Risk Factors and Development of a Prediction Model for Unplanned Reoperation Within 30 Days After Skin Flap Repair in Patients With Basal Cell Carcinoma

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BACKGROUND: Basal cell carcinoma (BCC) is the most common malignant skin tumor worldwide. Unplanned reoperation may occur after local flap repair, increasing patient suffering and medical burden. At present, evidence regarding the risk factors for and prediction models of unplanned reoperation after flap repair for BCC remains insufficient. The aim of this study was to explore the influencing factors associated with unplanned reoperation after flap repair for BCC and to construct a prediction model, thereby providing a basis for clinical risk assessment and individualized treatment.

METHODS: A retrospective cohort study was conducted. A total of 455 patients with BCC who underwent local flap repair at Jiangnan University Medical Center from January 2020 to December 2025 were enrolled. The patients were divided into a reoperation group (45 cases, 9.9%) and a non-reoperation group (410 cases, 90.1%) according to whether unplanned reoperation occurred within 30 days after surgery. Demographic characteristics, tumor-related characteristics, and surgery-related characteristics were collected. Univariate and multivariate logistic regression analyses were used to identify independent influencing factors, and a prediction model was constructed. Receiver operating characteristic (ROC) curve analysis, calibration curves and decision curve analysis (DCA) were used to evaluate the discrimination, calibration and clinical utility of the model. Model performance was internally validated using 1000 bootstrap resampling iterations.

RESULTS: Multivariate logistic regression analysis showed that preoperative fasting glucose, infiltration depth, systemic immune-inflammation index (SII; per 10-unit increase), and flap aspect ratio were independent influencing factors for unplanned reoperation. The AUC of the prediction model was 0.852 (95% CI: 0.792–0.912), with a sensitivity of 0.80 and a specificity of 0.79 at the optimal cut-off value. The calibration curve (Hosmer-Lemeshow test, $p = 0.17$) and decision curve analysis showed that the model had a good fit and provided a net clinical benefit. Internal validation using 1000 bootstrap resampling iterations yielded an optimism-corrected AUC of 0.841.

CONCLUSIONS: Preoperative fasting glucose, infiltration depth, SII, and flap aspect ratio are independent risk factors for unplanned reoperation after BCC flap repair. The prediction model based on these variables demonstrated good discrimination and calibration in this single-center cohort, with potential clinical utility. Further external validation is needed before its application in clinical decision-making. However, as this study focused solely on reoperations occurring within the 30-day postoperative period, late reoperations due to positive margins or residual tumors beyond this period were not captured. Studies with extended follow-up are warranted to comprehensively assess the full spectrum of reoperation risk.

Keywords: skin basal cell carcinoma; flap repair; unplanned reoperations; risk factors; prediction model

Introduction

Basal cell carcinoma (BCC) is the most prevalent skin malignancy worldwide, accounting for approximately 80% of all non-melanoma skin cancers [1,2,3,4], with surgical resection remaining the cornerstone of treatment. For large or invasive BCCs, especially those located in high-risk facial areas, local flap repair is frequently required to reconstruct tissue defects and restore function and aesthetics. Although flap repair is generally effective, it can be complicated by distal necrosis, hematoma, infection, or wound dehiscence. A proportion of these complications are severe enough to necessitate unplanned reoperation within 30 days postoperatively—a hard endpoint that substantially increases patient suffering, prolongs hospitalization, and increases medical costs, while potentially compromising long-term oncologic and aesthetic outcomes [5,6,7,8,9,10,11]. To date, most studies on BCC surgical outcomes have focused on complication rates, such as flap necrosis, infection, or wound healing disturbances

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[12,13,14,15,16], rather than on the more clinically meaningful endpoint of unplanned reoperation. Moreover, the few studies that have examined reoperation risk have been limited by small sample sizes, enrollment from a single anatomic site, and inconsistent variable selection, making it difficult to draw generalizable conclusions or establish a reliable prediction tool. Importantly, while numerous risk factors for flap-related complications have been identified—including patient comorbidities, tumor subtypes, and surgical characteristics—their ability to specifically predict the need for a secondary surgical intervention remains poorly characterized.

Unlike previous investigations that have primarily focused on flap survival, necrosis, infection, or wound healing as standalone outcomes, the present study specifically targets unplanned reoperation as the primary endpoint. This distinction is clinically important, as reoperation represents a more definitive and consequential event—one that directly reflects failure of the initial surgical strategy and imposes substantial physical, psychological, and economic burdens on patients. While risk factors for flap-related complications have been extensively documented, their ability to predict the actual need for a secondary surgical intervention remains largely unverified. Furthermore, many prior studies have merely reconfirmed well-established associations (e.g., diabetes with impaired healing and smoking with microvascular compromise) without translating these findings into actionable risk stratification tools. In contrast, our study seeks to develop and validate a pragmatic prediction model that integrates readily available clinical and pathological variables to estimate an individual patient's probability of requiring reoperation, thereby providing surgeons with a practical tool for perioperative planning and counseling of high-risk patients.

In view of this, the present study adopted a retrospective cohort design and enrolled 455 patients with BCC who underwent flap repair. Clinical data, including demographic characteristics, tumor-related characteristics, and surgery-related characteristics, were systematically collected. Univariate and multivariate logistic regression analyses were used to identify independent influencing factors for unplanned reoperation. The discrimination, calibration and clinical utility of the model were evaluated using receiver operating characteristic (ROC) curve analysis, calibration curves and decision curve analysis, respectively, with the aim of providing evidence to support clinical risk assessment, identification of high-risk patients, and individualized treatment decision-making.

Materials and Methods

Study Participants

This retrospective cohort study included patients with BCC who underwent flap repair at Jiangnan University Medical Center from January 2020 to December 2025. A total of 455 patients were enrolled, including 45 patients (9.9%) who underwent unplanned reoperation and 410 patients (90.1%) who did not undergo reoperation. All reoperations occurring within 30 days postoperatively were identified through a review of our hospital's electronic medical record system and routine postoperative follow-up records. This study was approved by the ethics committee of Jiangnan University Medical Center (approval number: WXEY-2026-1009) and was conducted in accordance with the Declaration of Helsinki.

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: (1) postoperative pathological diagnosis of BCC; (2) receipt of local flap repair; and (3) complete clinical and pathological data. The exclusion criteria were as follows: (1) presence of other types of malignant skin tumors (such as squamous cell carcinoma, melanoma, Merkel cell carcinoma, etc.); (2) severe coagulopathy, immunodeficiency or uncontrolled systemic diseases; and (3) incomplete clinical data or loss to follow-up. Patients were divided into two groups according to whether unplanned reoperation occurred within 30 days after surgery: the reoperation group and the non-reoperation group.

Surgical Procedures and Margin Assessment

All surgeries were performed by experienced plastic surgeons specializing in skin tumor reconstruction. The surgical protocol comprised three sequential phases: tumor excision, intraoperative margin assessment, and flap reconstruction. After macroscopic tumor resection with a standard safety margin (typically 3–5 mm for well-defined lesions and 5–10 mm for ill-defined or high-risk subtypes), the excised specimen was oriented and submitted for pathological examination. Intraoperative frozen section analysis was performed when clinically indicated, whereas permanent pathological examination was used for definitive histopathological assessment. Intraoperative margin assessment was performed prior to flap reconstruction to confirm the absence of residual tumor at the resection bed. If a surgical margin was reported as positive during intraoperative consultation, additional tissue was excised from the corresponding site and re-evaluated until negative margins were confirmed. Flap reconstruction was undertaken only after negative margins were confirmed, either intraoperatively by frozen section analysis or, in selected cases, by permanent pathology after delayed closure. Intraoperative frozen section analysis was performed when the findings were expected to immediately influence surgical management, such as the extent of resection or lymph node dissection. Delayed closure was considered when frozen section analysis was unreliable or unavailable for definitive margin assessment and the anticipated morbidity of immediate closure outweighed the risks associated with awaiting permanent histopathological results. Thus, the decision to proceed with flap repair was contingent upon margin clearance,

and all reconstructive procedures were performed after margin status had been determined. For patients with positive margins identified only on final permanent pathology (i.e., not detected intraoperatively), reoperation for margin revision was performed as a separate procedure and was recorded as an outcome event if it occurred within 30 days. Flap type (advancement, rotation, or transposition) and dimensions were determined based on the size and location of the defect, local tissue laxity, and vascular supply, with the flap aspect ratio (length/width) documented intraoperatively immediately after flap elevation.

Data Collection

Demographic and clinical characteristics, including age, gender, body mass index (BMI), smoking history, hypertension, and American Society of Anesthesiologists (ASA) classification, were retrospectively collected from the hospital electronic medical record system. Tumor-related characteristics included the pathological subtype of BCC (high-risk subtypes included invasive BCC, sclerosing BCC, micronodular BCC, and basosquamous carcinoma; low-risk subtypes included nodular BCC, superficial BCC, pigmented BCC, and fibroepithelioma), tumor location (head and neck, trunk, or limbs), and maximum tumor diameter (mm). Surgery-related characteristics included flap aspect ratio (ratio of flap length to width), flap type (advancement, rotation, or transposition flap), defect area (cm^2), and operative time (min). Additionally, preoperative fasting glucose (mmol/L), tumor infiltration depth (mm), and hematological parameters, including platelet, lymphocyte, and neutrophil counts, were collected. Tumor infiltration depth was assessed histopathologically and measured as the perpendicular distance from the basement membrane of the adjacent normal mucosa to the deepest point of tumor infiltration. The systemic immune-inflammation index (SII) was calculated as platelet count × neutrophil count / lymphocyte count, and the platelet-to-lymphocyte ratio (PLR) was calculated as platelet count / lymphocyte count. Preoperative SII was calculated using the most recent complete blood count results obtained within 7 days before surgery. When multiple measurements were available, the results closest to the time of surgery were selected. All variables were selected based on their availability before the occurrence of unplanned reoperation, ensuring that the model used only pre-outcome information for risk prediction.

Definitions of Outcome Measures and Variables

The primary outcome of this study was unplanned reoperation, defined as any unplanned reoperation due to complications at the same surgical site (including positive margins, flap necrosis, hematoma, infection, etc.) within 30 days after surgery. According to the WHO classification of skin tumors (5th edition), BCC subtypes were categorized as high-risk or low-risk. High-risk subtypes included invasive BCC, sclerosing (morphea-like type) BCC, micronodular BCC, and basosquamous carcinoma, whereas low-risk subtypes included nodular BCC, superficial BCC, pigmented BCC, and fibroepithelioma. Resection margin status was determined according to the postoperative pathological report. A positive margin was defined as the presence of tumor cells at the resection margin, whereas a negative margin was defined as the absence of tumor cells at the resection margin. Flap length was defined as the linear distance from the pivot point (the base of the flap) to the distal tip of the flap, and flap width was measured as the maximum width perpendicular to the longitudinal axis at the widest point of the flap. Both measurements were obtained from intraoperative records documented by the attending surgeon immediately after flap elevation and prior to inset. The flap aspect ratio was calculated as flap length divided by flap width. For regression analysis, the high-risk subtype group was designated as the reference category, with the low-risk subtype compared against it. This coding strategy was used to estimate the protective effect of low-risk histology relative to high-risk histology, thereby yielding an odds ratio (OR) of less than 1 for the low-risk group.

Statistical Analysis

Statistical analyses were performed using R version 4.5.2 (Wooden Christmas-Tree) and SPSS 26.0 (IBM, Armonk, NY, USA). The Shapiro-Wilk test was used to assess the normality of continuous data. Normally distributed continuous variables were expressed as Mean ± standard deviation (Mean ± SD), and comparisons between groups were performed using the independent samples *t*-test. Non-normally distributed continuous variables were expressed as the median (1st quartile, 3rd quartile) [M (Q_1, Q_3)], and comparisons between groups were performed using the Mann-Whitney U test. Count data were expressed as the number of cases (percentage) [n (%)], and comparisons between groups were performed using the chi-square test or Fisher's exact test. Candidate variables for univariate analysis were selected based on clinical relevance and evidence from previous literature. Univariate logistic regression analysis was used to identify potential influencing factors associated with unplanned reoperation. Variables with $p < 0.10$ in the univariate analysis were included as candidate predictors in the multivariate logistic regression model. This threshold ($p < 0.10$) was chosen instead of the more conventional $p < 0.05$ to minimize the risk of type II error and avoid premature exclusion of potentially important predictors, given the limited number of outcome events (45 cases, 9.9%). Independent influencing factors were then selected using stepwise backward elimination based on the Akaike information criterion (AIC). To address the inherent limitations of stepwise regression, including model instability, overfitting, and the potential omission of clinically meaningful variables, the final model was constrained to four predictors to maintain an adequate events-per-variable ratio (EPV ≈ 11:1, exceeding the recommended minimum of 10:1),

and internal validation was performed using 1000 bootstrap resampling iterations to assess optimism-corrected performance. The linearity assumption between continuous variables and the logit of the outcome probability was assessed using the Box-Tidwell test. Receiver operating characteristic (ROC) curve analysis was performed to evaluate model discrimination. The area under the curve (AUC), sensitivity, specificity and optimal cut-off value determined by the Youden index were calculated. To compare the discriminative ability of the combined model with that of individual-variable models, the DeLong test was used to compare the AUCs. Calibration Curves and the Hosmer-Lemeshow goodness-of-fit test were used to evaluate model calibration, and 1000 bootstrap resampling iterations were used to assess the stability of the calibration curve. Internal validation was performed using 1000 bootstrap resampling iterations to obtain optimism-corrected performance measures, including the corrected AUC and calibration slope. Decision curve analysis (DCA) was used to evaluate the net clinical benefit of the prediction model across different threshold probabilities. All tests were two-sided, and $p < 0.05$ was considered statistically significant.

Results

Comparison of Baseline Characteristics of Patients

A total of 455 patients with BCC who underwent flap repair were included in this study. Among them, 45 patients (9.9%) underwent unplanned reoperation after surgery, whereas 410 patients (90.1%) did not undergo reoperation. Among the 45 cases of unplanned reoperation, the reasons were positive margins in 10 cases (22.2%), flap necrosis in 10 cases (22.2%), hematoma in 10 cases (22.2%), infection in 6 cases (13.3%), and other causes in 9 cases (20.0%). The comparison of baseline characteristics between the two groups is shown in Table 1. Significant differences were observed between the two groups in BCC subtype ($p < 0.001$), preoperative fasting glucose ($p < 0.001$), infiltration depth ($p < 0.001$), SII ($p < 0.001$), and flap aspect ratio ($p < 0.001$). PLR showed a borderline trend toward statistical significance ($p = 0.06$). No significant differences were observed between the two groups in age, gender, BMI, smoking history, hypertension, ASA classification, tumor diameter, defect area, operative time, flap type, compression dressing, or tumor location (all $p > 0.05$).

Univariate Logistic Regression Analysis

The results of the univariate logistic regression analysis are shown in Table 2. BCC subtype was significantly associated with unplanned reoperation (OR = 0.37, 95% CI: 0.20–0.71, $p < 0.001$). Preoperative fasting glucose was significantly associated with unplanned reoperation (OR = 2.07, 95% CI: 1.54–2.79, $p < 0.001$). Infiltration depth was also a significant risk factor (OR = 2.56, 95% CI: 1.61–4.06, $p < 0.001$). SII (per 10-unit increase) demonstrated a significant positive association with unplanned reoperation (OR = 1.07, 95% CI: 1.04–1.11, $p < 0.001$). Flap aspect ratio remained a strong risk factor (OR = 5.52, 95% CI: 2.92–10.45, $p < 0.001$). PLR showed a borderline association (OR = 1.01, 95% CI: 1.00–1.02, $p = 0.08$). Other variables, including gender, smoking history, hypertension, ASA classification, tumor location, flap type, age, BMI, tumor diameter, defect area, operative time, and compression dressing, were not significantly associated with unplanned reoperation (all $p > 0.05$). The effect estimate for the limb group was not reliably estimable because no reoperation events occurred in this group, resulting in complete separation.

Multivariate Logistic Regression Analysis

Variables with $p < 0.1$ in the univariate analysis were included in the multivariate logistic regression model, and independent influencing factors were identified using stepwise backward elimination. The results showed (Table 3) that four variables—preoperative fasting glucose, infiltration depth, SII (per 10-unit increase), and flap aspect ratio—were independent influencing factors for unplanned reoperation. Among them, flap aspect ratio was the strongest risk factor, followed by infiltration depth and preoperative fasting glucose. SII (per 10-unit increase) also demonstrated a significant positive association with unplanned reoperation. Based on these four independent influencing factors, a prediction model was constructed, and the logistic regression equation was as follows: $\text{Logit(P)} = -14.18 + 0.06 \times (\text{SII}/10) + 0.94 \times (\text{Infiltration Depth}) + 0.73 \times (\text{Preoperative Fasting Glucose}) + 1.57 \times (\text{Flap Aspect Ratio})$. The Box-Tidwell test confirmed that the continuous variables assessed for the final model satisfied the linearity assumption (preoperative fasting glucose: $p = 0.116$; infiltration depth: $p = 0.119$; SII: $p = 0.083$), allowing these variables to be entered into the logistic regression model in their original continuous form.

Performance Evaluation of the Prediction Model

The discriminative performance of the prediction model was evaluated using ROC curve analysis. As shown in Fig. 1, the combined model incorporating preoperative fasting glucose, infiltration depth, SII (per 10-unit increase), and flap aspect ratio achieved an AUC of 0.85 (95% CI: 0.79–0.91), indicating good discriminative ability. The individual predictors yielded AUCs of 0.74 (95% CI: 0.67–0.81) for preoperative fasting glucose, 0.64 (95% CI: 0.56–0.73) for infiltration depth, 0.69 (95% CI: 0.62–0.76) for SII, and 0.73 (95% CI: 0.64–0.81) for flap aspect ratio. The optimal cut-off value determined by the Youden index was 0.102. At this threshold, the model demonstrated a sensitivity of 0.80 (95% CI: 0.68–0.92) and a specificity of 0.79 (95% CI: 0.75–0.83). To further evaluate the added predictive value of combining multiple predictors, the AUC of the combined model was compared with those of the individual-variable models using the DeLong test. The

Table 1. Baseline characteristics of the patients in the reoperation group and the non-reoperation group.

Variables	Total (n = 455)	Non-reoperation group (n = 410)	Reoperation group (n = 45)	Statistic	*p*
Age (years), Mean ± SD	62.25 ± 13.68	62.39 ± 13.22	61.00 ± 17.46	$t = 0.52$	0.61
Flap aspect ratio, Mean ± SD	2.71 ± 0.54	2.67 ± 0.51	3.14 ± 0.60	$t = –5.79$	<0.001
Preoperative fasting glucose (mmol/L), Mean ± SD	5.08 ± 1.17	4.99 ± 1.16	5.91 ± 0.92	$t = –6.19$	<0.001
Infiltration depth (mm), Mean ± SD	1.23 ± 0.67	1.19 ± 0.63	1.62 ± 0.82	$t = –3.39$	<0.001
BMI (kg/m^2), M (Q_1, Q_3)	25.10 (23.45, 26.30)	25.10 (23.50, 26.28)	25.40 (23.20, 26.40)	Z = –0.48	0.63
Tumor diameter (mm), M (Q_1, Q_3)	12.00 (7.00, 20.00)	12.00 (7.00, 20.00)	14.00 (8.00, 19.00)	Z = –1.21	0.23
Defect area (cm^2), M (Q_1, Q_3)	5.50 (3.30, 7.70)	5.50 (3.30, 7.70)	4.70 (3.00, 7.30)	Z = –0.78	0.44
Operative time (min), M (Q_1, Q_3)	81.00 (62.00, 101.00)	81.00 (62.00, 101.00)	85.00 (66.00, 97.00)	Z = –0.41	0.68
PLR, M (Q_1, Q_3)	105.80 (91.66, 123.52)	104.99 (90.26, 122.15)	111.30 (97.40, 136.16)	Z = –1.89	0.06
SII, M (Q_1, Q_3)	306.66 (243.81, 381.17)	296.22 (239.15, 375.89)	367.35 (322.36, 416.32)	Z = –4.24	<0.001
Gender, n (%)				$\chi^2 = 0.23$	0.63
Female	258 (56.70)	234 (57.07)	24 (53.33)		
Male	197 (43.30)	176 (42.93)	21 (46.67)		
Smoking history, n (%)				$\chi^2 = 2.57$	0.11
No	363 (79.78)	323 (78.78)	40 (88.89)		
Yes	92 (20.22)	87 (21.22)	5 (11.11)		
Hypertension, n (%)				$\chi^2 = 2.66$	0.10
No	330 (72.53)	302 (73.66)	28 (62.22)		
Yes	125 (27.47)	108 (26.34)	17 (37.78)		
ASA grade, n (%)				$\chi^2 = 1.74$	0.42
I	129 (28.35)	119 (29.02)	10 (22.22)		
II	251 (55.16)	222 (54.15)	29 (64.44)		
III	75 (16.48)	69 (16.83)	6 (13.33)		
BCC subtype, n (%)				$\chi^2 = 9.72$	<0.001
high_risk	107 (23.52)	88 (21.46)	19 (42.22)		
low_risk	348 (76.48)	322 (78.54)	26 (57.78)		
Tumor location, n (%)				$\chi^2 = 3.13$	0.21
head_neck	355 (78.02)	317 (77.32)	38 (84.44)		
limb	26 (5.71)	26 (6.34)	0 (0.00)		
trunk	74 (16.26)	67 (16.34)	7 (15.56)		
Compression dressing, n (%)				$\chi^2 = 0.35$	0.55
No	254 (55.82)	227 (55.37)	27 (60.00)		
Yes	201 (44.18)	183 (44.63)	18 (40.00)		
Flap type, n (%)				$\chi^2 = 1.08$	0.58
advancement	193 (42.42)	177 (43.17)	16 (35.56)		
rotation	143 (31.43)	128 (31.22)	15 (33.33)		
transposition	119 (26.15)	105 (25.61)	14 (31.11)		

BMI, body mass index; PLR, platelet-to-lymphocyte ratio; SII, systemic immune-inflammation index; ASA, American Society of Anesthesiologists.

combined model achieved an AUC of 0.852, which was significantly higher than those of preoperative fasting glucose alone ($p < 0.001$), infiltration depth alone ($p < 0.001$), SII alone ($p < 0.001$), and flap aspect ratio alone ($p < 0.001$). These results demonstrate that the combined model provides significantly better discriminative ability than any individual predictor, supporting the incremental value of integrating multiple risk factors. Internal validation was performed using 1000 bootstrap resampling iterations to assess the optimism-corrected performance of the model. The optimism-corrected AUC was 0.84 (95% CI: 0.79–0.91).

The calibration curve analysis showed good calibration of the model (Fig. 2). The Hosmer-Lemeshow goodness-of-fit test ($\chi^2 = 11.89$, df = 8, $p = 0.17$) further indicated that the model had a good fit. After 1000 bootstrap resampling iterations, the average slope of the calibration curve was 0.909 (95% CI: 0.736–1.293), and the average intercept was 0.010 (95% CI: –0.019–0.027), supporting the stability of the model calibration.

Decision curve analysis (Fig. 3) showed that, across threshold probabilities of approximately 10%–80%, the prediction model provided a higher net benefit than the “all inter-

Table 2. Univariate logistic regression analysis of factors associated with unplanned reoperations.

Variables	β	S.E	Z	*p*	OR (95% CI)
Gender					
Female					1.00 (Reference)
Male	0.15	0.32	0.48	0.63	1.16 (0.63 ~ 2.16)
Smoking history					
No					1.00 (Reference)
Yes	–0.77	0.49	–1.57	0.12	0.46 (0.18 ~ 1.21)
Compression dressing					
No					1.00 (Reference)
Yes	–0.19	0.32	–0.59	0.55	0.83 (0.44 ~ 1.55)
Hypertension					
No					1.00 (Reference)
Yes	0.53	0.33	1.62	0.11	1.70 (0.89 ~ 3.22)
ASA grade					
I					1.00 (Reference)
II	0.44	0.38	1.15	0.25	1.55 (0.73 ~ 3.30)
III	0.03	0.54	0.06	0.95	1.03 (0.36 ~ 2.97)
Bcc subtype					
high_risk					1.00 (Reference)
low_risk	–0.98	0.32	–3.03	<0.001	0.37 (0.20 ~ 0.71)
Tumor location					
head_neck					1.00 (Reference)
limb	NE	NE	NE	NE	NE
trunk	–0.14	0.43	–0.32	0.75	0.87 (0.37 ~ 2.04)
Flap type					
advancement					1.00 (Reference)
rotation	0.26	0.38	0.69	0.49	1.30 (0.62 ~ 2.72)
transposition	0.39	0.39	1.01	0.31	1.47 (0.69 ~ 3.14)
Age	–0.01	0.01	–0.65	0.52	0.99 (0.97 ~ 1.02)
BMI	0.04	0.09	0.44	0.66	1.04 (0.87 ~ 1.24)
Tumor diameter	0.01	0.01	0.79	0.43	1.01 (0.99 ~ 1.03)
Flap aspect ratio	1.71	0.33	5.25	<0.001	5.52 (2.92 ~ 10.45)
Defect area	–0.05	0.06	–0.73	0.47	0.95 (0.84 ~ 1.08)
Operative time	0.00	0.01	0.37	0.71	1.00 (0.99 ~ 1.02)
PLR	0.01	0.01	1.77	0.08	1.01 (1.00 ~ 1.02)
Infiltration depth	0.94	0.24	3.98	<0.001	2.56 (1.61 ~ 4.06)
Preoperative fasting glucose	0.73	0.15	4.82	<0.001	2.07 (1.54 ~ 2.79)
SII (per 10)	0.07	0.02	4.01	<0.001	1.07 (1.04 ~ 1.11)

Note: NE, not estimable. Complete separation occurred in the limb group because no reoperation events were observed (0/26), resulting in unreliable maximum likelihood estimates for the corresponding logistic regression parameters.

Table 3. Multivariate logistic regression analysis of factors associated with unplanned reoperations.

Variables	β	S.E	Z	*p*	OR (95% CI)
SII (per 10)	0.06	0.02	3.04	<0.001	1.06 (1.02 ~ 1.11)
Infiltration depth	0.94	0.26	3.56	<0.001	2.56 (1.53 ~ 4.30)
Preoperative fasting glucose	0.73	0.17	4.22	<0.001	2.07 (1.48 ~ 2.91)
Flap aspect ratio	1.57	0.34	4.61	<0.001	4.79 (2.46 ~ 9.33)

vention" and "no intervention" strategies, suggesting potential clinical utility within the study cohort.

Discussion

This study found that the incidence of postoperative unplanned reoperation among patients with BCC who underwent flap repair was 9.9%. Preoperative fasting glucose,

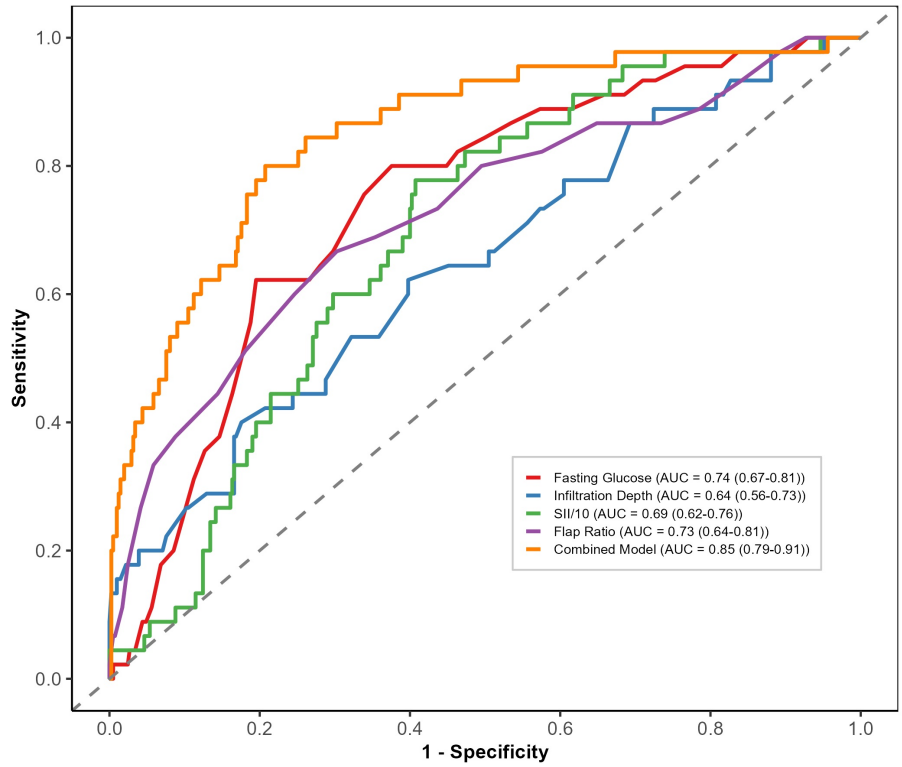


Fig. 1. ROC curve of the prediction model for unplanned reoperations.

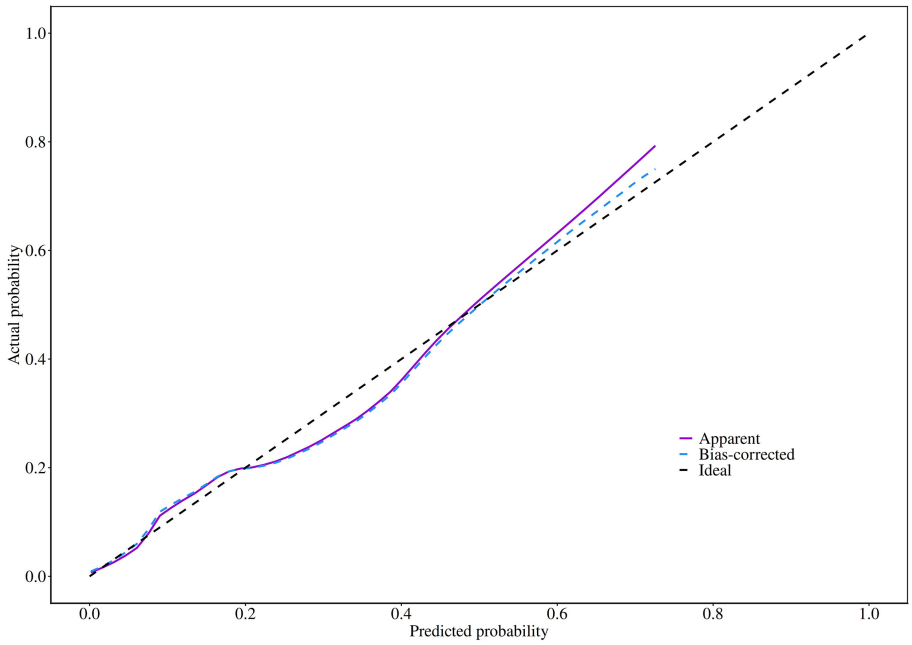


Fig. 2. Calibration curve of the prediction model for unplanned reoperations.

infiltration depth, SII, and flap aspect ratio were identified as independent risk factors for early unplanned reoperation within 30 days, with flap aspect ratio showing the strongest association. The prediction model based on these factors demonstrated good discrimination and calibration, and provided a positive net clinical benefit across a wide range of threshold probabilities. The observed 30-day unplanned reoperation rate of 9.9% provides an estimate of the early reoperation burden following flap reconstruction for BCC in our cohort. However, direct comparisons with previous studies are limited by differences in patient populations, surgical procedures, follow-up periods, and definitions of

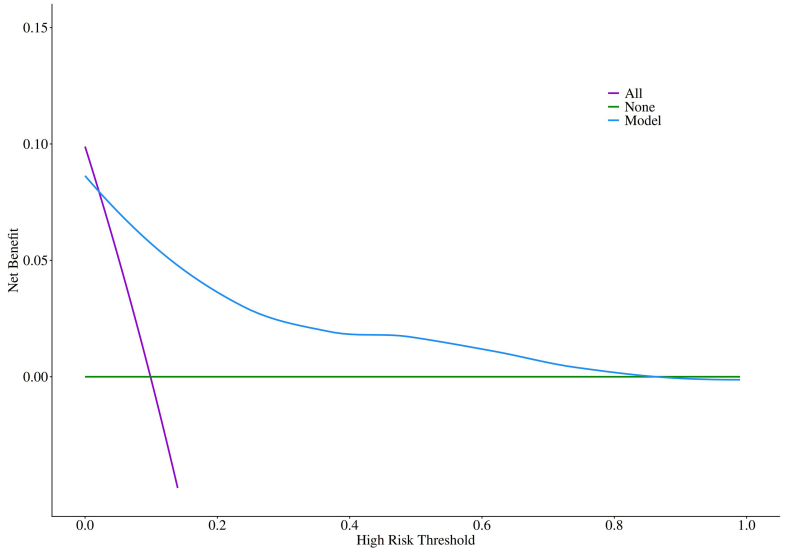


Fig. 3. Decision curve analysis.

reoperation. The prediction model demonstrated good discrimination (AUC = 0.852), with an optimism-corrected AUC of 0.841 following internal validation. Calibration analysis and decision curve analysis also suggested potential predictive performance and clinical utility within this cohort. Nevertheless, these findings require external validation before their generalizability can be established.

Elevated preoperative fasting glucose was associated with an increased risk of unplanned reoperation in our cohort. This association may be partly explained by the potential adverse effects of hyperglycemia on leukocyte function, collagen synthesis, wound healing, and microvascular perfusion [17,18]. These findings suggest that preoperative fasting glucose may be a relevant factor in perioperative risk assessment for patients with BCC undergoing flap reconstruction. However, whether interventions targeting glycemic control can reduce the risk of reoperation requires further investigation. Tumor infiltration depth was also identified as an independent risk factor. Deeper tumor infiltration may indicate more aggressive local invasion, which often requires more extensive resection, resulting in larger soft tissue defects and more complex flap reconstruction. These factors may compromise flap vascularity and increase the risk of postoperative complications requiring reoperation. Additionally, deeply infiltrative tumors are more likely to involve deep surgical margins, potentially necessitating secondary resection [14,19,20]. In this study, each 1-mm increase in infiltration depth was associated with a 2.56-fold increase in the risk of reoperation.

SII was identified as an independent risk factor for unplanned reoperation. SII, calculated as platelet count × neutrophil count / lymphocyte count, is a novel biomarker that reflects the balance between systemic inflammatory and immune status. Elevated SII levels have been associated with poor prognosis in various malignancies [21]. In the context of flap repair, a higher SII may indicate a pro-inflammatory state that impairs wound healing, increases susceptibility to infection, and compromises microcirculatory perfusion, thereby increasing the risk of flap necrosis and subsequent reoperation.

Flap aspect ratio was the risk factor with the highest OR value in this study. As the flap aspect ratio increases, blood supply to the distal end of the flap may become compromised, thereby increasing the risk of flap necrosis. Peng et al. [22] analyzed 435 distally based sural flaps and found that the rate of partial necrosis increased significantly when the flap length-width ratio exceeded 5:1. Traditional principles of plastic surgery also suggest that the length-to-width ratio of random flaps should generally be limited to 2:1 or 3:1, beyond which the risk of distal ischemic necrosis increases substantially due to distal hypoperfusion. However, these thresholds are not universally applicable across all anatomical sites. Regions with robust vascularity, such as the face and scalp, may tolerate higher ratios, whereas areas with relatively poorer blood supply, such as the distal extremities, may require more conservative flap designs. In our cohort, most cases (78.0%) were located in the head and neck region, whereas only 22.0% involved the trunk or limbs. Because of this uneven distribution, stratified analysis by anatomical site was not feasible, and our findings regarding flap aspect ratio are therefore most directly applicable to head and neck BCC reconstruction. Accordingly, although we recommend that the flap aspect ratio be kept as conservative as possible during flap design—ideally below 3:1 when feasible—we emphasize that this threshold should be interpreted in the context of the specific anatomical region and its vascular characteristics. For cases requiring a large flap aspect ratio, delayed flap techniques or alternative reconstructive methods with a more reliable blood supply should be considered. Future studies with larger and more

balanced samples across anatomical regions are needed to establish site-specific guidelines for flap aspect ratio.

Regarding the clinical application of the model threshold, the optimal cut-off value derived from the Youden index should be interpreted as a tool for risk stratification rather than an absolute criterion for determining the need for reoperation. This threshold corresponds to the predicted probability at which the model achieves the best balance between sensitivity and specificity in our cohort; however, clinical decision-making should integrate this probability estimate with other contextual factors, including tumor location, patient comorbidities, surgical findings, and individual preferences. For instance, patients with a predicted probability above the threshold may be considered for more intensive perioperative monitoring, stricter glycemic control, or optimized flap design, whereas those below the threshold may be considered at relatively lower risk. The threshold is intended to assist, not replace, clinical judgment, and its application should be tailored to the specific clinical setting and patient population. The prediction model demonstrated good discrimination and calibration following internal validation, with potential clinical utility. However, external validation is required before its use in routine clinical practice.

Our study has several limitations. First, this was a single-center retrospective study, and selection bias and information bias may therefore have been present. The quality of the data depended on the completeness and accuracy of the medical records. Second, due to limitations in the available data, this study was unable to incorporate factors such as surgeon experience and technical proficiency—which may significantly influence flap design strategy, the precision of margin control, and ultimately flap survival and reoperation risk—as well as detailed flap design parameters (e.g., pivot point location and flap elevation depth) and standardized postoperative care protocols (e.g., antimicrobial regimens and wound dressing frequency). Third, perioperative glycemic status was incompletely assessed because data on HbA1c levels and antihyperglycemic treatment regimens (e.g., insulin or oral hypoglycemic agents) were unavailable, which may have confounded the relationship between glycemic control and reoperation risk. Fourth, the definition of and decision-making regarding unplanned reoperation may be subjective, and different surgeons may have different indications for reoperation. To minimize this bias, we applied a conservative and consistent definition: only cases with explicit documentation of a secondary surgical procedure within 30 days postoperatively were included. Nevertheless, variation in surgeons' thresholds for reoperation may affect the generalizability of our findings, and future prospective studies with predefined objective criteria (e.g., standardized thresholds for margin positivity, extent of necrosis, or hematoma size) are needed to validate our model. Additionally, our outcome was restricted to reoperations occurring within 30 days, and late reoperations due to positive margins or local recurrence beyond this period were not captured. Fifth, although the sample size was 455 cases, there were only 45 cases (9.9%) in the reoperation group, which may have affected the stability of the multivariate regression model. Future studies with larger sample sizes are therefore needed for further validation. Sixth, the distribution of anatomical sites was heavily skewed toward the head and neck region (78.0%), with only 22.0% of cases involving the trunk or limbs. This imbalance precluded robust subgroup analyses to determine whether the predictive value of flap aspect ratio differs across anatomical regions with distinct vascular characteristics. Therefore, our findings regarding flap aspect ratio are most directly applicable to head and neck BCC reconstruction and should be extrapolated to other anatomical sites with caution. Seventh, BCC pathological subtypes were categorized only into high-risk and low-risk groups without further quantification of risk differences among individual high-risk subtypes because of the limited number of cases within each specific subtype; this aggregation may have masked heterogeneous risks among aggressive histologic variants. Finally, although we prespecified candidate predictors based on clinical relevance and employed AIC-based backward elimination with bootstrap validation, the inherent limitations of stepwise regression—including potential model instability, overfitting, and the possible omission of clinically relevant variables—cannot be fully eliminated. External validation in independent cohorts is needed to further confirm the generalizability of our model.

Conclusions

Preoperative fasting glucose, infiltration depth, SII, and flap aspect ratio are independent risk factors for early unplanned reoperation within 30 days after BCC flap repair. The prediction model based on these four factors demonstrated good discrimination, calibration, and clinical utility and may assist clinicians in risk assessment and individualized treatment decision-making, thereby providing clinically relevant guidance for reducing the rate of unplanned reoperation after BCC flap repair.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding authors upon reasonable request.

Author Contributions

MLL, XLZ and YJ designed the research study. MLL and YJ performed the research. XLZ and YJ analyzed the data. MLL drafted the article. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study obtained approval from Jiangnan University Medical Center (approval number: WXEY-2026-1009). All patients signed a written informed consent. The study conformed to the provisions of the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Kaur H, de Mesy Bentley KL, Rahman SM, Cohen PR, Smoller BR. Cutaneous Superficial Basal Cell Carcinoma is a Basal Cell Carcinoma In Situ: Electron Microscopy of a Case Series of Basal Cell Carcinomas. Dermatology and Therapy. 2024; 14: 1359–1366. https://doi.org/10.1007/s13555-024-01151-x

[2] Cohen PR, Kurzrock R. Cutaneous Basal Cell Carcinoma In Situ: A Review of the World Literature. Cureus. 2024; 16: e69691. https://doi.org/10.7759/cureus.69691

[3] Cocuz IG, Manole M, Popelea MC, Niculescu R, Cocuz ME, Sabău AH, et al. The Epidemiological and Histopathological Profiling of Basal Cell Carcinoma: Insights from a 4-Year Institutional Cohort in a Romanian Clinical County Hospital. Diagnostics (Basel, Switzerland). 2025; 15: 2377. https://doi.org/10.3390/diagnostics15182377

[4] Schmults CD, Blitzblau R, Aasi SZ, Alam M, Amini A, Bibee K, et al. Basal Cell Skin Cancer, Version 2.2024, NCCN Clinical Practice Guidelines in Oncology. Journal of the National Comprehensive Cancer Network: JNCCN. 2023; 21: 1181–1203. https://doi.org/10.6004/jnccn.2023.0056

[5] Revend L, Revend D, Dudde F. Basal cell carcinoma of the head and neck: Surgical management and postoperative strategies - A researcher's perspective. Oncoscience. 2026; 13: 55–61. https://doi.org/10.18632/oncoscience.646

[6] Veija T, Koivunen V, Mäkelä L, Koljonen V. Immediate local flap versus skin graft reconstruction after standard excision of basal cell carcinoma of the nose. JPRAS Open. 2025; 44: 364–374. https://doi.org/10.1016/j.jpra.2025.03.017

[7] Tchernev G, Wollina U, Temelkova I. High-Risk Basal Cell Carcinomas of the Head and Neck: Selected Successful Surgical Approach in Three Bulgarian Patients! Open Access Macedonian Journal of Medical Sciences. 2019; 7: 1665–1668. https://doi.org/10.3889/oamjms.2019.360

[8] Lee SO, Kim TG, Chung KJ. Minimizing Surgical Margins in Basal Cell Carcinoma: A Single Institution's Experience with Excision and Reconstruction Methods. Archives of Plastic Surgery. 2024; 52: 30–35. https://doi.org/10.1055/s-0044-1788780

[9] Lee KT, Kim J, Jeon BJ, Pyon JK, Bang SI, Mun GH. Longitudinal analysis of long-term outcomes of abdominal flap-based microsurgical reconstruction and two-stage prosthetic reconstruction. Scientific Reports. 2023; 13: 4062. https://doi.org/10.1038/s41598-023-31218-2

[10] Tabatabai MK, Sieborg J, Karmisholt KE, Mårtensson NL, Schmidt G, Wenande E, et al. Margin Status following Simple Excision of Head and Neck Basal Cell Carcinoma: A Population-Based, Cross-Sectional Study of 9,291 Excisions. Acta Dermato-venereologica. 2025; 105: adv44224. https://doi.org/10.2340/actadv.v105.44224

[11] Fiorentini C, Bedini A, Mandel VD, Bacca E, Menozzi M, Reggiani C, et al. Comparison of two perioperative antibiotic schedules in patients undergoing surgical reconstruction with dermal matrix after excision of skin cancer. International Wound Journal. 2020; 17: 937–943. https://doi.org/10.1111/iwj.13354

[12] Rau AS, Reinikovaite V, Schmidt EP, Taraseviciene-Stewart L, Deleyiannis FWB. Electronic Cigarettes Are as Toxic to Skin Flap Survival as Tobacco Cigarettes. Annals of Plastic Surgery. 2017; 79: 86–91. https://doi.org/10.1097/SAP.0000000000000998

[13] Di Stefani A, Chimenti S. Basal cell carcinoma: clinical and pathological features. Giornale Italiano Di Dermatologia E Venereologia: Organo Ufficiale, Societa Italiana Di Dermatologia E Sifilografia. 2015; 150: 385–391.

[14] Iurilli M, Cazzato V, Ramella V, Papa G. Exploring the role of surgical margins and reoperation in basal cell carcinoma recurrence: a study of 3036 cases. Archives of Dermatological Research. 2025; 317: 604. https://doi.org/10.1007/s00403-025-04084-3

[15] Kundnani NR, Tirziu RV, Borza C, Tirziu C, Sharma A, Rosca CI, et al. Implication of wide surgical excision in minimizing positive margins and consequential secondary excision - a retrospective comparative study involving 106 basal cell carcinoma cases. European Review for Medical and Pharmacological Sciences. 2021; 25: 4283–4288. https://doi.org/10.26355/eurrev_202106_26134

[16] Panse NS, Bhatt YC, Tandale MS. What is safe limit of the perforator flap in lower extremity reconstruction? Do we have answers yet? Plastic Surgery International. 2011; 2011: 349357. https://doi.org/10.1155/2011/349357

[17] Abu-Baker A, Țigăran AE, Timofan T, Ion DE, Gheoca-Mutu DE, Avino A, et al. A Systematic Review and Meta-Analysis of Anterolateral Thigh Flap Outcomes in High-Risk Diabetic Foot Reconstruction. Journal of Clinical Medicine. 2025; 14: 8481. https://doi.org/10.3390/jcm14238481

[18] Kim YS, Lee HY, Jang JY, Lee HR, Shin YS, Kim CH. Redox treatment ameliorates diabetes mellitus-induced skin flap necrosis via inhibiting apoptosis and promoting neoangiogenesis. Experimental Biology and Medicine (Maywood, N.J.). 2021; 246: 718–728. https://doi.org/10.1177/1535370220974269

[19] Maher NG, Prosser N, Aivazian K, Colebatch AJ, Ferguson PM, Karim RZ, et al. Inter-rater concordance of basal cell carcinoma subtypes: influences on reporting format and opportunities for further classification modifications. Pathology. 2023; 55: 800–805. https://doi.org/10.1016/j.pathol.2023.04.003

[20] Sonntag SR, Beach R, Gniesmer S, Tohme J, Grisanti S, Mohi A, et al. Aggressive subtypes in basal cell carcinomas might need different treatment and follow-up due to the higher risk of surgically uncontrollable recurrences. Graefe's Archive for Clinical and Experimental Ophthalmology = Albrecht Von Graefes Archiv Fur Klinische Und Experimentelle Ophthalmologie. 2025; 263: 2033–2040. https://doi.org/10.1007/s00417-025-06807-8

[21] Li S, Zhu YY, Musonye HA, Shi QQ, Deng JJ, Pan HF, et al. Associations of systemic inflammatory markers with cancer survival outcomes: a systematic umbrella review. Future Oncology (London, England). 2026; 22: 729–739. https://doi.org/10.1080/14796694.2026.2630979

[22] Peng P, Dong Z, Wei J, Liu L, Luo Z, Cao S, et al. Revisit of flap factors relating to partial necrosis of distally based sural flaps: an analysis of 435 cases in a single center. European Journal of Trauma and Emergency Surgery: Official Publication of the European Trauma Society. 2022; 48: 2359–2368. https://doi.org/10.1007/s00068-021-01737-6

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