Learning objectives

• Understanding incidence, prevalence, risk factors and causes of breast implants failure.
• Showing the typical MR imaging appearances of the various implants types in patients with clinical signs or symptoms suggesting breast implant rupture.
• Explaining the typical MR features of intra- and extra-capsular rupture in patients who underwent breast surgery either for cancer or aesthetic reasons.
• Underlining the most common pitfalls of MR imaging to avoid misdiagnosis.

Background

HISTORY OF MAMMOPLASTY

Breast implants have been used for about four decades for both reconstructive and aesthetic purposes. For the first time, in 1854, Velpeau described some techniques which modified and corrected altered shapes and sizes of the breast. Later in 1889 Gersuny used local paraffin injections to increase breast volume, and even though it could be noted a cosmetic amelioration, there were numerous complications such as solid masses- granulomas, cutaneous erosion and cutaneous fistulas, migration, blindness or pulmonary embolism.

In 1895, Czerny trasplanted a patient’s lipoma to her to fill out a defect caused by removal of an adenoma.

E.Lexer in 1925 and Berson in 1944 proposed other autologous materials like dermis grafts and fat dermis graft, from the gluteal region, but the results were too unpredictable, with atrophy noted to be up to 50%, and giant calcifications and cysts of fat necrosis were frequently observed.[1-2]

The first injection of liquid silicon appeared in the fifties and it was performed for breast augmentation; in that period the silicone was considered as an inert substance with the advantage that its consistence approached that of normal breast tissue, although important complications occurred, such as hard, painful nodules and/or inflammation. [1,3-5]

In the same period plastic implants, most in the form of a sponge made from polyethylene, Teflon and silicone sponge were experimented for breast reconstruction and augmentation. Pangmann is considered the first who seriously studied the use of
sponges for breast augmentation; in fact he introduced a sponge-like implant made of polyvinyl alcohol (PVA) to promote implant integration into the surrounding breast tissue by growth into sponge pores.[1,5-6]. Soon some complications appeared such as incrustation and scar retraction reducing volume and softness of the implant; sometimes the implant contracted into a rock-hard formation, seroma formation, fistulization and infection.

The design of the implant was revolutioned by T. Cronin and F. Gerow; they wrapped a smooth and thin envelope of rubbery silicone elastomer (polysiloxisanes) around a soft but firm silicone gel compound[1,7].

Compared to the already existing implants, these new implants conserved better their form, softness with less local tissue reaction. This "natural feel" Silastic gel prosthesis became the implant of choice and the golden standard. In 1969 Cronin and Gerow made the envelope thinner and stronger and redesigned the shape to a tear-drop, resembling a normal looking breast; in addition, Dacron patches were integrated on the posterior side of the implants in order to stabilize its position because of the integration of these patches to the pectoralis fascia. But it was found that Dacron-backed prosthesis reacted unfavourably to any tendency to capsular contracture; so thin-walled discoid non-backed prostheses became the favoured shape and design[1].

Ashley described a new textured gel-filled implant with a polyurethane foam coating the silicone shell, which resulted in decreased capsular contracture (2-15% sub glandularly, compared to 20-59% when smooth implants are used) and remained soft more consistently than the smooth surface implants (fibroblast proliferation into the polyurethane in many directions)[1].

In the 80’s H. Becker introduced a permanent inflatable implant to augment breast volume for aesthetic reasons; the advantages of these implants were a shorter scar and the possibility to adjust the volume preoperatively and postoperatively to obtain a perfect symmetry[1,8].

In 1990 the implant with an anatomical shape, based on the teardrop designed first introduced by Cronin and Gerow, was reintroduced, because it was suppose to bring a better aesthetic result to the upper pole of the breast, which is often too full when round implants are used [1].

So, over the years, three generations of silicone gel-filled breast implants have been manufactured, based primarily on the type of silicone gel and type of elastomeric shell. The first one was manufactured between approximately 1960 to the mid 1970s. These silicone implants had a thick elastomeric shell with firm silicone gel. The second
generation was created between the mid 1970s and the late 1980s; they had a thin elastomeric shell, with the silicone gel being less viscous. The third generation of silicone gel-filled breast implants was manufactured between the late 1980s until the present and they have a multilayer shell with a barrier layer and thick silicone gel. [9]

Saline filled implants have been introduced for the first time by Arion in 1965, but since then they comprised only 10% of the implants placed; showed advantages consisting in the fact that saline is wholly harmless and if the silicone elastomer ruptures, the saline solution is rapidly absorbed by the surrounding tissues. Other advantages were to be harmless and a very low capsular contracture rates, especially when placed behind the pectoralis muscle (1-6%). But on the other hand, they showed a less natural appearance (folds, consistence) and an incidence rate of deflation of 1-16%.[1]

To date, over 240 breast implant styles from American manufacturers alone [10].

The actual number of styles is far larger because many implants of a single style from a single manufacturer evolved through many variants over the years. Also, the "custom" implant type alone is diverse, but single-lumen and double-lumen silicone implants are the most commonly encountered.

A single-lumen silicone implant (Fig.1) has an outer silicone Silastic shell containing homogeneous high-signal-intensity viscous silicone on T2-weighted images. A double-lumen silicone implant typically has an inner lumen of high-signal-intensity silicone surrounded by a smaller outer lumen that contains saline and has different signal intensities, depending on the pulse sequence. A variety of other types of implants are occasionally placed, including reverse double lumen implants (saline in the inner lumen and silicone in the outer lumen). (Figg.2-3).

The implants are usually oval and have a smooth or textured surface. After surgical placement, a thin fibrous capsule (scar tissue) normally forms around the prosthesis (Fig 4).

**EPIDEMIOLOGY**

Recently cosmetic breast implants have become more popular throughout the world.

Since their introduction in the1960s, silicone breast implants have been placed in more than 2 million American women. Of these implants, 80% have been placed for augmentation mammoplasty and remainder for breast reconstruction.

However, there is an insufficient knowledge about the frequency and severity of local complications such as rupture, and capsular contracture has been the focus of many reviews. [11-14].
BREAST RECONSTRUCTION

The techniques of breast reconstruction have evolved and matured over the past 25 years. Methods of breast reconstruction include implant and autologous tissue reconstruction. Breast reconstruction with use of implants is the simplest technique.

Breast implants may be surgically placed with two techniques placed anterior or posterior to the pectoralis major muscle.

In the first case the prostheses are located subglandularly (anterior to the pectoralis major muscle).

The advantages of this placement are:

- good control of breast shape;
- absence of breast shape variations during pectoralis major muscle contraction;
- good control of submammary fold position and its shape;
- post-operative course quicker than the sub-pectoral placement.

The disadvantages are:

- Higher risk of visibility or palpability of implant margins (in patients with thin skin or with big implants);
- higher visibility of capsular contracture, if present;
- increase of capsular contracture incidence.

Another placement is subpectoral, that is posterior to the pectoralis major muscle (Fig.5).

The advantages of this placement are:

- lower risk of visibility or palpability of implant margins;
- suitable for patients with thin skin;
- lower incidence of capsular contracture;
- lower visibility of capsular contracture, if present.

The disadvantages are:

- Less control of breast shape;
- lateral displacement of implant and increasing of inframammary space;
breast shape variations during pectoralis major muscle contraction;

• higher risk of upward displacement of the prosthesis;

• post-operative course longer.

Surgery-related Complications

Complications secondary to surgery include seroma, infections, hemorrhage, flap necrosis, lymphedema and axillary contracture[15-16]

Seroma is a serous fluid collection in the axillary dead space or over the anterior chest wall; it is the most common complication of breast surgery, with reported rates as high as 60% [17,18].

Infection is the second most common complication rating 3.6% [19], characterized by either cellulitis or tissue suppuration.

Abscess secondary to a necrotizing infection is relatively minor, and aggressive wound management resulted in healing of the abscess [20]. (Figg. 6-7).

Haematoma is a haematic fluid collection (Figg. 8-9).

Guidelines of breast implants

Post-operative care depends on the surgical procedure used and individual patient recovery and response. Patients need to be monitored for a minimum of ten weeks following the surgical procedure.

From the literature we have three possible scenarios in the work-up of women with possible breast implant rupture. In an asymptomatic woman the best estimate for breast implant rupture varies from 6.5 to 8%. In this patient ultrasonography (US) is the best initial diagnostic tool. If US shows no rupture, the probability decreases 2.2%, which obviates any work-up. Instead if US shows rupture the probability a true rupture increases to a 37.8%, which may not be high enough to recommend explanation. But if MRI is positive for a rupture, the probability of true rupture increases to 94-98% which is a high value to recommend implant removal.

The most recent U.S. Food and Drug Administration guidelines recommend magnetic resonance imaging (MRI) examination 3 years after silicone implants are placed and every 2 years there after to evaluate for silent implant rupture.[21,22]

The Medicines and Healthcare Regulatory Authority recommends removal of these implants if there are problems, such as implant rupture.
MR findings should be correlated with clinical history, physical examination. Silicone implant rupture has been linked to breast pain, parasthesiaes, asymmetric swelling, breast contracture, decrease in breast implant volume. The incidence of silicone implant rupture is 15 to 33 percent in symptomatic women with pain or capsular contracture. This incidence, however, is dependent on the generation of implant and the length of implantation. [23-25]

**Breast implant rupture**

Complications related to breast implants include:

- fibrous or calcific capsular contracture (Figg. 10-11),
- rupture and leakage,
- localized pain,
- deformity,
- paresthesias.

In addition, it has been reported that silicone-gel implants may be associated with the development of generalized autoimmune disorders [26].

**MRI TECHNIQUE**

High field strength magnets of 1.0±1.5 T are preferred in the case of silicone breast implants because they are able to use MRI sequences that can appropriately suppress or emphasize signal from water, fat or silicone. Moreover, these types of magnets are better suited to detect implant ruptures.

Low field magnets can also be used to image silicone breast implants, but the number of MRI sequences to suppress or emphasize the above-mentioned is limited; moreover a lack of adequate homogeneity prevents chemically selective fat suppression and may compromise image quality.

There is a linear relationship between magnetic field strength (B0) and signal-to-noise ratio (SNR). With greater B0, the SNR is higher, and images with higher spatial resolution can be obtained in a relatively short acquisition time if appropriate pulse sequences are used. The magnetic field should be homogeneous across the entire field of view, which includes both breasts.
In the diagnosis of implant ruptures several types of sequences without contrast injection can be used.

Generally the silicone gel in the implant has a homogeneous low signal intensity on T1-weighted images and a high signal intensity on T2-weighted images. It is possible to use either silicone-suppressed or silicone-selective sequences. We can combine this with fat-suppression and produce a "silicone-only" image.

Mild compression applied to the breast in the lateral-to-medial direction decreases the amount of tissue to be imaged in that direction and thereby decreases the image acquisition time, an effect that is particularly useful for imaging in the axial and sagittal planes. Compression also decreases patient motion during each sequence and between sequences and thus enables the avoidance of signal misregistration on subtracted images.

A variety of imaging protocols can be used to evaluate the breast.

MRI examinations in our department, were performed with 1.5T clinical scanner with a dedicated bilateral breast surface coil. Although there is no standard recommendation, we advocate bilateral breast imaging for several reasons, including the usefulness of assessing symmetry and evaluation of the contro-lateral breast in patients with newly diagnosed breast carcinoma.

The scanner was a high field whole body scanner doing 2D and 3D scans with fat saturation and silicone excitation properties. The scanning protocol included:

- **T2 TIRM axial** (parameters: field of view was 30 or 10 cm; matrix size was 448x448; section thickness 4mm, TR: 9570 TE 95)

- **T1 FLASH 3d axial** (parameters: field of view was 30 or 10 cm; matrix size was 448x448; section thickness 2mm TR 16 TE 4.76)

- **T2 TIRM coronal** (parameters field of view was 40 or 10 cm; matrix size was 448x448; section thickness 4mm, TR: 9570 TE 95 :)

- **T2 TIRM sagital silicone-selective** (parameters: field of view was 24 or 10 cm; matrix size was 256x256; section thickness 4mm, TR: 6260 TE 89, bandwidth, 13 kHz)

- **T2 TIRM sagittal water selective** (parameters: field of view was 24 or 10 cm; matrix size was 256x256; section thickness 4mm, TR: 6260 TE 89, bandwidth, 13 kHz)

Informed consent was obtained for all cases.

**Breast implants: MRI role**
MRI has two roles in patients with breast implants:

- detection of implant rupture, especially in intracapsular rupture;
- in carcinoma detection in patients in which the prosthesis impairs sufficient evaluation of the breast tissue;

MRI is the most sensitive and specific study to evaluate breast implant rupture (sensitivity 74-96% and specificity 94-98%) but because of its high costs, is not suitable as a screening tool and should only be used in cases of US suspected rupture or after radical mastectomy. In these cases, MRI is the method of choice.[27,28]

Mammography is ideal for breast parenchymal evaluation and obvious extracapsular silicone implant rupture.

However it is of limited use in the evaluation of implants because a portion of the implant is never imaged and the internal structure is obscured by the radiopaque silicone, so it fails, however, to consistently detect intracapsular implant rupture [29,30]

US is valuable in the evaluation of implant integrity when extracapsular silicone or a collapsed shell floating within the silicone bed may be confidently identified.

**INTRACAPSULAR implant rupture** is defined as rupture of the implant shell (elastomeric envelope) with silicone leakage that does not macroscopically extend beyond the fibrous capsule that commonly forms around silicone implants. The most reliable magnetic resonance criteria is the presence of multiple curvilinear low-signal-intensity lines seen within the high -signal-intensity silicone gel, the so-called "linguine sign" (Fig.12). These curvilinear lines represent the collapsed implant shell floating within the silicone gel. Without other magnetic resonance evidence of implant rupture such as the collapsed implant shell or free silicone within the breast parenchyma, water droplets or small amounts of air within a silicone implant are not reliable signs of implant rupture.

An uncollapsed silicone implant rupture is defined as a tear of the silicone implant shell; the implant shell does not collapse or only partially collapses. The linguine sign will not be present. The magnetic resonance finding of uncollapsed rupture is the presence of free silicone outside the implant shell but still contained by the fibrous capsule. **The sub-capsular line** (Figg.13-14-15) is an early variant of linguine sign; hypodense lines run almost parallel to the fibrous capsule and just beneath this. The beginning and the ending of each line can be followed to the surface of the implant. A small amount of free silicone is on the outside of the silicone shell, separating the shell and the fibrous capsule. The orientation parallel to the fibrous capsule helps to differentiate sub-capsular lines from radial folds (Fig.2), which show a sharp angulation with the capsule. This is a certain sign of rupture.[31;32]
As possible diagnostic signs suggesting an early intracapsular implant rupture there are the **teardrop sign** (Fig.16), representing the invagination of the silicone membrane containing a droplet of silicone, and the **noose sign or key-hole sign** (Fig.17), that is a local invagination of the silicone membrane, where the two membranes do not touch; a small amount of free silicone is seen on the outside.[31]

Unlike rupture, gel bleed is microscopic silicone leakage through an intact implant shell. [34,40-42]

**Extracapsular** silicone implant rupture (Fig.18), the less common type of implant rupture, is defined as rupture of both the implant shell and the fibrous capsule with macroscopic silicone leakage that extends beyond the fibrous capsule into surrounding tissues. Focal areas of high signal intensity, representing free silicone, can be identified on MRI. In addition to free silicone in the surrounding breast parenchyma, the linguine sign is often present with extra-capsular ruptures.[33-39]

Occasionally, round foci with water/serum can be seen mixing with the silicone gel within the implant. They can be seen if steroid or antibiotics were installed into the lumen preoperatively, or if there is an influx of serum/water into the implant through a defect membrane. Reynolds et al reasoned that the silicone envelope acts as a semi-permeable barrier and that fluid from the surrounding tissue enters the implant, causing the droplet. They appear as small hypointense elements in the silicone. The presence of many droplets is accepted as being indicative for implant rupture and, in this case, they are usually seen in combination with the collapsed envelope.

In double-lumen implants rupture, the "salad-oil sign" appears (Figg. 19-20). It could be an additional sign of rupture, but it could be seen in implants injected with povidone-iodine, saline or steroids.[32]. The train rail sign appears as two hypointense parallel lines in close proximity forming a double-contoured sub-capsular line within the silicone gel. It represents both membranes in a double lumen implant that have ruptured and it is a certain sign of rupture.[31].

**Images for this section:**
Fig. 1: Axial T2-weighted TIRM scan of a single-lumen silicone implant.
Fig. 2: Axial T2-weighted TIRM image. Reverse double-lumen implant: saline in the inner lumen (red arrow) and silicone in the outer lumen (yellow arrow).
**Fig. 3:** Double-lumen silicone implant. Same case of the previous image (Fig.2). Sagittal T2-weighted water suppressed TIRM image shows that the external lumen is made of silicone (yellow arrow), while the internal lumen contains saline (red arrow). This is a reverse double-lumen implant.
**Fig. 4:** Axial T2-weighted TIRM image. Fibrous capsule and radial folds. A fibrous capsule (green arrow) begins forming around the implant shell immediately after surgery as a natural foreign body reaction. Note posterior and medial radial folds (yellow arrows), presenting as thick hypointense lines running perpendicular to the implant shell toward the center of the implant.
Fig. 5: Sagittal T2-weighted water suppressed TIRM image of a subpectoral silicone implant. Note the pectoralis major muscle (yellow arrows).

Fig. 6: Abscess formation after breast augmentation. Axial silicone suppressed T2 TIRM scan. 40-year-old woman who presented with fever and left breast painful engorgement with redness few months after breast surgery for tuberous breast malformation. Note hyperintense changes of the subcutaneous fat of the left breast, representing inflammatory response, and a fluid collection in the inner quadrants, beyond the silicone implant (red arrow). A small fluid collection can be seen in the right breast (yellow arrow). Both the prostheses were removed and a Staphylococcus aureus infection was found.
Fig. 7: Same case of the previous image (Fig. 6). Abscess formation after breast augmentation. Sagittal silicone suppressed T2 TIRM scan of the left breast. Note hyperintense changes of the subcutaneous fat and fluid collections surrounding the implant because of an inflammatory response.
Fig. 8: Subcapsular hematoma. Axial T1 weighted FLASH3d image of a single lumen silicone implant in a patient who had undergone a recent additive mastoplasty. Note a hyperintense rim surrounding the implant shell (red arrows).

Fig. 9: Same case of Fig. 8. Subcapsular hematoma. Sagittal T2-weighted silicone suppressed TIRM image(a) and sagittal T2-weighted water suppressed TIRM image (b) of a single lumen silicone implant. History of recent additive mastoplasty. The fluid collection, (red arrows), forming a hyperintense rim around the implant shell, is not suppressed by silicone suppression, supporting the MR diagnosis of subcapsular hematoma. The silicone implant was surgically removed and a haematomatic collection was found at surgery.

Fig. 10: Capsular contracture occurring after radiation therapy. Axial T2 TIRM image in a and post-contrast subtraction image of the right breast in b in a patient with previous
history of additive mastoplasty. Note a breast cancer occurring in the right breast (red arrows).

![Image](image_url)

**Fig. 11:** Capsular contracture occurring after radiation therapy. Same case of Fig. 21. Several months after quadrantectomy and radiation therapy for breast cancer, the radiologist noticed the shrinking of the capsule compressing the implant.
**Fig. 12:** Linguine sign. Note multiple hypointense folded wavy lines within the silicone gel (red arrow), representing the collapsed silicone shell.
**Fig. 13:** Sagittal T2-weighted "silicone only" sequence. Subcapsular line sign (red arrows). Hypointense lines running almost parallel to the fibrous capsule and just beneath this (red arrows). It derives from an uncollapsed rupture, with a small amount of free silicone separating the shell and the fibrous capsule (yellow arrow).

**Fig. 14:** Intracapsular rupture of silicone bag prosthesis. Axial T2 weighted TIRM image. Note the subcapsular line sign (arrows) in the left implant.
Fig. 15: Intracapsular rupture of silicone bag prosthesis. Coronal water suppressed T2 weighted TIRM image. Note the subcapsular line sign (arrows) in the left implant.
**Fig. 16:** Teardrop sign (red arrow). Sagittal T2-weighted water suppressed TIRM scan of a single-lumen silicone implant. The teardrop sign consists of an invagination of the implant shell containing a drop of silicone. Unlike the noose sign, the two sides of the membrane touch each other.

**Fig. 17:** Coronal T2-weighted "silicone only" sequence. Noose sign or key-hole sign (red arrow). Note on the top of the implant a focal invagination of the implant membrane, where the two sides do not touch. A small amount of silicone is seen outside the implant shell.
**Fig. 18:** Extracapsular implant rupture. Sagittal water suppressed T2 TIRM image of a single lumen silicone implant. Note the linguine sign (black arrow), suggestive of intracapsular failure, and an evident extracapsular seepage, most likely as silicone granulomas, at the superior and inferior border (yellow arrows).
Fig. 19: Salad oil sign. Axial T2 TIRM image of a double-lumen prosthesis. In the outer compartment we see multiple high signal intensity nodules (arrows), suggesting a mixing of the content of the two compartments after rupture of the inner membrane of the breast implant.
**Fig. 20:** Salad oil sign. Same case of Fig. 19. On the "silicone only" sequence we see a high signal intensity of the outer compartment and the presence of well-defined low signal intensity nodules in the inner lumen, suggesting a mixing of the content of the two compartments after rupture of the inner membrane of the breast implant and formation of drops of saline in the silicone substance (green arrows). This reaction is comparable with the effect of salad oil in water. "Water only" sequence in b; note a water droplet in the outer lumen.
**Fig. 21:** Ageing implants (1989-2009). Axial T2-weighted TIRM scan. The gel changes with time, possibly due to the slow, on-going reaction catalysed by the platinum catalyst (zero oxidation state) used in the original formulation of the gel.

**Fig. 22:** Axial T2-weighted TIRM scan (a) and sagittal silicone suppressed T2 TIRM image (b) of a patient with a circumscribed subcapsular fluid collection (arrows) anteriorly the silicone implant.
Imaging findings OR Procedure details

A CASE-BASED APPROACH

The study material for this report consists of a cohort of women with single-lumen or double-lumen implants who underwent between January 2008 and July 2010 either one or two MRIs before removal the implants.

The MRI examination was performed at one of two MRI centres of our Hospital. All scanners (1.5 T) were equipped with a dedicated breast coil, which has been shown to increase both the sensitivity and specificity of MRI.

At our institution patients with breast prostheses are examined with T1-weighted Fast low Angle Shot (FLASH) 3d and T2-weighted Turbo Inversion Recovery in the Magnitude (TIRM) sequences in the axial plane. The sagittal images are obtained with T2-weighted fat saturated and silicone excited (silicone hyperintense, water suppressed) or water excited (silicone suppressed, water hyperintense) TIRM sequences. Also a coronal T2-weighted fat saturated sequence could be used.

Intravenous contrast is given in selected cases, depending on the clinical suspicion. The post-contrast study consists of T1-weighted fat saturated FLASH3d sequences.

CASE 1

Case History:

Magnetic resonance imaging scans of a 45-year-old woman with single-lumen silicone implants. No informations available about implant type and implantation year.

Image analysis:

Axial T2-weighted TIRM image (Fig. 1) demonstrates a normal signal-lumen silicone implant on the left, surrounded by a small amount of fluid.

On the outer side of the right implant there is a hypointense line running parallel to the fibrous capsule and just beneath this. The beginning and the ending of the line can be followed to the surface of the implant. This sign was interpreted as an uncollapsed rupture: a small amount of free silicone is on the outside of the silicone shell, separating the shell and the fibrous capsule.

Coronal T2-weighted TIRM image (Fig. 2) confirms the presence of free silicone on the external aspect of the silicone shell.
Besides, on the infero-medial contour of the right implant (Fig. 2), there is a local invagination of the silicone membrane, where the two membranes do not touch, containing a droplet of silicone. This aspect is called "noose sign" or "key-hole sign" and it should be seen in more than one picture to arise the suspicion of intracapsular rupture.

In both axial (Fig. 1) and coronal scans (Fig. 2) one can see silicone gel surrounding the right implant shell but contained by the fibrous capsule.

This is an example of early intracapsular rupture (uncollapsed rupture).

Findings at surgery:

The MR images corresponded well with findings at surgery of a small amount of free silicone on the outside of the right implant and a small hole in the membrane.

**CASE 2**

**Case history:**

A 30 years old patient who had undergone a reductive mastoplasty and mastopexy for gigantomastia; because of the recurrence of breast ptosis, a bilateral additive mastoplasty had been performed. She referred to our institution for the onset of pain in her left breast.

No informations available about implant type.

**Image analysis:**

Axial T2 TIRM sequence (Fig. 3) shows a hypointense structure within the left implant that is in contact with the silicone shell and was thus classified as a radial fold.

Sagittal water suppressed-silicone excited view (Fig 4) of the left breast shows a teardrop at the top of the implant and small hypointense elements in the silicone. Sagittal silicone suppressed-water excited view at the same level (Fig 5) demonstrates that there is water mixed in the silicone gel.

The punctuate changes in signal intensity within the implants can be seen if there is an influx of serum/water into the implant through a defect membrane.

The presence of the teardrop sign and of water droplets mixed in the silicone gel led to MR diagnosis of intracapsular rupture of the left implant.

**Findings at surgery:**

Implant rupture was surgically confirmed.
CASE 3:

Case history:

A 57 years old patient underwent at our institution a first standard MRI examination with contrast agent. The patient was recalled to undergo a second MRI examination for studying the breast implants because the radiologist noticed the presence of bilateral silicone abnormalities.

The patient had history of additive mastoplasty 9 years before (subglandular single-lumen silicone implants).

Image analysis:

In the first MRI examination (Fig. 6) the radiologist noticed abnormal subcapsular lines at anterior and posterior margin of both the implants.

The patient was recalled and two months later, in the axial T2 TIRM scan (Fig. 7), a focal discontinuity of the inner side of the right fibrous capsule was noticed.

Coronal and sagittal T2-weighted water suppressed-silicone excited scans of both the implants (Fig. 8-9) showed the presence of extracapsular silicone.

Findings at surgery:

At surgery extracapsular rupture of both the implants was seen.

CASE 4:

Case history:

A 52 years old patient with previous history of left mastectomy and right additive mastoplasty for breast cancer.

She underwent breast MRI because of the onset of clinical signs and symptoms of breast implant failure on her right breast: the breast had become softer during the last few years.

Image analysis:

MRI examination with axial T2 TIRM sequence (Fig. 10) shows on the right breast a partially collapsed implant shell and a curvilinear low-signal-intensity line within the silicone implant.

These findings configure the 'linguine sign' that is typical of intracapsular rupture.
In sagittal images of the right breast obtained with silicone signal suppression (Fig. 11b) and water signal suppression (Fig. 11a) the right prosthesis is characterized by a serum/silicone mixture; also a large lump of extracapsular silicone can be seen inferiorly.

Coronal view (Fig. 12) enhances the visualization of visible deformity in the fibrous capsule, a finding suggestive of extracapsular spread of the silicone gel.

Findings at surgery:

At surgery the right implant was totally disrupted and siliconomas were found into the surrounding tissues because of an extravasation of silicone gel outside the fibrous capsule.

CASE 5:

Case history:

A 53 years old patient with previous history of bilateral additive mastoplasty. No informations available about implant type.

Image analysis:

In the right breast silicone is present beyond the fibrous capsule as a nodule (granuloma/siliconoma) (Fig. 13), but no other abnormal MR findings are present except a thick fibrous capsule (Fig. 14).

Coronal (Fig. 14) water suppressed T2-weighted image shows in the left breast extracapsular spread of silicone and a visible incoherency in the fibrous capsule on its internal side.

Extracapsular silicone can take any form, often as a nodule or as streaks of silicone in close relation with the fibrous capsule. On the other hand, abnormal bulgings of the breast implants do not generate theirself a possible rupture diagnosis.

The radiologist posed the suspicion of bilateral extracapsular rupture.

Findings at surgery:

The right implant was described as intact as surgery, but surrounded by a thick fibrous capsule. The right lump described in the MRI examination was sent for histological examination, where a silicone granuloma was described.

The extracapsular rupture of the left implant was confirmed.

CASE 6:
Case history:

A 59 years old patient with previous history of bilateral mastectomy and breast reconstruction with double-lumen breast implants. She underwent MRI examination because of a recent trauma on her right breast.

Image analysis:

Axial T2-weighted TIRM image (Fig.15a) and axial T1-weighted GRE scan (Fig.15b) show right breast enlargement, resulting in a breasts' asymmetry, because of the presence of a fluid collection into the right implant pocket. This collection looks hyperintense in both T2 and T1 acquisitions.

In sagittal "silicone only" (Fig. 16a) and "water only" (Fig. 16b) sequences of the right breast, the inner lumen is well recognisable and looks intact, while the outer membrane is partially collapsed, floating into a collection of silicone mixed with saline and/or inflammatory/haematic fluid.

On the basis of these findings, the radiologist posed the suspicion of intracapsular rupture of the outer membrane of the right breast and possible intracapsular haematoma.

Sagittal views of the left breast (Fig. 17) show the presence of a double-lumen silicone implant with collapse of the outer membrane (linguine sign), because of an intracapsular rupture.

Findings at surgery:

At surgery in the right implant pocket an haematic collection with free silicone was found.

Also the intracapsular rupture of the left implant was surgically confirmed.

CASE 7:

Case history:

A 42 years-old patient with bilateral cosmetic augmentation underwent MRI examination for the onset of severe bilateral breast ptosis.

Image analysis:

Axial T2 TIRM image (Fig. 18) shows that the intraluminal content of the right implant is somewhat inhomogeneous because of the presence of small hyperintense elements in the silicone substance; a sagittal T2-weighted MR-image of the right breast with silicone suppression (saline only sequence) (Fig. 19) reveals the presence of water/serum mixed in the silicone gel.
On the basis of these findings, the radiologist posed the suspicion of intracapsular rupture of the right implant. On the other hand, in the coronal view (Fig. 20), one can see an asymmetry of the augmented breasts with a large inferolateral contour deformity, suggestive of extracapsular spread.

Finally, in the coronal view of the left prosthesis (Fig. 21), subtle hypointense lines running parallel to the capsular profile were noticed, arising the suspicion of an early intracapsular failure.

**Findings at surgery:**

At surgery extracapsular silicone was found on the right, while the left implant was intact.

**CASE 8:**

**Case history:**

A 58-years-old patient with previous history of right breast reconstruction for breast cancer and left breast augmentation. She presented with a decrease in the right breast implant volume.

**Image analysis:**

Axial T2-weighted TIRM image (Fig. 22) and sagittal silicone-suppressed (Fig. 23) and silicone-specific (Fig. 24) T2-weighted images of the right breast show an implant with two lumens, both of which are filled with silicone.

The inner lumen retains a nearly spherical shape, while the outer wall of the implant appears collapsed, suggesting an intracapsular rupture of the outer membrane. Besides, in the sagittal silicone-specific sequence (Fig. 25), the back patch of the inner lumen appears displaced along the inferior border of the inner shell and is partially separated from the outer wall.

The displacement of the back patch was considered a sign of rupture of the double-lumen implant.

**Findings at surgery:**

An intracapsular collection of silicone gel, with an intact inner lumen was found at surgery. This case illustrates that evaluating the correct position of the back patch using axial and sagittal images can help to correctly identify the type and integrity of the implant.

**CASE 9:**

**Case history:**
A 42 years-old patient with previous history of bilateral breast augmentation (single-lumen silicone implants). She was complaining of a strange softening on her left breast.

**Image analysis:**

Axial T2-weighted TIRM scan (Fig. 26a) and sagittal "silicone only" sequence (Fig. 27b) reveal a totally collapsed implant shell; an abnormal signal intensity of the silicone gel is more evident in the water only sequence (Fig. 27a). Also a large superolateral contour deformity can be observed (Figg. 26b-27b), arising the suspicion of extracapsular spread.

**Findings at surgery:**

At surgery the implant was ruptured (intracapsular rupture); the free silicone was found within an intact, but superiorly thinned fibrous capsule consistent with a herniation. This case is an example of true-positive MR diagnosis of extracapsular rupture.

**Images for this section:**

![Fig. 1: Case 1. Axial T2-weighted TIRM scan. Note a small fluid collection on the left (red arrow) and a subcapsular line on the right (black arrow).](image-url)
Fig. 2: Case 1. Coronal T2-weighted TIRM image. Note the subcapsular line sign (black arrow) and the key-hole sign (green arrow).

Fig. 3: Case 2. Axial T2-weighted TIRM scan. Note a radial fold (green arrow).
Fig. 4: Case 2. Sagittal T2-weighted water suppressed TIRM scan of the left breast. Note the teardrop sign (black arrow) and small hypointense elements in the silicone (red arrows).
Fig. 5: Case 2. Sagittal T2-weighted silicone suppressed TIRM scan of the left breast. Note the small hyperintense elements in the silicone (red arrows).

Fig. 6: Case 3. Axial T2 TIRM scan. First MRI examination. Note abnormal subcapsular lines.
**Fig. 7:** Case 3. Axial T2 TIRM scan. Second MRI examination. Note a focal disruption of the fibrous capsule (red arrow).

**Fig. 8:** Case 3. Coronal T2-weighted water suppressed TIRM image. Note a small amount of silicone outside the fibrous capsule bilaterally (red arrows).
Fig. 9: Case 3. Sagittal T2-weighted water suppressed TIRM scans of the right (a) and the left (b) breast. Note extracapsular silicone (yellow arrows) at the top (a, b) and beneath (b) the implants.

Fig. 10: Case 4. Axial T2 TIRM scan. Note the linguine sign (red arrows).
**Fig. 11:** Case 4. Sagittal T2-weighted water suppressed TIRM scan of the right breast in a. Sagittal T2-weighted silicone suppressed TIRM scan of the right breast in b. Inferiorly a large lump of extracapsular silicone is seen (red arrows).
**Fig. 12:** Case 4. Coronal T2-weighted water suppressed TIRM image. Note the extracapsular silicone (red arrow).

![Fig. 12](image12.png)

**Fig. 13:** Case 5. Axial T2 TIRM scan. Note siliconoma (yellow arrow), linguine sign (green arrow) and extracapsular spread of silicone (red arrow).

![Fig. 13](image13.png)

**Fig. 14:** Case 5. Coronal T2-weighted water suppressed TIRM image. Note extracapsular silicone (yellow arrows) and an herniation of the fibrous capsule (red arrow).

![Fig. 14](image14.png)
**Fig. 15:** Case 6. Axial T2 weighted TIRM scan (a) and axial GRE T1 weighted scan (b) of a 59 years old patient with history of recent trauma. Note the breast asymmetry because of the presence of a fluid collection into the right implant pocket (blu arrows), that appears hyperintense in GRE sequence because of an high proteic content. An intracapsular haematoma was found at surgery. Note also the intact inner membrane (red circle) and a collapsed outer membrane (green arrow) of the left implant. The signal intensity of the silicone of the right implant looks different from the left implant probably due to degenerative phenomena occurring during time.
Fig. 16: Case 6. Same case of Fig 15. Sagittal "silicone only" (a) and "water only" (b) images of the right breast. Note the intact inner lumen (red circle) and the partially collapsed outer membrane of the implant (green arrows) configuring the so called "linguine sign". The implant pocket contains silicone mixed with saline and/or inflammatory fluid. Intracapsular rupture of the outer lumen and an intracapsular haematoma (recent breast trauma) were found at surgery.
Fig. 17: Case 6. Same case of Figg 15-16. Sagittal "silicone only" (a) and "water only" (b) images of the left breast. Note the intact inner lumen (red circle) and the partially collapsed outer membrane of the implant (yellow arrows) configuring the so called "linguine sign". Intracapsular rupture of the outer lumen of the prosthesis was found at surgery.
Fig. 18: Case 7. Axial T2-weighted TIRM image of a 42 years-old patient with bilateral cosmetic augmentation. Note small areas of signal abnormality on the anterior aspect of the right breast (arrows).
Fig. 19: Case 7. Sagittal T2-weighted MR-image of the right breast with silicone suppression (saline only sequence) reveals the presence of water/serum mixed in the silicone gel (arrow).
Fig. 20: Case 7. Coronal T2 weighted TIRM image with water suppression (silicone only sequence). Note an asymmetry of the augmented breasts with a bulging of the inferolateral border of the right implant. An extracapsular rupture of such implant was surgically found.
**Fig. 21:** Case 7. Coronal water suppressed T2 TIRM scan of the left breast. Note subtle implant abnormalities that were interpreted as an early intracapsular rupture. The implant was intact at surgery.

**Fig. 22:** Case 8. Axial T2-weighted TIRM image of a 56 years old patient with hisory of right mastectomy for breast cancer and left additive mastoplasty. On the right a double-lumen silicone implant is present. Note the intact inner membrane (black arrows) and a collapsed outer membrane (yellow arrows).
Fig. 23: Case 8. Same case of Fig. 22. Sagittal "water only" image of the right breast. Note the intact inner lumen (red circle) and drops of water/serum (yellow arrows) within the fibrous capsule. Intracapsular rupture of the outer lumen of the prosthesis was found at surgery.
Fig. 24: Case 8. Same case of Figg 22-23. Sagittal "silicone only" image of the right breast. Note the intact inner lumen (red circle) and the partially collapsed outer membrane of the implant (green arrow) configuring the so called "linguine sign". The intracapsular silicone is not homogeneous because of the presence of water/serum (yellow arrow) mixed in the silicone. Intracapsular rupture of the outer lumen of the prosthesis was found at surgery.
Fig. 25: Case 8. Same case of Figg 22-23-24. Sagittal "silicone only" image of the right breast. Note the linear low-signal patch displaced inferiorly (red arrows).

Fig. 26: Case 9. Axial T2-weighted TIRM scans (a-b). Note the "linguine sign" (black arrow in a). The supero-lateral border of the left implant is bulging more than usual (red arrow in b). Intracapsular rupture of the left prosthesis was found at surgery.
Fig. 27: Case 9. Same case of Fig. 25. Sagittal "water only" (a) and "silicone only" (b) images of the left breast. The signal of the silicone is not homogeneous in a (yellow arrow). Note the collapsed membrane of the implant (black arrow in b) configuring the "linguine sign" and an abnormal configuration of the superior portion of the fibrous capsule (red arrow in b). Intracapsular rupture of the prosthesis was found at surgery; also an intact but herniated fibrous capsule was seen.
Conclusion

Mammography, ultrasonography, magnetic resonance imaging and computed tomography have all been used to evaluate silicone breast implant rupture. Each modality has specific advantages that may make a particular modality the study of choice for an individual patient.

Magnetic resonance imaging has shown the highest sensitivity and specificity for the evaluation of the integrity of the breast implants. The MR examination must include pictures in at least two planes and silicone specific sequences to look for extracapsular silicone.

In our experience, MRI can detect intracapsular and extracapsular rupture as well as other less common complications of breast reconstruction such as infection or haematomas.

Personal Information

References

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