Clinical Research

Comparison between free and pedicled anterolateral thigh flaps and surgical outcomes in soft tissue reconstruction

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ABSTRACT

BACKGROUND The anterolateral thigh (ALT) flap, harvested either as a free flap with microsurgical anastomosis or as a pedicled flap with an intact blood supply, is widely used to repair soft tissue defects. This study aimed to evaluate the ALT flap, both free and pedicled variants, as a reliable option for reconstruction, focusing on flap viability and complications.

METHODS This cross-sectional study included 30 patients who underwent free or pedicled ALT flap reconstruction at IGNG Ngoerah Hospital, Bali, between 2020 and 2024. Inclusion criteria were complete medical records and confirmed vascular flow on preoperative Doppler ultrasound. Statistical analysis was performed using Fisher's exact test for bivariate analysis. The primary outcomes evaluated were the incidence of complications and their association with the type of flap.

RESULTS ALT flaps were used as free flaps in 60% of cases and as pedicled flaps in 40%. Most patients were adult males, with flap placements mainly in the abdomen (36.7%). Wound dehiscence and necrosis occurred in 13.3% of cases. Wound dehiscence and complications requiring follow-up occurred more frequently in patients undergoing free flap procedures (38.9% *versus* 8.3%, $p<0.001$; 22.2% *versus* 0%, $p = 0.001$). In contrast, the incidence of necrosis was comparable between the two flaps (16.75% *versus* 8.3%, $p = 0.632$).

CONCLUSIONS The free ALT flap showed a higher risk of partial flap necrosis and required more intensive monitoring. Pedicled ALT flap demonstrated a lower complication rate and more straightforward postoperative care, suggesting a more favorable option.

KEYWORDS necrosis, reconstructive surgical procedures, soft tissue injuries, surgical flaps, thigh, wound dehiscence

Flaps are tissue segments used for functional, reconstructive, and cosmetic purposes that may sustain their own blood supply when displaced from anatomical sites. Tissue segments can include skin, subcutaneous tissue, and complex composite tissues, such as muscle, fat, bone, and fascia. Soft tissue reconstruction constitutes a critical component of modern surgical practice, particularly in cases involving extensive tissue loss resulting from trauma, oncological resection, or congenital anomalies.[1,2]

The anterolateral thigh (ALT) flap is a widely favored procedure because of its benefits, including extended vascularization, a broad skin area, and minimal donor site complications.[1,2] Owing to its versatile composition and vascular supply, the ALT flap can be used to reconstruct various anatomical regions, including the lower abdomen, perineum, groin, gluteal region, and thigh. The flap can be harvested either as a free flap with a microsurgical anastomosis or as a pedicled flap with an intact blood supply. Both

techniques have proved successful; however, whether to use a free or pedicled ALT flap is often based on the surgeon's preference, the defect site, and the resources available at the institution.[3] Free ALT flaps offer a broader reach and greater positional flexibility through microsurgical transfer, making them ideal for distant reconstruction. In contrast, pedicled ALT flaps retain their native blood supply without the complexity of microsurgical anastomosis.

A high number of soft tissue injuries and defects occur in Indonesia due to trauma, oncologic resections, and infections.[4] Although free and pedicled ALT flaps are widely used in soft tissue reconstruction, studies comparing the outcomes and complication rates between free and pedicled flaps in an Indonesian population are limited. lacking with limitations. For instance, Summa et al[5] substantiated the use of ALT flaps in abdominal wall reconstruction, but found no significant differences in outcomes between the free and pedicled forms. However, the lack of comparative analyses across several anatomical indications limits the generalizability of these findings to a wider surgical community. Similarly, Kayano et al[6] reported that pedicle and free ALT flaps are reasonable choices for complicated abdominal wall reconstructions, noting longer operative times for the free ALT flaps but similar complication rates for both techniques.

This study aimed to further validate the ALT flap, both free and pedicled, as a dependable choice for soft-tissue defect restorations by evaluating the complications, intervention types, and outcomes.

METHODS

This cross-sectional study used the total sampling method. The inclusion criteria were patients of any age who underwent free or pedicled ALT flap reconstruction at the IGNG Ngoerah Hospital between 2020 and 2024 with complete medical records, including demographic data (age and sex), comorbidities, surgical technique, flap type, Doppler ultrasound findings, complications (wound dehiscence and necrosis), and the need for reoperation within the three-month postoperative period owing to these complications. All surgical procedures were performed by a plastic surgeon with 16 years of clinical experience. Patients with incomplete records were excluded. Imputation techniques were not applied to the missing data. All patients were followed up for at least one month postoperatively.

All data were obtained from the electronic medical records. The type of flap used (free or pedicled) was recorded in the operative and surgical notes. The outcome variables included flap viability, wound dehiscence, necrosis, and the need for further surgical procedures (total wound dehiscence and flap necrosis). The patients were assessed using postoperative notes, discharge summaries, and follow-up records. Predictor variables included patient demographics, comorbidities (e.g., diabetes and hypertension), and defect location, as recorded during preoperative assessments and surgical indications.

A plastic surgeon with 16 years of experience performed postoperative vascular assessments using Doppler ultrasonography. A strong flow was classified as a triphasic waveform with a constant amplitude and no signal demodulation, indicating normal arterial patency. In contrast, any arterial obstruction, whether critical or noncritical in terms of proximal arterial flow, was defined as monophasic or biphasic waveforms, decreased peak systolic velocities, or attenuated signals, which denote arterial narrowing or obstruction. The venous flow was assessed using Doppler ultrasonography. The features of venous congestion included reverse flow, turbulence of the return flow, or the absence of continuous low-resistance signals.[1,2] Wound dehiscence was characterized as a partial or total separation of any surgical wound within the first 14 days postoperatively but before the complete repair of the wound; this was verified in the clinical notes or by direct examination.[7] Necrosis implies that any part of the flap has died, as evidenced by the presence of black or otherwise non-viable tissue; this was noted during follow-up evaluations or when debridement was required.[8] Indications for surgical exploration or further follow-ups included necrosis, dehiscence, non-progressive infection requiring debridement, or any complications otherwise associated with conservative management.[9]

To ensure comparability between the groups, all variables were assessed using standardized definitions and careful documentation from patient medical records. The same procedures, instruments, and criteria were uniformly applied to the free and pedicle flap groups. To address potential confounding factors, key clinical covariates, such as patient age, comorbidities

(e.g., diabetes mellitus and hypertension), smoking status, defect location, and flap size, were identified a priori based on clinical relevance and a literature review. These covariates were assessed and balanced between the groups during the descriptive analysis. In addition, bivariate analyses using Fisher's exact test were employed to evaluate the associations between the flap type and categorical outcomes (e.g., venous congestion, arterial blockage, wound dehiscence, and necrosis). Although a multivariate analysis was not performed due to the limited sample size, efforts were made to standardize surgical techniques and perioperative care, along with stratified subgroup reporting, to minimize confounding bias. A *p*-value <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS version 30.0 (IBM Corp., USA).

RESULTS

In total, 40 cases were reviewed, of which 10 were excluded because of incomplete records. Thus, 30 patients met the inclusion criteria and were included in the study; 18 patients (60%) underwent free ALT flap reconstruction, and 12 (40%) received pedicled ALT flaps. The average follow-up duration was three months. Most patients were adult males, and most defects were located in the abdomen and lower limbs. Immediate postoperative Doppler ultrasonography showed strong arterial flow in all cases, with venous congestion or delayed arterial blockage observed in only one patient. Complications, such as wound dehiscence and necrosis, occurred in 13.3% of patients (95% confidence interval: 3.8–30.7%). Necrosis occurred more frequently in the free-flap group than in the pedicle group, although the difference was not statistically significant ($p = 0.632$). However, significantly more patients in the free-flap group required follow-up procedures (such as debridement and re-suturing surgery) than those in the pedicle group ($p = 0.001$). Wound dehiscence was observed exclusively in the free-flap group, which differed significantly from the pedicle group ($p<0.001$). Detailed demographic data and participant outcomes are presented in Table 1.

Table 1. Characteristics of study samples and association between interventions

Variables	Intervention to patients	
	Free ALT, n (%) (N = 18)	Pedicled ALT, n (%) (N = 12)
Age (years)		
<18	2 (11.1)	0 (0)
18–65	15 (83.3)	12 (100)
>65	1 (5.6)	0 (0)
Sex		
Male	17 (94.4)	10 (83.3)
Female	1 (5.6)	2 (16.7)
Flap location		
Face	0 (0)	1 (8.3)
Neck	0 (0)	1 (8.3)
Abdomen	2 (11.1)	8 (66.7)
Upper Limb	4 (22.2)	2 (16.7)
Lower Limb	12 (66.7)	0 (0)
Flap size (cm^2)		
<100	2 (11.1)	3 (25.0)
>100	16 (88.9)	9 (75.0)
Doppler ultrasound		
Strong flow	18 (100)	12 (100)
Weak flow	0 (0)	0 (0)
Venous congestion	1 (5.6)	0 (0)
Arterial clogging	1 (5.6)	0 (0)
Wound dehiscence*	4 (22.2)	0 (0)
Necrosis†	3 (16.8)	1 (8.3)
Complications that require further follow-ups‡	7 (38.9)	1 (8.3)

ALT=anterolateral thigh
*$p<0.001$; †$p = 0.632$; ‡$p = 0.001$. All statistical analyses were performed using Fisher's exact test

DISCUSSION

This study highlighted the differences in complication profiles between free and pedicled ALT flaps. Flap necrosis occurred exclusively in the free-flap group, suggesting a higher vulnerability of free flaps to ischemic complications. This was most likely attributable to the complexity associated with the microsurgical anastomoses necessary for free flaps, as a single small technical error, thrombosis, or slight misalignment—often undetectable intraoperatively—can easily result in compromised perfusion and subsequent tissue loss. In contrast, when pedicled flaps are used, physiological perfusion and venous return are directly maintained by the native vasculature without the need for microvascular connections, thus enabling better flap viability. This intrinsic vascular continuity underpins the more favorable outcomes associated with pedicled ALT flaps, particularly in anatomically stable regions, such as the groin, perineum, and lower

abdomen, which is consistent with the findings of Mishra et al[10] and Sharma et al.[11]

Wound dehiscence occurred more frequently in the free-flap group than in the pedicle flap group, but the difference was statistically insignificant. Nonetheless, the anatomical context is clinically relevant. Free flaps are predominantly used for lower limb defects, which are regions subjected to significant mechanical tension, shear forces, and postoperative movement, all of which can compromise wound healing. Although pedicle flaps were used in areas not typically considered optimal for healing, no wound dehiscence occurred, suggesting a possible advantage conferred by the stable vascular supply and limited movement in these regions. In agreement with the findings of Lee et al,[7] these results reaffirm that flap placement and vascular dynamics are significant determinants of the postoperative outcome. Proper flap placement and monitoring of vascular dynamics (including blood flow, perfusion, and microvascular anastomosis integrity) are significant determining factors for successful postoperative outcomes in free-flap reconstruction. Knoedler et al[12] stated that the survival of free flaps depends on the patency and integrity of the microvascular anastomosis. In our study, the one case of venous congestion in the free-flap group further highlighted the sensitivity of these flaps to slight disturbances in venous outflow, which can pathologically provoke necrosis and dehiscence. Despite confirming adequate arterial inflow with Doppler ultrasonography, venous congestion suggests that the dynamics of flap survival involve both inflow and outflow. Notably, a systematic review of 4,747 deep inferior epigastric perforator and transverse rectus abdominis myocutaneous flaps reported 2.8% intraoperative venous congestion despite patent anastomoses, underscoring the critical role of venous outflow in flap survival.[13]

Necrosis rates were higher, yet statistically insignificant (p = 0.632), in the free-flap group than in the pedicle flap group. Although this difference was not statistically significant, the pattern is clinically significant. Lese et al[14] reported that longer pedicle lengths and larger flap sizes, which are common in free flaps, may increase the incidence of vascular compromise. Complications requiring reoperation were significantly more frequent when using free flaps. Mohanty et al[15] described similar results. In their multicenter series, 36.8% of patients experienced postoperative complications, including partial or total necrosis. Despite these differences, both techniques showed high flap survival, confirming the overall reliability of ALT flaps. In this study, eleven patients (61.1%) who underwent free ALT flap reconstruction experienced successful outcomes, similar to the results reported by Atilgan et al[16] in a similar cohort, where the outcome was successful in 96% of cases. Pedicled ALT flaps used for reconstruction in the groin, inguinal, and lower abdominal areas showed excellent results, and only one minor case of venous congestion was managed in the intraoperative extension of the pedicle.

In general, free ALT flaps offer diverse options for distal reconstructions; however, they are also subject to a considerably higher rate of priori complications because of microvascular technical demands and site-specific risks. Pedicled ALT flaps, with all vascularities preserved intact and less exposure to tensile forces, remain a robust option for reconstructing nearby regional defects. Thus, individualized flap selection needs to be established according to the defect site, vascular condition, and surgeon expertise to ensure maximal clinical benefits.

This study has several limitations. First, its retrospective nature limited the ability to control for all possible confounding variables. Although every effort was made to include relevant predictors, such as age, comorbidities, and defect location, other unmeasured factors could have still influenced the outcomes. Second, the relatively small sample size limits the statistical power of this study. Third, the study was conducted in a single tertiary care center; therefore, it may not accurately reflect the surgical practices, postoperative care protocols, or patient population characteristics in other institutions. Therefore, the external validity may also be limited, especially in institutions with different resource policies or expertise related to microvascular and flap reconstruction. Finally, the limitations regarding follow-up data made it difficult to evaluate delayed complications, recurrence of soft tissue defects, or donor site morbidity, and the three-month follow-up period precluded long-term evaluation of donor site morbidity and aesthetic outcomes.

In conclusion, the ALT flap is a reliable and versatile technique for soft tissue reconstruction. While both pedicled and free flaps demonstrated high success rates, the pedicled ALT flap was associated with

fewer complications, particularly wound dehiscence and the need for reoperation. These differences are influenced by flap vascular stability and the mechanical environment of the recipient site. When anatomically feasible, pedicle flaps offer a safer and more efficient reconstruction solution. However, careful microsurgical planning and postoperative monitoring are essential in flap-free cases to minimize complications. Further prospective multicenter studies with larger sample sizes are warranted to validate these findings and assess long-term outcomes.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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