A pictorial essay of breast implant imaging and implant complications

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Gozde Arslan*, Levent Celik**, Rahmi Cubuk***

**Maltepe University, Department of Radiology, Maltepe, Istanbul. Turkey*
***Maltepe University, Department of Radiological Imaging, Maltepe, Istanbul, Turkey*
****Study Institution: Maltepe University Hospital, Radiology Department, Maltepe, Istanbul, Turkey*

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Nowadays as more breast conserving surgeries and mastectomies are being performed, more breast implants are being used. Follow-up of these patients is as important as treatment. We, radiologists should be aware of normal imaging appearance of implants during follow ups. We should also be aware of complications which we may encounter during controls. In our essay, we aim to show the normal and pathological appearence of implants by sharing ultrasound, mammography and MR images from our clinic.

KEY WORDS: Breast, Implants, MRI, Rupture

Breast Implants

Breast implants were developed in 1961 by American plastic surgeons Thomas Cronin and Frank Gerow. The first use of these implants were for breast augmentation in 1962 [1]. Nowadays they are used for esthetic reasons or for oncoplastic cancer surgery (submastectomy and breast sparing surgery in patients with breast cancer) [2]. On 2000, The FDA approved the first PMAs for saline-filled breast implants [3]. After the approval of silicone gel filled breast implants on 2006, there has been an increase in use of silicone implants for cosmetic reasons. On 2006, a nation wide study among Sweden women was conducted and it was found that women who have undergone breast implantation have a reduced risk for breast cancer, most likely due to differences in lifestyle or reproductive characteristics [3]. These studies have reduced fear for implants and today approximately 5% of american women are using silicone implants. This is why we have to be familiar with implants and complications. Silicon does not occur as a single element in nature; it is most commonly found combined with oxygen in the form of silica. It is one of the earth's most common elements. Silicones are synthetic polymers produced by alternating atoms of silicon and oxygen known as a siloxane linkage (Si-O-Si). They are typically heat-resistant and rubber-like, and are used in many industries like aviation, construction, electronics, paints, restoration, sealants, transportation, textiles and health care.

Many implant types are available. Implants are either saline or silicone based. They may have a single or double lumen and can be placed either subglandular or subpectoral. Implants outer shell can either be textured (with 300-800 micron pores) or smooth (thin and shiny). Textured shell implants have a lower rate of capsular contraction but may have periimplant fluid collections due to inflammatory reaction caused by formation of peri-implant synovial tissue and secretion of proteoglycans by synovial secretory cells. Smooth shell implants feel soft and natural but are may cause capsular contraction more often (Fig. 1).

Despite a decrease in prosthesis related complications due to better technology, they do still occur. In this paper,

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Correspondence to: Gozde Arslan, Basibuyuk mahallesi, Emek caddesi, Narcity C1-26, Maltepe, Istanbul. Turkey. (e-mail: gunesgozde@gmail.com)

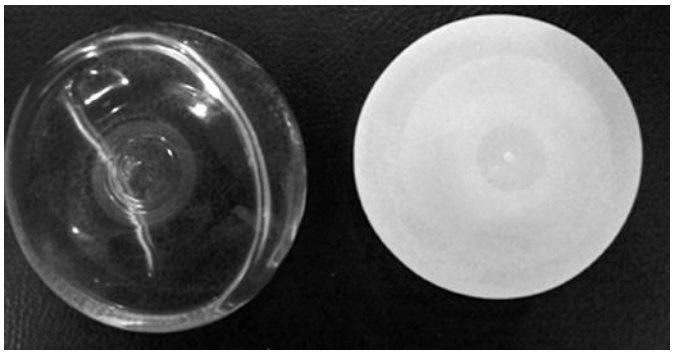


Fig. 1: Textured (right) and smooth (left) breast implants.

We report frequently seen breast prosthesis complications accompanied by their radiological appearence. We will generally use the term" silicone" instead of implant since salin implants are rarely used nowadays

Breast Implant Imaging

Mammography

Mammography is generally not prefered by patients with breast implants. This modality requires the compression of breast tissue, leading to the fear of implant rupture [3]. Although there are adverse effect reports which happened during mammography, the risk of rupture does not pose a contraindication for mammography [4]. CC and MLO sequences are routinely obtained. The silicone should appear eliptical or conical (Fig. 2). Spherical appearence may indicates a contraction. In intracapsular rupture, contour angulation, irregularity or herniation may be observed. The diagnosis of extracapsular rupture is difficult. Focal or diffuse calcifications may be seen on the implant surface. (Fig. 3A, B). This has no cli-

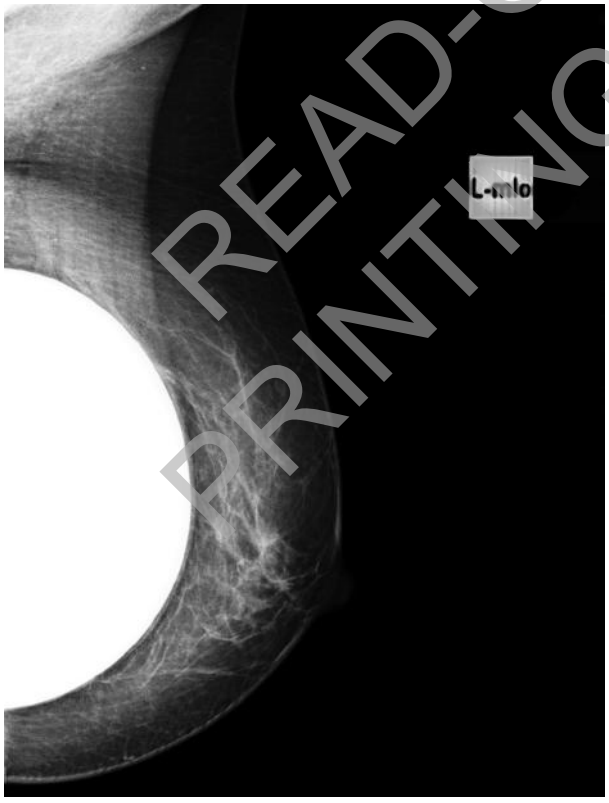


Fig. 2: MLO Mammography of left breast. Subpectoral implant material.

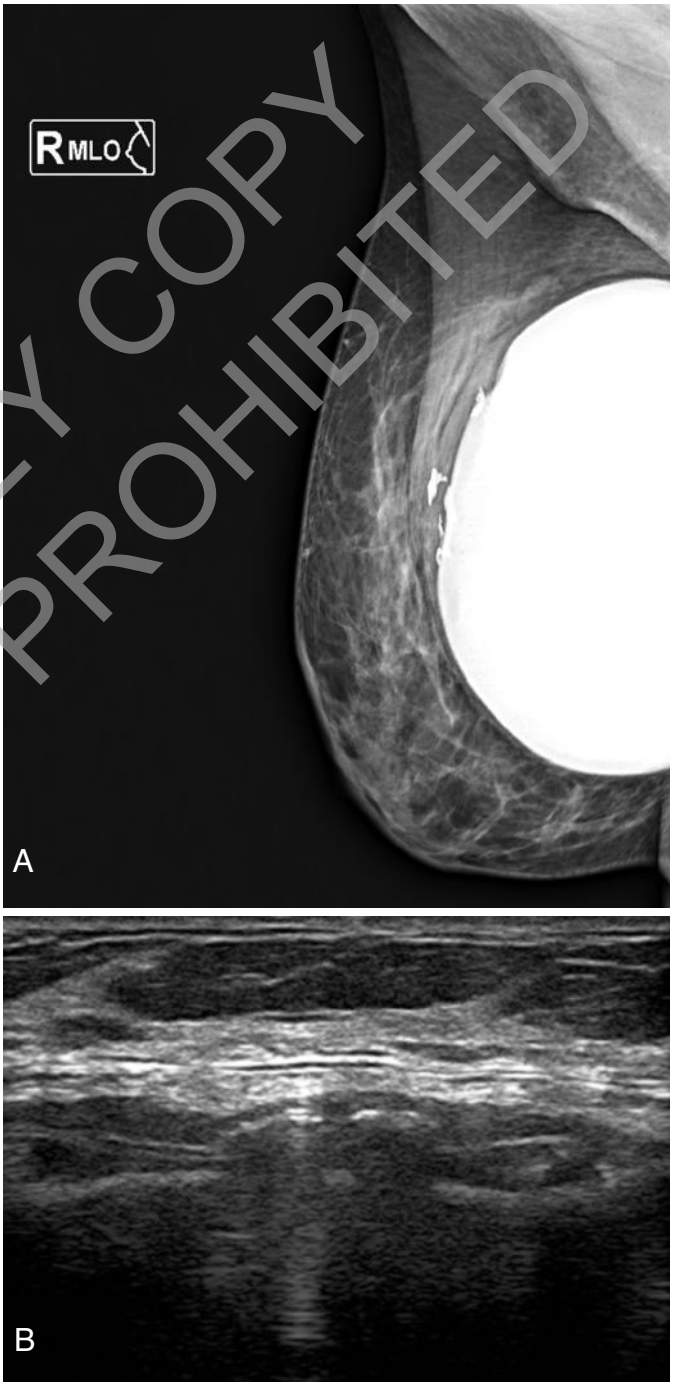


Fig. 3: A) Silicone outer membrane calcifications on right MLO mammography; B) sonography.

Fig. 4: Right MLO mammography. Subpectoral implant with expander.

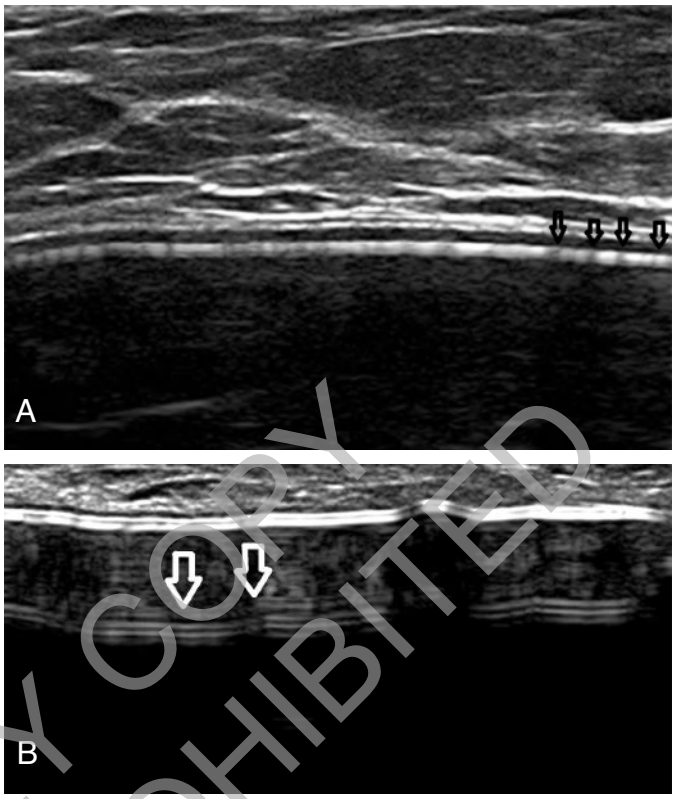


Fig. 5: A) Sonographic images of textured, B) smooth implants. Textured implant and tiny posterior acoustic shadows on posterior membrane. Smooth implant and prominent reverberation artefact.

nical significance [5]. For some cases, expanders may be used temporarily. (Fig. 4). The purpose of the expander is to create a soft pocket to contain the permanent implant. Three to four weeks after the mastectomy, the expander is placed and it is filled with silicone or saline. A few months later, the expander is removed and permenant implant is placed.

Ultrasonography (US)

This is the first modality of choice due to its ease of access and applicability. It is performed in the supine or oblique position using a 7-12 mhz linear transducer. The implant material is sonolucent. Based on our experience, textured and smooth shell implants can not be differentiated on mammography and MRI but may only be differentiated on sonographic imaging. (Fig 5A-B). Textured implants have multifocal tiny posterior acoustic shadowings on inner membrane whereas smooth implants have a smooth outer membrane but a prominent reverberation artefact. To the best of our knowledge; there is no literature about this differentiation. On US, reverberation artefact is observed between the capsule and neighbouring breast tissue (Fig. 6).

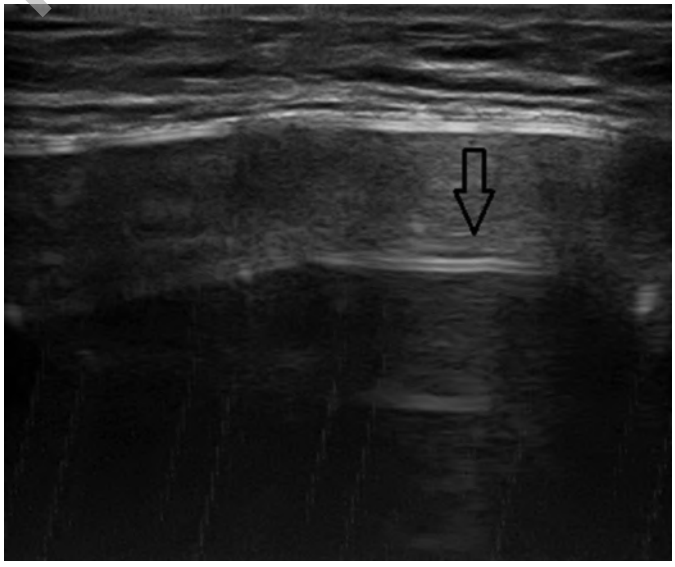


Fig. 6: The sonographic appearence of silicone material. Reverberation artefact is observed between the fibroglandular tissue and silicone.

Reverberation artefact is defined as when the ultrasound beam reflects back and forth between the reflectors ("revereberates"), (in this case between the fibroglandu-

lar tissue and silicone) the ultrasound transducer interprets the sound waves returning from the reverbration as deeper structures since it took longer for the wave to return to the transducer. Due to this artefact, the diagnosis of intracapsular rupture is difficult. Mild compression, high frequency harmonic imaging and compound imaging may decrease the effect of this artefact. Folding, wrinkling and lobulation of the implant membrane is frequent. When wrinkled, only the outer contour is lobulated. The inner contour is observed as adhered to the gel. In folding, the outer contour is normal, the elastomer shell seperates from the shell and a potential space forms. If there is no evident fluid in this space, and if the folds are thin, then this is accepted as being normal.

Magnetic Resonance Imaging (MRI)

It is the golden standard for silicone imaging. It is performed with a dedicated breast coil when the patient is in the supine position. The european society of breast imaging guidelines for breast mri requires T1, T2 W spin echo sequences and A T1-weighted 3D or 2D (multi-slice) spoiled gradient echo pulse sequence before and after contrast injection [6]. In our clinic; axial non fat sat T1 weighted sequence (T1WS), axial-sagittal fat-supressed T2 weighted sequence (T2WS), axial silicone only sequence, high resolution T1 3d fat-supressed sequence, dynamic contrast 3d T1WS axial and sagittal images are routinely obtained. The silicone only sequence is an inversion recovery sequence where water and fat are supressed and the silicone is clearly visable. (Fig. 7).
For fast spin echo images, fat appears less bright than silicone or water because it has a shorter value of T2 weighted images. So theoretically, On water suppressed T2 weighted fse images silicone is the brightest substance. Silicone molecule methyl protons are more shilded from the main magnetic field than protons on fat molecules by about 1.5 ppm. In practice the fat and silicone peaks are usually seperated by 80 to100 Hz. [7]. In silicone supressed sequences, the silicone is supressed and surrounding fluids can easily be distinguished. Silicone leakage is best detected with this sequence. In silicone supressed sequences, the silicone is supressed and surrounding fluids can easily be distinguished. Any neighbouring fluids or infection can be detected with this sequence. Contrast is not necessary if there is no suspicion of malignancy.
We have created phantoms for major MRI sequences of implant imaging. We have put liquid oil and water inside the phantom and we have inserted silicone implant in the middle.

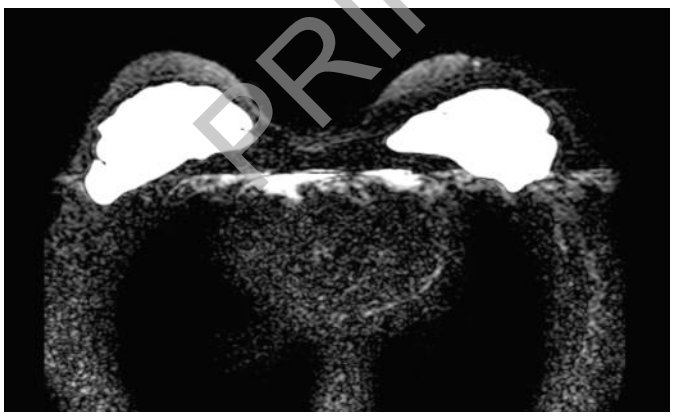


Fig. 7: Axial section, silicone only MRI sequence. Only silicone appears hyperintense and all other structures are suppressed-hypointense.

Fig. 8: On T2 FSE MRI sequence. Water is the brightest object.

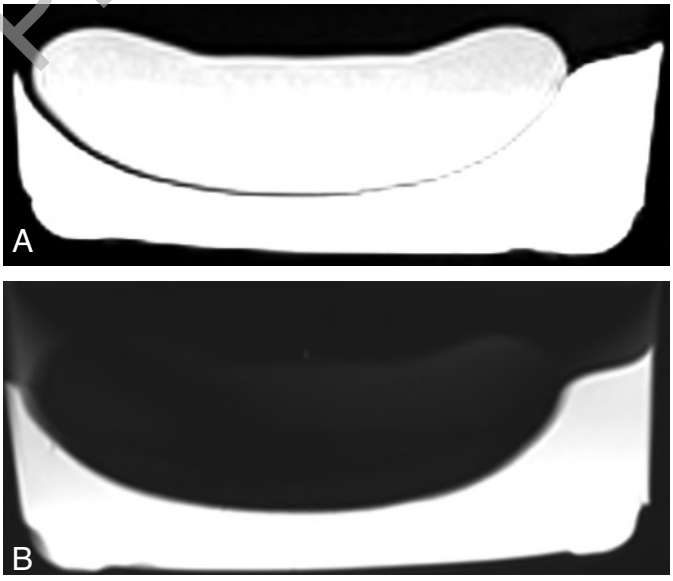


Fig. 9: A) We apply T2W Fat sat method for supprresing the fat. On this sequence water is the brightest subject. This is spectral saturation method for fat saturation. Fat is saturated on this sequence. Silicone is also saturated because it has a chemical shift of only 4.8 ppm which is only 1.3 ppm more than the fat signal. (80 Hz at 1.5T); B) This time we apply T2W stir (short tau inversion recovery) method for suppressing fat. Stir is an inversion revovery technique for suppresing fat. Now only fat is saturated and the silicone and water are bright.

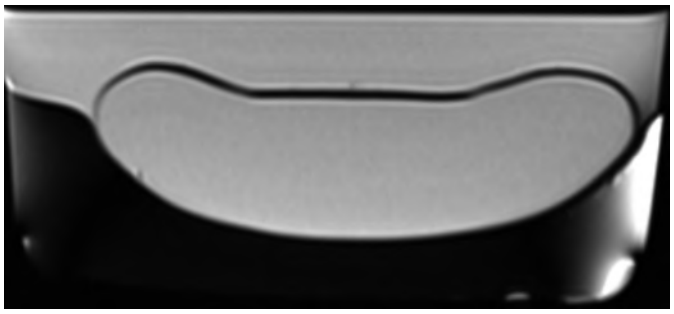


Fig. 10: On water sat T2 MRI sequence silicone and fat are bright.

Fig. 11: On stir+ water sat T2 sequence silicone is the brighthest object. This is the silicone only sequence that is used on modern mri devices.

Complications of Implants

1. *Peri-Implant Reactive Free Fluid*

Minimal peri-implant fluid collections are frequently observed and accepted as being normal. It occurs secondary to an inflammatory reaction to the implant. It is generally small in amount. It may cause pain if there is a fast increase in fluid. It is observed as hypoechogenicity neighouring the implant on US or hyperintensity on T2WS MRI images (Fig. 12). The fluid is clear and there is no accompanying fibroglandular enflammation. It can be aspirated if it is infected or causes pain.

Fig. 12: Axial section, T2 tse MRI sequence. There is minimal free fluid neighbouring the right implant.

2. *Silicone Lymphadenopathy*

In the breast, more than 75% of the lymph drainage, particularly from the outer quadrants, are to the ipsilateral axillary lymph nodes. The remaining 25% drains to the internal mamamarian lymph nodes, inner quadrant nodes of the contralateral breast and to the inferior phrenic lymph nodes. Silicone lymphadenopathy was first described in 1978 by Wintsch et al Hausner et al. [8,9] and Capozzi et al. [10]. Even without obvious silicone rupture, in some cases, silicone material can be transported to regional nodes causing silicone lymphadenopathy. There are 2 types of silicone lymphadenopathy:

– Elastomere particules are transported to the lymph nodes leading to a non-necrotizing granulamatous reaction;

– Silicone droplets are transported to the lymph nodes. This may be secondary to extracapsular rupture.

The axillary lymph nodes are the major lymphatic drainage of the breast, therefore, silicone lymphadenopathy is most frequenty observed at the axillary lymph nodes. Internal mammary, supraclavicular, cervical and mediastinal lymph nodes are less frequently involved [11]. It may manifest with pain and fever. It is characterised by increased density of lymph nodes on mammography. (Fig. 13A). On US, increase lymph node size and high echogenic areas compatible with silicone material are observed. (Fig. 13B). Diagnosis is made when lymph nodes appear with the same intensity as silicone on MRI silicone only sequence (Fig. 13C).

Definitive diagnoses can be made by lymph node exsicion and when the pathological findings or foreign body reactions are observed. Pathologically, histochemical techniques, electron microscopy or spectroscopy may be used. In patients with a history of breast cancer, it must be distinguished from axillary lymph node involvement [12]. Silicone lymphadenopathy firstly involves the central sinus of the lymph node, whereas metastasis firstly involves the cortex, aiding in differential diagnosis. After diagnosis, patients are generally followed every 6 months. Rarely, silicone may enter the systemic circulation and be transported to distant organs.

3. *Infection*

Painful fluid accumulation neighbouring silicone should bring infection to mind. It is accompanied by erythema, fever and pain. The internal structure of the fluid is analysed on US. Echogenic septations or punctate echogenic foci inside the fluid may be observed. Neighbouring fibroglandular tissue is enflamed. Increased vascularisation on color doppler is also suggestive of infection. The collection is observed on MRI as hypointense on T1WS, it is supressed on silicone only sequence and hyperintense on silicone supressed sequence (Fig. 14).

4. *Peri-Intracapsular Hematoma*

In 1979, Georgiade et al. [13] first reported hematoma of a breast implant. It may be observed in the early or late

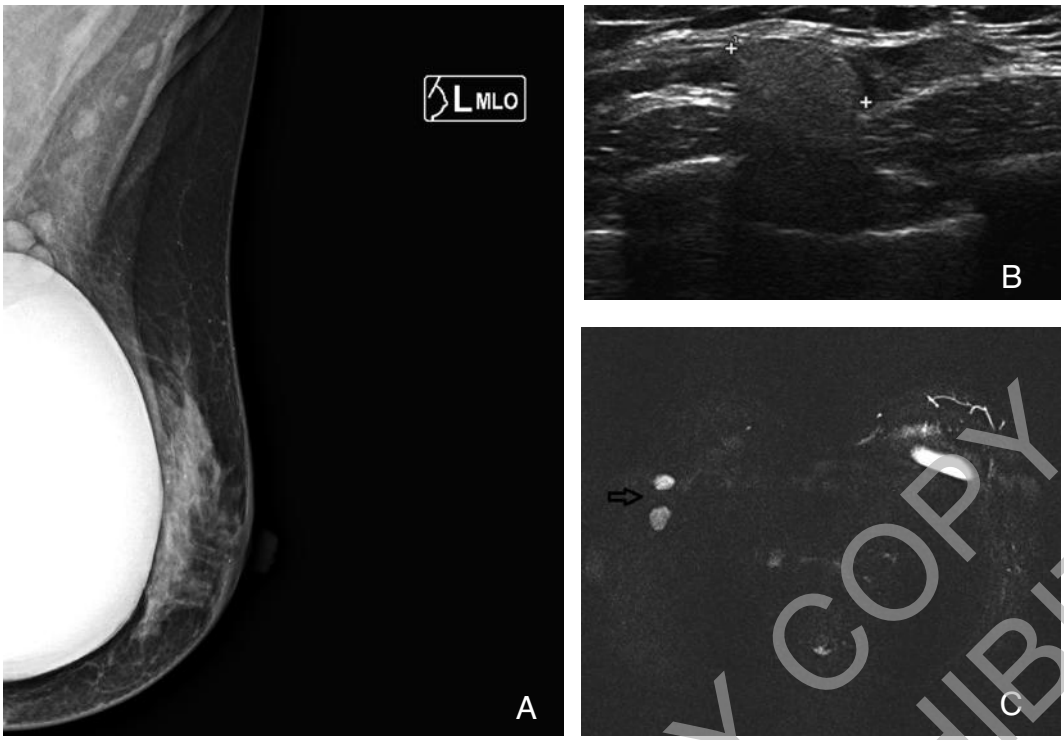


Fig. 13: A) High density left axillary lymph nodes on left MLO mammography. B) Silicone material is seen as snowstorm artefact on lymph nodes on sonography of the same axilla. C) Lymph nodes with same intensity as silicone are seen in the right axillary area on axial plane, silicone only MRI sequence.

term. While easily diagnosed in the early stage, its diagnosis is more difficult in the late term when there is no history of trauma. Large hematomas can be observed without a history of trauma, even years after implant placement. Friction of the implant against the capsule and subsequent erosion of the capsulary artery is thought to lead to the hematoma. Patients present with a complaint of a lump or swelling that is increasing in size. Hematoma may ocur around the capsule or between membranes of the capsule. Mammography demonstrates a high density area surrounding the silicone (Fig. 15) and the hematoma is demonstrated by MRI as hyperintense on precontrast T1 series and hypointense on silicone only sequence. Hematoma may be overlooked if T1WS is not imaged (Fig. 16).

After diagnosis, surgical capsulectomy is performed. Acute, subacute and chronic bleeding areas are nested within one another. Fluid and hematoma are excised. Concurrent bacterial infection must be considered.

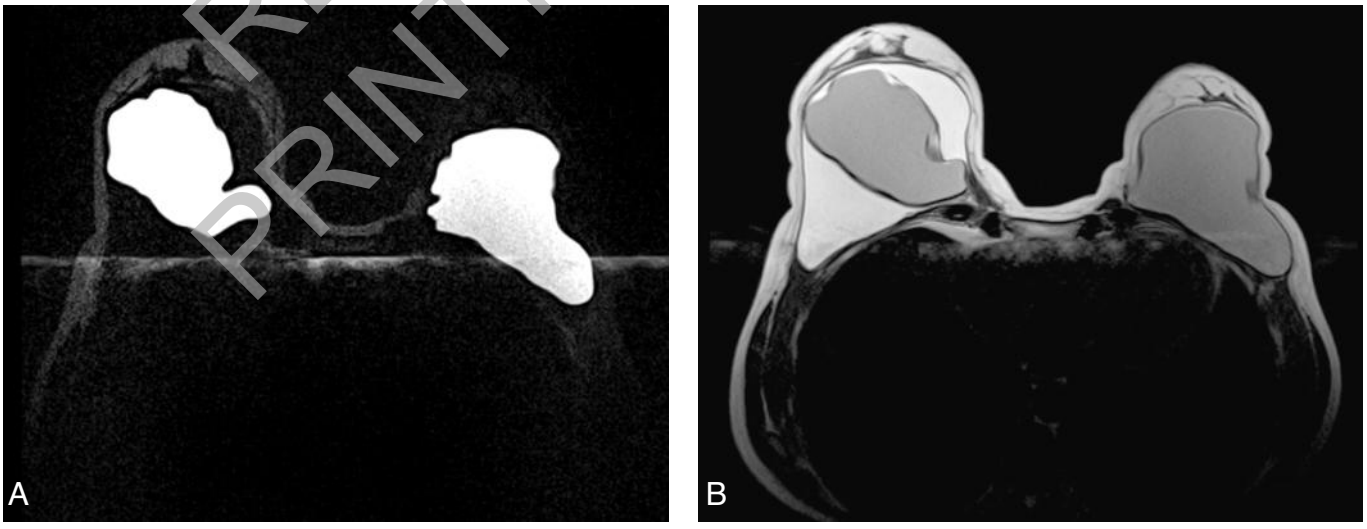


Fig. 14: A) Axial plane, non fat sat T2WS; B) silicone only MRI sequence. Fluid collection is seen neighbouring the right implant, hyperintense on T2WS and suppressed on silicone only sequence.

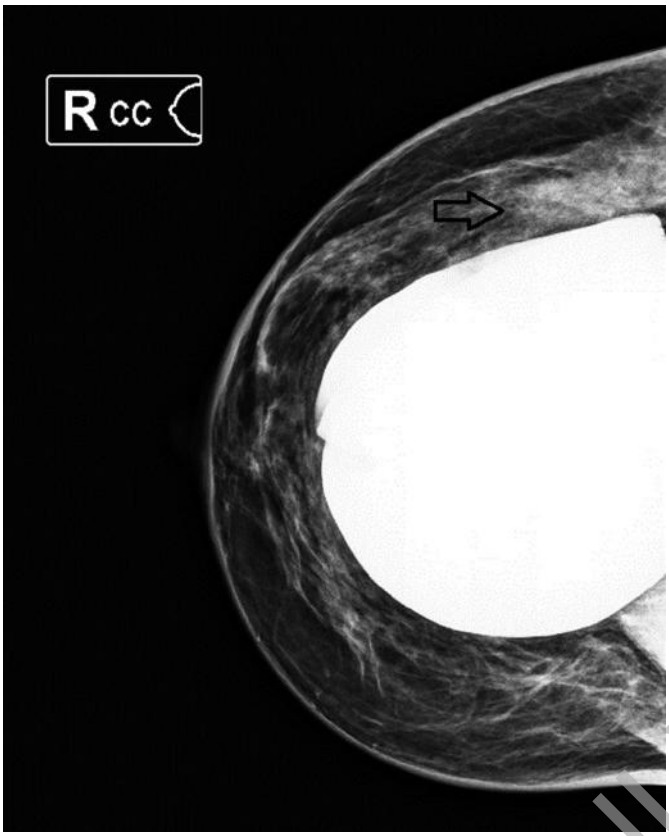


Fig. 15: Right MLO mammography. High density patchy areas are seen superior to the silicone.

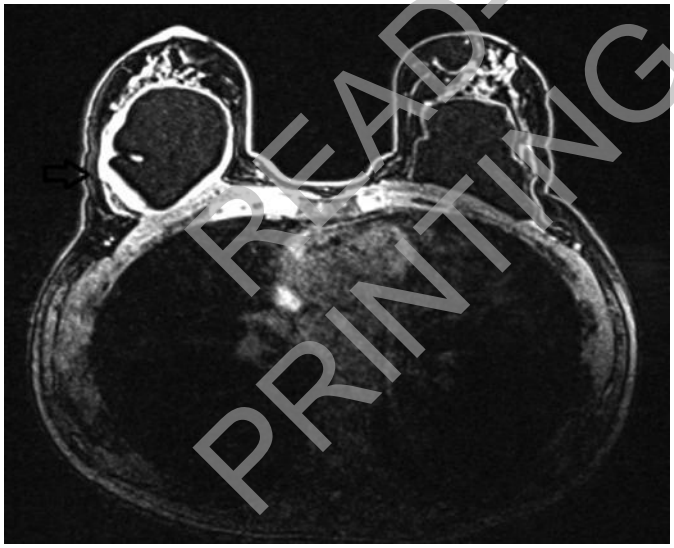


Fig. 16: Axial precontrast T1WS.The hyperintense collection (hematoma) is seen between membranes on precontrast T1WS of right breast. The tension around the capsule is clearly seen.

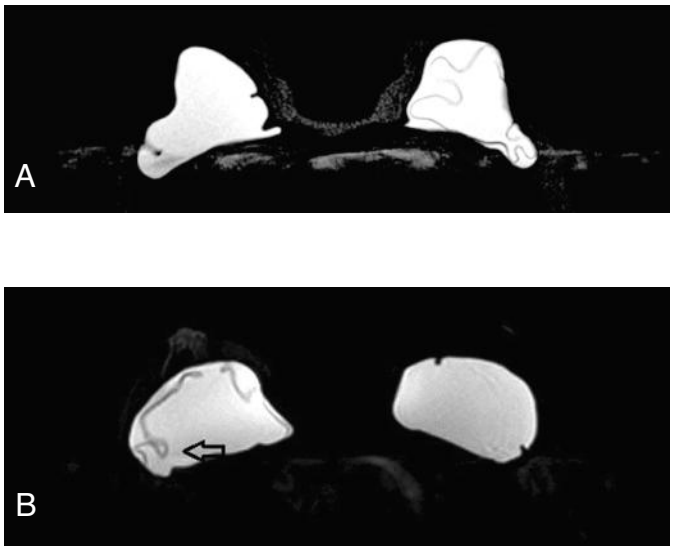
5. *Rupture*

Silicone rupture is the most frequently seen long term complication. The risk is directly related to the age of the implant. The average incidence is 2 for every 100 implant years. The incidence is in the first 5 and 10 years is 2% and 15% resepectively [14]. Patients generally present with asymmetry, palpable mass or pain. Pain is a symptom strongly suggestive of rupture. There are 2 types of rupture. Intracapsular rupture is the most frequently observed.

a) Intracapsular rupture: It occurs when the shell of the implant ruptures but the fibrous capsule formed by the breast remains intact. Silicone does not freely extravasate. This makes it difficult to detect on mammography or ultrasonography. Mamography may reveal irregularity of the breast contours and hearniaton (Fig. 17).

Intracapsular rupture is best seen on MRI. Some signs on MRI are suggestive of intracapsular rupture. Linguine sign, key hole sign and wavy line sign are some of these. The linguine sign demonstrates the free floating membrane within the silicone (Fig. 18A). The key hole sign is the appearence of the seperated inner membrane resembling a key hole (Fig. 18B). The wavy line sign is similar to the linguine sign. It is due to the freefloating

Fig. 17: Left MLO mammography. Subpectoral implant can be observed. There is increased outward convexity on the superiour contour. This was defined as herniation and was compatible with intracapsular rupture.



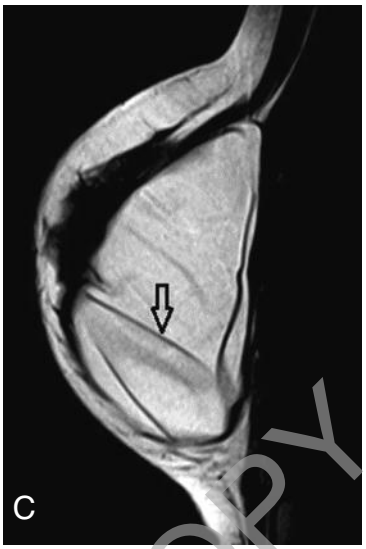


Fig. 18: A) Linguine sign suggestive of intracapsular rupture can be seen within the left breast implanton axial plane silicone only sequence. B) Keyhole sign observed within the left implant, suggestive of intracapsular rupture. C) Wavy line sign is seen within the left implant, suggestive of intracapsular rupture on sagittal section, non fat sat T2WS MRI.

Fig. 19: Right MLO mammography. Compatible with extracapsular rupture

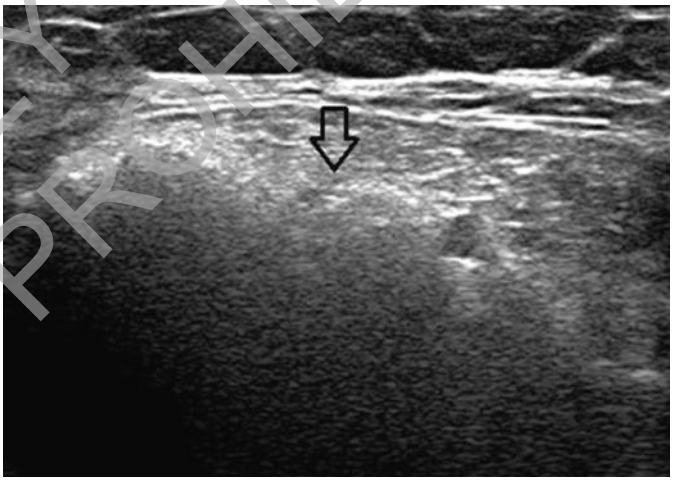


Fig. 20: US image demonstrating posterior artefact of silicone extravasation outside of the capsule to the right axillary area.

of part of the inner membrane in the silicone (Fig. 18C) [15].In intracapsular ruptures, the silicone extravasates between the fibrous capsule and the outer cover of the implant, leading to exapansion of this space. Progression may lead to extracapsular rupture.

b) Ekstracapsular rupture: It is the macroscopic leakage of the silicone outside the capsule. The extravasated silicone leads to inflammatory reaction and the formation of foreign body granuloma. On mammography, the hyperdense silicone is easily seen outside of the breast tissue (Fig. 19). Sonographically named as "snowstorm sign", echogenic nodules with a clear anterior border yet vague acoustic shadowing on the posterior are detected. This is due to the extravasation of silicone outside the capsule (Fig. 20). Diagnosis is best

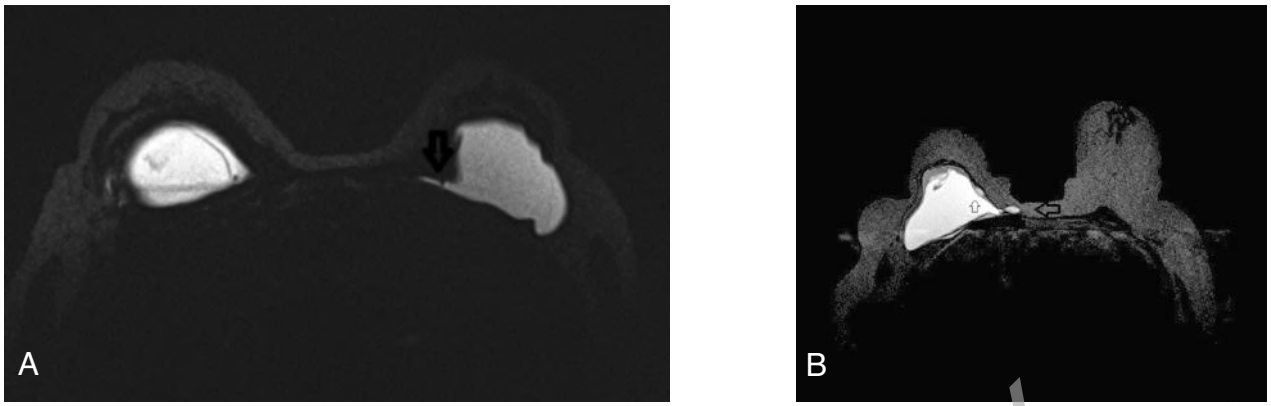


Fig. 21: A) Axial section, silicone only MRI sequence demonstrating irregular contour of the left breast and silicone extravasation from the medial aspect. This is compatible with extracapsular rupture. B) Axial section, silicone only MRI sequence demonstrating extravasation of silicone outside of the capsule on the medial aspect of the right breast. This is compatible with extracapsular rupture. Pouch sign can be seen medially, compatible with extracapsular rupture.

made with MRI. Fluid outside the breast tissue with the same intensity as silicone on silicone only sequences are diagnostic. These findings are supressed on silicone suppressed sequences (Fig. 21A-B). Pouch sign is an important finding demonstrating the emergence of silicone outside of the capsule. Close followup is required due to the high risk of extracapsular rupture (Fig. 21B).

Riassunto

Attualmente con la maggiore diffusione della chirurgia della mammella sia conservativa che demolitiva, è sempre più diffuso l'impiego di protesi mammarie. Il followup di queste pazienti è altrettanto importante dello stesso trattamento. Noi radiologi dobbiamo essere bene al corrente degli aspetti normali in imaging delle pretesi durante i followup ed altrettanto dobbiamo essere consci delle complicanze che si possoino incontrare nel corso dei controlli.
Lo scopo di questo nostro saggio è quello di fornire un panorama degli aspetti normali e patologici delle protesi impiantate, confrontando immagini ecografiche, mammografiche e di risonanza magnetica tratte dalla nostra esperienza clinica.

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