

Surveillance of mastectomies with immediate breast reconstruction: results of a survey by the French Society of Senology and Breast Pathology (SFSPM)

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Abstract

Background: A survey on post-mastectomy surveillance after immediate breast reconstruction (IBR), among specialists of the French SFSPM was conducted.

Methods: Three sets of questions were established for prophylactic mastectomies, for ductal carcinoma in situ (DCIS), and for invasive breast cancer (BC). Questions were asked about systematic clinical examination, systematic ultrasound, systematic mammography, systematic magnetic resonance imaging (MRI), and questions about surveillance proposals according to guidelines, after a consensus meeting, and adapted to patient wishes.

Results: For prophylactic mastectomies, significant differences were reported for clinical examination by different specialists, for frequency of MRI. For DCIS, distribution of surveillance modalities differed significantly for the frequency of clinical examination according to medical specialty and centers, for shared surveillance or by a surgeon or gynecologist and for the size of the DCIS according to centers. For invasive BC, a significant different distribution was observed according to centers for shared surveillance by clinical examination, for the duration of ultrasound surveillance according to physician specialties, for selected surveillance by mammography according to centers, and for systematic MRI according to centers. The distribution of responses differed significantly according to centers and specialties for tumor subtypes, and according to centers for histological type. This survey suggests that after mastectomy with IBR, follow-up may include a clinical exam every 6 months for DCIS and invasive BC, and annually for prophylactic mastectomy. Follow-up should be shared between specialists and continued for at least 10 years. Annual ultrasound may be performed for at least 10 years, while mammography and MRI should be reserved for selected cases.

1. Introduction

Breast cancers (BC) are the most common cancers and the leading cause of cancer death in women. Total mastectomy remains a frequent treatment for BC, accounting for 20% to 40% of surgeries (1–5), despite technical advancements, including oncoplastic techniques (6). The indications for prophylactic mastectomies or risk-reducing mastectomies have increased due to the more frequent identification of BRCA mutations or other deleterious mutations, as well as a high risk of breast cancer associated with family history, even without an identified mutation (7).

After risk-reducing mastectomy, BC can still occur in about 2% of cases, developing from residual glandular tissue (8–11). Even after a well-conducted complete mastectomy, glandular islands may persist, particularly subcutaneously or at the periphery of the mastectomy, where cancer can develop (12–14). In the treatment of in situ or invasive cancer, mastectomy may be considered as up-front surgery or after neoadjuvant chemotherapy due to the size of the lesions relative to breast volume or patient choice, even when breast-conserving surgery is possible. Local recurrence is infrequent but possible, also related to residual glandular tissue.

Immediate breast reconstruction (IBR) is generally recommended for risk-reducing mastectomies and for in situ cancer mastectomies, and should be proposed in most cases of invasive breast cancer. In these cases, mastectomy will involve skin-sparing with nipple-areola complex (NAC) excision (SSM) or nipple-sparing mastectomy (NSM) (7). The risk of residual glandular tissue will be higher if the surgery preserves a thicker

subcutaneous tissue layer, requiring a balance between the risk of wound complications due to poor vascularization of skin flaps and the risk of residual glandular tissue. A thickness of 2 mm to a maximum of 5 mm is considered optimal for skin flap dissection, and a tumor-areola distance of 2 cm or even 1 cm is usually considered necessary for performing a NSM. In the case of risk-reducing mastectomy, the consensus is to propose a NSM.

IBR are frequently performed using breast implants or autologous pedicle or free flaps. More recently, IBR have been proposed using exclusive lipofilling (15, 16). Secondary complications are not uncommon, particularly after implant reconstruction (17% to 42%) (17–19), and after radiotherapy, including capsular contracture, implant rupture, infection, or more rarely anaplastic large cell lymphoma, which may lead to implant change, removal, or conversion to another reconstruction technique.

Post-mastectomy surveillance aims to detect local recurrence and secondary complications (20). Surveillance methods after IBR lack consensus and vary among teams and specialists. The goal of this study was to conduct a survey on post-mastectomy surveillance practices after breast reconstruction, among specialist physicians belonging to the French Society of Senology and Breast Pathology (SFSPM) based on different mastectomy indications.

2. Methods

The survey was conducted between July and September 2024 among physicians of the SFSPM. Physicians were categorized by specialty (surgeon, radiologist, medical oncologist, radiation oncologist, and onco-geneticist), practice setting (cancer center, university hospital, regional hospital and private practice), and age (< 50 years, 50–60 years, and > 60 years).

Three sets of questions were established based on the situations: prophylactic mastectomies with IBR, mastectomies for ductal carcinoma in situ (DCIS) with IBR, and mastectomies for invasive cancer with IBR. For each of the three groups, questions were asked about systematic clinical examination, systematic ultrasound, systematic mammography, and systematic magnetic resonance imagery (MRI) (yes or no, frequency, by which physicians and for what duration), and questions about surveillance proposals according to guidelines, after a consensus meeting, and adapted or not to patient wishes (**Table S 1**).

For DCIS, the proposed surveillance modalities differed according to the patient's age, the size of the DCIS, the excision margins, the type of mastectomy (NSM or SSM), and the type of reconstruction (implant or autologous). For invasive cancers, the proposed surveillance modalities differed according to the tumor subtype, histological type, evolution risk, type of mastectomy (NSM vs. SSM), and type of reconstruction (implant or autologous).

All answers were analyzed to determine surveillance modalities for all physicians and the existence of significant differences according to the specialties of the physicians, their practice setting, and their age.

This protocol was approved in accordance with SFSPM (French Society of Senology and Breast Pathology) scientific board. This study consisted of a survey conducted among healthcare professionals and did not involve patients, human biological samples, or personal health data. Therefore, it did not fall within the scope of research involving human participants under French regulations (Loi Jardé). Nevertheless, the study was

submitted to the Institutional Ethics Committee of Hôpital Européen for ethical review and conducted in accordance with institutional ethical guidelines. The study was registered under reference number 2026-07-02-GH.

Statistics: Comparisons were determined using the Chi-2 test. All statistical tests were two-sided. The level of statistical significance was set at a p-value ≤ 0.05 . Statistical analyses were performed using SPSS 16.0 (SPSS Inc., Chicago, Illinois, USA).

3. Results

Population: 69 responses were recorded from 49 surgeons, 7 radiologists, 7 radiation oncologists, 3 medical oncologists, and 3 onco-geneticists. Some of the responses included the attitude of several doctors on the team. The distributions according to specialty, practice setting, and age are reported in Table 1.

Table 1
Distribution according to specialty, practice setting, and age.

		All doctors		Cancer center		UH		RH		Private		Chi 2
		Nb	%	Nb	%	Nb	%	Nb	%	Nb	%	p
		69		37	53.6	5	7.2	9	13.0	18	26.1	
Speciality	surgeon	49	71.0	24	64.9	4	80.0	8	88.9	13	72.2	0.637
	radiologist	7	10.1	2	5.4	1	20.0	1	11.1	3	16.7	
	oncologist	3	4.3	3	8.1	0		0		0		
	radiotherapeute	7	10.1	5	13.5	0		0		2	11.1	
	oncogenetic	3	4.3	3	8.1	0		0		0		
Age groups	< 50 years	40	58.0	21	56.8	4	80.0	4	44.4	11	61.1	0.713
	50–60 years	17	24.6	9	24.3	0		4	44.4	4	22.2	
	> 60 years	12	17.4	7	18.9	1	20.0	1	11.1	3	16.7	

Nb: number, UH: University Hospital, RH: Regional Hospital.

3.1. Prophylactic Mastectomies with Immediate Breast Reconstruction

A systematic clinical examination for surveillance was proposed in the vast majority of cases (95.6%), every 6 months for 25.2% of respondents and annually for 67.7%, shared between surgeons and gynaecologists in 63.1% of respondents, for duration of more than 10 years in 96.8% (Table 2).

Table 2
Clinical exam, ultrasonography, mammography and MRI for prophylactic mastectomy, DCIS and invasive breast cancer.

Prophylactic		Clinical exam		Ultrasonography		Mammography		MRI	
		Nb	%	Nb	%	Nb	%	Nb	%
Examination	Yes	65	95.6	40	58.8	19	27.9	7	10.3
	No	3	4.4	28	41.2	49	72.1	61	89.7
	unknown	1		1		1		1	
Frequency	6 months	19	29.2	0		0		0	
	annual	44	67.7	37	94.9	18	94.7	15	71.4
	2 years	2	3.1	2	5.1	1	5.3	6	28.6
	unknown	4		30		50		48	
By which	surgeon	10	15.4						
	Gynecologist	14	21.5						
	Shared	41	63.1						
	unknown	4							
total time	> 10 years	61	96.8	37	94.9	17	89.5	19	86.4
	10 years	1	1.6	1	2.6	1	5.3	1	4.5
	5 years	1	1.6	1	2.6	1	5.3	2	9.1
	unknown	6		30		50		47	
Selective cases	No					13	44.8	9	25.0
	Yes					16	55.2	27	75.0
	unknown					40		33	
DCIS		Nb	%	Nb	%	Nb	%	Nb	%
Examination	Yes	44	97.8	56	82.4	17	25.0	7	10.3
	No	1	2.2	12	17.6	51	75.0	61	89.7
	unknown	24		1		1		1	
Frequency	6 months	35	52.2	1	1.8	0	0	0	
	annual	32	47.8	52	92.9	17	100	6	85.7
	2 years	0	0	3	5.4	0	0	1	14.3
	unknown	2		13				62	
By which	surgeon	15	22.4						

Prophylactic		Clinical exam		Ultrasonography		Mammography		MRI	
		Nb	%	Nb	%	Nb	%	Nb	%
	Gynecologist	8	11.9						
	Shared	44	65.7						
	unknown	2							
total time	> 10 years	45	68.2	41	73.2	14	87.5	4	66.7
	10 years	3	4.5	2	3.6	0	0	2	33.3
	5 years	18	27.3	13	23.2	2	12.5	0	
	unknown	3		13		53		63	
Selective cases	No					6	42.9	4	14.8
	Yes					8	57.1	23	85.2
	unknown					55		42	
Invasive BC		Nb	%	Nb	%	Nb	%	Nb	%
Examination	Yes	67	100	60	88.2	19	27.9	27	39.7
	No	0		8	11.8	49	72.1	41	60.3
	unknown	2		1		1		1	
Frequency	6 months	47	69.1	0	0	0	0	0	0
	annual	21	30.9	59	98.3	19	100	27	90.0
	2 years	0	0	1	1.7	0	0	3	10.0
	unknown	1		9		50		39	
By which	surgeon	16	23.5						
	Gynecologist	4	5.9						
	Shared	48	70.6						
	unknown	1							
total time	> 10 years	48	71.6	47	81.0	18	94.7	18	60.0
	10 years	2	3.0	2	3.4	1	5.3	5	16.7
	5 years	17	25.4	9	15.5	0		7	23.3
	unknown	2		11		50		39	
Selective cases	No					10	58.8	23	34.8
	Yes					7	41.2	43	65.2

Prophylactic		Clinical exam		Ultrasonography		Mammography		MRI	
		Nb	%	Nb	%	Nb	%	Nb	%
	unknown					52		3	
BRCA	No							6	8.8
	Yes							62	91.2
	unknown							1	

Nb: number, MRI: Magnetic resonance imagery, DCIS: ductal carcinoma in situ, BC: breast cancer.

A systematic ultrasound was proposed by 58.8% of respondents, mainly annually and for duration of more than 10 years (94.9%).

A systematic mammography was recommended by 27.9% of respondents, annually for 94.7% and for duration of more than 10 years in 89.5%. Sixteen respondents who did not consider systematic mammography proposed mammography only selectively.

A systematic MRI was proposed by 10.3%, and in these cases, annually for 71.4% and for duration of more than 10 years in 86.4% of responses. However, 27 respondents proposed an MRI selectively.

A significantly different or near-significant distribution was observed for the performance of clinical examination by different speciality of physicians (0.020), for the performance of systematic mammography according to different specialists (0.062), and for the frequency of systematic MRI according to centers (0.043) (Table 3). The clinical examination was proposed in 100% of cases in a shared manner for radiologists (n = 6), oncologists (n = 2), and onco-geneticists (n = 3), in 28.6% and 35.7% in a shared manner and by gynaecologists only, respectively, for radiotherapists, in 21.3%, 19.1%, and 68.3% by surgeons, gynaecologists, and in a shared manner, respectively, for the 47 responding surgeons. A systematic mammography was proposed by 22.4% of surgeons (11/49), by 28.6% of radiologists (2/7), by 1 of 2 oncologists, by 71.4% of radiation oncologists (5/7), and by none of the 3 onco-geneticists. When an MRI was proposed, it was proposed annually in 90.9% of cancer centers (10/11), in 100% of the 2 regional hospitals, by 42.9% of private practitioners (3/7), every 2 years for a university center (100%), and 57.1% of private practitioners (4/7).

Surveillance modalities were recommended by 58.8% of physicians according to guidelines, by 38.2% after a consensus meeting, and by 71.2% adapted to patient wishes (Table 4) in a significantly different manner according to specialties for consensus meetings (0.039): for all oncologists (n = 2) and onco-geneticists (n = 3), 36.7% of surgeons (18/49), 28.6% of radiation oncologists (2/7), and 14.3% of radiologists (1/7).

Table 3
Univariate analysis according to speciality and center for prophylactic mastectomy, DCIS and invasive breast cancer.

	Clinical exam		Ultrasonography		Mammography		MRI	
	speciality	center	speciality	center	speciality	center	speciality	center
	Chi 2	Chi 2	Chi 2	Chi 2	Chi 2	Chi 2	Chi 2	Chi 2
Prophylactic	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>
Examination	0.702	0.179	0.168	0.381	0.062	0.626	0.321	0.305
Frequency	0.946	0.079	0.695	0.862	0.857	0.131	0.085	0.043
By which	0.020	0.332	NA	NA	NA	NA	NA	NA
total time	0.999	0.753	0.948	0.750	0.140	0.390	0.084	0.698
Selective cases	NA	NA	NA	NA	0.219	0.172	0.181	0.683
DCIS	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>
Examination	0.910	0.563	0.900	0.452	0.137	0.379	0.791	0.158
Frequency	0.053	0.635	0.988	0.623	NA	NA	0.857	0.646
By which	0.189	0.036	NA	NA	NA	NA	NA	NA
total time	0.514	0.218	0.226	0.124	0.602	0.712	0.667	0.269
Selective cases	NA	NA	NA	NA	0.250	0.177	0.520	0.372
Invasive BC	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>
Examination	NA	NA	0.746	0.286	0.259	0.626	0.062	0.002
Frequency	0.174	0.487	0.979	0.342	NA	NA	0.844	0.797
By which	0.202	0.001	NA	NA	NA	NA	NA	NA
total time	0.927	0.898	0.012	0.066	0.857	0.857	0.958	0.606
Selective cases	NA	NA	NA	NA	0.472	0.015	0.240	0.101

DCIS: ductal carcinoma in situ, BC: breast cancer. Bold character: significant p-value.

Table 4
Surveillance modalities according to guidelines, concertation and adapted for prophylactic mastectomy, DCIS and invasive breast cancer.

Prophylactic		Guidelines		Concertation		Adapted	
		Nb	%	Nb	%	Nb	%
	No	28	41.2	42	61.8	19	28.8
	Yes	40	58.8	26	38.2	47	71.2
	unknown	1		1		3	
Chi 2: p Center		0.197		0.056		0.425	
Chi 2: p Speciality				0.039		0.581	
DCIS		Nb	%	Nb	%	Nb	%
	No	29	42.6	43	63.2	18	27.7
	Yes	39	57.4	25	36.8	47	72.3
	unknown	1		1		4	
Chi 2: p Center		0.252		0.180		0.192	
Chi 2: p Speciality		0.089		0.158		0.482	
Invasive BC		Nb	%	Nb	%	Nb	%
	No	26	38.2	42	61.8	20	31.2
	Yes	42	61.8	26	38.2	44	68.8
	unknown	1		1		5	
Chi 2: p Center		0.118		0.350		0.307	
Chi 2: p Speciality		0.482		0.251		0.398	

Nb: number, DCIS: ductal carcinoma in situ, BC: breast cancer.

3.2. Mastectomies with Immediate Reconstruction for Ductal Carcinoma in Situ (DCIS) (Table 2)

A systematic clinical examination was recommended in the vast majority of cases (97.8%), every 6 months or annually in half of the cases, in a shared manner in 65.7% of cases, and for duration of more than 10 years in 68.2% of respondents, with 27.3% proposing duration of 5 years.

A systematic ultrasound was proposed by 82.4% of respondents, annually for 92.9%, and for duration of more than 10 years for 73.2%, with 23.2% proposing duration of 5 years.

Seventeen physicians (25.0%) proposed a systematic mammography, annually for all and in 87.5% of cases for more than 10 years, with duration of 5 years for 12.5% of physicians.

A systematic MRI was proposed by 7 physicians (10.3%), annually for 85.7%, and in all cases for duration of 10 years or more. An MRI was proposed selectively by 85.2% of the 27 responding physicians.

A significantly different or near-significant distribution was observed for the frequency of clinical examination performance according to medical specialty (0.053) and according to centers for shared surveillance or by a surgeon or gynaecologist (0.036) (Table 3).

The surveillance modalities for DCIS differed for 22.1% of physicians according to the patient's age, for 16.2% according to the size of the DCIS, for 31.3% according to the excision margins, for 6.1% in the case of NSM compared to SSM, and for 10.3% in the case of implant-IBR compared to autologous reconstruction (Table 5). According to specialties and centers, the distribution of responses differed significantly only for the size of the DCIS according to centers (0.007).

Table 5
Difference of surveillance modalities for DCIS and invasive BC according to age, tumor characteristics and surgery.

DCIS: differ	with age		with size		with margins		NSM vs SSM		Implant vs autologous	
	Nb	%	Nb	%	Nb	%	Nb	%	Nb	%
No	53	77.9	57	83.8	46	68.7	62	93.9	61	89.7
Yes	15	22.1	11	16.2	21	31.3	4	6.1	7	10.3
unknown	1		1		2		3		1	2.2
Chi 2: p Center	0.596		0.007		0.133		0.170		0.478	
Chi 2: p Speciality	0.735		0.882		0.348		0.561		0.554	
invasive: differ	sub types		Histology		Risk		NSM		Implant vs autologous	
	Nb	%	Nb	%	Nb	%	Nb	%	Nb	%
No	21	31.3	50	74.6	36	53.7	58	86.6	61	89.7
Yes	46	68.7	17	25.4	31	46.3	9	13.4	7	10.3
unknown	2		2		2		2		1	
Chi 2: p Center	0.002		0.015		0.477		0.219		0.478	
Chi 2: p Speciality	0.025		0.359		0.688		0.543		0.791	

Nb: number, DCIS: ductal carcinoma in situ, BC: breast cancer, NSM: nipple sparing mastectomy, SSM: skin sparing mastectomy.

Surveillance modalities were recommended by 57.4% of physicians according to guidelines, by 36.8% after a consensus meeting, and by 72.3% adapted to patient wishes (Table 4), without significant difference according to specialties and practice setting.

3.3. Mastectomies with Immediate Breast Reconstruction for Invasive Breast Cancer

A systematic clinical examination was proposed in all cases, annually by 30.9% and every 6 months by 69.1%, mainly in a shared manner (70.6%), for more than 10 years by 71.6%, and for 5 years by 25.4% of physicians (Table 2).

A systematic ultrasound was recommended by 88.2% of physicians, annually for 98.3%, for more than 10 years for 81.1%, and for 5 years for 15.5% of physicians (Table 2).

A systematic mammography was proposed by 19 physicians (27.9%), annually for all, for 10 years or more for all, and only selectively for 41.2% (7/17) of responding physicians (Table 2).

A systematic MRI was proposed by 27 physicians (39.7%), annually for 90.0%, for more than 10 years for 60.0%, and for 5 years for 23.3%. An MRI was proposed selectively by 65.2% of physicians and by 91.2% in the case of BRCA mutation (Table 2).

A significant different distribution was observed according to centers for shared surveillance by clinical examination or by a surgeon or gynecologist (0.001), for the duration of ultrasound surveillance according to physician specialties (0.012), for selected surveillance by mammography according to centers (0.015), and for systematic MRI according to centers (0.002) (Table 3).

The surveillance modalities for invasive cancers differed for 68.7% of physicians according to tumor subtype, particularly for triple-negative cancers (35/67), for 25.4% according to the histological type of the tumor, for 46.3% according to the risk of evolution, for 13.4% in the case of NSM, and for 10.3% in the case of implant-IBR versus autologous reconstruction (Table 5). The distribution of responses differed significantly according to centers (0.002) and according to specialties (0.025) for tumor subtypes, and according to centers for histological type (0.015).

Surveillance modalities were recommended by 61.8% of physicians according to guidelines, by 38.2% after a consensus meeting, and by 68.8% adapted to patient wishes (Table 4), without significant difference according to specialties and practice setting.

For all three groups of mastectomies, no significant difference was observed according to the age groups of the responding physicians.

4. In summary

For prophylactic mastectomies, follow-up practices differed significantly between specialists, particularly regarding clinical examination and the use of MRI, which varied according to center policies and specialty-specific consensus.

For DCIS mastectomies, a significant difference or near-significant distribution was observed for the frequency of clinical examination according to medical specialty and according to centers for shared surveillance or by a

surgeon or gynaecologist. The distribution of surveillance modalities differed significantly only for the size of the DCIS according to centers.

For invasive breast cancer, a significant different distribution was observed according to centers for shared surveillance by clinical examination, for duration of ultrasound surveillance according to physician specialties, for selected surveillance by mammography according to centers, and for systematic MRI according to centers. The distribution of responses differed significantly according to centers and specialties for tumor subtypes, and according to centers for histological type.

These results allow the following monitoring methods to be proposed (Table 6): For prophylactic mastectomies with IBR: a clinical exam annually, shared and ≥ 10 years, ultrasound annually and ≥ 10 years, mammography and MRI only in selective cases. For DCIS and invasive breast cancer mastectomies with IBR: a clinical exam every 6 months, shared and ≥ 10 years, ultrasound annually and ≥ 10 years, mammography and MRI only in selective cases.

Table 6
Surveillance modalities proposed for prophylactic mastectomy, DCIS and invasive breast cancer.

Surveillance modality	Prophylactic mastectomy	DCIS	Invasive breast cancer
Clinical examination	Yes – annually – shared – ≥ 10 years	Yes – every 6 months – shared – ≥ 10 years	Yes – every 6 months – shared – ≥ 10 years
Ultrasonography	Yes – annually – ≥ 10 years	Yes – annually – ≥ 10 years	Yes – annually – ≥ 10 years
Mammography	No (except selective cases)	No (except selective cases)	No (except selective cases)
MRI	No (except selective cases)	No (except selective cases)	No (except selective cases)

DCIS: ductal carcinoma in situ, MRI: Magnetic resonance imagery.

5. Discussion

Results of the survey allowed to propose after mastectomy with IBR a surveillance with a clinical exam every 6 months for DCIS and invasive breast cancer and annually for prophylactic mastectomy, shared and ≥ 10 years, ultrasound annually and ≥ 10 years, mammography and MRI only in selective cases.

The objective of loco regional surveillance after mastectomy with IBR is to detect early local and regional lymph node recurrences, contralateral cancers as well as secondary complications related to reconstruction, particularly after reconstruction with breast implants. Loco regional secondary complications include peri-prosthetic capsular contracture and prosthetic ruptures, siliconomas, infections, skin damage or even necrosis, breast deformities and skin retractions, and cytosteatonecrosis.

Mastectomy rate: Total mastectomies for BC are indicated for 12 to 30% of patients and up to 40% (1, 2, 5, 21), and was 12.2% in a large French cohort of invasive breast cancer treated by up-front surgery (3). It was 36.6% (1571/4287) for women treated from 2006 to 2018 in Lao N et al study (22).

Mastectomy rate significantly increased according to periods of treatment (3): 15.5% before 2005, 17.8% from 2005 to 2010, 30.8% from 2011 to 2015 and 28.5% after 2015 among a French cohort. In France, between years 2011 to 2017, mastectomy rate was 26.4% (62.195/235.368) with higher rates of mastectomy for young patients (39.7% and 41.3% for patients < 30 years and 30–39 years respectively) and older patients (43.4% for patients > = 80 years) (23).

IBR rate: IBR should be systematically offered except in the few situations where it is contraindicated: inflammatory BC and significant and/or multiple co-morbidities. Overall reconstruction rates have risen from 8% in 1995 to 41% in 2013 according to the National Cancer Database (24, 25). Between 1998 and 2008, IBR rate increase from 21% to 38% (26, 27).

IBR rate was 16.1% between 2008–2014 in France (28), 10% to 2005 and 23.3% from 2013 to 2014 in UK and 9.6% in China in 2018. Reconstructions rates were 45% in 2010 and 54% in 2015 in US (27). In the study reported by Laas E et al in 2025 (16), mastectomy rate was 40% (20.043/50.178) and breast reconstruction rate was 64.5% (12.930/20.043). IBR rate was 11% of mastectomies (2115/20043) and 16.4% of breast reconstructions (2115/12.930).

5.1. Loco regional recurrence rate and location, and PMRT.

Loco regional recurrence rate for patients treated for breast cancer was 1.64% (26/1571) in Lao N et al study over a median follow-up of 6.78 years (22). Among 137 patients with IBR (8.7%), 28.5% received PMRT and no loco regional recurrence was reported. Average time from surgery to recurrence was 1.9 ± 1.6 years with average recurrence size of 2.9 ± 2.4 cm. The majority (78%) had recurrences confined to the skin/subcutaneous or pectoralis muscle levels. Five patients (19%) presented with axillary recurrence alone. These loco-regional recurrences represent 1.7% of all mastectomy patients. Only one of these patients (representing 3.8% of all loco-regional recurrences and 0.06% of all mastectomy patients) presented with a deep chest wall recurrence, including ribs, intercostal muscles, and serratus anterior muscle.

The majority of recurrences were found in the skin/subcutaneous layers (64.7 to 100%: 85.1%, 177/208), followed by pectoralis muscle (0 to 35.3%: 9.1%, 19/208), and in the skin/subcutaneous or pectoralis muscle in 90.1% (292/324), with very few recurrences within the deep chest wall (0 to 33.3%: 9.9%, 32/324) (22).

In subpectoral implant-IBR, 93% of recurrences were located in the ESTRO-target volume of PMRT and 7% developed in the pectoralis major and deep thoracic muscle. In prepectoral implant-IBR, all recurrent tumors occurred within the ESTRO-target volume (29).

In Salvestrini et al study, among 140 patients treated by mastectomy with IBR and PMRT, 10 (7.1%) developed a local recurrence after a median follow-up of 72 months, with average time of 27 months (range 3–87) and an average size of 18.5mm (range 6–30) (30). No recurrence was detected under the implant, 8 patients (80%) had relapse above the implant and 2 (20%) patients relapsed on IMN chain. Seven recurrences occurred after prepectoral implant-IBR (7/105) and 3 after subpectoral implant-IBR (3/35), without significant difference.

Consequently, post-mastectomy patients with subpectoral IBR (31), where the pectoralis and subcutaneous tissues are anterior to the implant, can be treated while excluding structures deep to implant to avoid delivering radiation circumferentially around the implant. This differs from reconstruction using autologous tissue and pre-

pectoral implant IBR. Complication rates in patients who underwent PMRT after IBR vary across studies (32, 33). However, a meta-analysis of fifteen trials including 5,314 patients demonstrated a fivefold increase in the risk of capsular contracture, reaching 32.6% with radiotherapy and a doubling of the reconstruction failure rate, to 17.3% after PMRT (34, 35). Reinders et al. reported a 21% reconstruction failure rate with implant-based versus no reconstruction failures with autologous tissue transfer IBR in patients undergoing PMRT (36) and Berry et al. report major complication rates of 45% and 21% in patients with implants versus autologous tissue transfers (37). Irradiating only the anterior capsule of the implant, targeting the skin, subcutaneous tissues and the pectoralis major muscle, should reduce these complications by excluding the deep chest wall from irradiation (38). There is potential for IMRT to reduce the risk of reconstruction failure and other major complications (26) and 3-dimensional conformal radiotherapy is recommended, with intensity-modulated radiotherapy advised when three-dimensional conformal radiotherapy is unable to achieve treatment goals (39).

Risk-reducing mastectomy in high-risk patients, confer a 90–94% reduction in breast cancer risk (8–12). In Carbine NE et al Cochrane systematic review (11), breast cancer incidence after risk-reducing mastectomy in 7 studies for women who had BRCA1/2 mutations was 0 to 2%. More recently, Metcalfe K et al reported 20 incident breast cancers after risk-reducing mastectomy among 827 women (2.4%) after a mean follow-up of 6.3 years (13). In BRILLANT-BRCA study (12) authors reported that the residual breast volume evaluated with MRI on the risk-reducing mastectomy side was significantly higher compared to the breast cancer side ($p = 0.007$), and higher body mass index was associated with a higher residual breast volume ($p < 0.0001$), but residual breast volume was not significantly related with breast cancer outcomes. However, Dietzel et al (14) reported that postoperative residual glandular tissue is an important tool for quantifying the risk of developing breast cancer after risk-reducing mastectomy and different effects on residual glandular tissue were shown for breast density, skin flap, surgical method, preoperative breast volume, and surgeon experience. Moreover, a recent meta-analysis (40) reported that surgical method, surgical indication and surgeon experience were significant factors for residual glandular tissue.

5.2. Modalities of follow-up

In Smith D et al meta analysis including 16 studies (20), the pooled overall cancer detection rates were 1.86/1000 (95%CI, 1.05–3.30) for mammography, 2.66/1000 (95%CI, 1.48–4.76) for ultrasonography, and 5.17/1000 (95%CI, 1.49–17.75) for MRI. Six studies used mammography, 5 used ultrasonography, 3 used MRI and 2 used mammography and ultrasonography at the same time. The time interval for surveillance varied between 6 and 12 months. For mastectomy with reconstruction, the pooled overall cancer detection rate (4.73/1000; 95%CI, 2.32–9.63) was lower than that among patients who underwent mastectomy without reconstruction. When palpable lesions at the time of imaging were excluded, the pooled clinically occult cancer rate was 2.96/1000 (95%CI, 1.38–6.32) among patients who underwent mastectomy without reconstruction and 1.06/1000 (95%CI, 0.41–2.73) among patients with reconstruction. Authors concluded that the current evidence on the potential role of imaging surveillance after mastectomy is limited.

5.3. Limitations

This survey focuses on a small number of doctors, but some responses include several doctors from the same team, which represents a broad cross-section of French practice. Despite variety of practice in the type of examination, their frequency and duration depending on the specialty and type of institution, the results of this survey allow us to propose a relatively consensual monitoring approach.

6. Conclusion

Due to the absence of high-level scientific evidence for imaging follow-up after mastectomy with or without reconstruction, a proposition of clinical practice from a survey can be considered as contributive. Results of this French survey allowed to propose after mastectomy with IBR a follow-up with a clinical exam every 6 months for DCIS and invasive breast cancer and annually for prophylactic mastectomy, shared between specialists during ten years or more, an ultrasound annually and ≥ 10 years, mammography and MRI only in selective cases. However, this is a survey and not a French reference document from the SFSPM, which uses a different, specific methodology.

Declarations

Ethics committee: This research do not involves human patients. However, this protocol was approved in accordance with SFSPM (French Society of Senology and Breast Pathology) scientific board. This study consisted of a survey conducted among healthcare professionals and did not involve patients, human biological samples, or personal health data. Therefore, it did not fall within the scope of research involving human participants under French regulations (Loi Jardé). Nevertheless, the study was submitted to the Institutional Ethics Committee of Hôpital Européen for ethical review and conducted in accordance with institutional ethical guidelines. The study was registered under reference number 2026-07-02-GH.

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Author Contribution

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Data Availability

The Ungdata surveys that support the findings of this study are available from corresponding author. The data are available upon request to corresponding author.

References

1. Krag, D. N. et al. Sentinel-lymph-node resection compared with conventional axillary-lymph node dissection in clinically node-negative patients with breast cancer: overall survival findings from the NSABP B-32 randomized phase 3 trial. *Lancet Oncol.* 11, 927–933 (2010).
2. Houvenaeghel, G.; Cohen, M.; Raro, P.; De Troyer, J.; Gimbergues, P.; Tunon de Lara, C.; Ceccato, V.; Vaini-Cowen, V.; Faure-Virelizier, C.; Marchal, F.; et al. Sentinel node involvement with or without completion axillary lymph node dissection: Treatment and pathologic results of randomized SERC trial. *NPJ Breast Cancer* 2021, 7, 133.
3. Houvenaeghel G, Lambaudie E, Cohen M, Classe JM, Reyat F, Garbay JR, et al. Therapeutic escalation - De-escalation: Data from 15.508 early breast cancer treated with upfront surgery and sentinel lymph node biopsy (SLNB). *Breast.* 2017 Aug;34:24-33. doi: 10.1016/j.breast.2017.04.008.
4. Houvenaeghel G, Cohen M, Raro P, De Troyer J, de Lara CT, Gimbergues P, Gauthier T, Faure-Virelizier C, Vaini-Cowen V, Lantheaume S, Regis C, Darai E, Ceccato V, D'Halluin G, Del Piano F, Villet R, Jouve E, Beedassy B, Theret P, Gabelle P, Zinzindohoue C, Opinel P, Marsollier-Ferrer C, Dhainaut-Speyer C, Colombo PE, Lambaudie E, Tallet A, Boher JM; Others investigators (SERC trial group). Overview of the pathological results and treatment characteristics in the first 1000 patients randomized in the SERC trial: axillary dissection versus no axillary dissection in patients with involved sentinel node. *BMC Cancer.* 2018 Nov 21;18(1):1153. doi: 10.1186/s12885-018-5053-7.
5. Matala, C.M.; McIntosh, S.A.; Purushotham, A.D. Immediate breast reconstruction after mastectomy for cancer. *Br. J. Surg.* 2000, 87, 1455–1472. Kummerow KL, Du L, Penson DF, Shyr Y, Hooks MA. Nationwide trends in mastectomy for early-stage breast cancer. *JAMA Surg.* 2015 Jan;150(1):9-16. doi: 10.1001/jamasurg.2014.2895.
6. Cohen M, Bouteille C, Houvenaeghel GF. Oncoplasty and immediate breast reconstruction. *Bull Cancer.* 2025 Jul-Aug;112(7-8):878-892.
7. Houvenaeghel G, Cohen M, Dammacco MA, D'Halluin F, Regis C, Gutowski M, Acker O, Fournier M, Bannier M, Lusque A, Jouve E; MAPAMc trial group. Prophylactic nipple-sparing mastectomy with immediate breast reconstruction: results of a French prospective trial. *Br J Surg.* 2021 Apr 5;108(3):296-301.
8. Hartmann LC, Schaid DJ, Woods JE, Crotty TP, Myers JL, Arnold PG et al. Efficacy of bilateral prophylactic mastectomy in women with a family history of breast cancer. *N Engl J Med* 1999;340: 77–84
9. Meijers-Heijboer H, van Geel B, van Putten WLJ, Henzen-Logmans SC, Seynaeve C, Menke-Pluymers MBE et al. Breast cancer after prophylactic bilateral mastectomy in women with a BRCA1 or BRCA2 mutation. *N Engl J Med* 2001;345:159–164
10. Contant CME, Menke-Pluymers MBE, Seynaeve C, Meijers-Heijboer EJ, Klijn JGM, Verhoog LC et al. Clinical experience of prophylactic mastectomy followed by immediate breast reconstruction in women at hereditary risk of breast cancer (HB(O)C) or a proven BRCA1 and BRCA2 germ-line mutation. *Eur J Surg Oncol* 2002;28:627–632
11. Carbine NE, Lostumbo L, Wallace J, Ko H. Risk-reducing mastectomy for the prevention of primary breast cancer. *Cochrane Database of Systematic Reviews* 2018, Issue 4.
12. Kaidar-Person O, Faermann R, Polikar D, Cohen K, Bernstein-Molho R, Morrow M, Boersma LJ, Offersen BV, Poortmans P, Sklair-Levy M, Anaby D. A BRILLIANT-BRCA study: residual breast tissue after mastectomy

and reconstruction. *Breast Cancer Research and Treatment* (2024) 208:359–367

13. Metcalfe K, Huzarski T, Gronwald J, Kotsopoulos J, Kim R, Moller P, Pal T, Aeilts A, Eisen A, Karlan B, Bordeleau L, Tung N, Olopade O, Zakalik D, Singer CF, Foulkes W, Couch F, Neuhausen SL, Eng C, Sun P, Lubinski J, Narod SA; Hereditary Breast Cancer Clinical Study Group. Risk-reducing mastectomy and breast cancer mortality in women with a BRCA1 or BRCA2 pathogenic variant: an international analysis. *Br J Cancer*. 2024 Feb;130(2):269-274. doi: 10.1038/s41416-023-02503-8.
14. Dietzel F, Kolberg L, Vesper AS, Hoffmann J, Nestle-Krämling C, Zwiefel K, Friebe V, Sawicki LM, Bruckmann NM, Jannusch K, Morawitz J, Antoch G, Fehm TN, Kirchner J, Mohrmann S. Factors Influencing Residual Glandular Breast Tissue after Risk-Reducing Mastectomy in Genetically Predisposed Individuals Detected by MRI Mammography. *Cancers (Basel)*. 2023 Jan 29;15(3):829. doi: 10.3390/cancers15030829.
15. Fitoussi A, Kais Razzouk. Autologous Fat Grafting as a Stand-alone Method for Immediate Breast Reconstruction After Radical Mastectomy in a Series of 15 Patients (9 with irradiation, mean 3 procedures and 2 minor complications). *Ann Plast Surg* 2022 Jan 1;88(1):25-31.
16. Laas E, Gaillard T, Couturaud B, Darrigues L, Dumas E, Hamy AS, Feron JG, Reyat F, Husson F, Jannot AS. The Impact of Fat Graft Reconstructive Surgery on Prognosis in Young Women with Breast Cancer: A Study from the French Insurance Databases. *Plast Reconstr Surg*. 2025 Nov 1;156(5):691-701.
17. Houvenaeghel G, Bannier M, Bouteille C, Tallet C, Sabiani L, Charavil A, Bertrand A, Van Troy A, Buttarelli M, Teyssandier C, Tallet A, de Nonneville A, Cohen M. Postoperative Outcomes of Pre-Pectoral Versus Sub-Pectoral Implant Immediate Breast Reconstruction. *Cancers (Basel)*. 2024 Mar 12;16(6):1129. doi: 10.3390/cancers16061129.
18. Simon, P.; Barrou, J.; Cohen, M.; Rua, S.; Lambaudie, E.; Houvenaeghel, G. Types of Mastectomies and Immediate Reconstructions for Ipsilateral Breast Local Recurrences. *Front. Oncol*. 2020, 10, 567298.
19. Houvenaeghel, G.; Cohen, M.; Sabiani, L.; Van Troy, A.; Quilichini, O.; Charavil, A.; Buttarelli, M.; Rua, S.; Tallet, A.; de Nonneville, A.; et al. Mastectomy and Immediate Breast Reconstruction with Pre-Pectoral or Sub-Pectoral Implant: Assessing Clinical Practice, Post-Surgical Outcomes, Patient's Satisfaction and Cost. *J. Surg. Res*. 2022, 5, 500–510.
20. Smith D, Setara Sepehr, Andreas Karakatsanis, Fredrik Strand, Antonis Valachis. Yield of Surveillance Imaging After Mastectomy With or Without Reconstruction for Patients With Prior Breast Cancer. A Systematic Review and Meta-analysis. *JAMA Network Open*. 2022;5(12): e2244212.
21. Kummerow KL, Du L, Penson DF, Shyr Y, Hooks MA. Nationwide trends in mastectomy for early-stage breast cancer. *JAMA Surg*. 2015 ; 150(1) :9-16.
22. Lao N, Brackstone M, Formenti SC, Doherty C, Perera F, Chow R, DeLyzer T, Grant A, Boldt G, Lock M. Redefining postmastectomy radiation contouring in the era of immediate breast reconstruction : An accurate assessment of local recurrence risk. *Clin Transl Radiat Oncol*. 2021 ; 6 :29 :33-39.
23. Dumas E, Laot L, Coussy F, Grandal Rejo B, Daoud E, Laas E, Kassara A, Majdlin A, Kabirian R, Jochum F, Gougis P, Michel S, Houzard S, Le Bihan-Benjamin C, Bousquet PJ, Hotton J, Azencott CA, Reyat F, Hamy AS. The French Early Breast Cancer Cohort (FRESH): A Resource for Breast Cancer Research and Evaluations of Oncology Practices Based on the French National Healthcare System Database (SNDS). *Cancers (Basel)*. 2022 May 27;14(11):2671. doi: 10.3390/cancers14112671. Razdan SN, Cordeiro PG, Albornoz CR, Disa JJ, Panchal HJ, Ho AY, et al. National Breast Reconstruction Utilization in the Setting of Postmastectomy Radiotherapy. *J Reconstr Microsurg*. 2017;33:312–7.

24. Razdan SN, Cordeiro PG, Albornoz CR, Disa JJ, Panchal HJ, Ho AY, et al. National Breast Reconstruction Utilization in the Setting of Postmastectomy Radiotherapy. *J Reconstr Microsurg*. 2017;33:312–7.
25. Morrow M, Scott SK, Menck HR, Mustoe TA, Winchester DP. Factors influencing the use of breast reconstruction postmastectomy: a National Cancer Database study. *Journal of the American College of Surgeons*. 2001;192:1–8.
26. Lee CT, Ruth K, Patel S, Bleicher R, Sigurdson E, Weiss S, Hayes S, Anderson P, Wong JK. Factors Associated with Reconstruction Failure and Major Complications After Postmastectomy Radiation to a Reconstructed Breast. *Pract Radiat Oncol*. 2023 Mar-Apr;13(2):122-131. doi: 10.1016/j.prro.2022.09.005.
27. Panchal H, Matros E. Current Trends in Postmastectomy Breast Reconstruction. *Plast Reconstr Surg*. 2017;140:7S–13S.
28. Nègre G, Balcaen T, Dast S, et al. Breast reconstruction in France, observational study of 140,904 cases of mastectomy for breast cancer. *Ann Chir Plast Esthet*. févr 65 (2020): 3643.
29. Joo JH, Yang JD, Park HY, Park J, Wu ZY, Ko B, Park J, Kim SS. The patterns and spatial locations of local recurrence in breast cancer with implant-based reconstruction after mastectomy. *Radiother Oncol*. 2022 May;170:111-117. doi: 10.1016/j.radonc.2022.02.028.
30. Salvestrini V, Valzano M, Meattini I, Becherini C, Visani L, Francolini G, Morelli I, Bertini N, Orzalesi L, Bernini M, Bianchi S, Simontacchi G, Livi L, Desideri I. Anatomical assessment of local recurrence site in breast cancer patients after breast reconstruction and post-mastectomy radiotherapy: implications for radiation volumes and techniques. *Radiol Med*. 2024 Jun;129(6):845-854. doi: 10.1007/s11547-024-01812-z.
31. Kaidar-Person O, Vrou Offersen B, Hol S, Arenas M, Aristei C, Bourgier C, et al. ESTRO ACROP consensus guideline for target volume delineation in the setting of postmastectomy radiation therapy after implant-based immediate reconstruction for early stage breast cancer. *Radiother Oncol*. 2019;137:159-166.
32. Momoh AO, Ahmed R, Kelley BP, Aliu O, Kidwell KM, Kozlow JH, et al. A systematic review of complications of implant-based breast reconstruction with prereconstruction and postreconstruction radiotherapy. *Ann Surg Oncol* 2014;21(1):118–24.
33. Berbers J, van Baardwijk A, Houben R, Heuts E, Smidt M, Keymeulen K, et al. Reconstruction: before or after postmastectomy radiotherapy?" a systematic review of the literature. *Eur J Cancer* 2014;50(16):2752–62.
34. Pu Y, Mao T-C, Zhang Y-M, Wang SI, Fan D-L. The role of postmastectomy radiation therapy in patients with immediate prosthetic breast reconstruction: a meta-analysis. *Medicine* 2018;97:6(e9548).
35. Christante D, Pommier SJ, Diggs BS, Samuelson BT, Truong A, Marquez C, et al. Using Complications Associated With Postmastectomy Radiation and Immediate Breast Reconstruction to Improve Surgical Decision Making. *Arch Surg-Chicago*. 2010;145:873–8.
36. Reinders FCJ, Young-Afat DA, Batenburg MCT, Bruekers SE, van Amerongen EA, Macare van Maurik JFM, et al. Higher reconstruction failure and less patient-reported satisfaction after post mastectomy radiotherapy with immediate implant-based breast reconstruction compared to immediate autologous breast reconstruction. *Breast Cancer*. 2020;27:435–44.
37. Berry T, Brooks S, Sydow N, Djohan R, Nutter B, Lyons J, et al. Complication rates of radiation on tissue expander and autologous tissue breast reconstruction. *Ann Surg Oncol*. 2010;17 Suppl 3:202–10.
38. National Library of Medicine (U.S.) (2018, November –). The DBCG RT Recon Trial: Delayed-immediate versus delayed breast reconstruction in early breast cancer patients treated with mastectomy and adjuvant

loco-regional radiation therapy. A multicenter randomized clinical trial. Identifier NCT03730922.

<https://clinicaltrials.gov/ct2/show/NCT03730922>.

39. Jimenez RB, Abdou Y, Anderson P, Barry P, Bradfield L, Bradley JA, Heras LD, Khan A, Matsen C, Rabinovitch R, Reyna C, Salerno KE, Schellhorn SE, Schofield D, Taparra K, Washington I, Wright JL, Zeidan YH, Zellars RC, Horst KC. Postmastectomy Radiation Therapy: An ASTRO-ASCO-SSO Clinical Practice Guideline. *J Clin Oncol*. 2025 Oct 20;43(30):3292-3311. doi: 10.1200/JCO-25-01747.
40. Rocco, N.; Montagna, G.; Criscitiello, C.; Nava, M.B.; Privitera, F.; Taher, W.; Gloria, A.; Catanuto, G. Nipple Sparing Mastectomy as a Risk-Reducing Procedure for BRCA-Mutated Patients. *Genes* 2021, 12, 253.

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