




Patient-reported outcomes 3 and 18 months after mastectomy and immediate prepectoral implant-based breast reconstruction in the UK Pre-BRA prospective multicentre cohort study

Kate L. Harvey¹, Leigh Johnson¹, Parisa Sinai¹, Nicola Mills², Paul White³, Christopher Holcombe⁴ and Shelley Potter^{1,5,*}  ; on behalf of The Pre-BRA Feasibility Study Steering Group[†]

¹National Institute for Health Research Bristol Biomedical Research Centre, University Hospitals Bristol and Weston NHS Foundation Trust, and University of Bristol, Bristol, UK

²Population Health Sciences, Bristol Medical School, Bristol, UK

³Applied Statistics Group, University of the West of England, Bristol, UK

⁴Breast Unit, Royal Liverpool University Hospital, Liverpool, UK

⁵Bristol Breast Care Centre, North Bristol NHS Trust, Bristol, UK

*Correspondence to: Shelley Potter, Translational Health Sciences, Bristol Medical School. Learning and Research Building, Southmead Hospital, Bristol BS10 5NB, UK (e-mail: shelly.potter@bristol.ac.uk)

[†]The Pre-BRA study steering group are listed at the end of the manuscript and are PUBMED citable collaborators on this manuscript.

Previous presentation: A preliminary analysis of the work was presented at the Association of Breast Surgery Meeting May 2022 (published abstract *EJSO* (2022); 48(5): E189–90, <https://doi.org/10.1016/j.ejs.2022.03.022>) and the San Antonio Breast Cancer Symposium, Texas, December 2023 (published abstract: *Cancer Research* (2024) 84 (9 suppl):PO2-22-12 <https://doi.org/10.1158/1538-7445.SABCS23-PO2-22-12>).

Abstract

Introduction: Prepectoral techniques are becoming standard of care for implant-based breast reconstruction due to reduced impact on chest wall function and improved patient satisfaction. Evidence to support these benefits, however, is lacking. Here, patient-reported outcomes (PROs) of prepectoral breast reconstruction (PPBR) in the Pre-BRA cohort are reported.

Methods: Women undergoing PPBR after mastectomy for breast cancer or risk reduction between July 2019 and December 2020 were recruited. Participants completed the BREAST-Q preoperatively and at 3 and 18 months following surgery together with a single item evaluating overall satisfaction at 18 months. Women completing at least one BREAST-Q scale at any timepoint were eligible for inclusion. Questionnaires were scored according to the developers' instructions and scores compared over time. Exploratory analysis, adjusting for baseline scores was performed to explore factors impacting PROs.

Results: In total 338 of 343 (98.5%) women undergoing PPBR at 40 UK centres were included in the analysis. Compared with baseline scores, women reported statistically significant and clinically meaningful decreases in both 'Physical' and 'Sexual well-being' at 3 and 18 months. Adjusting for baseline, at 18 months, those experiencing implant loss or having surgery for malignancy reported lower scores in all BREAST-Q domains. Overall, two-thirds of women (167/251) rated the outcome of their reconstruction as 'excellent/very good', but experiencing major complications, implant loss, and being dissatisfied with wrinkling/rippling in the reconstructed breast were associated with reduced satisfaction.

Conclusions: PPBR impacts postoperative physical well-being and PROs are variable. These findings should be discussed with patients to support informed decision-making based on realistic expectations of outcome.

Study registration: ISRCTN11898000.

Introduction

Up to 40%¹ of the 55 000² women diagnosed with breast cancer each year in the UK will undergo a mastectomy as part of their treatment. Mastectomy can profoundly impact women's well-being and the National Institute of Health and Care Excellence recommends that breast reconstruction should be routinely offered to improve quality of life³.

Implant-based reconstruction is the most performed reconstructive procedure worldwide^{4,5} and over the last decade,

the technique has evolved rapidly despite a lack of high-quality evidence to support best practice. Traditionally, a two-stage procedure was performed, with initial placement of a tissue expander under the pectoralis muscle. After gradual expansions a second operation was performed to insert a definitive fixed-volume implant. The introduction of biological and synthetic meshes allowed the creation of a larger subpectoral pocket at the initial operation, thus allowing a fixed-volume implant to be inserted in a single stage. The use of mesh

Received: September 08, 2024. Revised: November 13, 2024. Accepted: January 13, 2025

© The Author(s) 2025. Published by Oxford University Press on behalf of BJS Foundation Ltd.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

allowed women to avoid a second operation and was perceived to result in better cosmetic outcomes through improved lower pole projection. Subpectoral mesh-assisted reconstruction therefore rapidly became standard of care despite a lack of high-quality evidence to support the proposed benefits^{6–11}.

Most recently, the technique has evolved so that the implant, usually supported by mesh, is placed on top rather than underneath the pectoralis muscle¹². This prepectoral technique avoids 'implant animation', the upwards movement of the implant seen when the chest wall muscles contract. It is also hypothesized to have less impact on chest wall function as the pectoralis muscle is not lifted, and to lead to better cosmetic outcomes than subpectoral techniques as the implant is placed in a more anatomical position¹². Subcutaneous implant-based reconstruction, however, was previously abandoned by the reconstructive community due to unacceptable complication rates^{13–16}. High-quality evidence is therefore needed not only to demonstrate that the technique is safe, but also that the proposed improvements in patient-centred outcomes are realized.

Although there is a rapidly growing body of evidence to suggest that the complication rates of pre- and subpectoral reconstruction are broadly comparable^{17,18}, studies exploring the hypothesized improvements in patient-reported outcomes (PROs) following prepectoral breast reconstruction (PPBR) remain scarce. Current evidence is limited to often small^{19–23}, single-centre²⁴ studies that only assess PROs at a single timepoint, thus limiting their value. Few studies have assessed how PROs change over time and these results are conflicting^{25,26}. As breast reconstruction is performed to improve quality of life, high-quality multicentre studies evaluating the longitudinal impact of PPBR on PROs are urgently needed.

Pre-BRA is a multicentre prospective study²⁷ that aimed to establish the safety and effectiveness of PPBR to inform the design of a future trial comparing pre- and subpectoral techniques. Here, the impact of PPBR on patient-reported outcomes at 3 and 18 months following surgery in women participating in the Pre-BRA study is reported.

Methods

Study design and participants

Pre-BRA was a single-arm, multicentre, IDEAL Phase 2a/2b prospective observational cohort study with embedded qualitative methods²⁷. Full ethical approval was obtained (NRES OXFORD-B South Central Committee Ref:19/SC/0129. IRAS ID: 255421) and the study was prospectively registered prior to commencing participant recruitment (ISRCTN11898000). The short-term safety outcomes have been reported elsewhere²⁸. The study methods have been described in detail elsewhere^{27,28}, but in brief: women aged 16 or over undergoing mastectomy for malignancy or risk-reduction who elected to undergo immediate implant-based reconstruction and who were considered technically suitable for a prepectoral procedure by their operating surgeon were eligible to participate in the study.

Procedures

Eligible patients were prospectively identified from multidisciplinary meetings, clinics and operating lists at participating centres and given a study information sheet by their local surgical teams. Patients who elected to participate provided written consent and completed baseline PRO questionnaires. Baseline demographic data were collected via electronic case report forms (CRFs) hosted on REDCap²⁹.

All participants underwent immediate prepectoral implant-based reconstruction as per local practice. Type of mastectomy (skin-sparing, nipple-sparing, or skin-reducing), choice of implant (tissue expander, fixed-volume implant or adjustable implant), and use and type of mesh (biological or synthetic) were as per surgeon and patient preference. Raising the pectoralis muscle was prohibited but if, intraoperatively, the operating surgeon felt that prepectoral reconstruction was not possible for safety reasons (for example poor-quality skin flaps) and the preoperative surgical plan was modified, the modification (for example conversion to subpectoral reconstruction) and rationale were captured on the operative CRF. Use of antibiotics, drains, and dressings were as per local practice.

All complications were defined a priori using standardized definitions^{10,30,31} and complication and oncological data were collected by clinical, or case note review at 30 days and 3 months as per local practice.

Outcome measures

Participants were asked to complete the validated BREAST-Q questionnaire³² either electronically or on paper as per patient preference at 3 and 18 months post surgery. At 18 months, participants were also asked to rate the overall outcome of their reconstruction on a 5-point Likert scale (excellent/very good/good/fair/poor) consistent with the evaluation in the UK National Mastectomy and Breast Reconstruction Audit^{33,34} and other large-scale UK-based studies¹⁰ and to report the receipt of any additional unplanned surgical procedures, in particular unplanned implant removal.

BREAST-Q questionnaire

The BREAST-Q is a validated questionnaire robustly developed for patients undergoing breast reconstruction^{32,35}. It consists of four main scales: 'Satisfaction with breasts', 'Physical well-being: chest', 'Sexual well-being', and 'Psychosocial well-being'. Each scale is Rasch-transformed to give a score out of 100, with higher scores reflecting better outcomes. A four-point difference in 'Satisfaction with breast', 'Psychosocial' and 'Sexual well-being' domains and a three-point difference in the 'Physical well-being: chest' domain represent the minimum clinically important difference³⁶.

Two additional BREAST-Q scales with particular relevance to PPBR were also evaluated at 3 and 18 months post surgery: the two-item 'Satisfaction with implants' scale evaluating satisfaction with wrinkles/ripples that were visible and/or palpable in the reconstructed breast and the newly developed 12-item 'Animation deformity' scale, designed to assess the impact of chest wall animation on quality of life³⁷.

Sample size and statistical analysis

Sample size considerations

The Pre-BRA study was powered to detect an unacceptable implant loss rate of >9% at 3 months^{27,28}. This was based on the implant loss rate observed in the UK iBRA study that included over 2000 implant-based reconstructions from 81 centres¹⁰. The PRO study was exploratory and hypothesis generating so no formal sample size calculation was performed.

Statistical analysis

Pre-BRA participants were included in the PRO analysis if they had completed at least one of the main BREAST-Q scales at any timepoint. Those who did not meet this criterion were excluded.

Simple summary statistics were calculated to describe demographic, procedure, and outcome data. Categorical data were summarized by counts and percentages and continuous data by mean and standard deviation.

The BREAST-Q questionnaire was scored according to the developers' instructions and unadjusted scores at 3 and 18 months compared with baseline values using a paired t-test. Linear regression, adjusting for baseline scores was used to explore patient, procedure, and treatment-related factors hypothesized to impact PROs at 18 months based on the literature³⁸⁻⁴¹ and expert opinion. These included age (<45 years versus older), BMI (>30 versus <30), smoking status (current versus non-smoker), co-morbidities (yes/no); indication for surgery (malignancy versus risk reduction), unilateral versus bilateral reconstruction, nipple preservation versus not, high mastectomy weights (>600 g versus <600 g), receipt of chemotherapy or radiotherapy and experiencing any complication, major complications requiring readmission or re-operation at 3 months or implant loss at any timepoint.

For implant reconstruction specific domains only measured post surgery, 3 and 18 month scores were calculated and compared. The 'Satisfaction with implants' scale does not have formal scoring guidance so the scores for each item was dichotomized into 'Very/Somewhat satisfied' versus 'Very/Somewhat dissatisfied' and the proportions of women reporting dissatisfaction with the look and/or feel of ripples/wrinkles in their reconstructed breast at each timepoint compared using chi-squared statistics.

The single item on overall satisfaction with the outcome of surgery was dichotomized into 'excellent/very good' versus 'good/fair/poor' consistent with the approach used in previous studies to facilitate comparison of techniques^{42,43} and an exploratory univariable analysis using chi-squared statistics performed to explore whether the hypothesized factors listed above impacted overall satisfaction.

Results

Of the 347 women planned for PPBR at 40 UK sites between 1 July 2019 and 31 December 2020, 343 successfully underwent the procedure. Prepectoral reconstruction was abandoned intraoperatively in four patients due to concerns about skin-flap viability. Of the 343 women undergoing PPBR, 326/343 (95.0%), 296/343 (86.3%), and 255/343 (74.3%) women completed at least one main BREAST-Q scale at baseline, 3 and 18 months respectively, and a total of 338/343 (98.5%) were eligible for inclusion in the analysis.

Demographics of the PRO cohort are summarized in Table 1. The mean age of participants was 48.6 years (s.d. 10.9). Most women had surgery for malignancy ($n = 295$, 87.3%) and a quarter ($n = 84$, 24.9%) had bilateral reconstruction. Approximately 40% of participants experienced at least one postoperative complication at 3 months ($n = 141$, 41.7%) and 20% ($n = 68$) had a major complication requiring readmission and/or re-operation. In addition to the 27 women who had experienced implant loss by 3 months, a further 12 self-reported having their implant removed between 3 and 18 months. A total of 39 women (11.6%) therefore experienced implant loss in the cohort overall. Women who experienced a major complication or lost their implant were significantly less likely to complete the 18 month questionnaire (38/68 (55.9%) major complications versus 217/270 (80.4%) no complications, $P < 0.001$; 20/39 (51.3%) implant loss versus 235/299 (78.6%) no implant loss, $P < 0.001$). Of the 20 patients reporting an implant

Table 1 Demographics of the Pre-BRA PROMs cohort

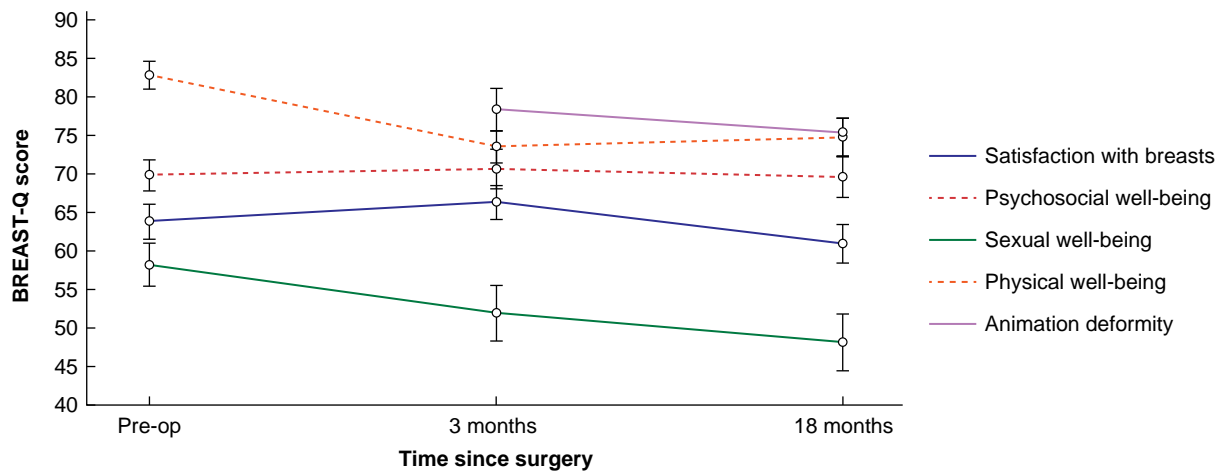
	N = 338
Age, years (mean,sd)	48.6 (10.9)
Age group	
<45	125 (37.0)
45-59	158 (46.8)
60 and over	55 (16.3)
BMI	
Underweight <18.5	3 (0.9)
Normal 18.5-24.9	167 (49.4)
Overweight 25-29.9	91 (26.9)
Obese >30	68 (20.1)
Not reported	9 (2.7)
Smoking	
Smoker	40 (11.8)
Non-smoker	295 (87.3)
Not reported	3 (0.9)
Laterality	
Unilateral	254 (75.2)
Bilateral	84 (24.9)
Indication for surgery	
Malignancy	295 (87.3)
Risk reduction	43 (12.7)
Co-morbidity	
Yes	84 (24.9)
No	244 (72.2)
Not reported	10 (3.0)
Nipple-sparing procedure	
At least one	179 (53.0)
Nipple sacrificing	158 (46.8)
Not reported	1 (0.3)
Complications at 3 months	
Any complication	141 (41.7)
Implant loss	27 (8.0)
Major complications requiring readmission or re-operation	68 (20.1)
Infection	65 (19.2)
Implant loss at any time point*	39 (11.6)
Chemotherapy	
Yes	67 (19.9)
Not required	209 (61.8)
Already received	44 (13.0)
Not reported	18 (5.3)
Radiotherapy	80 (23.7)
Endocrine therapy	181 (53.6)
PROMs completion†	
Baseline	326 (96.4)
3 months	296 (87.6)
18 months	255 (75.4)

*Includes 12 women self-reporting implant loss at 18 months. †At least one BREAST-Q scale.

loss who completed the 18-month questionnaire, 9 (45.0%) reported having a secondary reconstruction with either an implant ($n = 7$) or an autologous ($n = 2$) procedure.

Main BREAST-Q scales

Unadjusted BREAST-Q scores at baseline, 3, and 18 months following surgery are summarized in Fig. 1 and Table S1. Compared with scores at baseline, women reported statistically significant and clinically meaningful decreases in both their 'Physical well-being: chest' (baseline to 3 months -9.6 (95% c.i. -12.2, -6.9), $P < 0.001$; baseline to 18 months -8.5 (95% c.i. -11.5, -5.5), $P < 0.001$) and 'Sexual well-being' (baseline to 3 months -8.1 (95% c.i. -11.7, -4.4), $P < 0.001$; baseline to 18 months -10.7 (95% c.i. -14.8, -6.6), $P < 0.001$) scores at 3 and 18 months after surgery, but no significant changes were seen between 3 and 18 months (Fig. 1). There were no significant changes in 'Satisfaction with breasts' scores between baseline and 3 months and only



BREAST-Q scale	3 months versus baseline scores			18 months versus baseline scores			18 versus 3 month scores		
	n	Difference in means (95% c.i.)	P [†]	n	Difference in means (95% c.i.)	P [†]	n	Difference in means (95% c.i.)	P [†]
Satisfaction with breasts	258	2.2 (-0.9, 5.3)	0.161	232	-3.4 (-6.7, -0.2)	0.039	219	-5.4 (-7.8, -2.9)	<0.001
Psychosocial well-being	283	0.6 (-1.9, 3.1)	0.643	243	-1.8 (-4.5, 0.9)	0.195	237	-2.0 (-4.3, 0.2)	0.072
Sexual well-being	169	-8.1 (-11.7, -4.4)	<0.001	144	-10.7 (-14.8, -6.6)	<0.001	140	-3.3 (-6.7, 0.2)	0.062
Physical well-being	280	-9.6 (-12.2, -6.9)	<0.001	244	-8.5 (-11.5, -5.5)	<0.001	239	0.4 (-1.9, 2.6)	0.753
Animation deformity	-	-	-	-	-	-	226	-4.0 (-6.5, -1.5)	0.002

c.i. - confidence intervals, [†]paired t-test

Fig. 1 Changes in unadjusted BREAST-Q scores over time

borderline decreases in scores between baseline and 18 months. Statistically significant and clinically meaningful decreases in 'Satisfaction with breasts' scores were, however, seen between 3 and 18 months in women completing the questionnaire at both timepoints (-5.4, 95% c.i. -7.8, -2.9, $P < 0.001$). No other significant changes were seen (Fig. 1).

Exploratory analyses of factors impacting 18-month BREAST-Q scores, adjusting for baseline are summarized in Table 2. Women having PPBR for risk reduction reported significantly higher scores across all domains than those having surgery for malignancy. Women with larger mastectomy specimens reported relatively better 'Psychosocial well-being' compared with those whose mastectomy weights were lower, and those having bilateral reconstruction reported better 'Sexual well-being' than those having unilateral surgery. By contrast, women receiving radiotherapy and those with BMIs >30 reported worse 'Physical well-being: chest' scores at 18 months. Experiencing implant loss had the most marked impact on PROs, with decreases of 19–23 points across all BREAST-Q domains at 18 months (Table 2).

Implant-specific BREAST-Q scales

At 3 months, approximately a third of women (94/273, 34.8%) reported dissatisfaction with the ripples/wrinkles in their reconstructed breast, but this proportion increased significantly to 45.6% (111/244) by 18 months ($P < 0.001$). Unadjusted scores for 'Animation deformity' decreased from 78.4 (95% c.i. 76.0, 80.9) at 3 months to 75.4 (95% c.i. 72.6, 78.2) at 18 months. When scores were compared in women completing the scale at both timepoints, a statistically significant decrease of 4.0 points (95% c.i. -6.5 to -1.5, $P = 0.002$) was seen (Fig. 1).

Overall satisfaction with the outcome of reconstruction

At 18 months, two-thirds of women (167/251, 66.5%) rated the outcome of their reconstruction as 'excellent' or 'very good'. In

the exploratory analysis, only experiencing a major complication, implant loss, and dissatisfaction with ripples/wrinkles in the reconstructed breast were associated with reduced overall satisfaction at 18 months. Women with mastectomy weights >600 g were more satisfied with the outcome of their surgery than those whose mastectomy weights were smaller (Table 3).

Discussion

This is the first prospective multicentre study to evaluate the longitudinal impact of PPBR on PROs using a validated questionnaire. It suggests that contrary to the perceived benefits of the technique over subpectoral reconstruction, women undergoing PPBR report statistically significant and clinically meaningful decreases in their 'Physical well-being: chest' scores following surgery even though their pectoralis muscle is not raised. Undergoing surgery for malignancy (rather than risk reduction) and experiencing implant loss resulted in significantly lower BREAST-Q scores in all domains in the exploratory analysis. Implant loss rates were also a third higher than previously reported²⁸ as 12 women self-reported having their implant removed between 3 and 18 months. Indeed, the true proportion of women experiencing implant loss is likely to be even higher than the 11.6% reported here, as these delayed implant loss were identified by patient self-report and women who lose their implant have been shown to be significantly less likely to complete follow-up PRO questionnaires in similar studies⁴², raising further safety concerns regarding the technique²⁸.

Unanticipated issues with PPBR included women reporting ongoing concerns with 'implant animation' despite prepectoral implant placement. Indeed, 'Animation deformity' scores decreased significantly between 3 and 18 months, suggesting these issues worsened over time. In addition, 45% of women reported dissatisfaction with the look or feel of ripples/wrinkles in their reconstructed breast at 18 months compared with a

Table 2 Exploratory analysis of factors impacting 18-month BREAST-Q scores, adjusting for baseline

	Psychosocial well-being, n = 251		Physical well-being chest, n = 252		Sexual well-being, n = 164		Satisfaction with breasts n = 245	
	Coefficient (95% c.i.)	P	Coefficient (95% c.i.)	P	Coefficient (95% c.i.)	P	Coefficient (95% c.i.)	P
Age								
<45	Reference		Reference		Reference		Reference	
45–59	–1.06 (–6.65, 4.53)	0.710	–3.62 (–9.14, 1.90)	0.198	–7.63 (–15.36, 0.10)	0.053	–0.32 (–6.98, 4.32)	0.644
60 and over	4.07 (–4.47, 10.62)	0.423	–2.51 (–9.82, 4.79)	0.499	–7.68 (–20.62, 5.26)	0.243	–0.59 (–8.14, 6.96)	0.878
BMI								
>30	Reference		Reference		Reference		Reference	
≤30	–5.99 (–12.69, 0.71)	0.079	–11.40 (–17.82, –4.99)	0.001	–5.26 (–15.87, 5.34)	0.328	–5.14 (–12.07, 1.78)	0.145
Smoking								
No	Reference		Reference		Reference		Reference	
Yes	–8.50 (–17.02, 0.02)	0.051	–7.46 (–15.81, 0.89)	0.080	–0.26 (–12.46, 11.95)	0.967	–9.66 (–18.32, –0.99)	0.029
Laterality								
Bilateral	Reference		Reference		Reference		Reference	
Unilateral	1.90 (–3.65, 7.46)	0.501	–0.64 (–4.94, 6.21)	0.823	12.77 (5.20, 20.35)	0.001	1.98 (–3.61, 7.47)	0.486
Indication for surgery								
Risk reduction	Reference		Reference		Reference		Reference	
Malignancy	10.94 (3.64, 18.23)	0.003	10.09 (2.90, 17.27)	0.006	15.51 (5.66, 25.37)	0.002	8.65 (1.41, 15.90)	0.019
Co-morbidity								
No	Reference		Reference		Reference		Reference	
Yes	–3.34 (–9.22, 2.55)	0.266	1.12 (–4.73, 6.97)		–0.31 (–9.13, 8.50)	0.944	1.95 (–4.13, 8.05)	0.527
Nipple-sparing procedure								
No	Reference		Reference		Reference		Reference	
Yes	3.37 (–1.68, 8.42)	0.190	–3.58 (–8.58, 1.43)	0.160	0.26 (–7.19, 7.72)	0.944	–4.59 (–9.68, 0.51)	0.077
Mastectomy Weight								
<600 g	Reference		Reference		Reference		Reference	
>600 g	8.81 (2.57, 15.06)	0.006	6.55 (0.19, 12.92)	0.044	10.24 (0.34, 20.15)	0.043	–5.72 (–9.90, 12.33)	0.090
Chemotherapy								
None	Reference		Reference		Reference		Reference	
Neoadjuvant	–1.22 (–9.17, 6.73)	0.763	–5.35 (–13.05, 2.36)	0.173	–4.96 (–15.37, 5.46)	0.348	–6.29 (–14.47, 1.88)	0.131
Adjuvant	–3.07 (–9.40, 3.26)	0.341	–7.90 (–14.22, –1.57)	0.015	–5.78 (–15.06, 3.501)	0.221	–7.31 (–13.72, –0.90)	0.026
Radiotherapy								
No	Reference		Reference		Reference		Reference	
Yes	–5.16 (–11.08, 0.76)	0.087	–9.33 (–15.04, –3.61)	0.001	–4.66 (–13.53, 4.21)	0.301	–3.70 (–9.78, 2.38)	0.232
Any complication								
No	Reference		Reference		Reference		Reference	
Yes	–2.36 (–7.61, 2.88)	0.376	–2.90 (–8.04, 2.24)	0.269	3.77 (–4.06, 11.60)	0.352	–1.87 (–7.12, 3.39)	0.485
Major complication	–3.03 (–10.37, 4.30)	0.416	–4.08 (–11.34, 3.18)	0.269	–0.38 (–12.05, 11.28)	0.948	–7.26 (–14.51, 0.00)	0.050
Implant loss at any timepoint								
No	Reference		Reference		Reference		Reference	
Yes	–20.98 (–30.61, –11.35)	<0.001	–20.54 (–29.81, –11.26)	<0.001	–18.97 (–32.39, –5.54)	0.006	–22.83 (–32.51, –13.16)	<0.001

third at 3 months, suggesting that this issue became more problematic as the postoperative swelling and seroma resolved. Two-thirds of women, however, rated the outcome of their reconstruction as either ‘Very good’ or ‘Excellent’, but experiencing major complications, implant loss, and/or being dissatisfied with the wrinkles/ripples in the reconstructed breast were associated with significantly lower levels of satisfaction overall.

It is unclear why PPBR, which does not disturb the pectoralis muscle, results in such significant reductions in ‘Physical well-being: chest’ score at 3 and 18 months. One explanation may be that all women in the cohort underwent skin/nipple-sparing or skin-reducing mastectomy and immediate implant reconstruction so they could experience tightness and discomfort from surgical scarring, even though the pectoral muscle was not raised. Indeed, although the UK multicentre iBRA PRO study suggested PPBR may be associated with improved ‘Satisfaction with breasts’ compared with subpectoral techniques, the number of patients undergoing

PPBR was small ($n=14$) and unadjusted scores in this larger cohort of women undergoing exclusively PPBR are almost identical to those in the iBRA cohort, most of whom underwent subpectoral mesh-assisted procedures⁴². Patient-reported outcomes after pre- and subpectoral reconstruction have been shown to be equivalent in other longitudinal studies²⁶, but high-quality PRO studies are limited and systematic reviews comparing PROs in patients undergoing pre- and subpectoral procedures have generated conflicting results^{17,44}. There is therefore an urgent need for high-quality multicentre studies to explore the longer-term impact of PPBR on PROs. This is vital as current data suggest that PPBR does not translate into improved PROs compared with other types of implant-based procedures⁴². As these outcomes are consistently poorer than those seen after autologous reconstruction⁴¹ or oncoplastic breast-conserving surgery⁴⁵, these findings should be shared with women considering PPBR to ensure they are fully informed about the likely outcomes of their surgery.

Table 3 Exploratory analysis of factors impacting overall satisfaction with reconstruction at 18 months

	Excellent/ very good (n = 167, 66.5%)	Good/fair/ poor (n = 84, 33.5%)	P*
Age			
<45	66 (39.5)	25 (29.8)	0.253
45–59	75 (44.9)	41 (48.8)	
60 and over	26 (15.6)	18 (21.4)	
BMI			
>30	139 (83.2)	61 (72.6)	0.057
≤30	24 (14.4)	20 (23.8)	
Not reported	4 (2.4)	3 (3.6)	
Smoking			
Yes	13 (7.8)	11 (13.1)	0.172
No	153 (91.6)	72 (85.7)	
Not reported	1 (1.1)	1 (1.2)	
Bilateral reconstruction	46 (27.5)	27 (32.1)	0.499
Indication for surgery			
Malignancy	144 (86.2)	74 (88.1)	0.679
Risk reduction	23 (13.8)	10 (11.9)	
Co-morbidities			
Yes	37 (22.2)	27 (32.1)	0.085
No	124 (74.3)	54 (64.3)	
Not reported	6 (3.6)	3 (3.6)	
Nipple-sparing procedure			
Yes	88 (52.7)	47 (56.0)	0.66
No	78 (46.7)	37 (44.1)	
Not reported	1 (0.6)	0 (0)	
Mastectomy weight			
<600 g	24 (14.4)	23 (27.4)	0.008
>600 g	137 (82.0)	55 (65.5)	
Not reported	6 (3.6)	6 (7.1)	
Chemotherapy			
None	108 (64.7)	48 (57.1)	0.164
Neoadjuvant	19 (11.4)	13 (15.5)	
Adjuvant	29 (17.4)	23 (27.4)	
Not reported	11 (6.7)	0 (0)	
Radiotherapy	33 (19.8)	23 (27.4)	0.171
Any complication	58 (34.7)	35 (41.7)	0.283
Major complication	19 (11.4)	18 (21.4)	0.034
Implant loss at any timepoint	5 (3.0)	13 (15.5)	<0.001
Dissatisfied with look or feel of ripples/wrinkles in the reconstructed breast at 18 months			
Yes	51 (30.5)	60 (76.9)	<0.001
No	113 (67.7)	18 (21.4)	
Not reported	3 (1.8)	6 (7.1)	

*Chi-squared test.

This study provided much-needed data regarding the impact of PPBR on PROs, but it has limitations that require consideration. This is a single-arm study, so it is not possible to directly compare the PROs of PPBR with other IBBR techniques. Prepectoral reconstruction, however, has now become the standard of care in the UK, so a comparative study would be challenging. Response bias is a key concern in PRO studies with ethnicity and sociodemographic status shown to impact response rates^{39,46}. In addition, as previously reported⁴², women experiencing major complications and implant loss were significantly less likely to complete the 18-month questionnaire. Implant loss has been shown to profoundly impact women's quality of life⁴⁷, so it is possible that the PROs of the PPBR are overestimated here. Furthermore, almost 50% of patients reporting implant loss in this study who did complete the 18-month questionnaire also reported receiving a secondary reconstruction. This may have impacted their scores, but the

numbers are too small for any subgroup analysis to be meaningful, and the proportion of women experiencing implant loss in the cohort overall is small. The scores in the Pre-BRA cohort and the recently published clinical reference values for the BREAST-Q in patients having implant-based reconstruction⁴⁸ are similar, thus suggesting they are reflective of the outcomes of implant reconstruction as a whole. Multiple factors are known to impact patient-reported outcomes after breast reconstruction^{41,46,49} and although an exploratory analysis was performed, the cohort was too small to meaningfully undertake a more detailed statistical analysis adjusting for all possible confounders. The aim of this study, however, was exploratory and hypothesis generating and as such it provides valuable insights into the short-term impact of PPBR on PROs. The clinical and PROs of implant-based reconstruction, however, have been shown to change significantly over time^{38,46,50}, and therefore studies with longer follow-up will be essential to fully determine the outcomes of the technique, especially in the context of postmastectomy radiotherapy.

There remains an urgent need for high-quality data regarding the short- and long-term impact of PPBR on PROs to support women to make informed decisions about surgery. Ideally comparative data are needed, but the Best-BRA study demonstrated that an RCT comparing pre- and subpectoral techniques was not feasible in the UK due to rapid changes in practice and loss of surgeon equipoise⁵¹. The OPBC-02/PREPEC trial, an international pragmatic RCT with 372 participants, has successfully accrued and is now in follow-up⁵². The primary outcome is patient-reported chest function assessed with the BREAST-Q at 24 months and therefore the trial will provide important comparative data. However, real-world data involving larger numbers of participants are needed to establish best practice and fully explore the long-term clinical and patient-reported outcomes of PPBR. The ongoing EUBREAST iPREPARE study⁵³ is an international prospective PPBR registry with a target recruitment of 1236 women. This large-scale study includes embedded electronic PROs and will allow factors impacting outcomes to be explored and tracked over time.

Evolution of surgical techniques is essential to improve outcomes for patients, but this study adds to the growing body of data to suggest that PPBR fails to deliver on the hypothesized benefits of the technique compared with more established subpectoral procedures. Furthermore, almost half of women are dissatisfied with the ripples/wrinkles in their reconstructed breast, adversely impacting their satisfaction overall. Implant loss rates may also be higher than previously reported, raising ongoing concerns regarding safety. Further large-scale studies exploring how the clinical and patient-reported outcomes of PPBR change over time, particularly regarding late (>3 months) implant loss and the impact of factors such as chest wall radiotherapy on these outcomes are needed. For now, the findings of this study and the uncertainties regarding the long-term outcomes of the technique should be transparently shared with women considering breast reconstruction to support fully informed decision-making based on realistic expectations of the likely results.

Collaborators

The Pre-BRA Feasibility Study Steering Group

Peter Barry (Royal Marsden NHS Foundation Trust, London, UK); Simon Cawthorn (North Bristol NHS Trust, Bristol, UK); Matthew Gardiner (Frimley Health NHS Foundation Trust, Frimley, UK); Gareth Irwin (City Hospital, Belfast, UK); Cliona Kirwan (University of Manchester, Manchester, UK); Mairead McKenzie

(Patient Advocate, Independent Cancer Patients Voice, London, UK); Shireen McKenzie (Leeds University Teaching Hospital, Leeds, UK); Rachel O'Connell (Royal Marsden NHS Foundation Trust, London, UK); Georgette Oni, Tim Rattay (University of Leicester, Leicester, UK); Pankaj Roy (University Hospitals Oxford NHS Trust, Oxford, UK); Joanna Skillman (University Hospitals Coventry and Warwickshire, Coventry, UK); Soni Soumian (University Hospitals of the North Midlands, Stoke on Trent, UK); Raghavan Vidya (Royal Wolverhampton NHS Trust, Wolverhampton, UK); Lisa Whisker (Worcester Acute Hospitals NHS Trust, Worcester, UK); and Samantha Williams (Great Western Hospitals NHS Hospitals Foundation Trust, Swindon, UK).

Funding

This work was supported by a One Year Royal College of Surgeons of England Blond McIndoe Foundation Research Fellowship, the Association of Breast Surgery and the NIHR Biomedical Research Centre at University Hospitals Bristol and Weston NHS Foundation Trust and the University of Bristol. S.P. is an NIHR Clinician Scientist (CS-2016-16-019). The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

Disclosure

The authors have no conflict of interest to declare.

Supplementary material

Supplementary material is available at *BJS* online.

Data availability

Data are available upon reasonable request. De-identified participant data will be available from the senior author after completion of the study and planned analyses following review by the study steering group. Reuse will be permitted with consent of the study steering group. No additional information will be available.

Author contributions

Kate Harvey (Funding acquisition, Methodology, Project administration, Writing—review & editing), Leigh Johnson (Formal analysis, Writing—review & editing), Parisa Sinai (Investigation, Project administration, Writing—review & editing), Nicola Mills (Formal analysis, Funding acquisition, Methodology, Supervision, Writing—review & editing), Paul White (Data curation, Formal analysis, Methodology, Supervision, Writing—review & editing), Christopher Holcombe (Conceptualization, Funding acquisition, Methodology, Writing—review & editing), Shelley Potter (Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Visualization, Writing—original draft), and The Pre-BRA Feasibility Study Steering Group (Methodology)

References

1. Malata CM, McIntosh SA, Purushotham AD. Immediate breast reconstruction after mastectomy for cancer. *Br J Surg* 2000;**87**: 1455–1472
2. Cancer Research UK. CRUK website 2018. <https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/breast-cancer#heading-Zero> (accessed 17 July 2024)
3. NICE. Early and locally advanced breast cancer: diagnosis and management NICE guideline [NG101] 2018. <https://www.nice.org.uk/guidance/ng101> (accessed 17 July 2024)
4. Mennie JC, Mohanna PN, O'Donoghue JM, Rainsbury R, Cromwell DA. National trends in immediate and delayed post-mastectomy reconstruction procedures in England: a seven-year population-based cohort study. *Eur J Surg Oncol* 2017;**43**:52–61
5. Albornoz CR, Bach PB, Mehrara BJ, Disa JJ, Pusic AL, McCarthy CM et al. A paradigm shift in U.S. breast reconstruction: increasing implant rates. *Plast Reconstr Surg* 2013;**131**:15–23
6. Dikmans RE, Negenborn VL, Bouman MB, Winters HA, Twisk JW, Ruhé PQ et al. Two-stage implant-based breast reconstruction compared with immediate one-stage implant-based breast reconstruction augmented with an acellular dermal matrix: an open-label, phase 4, multicentre, randomised, controlled trial. *Lancet Oncol* 2017;**18**:251–258
7. Negenborn VL, Young-Afat DA, Dikmans REG, Smit JM, Winters HAH, Don Griot JPW et al. Quality of life and patient satisfaction after one-stage implant-based breast reconstruction with an acellular dermal matrix versus two-stage breast reconstruction (BRIOS): primary outcome of a randomised, controlled trial. *Lancet Oncol* 2018;**19**:1205–1214
8. Lohmander F, Lagergren J, Roy PG, Johansson H, Brandberg Y, Eriksen C et al. Implant based breast reconstruction with acellular dermal matrix: safety data from an open-label, multicenter, randomized, controlled trial in the setting of breast cancer treatment. *Ann Surg* 2019;**269**:836–841
9. Lohmander F, Lagergren J, Johansson H, Roy PG, Frisell J, Brandberg Y. Quality of life and patient satisfaction after implant-based breast reconstruction with or without acellular dermal matrix: randomized clinical trial. *BJS Open* 2020;**4**: 811–820
10. Potter S, Conroy EJ, Cutress RI, Williamson PR, Whisker L, Thrush S et al. Short-term safety outcomes of mastectomy and immediate implant-based breast reconstruction with and without mesh (iBRA): a multicentre, prospective cohort study. *Lancet Oncol* 2019;**20**:254–266
11. Mylvaganam S, Conroy E, Williamson PR, Barnes NLP, Cutress RI, Gardiner MD et al. Variation in the provision and practice of implant-based breast reconstruction in the UK: results from the iBRA national practice questionnaire. *Breast* 2017;**35**:182–190
12. Tasoulis MK, Iqbal FM, Cawthorn S, MacNeill F, Vidya R. Subcutaneous implant breast reconstruction: time to reconsider? *Eur J Surg Oncol* 2017;**43**:1636–1646
13. Snyderman RK, Guthrie RH. Reconstruction of the female breast following radical mastectomy. *Plast Reconstr Surg* 1971;**47**: 565–567
14. Gruber RP, Kahn RA, Lash H, Maser MR, Apfelberg DB, Laub DR. Breast reconstruction following mastectomy: a comparison of submuscular and subcutaneous techniques. *Plast Reconstr Surg* 1981;**67**:312–317
15. Rebowe RE, Allred LJ, Nahabedian MY. The evolution from subcutaneous to prepectoral prosthetic breast reconstruction. *Plast Reconstr Surg Glob Open* 2018;**6**:e1797
16. Wagner RD, Braun TL, Zhu H, Winocour S. A systematic review of complications in prepectoral breast reconstruction. *J Plast Reconstr Aesthet Surg* 2019;**72**:1051–1059
17. Ostapenko E, Nixdorf L, Devyatko Y, Exner R, Wimmer K, Fitzal F. Prepectoral versus subpectoral implant-based breast

- reconstruction: a systemic review and meta-analysis. *Ann Surg Oncol* 2023;**30**:126–136
18. Zhu L, Liu C. Postoperative complications following prepectoral versus partial subpectoral implant-based breast reconstruction using ADM: a systematic review and meta-analysis. *Aesthetic Plast Surg* 2023;**47**:1260–1273
 19. Cattelani L, Polotto S, Arcuri MF, Pedrazzi G, Linguadoca C, Bonati E. One-step prepectoral breast reconstruction with dermal matrix-covered implant compared to submuscular implantation: functional and cost evaluation. *Clin Breast Cancer* 2018;**18**:e703–e711
 20. Bernini M, Calabrese C, Cecconi L, Santi C, Gjonedaj U, Roselli J et al. Subcutaneous direct-to-implant breast reconstruction: surgical, functional, and aesthetic results after long-term follow-up. *Plast Reconstr Surg Glob Open* 2016;**3**:e574
 21. Manrique OJ, Kapoor T, Banuelos J, Jacobson SR, Martinez-Jorge J, Nguyen MT et al. Single-stage direct-to-implant breast reconstruction: a comparison between subpectoral versus prepectoral implant placement. *Ann Plast Surg* 2020;**84**:361–365
 22. Thangarajah F, Treeter T, Krug B, Hellmich M, Eichler C, Hanstein B et al. Comparison of subpectoral versus prepectoral immediate implant reconstruction after skin- and nipple-sparing mastectomy in breast cancer patients: a retrospective hospital-based cohort study. *Breast Care (Basel)* 2019;**14**:382–387
 23. Le NK, Persing S, Dinis J, Gabrick KS, Wu RT, Sinnott CJ et al. A comparison of BREAST-Q scores between prepectoral and subpectoral direct-to-implant breast reconstruction. *Plast Reconstr Surg* 2021;**148**:708e–714e
 24. Asaad M, Yu JZ, Tran JP, Liu J, O'Grady B, Clemens MW et al. Surgical and patient-reported outcomes of 694 two-stage prepectoral versus subpectoral breast reconstructions. *Plast Reconstr Surg* 2023;**152**:43s–54s
 25. Casella D, Di Taranto G, Marcasciano M, Sordi S, Kothari A, Kovacs T et al. Evaluation of prepectoral implant placement and complete coverage with TiLoop bra mesh for breast reconstruction: a prospective study on long-term and patient-reported BREAST-Q outcomes. *Plast Reconstr Surg* 2019;**143**:1e–9e
 26. Rampal R, Jones SJ, Hartup S, Robertson C, Tahir W, Jones SL et al. Three and twelve-month analysis of the PROM-Q study: comparison of patient-reported outcome measures using the BREAST-Q questionnaire in pre- vs. sub-pectoral implant-based immediate breast reconstruction. *Breast Cancer Res Treat* 2024;**208**:275–282
 27. Harvey KL, Mills N, White P, Holcombe C, Potter S; Pre-BRA Feasibility Study Steering Group. The Pre-BRA (pre-pectoral breast reconstruction evaluation) feasibility study: protocol for a mixed-methods IDEAL 2a/2b prospective cohort study to determine the safety and effectiveness of prepectoral implant-based breast reconstruction. *BMJ Open* 2020;**10**:e033641
 28. Harvey KL, Sinai P, Mills N, White P, Holcombe C, Potter S. Short-term safety outcomes of mastectomy and immediate prepectoral implant-based breast reconstruction: Pre-BRA prospective multicentre cohort study. *Br J Surg* 2022;**109**:530–538
 29. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;**42**:377–381
 30. O'Connell RL, Rattay T, Dave RV, Trickey A, Skillman J, Barnes NLP et al. The impact of immediate breast reconstruction on the time to delivery of adjuvant therapy: the iBRA-2 study. *Br J Cancer* 2019;**120**:883–895
 31. Potter S, Davies C, Holcombe C, Weiler-Mithoff E, Skillman J, Vidya R et al. International development and implementation of a core measurement set for research and audit studies in implant-based breast reconstruction: a study protocol. *BMJ Open* 2020;**10**:e035505
 32. Pusic AL, Klassen AF, Scott AM, Klok JA, Cordeiro PG, Cano SJ. Development of a new patient-reported outcome measure for breast surgery: the BREAST-Q. *Plast Reconstr Surg* 2009;**124**:345–353
 33. Jeevan R, Cromwell D, Browne J, van der Meulen J, Pereira J, Caddy C et al. National Mastectomy and Breast Reconstruction Audit 2010. Third Annual Report IC28050110 ed2010 6/2010
 34. Jeevan R, Cromwell D, Browne J, van der Meulen J, Pereira J, Caddy C et al. National mastectomy and breast reconstruction audit 2011. IC20010111 ed2011 2011
 35. Davies CF, Macefield R, Avery K, Blazeby JM, Potter S. Patient-reported outcome measures for post-mastectomy breast reconstruction: a systematic review of development and measurement properties. *Ann Surg Oncol* 2021;**28**:386–404
 36. Voineskos SH, Klassen AF, Cano SJ, Pusic AL, Gibbons CJ. Giving meaning to differences in BREAST-Q scores: minimal important difference for breast reconstruction patients. *Plast Reconstr Surg* 2020;**145**:11e–20e
 37. Tsangaris E, Pusic AL, Kaur MN, Voineskos S, Bordeleau L, Zhong T et al. Development and psychometric validation of the BREAST-Q animation deformity scale for women undergoing an implant-based breast reconstruction after mastectomy. *Ann Surg Oncol* 2021;**28**:5183–5193
 38. Santosa KB, Qi J, Kim HM, Hamill JB, Wilkins EG, Pusic AL. Long-term patient-reported outcomes in postmastectomy breast reconstruction. *JAMA Surg* 2018;**153**:891–899
 39. Berlin NL, Momoh AO, Qi J, Hamill JB, Kim HM, Pusic AL et al. Racial and ethnic variations in one-year clinical and patient-reported outcomes following breast reconstruction. *Am J Surg* 2017;**214**:312–317
 40. Santosa KB, Qi J, Kim HM, Hamill JB, Pusic AL, Wilkins EG. Effect of patient age on outcomes in breast reconstruction: results from a multicenter prospective study. *J Am Coll Surg* 2016;**223**:745–754
 41. Pusic AL, Matros E, Fine N, Buchel E, Gordillo GM, Hamill JB et al. Patient-reported outcomes 1 year after immediate breast reconstruction: results of the mastectomy reconstruction outcomes consortium study. *J Clin Oncol* 2017;**35**:2499–2506
 42. Sewart E, Turner NL, Conroy EJ, Cutress RI, Skillman J, Whisker L et al. Patient-reported outcomes of immediate implant-based breast reconstruction with and without biological or synthetic mesh. *BJS Open* 2021;**5**:zraa063
 43. Sewart E, Turner NL, Conroy EJ, Cutress RI, Skillman J, Whisker L et al. The impact of radiotherapy on patient-reported outcomes of immediate implant-based breast reconstruction with and without mesh. *Ann Surg* 2022;**275**:992–1001
 44. Ching AH, Lim K, Sze PW, Ooi A. Quality of life, pain of prepectoral and subpectoral implant-based breast reconstruction with a discussion on cost: a systematic review and meta-analysis. *J Plast Reconstr Aesthet Surg* 2022;**75**:2550–2560
 45. Davies C, Johnson L, Conefrey C, Mills N, Fairbrother P, Holcombe C et al. Clinical and patient-reported outcomes in women offered oncoplastic breast-conserving surgery as an alternative to mastectomy: ANTHEM multicentre prospective cohort study. *Br J Surg* 2024;**112**:znae306
 46. Johnson L, White P, Jeevan R, Browne J, Gulliver-Clarke C, O'Donoghue J et al. Long-term patient-reported outcomes of immediate breast reconstruction after mastectomy for breast cancer: population-based cohort study. *Br J Surg* 2023;**110**:1815–1823

47. Mahoney B, Walklet E, Bradley E, Thrush S, Skillman J, Whisker L et al. Experiences of implant loss after immediate implant-based breast reconstruction: qualitative study. *BJS Open* 2020;**4**: 380–390
48. Nelson JA, Chu JJ, McCarthy CM, Stern CS, Shamsunder MG, Pusic AL et al. BREAST-Q REACT: clinical reference values for the BREAST-Q in post-mastectomy breast reconstruction patients. *Ann Surg Oncol* 2022;**29**:5280–5293
49. Nelson JA, Allen RJ Jr, Polanco T, Shamsunder M, Patel AR, McCarthy CM et al. Long-term patient-reported outcomes following postmastectomy breast reconstruction: an 8-year examination of 3268 patients. *Ann Surg* 2019;**270**:473–483
50. Johnson L, White P, Jeevan R, Browne J, Gulliver-Clarke C, O'Donoghue J et al. Rates of revision and secondary reconstruction procedures 8 years following immediate breast reconstruction: results from the brighter long-term breast reconstruction outcome study. *Eur J Surg Oncol* 2022;**48**:e192
51. Roberts K, Mills N, Metcalfe C, Lane A, Clement C, Hollingworth W et al. Best-BRA (is subpectoral or pre-pectoral implant placement best in immediate breast reconstruction?) A protocol for a pilot randomised controlled trial of subpectoral versus pre-pectoral immediate implant-based breast reconstruction in women following mastectomy. *BMJ Open* 2021;**11**:e050886
52. Kappos EA, Schulz A, Regan MM, Moffa G, Harder Y, Ribi K et al. Prepectoral versus subpectoral implant-based breast reconstruction after skin-sparing mastectomy or nipple-sparing mastectomy (OPBC-02/PREPEC): a pragmatic, multicentre, randomised, superiority trial. *BMJ Open* 2021;**11**:e045239
53. Micco RD, Banys-Paluchowski M, Cardoso M-J, de Boniface J, Gulluoglu BM, Kaidar-Person O et al. Abstract PO5-19-02: I-PREPARE: international prospective REgistry on Pre-pectoRAL breast reconstruction (EUBREAST 11R-NCT 05817175). *Cancer Res* 2024;**84**:PO5-19-02.