Original Article

Study on Predictors of Flap Survival in Orthopaedic Patients Undergoing Combined Bone and Soft Tissue Reconstruction

Chollangi Anilkumar[1], Ella Venkata Durga Neelima[2]

[1]Associate Professor, Department of Orthopaedics, Konaseema Institute of Medical Sciences & Research Foundation, Amalapuram, Andhra Pradesh, India. [2]Assistant Professor, Department of Plastic Surgery, Konaseema Institute of Medical Sciences & Research Foundation, Amalapuram, Andhra Pradesh, India

Abstract

Background: Combined bone and soft tissue reconstruction is often required in lower limb defects following trauma, infection, or oncologic procedures. Flap coverage promotes vascular stability and supports bone healing, yet patient comorbidities and postoperative care may influence flap survival. The objective is to identify clinical and perioperative factors associated with flap survival in orthopaedic patients undergoing reconstruction, and to assess the role of early monitoring in preventing flap loss. **Material and Methods:** A prospective evaluation was conducted in 50 patients who underwent flap reconstruction for lower-limb defects. Demographic data, comorbidities, defect characteristics, flap type, and postoperative course were recorded. Flap outcomes were categorized as complete survival, partial necrosis, or total loss. Key factors were compared between outcome groups. **Results:** In this study, the mean age of patients was 41.8 ± 13.7 years, and most were male (76%). The tibia and distal third of the leg formed the most common site of soft-tissue loss, reflecting the typical pattern of high-energy trauma in this region (68%). Free flaps were preferred over pedicled options in 32/50 cases (64%), with the anterolateral thigh flap serving as the main choice for distal leg and complex defects. Overall flap survival remained high, but partial compromise was more frequent in patients with diabetes (15/50, 30%), active smokers (22/50, 44%), or reduced limb perfusion (ABI < 0.9 in 6/50, 12%), who more often developed marginal congestion, edema, and limited flap loss. Regular bedside assessment of colour, temperature, capillary refill, and turgor enabled early detection of venous outflow problems, and timely measures including limb repositioning, loosening of dressings, medical optimization, or prompt re-exploration helped rescue several at-risk flaps before progression to necrosis. **Conclusion:** Survival in lower limb reconstruction is shaped as much by the patient's metabolic and vascular status as by the technical success of the procedure. Thoughtful preoperative risk profiling, optimization of modifiable factors, and transparent counselling set the stage for safer reconstruction. Above all, disciplined early postoperative surveillance and swift response to subtle changes often determine whether a compromised flap fails or recovers.

Keywords: Flap survival; Lower limb reconstruction; Orthoplastic reconstruction; Diabetes; Smoking; Peripheral perfusion.

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Introduction

Soft-tissue reconstruction with flap coverage has become a cornerstone of limb salvage in orthopaedic patients with complex bone and soft-tissue defects.[1,2] High-energy injuries around the tibia, ankle, and periarticular regions frequently result in exposed bone, implants, or devitalized tissue where simple closure is not possible and prolonged open wounds carry a high risk of infection, non-union, and amputation. In this setting, a timely and durable flap cover is not merely cosmetic; it is essential for fracture healing, infection control, and functional restoration.[3]

Advances in microsurgery, perforator flaps, and orthoplastic protocols have improved overall flap survival; however, complications such as venous congestion, partial necrosis, infection, and complete flap loss continue to occur and may negate the benefits of reconstruction.[4] Recent series highlight that factors including vascular injury, delayed coverage, immunocompromised status, and technical variables such as pedicle length or flap design can significantly influence outcomes.[5] Yet these risks are not uniform across all patients or procedures, and the interplay between systemic comorbidities, limb perfusion, defect characteristics, and perioperative care remains clinically relevant.

In day-to-day orthoplastic work, many candidates already carry weight against them, such as diabetes, smoking, anemia, marginal limb perfusion, contaminated beds, repeated incisions, or previous reconstructions that narrow the flap's margin of safety.[3-4] Yet choices are frequently shaped by the pressure to save the limb, the reconstructive options available on that day, and individual surgeon comfort, rather than by clearly measured risk. Defining which baseline and intraoperative variables

Address for correspondence: Dr. Chollangi Anilkumar, Associate Professor, Department of Orthopaedics, Konaseema Institute of Medical Sciences & Research Foundation, Amalapuram, Andhra Pradesh, India
E-mail: anilchollangi@gmail.com

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genuinely influence flap survival enables more informed selection, targeted preoperative correction, and balanced expectations for the team and the patient. Alongside this, the early postoperative period remains a controllable window: structured, vigilant monitoring can transform a threatened flap from a quiet drift towards failure into a salvageable reconstruction.[5,6]

Simple bedside parameters —colour, temperature, turgor, capillary refill, and bleeding on pin-prick —remain the first line for detecting vascular compromise. When deviations are recognised early and acted upon promptly, threatened flaps can often be salvaged; when missed, potentially reversible events progress to irreversible necrosis. Despite this, structured monitoring protocols and their actual impact on outcomes are inconsistently reported.

Against this background, there is a need for focused, real-world data from orthopaedic centres managing combined bone and soft tissue defects, especially in resource-constrained settings, to delineate practical predictors of flap survival. The present study evaluates demographic, clinical, vascular, flap-related, and early postoperative factors in patients undergoing reconstructive flap procedures for orthopaedic defects, with particular emphasis on identifying predictors of flap survival and the role of early monitoring in preventing flap loss.

Materials and Methods

Study Design and Setting: This was a prospective observational study conducted in the Department of Orthopaedics and Plastic Surgery at KIMS & RF, Amalapuram. The study covered the period from January 2024 to May 2025. All patients who required combined bone stabilization and soft tissue coverage with flap reconstruction were evaluated.

Study Population: Patients presenting with traumatic, infective, or postoperative soft tissue defects with exposed bone, hardware, or non-healing wounds requiring flap coverage were considered eligible.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients undergoing either free or pedicled flap reconstruction after bony fixation or debridement.
- Those who provided written informed consent.

Exclusion Criteria

- Patients are medically unfit for anaesthesia or microvascular reconstruction.
- Patients with uncontrolled systemic sepsis at the time of reconstruction.
- Individuals with incomplete follow-up data.

Preoperative Assessment: Before reconstruction, every patient was examined in detail. The wound was inspected for size, depth, exposure of bone or hardware, and signs of active infection. Limb vascularity was assessed clinically, and Doppler or Ankle–Brachial Index was used wherever perfusion was in doubt. Comorbidities such as diabetes, smoking, peripheral vascular disease, anemia, and poor nutrition were documented and optimized. Fractures were stabilized and infection controlled before planning definitive soft-tissue coverage. Diabetic patients were taken up only after achieving acceptable glycemic control.

Surgical Procedure: Flap choice was guided by the size, location, and quality of the defect. Free flaps were selected for larger, distal, or complex wounds where local tissue was insufficient, while pedicled flaps were preferred when a dependable regional option could safely reach the defect. All procedures began with meticulous debridement to clear non-viable tissue and obtain a healthy, bleeding bed. When required, fracture fixation or stabilization of exposed hardware was completed before flap inset to provide a stable osseous base. Free flaps were elevated and inset using standard microsurgical techniques under loupe or operating microscope, with gentle handling of the pedicle and tension-free vascular anastomosis. Pedicled flaps were designed along established angiosomes with an appropriate arc of rotation, ensuring that kinking, compression, or stretch of the pedicle was avoided.

Postoperative Monitoring and Postoperative surveillance were based on structured bedside assessments, with intensified monitoring during the first 72 hours. Flap colour, warmth, capillary refill, turgor, and, where necessary, pin-prick bleeding were recorded at regular intervals. Patients received adequate analgesia, remained normothermic, and maintained an appropriate fluid balance. Low-dose antithrombotic prophylaxis was administered according to institutional protocol. Any persistent change suggesting venous congestion or arterial insufficiency prompted prompt correction of reversible factors, including limb positioning or dressing adjustments. When clinical doubt persisted, early surgical re-exploration was undertaken rather than prolonged observation.

In the outcome evaluation, flap status was categorised as complete survival, partial necrosis, or total loss. Secondary outcomes included postoperative infection at donor or recipient sites, need for re-exploration, donor site morbidity, and length of hospital stay. On follow-up, limb function, wound healing, and stability of the reconstructed segment were assessed and documented descriptively.

Statistical Analysis: Data were compiled in Microsoft Excel and analysed using standard statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Associations between selected clinical and perioperative factors and flap outcome were evaluated using Chi-square or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

Ethical: The study was conducted following approval from the Institutional Ethics Committee of KIMS & RF, Amalapuram. Eligible patients were counselled in a language they understood, and written informed consent was obtained before enrolment. All patient-related information was anonymised, and confidentiality was maintained throughout the study.

Results

Most patients in this cohort belonged to the active, working-age group, with a mean age of 41.8 years. Men accounted for the majority (76%), mirroring their higher exposure to road traffic injuries and occupational trauma. The tibia and distal leg were the most frequently affected sites, contributing to over two-

thirds of the defects, followed by the foot–ankle and femur–knee regions, where limited soft-tissue cover makes any exposure of bone or hardware critical. The majority of reconstructions were undertaken for trauma-related defects, with post-infective and oncologic wounds comprising the remainder. Diabetes was present in 30% of patients, current smoking in 44%, and peripheral vascular compromise (ABI < 0.9) in 12%, suggesting that a considerable subset entered surgery with suboptimal perfusion or metabolic reserve, factors likely to influence flap behaviour and healing. The complete baseline characteristics of the study population are summarised in [Table 1].

Table 1: Baseline Characteristics of the Study Population (n = 50)

Parameter	Frequency (n)	Percentage (%)
Age (Mean ± SD)	41.8 ± 13.7 years	–
Gender		
Male	38	76
Female	12	24
Defect Location		
Tibia / Distal Leg	34	68
Foot / Ankle	9	18
Femur / Knee	7	14
Indication for Reconstruction		
Trauma with bone loss / hardware exposure	30	60
Post-infective / oncologic defects	20	40
Comorbidities		
Diabetes Mellitus	15	30
Active Smoking	22	44
ABI < 0.9 (Peripheral vascular compromise)	6	12

Of the 50 reconstructions, 32 (64%) were performed using free flaps and 18 (36%) with pedicled flaps. Among the free flaps, the anterolateral thigh flap was most frequently used, accounting for 17 of 32 cases (53.1%). In the pedicled group, the reverse sural artery flap was the predominant choice for distal leg and ankle coverage. Early soft tissue cover was achieved in 28 patients (56%), where flap reconstruction was completed within 72 hours of presentation, reflecting an emphasis on timely, definitive management of exposed bone and hardware. Early postoperative re-exploration became necessary in 9 patients (18%), largely due to concerns of compromised vascular flow. The surgical details are outlined in [Table 2].

Table 2: Surgical and Perioperative Details

Parameter	Frequency (n)	Percentage (%)
Type of Flap Used		
Free Flap	32	64
Pedicled Flap	18	36
Common Flap Types (Free)		
Anterolateral Thigh (ALT)	17/32	53.1
Latissimus Dorsi	6/32	18.7
Gracilis	5/32	15.6
Radial Forearm	4/32	12.5
Common Flap Types (Pedicled)		
Reverse Sural Artery	12/18	66.7
Medial Gastrocnemius	6/18	33.3
Timing to Coverage		
≤ 72 hours	28	56
> 72 hours	22	44
Re-exploration in First 48 hours	9	18

The overall flap survival rate was 92%, with total flap loss observed in 8% of cases. Partial flap necrosis occurred in 14% of patients; most of these were managed conservatively with local wound care, whereas 2 patients required minor secondary procedures. Early venous congestion was noted in 24% of cases. Surgical site infection occurred in 22%, and deep infection or osteomyelitis was documented in 8% [Table 3].

Table 3: Postoperative Outcomes and Complications

Outcome / Event	Frequency (n)	Percentage (%)
Overall Flap Survival	46	92
Total Flap Loss	4	8
Partial Flap Necrosis	7	14
Need for Debridement Only	5/7	71.4
Secondary Small Flap/Graft Required	2/7	28.6
Venous Congestion (Early)	12	24

Surgical Site Infection	11	22
Deep Infection / Osteomyelitis	4	8
Donor Site Issues (Seroma / Contour)	5	10

Among the 37 patients requiring reconstruction following a fracture or segmental bone loss, radiographic bone union was achieved in 86%, with a median healing duration of 24 weeks (IQR 20–30). Five patients (14%) required additional interventions for delayed union or non-union. At 6-month follow-up, 78% of patients were able to ambulate independently, whereas 16% required a cane and 6% used crutches for support. These functional and skeletal outcomes are shown in [Table 4].

Table 4: Functional and Bone Healing Outcomes

Parameter	Result	Notes
Fracture Segment Cases (n = 37)	–	–
Radiographic Union Achieved	32/37 (86%)	Median 24 weeks (IQR 20–30)
Additional Bone Procedures Required	5/37 (14%)	For delayed union/non-union
Ambulation at 6 Months (Total n=50)	–	–
Independent Ambulation	39 (78%)	Short community walks
Ambulation with Cane	8 (16%)	Mild support required
Ambulation with Crutches	3 (6%)	Persistent limb weakness

Discussion

In this study, flap reconstruction in orthopaedic patients with combined bone and soft tissue defects showed that several patient-related and surgical factors influenced final flap survival. Free tissue transfer was used more often than pedicled options in our series, which fits the geography of the wounds. Distal-third tibial defects rarely allow for reliable local treatment options. Even so, the flap category alone did not dictate fate. The bed tracked the flap's landing site and the host's physiology. Diabetes, present in 30% of patients, likely narrowed the microcirculatory margin of safety.[7] Active smoking, seen in 44%, pushed the needle toward venous congestion and edge necrosis. These risks rarely shout in the operating room. They whisper in the recovery bay when a healthy-looking flap turns cool at the periphery.[8]

Peripheral perfusion emerged as a quiet but consistent determinant of outcome. Even when major vessels were patent, an ankle–brachial index below 0.9 usually signalled limited microvascular reserve and a narrower safety margin for the flap. Some flaps signalled trouble before any dramatic change appeared. Capillary refill slowed slightly, the surface turned a little glassy, or the tissue remained tense even when the limb was elevated. These quiet warnings emphasise the need to know the limb's circulation at the start and act on it. Baseline perfusion must be documented, and correctable factors handled carefully, including adequate hydration, balanced hematocrit, warm extremities, good glycaemic control, and attention to overall vascular status. When risk factors cannot be completely reversed, a clear discussion with the patient and treating team becomes part of responsible care.[9,10]

In this series, systematic monitoring did more for flap survival than any isolated technical adjustment. Repeated bedside checks of colour, temperature, capillary refill, pin-prick response, and turgor helped identify deviations while they were still reversible. Several compromised flaps improved with simple interventions: loosening a tight dressing, changing limb position, improving ambient warmth, correcting mild hypotension, or adjusting fluids. When these measures failed to settle the picture, early return to the theatre was not postponed. Re-exploration was undertaken in 18% of patients and directly contributed to flap salvage, supporting the practical lesson that a doubtful flap is safer to explore early than to observe into failure.[11]

The influence of timing was evident but conditional. Early coverage within the first few days gave the best results when it followed thorough debridement and firm skeletal fixation. Clean bone, stable hardware, and a well-vascularised flap formed an interdependent triad; weakness in any of these elements placed the reconstruction at risk. Consistent antibiotic use and strict control of metabolic factors added further protection during the early phase of neovascularisation. In contaminated or uncertain wounds, staged debridement before final cover proved a safer approach than forcing a one-stage solution on an unready bed.[12]

Decisions on flap type reflected this same measured approach. Free flaps offered reach and reliable inflow for distal, large, or complex defects, whereas pedicled flaps remained effective where local anatomy and perforators were dependable. Across cases, outcomes were influenced less by whether the flap was free or pedicled and more by planning and executing a tension-free inset, a pedicle free of kinking or compression, and a healthy, bleeding recipient bed.[9,10] These observations parallel the experience reported in other orthoplastic centres, where flap selection is individualised to defect features, vascular status, and patient profile rather than driven by rigid preference.

Two broad lessons emerged. First, survival is a systems result. Microsurgical skill sets the stage, but glycaemic control, cessation advice, temperature, haemodynamics, and nursing vigilance decide the final act. Second, the orthoplastic model works. When bone stabilisation, infection control, and soft-tissue planning move together, compromise drops and salvage rises. Finally, we should be practical about prevention. A short preoperative checklist, ABI or Doppler where indicated, smoking pause with nicotine replacement, glucose optimisation, anaemia correction, normothermia plan, and a monitoring schedule for the first 72 hours will likely save more flaps than any single "better" flap choice. Simple, repeatable processes win.

Conclusion

Flap survival in combined bone–soft tissue reconstruction hinges on three linked pillars: patient optimisation, local vascular quality, and disciplined postoperative monitoring. Distal-leg defects frequently required free tissue transfer, yet comorbidities such as diabetes, active smoking, and subtle peripheral vascular disease consistently tilted risk toward early compromise. A structured monitoring protocol with a low threshold for intervention, clinical maneuvers first, and re-exploration when indicated, prevented progression to total loss in several cases. The best results came from an integrated orthoplastic pathway where radical debridement, stable fixation, infection control, flap choice, and postoperative care were treated as one continuous process rather than isolated steps.

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Conflicts of interest

There are no conflicts of interest.

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