

Comparing Plastic Surgeon Operative Time for DIEP Flap Breast Reconstruction: 2-stage More Efficient than 1-stage?

Christopher J. Issa, BSc*
 Stephen M. Lu, MD, MDiv†
 Elizabeth M. Boudiab, MD‡
 Jeffrey DeSano, DO§
 Neil S. Sachanandani, MD§
 Jeremy M. Powers, MD§
 Kongkrit Chaiyasate, MD§

Background: The deep inferior epigastric perforator flap for breast reconstruction is associated with lengthy operative times that remain an issue for plastic surgeons today. The main objective of this study was to determine if a 2-stage deep inferior epigastric perforator flap reconstruction resulted in a shorter total plastic surgeon operative time compared with an immediate reconstruction.

Methods: A retrospective chart review was conducted on all patients who underwent deep inferior epigastric perforator flap breast reconstruction from February 2013 to July 2020 by the senior author. Patient demographics, medical comorbidities, mastectomy characteristics, expander placement, reconstructive procedures, operative time, and complications were tabulated.

Results: The study included a total of 128 patients. For immediate/1-stage flap reconstruction, average operative times for the plastic surgeon were 427.0 minutes for unilateral procedures, and 506.3 minutes for bilateral procedures. For delayed/2-stage reconstruction, average combined plastic surgeon operative times were 351.1 minutes for unilateral expander followed by flap reconstruction (75.9 minutes shorter than immediate unilateral, $P = 0.007$), and 464.8 minutes for bilateral reconstruction (41.5 minutes shorter than immediate bilateral, $P = 0.04$). Total patient time under anesthesia was longer for 2-staged bilateral reconstruction ($P=0.0001$), but did not differ significantly for unilateral reconstruction. Complications between immediate and delayed groups were not significantly different.

Conclusions: We found that staged reconstruction over 2 procedures resulted in a significant reduction in operative time for the plastic surgeon for both unilateral and bilateral reconstruction. With amenable breast surgeons and patients, the advantages of controlling scheduling and the operating room may encourage plastic surgeons to consider performing free flap reconstruction in a delayed fashion. (*Plast Reconstr Surg Glob Open* 2021;9:e3608; doi: [10.1097/GOX.0000000000003608](https://doi.org/10.1097/GOX.0000000000003608); Published online 7 June 2021.)

INTRODUCTION

Breast cancer remains the most common type of non-skin cancer among women today, affecting 1 in 8 women in the United States.^{1,2} Interestingly, studies have shown that

breast reconstruction is one of the most important factors that can improve a patient's overall well-being following a mastectomy.³⁻⁵ Fortunately, through advancements in silicone implant safety and reconstructive microsurgery, along with the passing of the Woman's Health and Cancer Rights Act in 1998, both implant and tissue-based breast reconstruction have become more accessible and popular over time.⁶ Autologous breast reconstruction has specifically been shown to play a pivotal role in postmastectomy treatment plans, as it allows patients to be restored with natural and aesthetically appealing reconstructed breasts.⁷ One of the most common flap options, the deep inferior epigastric perforator (DIEP) free flap has been shown to significantly improve patients' long-term breast satisfaction and psychosocial/sexual well-being.⁸

From the *Oakland University William Beaumont School of Medicine, Auburn Hills, Mich.; †Division of Plastic and Reconstructive Surgery, UPMC Pinnacle, Mechanicsburg, Pa.; ‡Department of General Surgery, Beaumont Health System, Royal Oak, Mich.; and §Division of Plastic and Reconstructive Surgery, Beaumont Health System, Royal Oak, Mich.

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The DIEP flap has remained the gold standard for perforator flap reconstruction due to its consistent anatomy and low morbidity.^{9–12} Moreover, with an increase in experienced microsurgeons and enhanced recovery protocols, DIEP flap breast reconstruction has become further refined with shorter postoperative recovery times.¹³ Despite higher long-term patient satisfaction in autologous breast reconstruction compared with breast implants,^{14–16} implant-based reconstruction remains more common due to shorter operative time, limited availability of microsurgeons, and comparatively favorable insurance reimbursements.^{6,17,18}

Several studies have examined the issue of optimizing efficiency of autologous breast reconstruction but were typically performed in the context of immediate reconstruction. In our institution and others, however, 2-stage delayed reconstruction is the norm—a tissue expander is placed at the first stage for preservation of the skin envelope; after expansion and any adjuvant therapies are completed, the expanders are removed and replaced with DIEP flaps in the second stage. The primary objective of this study was to compare the plastic surgeon's operative time and case involvement between DIEP flap reconstruction immediately following mastectomy (single-stage), versus immediate placement of tissue expander(s) followed by delayed DIEP flap reconstruction (2-stage). Secondary objectives included comparing total patient time under anesthesia and overall complications. We hypothesized that the operative time for the plastic surgeon to place tissue expanders and then return at a later date to perform free flap reconstruction would be the same or less than the time required for immediate flap reconstruction at the time of mastectomy.

METHODS

A retrospective chart review was conducted on all patients who underwent DIEP flap breast reconstruction from February 2013 to July 2020 by the senior author. Investigators recorded patient demographics and comorbidities, including age, BMI, smoking status, hypertension, diabetes, coagulation disorders, adjuvant radiation therapy, and adjuvant chemotherapy (Table 1). Patients were separated by unilateral/bilateral mastectomy and immediate or delayed reconstruction. Those who underwent stacked/bipedicled flaps, delayed DIEP flap reconstruction without first-stage tissue expander placement, or bilateral reconstruction in which one breast was reconstructed in a delayed fashion and the other breast was reconstructed in an immediate fashion, were excluded from this analysis.

Because operative times for initial tissue expander surgeries performed at outside facilities were not available, only immediate tissue expander placements performed by the senior author in preparation for DIEP flap reconstruction were included. All immediate DIEP flap reconstructions for the study period from 2013 to 2020 were included, as operating personnel were consistent with attending plastic surgeon, resident or fellow, and first assist present, typically starting at the same time as

Table 1. Patient Characteristics

| Patient Characteristics | Immediate DIEP Flap Reconstruction (n = 21) | Delayed DIEP Flap Reconstruction (n = 107) | P |
|----------------------------|---|--|------|
| Age (mean, range), y | 49.38, 27–69 | 50.61, 26–71 | 0.61 |
| BMI (mean, range) | 30.98, 23.12–46.88 | 33.57, 19.79–50.30 | 0.09 |
| Smoker | 3 (14.29%) | 6 (5.61%) | 0.17 |
| Hypertension | 7 (33.33%) | 29 (27.10%) | 0.60 |
| Prediabetes/diabetes | 1 (4.76%) | 6 (5.61%) | 0.99 |
| Coagulation problems | 0 | 2 (1.87%) | 0.99 |
| Adjuvant radiation therapy | 4 (19.05%) | 34 (31.78%) | 0.30 |
| Adjuvant chemotherapy | 2 (9.52%) | 19 (17.76%) | 0.52 |

the breast surgeon. For delayed flap reconstruction, we included patients from March 2016 to July 2020, to reflect consistency of the operative team, which included the attending surgeon and microsurgery fellow raising the flaps, and a plastic surgery resident and advanced practice provider preparing the chest recipient sites, followed by microsurgical anastomosis and inset with simultaneous closure of the abdomen.

Operative time for immediate tissue expander insertion was measured from entry of the plastic surgeon until skin closure, based on times recorded by the circulating nurse in the electronic medical record. The average operative times for unilateral and bilateral tissue expander placements were added to the respective average delayed DIEP flap reconstruction times, to yield the combined two-stage flap reconstruction procedural time (Fig. 1). For immediate reconstruction, our institution's norm is for the plastic surgeon to work concurrently with the breast surgeon; therefore, operative time for the whole procedure (mastectomy and DIEP flap) was considered as the plastic surgeon's total operative time (Fig. 1). The type of mastectomy and postoperative complications were recorded.

Although our primary focus was the operative time required of the plastic surgeon, we also wanted to capture the total patient time under anesthesia. In immediate reconstruction, we considered this time to be equivalent to the plastic surgeon's operative time. In delayed reconstruction, we added the time of the mastectomy to the previously calculated plastic surgeon's time (the time for immediate tissue expander placement plus the delayed DIEP free flap reconstruction) (Fig. 1).

For analysis, the plastic surgeon's operative time for 1-stage immediate flap reconstruction was compared with the combined operative time in 2-stage expander followed by delayed flap reconstruction, with groups distinguished by laterality (unilateral versus bilateral). Total patient time under anesthesia was similarly compared between the single-stage and 2-stage groups. Using Microsoft Excel (Redmond, Wash.), descriptive statistics, measures of central tendency, and measures of variability were used to describe absolute, mean, and SD results, respectively. Additionally, using GraphPad QuickCalcs (Graphpad Software, San Diego, Calif.), Fisher's exact test was used to compare patient characteristics (excluding age and BMI) and flap complications, and an unpaired *t* test was used to

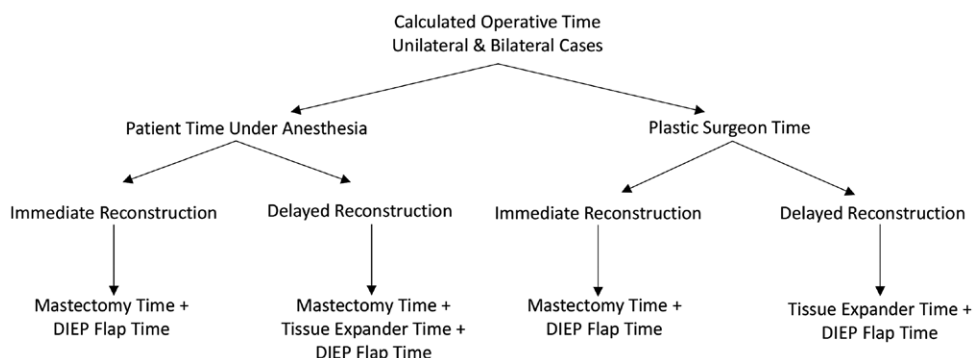


Fig. 1. Schematic diagram for the calculated operative times for both plastic surgeon and patient in each reconstructive subgroup.

compare age, BMI, and operative times. Values of $P < 0.05$ were considered statistically significant.

RESULTS

A total of 263 patients underwent immediate or delayed DIEP free flap breast reconstruction from February 2013 to July 2020 by the senior author. Following application of inclusion/exclusion criteria, 128 patients were included in the study. Of these patients, 21 had immediate reconstruction, and 107 had 2-staged/delayed reconstruction. There was no significant difference in patient characteristics between immediate and delayed reconstruction (Table 1).

Immediate/1-stage Flap Reconstruction Patients

Within the 21 immediate reconstruction patients, 6 underwent unilateral flap reconstruction, and 15 underwent bilateral flap reconstruction. Average operative (OR) times were 427.0 minutes for unilateral mastectomy/unilateral reconstruction, and 506.3 minutes for bilateral mastectomy/bilateral reconstruction (Table 2).

Delayed/2-stage Flap Reconstruction Patients

Within the 107 delayed reconstruction patients, 23 were unilateral single flap reconstructions, and 84 were bilateral flap reconstructions. Of these patients, 51 had

tissue expanders placed by the senior surgeon for which operative times were available, 15 of whom were unilateral, and 36 of whom were bilateral. Of the 51 tissue expander placements, 9 (18%) developed complications. Average OR for tissue expander placement was 62.20 minutes when done unilaterally, and 64.00 minutes when done bilaterally (Table 2). Considering the 107 delayed DIEP flaps performed in the study period, the average operative time for a delayed unilateral DIEP was 288.9 minutes, and for a bilateral DIEP was 400.8 minutes. Average combined operative times for the plastic surgeon employing a 2-stage approach was 351.1 minutes for unilateral expander/delayed DIEP flap, and 464.8 minutes for bilateral expander/delayed DIEP flap (Table 2). On comparison, the combined plastic surgeon's operative time for delayed unilateral single flap reconstruction was significantly shorter than immediate unilateral reconstruction by 75.90 minutes ($P = 0.007$); and the combined time for delayed bilateral flap reconstruction was significantly shorter than immediate bilateral reconstruction by 41.50 minutes ($P = 0.045$) (Table 2).

Total Patient Time under Anesthesia

The total patient time was also recorded in Table 2. The average mastectomy and tissue expander placement time was 142.4 minutes when done unilaterally ($n = 15$),

Table 2. Operative Times for DIEP Flap Breast Reconstruction

| Procedures for Breast Reconstruction | Total Number of Patients (n = 128) | Average TE OR Time (min) (n = 51) | Average Mx and TE OR Time (min) (n = 51) | Average Delayed DIEP OR Time (min) | Total Average Plastic Surgeon Time (min) | Total Patient Time (min) |
|--------------------------------------|------------------------------------|------------------------------------|--|------------------------------------|--|-------------------------------------|
| Immediate unilateral DIEP flap | 6 | N/A | N/A | N/A | 427.0* ± 79.69 (range: 268.0–481.0) | 427.0 ± 79.69 (range: 268.0–481.0) |
| Delayed unilateral DIEP flap | 23 | 62.20 ± 21.78 (range: 32.00–102.0) | 142.4 ± 45.84 (range: 80.00–239.0) | 288.9 ± 50.66 (range: 206.0–423.0) | 351.1* ± 50.66 (range: 268.2–485.2) | 431.3 ± 50.66 (range: 348.4–565.4) |
| Immediate bilateral DIEP flap | 15 | N/A | N/A | N/A | 506.3† ± 94.61 (range: 312.0–670.0) | 506.3‡ ± 94.61 (range: 312.0–670.0) |
| Delayed bilateral DIEP flap | 84 | 64.00 ± 29.56 (range: 20.00–137.0) | 204.7 ± 58.96 (range: 119.0–347.0) | 400.8 ± 68.59 (range: 233.0–615.0) | 464.8‡ ± 68.59 (range: 297.0–679.0) | 605.5‡ ± 68.59 (range: 437.7–819.7) |

* $P = 0.007$.

† $P = 0.04$.

‡ $P = 0.0001$.

Mx, mastectomy; TE, tissue expander; and OR, operative.

and 204.7 minutes when done bilaterally ($n = 36$). Thus, for delayed reconstruction, total patient time under anesthesia was 431.3 minutes for unilateral single flap, and 605.5 minutes for bilateral flaps. Total patient time in immediate reconstruction was the same as the previously reported plastic surgeon time. On analysis, the total patient time was shown to be significantly longer (99.20 minutes) for delayed bilateral reconstruction in comparison with immediate bilateral reconstruction ($P = 0.0001$) (Table 2). However, no significant difference was noted in the unilateral reconstructive procedures (427 minutes (immediate) versus 431.3 minutes (delayed), $P = 0.87$).

Takebacks and Complications

All patients receive 30 milligrams of Lovenox twice a day for prophylactic anticoagulation. A total of 4 takebacks were recorded—1 for immediate reconstruction (4.76%), and 3 for delayed reconstruction (2.80%). Flap salvage was obtained for 2 of 4 takebacks with surgical intervention and 5000 I.U. Heparin intravenous bolus. One flap loss occurred for each immediate (4.76%) and delayed (0.93%) subgroup, with no significant difference noted on statistical analysis (Tables 3 and 4).

DISCUSSION

Optimization of DIEP flap breast reconstruction has become a main focus for plastic surgeons. Through advancements in operative techniques, equipment, and postoperative care pathways, experienced microsurgeons are now able to perform DIEP flap reconstruction with highly aesthetic outcomes and shorter recovery times.^{13,19} Despite these advances, concerns persist from patients, referring surgeons, and plastic surgeons regarding the relatively long operative time needed to complete the surgery.

The primary objective of our study was to compare the plastic surgeon's operative time between immediate DIEP flap reconstruction at the time of mastectomy with a 2-stage strategy involving initial expander placement followed by delayed DIEP flap reconstruction. A secondary objective of the study was to compare a patient's total time under anesthesia with the 2 different surgical protocols, as well as postoperative flap complications. Through our retrospective study, the 2-stage immediate expander/delayed DIEP flap was more efficient with respect to the plastic surgeon's time for both unilateral and bilateral procedures. Total patient time under anesthesia was significantly longer by about 99 minutes for 2-staged bilateral procedures, but did not significantly differ for unilateral procedures.

Flap complication rates were low in both groups and did not differ significantly.

Literature has shown that longer operative times result in an increase in probability of complications for every additional 30 minutes under anesthesia.²⁰ Cheng et al conducted a systematic review analyzing a multitude of surgical specialties, and found that the likelihood of a surgical site infection increased by 17% for every additional 30 minutes, and by 37% for every additional 60 minutes.²¹ Furthermore, Mlodinow et al examined over 19,000 general plastic surgery cases and found that longer surgical duration was associated with increased venous thromboembolism rates.²² Thus, although it has not been studied extensively, it is possible that splitting a long procedure into 2 shorter ones may reduce the risk of surgical complications; however, further research is needed to ensure that the benefit of reducing surgical complications is not erased by the additive increase in anesthetic complications of an additional general anesthetic.

Several recent studies have compared immediate versus 2-staged delayed breast reconstruction flap techniques, with studies reporting relative equivalence in aesthetic outcomes,²³ but lower complication rates in delayed reconstruction.²⁴ Although patients benefit from a single anesthetic, shorter time under anesthesia, and instant aesthetic results with immediate reconstruction, the disadvantages of a longer operative time, potentially higher risk of complications, and unexpected oncologic findings, represent definite downsides of this approach. There are many advantages of placing an initial expander and returning later for free flap reconstruction including: delaying the mastectomy flap, completing adjuvant therapies, maintaining optimal aesthetic results following postmastectomy radiotherapy,²³ easier scheduling with the breast surgeon, easier accommodation of urgent scheduling needs, a defined pocket for flap inset, the ability to bury the flap with the preserved skin if desired, and plastic surgeon direction of the operating room team. Certainly, tissue expander related complications must be considered in the full analysis of the 2 strategies.

By maximizing efficiency while maintaining patient safety, DIEP flap breast reconstruction can become a suitable option for many postmastectomy patients. Research has shown that patients tend to choose implant-based reconstruction over autologous breast reconstruction due to a smaller surgical impact and shorter recovery times.¹⁹ Thus, by demonstrating that DIEP flap reconstruction can be performed efficiently in a 2-staged delayed fashion, patients who desire autologous reconstruction but are concerned about operative time may be reassured. It

Table 3. DIEP Flap Breast Reconstruction Complications

| Patients with Takebacks | DIEP Procedure | Complications | Intervention (Return to the OR) | Outcome |
|-------------------------|---------------------|-------------------------|--|--------------|
| Patient 1 | Immediate bilateral | POD 5-flap thrombosis | POD 5-unable to maintain perfusion due to hypercoagulability | Flap loss |
| Patient 2 | Delayed unilateral | POD 0-venous congestion | POD 0-revision of venous anastomosis | Flap salvage |
| Patient 3 | Delayed bilateral | POD 0-hematoma | POD 0-controlled bleeding perforator. | Flap salvage |
| Patient 4 | Delayed bilateral | POD 1-venous congestion | POD 1-revision of venous anastomosis | Flap loss |
| | | POD 3-flap thrombosis | POD 3-revised with venous and arterial anastomosis, but unable to reestablish flow due to hypercoagulability | |

POD, postoperative day.

Table 4. Comparison of DIEP Flap Breast Reconstruction Complications

| | Immediate DIEP (n = 21) | 2-staged Delayed DIEP (n = 107) | P |
|-------------|-------------------------|---------------------------------|------|
| Takebacks | 1 (4.76%) | 3 (2.80%) | 0.52 |
| Flap losses | 1 (4.76%) | 1 (0.93%) | 0.30 |

is important to note that accomplishing efficient operative time for these complex procedures requires an experienced operating room team which takes time to develop.

Our study demonstrates that 2-stage DIEP flap breast reconstruction is more efficient for the plastic surgeon in both unilateral and bilateral procedures, without significantly prolonging the patient's total time under anesthesia in unilateral reconstruction. However, there were several important limitations of our study. One of these limitations include a relatively small sample size, primarily in the immediate reconstruction group, as most DIEP flap reconstructions at our institution are done in a delayed fashion. Furthermore, our study was inadequately powered to detect complications related to undergoing an additional general anesthetic, nor did we compare long term patient reported outcomes or revision rates between the 2 approaches. Additionally, because our surgical team consisted of a microsurgical fellow and plastic surgery resident, our data are limited to well-established surgical teams that may not be available at most nonacademic practice settings. However, co-attending surgeon models with adequate advanced practice provider support may be an analogous alternative. These are all important considerations and will be a focus of future study in this area.

CONCLUSIONS

We found that reconstruction over 2 procedures resulted in a significant reduction in total OR time for the plastic surgeon for both unilateral and bilateral reconstruction, without significantly prolonging total patient time under anesthesia for unilateral reconstruction. Future studies are required to track anesthetic-related complications and long-term outcomes.

Through the findings of this study, patients desiring autologous reconstruction may be informed that placing an initial expander and delaying flap reconstruction allows for the preservation of skin envelope and completion of adjuvant therapies, and only significantly prolonging time under anesthesia by about 99 minutes in bilateral reconstruction. With amenable breast surgeons and patients, the advantages of controlling scheduling and the operating room may encourage plastic surgeons to consider performing free flap reconstruction in a delayed fashion.

Kongkrit Chaiyasate, MD
3555 W. 13 Mile Rd, Suite N120
William Beaumont Hospital Royal Oak
Royal Oak, MI 48073
E-mail: kongkrit.chaiyasate@beaumont.edu

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