MRI of breast implant: broken or not broken?

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Authors: M. Pancot, A. Dal Col, C. Zuiani, M. Bazzocchi; Udine/IT
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Learning objectives

To identify imaging features and pitfalls in recognition of breast implant rupture at Magnetic Resonance Imaging (MRI).

We review the role of MRI in evaluation of breast implant. The aim is to show MRI findings of certain and possible intracapsular and extracapsular breast implant rupture, as well as to identify the main MRI pitfalls in evaluation of breast prosthesis.
Background

Breast augmentation was first described in 1895 by Czerny. He was a German Bohemian surgeon, who performed breast reconstruction using autologous fat implantation. A great and rapid evolution in breast augmentation technique has been developed since. In cosmetic surgery, injection of polyacrilamide gel has been used for soft-tissue contour correction or breast augmentation. Myocutaneous flaps are considered a viable technique for breast reconstruction after mastectomy.

However, implants are the most common breast augmentation technique for cosmetic augmentation, reconstruction after mastectomy or correction of congenital malformations. As a matter of fact, the number of women with breast implants is increasing in recent years.

At least 14 different types of breast implants are available on the market, depending on lumen number and filler type, as shown in Table 1 on page .

Breast prosthesis most frequently used in clinical practice are:

1. **single-lumen gel** (Fig. 1 on page 5): Single-lumen gel breast implants have only one lumen, filled by silicone gel. They can be divided into two different categories, as reported in Table 2 on page 6.

2. **standard double-lumen** (Fig. 2 on page 7): Standard double-lumen breast implants consist of two lumens, the inner one filled by silicone gel and the outer one filled by saline.

3. **reverse double-lumen** (Fig. 3 on page 8): As standard double-lumen breast implants, also reverse double-lumen breast prosthesis are composed of two lumens, but the inner one is filled by saline, while the outer one is filled by silicone gel.

Breast implants can be surgically introduced using a wide variety of different approaches. The most common ones are reported in Fig. 4 on page 9. Each of them has advantages and disadvantages. For example, inframammary incision is technically simple but it leaves an obvious scar, while periareolar incision leaves a minimal scar but it can lead to a decrease in nipple sensitivity. At last, axillary incision leaves a minimal scar, as well as periareolar incision, but it's technically more difficult to perform.

Breast implants can be positioned either deep to the glandular tissue (retroglandular or subglandular) (Fig. 5 on page 10) or deep to the pectoralis major muscle (retropectoralis or subpectoralis) (Fig. 6 on page 11).

After positioning, a fibrous tissue develops around the implant, as a physiological response to a foreign body; this process is called "encapsulation".
In the postoperative period, early complications and late complications can be seen, as reported in Table 3 on page 12. Capsular contracture is an abnormal constriction of the fibrous capsule, most frequently associated with smooth-surfaced silicone implants and it's almost always clinically diagnosed.

However, the main cause of removal as well as the principal complication in women with breast implants is rupture. This condition seems to be directly related to implant's age, with increasing risk of rupture in prosthesis older than 10-15 years. Implant ruptures can have various causes, even if most of them have no obvious traumatic origin and they are difficult to clinically diagnose, because they are asymptomatic in most of cases. Rarely clinical features are present; they are listed in Table 4 on page 13.

On the basis of the location of ruptured silicone with respect to the fibrous capsule, implant ruptures can be classified as intracapsular or extracapsular (Fig. 7 on page 14). Intracapsular rupture is caused by a tear in the implant shell, not associated with damage of the fibrous capsule. Consequently, there is silicone outside the implant shell but within the fibrous capsule. On the contrary, in extracapsular rupture both the implant shell and the fibrous capsule are broken, so that silicone spreads into the adjacent breast parenchyma, toward the pectoralis major muscle or the axillary lymph nodes.

Imaging plays an important role in identifying implant ruptures.

Mammography is of little value in the assessment of implant integrity. Mammographic features suggestive of implant rupture can be divided into two different groups, as reported in Table 5 on page 15.

Ultrasonography (US) shows variable sensitivity (50-77%) and specificity (55-84%) in detecting implant ruptures. It evaluates morphology, contour and contents of breast prosthesis, perimplant tissue and axillae, but it's limited in assessing the posterior wall of the implants, cause of the marked attenuation of the ultrasound beam by silicone. Features, that may be seen at US, are distinguished into three groups, as shown in Table 6 on page 16. Examples of low level echoes, radial fold and snowstorm sign are represented in Fig. 8 on page 17, Fig. 9 on page 18 and Fig. 10 on page 19.

Generally, mammography and US are an useful first approach in women with breast prosthesis, but MRI shows better performance in identifying implant ruptures, especially thanks to its multiplanar capability and its high contrast and spatial resolution.
<table>
<thead>
<tr>
<th>Breast implant Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-lumen Gel</td>
<td>Silicone gel-filled</td>
</tr>
<tr>
<td>Single-lumen adjustable</td>
<td>Silicone gel-filled; a variable amount of saline can be added at time of placement</td>
</tr>
<tr>
<td>Saline-filled; dextrane-filled</td>
<td>Dextrane-filled; PVP-filled; saline-filled</td>
</tr>
<tr>
<td>Standard double-lumen</td>
<td>Silicone gel inner lumen; saline outer lumen</td>
</tr>
<tr>
<td>Reverse double-lumen</td>
<td>Saline inner lumen; silicone gel outer lumen</td>
</tr>
<tr>
<td>Reverse adjustable PVP-filled</td>
<td>Silicone gel inner and outer lumen; a variable amount of saline can be added to inner lumen at time of placement</td>
</tr>
<tr>
<td>Gel-gel double-lumen</td>
<td>Silicone gel inner and outer lumen</td>
</tr>
<tr>
<td>Triple lumen</td>
<td>Silicone gel inner and middle lumens; saline outer lumen</td>
</tr>
<tr>
<td>Cavon “cast gel”</td>
<td>Cohesive silicone gel; no shell</td>
</tr>
<tr>
<td>Custom</td>
<td>Nonstandard implant type, size, shape and fill</td>
</tr>
<tr>
<td>Soft pectus</td>
<td>Solid silicone elastomer pectoralis muscle replacement</td>
</tr>
<tr>
<td>Sponge (not adjustable)</td>
<td>Solid/hollow; simple/compound; encased in plastic bag</td>
</tr>
<tr>
<td>Sponge (adjustable)</td>
<td>Silicone elastomer shell; polyurethane sponge inside; dextran/saline-filled</td>
</tr>
<tr>
<td>Other</td>
<td>Triglyceride/other fill</td>
</tr>
</tbody>
</table>

**Table 1**

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Fig. 1: axial T2 weighted short-tau inversion recovery (A) and axial turbo inversion recovery magnitude silicone exciting (water-suppressed) (B) sequences, representing a single-lumen breast implant.

Fig. 1

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<table>
<thead>
<tr>
<th>Polyurethane coated</th>
<th>Without polyurethane coating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• smooth silicone elastomer shell</td>
</tr>
<tr>
<td></td>
<td>• textured silicone elastomer shell</td>
</tr>
</tbody>
</table>

Table 2

© Institute of Radiology, Institute of Radiology, University Hospital S. Maria della Misericordia - Udine/IT
Fig. 2: axial T2 weighted short-tau inversion recovery (A) and axial turbo inversion recovery magnitude silicone exciting (water-suppressed) (B) sequences, representing a standard double-lumen breast implant.
Fig. 3: axial T2 weighted short-tau inversion recovery (A) and axial turbo inversion recovery magnitude silicone exciting (water-suppressed) (B) sequences, representing a reverse double-lumen breast implant.

Fig. 3

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Fig. 4: different surgical approaches for breast implant introduction. Red line: inframammary incision. Green line: periareolar incision. Blue line: axillary incision. Black line: transumbilical incision.

Fig. 4

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**Fig. 5**: breast implant positioned deep to the glandular tissue (retroglandular or subglandular). A) sagittal T2 weighted turbo-spin-echo sequence representing a retroglandular breast implant.

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Fig. 6: breast implant positioned deep to the pectoralis major muscle (retropectoralis or subpectoralis). A) sagittal T2 weighted turbo-spin-echo sequence representing a retropectoralis breast implant.
| Early complications | • hematoma  
|                     | • infection |
| Late complications  | • capsular contracture  
|                     | • silicone granuloma formation  
|                     | • rupture  |

Table 3

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| Nonspecific findings | • palpable nodules  
|                     | • asymmetry of the breast  
|                     | • tenderness of the breast  
| 
| Symptoms            | • breast pain  
|                     | • loss of the shape of the breast  
|                     | • displacement of the implant  
|                     | • mass formations  
|                     | • inflammatory reaction  

**Table 4**

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Fig. 7: classification of breast implant ruptures. A) intracapsular rupture. B) extracapsular rupture.

Fig. 7

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<table>
<thead>
<tr>
<th>Not specific signs</th>
<th>Specific features</th>
</tr>
</thead>
<tbody>
<tr>
<td>• periprosthetic dense band</td>
<td></td>
</tr>
<tr>
<td>• periprosthetic calcification</td>
<td></td>
</tr>
<tr>
<td>• asymmetry</td>
<td></td>
</tr>
<tr>
<td>• focal herniation</td>
<td></td>
</tr>
<tr>
<td>• extravasation of silicone</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5**

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| Features suggestive of intracapsular rupture | • stepladder sign  
• small pocket of silicone |
| Features suggestive of extracapsular rupture | • snowstorm sign  
• silicone granulomas |
| Pitfalls | • radial folds  
• low level echoes  
• reverberation artifact |

**Table 6**

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Fig. 8: low level echoes within the implant.
Fig. 9: radial fold (normal infolding of the implant membrane into the silicone gel).

Fig. 9

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**Fig. 10**: snowstorm sign in a periprosthetic lymph node.
Findings and procedure details

MRI has high sensitivity (72-94%) and specificity (85-100%) in depicting breast implant failure. It can distinguish between intracapsular and extracapsular rupture and identify extravasation of silicone into the adjacent breast parenchyma.

MRI examination requires a dedicated breast coil and a high-field-strength magnet of at least 1.5 T. The patient is positioned prone, with arms along the body and the breast placed into the dedicated coil, avoiding the formation of cutaneous folds. The patient has to stay as still as possible during the examination, so that motion artefacts do not affect the sequences performed.

It is essential to know patient's breast implant type for an accurate evaluation of MRI images obtained.

Example of MRI protocol for evaluation of breast implants is reported in Table 7 on page 23. The use of contrast agents for assessing breast implant integrity is not recommended.

MRI findings can be divided into three different categories:

1. **features of intracapsular rupture**: These include signs of certain implant failure (Table 8 on page 23) and signs of possible implant rupture (Table 9 on page 24).

The linguine sign represents the collapsed implant shell. It appears as a lot of hypointense folded wavy lines within the silicone gel, often arranged more or less parallel to the fibrous capsule (Fig. 11 on page 25).

The subcapsular line is an early variant of the linguine sign, representing an implant shell, that is broken, but not collapsed into the silicone gel. It is characterized by the presence of one or more hypointense lines, running almost parallel to the fibrous capsule and just beneath it. A small amount of silicone is on the outside of the implant shell, separating it from the fibrous capsule (Fig. 12 on page 26).

The train rail sign is related to double-lumen implant rupture. In this case, two hypointense parallel lines in close proximity form a double-contoured subcapsular line within the silicone gel (Fig. 13 on page 27).

The teardrop sign appears as an invagination of the silicone membrane, containing a droplet of silicone. Generally, it is seen in more than one image (Fig. 14 on page 28).

The key-hole sign is a local invagination of the silicone membrane, where the two layers of the membrane do not touch (Fig. 15 on page 29).
When water and silicone gel are mixed together, small hypointense elements are seen within the implant. These are the so called "punctuate changes in signal or droplets" (Fig. 16 on page 30).

2. **features of extracapsular rupture**: Also in this group, signs of certain rupture are distinguished from those of possible rupture, as listed in Table 10 on page 31 and Table 11 on page 32.

Extracapsular silicone can be seen when there is a concomitant intracapsular rupture. Silicone is present beyond both the implant shell and the fibrous capsule, often forming nodules or granulomas. In most of cases, there is a slight connection with the intracapsular silicone (Fig. 17 on page 33).

A breast implant with irregular margin presents vague and not clear defined border. A larger change in contour is seen when the border of the implant is bulging more than usual (Fig. 18 on page 34).

3. **pitfalls**: They include signs that mimic an implant failure, as reported in Table 12 on page 35.

Simple radial folds are present in normal not-ruptured implant. They appear as hypointense solid lines, extending from the surface of the implant in a perpendicular manner and ending blindly in the silicone gel (Fig. 19 on page 36).

Complex radial folds are similar in appearance to the simple ones, but they are longer and multidirectional. They can mimic the linguine sign, but they are different from it because they are formed by two layers of membrane (Fig. 20 on page 37).

Periprosthetic fluid is considered a normal feature, probably due to an inflammatory response (Fig. 21 on page 38).

Periprosthetic calcifications can lead to an irregular aspect of the implant border, mimicking an extracapsular rupture (Fig. 22 on page 39).
<table>
<thead>
<tr>
<th>Sequences</th>
<th>Acquisition plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2 weighted short-tau inversion recovery</td>
<td>axial</td>
</tr>
<tr>
<td>Turbo inversion recovery magnitude silicone exciting (water-suppressed)</td>
<td>axial</td>
</tr>
<tr>
<td>T1 weighted three-dimensional fast low-angle shot</td>
<td>axial</td>
</tr>
<tr>
<td>T2 weighted turbo-spin-echo</td>
<td>sagittal</td>
</tr>
</tbody>
</table>

**Table 7**

© Institute of Radiology, Institute of Radiology, University Hospital S. Maria della Misericordia - Udine/IT
| Signs of certain intracapsular implant failure | • linguine sign  
• subcapsular line  
• train rail sign |
| Signs of possible intracapsular implant failure | • teardrop sign  
• key-hole sign  
• droplets/punctuate changes in signal |

Table 9

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**Fig. 11**

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Fig. 11: A e B) sagittal T2 weighted turbo-spin-echo sequences, showing an example of linguine sign (red arrows).
**Fig. 12**: axial turbo inversion recovery magnitude silicone exciting (water-suppressed) (A) and axial T2 weighted short-tau inversion recovery (B) sequences, representing an example of subcapsular line (red arrows).

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**Fig. 12**

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Fig. 13: example of train rail sign.
Fig. 14: axial turbo inversion recovery magnitude silicone exciting (water-suppressed) (A) and axial T2 weighted short-tau inversion recovery (B) sequences, showing an example of teardrop sign (red arrows).

Fig. 14

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Fig. 15: axial turbo inversion recovery magnitude silicone exciting (water-suppressed) (A) and axial T2 weighted short-tau inversion recovery (B) sequences, representing an example of key-hole sign (red arrows).

Fig. 15

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Fig. 16: axial T2 weighted short-tau inversion recovery (A) and sagittal T2 weighted turbo-spin-echo (B) sequences, showing an example of droplets (red arrows).

Fig. 16

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| Signs of certain extracapsular implant rupture | extracapsular silicone |

**Table 10**

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| Signs of possible extracapsular implant rupture | • irregular margin  
|                                             | • larger change in contour |
Fig. 17: sagittal T2 weighted turbo-spin-echo (A), axial turbo inversion recovery magnitude silicone exciting (water-suppressed) (B) and axial T2 weighter short-tau inversion recovery (C) sequences, representing an example of extracapsular silicone (red arrows).

Fig. 17
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**Fig. 18**: example of irregular margin (A) and larger change in contour (B).
<table>
<thead>
<tr>
<th>Pitfalls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• simple radial folds</td>
</tr>
<tr>
<td></td>
<td>• complex radial folds</td>
</tr>
<tr>
<td></td>
<td>• periprosthetic fluid</td>
</tr>
<tr>
<td></td>
<td>• periprosthetic calcifications</td>
</tr>
</tbody>
</table>

**Table 12**

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Fig. 19: A) sagittal T2 weighted turbo-spin-echo sequence, representing an example of simple radial fold (red arrow).
Fig. 20: sagittal T2 weighted turbo-spin-echo (A), axial turbo inversion recovery silicone exciting (water-suppressed) (B) and axial T2 weighted short-tau inversion recovery (C) sequences, showing an example of complex radial folds, mimicking linguine sign (red arrows).
Fig. 21: A) axial T2 weighted short-tau inversion recovery sequence, representing an example of periprosthetic fluid (red arrow).
Fig. 22: example of periprosthetic calcifications.
**Conclusion**

Rupture is the principal cause of removal, as well as the most frequent complication in women with breast implants. This condition is difficult to clinically diagnose, because it is asymptomatic in most of cases. Therefore, imaging plays an important role in identifying breast implant failure. Even if mammography and US can be considered an useful first approach in women with breast prosthesis, MRI shows better performance in evaluating breast implants. Thanks to its multiplanar capability and its high spatial and contrast resolution, MRI appears to be superior to both, mammography and US, in identifying features suggestive of implant failure, showing high sensitivity (72-94%) and specificity (85-100%).
Personal information

C. Zuiani; M. Pancot. Department of Radiology, Università di Udine, Azienda Ospedaliera Santa Maria della Misericordia, Udine, Italy

Mail to: martypancot@libero.it
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