Magnetic Resonance Imaging after Breast Oncoplastic Surgery: An Update

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Summary

Breast-oncoplastic surgery, allowing local tumor control and a better cosmetic outcome, is oncologically safe when applied to early-stage breast cancer. Breast cancer recurrence following conservative therapy may occur during the first 5 years after treatment, with a peak incidence after 2 years. Therefore, during the follow-up period, patients undergo a series of ultrasound (US) and mammographic examinations. However, after surgery and radiation therapy, several modifications occur in the treated breast, causing difficulties in image interpretation, especially when local recurrence is suspected. Although not included in routine follow-up, magnetic resonance imaging (MRI) is often used in clinical practice, being considered more sensitive than the conventional imaging examinations in discriminating between post-surgical tissue modifications and tumor recurrence. In this review article, we analyze expected and pathologic breast MRI findings after conservative oncoplastic surgery compared to US and mammographic findings in order to distinguish local recurrence and avoid potential pitfalls in image interpretation.

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Introduction

Breast cancer is the most common malignancy in women worldwide [1]. The introduction of mammographic screening programs has led to an increase in the number of breast cancer cases diagnosed at an early stage [2], often as non-palpable lesions [3], that can be treated with breast-conserving surgery (BCS) [4, 5], as also described for sarcomatous breast lesions [6, 7]. BCS followed by radiation treatment represents the standard of care in patients with early-stage breast cancer [8]. Several studies confirmed that this procedure shows equivalent survival rates (more than 20 years) compared to mastectomy [8–10]. Breast oncoplastic surgery (BOS) comprises the surgical excision of breast cancer that allows oncologically safe breast conservation and breast remodeling, reducing postoperative deformities [11–13]. Local tumor recurrence is the most important issue after BOS and is directly related to the presence of residual tumor cells in the remaining breast parenchyma [13, 14]. In fact, most cases of isolated local recurrence (i.e., without systemic metastases) usually occur in the first 2–3 years after surgery [9]. Moreover, after surgery and radiation therapy, several changes occur in the breast tissue which may cause difficulties in image interpretation during the follow-up period, especially when local recurrence is suspected [15, 16]. There is currently no sufficient evidence to recommend or not recommend magnetic resonance imaging (MRI) in the follow-up of patients having undergone BCS [17]. Current guidelines do not recommend MRI for routine breast cancer follow-up in asymptomatic patient; its use is recommended only in the case of clinical or radiologic suspicious findings [17]. Usually patients undergo a series of ultrasound (US) and mammographic examinations performed at different times during the follow-up period [15, 16, 18]. MRI may be considered after BOS as an evaluation tool for resid-

Fig. 1. Patient having previously undergone breast oncoplastic surgery (BOS). **a** Mammographic examination showing a typical radiolucent rounded image surrounded by a thin radiopaque rib. **b** Ultrasound image documenting a hypoechoic area with blurred margins and posterior acoustic shadowing. **c, d, e** Magnetic resonance imaging findings documenting a round focal lesion with high signal intensity in T1 non-fat-saturated sequence (c), and low intensity in T2 short tau inversion recovery (d) and T1 fat-saturated sequence (e). The morphological and signal intensity findings are suggestive of fat necrosis.

ual disease in the case of post-resection positive tumor margins, and for the evaluation of suspicious recurrences that present on either clinical examination or mammography/US examination; third, MRI is recommended as a screening tool in all patients at high risk of recurrence after breast cancer treatment [19]. Unfortunately, early postoperative MRI is affected by the strong enhancement of resection margins in response to inflammatory postoperative reactions. Therefore, MRI is unable to exclude possible residual tumor until at least 12–18 months after completion of breast-conserving therapy [19]. However, in the clinical setting, MRI is often used as part of the routine post-treatment follow-up, being considered more sensitive than conventional imaging investigations in discriminating between postsurgical tissue modifications and tumor relapse with a high negative predictive value and a sensitivity of 90–100% and a specificity of 89–92%, preventing unnecessary biopsies [20, 21]. The European Society of Breast Cancer Specialists (EUSOMA) guidelines for breast MRI indicate that the examinations should be performed with at least 1.0-tesla magnets and bilateral dedicated coils. In order to reduce the risk of false positives, premenopausal women should undergo the examination ideally on days 6–13 of the menstrual cycle [22]. The MRI protocol should include a morphologic study, using at least 1 unenhanced high-contrast sequence such as T2-weighted fast/turbo spin-echo with or without fat saturation, short tau inversion recovery (STIR), or spectral presaturation with inversion recovery (SPAIR) sequences, followed by a 2D or 3D gradient-echo T1-weighted dynamic sequence acquired after the injection of a 2-compartment (vascular/interstitial) gadolinium-chelate at a standard dose of 0.1 mmol/kg and an injection rate of 2–3 ml/s, followed by saline flushing [22]. More recently, diffusion-weighted imaging (DWI) has become established in the clinical setting. DWI-MRI is a functional technique where contrast is based upon measuring the random Brownian motion of water molecules within a tissue. Highly cellular tissues or those with cellular swelling exhibit lower diffusion coefficients, and thus diffusion is particularly useful in tumor characterization [23].

The aim of this article is to describe common and uncommon breast MRI findings after BOS in order to identify potential pitfalls and aid the discrimination between normal and pathologic findings suspicious for tumor recurrence in image interpretation.

Fat Necrosis

Breast fat necrosis (FN) is a common benign inflammatory process resulting from aseptic fat saponification. Common causes of FN include surgery, radiotherapy, or trauma, especially in association with anticoagulation therapy [24, 25]. These influences cause blood vessel rupture with subsequent activation of lipolytic enzymes [24]. Normal adipose tissue is composed of cells containing triglycerides. Fatty acids, released from triglycerides into the interstitial space, form a complex with calcium, liquefying the tissue and causing aseptic fat saponification [25]. Fat necrosis frequently occurs in the subcutaneous fat tissue and in the subareolar region, both of which have a predominantly adipose composition. A recent study by Dolan et al. [26] compared imaging and biopsy results after BOS and breast lumpectomy. The rate of fat necrosis after oncoplastic BCS was 18% on clinical and 15% on US examination, and 7% were confirmed by pathology, showing that patients undergoing BOS require significantly more US examinations and subsequent biopsies than patients undergoing lumpectomy. This was mainly due to FN developing after BOS in the majority of cases.

FN is usually asymptomatic; however, sometimes patients may present with a palpable mass, ecchymosis, erythema, or skin thickening. The mammographic image is usually clear, showing a radiolucent rounded image surrounded by a thin radiopaque rib [27]. However, the possible presence of calcifications may lead to the suspicion of disease relapse [27]. The US image may also be misleading, showing an apparent hypoechoic area with blurred margins and posterior acoustic shadowing [28, 29] (fig. 1). On MRI, FN has different presentations depending on the stage of the process [30]. The most common MRI image is a round or oval mass showing

Fig. 2. Patient having recently undergone conservative surgery and radiotherapy for cancer in the lower quadrants of the right breast. **a** Axial T2 short tau inversion recovery sequence showing widespread edema of the breast and diffuse skin thickness; **b** post-contrastographic image showing no pathologic enhancement.

high signal intensity on T1-weighted non-fat-saturated images, which appears hyperintense on T2-weighted non-fat-saturated and hypointense on fat-saturated images (fig. 2). In particular, T1-weighted fat-suppressed sequences are helpful to differentiate fat from blood which also shows high-signal intensity on T1-weighted images [30]. As fat-containing lesions are extremely uncommon in malignant conditions, the presence of fat is extremely useful for differentiating FN from a malignant lesion [31, 32]. A fat-fluid level may be present [33]. In post-contrastographic images, FN shows several degrees of enhancement, depending on the stage (acute or chronic) of the inflammatory process [32]. More recent lesions present with irregular contours and may have variable enhancement surrounding the lesion, while older lesions show marked irregularity, retraction, and fibrosis, and generally do not enhance [32].

Lipofilling

Patients' expectations for a natural-shape after BOS are high [34]. Lipofilling is a reconstructive and aesthetic technique increasingly used in breast surgery, both in BCS and for reconstruction after radical surgery [35]. Firstly described by Czerny [36] in 1895 who performed breast augmentation with a lipoma removed from the patient's lumbar region, in the 1980s, lipofilling raised concerns regarding the modifications and scarring that this procedure could cause in the breast, which in turn could interfere with breast screening [37, 38]. In 2009, the American Society of Plastic Surgeons (ASPS) Fat Graft Task Force assessed the efficacy of the procedure in 283 patients, documenting only 37 (12.7%) complications, the most frequent being liponecrosis in 16 (5.7%) cases [39]. The main diagnostic difficulties in evaluating patients having undergone breast lipofilling after BOS are mainly related to FN [32]. Patients may clinically present with palpable and painful mammary swelling, and the mammographic and US images may be misleading. In these cases, MRI, thanks to fat-suppressed and post-contrastographic sequences which demonstrate a non-enhancing fat-containing mass on T1-weighted images, may be helpful in discriminating between breast cancer relapse and liponecrosis [31, 33].

Breast Edema and Skin Thickening

After BOS, breast edema and skin thickening are often found due to small vessel damage. Edema of the mammary gland post-surgery usually occurs close to the incision area, while edema after radiation therapy usually encompasses the entire breast [40, 41]. The clinical examination reveals all the signs of inflammation such as skin that is warm to the touch and reddened, tissue stiffness, and soreness [41]. Skin thickening and breast edema can cause diagnostic difficulties in the mammographic examination because of the increase in breast density [42]. In these cases, the US image shows diffuse structural dishomogeneity and edematous imbibition, together with evidence of skin thickening. This modification may be better evaluated through MRI on T2-weighted sequences with fat suppression if the skin is thicker than 4 mm, and it is best appreciated when compared to the contralateral breast [40]. No enhancement is found after contrast administration (fig. 2). These alterations are more evident during the first 6 months after radiation therapy and usually become reduced and stabilized over a 2–3-year period in the majority of patients [40]. An increase in skin thickening or breast edema after this period warrants further investigation, being suspicious for inflammatory breast cancer [43].

Fluid Collection

The most common fluid collections occurring after BOS are seroma and hematoma [44–46]. Seroma is a frequent complication, particularly after axillary lymph node dissection [44]. The mammographic image usually depicts an area of homogeneously increased density, while the US findings document an anechoic fluid collection with no hyperechoic component due to fibrin clot formation, which would be present in the case of hematoma. Seroma shows low signal intensity on T1-weighted sequences and high signal intensity on T2-weighted sequences, with or without fat suppression [45]. Hematoma is a less common postsurgical complication (reported incidence of 2–10% of cases) often occurring in patients receiving anticoagulant therapy or non-steroidal anti-in-

flammatory drugs [46]. Presentation may vary, depending on the location and the size of the hematic collection. Large hematomas may need surgical evacuation [47]. On MRI, breast hematomas show a varying signal according to the hemoglobin degradation status (high signal on T1-weighted in the subacute stage, low signal on T1/T2-weighted in the chronic stage) [48]. If a fluid collection resolves on its own without an invasive procedure, the same images will likely not be seen in follow-up investigations. However, as they dissipate, fibrous tissue in the site of the fluid collection can appear as an architectural distortion [48].

Fibrosis, Architectural Distortion, and Skin Retraction

Fibrosis is a radiologic finding of the late phase after BOS. The mammographic imaging of the breast scar is usually a focal distortion of the normal parenchymal architecture, while the US im-

aging may appear as an interruption of the normal tissue together with structural alterations [48]. On MRI, fibrosis has a heterogeneous signal, appearing hypointense on T1/T2-weighted images and showing variable degrees of enhancement in the earliest phase of the process and no enhancement in the late phase [48] (fig. 3). Architectural distortion and skin retraction are usually the result of different processes including postsurgical scar consolidation, FN, and severe fibrosis with disorganization of the collagen production. The typical MRI finding in the morphologic sequences without fat suppression is a spiculated irregular tissue area associated with changes in the contour of the skin [49]. These alterations can mimic a malignant recurrence [49]. The distinction is based on the dynamic enhancement pattern on contrast-enhanced MRI [49].

Tumor Recurrence

Local tumor recurrence is the relapse, after a variable period of time, of tumor cells in the original tumor site despite surgical treatment, while regional tumor recurrence is the additional spread of the primary cancer outside the breast, frequently involving the axillary lymph nodes [50]. Breast cancer recurrence following conservative surgery and radiotherapy usually occurs during the first 5 years after treatment, with a peak incidence after 2 years [9, 13, 51]. The risk of local tumor relapse in patients having undergone BOS is higher than in patients after mastectomy, in particular in premenopausal women and in the case of an invasive cancer with an extensive intraductal component [51]. The rate of local recurrence is 2% per year [51]. One of the most important current indications for performing an MRI study is to distinguish, after BOS, a tumor recurrence from scar tissue, with a sensitivity of 75–100% [52]. The sensitivity of MRI is higher at least 12–18 months after breast surgery compared to that of mammography (35–40%) [52]. MRI is a useful tool in the case of suspected recurrence when the conventional imaging techniques (i.e., mammography and US) are inconclusive or in conflict with the physical examination or other clinical indicators. Moreover, MRI is accurate in assessing the residual tumor extent in women after lumpectomy with close or positive resection margins [22, 53]. Some categories of patients, including those whose primary tumor was occult on mammography and those with infiltrating lobular cancer, should undergo a follow-up course based on MRI because of concerns that ipsilateral recurrent tumors will be difficult to detect through first-step breast investigations (i.e., mammography and US) [22].

Fig. 3. Patient having previously undergone breast oncoplastic surgery (BOS). **a** Axial T2 short tau inversion recovery and **b** T1 non-fat-saturated image showing the surgical scar and alteration of the surrounding parenchyma. **c** After injection of contrast, no enhancement of the scar is detectable.

Fig. 4. Axial T2 non-fat-saturated imaging **a** showing parenchymal distortion post-surgery. **b** After contrast administration, a mass-like enhancement near the surgical scar is evident, suggestive for local tumor recurrence, which was confirmed by core needle biopsy. The histopathologic diagnosis was invasive ductal carcinoma with foci of ductal carcinoma in situ.

Dynamic contrast-enhanced MRI more accurately reveals the presence, location, and extent of tumor recurrence compared to breast US or mammography [22]. The main advantage of MRI is the rapid contrast enhancement of malignant lesions compared to benign postoperative breast modifications [54] (fig. 4). On DWI, the tumor relapse shows diffusion restriction, while in post-contrastographic sequences it presents with rapid and intense contrast enhancement. In contrast, the majority of scars does not show diffusion restriction and does not significantly enhance [54]. Considering the diagnostic radiologic findings, if a suspicious enhancement is identified in the surgically treated breast gland, we believe that a core needle biopsy is indicated to confirm the suspected recurrence before performing surgery.

Conclusion

Breast cancer is the most common cancer in women. BOS has the purpose of achieving radical tumor excision while preventing local recurrence and reducing postoperative aesthetic deformities. MRI is the most sensitive technique in detecting local breast cancer recurrence. Although current guidelines do not recommend the use of MRI in the routine follow-up after BCS, it should be performed in uncertain cases, as well as in patients at high risk of tumor relapse.

Disclosure Statement

The authors declare that they have no competing interests.

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