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A systematic review of oncoplastic volume replacement breast surgery: oncological safety and cosmetic outcome

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ABSTRACT

Introduction Oncoplastic breast conserving surgery allows higher volume excision to achieve oncological safety with minimal aesthetic compromise. The primary outcome of this study was to assess the oncological safety in the setting of volume replacement oncoplastic breast conserving surgery. The secondary objective was to assess cosmetic outcome.

Methods A systematic literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines to explore the oncological safety of oncoplastic breast conserving surgery, with particular focus on volume replacement. Resection margin rates, re-excision rates, conversion to mastectomy rates, local and distant disease recurrence, volume replacement techniques, cosmetic outcomes and patient-reported outcome measures were assessed.

Findings The search criteria identified 155 articles, of which 40 met the inclusion criteria. These studies included 2,497 patients with a mean age of 47.8 years (range 38.4–59.6 years), a body mass index of 24.3kg/m^2 (22.1–28.0kg/m^2), with a mean follow-up of 37.1 months (6–125 months). A variety of volume replacement techniques were used, most commonly latissimus dorsi and chest wall perforator flaps. Whole mean pathological tumour size was 29.7mm (17–65mm) and mean specimen weight was 123.6g (46.5–220g). Mean re-excision rate was 7.2% and completion mastectomy rate was 2.3%. Locoregional and distant recurrence rate was 2.5% (0–8.1%) and 3.1% (0–14.6%), respectively. There were a variety of patient-reported outcome measures employed, with overall good to excellent outcomes.

Conclusions This review demonstrates that volume replacement oncoplastic breast conserving surgery is a safe option in terms of re-excision, completion mastectomy rates, and local and distant recurrence. Available patient-related outcome measures and cosmetic assessment tend towards better outcomes compared with wide local excision and mastectomy. However, data are significantly limited, with a paucity of high-level evidence, and it is therefore necessary to be cautious regarding the strength and interpretation of data in this review. Further prospective studies are required on this subject.

KEYWORDS
Oncological safety – Oncoplastic surgery – Breast conservation – Breast conserving surgery – Volume replacement – Resection margins – Recurrence – Survival – Aesthetic outcome – Cosmetic outcome – Cosmesis

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Introduction

Breast cancer remains the most frequently diagnosed cancer among women worldwide, affecting 1.5 million women each year.[1] The primary aim of breast conserving surgery is achieving oncological safety through complete tumour excision with clear margins. Breast conserving surgery with adjuvant whole breast irradiation is well established as an oncologically safe option in the management of early breast cancer. As surgical techniques have moved away from more radical approaches towards breast conservation and the use neoadjuvant therapy increased, oncoplastic surgery has evolved from breast conserving surgery, allowing for higher volume excision without compromising cosmesis and maintaining breast appearance.[2,3] This avoids the need for mastectomy while still maintaining local control, achieving better cosmetic outcome and reducing complications.[4]

Percentage of breast tissue excised has been found to correlate with aesthetic outcome, which is still reported as poor in up to half of the patients.[5,6] Oncoplastic breast conserving surgery (OBCS) has developed as a means of addressing this issue. OBCS can be classified into volume displacement or volume replacement techniques. Volume displacement involves the filling of a defect through transposition of a glandular or a dermoglandular flap of breast tissue, which often requires symmetrisation of the

contralateral breast. Volume replacement, which is the main focus of this review, involves the use of autologous tissues to replace volume loss. Breast symmetrisation of the contralateral breast is an integral part of OBCS and should always be considered in either an immediate or a delayed fashion.

The term 'volume replacement' was first described in a full paper by Raja *et al* in 1997.[7] Multiple oncoplastic volume replacement techniques have evolved including latissimus dorsi flap, thoracodorsal artery perforator (TDAP) flap, lateral/anterior/medial intercostal artery perforator (LICAP/AICAP/MICAP) flap, lateral thoracic artery perforator (LTAP) flap, thoracoepigastric flap, omental flap and lateral adipose tissue flap. The aim of these techniques is to fill the excised defect thus eliminating deformity and maintaining breast appearance.

The purpose of this review was to assess the best level of evidence available on the oncological safety of volume replacement OBCS. Positive margin rates, re-excision rates, conversion to mastectomy rates, effect on adjuvant therapy, local and distant disease recurrence and volume replacement techniques in the setting of breast cancer were evaluated. The second aim was to assess cosmetic outcomes and the use of patient-related outcome measures (PROMs) in this setting. Assessment of such evidence could aid both clinicians and patients in making an informed decision on OBCS.

Methods

A search was conducted through MEDLINE, EMBASE and Dynamed Plus databases to identify randomised controlled trials, cohort studies and case series of more than 10 patients who underwent volume replacement OBCS. The databases were searched from 1974 to 2020. The protocol from Hu *et al* was used as guidance.[8] This was supplemented by a manual search of relevant references.

A comprehensive search was performed using the following keywords: 'breast cancer' [All Fields] AND 'oncoplastic' [All Fields] AND 'partial breast reconstruction' [All Fields] AND 'breast conserving therapy' [All Fields] AND 'volume replacement' [All Fields].

Two researchers (CLR and SB) performed the search independently and assessed results using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines to identify and filter out relevant articles.[9] All searches were conducted in February 2019 and March 2020. Only full publications in English were considered, abstracts were excluded.

Inclusion criteria were: (i) patients undergoing volume replacement OBCS for breast cancer; (ii) immediate reconstruction; (iii) evaluation of oncological and/or aesthetic outcomes; (iv) peer-reviewed articles. Exclusion criteria were: (i) breast conservation for benign tumours; (ii) reconstruction following mastectomy; (iii) case reports; (iv) series with less than 10 patients; (v) less than six months of follow-up; (vi) articles not in English; (vii) incomplete papers.

Study quality was evaluated based on study design, patient numbers, selection criteria and duration of follow-up. Studies were manually filtered for the following data: author name, year of publication, country/institution, study type, number of cases, patient age, preoperative breast/bra size, tumour type, grade and stage, lymph node status, hormone receptor status, multifocality, neoadjuvant and adjuvant therapies, volume replacement technique and patient follow-up time. Oncological outcomes including re-excision rates, conversion to mastectomy, local and distant disease recurrence and survival were assessed, as well as complications, cosmetic outcomes and PROMs.

The data were extracted and stored in a standardised database by two independent investigators. Following initial blinding of the reviewers, on completion of data collection the articles selected were discussed and assessed in greater detail.

Outcomes of interest were presented in tables and text format around the primary and secondary outcomes. There was limited scope for meta-analysis owing to the small, heterogeneous studies assessed.

Findings

The literature search identified 155 articles, 40 of which met the inclusion criteria (Figure 1).[6,10–48] The publication period for the search was from 1974 to 2020 and the studies that were included were published between 1997 and 2020. Data were extracted from the 40 relevant studies that collectively assessed 2,497 patients with a mean age of 47.8 years (range 38.4–59.6 years) and a body mass index of 24.3kg/m^2 (22.1–28.0kg/m^2). Study types included 26 prospective and 14 retrospective studies, all of which were observational. Follow-up time ranged from 6 to 125 months, with a mean of 37.1 months.

A total of 19 papers included tumour type, 14 included stage and only 5 included hormone receptor status. Five papers included patients with multifocal tumours, one of which all patients included had multifocal disease. Lymph node status was reported in 15 studies.

Only four papers included preoperative breast/bra size.[20,35,47,48] Tumour location was reported in 23 papers, although there was variation in how location was described. The most commonly used oncoplastic volume replacement techniques included latissimus dorsi, TDAP, ICAP and LTAP flaps in 20, 12, 11 and 8 papers, respectively. Less commonly used flaps included thoracoepigastric, omental, medial circumflex femoral artery perforator (MCFAP) and internal mammary artery perforator (IMAP) flaps.

Mean tumour size was 29.7mm (17–65mm) and mean specimen weight was 123.6g (46.5–220g). Although the majority considered an involved or positive margin less than 1–2mm, there was some variation among institutions, with some considering a positive margin as less than 5mm,[41] and others less than 10mm.[26] Overall, there was an 11.3% (0–29.3%) positive margin rate.

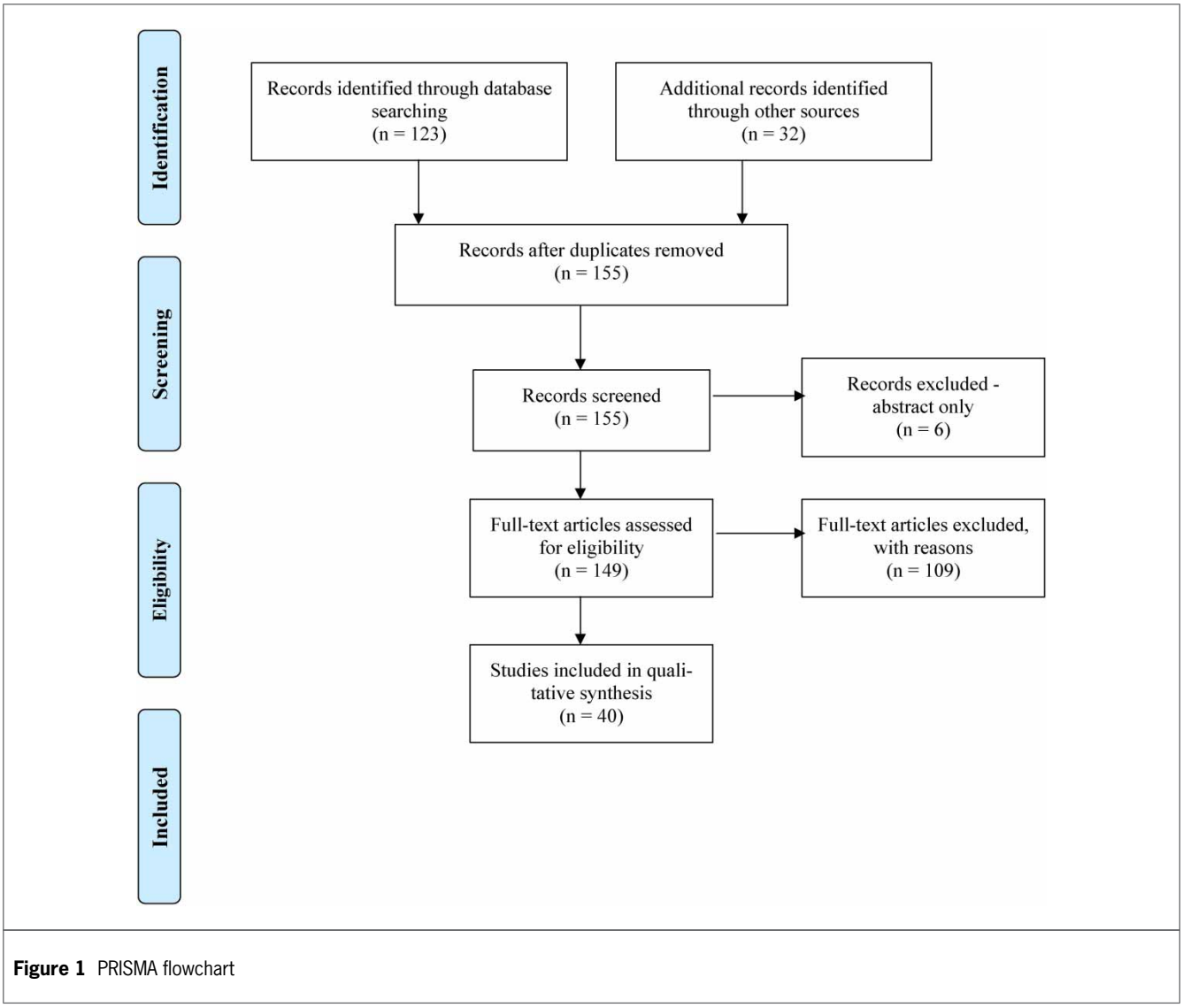

Figure 1 PRISMA flowchart

The re-excision rate, however, was only 7.2% (0–26.7%) because of the variability in what was deemed a positive margin. Conversion to mastectomy was only 2.3% (0–10.3%).

There was limited information on oncological outcomes (Table 1). Thirty-one papers were included in this assessment.[11,14,16–20,22–27,29–31,33–43,45–48] A total of 1,729 patients were included, with a mean follow-up of 40.8 months (6–125 months). Locoregional and distant recurrence was 2.5% (0–8.1%) and 3.1% (0–14.6%) at 43.7 months and 36.4 months, respectively.

Overall survival and disease-free survival were 96.8% (93.3–100%) and 92.6% (84.6–100%) at 49.8 months and 39.0 months respectively, with a mortality rate of 5.9% (0–35.0%) at a mean follow-up of 48.9 months. The mortality was skewed due to low numbers of papers reporting these data and one outlying paper, which had a mortality rate of 35% at a mean follow-up of 60 months.[44] In this paper, all patients were given preoperative radiotherapy and had a positive margin rate of 25%. Discounting this paper, the mean mortality is 2.7% (0–7.3%) at 47.5 months.

Several of the older studies were involved with adjuvant radiotherapy trials at the same time as patient recruitment to the volume replacement studies.[37,44] There were also institutions that did not employ routine adjuvant radiotherapy,[26,27,41] hence there is a considerable discrepancy in its use, ranging from 33.3% to 100%, with more recent studies tending towards 100%.[11,18–20,23,25,33,34,38,39,48]

Overall complications ranged from 0% to 65.7%, with a mean of 21.1%. Complications described were divided into minor (I–II) and major (III–IV) as per the Clavien–Dindo classification: 17.1% (0–52%) and 5.6% (0–13.7%), respectively. The majority of these complications were seroma formation (particularly donor site), fat necrosis, haematoma and wound infection. These results

Table 1 Oncological outcomes in volume replacement surgery

Authors	Year	Institution, country	Cases (*n*)	Mean follow-up (months)	Pathological characteristics	Stage (%)	Neoadjuvant therapy	PMR	RE	CM	Adjuvant therapy	LRR (%)	DR (%)	OS (%)	DFS (%)	Mortality (%)
Soumian *et al*[40]	2020	University Hospitals of North Midlands NHS Trust, UK	112	15	Inv 96 (85.7%); DCIS 16 (14.3%); ER + ve 85 (88.5%)	NR	Chemo 16 (14.3%)	15 (13.4%)	15 (13.4%)	1 (0.9%)	Radio 110 (98.2%), chemo 31 (27.7%), endocrine 85 (75.9%)	0.9	0.9	NR	NR	NR
Jae Bong *et al*[22]	2019	Kyungpook National University, Korea	40	25.6	NR	NR	NR	3 (7.5%)	NR	NR	NR	NR	NR	NR	NR	NR
Zhou *et al*[48]	2019	Sun Yat-sen University Cancer Centre, China	32	12	IDC 29 (91%); DCIS 1 (3%); other 2 (6%)	T1 13 T2 87	NR	0 (0%)	0 (0%)	0 (0%)	Radio 32 (100%)	0	0	NR	NR	NR
Schwartz *et al*[39]	2018	Georgia Breast Surgery, United States	25	6	NR	NR	Chemo 7 (28%)	3 (12%)	3 (12%)	0 (0%)	Radio 25 (100%), chemo 6 (24%)	NR	NR	NR	NR	NR
Wang *et al*[43]	2017	Peking University Cancer Hospital & Institute, China	33	12	NR	NR	NR	NR	NR	NR	NR	0	0	NR	NR	NR
Jae Bong *et al*[23]	2017	Kyungpook National University, Korea	33	25.2	IDC 31 (93.9%) DCIS 2 (6.1%)	0 6.1 1A 33.3 2A 33.3 2B 27.3	NR	3 (9.1%)	3 (9.1%)	NR	Radio 33 (100%), chemo 21 (63.6%)	NR	NR	NR	NR	NR
Harman *et al*[18]	2017	St Mark's Women's Health Centre, New Zealand	15	36	NR	NR	NR	NR	NR	NR	Radio 15 (100%)	0	0	NR	NR	0
Lee *et al*[29]	2017	Kyungpook National University, Korea	90	72	NR	0 6.7 1A 47.8 2A 25.6, 2B 16.7, 3A 3.4	NR	NR	NR	NR	NR	1.1	4.4	98.9	NR	1.1
Khan *et al*[25]	2017	Edinburgh Breast Unit, UK	35	36	NR	NR	NR	8 (22.9%)	8 (22.9%)	NR	Radio 35 (100%)	NR	NR	NR	NR	NR
Mele *et al*[31]	2017	Winchester Breast Unit, UK	261	125	NR	NR	NR	NR	NR	NR	Radio 188 (83.6%)	8	NR	NR	NR	NR
Van Huizum *et al*[42]	2017	Netherlands Cancer Institute, Netherlands	12	35.3	IDC 7 (58.3%) DCIS 3 (25%) ILC 1 (8.3%) Phyllodes 1 (8.3%)	T1 66.7, T2 8.3	Chemo 3 (27.3%)	1 (8.3%)	1 (8.3%)	1 (8.3%)	Radio 9 (81.1%), chemo 3 (37.5%), endocrine 2 (18.2%)	NR	NR	NR	NR	NR

Ho *et al*[20]	2016	Queen Elizabeth University Hospital, UK	30	48.5	IDC 23 (76.7%) ILC 5 (16.7%) DCIS 1 (3.3%) mixed 1 (3.3%) ER + ve 79.3% PR + ve 72.4% HER2 +ve 13.8%	0 3.3, 1A 26.7, 1B 3.3, 2A 53.3, 3A 3.3, 3C 3.3	Chemo 2 (6.7%)	3 (10%)	3 (10%)	0%	Radio 30 (100%), chemo 14 (46.7%), Herceptin 4 (13.3%), endocrine 22 (73.3%)	3.3	0	NR	NR	NR
Zaha *et al*[46]	2015	Nakagami Hospital, Japan	30	64	NR	T0 20, T1 33.3, T2 46.7	NR	1 (3.3%)	1 (3.3%)	0%	NR	0	0	NR	NR	NR
Lee *et al*[27]	2014	Kyungpook National University, Korea	72	40.9	IDC 63 (87.5%) ILC 2 (2.8%) DCIS 6 (8.3%) mucinous 1 (1.4%) ER + ve 76.4%, PR + ve 68.1%, HER2 +ve 18.1%, triple –ve 12.5%	0 8.3, 1A 41.7, 2A 25, 2B 15.3, 3A 4.2, 3B 1.4, 3C 4.2	Chemo 4 (5.6%)	NR	0 (0%)	NR	Radio 68 (94.4%), chemo 49 (68.1%), Herceptin 49 (68.1%), endocrine 53 (73.6%)	2.8	5.6	NR	39.7m	0
Kijima *et al*[26]	2013	Kagoshima University Graduate School of Medicine and Dental Sciences, Japan	15	11.2		T1 93.3, T2 6.7	Chemo/radio/ endocrine 0	NR	NR	NR	Radio 5 (33.3%), chemo 6 (40%), endocrine 14 (93.3%)	0	0	NR	NR	NR
Hamdi *et al*[17]	2013	Brussels University Hospital, Belgium	93	48	NR	NR	NR	2 (2.2%)	NR	NR	NR	NR	NR	NR	NR	NR
Rose *et al*[38]	2012	Sydvestjysk Sygehus, Denmark	15	NR	IDC 15 (100%)	NR	NR	4 (26.7%)	4 (26.7%)	0 (0%)	Radio 15 (100%)	NR	6.7	93.3	93.3	6.7
Hernanz *et al*[19]	2011	University of Cantabria, Spain	41	58	IDC 27 (65.9%) ILC 10 (24.4%) Phyllodes/ apocrine/solid/mixed each 1 (2.4%), ER + ve 46.3% PR + ve 53.7% HER2 +ve 26.8% triple –ve 31.7%	NR	NR	12 < 2mm (29.3%), 0 involved	0 (0%)	NR	Radio 38 (100%)	2.4	14.6	NR	NR	7.3
El-Marakby *et al*[14]	2011	National Cancer Institute, Cairo, Egypt	50	33	IDC 82%, ILC 10%	NR	NR	0 (0%)	0 (0%)	0 (0%)	Radio 92%, chemo 86%, endocrine 74%	4	2	NR	NR	NR
Zaha *et al*[47]	2010	Nakagami Hospital, Japan	24	35	NR	Tis 25, T1 8, T2 50, T3 17	NR	1 (4.2%)	NR	NR	Radio 54%	0	0	NR	NR	NR
Almasad *et al*[11]	2008	Jordan University Hospital, Amman, Jordan	25	48	IDC 21 (84%) medullary 3 (12%) tubulolobular 1 (4%)	NR	Chemo 1 (4%)	NR	NR	NR	Radio 25 (100%), chemo 24 (96%)	8	4	NR	NR	4

Navin *et al*[35]	2007	Bassetlaw Hospital, UK	51	33	IDC 40 (78.5%) ILC 3 (5.9%) Mixed inv 4 (7.9%) DCIS 2 (3.9%), medullary/mucinous each 1 (1.9%)	NR	NR	2 (3.9%)	0 (0%)	4 (7.8%)	Radio 47 (92.2%)	0	0	100	100	0
Naguib *et al*[34]	2006	National Cancer Institute Cairo, Egypt	29	19	NR	NR	Chemo 7 (24.1%)	NR	NR	NR	Radio 29 (100%)	0	6.9	NR	NR	NR
Munhoz *et al*[33]	2006	University of Sao Paulo, Brazil	34	23	NR	NR	NR	NR	NR	NR	Radio 34 (100%), chemo 12 (35.3%)	0	NR	NR	NR	NR
Takeda *et al*[41]	2005	Tohoku University School of Medicine, Japan	266	72	NR	NR	NR	NR	NR	NR	Radio 165 (62%)	5.6	NR	NR	NR	NR
Woerdeman *et al*[44]	2004	Netherlands Cancer Institute, Netherlands	20	60	NR	NR	Radio 20 (100%)	5 (25%)	NR	NR	Chemo 5 (25%), endocrine 8 (40%)	5	NR	NR	NR	35
Losken *et al*[30]	2004	Emory University School of Medicine, United States	39	44.4	IDC 30 (77%), ILC 4 (10.3%), DCIS 2 (5.1%), Phyllodes 2 (5.1%), ADH 1 (2.5%), ER/PR + ve 64%, ER/PR –ve 20%	NR	Chemo 5 (13%), radio 1 (2.6%)	9 (23.1%)	4 (10.3%)	4 (10.3%)	Radio 33 (91.7%)	5.1	7.7	94.9	84.6	5.1
Gendy *et al*[16]	2003	Royal Hampshire County Hospital, UK	49	53	IDC 37 (75.5%), ILC 2 (4.1%), mixed 2 (4.1%), DCIS 4 (8.1%), special type 4 (8.1%)	NR	NR	0 (0%)	0 (0%)	0 (0%)	Radio 37 (75.5%)	4.1	NR	NR	NR	NR
Kat *et al*[24]	1999	Stoke Mandeville Hospital NHS Trust, UK	30	NR	IDC 27 (90%), ILC 2 (6.7%), tubular 1 (3.3%)	NR	NR	0 (0%)	0 (0%)	0 (0%)	Radio 30 (100%)	NR	NR	NR	NR	NR
Rainsbury *et al*[37]	1998	Royal Hampshire County Hospital, UK	62	43	NR	NR	NR	8 (12.9%)	4 (6.5%)	0 (0%)	Radio 32 (54.8%)	8.1	NR	NR	NR	NR
Ohuchi *et al*[36]	1997	Tohoku University School of Medicine, Japan	66	48	IDC 66 (100%)	NR	NR	NR	NR	NR	NR	0	NR	NR	NR	0

ADH, atypical ductal hyperplasia; CM, completion mastectomy; DCIS, ductal carcinoma in situ; DFS, disease-free survival; DR, distant recurrence; ER, estrogen receptor; IDC, invasive ductal carcinoma; ILC, infiltrating ductal carcinoma; Inv, invasive; LRR, locoregional recurrence; NR, not recorded; OS, overall survival; PMR, positive margin rate; PR, progesterone receptor; RE, re-excision rate; +ve, positive; –ve, negative

demonstrate that most volume replacement surgery complications can be managed conservatively. There was little information on complications leading to delay in adjuvant therapy, with only four studies mentioning this; three leading to no delay and one study quoting 16% of patients experiencing delay secondary to complications.[39] Patient-reported and cosmetic outcomes (Table 2) lacked standardisation; however, among patients the Breast-Q,[13,23,25] with satisfaction expressed on a scale of 1–10[16] or poor to excellent,[10–12,22] and the Modified Michigan cosmetic and overall outcomes[6,45] were most commonly used. In terms of surgeon reported cosmetic outcome, panel assessments were most frequently used.[12,18,19,22,46,47] Overall, results tended towards good to excellent outcomes as reported by the patients and surgeons.

Discussion

As with any emerging technique, oncological safety is of prime concern. OBCS has the advantage of allowing for higher volume surgical resection, thereby reducing positive resection margins and subsequent re-excision and mastectomy rates. This may have the added benefit of preventing delays in adjuvant therapy due to lower rates of positive margins encountered and obviating further surgery.[49] OBCS can also improve cosmesis and patient satisfaction as compared with mastectomy and standard breast conserving surgery.

Oncological safety: resection margins and re-excision

Re-excision rates are of the upmost importance in allowing for accurate assessment of tumour size, margin status and local recurrence, as well as minimising impact on cosmetic outcome.

A 1mm margin is generally accepted as clear for both ductal carcinoma in situ and invasive breast cancer, and does not warrant re-excision according to the Association of Breast Surgeons guidelines.[50] National Institute for Health and Care Excellence guidelines recommend margins of 2mm or more in breast cancer resection specimens. However, margins of greater than 1mm are not associated with lower recurrence rates. Positive surgical margins occur in 20–40% of all conventional breast conserving surgery, with 20% undergoing re-excision.[51,52]

Previous studies have clearly demonstrated a reduction in re-excision rates in the setting of OBCS as compared with standard breast conserving surgery or wide local excision.[53,54] Despite this, some critics are concerned that tissue rearrangement may inhibit the ability to perform an accurate re-excision.

De La Cruz *et al* carried out the largest comprehensive literature review assessing oncological safety in OBCS. They evaluated over 6,000 patients and found re-excision rates of 6.0%.[49] Crown *et al* assessed a total of 812 patients undergoing either OBCS or wide local excision. Of these, 18% underwent re-excision in the OBCS cohort, as compared with 32% in the standard wide local excision group ($p < 0.0001$).[54] These findings are supported by a similar study by Chakravorty *et al*, who reported significantly lower rates of re-excision in the OBCS group (2.7%) as compared with standard breast conserving surgery (13.4%; $p < 0.001$).[53] This study supports these findings, demonstrating a re-excision rate of 7.2% in the setting of volume replacement OBCS, but it also highlights that the management of positive margins is not standardised.

Oncological safety: conversion to mastectomy rates

Several papers have demonstrated a reduction in mastectomy rates with the introduction of OBCS. Crown *et al* demonstrated that, in the OBCS cohort, 15% required completion mastectomy, as compared with 34% in the wide local excision cohort ($p < 0.001$), despite the average tumour size in the OBCS group being larger.[16] In this study, the whole mean tumour size was 29.7mm, with a completion mastectomy rate of only 2.3%.

Oncological safety: adjuvant therapy

Radiotherapy is advocated in breast conserving surgery, whether conventional or oncoplastic. Current UK guidelines recommend that adjuvant therapy be commenced within 31 days of completion of surgery wherever clinically possible. Delaying radiotherapy beyond eight weeks has been demonstrated to have a detrimental effect on local recurrence.[5] Yoon *et al* also highlighted that boost after whole breast radiotherapy has been demonstrated to reduce local recurrence. This finding is of particular importance in this setting, as young women are at greater risk of local recurrence and more likely to undergo OBCS.[55] There was very little information in this review about the impact of complications in the setting of volume replacement and its impact on adjuvant therapy.

Oncological safety: local and distant disease recurrence rates

Evidence relating to local and distant recurrence rates after OBCS have shown similarities to mastectomy, together with striking similarities in histopathological results.[56] Previously, this has been demonstrated by Mansell *et al* in consecutive patients treated with breast conserving surgery, mastectomy with or without reconstruction and OBCS.[57] Histological variables including tumour size, grade, nodal and hormonal status were found to be more adverse in OBCS compared with breast conserving surgery and similar to mastectomy. Five-year local recurrence was found to be similar in all three groups, while distant recurrence was higher after mastectomy and OBCS, most probably related to tumour biology. This is supported by both Losken and Chand, who found that therapeutic mammoplasty and volume replacement with mini-latissimus dorsi flaps, respectively, had no effect on local recurrence.[13,58] However, Chakravorty *et al* demonstrated similar local recurrence rates of 2.7% and 2.2%, but distant

Table 2 Patient reported outcomes and cosmetic outcomes

Authors	Year	Institution/Country	VR Technique (%)	Overall complications (%)	Complications CD I-II (%)	Complications CD III-IV (%)	PROMs	Surgeon-reported outcomes
Soumian *et al*[40]	2020	University Hospitals of North Midlands NHS Trust/UK	LICAP (± LTAP) 75, LTAP 2.7, AICAP 12.5, MICAP 9.8	7.1	NR	2.7	NR	NR
Gwak *et al*[15]	2020	The Catholic University of Korea, Korea	Diced ADM 100	20.5	12	8.5	Cosmetic satisfaction 9.7/10, overall satisfaction 9.5/10	Cosmetic satisfaction 9.7/10, overall satisfaction 9.4/10
Abdelrahman *et al*[10]	2019	Benha University, Egypt	LD 50, TDAP 50	40.5	NR	NR	Patient satisfaction: excellent 26.2%, good 52.4%, fair 11.9%, poor 9.5%	NR
Jae Bong *et al*[22]	2019	Kyungpook National University, Korea	LICAP 100	22.5	NR	NR	Cosmetic satisfaction: excellent 57.5%, good 37.5%, fair 7.5%	Panel assessment: excellent 47.5%, good 42.5%, fair 10.0%
Zhou *et al*[48]	2019	Sun Yat-sen University Cancer Centre, China	LD miniflap 100	9	NR	NR	DASH 10.6/30, cosmetic satisfaction > 90% very or extremely	NR
Schwartz *et al*[39]	2018	Georgia Breast Surgery, USA	LICAP 100	40	40	0	NR	NR
Chand *et al*[13]	2017	Royal Hampshire County Hospital, UK	LD miniflap 100	NR	NR	NR	BREAST-Q: overall experience excellent or very good 78%, preferable to mastectomy 88%, would undergo again 73%	NR
Wang *et al*[43]	2017	Peking University Cancer Hospital and Institute, China	TDAP 100	6.1	NR	NR	NR	NR
Amin *et al*[12]	2017	National Cancer Institute, Egypt	TDAP 100	20	NR	2.5	Cosmetic satisfaction: excellent 10.0%, good 70.0%, fair 15.0%, poor 5.0%	Panel assessment: excellent 5.0%, good 57.5%, fair 30.0%, poor 7.5%
Jae Bong *et al*[23]	2017	Kyungpook National University, Korea	LICAP 57.6, TDAP 42.2	48.5	NR	12.1	Modified BREAST-Q: excellent 45.5%, good 39.4%, fair 15.2%	NR
Harman *et al*[18]	2017	St Mark's Women's Health Centre, NZ	Biozorb (polylactic acid and titanium clips) 100	6.7	6.7	NR	NR	Panel assessment: 8% palpable at 12m, all excellent at 36 months
Lee *et al*[29]	2017	Kyungpook National University, Korea	ICAP/LTAP, TDAP, LD – numbers NR	NR	NR	NR	NR	NR
Khan *et al*[25]	2017	Edinburgh Breast Unit, UK	Lipofilling 100	NR	NR	NR	BREAST-Q – VR better than standard BCS in all domains	NR
Mele *et al*[31]	2017	Winchester Breast Unit, UK	LD miniflap 100	NR	NR	NR	NR	NR
Van Huizum *et al*[42]	2017	Netherlands Cancer Institute, The Netherlands	IMAP 100	0	0	0	Breast cosmesis 7.9/10, nipple cosmesis 9.3/10	NR
Ho *et al*[20]	2016	Queen Elizabeth University Hospital, UK	TE 43.3, LICAP 16.7, matrix rotation 26.7, TDAP 6.7, LTAP 3.3, crescent 3.3	26.7	20	6.7	NR	NR

Zaha *et al*[46]	2015	Nakagami Hospital, Japan	Omental 100	10	6.7	3.3	BCCT.core: excellent 43.3%; good 43.3%, fair 13.3%, poor 0%	Panel assessment: excellent 66.7%, good 20.0%, fair 3.3%, poor 10.0%
Lee *et al*[27]	2014	Kyungpook National University, Korea	LD 63.4, ICAP 13.4, LTAP 10.2, TDAP 9.3, TE 3.7	14.1	NR	NR	Cosmetic satisfaction: 82.3% satisfied	NR
Park *et al*[6]	2014	Daegu Fatima Hospital, Korea	ICAP 50, LD 21.4, TE 14.3, TDAP 7.1	21.4	NR	NR	Modified Michigan: cosmetic satisfaction 86.0%, overall satisfaction 79.0%	Panel assessment 1–5: 4.16/5
Lee *et al*[28]	2014	Kyungpook National University, Korea	ICAP 34.7, LTAP 18.1, ELD 18.1, TDAP 15.3, LD 6.9, TE 4.2, inf chest wall 2.8	18.1	18.1	NR	NR	NR
Morishima *et al*[32]	2014	Osaka Rosai Hospital, Japan	Lateral tissue flap 100	NR	NR	NR	NR	Sawai's criteria: Bp 8.87, Bq 6.67
Izumi *et al*[21]	2013	Osaka General Medical Center, Japan	MCFAP 100	20	NR	NR	NR	Photographic assessment: excellent 53.3%, very good 26.7%, good 13.3%, fair 6.7%
Kijima *et al*[26]	2013	Kagoshima University Graduate School of Medicine and Dental Sciences, Japan	TDAP 100	NR	NR	NR	NR	Sawai's criteria: excellent 36.3%, good 63.6%
Hamdi *et al*[17]	2013	Brussels University Hospital, Belgium	LD/TDAP/LICAP/SAAP – numbers NR	14.0	NR	3.2	NR	NR
Yang *et al*[45]	2012	Kyungpook National University, Korea	LD 50.5, ICAP 23.4, TDAP 11.2, LTAP 8.4, TE 6.5	13.5	NR	NR	Modified Michigan: cosmetic satisfaction 76.9%, overall satisfaction 81.7%	NR
Rose *et al*[38]	2012	Sydvestjysk Sygehus, Denmark	LTAP 100	6.7	0	6.7	NR	NR
Hernanz *et al*[19]	2011	University of Cantabria, Spain	LD 100	NR	NR	NR	NR	Panel assessment: excellent 6.8%, good 51.7%, fair 37.9% BCCT.core: excellent 13.0%, good 52.2%, fair 24.8%
El-Marakby *et al*[14]	2011	National Cancer Institute, Egypt	LD 90, LD miniflap 10	18	NR	12	NR	NR
Zaha *et al*[47]	2010	Nakagami Hospital, Japan	Omental 100	12.5	8.3	4.2	NR	Panel assessment: excellent 67%, good 26%, fair 4%, poor 0%, BRA 0.5
Almasad *et al*[11]	2008	Jordan University Hospital, Amman	Lateral tissue flap 100	NR	NR	NR	Cosmetic satisfaction: very good 56.0%, good 28.0%, fair 16.0%	NR
Navin *et al*[35]	2007	Bassetlaw Hospital, Worksop, UK	LD miniflap 100	2.0	NR	NR	Overall satisfaction 86%	NR
Naguib *et al*[34]	2006	National Cancer Institute, Egypt	LD 100	65.7	52.0	13.7	Cosmetic satisfaction: overall satisfaction 69%, asymmetry 17.2%, skin colour discrepancy 6.9%, NAC discrepancy 6.9%	NR

Munhoz *et al*[33]	2006	University of Sao Paulo School of Medicine, Brazil	LTAP 100	52.9	23.5	8.8	Cosmetic satisfaction very good–satisfactory: breast shape 96.8%, NAC 97.9%, breast symmetry 95.9%, overall cosmesis 97.0%, regret surgery 0%	Panel assessment: Overall cosmetic result very good-satisfactory 97.0%
Takeda *et al*[41]	2005	Tohoku University School of Medicine, Japan	Lateral tissue flap 100	NR	NR	NR	NR	NR
Woerdeman *et al*[44]	2004	Netherlands Cancer Institute, The Netherlands	LD 100	NR	NR	NR	Cosmetic satisfaction: 2.8/3	Panel assessment of cosmesis: 2.6/3
Losken *et al*[30]	2004	Emory University School of Medicine, Atlanta, USA	LD 100	31.0	12.8	2.6	NR	NR
Gendy *et al*[16]	2003	Breast Unit, Royal Hampshire County Hospital, UK	LD miniflap 100	18.4	6.4	12.0	Cosmetic outcome 83.5%, freedom of dress 89.0%, altered skin sensation 10%, altered NAC sensation 2%	Photographic panel assessment: 3.8, BRA: 2.2
Kat *et al*[24]	1999	Stoke Mandeville Hospital NHS Trust, UK	LD 100	33.3	33.3	0	NR	NR
Rainsbury *et al*[37]	1998	Royal Hampshire County Hospital, UK	LD miniflap 100	11.3	NR	NR	Physical and psychological assessment – more freedom of dress and less worried about residual cancer compared with BCS	BRA 10% < 2.0
Ohuchi *et al*[36]	1997	Tohoku University School of Medicine, Japan	Lateral tissue flap 84.4, LD 15.2	NR	NR	1.6	NR	NR

ADM, acellular dermal matrix; AICAP, anterior intercostal artery perforator; BCS, breast conserving surgery; Bp, partial breast resection; Bq, breast quadrantectomy; BRA, breast retraction assessment; DASH, disabilities of arm, shoulder and hand; ELD = extended latissimus dorsi; IMAP, internal mammary artery perforator; LICAP, lateral intercostal artery perforator; LD, latissimus dorsi; LTAP, lateral thoracic artery perforator; MCFAP, medial circumflex femoral artery perforator; MICAP, medial intercostal artery perforator; NAC, nipple–areolar complex; NR, not recorded; PROMs, patient-reported outcome measures; TDAP, thoracodorsal artery perforator; TE, thoracoepigastric; VR, volume replacement.

recurrence rates of 1.3% and 7.5% for OBCS and breast conserving surgery, respectively,[53] but this study had a median follow-up of only 28 months.[53]

Yoon *et al* assessed 10 papers in their systematic review, where local recurrence ranged from 0% to 10% at a mean follow-up of 40 months.[55] This systematic review once again supported these findings, with a locoregional and distant recurrence rate of 2.5% and 3.1% and a mean follow-up of 43.7 months and 36.4 months, respectively.

Oncological safety: survival

There is little data on overall and disease-free survival in the setting of volume replacement surgery specifically. However, in reference to OBCS, five-year disease-free survival has been found to be 91.7%, overall survival 93.8% and cancer-specific survival 96.1% in previous studies.[59] This is comparable with the findings in this review, with overall and disease-free survival of 96.8% (93.3–100%) and 92.6% (84.6–100%) at 49.8 months and 39.0 months, respectively. However, it is important to highlight that the limited studies reporting these data were mostly in the context of latissimus dorsi reconstruction.

Aesthetic outcome

Breast appearance after surgery can have a significant psychological impact on patients. Despite this, there is no consensus on how best to evaluate breast cosmesis. There are multiple factors that have the potential to affect cosmesis. These include tumour location, adjuvant therapy and patient factors; however, volume of tissue excised compared with breast volume is the single most important factor influencing cosmetic outcome.

Estimated percentage of breast volume excised has been shown to have a significant effect on patient satisfaction. By estimating volume through mammograms, subjective cosmetic assessment tools can be used to measure patient satisfaction. In relation to breast conserving surgery, studies have demonstrated less than 10% estimated percentage of breast volume excised correlates with a majority of patients being satisfied (83.5%), as compared with over 10% where volume is significantly reduced (37%).[60] In terms of location in the setting of conventional breast conserving surgery, Pukancsik *et al* demonstrated maximum breast volumes that were resectable without resulting in unacceptable aesthetic and functional outcomes or decreased quality of life. Percentage volumes were 18–19% in the upper outer quadrant ($p < 0.0001$), 14–15% in the lower outer quadrant ($p < 0.0001$), 8–9% in the upper inner quadrant ($p < 0.0001$) and 9–10% in the lower inner quadrant ($p < 0.0001$).[61]

In the setting of OBCS, patient satisfaction remains high with volume excision of less than 20%.[62] Once 20% of breast volume or more is excised, there is a significant risk of deformity. However, tumours located in the upper inner quadrant and lower pole have been found more commonly to lead to breast deformity, even when the volume excised is less than 20%.[63]

Current methods for evaluating cosmetic outcome vary widely from clinical assessment to photographic and geometric tools. Scoring methods most commonly involve subjective evaluation through patient self-evaluation and panel evaluation.[64] Studies have demonstrated that results between panel evaluation and observers, regardless of breast surgery experience, have similar results, indicating that a reliable cosmetic outcome score can be achieved. Objective evaluation is becoming increasingly widespread due to the increased efficiency this offers. This can be carried out through breast cancer conservation treatment – cosmetic results (BCCT.core) software. Studies have demonstrated BCCT.core software can provide valid cosmetic outcome scores when compared with panel evaluation. Not only does this allow for rapid and accurate assessment, it can also facilitate comparison among units.[51] A patient-centred cosmetic scoring method that is reliable and reproducible still requires development to aid decision making.

Patient-reported outcome measures

There is no standardised PROM currently used routinely in the setting of OBCS, although several tools are in existence. The BREAST-Q is a validated questionnaire-based tool using a Likert scale, which assesses physical, psychological and sexual wellbeing, cosmetic appearance and overall satisfaction.

Chand *et al* used the BREAST-Q questionnaire to assess breast appearance, physical, emotional and sexual wellbeing in patients who underwent either therapeutic mammoplasty or mini-latissimus dorsi flap with those who underwent mastectomy and immediate autologous reconstruction. Overall satisfaction was high in both groups, with 82% reporting 'excellent/very good' (mammoplasty 88%; mini-latissimus dorsi 78%), with therapeutic mammoplasty patients being significantly more satisfied with breast shape ($p < 0.05$), size ($p < 0.05$) and natural feel ($p < 0.01$) as compared with the mini-latissimus dorsi group, although they demonstrated similar scores for physical and emotional wellbeing; 89% felt that OBCS was better than mastectomy. Mean outcome scores for breast appearance, physical and emotional wellbeing persisted beyond 15 years.[15]

Kelsall *et al* used the validated Hopwood body image scale scores of psychosocial function and PROMs for breast appearance and return to function analysis comparing case-matched OBCS with mastectomy and immediate reconstruction. They found that overall body image scale score ($p = 0.002$), self-rated breast appearance, return to work and function (all $p < 0.001$) significantly favoured OBCS. This difference was most marked in women with larger breasts.[65]

Limitations

There are several difficulties interpreting the literature on volume replacement OBCS. Several papers were excluded purely on difficulty in separating volume displacement from replacement. The majority of publications that are

included are small, single-centre observational studies with heterogeneous patient groups and short-term follow-up. The data gathered are hugely variable and tend towards focusing on oncological outcomes, cosmetic outcomes or complications. Few studies cover all these parameters.

There are a few studies included that were conducted prior to the standardised treatment of radiotherapy following breast conserving surgery or OBCS and, as such, some patients may have had this preoperatively or omitted all together, influencing rates of local recurrence and skewing data as a result.

There is variability in what is considered a positive margin, depending on when and where the study was conducted. Eastern papers have a tendency to manage involvement of less than 10mm with radiotherapy (rather than re-excision less than 1mm) and greater than 20mm margin without.

There is paucity of data on recurrence and survival, with most of the limited data available concerning latissimus dorsi reconstruction.

In terms of function and cosmesis, there are no standardised PROMs in the setting of OBCS. There is also no standardised panel assessment. With this type of assessment comes observer expectancy bias.

Conclusion

This systematic review demonstrates that volume replacement surgery is safe compared with breast conserving surgery and mastectomy. It also demonstrates that cosmetic outcomes are generally favourable, with improved outcomes when compared with breast conserving surgery and mastectomy. However, there currently remains a lack of high-level evidence supporting the oncological safety of volume replacement OBCS.[66] The interpretation and strength of data within this review must be regarded with care due to limited numbers of studies on this subject, the large variation in patient numbers within papers and the heterogeneity of data reported. There is a need for prospective multicentre studies directly comparing standard wide local excision/lumpectomy with OBCS in the setting of volume replacement.

The type of volume replacement OBCS employed is based on a range of clinical, oncological and patient factors. As OBCS continues to become more popular, achieving a balance between oncological and breast form must be sought.

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