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Functional recovery after bilateral extended autologous latissimus dorsi breast reconstruction: A prospective observational study☆

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Summary *Background:* The impact of unilateral extended autologous latissimus dorsi (EALD) flap harvest and axillary surgery on shoulder function has been well described, but the impact of bilateral EALD flap harvest has not been clearly defined nor is it clear whether reconstructions should be synchronous or staged.
Methods: In this prospective observational study, patients undergoing bilateral EALD breast reconstruction (February 2003–December 2009) completed the disability, arm, shoulder and hand (DASH) questionnaire preoperatively and at five post-operative timepoints. Intensive shoulder physiotherapy was offered to those whose DASH score was >30 at 6 weeks or >20 at 12 weeks post-operatively.
Results: Sixty patients underwent bilateral EALD flap breast reconstruction (51 synchronous, 9 metachronous). Patients with pre-existing shoulder pathology ($n=1$) and those who failed to return any post-operative DASH questionnaire ($n=10$) were excluded from initial DASH analysis. However, these eleven patients were included in a separate analysis as an intention-to-treat analysis. Statistical analysis was performed using non-parametric, Friedman test and multiple comparison model. Forty-nine patients' DASH scores were analysed. DASH score initially increased after surgery and then returned to functionally normal within 3-6 months

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(median DASH: preoperative = 1 vs 6 weeks post-operation = 26, $p = <0.001$; vs 3 months = 19, $p = <0.001$; vs 6 months = 13, $p = <0.001$); thereafter, the scores remained less than 12 ($p = <0.001$). Median DASH score after synchronous reconstruction was not higher than that after metachronous reconstructions, although the metachronous sample size was small.

Conclusion: With appropriate patient selection and intensive physiotherapy, bilateral EALD breast reconstruction does not appear to cause significant long-term impairment of shoulder function, and patients can now be counselled about the likely timecourse of shoulder recovery. There seems no reason to stage bilateral reconstruction to reduce shoulder morbidity.

Introduction

The latissimus dorsi flap is a reliable, versatile and frequently used method in reconstructive breast surgery.[1-3] In 1998, Delay demonstrated that the extended latissimus dorsi flap is able to offer adequate volume for breast reconstruction and minimise the need for an additional prosthesis.[2,4] Accordingly, the extended autologous latissimus dorsi (EALD) flap accounted for 49% of all breast reconstructions in the Canniesburn Plastic Surgery Unit (2010-2011). The impact on upper limb function after unilateral reconstruction was previously studied in detail using the Disabilities, Arm, Shoulder and Hand (DASH) questionnaire – the timecourse of recovery and long-term functional outcomes were favourable, with no deleterious effect of donor site quilting found.[3]

Approximately 10% of all EALD breast reconstructions in the Canniesburn Plastic Surgery Unit are bilateral, and the frequency is increasing because of a proactive risk stratification and prophylactic mastectomy.[5,6] Reconstructions are performed either in one procedure (synchronous) for bilateral disease or at different timepoints (metachronous) for metachronous contralateral disease or risk reduction. The impact on shoulder and upper limb function of these bilateral EALD procedures is not known. This study therefore established the timecourse of functional recovery in such patients, using the DASH questionnaire.

Patients and methods

This was a prospective observational study with blinded data interpretation by an independent statistician. All patients undergoing bilateral EALD flap breast reconstruction within Canniesburn Plastic Surgery Unit between February 2003 and December 2009 were recruited ($n = 60$, 51 synchronous and 9 metachronous), and their clinical and demographic data were analysed (Table 1).

Patients were appropriately counselled and had selected their reconstructive technique before recruitment. This study did not have an impact on patient care.

Operative technique

Cases comprised a mixture of immediate (mainly skin-sparing mastectomy) and delayed reconstructions. Some cases involved delayed reconstruction of one breast and immediate reconstruction of the other. A previously described surgical technique[3] was used, similar to that described by Delay.[2,4] Fat was not harvested from the lower lumbar area because previous audit had demonstrated excessive fat necrosis (unpublished data).

Bilateral synchronous EALD breast reconstructions undertaken by a single operator were performed one side at a time, with insetting finalized bilaterally after being returned to the supine position. When dual operators were present, both breast pockets were created with the patient supine, before turning prone to raise both flaps and pass them into the breast pockets. The patient was turned supine for final in setting. Metachronous reconstructions were performed as previously described for unilateral reconstructions.[3]

Table 1 Demographic and cancer management summary data.

	BEBR cohort
N	60
Age	47 years (range 25-69)
BMI	26 (range 20-37)
Smoker	16 of 60
Chest circumference (median)	36 (range 32-42)
Cup size (median)	C (range A-E)
Preoperative DASH (median)	1; Interquartile range 7
Immediate vs Delayed reconstruction	45 vs 15*
Axillary dissection	41 of 60
Axillary radiotherapy	34 of 60
	19 prior to reconstruction
	14 subsequent
	1 pre and post reconstruction
Cytotoxic chemotherapy	44 of 60
	20 prior to reconstruction
	20 subsequent
	1 synchronous
	3 pre and post reconstruction

* Of 15 metachronous reconstructions, 6 unilateral mastectomy cases underwent delayed ipsilateral reconstruction plus delayed contralateral mastectomy and immediate reconstruction; 9 bilateral mastectomy cases underwent a unilateral delayed reconstruction followed by another unilateral reconstruction. BEBR – Bilateral EALD Breast Reconstruction.

Table 2 Descriptive analysis of Disabilities of the Arm, Shoulder and Hand (DASH) scores in the whole cohort of Bilateral Extended Breast Reconstruction (BEBR) with actual return and intention-to-treat analysis. The actual return was variable at different timepoints. In intention to treat analysis, missing data were replaced by carrying forward previous scores. The final median score in both analyses was <14 (Friedman test, $p < 0.00001$).

Timepoint	Group	N at timepoint	Median	Range	Interquartile range
Pre-op	AR	60	1	0-77	0-7
	ITT	60	1	0-77	0-7
6 weeks	AR	49	26	3-82	3-44
	ITT	60	25	0-82	19-39
3 months	AR	45	19	1-57	1-38
	ITT	60	20	0-82	9-33
6 months	AR	22	13	0-49	0-21
	ITT	60	13	0-82	0-21
12 months	AR	47	12	0-53	0-20
	ITT	60	13	0-82	7-22
12-36 months*	AR	48	10	0-48	6-16
	ITT	60	10	0-82	6-21

* Final timepoint; AR - actual return; ITT - intention to treat; N - Number.

In all reconstructions, donor site closure was performed over vacuum suction drains (Exudrain™, Astratec, Sweden) using deep (3/0 Vicryl™, Ethicon, U.K.) followed by subcuticular absorbable sutures (Vicryl™/Monocryl™, Ethicon, U.K.). The practice of donor site quilting (2/0 polydioxanone, PDSII™, Ethicon, U.K.) depended on surgeon's preference (28/60 of all cases; 22/49 of cases followed with DASH questionnaire).

Post-operative care

An active shoulder exercise programme was initiated on the first post-operative day.[3] Before discharge (after drain removal when <50 ml/24 h, or post-operative days 7-10), patients were instructed on a home exercise programme and given a written handout to follow. They were advised to continue the illustrated exercises until post-operative day 14, then to gradually increase range of movement. Physiotherapy follow-up was not routinely provided. Patients who showed slow recovery at 6 weeks (DASH score >30) and 3 months (DASH score >20) were contacted and offered intensive outpatient physiotherapy. All patients attended nurse-led dressing and breast care clinics as appropriate, in addition to surgical reviews.

Primary outcome measure - DASH

Patients were invited to complete the DASH questionnaire preoperatively (on admission before surgery) and at the following five post-operative timepoints: 6 weeks; 3, 6 and 12 months and at a subsequent final timepoint (12-36 months). Response rates were variable at different timepoints (Table 2) and lowest at the 6 month timepoint (22 of 60 patients).

Secondary outcome measures

In keeping with a previous work,[3] relevant demographic data (age, chest circumference and cup size), comorbidities, surgical treatment (timing of mastectomy and axillary dissection relative to reconstruction, adjuvant chemotherapy, radiotherapy or hormonal management), presence of pre-existing shoulder conditions, intraoperative details (operative time, division of latissimus dorsi tendon or thoracodorsal nerve) and length of hospital stay were prospectively recorded. Post-operative complications including wound dehiscence, formation of persistent donor site seroma (defined as serous collection requiring more than two aspirations) or those indicating re-operation were also recorded.

Statistical analysis

DASH scores were analysed from returned questionnaires at preoperative and five post-operative timepoints. Clinical data were extracted from prospective records by a blinded assessor. Statistical analysis of the anonymised dataset was undertaken by an external, blinded, senior statistician. Blinded assessors were used to reduce bias. DASH scores were tested for normality using the Shapiro-Wilk test. The scores were compared over time using a Friedman test on the intention-to-treat dataset, where missing data were replaced by carrying forward previous scores. Group comparisons at 3 months were done using Mann-Whitney tests. All analyses were done using MedCalc (www.Medcalc.be) at a 5% significance level.

Results

Description of cohort

Demographic and oncological data are summarised in Table 1. Patients were aged 25-69 years old (median 47 years). Forty-two patients had undergone axillary dissection, 34 had adjuvant radiotherapy and 44 received cytotoxic chemotherapy.

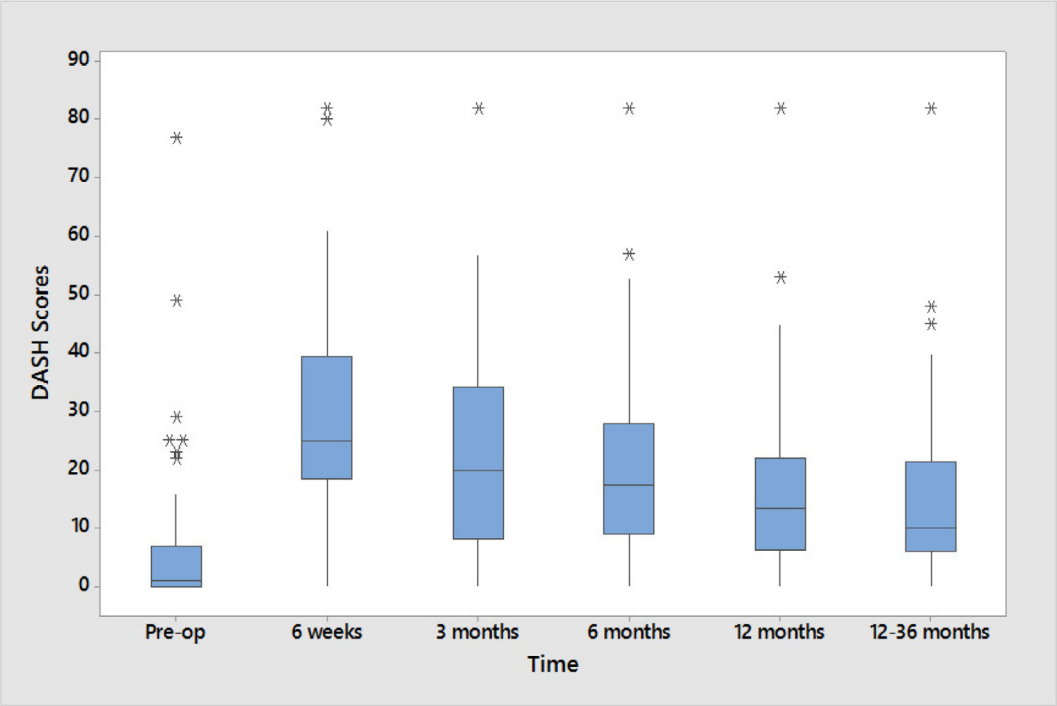

Figure 1 The boxplot and whisker plot show the distribution of DASH scores of the whole bilateral EALD breast reconstruction (BEBR) cohort over time, i.e. preoperative and 5 post-operative timepoints (Final timepoint – 12–36 months). The box denotes median (central bar of the box), interquartile range (upper and lower ends of the box), and range (minimum and maximum; vertical lines extending from the box – *whiskers*); * shows outliers in the dataset. The median DASH scores were significantly elevated at 6 weeks and 3 months post-operatively $p < 0.01$, but final scores remained less than 14 (functionally normal, i.e. ability to complete occupational tasks).

Bilateral metachronous extended breast reconstructions (BMEBR, $N = 9$) were performed at a median of 18 months apart. Bilateral synchronous extended breast reconstructions (BSEBR, $N = 51$) were performed for immediate reconstruction of bilateral mastectomy ($N = 37$), for delayed reconstruction after previous bilateral mastectomy ($N = 9$) or for synchronous reconstruction after previous unilateral mastectomy (delayed side) and subsequent contralateral mastectomy (immediate side) ($N = 5$).

All patients returned the preoperative DASH questionnaire, and returns at later timepoints were variable: 49/60 at 6 weeks (82%), 45/60 at 3 months (75%), 22/60 at 6 months (36%), 47/60 at 12 months (78%) and 48/60 at the final timepoint (80%).

Eleven patients did not return any post-operative DASH questionnaire, therefore, these patients were included in the intention-to-treat basis cohort ($N = 60$). The missing data of the cohort ($N = 11$) were replaced by carrying forward previous scores.

Surgical outcome data

Median operative duration for bilateral EALD breast reconstruction was 7 h (range 4–11 h), and inpatient stay was 8 days (range 4–10 days). Three patients (5%) required early reoperation for breast wound dehiscence ($N = 2$ treated by split-thickness skin grafting, $N = 1$ by direct closure), and two donor site infections were managed conservatively. Seven patients developed persistent donor site seroma (sufficient to indicate aspiration – 6 had no quilting and one quilting primarily), six were managed with aspiration and one required excision of seroma cavity and quilting of skin flaps. Nine received lipofilling to enhance breast contour ($N = 8$) or for fat necrosis ($N = 1$).

No flaps were lost, and no venous congestion was noted. No patient developed thromboembolic disease, fluid overload, significant basal atelectasis or respiratory infection/distress, ileus or delayed gut function or necrotising infection.

Timecourse of change in DASH score after bilateral EALD breast reconstruction

DASH score after all bilateral EALD breast reconstruction in patients at all timepoints is illustrated in Figure 1 and Table 2 (includes DASH return of actual return and intention-to-treat analysis dataset).

Statistical analysis was restricted to the datasets obtained from patients who returned post-operative DASH questionnaires ($N = 49$); median DASH scores at 6 weeks and 3 months after surgery were significantly elevated from the preoperative score (minimal clinically significant change = 12.7 points; median increase from preoperative DASH after 6 weeks = 25, after 3 months = 18; both $p = <0.001$). The scores then improved (median DASH score, 6 months = 13, $p = <0.001$; 12 months = 12, $p = <0.001$ and final timepoint = 10, $p = <0.001$). Final

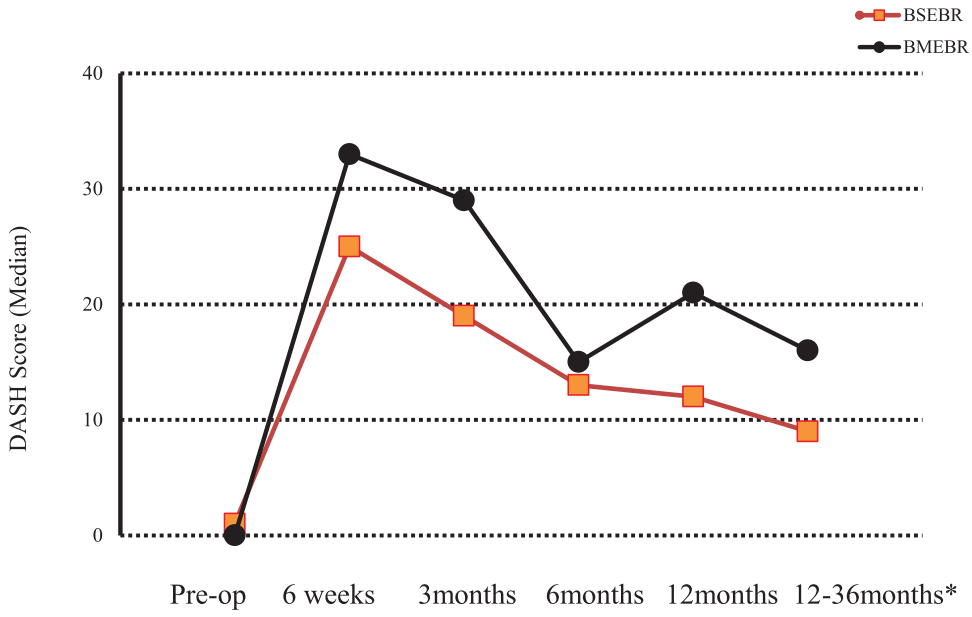

Figure 2 Timecourse of change in DASH score after Bilateral Synchronous EALD Breast Reconstruction (BSEBR) vs Bilateral Metachronous EALD Breast Reconstruction (BMEBR). The median scores were significantly higher at 6 weeks and 3 months but then it returned to "functionally normal" (ability to undertake daily activities). Bilateral metachronous group's scores were higher at all time-points in comparison to synchronous group, however the difference was not clinically and statistically significant. * Final timepoint.

functional outcome was 'functionally normal', as the median DASH score remained <14[26] (Table 2).

Intention-to-treat analysis (including the eleven patients who returned a preoperative DASH questionnaire but no post-operative questionnaire) yielded a similar pattern of results - scores were statistically significantly elevated at only 6 weeks and 3 months after surgery (median DASH score preoperative = 1; 6 weeks = 25, 3 months = 20, both $p = <0.0001$). The final outcome after 6 months remained 'functionally normal' <14 (Table 2).

DASH scores at 6 weeks and 3 months after EALD flap breast reconstruction correlate with long-term outcome

Twenty of 49 patients (40%) returning scores at 6 weeks had DASH score >30, and 17 of 45 (37%) who returned scores at 3 months had DASH score >20. This group was identified as at risk of developing poor outcome and hence offered additional physiotherapy.

Synchronous vs metachronous bilateral EALD reconstruction

Comparison of the DASH scores obtained from patients who underwent synchronous bilateral EALD breast reconstruction against those from patients who underwent metachronous bilateral EALD breast reconstruction (Figure 2) revealed that scores were higher in the metachronous group than in the synchronous group in all timepoint studies. This difference was not clinically (i.e. >12.7 points difference) or statistically significant at the 5% level (most likely due to a small sample size in the metachronous group). This observation remained similar within the intention-to-treat analysis. Recovery from synchronous bilateral EALD breast reconstruction is no worse than that occurring after each episode of metachronous reconstruction, and there is a trend towards better functional recovery after synchronous bilateral breast reconstruction.

Discussion

Breast cancer occurs bilaterally in 2-12% of women.[7,8] The published risk of synchronous contralateral breast cancer varies from 1% to 3% and that of metachronous contralateral disease is 1-12% of patients. The risk of developing any contralateral breast cancer is 1-5% per annum.[9-13] Furthermore, the increased availability of genetic and other breast cancer risk assessment tools has made risk-reducing interventions (including prophylactic mastectomy[14]) more common, also increasing the need for bilateral breast reconstruction.

Options for breast reconstruction after mastectomy include implant-based techniques, and those solely employing autologous tissue. Implant-based reconstruction is an attractive, easy, and convenient option, but the results may worsen with time, especially after radiotherapy.[15] In contrast, autologous reconstructions place greater demand on the patient in the short term but give more natural consistency with the native breast[16] and a reduced need for subsequent revision. Paolini et al.[17] presented a lower complication and reoperation rate than those published after bilateral implant with latissimus dorsi flap reconstruction (50%).

The most commonly used techniques for autologous breast reconstruction are pedicled or free abdominal flaps and latissimus dorsi flaps that may be either extended or combined with prosthesis. The free abdominal flap in its various forms has become a routine and highly effective technique for breast reconstruction,[18,19] but it has certain disadvantages that potentially include longer anaesthesia, protracted postoperative convalescence, abdominal pain, respiratory splinting, possible reduction of abdominal wall strength[20] and partial flap failure.[21] Complete flap loss occurs in a small percentage of every large reported series. Potentially life-threatening complications (e.g. pulmonary embolism[21] and abdominal necrotising fasciitis[22]) are rare but reported with greater frequency than for other reconstructive techniques.

Additionally, other patient factors such as diabetes mellitus, tobacco smoking, chest wall radiotherapy, abdominal scars and obesity can affect outcome.[23,24] However, the autologous latissimus dorsi is able to offer satisfactory outcomes even for these high-risk patients, and the extended flap can provide sufficient volume for implant-free breast reconstruction.[2,3,23,24]

Published literature suggests that, on balance, there is no significant long-term impact on shoulder function due to latissimus dorsi transfer, when assessed by a range of outcome measures,[3,25,26] although all studies document temporary shoulder dysfunction and infrequent patients with more noticeable long-term deficits.[2,27] The physical assessment methods used could be challenging,[28,29] but more robust studies have suggested the presence of some loss of power and endurance.[30] Pedicled transfer was also associated with mildly reduced function in certain activities (e.g. ladder climbing, painting above shoulder level and pushing up from a chair), although free flap transfer was not done. Spear and Hess[31] concluded that patients may experience deficits in adduction and extension during overhead or prolonged function but no decrease in the range of shoulder motion. The relative impact of latissimus dorsi transfer, as opposed to mastectomy or axillary treatment in breast reconstruction has not been clearly defined, and the majority of patients do not describe any significant impact on daily function.[3,27]

The DASH questionnaire for shoulder function assessment has been recognized as a simple, reliable and an acceptable functional assessment tool.[3,32] Using a 30 item self-administered questionnaire, it measures the patient-reported global functional deficit rather than focusing only on isolated movements. The score is calculated using the DASH formula, where a score of 0 correlates to no functional deficit and 100 correlates to maximum functional impairment. Evidence suggests that a DASH score of 20–30 indicates a level of function enabling to work, whereas that of 50–60 indicates inability to work and impairment of activities of daily living. To differentiate a true change in clinical status from potential measurement error requires a minimum change of 12.7 points (MDC95).[3,32]

After unilateral EALD breast reconstruction, Button et al.[3] demonstrated a statistically and clinically significantly increase in the DASH score at the initial post-operative review and up to 3 months after surgery. Shoulder function then returned to normal and remained so 3 years after surgery. This study demonstrates the same pattern of recovery, and lack of long-term deficit, after bilateral EALD breast reconstruction. Recovery from synchronous bilateral reconstruction was no worse than that after unilateral reconstruction or after each episode of bilateral staged reconstruction.

Koh and Morrison[33] reported a retrospective assessment of bilateral non-extended ALD reconstructions, applying the DASH questionnaire at one post-operative timepoint by telephone, in contrast to the established DASH methodology. Only four bilateral cases were reported, with no comment as to whether reconstructions were synchronous or metachronous. One case had a DASH score of 31. Although it was concluded that bilateral LD flap harvest can cause significant deficits in sporting ability and warned against use, there are apparent methodological weaknesses to the study, including lack of preoperative screening for shoulder dysfunction. Paolini et al.[17] reported one-off DASH score >12 months after delayed metachronous implant with latissimus dorsi flap reconstruction and showed infrequent functional deficit to relate to revisionary surgery due to complications. The results of this study show that the overwhelming majority of patients do not develop significant shoulder dysfunction and that the complication profile and recovery time are favourable in comparison to that of bilateral DIEAP flap reconstruction.

Yang et al.[34] conducted a prospective study of physical and functional disability and quality of life after immediate latissimus dorsi flap reconstruction by the manual muscle test, range of motion and DASH. The DASH analysis was performed at preoperative and three post-operative time-points (3 months, 6 months and 12 months). The authors reported significant increase in the functional disability at 3 months (mean scores at 3 months, 18.0 $+/-$ 8.89, $p < 0.001$) and reduced but persistently elevated at 12 months (mean scores at 12 months 13.8 $+/-$ 4.25, $p < 0.001$). The authors concluded that shoulder strength and range of motion returned to baseline but functional disability persisted at one year after reconstruction. They also reported confounding factor of a high dropout rate of their cohort (91 recruited and 31 analysed) and the small sample size and suggested a long-term follow-up required.

Use of the EALD flap also seems more pertinent than the DIEAP for the unilateral autologous reconstruction case, in whom risk stratification indicates an increased possibility of subsequent contralateral mastectomy. In these patients, the same reconstruction could then be used for the metachronously for the contralateral breast, if required, optimizing reconstructive symmetry.

We believe women should be appropriately counselled regarding options for breast reconstruction and that the selection of the technique should be individualised. Women should be screened to detect those with high sporting/occupational shoulder function requirements, or pre-existing shoulder pathology and should complete a DASH questionnaire to further detect those at risk of shoulder dysfunction from EALD breast reconstruction. These groups should carefully consider whether the EALD flap is the correct reconstruction for them. However, the majority of women can be advised that they will develop mild-to-moderate shoulder symptoms for approximately 6–12 weeks and then return to essentially normal function. There is no objective reason to avoid the use of the EALD

flap for bilateral reconstructions, and synchronous reconstruction offers the patient the least downtime. As for unilateral reconstruction, it seems pertinent to screen for a high DASH score at 6 weeks after surgery and target those patients with more intensive physiotherapy with the aim of improving long-term function.

Future studies should delineate the impact of EALD flap use in patients with challenging shoulder functional requirements (e.g. high-level gymnasts, golfers and swimmers).

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Conflict of interest

None.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjps.2019.01.013.

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