DOI: https://doi.org/10.30795/jfootankle.2025.v19.1874

Original Article

Risk factors for calcaneal fracture-related infection in open reduction and internal fixation: a retrospective cohort

Eduardo Cezar Silva dos Santos[1], Renato de Oliveira Arnaud Ferreira[1], Sabra Mariela Fernandes Falcão[1], Eduardo Araújo Pires[1], Dov Lagus Rosemberg[1], Daniel Araújo da Silva[1], Martha Lúcia Silva Katayama[1], Felipe Daniel Plata Rosa[1], Cláudia Diniz Freitas[1]

1. Hospital Alemão Oswaldo Cruz, Sao Paulo, SP, Brazil.

Abstract

Objective: To identify independent risk factors for calcaneal fracture-related infection (FRI) in open reduction and internal fixation (ORIF).

Methods: Retrospective and observational study using data extracted from the TriNetX international platform, including patients of both sexes with a confirmed diagnosis of calcaneal fracture submitted to surgical treatment with ORIF, with a 1-year follow-up. An adjusted multiple logistic regression test was used to identify independent variables, and the Kaplan-Meier and Log-Rank tests were used to assess disease-free survival.

Results: In total, 2,830 patients with a mean age of 50 years (SD ± 15) were evaluated, most of them men, 1,788 (63.8%). One hundred eighty-one patients had FRI within one year after surgical treatment. The following variables were independent risk factors for FRI: smoking [OR 1.8 (CI 0.02;0.06), p = 0.0001], alcohol abuse [OR 1.6 (CI 1.0;2.6), p = 0.045], chronic kidney disease [OR 2.23 (CI 1.13;4.39), p = 0.017], overweight [OR 2.8 (CI 1.34;5.89), p = 0.004], fall from height [OR 2.18 (CI 1.47;3.25), p = 0.0001] and open fracture [OR 2.13 (CI 1.07;4.23), p = 0.026].

Conclusion: Smoking, alcohol abuse, chronic kidney disease, overweight, fall from height, and open fracture were independent risk factors for infection.

Level of evidence II, observational study.

Keywords: Infections; Surgical wound infection; Heel bone; Bone fractures; Risk factors.

Introduction

Calcaneal fracture-related infection (FRI) can occur in up to 25% of open reduction and internal fixation (ORIF) procedures, resulting in restrictions on ambulation and occupational limitations with a substantial loss of quality of life[1].

Calcaneal fractures are the most frequent tarsal lesions[2] and the second most common among foot bones, although they represent only 2% of fractures in adults[3]. In addition to the aforementioned functional disability, FRI has a high cost to the public health system, as the patient requires several additional surgical interventions, making the treatment costly, with values that reach up to five times the value of the initial treatment[4].

Risk factors for infection can be modifiable and non-modifiable, and most are related to the patient's clinical comorbidities, lifestyle, and surgical management of the fracture[5]. Other factors are associated with the perioperative period, such as the management of open fractures following the appropriate protocols, fracture stabilization, prolonged hospitalization, and soft tissue involvement, which hinder the fracture consolidation process that, in the natural history of

Study performed at Hospital Alemão Oswaldo Cruz, Sao Paulo, SP, Brazil.

Correspondence: Eduardo Cezar Silva dos Santos. Rua Treze de Maio, 1815, 01323-903, Sao Paulo, Sao Paulo, Brazil. **Email:** eduardocezar.ortopedia@gmail.com. **Conflicts of interest:** None. **Source of funding:** None. **Date received:** October 14, 2024. **Date accepted:** July 18, 2025.

How to cite this article: Santos ECS, Ferreira ROA, Falcão SMF, Pires EA, Rosemberg DL, Silva DA, et al. Risk factors for calcaneal fracture-related infection in open reduction and internal fixation: a retrospective cohort. J Foot Ankle. 2025;19(2):e1874.

the disease, can have osteomyelitis and even amputation as an outcome[5,6].

Information on these risk factors for calcaneal ORIF infection is restricted in the literature. Therefore, the objective of this study is to identify independent risk factors for calcaneal fracture-related infection in open reduction and internal fixation.

Methods

Study design

This is a multicenter, observational, retrospective cohort study and cross-sectional analysis of men and women diagnosed with calcaneal fractures submitted to surgical correction with ORIF and evolved to FRI. The data was extracted from the international collaborative real-world evidence platform TriNetX, an international health research network that is updated weekly with data recorded in electronic medical records. This network comprises Healthcare Organizations (HCOs), including academic centers, specialized medical centers, and hospitals. In Brazil, the data are centralized at the DataLab for Innovation, Research, and Education of Hospital Alemão Oswaldo Cruz (HAOC) in Sao Paulo, which operates as a TriNetX hub institution in the country. TriNetX complies with the Health Insurance Portability and Accountability Act (HIPAA). This retrospective study is exempt from informed consent. The revised data are a secondary analysis of existing data, do not involve intervention or interaction with human subjects, and are de-identified under the HIPAA Privacy Rule standards.

The data used in this study were collected on December 31, 2024. At the time of data consultation, 2,830 patients were included in the TriNetX database. This study used a retrospective cohort design, reviewing electronic medical records from January 1, 2020 to January 1, 2023. Selected through ICD-10: S92.0. All included patients had at least 1-year follow-up after the initial event, were ≥ 18 years old, and underwent surgical treatment for calcaneal fracture with ORIF. Age < 18 years, fracture of more than one surgical site, FRI after 1-year follow-up, percutaneous fixation, pseudarthrosis, refractures, and patients submitted to arthrodesis were excluded from the study.

The variables collected were divided as follows: variables related to the patient; addressing the demographic characteristics of sex, mean age, race, comorbidities (identified by ICD-10)[7], and clinical conditions of the patient; related to the perioperative period, with information on fracture characteristics, trauma information, and fracture classification. For ORIF, the use of plate and screws and direct access routes to the fracture was considered, such as the access route of the tarsal sinus and the extended lateral.

Outcomes analyzed

Prevalence and risk factors for FRI in patients with calcaneal fractures submitted to surgical treatment with ORIF up to 1-year follow-up. The outcome of FRI was selected using the following ICD-10 codes: T81.4, T84.6, T84.60XA, and T84.6.

Sample size calculation and statistical analysis

The sample size calculation was developed in conjunction with the local Statistics and Epidemiology Laboratory. The expected event ratio and odds ratio data for the initial estimated calculation were used. The level of statistical significance adopted in the analysis was 5% (0.05). The two-sided test of significance was used. Continuous variables were expressed as mean ± standard deviation (SD), as they presented normal distribution. Analyses comparing these variables between infected and uninfected groups were performed using the unpaired Student's t-test. To test for normality, the Shapiro-Wilk test was used. The distributions of categorical variables were expressed as frequencies and percentages, and the respective comparisons were performed using the χ^2 test or Fisher's exact test, as appropriate. The analysis of the outcomes was conducted based on the time to occurrence of the primary event, as well as event-free survival and osteomyelitis curves, using the Kaplan-Meier method. The Log-rank test was used for statistical significance between the distribution curves. The statistical programs used were the R system and SPSS Statistics version 19.0, in addition to four programs or language tools intrinsic to the TriNetX platform system.

Results

Overall, 38,842 patients with calcaneal fractures were evaluated for inclusion in the study. Of these patients, 36,012 (92.7%) were excluded: 32,312 underwent non-surgical treatment, 1,517 were > 18 years, and 2,183 underwent percutaneous surgical treatment, totaling 196 patients in the final analysis. The mean age was 50 years (SD ± 15), with a majority of men, 1,788 (63.8%). During the evaluated period, 181 patients were diagnosed with FRI, resulting in an overall rate of 6.83% within 1-year follow-up (Figure 1).

Of the variables analyzed, those that presented statistical significance of FRI were smoking (p < 0.0001), alcohol abuse (p < 0.016), systemic arterial hypertension (p < 0.001), chronic kidney disease (p <0.002), overweight (p <0.01), grade I obesity (p < 0.0005), fall from a height greater than 3 meters (p < 0.0001), open fracture (p < 0.0001), intra-articular fracture (p < 0.0001), serum albumin < 3.5 g/dL (p < 0.0001), serum protein dosage less than 6 g/dL (p < 0.0001) and Hb1Ac between 5.7%-6.4% (< 0.0001). There was no statistical difference in relation to demographic data (Table 1).

However, in the multivariate analysis of risk factors for FRI, only the variables smoking, alcohol abuse, chronic kidney disease, overweight, fall from height, and open fracture were statistically significant. Some variables were almost twice as likely to develop infection, including smoking [OR 1.8 (CI 0.02;0.06)], alcohol abuse [OR 1.6 (CI 1.0;2.6)], and systemic arterial hypertension [OR 1.4 (CI 1.09;2.01)]. Chronic kidney disease [OR 2.23 (CI 1.13;4.39)], overweight [OR 2.8 (CI

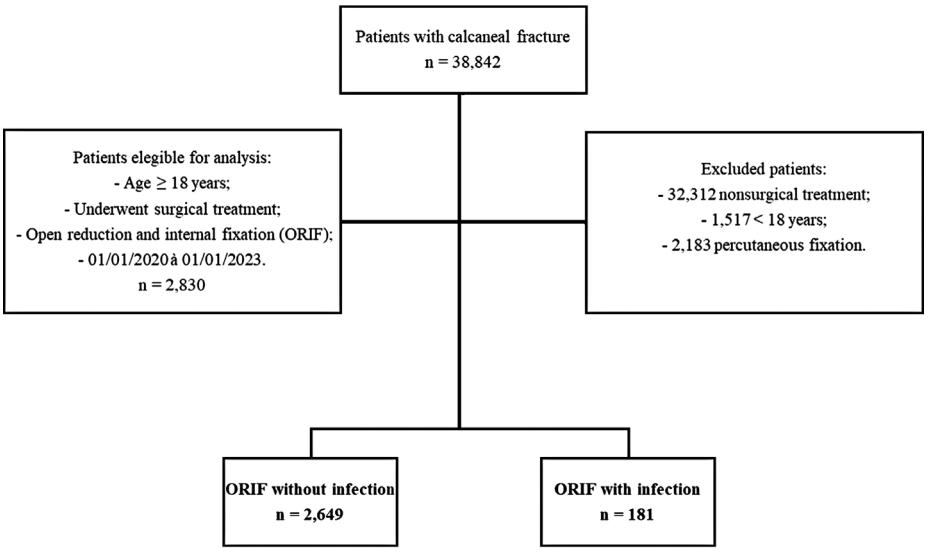

Figure 1. Algorithm for selecting the patients involved in the study.

Table 1. Risk factors for infection according to univariate analysis.

	Variables	With infection (n = 181)			Without infection (n = 2,649)			p-value
	Demographic data	**(Mean ± SD)**		**% cohort[a]**	**(Mean ± SD)**		**% cohort[a]**	
ICD-10	Age	46.4 ± 14.3	181	100%	46.9 ± 15.3	2.649	100%	0.65
	Men		121	66.85%		1.667	62.93%	0.28
	Women		51	28.18%		824	31.11%	0.40
	Race							
	White		132	72.93%		1.793	67.69%	0.14
	Black		16	8.84%		299	11.28%	0.31
	Unknown		21	11.60%		357	13.48%	0.47
	Comorbidities							
F17.2	Smoking		73	40.33%		716	27.03%	0.0001
F10	Alcoholism		26	14.37%		238	8.99%	0.016
I10	SAH[b]		64	35.36%		648	24.46%	0.001
E08-E13	Diabetes Mellitus		23	12.71%		228	8.61%	0.06
N18	Chronic kidney disease		13	7.18%		100	3.78%	0.02
	BMI[c] (Kg/m^2)	26.4 ± 7.13	133	73.48%	27.3 ± 5.98	1.658	62.59%	
	25-29.9		70	38.67%		787	29.71%	0.0111
	30-34.9		47	25.97%		424	16.01%	0.0005
	35-40		11	6.08%		185	6.98%	0.6422
	Fracture							
W13	Fall from high (> 3 m)		30	16.58%		176	6.64%	0.0001
S92.06	Intraarticular fracture		100	55.25%		1.070	40.39%	0.0001
S92.009A	Closed fracture		49	27.07%		641	24.20%	0.38
S92.009B	Open fracture		10	5.53%		31	1.17%	<0.0001
	Exams							
	Serum Albumin	3.7 ± 0.724	102	56.35%	4.04 ± 0.619	1.208	45.60%	< 0.0001
	< 3.5 g/dL		57	31.49%		356	13.44%	< 0.0001
	Serum protein	6.72 ± 1.06	94	51.93%	6.98 ± 2.19	1.142	43.11%	0.26
	< 6.0		36	19.89%		281	10.61%	< 0.0001
	HbA1c[d]	5.96 ± 1.5	59	32.60%	6.04 ± 1.77	593	22.39%	0.7314
	5.7-6.4%		21	11.60%		196	7.40%	0.0398
	> 6.5%		13	7.18%		119	4.49%	0.0968

% cohort: Percentage of sample in cohort; SAH[b]: Systemic arterial hypertension; BMI[c]: Body mass index, HbA1c[d]: Glycated Hemoglobin.

1.34;5.89)], fall from height [OR 2.18 (CI 1.47;3.25)], and open fracture [OR 2.13 (CI 1.07;4.23)] presented a two-fold higher adjusted odds ratio (Table 2).

In the survival analysis to evaluate the osteomyelitis outcome between the groups, statistically significant events were observed in the group of patients who evolved with infection (Figure 2).

Discussion

Open reduction and internal fixation in calcaneal fractures are challenging for the orthopedic surgeon, as there is a peculiar local anatomy and poor soft tissue envelopment in this area[8,9]. In our study, the overall infection rate was 6.83% and the prevalence was 7.49%. Our data are similar to the literature, which reports a prevalence of 9.7% and an incidence of 7.7% in closed fractures, and up to 45% in open fractures[10]. However, data were reduced in relation to the retrospective study by Lian Ding et al.[11], with an incidence of 17.8% in its cohort of 490 patients

Classically, the risk analysis of the FRI is related to the patient, the fracture, and the surgical procedure[12]. Modifiable lifestyle factors are important in preventing infection[13]. Among these factors, smoking and alcohol abuse can influence the outcome of infection and even delay the consolidation of fixed fractures[14]. In our study, patients who had the habit of smoking were 1.8 times more likely to become infected during surgical treatment. Although the evidence remains contradictory[15,16]. On the other hand, patients with alcohol abuse were 1.6 times more likely than those who did not use alcohol chronically. They are important factors in the rehabilitation of patients submitted to surgery and can be controlled during the perioperative period.

Indeed, the acute nature of fractures limits the ability to modify risk factors for FRI, particularly comorbidities. Nonetheless, these factors should be optimized to provide a more favorable window of opportunity for surgical intervention[17]. Complications of ankle and foot fractures correlated with chronic kidney disease are poorly described in the literature; however, the presence of this risk factor may increase the incidence of infection by three- to fourfold[18]. A similar statistically significant association was observed in this cohort, which may be linked to a secondary complication arising from diabetes progression.

Obesity is recognized as a modifiable risk factor for FRI, and it was statistically significant in our study. Although there are controversies about the relationship between obesity and FRI in other fracture sites[19,20], it is consistently associated with complications and infections in orthopedic procedures[21,22], as confirmed by studies with statistical significance, even in paired analysis[22]. In our sample, patients identified as overweight had a higher probability of the outcome investigated. However, an important finding is that morbid obesity did not correlate with infection outcome as reported in the literature, presenting a divergent pattern.

In lower limb orthopedic procedures, glycemic control and diabetes management are essential due to the high complication rates[23]. In this context, however, our study found no significant association between diabetes and infection, which contrasts with existing literature. Diabetes is known to impair immune cell function, thereby compromising both innate and adaptive immune responses[24]. On the other hand, the study by Endara et al. [25] showed a significant association between glycemic uncontrol and infection at the surgical wound incision. This discrepancy between our series and the literature may be related to the age group of young adults, the type of trauma, or even the reduced number of diabetic patients.

The role of open fractures and high-energy trauma is also well established in the literature for an outcome of FRI, and the risk of infection increases proportionally to the severity classification of the open fracture[26,27]. In our results, patients classified as open fracture had a risk probability twice as high as patients with closed fracture, corroborating the studies in the literature.

Suffering soft tissue envelopment due to trauma energy can impair osteosynthesis [27]. Our study corroborates this correlation by demonstrating an association between high-energy trauma—especially falls from height (greater than 3 meters)—and FRI's. In cases of extensive soft tissue involvement, some surgeons postpone the definitive surgical procedure to improve edema and reduce local hematoma[28]. However, there are controversies about the delay of calcaneal

Table 2. Multivariate analysis of independent risk factors associated with the infection

Variables	Odds ratio Adjusted	95% CI	p-value
Smoking	1.816	(0.021, 0.065)	0.0001
Alcoholism	1.624	(1.007, 2.618)	0.045
Chronic kidney disease	2.237	(1.137, 4.399)	0.017
Overweight	2.815	(1.345, 5.889)	0.004
Fall from high (>3 m)	2.189	(1.470, 3.258)	0.0001
Open fracture	2.133	(1.076, 4.231)	0.026

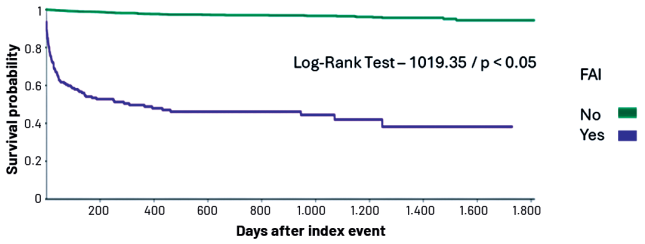

Figure 2. Kaplan-Meier survival curve for osteomyelitis considering fracture-related infection. TRINETX Database: 163 cases (Yes 92 cases, No 71 cases).

surgery for soft tissue improvement. As demonstrated by Abidi et al.[29], this delay increased the wound healing time by approximately 2.6 times.

Studies related to the prevention and mitigation of risk factors emphasize the need to consolidate and develop early intervention strategies following the diagnosis of FRI to prevent pseudarthrosis and osteomyelitis[26-29]. In our series, the survival analysis showed a high risk of osteomyelitis in patients with FRI.

Over the last decade, there has been growing concern about the need to understand the RFIs in various clinical scenarios, particularly in relation to the peculiarities of anatomical location, fracture patterns, types of implants, and access routes[29,30]. This study reinforces the need for improvement and stratification of studies on FRI, addressing the intrinsic characteristics of fracture location.

This study has several limitations. Initially, the retrospective nature of the study introduces an unavoidable selection bias, which relies on the accuracy and quality of medical records to populate the platform database. There is limited information on other factors described in the literature, such as the type of implants, use of previous external fixation, identification of microorganism, and access route used in surgical treatment. Patient-specific covariates (smoking, alcohol abuse, drug use, and medical comorbidities) depended primarily on the patient's report, and some of them might not be willing to disclose these coexisting bad habits and diseases.

Conclusion

Smoking, alcohol abuse, chronic kidney disease, overweight, fall from height, and open fracture were identified as risk factors predicting FRI. Indeed, the holistic view in the perioperative surgical approach helps to identify and mitigate risk factors for infection. We believe that the study provides evidence that will help prevent infection in calcaneal osteosyntheses. Future randomized controlled trials are needed to mitigate contributing factors to infection.

Author's contributions: Each author contributed individually and significantly to the development of this article: ECSS *(https://orcid.org/0000-0001-5018-3923) Conceived and planned the activities that led to the study, wrote the article, participated in the review process, approved the final version; interpreted study results, participated in the review process; and participated in the review process; CDF *(https://orcid.org/0000-0002-6649-2066) Interpreted study results, participated in the review process; ROAF *(https://orcid.org/0009-0008-8466-8900) Interpreted study results, participated in the review process; SMFF *(https://orcid.org/0009-0001-4712-6159) Interpreted study results, participated in the review process; FDPR *(https://orcid.org/0009-0007-9143-1162) Interpreted study results, participated in the review process; DAS *(https://orcid.org/0009-0008-8395-8797) Interpreted study results, participated in the review process; MLSK *(https://orcid.org/0009-0009-9003-0863) Interpreted study results, participated in the review process; EAP *(https://orcid.org/000-001-60088671) Interpreted study results, participated in the review process; DLR *(https://orcid.org/0000-0003-0183-8641) Interpreted study results, participated in the review process. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Hu JS, Huang CB, Mao SM, Fang KH, Wu ZY, Zhao YM. Development of a nomogram to predict surgical site infection after closed comminuted calcaneal fracture. BMC Surg. 2022;22(1):313.
2. Mitchell MJ, McKinley JC, Robinson CM. The epidemiology of calcaneal fractures. Foot (Edinb). 2009;19(4):197-200.
3. Thomas L, Mcnaughton G. Spontaneous Avulsion Fracture Of The Calcaneus In A Non-Diabetic Patient. Scott Med J. 2006;51(3):1-3.
4. Metsemakers WJ, Moriarty TF, Morgenstern M, Marais L, Onsea J, O'Toole RV, et al. The global burden of fracture-related infection: can we do better? Lancet Infect Dis. 2024;24(6):e386-93.
5. Backes M, Schepers T, Beerekamp MS, Luitse JS, Goslings JC, Schep NW. Wound infections following open reduction and internal fixation of calcaneal fractures with an extended lateral approach. Int Orthop. 2014;38(4):767-73.
6. Buijs MAS, van den Kieboom J, Sliepen J, Wever KLH, van Breugel JM, Hietbrink F, et al. Outcome and risk factors for recurrence of early onset fracture-related infections treated with debridement, antibiotics and implant retention: Results of a large retrospective multicentre cohort study. Injury. 2022;53(12):3930-7.
7. World Health Organization. The ICD-10 classification of mental and behavioural disorders: clinical descriptions and diagnostic guidelines. Geneva: World Health Organization; 1992.
8. Hao D, Chen C, Wang D, Yin Y. [Non-operation related risk factors of wound complications of calcaneal fractures using lateral extensive L-shaped incision]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2013;27(1):30-5. Chinese.
9. Paryavi E, Stall A, Gupta R, Scharfstein DO, Castillo RC, Zadnik M, et al. Predictive model for surgical site infection risk after surgery for high-energy lower-extremity fractures: development of the risk of infection in orthopedic trauma surgery score. J Trauma Acute Care Surg. 2013;74(6):1521-7.
10. Wang H, Pei H, Chen M, Wang H. Incidence and predictors of surgical site infection after ORIF in calcaneus fractures, a retrospective cohort study. J Orthop Surg Res. 2018;13(1):293.
11. Ding L, He Z, Xiao H, Chai L, Xue F. Risk factors for postoperative wound complications of calcaneal fractures following plate fixation. Foot Ankle Int. 2013;34(9):1238-44.

12. Santos EC, Prebianchi S, Santos IN, Kurihara MN, Dell'Aquila A, Finelli C, et al. Prior use of antibiotics and immunosuppression are risk factors for fracture-related infection during the COVID-19 pandemic period: a Brazilian prospective cohort study. BMC Musculoskelet Disord. 2022;23(1):535.
13. Ovaska MT, Mäkinen TJ, Madanat R, Vahlberg T, Hirvensalo E, Lindahl J. Predictors of poor outcomes following deep infection after internal fixation of ankle fractures. Injury. 2013;44(7):1002-6.
14. Jerjes W, Ramsay D, Stevenson H, Yousif A. Effect of chronic heavy tobacco smoking on ankle fracture healing. Foot Ankle Surg. 2024;30(4):343-8.
15. Alt V, Giannoudis PV. Musculoskeletal infections: A call for papers to continue the battle against this devastating global challenge. Injury. 2021;52(11):3187-8.
16. Smolle MA, Leitner L, Böhler N, Seibert FJ, Glehr M, Leithner A. Fracture, nonunion and postoperative infection risk in the smoking orthopaedic patient: a systematic review and meta-analysis. EFORT Open Rev. 2021;6(11):1006-19.
17. Metsemakers W-J, Handojo K, Reynders P, Sermon A, Vanderschot P, Nijs S. Individual risk factors for deep infection and compromised fracture healing after intramedullary nailing of tibial shaft fractures: A single centre experience of 480 patients. Injury. 2015;46(4):740-5.
18. Sinkler MA, Pennacchio CA, Kotchman HM, Vallier HA. Association of Chronic Kidney Disease and Complications Following Acute Torsional Ankle Fracture. Foot Ankle Int. 2022;43(12):1569-76.
19. Shaath MK, Lim PK, Andrews R, Chip Routt ML. Morbid obesity and short-term complications following acetabular fracture surgery: A comparative cohort study. Injury. 2020;51(11):2622-7.
20. Qi H, Duan W, Jia R, Wang S, An M, Long Y. Risk factors for surgical site infection after patellar fracture surgery in the elderly. J Orthop Surg Res. 2024 Dec 18;19(1):830. doi: 10.1186/s13018-024-05335-1. PMID: 39695794; PMCID: PMC11657550.
21. Bai Y, Zhang X, Tian Y, Tian D, Zhang B. Incidence of surgical-site infection following open reduction and internal fixation of a distal femur fracture: An observational case-control study. Medicine (Baltimore). 2019;98(7):e14547.
22. Janghala A, Niknam K, Freshman R, Cogan CJ, Zhang AL, Lansdown D. Effect of Obesity on Short- and Long-Term Complications After Ankle Fracture Fixation. J Orthop Trauma. 2024;38(9):e312-7.
23. Zhao D, Liang GH, Pan JK, Zeng LF, Luo MH, Huang HT, et al. Risk factors for postoperative surgical site infections after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. Br J Sports Med. 2023;57(2):118-28.
24. Trevelin SC, Carlos D, Beretta M, da Silva JS, Cunha FQ. Diabetes Mellitus and Sepsis: A Challenging Association. Shock. 2017;47(3):276-87.
25. Endara M, Masden D, Goldstein J, Gondek S, Steinberg J, Attinger C. The role of chronic and perioperative glucose management in high-risk surgical closures: a case for tighter glycemic control. Plast Reconstr Surg. 2013;132(4):996-1004.
26. Foster AL, Moriarty TF, Trampuz A, Jaiprakash A, Burch MA, Crawford R, et al. Fracture-related infection: current methods for prevention and treatment. Expert Rev Anti Infect Ther. 2020;18(4):307-21.
27. You DZ, Schneider PS. Surgical timing for open fractures: Middle of the night or the light of day, which fractures, what time? OTA Int. 2020;3(1):e067.
28. Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. Foot Ankle Int. 1998;19(12):856-61.
29. Marais LC, Zalavras CG, Moriarty FT, Kühl R, Metsemakers WJ, Morgenstern M. The surgical management of fracture-related infection. Surgical strategy selection and the need for early surgical intervention. J Orthop. 2023;50:36-41.
30. Metsemakers WJ, Morgenstern M, McNally MA, Moriarty TF, McFadyen I, Scarborough M, et al. Fracture-related infection: A consensus on definition from an international expert group. Injury. 2018;49(3):505-10.