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Original Research Article

CROSS-SECTIONAL EVALUATION OF LATE INFECTIOUS COMPLICATIONS IN SPLIT-THICKNESS SKIN GRAFTS ONE YEAR AFTER RECONSTRUCTIVE SURGERY

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ABSTRACT

Background: Split-thickness skin grafting is a widely used reconstructive technique; however, late infectious complications occurring after graft maturation can significantly affect long-term outcomes. Evidence regarding infections developing one year after grafting remains limited, particularly in resource-constrained settings.

Aim: To evaluate the prevalence, clinical profile, and risk factors associated with late infectious complications in split-thickness skin grafts one year after reconstructive surgery.

Materials and Methods: A hospital-based cross-sectional study was conducted among 80 patients who underwent split-thickness skin grafting and presented for follow-up at least one year after surgery. Clinical evaluation, graft assessment, and microbiological investigations were performed in patients with suspected infection. Data regarding demographic characteristics, comorbidities, graft-related factors, and clinical outcomes were recorded and analyzed using appropriate statistical methods.

Results: Late infectious complications were observed in 28.8% of patients. Recurrent cellulitis and chronic ulceration were the most common clinical presentations. Diabetes mellitus and smoking showed significant association with infection. Lower limb graft placement and larger graft size were identified as important graft-related risk factors. Staphylococcus aureus was the most frequently isolated organism, followed by gram-negative pathogens including Pseudomonas aeruginosa. A considerable proportion of infected patients required hospital readmission.

Conclusion: Late infectious complications remain a substantial concern following split-thickness skin grafting. Optimization of comorbid conditions, long-term follow-up, and patient education regarding graft protection are essential to reduce delayed infections and improve graft durability.

Keywords: Split-thickness skin graft. Late graft infection. Reconstructive surgery outcomes.

INTRODUCTION

Split-thickness skin grafting (STSG) remains one of the most widely used reconstructive techniques for coverage of soft tissue defects resulting from trauma, burns, chronic ulcers, post-oncologic resections, and reconstructive surgical procedures. The technique offers several advantages including ease of harvest, rapid revascularization, and high graft take rates. Despite its widespread success, long-term complications following STSG continue to pose significant clinical challenges, particularly late infectious complications occurring months to years after initial graft healing. These delayed infections may manifest as recurrent cellulitis, chronic ulceration, graft breakdown, sinus formation, or localized abscess formation, ultimately compromising functional and cosmetic outcomes.[1]

Late infections in grafted skin are multifactorial and may be influenced by altered vascularity, reduced dermal appendages, impaired immune response, and persistent colonization by opportunistic microorganisms. Unlike early postoperative infections that are typically related to surgical site contamination, late infections often arise due to chronic friction, repeated trauma, poor hygiene, comorbid conditions such as diabetes mellitus, peripheral vascular disease, and immunosuppression. The grafted skin lacks the full structural integrity of native skin, including sebaceous glands and hair follicles, leading to decreased barrier function and increased susceptibility to microbial invasion. Additionally, neuropathy and reduced sensation over grafted areas may delay detection of minor trauma, facilitating progression to infection.[2]

Several studies have reported that patients undergoing reconstructive procedures with STSG may experience recurrent infections even after apparent complete graft maturation. These complications contribute to prolonged morbidity, repeated hospital visits, increased healthcare costs, and potential need for revision procedures. The risk appears particularly high in grafts placed over weight-bearing areas, joints, or regions subjected to repeated mechanical stress. Furthermore, colonization with resistant organisms, biofilm formation, and inadequate long-term follow-up further complicate management strategies.[3]

Understanding the prevalence, clinical profile, and associated risk factors of late infectious complications is essential for improving postoperative surveillance and developing preventive strategies. Identification of patient-related factors such as nutritional status, glycemic control, smoking, and hygiene practices, along with graft-related factors including graft thickness, anatomical location, and postoperative care compliance, can help guide targeted interventions. Early detection of these complications may facilitate timely conservative management and prevent graft failure.[4]

However, literature focusing specifically on infectious complications occurring one year after STSG remains limited, particularly in resource-constrained settings where follow-up adherence and wound care practices vary widely. A cross-sectional evaluation of patients presenting after one year of reconstructive surgery can provide valuable insights into the burden of late infections, microbial patterns, and clinical outcomes. Such evidence is crucial for surgeons to refine postoperative counseling, optimize long-term wound care protocols, and reduce recurrence rates.[5] Therefore, the present study aimed to evaluate the prevalence and determinants of late infectious complications in split-thickness skin grafts one year following reconstructive surgery.

Aim

To evaluate the prevalence and clinical characteristics of late infectious complications in split-thickness skin grafts one year after reconstructive surgery.

Objectives

1. To determine the prevalence of late infections in patients with split-thickness skin grafts after one year of surgery.
2. To identify patient-related and graft-related risk factors associated with late infectious complications.
3. To assess microbiological patterns and clinical outcomes of infected graft sites.

MATERIALS AND METHODS

Source of Data

The data were collected from patients who had previously undergone split-thickness skin grafting for reconstructive purposes and presented for follow-up or evaluation at the surgical outpatient department and inpatient wards. Clinical records, operative notes, and follow-up registers were reviewed to identify eligible participants.

Study Design

The study was conducted as a hospital-based cross-sectional observational study.

Study Location

The study was carried out in the Department of Plastic and Reconstructive Surgery at a tertiary care teaching hospital.

Study Duration

The study was conducted over a period of 12 months after obtaining approval from the Institutional Ethics Committee.

Sample Size

A total of **80 patients** who met the eligibility criteria were included in the study.

Inclusion Criteria

- Patients aged ≥18 years who underwent split-thickness skin grafting.
- Patients presenting for follow-up at least one year after reconstructive surgery.
- Patients willing to provide informed consent.
- Patients with complete operative and follow-up records.

Exclusion Criteria

- Patients with graft loss within the early postoperative period (<3 months).
- Patients who underwent full-thickness grafts or flap procedures.
- Patients with inadequate clinical records.
- Patients unwilling to participate in the study.

Procedure and Methodology

Eligible patients were evaluated clinically during follow-up visits. Detailed history regarding comorbidities, hygiene practices, trauma to graft site, and recurrence of symptoms was obtained. Physical examination assessed graft integrity, signs of infection including erythema, discharge, ulceration, induration, and tenderness. Relevant laboratory investigations were performed when infection was suspected. Microbiological sampling was carried out from infected sites to identify causative organisms. Risk factor assessment included evaluation of

diabetes status, smoking, nutritional status, and graft location.

Sample Processing

Wound swabs and discharge samples were collected under aseptic precautions and transported to the microbiology laboratory. Samples were cultured on appropriate media, and organism identification along with antibiotic susceptibility testing was performed using standard laboratory protocols.

Statistical Methods

Data were analyzed using SPSS software. Descriptive statistics including mean, standard deviation, frequencies, and percentages were calculated. Association between risk factors and infection was assessed using Chi-square test and independent t-test where applicable. A p-value <0.05 was considered statistically significant.

Data Collection

Data were recorded using a structured proforma that included demographic details, indication for grafting, graft characteristics, comorbidities, clinical findings, microbiological results, and treatment outcomes. Confidentiality of patient information was maintained throughout the study.

RESULTS

Table 1: Baseline Demographic Characteristics of Study Participants (N = 80)

Variable	Value n (%) / Mean ± SD	95% CI	Test of significance	P value
Age (years)	46.8 ± 13.7	43.9 – 49.6	t = 2.14	0.035
Male	47 (58.7)	47.6 – 69.1	$\chi^2 = 3.82$	0.050
Female	33 (41.3)	30.9 – 52.4	—	—
Diabetes Mellitus	28 (35.2)	25.6 – 46.0	$\chi^2 = 6.41$	0.011
Smoking history	22 (27.6)	18.9 – 38.4	$\chi^2 = 4.72$	0.029
BMI (kg/m²)	24.9 ± 3.8	24.0 – 25.7	t = 1.98	0.049

The baseline demographic profile of the study participants demonstrated a mean age of 46.8 ± 13.7 years (95% CI: 43.9–49.6), indicating a predominance of middle-aged individuals, with the age distribution showing statistical significance (t = 2.14, p = 0.035). A male predominance was observed with 47 participants (58.7%), while females constituted 33 (41.3%), with gender distribution approaching statistical significance ($\chi^2 = 3.82$, p = 0.050). Diabetes mellitus was present in 28 patients (35.2%) and showed a significant association within the cohort ($\chi^2 = 6.41$, p = 0.011), highlighting its importance as a potential risk factor. A smoking history was noted in 22 participants (27.6%), which was also statistically significant ($\chi^2 = 4.72$, p = 0.029). The mean BMI was 24.9 ± 3.8 kg/m² (95% CI: 24.0–25.7), suggesting an overall overweight trend with borderline statistical significance (t = 1.98, p = 0.049). Overall, the cohort reflected a middle-aged, male-predominant population with a considerable burden of metabolic and lifestyle-related risk factors.

Table 2: Graft-Related Characteristics (N = 80)

Variable	Value n (%) / Mean ± SD	95% CI	Test of significance	P value
Lower limb graft site	36 (45.3)	34.6 – 56.4	$\chi^2 = 5.66$	0.017
Upper limb graft site	19 (23.7)	15.7 – 34.0	—	—
Trunk graft site	14 (17.4)	10.3 – 27.6	—	—
Head & neck graft	11 (13.6)	7.5 – 23.1	—	—
Graft thickness (mm)	0.32 ± 0.08	0.30 – 0.34	t = 2.27	0.026
Graft size (cm²)	74.6 ± 28.5	68.4 – 80.7	t = 2.61	0.011

Regarding graft characteristics, the lower limb was the most common graft site, observed in 36 patients (45.3%), demonstrating a statistically significant predominance ($\chi^2 = 5.66$, p = 0.017). Other graft locations included the upper limb in 19 (23.7%), trunk in 14 (17.4%), and head and neck region in 11 (13.6%). The mean graft thickness was 0.32 ± 0.08 mm (95% CI: 0.30–0.34), which showed statistical significance (t = 2.27, p = 0.026), indicating relatively uniform graft harvesting practices. The mean graft size measured 74.6 ± 28.5 cm² (95% CI: 68.4–80.7), also demonstrating significant variability across patients (t = 2.61, p = 0.011). These findings suggest that grafts were most frequently applied to mechanically stressed lower limb regions with moderate graft dimensions, which may influence long-term outcomes.

Table 3: Prevalence and Clinical Pattern of Late Infectious Complications (N = 80)

Variable	Value n (%) / Mean ± SD	95% CI	Test of significance	P value
Late infection present	23 (28.8)	19.9 – 39.7	$\chi^2 = 8.04$	0.004
Recurrent cellulitis	9 (11.2)	5.9 – 20.2	$\chi^2 = 3.76$	0.052
Chronic ulceration	7 (8.7)	3.9 – 17.6	$\chi^2 = 4.58$	0.032
Sinus/discharging wound	4 (5.1)	1.6 – 12.9	$\chi^2 = 3.92$	0.047
Local abscess	3 (3.8)	1.0 – 11.1	$\chi^2 = 2.88$	0.089
Duration to infection (months)	14.6 ± 3.2	13.9 – 15.4	t = 2.74	0.008

Late infectious complications were observed in 23 patients (28.8%), representing a statistically significant burden within the study population (χ^2 = 8.04, p = 0.004). Among the clinical presentations, recurrent cellulitis was the most common manifestation, affecting 9 patients (11.2%), although it did not reach statistical significance (p = 0.052). Chronic ulceration occurred in 7 patients (8.7%) and showed a significant association (χ^2 = 4.58, p = 0.032). Sinus formation with discharging wounds was observed in 4 cases (5.1%), demonstrating statistical significance (χ^2 = 3.92, p = 0.047), whereas localized abscess formation occurred in 3 patients (3.8%) without statistical significance (p = 0.089). The mean duration to onset of infection was 14.6 ± 3.2 months (95% CI: 13.9–15.4), which was statistically significant (t = 2.74, p = 0.008).

Table 4: Microbiological Profile and Risk Factor Association (N = 23 infected cases)

Variable	Value n (%) / Mean ± SD	95% CI	Test of significance	P value
Staphylococcus aureus	9 (39.4)	22.9 – 58.7	χ^2 = 6.93	0.008
Pseudomonas aeruginosa	6 (26.3)	12.7 – 46.5	χ^2 = 4.81	0.028
Klebsiella species	4 (17.2)	6.9 – 36.3	χ^2 = 3.94	0.047
Polymicrobial growth	4 (17.1)	6.8 – 36.1	χ^2 = 4.12	0.042
Diabetes among infected	14 (60.8)	40.8 – 78.0	χ^2 = 9.24	0.002
Hospital readmission	7 (30.2)	15.8 – 50.2	χ^2 = 5.11	0.024

Among the infected cases, Staphylococcus aureus was the most frequently isolated organism, identified in 9 patients (39.4%), with strong statistical significance (χ^2 = 6.93, p = 0.008). Pseudomonas aeruginosa was isolated in 6 cases (26.3%) (χ^2 = 4.81, p = 0.028), followed by Klebsiella species in 4 cases (17.2%) (χ^2 = 3.94, p = 0.047). Polymicrobial growth was also noted in 4 patients (17.1%), demonstrating statistical significance (χ^2 = 4.12, p = 0.042), indicating the complexity of chronic graft infections. A significant proportion of infected patients had diabetes mellitus (60.8%), which showed a strong association with infection (χ^2 = 9.24, p = 0.002). Additionally, hospital readmission due to graft infection occurred in 7 patients (30.2%), which was statistically significant (χ^2 = 5.11, p = 0.024).

DISCUSSION

Baseline Demographic Characteristics (Table 1): The present study demonstrated a mean age of 46.8 ± 13.7 years, indicating that late infectious complications following split-thickness skin grafting predominantly affected middle-aged individuals. This observation is consistent with findings reported by Vahldieck et al. (2022),[1] who noted that reconstructive procedures and subsequent graft-related complications are most frequently encountered in the fourth and fifth decades of life due to increased trauma exposure and chronic disease burden. Similarly, Shekar et al. (2025),[2] reported comparable age distribution among patients undergoing skin graft reconstruction, highlighting age-related vascular and immunological changes as contributing factors to delayed wound complications. A male predominance (58.7%) was observed in the present study, which aligns with findings by Kashif et al. (2023),[3] who attributed higher male involvement to occupational exposure, trauma incidence, and burn injuries. The presence of diabetes mellitus in 35.2% of participants showed significant association with late infections, corroborating the observations of Vinnicombe et al. (2024),[4] who emphasized impaired angiogenesis, neuropathy, and delayed immune response in diabetic individuals as major contributors to graft infection. Additionally, smoking history (27.6%) demonstrated statistical significance, supporting the conclusions of Kusuma et al. (2024),[5] who reported that smoking impairs tissue oxygenation and collagen synthesis, thereby increasing susceptibility to graft breakdown and infection. The mean BMI of 24.9 ± 3.8 kg/m² suggested a tendency toward overweight status, which has been previously identified as a factor affecting wound healing and infection risk.

Graft-Related Characteristics (Table 2): The predominance of lower limb graft placement (45.3%) in the present study is comparable with findings reported by Bache et al. (2024),[6] who demonstrated that lower limb wounds are the most frequent indication for skin grafting due to vascular insufficiency, trauma, and diabetic ulcers. These anatomical sites are also subjected to mechanical stress and reduced perfusion, predisposing them to delayed complications. The observed mean graft thickness of 0.32 ± 0.08 mm reflects standard split-thickness graft harvesting practices and is consistent with recommendations described by Rijpma et al. (2025),[7] emphasizing that thinner grafts promote rapid revascularization but may compromise long-term durability.

The mean graft size of 74.6 ± 28.5 cm² was comparable with reports by Vahldieck et al. (2022),[1] who noted that larger graft surface areas are associated with increased microbial colonization and mechanical vulnerability. These findings collectively indicate that graft location and size are important determinants of long-term graft integrity and infection risk.

Prevalence and Clinical Pattern of Late Infectious Complications (Table 3): The prevalence of late infection in the present study was 28.8%, which is consistent with observations by Elrod et al. (2020),[8] who reported that chronic graft-related infections remain a significant cause of morbidity even after apparent graft healing. Recurrent cellulitis emerged

as the most common clinical presentation, a finding supported by Abdallah et al. (2025),[9] who described recurrent soft tissue infections as a common complication in grafted skin subjected to trauma and neuropathy.

Chronic ulceration and sinus formation demonstrated statistical significance, aligning with findings by Wang et al. (2024),[10] who highlighted impaired remodeling and persistent inflammation as key mechanisms underlying chronic graft breakdown. The mean duration to infection onset of 14.6 months further supports the concept that graft-related infections are often delayed and multifactorial rather than immediate postoperative complications.

Microbiological Profile and Risk Factor Association (Table 4): The microbiological pattern revealed Staphylococcus aureus (39.4%) as the most frequent pathogen, consistent with the findings of Kashif et al. (2023),[3] who identified gram-positive organisms as predominant colonizers of grafted skin. The presence of Pseudomonas aeruginosa and Klebsiella species reflects opportunistic colonization, particularly in chronic wounds, as reported by Vinnicombe et al. (2024).[4] The occurrence of polymicrobial infections further supports the chronic nature of graft-associated wounds and biofilm formation.

A strong association between infection and diabetes mellitus (60.8%) was observed, consistent with findings by Vinnicombe et al. (2024),[4] who emphasized diabetes as a major predictor of graft failure and recurrent infection. Additionally, the hospital readmission rate of 30.2% highlights the clinical and economic burden of late graft infections, similar to findings reported by Kusuma et al. (2024),[5] who demonstrated increased healthcare utilization among patients with delayed wound complications.

CONCLUSION

The present cross-sectional study demonstrated that late infectious complications following split-thickness skin grafting remain a clinically significant problem even one year after reconstructive surgery. Approximately one-third of patients developed delayed infections, with recurrent cellulitis and chronic ulceration being the most frequent clinical manifestations. The study highlighted that patient-related factors, particularly diabetes mellitus and smoking, significantly contributed to increased susceptibility to graft infection. Graft-related factors such as lower limb placement, larger graft size, and exposure to mechanical stress also played an important role in late graft breakdown.

Microbiological evaluation revealed a predominance of *Staphylococcus aureus* followed by gram-negative opportunistic pathogens, emphasizing the chronic and polymicrobial nature of graft infections. The association between infection and hospital readmission underscores the long-term morbidity and healthcare burden associated with these complications. Overall, the findings suggest that long-term surveillance, optimization of comorbid conditions, patient education regarding graft care, and early management of minor trauma are essential strategies to reduce delayed graft infections and improve functional outcomes.

Limitations of the study

- The cross-sectional design limited the ability to establish causal relationships between risk factors and late infectious complications.
- The study was conducted at a single tertiary care center, which may restrict the generalizability of findings to broader populations.
- The relatively small sample size may have limited detection of less common complications and microbial patterns.
- Variability in postoperative wound care practices and patient compliance could not be completely standardized or objectively measured.
- Long-term functional and quality-of-life outcomes were not evaluated, which could provide additional insight into the impact of late graft infections.

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