

Trends in breast reconstruction practices in a specialized breast tertiary referral centre

N. O'Halloran¹, A. Lowery¹, O. Kalinina², K. Sweeney¹, C. Malone¹, R. McLoughlin¹, J. Kelly¹, A. Hussey¹ and M. Kerin¹

Departments of ¹Surgery and ²Mathematics, National University of Ireland Galway, Galway, Ireland

Correspondence to: Dr N. O'Halloran, Department of Surgery, The Lambe Institute, National University of Ireland Galway, Galway, Ireland (e-mail: niamhoh91@gmail.com)

Background: Breast reconstruction is an important component of multidisciplinary breast cancer management. The practice of breast reconstruction after mastectomy has evolved significantly in the past decade as a result of both increasing mastectomy rates and advances in reconstructive strategy. These changes have significantly influenced the contemporary surgical management of breast cancer. The aim of this study was to examine trends in breast reconstruction after mastectomy in an Irish population.

Methods: Data were reviewed from a database of all patients who had mastectomy with or without breast reconstruction at Galway University Hospital, a tertiary breast cancer referral centre, between 2004 and 2014. Trends in breast reconstruction after mastectomy were explored with respect to patient demographics, clinicopathological features, and neoadjuvant and adjuvant therapy.

Results: Of 1303 patients who underwent mastectomy during interval studied, 706 (54.2 per cent) had breast reconstruction after mastectomy. In 629 patients (89.1 per cent), breast reconstruction was performed in the immediate setting. Reconstruction rates increased over time from 20.5 per cent in 2004 to 44.7 per cent in 2014. Reconstruction was more commonly performed in younger patients and those with benign, *in situ* and early-stage disease. A negative relationship between radiotherapy and reconstruction was observed. A pedicled flap with or without an implant was the most commonly used reconstructive approach in patients receiving radiotherapy.

Conclusion: Breast reconstruction after mastectomy has become the standard of care in the surgical treatment of breast cancer. Recent trends show a transition favouring implant-based approaches.

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Introduction

Breast cancer is the most commonly diagnosed cancer in women, with approximately 1.7 million women diagnosed and treated worldwide annually¹. Although significant progress has been made in the multimodal management of breast cancer, complete surgical resection with disease-free margins remains the cornerstone of effective therapy. To achieve adequate locoregional control, approximately 40 per cent of patients have a total mastectomy^{2,3}. For these patients, breast reconstruction is proven to improve psychosocial and aesthetic outcomes⁴. Recent guidelines^{5,6} recommend that reconstruction should be discussed and offered as an option for the majority of

women undergoing mastectomy. Postmastectomy breast reconstruction (PMBR) has thus been incorporated into the contemporary surgical management of patients with breast cancer, resulting in increasing reconstruction rates, as reported in national audits of populations in both the UK and USA^{7,8}.

The practice of breast reconstruction has also been affected by changes in mastectomy patterns in recent years. As recognition of the genetic component of familial breast cancer grows and genetic testing has become more available, rates of bilateral prophylactic mastectomy and contralateral prophylactic mastectomy have increased in high-risk patients^{9,10}. Furthermore, a trend has also been reported for women who are eligible for breast-conserving

surgery to opt for mastectomy^{3,11–13} and contralateral prophylactic mastectomy in the unaffected breast^{13–17}, despite a lack of evidence of a survival advantage for this approach in the absence of a known genetic mutation.

As a consequence of both the increasing volume of risk-reducing surgery and improved survival of patients with breast cancer, surgical techniques for both mastectomy (such as skin- and nipple-sparing approaches¹⁸) and PMBR have evolved significantly over the past decade in an effort to maximize aesthetic and quality-of-life outcomes¹⁹.

The aim of this study was to review the experience of PMBR in a specialized breast tertiary referral centre over an 11-year interval (2004–2014), with respect to rates and trends in timing, type and clinicopathological characteristics associated with PMBR.

Methods

The study was undertaken at a single tertiary referral breast cancer centre (Galway University Hospital). Patients who underwent mastectomy with or without PMBR over an 11-year interval from 2004 to 2014 were identified from an institutional database. Data extracted included: patient demographics, tumour clinicopathology and therapeutic information. Details of operative procedures including breast-conserving surgery, mastectomy and reconstructive approach, and timing were obtained from operative records. Patients were categorized as having immediate breast reconstruction if a reconstructive procedure was undertaken on the same date and side as the index mastectomy. Patients who underwent multiple operations on the same side as part of staged reconstruction were included only once. All types of reconstruction (implants, autologous and combined approaches) were included.

All patients undergoing mastectomy were offered breast reconstruction, either as an immediate or delayed procedure. Patients were counselled in the outpatient clinic before surgery, with both autologous and implant reconstruction options discussed. Breast reconstruction was offered to older patients routinely unless there was an absolute contraindication. Breast reconstruction was discussed at a multidisciplinary meeting with radiation and medical oncology colleagues, where appropriate, and these recommendations were passed on to patients during counselling. However, the final decision lay with the patient.

The majority of implant-only breast reconstruction procedures were two-stage procedures using a tissue expander, which was later replaced by a permanent implant placed subpectorally. Direct-to-implant procedures were carried out with the insertion of an acellular dermal matrix (ADM) to improve implant coverage.

These data pertain to the work of five oncoplastic and two plastic surgeons. All implant-only procedures were performed by oncoplastic surgeons. All deep inferior epigastric perforator flap (DIEP) procedures were carried out by plastic surgeons. Autologous procedures were performed by both oncoplastic and plastic surgeons; however, the majority were undertaken by oncoplastic surgeons. Mastectomy and immediate reconstruction was done by oncoplastic surgeons, with plastic surgeons more commonly performing delayed reconstructive procedures. During the study interval, breast cancer services for the Northwest of Ireland were centralized to this tertiary referral centre. Overall, this institution receives referrals from four other centres.

Patients presenting with a strong family history of breast cancer, particularly at a younger age, were referred for genetic testing and counselling at a separate referral centre, in accordance with National Institute for Health and Care Excellence Guidelines²⁰. Currently patients are tested routinely only for *BRCA1* and *BRCA2* mutations.

Statistical analysis

Analysis was performed on trends in breast reconstruction practices for the whole patient population. Subgroup analysis of patients who had invasive disease was then undertaken, excluding those undergoing prophylactic mastectomy and therapeutic mastectomy for *in situ* disease. Subgroup analysis was also conducted according to patient age. The population was divided into patients aged 60 years and over, and those aged less than 60 years. A cut-off of 60 years was chosen to capture a postmenopausal 'elderly' population compared with a premenopausal younger, fitter population.

The association between categorical factors of interest and breast reconstruction was analysed using Pearson's χ^2 test of association. A multivariable logistic regression was undertaken to assess the effects of histology, nodal status, chemotherapy and radiotherapy on the likelihood that patients would have breast reconstruction after mastectomy. The Wald test was used to determine statistical significance for each of the explanatory variables. $P < 0.050$ was assumed to represent statistical significance. Data were analysed using SPSS® version 2.0 (IBM, Armonk, New York, USA).

Results

A total of 1303 mastectomies and 1885 wide local excisions were performed between 2004 and 2014. Some 706 patients who underwent mastectomy had PMBR, resulting in an overall reconstruction rate of 54.2 per cent over this

Table 1 Factors influencing reconstruction rate

	Mastectomy alone (n = 597)	Mastectomy and reconstruction (n = 706)	P†
Age (years)*	63.3(12.5)	49.0(10.2)	< 0.001‡
Histology			< 0.001
No disease (RRM)	6 (1.1)	50 (7.7)	
Non-invasive	29 (5.5)	88 (13.5)	
Invasive	495 (93.4)	512 (78.8)	
Radiotherapy	298 of 595 (50.1)	275 of 671 (41.0)	0.001
Invasive disease only			
T category			< 0.001
T1	87 (17.9)	150 (30.0)	
T2	230 (47.2)	214 (42.8)	
T3	130 (26.7)	121 (24.2)	
T4	40 (8.2)	15 (3.0)	
Nodal status			< 0.001
N0	168 (34.3)	235 (47.1)	
N1	168 (34.3)	160 (32.1)	
N2	92 (18.8)	67 (13.4)	
N3	62 (12.7)	37 (7.4)	
M category			< 0.001
M0	409 (91.7)	464 (96.5)	
M1	37 (8.3)	17 (3.5)	
Tumour grade			0.720
I	26 (5.6)	42 (9.4)	
II	256 (54.7)	244 (54.5)	
III	186 (39.7)	162 (36.2)	
Subtype			0.958
Luminal A	313 (65.5)	316 (65.0)	
Luminal B	68 (14.2)	75 (15.4)	
Basal type	54 (11.3)	53 (10.9)	
HER2	43 (9.0)	42 (8.6)	
Chemotherapy			< 0.001
Yes	274 (55.7)	360 (70.9)	
No	218 (44.3)	148 (29.1)	
Timing of chemotherapy			0.253
Neoadjuvant	93 (33.9)	109 (29.7)	
Adjuvant	181 (66.1)	258 (70.3)	
Hormone therapy	176 of 451 (39.0)	275 of 451 (61.0)	0.006

Values in parentheses are percentages unless indicated otherwise; *values are mean(s.d.). Some data are missing for all variables, except age. RRM, risk-reducing mastectomy; HER2, human epidermal growth factor receptor 2. † χ^2 test, except ‡independent-samples *t* test.

time. Six hundred and twenty-nine reconstructions (89.1 per cent) were performed in the immediate setting; the remaining 77 women underwent delayed reconstruction following a previous mastectomy.

The characteristics of patients who underwent mastectomy and PMBR are summarized in *Table 1*. Mean(s.d.) patient age was 55.6(13.3) years. There was no difference in mean age between the first 6 and last 5 years of the study. T2 tumours were the most common (444 of 987, 45.0 per cent), along with N0 disease (403 of 989, 40.7 per cent).

The majority of mastectomies were therapeutic (1124 of 1180, 95.3 per cent), with the remainder carried out as either contralateral or bilateral prophylactic mastectomies.

Table 2 Relationship between treatments and patient age

	Age < 60 years (n = 832)	Age ≥ 60 years (n = 471)
Mastectomy alone	230 (27.6)	367 (77.9)
Mastectomy and reconstruction	602 (72.4)	104 (22.1)
Reconstruction procedure*		
Implant/expander	147 (24.8)	38 (37.6)
Pedicled flap + implant/expander	187 (31.6)	26 (25.7)
Autologous pedicled flap	213 (36.0)	30 (29.7)
Free flap	45 (7.6)	7 (6.9)
Radiotherapy*		
Radiotherapy and reconstruction	229 (40.2)	45 (45)
No radiotherapy and reconstruction	341 (59.8)	54 (55)
Chemotherapy*		
Chemotherapy and reconstruction	316 (55.2)	51 (52)
No chemotherapy and reconstruction	256 (44.8)	48 (48)

Values in parentheses are percentages. *Data missing for some patients.

Influence of patient and clinicopathological factors on reconstruction practices

Patients who underwent PMBR were significantly younger than those who had mastectomy alone (*Table 1*). A higher proportion of younger patients (aged less than 60 years) underwent PMBR (602 of 832, 72.4 per cent) compared with older patients (104 of 471, 22.1 per cent) (*Table 2*). There was no difference in the most commonly carried out reconstruction procedure (latissimus dorsi (LD) flap with or without implant) between the two age groups.

On subgroup analysis of patients with invasive breast cancer (*Table 1*), patients with T1 disease were more likely to undergo PMBR than those with a T2, T3 or T4 tumour ($P < 0.001$). Patients with node-negative disease (N0) were more likely to undergo breast reconstruction compared with those with axillary metastases ($P < 0.001$). Patients with non-metastatic disease were more likely to undergo a reconstructive procedure than those with distant metastases ($P < 0.001$). Tumour grade ($P = 0.720$) and tumour biological subtype ($P = 0.958$) had no influence on the rate of PMBR.

Timing of breast reconstruction was not associated with clinicopathological factors, such as histology ($P = 0.056$), grade ($P = 0.552$), T category ($P = 0.150$), subtype ($P = 0.547$) or M status ($P = 0.793$) (*Table 3*).

Trends in mastectomy and reconstruction over time

The mastectomy rate at this institution declined significantly over the study interval. Some 74.3 per cent of patients undergoing surgical treatment for breast cancer received a mastectomy in 2004 (*Fig. 1*). There was a steady decline over time, with a mastectomy rate of 41.6 per cent

Table 3 Relationship between timing of reconstruction, tumour factors and therapy

	Delayed (n = 77)	Immediate (n = 629)	P*
Histology			0.056
No disease (RRM)	8 (15)	42 (7.0)	
Non-invasive	4 (8)	84 (14.1)	
Invasive	40 (77)	470 (78.9)	
Tumour grade			0.552
I	4 (11.4)	38 (7.6)	
II	18 (51.4)	226 (45.5)	
III	10 (28.6)	152 (30.6)	
DCIS	3 (8.6)	81 (16.3)	
T category			0.150
T0	7 (14)	43 (7.3)	
T1	9 (18)	141 (24.0)	
T2	21 (42)	193 (32.9)	
T3	10 (20)	111 (18.9)	
T4	0 (0)	15 (2.6)	
Tis	3 (6)	84 (14.3)	
Subtype			0.547
Luminal A	24 (59)	292 (55.1)	
Luminal B	7 (17)	68 (12.8)	
Basal	5 (12)	48 (9.1)	
HER2	2 (5)	40 (7.5)	
DCIS	3 (7)	82 (15.5)	
M category			0.793
M0	45 (98)	548 (97.2)	
M1	1 (2)	16 (2.8)	
Radiotherapy			0.610
No	39 (62)	355 (58.6)	
Yes	24 (38)	251 (41.4)	
Chemotherapy			0.226
No	33 (52)	270 (44.4)	
Yes	30 (48)	338 (55.6)	
Timing of chemotherapy			0.201
Adjuvant	18 (60)	239 (71.1)	
Neoadjuvant	12 (40)	97 (28.9)	

Values in parentheses are percentages unless indicated otherwise. Some data are missing for all variables. RRM, risk-reducing mastectomy; DCIS, ductal carcinoma *in situ*; HER2, human epidermal growth factor receptor 2. * χ^2 test.

in 2014. This coincided with an increase in the rate of breast-conserving surgery, from 25.7 per cent in 2004 to 58.4 per cent in 2014.

Rates of skin-sparing and nipple-sparing mastectomies were analysed for 2009–2014, as not all specimen descriptions within pathology reports before this date were available for analysis. Some 61.1 per cent of all mastectomies carried out during this time were skin-sparing, and 20.5 per cent were nipple-sparing. There was no significant change in trends for skin- and nipple-sparing mastectomies during these 6 years ($P=0.147$ and $P=0.143$ respectively).

The number of PMBRs increased over time from 16 of 78 (21 per cent) in 2004 to 51 of 114 (44.7 per cent) in 2014 (Fig. 2). Reconstructive approaches used included

prosthetic with implant/expander only (185 of 693, 26.7 per cent), combined pedicled flap and implant/tissue expander (213, 30.7 per cent), autologous pedicled flap (both LD and transverse rectus abdominis (TRAM) flaps) (243, 35.1 per cent) and free DIEP flaps (52, 7.5 per cent).

A change in the pattern of reconstruction was noted over the time interval analysed (Fig. 3). Over half of all reconstructive procedures in the first 5 years of the study (2004–2008) were LD flaps with insertion of an implant (162 of 303, 53.5 per cent). There was a significant increase in the rate of prosthetic implant-based reconstructions, from none being carried out in 2004 to this type of reconstruction being the most widely used procedure in 2014 (22 of 50, 44 per cent) ($P < 0.001$). The use of autologous pedicled flaps decreased from 2004 (7 of 13, 54 per cent) to 2014 (12 of 50, 24 per cent). Free DIEP flaps were introduced to the institution in 2009, with a mean of 8.8 per annum. ADMs were introduced in 2009 and their use increased over time. Only one of 74 reconstructions (1 per cent) was carried out with an ADM in 2009 compared with 18 of 74 (24 per cent) in 2013.

Rates of prophylactic mastectomy were analysed from 2009 to 2014. During this interval, there were no significant changes in this practice for either bilateral prophylactic mastectomies (mean 4 (range 3–5) per year; $P=0.788$) or contralateral prophylactic mastectomies (mean 4.5 (3–6) per year; $P=0.322$). A higher proportion of patients undergoing risk-reducing mastectomy or therapeutic mastectomy for *in situ* disease underwent PMBR compared with those with invasive breast cancer ($P < 0.001$) (Table 1). Twenty-nine bilateral prophylactic mastectomies were carried out, 16 among women with a *BRCA* gene mutation. There were 27 contralateral prophylactic mastectomies, four in patients with a *BRCA* gene mutation. Implant-only reconstruction was the most common type of reconstructive procedure in patients undergoing risk-reducing prophylactic mastectomies (19 of 49, 39 per cent), followed by pedicled flap with implant (16 of 49, 33 per cent).

Radiotherapy

An inverse relationship between radiotherapy and rates of reconstruction was observed ($P=0.001$). In the cohort of patients who underwent PMBR, 396 of 671 (59.0 per cent) did not receive radiotherapy compared with 297 of 595 (49.9 per cent) in the mastectomy-alone group. However, this trend was only significant for the latter half of the study (2009–2014; $P < 0.001$); there was no significant association between the receipt of radiotherapy and breast reconstruction in the first 5 years of the study ($P=0.953$). There was no significant correlation

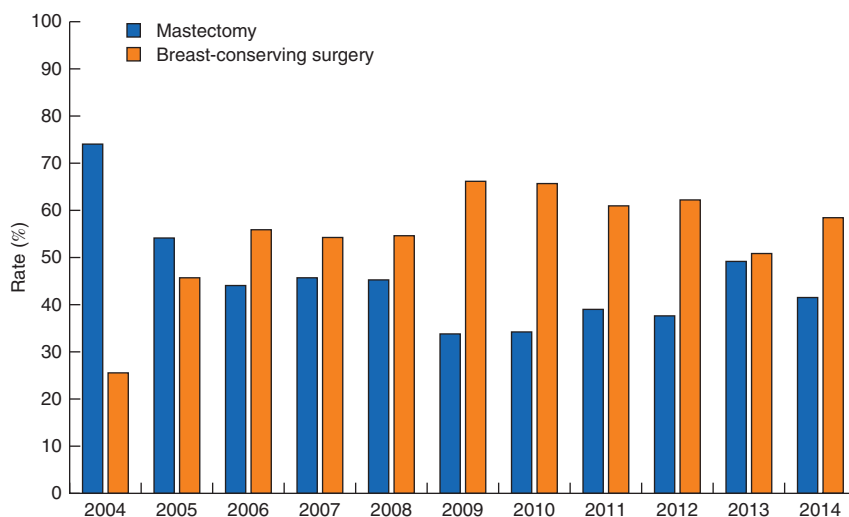


Fig. 1 Rates of mastectomy and breast-conserving surgery per year, 2004–2014



Fig. 2 Numbers of mastectomies and reconstructions per year, 2004–2014

between administration of postmastectomy radiotherapy (PMRT) and timing of reconstruction ($P=0.610$) (Table 3).

There was an association between receipt of radiotherapy and type of reconstruction ($P<0.001$). Pedicled flaps (with or without implant) (206 of 273, 75.5 per cent) were more common in those treated with PMRT. Implant-only (60, 22.0 per cent) and free flap (7 of 273, 2.6 per cent) procedures were less common in those patients who received radiotherapy. Between 2004 and 2008, there was no association between receipt of radiotherapy and reconstruction type ($P=0.524$). However, pedicled flaps with or without implant were still the most commonly carried out reconstruction type for those treated with radiotherapy (126 of 137, 92.0 per cent), with very few patients having implant-only reconstructions (11, 8.0 per cent). No free flaps were carried out for patients receiving radiotherapy during these 5 years. An association between radiotherapy and reconstruction type was observed for 2009–2014

($P<0.001$). Again, pedicled flaps with or without implants were the most common type of reconstruction (80 of 136, 58.8 per cent), but with an increase in the proportion of both implant-only (49, 36.0 per cent) and free flap (7, 5.1 per cent) procedures.

There was no statistically significant association between radiotherapy and PMBR in patients aged 60 years or more, whereas there was a significant inverse relationship between receipt of radiotherapy and rate of reconstruction in younger patients (odds ratio (OR) 0.55, 95 per cent c.i. 0.39 to 0.73; $P<0.001$). Of those undergoing breast reconstruction in the younger group, 229 of 570 (40.2 per cent) received radiotherapy and 341 did not. There was an association between age and reconstruction type in patients aged below 60 years ($P<0.001$). Pedicled flaps with or without an implant were most common in younger patients undergoing reconstruction (400 of 592, 67.6 per cent). No such association was observed in the older subgroup ($P=0.130$).

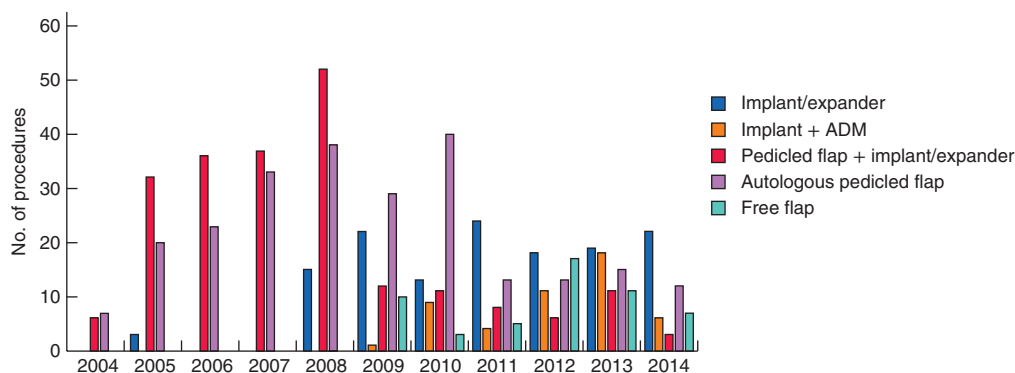


Fig. 3 Number of breast reconstruction procedures per year, 2004–2014. ADM, acellular dermal matrix

Chemotherapy

A higher percentage of those who underwent PMBR were treated with chemotherapy compared with those who did not have reconstruction ($P=0.002$) (Table 1). More patients aged less than 60 years underwent chemotherapy (461 of 800, 57.6 per cent) compared with older patients (181 of 464, 39.0 per cent). Of younger patients who had chemotherapy, 316 of 461 (68.5 per cent) underwent reconstruction, whereas only 51 of 181 (28.2 per cent) of older patients treated with chemotherapy underwent breast reconstruction (OR 1.92, 1.23 to 3.01; $P=0.004$).

Chemotherapy was associated with the type of reconstruction ($P<0.001$). Similar to radiotherapy, pedicled flaps with or without an implant (267 of 366, 73.0 per cent) were more common in those treated with chemotherapy. Implant-only (96 of 260, 36.9 per cent) and free flap (31 of 260, 11.9 per cent) reconstructions were more commonly performed in those not undergoing chemotherapy. There was an association between the age of patients in receipt of chemotherapy and the type of reconstruction. Pedicled flaps with or without implants were most common in younger patients receiving chemotherapy (235 of 314; 74.8 per cent; $P<0.001$), and there was no association between chemotherapy and reconstruction type in older patients ($P=0.130$). Fewer patients undergoing mastectomy were treated with chemotherapy from 2009 to 2014 (343 of 746, 46.0 per cent) than from 2004 to 2008 (301 of 522, 57.7 per cent). There was an association between timing of chemotherapy and the type of breast reconstruction ($P<0.001$). Of those who had chemotherapy and free flap reconstruction, the majority underwent neoadjuvant chemotherapy (12 of 17). Adjuvant chemotherapy was more common in all other types of reconstruction.

There was a sharp increase in the proportion of patients being treated with neoadjuvant chemotherapy over the course of the study ($P<0.001$). In 2004, only two of

39 patients (5 per cent) receiving chemotherapy received neoadjuvant treatment. In contrast, 32 of 55 patients (58 per cent) having chemotherapy received treatment in the neoadjuvant setting in 2014.

Multivariable analysis

Several co-variables had a significant association with PMBR on multivariable logistic regression analysis after adjusting for other variables. As regards histology, women undergoing therapeutic mastectomy for invasive breast cancer were less likely to have PMBR than those having risk-reducing mastectomy (OR 0.13, 95 per cent c.i. 0.06 to 0.33; $P<0.001$). Regarding nodal status, compared with women with N0 disease, those with axillary nodal metastasis were less likely to have PMBR (N1 disease, OR 0.57, 0.41 to 0.80, $P<0.001$; N2 disease, OR 0.44, 0.29 to 0.67, $P<0.001$; N3 disease, OR 0.35, 0.21 to 0.57, $P<0.001$). Patients treated with adjuvant radiotherapy were also less likely to have PMBR (OR 0.68, 0.49 to 0.94; $P=0.018$). In contrast, patients who had chemotherapy were more likely to have PMBR (OR 3.11, 2.27 to 4.25; $P<0.001$).

When these factors were analysed in relation to type of breast reconstruction they remained significantly associated with procedure type. Patients undergoing PMBR following therapeutic mastectomy for invasive breast cancer were more likely to have an implant-based reconstruction, either implant/expander (OR 2.14, 1.11 to 4.14; $P=0.024$) or an autologous/implant combined approach (OR 4.98, 2.45 to 10.11; $P<0.001$) (Table 4). Similarly, patients with node-positive disease were more likely to have an implant-based reconstruction (N3 disease, OR 3.20, 1.35 to 7.59; $P=0.008$). On analysis of treatment factors, the administration of adjuvant radiotherapy was the only independent predictor of a free flap reconstruction (OR 5.68, 2.52 to 12.82; $P<0.001$).

Table 4 Results of multivariable logistic regression analysis

	β	Standard error (β)	Odds ratio (e^{β})	P
Implant/expander				
Intercept	0.818	0.310	2.27	0.008
Histology				
No malignancy	0		1.00 (reference)	0.025
<i>In situ</i>	0.267	0.382	1.31 (0.62, 2.76)	0.484
Invasive cancer	0.760	0.337	2.14 (1.11, 4.14)	0.024
Nodal status				
N0	0		1.00 (reference)	0.009
N1	0.932	0.211	1.48 (0.98, 2.24)	0.064
N2	0.690	0.302	1.99 (1.10, 3.60)	0.022
N3	1.162	0.441	3.20 (1.35, 7.59)	0.008
Pedicled flap + implant/expander				
Intercept	0.890	0.313	2.44	0.004
Histology				
No malignancy	0		1.00 (reference)	< 0.001
<i>In situ</i>	0.680	0.402	1.97 (0.90, 4.34)	0.091
Invasive cancer	1.606	0.361	4.98 (2.45, 10.11)	< 0.001
Chemotherapy (yes versus no)	-1.033	0.217	0.36 (0.23, 0.55)	< 0.001
Autologous flap				
Intercept	1.652	0.131	5.22	< 0.001
Nodal status				
N0	0		1.00 (reference)	0.013
N1	0.377	0.189	1.46 (1.01, 2.11)	0.046
N2	0.775	0.264	2.17 (1.30, 3.64)	0.003
N3	0.543	0.298	1.72 (0.96, 3.09)	0.069
Chemotherapy (yes versus no)	-0.736	0.174	0.48 (0.34, 0.67)	< 0.001
Free flap				
Intercept	2.637	0.166	13.97	< 0.001
Radiotherapy (yes versus no)	1.738	0.415	5.68 (2.52, 12.82)	< 0.001

Values in parentheses are 95 per cent confidence intervals.

Discussion

Immediate breast reconstruction is the standard of care for patients with breast cancer, and is advantageous in that it retains the skin envelope, resulting in improved aesthetic outcomes, involves fewer operations to achieve the reconstructive goals, and has potential psychological benefits^{5,21,22}. The increasing rate of breast reconstruction at this institution reflects the specialization and multidisciplinary care available to patients from both oncoplastic and microvascular plastic surgeons. Immediate breast reconstruction with implant-based approaches is the current preferred approach; however, using a multidisciplinary approach, reconstructive choices after mastectomy can be tailored to the individual, and their disease and treatment considerations.

Younger patients are more likely to undergo PMBR, possibly because aesthetic outcomes are of higher priority in this cohort. In addition to this, women aged under 40 years are more likely to undergo risk-reducing surgery, either contralateral prophylactic mastectomy or bilateral prophylactic mastectomy, particularly in the case of a *BRCA* diagnosis or a strong family history²³. *BRCA1*

and *BRCA2* were the only genetic mutations identified in this population. A younger cohort of patients is less likely to be affected by co-morbidities such as cardiovascular or respiratory disease, making them more suitable candidates for longer and possible additional procedures required to complete the breast reconstruction²⁴. In the present cohort, patients aged under 60 years were more likely to undergo breast reconstruction than older patients, despite receipt of chemotherapy, which may be influenced by chemotherapy-induced morbidity in older patients in addition to treatment fatigue. The inverse relationship between radiotherapy and breast reconstruction was more pronounced in younger patients in this cohort, potentially as a result of the inferior reconstruction outcomes associated with the treatment. The present study reflects the real-world setting in a mature surgical group, suggesting that breast reconstruction rates are approximately 70 per cent in those aged less than 60 years, and 20 per cent in patients aged over 60 years.

Those with smaller tumours (T1) and those undergoing risk-reducing mastectomy were more likely to undergo PMBR. Patients with non-invasive disease require less neoadjuvant or adjuvant treatment, such as radiotherapy or

chemotherapy, and are therefore at a lower risk of complications after the reconstructive procedure²⁵. Conversely, there is a greater emphasis on oncological outcomes in those with a higher disease stage, which may act as a barrier to breast reconstruction. The complication rate is higher in patients who undergo PMBR, which may contribute to adjuvant therapy being delayed, failed reconstructions and a higher risk of recurrence²⁶.

The reconstruction rate between 2004 and 2014 was 54.2 per cent. This compares favourably with rates of 16–59 per cent internationally^{3,8,19,27–30}. The strongest predictors of PMBR cited were: age under 50 years; white race; higher income and education; and earlier disease stage³¹. This is reflected in the present cohort where younger age and earlier disease stage were predictive of PMBR. The rate of reconstruction increased over time (from 20.5 per cent in 2004 to 44.7 per cent in 2014), in keeping with international trends. There are several factors influencing the rising rates of breast reconstruction internationally. The introduction of the Women's Health and Cancer Rights Act of 1998, requiring health insurance policies in the USA to reimburse breast reconstruction procedures after mastectomy, has been paramount to the recent higher reconstruction rates in America³¹. In the present study, there was a peak in numbers of women undergoing PMBR in 2008 (Fig. 2). In the later years of the study, similar numbers of women underwent reconstruction and mastectomy alone. This may be explained by a peak in patients in receipt of radiotherapy in 2007 (59.4 per cent). PMRT-related complications over the next 2 years may have prompted surgeons to be more selective in offering reconstruction.

Skin- and nipple-sparing mastectomy have been associated with superior cosmetic and quality-of-life outcomes^{32,33}. Previously there were concerns regarding the oncological safety of these procedures; however, they have been proven to not increase rates of recurrence in patients undergoing mastectomy and have contributed to improving outcomes in breast reconstruction. The practice of skin- and nipple-sparing mastectomy is well established in this institution, and the increasing use of these techniques appears to have plateaued, with no significant change in the rates in the last 6 years of the present study.

There has been a change in the present study and internationally, in the preferred reconstructive approach. Earlier in the study period, autologous flaps were the most widely used. However, over time, implant-based reconstructions have become more common^{3,7,22,34–36}. This may be explained by implant reconstructions requiring less complicated operations and shorter operating times, lack of donor-site morbidity and no requirement for microvascular surgery expertise as in the case of some

autologous procedures (DIEP flaps). Complex patient selection and the requirement for preoperative CT (in DIEP flap surgery) also make autologous reconstructions a less attractive reconstructive technique^{35–37}. ADMs were first reported in 2005³⁸. Increasing utilization of ADMs may have contributed to the increase in implant-based reconstructions as their use obviates the need for total muscle coverage, which frequently requires the use of a tissue expander in a two-stage procedure. Therefore, immediate implant reconstructions with optimal aesthetic outcomes may be carried out in a single direct-to-implant procedure without the need for a second operation³⁹.

There was a trend towards the use of pedicled flaps with or without implants in the early years of the study, with few other options available, and a peak rate of autologous flap use was noted in 2008. More recently, there has been a much wider array of reconstructive procedures, without the peaks in reconstruction types observed at earlier time points. This may be attributed to the development of new techniques, wider expertise available with the centralization of services in a tertiary referral centre with both plastic and oncoplastic surgeons on site, and greater patient autonomy with the ability to offer a reconstruction more suited to each patient. These trends demonstrate how breast reconstruction is maturing as a surgical specialty with several options, allowing more suitable patient selection for each reconstruction type.

There was an inverse relationship between radiotherapy and breast reconstruction in the present cohort. PMRT has deleterious effects on complication rates and aesthetic outcomes in breast reconstruction, particularly implant-based reconstructions, as it can affect the symmetry, volume and projection initially achieved at the time of reconstruction⁴⁰. PMRT also increases the rates of grade 3 and 4 capsular contracture, and reduces the skin quality of the mastectomy flaps. The effect of PMRT on LD reconstruction can be catastrophic secondary to muscular atrophy⁴¹. It is believed that DIEP flap reconstruction is better suited to patients who require PMRT, although the number of DIEP flaps in the present cohort was small (52). The administration of adjuvant radiotherapy was the only independent predictor of this reconstructive approach on multivariable analysis.

Receipt of chemotherapy was not a barrier to breast reconstruction in the present study. There have been concerns that chemotherapy can contribute to increased adverse effects, such as impaired wound healing and infection in reconstructive procedures⁴². It has been shown that PMBR does not delay delivery of adjuvant chemotherapy, despite the increased rate of wound complications^{42,43}. Neoadjuvant chemotherapy did not influence whether or not a patient underwent reconstruction, or whether

reconstruction was carried out on an immediate or delayed basis. However, those in receipt of neoadjuvant chemotherapy were more likely to receive a DIEP flap over any other type of reconstruction. Although this result may be statistically significant, there were relatively few of these procedures in the present study, which may have skewed the data, and the results should be interpreted with caution.

Neoadjuvant chemotherapy has become the standard treatment for locally advanced breast cancer. The adoption of neoadjuvant chemotherapy in the treatment of breast cancer has had a significant influence on trends in mastectomy and reconstruction over time, partly because it increases the possibility of breast-conserving surgery in patients who were previously candidates for mastectomy or were considered inoperable⁴⁴. Although high overall, the rate of reconstruction at this institution started to decline towards the end of the study period³⁴. This may reflect a decreasing mastectomy rate as tumour downsizing with neoadjuvant chemotherapy has allowed greater use of breast-conserving surgery.

There are limitations to this study, as it is a retrospective, single-centre review of breast reconstruction practices. Smaller numbers of certain procedures, such as DIEP flaps, mean that the associations with clinicopathological factors must be interpreted with a degree of caution. However, the data are from a specialist breast tertiary referral centre and reflect the real-world experience in a mature, high-volume centre.

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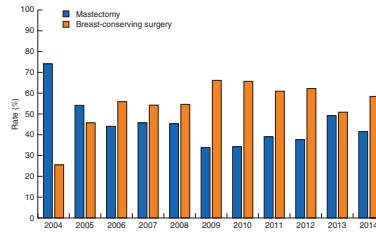
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Graphical Abstract

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Breast reconstruction postmastectomy has become the standard of care in the surgical treatment of breast cancer. Recent trends show a transition favouring implant-based approaches.