A nomogram for predicting post-operative wound complications after open reduction and internal fixation for calcaneal fractures

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Abstract
The purpose of our study was to determine the risk factors for post-operative wound complications (PWCs) after open reduction and internal fixation (ORIF) for calcaneal fracture and establish a nomogram prediction model. We retrospectively analysed the clinical data of patients who suffered from calcaneal fractures and had been surgically treated for ORIF in our institution between January 2010 and January 2020. Perioperative information was obtained through the electronic medical record system, univariate and multivariate analyses were performed to determine the risk factors of PWCs, and a nomogram model was constructed to predict the risk of PWCs. The predictive performance and consistency of the model were evaluated by the Hosmer–Lemeshow (H-L) test and the calibration curve. In total, 444 patients were enrolled in our study. Multivariate analysis results showed that smoking, limb swelling, angle of incision, and CRP were independent risk factors for skin necrosis. The AUC value for skin necrosis risk was 0.982 (95%CI 0.97-0.99). The H-L test revealed that the normogram prediction model had good calibration ability (P = .957). Finally, we found a correlation between PWCs and smoking, limb swelling, angle of incision, and CRP after ORIF for calcaneal fracture patients. Our nomogram prediction model might be helpful for clinicians to identify high-risk patients, as interventions could be taken early to reduce the incidence of PWCs.

Keywords
calcaneal fracture, nomogram, open reduction and internal fixation, post-operative wound complications
Key Messages

- The purpose of our study was to determine the risk factors for post-operative wound complications after open reduction and internal fixation (ORIF) for calcaneal fractures and establish a nomogram prediction model.
- Multivariate analysis results showed that smoking, limb swelling, angle of incision, and CRP were independent risk factors for PWCs.
- Our nomogram prediction model might be helpful for clinicians to identify high-risk patients, intervention could be taken early to reduce the incidence of PWCs.

1 | INTRODUCTION

Displaced intra-articular fractures of the calcaneal constitute 1% to 2% of all fractures. Treatment may consist of operative or conservative management. Open reduction and internal fixation (ORIF) is generally considered the best available approach for restoring the overall anatomy of the calcaneal and reconstructing the posterior talocalcaneal (subtalar) joint after a displaced intra-articular calcaneal fracture. The most widely surgical technique is open reduction and internal fixation with a plate, using an expanded L-shaped incision on the lateral wall of the heel and with or without bone grafting. However, the most common and recalcitrant complications are related to surgical incisions; examples include infection of the incision and necrosis of the skin margin. The incidence rate of post-operative wound complications (PWC) reported ranged from 10% to 27%, respectively. Even though some new minimally invasive surgical methods or new surgical incisions were invented by scholars in order to reduce the complications of surgical incisions, the extended lateral approach remains widely used.

Wound dressing, debridement, flaps repair, and even amputation are performed on patients who suffered wound complications. It is a heavy psychological and physiological blow to patients and implies a longer stay in the hospital, more expense, and more pain. Therefore, determining how to avoid wound complications is very important. A series of studies revealed that wound complication is a multifactorial problem and there is no one causative factor. Established patient-related risk factors associated with postoperative wound complications include diabetes, a higher body mass index (BMI), extended time (>5 days) between injury and surgery, and smoking. However, prior investigations were limited methodologically by small sample sizes, and lack of adjustment for confounders. It is still a challenging clinical problem and remains uncertain. Therefore, identifying those calcaneal fracture patients who might develop wound complications after ORIF is critical for implementing an effective intervention therapy to reduce complications and improve prognosis. Given that, the purpose of this study is to determine the risk factors associated with wound complications after calcaneal fracture with ORIF and to establish a normogram model to predict the incidence.

2 | MATERIALS AND METHODS

This study followed the guidelines of the “Declaration of Helsinki” and was approved by the hospital’s ethics committee. The requirement for informed consent was waived as the data were analysed anonymously and personal identifiers were completely removed.

2.1 | Patient group

In a retrospective cohort study, we analysed all patients who were treated for calcaneal fractures in our department between January 2010 and January 2020. Patients who were willing to participate in this study gave informed consent. The inclusion criteria for this trial were as follows: patients between 18 and 80 years of age, who had a displaced intra-articular calcaneal fracture with the treatment of ORIF. The exclusion criteria were as follows: patients with pathological fractures or nerve or vascular injury in the lower extremity, and patients who declined participation in the trial and the assigned treatment algorithm. In the end, there were 444 patients included in the final analysis.

2.2 | Treatment method and rehabilitation

All calcaneal fractures were managed with ORIF using an expanded L-shaped incision to expose the lateral wall of the calcaneal and subtalar joint. It was important to avoid rude traction to the flap during dissection. To
separate soft tissues with an electric scalpel was avoided. K-wires were used to hold the flap in place after the exposure. The calcaneal fracture was reduced and the smoothness of the subtalar joint and the height and width of the calcaneus was restored. For fractures with severe compression, bone defects were filled with autogenous, allograft, or artificial bone. After the reduction of the fracture fragments and articular surfaces, lateral plates designed for the calcaneus were used for fixation. The skin was carefully closed in layers using an Allgöwer-Donati approach or simple sutures with multifilament absorbable antibacterial sutures.

Patients were encouraged to start active range of motion exercises at the knee and the ankle as soon as possible. The majority of patients were encouraged to partially weight bear at 2 to 3 weeks after surgery. Patients were allowed to fully weight bear when there was no pain at the fracture site and radiological evidence of bone union.

2.3 Evaluation

All data were abstracted from the electronic medical record of our hospital. Demographic information of patients included: age, sex, body mass index (BMI), current drinking status, current smoking status, current diabetes mellitus (DM) status, current hypertension status, current thrombus status, allergic constitution, American Society of Anesthesiologists (ASA) classification. BMI was divided into two groups: >24, obesity; <24, no obesity; ASA was divided into two groups: ≥3, high, <3, normal. Thrombosis was defined as arteriovenous thrombosis detected by preoperative Doppler ultrasonography of the lower extremities. The allergic constitution was defined as an allergy to more than three foods or drugs.

Characteristics of fractures included limb swelling (compared to the healthy side), Sander’s classification, injury cause, injury type (closed or open), side involved (double or not), and coexisting injuries. The injury mechanism was classified as high energy if the fractures were caused by traffic accidents or falls from heights and sporting activity. Limb swelling was defined as the circumference from the front of the ankle to the heel.

Other treatment-related variables such as the time until the operation, the operation time, anaesthesia way (spinal anaesthesia or not), hormones used, whether to drain, bone graft, wound closure technique (Allgöwer Donati or not), blood loss, angle of incision. The angle of incision is defined as the angle between the L-shaped incision.

For preoperative variables of laboratory examination, we reviewed white blood cell (WBC), percentage of neutrophils, C-reactive protein (CRP), albumin, and D-dimer.

Wound complications were defined as persistent exudation over 2 weeks, or delayed suture removal; hematoma; infection of the incision (ie, positive bacterial culture); necrosis of the incision skin margin or dehiscence of the incision; deep infection, osteomyelitis, and sinus tract formation; the internal fixator was taken out before healing of the fracture, or there was persistent negative pressure drainage of the wound.

2.4 Statistical analysis

Continuous variables were expressed as the means ± standard deviations, and categorical variables were expressed as percentages. Comparisons between groups were performed using the \( \chi^2 \)-test and Student's \( t \)-test. Univariate analyses were used to evaluate the associations between different factors and wound complications. In order to determine the independent risk factors, variables achieving a significance of \( P < .1 \) were selected for multivariable analyses. Then, based on the regression coefficients of independent variables, we established the normogram prediction model of wound complications. The distinction of dichotomous results was usually evaluated by calculating the area under the curve (AUC) of the receiver operating characteristic (ROC) curve. Generally, a prediction model with an AUC of 0.5 to 0.75 was considered acceptable, and an AUC >0.75 means that the model shows excellent discrimination. Statistical analyses were carried out using R version 3.6.1 for Windows (R Foundation for Statistical Computing, Vienna, Austria). \( P \) values less than .05 (two-sided) were considered statistically significant. The calibration degree is evaluated by the Hosmer–Lemeshow (H-L) test, the goodness of fit test, and calibration curve. In addition, the calibration curve was used to judge the predictive consistency.

3 RESULTS

From January 2010 and January 2020, 490 consecutive calcaneal fracture patients in our hospital were involved in this study, and 46 were excluded: 20 with age less than 18 years, 15 with closed reduction, 3 with pathological fractures, 8 with conservative treatment. Ultimately, 444 patients meeting the inclusion criteria were enrolled in our study, of whom 30 (6.76%) suffered wound complications after ORIF, while the remaining 414 patients did
| Variable                  | necrosis group (n = 30) | Non-necrosis group (n = 414) | T or X² | P value |
|---------------------------|-------------------------|------------------------------|---------|---------|
| Age (year)                | 53.33 ± 18.52           | 49.64 ± 18.08                | T = 1.080 | .281 |
| Sex (male/female)         |                         |                              | 0.069   | .792   |
| Male:                     | 5                       | 77                           |         |        |
| Female:                   | 25                      | 337                          |         |        |
| BMI (≥24)                 |                         |                              | 1.645   | .200   |
| Yes                       | 5                       | 39                           |         |        |
| No                        | 25                      | 375                          |         |        |
| Drinking                  |                         |                              | 0.865   | .352   |
| Yes                       | 3                       | 24                           |         |        |
| No                        | 27                      | 390                          |         |        |
| Smoking                   |                         |                              | 6.097   | .014*  |
| Yes                       | 16                      | 130                          |         |        |
| No                        | 14                      | 284                          |         |        |
| DM                        |                         |                              | 13.24   | .001*  |
| Yes                       | 7                       | 24                           |         |        |
| No                        | 23                      | 390                          |         |        |
| Hypertension              |                         |                              | 0.173   | .678   |
| Yes                       | 4                       | 45                           |         |        |
| No                        | 26                      | 369                          |         |        |
| Thrombus                  |                         |                              | 3.263   | .071*  |
| Yes                       | 4                       | 22                           |         |        |
| No                        | 26                      | 392                          |         |        |
| Allergy                   |                         |                              | 0.743   | .389   |
| Yes                       | 3                       | 25                           |         |        |
| No                        | 27                      | 389                          |         |        |
| ASA (≥3)                  |                         |                              | 2.259   | .133   |
| Yes                       | 3                       | 17                           |         |        |
| No                        | 27                      | 397                          |         |        |
| Limb swelling (%)         | 49 ± 15.5               | 31.82 ± 13.6                 | T = 6.631 | .001* |
| Sanders type              |                         |                              | 2.549   | .466   |
| I                         | 2                       | 15                           |         |        |
| II                        | 21                      | 320                          |         |        |
| III                       | 4                       | 60                           |         |        |
| IV                        | 3                       | 19                           |         |        |
| Cause (high-energy)       |                         |                              | 1.706   | .191   |
| Yes                       | 7                       | 60                           |         |        |
| No                        | 23                      | 354                          |         |        |
| Open fracture             |                         |                              | 15.787  | .001*  |
| Yes                       | 7                       | 21                           |         |        |
| No                        | 23                      | 393                          |         |        |
| Double side               |                         |                              | 1.739   | .187   |
| Yes                       | 3                       | 19                           |         |        |
| No                        | 27                      | 395                          |         |        |
Among 30 patients with complications, there were 11 cases with wound dehiscence, 7 cases with hematoma, 9 cases with flap margin necrosis, and 3 cases with osteomyelitis. All patients with complications were eventually cured, either conservatively or surgically.

There were no statistically significant differences between the two groups regarding age, sex, BMI, drinking, hypertension, thrombus, allergic constitution, ASA (≥3), Sanders type, cause (high-energy), double side, coexisting injury, time of operation, anaesthesia way, the hormone used, bone graft, wound closure technique, blood loss, WBC, percentage of neutrophils, albumin (P > .1) (Table 1).

### TABLE 1 (Continued)

| Variable                      | necrosis group (n = 30) | Non-necrosis group (n = 414) | T or X²    | P value |
|-------------------------------|------------------------|-----------------------------|-----------|---------|
| Coexisting injury             |                        |                             | 2.438     | .118    |
| Yes                           | 4                      | 25                          |           |         |
| No                            | 26                     | 389                         |           |         |
| Time until operation (d)      | 6 ± 2.38               | 7.1 ± 1.99                  | 2.887     | .004*   |
| Time of operation (min)       | 86.73 ± 20.41          | 81.03 ± 20.46               | 1.475     | .141    |
| Anaesthesia (spinal anaesthesia) |                       |                             | 2.637     | .104    |
| Yes                           | 12                     | 109                         |           |         |
| No                            | 18                     | 305                         |           |         |
| Hormone                       |                        |                             | 0.221     | .638    |
| Yes                           | 6                      | 69                          |           |         |
| No                            | 24                     | 345                         |           |         |
| Drainage tube                 |                        |                             | 3.11      | .078*   |
| Yes                           | 10                     | 207                         |           |         |
| No                            | 20                     | 207                         |           |         |
| Bone graft                    |                        |                             | 0.2       | .655    |
| Yes                           | 10                     | 122                         |           |         |
| No                            | 20                     | 292                         |           |         |
| Allgöwer Donati suture        |                        |                             | 1.628     | .202    |
| Yes                           | 26                     | 385                         |           |         |
| No                            | 4                      | 29                          |           |         |
| Blood loss (mL)               | 77.63 ± 18.65          | 80.20 ± 16.91               | 0.798     | .425    |
| Angle of incision (°)         | 70.1 ± 10.39           | 95.42 ± 11.68               | 11.54     | .001*   |
| WBC (*10⁶)                    | 8.01 ± 2.62            | 8.30 ± 2.5                  | T = 0.424 | .672    |
| CRP, mg/L                     | 9.17 ± 5.84            | 6.23 ± 2.51                 | T = 5.462 | .001*   |
| Percentage of neutrophils (%) | 60.96 ± 12.03          | 60.01 ± 10.94               | 0.164     | .87     |
| Albumin, g/dL                 | 32.57 ± 4.24           | 32.59 ± 4.44                | 0.033     | .974    |
| D-dimer, μg/mL                | 12.43 ± 5.41           | 10.07 ± 5.49                | 2.279     | .023*   |

*P < .1.
The ratio of smoking and DM among patients with PWC was 53.3% (16/30) and 23.3% (7/30), respectively, which was significantly higher than the non-PWC group of 31.4% (130/414) and 5.8% (24/414), respectively ($P = .014$ and $P = .001$). In addition, there was a statistically significant difference in thrombus between the two groups: 13.3% (4/30) and 5.3% (22/414), respectively ($P = .071$). There was a statistically significant difference in limb swelling between the two groups: 49 ± 15.5% and 31.82 ± 13.6%, respectively ($P = .001$). The ratio of open fracture cases in the PWC group (23.3%, 7/30) was higher than that in the non-PWC group (5.1%, 21/414), $P = .001$. In the perioperative stage, among patients with PWC, the time until the operation was 6 ± 2.38d, whereas among the non-PWC participants, the time until the operation was 7.1 ± 1.99d ($P = .004$). Compared to the PWC group, the use of drainage tubes was significantly lower in the non-PWC necro-

### TABLE 2 multivariable Logistic regression of predictors for skin necrosis

| Variable         | OR     | 95% CI            | $P$ value |
|------------------|--------|-------------------|-----------|
| Smoking          | 18.44  | 3.053-111.387     | .001*     |
| DM               | 10.766 | 0.946-122.537     | .055      |
| Thrombus         | 4.528  | 0.289-70.821      | .282      |
| Limb swelling    | 1.055  | 1.011-1.101       | .013*     |
| Open fracture    | 8.467  | 0.904-79.329      | .061      |
| Time until operation | 0.821 | 0.614-1.099     | .185      |
| Drainage tube    | 0.870  | 0.231-3.268       | .836      |
| Angle of incision| 0.829  | 0.775-0.888       | .001*     |
| CRP              | 1.224  | 1.032-1.452       | .021*     |
| D-dimer          | 1.082  | 0.954-1.228       | .22       |

Abbreviations: CI, confidence interval; OR, odds ratio.

* $P < .05$.
sis group (10/30 vs 207/414, \( P < .078 \)). The average angle of incision of patients with PWC was 70.1 ± 10.39°, which was significantly less than the angle of the control group (95.42 ± 11.68°) \( (P = .001) \). In terms of laboratory examination, the CRP and D-dimer were 9.17 ± 5.84 mg/L and 12.43 ± 5.41 μg/mL, which were significantly shorter than those in the non-PWC group (6.23 ± 2.51 mg/L and 10.07 ± 5.49 μg/mL, respectively) \( (P = .001 \) and \( P = .023 \)). (Table 1).

The results of the univariate analysis showed that there was a significant difference in smoking, DM, thrombus, limb swelling, open fracture, time until the operation, drainage tube, angle of incision, CRP, and D-dimer \( (P < .1) \). After multivariate logistic regression analysis, smoking, limb swelling, angle of incision, and CRP were identified as independent risk factors of PWC after ORIF of calcaneal fracture (Table 2).

A nomogram was established to predict the risk for the PWC based on the multivariate logistic regression analysis (Figure 2). To use the nomogram, the points corresponding to each prediction variable were obtained, and the sum of the points was then calculated as the total score; the predicted risk corresponding to the total score was the probability of skin necrosis. For example, a smoking patient with a calcaneal fracture was hospitalised with limb swelling that was 48% that of the normal side when the operation began. The preoperative CRP was 20 mg/L and the angle of incision was 95°. The total score was 20+ 20 + 36 + 30 = 106, which corresponds to an almost 46% risk of PWC.

In addition, we drew the ROC curve of predicted probability and calculated the AUC value. The AUC value for skin necrosis risk was 0.982, suggesting that the nomogram prediction model has excellent discrimination (Figure 3); meanwhile, the 95%CI was 0.97 to 0.99. The Hosmer–Lemeshow test also showed that the nomogram prediction model had good calibration ability \( (P = .957, \text{Figure } 4) \).

4 | DISCUSSION

With the rapid development of construction and transportation industries, calcaneal fractures actually saw an uptick in their occurrence.23,24 Management of calcaneal fractures is a challenge to the trauma surgeon on account of its unique anatomical morphology and limited soft-tissue envelope. However, the benefits of operative treatment may be offset by the subsequent complications.25 With the wide application of expanded L-shaped incisions, PWCs are gradually discovered by orthopaedic physicians.4 For patients who are diagnosed with superficial infections, a good outcome can be achieved after active treatment. However, it is devastating to patients who are diagnosed with deep infections, even though there is low mobility. In order to decrease the incidence of PWC and improve clinical outcomes, it is necessary to understand which factors were associated with these complications.

This study was designed to evaluate patients in a retrospective manner, document calcaneal fracture patient characteristics that might have an impact on the incidence of PWC as a primary end-point, and create a predictive nomogram model of risk factors for PWC associated with ORIF. We included predefined standardised criteria and definitions for evaluating our outcome of interest: PWCs. We identified smoking, limb swelling, angle of incision, and CRP as independent risk factors in the incidence of surgical site PWC.

Cigarettes contain a lot of harmful substances, such as nicotine, and produce carbon monoxide, which can cause vasospasms and lead to wound complications.26,27 Wound healing is a dynamic process involving many factors and cell types including soluble mediators, blood cells, fibroblasts, endothelial cells, and extracellular matrix.28 Normal cutaneous wound healing is divided into several sequential but overlapping phases in space.
and time-homoeostasis, inflammation, granulation tissue formation, and tissue remodelling—that must occur in an orderly manner to achieve proper healing. Cigarette smoke is a complex mixture of more than 7000 toxic substances. Doctors avoid performing surgery on patients who smoke due to known complications in clot formation, healing times, and the quality of healing. It delays wound healing by delaying wound closure, increasing oxidative stress and its associated tissue damages, causing an imbalance in chemokines and cytokines that result in decreasing/delaying the inflammatory response, decreasing collagen deposition, decreasing angiogenesis, and increasing blood vessel leakage and clot formation. First-hand smoke (FHS), second-hand smoke (SHS) and third-hand smoke (THS) have been shown to negatively impact wound healing. Most studies have confirmed that active smoking is not conducive to wound healing. Assous and Bhamra reported that 70% of patients were active smokers in their infection group and 15% of patients were smokers in their non-infection group. Jun Su found that patients with calcaneal fractures who were smokers and had a higher BMI had a high risk of wound infections. Our data showed that active smoking was associated with PWC after open reduction and internal fixation, and multivariable logistic regression analysis showed that active smoking was an independent risk factor. We suggest that active smoking is a risk factor for PWC. Therefore, we suggest that patients with calcaneal fractures must quit smoking before and after surgery, otherwise it will increase the probability of PWC. The literature generally confirms that nicotine abstinence for 4 to 8 weeks preoperatively is advantageous and post-operative complications may be reduced if patients refrain from smoking for 10 days after surgery.

Calcaneal fractures are often accompanied by soft-tissue swelling and are associated with prolonged hospitalisation and soft-tissue complications. Definitive internal osteosynthesis cannot be undertaken until the swelling of the surrounding soft tissues has resolved. It is vitally important for the surgeon to delay surgery until the swelling subsides sufficiently, since wound edge necrosis, skin slough, and postoperative infections can be the consequence of a prematurely performed ORIF. This is especially true in high-energy calcaneal fractures, where a compromised soft tissue envelope with extensive oedema, fracture blisters, and ecchymosis may be present. Many surgeons performed surgery after detumescence of the injured foot and suggested that it is critical to avoid soft-tissue complications. Generally, calcaneal fractures are caused by high-energy impacts, and the relatively thin coverage of soft tissue on the heel also suffers severe injury. If early surgery is performed, the soft tissue again suffers trauma, which is bad for wound healing and may increase the incidence rate of wound infections. Waiting is the best way to reduce soft tissue swelling. Al-Mudhaffar et al did a retrospective study and indicated that more patients with wound complications underwent operation within 7 days after the injury. Wu Kai et al suggested complications after calcaneal surgeries may be reduced by postponing the surgery at least 7 days after fracture. Our univariate analysis demonstrated that time until the operation was associated with PWC, but the logistic analysis was not statistically significant. However, then limb swelling compared to the healthy side was a risk factor for PWC. We will combine...
other methods to treat extremity swelling, such as raising the limb, ice bracing and so on. On the other hand, emergency open reduction and internal fixation can only be adopted in patients with good calcaneal skin conditions without soft-tissue edema. In our experience, we would rather perform surgery when the patient has a positive “wrinkle test.” In conclusion, we need to wait for a good soft tissue condition before surgery.

Poor blood supply has been considered the reason for problems in lateral skin flap healing. Current studies of calcaneal vascular anatomy show that blood to the lateral heel is mainly supplied from the lateral calcaneal and tarsal arteries, and branches of the lateral malleolar artery. The blood supply of the incision corner is mainly from the lateral calcaneal artery (LCA). The complication in wound healing, such as ischemia of the lateral calcaneal flap, can arise from damage to the LCA (Figure 5). Borrelli et al concluded that, based on the position of the LCA, it was vulnerable to injury caused by the vertical incision in the lateral approach. We analysed the angle of the incision corner and found that when the angle was less than 90°, necrosis at the incision was prone to occur, and it was statistically significant. On the one hand, the angle of the flap is too small, and the corner of the flap is prone to ischemia and necrosis; on the other hand, the vertical incision may be too close to the LCA, which may cause damage, and finally, the blood supply at the corner of the incision will be limited and the flap will be necrotic. Sirisreetreerux et al discovered that the vertical limb of an incision during the extensile lateral calcaneal approach should be placed at the lateral edge of the Achilles tendon to avoid injuring the calcaneal branch of the peroneal artery through cadaver experiments. Their results demonstrated that LCA was located 11.6 ± 2.3 mm anterior to the lateral border of the Achilles tendon, which was comparable to previous cadaveric studies. Therefore, we recommend that when the incision is turned, the angle should be as large and arc-shaped as possible, and it cannot be an acute angle with an angle less than 90°. The incision should also try to avoid LCA.

CRP is an acute-phase protein synthesised in the liver and its concentration increases according to the inflammatory response. This is a sensitive indicator of postoperative systemic inflammatory response, and in our institution, it is routinely measured before and after surgery. Saul explored the relationship between CRP and postoperative infection after acetabular fracture. They made the conclusion that predicting surgical site infections after an acetabular fracture is most predictive when analysing the maximum overall CRP, the second peak, and the CRP after day 5. In spinal surgery, there is a high value of postoperative CRP kinetics in surgical site infections detection after dorsal spondylodesis. Moreover, they observed typical CRP levels with a specific course as indicative predictors that may facilitate early surgical site infections detection in clinical practice. Wright collected a group of patients who had soft-tissue reconstructions following open fractures of the lower limbs, chronic infection, osteomyelitis, and non-union and their postoperative CRP levels. Finally, peaks after day 4 indicate infective complications or further surgery and persistently elevated CRP following surgery is associated with infection and non-union. In our study, the higher level of CRP, the greater the probability of PWC, which has a certain connection with the physiologic changes. Therefore, we suggest that for calcaneal fracture surgery, if the preoperative CRP level is high, it is safe to wait until it has a downward trend or to a normal level.

There were several limitations in our study. First, this was a retrospective study, and selection bias was unavoidable. Second, we did not collect information about tourniquet use, perioperative antibiotic use, and cases of closed reduction treatment. Third, the data in this article came from a single centre and the amount of data was limited. Therefore, in the following work, we need to conduct a prospective multicentre study to obtain a larger sample size and apply the constructed nomogram algorithm for internal verification.

5  |  CONCLUSION

We found a correlation between PWCs and smoking, limb swelling, angle of incision, and CRP after ORIF for calcaneal fracture patients. Our nomogram prediction model might be helpful for clinicians to identify high-risk patients, as interventions could be taken early to reduce the incidence of PWCs.

CONFLICT OF INTERESTS

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

DATA AVAILABILITY STATEMENT

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

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