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EPIDEMIOLOGY

Yield of surveillance magnetic resonance imaging after bilateral mastectomy and reconstruction: a retrospective cohort study

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Abstract

Purpose There are no evidence-based guidelines for surveillance of women after bilateral mastectomy and reconstruction. Several societies recommend against routine breast imaging in this setting. Despite these recommendations, magnetic resonance imaging (MRI) is frequently used to follow these women. We sought to examine the findings on MRI studies done in this setting.

Methods This is a retrospective cohort study including all consecutive MRI exams done after bilateral mastectomy and reconstruction between January 2010 and April 2018. Data collected included demographic information, family history, BRCA status, indication for bilateral mastectomy, type of reconstruction, findings on MRI, and work-up of MRI findings. Cancer detection rate and interval cancer rates were calculated.

Results One hundred fifty-nine women had 415 surveillance MRI exams. Most (372, 90%) studies were done in women with implant-based reconstruction. Four hundred and five (98%; 95% confidence interval (CI) 96–99%) of the studies were negative. One breast recurrence was found on MRI (cancer detection rate 2.4 per 1000 MRI exams, 95% CI 0.4–13); however, this woman was simultaneously diagnosed with metastatic disease. The false-positive rate was 90% (95% CI 54–99%). During follow-up three women were diagnosed with local recurrence (interval cancer rate 5 per 1000, 95% CI 1.3–17) and 4 women were diagnosed with metastatic disease.

Conclusion The yield of surveillance MRI in women with bilateral mastectomy and reconstruction is very low. As most of the cohort had retro-pectoral implant-based reconstruction, it appears safe to recommend against surveillance MRI in this setting regardless of the indication for mastectomy.

Keywords Breast cancer · Bilateral mastectomy · MRI · Surveillance · BRCA

Introduction

Women undergoing bilateral mastectomy and reconstruction represent a heterogeneous group with different indications for mastectomy, and hence different risks for developing breast cancer (recurrence or a new primary).

Data on routine breast imaging in women after bilateral mastectomy and reconstruction (for risk-reduction or a history of breast cancer) are very limited and there is controversy regarding the role of breast imaging in this setting. The National Comprehensive Cancer Network (NCCN) recommends against routine imaging of reconstructed breasts in women with a history of breast cancer [1], as does The National Institute for Health and Care Excellence (NICE) in the UK [2]. As for women undergoing risk-reducing bilateral mastectomy, there are limited data to support routine breast imaging [3]. The National Hereditary Cancer Task

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Force [4] recommends against any kind of routine breast imaging for surveillance. Despite these recommendations, routine imaging of patients after breast reconstruction is still widely practiced, based on reports in the literature. Some routinely screen all women after mastectomy and reconstruction regardless of the indication [5]. Madorsky-Feldman completed a survey of 22 centers examining their protocol for surveillance of BRCA mutation carriers after risk-reducing mastectomy. Most centers responding, do not offer routine surveillance in this setting. In the centers that offer routine surveillance, use of MRI varies widely with some recommending annual MRI with or without an upper age limit, while others use MRI to assess residual breast tissue, and limit the use of surveillance MRI to women with a significant amount of residual breast tissue [6].

Our center performs surveillance MRI after bilateral mastectomy and reconstruction. The aim of this study was to assess the yield of MRI in this group of women, specifically the cancer detection rate. We hypothesized that the yield of surveillance MRI in this setting is very low.

Methods

This retrospective cohort study was approved by our Institutional Review Board, and the requirement for informed consent was waived. The study cohort included all consecutive surveillance breast MRI exams done after bilateral mastectomy and reconstruction at our center (tertiary medical center) between January 2010 and April 2018. MRI exams of women after bilateral mastectomy without reconstruction, and diagnostic MRI exams were excluded. A retrospective chart review was completed, and the data collected included: patient demographics, family history and genetic predisposition, indication for mastectomy, and type of reconstructive surgery (implant-based, autologous, or a combination). Of note, not all surgeries were done at our medical center.

Data on MRI exams included indication for MRI, findings on MRI, further work-up done due to the MRI findings, and post MRI follow-up (clinical or imaging). Position of the implants relative to the pectoralis muscle was determined from the MRI study. All data extracted from the imaging studies were based on the original interpretation by experienced breast radiologists. In cases in which the original MRI report was insufficient (i.e., type of reconstruction or position of implant not mentioned), a second breast radiologist completed another review in order to obtain the necessary data.

MRI protocol: From January 2010 to September 2014 all MRI studies were performed with a 1.5T imaging system (Signa, GE healthcare, Milwaukee, USA), and from October 2014 onward studies were performed in a 3T magnet (Skyra, Siemens, Erlangen, Germany) or 1.5T magnet (Aera, Siemens, Erlangen, Germany). Patients were scanned in the prone position. A dedicated breast coil was used for all examinations. In premenopausal women, the scan was performed during the second week of the menstrual cycle. After obtaining axial fat saturated T2-weighted images (TR/TE 5270/89 or 4328/101.4), an axial T1-weighted 3D gradient-echo sequence was performed before and after injection of contrast material. The image parameters from January 2010 to September 2014 were as follows: TR/TE 8.89/1.7; flip angle 10°; matrix size 512 × 512; field of view 38 × 38 cm^2. From October 2014 onward image parameters were: TR/TE 5.3/2.4; flip angle 10°; matrix size 384 × 384; field of view 38 × 38 cm^2. For contrast-enhanced sequences, a rapid bolus injection of gadolinium-based contrast agent was used with a calculated dose of 0.2 mmol/kg of body weight and at an injection rate of 2 ml per sec. Dynamic sequences included one pre-contrast and five post-contrast acquisitions. The first contrast-enhanced dynamic sequence was performed 60 s after injection and was followed by 4 additional scans. Subtraction images were also obtained. All MRI studies were processed using a commercially available computed aided-detection system (CAD stream, Merge healthcare Inc., Chicago, IL, USA). Interpretation was based on the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) terminology: category 1, negative; 2, benign; 3, probably benign; 4, suspicious; and 5, highly suggestive of a malignancy. Patients with category 3 lesions were recommended for short-term (6-month) MRI follow-up. Patients with category 4 or 5 lesions were recommended for second look ultrasound (US) and biopsy. Biopsy of BI-RADS categories 4 and 5 lesions was performed by ultrasound-guided core-needle biopsy or fine-needle aspiration. Suspicious lesions not visualized on ultrasound were recommended for MRI guided needle or excisional biopsy.

Outcomes: The medical records were used to determine the frequency of local and distant recurrence. Based on the detection modality and time from previous MRI exam, the cancer detection rate (CDR) of surveillance MRI and interval cancer rate (defined as cancer detected within 1 year from MRI exam) were determined.

Analyses: False-positive findings were defined as category 0, 3, 4, or 5 MRI with a benign imaging follow-up study (for BI-RADS 0 and 3) or a benign histologic diagnosis (for BI-RADS 4 and 5). False-positive rates, CDR of surveillance MRI and interval cancer rates were calculated; Binomial distributions were assumed and 95% confidence intervals (CI) were estimated using the Wilson procedure.

Results

After exclusion of women undergoing bilateral mastectomy without reconstruction (N = 34), and those undergoing diagnostic MRI exams ($N = 11$) the study included 159 women

who had in total 415 MRI exams during the study period. Most (65, 41%) women had one study, 33 had 2, 20 had 3, and 41 women had at least 4. The median number of studies per patient was two (range 1–9). Characteristics of the study group are summarized in Table 1. Median age of the women at the time of the MRI exam was 47 years (range 23–82). Most (111, 70%) underwent bilateral mastectomy for a diagnosis of cancer. More than half tested positive for a pathogenic mutation in BRCA. Three hundred seventy-two (90%) of the studies were done in women with implant-based reconstruction. All implant-based reconstructions were retro-pectoral, except for two women that had on one side a retro-pectoral and on the other side, a pre-pectoral implant placed.

Four hundred and five (98%, 95% CI 96–99%) MRI studies were negative (i.e., BI-RADS 1 or 2). Ten studies had findings on MRI (Figs. 1, 2), all in women with a history of breast cancer. Table 2 summarizes the MRI findings and subsequent work-up in these women. Work-up of these findings included five image-guided needle biopsies, one MRI guided surgery, and 3 second look ultrasounds; all with benign findings. One woman was found to have a suspicious mass, yielding a cancer detection rate of 2.4 per 1000 MRI exams (95% CI 0.4–13), however, she was diagnosed simultaneously with metastatic disease. The false-positive rate was 90% (95% CI 54–99%). There were no findings in all the surveillance MRI exams done in women after risk-reducing mastectomy. At least one year of follow-up was available for 301 (73%) of the studies. Three women were diagnosed with local recurrence after a negative MRI (6 months, 10 months,

Table 1 Characteristics of the study group

	N (%)
Mean age, years (SD)	48, 6 (11)
Median, years (range)	47, (23–82)
Indication for mastectomy	
Risk-reducing	31 (20)
Unilateral cancer	85 (54)
Bilateral cancer	26 (16)
Missing	17 (11)
Family history	
None or unknown	56 (35)
Yes	11 (7)
BRCA pathogenic mutation	92 (58)
Reconstruction type[a]	
Implant	371 (89)
Autologous	32 (8)
Combined	12 (3)

SD standard deviation

[a]Reconstruction type per MRI exam. Several women had delayed reconstruction, or an implant replaced by autologous reconstruction

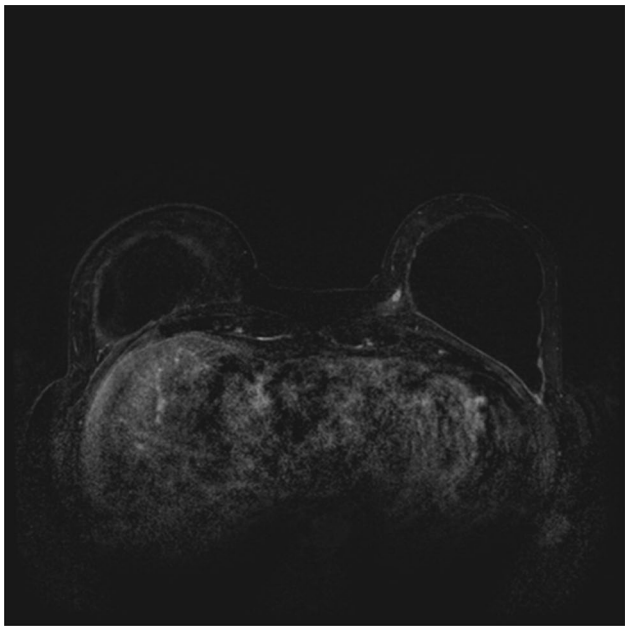

Fig. 1 Fifty-six-year-old woman after bilateral mastectomy and reconstruction with implants. Post-contrast T1 subtracted image showing a small enhancing mass in the lower inner quadrant of the left reconstructed breast. Second look ultrasound with percutaneous needle core biopsy was benign, one year follow-up MRI was negative

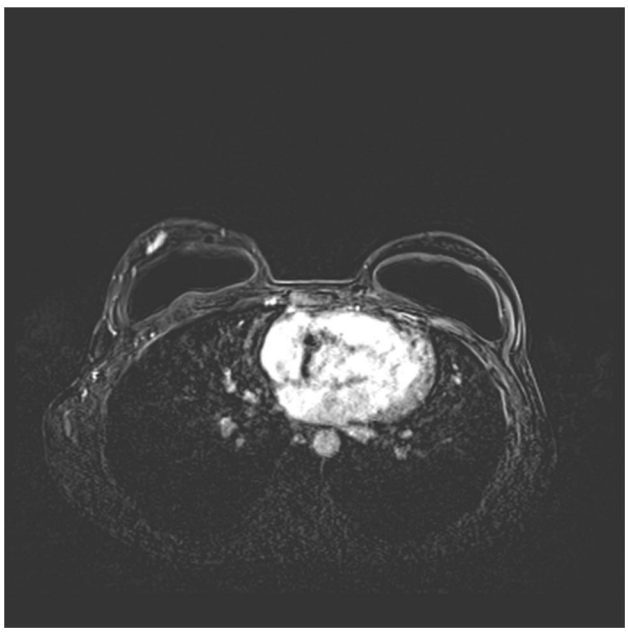

Fig. 2 Thirty-two-year-old woman after bilateral mastectomy and reconstruction with implants. Post-contrast T1 subtracted image showing linear enhancement on the right breast. Breast ultrasound was negative. Surgical biopsy after MRI guided localization was benign

Table 2 Summary of the women with findings on MRI

Age, years	Indication for bilateral mastectomy	Family history/BRCA status	Reconstruction	Findings on MRI	Work-up of MRI findings	Follow-up
39	Unilateral cancer	Carrier	Retro-pectoral implant	Suspicious mass	No, systemic disease	Systemic disease
49	Unilateral cancer	Carrier	Retro-pectoral implant	Axillary lymph node with thickened cortex	US, normal	Follow-up MRI, normal
57	Unilateral cancer	No[a]	Retro-pectoral implant	Slightly enlarged axillary lymph nodes	Needle biopsy, reactive lymph node	Follow-up MRI, normal
40	Unilateral, post local recurrence after mastectomy	Carrier	Retro-pectoral implant	Mass, possibly lymph node	Needle biopsy, intramammary lymph node	Follow-up MRI, normal
56	Unilateral cancer	Carrier	Retro-pectoral implant	Mass	Needle biopsy, benign	Follow-up MRI, normal
32	Unilateral cancer	No	Retro-pectoral implant	Linear enhancement in residual glandular tissue	MRI guided lumpectomy, benign	Follow-up MRI, normal
32	Unilateral cancer	No	Retro-pectoral implant	Focal enhancement in residual glandular tissue	Normal US	Normal MRI
40	Unilateral cancer	No	Retro-pectoral implant	Enhancing foci in residual glandular tissue	US guided FNA, benign	Follow-up MRI, normal
53	Unilateral cancer	Carrier	Retro-pectoral implant	Trabecular thickening in tissue	US, twice normal	Follow-up MRI and US, normal
33	Unilateral cancer	No	Retro-pectoral implant	Enhancing focus	US guided needle biopsy, benign	Follow-up MRI, normal

US ultrasound

[a]No family history or data not available

and 2 years after completing the study), yielding an interval cancer rate of 5 per 1000 (95% CI 1.3–17). Four women were diagnosed with metastatic disease during follow-up.

Discussion

Bilateral mastectomy is done for several indications (cancer, risk-reduction, or both) and with different types of reconstruction (none, implant-based, autologous, or a combination). Loco-regional recurrence after mastectomy for breast cancer varies considerably in different reports from 2.3% [7] and up to 30% [8]; whereas the risk of developing breast cancer in women undergoing risk-reducing mastectomy ranges from 0 to an annual incidence of 0.8% [9]. The role of routine breast imaging in these settings may differ.

After skin-sparing mastectomy residual breast tissue can be found in 60% of the women and correlates with the thickness of the skin flaps [10]. The site of a recurrent/new breast cancer after bilateral mastectomy is related to the location of the implant or new breast mound relative to the pectoralis muscle [7]. In most implant-based reconstructions, the implant is placed posterior to the pectoralis muscle with the posterior margin of excision displaced anteriorly to the reconstructed breast and therefore easily palpable. Zakhireh reviewed the data on loco-regional recurrence after bilateral mastectomy and concluded that most breast cancers in women with implant-based reconstruction are easily detectable by physical exam and therefore surveillance with imaging is not indicated [7]. In autologous reconstruction as well as pre-pectoral implant reconstruction, the posterior margin of excision is located posterior to the reconstructed breast. It is estimated that 50% of the recurrences in autologous or combined reconstructions are in the chest wall and therefore not amenable to early detection by physical examination [7].

Several studies examined the role of surveillance mammography after bilateral mastectomy and reconstruction. Lee et al. examined the role of surveillance mammography after bilateral mastectomy and Transverse Rectus Abdominis Myocutaneous (TRAM) flap reconstruction [11]. Five hundred fifty-four screening mammograms were done in 227 women post TRAM flap reconstruction. Eight exams required further evaluation. All were ultimately benign. They concluded that routine screening post TRAM flap

reconstruction with mammography is associated with a very low rate of diagnosis of non-palpable cancer. Helvie summarized results of 214 screening mammograms done in 113 asymptomatic women after TRAM flap reconstruction [12]. Two patients in this cohort were diagnosed with breast cancer. The authors concluded that the cancer detection rate of screening mammography for women with a previous history of cancer is 0.9%. However in a recent report from the same institution, the cancer detection rate of screening mammography in women after mastectomy and autologous breast reconstruction for breast cancer was lower (1.5 per 1000) [13]. In women undergoing surveillance mammography of autologous reconstruction after risk-reducing mastectomy, no cancer was diagnosed, prompting the authors to question the need for surveillance mammography in this setting [13]. As for women with implant-based reconstruction, one case report described a recurrence diagnosed by surveillance mammography [14].

Vanderwalde reported their experience with MRI after mastectomy in 48 women undergoing 79 MRI exams [15]. Sixty of these exams were done for surveillance. Sixty-eight exams were benign. In two, there were suspicious findings correlating with highly suspicious clinical findings. Pinel-Giroux reviewed the imaging findings in women post breast reconstruction and summarized their own experience in 119 women undergoing MRI after breast reconstruction [16]. They do not report the indication for mastectomy, if it was bilateral in all cases, the type of reconstruction, or the indication for performing MRI exams in these women. Thirty-seven (31%) studies required further evaluation, which included 14 diagnostic mammograms, 13 spot-magnification mammograms, 51 ultrasound exams, and 19 percutaneous breast biopsies. Five women were diagnosed with breast cancer, 3 of them with autologous breast reconstruction. As the clinical indication for the exam is not detailed, it is not clear if these cancers were symptomatic or not. To our knowledge, the present study is the largest study examining the yield of surveillance MRI in women after bilateral mastectomy and reconstruction. Of 415 surveillance MRI exams, 10 required further work-up. One woman was found to have a suspicious mass consistent with recurrence. This woman was diagnosed simultaneously with metastatic disease. Our findings underline the very low yield of surveillance MRI in this patient population and question the rationale for early detection of loco-regional recurrence after mastectomy as this often coincides with diagnosis of systemic disease [17].

This study is limited by its retrospective design, and the inclusion of a heterogeneous group of women with different indications for mastectomy and different types of reconstruction. Although the largest series to date to summarize findings on MRI in women post bilateral mastectomy and reconstruction, we were unable to perform subgroup analyses, such as assessment of the yield of MRI in women with different risks of recurrence or of primary breast cancer (based on age, BRCA status, or history and stage of cancer). MRI Surveillance may have a role in a certain subset of women. As 90% of the women in our study had implant-based reconstruction, we cannot comment on the role of MRI in women undergoing autologous or combined reconstruction; however, implants are more frequently used for breast reconstruction at present [13]. As not all women in the study are followed at our center, one year follow-up was not available for 27% of the exams.

In conclusion, in this retrospective cohort study of surveillance MRI in women after bilateral mastectomy and reconstruction, MRI was negative in 98% of the cases with a 90% false-positive rate. Despite lack of level one data, based on our results, it appears safe to recommend against surveillance MRI in women undergoing mastectomy and implant-based reconstruction regardless of the indication for mastectomy.

Compliance with ethical standards

Conflict of interest All the authors declared that they have no conflicts of interest.

Ethical approval The study was performed in accordance with the ethical standards of the Institutional Review Board after obtaining its approval, and informed consent requirement was waved.

References

1. NCCN Guidelines. https://www.nccn.org/professionals/physician_gls/pdf/breast.pdf (accessed September 29, 2018)
2. NICE Guidelines. https://www.nice.org.uk/donotdo/do-not-offer-surveillance-to-women-who-have-undergone-a-bilateral-mastectomy (accessed September 29, 2018)
3. Allain DC, Sweet K, Agnese DM (2007) Management options after prophylactic surgeries in women with BRCA mutations: a review. Cancer control 14:330–337
4. Horsman D, Wilson BJ, Avard D et al on behalf of the National Hereditary Cancer Task Force (2007) Clinical management recommendations for surveillance and risk-reduction strategies for hereditary breast and ovarian cancer among individuals carrying a deleterious BRCA1 or BRCA2 mutation. Obstet Gynaecol Can 29:45–60
5. Destounis S, Morgan R, Arieno A, Seifert P, Somerville P, Murphy P (2011) A review of breast imaging following mastectomy with or without reconstruction in an outpatient community center. Breast Cancer 18:259–267
6. Madorsky-Feldman D, Sklair-Levy M, Perri T et al (2016) An international survey of surveillance schemes for unaffected BRCA1 and BRCA2 mutation carriers. Breast Cancer Res Treat 157:319–327
7. Zakhireh J, Fowble B, Esserman LJ (2010) Application of screening principles to the reconstructed breast. J Clin Oncol 28:173–180
8. Barnsley GP, Grunfeld E, Coyle D, Paszat L (2007) Surveillance mammography following the treatment of primary breast cancer

with breast reconstruction: a systematic review. Plast Reconstr Surg 120:1125–1132
9. Carbine NE, Lostumbo L, Wallace J, Ko H (2018) Risk-reducing mastectomy for the prevention of primary breast cancer. Cochrane Database Syst Rev. https://doi.org/10.1002/14651858.CD002748.pub4
10. Torresan RZ, dos Santos CC, Okamura H, Alvarenga M (2005) Evaluation of residual glandular tissue after skin sparing mastectomies. Ann Surg Oncol 12:1037–1044
11. Lee JM, Georgian-Smith D, Gazelle GS et al (2008) Detecting nonpalpable recurrent breast cancer: the role of routine mammographic screening of transverse rectus abdominis myocutaneous flap reconstructions. Radiology 248:398–405
12. Helvie MA, Bailey JE, Roubidoux MA et al (2002) Mammographic screening of TRAM flap breast reconstructions for detection of nonpalpable recurrent cancer. Radiology 224:211–216
13. Noroozian M, Carlson LW, Savage JL et al (2018) Use of screening mammography to detect occult malignancy in autologous breast reconstructions: a 15-year experience. Radiology 289:39–48
14. Clark L, Ritter E, Glazebrook K, Tyler D (1999) Recurrent ductal carcinoma in situ after total mastectomy. J Surg Oncol 71:182–185
15. Vanderwalde LH, Dang CM, Tabrizi R, Saouaf R, Phillips EH (2011) Breast MRI after bilateral mastectomy: is it indicated? Am Surg 77:180–184
16. Pinel-Giroux FM, El Khoury MM, Trop I, Bernier C, David J, Lalonde L (2013) Breast reconstruction: review of surgical methods and spectrum of imaging findings. Radiographics 33:435–453
17. Buchanan CL, Dorn PL, Fey J et al (2006) Locoregional recurrence after mastectomy: incidence and outcomes. J Am Coll Surg 203:469–474