**DIEP Free Flap Breast Reconstruction: Surgical Procedure Type and Donor Site Morbidity**

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**Abstract**

Background

The use of abdominal tissue in post-mastectomy autologous breast reconstruction is a popular choice among reconstructive surgeons. This is the first study to evaluate donor complications comparing unilateral, bilateral and bipedicled DIEP breast reconstructions.

Methods

A retrospective chart review was conducted of all women undergoing rib-preserving DIEP free flap breast reconstruction at a University Hospital between 2008 and 2015 by the senior surgeon (CMM).

Results

A total of 130 patients were included in this study and divided into three groups: unilateral unipedicled (n=93), bilateral (n=19) and unilateral bipedicled (n=18). Age, smoking history, radiotherapy and chemotherapy exposure were similar across the three groups and did not influence donor site complication risk. Relative to the unipedicled unilateral group, the age and BMI-adjusted odds of complication were almost two-fold higher in the bilateral group (Odds ratio (95% CI): 1.97 (0.63, 6.19)), and approximately halved in the bipedicled group (Odds ratio (95% CI): 0.59 (0.22, 1.61)); however, these associations were not statistically significant. 75% of the complications were managed conservatively without recourse to surgery or readmission to hospital.

Conclusions

DIEP flap breast reconstruction is still fraught with donor site morbidity although most complications are minor and can be managed conservatively. These results suggest bipedicled DIEPs, like bilateral breast reconstructions, can be performed safely without undue increase in donor site complications.

Keywords

Bipedicled; breast reconstruction; DIEP flap; donor site morbidity

**Introduction**

The use of abdominal tissue in post-mastectomy autologous breast reconstruction is a popular choice among reconstructive surgeons because it creates a natural appearance with superior aesthetic results while avoiding the use of implants and their associated problems. A national audit of breast reconstruction in the UK reported higher levels of emotional and sexual wellbeing following breast reconstruction compared to mastectomy alone1, and autologous reconstruction utilising abdominal tissue has increased in popularity for breast reconstruction with superior cosmetic outcomes, a durable and natural appearance, and fewer complications following radiotherapy compared to implant-only reconstruction. Autologous-based breast reconstruction can also be successfully used in the salvage of failed implant reconstruction. Breast reconstruction using abdominally-based free flaps is particularly valuable in obese patients, where a body mass index (BMI) >30 kg/m2 is associated with an increased failure rate in implant reconstruction2.

Donor site morbidity associated with abdominal based flaps includes defective abdominal wall integrity and weakness, fat necrosis and wound-related complications. As microsurgical techniques have improved and in an attempt to reduce donor site morbidity, there has been a trend in moving away from pedicled or free Transverse Rectus Abdominis Myocutaneous (TRAM) flaps towards techniques which preserve the underlying muscle, such as the muscle-sparing free TRAM flap (ms-TRAM), the Deep Inferior Epigastric Perforator (DIEP) flap, or Superficial Inferior Epigastric Artery (SIEA) flaps. This trend has been observed in our own unit over the last 20 years.

In terms of patient risk factors, high BMI and smoking are well-documented determinants of donor site morbidity in all types of abdominal flap breast reconstruction3,4. With regards to chemotherapy, increased abdominal complications have been described in obese women who had chemotherapy prior to reconstruction with a ms-TRAM or DIEP flap, but not in chemotherapy patients with a normal BMI5.

A recent systematic review has found that in TRAM flap reconstruction the type of surgical procedure impacts on donor site morbidity, with abdominal wall function significantly decreased in bilateral pedicled TRAM or free TRAM procedures6. Perforator-based flaps such as the DIEP and SIEA flap have been shown to reduce donor site morbidity to some degree with sparing of the underlying muscle6,7. The individual flaps in unilateral and bilateral DIEP reconstructions are usually based on one Deep Inferior Epigastric Artery (DIEA) source pedicle. However, in women undergoing unilateral breast reconstruction but with limited abdominal donor tissue, a second pedicle from the contralateral DIEA or SIEA may also be dissected to maximize the amount of tissue harvested and maintain a robust blood supply using a bipedicled approach (Figures 1-3). Although comparison of unilateral versus bilateral DIEP procedures has been described8, to our knowledge there are no studies comparing bipedicled free DIEP flap reconstruction with unilateral and bilateral flaps in this respect. We hypothesized that harvesting a greater proportion of abdominal tissue for reconstruction, as in bipedicled or bilateral flaps, would be associated with increased complication rates.

**Methods**

A retrospective chart review was conducted of all women who underwent rib-preserving breast reconstruction using a DIEP flap at a University Hospital between July 2008 to June 2015 by the senior surgeon (CMM). Operative technique was therefore standardized. Patients were excluded who: (i) did not have a DIEP reconstruction, including SIEA flaps (n=20), (ii) did not undergo a rib-preserving approach (n=1), and/or (iii) had missing medical or follow-up information (n=27). Data were collected on patient demographics, operative details and postoperative complications, with a specific focus on donor site morbidity.

Donor site complications during follow-up were primarily diagnosed based on clinical assessment in addition to microbiology or radiological results where appropriate. Local infection was identified from the presence of wound pain, erythema, or wound exudate. Fat necrosis was defined as a firm, palpable lump greater than 1cm that has developed after 6 weeks post procedure. Seromas were also diagnosed clinically. Abdominal bulge was defined as a laxity of the abdominal wall leading to a contour defect, without the palpable abdominal wall defect that distinguished the hernias. Complications were categorized into minor versus major complications according to the Clavien-Dindo classification9, with grades 1 and 2 considered as minor complications and grade 3 complications requiring surgical intervention as major complications.

*Statistical Analysis*

The distributions of baseline characteristics and complications were compared between procedure types using non-parametric Kruskal-Wallis tests for continuous variables and Chi-squared tests for categorical variables. Logistic regressions were used to evaluate the odds of complication by procedure type; models were adjusted for potential confounding by age and BMI. In order to allow variables to be compared informatively across any pair of procedure types and without depending on the precision within any arbitrarily selected baseline group, 95% confidence intervals (CI) were estimated from floated variances10. To further characterize the shape of association of complication risk with BMI, univariate odds ratios (OR) were calculated within quartiles of BMI and plotted against the mean BMI level per quartile.

**Results**

From the 177 participants undergoing rib-preserving abdominal free flap breast reconstruction between 2008 and 2015, 130 participants matched the inclusion criteria and were included in the study. Individuals with missing data did not differ in terms of baseline characteristics from individuals with complete data. Out of the 130 included participants, 93 underwent unilateral procedures with unipedicled flaps, 19 underwent bilateral procedures, and 18 underwent unilateral procedures with bipedicled flaps.

Smoking history, radiotherapy and chemotherapy exposure were similar across the three groups (Table 1). However, patients undergoing bilateral reconstructions were significantly younger than those in the other two groups (Median=46 years; *P*=0.042). As expected, BMI was significantly lower in the bipedicled group (Median=25.0 kg/m2; *P*=0.001). This was because these were thinner patients in whom harvest of the entire lower abdomen on two pedicles was required to provide adequate tissue volume for one breast.

In our study, all flap transfers were successful, but the donor site complications were the primary focus of our analysis. All complications, no matter how minor or major, were included. 82 patients (63.1% of the study sample) developed a total of 124 donor site complications. Exactly three-quarters of complications were managed conservatively without recourse to surgery or readmission to hospital.

Clavien-Dindo grade 1 and 2 complications were considered minor (75%) and grade 3 complications requiring surgical intervention were classed as major complications (25%) (Figure 4). Thus although seroma, wound breakdown and fat necrosis were the most common complications, they were mainly treated conservatively in outpatient care. For instance, only 3/63 (5%) seromas, 7/25 (28%) cases of wound breakdown and 5/14 (36%) patients with fat necrosis required surgical intervention. In contrast, the majority of hernias (5/6; 83%) and bulges (2/3; 67%) were managed in the operating room, and hence were associated with higher costs. Figure 5 shows that proportionally there was an increased prevalence of major complications in the unilateral unipedicled group (26/31 major complications) and no major complications in the bipedicled group.

Relative to the unipedicled unilateral group, the univariate odds of complication were approximately two-fold higher in the bilateral group (OR=2.16, 95% CI: 0.66, 1.52) and almost halved in the bipedicled group (OR=0.46, 95% CI: 0.18, 1.17); however these associations had wide confidence intervals and attenuated toward the null upon further adjustment for age and BMI (Table 2). Though there may be a potential reduction in number of complications in the bipedicled group and an increased level in the bilateral group, overall in this study there was no statistically significant difference in donor site morbidity between the three types of DIEP procedure.

The most frequently encountered complications of DIEP surgery were seroma, wound dehiscence, and fat necrosis (Table 3, Figure 6). Seromas were the commonest complication, recorded in 49% (n=63) of the study sample. The prevalence was modestly higher in the bilateral reconstruction group at 63% compared to 48% of the unilateral unipedicled group, and almost double compared to the bipedicled group (33%). Minor wound dehiscence occurred following 19% of all procedures and was least common in the bipedicled group, affecting only 1 participant in this group (5.6%) compared to 22.6% of unilateral unipedicled reconstructions and 15.8% in bilateral reconstructions. Fat necrosis affected 11% (n=14) who had unipedicled flaps (including unilateral and bilateral reconstructions), but there were no cases within the bipedicled flap group. The remaining complications such as hernia formation, lower abdominal bulge and infection were uncommon. The development of any complication, minor or major, in DIEP flap surgery was highest (79.0%) in the bilateral (unpedicled) reconstruction group compared to 63.4% in the unilateral unipedicled group, and lowest (44.4%) in the unilateral bipedicled reconstructions, but this did not reach statistical significance (P=0.09).

The odds of complication did not differ materially by individual characteristics with the exception of BMI (Table 4). For each unit increase in BMI, the odds of complication increased by 10%. As shown in Figure 7, the shape plot for BMI suggested a non-linear association with odds of complication. While the odds were similar across the bottom two quartiles (i.e. 28.3 kg/m2 and below), they were elevated in the third quartile and markedly higher in the highest quartile (i.e. 31.4 kg/m2and above). Obese participants (i.e. BMI ≥ 30 kg/m2) had approximately three-fold higher odds of complications (OR=2.89, 95% CI: 1.29, 6.51) than non-obese participants.

Discussion

Our results demonstrate three main points. Firstly, complication rate was statistically similar across all three study groups, suggesting that bipedicled flaps may be utilised without an associated rise in donor site morbidity. Secondly, most complications were managed in an outpatient setting and were of a minor nature. Finally, our results support previous findings in that high BMI was associated with more complications.

The last two decades have seen a change in trend of flap choice used in autologous breast reconstruction11. Abdominal-based flaps are still among the most popular flap choice in autologous breast reconstruction, obviating the need for implants and their associated complications. A review of a retrospective cohort of our institution’s data between 1999-2005 highlighted a temporal change with a sharp decline in the use of pedicled TRAM flaps, a modest rise in free-TRAM flaps and a rapid increase in DIEP flaps performed12. Advancement of microsurgical techniques and evolution of perforator flaps has propelled free-tissue transfer for flap reconstruction. Koshima and Soeda first noted the harvest of lower abdominal tissue without sacrificing the rectus muscle in 1989, leading to the genesis of the DIEP flap and its associated reduced donor site morbidity13. This procedure was subsequently popularized for breast reconstruction in 1994 by both Allen and Treece in the USA and Blondeel and Boeckx in Europe14,15. As a result of ongoing refinement in techniques, DIEP reconstruction even fares well in comparison to elective abdominoplasty, with similar rates of infection, abdominal necrosis, and wound dehiscence/delayed healing, and with lower seroma rates occurring in DIEP flaps16.

This is the first study to compare DIEP donor site morbidity according to surgical type, including bipedicled flaps, however a multitude of literature exists contrasting the different methods for abdominal tissue harvest in relation to donor site morbidity. TRAM flap reconstruction is associated with a higher risk of abdominal bulge/hernia compared to both ms-TRAM and DIEP flaps7. Ms-TRAM flaps may also be associated with an increased risk of abdominal complications compared to DIEP and SIEA flaps5,17,18, though other studies have found hernia rates to be comparable between ms-TRAM and DIEP flap19,20. Furthermore, while a systematic review found that patients with unilateral pedicle TRAM, free TRAM and DIEP reconstructions were able to continue with activities of daily living, a significant degree of impairment was observed in women who underwent a bipedicled TRAM or bilateral free TRAM reconstruction6.

Patients also report better abdominal wall function following SIEA reconstruction, whose harvest is almost identical to an abdominoplasty, compared to unilateral ms-TRAM flaps and bilateral flaps that did not utilize an SIEA flap. However, existing studies provide no evidence of a significant difference in reported abdominal wall function between unilateral SIEA and DIEP flap reconstruction21.

While the use of bilateral and bipedicled TRAM flaps appears to be associated with increased donor site morbidity when compared to unilateral reconstruction, a systematic review by Wormald et al. found no difference in DIEP procedure type on incidence of post-operative haematoma, seroma and abdominal bulge/hernia between unilateral and bilateral DIEP reconstructions8. This was echoed in our findings.

Aside from type of flap procedure, there are other risk factors in autologous breast reconstruction using abdominal tissue. Obesity is a well-documented risk factor for donor site complications in DIEP flaps as mentioned above, and our study was in agreement with this. Contrary to other studies, we found no increased risk of donor site complications among patients with a smoking history, but this group represented a very small group of our patients. Figures from our own retrospective cohort in 2013 showed that smoking, obesity, previous abdominal scars and total muscle harvest increased the likelihood of developing a complication in TRAM flap reconstruction12. In DIEP reconstruction careful pre-operative planning and adaptation of reconstructive strategy permits good results in patients with previous abdominal scars22,23.

The goal of this study was to determine the difference in donor-site morbidity across all three groups. Our study suggests that overall donor site morbidity is similar across unilateral unipedicled, bilateral and unilateral bipedicled DIEP reconstruction groups and provides preliminary evidence that if a larger amount of tissue is required to reconstruct a breast, particularly in slim patients, a bipedicled approach can be performed without increasing the risk of donor site morbidity. In addition, although the associations were not statistically significant (likely due to sample size limitations), age and BMI adjusted odds ratios of developing donor site complications were increased by almost two-fold in bilateral reconstruction (OR=1.97) and decreased by approximately two-fold in bipedicled unilateral reconstructions (OR=0.59), and this may be of clinical importance.

Seroma, wound dehiscence and fat necrosis were the most common complication in our study. Definition of what may constitute a “complication” may lead to under-reporting of complications in the literature. While the number of patients developing a complication seems high, it is important to emphasize that all and any form minor and major complications were included. The vast majority of these complications were minor and managed conservatively in the outpatient setting. Wound complications and fat necrosis may be partly attributable to blood supply and wound closing tension amongst other attributing factors. Attempts to reduce seroma rates have involved reduction of dead space, conservative dissection of the abdominoplasty flap and use of quilting and progressive tension sutures24. It is important to continually strive to enhance our operative approaches to minimize morbidity, improve patient recovery and patient outcomes. The literature and our study highlight that perforator based abdominal flaps do not eliminate donor-site morbidity but raises awareness that the high prevalence of the commonest complications across all three groups (seroma and minor wound dehiscence) should be considered common sequelae of DIEP flap harvest.

Donor-site complications and morbidity play an important part in the recovery of the patient and overall patient satisfaction and outcomes. Obesity was the single most important risk factor in developing donor-site complications in this cohort. Overall the prevalence of donor site complications was lowest in the bipedicled group (44.4%) and highest in the bilateral reconstruction group (79.0%). Seroma and minor wound dehiscence were the most common sequelae of DIEP flap harvest, but the prevalence was lowest among the bipedicled group (33.3% and 5.6% respectively) and highest in the bilateral reconstruction group (63.2% and 15.8% respectively). These findings were of interest as the harvest of the additional contralateral pedicle actually reduced the prevalence of associated donor-site morbidity and complications in our cohort but only in unilateral reconstructions (bipedicled group).

Although this study advances the existing literature pertaining to bipedicled DIEP flap donor site morbidity, there are recognized limitations to the study design. Due to its retrospective design, data abstraction was limited to those patients for whom follow-up took place at the University Hospital. While this likely reduced the number of patients within each group and decreased statistical power, this differential loss to follow-up is unlikely to bias the association between procedure type and complication risks. A further limitation of the retrospective design was that postoperative assessment was not standardized and only clinically detectable complications were documented. The strengths of this study include that the operative procedure in this retrospective cohort was performed by a single experienced senior surgeon and that operations were performed using a rib-preserving approach to breast reconstruction with a standardized postoperative protocol. The demographics of our patient population and results are comparable to previous published data, however ideally a larger prospective cohort study would be required with standardization of postoperative clinical examination, inclusion of abdominal wall strength testing and quality of life surveys. There is a potential need for standardized reporting of complications in reconstructive procedures or DIEP flap surgery.

Conclusion

In conclusion, although perforator flaps using the DIEP can help reduce some of the donor site morbidity compared to abdominal based muscle flaps, we highlight that DIEP breast reconstruction still carries some degree of morbidity, which are primarily minor and can be managed conservatively with seroma and minor wound dehiscence being the commonest complication across all three groups. Finally, our study suggests that donor site morbidity does not differ materially by the type of DIEP free flap used and is largely similar in unilateral, bilateral and bipedicled breast reconstructions.

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**Figure and Table Legends**

Table 1**:** Summary and comparison of baseline characteristics of the study sample (n=130) of women who underwent rib-preserving DIEP reconstruction based on procedure type.

Table 2: Odds of donor site complication by DIEP procedure type (n=130).

Table 3: Prevalence distribution of all donor site complications by DIEP procedure type (n=130).

Table 4: Odds of complication by participant characteristics (n=130).

Figure 1: Pre-operative image of a patient due to undergo breast reconstruction.

Figure 2: Post-operative image of the same patient from Figure 1 who had a bipedicled DIEP flap breast reconstruction to the left breast.

Figure 3: Intra-operative image of a bipedicled flap.

Figure 4: Bar chart showing percentage of complications grouped according to Clavien-Dindo grade.

Figure 5: Bar chart comparing percentage of minor and major complications by procedure type.

Figure 6: Bar chart showing percentage of patients developing a complication in each of the three groups (total 124 complications, n=82).

Figure 7: Odds of complication by quartile of body mass index.

**Table 1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Characteristic | Unipedicled, Unilateral (n=93)  N (%) or  Median (IQR) | Unipedicled, Bilateral (n=19)  N (%) or  Median (IQR) | Bipedicled, Unilateral (n=18)  N (%) or  Median (IQR) | *P value* |
| Age, years | 49 (44, 54) | 46 (37, 52) | 49 (45, 52) | *0.042* |
| BMI, kg/m2 | 29.0 (26.0, 31.2) | 30.4 (26.2, 33.6) | 25.0 (23.3, 26.6) | *0.001* |
| Ever Smoker  No  Yes | 83 (89.3%)  10 (10.8%) | 18 (94.7%)  1 (5.3%) | 17 (94.4%)  1 (5.6%) | *0.64* |
| Chemotherapy  No  Yes | 23 (24.7%)  70 (75.3%) | 5 (26.3%)  14 (73.7%) | 3 (16.7%)  15 (83.3%) | *0.74* |
| Radiotherapy  No  Yes | 37 (39.8%)  56 (60.2%) | 7 (36.8%)  12 (63.2%) | 7 (38.9%)  11 (61.1%) | *0.97* |

*P* values are from Kruskal-Wallis and Χ2 tests as appropriate. Abbreviations: IQR, interquartile range; BMI, body mass index.

**Table 2**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Procedure Type |  | Univariate | |  | Age & BMI-adjusted | |
|  | **Odds Ratio** | **95% CI** |  | **Odds Ratio** | **95% CI** |
| Unipedicled, Unilateral  Unipedicled, Bilateral  Bipedicled, Unilateral |  | 1.00  2.16  0.46 | 0.66, 1.52  0.72, 6.51  0.18, 1.17 |  | 1.00  1.97  0.59 | 0.66, 1.52  0.63, 6.19  0.22, 1.61 |

Abbreviations: CI, confidence interval; BMI, body mass index.

**Table 3**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Complication | Unipedicled, Unilateral (n=93) | | Unipedicled,  Bilateral (n=19) | | Bipedicled,  Unilateral (n=18) | | *P value* |
|  | **N** | **%** | **N** | **%** | **N** | **%** |  |
| Wound dehiscence | 21 | 22.6% | 3 | 15.8% | 1 | 5.6% | *0.23* |
| Seroma | 45 | 48.4% | 12 | 63.2% | 6 | 33.3% | *0.19* |
| Fat Necrosis | 12 | 12.9% | 2 | 10.5% | 0 | 0% | *0.27* |
| Hernia | 4 | 4.3% | 1 | 5.3% | 0 | 0% | *0.65* |
| Bulge | 2 | 2.2% | 0 | 0% | 1 | 5.6% | *0.52* |
| Infection | 4 | 4.3% | 1 | 5.3% | 0 | 0% | *0.65* |
| Hematoma | 3 | 3.2% | 0 | 0% | 0 | 0% | *0.54* |
| Scar | 3 | 3.2% | 0 | 0% | 0 | 0% | *0.54* |
| Sinus | 1 | 1.1% | 0 | 0% | 0 | 0% | *0.82* |
| OVERALL | **59** | **63.4%** | **15** | **79.0%** | **8** | **44.4%** | ***0.09*** |

**Table 4**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Characteristic |  | Univariate | |  | Mutually adjusted | |
|  | **Odds Ratio** | **(95% CI)** |  | **Odds Ratio** | **(95% CI)** |
| Age, per year |  | 0.99 | 0.95, 1.03 |  | 0.99 | 0.95, 1.04 |
| BMI, per kg/m2 |  | 1.10 | 1.01, 1.21 |  | 1.10 | 1.00, 1.21 |
| Ever smoker v. never smoker |  | 0.80 | 0.24, 2.68 |  | 0.84 | 0.24, 2.91 |
| Chemotherapy v. no chemotherapy |  | 0.76 | 0.33, 1.80 |  | 0.76 | 0.25, 2.32 |
| Radiotherapy v. no radiotherapy |  | 0.89 | 0.43, 1.85 |  | 0.95 | 0.37, 2.44 |