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ORIGINAL ARTICLE

Deep surgical site infection after ankle fractures treated by open reduction and internal fixation in adults: A retrospective case-control study

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Information on ankle fractures is limited. The purpose of this study was to investigate the incidence and risk factors for deep surgical site infection (DSSI) after open reduction and internal fixation (ORIF). Adult patients who underwent ORIF for an ankle fractures at 3 level-I centres between January 2013 and June 2017 were included. Data on demographic, injury-related, and surgery-related variables and biochemical indexes from the laboratory were collected from patients' electronic medical records. Univariate analysis and multivariate logistic regression analysis model were used to perform the data analysis through SPSS 19.0. Within 1-year postoperatively, 2.83% (74/2617) of cases developed DSSI, with the earliest occurring at the 4th and latest at 147th day. *Pseudomonas aeruginosa*, methicillin-resistant *Staphylococcus aureus*, and methicillin-susceptible *Staphylococcus aureus* were the top 3 bacteria, causing 73% (37/51) of all the cases. Age (45–64 and ≥65 years), current smoking status, chronic heart disease, lower preoperative albumin level, open injury, and prolonged surgical duration were identified to be independently associated with DSSI occurrence. Preoperative active supplementation of nutrition, immediate smoking cessation, and optimisation of an operative plan for the reduction of surgical duration were feasible measures for DSSI prevention following ORIF of ankle fractures.

KEYWORDS
ankle fracture, DSSI, incidence, multicentre, ORIF

1 | INTRODUCTION

With the population aging and the rapid development of industry and transportation in China, ankle fractures have become a very common injury, both in the emergency and orthopaedic departments. It was reported in a national epidemiological database that ankle fractures accounted for 6.5% of all fractures and 37% of the tibial and fibular fractures in adults.[1] Moreover, in elderly patients, ankle fracture has been the third most reported injury, trailing behind only hip and wrist fractures.[1,2] Currently, open reduction and internal fixation (ORIF) remains the most prevalent treatment for ankle fractures, especially for those complex injuries.[3–7] However, substantial evidence suggested that postoperative deep surgical site infection (DSSI) could seriously affect the treatment outcomes, although with a relatively low incidence.[8] Even if treated promptly, these infections might still have catastrophic consequences, such as impaired joint function, limb loss, or even death.[9] With data from a large trauma unit in the United Kingdom, Korim et al[10] evaluated 710 cases of ankle fractures treated by ORIF and suggested that surgical site infections significantly result in lower

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functional scores (60 vs 90, Olerud and Molander Ankle Score). In addition, increased economic burden and medical resources consumption remain a concern.

Identification of risk factors associated with DSSI after ORIF of an ankle is the prioritised task for the reduction and prevention of this issue. Previously, numerous studies were conducted to investigate the risk factors associated with surgical site infection (SSI) or DSSI after orthopaedic surgeries.[10–14] However, as far as we know, only 1 study was performed to investigate the risk factors for DSSI after ankle fractures.[14] In that study, tobacco use and duration of surgery >90 minutes were identified as independent risk factors associated with DSSI, and cast application in the operation room was a protective factor.[14] Methodologically and statistically, an age- and gender-matched case–control method with a large sample (1923 patients and 131 DSSIs) and multivariate logistic regression was used, which appeared capable of resolving the issue.[14] However, the fewer potential variables included for data analysis might compromise the results. Many variables of potential predictive value in SSI occurrence after orthopaedic surgery were unreported, such as comorbidities, incision cleanliness, preoperative antibiotics use, postoperative drainage use, and some biochemical indexes from laboratory. In addition, the single-centre study design might be also a limitation in the generalisation of the results.

Given that, we conducted this retrospective multicentre study with 2 aims: to investigate the incidence and characteristics of DSSI after ORIF of ankle fractures and to test the hypothesis that some clinical variables and biochemical indexes from the laboratory were of independent predictive value in SSI occurrence.

Key Messages

- the incidence rate of DSSI following ORIF of an ankle fracture was 2.83% within 1 year postoperatively
- *Pseudomonas aeruginosa*, MRSA, and MSSA were the top 3 bacteria, causing 73% of all the DSSI cases
- age ≥45 to 64 years, current smoking status, chronic heart disease, lower preoperative albumin level, open injury, and prolonged surgical duration were identified as independently associated with DSSI after ankle fractures
- preoperative active supplementation of nutrition, immediate smoking cessation, and optimisation of an operative plan for reducing surgical duration were feasible measures for DSSI prevention

2 | MATERIALS AND METHODS

2.1 | Study design

From the electronic registry system and patients' electronic medical records, all adult patients (18 years and older) who had undergone ORIF of an ankle fracture from January 2013 to December 2016 were identified. The exclusion criteria were patients <18 years, pathological fractures, metastatic fracture, old fractures (>21 days from initial injury), and treatments other than ORIF (external fixation, conservative treatments, closed reduction and internal fixation, traction).

Data were collected regarding 4 aspects: patients' demographics, injury-related and surgery-related characteristics, and biochemical indexes from laboratory within the preoperative 24 hours. Demographics of patients included gender, age, living place, height and weight and the calculated body mass index (BMI, kg/m^2), smoking status, alcohol consumption, and comorbidities (hypertension, diabetes mellitus, chronic heart diseases, chronic obstructive pulmonary disease [COPD] and asthma, renal disease, liver disease, rheumatic disease, peripheral vascular disease, allergy to medications or foods, previous history of surgery at any site).

Injury-related variables included mechanism (low or high energy), fracture type (open or close), fracture sites (uni-, bi-, or trimalleolar fracture), and presence or absence of accompanied dislocation. Low-energy injury was defined as simple falls from standing height and high-energy injury as traffic accidents, fall from height, violent collisions, and sporting activity, similar to previous literature.[15]

Surgery-related variables included surgeon level, preoperative stay (interval between initial injury and operation), American Society of Anaesthesiologists anaesthesia type, incision cleanliness (clean, clean-contaminated, contaminated, dirty-infected), surgical duration (minutes), intraoperative blood loss, preoperative prophylactic use of antibiotic, and postoperative drainage.

Biochemical indexes within preoperative 24 hours included white blood cell (WBC), neutrophile (NEUT), lymphocyte (LYM), red blood cell (RBC), haemoglobin (HGB), total protein (TP), albumin (ALB), globulin (GLOB), and A/G value.

2.2 | Definition of SSI

Deep SSI was defined based on the standard Center for Disease Control (CDC) definitions[16] as infection that occurred within postoperative 1 year in patients with internal fixation material implanted and referred to infections involving deep soft tissue, muscle or fascia; persistent wound discharge or dehiscence; visible abscess or gangrenosis that required surgical debridement; and implant exchange or removal. This definition was previously used widely in literature.[15,17] SSI patients' EMRs and microbiological records were reviewed for recorded signs and symptoms of SSI and bacterial culture results.

2.3 | Statistical analysis

The Mann-Whitney *U* test or Student's *t* test was used to analyse the continuous variables, depending on the normality and homogeneity status of the data. Chi-square or Fisher's exact test was used to evaluate the differences of categorical variables between the DSSI group and the non-DSSI group. Finally, all categorical variables were entered into a multivariable logistic regression model using the stepwise backwards Wald method to determine independent risk factors for DSSI. The Hosmer-Lemeshow test was used to evaluate the goodness of fit of the final model, and $P > .05$ indicated an acceptable result; Nagelkerke R^2 was used to quantify the goodness of fit. All the tests were performed using the SPSS 19.0 software package (SPSS Inc., Chicago, Illinois).

3 | RESULTS

3.1 | Overall characteristics about fracture

During the study time window, a total of 2714 patients with 2729 ankle fractures (bilateral ankle fractures in 15 patients) treated by ORIF were included, and 5 deaths during hospitalisation and 105 cases with incomplete data were excluded. Therefore, 2605 patients with 2617 ankle fractures met the criteria and were finally included for data analysis. Of them, there were 1310 males and 1295 females, with a mean age of 44.4 years (range, 18-82). Most patients presented with low-energy injuries, accounting for 74.5% (1951/2617) of all the patients. About 5.6% (147/2617) of them were open fractures. Regarding fracture sites, there were 1173 cases (44.8%) of unimalleolar fractures, 800 (30.6%) bimalleolar and 644 (24.6%) trimalleolar fractures, and 540 (20.6%) of them were accompanied by dislocation. ORIF was performed at a mean of 3.5 days after the injury, and 72.6% (1901/2617) were performed within 1 week. The mean total length of hospital stay was 15.8 days.

3.2 | Characteristics of SSI

A total of 74 DSSIs in 74 patients occurred within 1 year postoperatively, indicating an incidence rate of 2.83% (74/2617; 95% CI, 2.19%-3.46%). Secretion and swabs from all the DSSI cases were cultured for bacterial species and drug susceptibility, and 51 cases presented with positive results. The results were as follows: 17 DSSIs were caused by *Pseudomonas aeruginosa*, 13 (25.5%) by methicillin-resistant *Staphylococcus aureus* (MRSA), 9 SSIs (17.6%) were polymicrobial, 7 (13.7%) by methicillin-susceptible *Staphylococcus aureus* (MSSA), 2 (3.9%) by bacillus coli, 2 (3.9%) by *Bacillus cereus*, and 1 (2.0%) by *Enterococcus faecalis*. The earliest diagnosis of SSI was at the 4th day after surgery, and the latest was at 147 days postoperatively, with a median occurrence at 26 days.

3.3 | Univariate analysis

Table 1 demonstrates the detailed comparison of results between both groups (non-DSSI vs DSSI). For continuous variables, there was significant difference between non-DSSI and DSSI groups in term of age (44.2 ± 14.5 vs 50.6 ± 12.4, $P < .001$), preoperative stay (3.5 ± 4.2 vs 4.7 ± 6.1, $P = .039$), surgical duration (101.6 ± 61.5 vs 127.3 ± 58.2, $P = .006$), preoperative neutrophile count (5.65 ± 2.63 vs 7.14 ± 3.31, $P = .014$), TP (70.5 ± 6.4 vs 65.6 ± 7.8, $P = .031$), and ALB (44.9 ± 4.4 vs 41.2 ± 4.5, $P = .026$). Regarding categorical variables, there was significant difference between non-DSSI and DSSI groups in term of age, BMI, injury mechanism, injury type, preoperative stay, chronic heart disease, surgical level, smoking status, surgical incision cleanliness, surgical duration, intraoperative blood loss, prophylactic antibiotics use, and preoperative total protein and albumin. Patients with DSSI had a significantly prolonged total hospital stay, about 12.1 days (27.6 ± 19.4 vs 15.5 ± 11.5, $P < .001$) longer than those without DSSI. In term of other variables, we did not observe the significant difference between both groups.

3.4 | Multivariate logistic regression analysis

We entered all the related categorical variables into the multivariate logistic regression model. After adjustment for confounding factors, higher age (45-64 years: odds ratio [OR], 3.1; 95% confidence interval [CI], 1.8-5.3 and ≥65 years: OR, 3.4; 95% CI, 2.1-7.6), current smoking status (OR, 2.7; 95% CI, 1.3-6.2), chronic heart disease (OR, 2.1; 95% CI, 1.2-5.5) and preoperative albumin <35 g/L (OR, 1.6; 95% CI, 1.0-4.4), open injury (OR, 4.6; 95% CI, 2.4-12.4), and surgical duration ≥180 minutes (OR, 3.1; 95% CI, 1.7-6.3) were significant risk factor or predictors for SSI occurrence. The results are detailed in Table 2.

The results of the Hosmer-Lemeshow test demonstrated the adequate fitness of the final model ($\chi^2 = 3.782$, $P = .821$; Nagelkerke $R^2 = 0.277$).

4 | DISCUSSION

DSSI is a serious complication after ankle fractures, causing repeated surgical debridement, implant removal, and even death, which imposes significant burdens on individual, family, and social institutions.[8,14] The reported incidence rates of DSSI following surgical ankle fracture are considerably varied, predominantly depending on the study designs, definitions of SSI, patients' medical conditions, injury severity, and surgical methods.[10,14,18,19] The focus of this retrospective multivariate study was to investigate the incidence and significantly independent risk factors for DSSI after ORIF of ankle fractures. The results showed that DSSI incidence rate following ORIF of an ankle fracture was 2.83% within 1 year postoperatively. Three modifiable risk factors,

TABLE 1 Univariate comparison of variables between ankle fracture patients with and without deep surgical site infection (DSSI)

Variables	Patients without SSI ($n = 2543$) (mean ± SD/*n*, %)	Patients with SSI ($n = 74$) (mean ± SD/*n*, %)	*P*-value
Age	44.2 ± 14.5	50.6 ± 12.4	<.001
18–44	1275 (50.1)	18 (24.3)	<.001
45–64	1061 (41.7)	46 (62.2)	
≥65	207 (8.1)	10 (13.5)	
Gender (male)	1281 (50.4)	39 (52.7)	.693
BMI	24.5 ± 3.4	25.1 ± 4.2	.137[a]
Reference (18.5-23.9)	1079 (42.4)	22 (29.7)	.01
Underweight (<18.5)	82 (3.2)	0	
Overweight (24–27.9)	894 (35.2)	27 (36.5)	
Obesity (28–31.9)	375 (14.7)	19 (25.7)	
Morbidity obesity (>32)	113 (4.4)	6 (8.1)	
Living place (city vs rural)	1012 (39.8)	33 (44.6)	.406
Mechanism (high vs low energy)	634 (24.9)	32 (43.2)	<.001
Open injury	134 (5.3)	13 (17.6)	<.001
Preoperative stay (interval between injury and surgery)	3.5 ± 4.2	4.7 ± 6.1	.039[a]
0-2 d	1002 (39.4)	31 (41.9)	.002
3-6 d	856 (33.7)	12 (16.2)	
≥7 d	685 (26.9)	31 (41.9)	
Total hospital stay (d)	15.5 ± 11.5	27.6 ± 19.4	<.001[a]
Diabetes mellitus	151 (5.9)	4 (5.4)	.848[b]
Hypertension	497 (19.5)	12 (16.2)	.476
Chronic heart disease	62 (2.4)	7 (9.5)	<.001[b]
Surgeon level			
Chief	863 (33.9)	28 (37.8)	.007
Vice chief	708 (27.8)	31 (41.9)	
Attending	808 (31.8)	14 (18.9)	
Resident	164 (6.4)	1 (1.4)	
Current smoking	531 (20.9)	23 (31.1)	.034
Alcohol drinking	639 (25.1)	19 (25.7)	.915
Previous operation in any site	539 (21.2)	18 (24.3)	.517
Fracture type			.324
Unimalleolar	1148 (45.1)	25 (33.8)	.153
Bimalleolar	773 (30.4)	27 (36.5)	
Trimalleolar	622 (24.5)	22 (29.7)	
Accompanied dislocation	519 (20.4)	21 (28.4)	.095
Incision cleanliness (II-IV)	177 (7.0)	18 (24.3)	<.001
Anaesthesia type (general vs regional)	157 (6.2)	2 (2.7)	.218[b]
Surgical duration (min)	101.6 ± 61.5	127.3 ± 58.2	.006
<60	481 (18.9)	4 (5.4)	<.001
60-119	1246 (49.0)	39 (52.7)	
120-179	612 (24.1)	19 (25.7)	
≥180	204 (8.0)	12 (16.2)	
Intraoperative blood loss (mL)	116.9 ± 179.9	111.2 ± 126.1	.542
<200	2074 (81.6)	62(83.4)	.01
200-399	361 (14.2)	6 (8.1)	
400-599	62 (2.4)	1 (1.4)	
>600	46 (1.8)	5 (6.8)	
Prophylactic antibiotics use	1863 (73.3)	39 (52.7)	<.001
Drainage use	915 (36.0)	28 (37.8)	.743
WBC (10^9/L)	7.62 ± 2.40	7.97 ± 2.40	.713

TABLE 1 (Continued)

Variables	Patients without SSI ($n = 2543$) (mean ± SD/n, %)	Patients with SSI ($n = 74$) (mean ± SD/n, %)	P-value
>10	386 (15.2)	11 (14.9)	.941
NEUT (10^9/L)	5.65 ± 2.63	7.14 ± 3.31	.014[a]
NEUT (>75)	521 (20.5)	21 (28.4)	.099
LYM (10^9/L)	1.85 ± 0.66	1.74 ± 0.73	.314
RBC (10^{12}/L)[c]	4.42 ± 0.56	4.48 ± 0.68	.863
<Lower limit	173 (6.8)	7 (9.5)	.373[b]
HGB (g/L)[c]	133.9 ± 18.1	138.2 ± 23.0	.281[a]
<Lower limit	196 (7.7)	8 (10.8)	.326
PLT (10^9/L)	230.7 ± 59.3	215.8 ± 63.1	.217
Reference (100-300)	2211 (86.9)	63 (85.1)	.671
<100	37 (1.5)	2 (2.7)	
>300	295 (11.6)	9 (12.2)	
TP (g/L)	70.5 ± 6.4	65.6 ± 7.8	.031[b]
TP < 60 g/L	189 (7.4)	14 (18.9)	<.001
ASA (≥III vs I and II)	439 (17.3)	23 (31.1)	.002
History of allergy	141 (5.5)	7 (9.5)	.151[b]
ALB (g/L)	44.9 ± 4.4	41.2 ± 4.5	.026[a]
ALB < 35 g/L	125 (4.9)	8 (10.8)	.023
GLOB (g/L)	25.6 ± 4.4	24.4 ± 4.2	.174
GLOB > 30 g/L	164 (6.4)	4 (5.7)	.718[b]

Abbreviations: ALB, albumin; A/G, albumin/globulin; ASA, American Society of Anesthesiologist; GLOB, globulin; HGB, haemoglobin; LYM, lymphocyte; NEUT, neutrophile; PLT, platelets; RBC, red blood cell; TP, total protein; WBC, white blood cell.

[a] Indicated Fisher's exact test.

[b] Indicated Mann-Whitney U test for variables and unmarked indicated χ^2 test or Student's t test.

[c] RBC reference range: female, 3.5 to 5.0/10^{12}; males, 4.0 to 5.5/10^{12}. HGB reference range: females, 110 to 150 g/L; males, 120 to 160 g/L.

including current smoking status, prolonged surgical duration, and lower preoperative albumin level, and 3 non-modifiable risk factors, including age ≥45 years, chronic heart disease, and open injury, were identified as independent risk factors associated with DSSI. In addition, we found that *P. aeruginosa*, MRSA, and MSSA remained the top 3 causative bacteria, which should be taken into full consideration when an SSI is suspected and broad-spectrum antibiotic treatment is decided.

TABLE 2 Multivariate analysis of factors associated with deep surgical site infection (DSSI) after open reduction and internal fixation (ORIF) of ankle fractures

Variables	Exp(B)	95% CI (lower limit)	95% CI (upper limit)	P-value
Age (y)				
Reference (18-44)				
45-64	3.1	1.8	5.3	.002
≥65	3.4	2.1	7.6	<.001
Incision cleanliness 2–4	1.8	1.1	3.2	.021
Current smoking	2.7	1.3	6.2	.034
Chronic heart disease	2.1	1.2	5.5	.041
Open injury	4.6	2.4	12.4	<.001
Surgical duration (min)				
Reference (<60)				
60-119	1.6	0.6	3.9	.373
120-179	1.9	0.9	4.7	.078
≥180	2.7	1.4	7.1	.005
Preoperative albumin <35 g/L	1.6	1.0	4.4	.047

In the previous literature, the incidence of DSSI was reported to be from 1.1% to 6% after orthopaedic surgery.[5,8,10,12,14,17,20,21] This wide range in literature may reflect differences in the definition of SSI, study design, sample size, and treatment diversity. In this study, we observed a median incidence figure (2.83%), which was partially was because of the large sample size in 3 level-I hospitals. In a UK single-centre study,[10] authors reported 1.1% for DSSI incidence, and in their study,[10] 710 patients above 18 years with closed or open ankle fractures were treated by ORIF, and these settings were all consistent with ours. Ovaska et al reported an incidence of 6.8% for DSSI after operative ankle fractures in a level-I trauma centre.[14] However, the definition criteria for DSSI used in the study was very broad, which included 3 conditions (clinical signs, positive bacterial cultures, and osteosynthesis material visible or palpable in the wound) but did not specify the involvement of deep fascia or muscles.[14] Sun et al[17] conducted a retrospective multicentre study of 1247 ankle fractures treated by ORIF and observed a DSSI incidence of 1.12% during patients' hospitalisation, which was far lower than ours (2.83%). We infer that the exclusion of open ankle fractures in their study might contribute to the large difference in DSSI incidence because open fractures generally caused more postoperative infections.[17] These varied results from various studies reflected overall trends of SSI and respective characteristics, which could be used as important references for clinical surgeons.

The lower albumin as a significant risk factor for DSSI after ankle fracture was first reported in this study, although it had been reported as risk factors for other complications or SSIs after other orthopaedic surgeries, like spine fusion, hip arthroplasty, and hip fractures.[22–24] Yuwen et al[25] conducted a meta-analysis of 13 studies including 112 183 patients with orthopaedic surgeries and concluded that preoperative albumin <35 g/L increased the SSI risk by 2.39 times, compared with those with albumin >35 g/L. In addition, lower albumin had been established as an increased risk of poor outcome of infection,[26] postoperative death,[27] and prolonged total hospital stay.[27] In contrast, the preoperative active supplementation of nutrition to reach a normal level of serum albumin had significant favourable effects on reduction of SSIs and other adverse events.[28,29] Therefore, we suggest that patients with serum albumin <35 g/L should be regularly supplemented with protein product via oral administration or intravenous injection and immediately admitted to the hospital.

Prolonged surgical duration and current smoking status as significant risk factors for DSSI after ankle fractures were identified in the study by Ovaska et al,[14] who found that current tobacco use and surgical duration >90 minutes significantly increased the DSSI risk by 3.7 times and 2.5 times, respectively. Authors also pointed out that prolonged surgical duration was more likely decided by the encountered intraoperative problems,[14] such as difficult reduction because of greater fracture severity and accidental cardiovascular events. For example, use of a tourniquet could provide a bloodless operative field, facilitating fracture reduction and helping to shorten surgical time, but it was related to the higher incidence of wound complications after foot and ankle surgery.[30] It is a pity that in this study, we did not include the above-mentioned 3 potential variables that affect the operation process. Smoking has been found to increase the risk of SSI[31] by 5 times and the risk of DSSI by 3 times[14] following ankle fracture surgery. Our findings supported this conclusion, and even after adjustment for other confounding variables, current smoking was still the strongest predictor for DSSI. Therefore, we encouraged every smoker undergoing surgical treatment for ankle fractures to quit smoking during the hospitalisation because even a small reduction in smoking could have beneficial effects, especially in those with compromised soft tissue.[32]

Open injury, advanced age, and chronic heart disease were identified as significant non-modifiable risk factors for DSSI after surgical ankle fractures in this study. The former 2 variables as significant risk factors for SSI in orthopaedic surgery had been reported in literature,[15,17,33] but the latter (chronic heart disease) was reported first in this study. The compromised soft tissue and skin conditions in open injury and inferior systemic conditions in elderly patients were the predominant contributor to DSSI.[12,14] The detailed relationship between SSI and chronic heart disease remains unclear. We infer that the weaker blood flow in veins in the lower limbs and ankle joints might be primarily responsible for the occurrence of DSSI, but this requires a prospective cohort study to confirm. We also observed that an ankle fracture and accompanied dislocation were not identified as risk factors for SSI occurrence, either in univariate or multivariate analyses ($P > .05$), which was consistent with most previous studies.[8,10,12,31,34] As far as we know, only 2 studies considered it a significant risk factor for SSI,[13,14] and the results of both studies were obtained using univariate rather than in multivariate analyses. Therefore, we thought that the relative weak negative effect of fracture dislocation for SSI was offset by other stronger variables, such as open fractures, smoking status, and prolonged surgical duration in the multivariate analyses.

Regarding other variables, although tested as significant in univariable analysis, they did not remain significant in the multivariable analysis, such as prolonged preoperative stay, polluted or dirty surgical incisions, more intraoperative blood loss, and higher percentage of NEUT. The reasons for the non-significant results might be multifactorial. On one hand, they were more likely to present as an accompanied result as prolonged preoperative stay might be suggestive of more morbidities or weaker systemic status in elderly patients or greater severity of injury requiring more time to recover. On the other hand, the sample size is still not large enough, although it is currently the largest one specifying DSSI after ankle fracture. Therefore, there remains some accidental, inevitable bias for certain variables. The retrospective design and sole reliance on electronic medical record (EMR) were the main limitations of this study, which may compromise the accuracy and precision of the collected data. In addition, some other variables were not available, such as fracture reduction quality, fixation type, and postoperative exercise, and therefore, there remains unmeasured confounding effects that affect DSSI occurrence after ankle fracture surgery.

In summary, the incidence of DSSI following ORIF of ankle fractures was 2.83% within 1 year postoperatively. *P. aeruginosa*, MRSA, and MSSA remained the top 3 causative bacteria and should be taken into consideration in clinical practice. Age (45–64 and ≥65 years), current smoking status, chronic heart disease, lower preoperative albumin level, open injury, and prolonged surgical duration were identified as independently associated with DSSI occurrence. Preoperative active supplementation of nutrition, immediate smoking cessation, and optimisation of operative plan for reduction of surgical duration were feasible measures for DSSI prevention following ORIF of ankle fractures.

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Conflict of interest

All the authors declare that they have no conflicts of interest.

Authorcontributions

H.Z. designed the study; J.M., S.Q., and Y.L. searched the EMR for data on variables of interest; F.Z. and Y.L. searched relevant literature and analysed and interpreted the data; J.M. and T.S. wrote the manuscript; and H.Z. approved the final version of the manuscript.

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