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Infections Following Skin Graft Surgery at Two Regional Centres - Characteristics, Risk Factors and Microbiology of Infection

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Abstract

Background: Skin grafts including split-thickness skin grafts (SSG) and full-thickness skin grafts (FTSG) are widely used in reconstructive surgery. Infection following grafting can compromise graft take and prolong hospitalisation, yet contemporary cohort data describing incidence, microbiology and graft-specific risk factors remain limited. Methods: We conducted a retrospective observational cohort study of 977 consecutive skin graft procedures performed in 116 patients at two regional hospitals in New South Wales, Australia, between 1 July 2021 and 13 August 2024. Post-graft infection was defined as a clinician-diagnosed graft site infection with microbiological confirmation. Infection incidence was estimated with exact 95% confidence intervals. Associations between graft characteristics and infection were explored using chi-square testing and binomial regression to estimate relative risks. Length of stay (LOS) was assigned to the index admission corresponding to each procedure and analysed using negative binomial regression to account for overdispersion. Results: Among 977 graft procedures, 66 infections occurred, giving an overall infection incidence of 6.8% (95% CI 5.3–8.5%). Median LOS was substantially longer in infected cases than non-infected cases (34 vs 3 days, $p < 0.001$). Full-thickness grafts to the face (RR 0.083, 95% CI 0.008–0.827) and nose (RR 0.038, 95% CI 0.004–0.378) were associated with a reduced incidence of infection, although estimates were imprecise because of sparse data. Among infections, Staphylococcus aureus accounted for approximately 47% of cases and Pseudomonas aeruginosa for approximately 20%. In a nested antimicrobial audit cohort of 111 split-thickness skin graft procedures, peri-operative prophylaxis was common, postoperative antibiotics were frequently prescribed and postoperative antibiotic prescribing was not associated with reduced infection although the analysis was underpowered. Conclusions: Post-graft infection occurred in 6.8% of procedures. This rate is comparable with contemporary literature and was associated with substantial morbidity. S. aureus and P. aeruginosa predominated. These findings support consideration of targeted preventive strategies, microbiology-informed empiric therapy and antimicrobial stewardship, while highlighting the need for prospective studies with more comprehensive risk adjustment.

Keywords: surgical site infection; skin graft; antimicrobial stewardship; microbiology; postoperative infection; antibiotic prophylaxis

1. Introduction

Skin grafts (SG) including split-thickness skin grafts (SSG) and full-thickness skin grafts (FTSG) are widely used in reconstructive and plastic surgery for trauma, burns and oncologic defects [1]. Infection following grafting can compromise graft take, prolong hospital stay and increase healthcare costs [2,3]. While surgical site infections (SSIs) are well described across many surgical specialties [4] large contemporary cohort data specific to skin grafting remain limited particularly in Australian inpatient settings.

The microbiology of post-SG infection is also not well characterised. Although *Staphylococcus aureus* and *Pseudomonas aeruginosa* are frequently implicated in wound infections [5,6] their relative contribution to graft-related infections has not been clearly defined in large cohorts.

This study aimed to quantify the incidence of post-graft infection in a large cohort, describe the associated microbiology and examine graft-related risk factors for infection including graft type and anatomical site. A secondary aim was to describe antimicrobial prescribing practices in a nested audit cohort of split-thickness skin graft procedures.

2. Methods

2.1. Study Design and Population

We conducted a retrospective observational cohort study of all SSG and FTSG procedures performed at Wyong and Gosford Hospitals (Central Coast Local Health District, NSW, Australia) between 1 July 2021 and 13 August 2024. All adult and paediatric patients undergoing grafting during the study period were eligible. Procedures were identified from institutional operative records, discharge summary diagnosis codes and electronic medical records. Microbiological information was obtained from electronic medical records and laboratory systems.

Cases were defined as graft procedures complicated by post-operative graft site infection meeting the predefined outcome definition. Where patients underwent multiple graft procedures, each procedure was analysed as a separate observation because infection risk was considered procedure specific.

2.2. Ethics and Governance

This project was conducted as a clinical audit using routinely collected data under local governance processes. Formal human research ethics committee approval and individual consent were not required.

2.3. Outcomes

The primary outcome was post-graft infection defined as a clinician-diagnosed graft site infection with microbiological confirmation, that is, a positive culture from a graft site specimen such as wound swab, aspirate or tissue. Where multiple cultures were obtained for a single episode, organisms were de-duplicated at the episode level.

Secondary outcomes were length of hospital stay, microbiological profile of infections and associations between graft type and anatomical site with infection. In the antimicrobial audit cohort, additional outcomes included peri-operative prophylaxis, postoperative antibiotic prescribing, microbiological sampling, directed therapy, infectious diseases consultation, length of antimicrobial therapy and infection follow-up.

2.4. Data Collection and Analysis

Data were extracted from electronic medical records, operative records and laboratory information systems. Variables included graft type, anatomical site, microbiology results and length of stay (LOS). Details on comorbidities such as diabetes, wound class, contamination status and peri-operative antibiotic prophylaxis were not consistently available in the main cohort and were therefore not analysed as covariates.

Infection incidence was estimated using exact (Clopper–Pearson) 95% confidence intervals. Associations between graft characteristics and infection were assessed using chi-square testing and binomial regression to estimate relative risks. Given the limited number of infection events and sparse data across graft subgroups analyses were restricted to univariable models and should be considered exploratory.

LOS was defined as the duration of the hospital admission during which the graft procedure was performed (index admission). For patients undergoing multiple graft procedures within a single admission, the same LOS was assigned to each procedure. LOS was analysed at the procedure level using negative binomial regression to account for overdispersion. Because procedures from the same patient were not independent, this approach does not account for within-patient clustering, may overestimate precision and thus results should be interpreted as exploratory. In addition, infection may have occurred during the admission, so the observed association between infection and LOS may reflect both prolonged stay due to infection and increased infection risk with longer hospitalisation.

Statistical significance was defined as a two-sided $p < 0.05$. Organism-specific regression analyses for S. aureus and P. aeruginosa were also explored but several graft categories were excluded due to perfect prediction and estimates were unstable because of sparse data.

3. Results

3.1. Infection Incidence

Among 977 graft procedures in 116 patients, 66 met the study definition for post-graft infection, giving an overall infection incidence of 6.8% (95% CI 5.3–8.5%) (Table 1). The high number of procedures per patient reflects repeated grafting, staged procedures and revision surgeries within the study cohort. Procedures were analysed as the unit of observation as repeat grafting occurred in some patients. A patient-level sensitivity analysis was not performed due to data limitations

Table 1. Study Population and Infection Prevalence.

Parameter	Value
Total procedures	977
Infections	66
Overall infection rate	6.8% (95% CI: 5.3 – 8.5%)
Study Period	1st July 2021 – 13th August 2024

3.2. Length of Stay

Hospitalisation was substantially longer among infected cases. The median LOS was 34 days in infected cases compared with 3 days in non-infected cases ($p < 0.001$), representing an approximately tenfold difference (Table 2). As noted above, this association may reflect both prolonged stay attributable to infection and increased infection risk during longer admissions.

Table 2. Infection Incidence and Length of Stay.

Measure	Numerator/Value	Denominator/Comparator	Result
Post-graft infection	66	977 procedures	6.8% (95% CI 5.3–8.5%)
LOS, infected cases	34 days	Median	$p < 0.001$ vs non-infected
LOS, non-infected cases	3 days	Median	$p < 0.001$ vs infected

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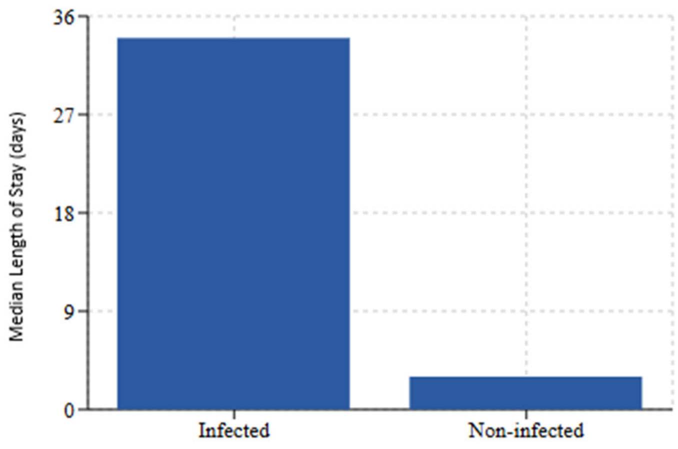

Figure 1. Median length of hospital stay by infection status. Infected patients had a 10-fold longer median hospital stay (34 vs 3 days, $P < 0.001$).

3.3. Graft Type and Anatomical Site Risk Associations

In graft-specific analyses, full-thickness grafts to the face were associated with a reduced incidence of infection (RR 0.083, 95% CI 0.008–0.827; p = 0.034), as were full-thickness grafts to the nose (RR 0.038, 95% CI 0.004–0.378; p = 0.005) (Table 3). However, these estimates were imprecise with wide confidence intervals reflecting sparse data and low numbers of events and should be interpreted as hypothesis-generating.

No other graft type–site categories demonstrated statistically significant associations with infection. Several categories contained small numbers of observations and some were excluded from regression analyses due to perfect prediction, limiting the stability of estimates.

Table 3. Significant Graft Type–Site Associations with Infection.

Graft category	Relative risk	95% CI	p value	Interpretation
Full-thickness graft to face	0.083	0.008–0.827	0.034	Reduced incidence; imprecise estimate
Full-thickness graft to nose	0.038	0.004–0.378	0.005	Reduced incidence; imprecise estimate

3.4. Microbiology

Microbiological isolates are summarised in Table 4. Among the 66 infections, Staphylococcus aureus was the most frequently identified organism, accounting for approximately 47% of cases. Pseudomonas aeruginosa was the second most common pathogen, representing approximately 20% of infections.

Across all procedures, *S. aureus* was isolated in 31 of 977 procedures (3.2%, 95% CI 2.2–4.5%) and *P. aeruginosa* in 15 of 977 procedures (1.5%, 95% CI 0.9–2.5%). Other organisms were less frequent, including *Escherichia coli* in 7 procedures (0.7%, 95% CI 0.3–1.5%) and *Group B streptococci* in 6 procedures (0.6%, 95% CI 0.2–1.3%). *Acinetobacter baumannii, Enterobacter cloacae, Enterococcus faecium, Granulicatella adiacens, Haemophilus influenzae, Morganella morganii, Proteus mirabilis, group A streptococci, group D streptococci* and *Yokenella regensburgei* were each isolated in five or fewer cases and collectively accounted for a minority of infections.

Methicillin-resistant S. aureus accounted for 26% of *S. aureus* isolates, and *Vancomycin-resistant Enterococcus* was identified in a single case.

Table 4. Microbiological Isolates.

Organism	n	% of all procedures	95% CI	Approx. % of infections
Staphylococcus aureus	31	3.2%	2.2–4.5%	~47%
Pseudomonas aeruginosa	15	1.5%	0.9–2.5%	~20%
Escherichia coli	7	0.7%	0.3–1.5%	~11%
Group B streptococci	6	0.6%	0.2–1.3%	~9%
Other organisms (combined)	≤5 each	≤0.5% each	Not estimated	~14% combined

3.5. Organism–Graft Type Associations

A reduced incidence of infection was observed in full-thickness grafts to the face and nose. No other graft sites demonstrated statistically significant associations. Organism-specific regression analyses did not demonstrate significant associations between graft type and infection due to *S. aureus* or *P. aeruginosa* although analyses were limited by small subgroup event counts.

For *S. aureus*, 66 infected cases were spread across 13 different graft categories after categories with perfect prediction were dropped, with one category accounting for nearly half of cases. For P. aeruginosa, 53 infected cases remained across 3 different graft categories after exclusions, again yielding imprecise estimates. Overall, graft type was not a significant predictor of *S. aureus* or *P. aeruginosa* infection.

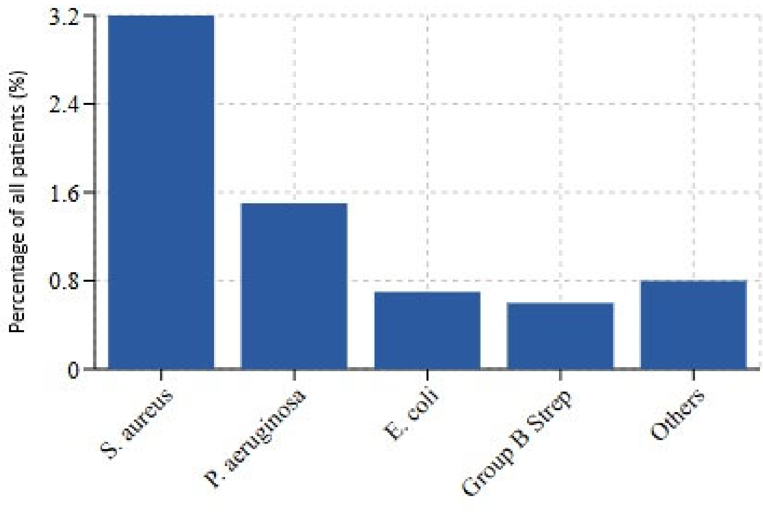

Figure 2. Distribution of microbiological isolates. *S. aureus* was the most common pathogen (3.2%), followed by *P. aeruginosa* (1.5%).

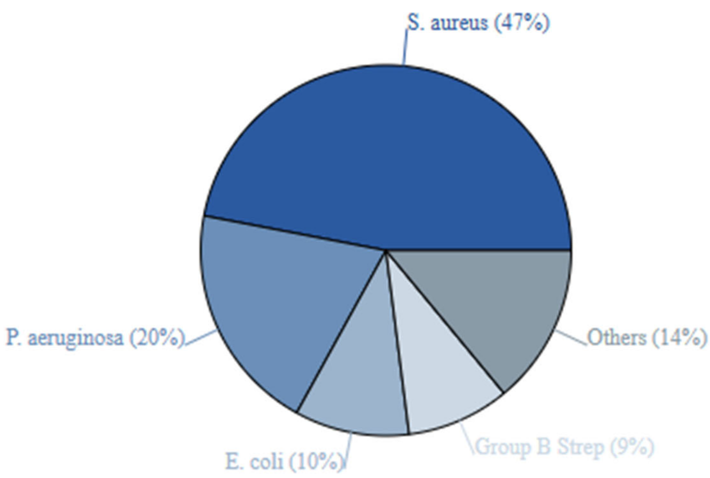

Figure 3. Proportion of infections by organism. *S. aureus* accounted for nearly half of all infections (47%), with *P. aeruginosa* representing 20%.

3.6. Antimicrobial Prescribing Practices in a Nested Audit Cohort

In a patient-level antimicrobial audit cohort of split-thickness skin graft procedures, 111 procedures were included for analysis (Table 5). Peri-operative antibiotic prophylaxis was administered in 89.2% of cases (99/111), most commonly cefazolin as a single preoperative dose.

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Postoperative antibiotics were prescribed in 68.5% of cases (76/111), most frequently cephalexin for 5–7 days.

Microbiological sampling was performed in 36.0% of cases (40/111), while directed antimicrobial therapy following culture results occurred in 10.8% of cases (12/111). Infectious diseases consultation was documented in 7.3% of cases (8/109), reflecting minor missing data for this variable. The median length of antimicrobial therapy was 5 days (IQR 0–5).

Among 106 cases with assessable infection follow-up, 7 infections occurred (6.6%). Postoperative antibiotic prescribing was not associated with infection (4/73 [5.5%] vs 3/33 [9.1%]; RR 0.60, 95% CI 0.14–2.54; p = 0.675), although the analysis was likely underpowered.

Cases with infection were more likely to undergo microbiological sampling (6/39 [15.4%] vs 1/67 [1.5%]; RR 10.31, 95% CI 1.29–82.50; p = 0.0096) and to involve infectious diseases consultation (3/8 [37.5%] vs 4/97 [4.1%]; RR 9.09, 95% CI 2.45–33.77; p = 0.0090). These associations are best interpreted as reflecting escalation of care rather than causal risk factors. Directed therapy, graft failure and length of therapy were not significantly associated with infection.

Table 5. Antimicrobial Prescribing Practices and Infection Outcomes in Nested Audit Cohort.

Variable	Value	Denominator	Comparative statistic	Interpretation
Peri-operative prophylaxis	99	111	89.2%	Commonly used
Postoperative antibiotics	76	111	68.5%	Frequently prescribed
Microbiological sampling	40	111	36.0%	Performed in minority
Directed therapy	12	111	10.8%	Uncommon
ID consultation	8	109*	7.3%	Uncommon
Median length of therapy	5 days	IQR 0–5		Short-course therapy common
Infections in follow-up cohort	7	106*	6.6%	Low event count
Post-op antibiotics vs no post-op antibiotics	4/73 vs 3/33	106*	RR 0.60 (95% CI 0.14–2.54); p = 0.675	No observed association; underpowered
Microbiological sampling in infected vs non-infected	6/39 vs 1/67	106*	RR 10.31 (95% CI 1.29–82.50); p = 0.0096	Escalation of care
ID consultation in infected vs non-infected	3/8 vs 4/97	105*	RR 9.09 (95% CI 2.45–33.77); p = 0.0090	Escalation of care

*Denominators vary due to missing data for specific variables.

4. Discussion

In this large two-site regional hospital cohort, post-graft infection occurred in 6.8% of procedures and was associated with a marked increase in LOS. Reported infection rates following skin grafting range from approximately 3% to 10% depending on patient population, wound complexity and surveillance definitions [16,17]. The observed incidence in our cohort falls within this range, suggesting a clinically meaningful but not excessive infection burden.

In our cohort, infected cases had a markedly prolonged LOS compared with non-infected cases. However because infection may occur during admission this association likely reflects both prolonged hospitalisation due to infection and increased infection risk associated with longer hospital stays.

Our microbiology profile was dominated by *S. aureus* and *P. aeruginosa*. This is biologically plausible given the established role of *S. aureus* in surgical site infection and skin and soft tissue disease [5] while *P. aeruginosa* is a recognised pathogen in chronic wounds and healthcare-associated infection [6]. Prior graft-focused studies have demonstrated variability in pathogen distribution depending on wound type and surgical setting. Unal et al. reported that infection-related graft loss occurred more frequently in vascular ulcers and burn wounds with *P. aeruginosa* the most commonly implicated organism [17]. Abdulmughni et al. also described high postoperative infection rates following split-thickness skin grafting with a predominance of gram-negative organisms including *P. aeruginosa* and *Klebsiella* species [18]. In contrast, our cohort demonstrated a lower overall infection incidence and was dominated by *S. aureus* with *P. aeruginosa* representing a substantial minority of infections. Differences in case mix, wound complexity and surveillance definitions may account for this variation [13].

The microbiological findings of this study may support a microbiology-informed approach to empiric therapy when graft infection is suspected. Given that S. aureus and P. aeruginosa accounted for the majority of infections empiric regimens such as piperacillin-tazobactam or cefepime that provide coverage for these organisms may be considered in selected high-risk patients with prompt de-escalation based on culture results.

The nested antimicrobial audit demonstrated high rates of peri-operative prophylaxis and frequent postoperative antibiotic prescribing, most commonly short courses of cephalexin. Postoperative antibiotics were commonly prescribed in the absence of confirmed infection, while microbiological sampling was performed in fewer than half of cases. Directed therapy following culture results and infectious diseases consultation were infrequent indicating that antimicrobial management was largely empiric.

Postoperative antibiotic prescribing was not associated with reduced infection in this cohort; however, the analysis was limited by small sample size and low event rates. Microbiological sampling and infectious diseases involvement were more common in infected cases reflecting appropriate escalation of care rather than causal associations. These findings highlight an opportunity for antimicrobial stewardship interventions in skin grafting practice, including reducing routine postoperative antibiotic prescribing, increasing microbiological confirmation where infection is suspected and promoting targeted therapy.

The role of peri-operative antibiotic prophylaxis in skin grafting remains uncertain. A systematic review and meta-analysis of elective skin graft procedures reported no statistically significant reduction in SSI with prophylactic antibiotics suggesting limited utility for routine prophylaxis in low-risk elective cases [14]. Australian Therapeutic Guidelines: Antibiotic recommend that routine prophylaxis is not required for clean skin surgery including skin grafting and should be reserved for selected high-risk situations such as contaminated wounds or patients with specific risk factors for adverse outcomes [15].

A reduced incidence of infection was observed in full-thickness grafts to the face and nose. This may reflect favourable vascular supply, smaller graft size, meticulous surgical technique and closer postoperative review of facial wounds. Reconstructive literature suggests FTSG can be used with acceptable complication rates and favourable aesthetic outcomes in selected settings [11,12]. However given the small number of events and limited adjustment for confounders this finding should be interpreted cautiously and validated in prospective studies.

Reported infection rates after skin surgery vary by setting, case mix and surveillance definitions. In dermatologic surgery systematic review data suggest SSI rates are generally low but higher among selected populations particularly immunosuppressed patients and those with diabetes [16]. Although our cohort included a broader reconstructive case mix and used a culture-confirmed case definition the overall rate observed is consistent with a clinically meaningful infection burden in inpatient grafting populations.

Limitations include the retrospective design, reliance on documentation and the requirement for microbiological confirmation which may underestimate clinically diagnosed infections. Only a subset of patients underwent microbiological sampling introducing potential selection bias. The analysis was conducted at the procedure level and multiple procedures per patient were treated as independent observations which may overestimate precision due to clustering. Additionally, limited availability of patient-level covariates such as comorbidities, wound class, graft size and peri-operative antibiotic use precluded multivariable adjustment and observed associations should be interpreted as exploratory. Sparse data across graft subgroups resulted in unstable estimates, wide confidence intervals and perfect prediction in regression models. The antimicrobial audit component was also underpowered to detect differences in infection outcomes.

Future work should prospectively collect key patient and procedural variables, apply standardised surgical site infection definitions and evaluate interventions likely to reduce infection and LOS including structured postoperative review pathways and risk-stratified prophylaxis. Linking microbiology to antimicrobial selection and stewardship outcomes may further reduce unnecessary broad-spectrum exposure while ensuring timely targeted therapy.

5. Conclusions

Post-skin graft infections occurred in 6.8% of procedures. This was a rate comparable with contemporary literature and infections were associated with substantial morbidity. *Staphylococcus aureus* and *Pseudomonas aeruginosa* were the most frequently identified pathogens. These findings support consideration of targeted preventive strategies and microbiology-informed empiric therapy while highlighting opportunities for antimicrobial stewardship and the need for prospective studies with more comprehensive risk adjustment.

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Institutional Review Board Statement: This project was conducted as a clinical audit using routinely collected data under local governance processes. Formal human research ethics committee approval was not required.

Informed Consent Statement: Patient consent was waived because this project was conducted as a retrospective clinical audit using routinely collected de-identified data.

Data Availability Statement: The data supporting the findings of this study contain confidential patient information and are available from the corresponding author upon reasonable request subject to institutional governance approval.

Conflicts of Interest: The authors declare no conflict of interest.

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