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ORIGINAL ARTICLE

Progression of the Deep Inferior Epigastric Perforator Flap Breast Reconstruction Technique at a Dedicated New Zealand Tertiary Plastic Surgery Unit: a Case Series Analysis

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Abstract
The deep inferior epigastric perforator (DIEP) flap is the gold standard in post-mastectomy breast reconstruction. Improved patient outcomes, reduced operating time and reduced complication rates are reportedly observed over consecutive DIEP series within surgical centres. The aim of this study is to investigate whether outcomes following DIEP flap reconstruction improve over time, by assessing two patient cohorts undergoing the procedure at a microsurgical unit seven years apart. A case analysis was undertaken to identify all patients who underwent primary DIEP flap reconstruction in 2011 and 2018. Outcomes recorded included clinic appointments, operating time, number of primary operations, additional operations and procedures, along with co-morbidities, BMI and radiotherapy rates. Immediate versus delayed and unilateral versus bilateral breast reconstruction was also recorded. Seven patients underwent primary DIEP reconstruction in 2011 and 29 in 2018. There was a significant reduction in additional operations performed in 2018 (p-value = 0.007) and a significant reduction in number of procedures (p-value = 0.043). When adjusted for an outlier, the total operating time for unilateral DIEP reconstruction was significantly shorter in 2018 (p-value = 0.018), along with reduced primary and total operating time for 2018 bilateral reconstructions. The 2018 cohort also had lower complication rates and fewer clinic appointments. This study illustrates how outcomes can improve with experience of DIEP flap reconstruction. The more complex DIEP flap requires investment in terms of skill acquisition and operative time, but is balanced by improvement in patient outcomes.

Keywords Breast reconstruction · Deep inferior epigastric perforator · Perforator flap · Microsurgery · Breast surgery

Introduction

Following mastectomy, the goal of breast reconstruction is to improve quality of life without adversely affecting detection of cancer recurrence. Formation of an aesthetically pleasing breast mound without unpleasant complications is an integral component of recovery.

The DIEP (deep inferior epigastric perforator) flap has become an increasingly popular choice in breast reconstruction, mainly due to its potential to reduce damage to the abdominal musculature. The pedicled TRAM (transverse rectus abdominis myocutaneous) flap was the first abdominal based autologous flap used for breast reconstruction [1]. However, associated complications, such as necrosis secondary to venous compression and abdominal wall weakness, led to the evolution of free TRAM and subsequently the muscle sparing DIEP flap [2].

By preserving the rectus abdominis muscle and fascia, the DIEP flap offers the same benefits of adequate volume replacement as the free TRAM flap, but with improved functional outcome for the donor site [3], reduced post-operative pain and a quicker recovery [4], and as such is now considered the 'gold standard' in post-mastectomy breast reconstruction [5]. However, it has been suggested that the improved donor site functional outcome offered by DIEP reconstruction may come at the expense of flap reliability, given the reduction in perforating vessels used compared with its predecessor, the free TRAM [3, 4]. In addition, due to the increased complexity of the operative technique,

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which requires careful dissection of the perforators, operative duration is longer.

Success rates are likely to be affected by patient and surgeon factors. It has been suggested that many of the complications may be reduced or even negated with careful patient selection and surgeon training [6, 7]. Several documented patient factors may affect outcome, including smoking, radiotherapy, obesity, hypertension, age, number of venous anastomoses, flap size and number of perforators [7]. As DIEP flap reconstruction has gained popularity over the past two decades, refinement of the ideal approach to patient selection, preoperative perforator identification and perforator dissection techniques has also occurred [7]. Therefore, optimisation of patient and technical factors may result in reduced complication rates over time.

The aim of this study is to investigate DIEP flap reconstruction at a dedicated microsurgical unit by assessing the outcomes of two patient cohorts seven years apart, to determine whether increased proficiency corresponds with improved clinical and patient outcomes.

Patients and Methods

Approval was gained from the research office for this project. A prospective case analysis was undertaken and the STROBE [8] guidelines for cohort studies were adhered to. All patients who underwent primary DIEP flap breast reconstruction were identified from the departmental breast reconstruction database and the hospital's electronic patient information management system 'Concerto'. Clinic and theatre documentation were reviewed from initial referral to date of discharge. 2011 and 2018 were selected as the cohort years as this gave a realistic timeframe over which changes to practice could be expected to occur. Both cohorts were followed up until June 2021. This time frame was selected to provide enough time for patients to complete their reconstructive journey.

Data was extracted regarding patient demographics, co-morbidities, BMI, complications, additional operations, operating time and clinic appointments. Patient demographics included age at initial DIEP reconstruction and ethnicity. Significant co-morbidities were recorded and included hypertension, diabetes and COPD/asthma. BMI was recorded. All patients were required to be non-smokers at the time of operation.

Complications were classified as either major or minor. Major complications were defined as those requiring surgical intervention and included total flap loss, anastomosis failure, infected seroma requiring washout and donor or breast wound necrosis requiring debridement in theatre. Minor complications were defined as those which were managed with antibiotics and/or treatment in clinic, e.g. fat necrosis, infection, seroma, cellulitis and minor wound dehiscence.

Additional operations were defined as any surgical episode following the primary DIEP procedure. These included balancing procedures, liposuction/lipofilling, scar revisions and procedures for any major complications (see Table 1). The number of procedures performed in each operation was also recorded. Primary DIEP reconstruction operation time was recorded, along with total operating time for all additional operations undertaken for the 2011 and 2018 DIEP cohorts. Clinic appointments were counted from the first pre-operative appointment including pre-admission, nurse and registrar led appointments.

Descriptive and analytical statistics were performed using SPSS software (IBM). Independent sample's *T*-test and Fisher's exact tests were used as indicated to compare significant differences between the 2011 and 2018 DIEP flap groups. A p-value of <0.05 was the accepted standard for statistical significance.

Table 1 Additional procedures for 2011 and 2018 cohorts

Procedure	DIEP 2011	DIEP 2018
Abdominal liposuction	2	1
Abdominal scar revision	4	8
Balancing	0	5
Bilateral breast reduction	1	0
Breast scar Z-plasty	0	1
Contralateral breast fat graft	0	1
Contralateral breast liposuction	0	1
Contralateral mastopexy	2	0
Contralateral reduction	2	1
Debridement DIEP breast eschar	0	1
Debridement necrotic breast skin flap	0	2
Deflation of expander and capsulotomy	0	1
DIEP breast anastomosis revision	1	3
DIEP breast fat graft	6	6
DIEP breast implant	0	1
DIEP breast liposuction	2	2
DIEP breast reduction	0	1
DIEP breast scar revision	1	3
DIEP breast washout	0	5
DIEP mastopexy	1	1
DIEP removal (failure)	1	0
Split thickness skin graft to DIEP breast	0	1
Grand total	23	45

Results

Seven women underwent 9 DIEPs in 2011 and 29 women underwent 38 DIEPs in 2018 at Middlemore Hospital. All patients in 2011 and 2018 underwent CT angiography pre-operatively to guide perforator selection.

Demographics

The average age was 49 in the 2011 DIEP cohort and 48 in the 2018 DIEP cohort. There was no significant difference in age between the two groups (p-value = 0.801). In both groups the majority were of New Zealand European origin (2011, $n = 4$; 2018, $n = 19$). One patient was of Maori descent in the 2011 group (14%) and two patients in 2018 (7%). The average BMI was 31 in the 2011 cohort and 29 in 2018. There was no significant difference in BMI between the two groups (p-value = 0.441). Three patients in the 2011 group had at least one co-morbidity compared with 14 patients in 2018. There was no significant difference in co-morbidities between the two groups (p-value = 0.804). Two patients in the 2011 DIEP group had pre-operative radiotherapy and two had post-operative radiotherapy. Five patients in the 2018 group had pre-operative radiotherapy and seven had post-operative radiotherapy. The difference in rates of radiotherapy between the groups was not statistically significant (p-value = 0.451)

Primary Reconstruction Episode

Just over four times as many DIEP flap reconstructions were performed in 2018 compared with 2011 ($n = 9$, 2011; $n = 38$, 2018). In 2011, delayed reconstruction was most common ($n = 5$), whereas in 2018, immediate reconstruction was favoured ($n = 32$). Five patients in 2011 received a unilateral primary DIEP reconstruction and two patients received bilateral. In 2018, 20 patients received a unilateral primary DIEP reconstruction and nine patients received bilateral.

Additional Operations

After their initial operation, six patients in the 2011 cohort and 18 in the 2018 cohort underwent at least one further surgical procedure. On average, the 2011 cohort underwent 2.1 additional operations per patient and the 2018 cohort underwent 1.2 additional operations per patient. The difference in number of additional operations between the two groups was statistically significant (p-value =0.007). See Fig. 1.

In 2011, 23 additional procedures were performed in 15 operations (3.3 procedures per patient). In 2018, 45 additional procedures were performed in 35 operations (1.5 procedures per patient). The difference in number of procedures performed between the two groups was statistically significant (p-value = 0.043). A summary of the additional procedures undertaken in the two cohorts is shown in Table 1.

Complications

Complications are summarised in Table 2

In the 2011 cohort, there were three major complications (33.3%), compared with six in the 2018 cohort (15.8%), giving a 17.5% reduction in major complications. Four minor complications were seen in 2011 (44.4%) compared with nine in 2018 (23.6%), giving a 20.8% reduction in minor complications. The reduction in major and minor complication rates seen in 2018 compared with 2011 was not statistically significant (minor p-value = 0.212, major p-value = 0.241).

Across the combined cohort, total flap loss was seen in only one DIEP reconstruction (in the 2011 group) giving an overall success rate of 98% across the two groups. Anastomosis failure was seen in one DIEP reconstruction in the 2011 group (11.0%) and two in the 2018 group (5.3%). Fat necrosis was seen in one DIEP reconstruction in the 2011 group (11.0%) and three in the 2018 group (7.9%).

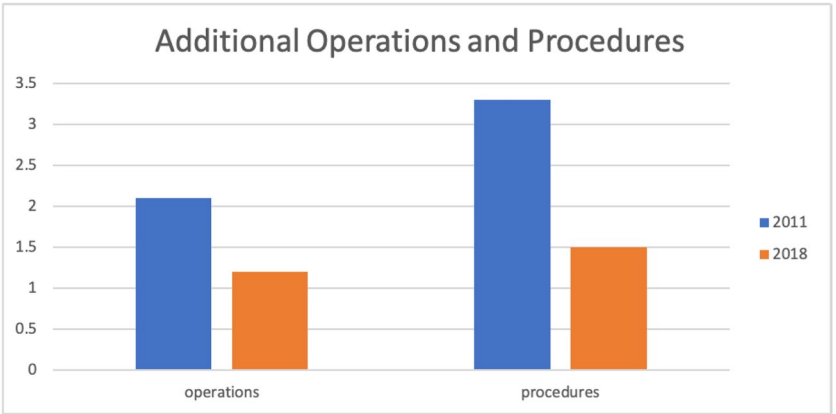

Fig. 1 Average operations and procedures for 2011 and 2018 cohorts

Table 2 Summary of complications

	DIEP 2011	DIEP 2018
Total DIEP flap reconstructions	$n = 9$	$n = 38$
Mean age (years)	49	48
Unilateral flap reconstruction	5	20
Bilateral flap reconstruction	2	9
Obesity (BMI ≥30)	5	10
Pre-op radiotherapy	2	5
Post-op radiotherapy	2	7
Major complications		
Total flap loss	1 (11%)	0 (0.0%)
Anastomosis failure	1 (11%)	2 (5.3%)
Abdominal wound necrosis requiring debridement	1 (11%)	0 (0.0%)
Breast skin necrosis requiring debridement	0 (0.0%)	2 (5.3%)
Nipple necrosis requiring debridement	0 (0.0%)	1 (2.6%)
Infected breast seroma requiring washout	0 (0.0%)	1 (2.6%)
Minor complications		
Fat necrosis	1 (11%)	3 (7.9%)
Abdominal wound infection requiring antibiotics	1 (11%)	2 (5.3%)
Breast skin infection requiring antibiotics	1 (11%)	0 (0.0%)
Breast seroma requiring drainage / antibiotics	0 (0.0%)	3 (7.9%)
Abdominal seroma requiring drainage / antibiotics	0 (0.0%)	1 (2.6%)
Donor site dehiscence	1 (11%)	0 (0.0%)

Clinic Appointments

In the 2011 cohort, there was a total of 98 clinic appointments attended, giving an average of 14 clinics per patient. In 2018, there was a total of 234 clinic appointments attended, giving an average of eight clinics per patient. There was on average a reduction of six clinic appointments per patient in 2018; however, this difference was not statistically significant (p-value = 0.093).

Operation Time

Average operating time for primary unilateral DIEP reconstruction was 511 min in 2011 and 499 min in 2018 (12-min reduction, p-value = 0.838). Average operating time for primary bilateral DIEP reconstruction was 952 min in 2011 and 737 min in 2018 (215-min reduction, p-value = 0.344). Average total operating time (inclusive of all surgical episodes) was 870 min in 2011 and 686 min in 2018, giving an average reduction in operating time of 184 min in the 2018 cohort (p-value = 0.104). See Fig. 2.

Average total operating time for unilateral DIEP reconstruction was 837 min in 2011 and 617 min in 2018 (220-min reduction, p-value = 0.148). Average total operating time for bilateral DIEP reconstruction was 953 min in 2011 and 827 min in 2018 (126-min reduction, p-value = 0.232)

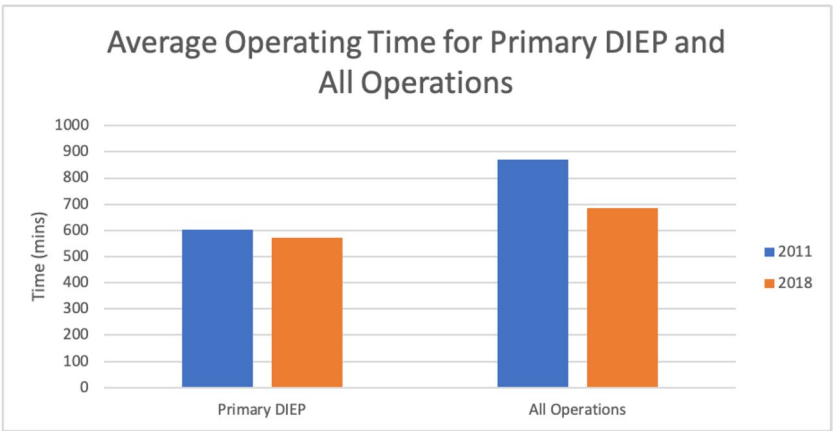

Fig. 2 Average operating time for primary DIEP and all subsequent operations

One of the patients who underwent a unilateral DIEP reconstruction in the 2018 group had an unusually high total operating time of 1664 min, which greatly deviated from the mean of 686 min. On further investigation, this patient underwent two operations of unusually long duration (13 h and 10 h) to manage venous congestion due to the patient having a rare venous drainage system. If this case is treated as an outlier and removed from statistical analysis, the total operating time was on average 275 min shorter in the 2018 unilateral DIEP reconstruction group, and this difference is statistically significant (p-value = 0.010).

In this study, one patient was of Maori descent in the 2011 cohort and two in the 2018 cohort. This represents 14% and 7% respectively of the subjects in this study. The patient of Maori descent in the 2011 cohort underwent 3 additional procedures (cohort average 3.3) and attended 11 clinic appointments (cohort average 14); they did not have any major or minor complications. The two patients of Maori descent in the 2018 cohort underwent an average of 2 additional procedures (cohort average 1.5) and attended an average of 6.5 clinics (cohort average 8). One of the patients had a minor complication.

Discussion

When investigating the rate of DIEP flap reconstructions at our unit in 2011 and 2018, we can see that it has grown in popularity over this 7-year period. In 2018 DIEP flap reconstructions were performed at a rate of over four times that of 2011. In addition, the most popular type of DIEP reconstruction transitioned from delayed in 2011, to immediate in 2018.

The increased popularity of DIEP flap reconstruction at our unit is supported by current trends in breast reconstruction [9–11], and the fact that the DIEP flap is now considered to be the gold standard [5]. The DIEP flap does however demand additional technical skill, in terms of judgement of perforator suitability and intramuscular perforator dissection [6]. This means that, despite being the accepted standard, fewer may be performed in some centres due to the perceived challenge compared with other types of breast reconstruction. For breast reconstruction surgeons, moving away from the free TRAM flap to the muscle sparing DIEP flap is likely to present a significant learning curve.

Studies have attempted to quantify the acute learning curve, reporting a pivotal number of procedures after which significant improvements are seen, reportedly ranging from 10 to 65 cases [6, 12, 13]. Studies investigating the DIEP flap learning curve have found reduced rates of flap loss and fat necrosis, along with reduced operating time, revision rates and postoperative hospital stay over consecutive series [6, 7, 12–14]. Overall levels of reported complications in DIEP flap reconstruction vary, with fat necrosis reported between 6.0 and 17.7% [3, 15–19], partial flap loss 2.5 to 8.7% [3, 15, 20], and total flap loss 0.5 to 5% [3, 4, 15–18, 20].

In this study, improved outcomes were seen in the 2018 group in terms of reduced complication rates, fewer additional operations and procedures along with shorter operating time and fewer clinic appointments. The reduction in number of additional operations and procedures performed for patients in the 2018 cohort compared with 2011 was statistically significant.

Complication rates in this study correlate with those reported in other studies, including the DIEP flap success rate of 97.2%, which is of a similar standard to reports in other studies. In addition, rates of fat necrosis are comparable to other studies [3, 16, 20]. Complication rates in this study are comparable to other studies with small numbers of patients, where morbidity requiring return to theatre was reported at 15%, total necrosis 5% and fat necrosis 10% [19].

Operating time for primary unilateral DIEP reconstruction in the literature is reportedly 289 to 462 min [5, 12, 21–23] which is comparable to the operating time found in this study at 499 min in 2018. At 737 min in 2018, primary bilateral DIEP reconstruction operating time in this study was longer than reported in the literature, which ranges from 438 to 570 min [22, 24, 25]. In this study, operating times for both unilateral and bilateral primary DIEP reconstructions were shorter in 2018 compared with 2011. When adjusted for an outlier in the 2018 unilateral reconstruction group, the reduction in operating time was statistically significant. Decreases in operating time seen in this study between 2011 and 2018 are not as great as reported in other studies looking at single surgeon consecutive case series, which have been reported to be as high as 54% [12].

In this study, the 2018 cohort underwent significantly fewer additional operations and procedures than the 2011 group, with a decrease of 0.9 operations and 1.8 procedures on average per patient. Other studies have reported comparable numbers of additional operations for DIEP flap reconstruction as seen in the 2018 cohort (1.2 per patient), at 1.06–1.4 per patient [26, 27].

The number of clinic appointments was also reduced in the 2018 cohort, with an average reduction of six clinic appointments per patient when compared with the 2011 group. On average, patients in the 2018 cohort had eight clinic appointments, which is comparable to findings from other studies [28].

As with all research conducted in New Zealand, it is important to consider the representation of indigenous populations and potential implications for health equality. The proportion of Maori patients in the 2011 and 2018 cohorts was 14% and 7% respectively. Maori populations made up 15.5% of the New Zealand population in 2011 and 17.5% in 2018 [29]. These findings suggest that Maori patients were under represented in this study. In addition, compared to

the rest of the patients, Maori patients attended fewer clinic appointments, but had similar numbers of additional procedures and complication rates. It is important to establish equity in access to breast reconstruction for all populations within New Zealand; however, it is difficult to draw conclusions here, due to the relatively small number of subjects in this study.

Although significant differences in patient outcomes were demonstrated between the two cohorts in this study, there are limitations which should be taken into account. A natural consequence of significantly more DIEPs performed in 2018 is that the sample sizes are asymmetrical, making comparisons between the groups subject to confounding variables. Whilst there was no significant difference in terms of age and BMI between the groups, technical factors relating to the DIEP operation itself were not investigated. This includes variables such as flap weight, mastectomy type, flap zone, perforator number, venous anastomoses, recipient vessels selection and reconstruction timing, which may have influenced flap outcome and potentially affected the comparison between the two groups. This is certainly an important consideration for future research in this area.

This study provides an insight into the progression of clinical and patient outcomes following the adoption of a new breast reconstruction technique at a single centre plastic surgery unit. The study demonstrates how proficiency with a new technique is reflected in improved patient outcomes and offers helpful insights into the clinical journey a patient undergoing DIEP flap reconstruction is likely to experience.

Declarations

Conflict of Interest The authors declare no competing interests.

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