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DELAYED TRAM FLAP FOR EXTENSIVE SOFT TISSUE DEFECTS AFTER MASTECTOMY: A TIME-EFFICIENT ALTERNATIVE TO FREE DIEP FLAP IN RESOURCE-LIMITED SETTINGS

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ABSTRACT

Objective: To prospectively compare flap survival and total length of operating time between delayed Transverse Rectus Abdominis Myocutaneous (TRAM) flap and Deep Inferior Epigastric Perforator (DIEP) flap breast reconstruction in patients who have undergone mastectomy.

Design: quasi-experimental study

Place and Duration of study: Department of Plastic Surgery, Lahore General Hospital, Lahore. From 20th November, 2025 to 20th April, 2026

Methodology: Two equal groups of 50 patients, with post mastectomy wounds with ages ranging from 33 to 54 years old were divided by researchers discretion (non Probability convenience sampling). Group A had breast reconstruction using Delayed TRAM flap whereas in Group B DIEP flap was performed. For statistical analysis was performed using SPSS version 29. Chi square and Fisher's exact tests were used to examine categorical variables. The independent sample t-test was used to examine continuous data and their means. The Shapiro-Wilk test was used to check normality. Results were presented with p-value <0.05, 95% confidence interval and power of 80%.

Results: The mean age was 41.18±8.03 years for Delayed TRAM flap and 44.96±9.52 years for DIEP flap. Mean wound size of 131.50±39.74 for Delayed TRAM flap and 126.56 ± 35.68 for DIEP flap. The Delayed TRAM flap demonstrated a significantly shorter mean operative time (303.68 ± 66.47min) compared to the DIEP flap (387.84 ± 69.53 min, p<0.0001). Flap survival was 96% in the Delayed TRAM group. The DIEP group had a 92% survival rate, with 3(6.0%) resulting in partial flap loss and 1(2.0%) resulting in complete flap failure.

Conclusion: The Delayed TRAM flap is a highly time-efficient and reliable alternative for post-mastectomy reconstruction. It provides superior vascular robustness and significantly reduced surgical duration, making it an ideal alternative for high-volume, resource-constrained surgical departments.

KEYWORDS: Mastectomy, Delayed Transverse Rectus Abdominis Flap, Delayed TRAM flap, Deep Inferior Epigastric Perforator Flap, DIEP flap.

INTRODUCTION

Breast cancer in Pakistan presents a significant public health challenge where approximately one in nine women are at risk. A large proportion of women present with advanced-stage cancers (Stage III and IV). This delayed presentation is attributed to a number of factors. Lack of education and awareness regarding breast cancer symptoms and the importance of early detection, among a few, lead many to disregard initial signs like painless lumps.(1) Also regular, organized national screening programs like mammography are largely unavailable or inaccessible, especially in rural areas.(1)

Cultural and societal norms further exacerbate the issue. Many women face reduced family support or shyness in discussing their health concerns, even with spouses.(2) Furthermore, females often prefer to be examined by female surgeons, a demographic that is scarce in the medical field.(3) Financial constraints and low socioeconomic status also deter women from seeking timely medical attention, as many cannot afford diagnostic tests or treatment.(1) Furthermore, societal norms lead some women resort to home remedies, traditional healers (Hakims), or alternative treatments, believing symptoms will resolve on their own, thus delaying conventional medical consultation.(3) This collective delay in seeking diagnosis and treatment leads to aggressive interventions such as

radical mastectomy, which involves the complete excision of the affected breast. This leads to significant physical disfigurement and profound social and emotional problems for these women.

There are several autologous options for breast reconstruction after mastectomy; Deep Inferior Epigastric Artery Perforator (DIEP) flap, Transverse Rectus Abdominis Myocutaneous (TRAM) flap, Latissimus Dorsi (LD) flap with breast implants, and the stacked Profunda Artery Perforator (PAP) flaps.(4) The current gold standard for breast reconstruction is considered to be the deep inferior epigastric perforator (DIEP) flap.(5) This microsurgical procedure involves transferring a skin fasciocutaneous paddle based on the Deep inferior epigastric artery as a free flap and anastomosing it to the Thoracodorsal Artery or Internal Mammary Artery.(5) However, the DIEP flap procedure demands a long operating time, significant microsurgical expertise, and a lengthy hospital stay. Following the procedure, postoperative care is also intense in the first 48-72 hours, usually requiring hourly monitoring of the flap in an HDU. This calls for a lot of human resources and in case of flap compromise, the patient needs to be timely rushed to the operating room to salvage the flap. This becomes a logistical nightmare in many high volume tertiary care setups as it further adds to their load. Furthermore, the DIEP flap cannot provide a voluminous breast and in cases where a large volume breast is required, it has to be augmented with some sort of stacked flap like the Profunda Artery perforator (PAP) flap. In tertiary care hospitals in Pakistan, resources are already severely limited, with a substantial portion being allocated to managing trauma patients, burn victims and cancers. Given these constraints, it becomes logistically challenging to realistically offer free tissue transfer techniques, such as the DIEP flap, to all post-mastectomy patients due to the extended surgical hours and increased financial and human resource demands. Consequently, there has been a realization and revival of the "old is gold" technique of delayed TRAM flap reconstruction. This approach provides an additional armamentarium to a microsurgically equipped department, offering a crucial cushion and breathing space to cater to patients who have undergone mastectomy and require further adjuvant chemotherapy and radiotherapy, thereby allowing for a more sustainable approach to breast reconstruction in a resource-constrained environment.

The traditional transverse rectus abdominis myocutaneous (TRAM) flap involves transferring skin, fat, and a portion, or in some cases the entire, rectus abdominis muscle from the abdomen to reconstruct the breast. To address potential issues with blood supply to the transferred tissue, particularly the distal portion of the flap, the concept of a "delayed" TRAM flap has been developed.(6) This approach involves a preliminary surgical procedure performed before the main flap transfer. The surgical technique of the delay procedure involves ligating the inferior epigastric vessels, which are a major blood supply to the flap.(7) This controlled reduction in blood supply stimulates the superior epigastric vessels, another major artery supplying the flap, to dilate and provide increased blood flow to the tissue by opening up vascular communication networks called choke vessels.(8) This physiological phenomenon, known as surgical delay, works by causing adjacent angiosomes to open up through the dilation of choke vessels.(9) This significantly enhances the flap's vascularity, giving it a better chance of survival and markedly reducing the risk of ischemia (inadequate blood flow) and subsequent fat necrosis after it is transferred to the chest. The delay period between the initial surgery and the final flap transfer can vary, ranging from a few days to a week or more, depending on the surgeon's preference.(8) The delayed flap also requires little continuous surveillance after it is transferred to the chest, thereby decreasing the human resources needed.

Delaying the TRAM flap allows for the capture of not only Zone I and III but can also extends to Zone II and IV of the abdominal tissue.(10) This expanded capture is a distinct advantage over the DIEP flap, which typically only reliably includes Zone I, Zone III and a portion of Zone II. The ability to recruit these additional vascular territories leads to a much larger and tissue harvest, providing the surgeon with more tissue to create a better and more voluminous breast mound, ultimately increasing flap survival and enhancing aesthetic outcomes.

Rationale of the study is to determine the outcomes of delayed TRAM flap in terms of decreased complications and operative time benefits. The DIEP Flap is the gold standard for autologous breast reconstruction but the amount of resources invested into making a DIEP flap successful are vast. On the other hand, the Delayed TRAM flap decreases the operative time, human resources and needs for reexploration incase of flap failure. It also give the advantage of giving a similar if not a larger voluminous breast.

MATERIALS & METHODS

This quasi-experimental study was conducted at the Department of Plastic and Reconstructive Surgery, Lahore General Hospital, from 20th November, 2025, to 20th April, 2026. Ethical approval was obtained from the institutional review board. Written informed consent was obtained by all study participants.

A total of 100 women aged 33 and above, requiring soft tissue reconstruction after unilateral or bilateral mastectomy and who had undergone atleast one parity, were enrolled and divided into two group A and group B of 50 women, based on non probability convenience sampling. Women who had undergone immediate breast reconstruction, had a previous abdominal surgery, were nulliparous or had significant comorbidity (uncontrolled hypertension, diabetes, active smokers) were excluded. Using a two-sided 95% confidence level, 80% power, and equal group allocation, the required sample size was calculated to detect a mean difference of operative time between DIEP flap (329± 80 minutes) and Delayed Tram Flap (288± 60.7 minutes).(11,12) Based on these parameters, 50 patients per group are needed, resulting in a total sample size of 100**.** It was calculated using OpenEpi.com.

Baseline characteristics were recorded, including age, body mass index (BMI), wound dimensions, and comorbidities such as diabetes and hypertension. Patients undergoing immediate breast reconstruction or those with a previous history of abdominal flap surgery or abdominoplasty were excluded.
For group A, 1st stage surgery was performed on these patients under Local Anaesthesia. Hesselbach's triangle was identified and deep inferior epigastric artery, which lies in its lateral wall was explored, identified and then ligated. Wound closed and dressing done. Patients were discharged and readmitted after 10 days for the 2nd procedure. After 10 days, 2nd stage surgery was performed where the Flap was raised on the Superior epigastric Artery, rotated, tunneled under the skin and placed to make the breast mound.
In group B, patients underwent DIEP flap reconstruction in a single stage, involving the isolation of inferior epigastric perforators and microvascular anastomosis to the recipient vessels under loupe magnification. Microscope was not available at the institution.
The primary outcome was total operative duration. Secondary outcomes included flap survival (complete, partial, or total loss) at day 7 and 3 months, flap dimensions (length, width, and projection), and postoperative complications such as infection, hematoma, and fat necrosis.
Collected Data was entered in SPSS 29. Quantitative variables such as age, wound size, and percentage of graft uptake were presented as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on the distribution assessed by the Shapiro–Wilk test for normality. Complication rates were compared between the two groups using chi-square tests. Operative time was compared using independent samples t-tests. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

Demographics and clinical paramenter (age, body mass, wound dimensions, comorbidites, and previous chemotherapy and radiotherapy) are compared between subgroups in Table I. Deep Inferior Epigastric Perforator flap group was significantly older than the delayed Transverse Rectus Abdominis Myocutaneous flap group (44.96 ± 9.52 vs 41.18 ± 8.03 years, p = 0.034). In contrast, body mass index, wound length, wound width, and wound area did not differ significantly between the two groups. Similarly, no statistically significant between-group differences were observed in the distribution of diabetes mellitus, hypertension, chemotherapy status, radiotherapy status, etiology of the defect, or side of surgery, indicating reasonable baseline comparability for most measured variables.
Total operative duration compared between the groups showed a significantly shorter total operative time in delayed TRAM flap than the Deep Inferior Epigastric Perforator flap group (303.68 ± 66.47 vs 387.84 ± 69.53 minutes, p < 0.001), with a mean difference of -84.16 minutes (95% confidence interval: -111.16 to -57.17).
Postoperative outcomes and flap dimensions are summarized in Table II. Flap survival status at day 7 did not differ significantly between groups using Fisher's exact test (p = 0.671). Infection, erythema, and hematoma rates were also comparable between the two groups. Flap width at day 7 was significantly greater in the DIEP group than in the Delayed TRAM group [20.00 (17.00-22.00) vs 18.00 (17.00-20.00) cm; p = 0.008]. Flap projection at day 7 was also significantly greater in the DIEP group [7.00 (6.00-8.00) vs 7.00 (6.00-7.00) cm; p = 0.042], whereas flap length did not differ significantly. At 3 months, the DIEP group retained significantly greater flap width [19.00 (17.00-21.00) vs 18.00 (16.00-19.00) cm; p = 0.002] and flap projection [7.00 (6.00-7.00) vs 6.00 (5.00-7.00) cm; p = 0.009], while flap length remained statistically comparable (Table II).

Table I. Demographic and clinical characteristics of the subgroups

Variable	Delayed TRAM (n=50)	DIEP (n=50)	Test value	p value	Mean difference / 95% confidence interval
Age (years), mean ± standard deviation	41.18 ± 8.03	44.96 ± 9.52	t = -2.147	0.034*	-3.78 (-7.28 to -0.29)
Body mass index (kg/m²), mean ± standard deviation	27.54 ± 3.07	27.12 ± 3.95	t = 0.594	0.554*	0.42 (-0.98 to 1.82)
Wound length (cm), mean ± standard deviation	13.32 ± 2.99	12.72 ± 2.67	t = 1.060	0.292*	0.60 (-0.52 to 1.72)
Wound width (cm), median (interquartile range)	10.00 (8.00-11.00)	10.00 (8.00-11.00)	U = --	0.555‡	—

Wound area (cm²), mean ± standard deviation	131.50 ± 39.74	126.56 ± 35.68	t = 0.654	0.515*	4.94 (-10.05 to 19.93)
Diabetes mellitus	8 (16.0%)	7 (14.0%)	$\chi^2 = 0.078$	0.779†	—
Hypertension	6 (12.0%)	8 (16.0%)	$\chi^2 = 0.332$	0.564†	—
Chemotherapy			$\chi^2 = 0.229$	0.633†	—
Adjuvant	22 (61.1%)	20 (55.6%)			
Neoadjuvant	14 (38.9%)	16 (44.4%)			
Radiotherapy			$\chi^2 = 0.518$	0.472†	—
Adjuvant	18 (81.8%)	16 (72.7%)			
Neoadjuvant	4 (18.2%)	6 (27.3%)			
Etiology of defect			Fisher = 0.409	0.984§	—
Ductal carcinoma in situ	6 (12.0%)	6 (12.0%)			
Invasive ductal carcinoma	32 (64.0%)	30 (60.0%)			
Invasive lobular carcinoma	8 (16.0%)	10 (20.0%)			
Lobular carcinoma in situ	4 (8.0%)	4 (8.0%)			
Site			$\chi^2 = 0.160$	0.689†	—
Left	26 (52.0%)	24 (48.0%)			
Right	24 (48.0%)	26 (52.0%)			

*Independent-samples t-test. †Pearson chi-square test. ‡Mann-Whitney U test. §Fisher's exact test. For Fisher's exact test in 2 x 2 tables, CI = confidence interval; IQR = interquartile range.

Table II. Postoperative outcomes and flap dimensions in the two groups

Variable	Delayed TRAM (n=50)	DIEP (n=50)	Test value	p value	Mean difference / 95% confidence interval
Flap survival status			Fisher = 1.242	0.671§	—
Complete survival	48 (96.0%)	46 (92.0%)			
Partial loss	2 (4.0%)	3 (6.0%)			
Total loss	0 (0.0%)	1 (2.0%)			
Infection	5 (10.0%)	4 (8.0%)	Fisher exact	1.000§	—
Erythema	8 (16.0%)	7 (14.0%)	$\chi^2 = 0.078$	0.779†	—
Hematoma	4 (8.0%)	3 (6.0%)	Fisher exact	1.000§	—
Flap width at day 7 (cm), median (interquartile range)	18.00 (17.00-20.00)	20.00 (17.00-22.00)	U = 871.500; Z = -2.639	0.008‡	—
Flap length at day 7 (cm), mean ±	14.22 ± 1.95	14.62 ± 2.07	t = -0.994	0.322*	-0.40 (-1.20 to 0.40)

standard deviation					
Flap projection at day 7 (cm), median (interquartile range)	7.00 (6.00-7.00)	7.00 (6.00-8.00)	U = 968.000; Z = -2.035	0.042‡	—
Flap width at 3 months (cm), median (interquartile range)	18.00 (16.00-19.00)	19.00 (17.00-21.00)	U = 807.000; Z = -3.087	0.002‡	—
Flap length at 3 months (cm), mean ± standard deviation	13.90 ± 1.87	14.30 ± 2.08	t = -1.012	0.314*	-0.40 (-1.19 to 0.39)
Flap projection at 3 months (cm), median (interquartile range)	6.00 (5.00-7.00)	7.00 (6.00-7.00)	U = 884.500; Z = -2.629	0.009‡	—

*Independent-samples t-test. †Pearson chi-square test. ‡Mann-Whitney U test. §Fisher's exact test. For Fisher's exact test in 2 x 2 tables. CI = confidence interval; IQR = interquartile range.

DISCUSSION

Breast Cancer in Pakistan often presents at later stages, requiring modified Radical mastectomies as opposed to breast conservating surgeries. This leads to women having chest deformities after treatment, which can be physically ghastly and psychologically damaging. Furthermore, due to a moajority of population presetingin high volume, tertiary care hospitals where resources are limited and budget constrainted, we must think of ways to manage patients under the given circumstances. Even if this management means challangeing the gold standards of practice.

The DIEP which is the gold standard due to its muscle sparing nature, proves challanging in these setups due to its increased operative time, demand of expertise and possible failure rates. This study highlights the delayed Transverse Rectus Abdominis Myocutaneous (TRAM) flap as a robust, time-efficient alternative.

The primary finding of this study was the significant difference in operative duration. The delayed TRAM group demonstrated a mean total operative time of 303.68 ± 66.47 minutes, compared to 387.84 ± 69.53 minutes for the DIEP group ($p<0.001$). This mean reduction of approximately 84 minutes is critical in tertiary care settings, where surgical theaters must accommodate a high volume of trauma and oncology cases.

The time saved allows to cater to more patients and help reduce the burden on these hospitals.. Literature supports that shorter operative times are correlated with decreased postoperative complications and lower hospital costs (13). In settings where microsurgical expertise or advanced equipment may be unavailable, the delayed TRAM allows surgeons to offer reliable autologous reconstruction without the exhaustive resource demand of a single-stage free tissue transfer.

The vascular robustness of the delayed TRAM flap is its most significant clinical advantage in this series. Flap survival was 96% in the delayed TRAM group, whereas the DIEP group had a 92% survival rate. For flaps that did not survive, operating rooms were arranged. But the process of arranging the operating room was strenuous. Due to limited operating theatres, and a huge load of patients, operating rooms had to be borrowed from other departments during their allocated time, Anaesthesia team had to be convinced about the urgency of the operation, nursing teams had to be arranged and microvascular instruments had to be on hand. All these small delays lead to an increase in time from discovering the flap failure to exploring the patient. Although salvage attempts were done, this still led to an 8% flap failure. All this points to better flap outcomes in delayed TRAM flap.(14)

In the delayed TRAM flap, by ligating the deep inferior epigastric artery early, we stimulate the superior epigastric vessels to dilate and open choke vessels. This phenomenon, extensively studied by Taylor and Palmer, allows the flap to capture not only Zones I and III but also Zones II and IV, providing a more robust blood supply than the DIEP flap(15, 16). For emerging plastic surgery units, this increased vascularity offered a higher guarantee of positive outcomes. Flaps that survived the initial insult meant that they could be easily transferred on the pedicle to the breast without worrying about flap failure(17,18). Only 2 flaps in this group had partial flap loss, that too was seen as necrosis of the edges of the flap. These flaps were then taken to the elective operating room at a later date, when the necrosis demarcated. This did not cause unnecessary human resource being wasted in trying to

arrange a theatre and disrupting the normal functioning of the hospital. Flap margins debridement was done and edges were re-sutured to allow it to heal completely.
Aesthetic evaluation revealed that while the DIEP flap produced significantly greater width and projection (**7.00 ± 1.01 cm**) compared to the delayed TRAM (**6.60 ± 0.90 cm**). The delayed TRAM still achieved substantial projection and volume. This finding is contrary to literature which suggests that while DIEP flaps are sophisticated, they can sometimes struggle to provide enough volume for large defects without stacking flaps.(19) The delayed TRAM flap's ability to recruit additional vascular territories allows for a larger and more robust tissue harvest(20). Further studies may be needed on patients with larger BMI, or bigger wounds to see of if Delayed TRAM flap can produce a more voluminous breast in the Pakistani population when compared to the DIEP flap.(21)
The limitations to the study were in considering the donor site morbidity. The DIEP flap is superior in terms of donor-site morbidity as it spares the rectus muscle. The study did not differentiate between taking Delayed TRAM flap with rectus Abdominis or using a Muscle sparing technique for a Delayed TRAM flap. Although when taking the muscle, necessary precautions like placing of abdominal mesh were taken, further longterm studies may be needed to see the outcome of these patients.

CONCLUSION

In resource-constrained environments, the gold standard must be redefined by what is both reliable and sustainable.(22) The DIEP flap, although being the gold standard, demands a lot of resources from a emerging plastic surgery departments in a high volume tertiary care hospital. The Delayed TRAM flap, although not ideal, still provides with sufficient outcomes to satisfy the patients needs and reduce unnecessary burden on an already resource depleted system.

Declarations

Ethical Approval

This study was approved by the Institutional Review Board of Lahore General Hosptial, Lahore (2025/ERC/66 Dated 15/10/2025)

Patients' Consent

Written informed consent was obtained from all participants prior to inclusion in the study

Competing Interest:

The authors declared no conflict of interest

Authors' Contributions

UI: Conceptualisation, Methodology, data collection, manuscript drafting
RA: Supervision, Conceptualisation, Study Design, critical revision of manuscript
MI: Clinical evaluation, Data collection, Manuscript review
FM, MAR: Clinical evaluation, Data collection
SZ: Statistical Analysis

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