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BREAST IMAGING
REVIEW

The current role of radiologists in a multidisciplinary team treating breast cancer

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ABSTRACT
In the last decade, advances in the diagnosis and treatment of breast cancer have achieved a significant increase in the general and disease-free survival of affected women but have also increased the complexity of therapeutic decisions. The decision-making process requires agreement between the physicians involved in the management of these patients. Radiologists must understand what other physicians expect and inform them about the usefulness of imaging modalities. This review attempts to provide an update on these subjects.

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The role of radiologists in breast cancer management was limited for many years to suggesting an initial diagnosis and detecting loco-regional recurrence after treatment by mammogram and breast ultrasonography (US). The Breast Imaging Reporting and Data System (BIRADS) of the American College of Radiology (ACR) (1) standardized the description and recommended management of breast lesions. BI-RADS has increased the radiopathological correlation of radiologists' reports, improving the reports' reliability (2). This system has also established a common language for all of the physicians involved in breast disease management, favoring agreement on decisions. Furthermore, advances in breast magnetic resonance imaging (MRI) and image-guided interventional procedures have increased our responsibility in the therapeutic decision-making process.

At the same time, new knowledge and technical progress have improved the management and prognosis of these patients. Breast-conserving treatment, and namely, lumpectomy plus postsurgical whole-breast radiotherapy (RT), has replaced mastectomy as the treatment of choice for stage I and II breast cancer according to the American Joint Committee on Cancer (AJCC Cancer Staging Manual, Table) (3), due to the similar overall survival (OS) and disease-free survival (DFS), lower morbidity, better cosmetic results, and minor changes in the self-esteem of the patients (4–6). Postsurgical adjuvant therapy (hormonotherapy or chemotherapy) significantly improved survival over the last 20 years. Currently, adjuvant therapy is based on identification of molecular markers in tumor tissue, which act as specific targets for treatments and/or provide prognostic information (7). Human genome decoding has led to the identification of several subtypes of breast cancer that have different systemic treatments and outcomes (7). Progress in presurgical or neoadjuvant therapy allows certain patients with locally advanced tumors (stage III) who had undergone a mastectomy several years ago to become candidates for breast-conserving treatment (4, 8–11). Significant differences in the OS or DFS between patients who received neoadjuvant or adjuvant therapy have not been observed (4, 12). Finally, patient concerns (self-esteem, risk of loco-regional recurrence) also influence the choice of treatment (6).

All of these improvements are increasing the complexity of the decision-making process (7, 10–13). Multidisciplinary teams (varying according the resources of each institution) composed of surgeons, gynecologists, medical and radiation oncologists, pathologists, and radiologists may be useful to determine the best decision for each patient. Our goal is to review the contribution of radiologists throughout the diagnostic and therapeutic process for patients with breast cancer, focusing on

Table. Anatomic stage and prognostic groups of breast cancer

Stage	T	N	M
0	Tis	N0	M0
Ia	T1[a]	N0	M0
Ib	T0		
	T1	N1mi	M0
		N1mi	M0
IIa	T0	N1[b]	M0
	T1[a]	N1[b]	M0
	T2	N0	M0
IIb	T2	N1	M0
	T3	N0	M0
IIIa	T0	N2	M0
	T1[a]	N2	M0
	T2	N2	M0
	T3	N1	M0
	T3	N2	M0
IIIb	T4	N0	M0
	T4	N1	M0
	T4	N2	M0
IIIc	Any T	N3	M0
IV	Any T	Any N	M1

[a]T1 includes T1mi.
[b]T0 and T1 tumors with nodal micrometastases only are excluded from Stage IIA and are classified Stage IB. M0 includes M0(i+).

The designation pM0 is not valid; any M0 should be clinical.
If a patient presents with M1 prior to neoadjuvant systemic therapy, the stage is considered Stage IV and remains Stage IV regardless of response to neoadjuvant therapy.
Stage designation may be changed if postsurgical imaging studies reveal the presence of distant metastases, provided that the studies are carried out within four months of diagnosis in the absence of disease progression and provided that the patient has not received neoadjuvant therapy.
Postneoadjuvant therapy is designated with "yc" or "yp" prefix. Of note, no stage group is assigned if there is a complete pathologic response to neoadjuvant therapy, for example, ypT0ypN0cM0.

Obtained from "The American Joint Committee on Cancer (AJCC) Cancer Staging Manual. 7th ed. Chicago: Springer Science and Business Media LLC, 2010." with the permission of AJCC.

areas of debate. Issues about diagnosis, treatment planning, the evaluation of responses to neoadjuvant therapy, surgery, radiofrequency ablation, RT, and post-treatment follow-up are discussed.

Diagnosis

The diagnosis of breast cancer is usually achieved by mammogram, breast US and image-guided percutaneous core biopsy. If microcalcifications or architectural distortion are observed, vacuum-assisted biopsy (with 8- to 14-gauge needle) removes more tissue than percutaneous core biopsy (with 14-gauge needle), decreasing the possibility of the underestimation of disease (14). A surgical biopsy will be necessary in two situations to exclude this risk (15): a) Radiopathological discordance, and namely, suspicious radiological findings are categorized as BIRADS code 4 or 5 and benign pathological findings. Images should be obtained during the interventional procedure and should correspond to the specimen to verify that the lesion has been sampled accurately, especially in case of microcalcifications (14). If the biopsy was not accurately on-target, it must be repeated. b) Atypical ductal hyperplasia is a very high-risk lesion. In other high-risk lesions (*in situ* lobular carcinoma, atypical lobular hyperplasia, papillomas, radial scar, and flat epithelial atypia) there is no standard of care (surgery vs. follow-up). Small preliminary studies have suggested that gadolinium contrast-enhanced breast MRI may be useful in determining the most appropriate option. Prospective trials are needed to decide how to manage these lesions (15).

A subset of women at increased risk of developing breast cancer has been identified based on clinical experience and genetic tests. Unlike population-screening programs for early diagnosis that are based on periodic mammograms in women at average risk, which have achieved a reduction in mortality close to 30% in the last decades in developed countries, there is currently no evidence of improvement in the survival of high-risk women with periodic breast-imaging procedures. However, this improvement has been suggested by numerous observational studies, leading to the publication of guidelines recommending the use of periodic mammograms. Mammograms and MRI performed concurrently every year or staggered every six months are reasonable options (16).

Treatment planning

After diagnosis, the multidisciplinary team will decide upon a suitable treatment for each patient. Breast cancer treatment varies depending on the disease stage, including the evaluation of tumor spread inside the breast, the location and characterization of lymph nodes in the axilla, and the detection of distant metastases; and the molecular markers in tumor tissue (estrogen and progesterone receptors [ER and PgR] and human epidermal growth factor receptor 2 [HER2]) (3, 4, 7, 12, 13). The staging determines locoregional treatment, and the molecular markers dictate the systemic treatment (hormonotherapy, trastuzumab, and chemotherapy; single or combined regime). The staging, histological grade (grade 3 has a higher risk of systemic dissemination than grade 1) and Ki-67 proliferative index (high if greater than 30%) also influence the choice of systemic treatment (7, 13, 17).

Extension inside the breast

MRI is the best technique to assess tumor volume, including the invasion of the pectoral muscle in posterior tumors (18), with abnormal enhancement of the muscle in postgadolinium images (Fig. 1). MRI is the most sensitive imaging method to detect multifocality (the presence of two or more foci

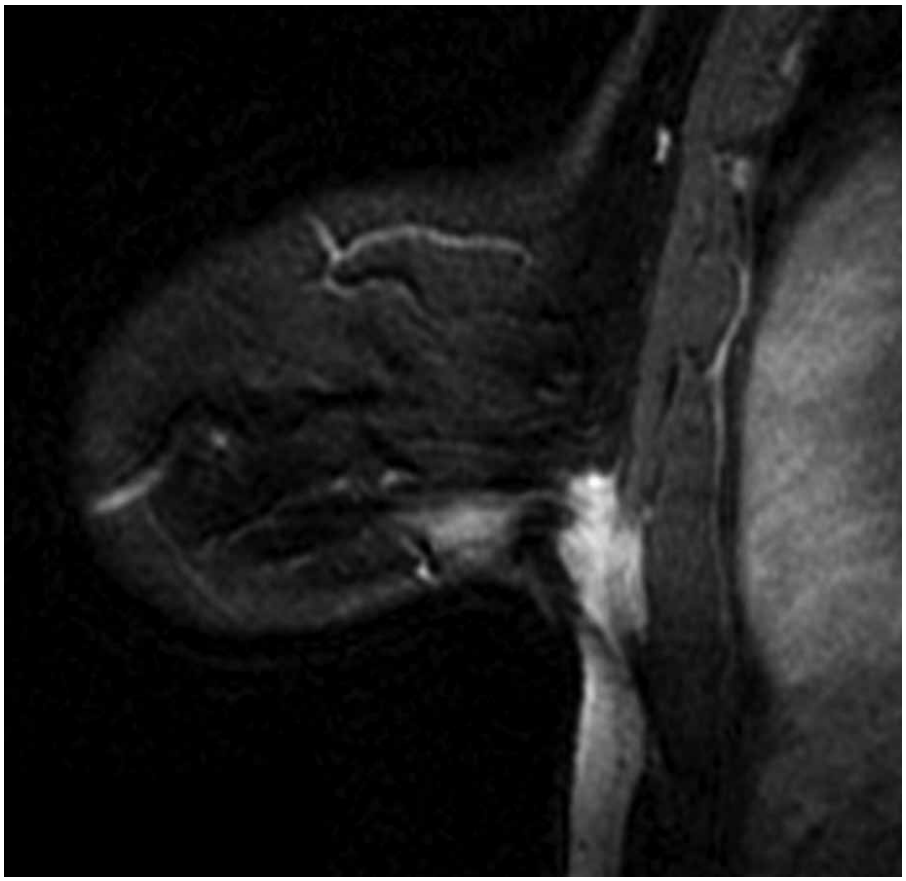

Figure 1. Sagittal, fat-suppressed, contrast-enhanced T1 MR image of a 49-year-old woman with pectoral muscle involvement in multicentric invasive carcinoma. There is a nodule in the inner internal quadrant adjacent to the chest wall with abnormal enhancement of the pectoral muscle. The extensive infiltration of the pectoral muscle was demonstrated in surgical specimen after mastectomy.

of cancer within the same breast quadrant) and multicentricity (presence of several foci of cancer in different quadrants). In the majority of cases, multicentricity excludes breast-conserving treatment (4, 19), so a mastectomy would be the most appropriate option, although breast-conserving treatment may occasionally be a reasonable alternative (5, 19), especially in absence of an extensive intraductal component. However, therapeutic changes caused by the discovery of additional lesions by MRI have not improved DFS (20), suggesting that the disease could be controlled by RT or systemic treatment. Furthermore, MRI is a relatively expensive procedure and yields a significant percentage of false positives (predictive positive value of 52%–77%) for invasive ductal carcinoma (20, 21). Therefore, it is necessary to confirm the diagnosis by percutaneous core biopsy after a second look focused on the MRI findings or to perform an MRI-guided biopsy, which is available in a few institutions, if additional foci are not observed by mammogram or US. Diffusion-weighted imaging (DWI), a noncontrast sequence of MRI, improves breast lesion characterization without decreasing the sensitivity, reducing the number of negative biopsies if multicentricity is suspected (18). Currently, routine pretreatment MRI in all patients with invasive ductal carcinoma remains controversial (4, 8, 13, 18, 20–23), but seems to be indicated in those patients with invasive lobular carcinoma. This condition has a higher risk of microscopic spread than invasive ductal carcinoma, allowing better-delimited tumor margins than mammography and US. Invasive lobular carcinoma might have an impact on adequate complete surgical management, which is assumed to be pathologically confirmed surgical eradication of the tumor. A percutaneous core biopsy of additional tumor foci will be needed to minimize the harm of overtreatment, as in invasive ductal carcinoma. Large prospective randomized clinical trials are necessary to determine whether preoperative MRI can improve DFS or OS in patients with invasive lobular carcinoma (24).

MRI is also indicated before neoadjuvant therapy in patients with potentially operable stage IIIa breast cancer (18, 23) or at stage II if the tumor is too large with respect to the breast volume, provided that performing an MRI does not significantly postpone neoadjuvant therapy initiation (23). Pretreatment MRI facilitates comparison with postneoadjuvant therapy imaging, enabling accurate preoperative planning. Molecular markers from percutaneous core biopsy samples should be required to select the appropriate neoadjuvant therapy (25), enabling an earlier beginning of treatment. In patients with multifocal/multicentric breast cancer and candidates for neoadjuvant therapy, obtaining molecular markers in each focus has been suggested (17), because heterogeneity among foci with the same histotype in terms of biological features is possible, changing the appropriate neoadjuvant therapy. However, these findings were obtained from the analysis of surgical specimens rather than biopsy samples.

It is useful to implant metallic markers inside the tumor prior to neoadjuvant therapy to avoid the risk of losing sight of the tumor during surgery, which occurs in 10%–50% of cases (9, 25). Current nickel-platinum metallic markers are compatible with MRI (Fig. 2). If neoadjuvant therapy shrinks the tumor volume significantly, breast-conserving treatment will be performed (4, 8–11, 23). In carefully selected stage IIIb to IIIc breast cancer patients, neoadjuvant therapy could downstage the tumor to enable breast-conserving treatment, although the data are sparse, and the usual treatment will be neoadjuvant therapy plus mastectomy and RT, as in poor responders to neoadjuvant therapy and in inflammatory breast carcinoma (11).

Axillary spread

The most common site of the lymphatic metastases of breast cancer is the axillary lymph nodes, even in me-

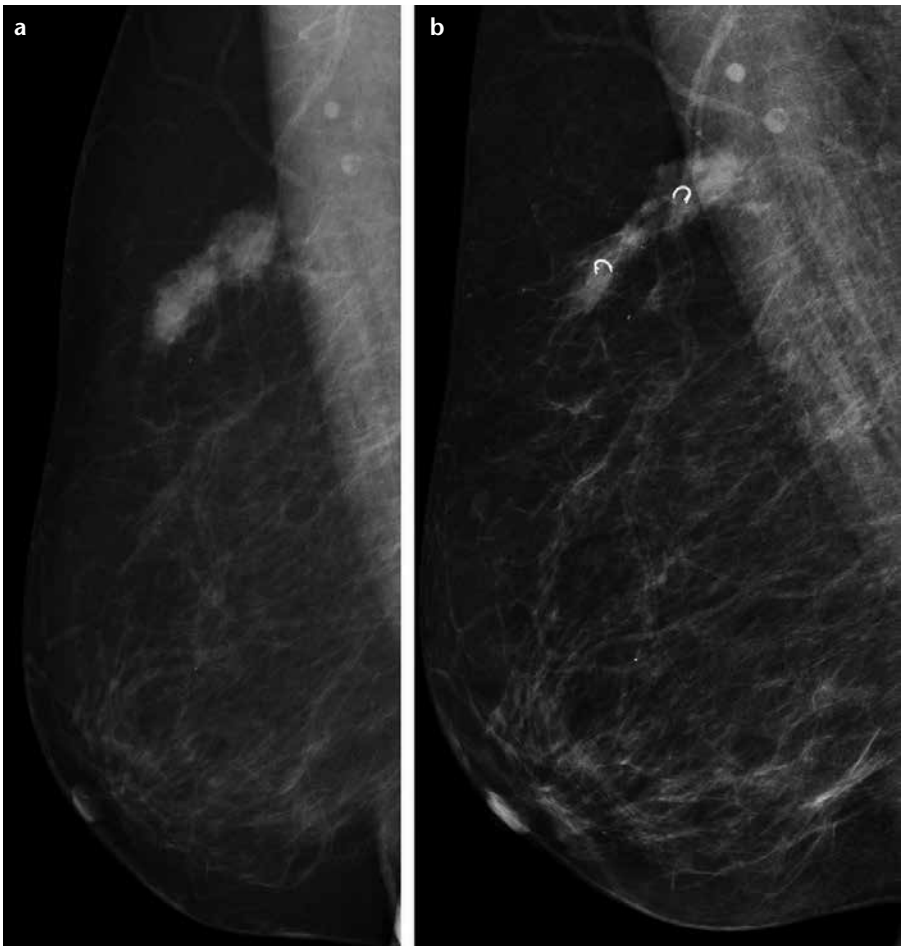

Figure 2. a, b. A 48-year-old woman with locally advanced invasive ductal carcinoma in the upper-external quadrant of the right breast. Mediolateral oblique mammograms before **(a)** and after **(a)** neoadjuvant chemotherapy show a partial response to the treatment. Two metal markers were implanted into the lesion prior to neoadjuvant chemotherapy.

dially located tumors. It is essential to know the axillary status for staging, choosing the appropriate treatment and establishing the patient´s prognosis (26, 27). Sentinel lymph node biopsy has replaced axillary lymphadenectomy as the method of choice for detecting lymph node metastases because this technique reduces the axillary morbidity (lymphedema, paresthesias) without a reduction in diagnostic accuracy in experienced institutions. However, a degree of risk persists, and the method is highly dependent on the surgeon's experience and is time- and resource-consuming, so it is advisable to minimize the number of procedures (27, 28). Axillary US and axillary US-guided fine-needle aspiration or percutaneous core biopsy are rapid, inexpensive and safe methods of staging the disease of the axilla, and there is much evidence of usefulness (26–28). Axillary US should be performed to detect lymph nodes suspected of malignancy, which are characterized by a cortical thickening greater than 3 mm, a bulge in contour and the absence of a central fatty hilum (the most suspicious features), a rounded (not oval) shape and predominantly peripheral vascularization (26, 27, 29). For detection, a fine-needle aspiration or percutaneous core biopsy must be performed. A positive result makes sentinel lymph node biopsy an unnecessary technique at this time, and axillary lymphadenectomy, with the dissection of axillary levels I and II (low and middle), should be performed during a surgical breast procedure. If a negative result is obtained or if suspicious lymph nodes are not observed by axillary US, a sentinel lymph node biopsy must be performed because it is a more sensitive method (3, 4, 26).

Axillary US and axillary fine-needle aspiration or percutaneous core biopsy offer a low yield in patients with tumors less than 1 cm in diameter, so it only seems advisable to perform axillary US in patients with tumors larger than 1 cm (26).

The choice between fine-needle aspiration and percutaneous core biopsy depends on the radiologist's experience and the cytology support in each institution. Fine-needle aspiration has several advantages, as this method is less aggressive, better tolerated by the patients, less expensive, and has a sensitivity is similar to that of percutaneous core biopsy. Although fine-needle aspiration is less specific, a positive result for metastatic adenocarcinoma is sufficient to obviate sentinel lymph node biopsy (26).

Patients with abnormal axillary US and a positive fine-needle aspiration or biopsy are considered to be clinically node-positive and were not included in the conclusions of the Z0011 trial (30). In particular, in patients with limited sentinel lymph node metastases, axillary lymphadenectomy does not improve survival, and the risk of loco-regional recurrence seems to be controlled by RT and adjuvant therapy.

Distant spread

In stages I and II, it is not necessary to perform additional radiological studies, such as total-body computed tomography (CT) or bone scintigraphy, to consider a woman free of metastases if there are no suspicious symptoms or blood-test alterations, as distant metastases are uncommon in these stages (11). Moreover, the indiscriminate use of these tools would produce a high false-positive rate, causing unjustified anxiety in many patients and a remarkable increase in costs (31). These procedures (or at least chest radiography plus liver US instead of CT) are recommended in stage III, which has a significantly higher risk of distant metastases (3, 11, 31). A pathological confirmation of metastases should be performed whenever feasible by fine-needle aspiration, percutaneous core biopsy or surgical biopsy (3).

Evaluation of response to neoadjuvant therapy

The best available marker for OS and DFS after neoadjuvant therapy is

the pathological complete response, and namely, the absence of invasive carcinoma after removing the volume where the tumor was located, corresponding to grade 5 of the Miller and Payne histological grading system (32). To evaluate the degree of response to neoadjuvant therapy is a major challenge in radiology. MRI clearly seems to be the best imaging technique for this assessment (9–11, 18, 22, 23, 33), identifying residual disease after treatment (tumor persistence). However, the correlation between the residual size of the tumor determined by MRI and the pathology is not accurate, with a risk of over- or underestimation. The benefit to OS and DFS of additional MRI during treatment, aimed to assess the early and intermediate tumor responses (chemosensitivity), is yet to be established (23).

Chemosensitivity

The question is how to distinguish responder from nonresponder tumors after the first cycle of neoadjuvant therapy to detect the need for a change in therapy. At this stage, morphological changes are not observed. Only modifications in perfusion and metabolism that can be detected by molecular imaging techniques, such as magnetic resonance (MR) spectroscopy, DWI, positron emission tomography (PET), and single-photon emission CT (SPECT) are observable (8). These techniques have limited spatial resolution, but MR spectroscopy and DWI can be reinforced with MRI, and PET or SPECT with CT (12). It has been reported that MR spectroscopy can distinguish responder from nonresponder tumors 24 hours after the first cycle. In responder tumors, MR spectroscopy detects a decrease in the choline peak, which is a marker of cell turnover or cell membrane breakdown (18).

DWI detects changes in water diffusion, which is restricted in invasive cancers, which show a high DWI signal intensity. However, this behavior is not specific, so the use of the apparent diffusion coefficient (ADC) is recommended to assess changes in water diffusion. A high DWI intensity has a low ADC value (33); therefore, the ADC value is lower in breast cancer than in normal tissue or benign lesions. After neoadjuvant therapy, a low ADC value would suggest a low cytotoxicity, and therefore, the presence of viable tumor tissue. Large prospective studies are needed to establish the reliability of MR spectroscopy and DWI for assessing chemosensitivity (11, 23).

The changes monitored by MRI in patients who receive neoadjuvant therapy are predictive of responses in basal-like or triple-negative (ER-, PgR, and HER2-) and HER2-like (ER and PgR-, HER2+) subtypes but not in the most common luminal subtypes (ER or PgR+) (34). Basal-like cancers have a worse prognosis and greater association with BRCA mutations (13, 35). BRCA mutation carriers have an up to 70% chance of developing breast cancer over their lifetime (22) and a higher incidence of new primary cancer (5). Unlike local recurrences, new primary cancers appear in different locations than the primary tumor, with a different histological pattern and after a long time interval (5). Because there is no definitive correlation between BRCA mutations and a significant increase in loco-regional recurrence, the presence of these mutations does not contraindicate breast-conserving treatment (5, 35, 36).

Tumor persistence

MRI is the best technique to identify residual tumor but has a certain risk of underestimation due to the vascular obliteration caused by neoadjuvant therapy. Neoadjuvant therapy reduces tumor vitality but also gadolinium enhancement, therefore decreasing the ability to detect the tumor (23, 37). Six weeks after the first cycle, the pathological uptake and washout curve disappears or slows (37). Residual tumor has been surgically identified in up to 30% of cases without a tumor visible by MRI (MRI false negatives), with greater residual tumor for non-mass-forming lesions than for mass-forming lesions. Greater underestimation is also observed with the use of taxanes than with the use of other chemotherapeutic agents (23, 37). In any case, surgery must be performed after neoadjuvant therapy, even without MRI evidence of disease (8, 18).

The measurement of responses according to the Response Evaluation Criteria in Solid Tumors (RECIST) is advisable (23, 38). In RECIST, four groups are categorized: complete responders (the complete vanishing of the tumor), partial responders (a decrease in the sum of the tumor lengths by 30% or more compared with the baseline examination and/or evidence of residual nonmeasurable disease) (Fig. 3), progressive disease (an increase in the sum of the tumor lengths by 20% or more compared with the smallest total length during treatment or the appearance of incontrovertible new disease) and stable disease (the remainder) (38). New volumetric methods to improve the assessment of the response to neoadjuvant therapy are being developed (39).

DWI has a diagnostic ability equivalent to MRI for the detection of residual tumor after neoadjuvant therapy. As DWI does not need gadolinium, this method could be advantageous in women with impaired renal function (33).

The delay after finishing neoadjuvant therapy and before surgery should be as short as possible and should intercalate MRI. In the clinical and conventional imaging of poor responders (progressive or stable disease), MRI usually confirms the results (very low rate of false positives) and is thus unnecessary (23).

Surgery

If lumpectomy is feasible, the radiologist can help the surgeon to obtain negative surgical margins, or the presence of tumor cells more than 1 mm in distance from the specimen's edges, although there is no consensus about the adequate width (Fig. 4) (4, 5). Obtaining negative margins is the key to avoiding loco-regional recurrence, which is the main problem in breast-conserving treatment (5, 22), affecting DFS and OS (40). It has been shown that a significant improvement in long-term local control with margins wider than 1 mm is unlikely (41). Two radiological procedures are useful (4, 5): a) Presurgical installation of a mammogram- or US-guided wire in or near the tumor. The radiology report must include the path of the wire, whether the wire passes through the lesion and the distance from the skin at the entrance of the wire to the skin overlaying the tumor. The surgeon will make an incision in the skin overlaying the tu-

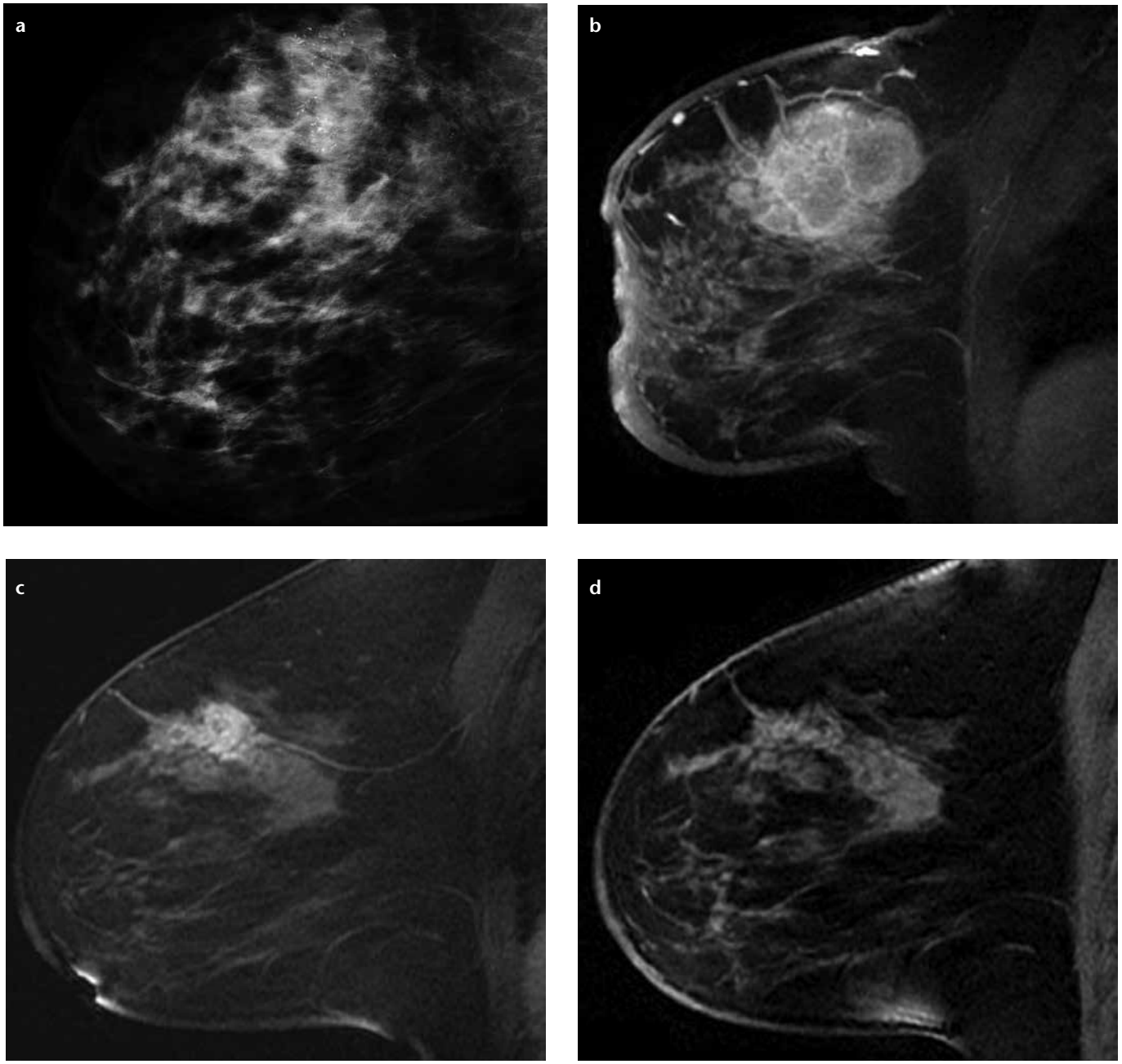

Figure 3. a–d. A 40-year-old woman with locally advanced invasive ductal carcinoma. A mediolateral oblique mammogram of the right breast **(a)** shows a 3.2 cm long-axis lobulated mass in the upper quadrants with associated microcalcifications. Moreover, several suspicious axillary lymph nodes were observed on US (not shown). A BIRADS code 5 (predictive positive value for cancer higher than 95%) was assigned. A diagnosis of triple-negative invasive ductal carcinoma with axillary invasion was obtained by US-guided percutaneous core biopsy in both lesions. Sagittal, fat-suppressed, contrast-enhanced T1 MR images before neoadjuvant chemotherapy **(b)**; after four cycles of doxorubicin plus cyclophosphamide, with one cycle every three weeks **(c)**; and after completion of treatment with four cycles of the taxane docetaxel (Taxotere®, Sanofi-Aventis, Paris, France), with one cycle every three weeks **(d)** are seen. In image before neoadjuvant chemotherapy **(b)**, a 6 cm long-axis lobulated mass with intense enhancement was observed, occupying both upper quadrants (multicentric tumor). In image **(c)**, the mass shrunk to 2.5 cm, and only one lymph node was observed. In image **(d)**, axillary lymph nodes and suspicious images of the breast (mass or enhancement) were not observed. According to RECIST, the tumor was categorized as a complete responder. Two weeks later, a mastectomy plus axillary lymphadenectomy was performed, and scattered nests of carcinoma in the upper quadrants of the breast and axillary lymph nodes were detected.

mor or as close as possible, attempting to remove the tumor in a single specimen, with negative margins and good cosmetic results. US-guided intraoperative installation depends on radiologist availability. b) Radiography or US of the surgical specimen before intraoperative margin study to assess whether the lesion is fully included. This step is more important in nonpalpable lesions, such as microcalcifications. It must be reported to the surgeon if the surgical margins need to be extended.

Between 20% and 30% of women undergoing lumpectomy may require additional surgery due to positive margins (Fig. 5) (42). Postoperative breast MRI is the most useful technique for

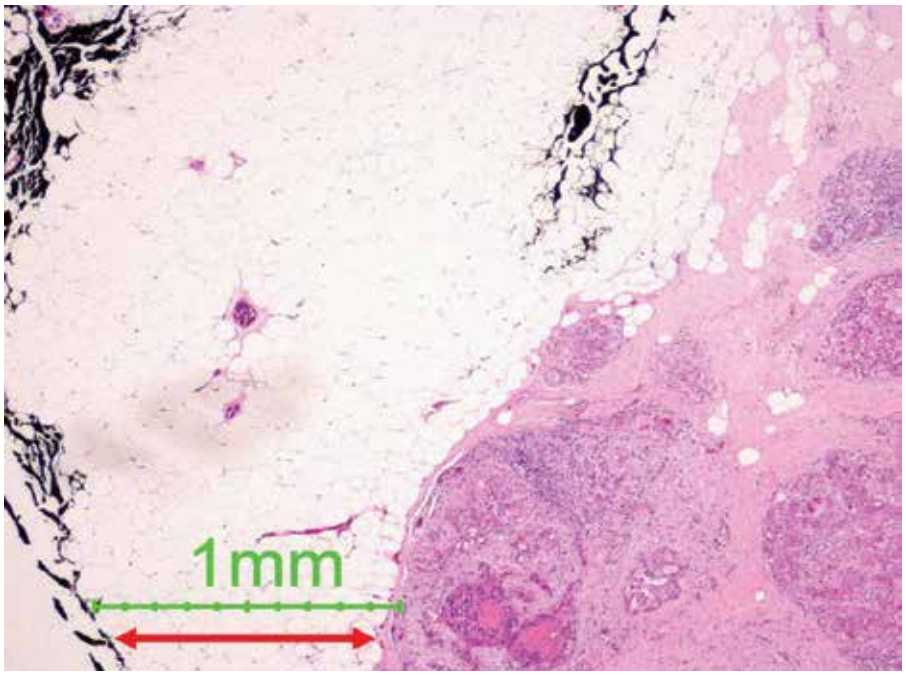

Figure 4. A 61-year-old woman with invasive ductal carcinoma. Microphotograph of the surgical specimen stained with hematoxylin-eosin (H-E) at the original magnification (×4) is seen. The tumor tissue is less than 1 mm from the edge of the specimen, marked with ink at the bottom of the photograph (*double-headed red arrow,* narrow margin). The width corresponding to 1 mm is shown by a scale in green. At the upper part of the photograph, the margin is negative because the space between the tumor tissue, and the edge of the specimen is wider than 1 mm and is occupied by adipose tissue.

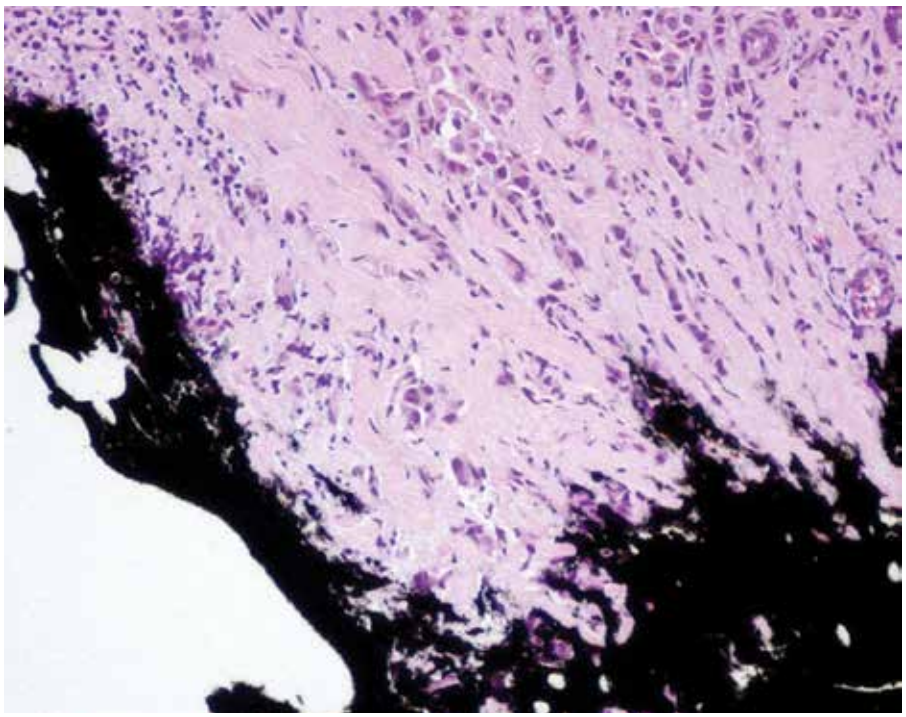

Figure 5. A 50-year-old woman with invasive ductal carcinoma with positive margins. Microphotograph of the surgical specimen stained with H-E at the original magnification (×40) is seen. The tumor tissue is in direct contact with the edge of the specimen, which is marked with ink.

evaluating residual tumor and deciding upon the extent of the additional excision. However, this method is not included in the current practice of many institutions. MRI should be performed as soon as possible after surgery (18, 22). A ring enhancement detected by MRI around the postsurgical seroma, with a thick contour (larger than 5 mm) that is nodular or irregular, suggests the presence of residual tumor, and a thin and uniform enhancement suggests the absence of disease. In tumors with microcalcifications, a mammogram will be preferable (22).

Radiofrequency ablation in early breast cancer

The possibility of avoiding surgery in early cases using percutaneous procedures performed by radiologists is being evaluated. The most promising technique seems to be radiofrequency ablation, based on the high sensitivity of tumor cells to hyperthermia (43). The main inconvenience of radiofrequency ablation is that this method does not allow surgical margin evaluation. There are still no data about DFS, OS, or long-term cosmetic results because the research period has been brief. Studies suggest that radiofrequency ablation can be an alternative in tumors less than 2 cm in diameter (T1) without an associated *in situ* component, which are clearly visible using the imaging technique with which radiofrequency ablation is performed (usually US). The tumors should also be located 1 cm away from the skin or the pectoral muscle to avoid lesions (43). It is necessary to exclude axillary involvement before radiofrequency ablation. As ablation makes the posterior evaluation of molecular markers impossible, these markers must be determined from a previous biopsy (43). Radiofrequency ablation is not recommended in invasive lobular carcinoma due to this cancer's higher risk of microscopic spread (44).

Radiotherapy post-treatment follow-up

Whole-breast RT is performed after breast-conserving surgery, except in patients with absolute (pregnancy, previous breast RT) or relative (connective tissue disorders, except rheumatoid arthritis) contraindications because this method eliminates residual microscopic tumor foci, achieving a significant decrease in loco-regional recurrence (4, 5, 8, 13, 37, 45) and improving OS and DFS (8, 34, 40).

Clinical history, physical examination, and mammography are the key elements required for the early detection of loco-regional recurrence after treatment (8, 12, 46, 47), improving OS (48). Most guidelines recommend performing the first mammogram one year after the initial diagnosis and at least six months after the end of RT because radiation effects are more visible from 6–12 months after RT and disappear over time. Mammograms are recommended yearly for a long time or even for life (46, 47), including for the contralateral breast (4). Mammographic stability (the absence of changes in two successive controls) is usually achieved 2–3 years after treatment (4, 46, 49). Subsequent findings will be considered suspicious for loco-regional recurrence and must be biopsied unless the findings are benign according to the BIRADS criteria (Fig. 6). Most of the recurrences appear 3–5 years after the initial diagnosis, but recurrence has also been described during the following 15 years (4, 46, 47).

The changes in breast tissue due to RT are an increase in density, skin thickening, microcalcifications or architectural distortion, and the differential diagnosis of loco-regional recurrence may be difficult in certain cases (46, 49). Additional mammographic projections, US, percutaneous core biopsy, or even MRI may be needed if it is not possible to perform a biopsy (23, 47). MRI improves the differentiation of a radial scar from locoregional recurrence when imaging is performed 12–18 months after the end of RT but could also be useful after only three months (50). In any case, there is no evidence regarding the value of routine MRI follow-up (23, 47), bone scintigraphy, PET or CT scans, liver US, or chest radiography (47).

Accelerated partial breast irradiation consists of applying RT only to the tumor bed and surrounding areas, decreasing the radiation dose delivered to the uninvolved portions of the breast and adjacent organs. Possible applications could be in those women who underwent previous RT of the thorax and breast for lymphoma treatment (13) or in selected women older than 60 years with early breast cancer, but it is unlikely that accelerated partial breast irradiation will replace RT for most patients treated with lumpectomy (45). There are no available data that justify previous breast MRI to accelerated partial breast irradiation (45), although in certain articles, this method is recommended (23).

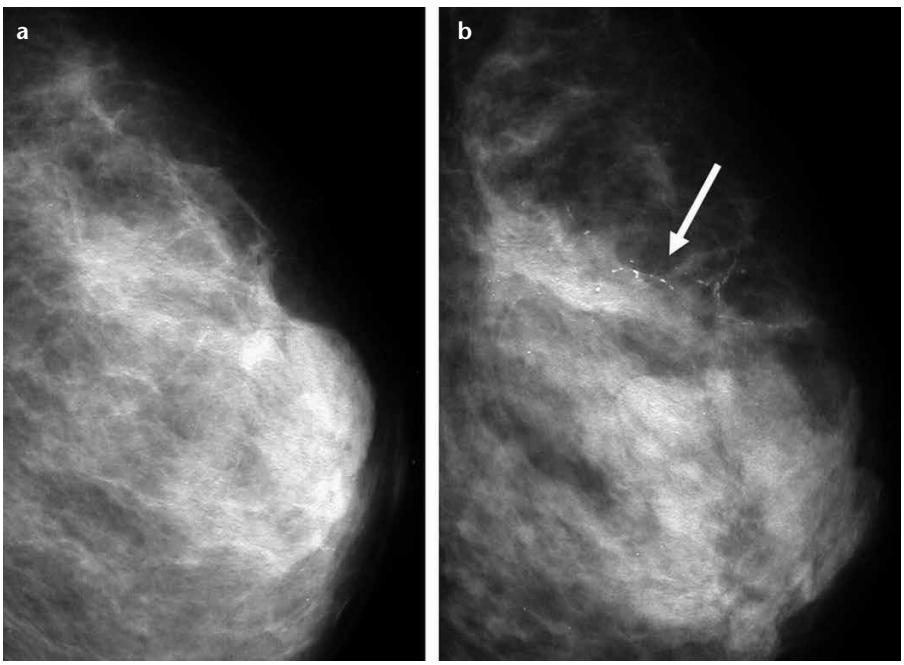

Figure 6. a, b. A 33-year-old woman with invasive ductal carcinoma with an extensive intraductal component in the upper outer quadrant of the left breast underwent breast-conserving treatment. Mediolateral oblique mammogram one year after treatment **(a)** is seen. The same projection one year later **(b)** showed suspicious microcalcifications with a ductal distribution in the surgical bed *(arrow)*. A BIRADS code 4 was assigned (predictive positive value for cancer, 2%–95%), and a biopsy with stereotactic guidance was performed. An invasive ductal carcinoma was diagnosed. In this case, the recurrence appeared earlier, two years after finishing the treatment, whereas recurrence usually takes at least three years. A mastectomy was subsequently performed.

Conclusion

The role of radiologists in the management of breast cancer is summarized in the following points:

- Diagnosis should be performed using a mammogram, US and imaging-guided percutaneous core biopsy or vacuum-assisted biopsy, and a surgical biopsy should be recommended in cases of radio-pathologic discordance (if the lesion was incorrectly sampled, repeat percutaneous core biopsy) or atypical ductal hyperplasia. In other high-risk lesions, there is no standard of care. In high-risk women, screening with breast imaging procedures is advisable, but there is not yet robust evidence of these methods' impact on improving survival.
- If invasive lobular carcinoma is diagnosed or if pectoral muscle infiltration is suspected due to a mammogram or US, MRI should be performed for staging. The need for pretreatment MRI in all patients with invasive ductal carcinoma is not clearly established. If multifocality/multicentricity is suspected, the malignancy in each focus should be confirmed by a percutaneous core biopsy because such features would alter the type of surgery. DWI can help to select the most suspicious focus, reducing the number of negative biopsies.
- An ipsilateral axillary US should be performed if the tumor is greater than 1 cm in diameter. If suspicious lymph nodes are observed, a fine-needle aspiration or percutaneous core biopsy must be performed.
- When locally advanced carcinoma is suspected due to the tumor volume and/or degree of axillary spread, requesting molecular

marker testing in percutaneous core biopsy samples is advisable because this information allows the earlier planning of neoadjuvant therapy.

- In locally advanced carcinoma or whenever metastases are suspected, bone scintigraphy and total-body CT (or at least chest radiography and liver US) are recommended. A histopathologic confirmation of suspicious lesions is needed.
- Before neoadjuvant therapy, a metallic marker should be implanted into the lesion. Pretreatment MRI and MRI after the end of neoadjuvant therapy should be performed to establish the surgical decision. MRI during treatment for monitoring the response and noncontrast sequences to assess chemosensitivity requires large prospective studies to establish this method's reliability.
- The placement of a wire into the tumor before surgery and imaging studies of surgical specimens help to obtain negative margins. If new surgery is necessary due to positive margins, MRI would be advisable for planning the procedure, and a mammogram is necessary in tumors with microcalcifications.
- Large prospective trials are needed to assess the reliability of radiofrequency ablation.
- After treatment, a long-term follow-up is necessary for the early detection of loco-regional recurrence or new tumors, usually with annual mammograms. If suspicious findings are observed, a percutaneous core biopsy is needed. MRI or other image scans are not recommended in routine breast cancer surveillance.

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Conflict of interest disclosure

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