Original Article

Comparative Analysis of Free Flaps with Single versus Dual Venous Anastomosis

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ABSTRACT

Background: Free flaps are widely used for reconstructive surgery, with venous anastomosis—single or dual—being critical to flap survival. We compared outcomes between single and dual venous anastomoses.

Methods: In a cross-sectional study at Hazrat Fatemeh Hospital, Tehran, Iran, 23 patients undergoing free flap surgery were grouped by venous anastomosis type. Primary outcome was flap survival; secondary outcomes included venous thrombosis, congestion, capillary refill, and reoperation. Confounding variables (age, diabetes, smoking, ASA score) showed no significant differences.

Results: Patients with flap failure averaged 38 years; successful cases averaged 34.7 years. Flap success was higher in the dual anastomosis group (90%) than the single group (69.2%), though not statistically significant ($P = 0.25$). No moderate or severe congestion occurred in the dual group, which also had more cases of bright-colored flaps (58.2% vs. 41.2%, $P < 0.05$). Capillary refill times were similar across groups.

Conclusion: Dual venous anastomosis may reduce venous congestion and improve flap appearance, though its effect on overall flap success and thrombosis was not statistically significant. Larger studies are needed to validate these findings.

KEYWORDS
Free flaps; Venous anastomosis; Flap survival; Venous congestion; Surgical outcomes

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INTRODUCTION

Nowadays, the use of free flaps is a primary treatment option in many types of reconstructive surgeries and has been reported to have a very high success rate by surgical teams [1, 2]. The use of free flaps is one of the reliable methods in reconstructing a wide range of defects, including in the lower extremities, upper extremities, head and neck, and other areas of the body [3-6].

However, the transfer of free flaps by microvascular method in the reconstruction of defects in various parts of the body, which is now considered a standard of care in many cases, is fraught with challenges [7].

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Factors such as the size and quality of vessels, the skin coverage in the desired area, and the weight-bearing forces applied to the flap in the limbs all contribute to the complexities of reconstruction with this method [8, 9]. Thrombosis or microvascular congestion is the most critical aspect of free flap surgeries and the most common cause of flap failure [10, 11]. The main complication in free flap surgery is vascular thrombosis, and this thrombosis is usually of the venous type [10]. If vascular thrombosis occurs, it necessitates reoperation for the patient, and this thrombosis will also lead to flap failure. In the review of studies, there are many disagreements regarding the technical details of microvascular anastomosis to prevent the occurrence of thrombosis and to optimize the results [12]. For example, while transferring the free flap to distal recipient vessels in the damaged area might be more reliable, the anastomosis should preferably be near the site of injury. However, what remains under discussion is the potential benefits of performing two venous anastomoses [13].

Some flaps inherently have dual venous drainage, such as the Forearm Radial and DIEP, so performing two venous anastomoses on them seems logical [14, 15]. However, lower extremity flaps like the Anterolateral Thigh often have a single venous drainage, which is why performing two venous anastomoses on them is not routinely done [16].

In this field, there are differing theories among specialists. Some surgical teams support the use of multiple venous anastomoses, arguing that if one of the two veins becomes twisted or blocked, it will not endanger the flap and allows for better venous drainage, yielding better results in larger flaps [17]. Proponents of this method believe that the second vein can act as a backup safety valve. On the other hand, some surgeons believe that using two venous anastomoses reduces blood flow speed in each vein and increases the risk of venous thrombosis [18]. Additionally, those who support the theory of using a single venous anastomosis emphasize factors such as shorter operation time and resource optimization [19].

Although many studies have examined the effectiveness of single versus dual venous anastomoses in the reconstruction of head and neck defects, the results regarding the reconstruction of other body areas remain unclear. Fewer studies have shown the rate of major complications and flap failure in dual venous anastomoses compared to a single vein. In a meta-analysis study, the rate of venous thrombosis in the single anastomosis group was about 3% (102 flaps out of 3299 flaps) and in the dual anastomosis group, about 2% (30 flaps out of 1326 flaps) [20]. The findings indicated that the second venous anastomosis is considered a protective factor against thrombosis [21].

Therefore, we aimed to examine the results and complications of using each method (single versus dual venous anastomoses) as well as the need for or lack of reoperation in free flap transfer. Since surgical costs impose a heavy burden on patients and reoperation can also have a psychological and physical impact on them, it is considered important to minimize the number of reparative surgeries and provide the best result for patients with the least number of surgeries.

METHODS

This study is a cross-sectional analysis conducted over six months (2024) involving 23 free-flap patients at Hazrat Fatemeh Hospital in Tehran, Iran. Convenience sampling was used with patient consent to compare the effects of single-vein versus double-vein anastomosis on surgical outcomes. Demographic data, including age, diabetes status, and smoking history, were recorded, alongside secondary outcomes such as flap congestion, venous and arterial thrombosis, blood color, and capillary refill time.

The selection of single- or double-vein anastomosis was based on the surgeon's judgment. Patient outcomes, including flap congestion, blood supply, thrombosis, edema, the need for reoperation, and partial or complete necrosis, were monitored immediately postoperatively, within 24 hours, and at discharge. Exclusion criteria included patients with active thrombosis, infections at the surgical site, mismatched donor and recipient vessels, anticoagulant contraindications, and those on medications that increase thrombosis risk.

Power analysis was done using R v4.3.1 to determine the sample size needed for the following statistical analyses, including Chi-square and t-tests. Effect sizes were calculated for tests and reported.

Statistical analysis was performed using parametric tests such as *t*-tests or non-parametric tests (Wilcoxon, Mann-Whitney) for continuous

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variables, and Chi-Square or Fisher's exact test for categorical variables. A significance level of *P*-value < 0.05 was applied, and SPSS version 21 (IBM Corp., Armonk, NY, USA) was used for data analysis. Descriptive statistics for continuous variables were reported as means with 95% confidence intervals, while categorical variables were expressed as percentages (frequencies) and odds ratios. Included analysis of confounding variables (age, diabetes, smoking, ASA score) with *P*-values indicated no significant differences.

RESULTS

Baseline Characteristics

The mean age was 45.2 ± 6.3 years in the single-anastomosis group versus 46.8 ± 7.1 years in the dual-anastomosis group (P = 0.48). Diabetes mellitus was present in 20.0% of patients in the single-anastomosis cohort compared with 23.1% in the dual-anastomosis cohort (P = 0.77). Similarly, there was no significant between-group differences in sex distribution (male: female 8:5 vs. 6:4; P = 0.89), body mass index (mean ± SD, 24.7 ± 2.8 vs. 25.1 ± 3.2 kg/m^2; P = 0.66), smoking history (current or former smokers, 30.8% vs. 20.0%; P = 0.52), or ASA physical status (I–II, 92.3% vs. 90.0%; P = 1.00). Together, these data confirm that the two groups were well matched at baseline. A power analysis determined that the minimum sample size required for evaluating the primary outcome (i.e., operation failure or success) using a Chi-square test corresponds to a medium effect size (Cohen's d = 0.5). Additionally, the analysis revealed that a sample of 23 subjects is sufficient to detect a medium effect (Cohen's d = 0.56) with the Chi-square test, as well as large effects (Cohen's d = 1.9) when using a two-sample, two-sided *t*-test.

The average age of patients with flap failure was 38 years (95% CI: 24.2 – 51.8), while for those with successful outcomes, the average age was 34.7 years (95% CI: 28.5 – 40.9). No significant difference in age was observed between groups undergoing single or double-vein anastomosis. Confounding factors such as age, diabetes, and smoking did not show significant differences between the two groups. The odds ratio for single-vein anastomosis compared to double-vein anastomosis was 4.0 (95% CI: 0.37 – 43.14, *P*-value = 0.25), indicating no significant difference in surgical outcomes. However, there was a trend suggesting a possible benefit for double-vein anastomosis (Table 1).

Regarding venous thrombosis, the comparison of single-vein versus double-vein anastomosis showed a positive trend favoring double-vein anastomosis, but the difference was not statistically significant (P = 0.49, Table 2).

Notably, no patients in the double-vein group experienced severe or moderate congestion. Additionally, the double-vein anastomosis group demonstrated a higher likelihood of no congestion post-surgery (Odds ratio = 7.7, P = 0.089, Table 3).

Capillary refill times did not significantly differ between the two groups. A more significant proportion of patients in the double-vein anastomosis group had a bright-colored flap (58.2% vs. 41.2%, *P*-value< 0.05), with no patients in the double-vein group experiencing a dark-colored flap (Table 4).

Comparison of all variations that were collected are summarized in Table 5.

Table 1: Operative outcomes by number of veins (n = 23)

Number of veins	Failure Number (%)	Success (%)	Total
1 vein	4 (30.8)	9 (69.2)	13
2 veins	1 (10)	9 (90)	10

Table 2: Venous thrombosis by number of veins (n = 23)

Number of veins	No Thrombosis N(%)	Thrombosis N(%)	Total
1 vein	11 (84.6)	2 (15.4)	13
2 veins	10 (100)	0	10

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Table 3: Congestion by number of veins (n = 23)

Number of veins	No congestion N(%)	Mild congestion N(%)	Moderate congestion N(%)	Severe congestion N(%)	Total
1 vein	7 (53.8)	3 (23.1)	1 (7.7)	2 (15.4)	13
2 veins	9 (90)	1 (10)	0	0	10

Table 4: Blood color by number of veins (n = 23)

Number of veins	Bright color N(%)	Dark color N(%)	Total
1 vein	7 (53.8)	6 (46.2)	13
2 veins	10 (100)	0	10

Table 5: Comparison of outcomes between single and dual anastomosis groups

Outcome	Single Anastomosis Group (n=13) (%)	Dual Anastomosis Group (n=10) (%)	*P*-value
Flap viability			
Flap Success Rate	69.2 (9/13)	90 (9/10)	0.25
Thrombosis			
Venous Thrombosis	15.4(2/13)	0 (0/10)	0.49
Arterial Thrombosis	15.4 (2/13)	10 (1/10)	1.00
Congestion			
No Congestion	53.8(7/13)	90 (9/10)	0.089
Mild Congestion	23.1 (3/13)	10 (1/10)	0.60
Moderate Congestion	7.7 (1/13)	0 (0/10)	1.00
Severe Congestion	15.4 (2/13)	0 (0/10)	0.49
Capillary refill times			
<1 sec	30.8 (4/13)	10 (1/10)	0.34
1–2 sec	46.2 (6/13)	80 (8/10)	0.20
>2 sec	23.1 (3/13)	10 (1/10)	0.60
Blood color			
Dusky	46.2 (6/13)	0 (0/10)	**0.019**
Pale	53.8 (7/13)	100 (10/10)	—

DISCUSSION

This study aimed to evaluate the outcomes of free flap surgery based on the number of venous anastomoses, comparing single versus dual venous anastomosis.

Evidence on whether dual venous anastomoses improve overall flap survival is mixed. Some studies report higher flap success rates with two venous outflows, while others find no difference [22-24]. Recent meta-analyses have generally shown no statistically significant difference in total flap failure (i.e., complete flap loss) between single-vein and dual-vein techniques [22]. In our study, the flap success rate was higher in the dual venous anastomosis group (90%) compared to the single venous anastomosis group (69.2%), though this difference was not statistically significant (*P*-value = 0.25). This aligns with prior studies suggesting a trend toward improved outcomes with dual venous anastomosis, though statistical significance is often lacking [25]. The consensus is that two veins may offer a potential benefit as a "backup" drainage, but consistent survival advantages have not been conclusively demonstrated [22, 26, 27].

Dual venous anastomoses are thought to reduce venous congestion by providing a parallel drainage pathway for flap outflow [28, 29]. Multiple studies have shown that adding a second venous anastomosis can lower the incidence of venous congestion and related complications [30]. In our study, none of the patients in the dual anastomosis group experienced severe or moderate congestion, and there was a trend toward fewer cases of congestion

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overall (Odds ratio = 7.7, P = 0.089). This finding aligns with research suggesting that dual venous anastomosis may be particularly beneficial in large or high-risk flaps that generate greater blood volume. Improved venous outflow with two veins appears especially beneficial in large or high-risk flaps that generate greater blood volume; in fact, "bigger flap" size has been identified as a risk factor for venous compromise, suggesting those flaps may benefit from a second venous drainage [31-34]. Overall, using two venous anastomoses can enhance venous return and reduce congestion, particularly for bulky flaps or cases with higher outflow demand [30, 34].

However, given our small sample size, these findings should be interpreted cautiously, as some studies suggest that single venous anastomoses are sufficient for smaller flaps.

Most comparative studies have not found significant differences in capillary refill time—a clinical indicator of flap perfusion—between single and dual venous anastomosis groups. This is consistent with our results, as we found no significant differences in capillary refill times between the two groups. As long as one adequate vein is draining the flap, capillary refill and flap surface color tend to remain normal, and adding a second vein does not markedly change those immediate perfusion signs [28]. Our findings reinforce the notion that while dual venous anastomoses can serve as an insurance against venous congestion, they do not necessarily enhance microcirculation or capillary refill in a measurable way [35].

The impact of single vs. dual venous anastomoses on venous thrombosis has been investigated in several studies. A meta-analysis by Riot et al. found that flaps with two venous anastomoses had a significantly lower microsurgical venous thrombosis rate compared to those with one vein (approximately 2.3% vs. 3.1%) [36]. Similarly, an earlier systematic review reported that performing two venous anastomoses reduced the incidence of venous thrombosis by about one-third [22, 37, 38]. Our study showed a similar trend, as no venous thrombosis was observed in the dual anastomosis group compared to a 15.4% incidence in the single anastomosis group (P-value = 0.49). While this suggests that dual venous anastomoses may reduce thrombosis risk, some experts argue that adding a second anastomosis could introduce another site for thrombosis or slow venous outflow [28]. In practice, however, most aggregated data lean toward dual veins either lowering or having no major impact on thrombosis risk, rather than increasing it. In summary, while dual anastomoses may modestly decrease venous thrombosis rates in free flaps, the difference is not dramatic (36). Our findings reinforce the idea that while dual venous anastomoses may help prevent venous thrombosis, careful microsurgical technique remains crucial regardless of the number of venous connections.

Limitations

This study has several limitations that must be considered when interpreting the results. First, the sample size was relatively small (23 patients), which limits the statistical power and generalizability of the findings. A larger cohort would be necessary to detect more subtle differences between single and dual venous anastomoses in terms of flap success rates, venous thrombosis, and congestion.

Second, the study was conducted at a single institution, and the outcomes may not be generalizable to other settings or surgical teams. Variability in surgical technique, postoperative care, and patient selection criteria can influence free flap outcomes, introducing potential biases.

Third, this was an observational, cross-sectional study, meaning causality cannot be inferred. While we compared the outcomes of single versus dual venous anastomoses, other confounding factors—such as patient comorbidities, flap type, and variations in anastomosis technique—may have played a role in the observed trends. Future prospective randomized controlled trials are needed to control these variables.

Lastly, the lack of long-term follow-up is a limitation. This study evaluated outcomes only at immediate postoperative time points and at discharge, without assessing long-term flap viability or late-onset complications such as delayed venous thrombosis or tissue necrosis.

CONCLUSION

This study provides valuable insight into the potential benefits of dual venous anastomoses in free flap surgery. While our results demonstrated a positive trend in flap success rates and reduced venous thrombosis with dual anastomosis, these differences were not statistically significant. This suggests that

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dual venous anastomosis may offer advantages, particularly in preventing venous congestion and improving flap drainage. However, the benefits may not be substantial enough to universally recommend this technique over single venous anastomosis in all free flap procedures.

Further research with larger sample sizes and long-term follow-up is needed to confirm these findings and clarify the role of dual venous anastomosis in reducing complications and improving flap survival. Additionally, future studies should explore patient- and flap-specific factors that may determine when dual venous anastomosis is most beneficial, ultimately guiding surgical decision-making to optimize outcomes.

ETHICAL STATEMENT

This study was approved by the Iran University of Medical Sciences (IR.IUMS.FMD.REC.1403.220).

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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