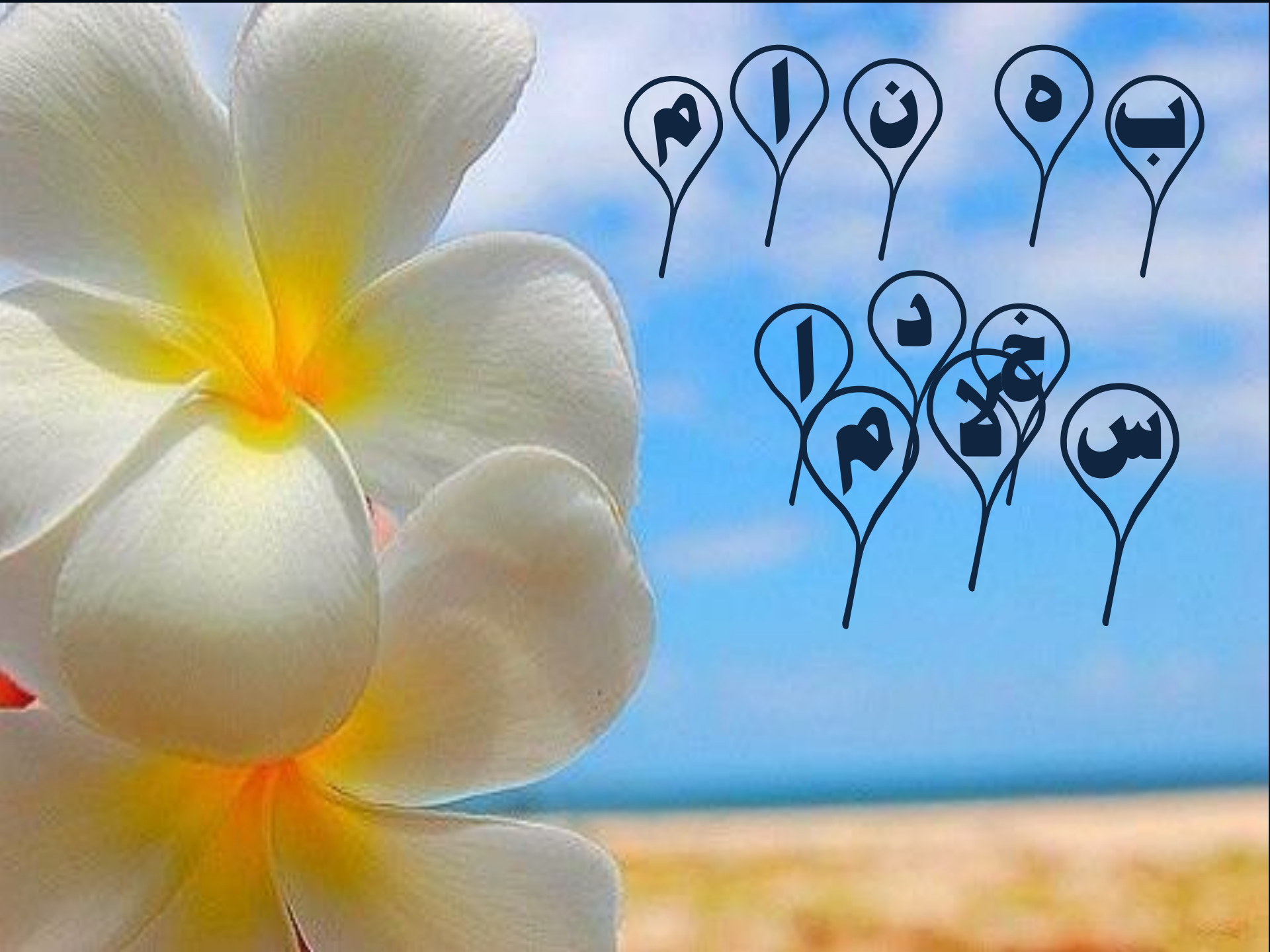

بسم الله الرحمن الرحيم

Breast Implant Imaging

N.Sadighi
TUMS
ADIR

Breast Implant

80% for breast augmentation and 20% for breast reconstruction after mastectomy

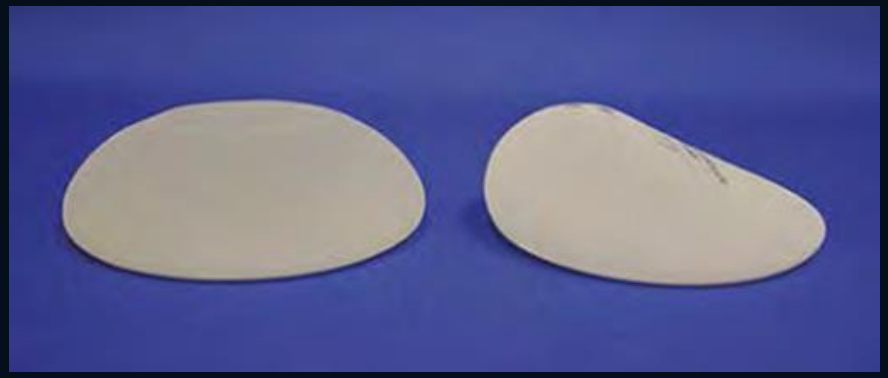
No relationship between silicon implant and CTD or Breast Ca.

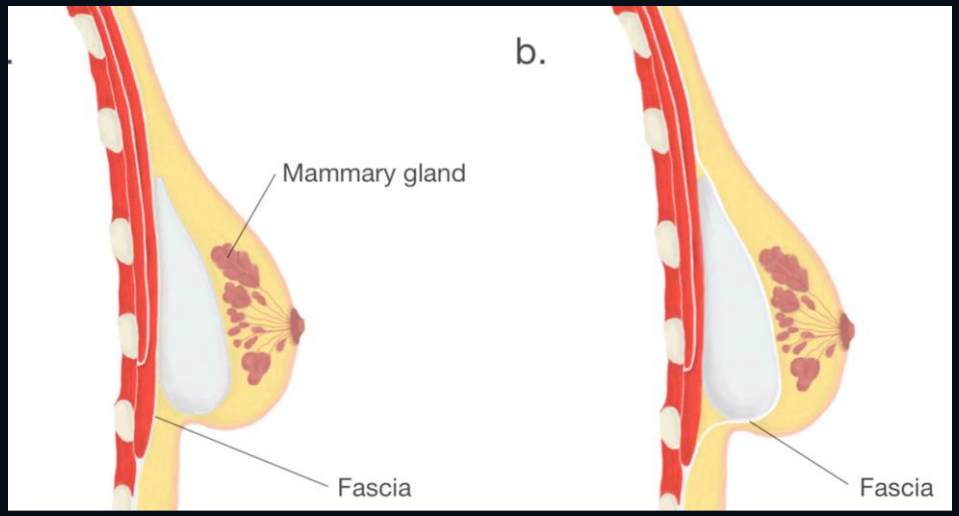
Type: The most common is single lumen with silicon elastomer shell and filled with silicon.

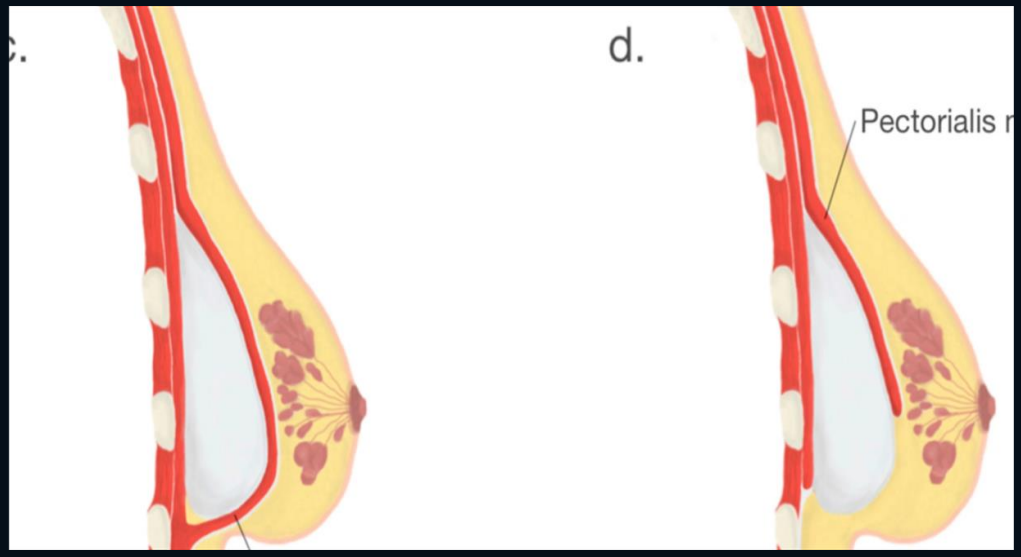
Single-lumen silicone
Single-lumen saline
Double-lumen: saline outer, silicone inner
Single-lumen silicone, outer polyurethane mesh coating
Single-lumen, lipid-filled
Complex or custom implants
Stacked implants
Direct silicone or paraffin injections

Category	Types
Fill	Saline, silicone, miscellaneous (polyvinyl alcohol sponge, lipid, etc.)
Shape	Round, anatomic
Surface	Smooth, texture
Chamber	Single-lumen, multilumen

Shape: Round or Anatomic (Anatomic-shaped implants provide a more natural shape)

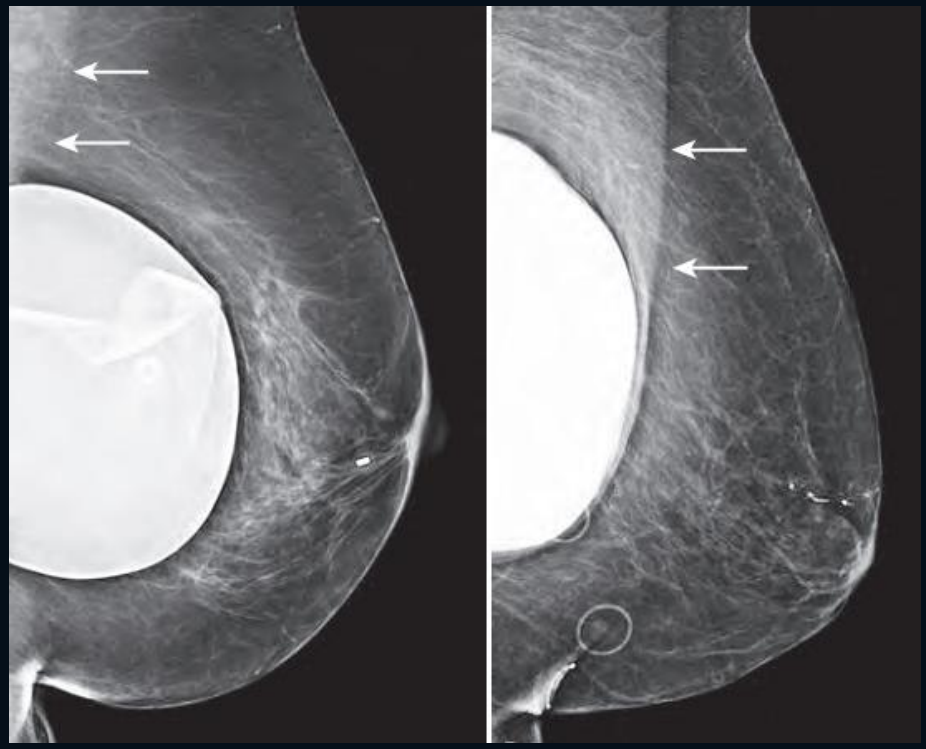



b.
Mammary gland
Fascia
Fascia


d.
Pectorialis

Implant Position

- Sub-glandular (pre-pectoral): shadow of the pectoralis muscle is underneath the implant on MLO
- Sub-pectoral: pectoralis muscle curves over the implant



Implant Position

- Prepectoral:
- Placement may not be possible if the remaining breast skin **is not thick and healthy** enough after some tissue has been removed.
- a potential risk of implant rippling and **wrinkling** showing through the skin if the implant is not covered by enough soft tissue
- a slightly higher **risk** **of developing an infection** around the implant compared to subpectoral
- a possible risk that the implant **shifts out of the correct position** over time, if breast skin is thin
-

Subpectoral:

Placement may not be possible if some of the chest muscle or a lot of the layer of tissue on top of the chest muscle was removed during the mastectomy.

Possibly more discomfort during recovery from the surgery and, in some cases, chronic pain, tightness, and weakness (because the chest muscle was cut and/or divided during the procedure)

Higher risk of dynamic distortion (or animation deformity), which makes the breasts move in unnatural looking ways when you flex your chest muscle

Implant Imaging

- Mammography : technique and normal finding
- US: normal finding
- MRI: technique and normal finding

Mammography in the presence of implant

Implant can be ruptured if compressed too hard

4 views:

- ✓ 2 (CC and MLO/ML) standard views with limited compression (includes implant and tissue around it) for implant integrity and breast tissue: can miss cancer due to insufficient comp.
- ✓ 2 (CC and MLO/ML) implant-displaced views with strong compression for breast tissue (technologist compresses only the breast tissue in front of the implant by carefully displacing the implant out of the field of view)

- 5% of screenings show asymptomatic rupture
- Fine-detail views like Spot compression, tomosynthesis, needle localization, ultrasound-guided core biopsy, and stereotactic core biopsy all can be performed
- (Take informed consent for possible rupture following Bx)

Limitations:

A mass can be seen only on one view

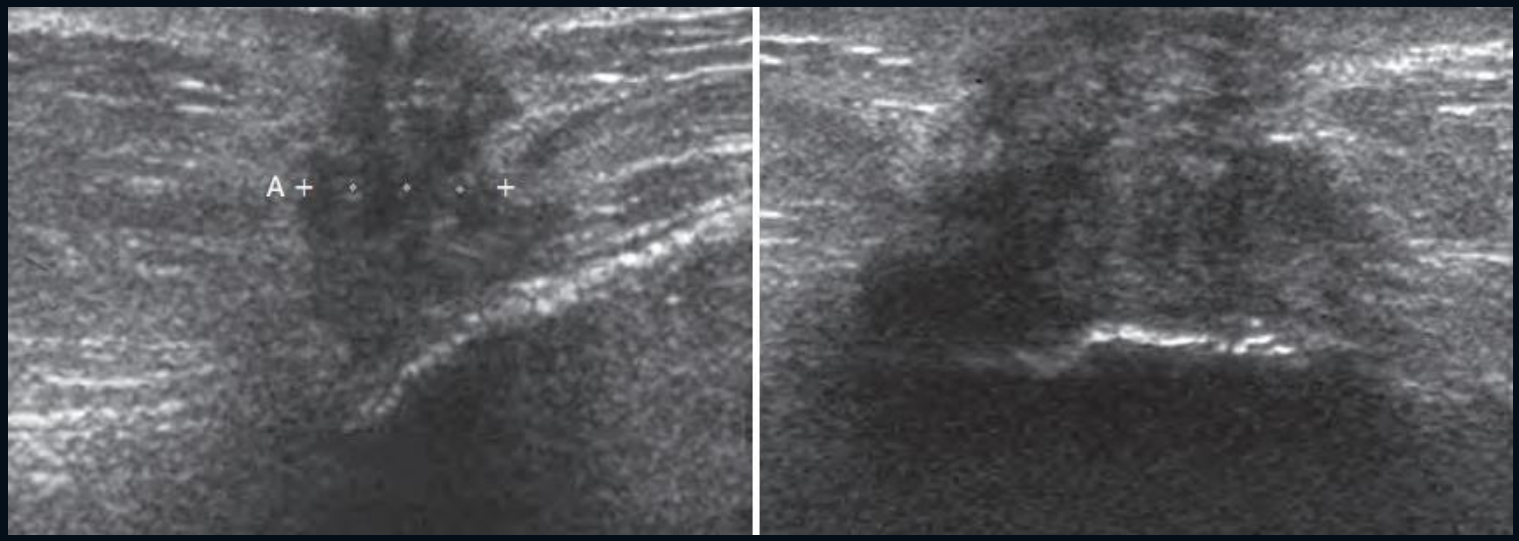
Even in the implant-displaces view; at least 20% of the breast tissue is hidden by the implant.

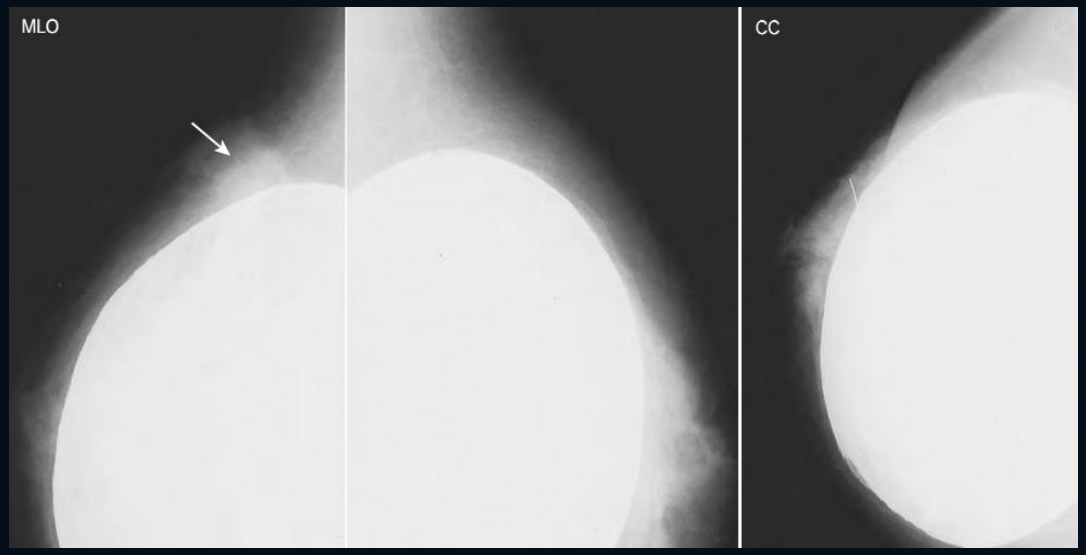
A mass near the fibrous capsule on standard views with limited compression may not be evident on implant-displaced views, because masses on the fibrous capsule can be pushed away from the field of view with the implant-displaced views.

Standard mammograms with limited comp.

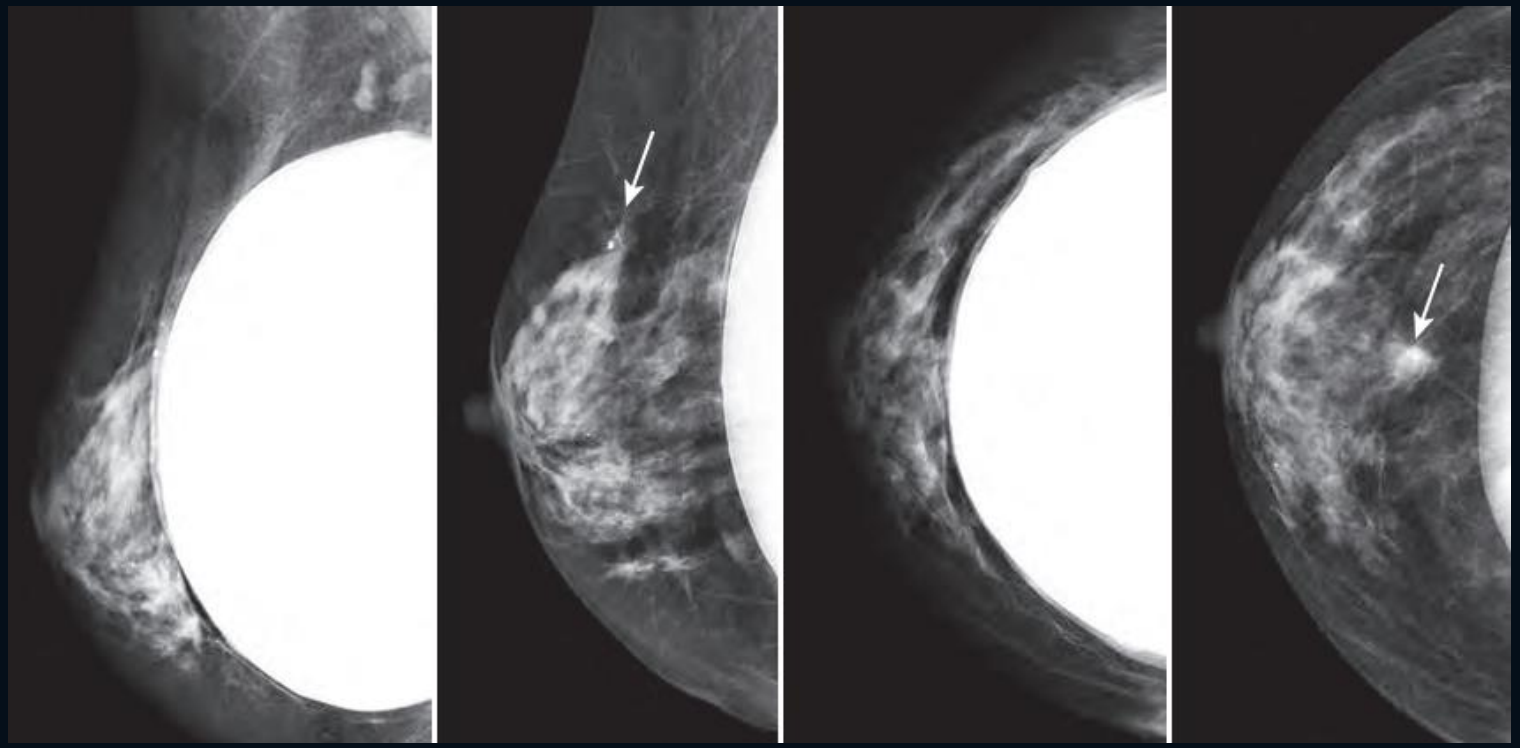
Implant-displaced mammograms

Breast cancer visualized on only one limited-compression mammogram:





Breast cancer visualized on only Implant-displaced mammograms:



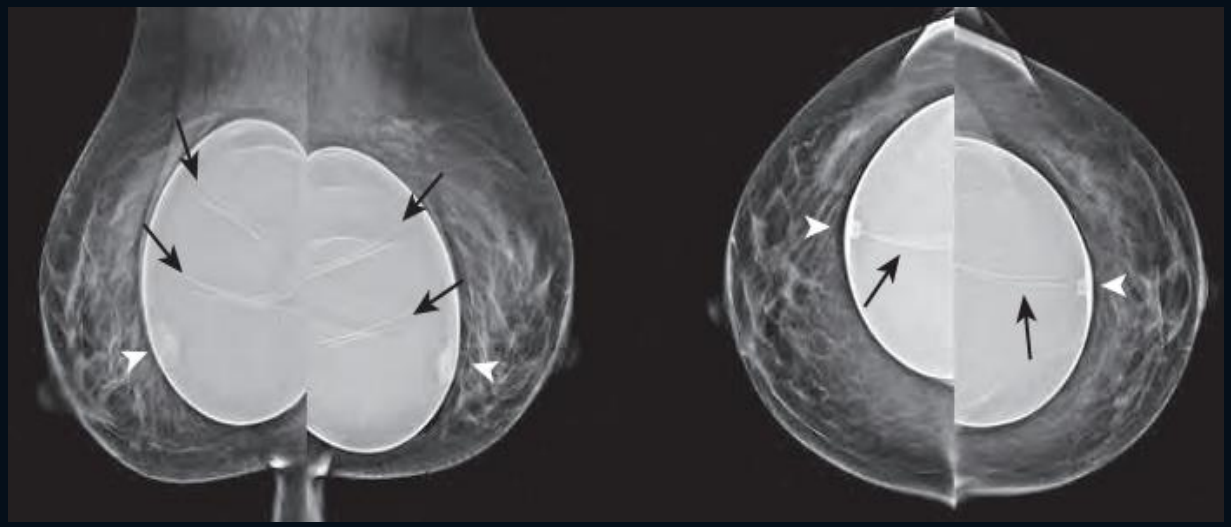
Normal Implants on Mammography

Single lumen silicon: dense

Double lumen: lucent saline and dense silicon portions (each can be inner/outer)

Wrinkle can be normally seen.

Normal subpectoral saline implants: note envelope wrinkles (arrows) and injection ports (arrowheads) in which the surgeon adds saline to increase or decrease the implant size at surgery



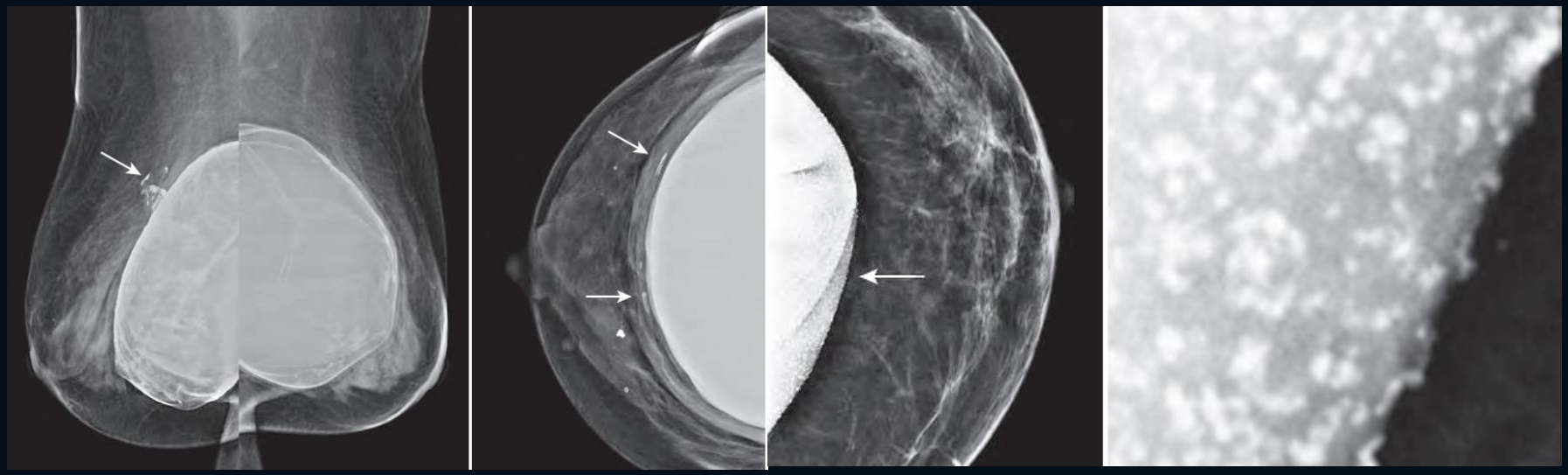
Normal Implants on Mammography

Fibrous capsule is not visible unless calcifies (dystrophic calc: usually sheet-like, can be nodular)

Capsular calcifications correlate with implant age (not imply capsular contracture or rupture)

Implant-displaced views displace the capsular calcifications away from the implant.

Fine mesh like calc. may occur in polyurethane-covered implants (sponge-like material): may be mistaken with cancer calc. especially after implant removal



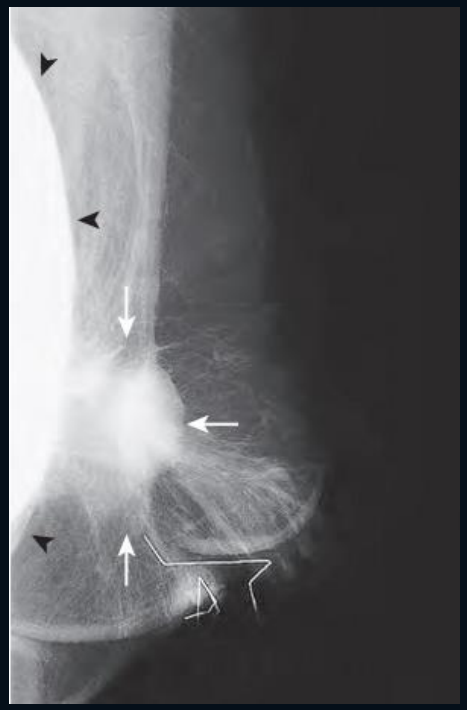
Mammography after Implant Removal

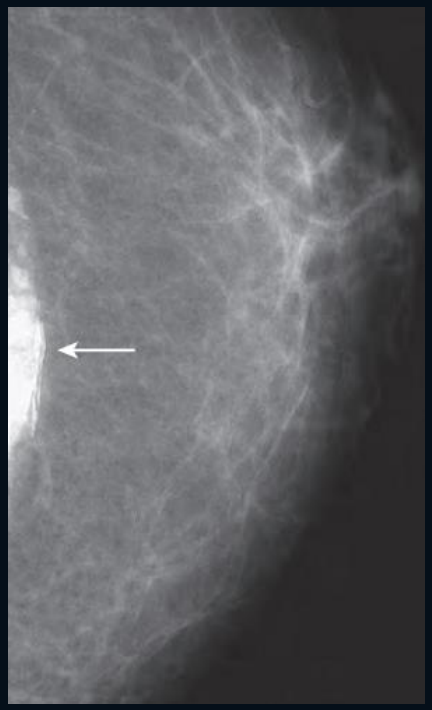
Fibrous capsule remains in place:

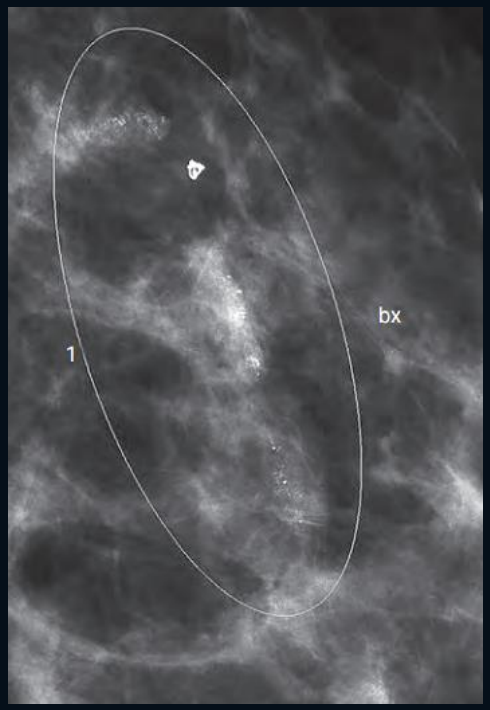
Cavity may resolve completely, or may scar and cause architectural distortion, or may fill with fluid and look like a mass.

If the capsule has calc.: dystrophic sheet-like curvilinear pattern at the chest wall.

Remnant of FC calc. or calcifying polyurethane: can mimic DCIS .







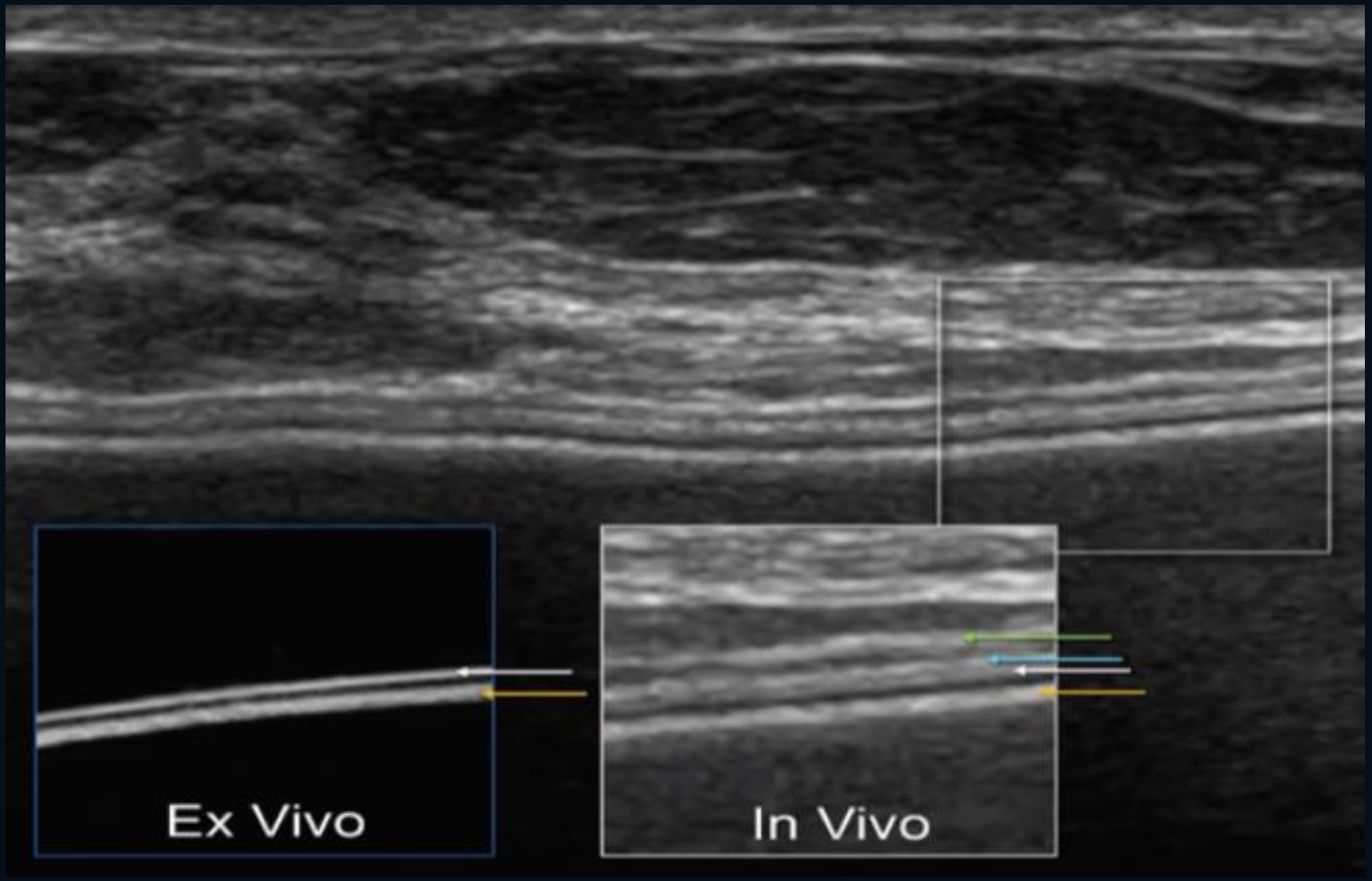
US of Normal Implant

Well-defined **trilaminar fibrous capsule–elastomer shell complex** (shell thickness: **1 to 1.5**mm)

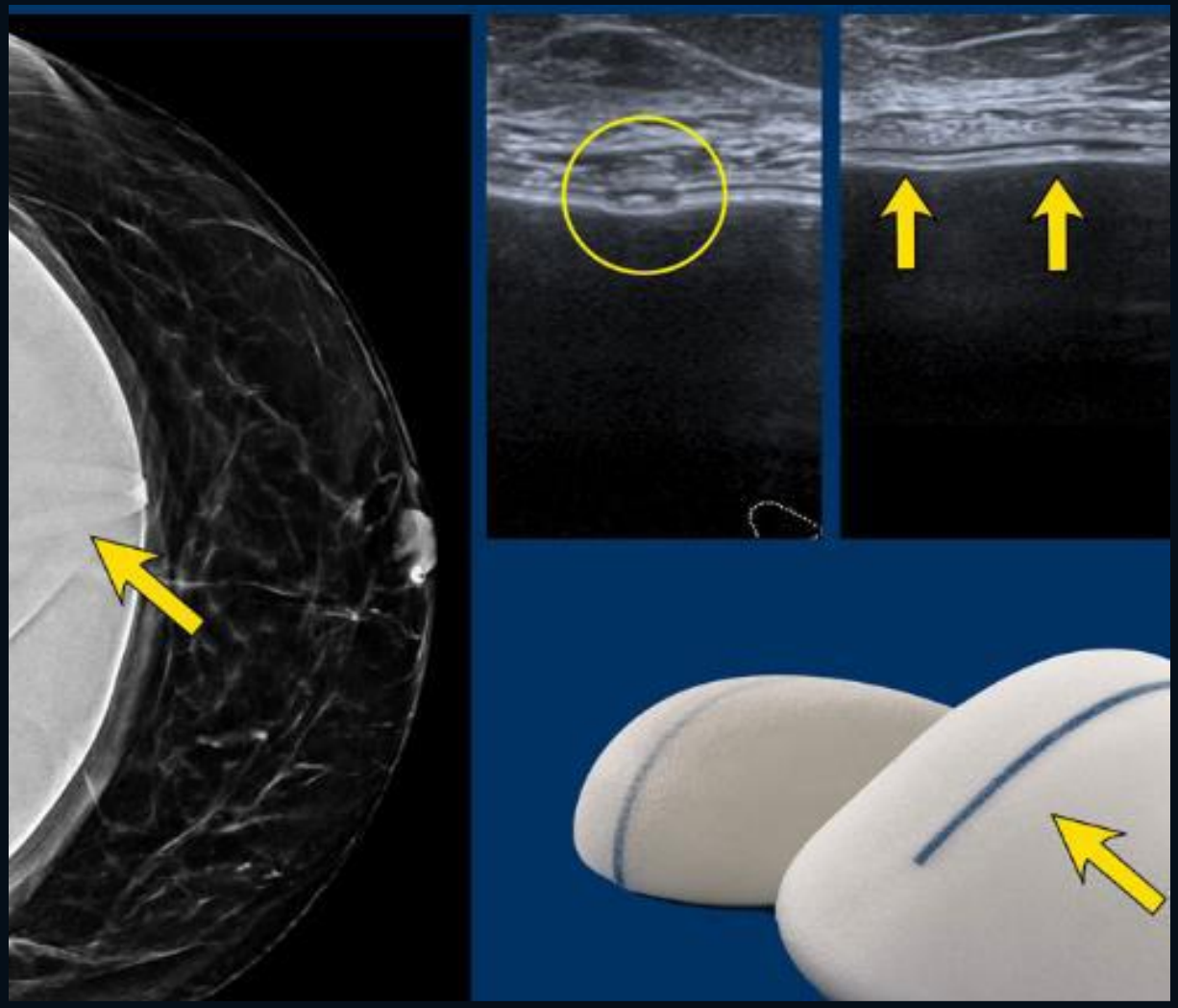
Superficial hyperechoic line (green arrow): outer aspect of the fibrous capsule

Deep hyperechoic line (yellow arrow): inner aspect of the elastomer shell.

Middle hyperechoic line: a combination of the inner aspect of the fibrous capsule (blue arrow) and the outer aspect of the elastomer shell (white arrow).

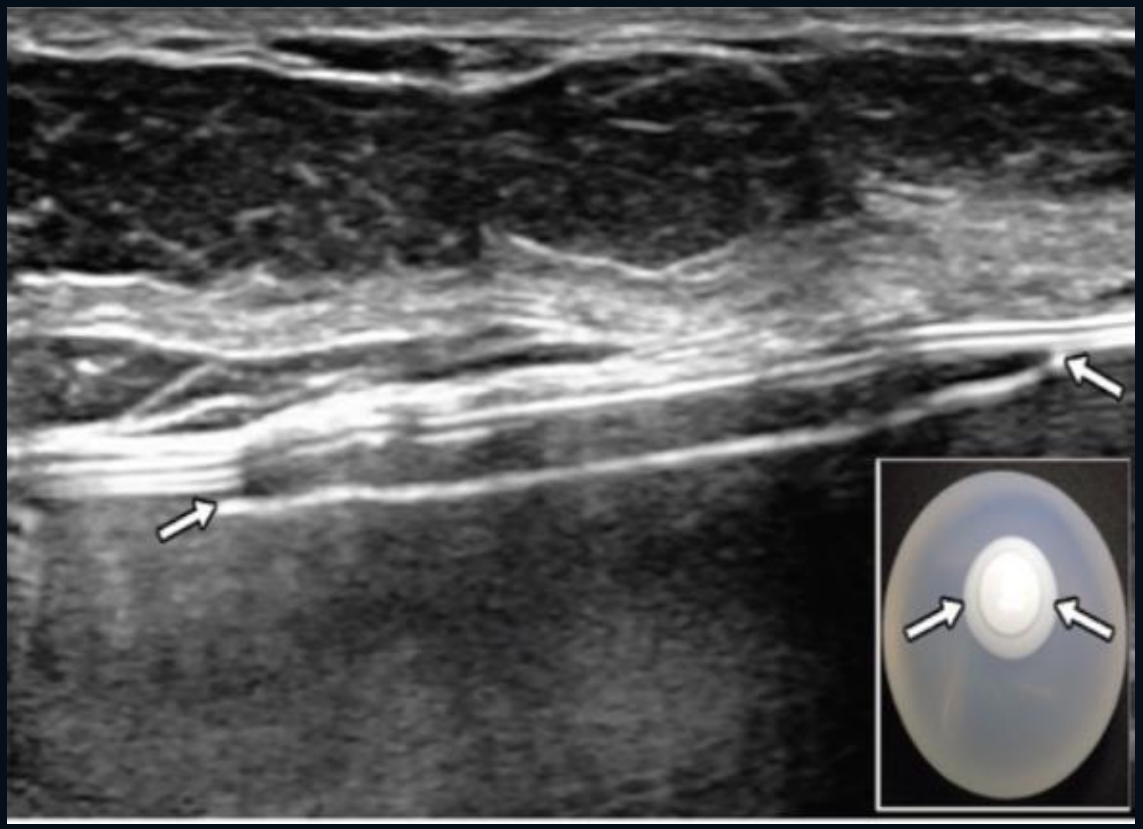

Ex Vivo
In Vivo

Markings



Fill valve

Silicone patch {textured} results in localized expansion of a portion of the normal trilaminar line, mimicking the subcapsular line sign. Homogenous and anechoic **silicone** lumen



MRI of Implant

only silicone implants should typically undergo MRI

Saline implants do not usually require imaging confirmation after deflation

Tissue expanders are generally considered a contraindication to MRI because may contain magnetic localization devices to define the fill port

Saline vs. Silicone Implant on MRI:

Signal Intensity:

saline : very bright relative to fat on T2, darker than silicone on T1

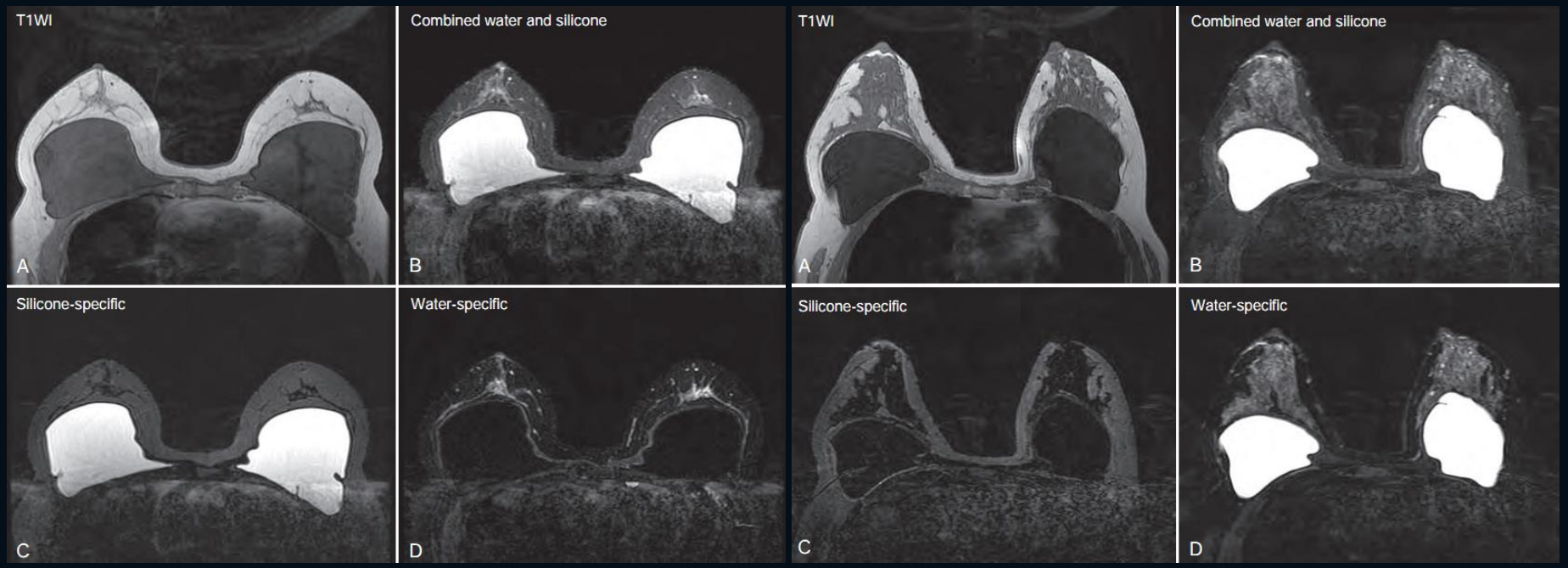
silicone: intermediate signal intensity on T2

Saline implants have fill valves (also known as injection ports) that are readily identified along the margin of the elastomer shell, frequently in a subareolar location. Small localization marks or larger patches characteristic of some silicone implants should not be mistaken for saline fill valves

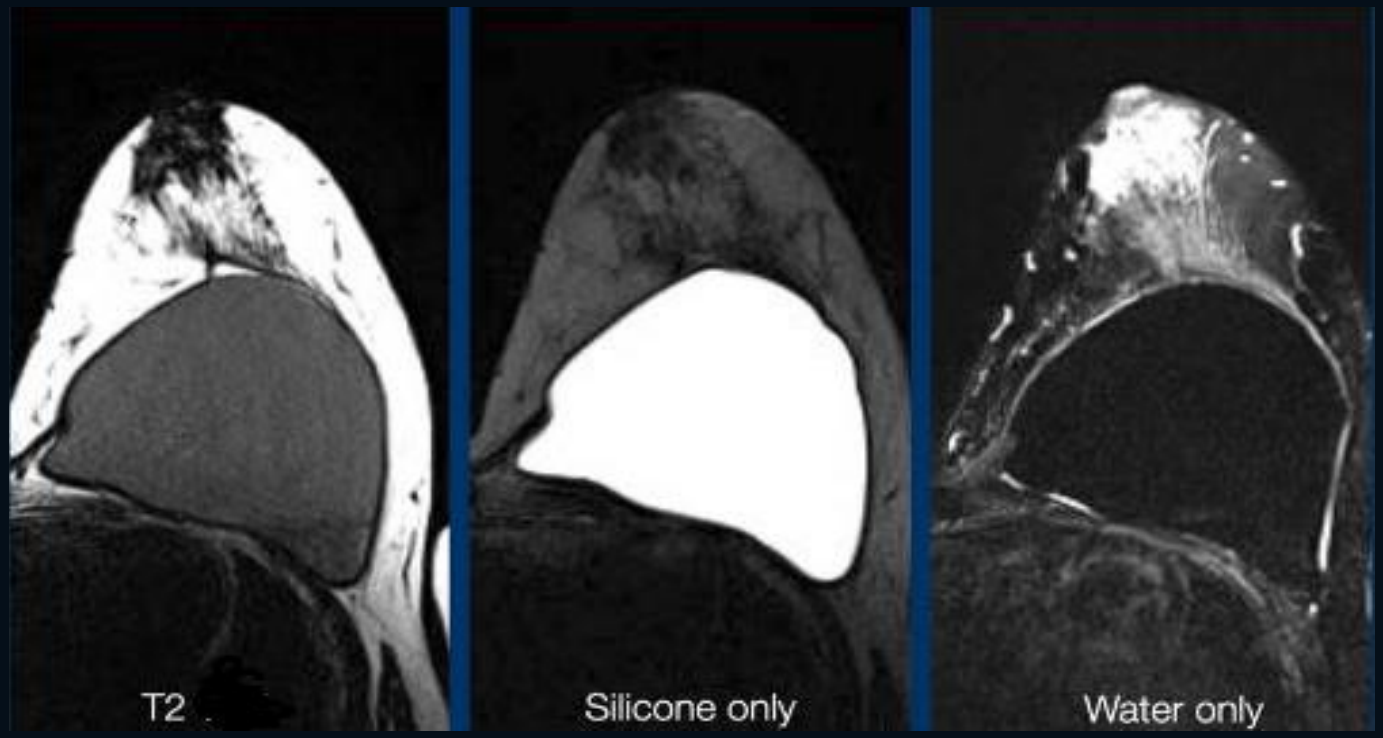
MRI of Implant

silicon implant

saline implant



	Silicone	Fat	Water
T2 FSE	●	●	○
Silicone only T2 FS/STIR Water suppressed	○	●	●
Water only T2 FS/STIR Silicone suppressed	●	●	○



MRI

Protocol:

T1

T2-FSE (Axial and Sagittal): orthogonal planes to diff. ICR from complex radial folds

T2- STIR (Axial)

Silicone-specific T2 (water-sat T2-STIR or T2-STIR with phase-based separation)

Optional; Water-specific T2 (silicone-sat T2-STIR or T2-STIR with phase-based separation)

Gd: unnecessary unless need form evaluation of other implant-related complications (infection or lymphoma) or patients with known or suspected cancer

Basis	Suppression of Fat Signal	Suppression of Water or Silicone Signal	MRI Sequences	Signal Intensity on MRI		
				Fat	Water	Silicone Gel
T2	NA	NA	T2 FSE	High	High	High
	Inversion recovery		T2 FSE + STIR	Dark	High	High
		Saturation pulse	T2 FSE + STIR + Water-sat[a]	Dark	Dark	High[c]
			T2 FSE + STIR + silicone-sat	Dark	High	Dark
		PBS[b]	T2 FSE + STIR + PBS; water only	Dark	High	Dark
			T2 FSE + STIR + PBS; silicone only	Dark	Dark	High[c]
			T2 FSE + STIR + PBS; combined	Dark	High	High
T1	NA	NA	T1	High	Very low	Low

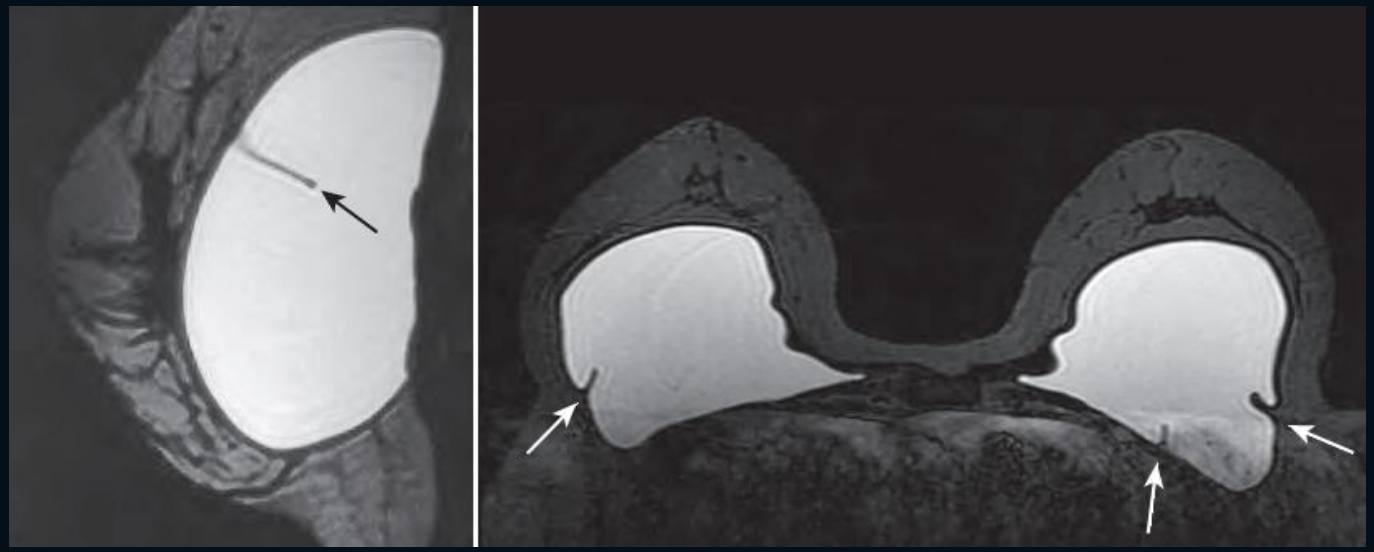
MRI

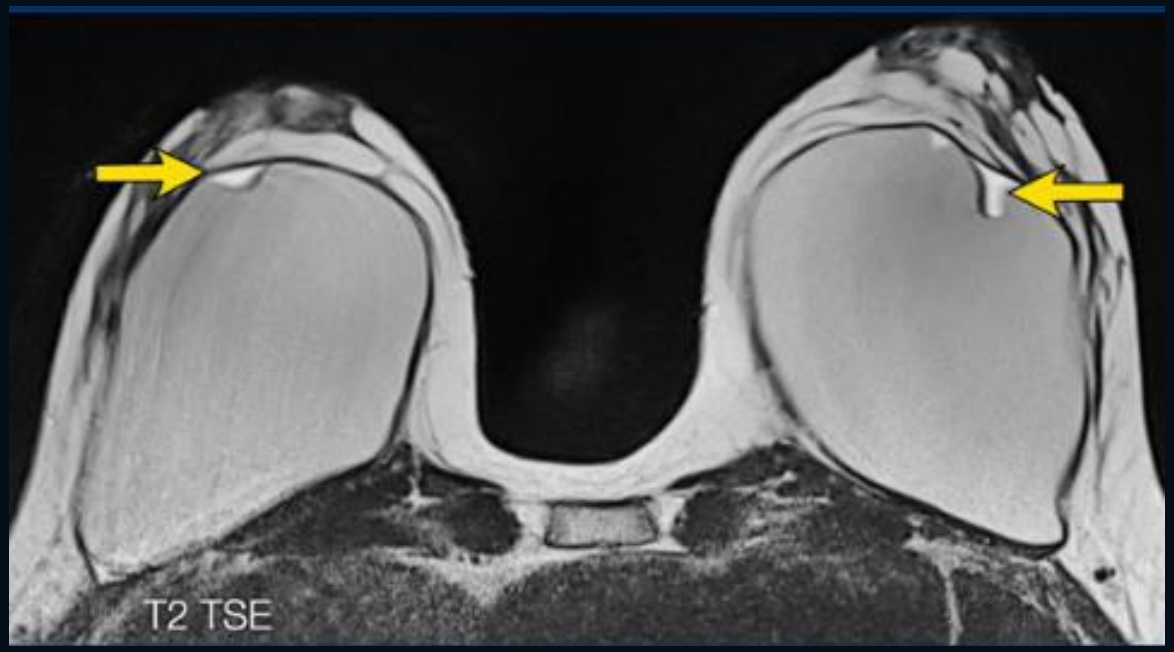
Non-specific finding:

Minor implant bulge or herniation

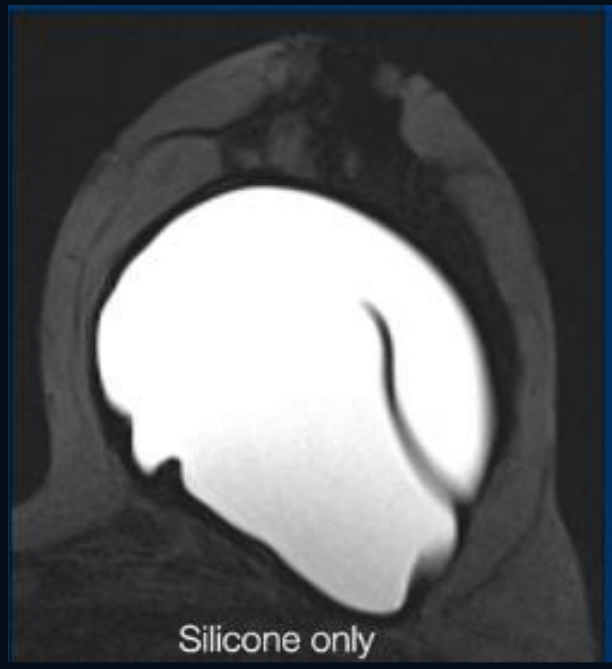
Reactive fluid around the implant and water droplets in a radial fold (classified as nonspecific findings but are noted in the report particularly if the findings are marked or implant infection is suspected

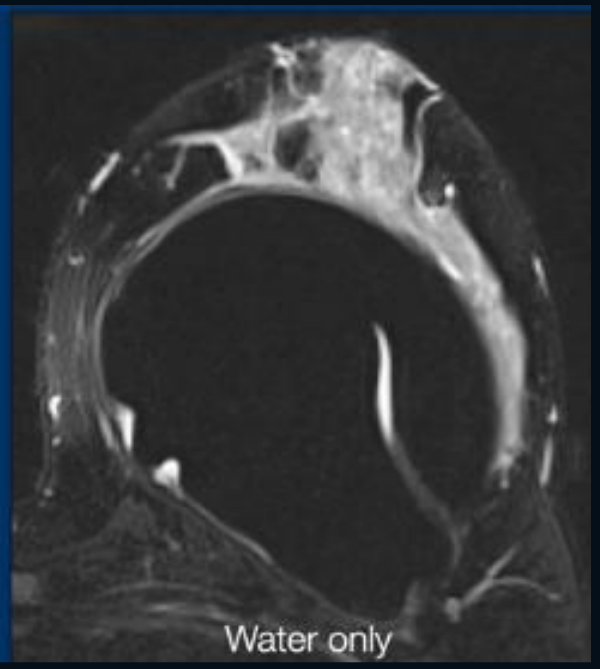
Radial folds (dark lines that extend to the periphery of the implant):





Radial folds





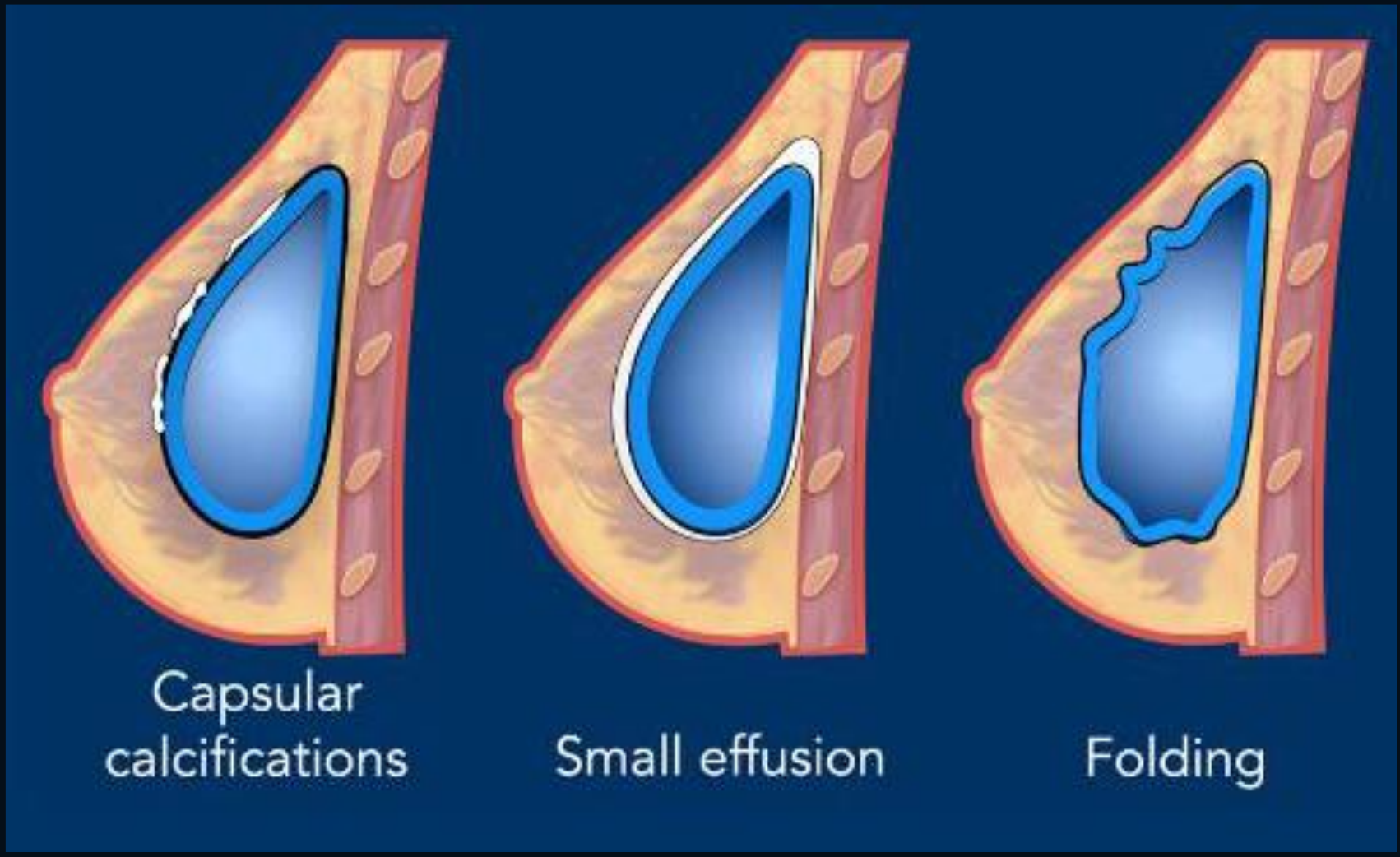
Implant Complications

- Collections (hematoma, seroma, infection)

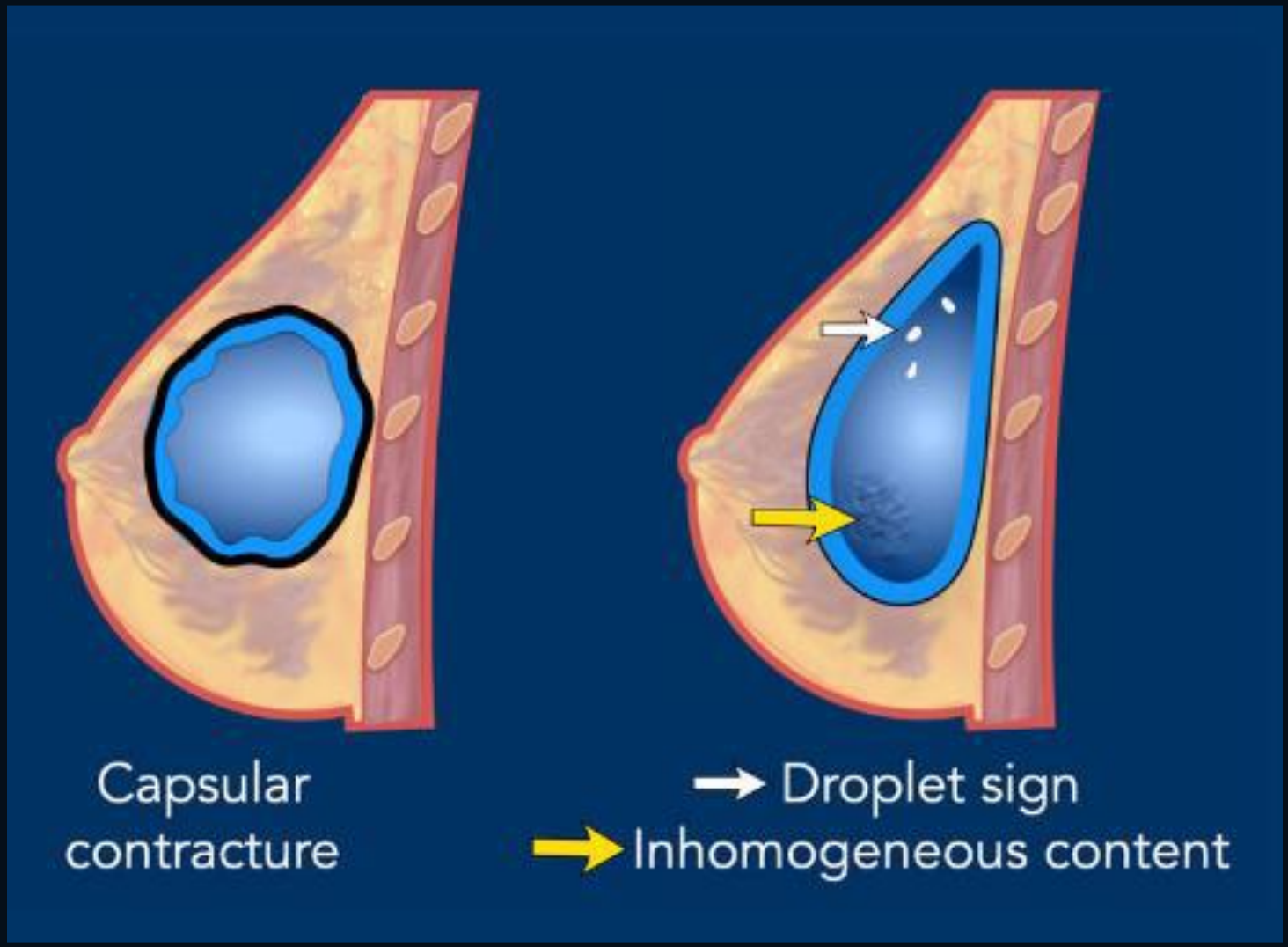
- Displacement
- Pain, breast feeding difficulty

- Fibrous capsule contraction
- Rupture and gel bleed
- Implant associated anaplastic large cell lymphoma
- Implant-associated fibromatosis

Normal	Inconclusive	Intracapsular R	Extracapsular R
Capsular formation	Droplet sign	Subcapsular line	
Capsular thickening	Diffuse slight inhomogeniety	Droplet, Noose and Keyhole sign*	
Capsular calcifications		Linguine sign	
Small (symmetrical) effusion	Extracapsular silicone without signs of rupture	Stepladder sign (US)	Extracapsular silicone with other signs of rupture
Radial deep complex folds			


Capsular calcifications
Small effusion
Folding

Degenerative changes



Fibrous Capsule contraction

The most common complication

Become hard and round on palpation and appearance

More in sub-glandular implants and less in textured sub-pectoral ones

R/x

- Open capsulotomy (surgical removal of FC)
- Closed capsulotomy: squeezing the implant to rupture the FC (risk of implant rupture)

Implant associated(BIA) ALCL

Implant associated anaplastic large cell lymphoma is very rare

Disease of the fibrous capsule, not breast parenchyma

Presentation: effusion (more common), mass

Reported interval from surgery and Dx: 1-32y

Seroma is very rare beyond 1 year after surgery; so in case of delayed effusion, cytology can be considered.

BIA-ALCL

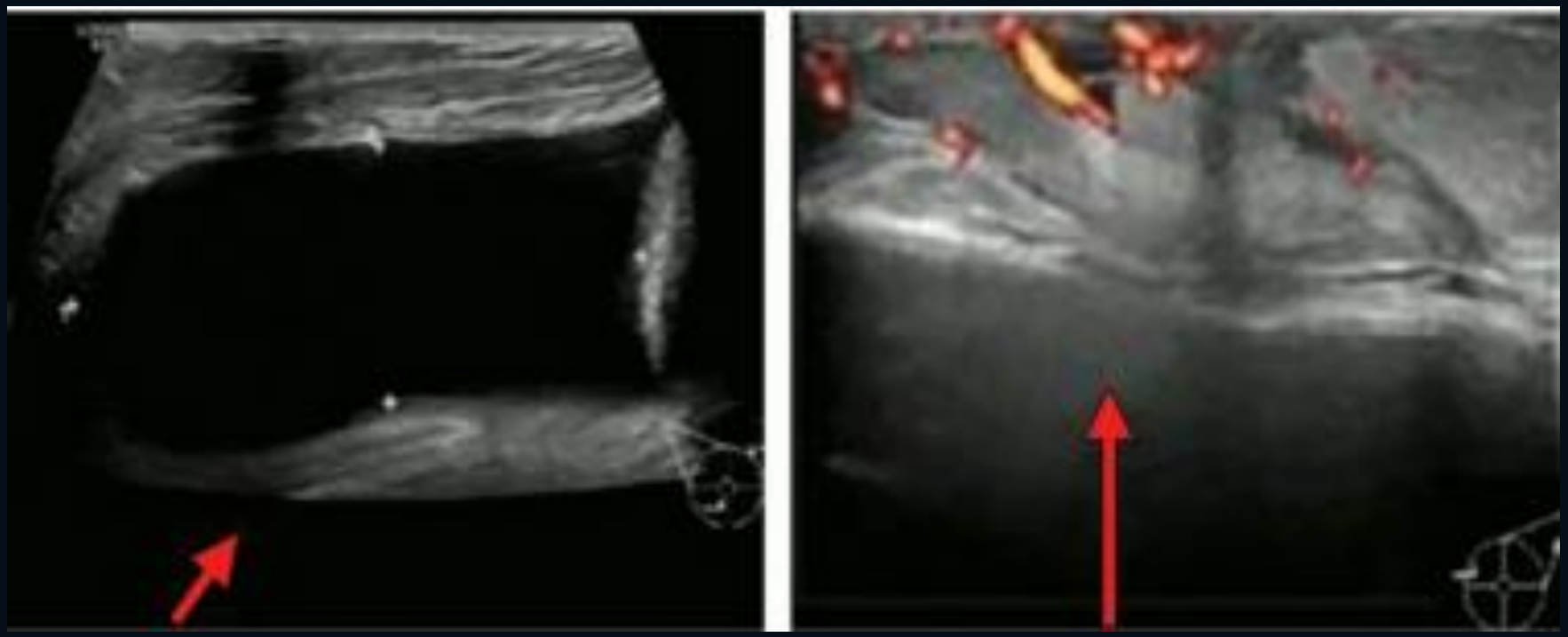
- usually manifests as a homogeneous
- peri-implant effusion with inflammatory changes in the periprosthetic breast tissue, associated in some cases with irregular capsule contour .
- -BIA-ALCL mass-foring type usually manifesting as an oval, hypoechoic, and well-circumscribed solid mass.

BIA-ALCL

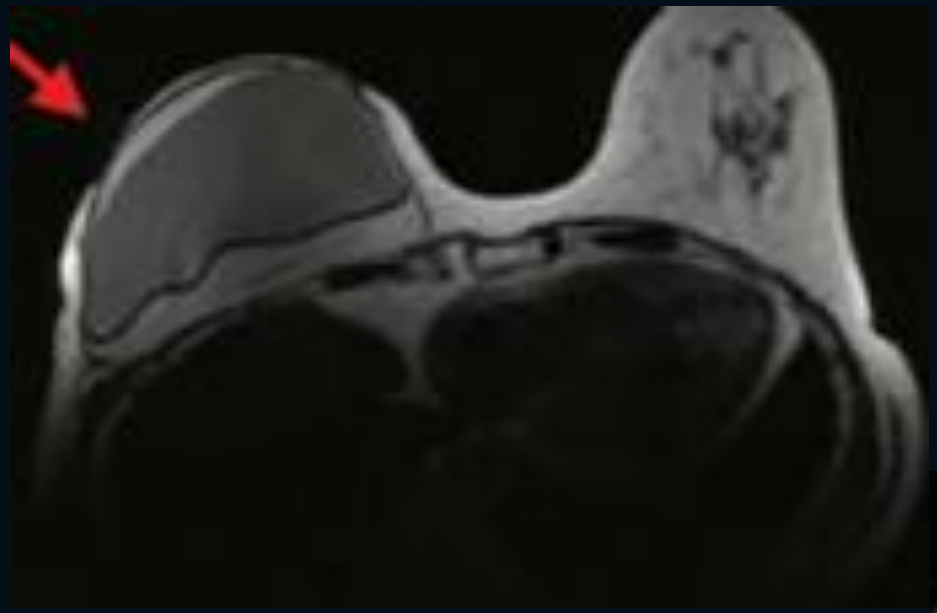
- …does not show hypervascularity at Doppler US.

- A complex-cystic mass has also been observed in BIA-ALCL.

BIA-ALCL

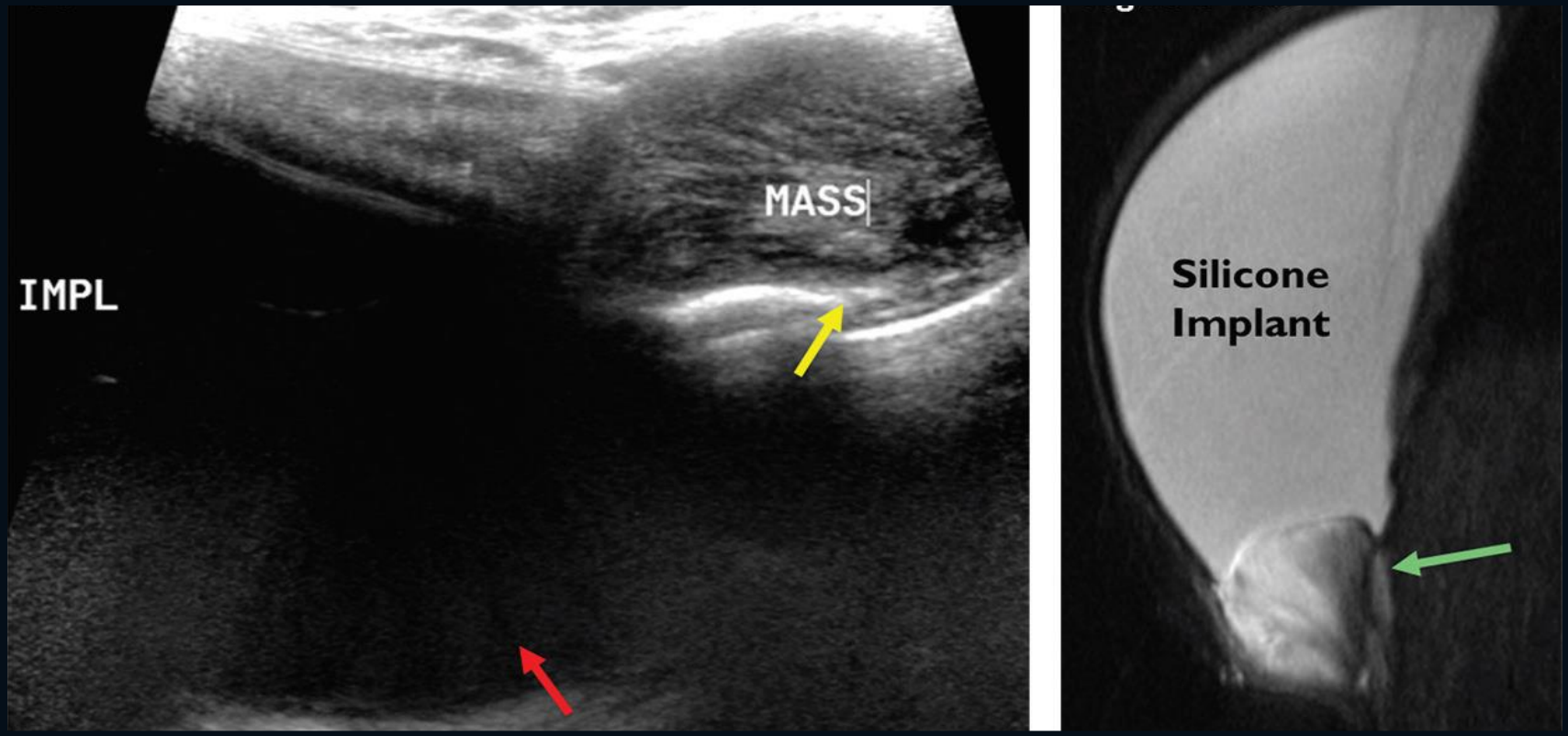


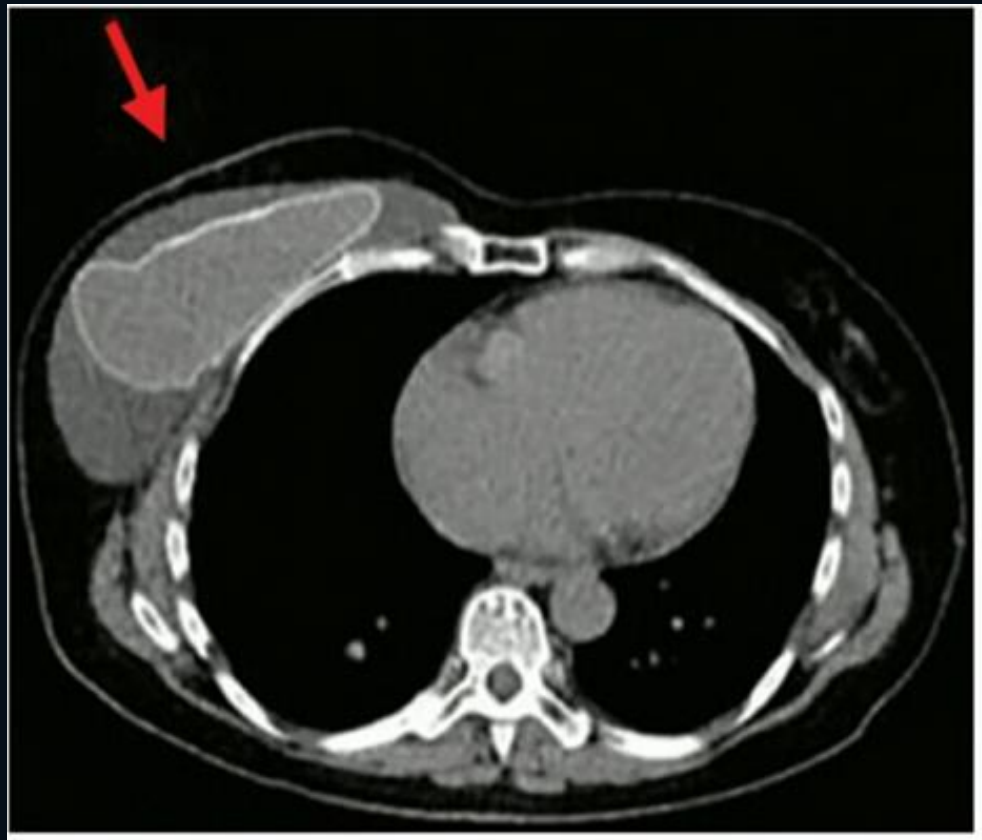
BIA-ALCL



Implant associated Fibromatosis

A mass adjacent to the implant





CT of BIA-ALCL in a 55-year-old woman who underwent right mastectomy and axillary node dissection followed by implant reconstruction, chemoradiotherapy, and immunotherapy (same patient as in Fig 1a–1d). After 9 years, the implant was exchanged; 7 years later, sudden new marked swelling of the right breast developed. CT image shows a large effusion (arrow) around the right breast implant with no associated mass component being defined, no local-regional or distant adenopathy, and no extranodal disease according to CT lymphoma staging criteria.

Rupture

Occurs more in retro-glandular position and presence of capsular retraction

Saline implant rupture:

saline diffuses into the breast tissue and the envelope shrinks back

saline (mixture of salt and water) is absorbed into the body with no major complications.

usually noticeable to the patient because her breast becomes noticeably smaller

Silicon implant rupture:

can be:

silent clinically without noticeable reduction in breast size.

-May include changes in breast size or shape,

-a palpable abnormality in the breast or axilla, pain, or skin tightening.

IC is usually asymptomatic.

EC may incite inflammatory changes to become clinically apparent.

Rupture

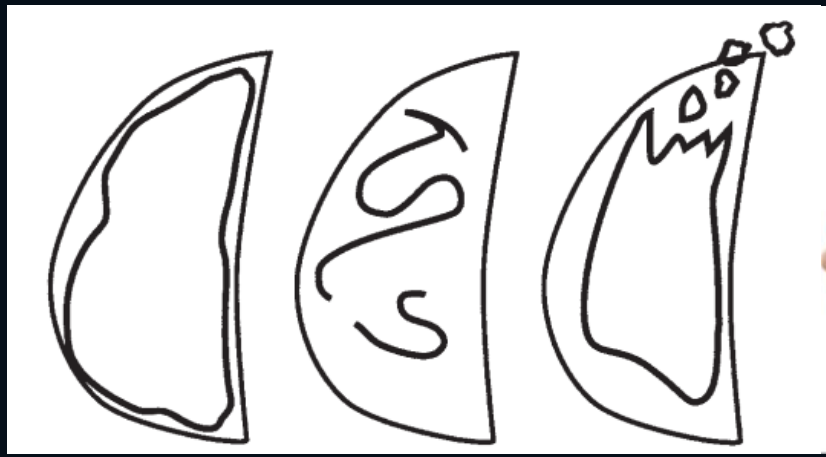
Silicone implant integrity is classified as

intact

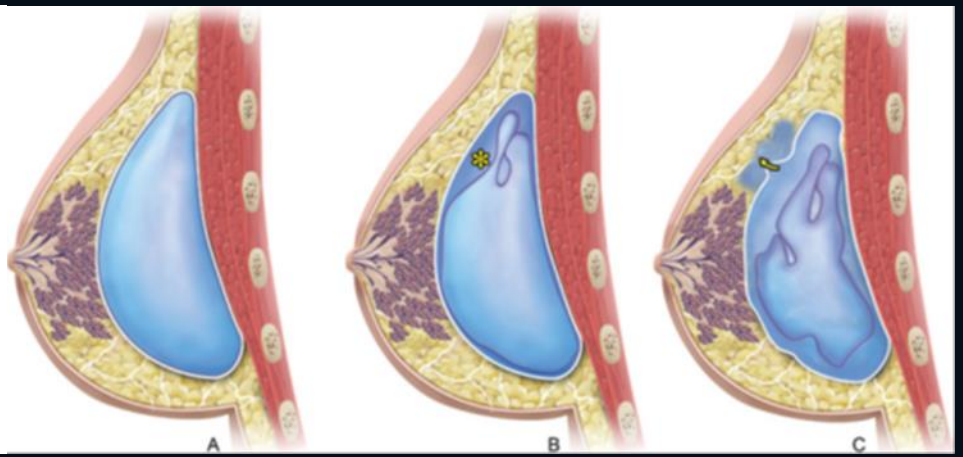
intact with gel bleed: silicone gel leakage through an intact implant envelope, although the existence of gel bleed versus small, undetected ruptures remains controversial

Intracapsular Rupture: surrounding fibrous capsule is intact

Extracapsular rupture: silicone gel extruded outside a broken fibrous capsule



Intact ICR ECR



Mammography of Implant Rupture

Findings:

1. Contour abnormality
2. Silicone outside implant
3. Silicone in Axillary nodes

Contour abnormality

Comparison with prior mammograms to identify subtle contour changes over time

Focal bulging: can occur in ECR, ICR, FC contraction, herniation of intact ES from FC

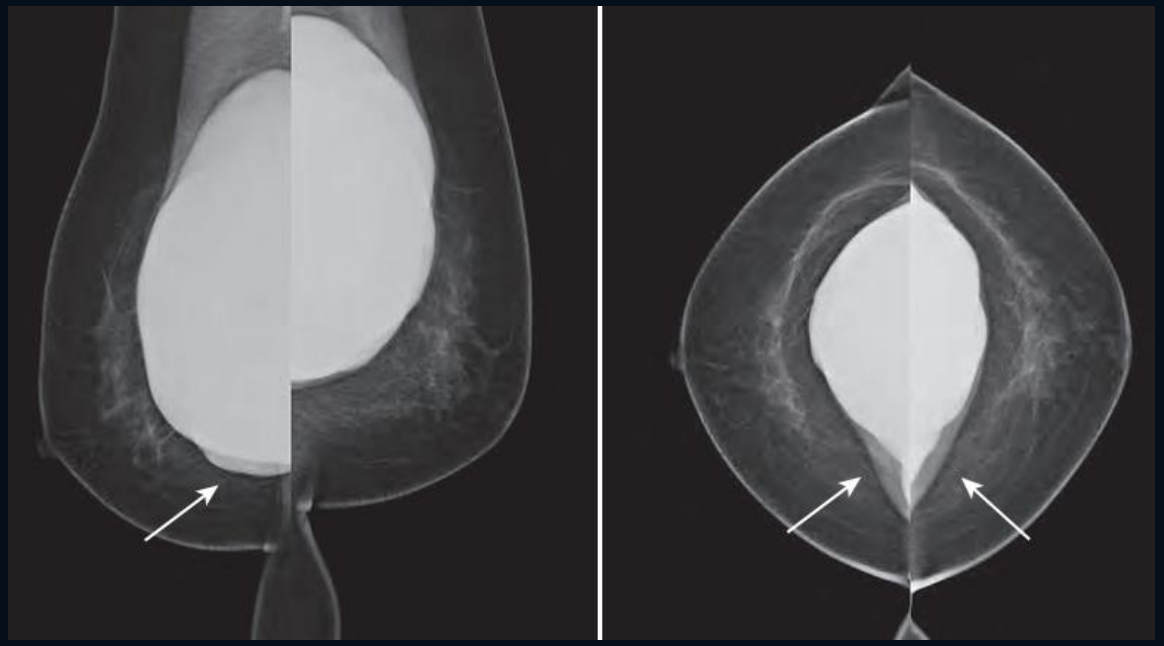
Undulations, frank bulges or herniations: needs evaluation by US or MRI.

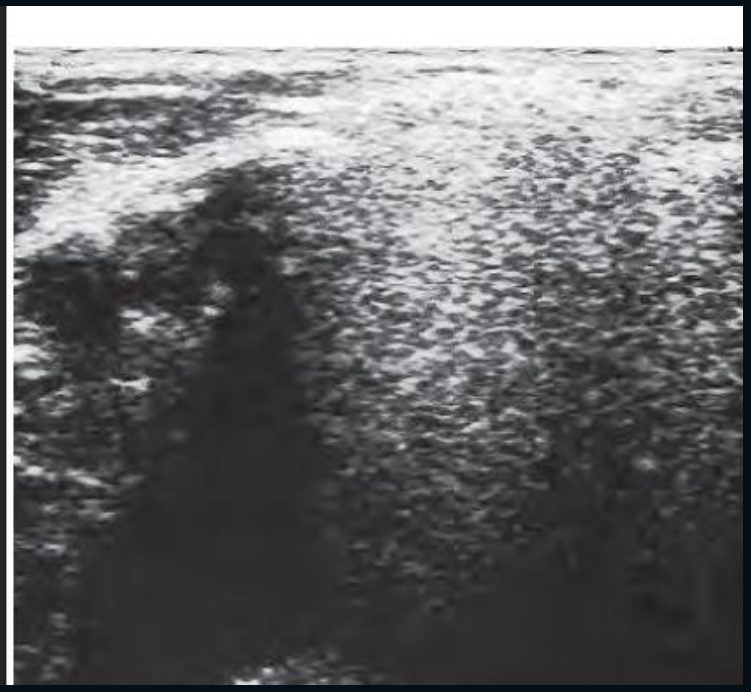
(Mammography Is not reliable for ICR)

Diffuse contour abnormality: May occur in ECR

More rounded implant may signify capsular contracture rather than problem with implant integrity.

ECR: abnormal contour



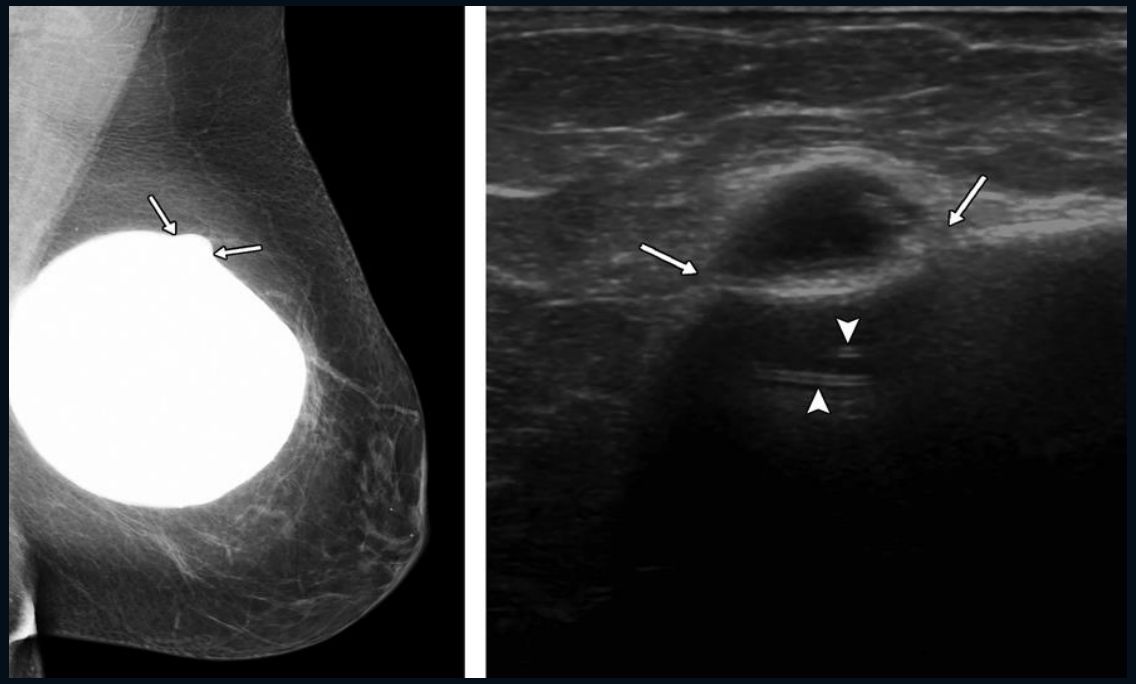


Intra-Capsular Rupture:

abnormal contour

Mammography: focal bulge (arrows) along the superior aspect of a silicone implant

US: bulge (arrows) along with parallel echogenic lines in the interior of the implant (arrowheads) that correspond to an inwardly displaced elastomer shell. Note the absence of the usual trilaminar line.



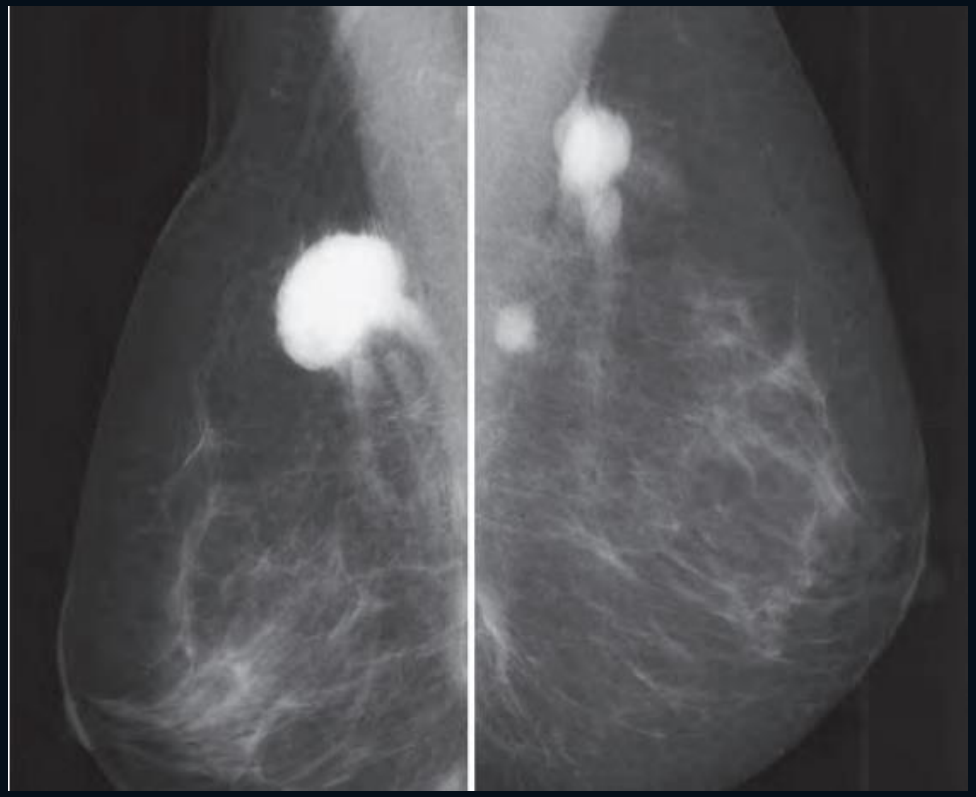
Mammography of Implant Rupture

Silicon globes outside the implant:

Mx:

- **Small amount of free silicone** in breast may appear as a high-density focal asymmetry that can be suspicious for malignancy particularly when the **ruptured implant** has been removed.
- More confluent collections of silicone can range in appearance from **oval circumscribed** masses to **irregular** masses with indistinct or potentially spiculated margins. A high level of suspicion for silicone is needed to avoid **unnecessary biopsy.**
- Extracapsular silicone may extend along the pectoralis major muscle or subcutaneous tissues

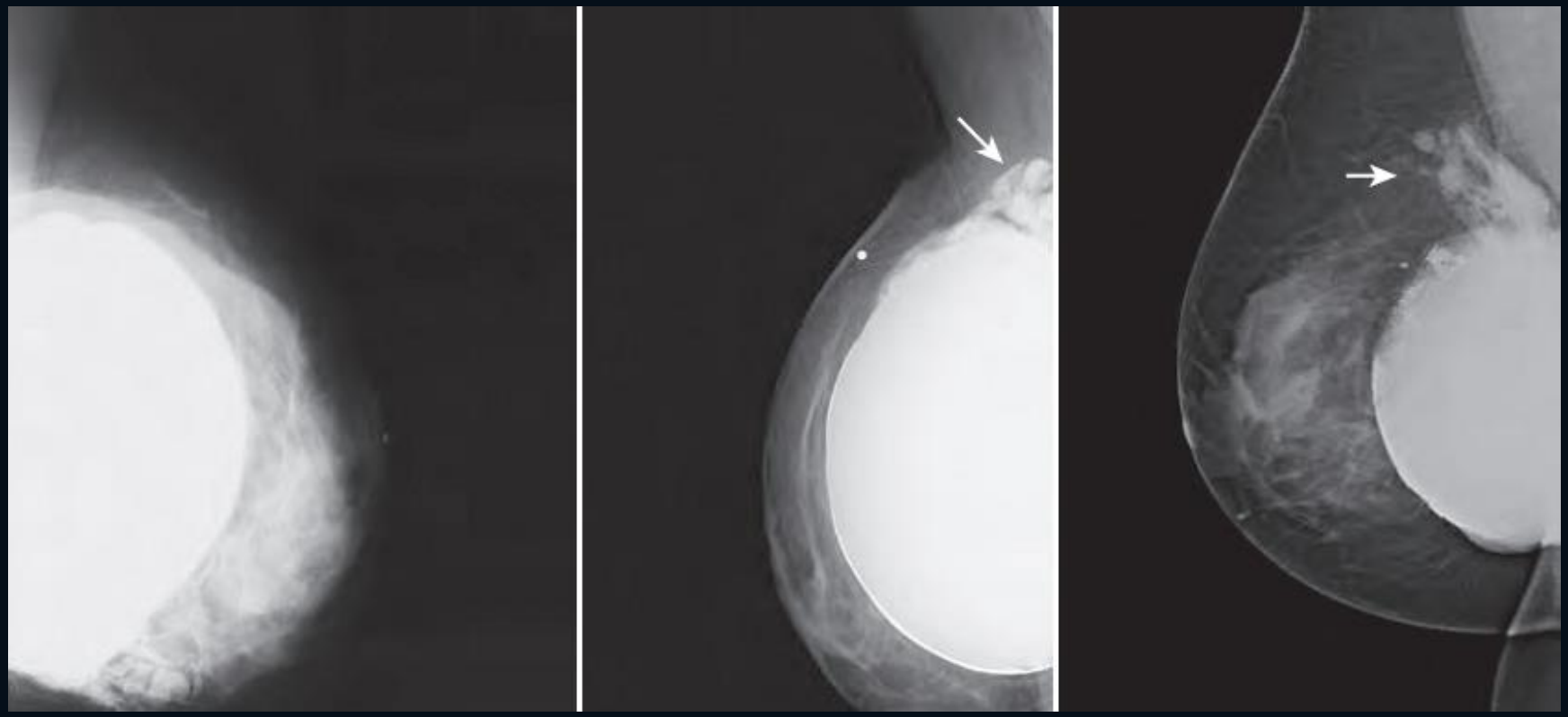
Mammography after Implant Removal with history of extracapsular rupture



DDx:

1. High density silicone outside the expected contour of the implant,
2. H- (in the absence of a history of implant rupture or revision) signifies ECR. (Mammography is reliable for ECR, No supplemental imaging is usually required)
3. F+: May be retained silicon following removal of ruptured previous implant (makes it impossible to tell if the ???new implant has ruptured)
4. F-: May not be seen (masked by the implant)

ECR: blobs of extruded silicons

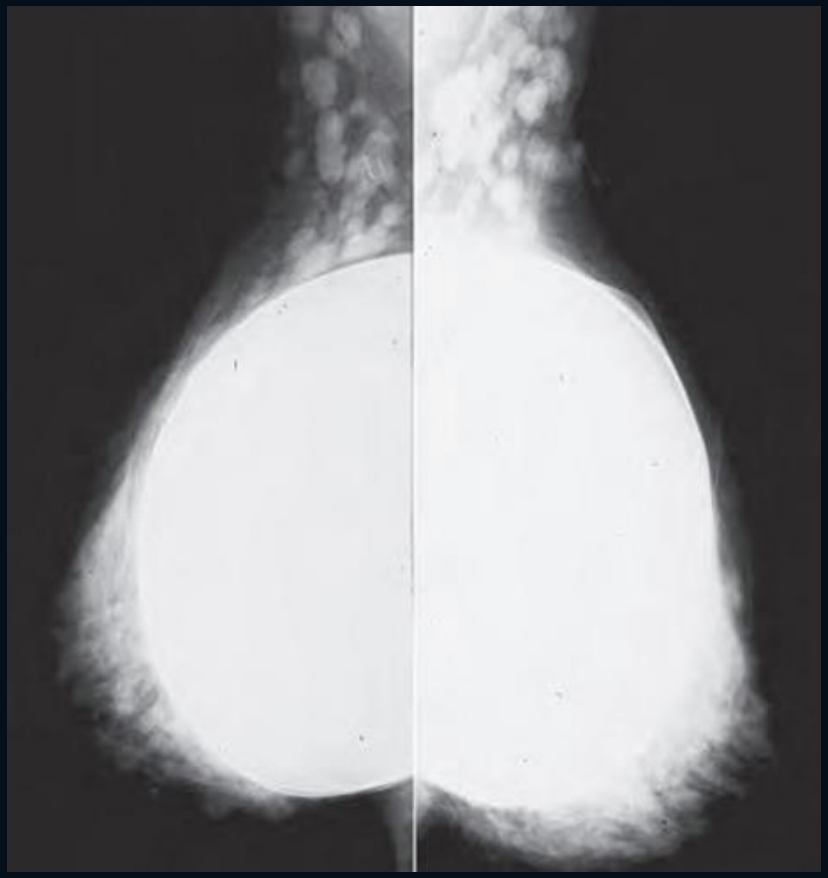


Mammography of Implant Rupture

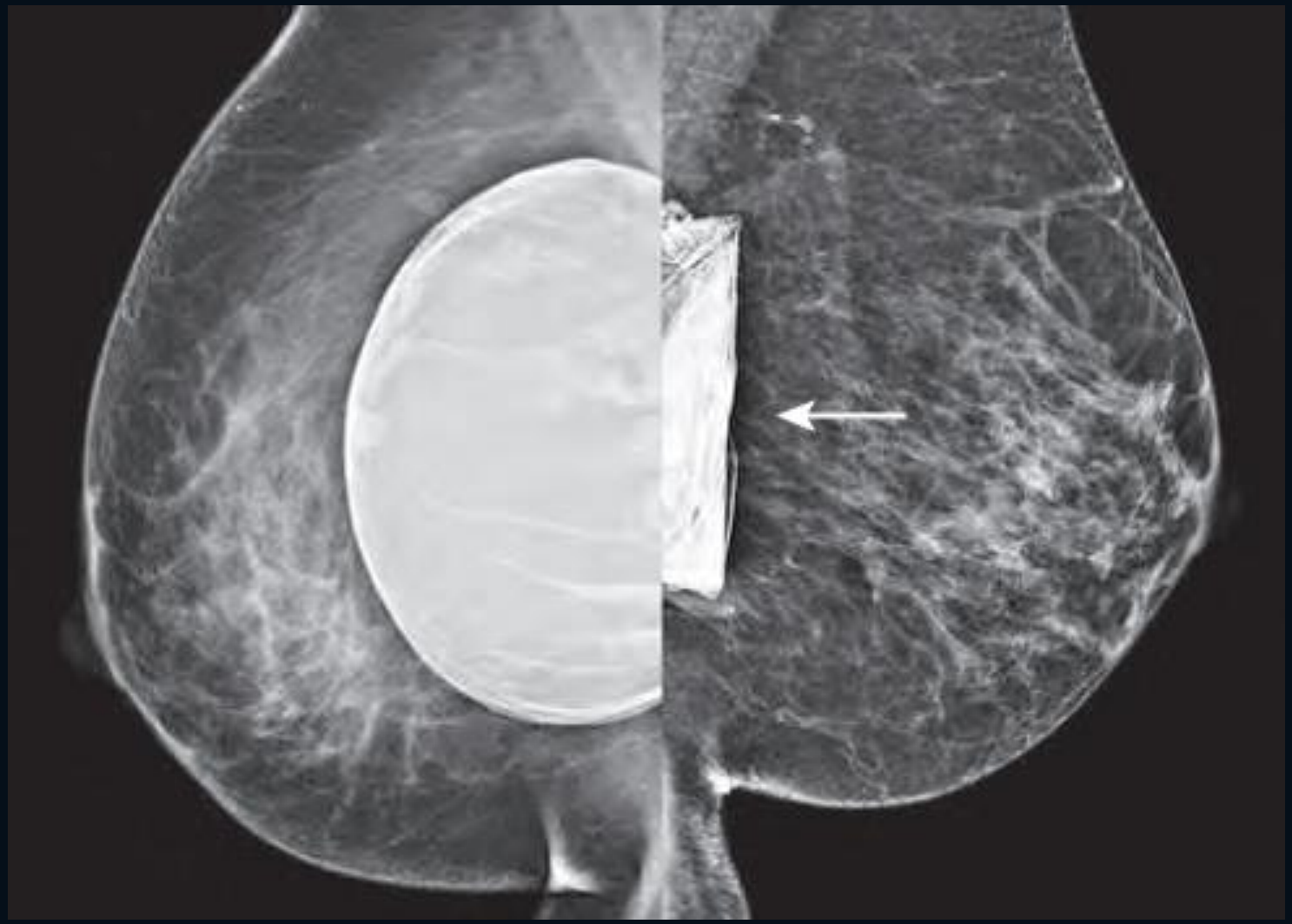
Silicone in LNs:

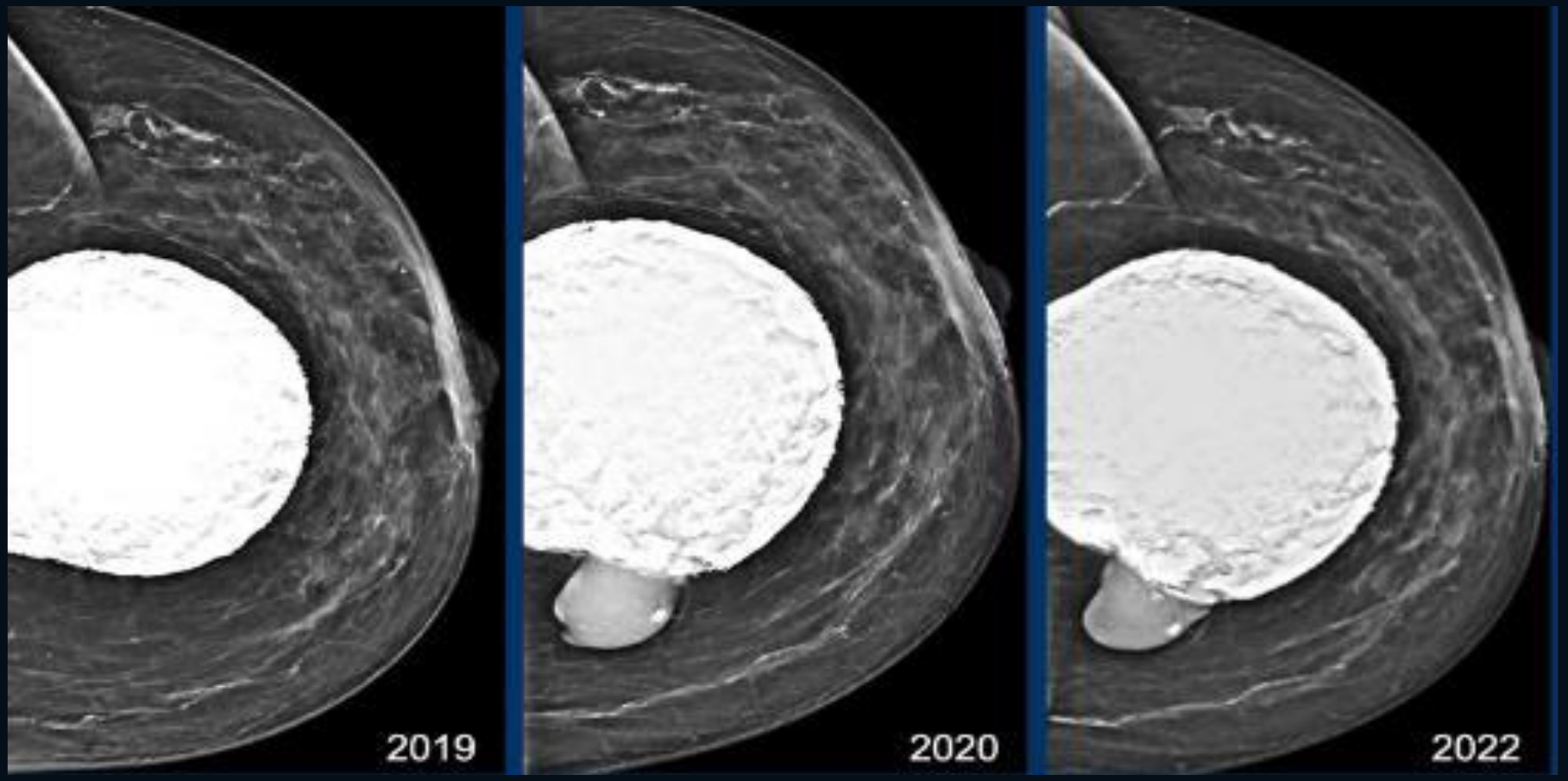
The mere presence of silicone within **axillary nodes** **is not sufficient** to diagnose implant rupture (may be **gel** **bleed** as escape of small un-polymerized silicone through an intact elastomer shell); however, silicon in lymph nodes needs evaluation by **US or MRI**.

Silicone in axillary nodes: Hx of removal of ruptured implant (ECR), replaced with new ones



saline implant rupture: collapsed envelope at the chest wall




2019
2020
2022

US - ICR

ICR:

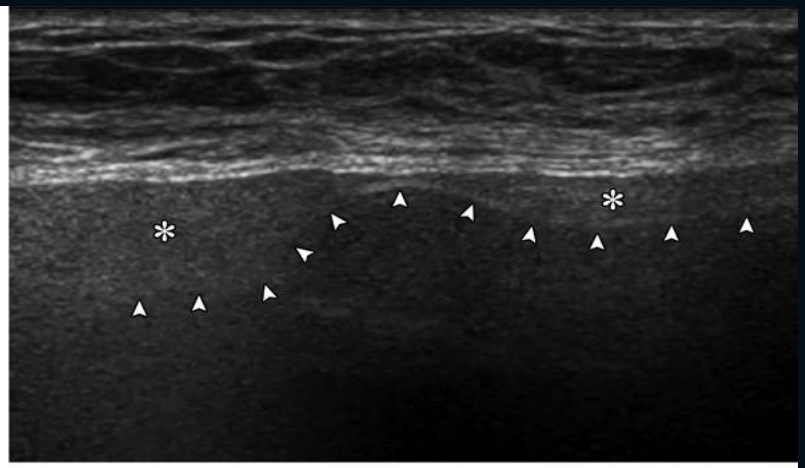
- **Uncollapsed ES - Silicon in radial fold (Keyhole** or noose sign) **collection** of intracapsular silicone within the apex of a **radial fold (a)**

- Minimal Collapse **of ES - Silicon in intracapsular space: Subcapsular line sign** (arrowheads): shell is pushed inwardly by intracapsular silicone (*)**(b);** Finally **complete loss** of the normal trilaminar line due to extrusion of silicone into the **intracapsular space**. The internal echogenicity of the implant has increased, with diffuse low-level echoes corresponding to a large amount of silicone within the intracapsular space. **(d)** arrowhead: a short subcapsular line

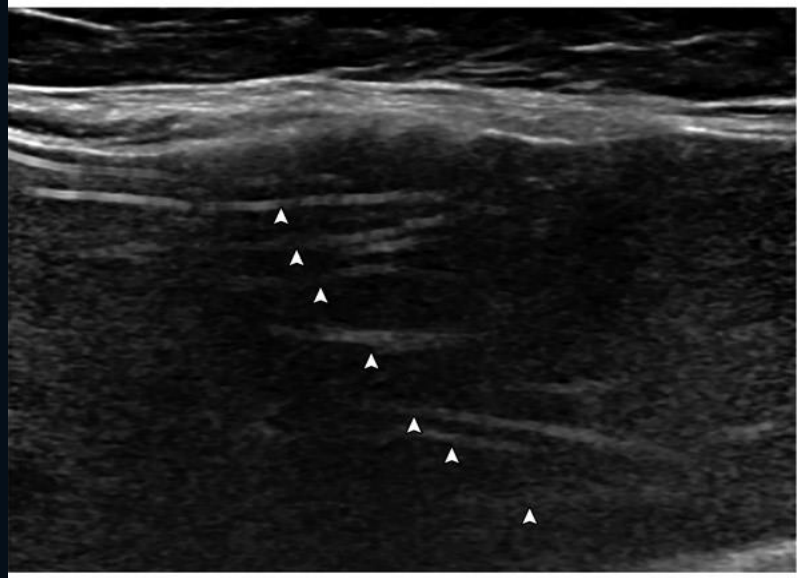
- **Partial or Full Collapse of ES- Stepladder** sign **(**equivalent to **linguine sign** on MRI): Collapsed and highly infolded elastomer shell as Multiple **discontinuous** linear echoes or wavy lines in the lumen that do not extend to the periphery of the implant **(c)**; occur in both ECR or ICR

- Less definitive signs: diffuse linear echoes or diffuse low-level echoes within the implant

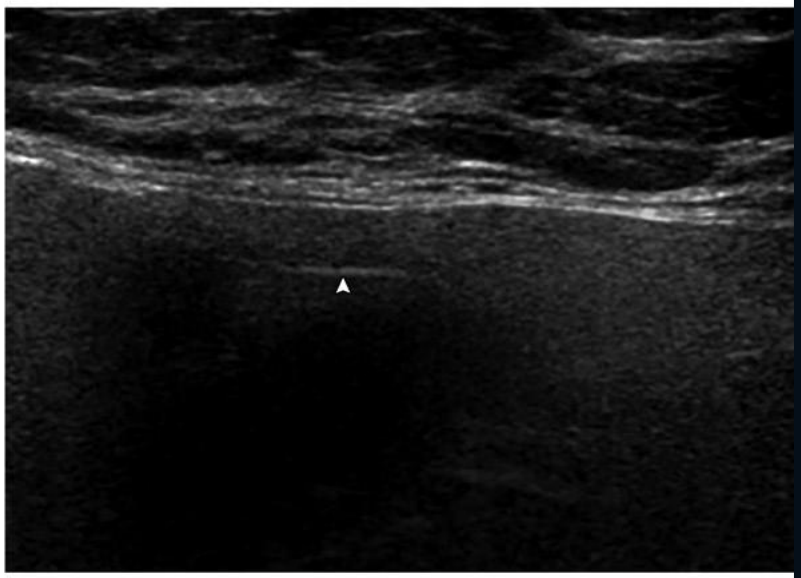
a.



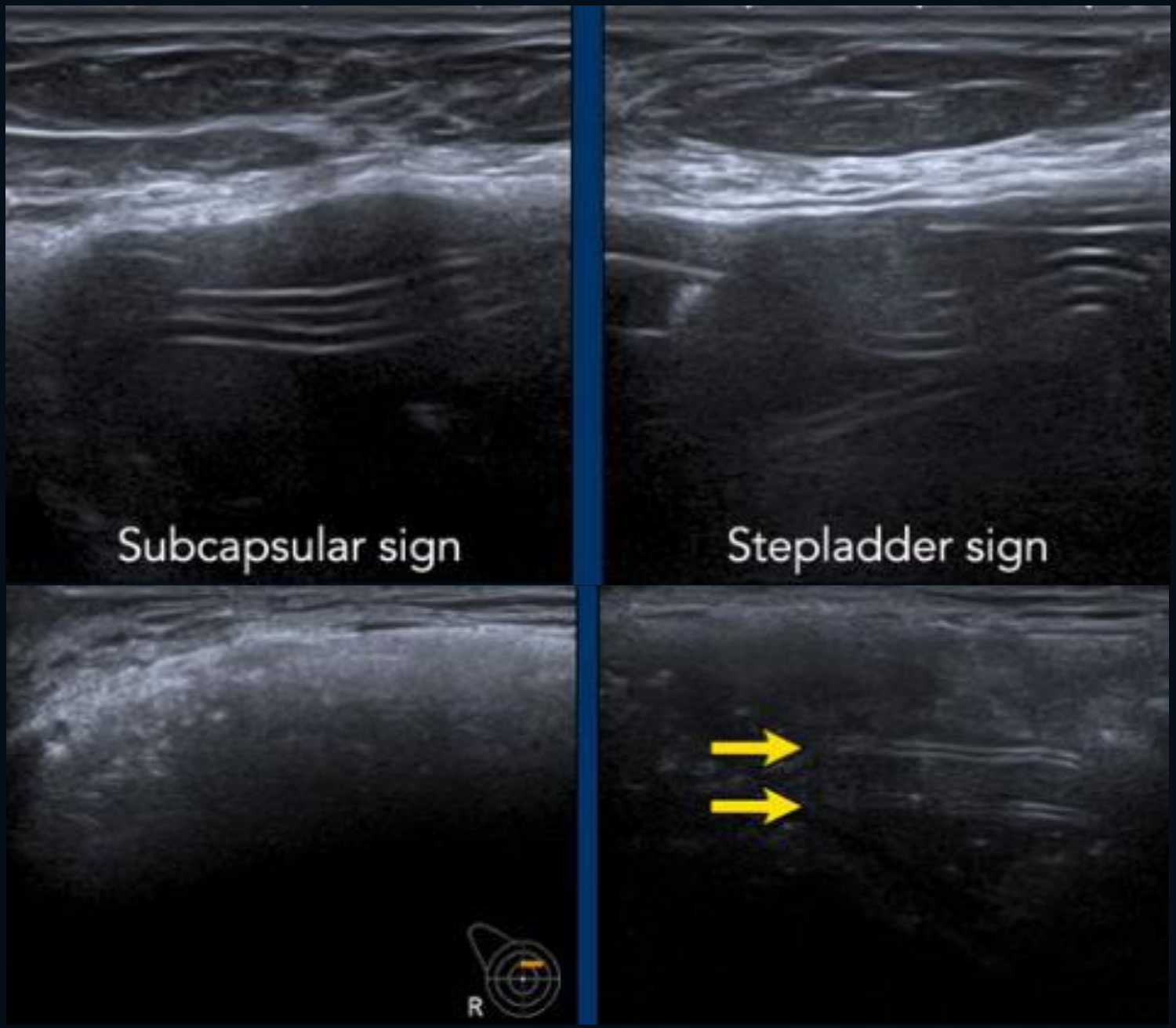
b.



c.



d.


Subcapsular sign
Stepladder sign
R

US - ICR

False positive of ICR:

Mimickers of **stepladder** sign:

- **Reverberation** artifact: a band of multiple closely-spaced lines in the near field parallel to the capsule-shell complex (a). May be minimized by lighter compression or **harmonic** imaging

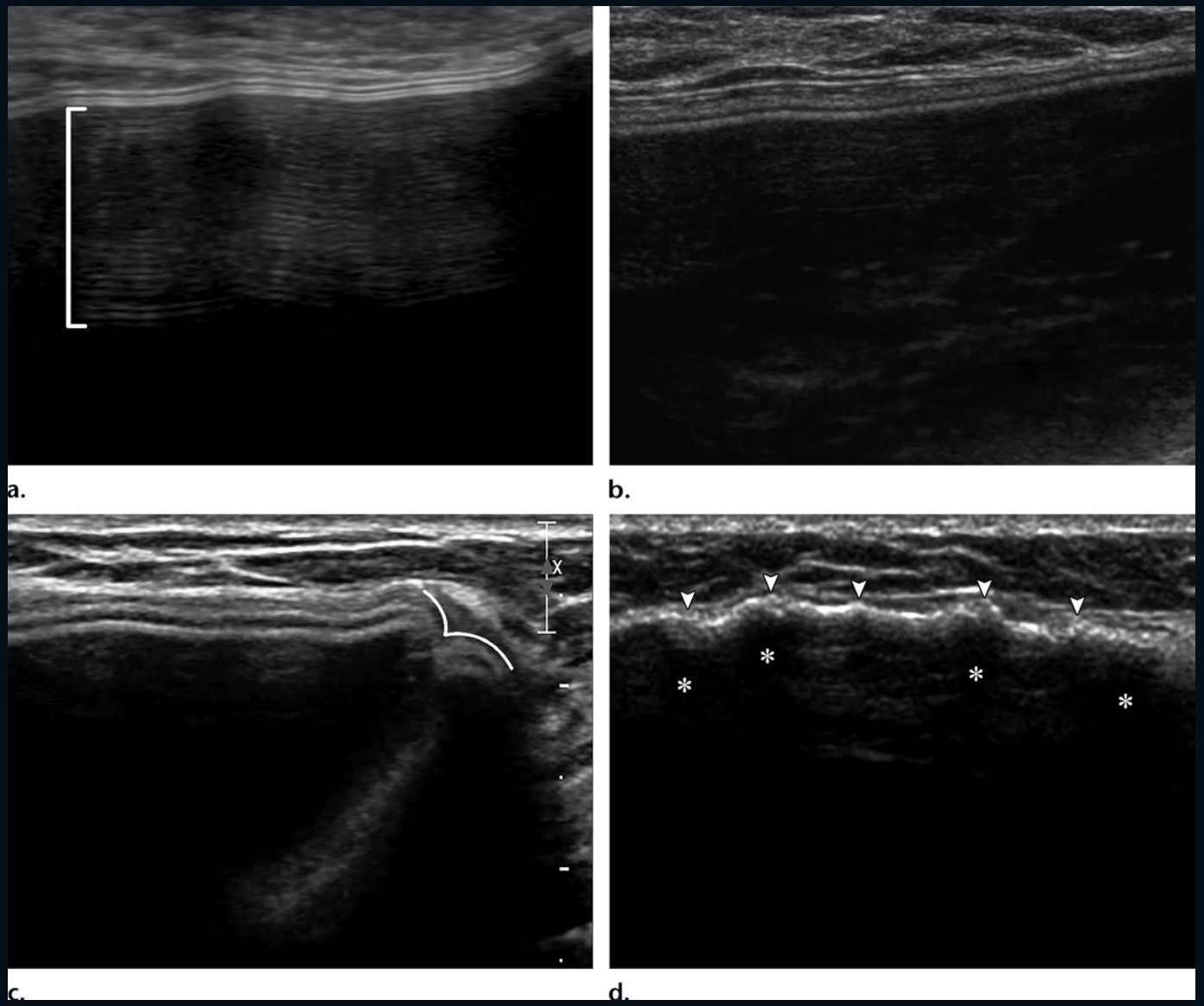
- **Low-level internal echoes** scattered throughout the implant lumen result from aggregation or solidification of silicone gel over time:(b)

- Radial fold (always extends to the periphery) or intact multi-lumen implant

Loss of trilaminar line

- **Infolding** of the elastomer shell at the base of a radial fold, causing the trilaminar line to pucker inward (curved white line) (c).

- **Dense calcification** of the capsule: rough contour with shadowing that obscures trilaminar line (d).

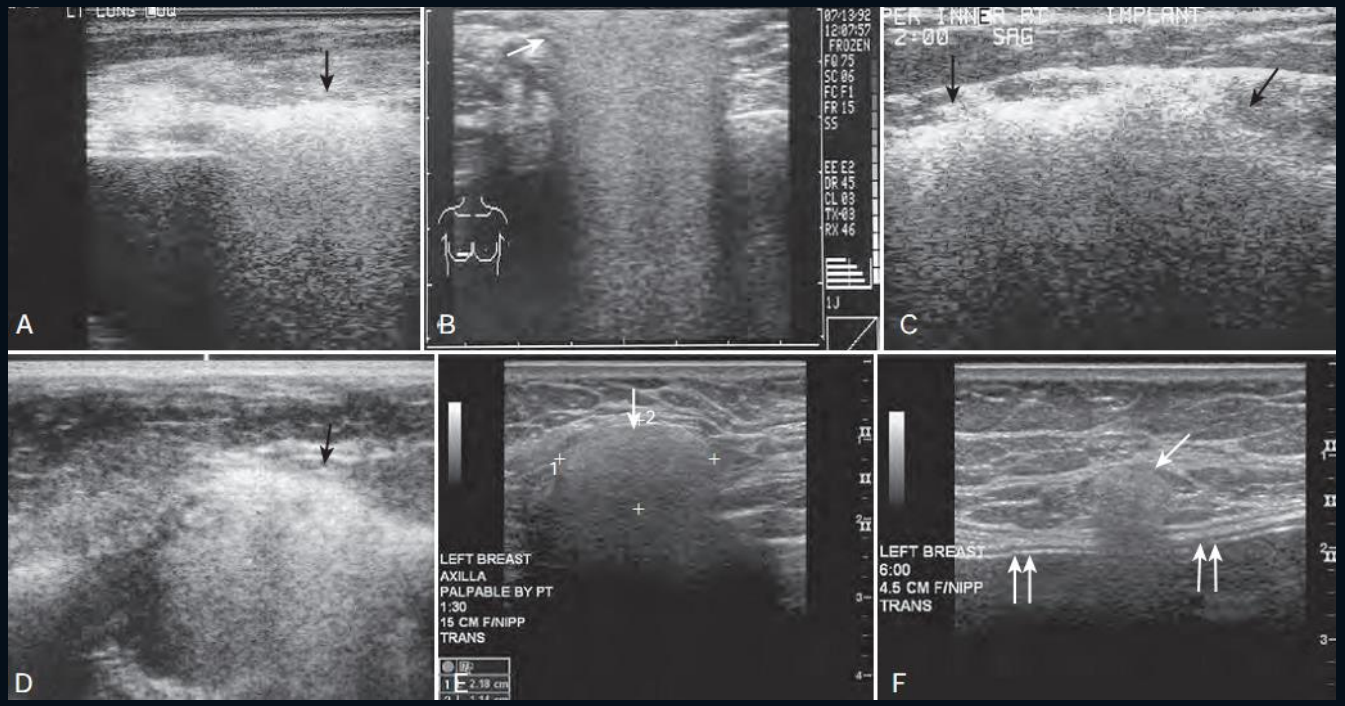

a.
b.
X
c.
d.

US - ECR

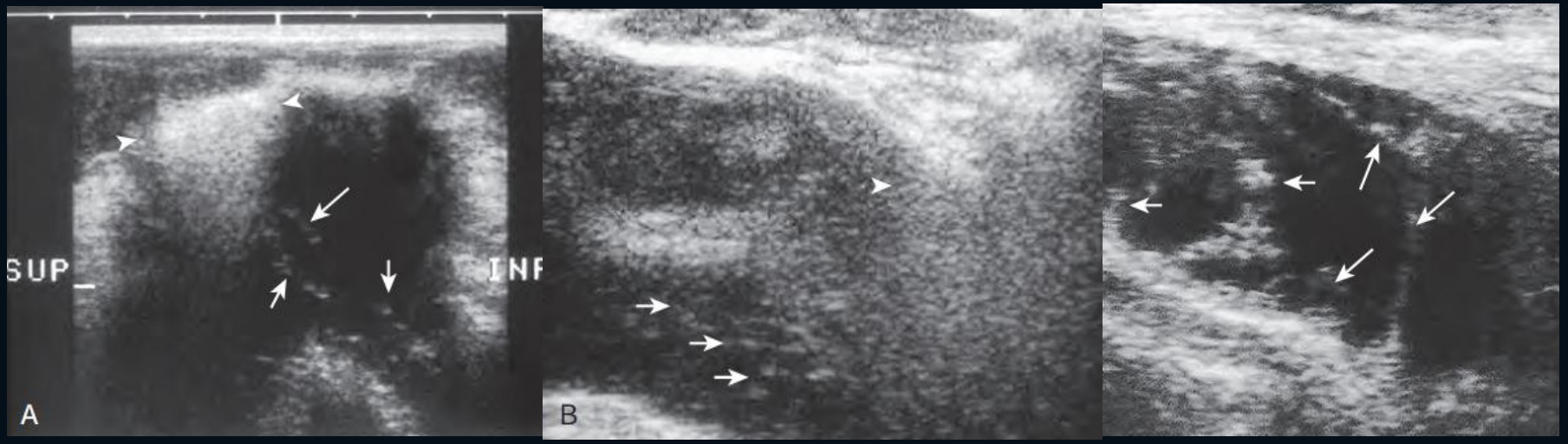
ECR:

- Snow storm: echogenic noise like gas (can be large or focal); direct silicon/paraffin inj. has the same appearance
- Hypoechoic mass of silicon globe (similar to the main implant): can be confirmed by skin marker and correlation with mammography
- Signs of ICR

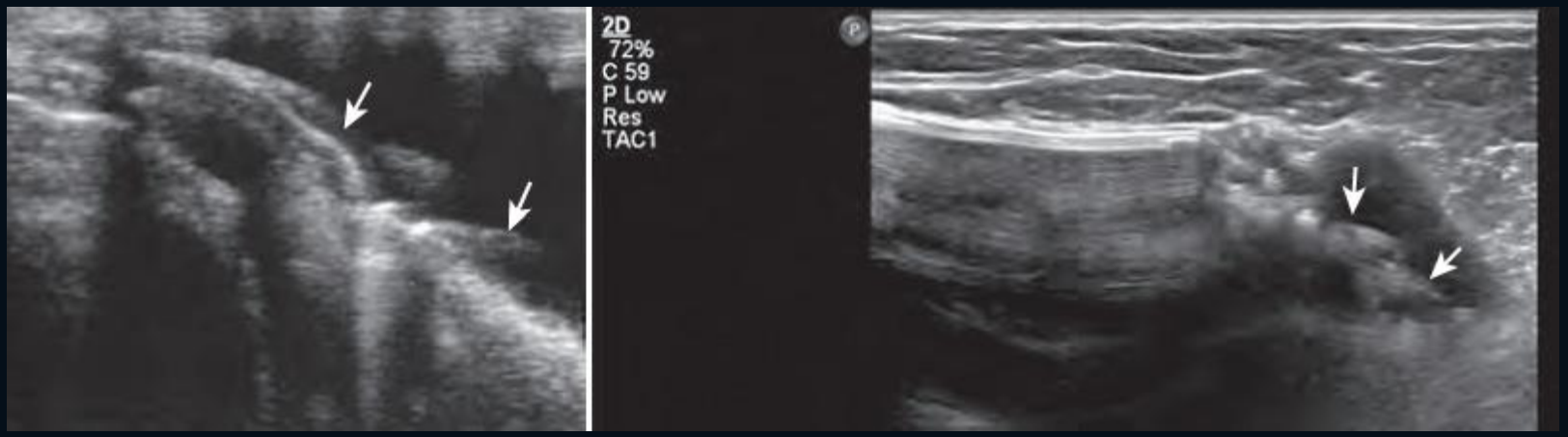
(silicon granuloma may be seen as focal snow storm of hypoechoic mass)



Snow storm (E and F are silicon granuloma; underlying implant in F is intact)



A, B: Stepladder sign with snowstorm in ECR
C: stepladder sign in ICR



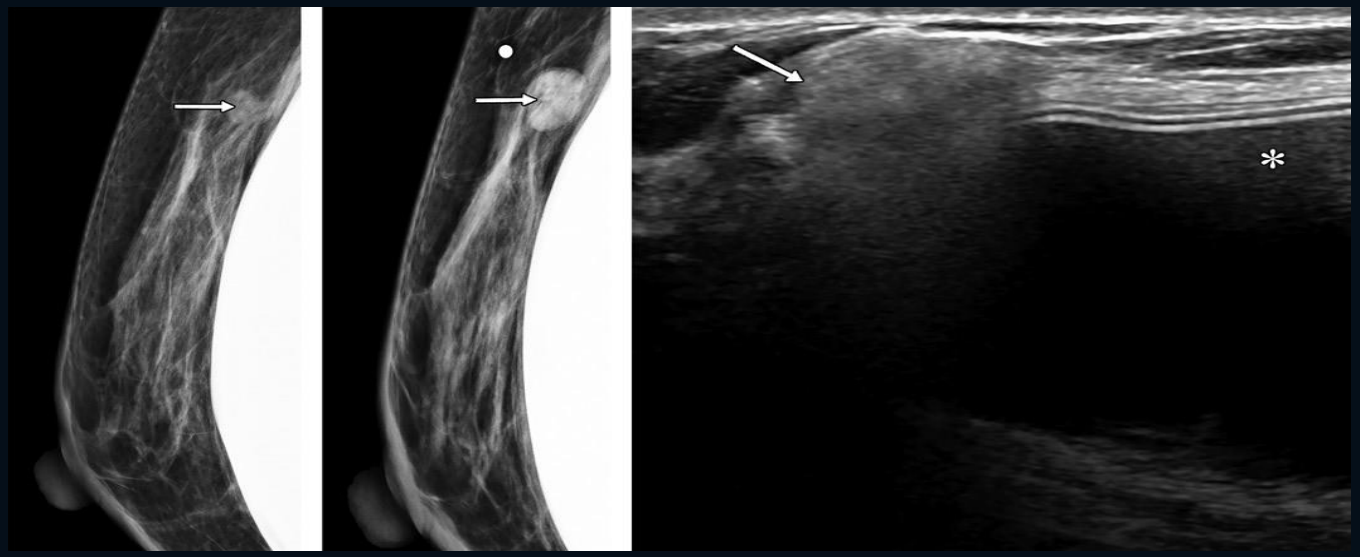
False positive of stepladder sign in multi-lumen implant

US - Gel bleed

Gel bleed:

Snow storm with apparently intact implant

Breast tissue is in direct contact with silicon, so usually the implant is removed



Right MLO mammogram demonstrates an oval isodense mass (arrow) adjacent to the implant.

Enlargement and increased density of the mass 3 years later (arrow)

US reveals **snowstorm** within an intra-mammary lymph node (arrow) due to extracapsular silicone. The implant is anechoic with normal configuration of the shell-capsular complex, indicating an intact implant.

MRI - ICR

keyhole or teardrop sign:

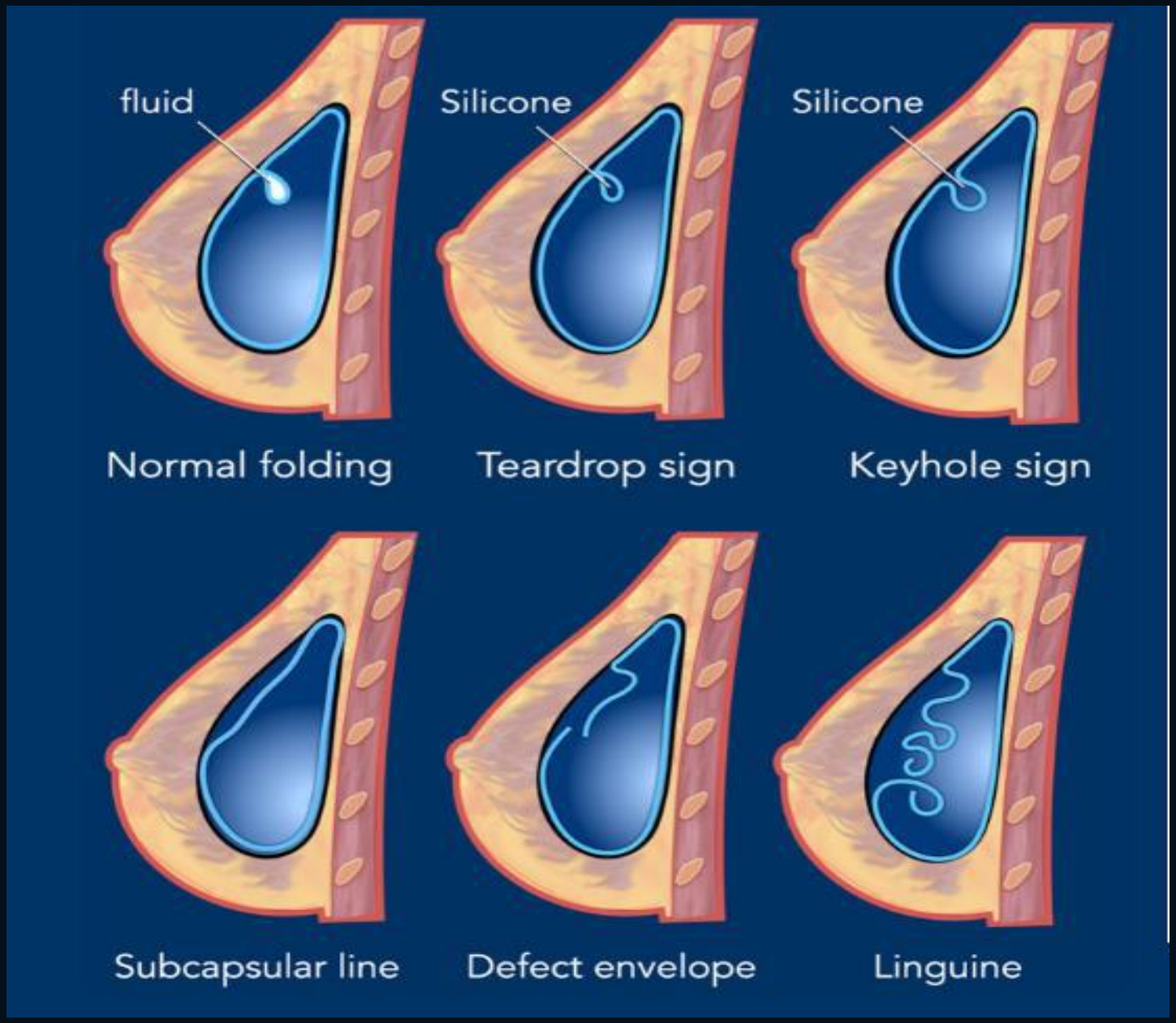
- silicone outside the implant envelope within a short radial fold outside the implant envelope.
- Normal radial fold is totally black inside, whereas a teardrop sign is white inside because of the leaked silicone

Subcapsular line

- Dark line parallel to ES, cannot be traced to the periphery (incomplete shell collapse)

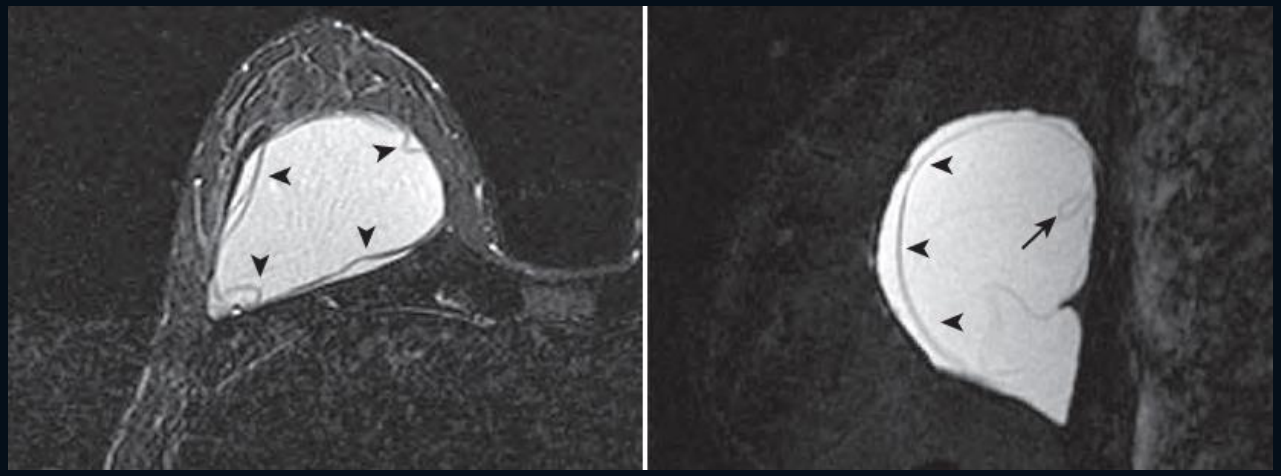
Linguine sign

- Curvy noodle-shaped dark lines inside the implant that do not extend to the periphery (collapsing ruptured implant shell)

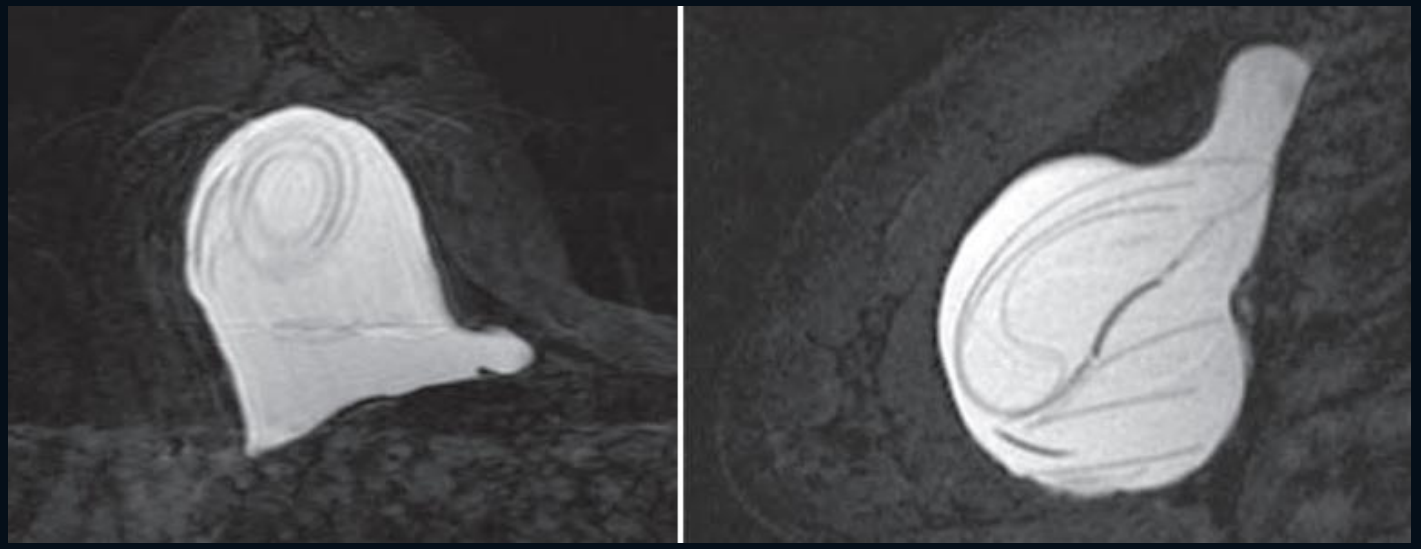

fluid
Silicone
Silicone
Normal folding
Teardrop sign
Keyhole sign
Subcapsular line
Defect envelope
Linguine

MRI - ICR

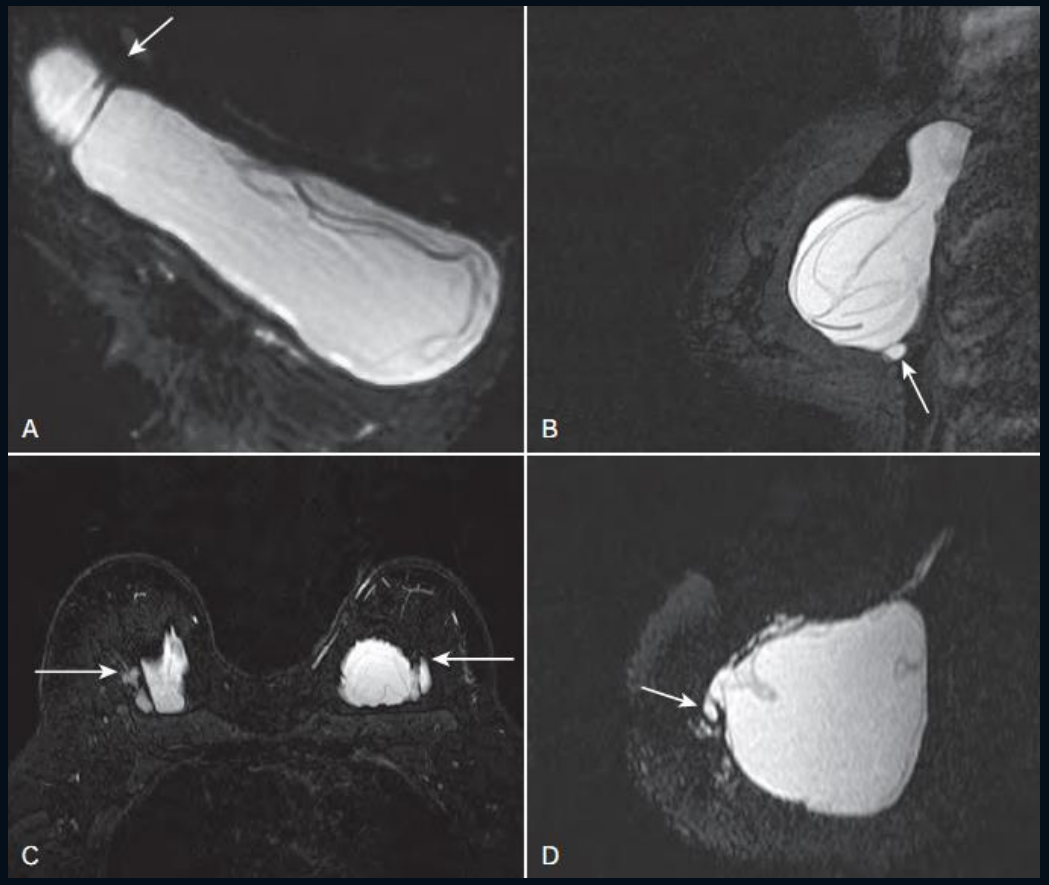
Subcapsular lines (arrowheads) and a keyhole sign (arrow)



Linguine sign:



MRI - ECR



Extravasation of silicone outside the fibrous capsule within the breast parenchyma or axilla

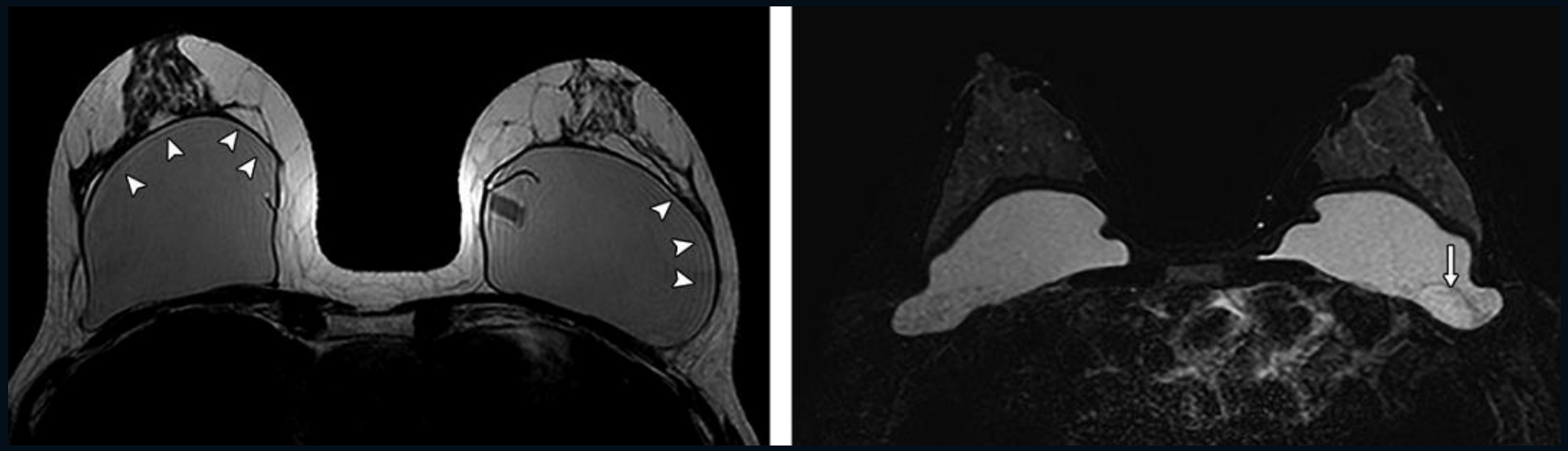
Signs of intra-capsular rupture will nearly always be present.

Severe gel bleed is diagnosed if a thin coating of silicone is identified around the periphery of the implant, but the implant is intact.

MRI – False positive of ICR

Truncation (or Gibbs) artifact: one or more lines parallel to Elastomer Shell. The artifact is related to the abrupt interface changes at the implant boundary.

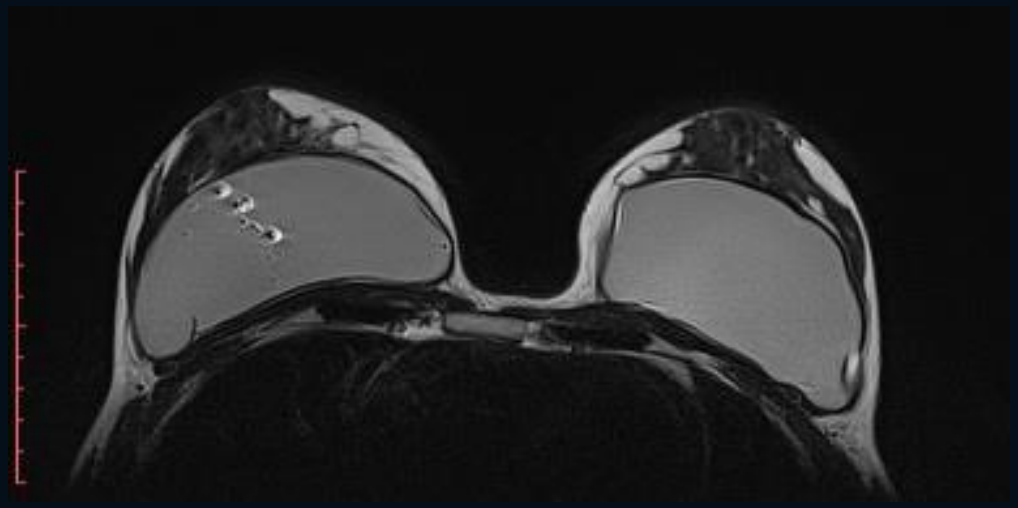
Ghosting artifact: from patient or cardiac motion may also cause spurious lines to appear within an implant in the phase-encoding direction

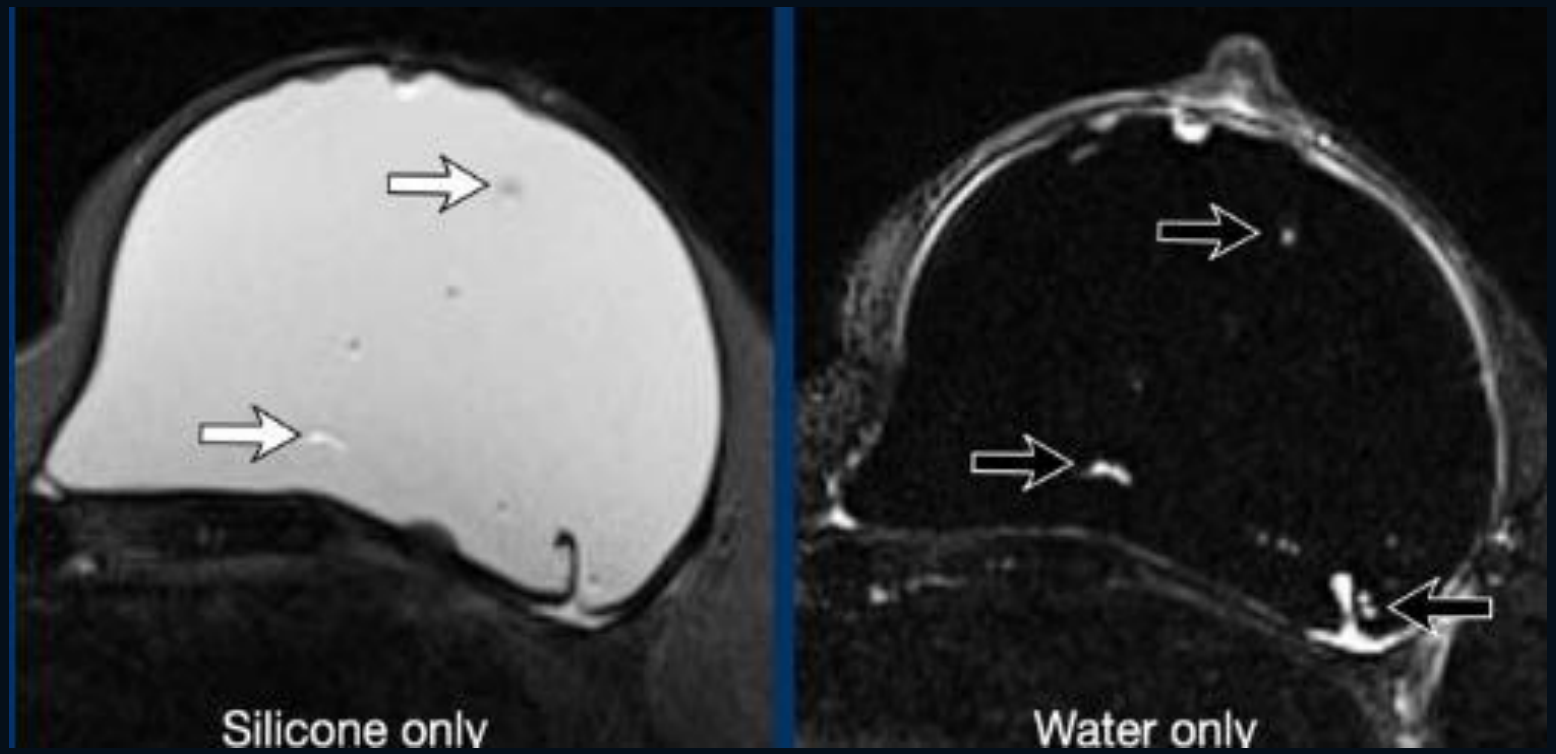


MRI - ICR

The salad oil sign (droplet sign):

- Small rounded high T2 signal foci within a breast implant on MRI (hypointense foci on the water-suppressed sequences)
- Represents water droplets or small amounts of gas within the silicone.
- This imaging sign is non-specific and should not be used alone to diagnose ICR
- Water droplets floating within the silicone gel may be a consequence of the plastic surgeon injecting steroids, betadine or antibiotics at the time of implant placement

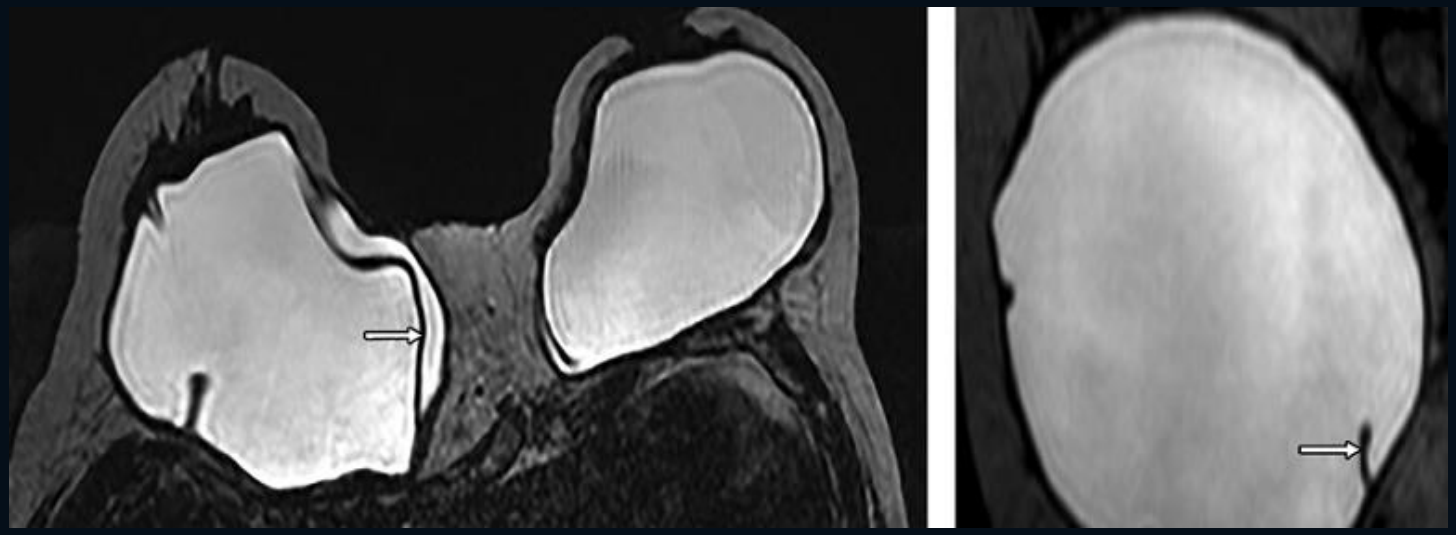



Silicone only
Water only

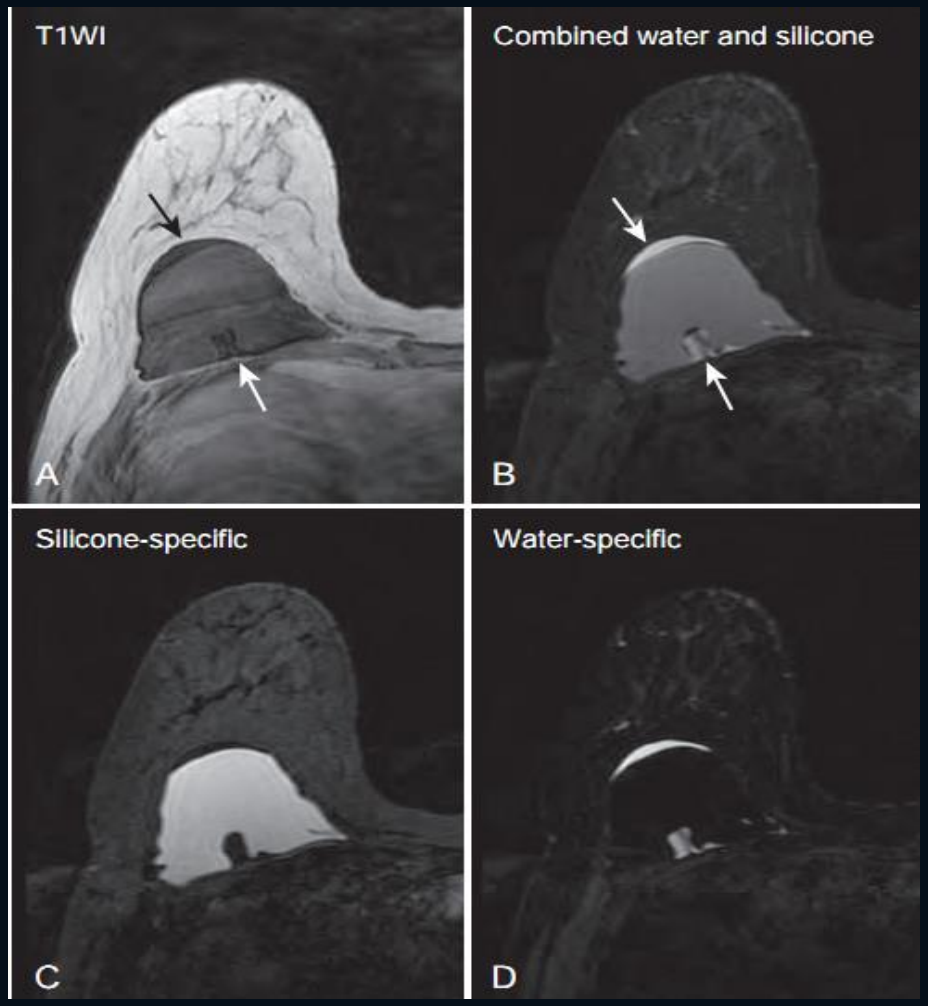
MRI – False positive of ICR

Radial folds:

- Perpendicular to the implant capsule (subcapsular lines are parallel to the capsule)
- Appear thicker than subcapsular lines (two layers of the elastomer shell are interposed)
- Complex radial folds are more difficult to differentiate: If the lines are always separated from the fibrous capsule by some amount of silicone gel, ICR may be present.



MRI – False positive of rupture
Double lumen

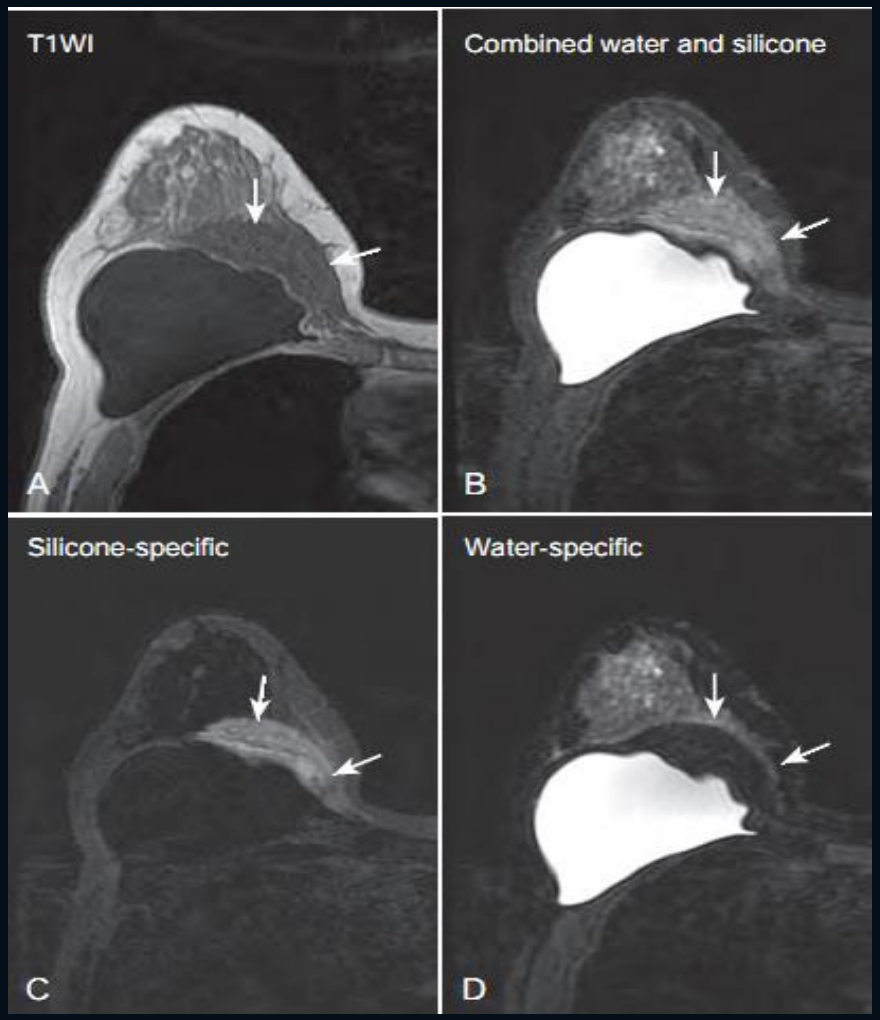


Implants with multi-lumen structures or rare implant materials

Peri-implant effusion: can be differentiated on Silicone-specific sequence

Saline outer, silicone inner double-lumen implant

MRI – False positive of rupture

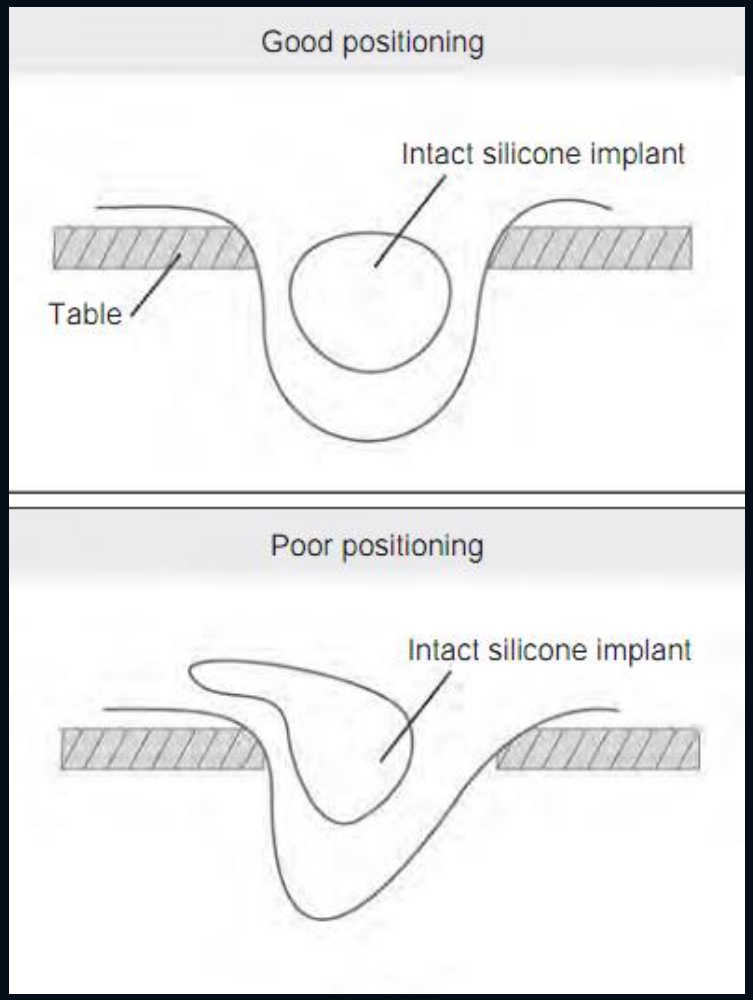


- Implant replacement after rupture (redo): may not completely remove all silicone material extruded from the rupture.

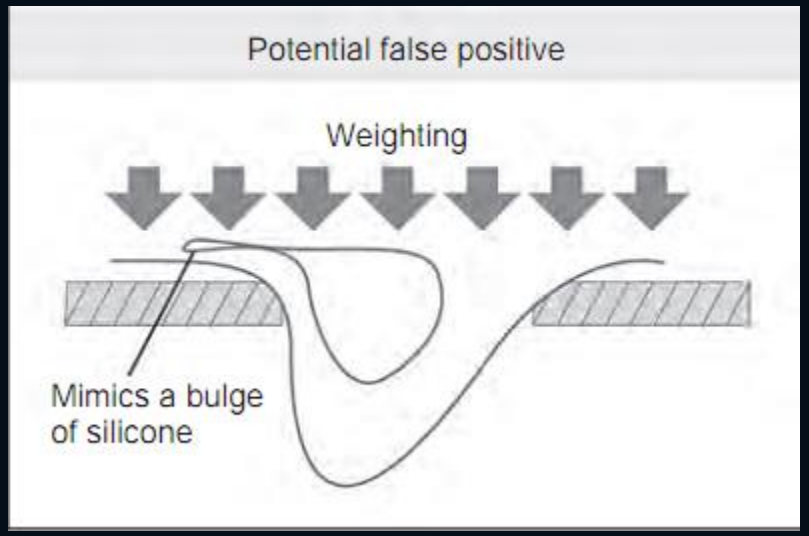
History is very important.

Saline implant in a patient with previously ruptured silicone implant (arrow: residual silicone)

MRI – False positive of rupture



- Poor positioning at MRI: produces artificial bulges by squeezing a part of implant between the coil and the chest wall



Rupture

	ICR	ECR
Mammo.	-	Contour change Silicone in breast tissue, duct, lymph node
US	Stepladder sign Sub-capsular line Keyhole sign	EC silicone (Snow storm or hypoechoic mass) Sign of ICR
MRI	Linguine sign Sub-capsular line Keyhole sign	EC silicone Sign of ICR

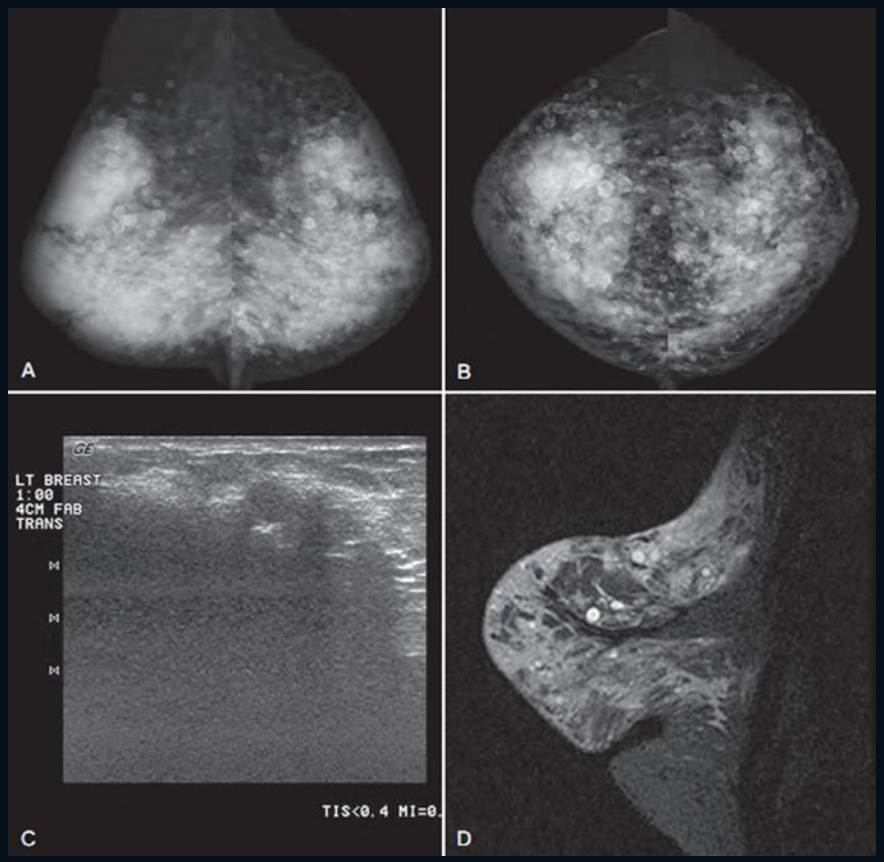
Imaging Modality	Intracapsular	Extracapsular	Gel Bleed
Mammography	Not present	Silicone globs in breast tissue Silicone in lymph nodes Silicone in ducts Implant contour deformity (occasionally seen)	Occasionally seen
Ultrasound	Stepladder sign	Snowstorm or echodense noise Hypoechoic mass	Snowstorm or echodense noise
Magnetic resonance imaging	Linguine sign Teardrop/keyhole sign Subcapsular lines Water droplets (occasionally seen)	Silicone outside the envelope Signs of intracapsular rupture	Teardrop/keyhole sign Subcapsular lines

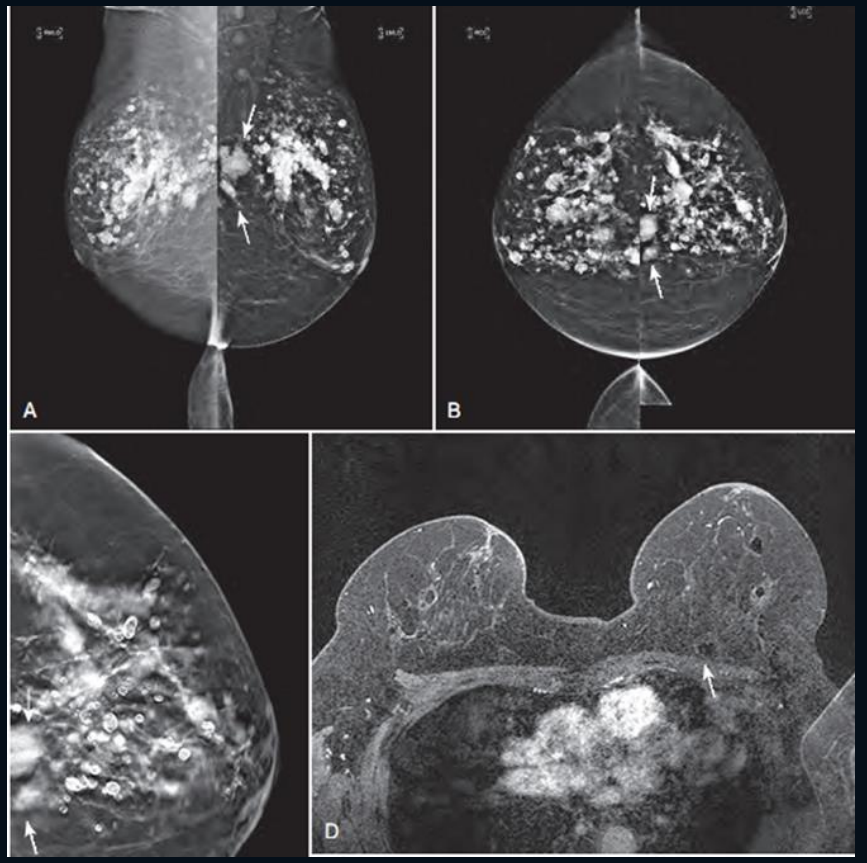
Direct silicone/paraffin injection

Silicone within the breast and extensive fat necrosis type calcifications

Prohibited by FDA since 1970

(arrows: paraffin globules and paraffin granulomas mimicking cancer on mammogram)


A
B
LT BREAST
1:00
4CM FAB
TRANS
TIS<0.4 MI=0.
C
D


A
B
D

Breast reconstruction

After mastectomy:

Immediate reconstruction

- Some women have breast implants placed immediately after the mastectomy (called direct-to-implant reconstruction). Other women have tissue expanders placed first followed by implant, autologous tissue or combination of both

- **Radiation** often causes the skin over an implant to become tighter, tougher, and more rigid, and it can raise your risk of complications including infection around the implant, capsular contracture, extrusion of the implant, and asymmetry. You may get a tissue expander at the time of the mastectomy, and then months later, decide for implant or flap reconstruction.

Delayed reconstruction:

- Months or years after the mastectomy and other breast cancer treatments are completed.
- This approach may be used if:

✓ skin is too tight to close over a tissue expander or implant
✓ the breast skin doesn't have a good enough blood supply after the mastectomy
✓ you'd like to take more time to decide about whether to get reconstruction or which type to get

Breast reconstruction

Tissue expanders

- TE is temporary, **empty implant** that is gradually inflated with saline over time
- TE has a tiny valve under the skin. Saline is injected into the valve, filling the expander in stages.
- It usually takes **2 to 6 months** for the skin to be expanded enough.

Single lumen expander

Double lumen expander with inferior and superior chambers (more flexible for optimal expansion)