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Original Article

Patient-reported outcomes of immediate implant-based breast reconstruction with and without biological or synthetic mesh

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Abstract

Background: Biological and synthetic meshes may improve the outcomes of immediate implant-based breast reconstruction (IBBR) by facilitating single-stage procedures and improving cosmesis. Supporting evidence is, however, limited. The aim of this study was to explore the impact of biological and synthetic mesh on patient-reported outcomes (PROs) of IBBR 18 months after surgery.

Methods: Consecutive women undergoing immediate IBBR between February 2014 and June 2016 were recruited to the study. Demographic, operative, oncological and 3-month complication data were collected, and patients received validated BREAST-Q questionnaires at 18 months. The impact of different IBBR techniques on PROs were explored using mixed-effects regression models adjusted for clinically relevant confounders, and including a random effect to account for clustering by centre.

Results: A total of 1470 participants consented to receive the questionnaire and 891 completed it. Of these, 67 women underwent two-stage submuscular reconstructions. Some 764 patients had a submuscular reconstruction with biological mesh (495 women), synthetic mesh (95) or dermal sling (174). Fourteen patients had a prepectoral reconstruction. Compared with two-stage submuscular reconstructions, no significant differences in PROs were seen in biological or synthetic mesh-assisted or dermal sling procedures. However, patients undergoing prepectoral IBBR reported better satisfaction with breasts (adjusted mean difference +6.63, 95 per cent c.i. 1.65 to11.61; $P = 0.009$). PROs were similar to those in the National Mastectomy and Breast Reconstruction Audit 2008–2009 cohort, which included two-stage submuscular procedures only.

Conclusion: This study found no difference in PROs of subpectoral IBBR with or without biological or synthetic mesh, but provides early data to suggest improved satisfaction with breasts following prepectoral reconstruction. Robust evaluation is required before this approach can be adopted as standard practice.

Introduction

Over 2 million women worldwide are diagnosed with breast cancer each year[1], approximately 40 per cent of whom undergo mastectomy as the primary surgical treatment for their disease[2,3]. The UK National Institute for Health and Care Excellence recommends that all women undergoing mastectomy should be offered immediate breast reconstruction to minimize the negative impact of surgery on their quality of life (QoL)[4,5], and approximately 21 per cent of women in the UK undergoing mastectomy elect to have immediate reconstruction[6]. Currently, implant-based procedures are the most commonly performed reconstructive technique in both the UK[7] and the USA[8].

Traditionally, implant-based breast reconstruction (IBBR) has required two sequential operations to achieve placement of a definitive implant in a subpectoral pocket[9,10]. At the first procedure, a tissue expander is placed under the pectoralis major muscle. A series of saline injections over several weeks are used to increase the expander volume gradually, a process that is

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time-consuming and may cause discomfort for the patient[11]. Once the submuscular pocket is sufficiently large, the expander is removed and replaced with a fixed-volume implant, committing the patient to a second operation and associated risks.

Since the early 2000s, new techniques have emerged that allow the creation of a larger submuscular pocket that can accommodate a definitive implant at the first operation[12]. These single-stage techniques involve the use of an 'internal bra' or sling between the lower edge of the pectoralis muscle and the chest wall, extending the subpectoral pocket. This sling can be formed from a biological mesh (such as acellular dermal matrix (ADM)), synthetic mesh (for example titanium-coated polypropylene) or a dermal sling (using de-epithelialized skin)[13]. In addition to no necessitation for a second procedure, these techniques may produce better cosmetic outcomes by improving inframammary fold control and lower pole projection[14–16]. More recently, prepectoral techniques have emerged, which involve wrapping the implant in biological or synthetic mesh and placing it on top of the pectoralis muscle[17]. Avoiding muscle disruption may reduce postoperative pain and prevent distressing 'breast animation' (the upwards movement of the implant seen when the pectoralis muscle contracts)[17].

Biological and synthetic mesh-assisted IBBR techniques have been introduced and widely adopted into practice on the basis that they improve outcomes for patients; however, there is little high-quality evidence to support these proposed benefits[18,19]. In particular, patient-reported outcome (PRO) data are lacking. One RCT of 142 patients compared PROs in patients undergoing two-stage IBBR and single-stage reconstruction with mesh (ADM) using the validated BREAST-Q questionnaire[20]. Despite higher complication rates in patients undergoing ADM-assisted IBBR, including reoperation and implant loss, this multicentre Dutch study[20] found no difference in PROs 1 year after placement of the definitive implant. Reasons for this are unclear, but most patients in the ADM group who experienced implant loss went on to have a secondary reconstruction and did not complete PRO questionnaires until after this had been done[21]. A large North American multicentre cohort study[22] of 1297 patients, comparing outcomes in women undergoing two-stage reconstructions with and without ADM, however, reported no difference in either clinical outcomes or PROs 2 years after reconstruction. Analysis of outcomes in patients undergoing single (99 women) and two-stage (1328) reconstructions in the same cohort also demonstrated no difference in clinical outcomes or PROs at 2 years. The use of mesh, however, was not reported, and the study was potentially underpowered to detect a difference between the groups[23]. Recent studies have reported the PROs of biological[24] and synthetic[25] mesh-assisted prepectoral reconstructions. These studies, however, were small, retrospective, and conducted at either a single or two centres, limiting their generalizability to other settings. Uncertainty therefore remains regarding the impact of the use of biological and synthetic mesh on PROs, and further work is needed[26].

The iBRA (implant Breast Reconstruction Evaluation) study is a four-phase study aiming to inform the feasibility, design and conduct of a future trial in immediate IBBR. Phase 2, a UK prospective multicentre cohort study, explored the clinical and patient-reported outcomes of different approaches to immediate IBBR with and without biological and synthetic mesh. The short-term safety outcomes have been published elsewhere and showed no evidence of a difference in key complications between different approaches to IBBR[13]. High-quality PRO data are therefore vital to support the ongoing use of mesh-assisted techniques, and to help patients make informed decisions regarding surgery. This study reports the 18-month PROs of IBBR from patients in the iBRA cohort study and explores the impact of different IBBR techniques, performed with and without biological and synthetic mesh, on patient satisfaction and QoL.

Methods

The iBRA study prospectively recruited consecutive women aged 16 years or above undergoing immediate IBBR for malignancy or risk reduction between 1 February 2014 and 30 June 2016. Patients undergoing skin- or nipple-sparing mastectomy followed by immediate IBBR were eligible for inclusion. All UK breast or plastic surgical units performing IBBR were invited to participate via the UK Trainee Collaborative Research Network, the Association of Breast Surgery, and the British Association of Plastic, Reconstructive and Aesthetic Surgeons[13]. The protocol[27] was published in 2016.

Any IBBR technique could be used, including standard two-stage procedures, submuscular reconstructions with biological or synthetic mesh or dermal sling, and prepectoral reconstructions. As the study aimed to describe current practice and inform future research, procedural details were recorded but no restrictions were placed on the techniques used[13]. Product choice, implant positioning and use of laminar flow, antibiotics and drains were according to local policy or surgeon preference. Patients were excluded from the study if undergoing delayed reconstruction, implant reconstruction in combination with an autologous flap, or revision of a previously performed breast reconstruction. Patients undergoing primary implant reconstruction recruited to the study who subsequently required revision remained eligible for inclusion[27].

Eligible patients were identified prospectively from clinics, multidisciplinary team (MDT) meetings and theatre lists. Demographic, operative, oncological and 3-month complication data were collected by the team by clinical or case note review. Patients who consented received electronic or postal questionnaires, according to their preference, at 3 and 18 months after surgery. The 3-month questionnaire included questions regarding satisfaction with information, pain, postoperative complications and adjuvant treatment. These results have been reported elsewhere[13]. The 18-month questionnaire assessed patient satisfaction and QoL using the BREAST-Q as per the methodology of the UK National Mastectomy and Breast Reconstruction Audit (NMBRA)[6]. Reminders were sent after 1 month if no response had been received. Follow-up was complete in December 2017. Anonymized data were recorded using REDCap (www.project-redcap.org), a secure online database[28].

Study governance and consent to participate

Ethical approval was not required, as defined by the Health Research Authority decision tool[29]. Local audit approval was obtained for each centre before study recruitment was commenced. Clinical and PRO data were collected as recommended by guidelines for good practice[6].

Patients were approached for written consent to receive questionnaires by members of the clinical team, either in clinic or during their hospital stay, according to local study team preference. This was consistent with the methodology used in the NMBRA[6]. Where consent was obtained, patient contact details were sent securely to the coordinating centre and questionnaires were distributed centrally to allow accurate follow-up and minimize missing data[27].

Patient population

Women from the iBRA cohort who returned the 18-month PROs questionnaire were eligible for inclusion in this analysis. Patients were excluded if no data regarding the specific type of IBBR performed had been recorded or the completed 18-month PRO questionnaire had not been received.

Outcomes

This was the planned analysis of the 18-month PROs of patients undergoing IBBR with and without mesh in the iBRA cohort study[27].

PROs were assessed using the validated BREAST-Q postoperative reconstruction module (version 1)[30,31]. The BREAST-Q is a validated questionnaire developed robustly using Rasch methodology, for use in a breast reconstruction population, and includes five domains: satisfaction with breasts; satisfaction with outcome; physical well-being (chest); psychosocial well-being; and sexual well-being[31,32]. This was selected as it assessed key PRO domains included in the reconstructive breast surgery core outcomes set[33]. The 18-month questionnaire also included a single-item assessment of overall satisfaction with reconstructive outcome on a five-point Likert scale (excellent, very good, good, fair and poor), as per the 2008–2009 UK NMBRA[34].

The study was registered as ISRCTN37664281 and has been reported according to STROBE guidelines[35]. Short-term safety outcomes were published in 2019[13].

Statistical analysis

Patients were categorized by the reconstructive technique used: standard two-stage submuscular; submuscular with biological mesh, synthetic mesh or dermal sling; prepectoral; and other. Patients who received different techniques per breast were included in the 'other' category.

Simple summary statistics were used to describe patient demographics, procedures performed to the breast and axilla, oncological data, 3-month complications, and 18-month PROs across the patient groups. Comparisons were made between the groups of patients who did and did not consent to receive questionnaires; those who returned the 18-month questionnaire and non-responders; and between groups of patients who underwent different types of IBBR. Categorical data are summarized by counts and percentages, and continuous data by median (i.q.r.; range) values.

Questionnaire responses for the BREAST-Q domains were summed and transformed according to the developers' instructions using the specifically designed Q-Score software[30]. This generated a score from 0 to 100 for each domain, where higher scores indicate greater patient satisfaction or QoL[31]. BREAST-Q scores were treated as continuous variables. For the purpose of analysis, the single-item overall outcome score was dichotomized into 'excellent or very good' and 'good, fair or poor'. Median (i.q.r.; range) scores for each BREAST-Q domain were calculated, alongside percentages rating the overall outcome as 'excellent' or 'very good' for each group in order to compare the findings against those reported in the NMBRA[2] and published national quality standards[36].

The effect of different approaches to IBBR with and without biological and synthetic mesh on each outcome domain were explored using multivariable mixed-effects linear and logistic regression models, including a random effect to account for potential clustering by centre. The reference group was two-stage submuscular reconstruction without mesh. Models were adjusted for clinically relevant confounders identified by the study steering group, based on the literature and clinical expertise. These confounders were: age, BMI, smoking status, ASA grade, indication (malignancy, risk reduction or both), bilateral surgery, nipple-sparing *versus* other mastectomy types, 3-month complications (infection, implant loss, readmission or reoperation), axillary surgery, postoperative radiotherapy, and adjuvant chemotherapy and endocrine therapy. A complete case analysis was undertaken, and robust residual estimates were used to ensure the assumptions of the regression models were not violated.

Results

The iBRA study recruited 2108 patients from 81 centres between 1 February 2014 and 30 June 2016. Consent to receive postoperative questionnaires was gained from 1470 women (69.7 per cent), and 891 of women (60.6 per cent) returned them. Of the patients who returned the questionnaire, 12 (1.3 per cent) were excluded as details of the type of IBBR performed were not reported; 879 women were therefore eligible for inclusion in the analysis.

Participant demographics

Patients who consented to receive PROs questionnaires were demographically representative of the overall iBRA cohort (*Table S1*). However, the 891 patients who returned the 18-month questionnaire were less likely than 579 non-responders to smoke (7.0 *versus* 14.2 per cent respectively; $P < 0.001$) or to have experienced complications, in particular reoperation (16.8 *versus* 22.3 per cent; $P = 0.008$) and implant loss (5.7 *versus* 12.6 per cent; $P < 0.001$) at 3 months. Questionnaire response rates were similar for different types of IBBR. Full cohort demographics by PRO status (consented, not consented; responders and non-responders) are summarized in *Table S1*.

The median age of patients who returned the questionnaire was 50 (i.q.r. 45–58) years. Median BMI was 24.6 (i.q.r. 22.3–28.0) kg/m^2, highest in the group of patients who had dermal sling reconstructions (median 28.6 (range 13.3–42.6) kg/m^2). Sixty-two patients (7.0 per cent) were current smokers and 56 (6.3 per cent) had received previous radiotherapy to the ipsilateral breast. Some 732 patients (82.2 per cent) underwent mastectomy for malignancy in at least one breast, and 157 patients (17.6 per cent) had risk reduction surgery only (*Table 1*).

The majority of patients had a submuscular reconstruction using biological mesh (495 women, 55.6 per cent). One in five (174, 19.5 per cent) received submuscular IBBR with a dermal sling, and a smaller proportion (95, 10.7 per cent) underwent a submuscular reconstruction using synthetic mesh. Of the patients undergoing mesh-assisted IBBR, the majority (500 of 590, 84.7 per cent) had a planned single-stage procedure. Only 67 patients (7.5 per cent) received traditional two-stage submuscular reconstructions. Fourteen women (1.6 per cent) had mesh-assisted prepectoral reconstructions (all single stage), which were introduced towards the end of the study recruitment period at a small number of centres ($n = 5$) (*Table 2*). Thirty-four patients (3.8 per cent) underwent other techniques (29, 3.3 per cent) or different techniques per breast (5, 0.6 per cent), and details of the type of IBBR performed was not reported for 12 women (1.3 per cent). Further details of patients who had other types of IBBR, and those in whom details were not reported, are summarized in *Tables S2–S5*. Of the 732 patients with malignancy, 574 (78.4 per cent) also underwent axillary surgery, and approximately one-third were recommended adjuvant chemotherapy (242, 33.1 per cent) or radiotherapy (207, 28.3 per cent) (*Table 3*).

Table 1 General demographics of patients who returned the 18-month questionnaire, by type of implant-based breast reconstruction

	All patients* ($n = 891$)	Submuscular ($n = 67$)	Dermal sling ($n = 174$)	Biological mesh ($n = 495$)	Synthetic mesh ($n = 95$)	Prepectoral implant ($n = 14$)
Age						
Median (i.q.r.; range)	50 (45–58; 16–83)	50 (44–59; 16–73)	53 (46–60; 24–81)	50 (44–58; 25–78)	52 (45–60; 25–83)	50 (37–52; 19–71)
Not known	5 (0.6)	0 (0)	1 (0.6)	3 (0.6)	0 (0)	0 (0)
BMI (kg/m^2)						
Median (i.q.r.; range)	24.6 (22.3–28.0; 16.4–42.6)	23.1 (21.2–25.5; 17.0–40.7)	28.6 (25–32.3; 13.3–42.6)	23.9 (21.8–26.2; 16.4–39.0)	25 (22.6–29.0; 17.9–36.8)	24.6 (23.3–25.6; 8.7–35.3)
Not obese (<30)	706 (79.2)	54 (81)	100 (57.5)	441 (89.1)	71 (75)	13 (93)
Obese (≥30	138 (15.5)	9 (13)	67 (38.5)	33 (6.7)	19 (20)	1 (7)
Not known	47 (5.3)	4 (6)	7 (4.0)	21 (4.2)	5 (5)	0 (0)
Smoking status						
Non-smoker	719 (80.7)	51 (76)	140 (80.5)	402 (81.2)	79 (83)	9 (64)
Ex-smoker	99 (11.1)	10 (15)	20 (11.5)	51 (10.3)	11 (12)	4 (29)
Current smoker	62 (7.0)	6 (9)	11 (6.3)	38 (7.7)	5 (5)	1 (7)
Nicotine replacement	4 (0.4)	0 (0)	2 (1.1)	2 (0.4)	0 (0)	0 (0)
Not known	7 (0.8)	0 (0)	1 (0.6)	2 (0.4)	0 (0)	0 (0)
Diabetes						
Yes	20 (2.2)	0 (0)	10 (5.7)	5 (1.0)	3 (3)	0 (0)
No	863 (96.9)	65 (97)	162 (93.1)	488 (98.6)	91 (96)	14 (100)
Not known	8 (0.9)	1 (1)	2 (1.1)	2 (0.4)	1 (8)	0 (0)
ASA grade						
I	528 (59.3)	35 (52)	79 (45.4)	322 (65.1)	62 (65)	8 (57)
II	336 (37.7)	29 (43)	87 (50.0)	166 (33.5)	30 (32)	6 (43)
III	20 (2.2)	3 (4)	8 (4.6)	5 (1.0)	2 (2)	0 (0)
IV	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Not known	7 (0.8)	0 (0)	0 (0)	2 (0.4)	1 (1)	0 (0)
Indication						
Malignancy	732 (82.2)	57 (85)	141 (81.0)	412 (83.2)	78 (82)	9 (64)
Risk reduction	157 (17.6)	10 (15)	33 (19.0)	83 (16.8)	17 (18)	5 (36)
Not known	2 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Previous radiotherapy to ipsilateral breast						
Yes	56 (6.3)	3 (4)	8 (4.6)	35 (7.1)	6 (6)	0 (0)
No	832 (93.4)	64 (96)	166 (95.4)	460 (92.9)	87 (92)	14 (100)
Not known	3 (0.3)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)
Neoadjuvant chemotherapy						
Yes	82 (9.2)	7 (10)	21 (12.1)	41 (8.3)	8 (8)	1 (7)
No	799 (89.7)	59 (88)	152 (87.4)	449 (90.7)	85 (89)	13 (93)
Not known	10 (1.1)	1 (1)	1 (0.6)	5 (1.0)	2 (2)	0 (0)
Neoadjuvant endocrine therapy						
Yes	36 (4.0)	4 (6)	9 (5.2)	18 (3.6)	1 (1)	0 (0)
No	847 (95.1)	63 (94)	163 (93.7)	474 (95.8)	93 (98)	14 (100)
Not known	8 (0.9)	0 (0)	2 (1.1)	3 (0.6)	1 (1)	0 (0)

Values in parentheses are percentages unless indicated otherwise. *Details of patients with 'other' and 'not known' types of implant reconstruction are summarized in Table S2.

Table 2 Operative details and 3-month outcomes for patients who returned the 18-month questionnaire

	All patients* ($n = 891$)	Submuscular ($n = 67$)	Dermal sling ($n = 174$)	Biological mesh ($n = 495$)	Synthetic mesh ($n = 95$)	Prepectoral ($n = 14$)
Laterality of procedure						
Unilateral	669 (75.1)	51 (76)	134 (77.0)	379 (76.6)	66 (69)	8 (57)
Bilateral	220 (24.7)	16 (24)	40 (23.0)	116 (23.4)	29 (31)	6 (43)
Not known	2 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Planned procedure						
Single-stage reconstruction	700 (78.6)	26 (39)	121 (69.5)	423 (85.5)	77 (81)	14 (100)
Two-stage reconstruction	184 (20.7)	40 (60)	51 (29.3)	69 (13.9)	17 (18)	0 (0)
Different approach per breast	7 (0.8)	1 (1)	2 (1.1)	3 (0.6)	1 (1)	0 (0)
Not known	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Type of mastectomy						
Skin-sparing	492 (55.2)	46 (69)	40 (23.0)	325 (65.7)	60 (63)	6 (43)
Skin and nipple-sparing	213 (23.9)	13 (19)	8 (4.6)	143 (28.9)	29 (31)	8 (57)
Reduction (Wise) pattern	162 (18.2)	1 (1)	124 (71.3)	18 (3.6)	4 (4)	0 (0)
Other	8 (0.9)	5 (7)	1 (0.6)	1 (0.2)	1 (1)	0 (0)
Different approach per breast	13 (1.5)	2 (3)	1 (10.6)	7 (1.4)	1 (1)	0 (0)
Not known	3 (0.3)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)
Incision						
Periareolar	49 (5.5)	3 (4)	1 (0.6)	37 (7.5)	5 (5)	1 (7)
Lateral	80 (9.0)	3 (4)	2 (1.1)	56 (11.3)	14 (15)	3 (21)
Inframammary	93 (10.4)	7 (10)	2 (1.1)	65 (13.1)	9 (9)	4 (29)
Elliptical, removing NAC	405 (45.5)	44 (66)	3 (1.7)	293 (59.2)	51 (54)	5 (36)
Wise pattern	215 (24.1)	2 (3)	161 (92.5)	26 (5.3)	6 (6)	0 (0)
Other	36 (4.0)	7 (10)	5 (2.9)	13 (2.6)	8 (8)	1 (7)
Different approach per breast	7 (0.8)	1 (1)	0 (0)	4 (0.8)	1 (1)	0 (0)
Not known	6 (0.7)	0 (0)	0 (0)	1 (0.2)	1 (1)	0 (0)
Mastectomy weight (g)						
Median (i.q.r.; range)	380.5 (250–582; 0–1802)	275 (146–433; 0–1538)	665 (507–903; 140–1802)	322 (225–460; <1–1236)	390 (261–557; 83–1164)	342 (250–455; 167–750)
Not known	45 (5.1)	4 (6)	5 (2.9)	22 (4.4)	4 (4)	1 (7)
Prosthesis used						
Fixed-volume implant	212 (23.8)	18 (27)	41 (23.6)	121 (24.4)	20 (21)	0 (0)
Combined expander or implant	521 (58.5)	18 (27)	84 (48.3)	318 (64.2)	61 (64)	13 (93)
Temporary expander	148 (16.6)	31 (46)	48 (27.6)	54 (10.9)	13 (14)	0 (0)
Different approach per breast	3 (0.3)	0 (0)	0 (0)	2 (0.4)	0 (0)	0 (0)
Not known	7 (0.8)	0 (0)	1 (0.6)	0 (0)	1 (1)	1 (7)
Implant size (ml)						
Median (i.q.r.; range)	375 (290–450; 100–800)	317.5 (190–400; 100–615)	480 (410–555; 215–690)	352.5 (270–420; 120–650)	410 (295–470; 135–800)	425 (340–450; 290–685)
Not known	375 (42.1)	49 (73)	91 (52.3)	179 (36.2)	34 (36)	2 (14)
Axillary surgery						
None	234 (26.3)	18 (27)	43 (24.7)	129 (26.1)	28 (29)	5 (36)
SNB	383 (43.0)	24 (36)	75 (43.1)	221 (44.6)	40 (42)	6 (43)
Axillary sample	10 (1.1)	2 (3)	0 (0)	7 (1.4)	1 (1)	0 (0)
Axillary clearance	88 (9.9)	9 (13)	19 (10.9)	46 (9.3)	8 (8)	2 (14)
SNB and ANC	18 (2.0)	1 (1)	5 (2.9)	9 (2.8)	2 (2)	0 (0)
Previous axillary staging	79 (8.9)	7 (10)	15 (8.6)	47 (9.5)	5 (5)	0 (0)
Different approach per breast	75 (8.4)	6 (9)	17 (9.8)	36 (7.3)	11 (12)	1 (7)
Not known	4 (0.4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Duration of surgery (min)						
Median (i.q.r.; range)	180 (150–210; 60–480)	150 (120–190; 60–380)	180 (150–240; 75–480)	180 (150–210; 69–445)	171 (142–190; 70–330)	180 (150–180; 106–330)
Not known	76 (8.5)	5 (7)	8 (4.6)	47 (9.5)	3 (3)	1 (7)

(continued)

Table 2. (continued)

	All patients* (*n* = 891)	Submuscular (*n* = 67)	Dermal sling (*n* = 174)	Biological mesh (*n* = 495)	Synthetic mesh (*n* = 95)	Prepectoral (*n* = 14)
Reoperation at 3 months						
Yes	150 (16.8)	10 (15)	24 (13.8)	87 (17.6)	17 (18)	5 (36)
No	735 (82,5)	57 (85)	150 (86.2)	408 (82.4)	78 (82)	9 (64)
Not known	6 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Readmission at 3 months						
Yes	147 (16.5)	10 (15)	27 (15.5)	80 (16.2)	16 (17)	6 (43)
No	738 (82.8)	57 (85)	147 (84.5)	415 (83.8)	79 (83)	8 (57)
Not known	6 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Infection at 3 months						
Yes	229 (25.7)	10 (15)	63 (36.2)	113 (22.8)	23 (24)	5 (36)
No	656 (73.6)	57 (85)	111 (63.8)	382 (77.2)	72 (76)	9 (64)
Not known	6 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Implant loss at 3 months						
Yes	51 (5.7)	6 (9)	7 (4.0)	26 (5.3)	7 (7)	2 (14)
No	834 (93.6)	61 (91)	167 (96.0)	469 (94.7)	88 (93)	12 (86)
Not known	6 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Values in parentheses are percentages unless indicated otherwise. *Details of patients with 'other' and 'not known' types of implant reconstruction are summarized in *Table S3*. NAC, nipple–areola complex; SNB, sentinel node biopsy; ANC, axillary node clearance.

At 3 months, 229 patients (25.7 per cent) had required treatment for postoperative infection, 147 (16.5 per cent) had been readmitted to hospital for a complication, and 51 (5.7 per cent) had experienced implant loss (*Table 2*). The type of IBBR performed did not appear to be a risk factor for any of the key safety outcomes in the full cohort of patients, details of which have been reported elsewhere[13].

Outcomes

The 18-month PROs by type of IBBR performed are summarized in *Table 4*, alongside the 18-month adjusted outcomes from the NMBRA[2]. Most questionnaires were returned with all items completed. The number of sufficiently complete responses to be used for analysis were similar for each domain, with the exception of sexual well-being, which was an optional scale (*Table 5*).

Across all domains, median BREAST-Q scores and overall outcome ratings were similar in all patient groups, irrespective of the type of IBBR performed, and were largely consistent with the unadjusted mean scores reported in the NMBRA (*Table 4*)[37]. Patients in the iBRA cohort, however, were less satisfied with the overall outcomes of their reconstruction than those in the NMBRA[37].

Mixed-effects linear and logistic regression models were used to evaluate the impact of different approaches to IBBR on BREAST-Q scores (*Table 5*) and patient rating of overall outcome (*Table S6*). In this analysis, there was no evidence of an association between type of IBBR performed and differences in satisfaction with outcome, physical well-being, sexual well-being, psychosocial well-being or rating of overall outcome. Patients who had prepectoral reconstructions reported higher scores in the satisfaction with breasts domain (adjusted mean difference in BREAST-Q score +6.63, 95 per cent c.i. 1.65 to 11.61; $P = 0.009$,). However, there was no evidence of a difference in scores for any other domain or overall outcome rating in this group.

Discussion

This large multicentre prospective cohort study of 879 women undergoing immediate IBBR with and without biological or synthetic mesh does not suggest that the addition of mesh improved PROs 18 months after surgery. Furthermore, patient satisfaction and QoL, as measured by the BREAST-Q, were remarkably similar to those reported in the 2007–2008 NMBRA, which included only patients undergoing two-stage IBBR without mesh. Although it is acknowledged that patient expectations of reconstructive surgery may have changed over time, this comparison further suggests that the introduction of mesh-assisted techniques has done little to improve the PROs of IBBR.

Although this study found no evidence to support a PRO benefit associated with biological or synthetic mesh use in subpectoral breast reconstruction, it has generated early data to suggest that prepectoral techniques may improve PROs. Women undergoing prepectoral reconstructions reported greater satisfaction with breasts than those undergoing subpectoral techniques. This difference may be clinically significant as it exceeds the recently reported minimum clinically important difference in BREAST-Q score (4 points)[38]. These findings, however, should be interpreted with caution as the prepectoral group was small (14 patients), with the technique introduced late in the recruitment period. Furthermore, prepectoral reconstructions were performed in only 5 of the 81 centres recruiting patients to the study. Their outcomes, therefore, may be biased by the skills and experience of a small group of highly expert operating surgeons, and may

Table 3 Details of malignancy for all patients with cancer who returned the 18-month questionnaire

	All patients* ($n = 732$)	Submuscular ($n = 57$)	Dermal sling ($n = 141$)	Biological mesh ($n = 412$)	Synthetic mesh ($n = 78$)	Prepectoral ($n = 9$)
Laterality of malignancy						
Unilateral	698 (95.4)	53 (93)	137 (97.2)	396 (96.1)	71 (91)	7 (78)
Bilateral	34 (4.6)	4 (7)	4 (2.8)	16 (3.9)	7 (9)	2 (22)
Invasive status						
Invasive	513 (70.1)	37 (65)	92 (65.2)	296 (71.8)	52 (67)	8 (89)
Ductal carcinoma *in situ*	165 (22.5)	10 (18)	39 (27.7)	92 (22.3)	18 (23)	0 (0)
Different status per breast	5 (0.7)	0 (0)	0 (0)	4 (1.0)	1 (1)	0 (0)
Not known	49 (6.7)	10 (18)	10 (7.1)	20 (4.9)	7 (9)	1 (11)
Grade						
Low grade or well differentiated	73 (10.0)	3 (5)	10 (7.1)	47 (11.4)	10 (13)	0 (0)
Intermediate grade or moderately differentiated	319 (43.6)	28 (49)	62 (44.0)	181 (43.9)	27 (35)	4 (44)
High grade or poorly differentiated	273 (37.3)	15 (26)	57 (40.4)	153 (37.1)	32 (41)	3 (33)
Different per breast	13 (1.8)	1 (2)	2 (1.4)	6 (1.5)	2 (3)	1 (11)
Not known	54 (7.4)	10 (18)	10 (7.1)	25 (6.1)	7 (9)	1 (11)
Size of lesion						
Median (i.q.r.; range)	24 (14–45; 0–750)	25 (15–50; 2.5–125)	30 (15–50; 0–750)	22 (14–40; 0–145)	28 (14–52; 1.2–106)	18 (13.3–31; 9–18)
Not known	63 (8.6)	10 (18)	15 (10.6)	26 (6.3)	8 (10)	1 (11)
No. of involved nodes (i.q.r.; range)	0 (0–0.5; 0–32)	0 (0–1; 0–22)	0 (0–0.75; 0–12)	0 (0–0; 0–32)	0 (0–1; 0–19)	0 (0–0.75; 0–5)
Not known	56 (7.7)	10 (18)	9 (6.4)	22 (5.3)	8 (10)	1 (11)
Planned adjuvant chemotherapy†						
Yes	242 (33.1)	25 (44)	40 (28.4)	135 (32.8)	27 (35)	5 (56)
No	434 (59.3)	22 (39)	91 (64.5)	252 (61.2)	45 (58)	3 (33)
Not known	56 (7.7)	10 (18)	10 (7.1)	25 (6.1)	6 (8)	1 (11)
Planned adjuvant radiotherapy†						
Yes	207 (28.3)	23 (40)	40 (28.4)	109 (26.5)	24 (31)	2 (22)
No	470 (64.2)	23 (40)	91 (64.5)	280 (68.0)	48 (62)	6 (67)
Not known	55 (7.5)	11 (19)	10 (7.1)	23 (5.6)	6 (8)	1 (11)
Planned adjuvant endocrine therapy†						
Yes	470 (64.2)	31 (54)	85 (60.3)	271 (65.8)	51 (65)	8 (89)
No	213 (29.1)	16 (28)	47 (33.3)	122 (29.6)	21 (27)	0 (0)
Not known	49 (6.7)	10 (18)	9 (6.4)	19 (4.6)	6 (8)	1 (11)

Values in parentheses are percentages unless indicated otherwise; *Details of pathology and adjuvant treatment in patients with 'other' and 'not known' types of implant reconstruction are summarized in *Table S4*
†Planned adjuvant therapies as per multidisciplinary team recommendation.

Table 4 Patient-reported outcomes at 18 months by method of reconstruction

	All patients† (n = 891)	Submuscular (n = 67)	Dermal sling (n = 174)	Biological mesh (n = 495)	Synthetic mesh (n = 95)	Prepectoral (n = 14)	NMBRA 2008–2009‡
Satisfaction with breasts*	59 (48–71; 0–100)	54.5 (45–73; 11–100)	58 (47–67; 0–100)	61 (48–73; 0–100)	56 (47–71; 0–100)	63 (48–78; 27–100)	55
n	879	66	173	487	94	14	
Satisfaction with outcome*	67 (55–86; 0–100)	67 (55–100; 0–100)	74 (55–86; 0–100)	73 (55–86; 0–100)	67 (61–86; 0–100)	74 (61–86; 0–100)	–
n	872	66	168	486	93	14	
Psychosocial well-being*	67 (52–86; 0–100)	67 (50–92; 14–100)	63 (49–82, 0–100)	67 (53–86, 0–100)	67 (52–86; 0–100)	63 (53–100, 28–100)	65
n	873	66	168	486	94	14	
Sexual well-being*	46 (33–60; 0–100)	49 (32–63; 0–100)	41 (29–54; 0–100)	47 (34–63; 0–100)	50.5 (30.5–63; 0–100)	47.5 (26–83; 0–100)	46
n	653	47	123	374	68	10	
Physical well-being*	74 (66–85; 13–100)	72.5 (66–85; 36–100)	71 (60–85; 25–100)	74 (66–85; 13–100)	74 (63–81; 33–100)	75.5 (63–85; 36–100)	75
n	875	66	170	486	93	14	
Satisfaction with overall outcome							
Excellent	301 (33.8)	20 (30)	54 (31.0)	173 (34.9)	32 (34)	4 (29)	520 (33.9)
Very good	285 (32.0)	19 (28)	59 (33.9)	157 (31.7)	32 (34)	5 (36)	505 (33.0)
Good	161 (18.1)	16 (24)	34 (19.5)	84 (17.0)	19 (20)	2 (14)	288 (18.8)
Fair	97 (10.9)	8 (12)	14 (8.0)	58 (11.7)	8 (8)	2 (14)	145 (9.5)
Poor	38 (4.3)	3 (4)	9 (5.2)	20 (4.0)	3 (3)	1 (7)	74 (4.8)
Not known	9 (1.0)	1 (1)	4 (2.3)	3 (0.6)	1 (1)	0 (0)	–
N	882	66	170	492	94	14	
Satisfaction with overall outcome							
Excellent/Very good	586 (65.8)	39 (58)	113 (64.9)	330 (66.7)	64 (67)	9 (64)	–
Good/Fair/Poor	296 (33.2)	27 (40)	57 (32.8)	162 (32.7)	30 (32)	5 (36)	–
Not known	9 (1.0)	1 (1)	4 (2.3)	3 (0.6)	1 (1)	0 (0)	–
N	882	66	170	492	94	14	

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.; range). n indicates the number of patients who completed the relevant part of the questionnaire. †Scores for patients with 'other' and 'not known' types of implant reconstruction are summarized in *Table S5*. ‡Unadjusted mean outcome scores from patients in the National Mastectomy and Breast Reconstruction Audit (NMBRA) 2007–2008 cohort who underwent implant-based breast reconstruction[34].

Table 5 Adjusted mean differences in BREAST Q domain scores compared with patients undergoing submuscular reconstruction

	Adjusted mean difference in score*	P
Satisfaction with breasts (*n* = 801)		
Dermal sling	0.66 (−4.29, 5.61)	0.79
Biological mesh	2.56 (−1.67, 6.78)	0.24
Synthetic mesh	0.61 (−4.56, 5.79)	0.82
Prepectoral	6.63 (1.65, 11.61)	0.009
Other/different per breast	2.65 (−4.86, 10.17)	0.49
Satisfaction with outcome (*n* = 794)		
Dermal sling	2.14 (−5.44, 9.71)	0.58
Biological mesh	2.41 (−4.75, 9.56)	0.51
Synthetic mesh	2.72 (−5.07, 10.51)	0.49
Prepectoral	1.92 (−9.37, 13.22)	0.74
Other/different per breast	3.21 (−4.09, 10.52)	0.39
Psychosocial well-being (*n* = 795)		
Dermal sling	−3.55 (−9.28, 2.17)	0.22
Biological mesh	−0.37 (−5.45, 4.72)	0.89
Synthetic mesh	−1.82 (−8.01, 4.37)	0.57
Prepectoral	0.43 (−4.46, 5.32)	0.86
Other/different per breast	0.04 (−9.36, 9.43)	0.99
Sexual well-being (*n* = 591)		
Dermal sling	−3.93 (−11.12, 3,27)	0.29
Biological mesh	1.15 (−5.60, 7.90)	0.74
Synthetic mesh	0.75 (−8.70, 10.20)	0.88
Prepectoral	0.43 (−14.92, 15.79)	0.96
Other/different per breast	−7.88 (−17.24, 1.48)	0.10
Physical well-being (*n* = 797)		
Dermal sling	−1.78 (−6.31, 2.74)	0.44
Biological mesh	1.72 (−1.97, 5.41)	0.36
Synthetic mesh	−0.88 (−5.29, 3.54)	0.70
Prepectoral	1.22 (−5.47, 7.90)	0.72
Other/different per breast	6.20 (0.09, 12.30)	0.05

Values in parentheses are 95 per cent confidence intervals. *Adjusted for age, BMI, smoking status, ASA grade, indication (malignancy or risk reduction), unilateral versus bilateral surgery, mastectomy type (nipple-sparing versus other), 3-month complications, and adjuvant systemic therapies, radiotherapy and axillary surgery. Random-effects analysis included to adjust for clustering by centre.

not be generalizable to the wider reconstructive community. No differences were seen in other BREAST-Q domains, most notably physical well-being, which includes an assessment of arm and chest wall function, and it is possible the observed improvement in satisfaction with breasts may have occurred due to multiple testing. Prepectoral reconstruction has been widely adopted worldwide[39–41] since the iBRA study, and further work is needed urgently to evaluate robustly both the clinical and patient-reported outcomes of this technique, as data are currently lacking[17,42].

This work contributes significantly to the limited published literature assessing PROs of IBBR; however, it has several limitations. First, this is a non-randomized observational study and therefore at risk of potential biases such as confounding. Although known, clinically relevant confounders were adjusted for, outcomes may have been subject to bias due to unknown factors. In addition, response bias may have impacted the findings, as patients who returned the 18-month questionnaire were marginally older, less likely to smoke, and, perhaps most importantly, were less likely have experienced complications including implant loss at 3 months than the non-responders.

The study was designed pragmatically as an audit to maximize participation and recruitment, but this limited the ability to optimize data quality and completeness. A complete case analysis was undertaken, limiting the numbers of patients included in the regression models and introducing the potential for bias owing to data missingness. Finally, the study assessed PROs 18 months after surgery. Although these data are important, PROs may evolve over time. Future work should ideally include longer-term follow-up with further assessment at 5 years to understand fully the outcomes of prosthetic reconstruction, as agreed in the recently developed core measurement set for IBBR[43].

Biological and synthetic mesh-assisted IBBR has been introduced with the aim of improving outcomes for patients, but there remains limited PRO evidence to support these claims. The majority of patients having mesh-assisted procedures in this study benefited from a single operation without the need for expansions or further surgery. Although single-stage surgery may benefit healthcare providers by reducing additional treatment costs, offsetting the costs of the mesh itself, it does not appear to improve PROs 18 months after surgery. Furthermore, given the continued uncertainty regarding the safety of biological and synthetic mesh-assisted techniques[18,19,44], urgent work is required to establish whether and how mesh can be used in IBBR to benefit patients.

Prepectoral techniques have recently been reintroduced into practice, with growing popularity among reconstructive surgeons. These data suggest that prepectoral reconstruction may be promising, but high-quality comparative research including long-term clinical and patient-reported outcomes, and late complications such as capsular contracture, is needed. Evaluation of long-term oncological outcomes are also required owing to concerns that the implant and mesh may affect the detection of cancer recurrence. Ideally, a well designed pragmatic RCT is required to establish definitively which reconstructive technique is most clinically and cost effective, and provides the best outcomes for patients. The iBRA RCT acceptability study has suggested that a trial may be feasible[45] and the Best-BRA external pilot study (ISRCTN10081873) will determine whether it is possible to recruit patients to an RCT comparing prepectoral and subpectoral techniques before progressing to a definitive large-scale trial. Similar RCTs are underway in Europe, and will generate much needed evidence to support practice and policy. Whilst awaiting further evidence, surgeons must be open with patients about the uncertainties in IBBR to help them make informed decisions about their reconstructive options.

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Supplementary material

Supplementary material is available at *BJS Open* online

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