Imaging Findings After Surgery

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21.1 Introduction

Breast cancer treatment has markedly improved in the last few decades. Radical mastectomy was initially considered the treatment of choice despite its associated morbidity. However, less aggressive surgeries such as modified radical mastectomy, simple mastectomy, skin-sparing mastectomy, and breast-conserving surgery have increasingly replaced radical mastectomy. Moreover, reconstructive surgeries such as oncoplastic surgery have entered the surgical scene, combining a safe oncological treatment approach with desirable aesthetic outcomes. Many women being treated for breast cancer have also undergone breast-enhancing procedures using exogenous material that are either heterologous or autologous. These procedures can be performed for purely aesthetic reasons or for reconstructive purposes in cases of breast cancer.

The greatest difficulty in assessing breast tissue postsurgery is to distinguish postsurgical changes from malignancy. Recurrence is possible despite the treatment of breast cancer, including in patients who have undergone mastectomy. Thus it is necessary to know the radiological techniques available to study recurrence in patients and to establish an appropriate follow-up.

Mammography can detect tumors which are then less likely to develop metastases during follow-up. However, mammography has limited sensitivity, from 55 to 68%. There are also difficulties in performing mammography correctly with adequate compression, and the radiologist does not always obtain good image quality with mammography. Mammography also presents difficulty in interpretation, for example, in differentiating spiculated scars from recurrence and differentiating edema (due to the RT) from lymphatic involvement. A clinical examination complements mammography in detecting recurrences, and a palpable lesion usually indicates worse prognosis.

Compared to clinical examination and mammography, MRI has high sensitivity, from 90 to 100%. It also has high specificity, from 83 to 93%. It is also able to reliably distinguish scar from recurrence 12 to 18 months posttreatment. Breast MRI allows both morphological and functional evaluation. Non-enhancement (absence of uptake) after intravenous contrast (IVC) suggests fibrosis rather than cancer. However, the presence of enhancement does not always indicate malignancy because there are many benign processes that can cause uptake, such as fat necrosis. Consequently, if the presence of fat inside the lesion cannot be determined with fat suppression sequences, a core biopsy is required.

Ultrasound has limited sensitivity for small or noninvasive lesions. Acoustic posterior shadowing on ultrasound presents difficulty in differentiating fibrous scar from recurrence.

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21.2 Imaging Findings After Surgery Without Any Material or Reconstruction

21.2.1 Mastectomy

An estimated 10–15% of patients will develop locoregional recurrence after treatment. Nearly a third of them will present with synchronous metastases at diagnosis. The most common form of presentation (50–70%) is local recurrence (Fig. 21.1a–c), which tends to be symptomatic. The patient has a single mass or multiple masses in the bed of mastectomy (chest wall or under the scar), diffuse skin thickening, trabecular thickening, or ulceration of skin. Recurrence can manifest radiologically as masses with signs of suspicion and/or calcifications

U. Veronesi et al. (eds.), *Breast Cancer*, DOI 10.1007/978-3-319-48848-6_21

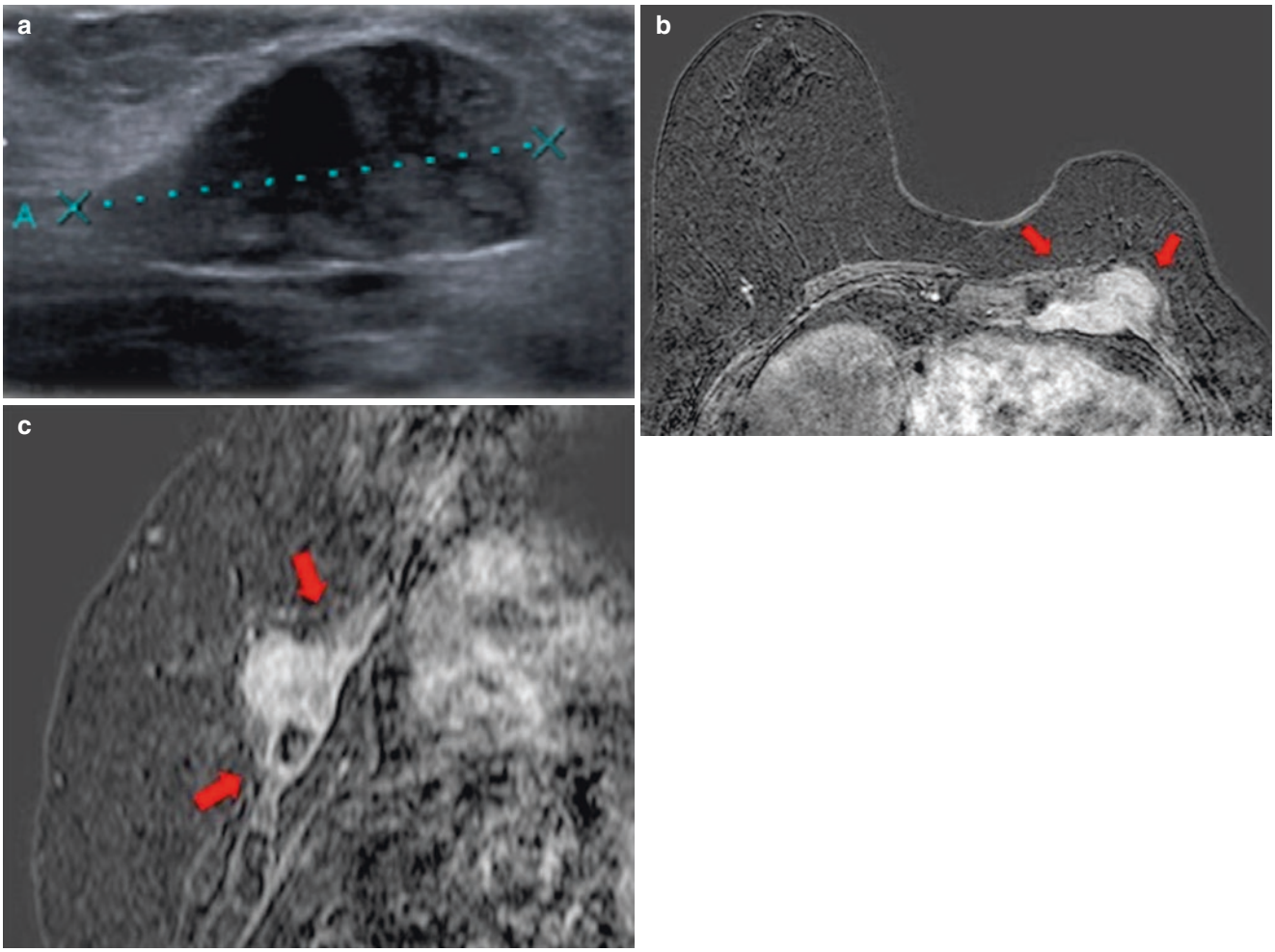

Fig. 21.1 Patient with history of left mastectomy noticed a palpable lump in the mastectomy site corresponding to recurrence. (**a**) Ultrasound: an anechoic and heterogeneous lesion, ill-defined in some margins and seeming to be in contact with the pectoral muscle, is seen. (**b**) Breast MRI (dynamic sequence, axial plan): a mass in the mastectomy site, involving the pectoral muscle, some ribs, and intercostal muscles and goes inside the thoracic cavity, is seen. (**c**) In the sagittal view, involvement is well seen in the costal and intercostal spaces

that in some cases can be difficult to distinguish from dystrophic calcifications or fat necrosis. Recurrence can also present in regional or distant lymph nodes (30–40%), which are usually asymptomatic (Fig. 21.2) and may not be palpable, at least initially. Some common locations are the supraclavicular, axillar, and internal mammary regions, where they can cause pain, brachial plexopathy, or arm lymphedema. Any new onset lymphedema after treatment should be evaluated to rule out regional recurrence.

21.2.1.1 Radiological Tests and Findings

1. *Mammography*: Mammography is not routinely performed for patients who have undergone mastectomy. However, it can be performed, and the mammogram can be examined for the presence of residual breast tissue, especially in cases of subcutaneous or incomplete mastectomy.

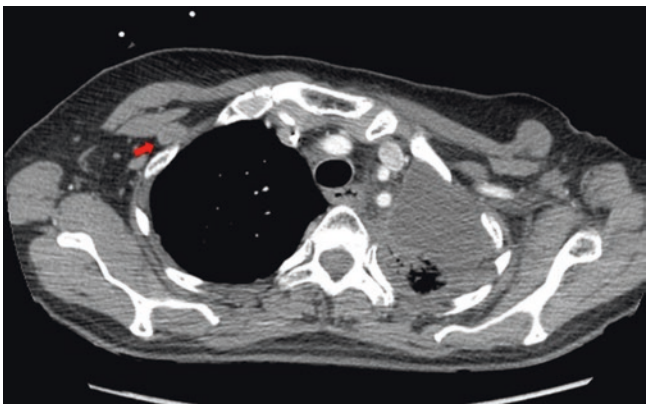

Fig. 21.2 Patient with history of left mastectomy. CT axial plane shows an enlarged and round retropectoral lymph node, suggesting recurrence. Despite retropectoral involvement, the axillary lymph nodes were negative and asymptomatic

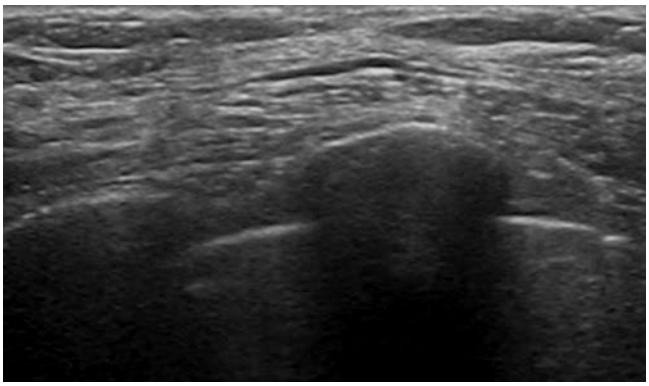

Fig. 21.3 Sonographic appearance of a mastectomy. The skin, subcutaneous tissue, and the pectoral muscle on the chest wall can be appreciated

2. *Ultrasound*: Patients who have undergone mastectomy may be examined by bed ultrasound. Ultrasound allows the physician to observe subcutaneous fat, postsurgical scarring, and fibrosis (Fig. 21.3). Nodular lesions on ultrasound suggest recurrence (Fig. 21.1a), and as patients undergoing mastectomy do not routinely undergo mammography, these should be evaluated carefully. Possible complications or benign findings such as seromas or hematomas should also be assessed.
3. *CT or MRI*: Postsurgical changes in the axillary level and the presence of residual breast tissue should be evaluated. The type of surgery and the presence or absence of the pectoral muscle should also be noted before the interpretation of findings.

21.2.1.2 Follow-Up Protocol

In the follow-up of patients, physical examination and ultrasound are usually performed. Mammography is performed only in cases where incomplete mastectomy or residual breast tissue is suspected and when technically feasible (Fig. 21.4). Breast MRI can be performed to show the absence of residual glandular tissue (Fig. 21.5). It has shown greater sensitivity and specificity than other techniques; however, it is rarely used routinely due to its availability and cost.

21.2.2 Breast-Conserving Surgery

There is a risk of recurrence in about 1–2% patients post-breast-conserving treatment per year. Early detection is crucial because it is associated with improved survival. Presentation of recurrence can manifest early or late. Early recurrence usually occurs at the site of the original tumor and represents failure in the eradication of the primary tumor (Fig. 21.6a, c, and d). Late recurrence (after 10 years of

Fig. 21.4 Patient with left mastectomy. Mammography (oblique view) was performed to rule out the presence of residual fibroglandular tissue

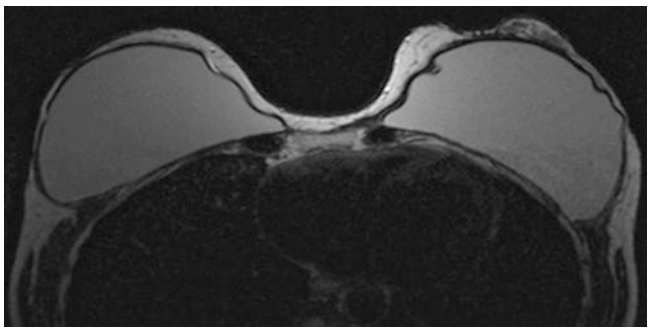

Fig. 21.5 35-year-old patient with a history of right breast cancer and positive BRCA1. Right mastectomy and prophylactic left mastectomy were performed. The patient was not a candidate for mammography. Breast MRI was performed to check whether there was residual fibroglandular tissue. T2 sequence shows the presence of residual fibroglandular tissue with slight enhancement on the left breast. A follow-up MRI was recommended

finishing the treatment) usually occurs in another quadrant or away from the treated area and usually represents new tumors.

Interpretation of imaging post-breast-conserving surgery can be complicated because postsurgical benign changes can simulate recurrence and make the follow-up overwhelming. Early recurrence usually occurs after 2 years following

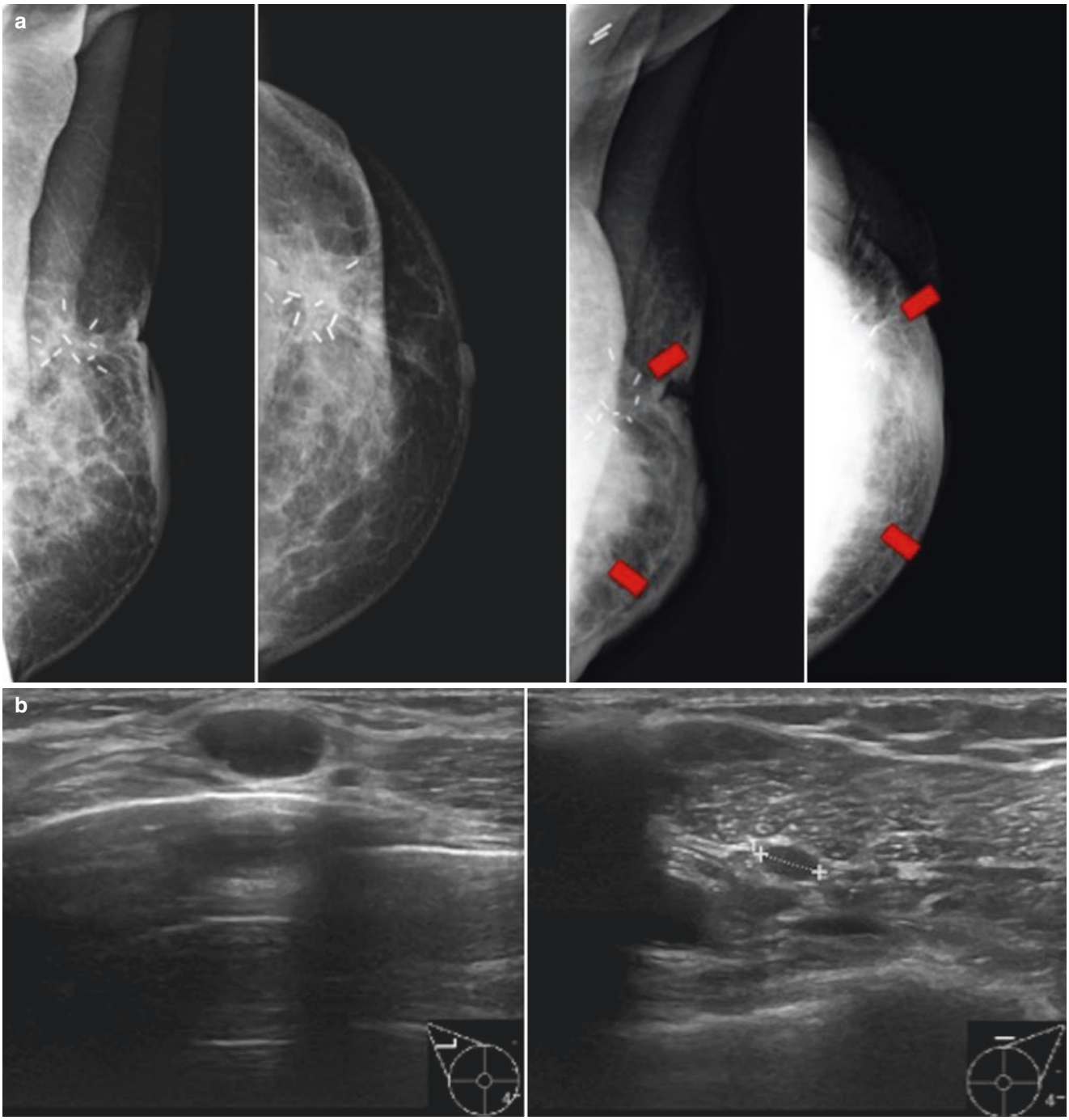

Fig. 21.6 Patient with triple negative breast carcinoma in the right UOQ and axillary involvement. The patient received neoadjuvant chemotherapy. MRI showed a complete response. Therefore, breast-conserving surgery was performed. After the surgery, the pathologist reported positive margins, and the patient received radiotherapy but was not reoperated. (**a**) Mammography with CC and oblique views: On the left, first mammogram after surgery shows a distortion relating to post-surgical changes adjacent to the clips. On the right, second follow-up mammogram shows a diffuse increase of density involving the pectoral muscle, in comparison with the previous mammogram, suggesting recurrence (*red lines*). Skin thickening was also noted. (**b**) Ultrasound confirmed these findings where new involvement of axillary and infraclavicular lymph nodes as well as contralateral axillary lymph nodes is also seen

treatment, whereas during the first 2 years, most radiological changes are due to benign changes. To distinguish recurrence-related and benign changes, radiologists need to be aware of the following expectations. Benign changes should decrease or remain stable over time. Stability is usually achieved 2–3 years after RT. After this, any postsurgical changes, density or new onset suspicious calcification, should rule out recurrence (Fig. 21.7).

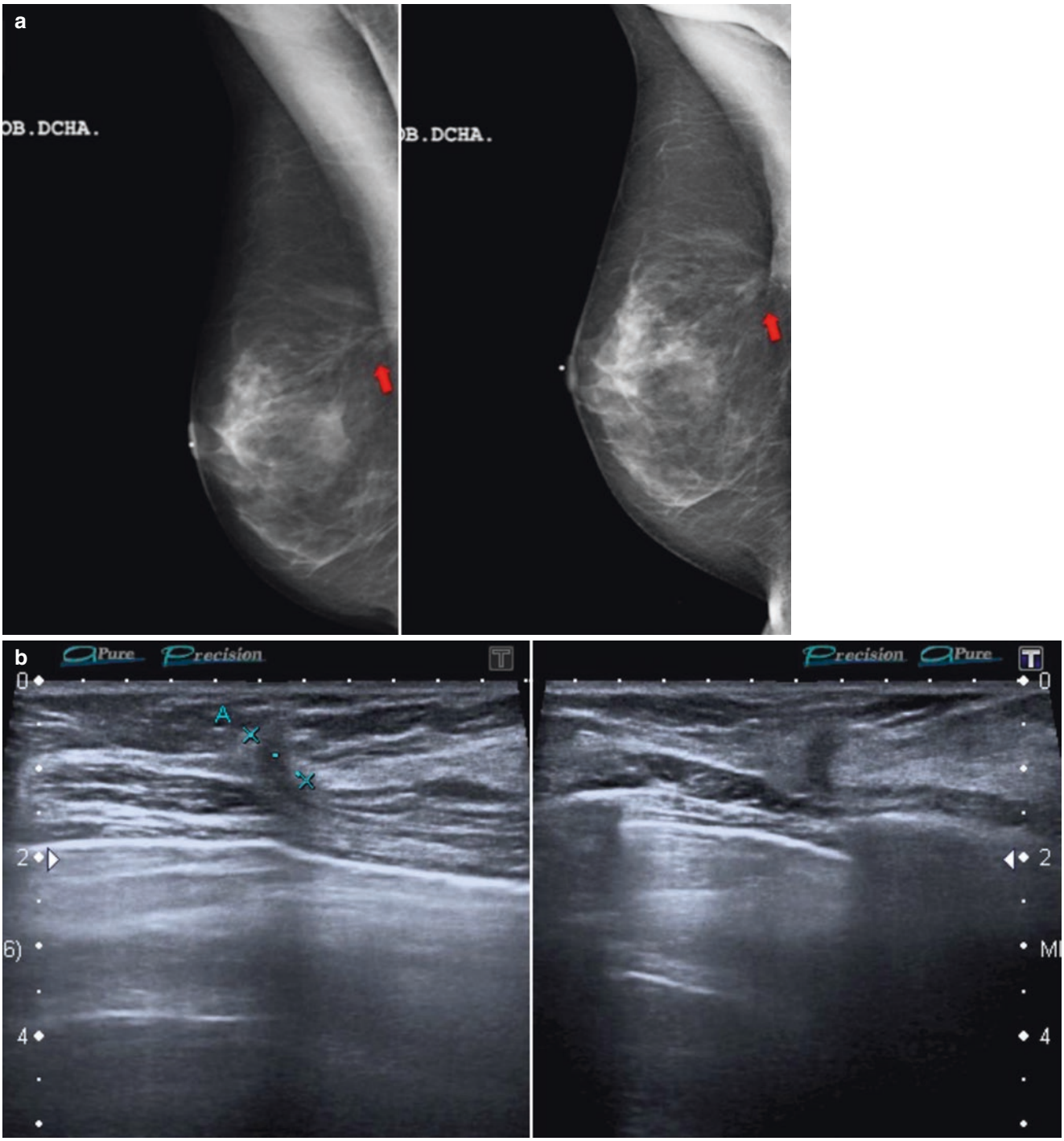

Fig. 21.7 Patient with breast-conserving treatment in the UOQ of the right breast. (**a**) Mammography oblique views: On the left, a follow-up mammogram a few years after surgery demonstrates subtle and stable distortion in the postsurgical area (*red arrow*). On the right, another mammogram a year after shows the distortion presenting a slight increase in density. An ultrasound was recommended. (**b**) A hypoechoic, ill-defined and irregular lesion can be seen with an antiparallel orientation suggesting malignancy that was confirmed with a core needle biopsy

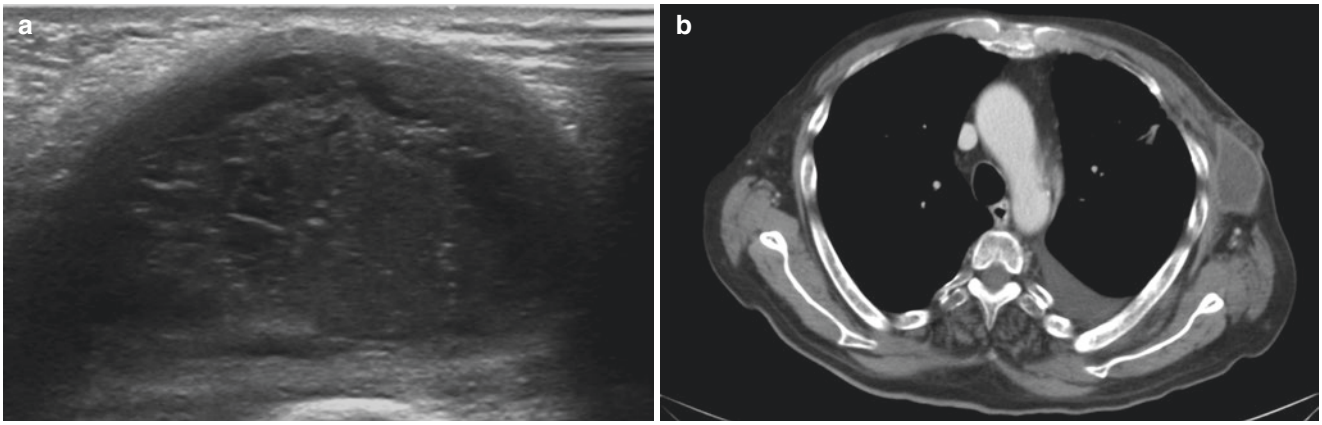

Fig. 21.8 Patient with a personal history of left mastectomy and axillary dissection. The patient showed a palpable lump in the axillary region corresponding to an evolved seroma/hematoma without changes in follow-up. In normal conditions, the seroma or hematoma is reabsorbed a few times after surgery. In this case, it did not happen although it was stable. (**a**) Ultrasound of the axillary region shows a complex lesion with internal septa and a thick wall relating to the palpable lesion. (**b**) CT shows fluid collection with different densities and thin enhancement of the wall

21.2.2.1 Radiological Tests and Findings

The following are considered benign findings after breast-conserving surgery:

Seroma/hematoma is present when there is fluid collection in the surgical area. In most cases, over time, seroma/hematoma will be reabsorbed and replaced by fibrosis and scarring. Fifty percent of the cases will last a month after surgery, 25% will last 6 months after surgery, and most of them will disappear within 12–18 months after surgery. Sometimes seroma/hematoma may persist over time (Fig. 21.8):

- *On mammogram*: Seroma/hematoma will appear as a highly dense, oval, or round mass. It can have well-defined margins or obscured margins when it lies within the distortion produced by benign postsurgical changes.
- *On ultrasound*: Seroma/hematoma will appear as an anechoic collection normally seen as a simple cystic lesion. Over time, seroma/hematoma will decrease in size and have increased echogenicity showing a complicated or complex appearance (septa, loculations, and/or thickening of the wall).
- *On CT and MRI*: Fluid collection will be seen in the surgical site. Water density and signal intensity will vary over time according to cancer stage.

Edema and skin thickening will be most highly expressed 6 months after RT and later evolve and regress in a similar way. The edema may be focal in the area of the lumpectomy (reflecting postsurgical changes) or be distributed diffusely (reflecting changes post-RT). If there is an increase of edema, the physician should perform differential diagnosis regarding tumor to lymph vessels, obstruction of venous drainage, or congestive heart failure and infection. Skin thickening is secondary to the damage produced on small vessels and can measure up to 1 cm in thickness. It is more evident when the treated breast is compared to imaging of the contralateral breast or to its appearance on the pretreatment mammogram (Fig. 21.9). On MRI these findings are well observed, especially on T1 sequence (where we can observe the skin thickening) and T2 sequence (where edema is clearly hyperintense) (Fig. 21.10).

Architectural distortion occurs as a result of changes in scarring and fat necrosis. It reaches its highest expression at 2 years. Thereafter, it will remain stable or decrease. Architectural distortion can have spiculated or irregular density as well as poorly defined margins and may be accompanied by skin retraction; these can resemble recurrence. A number of mammographic findings such as central radiolucency, appearance changes in different projections, and thick and curvaceous spiculations may suggest that the findings are more likely of postsurgical origin. Note that findings are not always reliable; for example, there are some lobular carcinomas that may also present central radiolucency. For this reason, it is essential to perform magnified and spot compressed views (Fig. 21.11) as well as a comparative study with previous mammograms (to verify the stability or progressive reduction in size and density) (Fig. 21.7), and if there is still some doubt, biopsy should be performed (Fig. 21.12).

Benign calcifications usually appear in the first 6–12 months in 28% of cases. They can usually be distinguished from pleomorphic calcifications associated with malignancy, but when there is uncertainty, additional views, tests, or biopsy are required. Benign calcifications can be dystrophic calcifications, which usually originate in areas of fat necrosis. These are irregular in shape, and they are

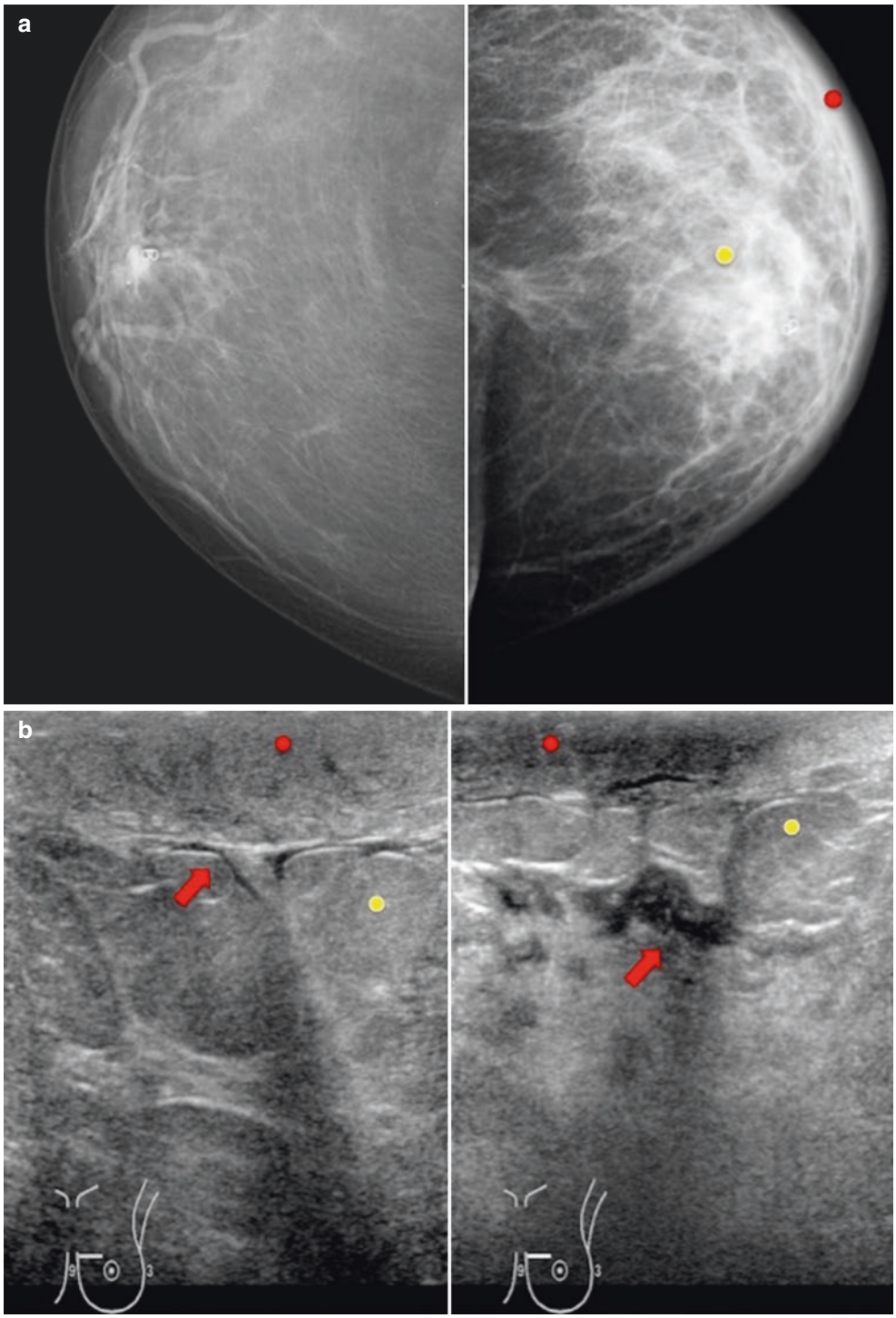

Fig. 21.9 Patient with breast-conserving treatment in the left breast with surgery in LIQ and RT. The patient presented with marked skin thickening with diffuse subcutaneous tissue edema at 6 months after finishing treatment as well as hot, red, and induration in the breast. (**a**) Bilateral mammography CC views show skin thickening (*red dot*), trabecular thickening, and increased density (*yellow dot*) relating to edema and post-radiotherapy changes. (**b**) Ultrasound shows skin thickening (*red dot*), diffuse increased echogenicity relating to edema (*yellow dot*), anechoic linear images between fatty islets relating to distended lymphatic vessels, and an anechoic nodular imaging relating to emerging abscess (*red arrows*). The patient was diagnosed with mastitis. The clinical context is always key because radiological findings of noncancerous entities may mimic breast carcinoma

usually larger than 1 cm. They often have a lucent center. Sometimes they show the typical appearance of rim or eggshell calcification. Benign calcifications can also be suture material, which represent calcium deposited on suture material. They are less common than dystrophic calcifications. They are typically linear or tubular in appearance, and when present, knots are frequently visible.

There is no universal agreement about when to perform the first mammography after finishing RT. In most cases, the first mammography is performed 6 months after RT. In some cases where tumors initially present with calcifications, the initial mammography is performed just before the beginning of RT to verify the absence of residual calcifications.

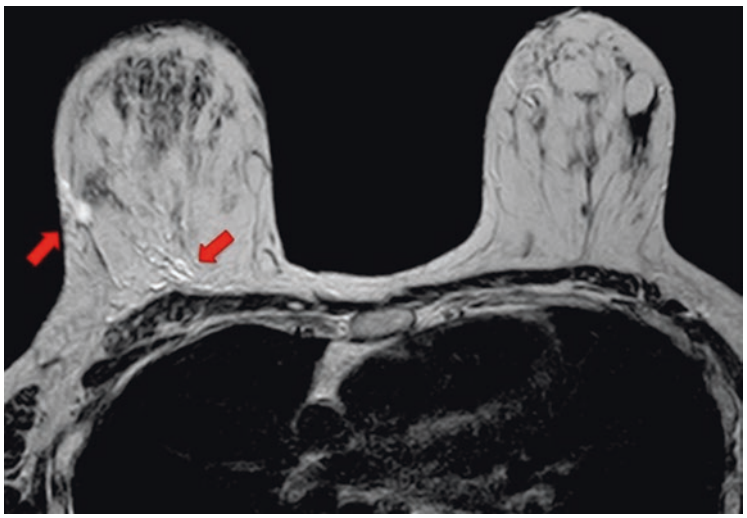

Fig. 21.10 Patient with breast-conserving surgery and subsequent RT treatment in the right breast presented with redness, skin thickening, and fever during her RT treatment. T2 sequence shows hyperintensities regarding the liquid and edema (*red arrow*)

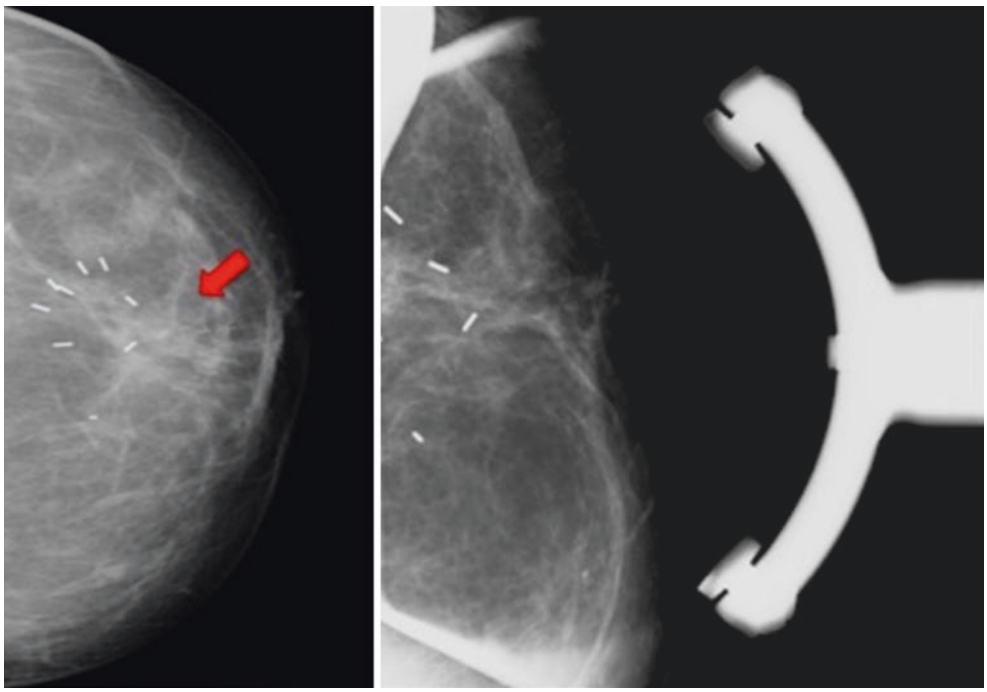

Fig. 21.11 Patient with personal history of breast-conserving surgery in the OUQ of left breast. A distortion image is seen in the area relating to scar tissue. CC view mammography (on the *left*) shows a distortion in the area of the surgical changes. A spot compression view (on the *right*) shows a fat center and dissociation

21.2.2.2 Follow-Up Protocol

A follow-up protocol could be:

- Initial mammography 6 months post-RT (in cases of tumors with calcifications, mammography could be performed just before RT to confirm complete removal of them).
- Annual mammography (± magnified and/or compressed projections) 2 years after RT. This should be considered as baseline as thereafter the posttreatment changes should remain stable or decrease.
- Annual ultrasound with mammography: Optional.

If available, breast MRI is the most useful imaging technique in evaluating cases after breast-conserving surgery because of its high negative predictive value. Nevertheless, if there is any doubt concerning its findings, a histological examination should be conducted.

21.2.3 Mastopexy

For patients who have undergone mastopexy, a new architectural pattern is established which can modify the normal radiological appearance of the breast. These modifications

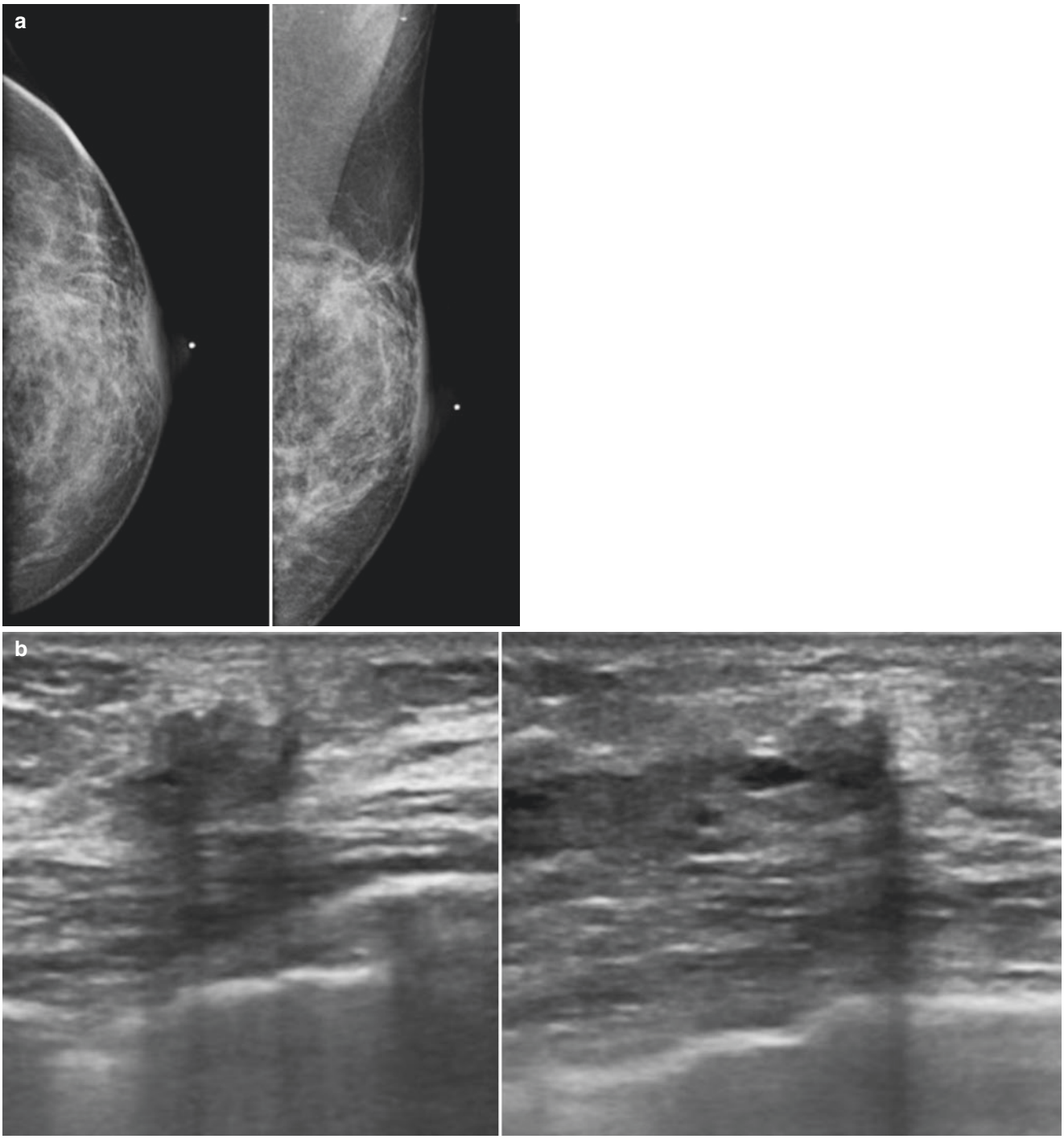

Fig. 21.12 Patient with a personal history of breast-conserving surgery in OUQ left breast. (**a**) Mammography shows architectural distortion in the area of the scar. (**b**) Ultrasound shows a nodular lesion corresponding to the surgical area. Although that image changed with probe position, it was suspicious so a core needle biopsy BAG was performed with result of scarring changes

are due especially to the presence of scars, remodeling and reorientation of breast tissue, and repositioning of the NAC. When mastopexy is performed for cosmetic purposes, postsurgical changes are usually bilateral; therefore, radiological findings are often in both breasts and can be compared. In cases where mastopexy is performed for symmetrization/contralateral reconstruction after mastectomy, radiological findings are asymmetrical and can seem suspicious especially if the patient's imaging history is unknown.

Imaging history should be reviewed to assess possible changes over time. Sometimes important radiological

findings after mastopexy can go unnoticed if the patient's previous history is unknown. Postsurgical findings should decrease over time, and any new or more evident findings should be investigated.

21.2.3.1 Radiological Tests and Findings

1. Mammography:
   - Distortions or focal asymmetries
   - Skin thickening or a dense periareolar line and sometimes in the vertical line that joins the periareolar region with the inframammary fold
   - Benign calcifications—usually skin calcifications, oil cysts predominantly of periareolar location, or coarse calcifications
   - Fibrous bands extending from the repositioned NAC
   - Reorientation of the breast tissue, with higher amount of tissue in the lower quadrants
2. Ultrasound:
   - Shadowing, usually related to scars
   - Heterogeneous areas of breast tissue relating to the repositioning of the gland
   - Ill-defined and heterogeneous lesions when there are fat necrosis changes
3. MRI:
   - New architectural pattern.
   - Cutaneous and subcutaneous postoperative changes, especially in the periareolar region, the vertical scar and the inframammary fold. Sometimes these changes cannot be noticed on mammogram and they can only be detected on MRI. They are more evident on gradient echo and black silicone sequences (Fig. 21.13).
   - If irregular enhancement is seen, differential diagnosis should be done to distinguish fibrosis, fat necrosis, or malignancy, and then, biopsy should be done.

21.2.4 Complications and Sequelae

Complications and sequelae should be considered when interpreting imaging and managing the follow-up of the patient. Seroma/hematoma will disappear in most cases but may persist and be clinically significant in some. In the latter scenario, both increased risk of infection and delayed healing have been shown, so seroma/hematoma may require aspiration or drainage. With cellulitis, skin and subcutaneous thickening and trabecular thickening can be seen. Sonographically they correspond to a diffuse increased echogenicity with hypoechoic septa regarding distended lymph vessels. An abscess (Fig. 21.9b) can occur as a late complication (approximately 5 months after surgery), because of a superinfection of a previous collection. The radiological appearance could be a complex lesion and on MRI could show a peripheral enhancement that sometimes can show a rude aspect. Sequelae include increased risk of infection, especially if there is axillary dissection. Radiation-induced cancer is unusual. The most common are lung cancer, breast cancer, leukemia, and radiation-induced sarcoma. There is cumulative incidence of radiation-induced sarcoma, from 0.07% 5 years after the radiotherapy to 0.48% 15 years after radiotherapy, with a latency period of 5–7 years after radiotherapy. The clinical presentation often mimics benign pathology (usually skin thickening that can be confused with normal posttreatment changes), which explains the delay in diagnosis and thus advanced staging with worse prognosis.

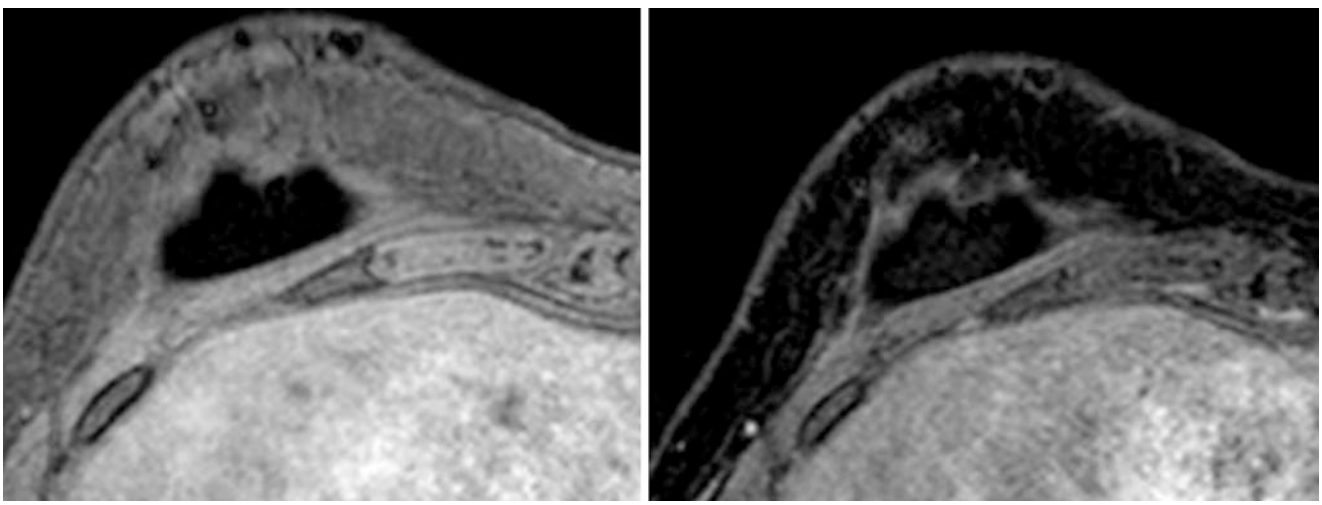

Fig. 21.13 Black silicone (on the *left*) and thrive postcontrast (on the *right*) sequences in a patient with previous history of left mastectomy and right symmetrization with mastopexy surgery unnoticed on other sequences. Postoperative changes on skin are seen

21.3 Imaging Findings After Surgery with Heterologous Material

Heterologous reconstruction is the most common type of reconstruction of an operated breast. The surgeon makes an incision in the skin usually including the NAC and removes the breast parenchyma through it. A pocket covered by a piece of skin is created where an implant will be placed (usually under the pectoralis major to prevent movement). The procedure may involve biological mesh and acellular dermal matrix to assist with the implant. It is advantageous over autologous reconstruction in several respects, including lower morbidity rates because there is no donor site, higher simplicity as it requires the shortest surgical time and recovery time, similar aesthetic presentation in color, texture, and sensitivity of the reconstruction to the adjacent tissue, and fewer scars. However, disadvantages include a very large and/or hypertrophic contralateral breast (usually ptotic) and a lack of a natural-looking breast causing patient refusal of the procedure. It is also contraindicated when there is poor skin quality due to RT or previous scars and insufficiency of the skin or pectoralis major to cover the implant.

More recently, free injection methods of different types of substances into the mammary gland have been also developed with a similar aim to that of implants, which is to increase breast size and to rebuild after surgery. They are especially useful in cases of partial defects. However, they remain controversial due to safety concerns including the possibility of migration of the injected substance to other parts of the body, their ability to promote the development of breast cancer, and the difficulty in assessing normal breast parenchyma after the procedure due to radiological findings and complications. Heterologous substances used in free injection techniques include free silicone, paraffin (no longer used), or hyaluronic acid (banned in some countries). These substances remain located in the mammary gland or in or under the pectoral muscle.

21.3.1 Implants

Clinical examinations are limited in their ability to evaluate implants and have low sensitivity for detecting ruptures. Thus, imaging techniques such as mammography, ultrasound, and MRI are clinically important.

21.3.1.1 Radiological Tests

The use of mammography is limited to evaluating the integrity of implants: extracapsular rupture, evident deformities, and capsular contractures, sometimes with calcifications. Silicone gel and saline implants will show a hyperdense appearance on mammogram (Fig. 21.14). The filling valve may be seen in the case of saline implants (Fig. 21.15). When there is a double lumen implant, both chambers can be distinguished; the inner chamber (saline) appears less dense than the outer chamber (silicone) (Fig. 21.16). Breast cancer screening in patients with implants will be affected since implants decrease the parenchymal visibility by 30–50%. Therefore, a full mammographic exploration should include:

- Oblique projection (both breasts).
- Cranio-caudal projection (both breasts).
- Eklund-modified compression technique, which is used in addition to the routine two-projection mammogram. It consists of posterosuperior displacement of the implants simultaneous to an anterior traction of the breast, pushing the implants toward the chest wall up to flatten. It provides significant improvement in image quality and displays a greater amount of breast tissue (Figs. 21.14 and 21.15).

Both silicone and saline implants have an anechoic appearance on ultrasound. Therefore, it is often not possible to distinguish sonographically between both if the patient's clinical history is not available (Fig. 21.17). Sometimes, however, it is possible to make a distinction if the filling valve of the saline implant is apparent (Fig. 21.18). The presence of a reverberation artifact and some subcapsular folds are normal findings. The main advantages of ultrasound are that it is a safe and noninvasive test, allows the integrity of the implant to be analyzed, allows the detection of extracapsular rupture (highly specific) and intracapsular rupture (where ultrasound's usefulness is more limited), and is the imaging technique of choice in guiding fine needle aspiration (FNA) or core needle biopsy to clarify suspicious lesions. Ultrasound provides a direct view of the breast in real time without risk of damage to the implant. The main limitations of ultrasound are that it is less capable for assessing the posterior aspect of the implant, it is highly dependent on the operator, and there are pitfalls when there is a lack of clinical history of the patient. For example, a hyperechoic line corresponding to the elastomer of the inner chamber in a double-lumen implant may be misinterpreted as a subcapsular line, leading to an incorrect diagnosis of an intracapsular rupture (Fig. 21.23a). Additionally, especially in very old implants with capsular contracture and with clinically suspected rupture, it is very common to find calcifications in the implant as well as ill-defined margins of the external capsule in the implant which may be misinterpreted as extracapsular rupture when there is no previous mammogram or CT for comparison.

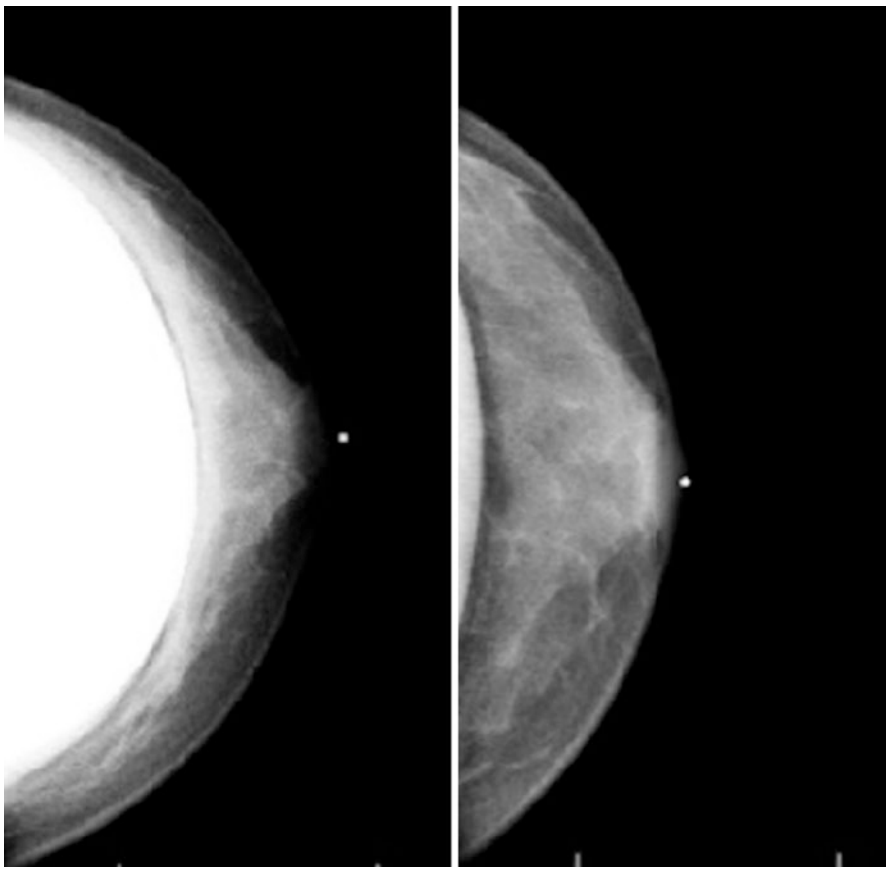

Fig. 21.14 Left breast mammography with CC projections in a patient with silicone gel implant. The silicone gel implant shows a hyperdense appearance on mammogram. The breast parenchyma is partially seen due to the implant (on the *left*), but with Eklund projection (on the *right*), the silicone gel implant can be displaced posteriorly (while the technician pushes the parenchyma to the anterior) to show most of it. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica

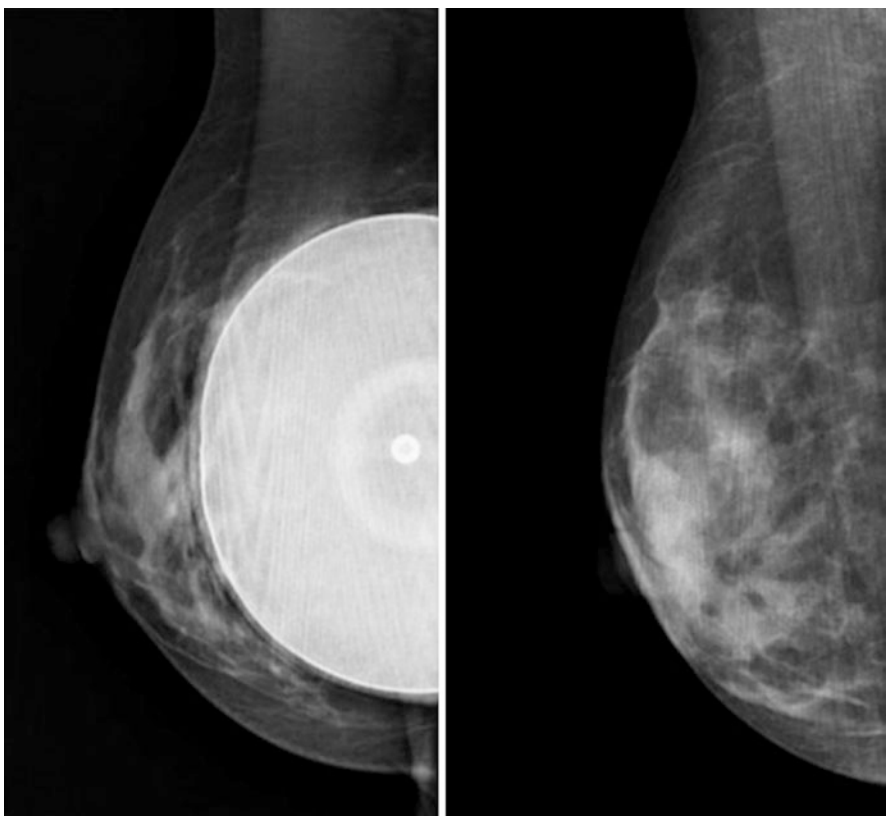

Fig. 21.15 Right breast mammogram with oblique projection in a patient with saline solution implant. The saline solution implant has a hyperdense appearance on mammogram, and the filling valve is seen at the center of the implant. The breast parenchyma is partially seen due to the implant (on the *left*). With Eklund projection (on the *right*), the saline solution implant is displaced to the posterior (while the technician pushes the parenchyma to the anterior) to show most of the parenchyma. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica

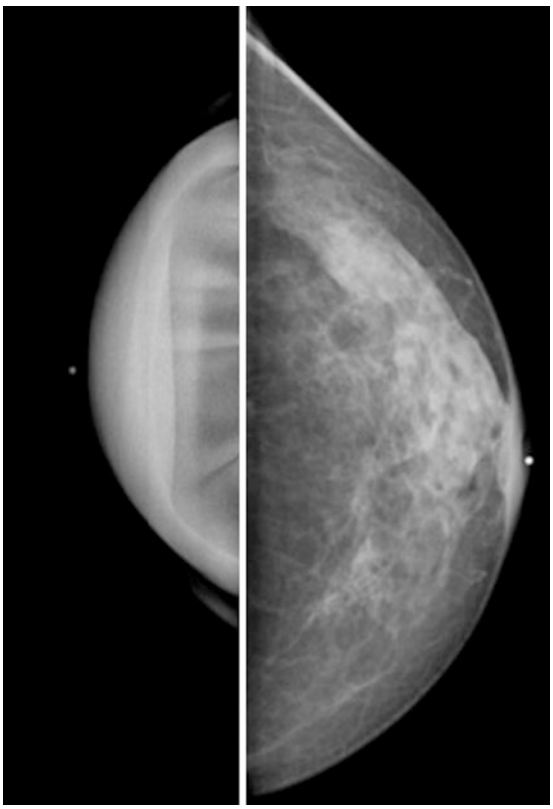

Fig. 21.16 Right breast mastectomy with a double-lumen expander. On mammography both chambers are identified. The inner chamber presents less density due to the saline solution

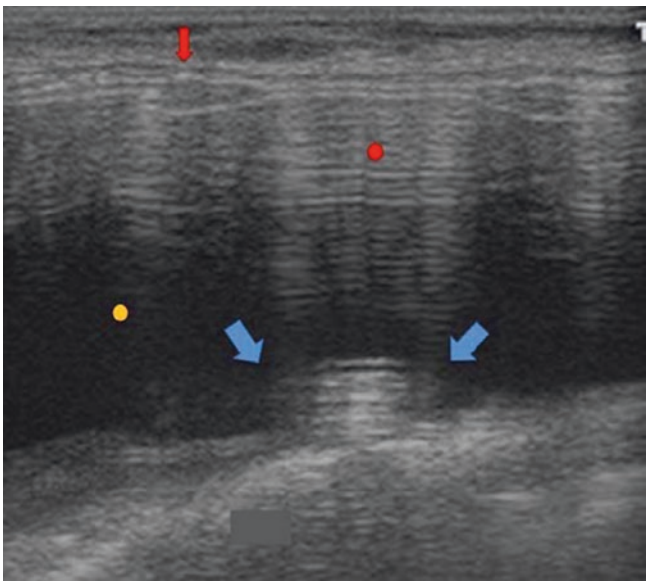

Fig. 21.18 Ultrasound appearance of a saline solution implant: Oval and anechoic mass identical to the silicone implant in Fig. 21.17 with a double hyperechoic line corresponding to the elastomer (*red arrow*) and reverberation artifact (*red dot*). The saline solution inside the implant presents an anechoic appearance (*yellow dot*). The only way to differentiate this implant from the silicone implant is to appreciate the filling valve in its posterior aspect (*blue arrows*). Sometimes it is not well seen with ultrasound because of the depth of the posterior margin of the implant. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica.

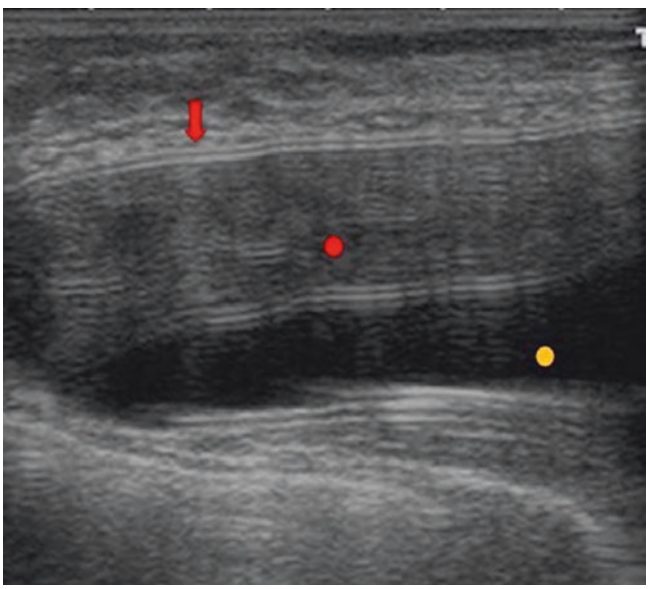

Fig. 21.17 Ultrasound appearance of a silicone gel implant: Oval and anechoic mass where the elastomer appears as double hyperechoic line (*red arrow*) with reverberation artifact below (*red dot*), and the silicone gel shows an anechoic appearance (*yellow dot*). There is no filling valve. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica.

Breast MRI is the most sensitive and reliable imaging technique available to assess implants and their associated complications. To obtain high-quality images, the use of high-field MRI machines with a breast-specific coil is required. MRI is performed when the patient is in a prone position to avoid respiratory movements that can affect the quality of the images. To examine silicone gel implants (Fig. 21.19), the protocol should include specific sequences for silicone, for example, white and black silicone sequences. The white silicone sequence is especially useful as the image will show only the white silicone, either intra- or extracapsular. Sagittal sequences should also be included so sutile intracapsular ruptures can be appreciated and the inferior edge of the implant can be better analyzed. One option is to perform the T2 sagittal sequence without fat suppression or to perform fine-slice imaging in the axial plane and sagittal reconstruction posteriorly. The use of an intravenous contrast agent is not necessary if MRI is only intended to evaluate the implant. However, it is useful if the patient has a history of breast cancer or a high-risk lesion. Silicone implants will have the following

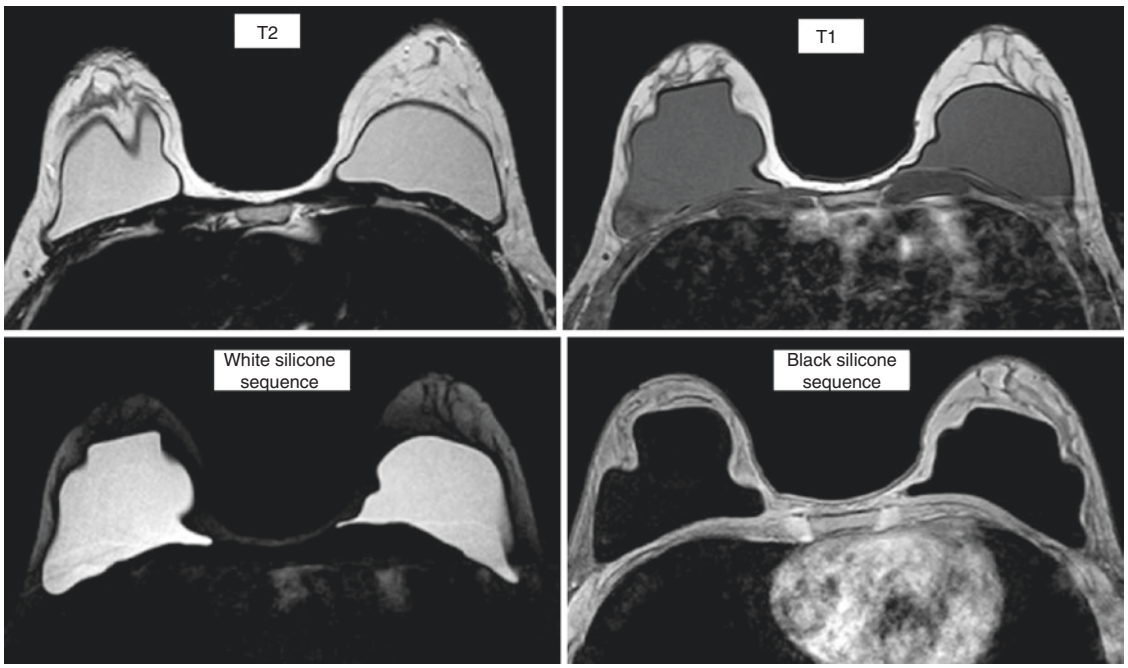

Fig. 21.19 Patient with silicone implants. Normal appearance of the silicone in different sequences

appearance on the different MRI sequences (Figs. 21.19 and 21.23):

- T1 sequence: Hypointensity.
- T2 sequence: Hyperintensity but not as intense as in a white silicone sequence or compared with a saline implant.
- STIR/SPAIR sequence: Hypointensity although sometimes this can vary depending on the composition of the implant.
- White silicone sequence: Marked hyperintensity, which contrasts with the rest of the breast.
- Black silicone sequence: Marked hypointensity.

Specific sequences for silicone make no sense if the implant is a single-lumen saline implant, since the implant will look exactly like liquid in all sequences (Fig. 21.20).

MRI is not useful to assess expanders with an anterior valve, since this has a metallic component (that can be seen on X-ray and on CT) (Fig. 21.21), and so an artifact is produced on that hemithorax (Fig. 21.22). However, it is possible to perform the MRI to assess the contralateral breast; although the valve can move a little because of the magnetic field, the surgeon, posteriorly, is able to locate the filling valve over a magnet. The only obstacle to MRI is if the patient notes a warm or burning sensation on the skin.

In cases of a bicameral implant, the filling valve is made of titanium and usually located adjacent to the chest wall, lateral to the implant and connected with it through a connector. Then, the patient may be subjected to breast MRI to assess both the breast with implant and the contralateral breast because there is no artifact on that hemithorax. Besides, there is no risk of implant movement or warmth on the skin. It is advisable to visualize all the connector routes and the valve to detect possible complications and ruptures. For that purpose, black silicone and thrive postcontrast sequences are useful (Fig. 21.23).

The main advantages of MRI are that it is a noninvasive technique, is useful in breast cancer screening as it achieves a better assessment of parenchymal lesions with the administration of intravenous contrast, and allows the assessment of the implant in three projections and the evaluation of intracapsular and extracapsular ruptures. It may show migration of silicone to lymph nodes (axillary and internal mammary) as well as soft tissue when there is an extracapsular rupture.

However, it is not free of disadvantages, such as cost, availability, motion and breathing artifacts, and false-positive cases.

21.3.1.2 Radiological Findings

Some findings are considered as normal on MRI, for example, a small amount of periprosthestic fluid; rippling, subcapsular folds (these can be differentiated from an intracapsular rupture because most times they have fluid on one side); and fibrous bands.

Complications include intracapsular rupture, extracapsular rupture, migration of the silicone gel to lymph nodes and

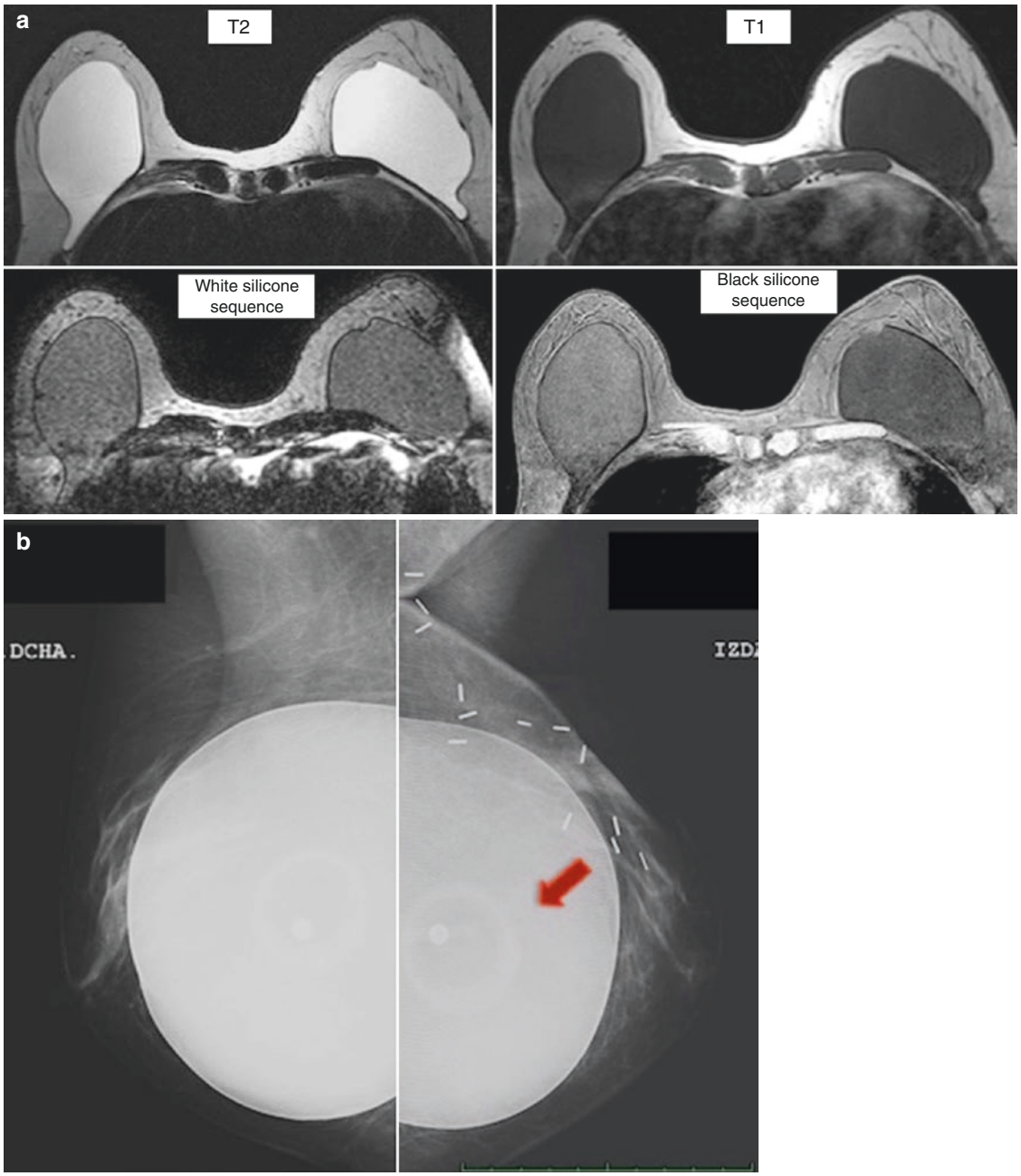

Fig. 21.20 Patient with breast-conserving surgery in UOQ of the left breast and reconstruction with saline solution implants. (**a**) MRI was performed without the presence of a radiologist, and the type of implants was unknown, so white silicone and black silicone sequences were made. The saline solution implants show identical signal intensity of the liquid which was hypointense on T1 and hyperintense on T2 (higher hyperintensity than silicone). On black and white silicone sequences, implants show similar signal intensity, slightly hypointense. This presentation may present a pitfall, suggesting a technical failure of the machine that is not able to suppress appropriately. (**b**) In this case and following a review of previous explorations, the patient had a mammogram where the filling valves could be seen in the posterior aspect of the implant (*red arrow*) supporting that these were saline implants

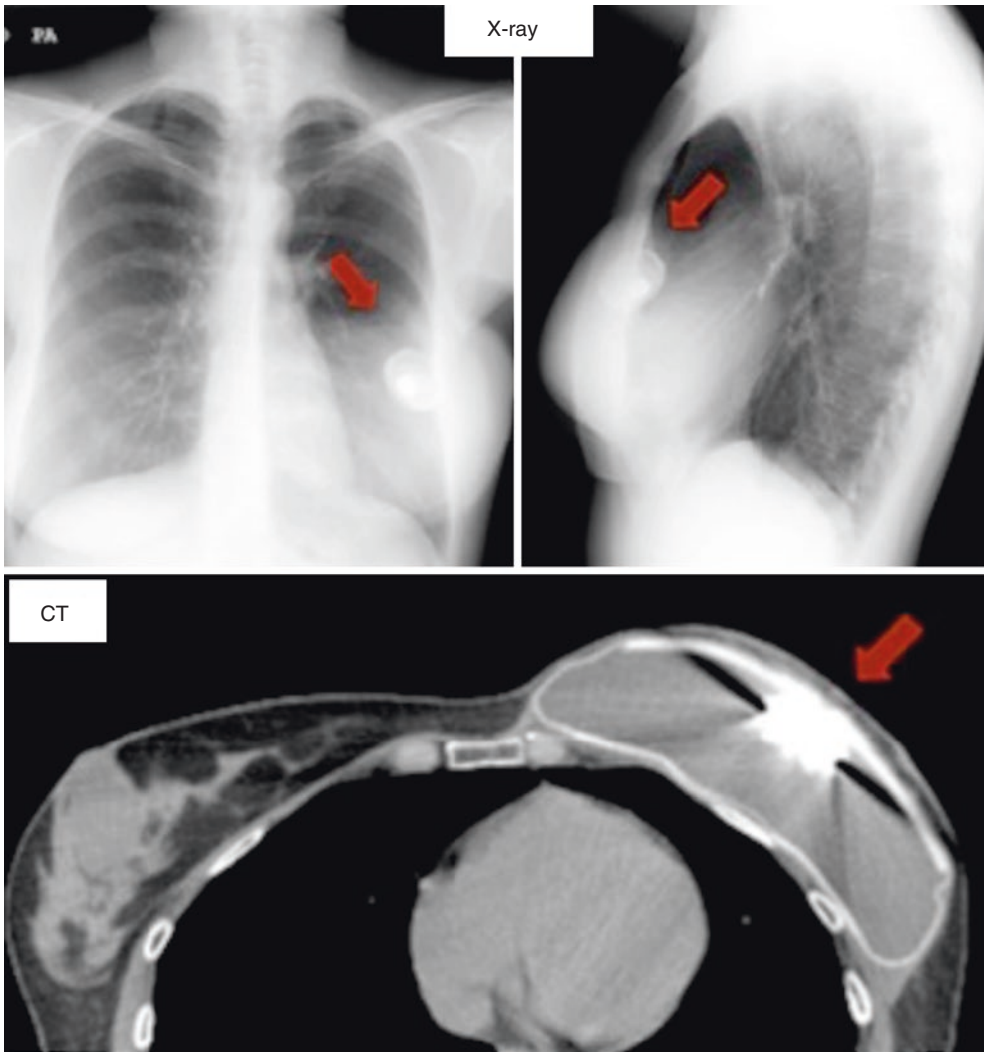

Fig. 21.21 Patient with left mastectomy and heterologous reconstruction with a unicameral saline solution expander with filling valve. The metallic component allows the expander to be seen on radiographs and on CT. The filling valve and the metallic artifact can be noticed (*red arrow*)

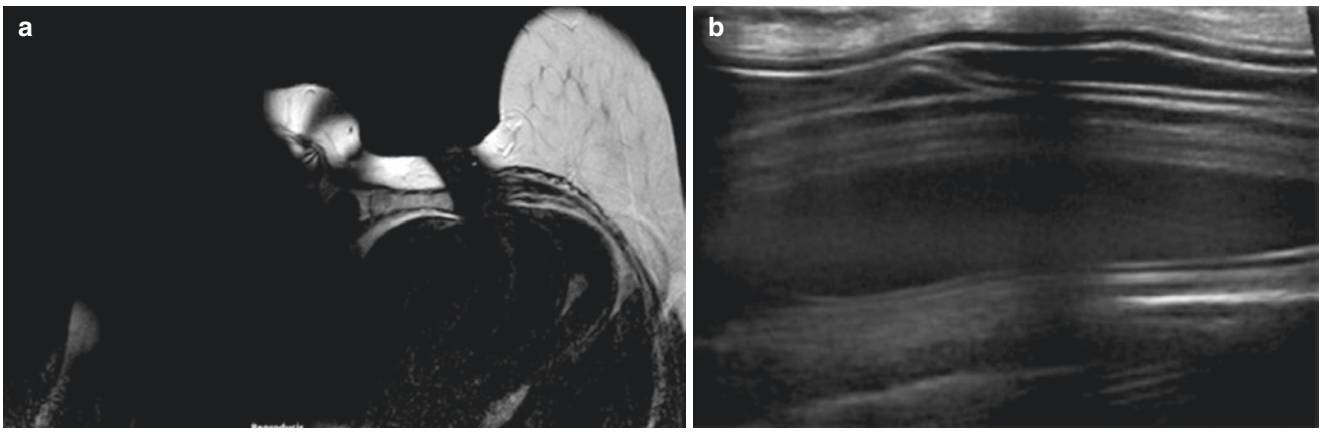

Fig. 21.22 Patient with personal history of right mastectomy and temporary reconstruction with an expander with a metallic valve. Breast MRI was performed due to surgeon request in the case of suspected rupture. There was no contraindication for the MRI except that it was not useful to evaluate either the operated breast or the expander, being able to only to assess the contralateral breast. (**a**) T2 sequence axial plane: The metallic component of the filling valve produces a magnetic artifact that prevents evaluation of the expander. However, the contralateral breast is clearly seen. (**b**) An ultrasound confirms collapse of the expander

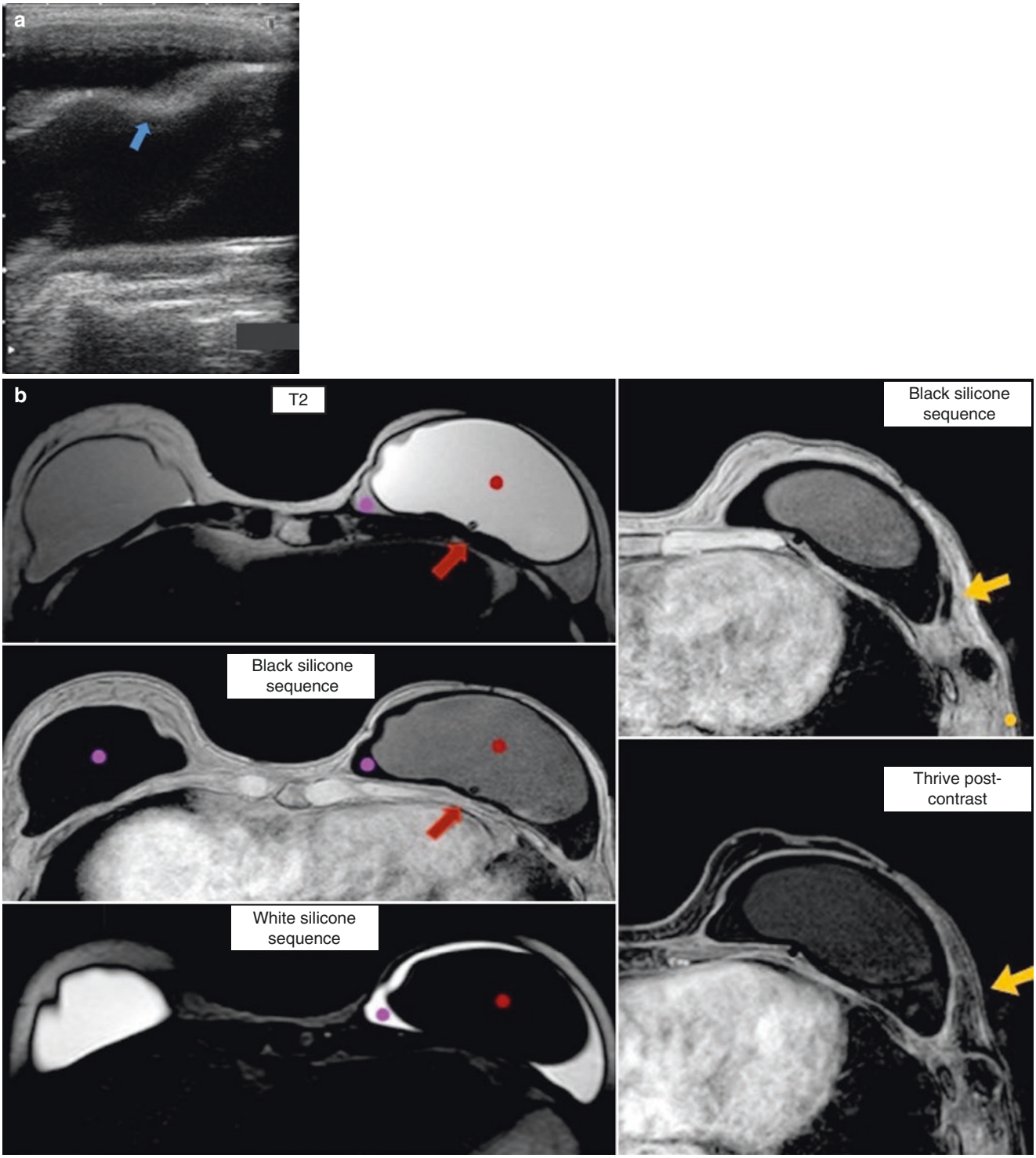

Fig. 21.23 Patient with bilateral mastectomy and left reconstruction with bicameral expander and right reconstruction with silicone implant. (**a**) Ultrasound: Two chambers separated by a hyperechoic line can be seen. It is a very common pitfall to misunderstand that line as the subcapsular line seen in intracapsular ruptures. (**b**) MRI with different sequences: Two chambers with different signal intensities can be seen. *Red dot*: internal chamber of saline solution. *Violet dot*: external chamber of silicone on the left breast and silicone implant on right breast. *Red arrow*: connector going from the posterior part of the expander through the lateral margin of the implant to the chest wall where the filling valve is located. Black silicone and thrive postcontrast sequences were very suitable to assess the connector in its path out of the implant (*yellow arrow*) and the filling valve (*yellow dot*). The connector should be assessed over its entire route to ensure that there are no ruptures

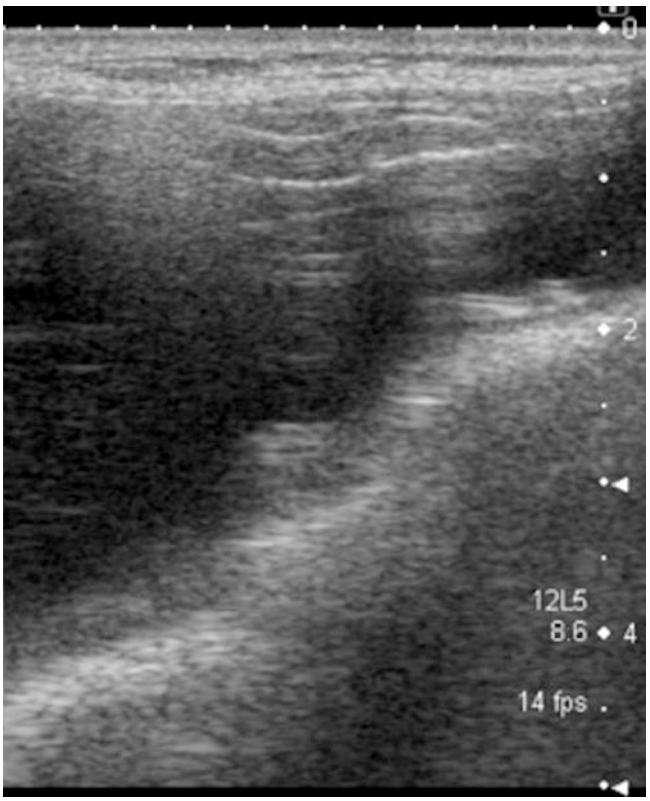

Fig. 21.24 Ultrasound showing an intracapsular rupture: stepladder sign. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica

soft tissues, capsular contracture (where the diagnosis is usually clinical), and displacement/herniation (where the diagnosis is usually clinical) (Fig. 21.30).

1. Radiological signs of intracapsular rupture:

It is difficult to detect intracapsular rupture on clinical exam or mammography. This complication is better seen on ultrasound or MRI, with the latter as the best option:

- On ultrasound:
  - Overall sensitivity and specificity rates range between 59–85% and 55–79%, respectively.
  - "Stepladder sign": Hyperechoic lines parallel to the elastomer resembling a ladder or railway (Figs. 21.24 and 21.28a).
  - Subcapsular irregular and discontinuous hyperechoic lines inside the implant (Figs. 21.25 and 21.29).
  - Hyperechoic content inside the implant (Figs. 21.25 and 21.29).
- On MRI:
  - Unicameral implant:

    Without collapse: "*Keyhole*," "*teardrop*," "*inverted loop*," or "*noose*" signs (Figs. 21.26 and 21.27). An implant without collapse appears as silicone on both sides of a radial fold. These signs indicate focal extravasation of silicone, which is confined to the fibrous capsule without extending cir-

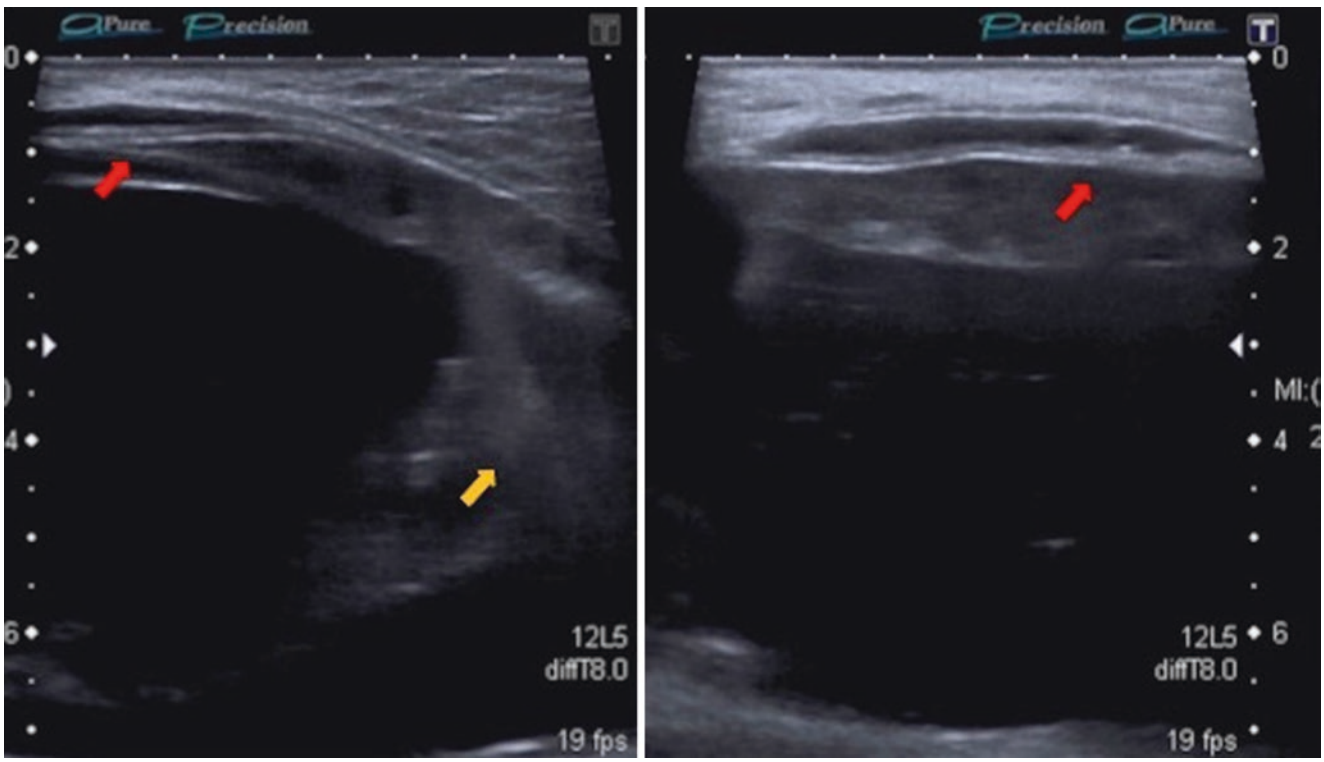

Fig. 21.25 Ultrasound showing an intracapsular rupture: Irregular subcapsular line under the shell (*red arrow*) and hyperechoic content and lines inside the implant (*yellow arrow*)

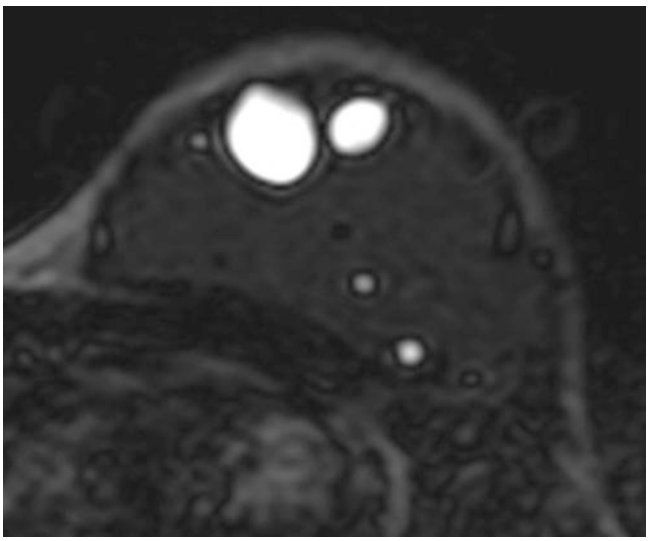

Fig. 21.26 Breast MRI with black silicone sequence: teardrop sign. The silicone appears completely black, and inside there are some white images due to water

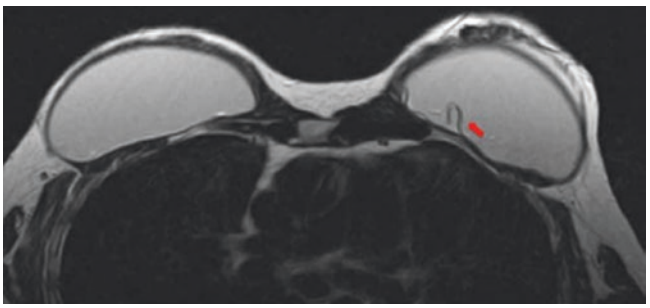

Fig. 21.27 Breast MRI with T2 sequence: inverted loop sign. There is a loop originating from the shell that goes inside the implant, with silicone on both sides

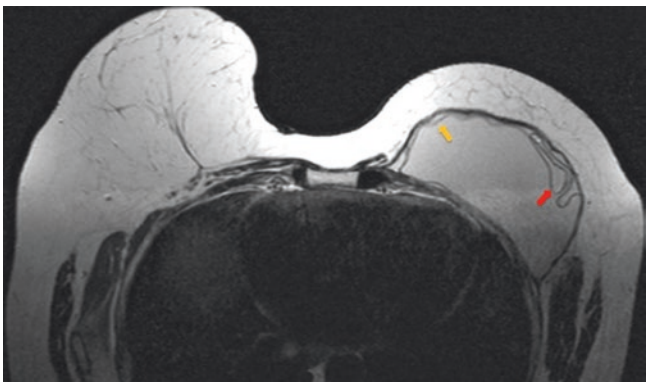

Fig. 21.28 Breast MRI with T2 sequence without fat suppression showing an intracapsular rupture: Linguini sign (*red arrow*) and a subcapsular line (*yellow arrow*)

Fig. 21.29 Patient with bilateral mastectomy with heterologous reconstruction involving double-lumen expanders with definitive intention. Breast MRI (T2 sequence, axial plane): Both chambers can be seen in both breasts. The inner chamber is white because it consists of saline solution, and the outer one is gray because it consists of silicone gel. A subcapsular line (*red arrow*) is seen beside both outer chambers with silicone signal on both sides of the line indicating bilateral intracapsular rupture

cumferentially due to the presence of adhesions at their ends. However, none of these signs is a reliable sign of rupture on its own. Other imaging features, assessed in combination, may better suggest intracapsular rupture.

With minimal collapse: "*Subcapsular line*" (Fig. 21.28). There is presence of a parallel and hypointense line to the fibrous capsule with silicone on both sides. It represents an evolution of the previous stage, but in this case the base of the invagination of the elastomer is greater than in cases with no collapse.

With partial or total collapse: "*Linguini*" or "*wavy line*" signs (Fig. 21.28) due to a free-floating shell within the implant. Internal and hypointense curved lines are seen without a perpendicular orientation to the shell. It represents rupture of the elastomer and the presence of silicone between it and the fibrous capsule. It is the most reliable sign of an intracapsular rupture with a sensitivity and specificity of 96 and 76%, respectively.

– Bicameral implant or expander: If the rupture is in the outer chamber, findings are similar to that of an intracapsular rupture in a single-lumen implant (Fig. 21.29). If the rupture is in the inner chamber, a "*salad oil*" sign or "*mixed signal intensities*" between both chambers may be seen. Subcapsular lines inside the saline chamber may also be seen (Fig. 21.30). As the saline chamber is ruptured, a decrease in the volume of the implant is also noticed.

Fig. 21.30 Patient with conserving surgery in the right breast with reconstruction using a double-lumen expander. Follow-up breast MRI was performed every year. T2 sequences are shown each year. In year 1, the double-lumen implant is seen with both intact chambers. However, herniation signs and capsular contracture are noted. In year 2, the inner chamber (with saline solution) shows subcapsular lines with the same signal on both sides of the line indicating an intracapsular rupture. However, the patient did not replace the implant. In year 3, the subcapsular lines inside the inner chamber persisted, and additionally a mixed signal intensity is seen not showing the typical white appearance of fluid signal

2. Radiological signs of extracapsular rupture:

Extracapsular rupture is evident as the silicone, when separated from the implant, extends beyond the implant capsule into the breast or axilla. The silicone shows up as free silicone in the parenchyma, as granuloma (siliconoma) when the body encapsulates the silicone that may manifest as a lump or tumor, or as silicone migration in lymph nodes and soft tissues.

The presence of silicone outside the fibrous capsule without evidence of fibrous capsule or shell rupture can occur in two circumstances:

- Previous implant rupture and posterior replacement where there are remains of previous extracapsular silicone in the breast (Fig. 21.31).
- Leakage of silicone due to permeability of the shell and/or the fibrous capsule. The lymphatic vessels pick up this leakage and carry it to the lymph nodes. The lymph nodes can present a snowstorm sign or simply show enlargement without a fat center because of reactive lymphadenitis (Fig. 21.32). Differential diagnosis should be done with extracapsular rupture with silicone migration to the lymph nodes and with lymph node involvement because of tumor.

Radiological signs of extracapsular rupture are:

- On mammography:
  - Oval and well-defined hyperdense masses outside the implant.
  - Change of the contour of the implant that may be detected on clinical exam or mammography.
  - Enlarged and hyperdense axillary lymph nodes due to silicone migration.

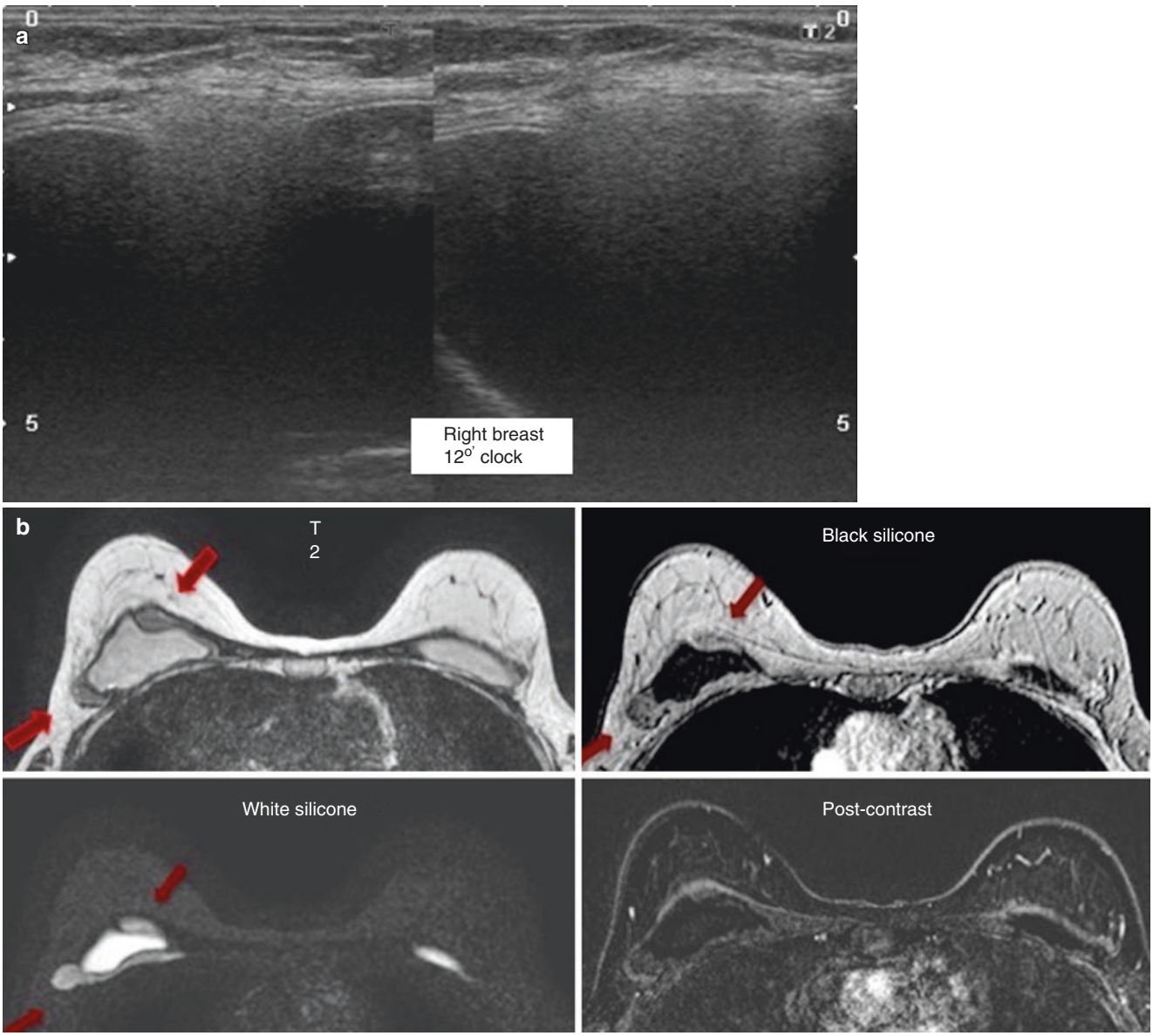

Fig. 21.31 Patient with personal history of extracapsular rupture with silicone extravasation. The surgeon referred the patient for replacement and cleaning. (**a**) Ultrasound was performed in a screening and a snowstorm sign was around some areas of the implant that prevented assessment of the capsule, suggesting extracapsular rupture. The patient wanted a definitive diagnosis before a new replacement surgery. (**b**) MRI was performed. An extracapsular material around the implant was seen, with signal intensity that did not correspond to free fluid but was similar to silicone (hyperintense) in silicone sequences (*red arrow*) and did not enhance after IVC. This could suggest a new extracapsular rupture; however, this signal intensity was not identical to intracapsular silicone on other sequences, and no evidence of discontinuity or rupture of the shell or fibrous capsule was seen. Therefore, these findings suggested remainders of the previous extracapsular rupture more than a new extracapsular rupture. That fact was confirmed with core needle biopsy with granulomatous reaction to foreign body result

- On ultrasound:
  - "*Snowstorm*" sign (Figs. 21.31 and 21.33): Highly specific. Extracapsular silicone appears as a hyperechoic image that prevents transmission of the ultrasound beam and the image resembles falling snowflakes.
  - Hypoechoic nodular lesions that are difficult to distinguish from solid nodules, usually due to a granulomatous reaction to a foreign body (silicone).
- On breast MRI:
  - Breast MRI is the most sensitive imaging technique for detecting small foci of migration.
  - In recent ruptures, free silicone shows a similar signal to the signal of the interior of the implant in all sequences, and there is no enhancement. However, over time, as granulation tissue builds up, the signal intensity changes and may present some enhancement after IVC administration.

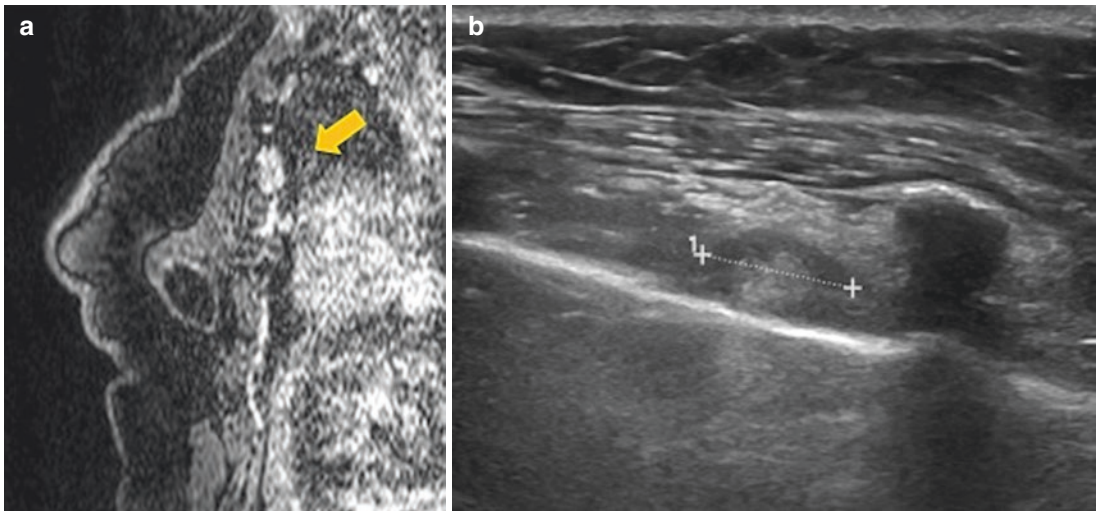

Fig. 21.32 Patient with bilateral mastectomy and heterologous reconstruction with an intracapsular rupture of the right implant. MRI showed an enlarged mammary internal lymph node that enhanced after IVC administration. (**a**) Dynamic sequence sagittal reconstruction shows an enlarged internal mammary lymph node without fat center (*yellow arrow*). Differential diagnosis should be done for an extracapsular rupture with silicone migration to lymph nodes, implant leakage with reactive lymphadenitis, or lymph node involvement due tumor as the patient had personal history of breast cancer. However, an extracapsular rupture was not seen and the external capsule was preserved. (**b**) Fine needle aspiration biopsy under ultrasound guidance was performed of that lymph node and the result was reactive lymphadenitis

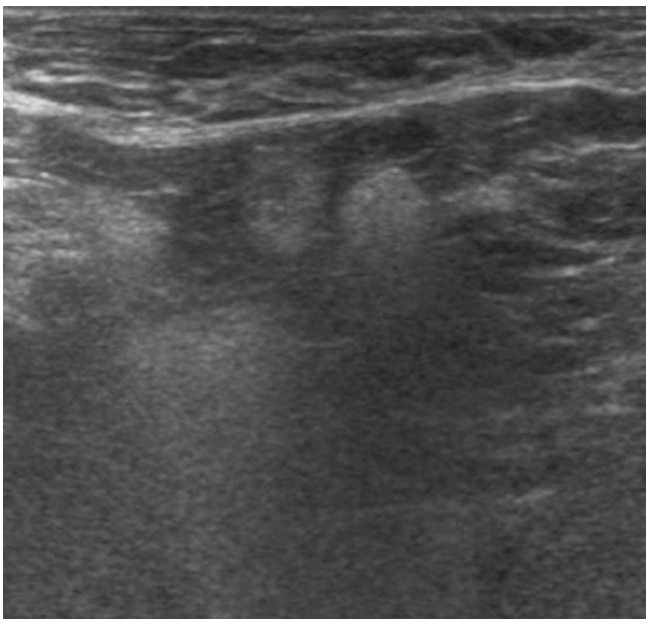

Fig. 21.33 Ultrasound showing hyperechoic lymph nodes with the snowstorm sign indicating extracapsular rupture and silicone migration to axilla. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica.

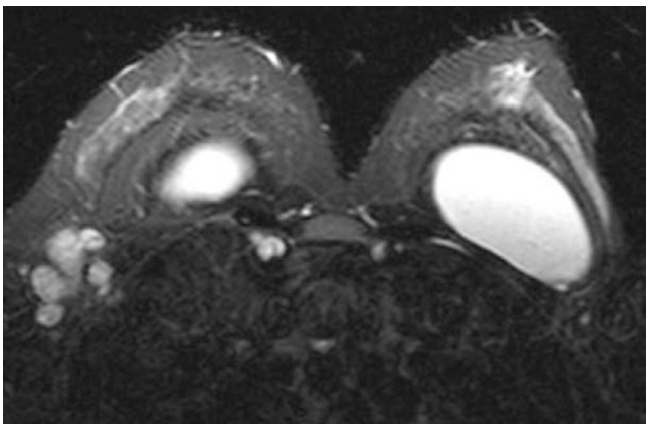

Fig. 21.34 Breast MRI, white silicone sequence, showing extracapsular silicone in the axilla and internal mammary lymph nodes. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica.

– Extracapsular silicone can be seen in the parenchyma, lymph nodes, or soft tissues (Fig. 21.34).

21.3.1.3 Follow-Up Protocol

1. Patients without a personal history of breast cancer:

Ruptures are frequently asymptomatic, and a clinical examination alone is not enough for diagnostic purposes. It is necessary to establish a diagnostic algorithm based on imaging in these patients.

Many studies show MRI as the technique of choice for evaluating the integrity of implants with a sensitivity of 72–94% and specificity of 85–100% and its superiority in detecting intracapsular rupture. This superiority of MRI, as well as the fact that the risk of rupture increases with implant longevity, has led the US FDA to recommend screening with MRI every 2 years from 3 years since the implant placement. However, due to its high cost and low availability, it is not routinely used as a screening method.

We recommend performing mammography as is performed for other patients without implants, according to age

and personal and family history but with the addition of Eklund projections and/or ultrasound.

This protocol could be:

- Mammography + Eklund projections ± Ultrasound
- Breast MRI when there are doubtful findings on mammography and ultrasound or when there are normal findings on mammography and ultrasound, but there is still a clinical suspicion of rupture.

2. Patients with a personal history of breast cancer:

Physical examination is more sensitive in operated patients. This is because over time the implant causes atrophy of the parenchyma and the implant shifts it to the skin (Fig. 21.35).

In addition, the sensitivity of mammography decreases over time. As such, we recommend that screening of these patients should include Eklund projections ± breast ultrasound. Breast MRI has the greatest sensitivity (Fig. 21.35), but it should be only used in doubtful cases of rupture. However, if the patient is younger than 50 years of age and has personal history of breast cancer and reconstructive surgery with implants, some protocols recommend an annual breast MRI as a screening method with the mammography and ultrasound.

Different options:

For symptomatic patients with suspected ruptures, ultrasound is the imaging technique of choice at the time of symptoms.

For asymptomatic patients, it is best to perform regular screening according to age but with the addition of Eklund projections and possibly ultrasound.

For patients with a history of breast cancer, specifically, if they have breast-conserving surgery and reconstructive surgery with an implant, it is best to perform a bilateral mammography along with Eklund projections and ultrasound annually. In patients who have had mastectomy and then reconstructive surgery with an implant, an annual ultrasound is recommended; mammography is not performed except in some cases where a single mammography is performed postsurgically to check for the absence of residual breast parenchyma.

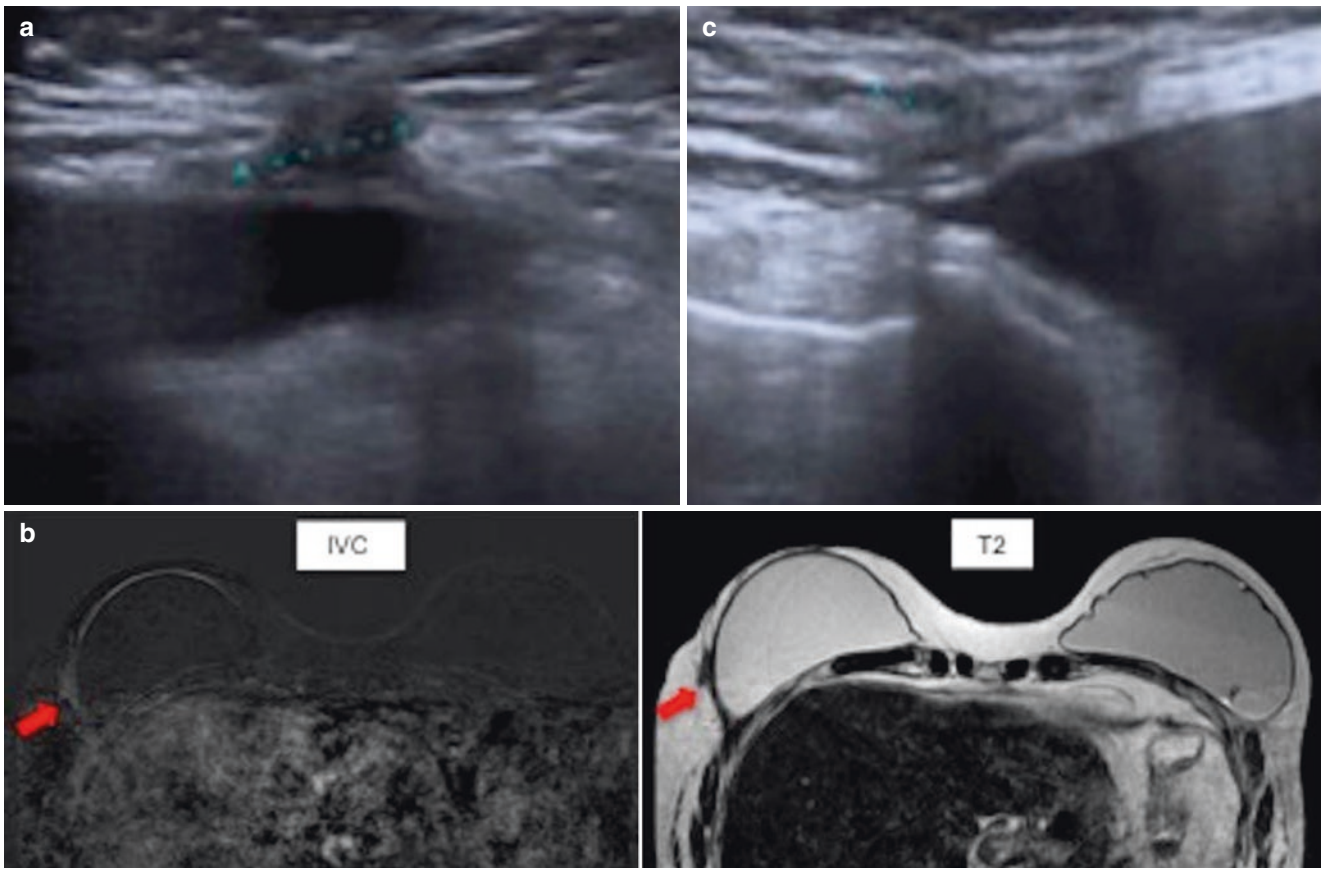

Fig. 21.35 Patient with a personal history of bilateral mastectomy. The patient noted a lump in the LOQ of right breast. (**a**) Ultrasound showing an ill-defined margin lesion in that location, adjacent to the implant, highly suggestive of malignancy. A breast MRI was performed due to difficulty in differentiating the suspicious finding from scar. (**b**) The lesion seen on ultrasound shows slight enhancement but irregular and ill-defined margins. (**c**) In a superior slice, another lesion is observed in the right UOQ with similar characteristics as the main lesion. (**d**) Second look ultrasound shows another ill-defined lesion in the UOQ, corresponding to the lesion observed on MRI. Both lesions were invasive ductal carcinoma confirming a multicentric recurrence after a bilateral mastectomy

Breast MRI is performed only in cases where conventional tests (mammography and ultrasound) are doubtful or inconclusive for rupture, when there are clinical suspicions of possible complications of the implants and as a screening method in patients with personal history of breast cancer younger than 50 years old.

21.3.2 Biological Mesh and Acellular Dermal Matrix

21.3.2.1 Radiological Tests and Findings

1. *Mammography*: Mammography is not usually performed in patients who have undergone mastectomy.
2. *Ultrasound*: Ultrasound is prone to pitfalls if it is unknown whether the patient has a biological mesh. Nodular or pseudo-nodular lesions are seen where the mesh is attached to the implant or the pectoral or serratus muscles (Fig. 21.36). They may present uncircumscribed margins and may lead to a core needle biopsy damaging the biological mesh.
3. *MRI* (Fig. 21.36) *and CT*: These tests help differentiate those images as they are usually bilateral and symmetrical (when the mastectomy and reconstruction are bilateral), show benign characteristics, and do not show enhancement after IVC administration.

21.3.3 Free Silicone Injection (Silicone Mastopathy)

21.3.3.1 Radiological Tests and Findings

Radiological features of free silicone are similar to that of an extracapsular rupture, although without an implant:

1. Mammography (Fig. 21.37):
   - Extremely dense masses ± rim calcification
   - Distortions
   - Breast asymmetries
   - Diffuse increase of parenchymal density complicating the display and assessment of suspicious lesions
   - Extremely dense lymph nodes
2. Ultrasound:
   - Nodular lesions with snowstorm sign
   - Nodular lesions with benign characteristics (oval and well defined, without shadowing)
   - Hypoechoic and/or heterogeneous nodules
   - Nodular lesions or areas with shadowing obscuring the posterior breast
3. MRI:
   - It is especially useful in clarifying clinical suspicions and/or uncertain diagnosis with ultrasound or mammography.

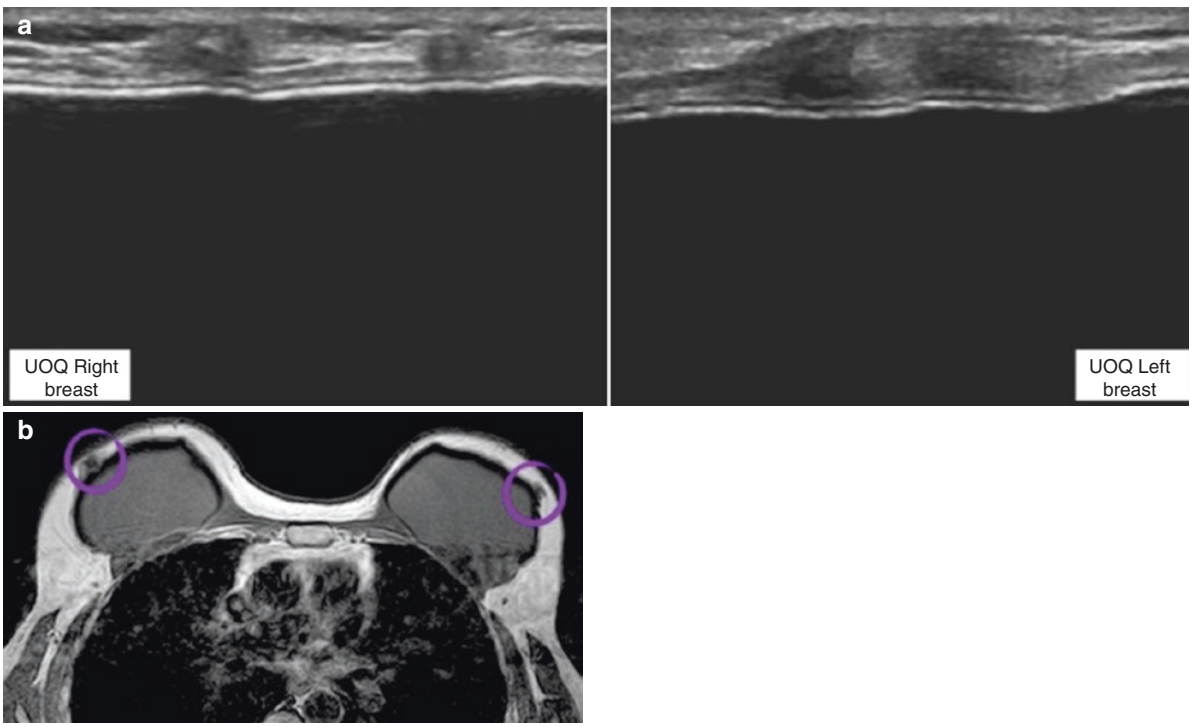

Fig. 21.36 Patient with bilateral mastectomy and heterologous reconstruction in a single surgical procedure with silicone implants and biological mesh. (**a**) First follow-up ultrasound shows nodular and solid appearance images, with ill-defined margins located in some locations. A core biopsy was recommended but as the patient had a recent bilateral mastectomy without complications and free margins, and an MRI was requested. (**b**) Breast MRI T1 sequence shows bilateral, symmetrical and hypointense nodular lesions in the junction areas of the mesh with the implant and the chest wall that had produced the sonographic pitfall

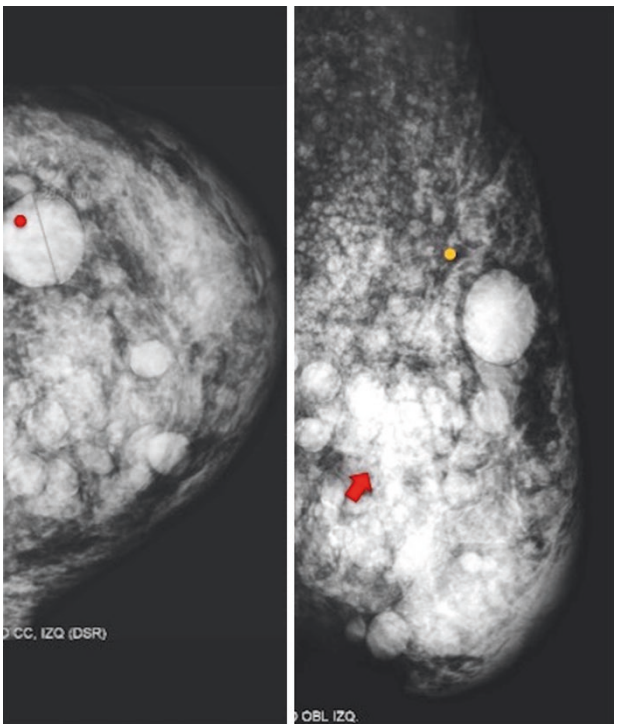

Fig. 21.37 Patient with free silicone injection in the thickness of the breast parenchyma. Right breast mammogram (oblique and craniocaudal views): There is a diffuse increase of breast density (*red arrow*), some distortion image (*yellow dot*), and some circumscribed and dense nodules (*red dot*). Some of these findings may be suspicious only with mammogram, preventing the dismissal of malignancy in the breast cancer screening. This image appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica

- Nodules with benign characteristics, with the same signal as silicone, without enhancement after IVC.
- Nodules with peripheral enhancement after IVC administration due to granulomatous reaction. If there is some doubt, a cytohistological exploration should be done.

21.3.4 Hyaluronic Acid

21.3.4.1 Radiological Tests and Findings (Fig. 21.38)

On mammography and ultrasound, findings are similar to those for free silicone injection. On MRI, nodules are similar to fluid nodules except when there is a granulomatous reaction:

1. *Mammography*: Usually dense and well-defined masses
2. *Ultrasound*:
   - Solid appearance lesion.
   - Simple, complicated, and complex cystic lesion. Over time the lesions usually evolve to a more solid appearance.
   - Septate and interconnected collections.
3. *Breast MRI*:
   - Lesions with identical signal intensity as fluid on T1 and T2 sequences, without enhancement after IVC administration.
   - Lesions with peripheral enhancement when granulomatous reaction is produced.

In any case, sometimes hyaluronic acid can produce images mimicking solid lesions that may show enhancement. It can also hinder the display of remaining breast parenchyma and consequently the diagnosis of breast cancer if it occurs.

21.4 Imaging Findings After Surgery with Autologous Material

In breast surgery using autologous material, the surgeon uses autologous or endogenous material from the body of the patient.

Autologous reconstruction, where the surgeon uses flaps from the body of the patient, is the technique of choice of all reconstructions using autologous material. It is less commonly performed compared to heterologous reconstruction, but its use has dramatically increased over the years. Among other factors, the number of mastectomies has increased, and autologous reconstruction offers several advantages over heterologous reconstruction, for example, better aesthetic outcomes, more natural-looking reconstructions, durability, better results over a radiated skin, and moreover, the technique is not limited by the amount of available skin after surgery. However, it also has several disadvantages. It is surgically more complex than heterologous reconstructions using implants. It is associated with a higher rate of complications such as in donor site as in neobreast and higher morbidity.

Free injection techniques using different autologous substances have also been developed. Lipofilling is a free injection technique similar to the injection of free silicone and hyaluronic acid; however, the fat used in lipofilling is autologous, and the technique is completely accepted worldwide. Lipofilling has several advantages over other free injection techniques, for example, the autologous fat avoids the possibility of rejection and granulomas, increased risk of breast cancer has not been demonstrated, and the free fat will have a similar appearance than breast fat, so it should not interfere with radiological interpretation on imaging and consequently with cancer diagnosis. For all those reasons, it is commonly used as a reconstructive technique and aesthetic procedure. However, sometimes new palpable lumps may appear mimicking cancer on imaging, requiring breast MRI or biopsy.

NAC reconstruction is also possible using autologous material. It is the final step after breast reconstruction in

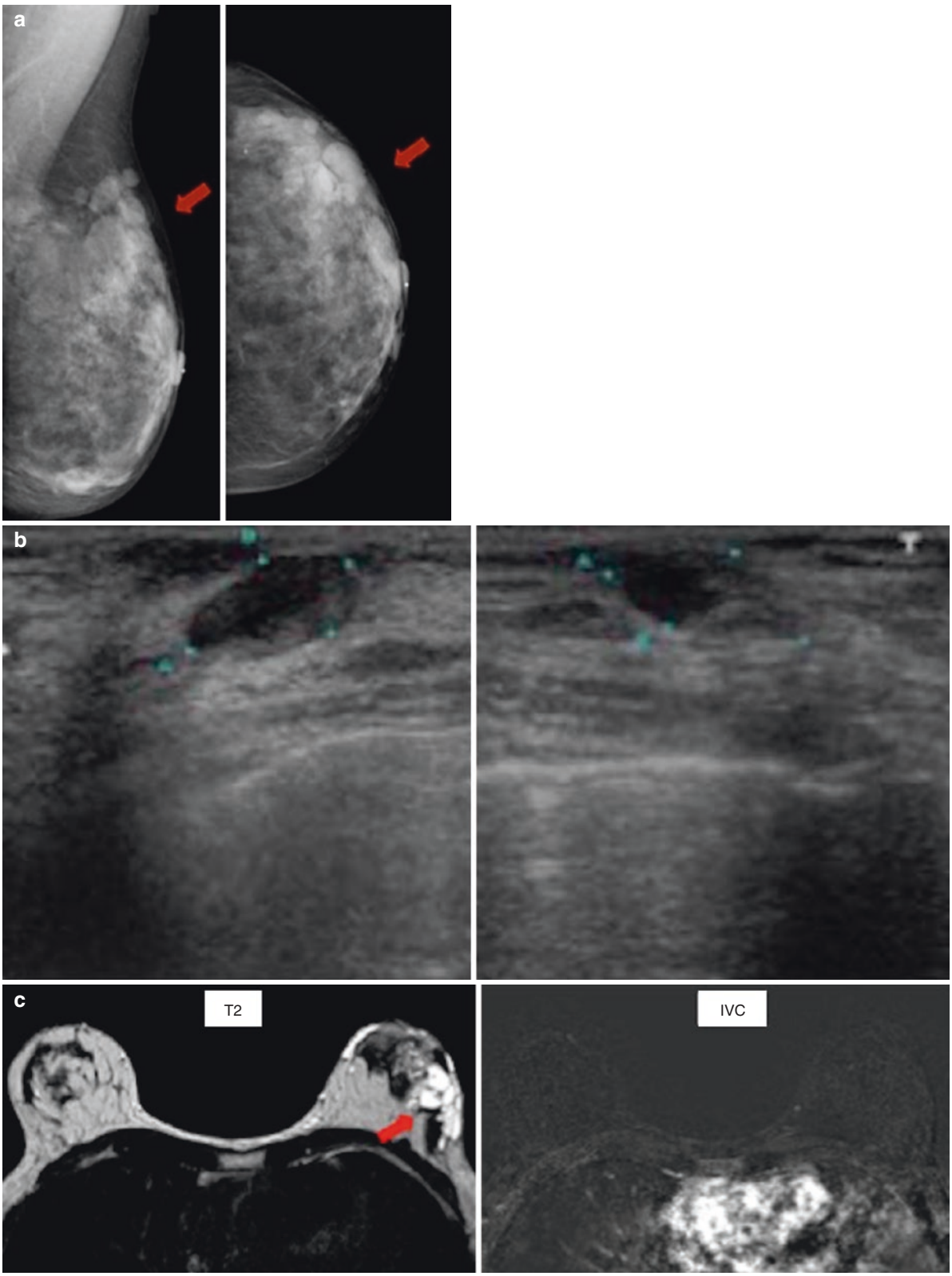

Fig. 21.38 Patient with free hyaluronic acid injection who had multiple palpable lumps at follow-up. (**a**) Mammogram of left breast (oblique and craniocaudal views): multiple nodular radiodense images, mostly located in the UOQ (*red arrow*), with some ill-defined margins and diffuse increased parenchymal density in the area. (**b**) Sonographic images: the mammographic nodules correspond to multiple nodular lesions (with complicated cystic and solid appearance) with uncircumscribed margins. (**c**) Breast MRI shows multiple nodules with an identical signal intensity of the liquid, different from the silicone and showing no enhancement in dynamic sequences. In this case, breast MRI allowed doubtful findings on mammogram and ultrasound to be solved. Figure 21.38b appeared in the European Aesthetic Plastic Surgery Journal (number 12). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica

cases where the nipple is not preserved. The aim is to achieve greater symmetry and similarity in texture and color with the contralateral NAC. It is usually performed as a separate step after breast reconstruction when postoperative changes have stabilized (usually 6–8 weeks). Skin and subcutaneous tissue flaps are used (usually labia minora and the contralateral NAC when a mastopexy is also performed). Sometimes, only the nipple is reconstructed while the areolar area is tattooed.

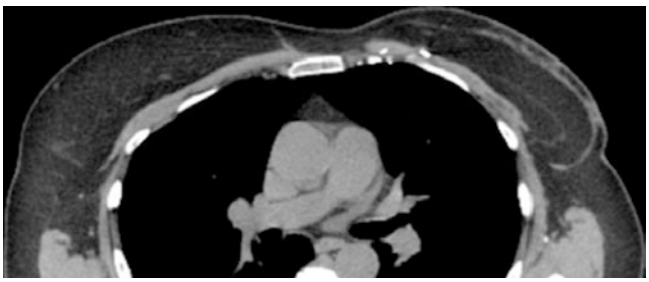

Fig. 21.39 Patient with left mastectomy and autologous reconstruction with DIEP flap. There is a contact line between the subcutaneous fat of the original breast and the flap fat. On CT there is a hyperdense line with variable thickness

21.4.1 Autologous Reconstruction

21.4.1.1 Radiological Tests

Physical examination and ultrasound are useful in the follow-up of patients who have undergone mastectomy without reconstruction. Nevertheless, they are less sensitive in patients who have undergone autologous reconstruction. Many tumor recurrences are located deep in the flap so they are not palpable. Reconstruction also decreases the contrast between the lesion (hypoechoic) and fat surrounding (hypoechoic too), rendering ultrasound ineffective. Frequent scars and fat necrosis often make it difficult to assess possible lesions with ultrasound and can produce hard palpable lumps that complicate the physical examination.

Mammography is useful in evaluating calcifications or microcalcifications by fat necrosis. It is also useful in detecting recurrence as it will increase the contrast between the flap (hypodense or fat) and possible recurrence (hyperdense).

Although breast MRI requires IVC administration, it allows the physician to distinguish benign tissue from recurrence in many cases because it can demonstrate fat inside the lesion (fat necrosis) or absence of enhancement after administration of IVC.

21.4.1.2 Radiological Findings

1. Distinguishing different types of flaps on imaging:

It is important to be able to differentiate different types of flaps on imaging, since clinical information often does not specify what type the patient has. Fat is key to recognizing an autologous flap in general. All flaps have in common the transfer of skin and fat and therefore, a fatty breast will be seen in all radiological tests. Muscle indicates a myocutaneous flap. The muscle is seen as a soft tissue density although there are atrophic changes over time and its appearance becomes more fatty. Vascularization is key to recognizing a muscle-sparing free flap with vascular anastomosis. Vascularization is assessed on breast MRI. The internal mammary region must be observed since this is the place where anastomosis was done and is sometimes the only sign of the presence of a flap or previous failed flap. It is important to note if there is IVC in the transferred vessels as this is a sign of viability.

There is a contact line formed between subcutaneous fat of the native breast and the fat transferred (Fig. 21.39). It is possible to distinguish three types of lines depending on its thickness: type 1, thickness smaller than 1 mm (almost not visible); type 2, thickness from 1 to 3 mm; and type 3, thicker than 3 mm. If the line increases in thickness after a month of surgery, then a recurrence, infection, or inflammation should be considered.

Characteristics of the main flaps:

- *Pedicled TRAM flap* (Fig. 21.40): Fatty breast is seen. Muscle density is seen anteriorly to the chest wall in a triangular shape. On breast MRI, the muscle density can be followed distally going to the abdomen (usually contralateral hemi-abdomen). In abdominal slices (CT or MRI), the absence of one rectus abdominis muscle and signs of postsurgical changes (metallic clips) can be seen.
- *Free TRAM flap* (Fig. 21.41): Fatty breast is seen. As in the pedicled TRAM flap, a muscle density is seen anteriorly to the chest although when there is atrophy this is not possible. The muscular density does not continue to the abdomen. In abdominal slices (CT or MRI), only a partial defect of the rectus muscle is seen. Postsurgical changes in the mammary internal region are seen because of vascular anastomosis in that area.
- *DIEP flap* (Fig. 21.42): Fatty breast is seen. There is no muscle density because there is no muscle transferred. In abdominal slices, the rectus muscle is complete although postsurgical changes can be seen as there are metallic clips inside it due to the harvesting of perforating branches of deep epigastric artery. Postsurgical changes are also seen in the internal mammary chain because of vascular anastomosis.
- *SIEA flap*: Fatty breast is seen. There is no muscle density because there is no muscle transferred. In abdominal slices, a complete and intact rectus muscle is seen, without any postsurgical change.

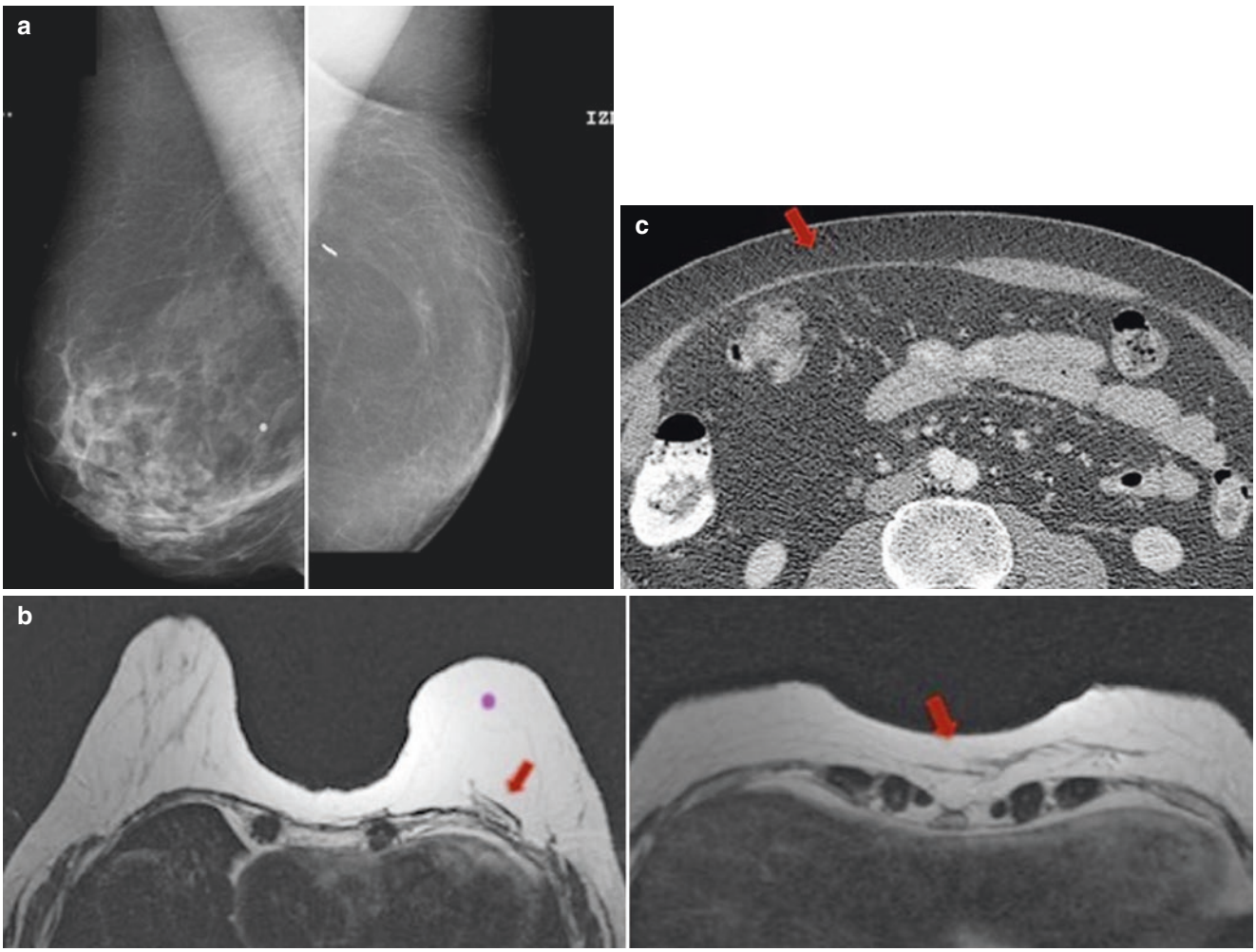

Fig. 21.40 Patient with left mastectomy and autologous reconstruction with pedicled TRAM. (**a**) On mammogram, a left fatty breast and the presence of metallic clips are indicating the presence of an autologous reconstruction. (**b**) Breast MRI with axial T2 sequence in two different slices: In the more superior slice, a left fatty breast (*purple dot*) is confirmed, and there is a muscle structure (*red arrow*) just beside to the anterior chest and the pectoralis muscle wall corresponding to a muscle with some hyperechoic lines inside relating to fatty atrophy. In the lower slice, the muscular density crosses the midline going to the abdomen. That is the key to knowing it is a pedicled TRAM flap. (**c**) Abdominal CT with IVC administration shows the absence of the right rectus abdominis muscle confirming the pedicled TRAM

- *LDM flap* (Fig. 21.43): Fatty breast is seen. The muscle density is seen as a band that comes from the back and parallel to the chest wall. When it is combined with an implant, it is usually seen posterior to the muscle band and is easily recognized on mammogram and the other tests. However, when there is only a partial defect or when it is not combined with an implant, it may be more difficult to recognize it on mammogram if the type of reconstruction is unknown. MRI will be useful (Fig. 21.13).
- *TDAP flap* (Fig. 21.44): Fatty breast is seen. There is no muscle density because there is no muscle transferred. Some vessels can be identified going to the back, related to the thoracodorsal pedicle.

It is important to examine all slices (from the most proximal to the most distal or superior abdominal slices). Special emphasis should be placed on these areas: the internal mammary chain (if there are postoperative changes, then there was microsurgery followed by a free TRAM, DIEP, SIEA, TUG, SGAP, or IGAP flap), the neobreast (if there is a muscle density, then there is a TRAM or LDM flap), the lateral chest wall looking at the latissimus dorsi muscle or its vascular pedicle (which indicates a LDM or TDAP flap), and finally the lower slices (if there is a muscle band, then there is a TRAM flap). All these are important especially in cases where a second flap has to be done because of a previous failure of another flap. It is possible to see a transferred LDM flap and postsurgical changes in the internal mammary chain, which means a previously failed DIEP or free TRAM flap. Another possibility is seeing a transferred LDM flap without an implant and asymmetry in relation to the contralateral breast suggesting complication and removal of the implant

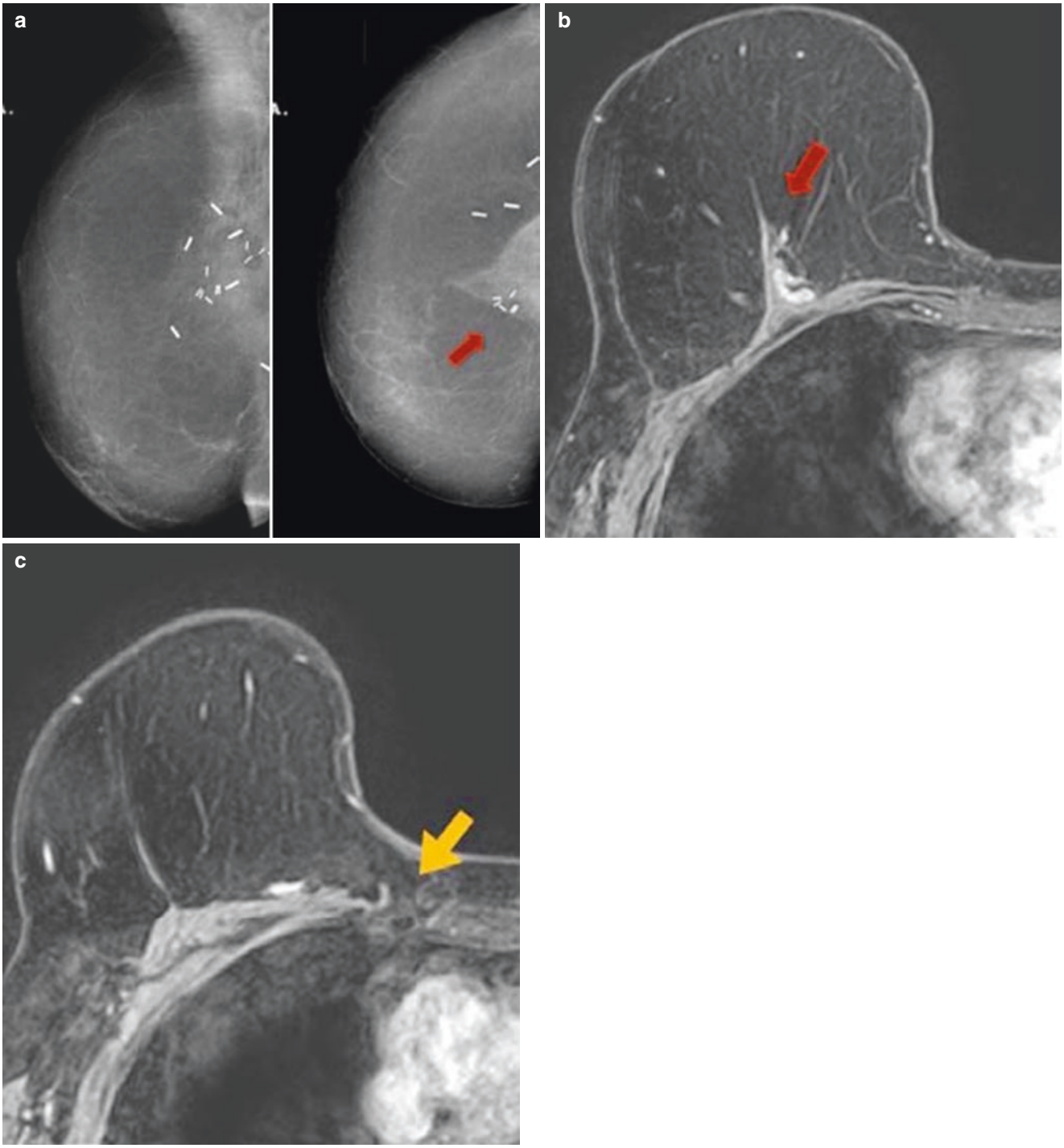

Fig. 21.41 Patient with right mastectomy and autologous reconstruction with free TRAM flap. (**a**) On mammogram, a muscular density is seen anteriorly to the chest wall and the pectoral muscle (*red arrow*). (**b**) Breast MRI with dynamic sequences showing the muscle transferred anteriorly to the pectoral muscle, with metallic clips and some vessels indicating good viability of the flap. (**c**) Breast MRI with dynamic sequences in an upper slice, at the level of the internal mammary vessels. The postoperative changes in the internal mammary vessels (*yellow arrow*) indicate the presence of vascular anastomosis and the presence of a free TRAM flap

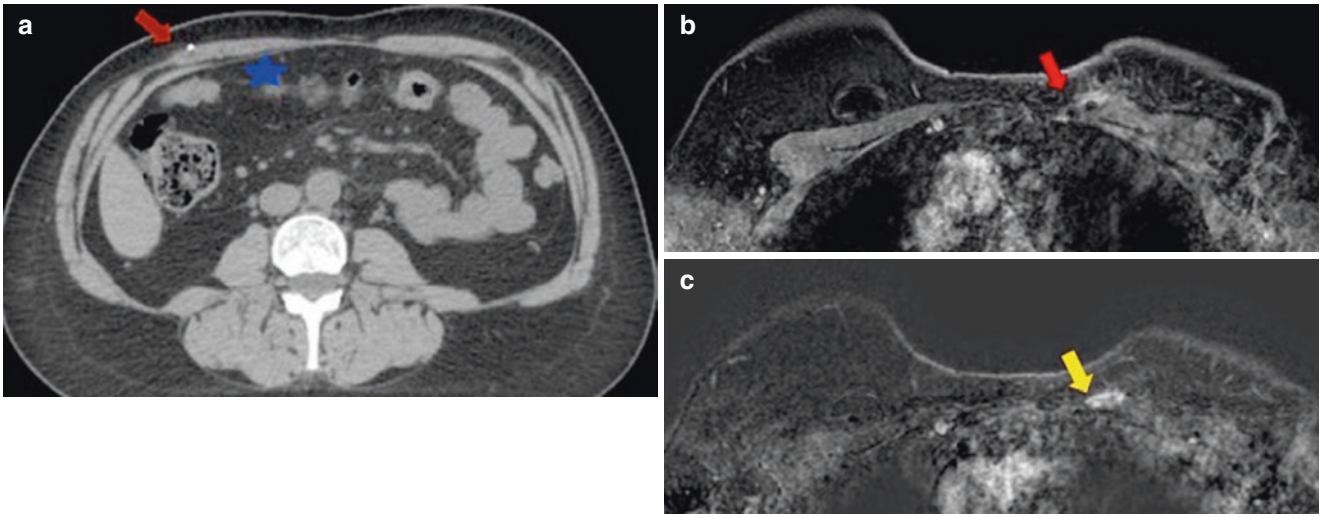

Fig. 21.42 Patient with left mastectomy and autologous reconstruction with DIEP flap. (**a**) Abdominal CT shows metallic clips (*red arrow*) on the rectus abdominis muscle indicating postoperative changes. However, the muscle is complete so it is not a free TRAM flap but a DIEP flap (*blue star*). (**b**) Dynamic sequence breast MRI shows metallic clips (*red arrow*) in the area of the internal mammary chain indicating the presence of vascular anastomosis. (**c**) Axial first subtraction sequence shows good vessel enhancement (*yellow arrow*) in the anastomosis, indicating good viability of the flap

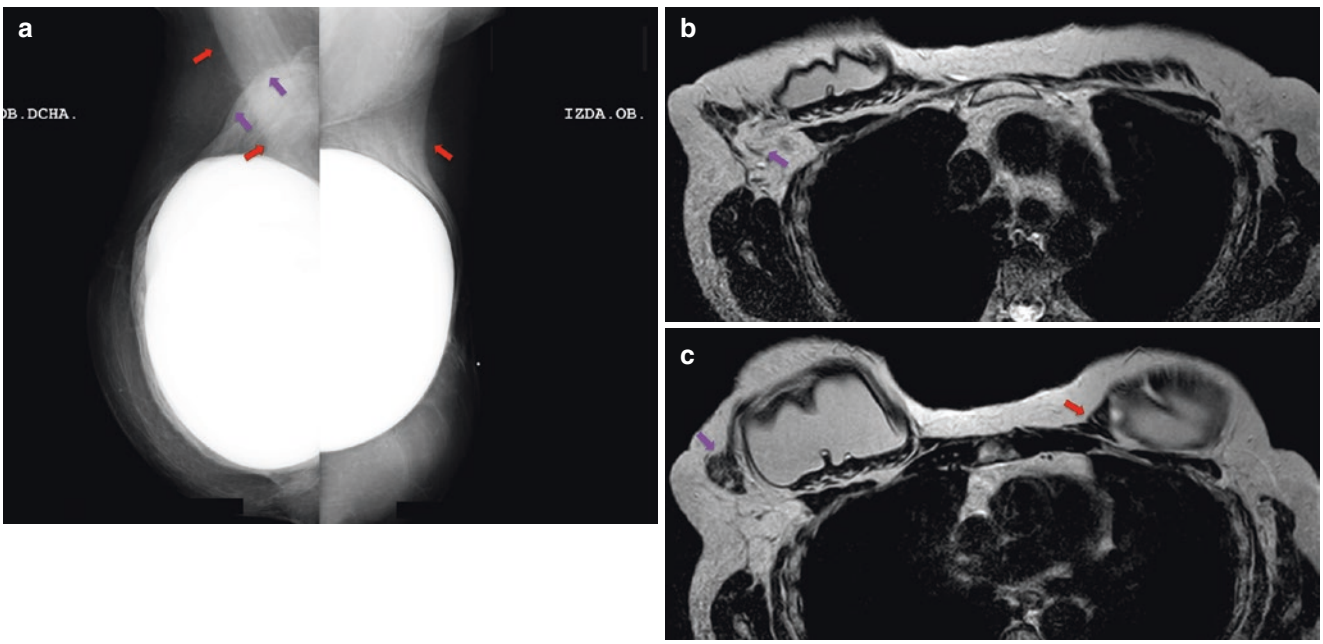

Fig. 21.43 Patient with bilateral mastectomy who had autologous reconstruction with an implant and LDM flap in the right breast and heterologous reconstruction in the left breast. The patient presented with a right axillary palpable lesion. (**a**) Mammography with oblique projections of both breasts: Both implants can be seen. In the left breast, the implant is located posteriorly to the pectoralis muscle (*red arrow*). In the right breast, the implant is located anteriorly; soft tissue visualized corresponds to the LD muscle (*purple arrow*) and the palpable area corresponds to the prominent and thick LD muscle containing fat just below. (**b**) and (**c**) Breast MRI T2 sequences confirm the presence of the pectoral muscle (*red arrow*) (posteriorly to the implant in the right breast and anteriorly in the left breast) and the LD muscle coming from the back and located anteriorly to the implant in the right breast making a prominence in the axillary region

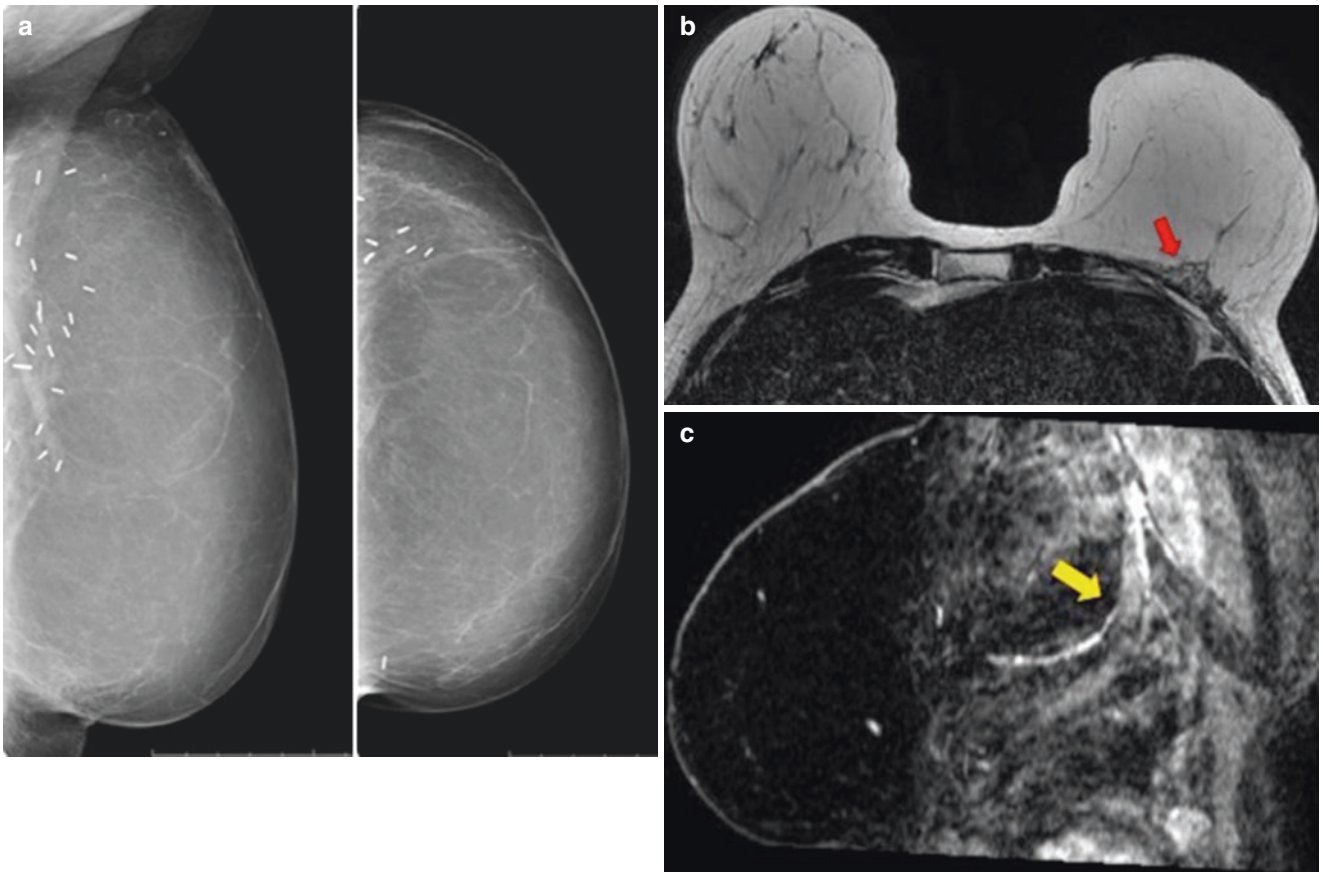

Fig. 21.44 Patient with left mastectomy. The patient had a failed autologous reconstruction with pedicle TRAM flap and later underwent a new autologous reconstruction with TDAP flap. (**a**) Mammogram shows a fatty breast with metallic clips that suggested a reconstructed breast. (**b**) Breast MRI with T2 sequence confirms the presence of a fatty and reconstructed breast with a muscular structure anteriorly to the pectoral muscle suggesting a TRAM flap (*red arrow*). (**c**) However, on a sagittal reconstruction of a dynamic sequence, a vascular structure (*yellow arrow*) is seen coming from the back corresponding to a perforating branch of the thoracodorsal artery and without any accompanying muscle, indicating a TDAP flap

(Fig. 21.45). An LDM or TDAP flap with perforating vessels going to the back and a muscle density in the deep of the neobreast indicates a previously failed TRAM flap and a second attempt with an LDM flap or a TDAP flap (Fig. 21.44).

2. Assessing complications of the neobreast:

Fat necrosis is one of the most common complications, especially with a pedicled TRAM flap. It is often caused by problems in the vascularization of the flap. Clinically it is suspected because the patient notes a new, hard, and palpable lesion, close to the scar. It is easily confused with recurrence. Radiologically, it is said to be a great imitator of cancer and complicates differential diagnosis. On mammogram, calcifications (from benign to punctate or pleomorphic calcifications) (Fig. 21.46), dense masses with irregular margins or even distortion images can be seen. On ultrasound, a wide spectrum of findings can be seen, from typically benign oil cysts (which are often mistaken for simple cysts) or hyperechoic lesions because of the presence of fat to hypoechoic, solid, and poorly defined lesions (Fig. 21.47). On breast MRI, a wide spectrum of findings can also be seen: typical image of an oil cyst (well-defined, oval, or round lesion hypointense on T2), a fat-containing solid lesion (hyperintense on both T1 and T1 sequences, suppressed on fat suppressed images that may or may not present peripheral or eccentric enhancement after IVC) (Figs. 21.46 and 21.49), or an irregular lesion with suspicious enhancement after IVC (Fig. 21.47). Conventional tests are enough to diagnose typically benign findings, whereas a breast MRI and/or biopsy are needed to diagnose BI-RADS® 4 and 5 lesions.

Venous congestion (Fig. 21.48) occurs especially in cases where vascular anastomosis is required. Mammographically, a diffuse increase density is seen (whereas usually a low or hypodense density is presented because of fat). On ultrasound, cutaneous and trabecular thickening and diffuse increased echogenicity of fat are seen. On breast MRI, edema and a diffuse increased enhancement related to inflammatory changes are seen.

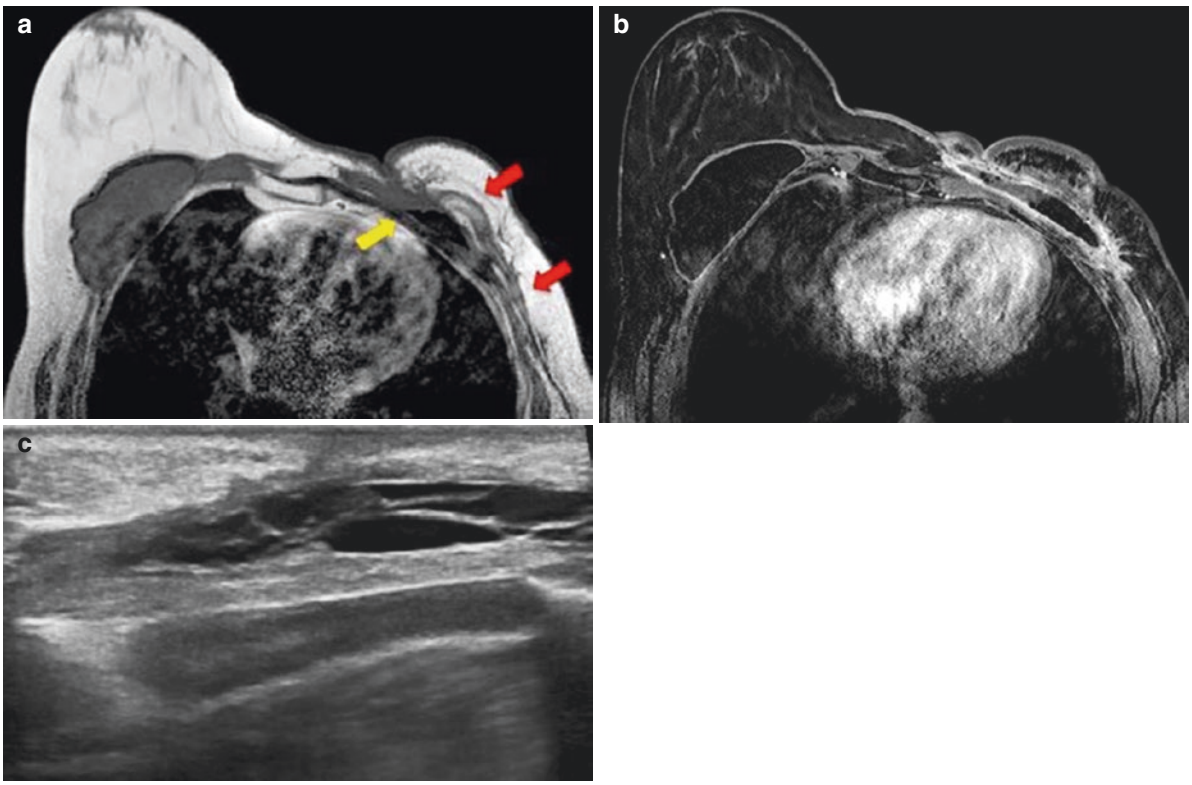

Fig. 21.45 Patient with left mastectomy and failed autologous reconstruction with LDM flap and implant. Due to recurrent peri-prosthetic infection, the implant was eventually removed but the transferred LD stayed. (**a**) Breast MRI with T1 sequences shows the LDM flap (*red arrow*) coming from the back and located anteriorly to the pectoral muscle and also anteriorly to a complex and fluid collection (*yellow arrow*) relating to residual abscess. (**b**) The dynamic sequence shows a thick peripheral enhancement around the collection suggesting infection. (c) Ultrasound shows a tabicated fluid collection; an FNA was performed to obtain an antibiogram

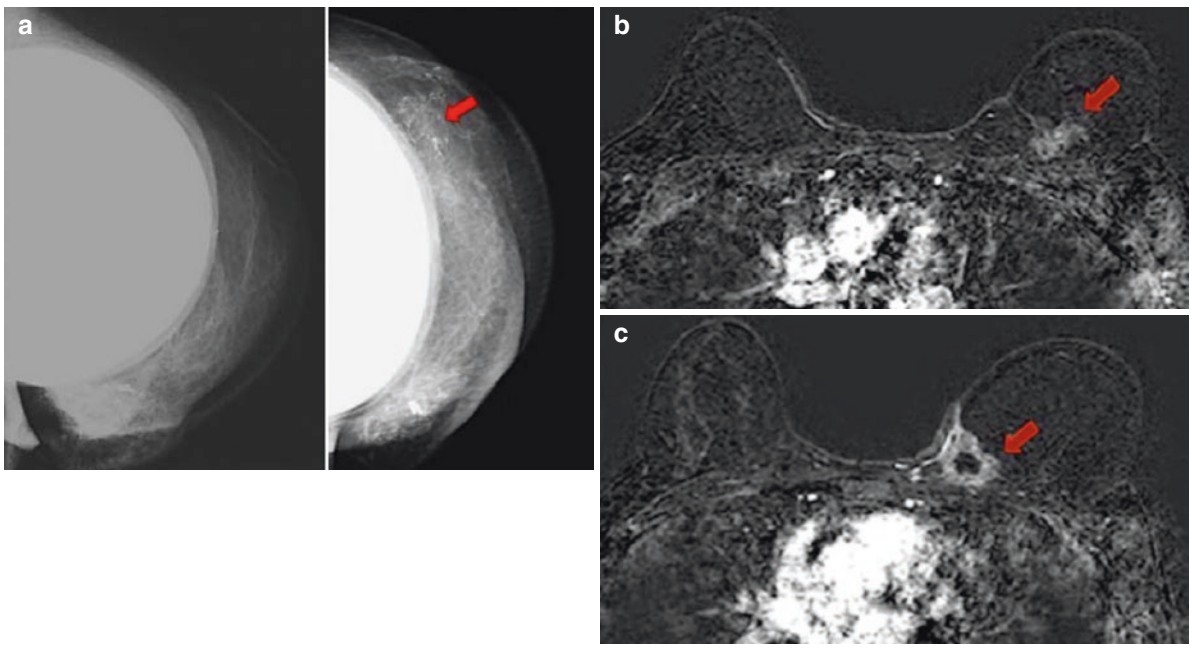

Fig. 21.46 Patient with left mastectomy and autologous reconstruction with LDM flap and implant. The patient had capsular contracture and also noted a new palpable lump in the outer quadrants of the left breast underlying scar. (**a**) Craniocaudal and Eklund projections of the left breast: When the implant was pushed back, a group of new pleomorphic calcifications (*red arrow*) is seen in the outer quadrants that correlated with the palpable area. Those calcifications would be suspicious but a breast MRI was performed. (**b**) A dynamic sequence in a superior slice shows the presence of heterogeneous and ill-defined enhancement in that area. (**c**) In a lower slice, the lesion shows a fat center, indicating fat necrosis. Biopsy was not recommended. Figure 21.46a appeared in the European Aesthetic Plastic Surgery Journal (number 14) and Figures 21.46b and 21.46c appeared in the European Aesthetic Plastic Surgery Journal (number 13). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica

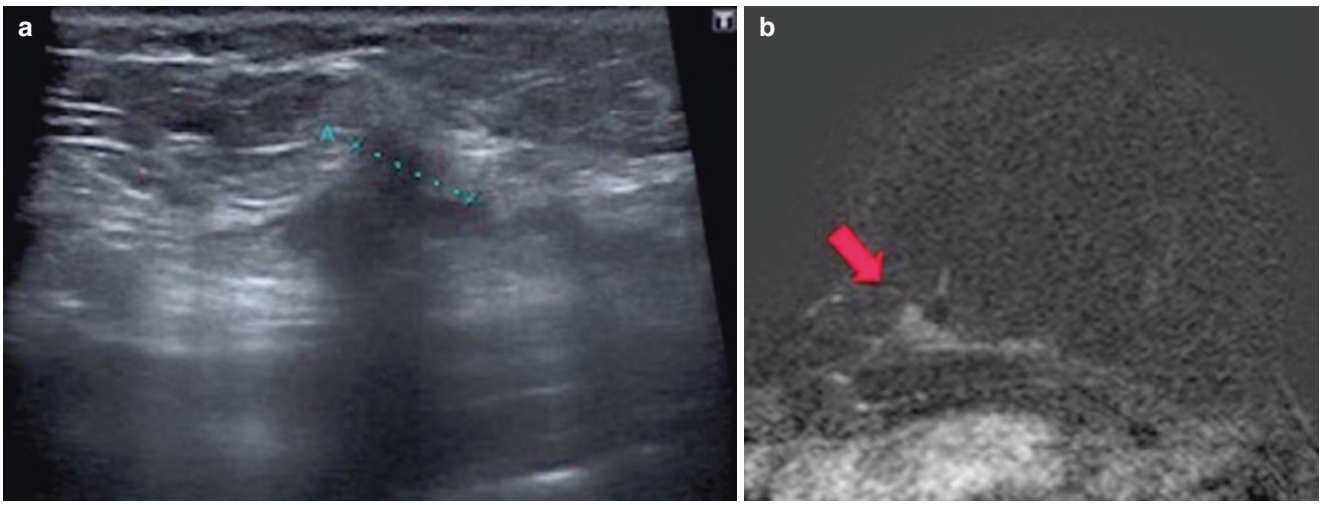

Fig. 21.47 Patient with left mastectomy and autologous reconstruction with DIEP flap. The patient had a superficial, palpable lesion in the UIQ of the left breast. (**a**) Ultrasonography shows a suspicious irregular hypoechoic and poorly defined lesion, with posterior acoustic shadowing. (**b**) Subtracted image after IVC administration: An irregular and ill-defined lesion in that area is seen without a fat center. A core biopsy was performed with fat necrosis result. In this case, the biopsy was necessary to demonstrate the fat necrosis

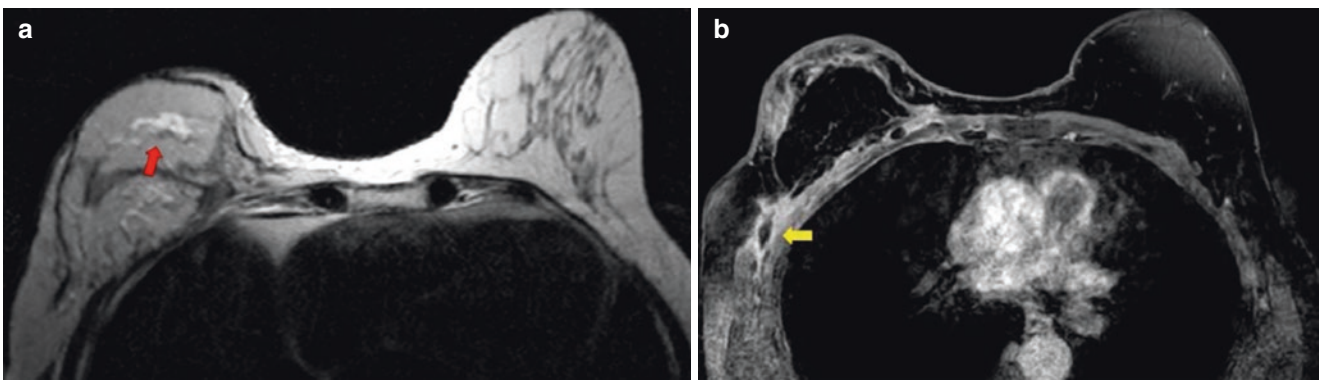

Fig. 21.48 Patient with right mastectomy and autologous reconstruction with DIEP flap who had complications with congestive changes. (**a**) Breast MRI T2 sequence shows edema, cutaneous and trabecular thickening, and fluid collection (*red arrow*). (**b**) Dynamic sequence after IVC administration shows irregular enhancement, predominantly in the periphery of the flap, in the periphery of an organized fluid collection beside the flap (*yellow arrow*), and in the vascular areas. The appearance in some slices looked like an implant. This image originally appeared in the European Aesthetic Plastic Surgery Journal (number 14). Reproduced with permission from the Asociación Española de Cirugía Estética Plástica

Fluid collections (Fig. 21.49) are usually related to postoperative seroma with simple cyst appearance. Sometimes a complicated or complex cyst can be seen, and then the possibility of bleeding, secondary infection, or abscess (Fig. 21.45) should be considered.

Imaging can also assess tissue necrosis and wound closure failure.

21.4.1.3 Follow-Up Protocol

The possibility of recurrence after breast-conserving surgery and mastectomy is low. In autologous reconstruction, the recurrences are located predominantly in two areas:

- *Superficial zone*: in the contact line between the flap and the subcutaneous fat of the native breast. It is usually detected by physical examination although sometimes it can be an incidental finding in a screening test (Fig. 21.50). On imaging, special attention should be paid to the variations and increases of thickness of that line that are not justified by infection or inflammation.
- *Deep zone*: in the posterior margin of the bed mastectomy, typically along the pectoralis major muscle, deep to the flap. Given its deep location, it is not usually detected by physical examination.

Since the incidence of recurrence is so low, there is debate about whether follow-up should be performed in these patients. However, possible screening with annual mammography and ultrasound has been suggested, relegating breast MRI to evaluating possible complications or indeterminate findings on conventional tests.

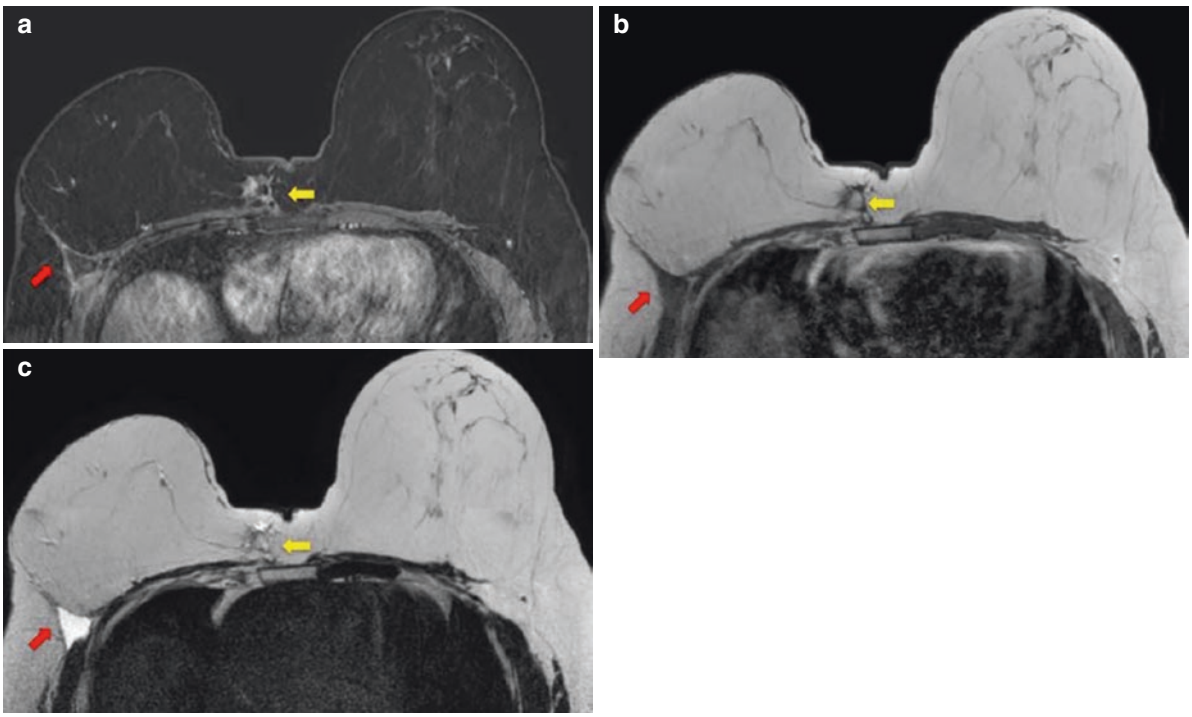

Fig. 21.49 Patient with right mastectomy who had a new palpable lesion in the inner quadrants. (**a**) Breast MRI dynamic shows a fluid collection in the outer quadrants (*red arrow*) with thin and low enhancement and an irregular lesion in the inner quadrants (*yellow arrow*) relating to the palpable lesion. (**b**) and (**c**) T1 and T2 sequences confirm the presence of a simple fluid collection relating to seroma in the outer quadrants and in the inner quadrants the palpable lesion has fat inside indicating fat necrosis. For that reason, biopsy was not necessary

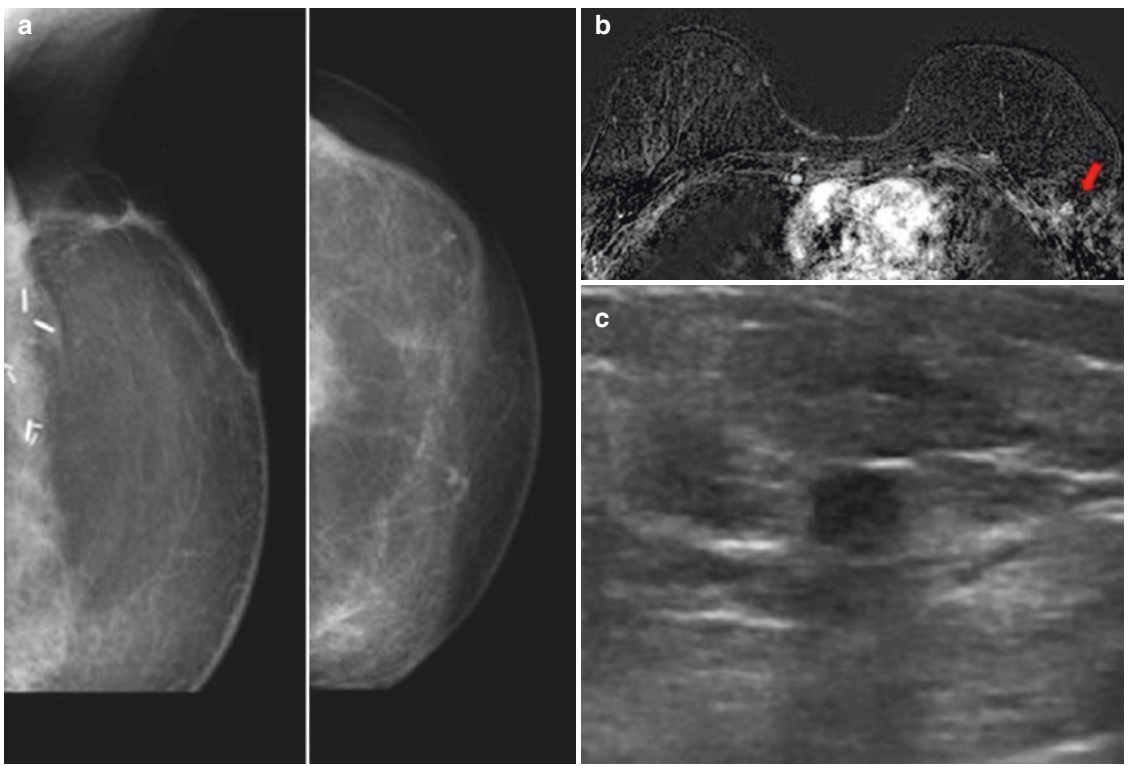

Fig. 21.50 Patient with left mastectomy and DIEP reconstruction with a millimetric recurrence visualized only on a follow-up MRI. (**a**) Left mammography shows a fatty breast without suspicious findings. (**b**) Breast MRI subtracted image shows a small, irregular and ill-defined lesion located in the contact area of the flap with the native breast in the outer quadrants, in the periphery of the flap (*red arrow*). (**c**) Second look ultrasound was performed; a millimetric lesion was found and biopsied with the result of invasive ductal carcinoma, confirming recurrence

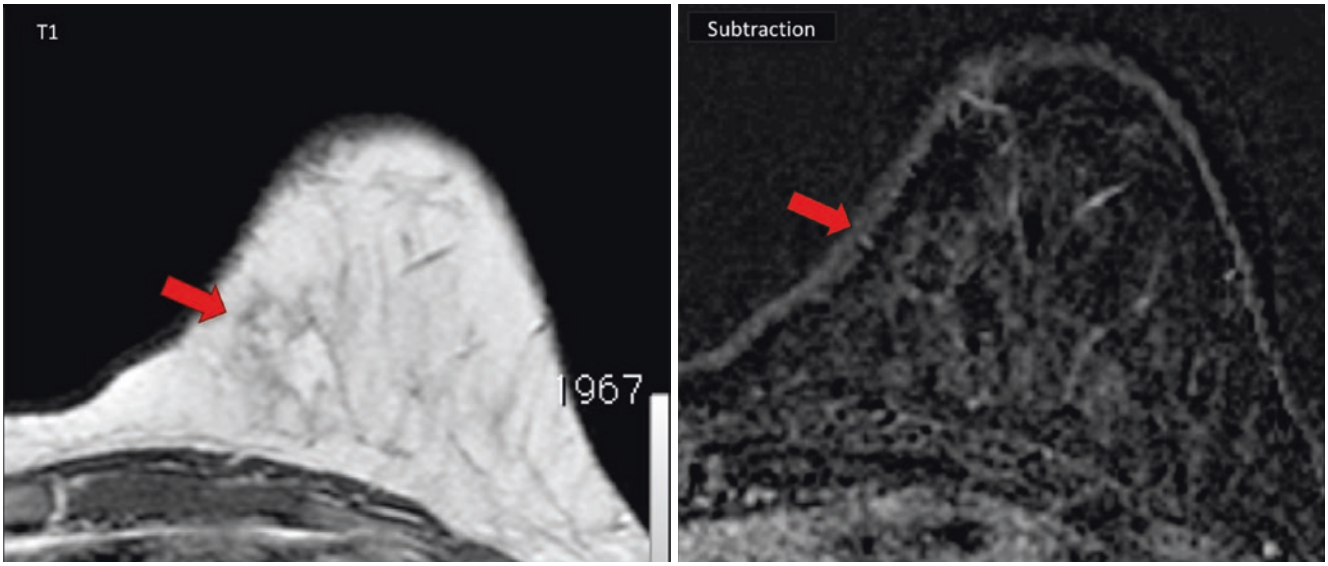

Fig. 21.51 Patient with a personal history of lipofilling for aesthetic reasons. After some time, she presented with a palpable lump at that location. However, conventional imaging tests (mammography and ultrasound) were completely normal. For that reason, an MRI was performed. Only a slight fat trabeculation in that area was seen, without any lesion and with no enhancement (*red arrow*), because the injected fat and the normal fat of the breast fused together. In cases like this where the patient's personal history is unknown, the radiological finding would be a BI-RADS® 1

21.4.2 Lipofilling, Lipomodeling, or Free Fat Grafting

21.4.2.1 Radiological Tests and Findings

1. BI-RADS® 1 Identical to normal breast fat (Fig. 21.51): It is the ideal situation. It is common for the radiologist not to identify a breast with lipofilling if he does not know the patient's clinical history. On mammogram, free fat will mix with the normal fat not giving any especial finding; only the breast will appear as a less dense breast due to free fat, consequently allowing better detection of possible cancer because of increased contrast with a radiodense mass or calcifications. On ultrasound and breast MRI, it would also be indistinguishable from the rest of the mammary fat.
2. BI-RADS® 2 Benign findings (Fig. 21.52): Oil cyst is the most common manifestation when the lipofilling shows radiographic abnormalities. Benign calcifications (usually coarse or rim calcifications) can also be seen. The breast MRI usually shows solid lesions with a fat center, without enhancement or with rim and thin enhancement related to fat necrosis. For that reason, it is important to review T1, T2, and fat suppressed sequences.
3. BI-RADS® 3 Probably benign findings (Fig. 21.53): Round or oval, well-defined solid lesions with type I enhancement curve or a new complicated cyst.
4. BI-RADS® 4 Suspicious findings (Fig. 21.54) especially due to fat necrosis. On mammogram, a distortion image or suspicious calcifications can be seen. On ultrasound, irregular solid lesions with posterior shadowing can be noticed and on MRI lesions with type II or III enhancement curves can be found.

21.4.2.2 Follow-Up Protocol

There is no established protocol because its use has increased only rather recently. Although it seems proven that this technique is not associated with an increase of breast cancer, there are still no conclusive and statistically significant studies regarding its association with complications and with radiological findings. For that reason, if it is possible, it is recommended to have a mammogram and/or ultrasound prior to the lipofilling. Some authors have even recommended performing a baseline mammogram 6 months after lipofilling to be able to assess posterior changes. However, many changes could happen after 6 months, for example, fat necrosis, and other findings change over time despite being benign. Additional tests and interventional procedures present a greater burden on the patient and increase anxiety and concern. For that reason, we try to distinguish two situations:

1. Symptomatic patient with a new palpable lesion: The mammogram and ultrasound should be performed. The breast MRI and/or biopsy may be performed if previous tests are inconclusive or if the patient has a personal history of breast cancer or high risk or family history.
2. Asymptomatic patient: annual mammogram ± ultrasound. Other option is to perform a mammogram and ultrasound 6 months after injection as baseline tests and later performing other tests if there are changes.

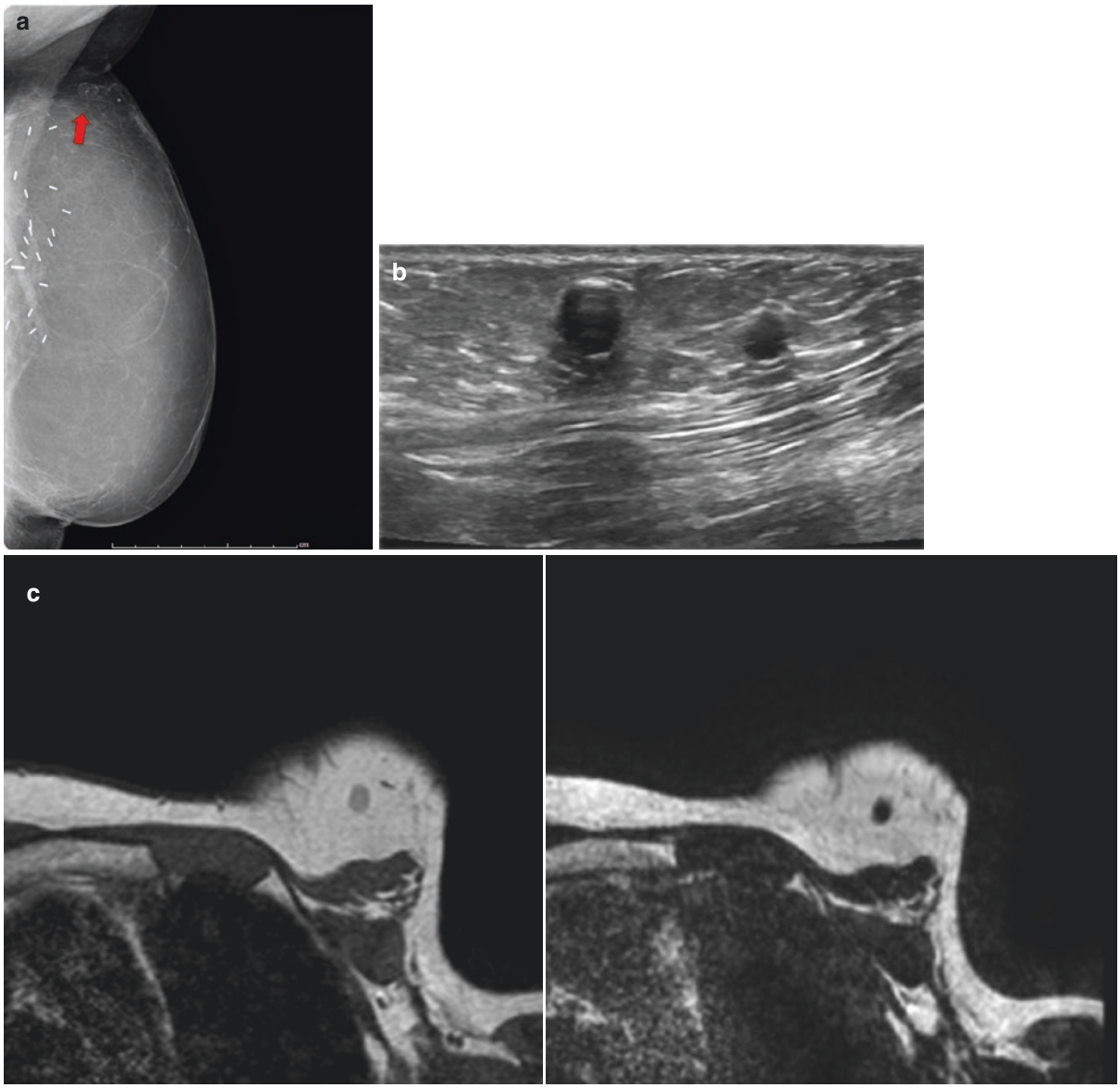

Fig. 21.52 Patient with left mastectomy and autologous reconstruction with a DIEP flap and lipofilling injection a second time in upper quadrants to fill a small defect. The patient presented with a new palpable lump at some time after injection. Mammogram, ultrasound, and MRI were performed, and a BI-RADS® 2 classification was made. (**a**) Oblique view of left mammogram only shows rim calcification related to the palpable lesion. (**b**) Ultrasound shows several lesions with simple cystic appearance. Although appearing as simple cysts they were really oil cysts as MR confirmed, being hypointense on T2, iso-/hyperintense on T1 and with no enhancement after IVC administration (**c**)

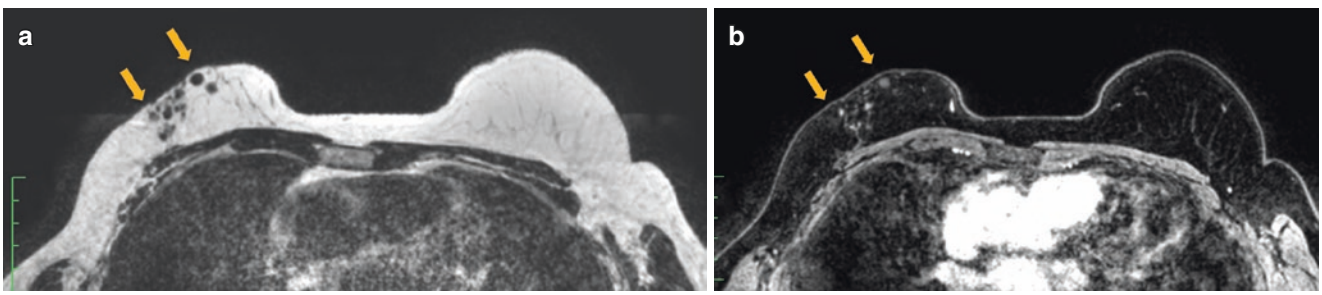

Fig. 21.53 Patient with right breast-conserving surgery and lipofilling in UOQ. The patient presented with some new palpable lumps in that area after lipofilling (*yellow arrows*). MRI shows (**a**) several round lesions, most of them well defined, hypoechoic on T2 and (**b**) with a soft enhancement with type I curve on subtracted image. With those characteristics, it was classified as BI-RADS® 3, and a follow-up was recommended

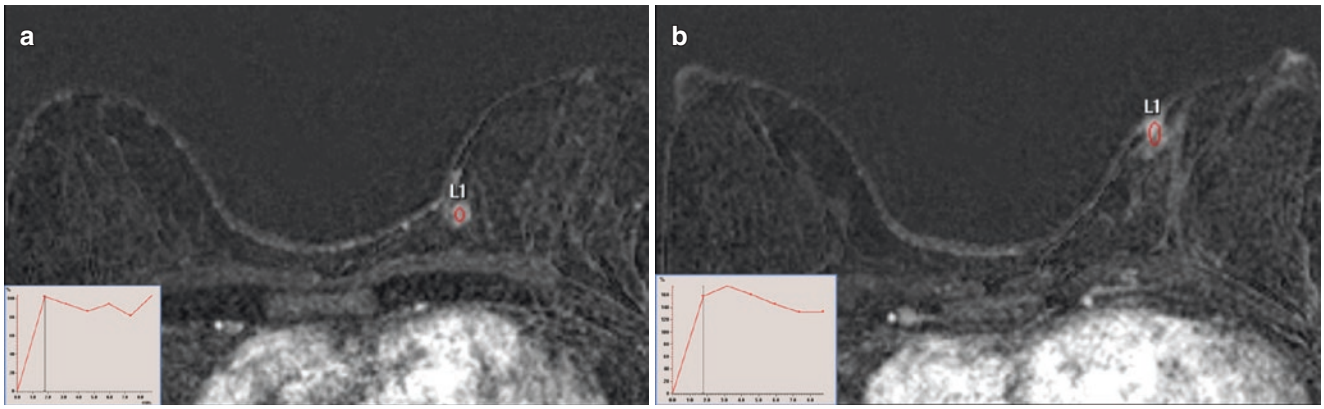

Fig. 21.54 Patient with a history of breast-conserving surgery in the UIQ of left breast with a lipofilling injection in that area. The mammogram did not show any significant finding, only metallic clips. Ultrasound showed several lesions with solid or complicated cystic appearance, but some of them had ill-defined margins. For that reason, MRI was performed. (**a**) One of the lesions shows well-defined margins but a type III curve. (**b**) Another lesion shows spiculated and irregular margins and a type III curve. Therefore, the lesions were classified as BI-RADS® 4, and cytology was performed with the result of fat necrosis

21.4.3 NAC Reconstruction

21.4.3.1 Radiological Tests and Findings

Findings on imaging are not common, but sometimes, when the reconstruction is very fresh, the following can be observed:

1. On mammogram: a radiodense periareolar line can be seen.
2. On MRI: areola skin thickening that can be asymmetrical to the contralateral NAC. Like in mastopexy, periareolar changes can be appreciated especially in gradient echo and fat suppression sequences. Sometimes the new NAC can enhance especially if the reconstruction is recent, which must not be confused with a malignancy. Other times a magnetic artifact produced by the tattoo ink can be observed.

Acknowledgments The authors would like to thank Dr. Martina Marin Gutzke from the San Rafael Hospital, Madrid, Spain, for providing surgical images, as well as Joanne Chin from Memorial Sloan Kettering Center for providing editorial support.

Suggested Readings

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