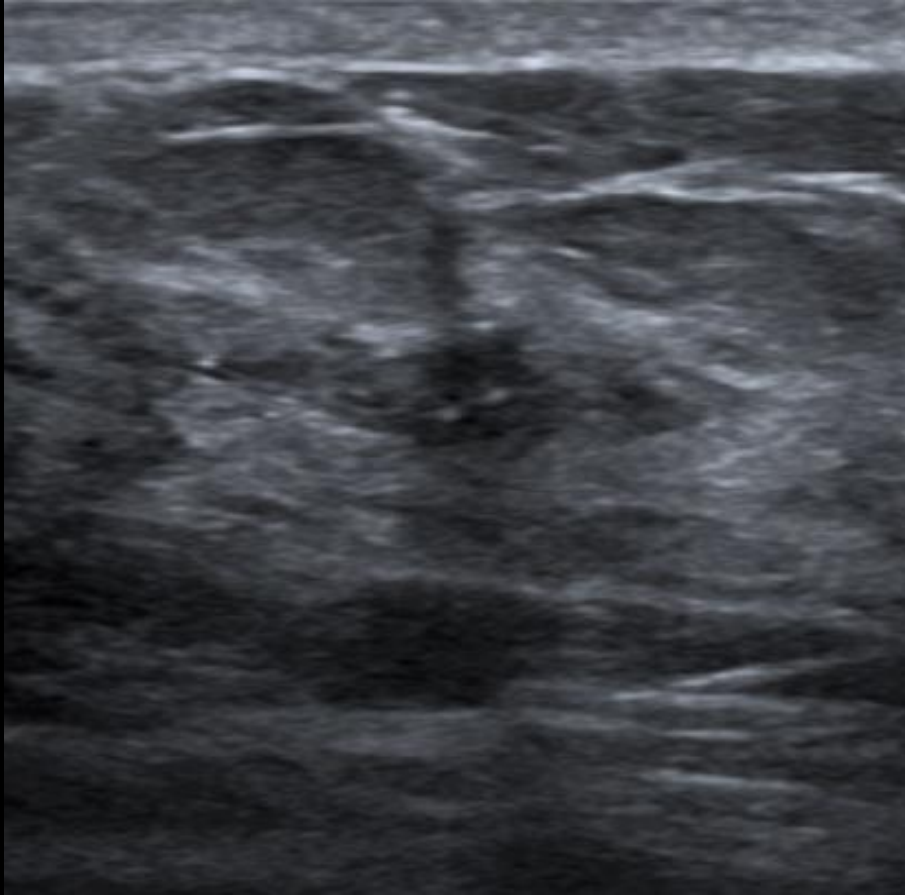


Lateral

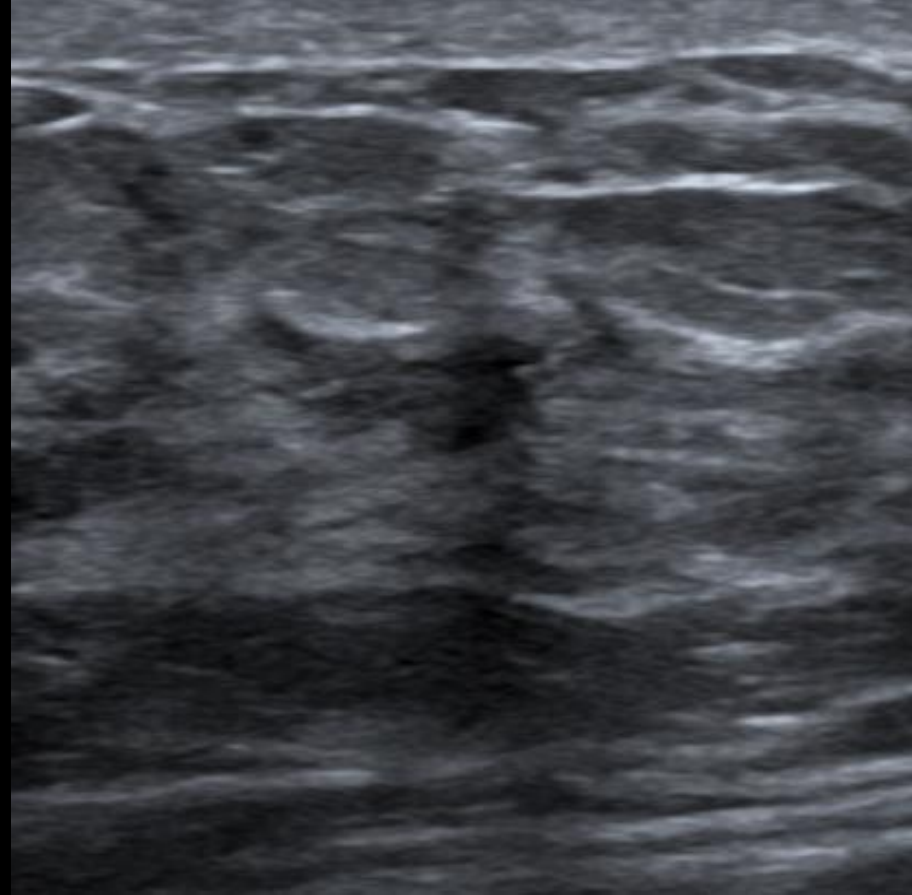


CC

Biopsy using ultrasound core?

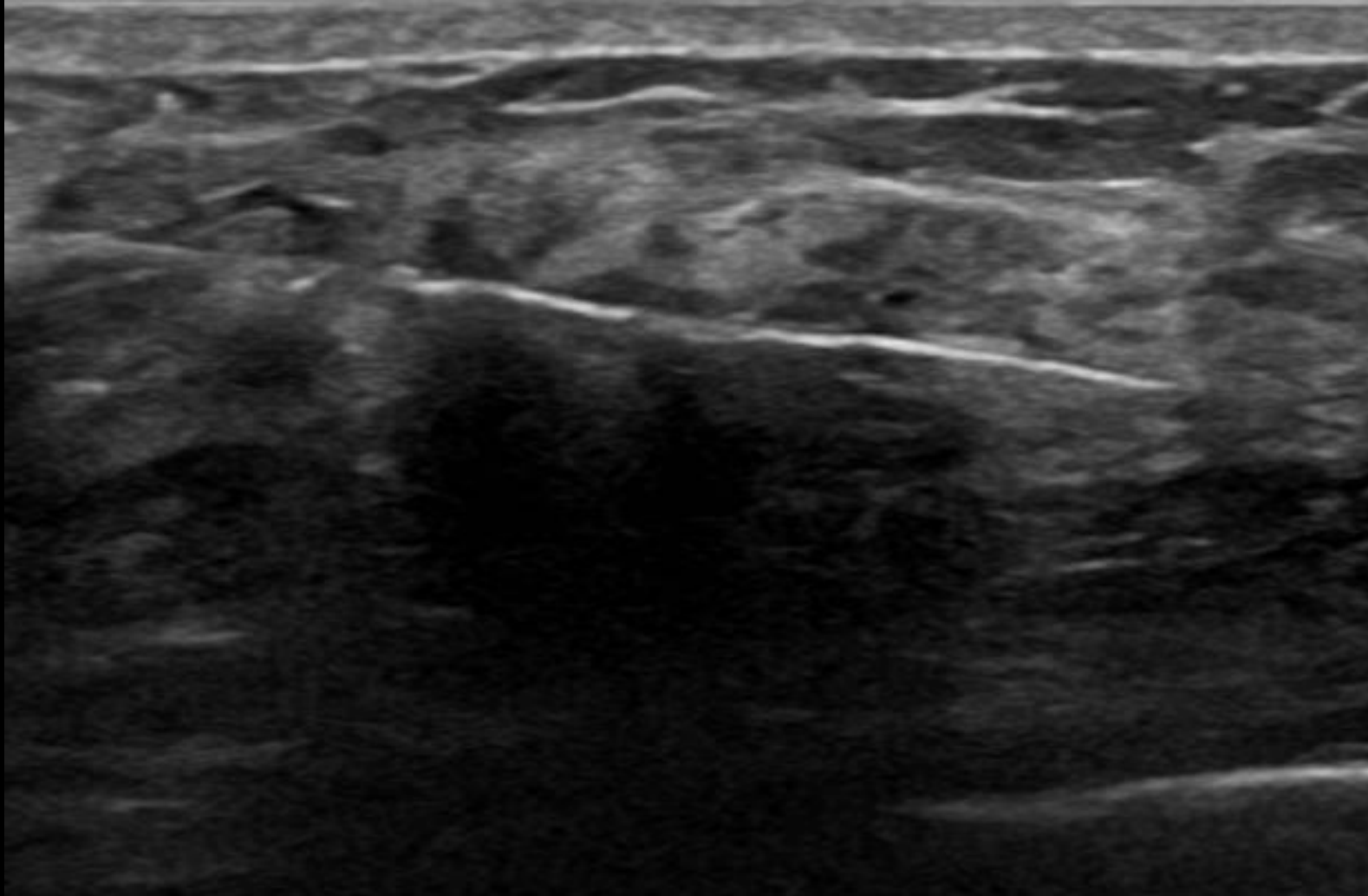


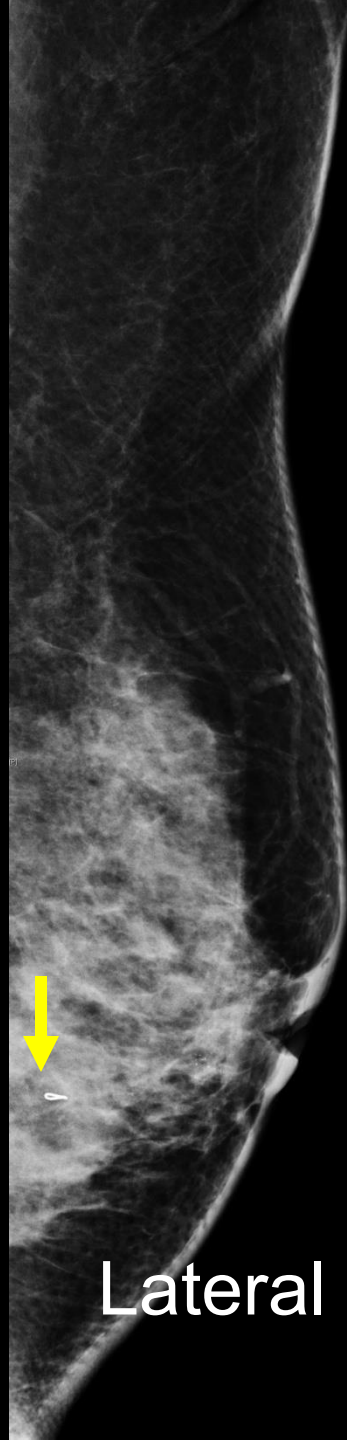
Transverse



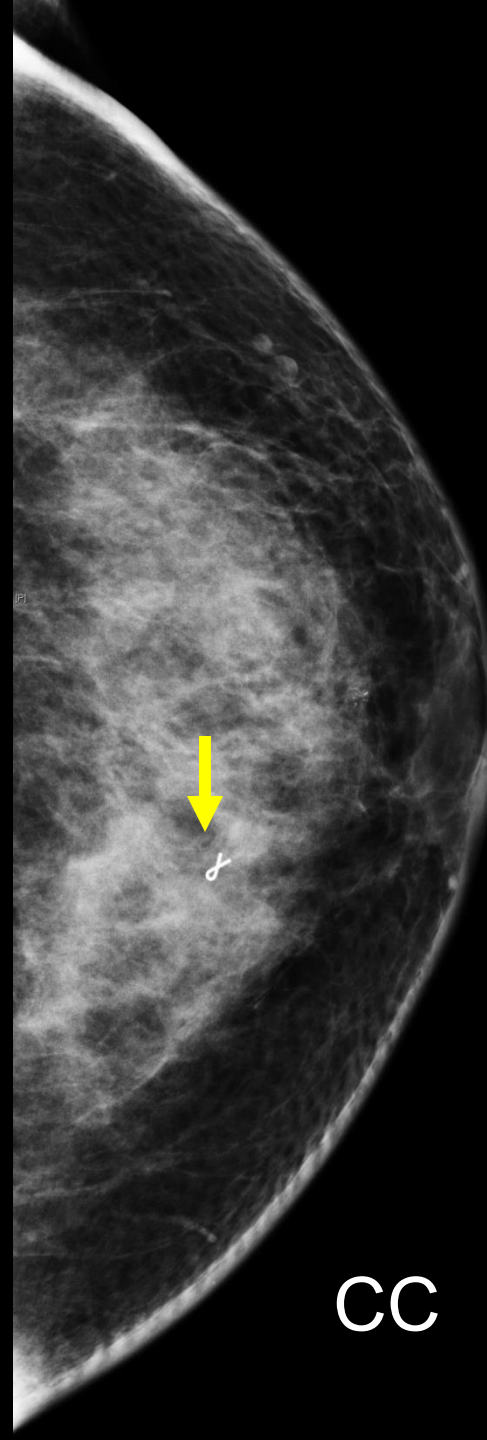
Sagittal

Fibrocystic change; Benign fibrofatty tissue
No calcifications seen





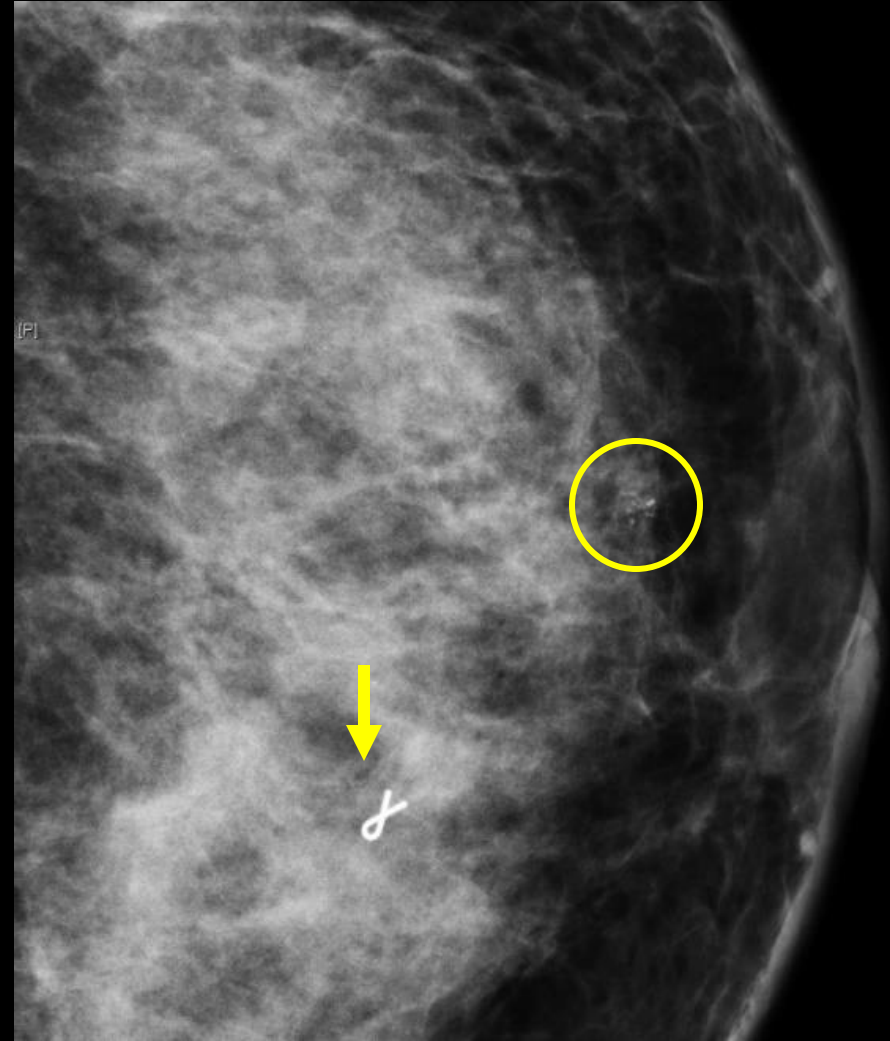
Lateral



CC



Lateral



CC

MRI in Evaluating Calcifications

- MRI should not be used to obviate biopsy of indeterminate calcifications
 - Multicenter study of 74 BI-RADS 4 or BIRADS 5 calcifications¹
 - Sensitivity 80%
 - PPV 86%
 - NPV 71%
 - Accuracy 80%

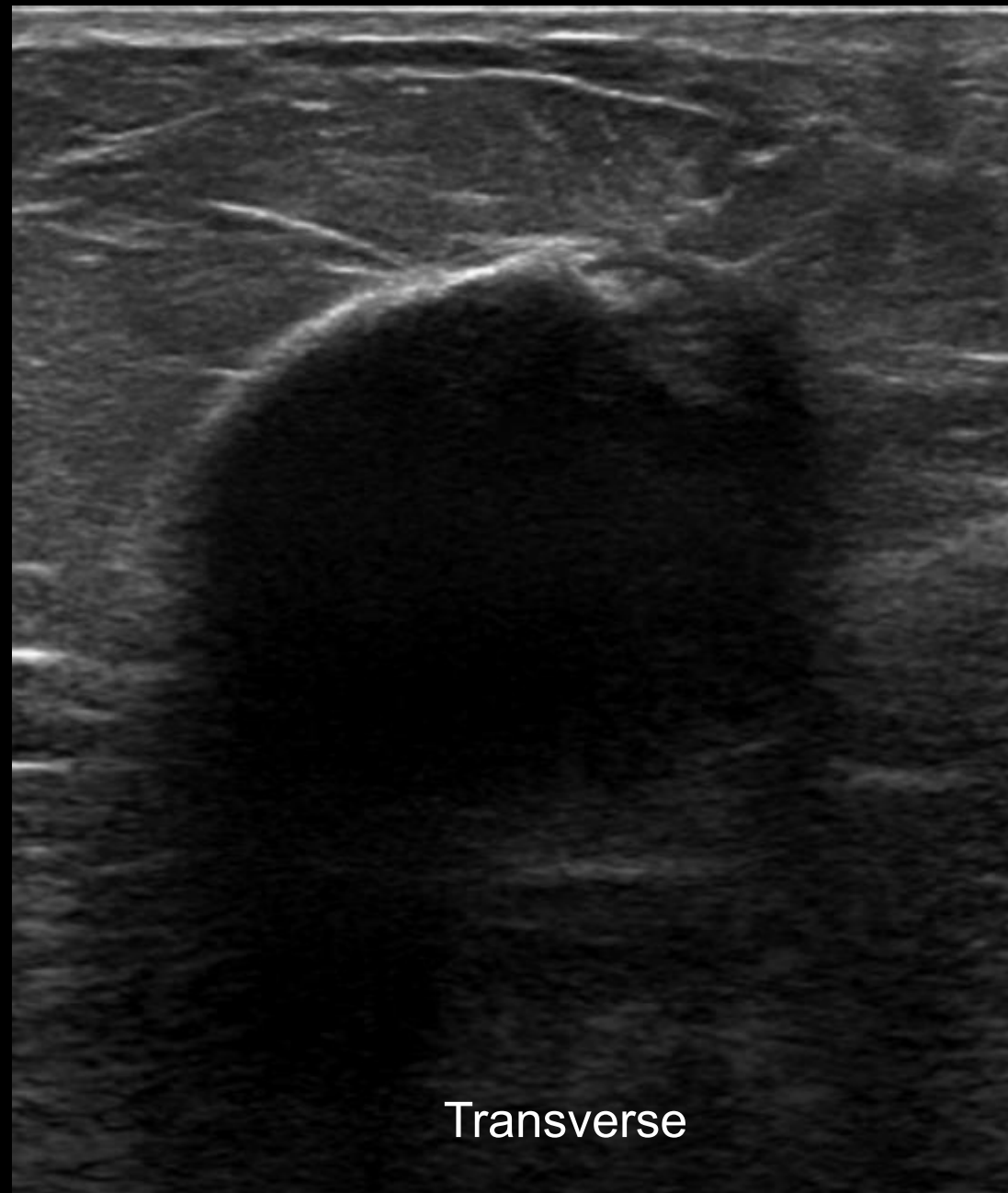
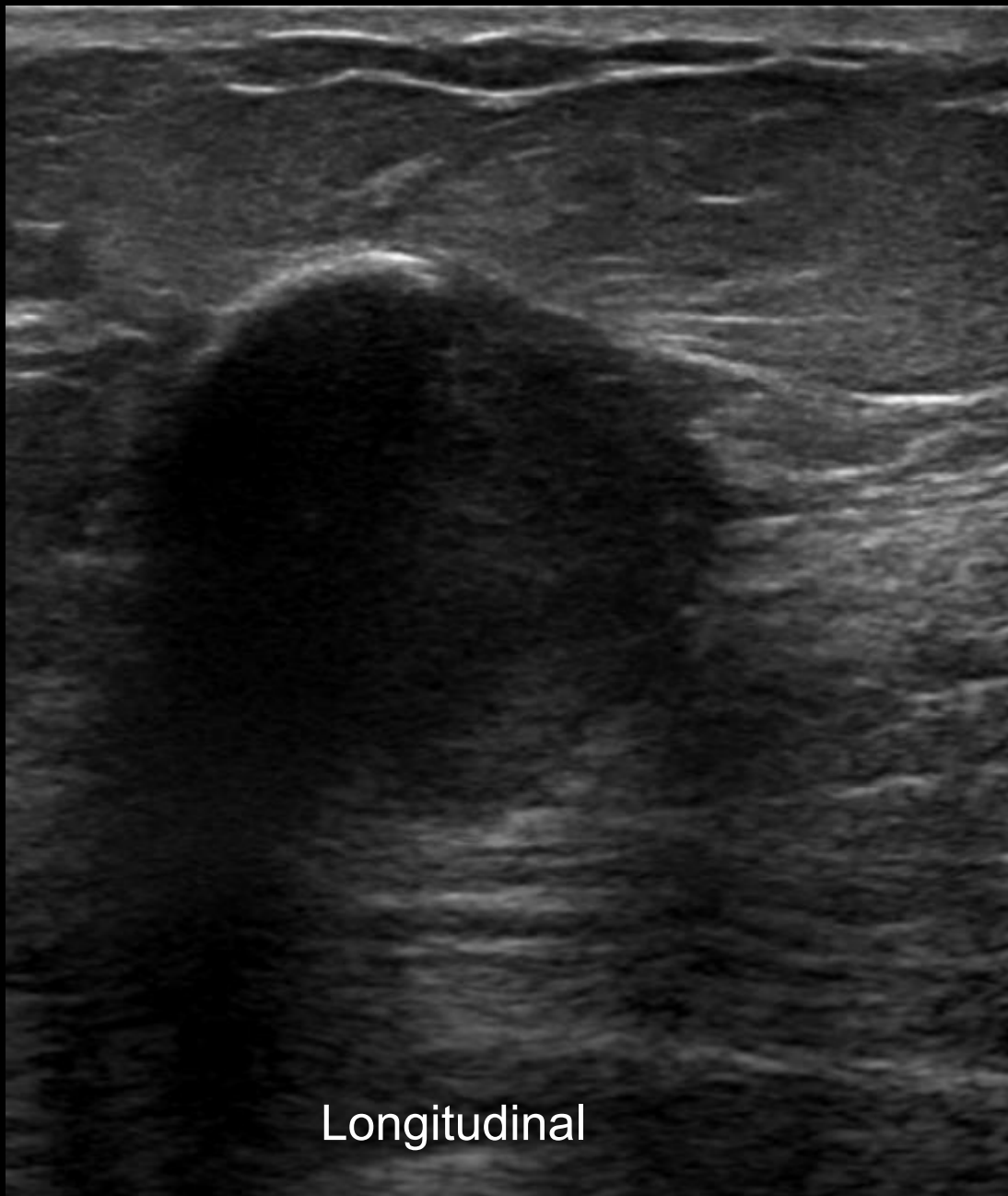
1. Bazzocchi M et al. AJR Am J Roentgenol 2006; 186:1723-32.

MRI in Evaluating Calcifications

- Obviating biopsy
 - Multicenter trial in 2006¹
 - N = 112 cases of suspicious calcifications
 - Sensitivity 87%; NPV 71%
 - MRI cannot be used to exclude biopsy of mammographic suspicious calcifications
- Targeting specific biopsy site(s)
 - To identify site(s) of malignancy
 - To identify site(s) of invasive disease

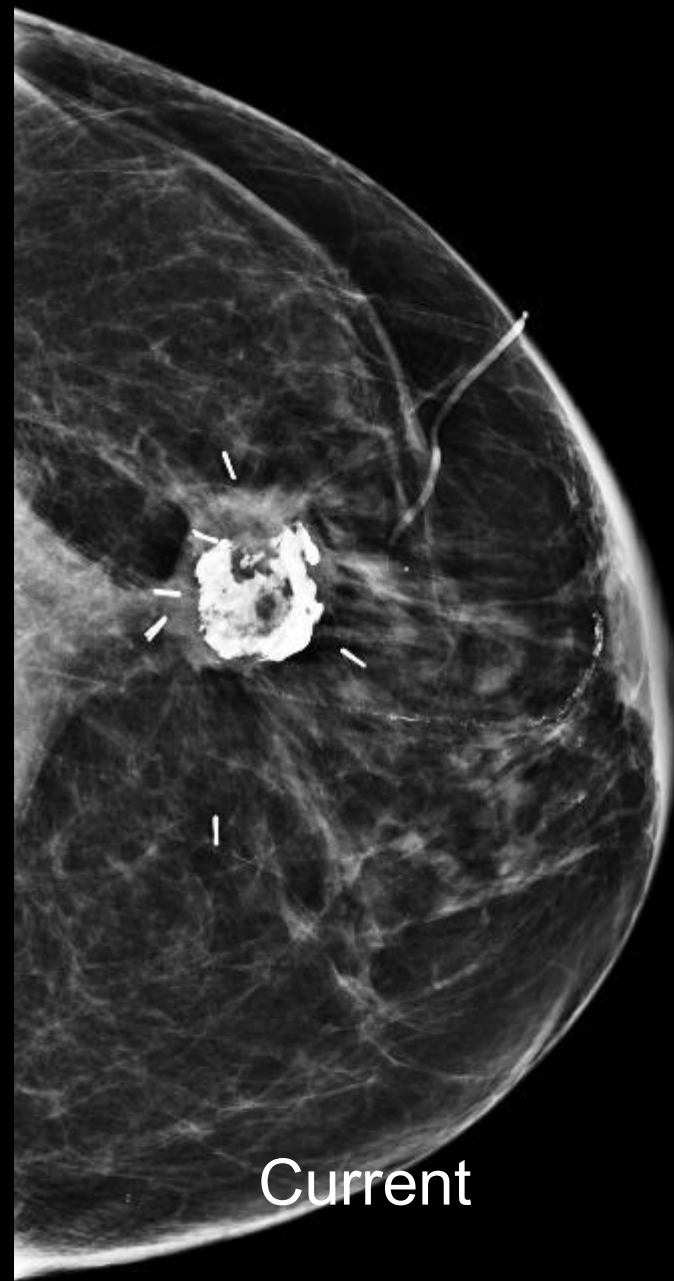
1. Bazzocchi M et al. AJR Am J Roentgenol 2006; 186:1723-32.

Important to correlate mammography findings with US (and other imaging) findings, as well as clinical history



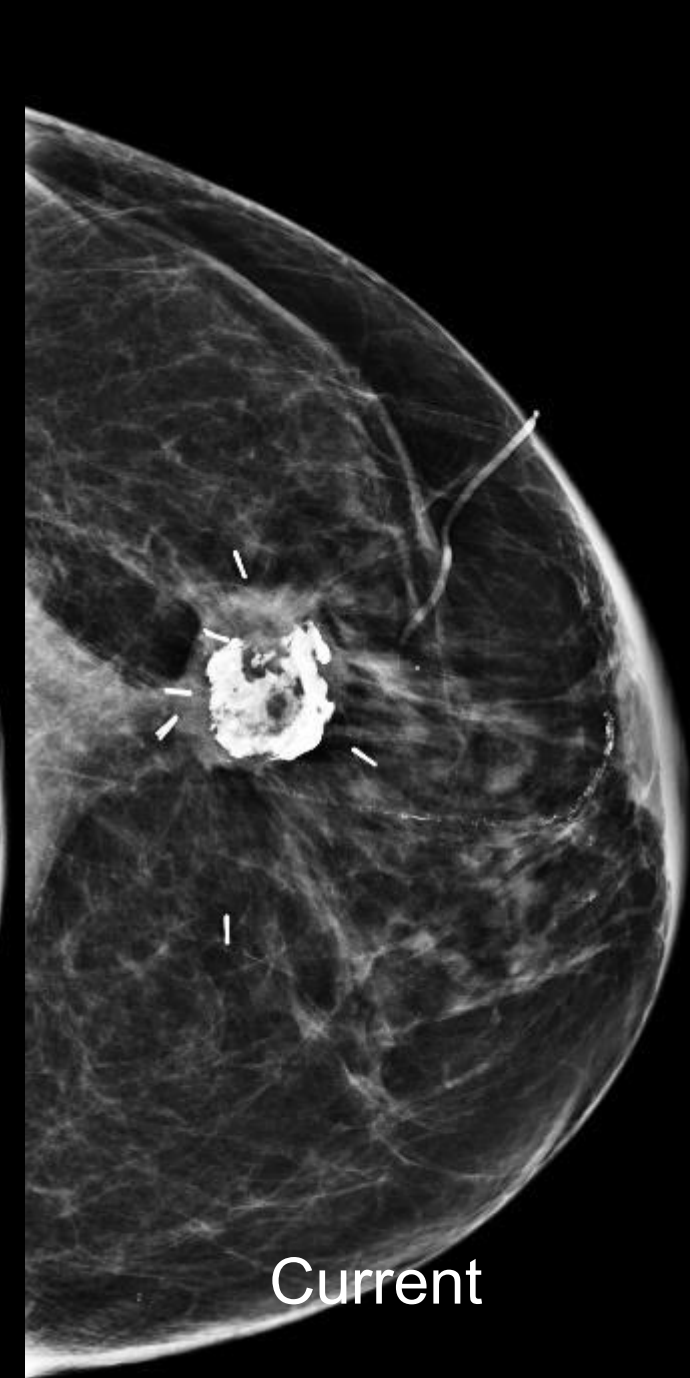
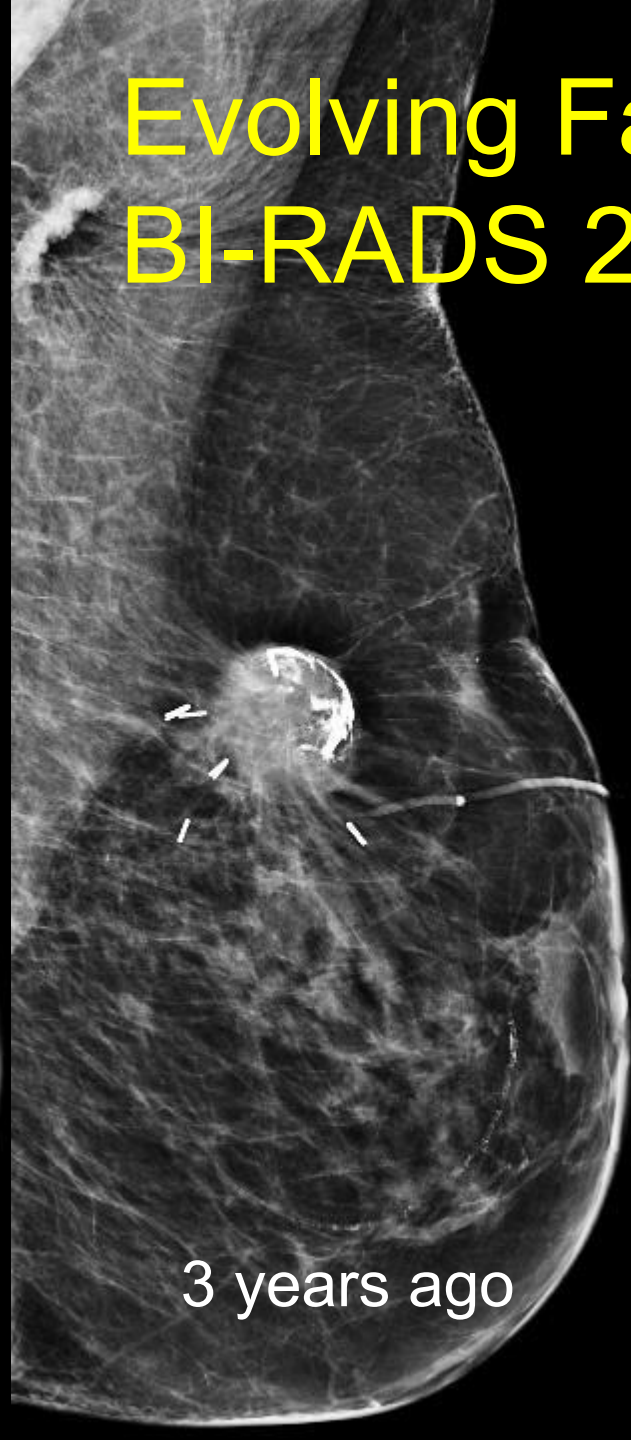


Current



Current

Evolving Fat Necrosis BI-RADS 2 Benign



Take-home Points

- Spot compression magnification
- Morphology & distribution
- Assign BI-RADS 3 appropriately
- Use BI-RADS lexicon to guide management

Thank you

JWLeung@mdanderson.org

#drjessicaleung