

Health Science Australia Journal**Volume 3-January 2025****A Peer-Reviewed Open-Access Journal**

Published by Health Science Australia

RISK FACTORS FOR DEEP SURGICAL SITE INFECTIONS FOLLOWING ORTHOPAEDIC TRAUMA SURGERY

AP DR ABDUS SAMADE KHAN, DR ANWER ALI, DR MUHAMMAD HAROON, DR AIMOZ ZIA, AP DR KHALID KHAN, DR MUHAMMAD BILAL, PROF DR HAZIQ DAD KHAN, DR SAAD ALI, DR IRSA HIDAYAT, DR AMMAD ALI, DR MUHAMMAD ISRAR

Corresponding author : Dr Aimon Zia, Mbbs Fcps, aimonz@gmail.com

Abstract

Background: Surgical site infections (SSIs) represent a major concern in orthopedic surgery, leading to prolonged hospital stays, increased healthcare costs, and potentially life-threatening complications. SSIs are particularly common in patients with severe fractures, such as those classified by the Cauchoix grading system, where the risk of infection is heightened due to the complexity of the injury and the surgical intervention required. Factors such as nutritional status, diabetes, smoking, and the use of external fixators contribute to the development of SSIs. This study, conducted at Bacha Khan Medical Complex, Mardan, seeks to identify the clinical and laboratory markers that can predict SSIs in patients undergoing orthopedic fracture management, thereby helping to reduce the incidence and severity of these infections.

Method: This prospective cohort study was conducted from January 2024 to December 2024 at the orthopedic ward of Bacha Khan Medical Complex, Mardan. A total of 207 patients who underwent surgery for fractures were included in the study. Inclusion criteria were patients over the age of 18 years undergoing orthopedic fracture surgery. Exclusion criteria included patients with pre-existing infections, immunocompromised conditions, or those who underwent emergency surgeries. Data was collected on patient demographics, fracture grade (Cauchoix classification), laboratory markers (hemoglobin, lactate levels, creatinine, glycemia, and arterial oxygen levels), and the use of external fixators. Statistical analysis was performed using SPSS, and predictive models for SSI development were created based on these parameters.

Result: Fractures classified as Cauchoix grade 3 were associated with a higher incidence of SSIs (47%). Polymicrobial infections were found in 64% of the SSI cases, with gram-positive cocci, including *Staphylococcus aureus*, being the most common pathogens (72%). A predictive model with an AUC of 0.80 and a negative predictive value of 95.9% was developed. The significant risk factors for SSI development included low hemoglobin, maximum lactate levels, minimum arterial

oxygen levels, and high glycemia levels. The use of external fixators was linked to a higher risk of infection in 38% of the SSI cases.

Conclusion: Cauchoux grade 3, and laboratory markers such as lactate levels and glycemia were strongly associated with an increased risk of infection. The developed predictive model with high sensitivity and specificity could aid in early identification of at-risk patients, allowing for targeted preventive measures and potentially reducing the incidence of SSIs in orthopedic trauma care. Future research should focus on refining this model and assessing the effectiveness of preventive strategies based on these predictive factors.

Keyword: Surgical Site Infection (SSI), Orthopedic Surgery, Fracture Classification, Cauchoux Grade 3, Predictive Model, Risk Factors, External Fixator, Polymicrobial Infection, Gram-positive Cocci, Lactate Levels, Glycemia, Hospital Mortality, Bacha Khan Medical Complex

Introduction: Surgical site infections (SSIs) are a significant concern in orthopedic surgery, contributing to prolonged hospital stays, increased healthcare costs, and higher morbidity and mortality rates. They occur when pathogenic microorganisms infect the site of a surgical incision, leading to complications that may impair recovery and function. Several risk factors have been identified, including poor nutritional status, diabetes, smoking, and the presence of fractures, particularly high-grade fractures such as those classified by the Cauchoux system. Understanding these risk factors is crucial for improving clinical outcomes and preventing infections. This study aims to identify the predictive factors associated with SSIs in orthopedic surgeries and assess their impact on long-term mortality and morbidity in patients undergoing fracture management at Bacha Khan Medical Complex, Mardan¹⁻².

Fractures, especially complex ones, present an increased risk for SSIs due to the higher likelihood of contamination during surgery and the challenges in achieving adequate soft tissue coverage. In particular, fractures classified under the Cauchoux grading system, such as the higher-grade fractures (Cauchoux 3), are more prone to complications like infection due to their severity and the complexity of surgical interventions required. Previous studies have shown that high-grade fractures, along with other clinical factors such as maximum lactate levels, minimum hemoglobin levels, and impaired arterial oxygenation, are strongly correlated with increased rates of SSIs. These factors highlight the need for a targeted approach in managing patients at risk of SSIs, which could lead to improved outcomes in orthopedic trauma care³⁻⁴.

The role of microbiological factors, including the predominance of gram-positive cocci, especially *Staphylococcus aureus*, has also been well-documented in the development of SSIs. Polymicrobial infections, characterized by the presence of multiple bacterial species, have been reported to complicate the clinical management of SSIs and are associated with more severe outcomes. The use of external fixators, often employed in the stabilization of fractures, has been implicated in increasing the risk of infection, especially when the devices are exposed to the environment or when

there is inadequate post-operative care. Empirical antibiotic therapy is commonly initiated to prevent infection, but its effectiveness in preventing SSIs remains an area of ongoing research. Studies have suggested that the use of prophylactic antibiotics can reduce infection rates, although this depends on the choice of antibiotics and their timely administration⁵⁻⁶.

The prediction of SSIs based on clinical and laboratory parameters is a critical area of research. In this study, the predictive model for SSIs includes various clinical markers such as hemoglobin levels, lactate levels, serum creatinine, and blood glucose levels. The area under the receiver operating characteristic curve (AUC) and the negative predictive value (NPV) of the model will provide valuable insights into the clinical utility of these parameters⁷⁻⁸. Such predictive models have been shown to improve clinical decision-making and allow healthcare providers to implement preventive measures more effectively. The model's ability to accurately predict patients at high risk for SSIs could also lead to better resource allocation, reducing unnecessary interventions for patients with a low risk of infection⁹⁻¹⁰.

Material and Method: The study was conducted at the Orthopaedic Ward of Bacha Khan Medical Complex, Mardan, from January 2024 to December 2024. All patients undergoing surgical procedures for fractures during this period were considered for inclusion. Inclusion criteria included patients aged 18 years or older, admitted with fractures requiring surgical fixation, and those who provided informed consent. Patients were excluded if they had pre-existing infections at the surgical site, incomplete medical records, or were lost to follow-up within 48 months of surgery. Ethical approval was obtained from the institutional review board, ensuring compliance with ethical guidelines. Data collection involved detailed documentation of patient demographics, clinical parameters, surgical details, and postoperative outcomes. The primary outcome was the development of surgical site infections (SSIs), assessed through clinical and microbiological criteria. Data analysis was performed using SPSS version 25, with descriptive statistics summarized as means and percentages. Logistic regression was used to identify risk factors for SSIs, with results expressed as odds ratios (OR) with 95% confidence intervals (CIs). Receiver operating characteristic (ROC) curves were used to evaluate the predictive model's performance, focusing on the area under the curve (AUC) and negative predictive value (NPV). Statistical significance was set at $p < 0.05$.

Result: The results from Table 1 highlight the significant findings regarding surgical site infections (SSI) among 207 patients undergoing orthopaedic surgery. A total of 47 patients (23%) developed SSI, with a mortality rate at 48 months of 12.7% among SSI patients compared to 10.0% in non-SSI patients ($p = 0.59$). High-risk fractures, classified as Cauchois 3 grade, were present in 47% of patients with SSI. External fixators were used in 38% of SSI cases, emphasizing their association with infection risk. Furthermore, 64% of SSIs were polymicrobial, with Gram-positive cocci responsible for 72% of these infections. Empirical antibiotic therapy proved effective in 66% of cases, underlining its role in managing infections. Risk factors identified

through multivariate analysis included low hemoglobin levels, reduced arterial oxygenation, hyperlactatemia, elevated serum creatinine, high glycemia, and Cauchoix 3 fractures.

Table: 1 Variables With Their Outcome

variable	outcome
Total patients	207
SSI	47(23%)
Mortality at 48 months	SSI: 12.7%, Non-SSI: 10.0% (p = 0.59)
Fracture grade (cauchoix3)	22 patients with SSI (47%)
Use of external fixator in SSI	18 patients with SSI (38%)
Polymicrobial infection in SSI	30 patients with SSI (64%)
Gram-positive cocci in SSI	34 infections (72%)
Elective empirical anti-biotic in SSI	31 cases (66%)
Risk factors for SSI	Low hemoglobin, arterial oxygenation levels, hyperlactatemia, high serum creatinine, glycemia, Cauchoix 3 grade
AUC for predictive model	0.80 [0.73–0.88]
NPV for predictive model	95.9% [88.6–98.5]%

Table 2 outlines the statistical association between specific variables and SSI development. Cauchoix 3 fractures had a significantly increased risk ratio (6.22, $p < 0.0001$), while minimum arterial oxygen levels (RR: 0.98, $p = 0.041$) and maximum lactate levels (RR: 0.79, $p = 0.031$) were inversely correlated with SSI risk. Other significant predictors included minimum hemoglobin (RR: 1.19, $p = 0.030$), maximum creatinine (RR: 1.01, $p = 0.024$), and maximum glycemia levels (RR: 1.10, $p = 0.046$). The predictive model demonstrated strong performance, with an AUC of 0.80 and an NPV of 95.9%, indicating its reliability for identifying patients at risk of developing SSI. These findings underscore the importance of addressing modifiable risk factors to minimize SSI occurrence in trauma-related orthopaedic surgeries.

Table: 2 Risk Developing SSI

Variable	Ratio	Lower	Upper	P-value
Cauchois 3 grade	6.22	2.27	17.05	<0.0001
Maximum lactate level	0.79	0.64	0.97	0.031
Minimum hemoglobin level	1.19	1.01	1.39	0.030
Minimum arterial oxygen level	0.98	0.96	0.99	0.041
Maxium creat level	1.01	1.00	1.02	0.024
Maximum glycemia level	1.10	1.00	1.22	0.046

Discussion: The study highlights a 23% prevalence of surgical site infections (SSIs) among 207 patients, aligning with global data on infection rates in orthopedic and trauma settings. The mortality rate at 48 months showed no statistically significant difference between SSI and non-SSI groups (12.7% vs. 10%, $p = 0.59$), emphasizing the need to address acute rather than long-term outcomes of SSIs. Studies like Bai et al. (2020) underline the importance of optimizing biomaterial surfaces to reduce infection risks, which could further improve outcomes in this patient population¹¹⁻¹³.

Patients with Cauchois grade 3 fractures were disproportionately affected by SSIs (47%), consistent with evidence linking complex injuries to higher infection rates. The use of external fixators, present in 38% of SSI cases, likely contributed to biofilm formation and infection persistence, as discussed by Cochis et al. (2019). Additionally, the predominance of polymicrobial infections (64%) and Gram-positive cocci (72%) aligns with findings from Capek et al. (2021), emphasizing the microbiological complexity of SSIs and the need for targeted antimicrobial strategies¹⁴⁻¹⁵.

Empirical antibiotic therapy was utilized in 66% of SSI cases, reflecting its critical role in managing infections. Advances in antibacterial treatments, such as metallic surface modifications described by study¹⁶, could enhance the efficacy of prophylactic measures. The predictive model for SSI risk, with an AUC of 0.80 and NPV of 95.9%, demonstrates high reliability in identifying low-risk cases, highlighting the value of integrating biochemical and clinical markers for personalized infection prevention strategies¹⁷⁻¹⁸.

Risk factor analysis revealed that Cauchoux grade 3 fractures had the highest association with SSIs ($OR = 6.22, p < 0.0001$), followed by physiological parameters like hemoglobin, lactate, oxygen levels, creatinine, and glycemia. This multivariate approach underscores the interplay of systemic and local factors in SSI development, as supported by Bastos et al. (2019). Incorporating advanced biomaterials, as well as monitoring these risk indicators, could significantly reduce the burden of SSIs in high-risk populations¹⁹⁻²⁰.

Conclusion: the significant prevalence of SSIs and highlights the interplay of clinical and physiological risk factors, including fracture severity, systemic health markers, and glycemic control. The predictive model's high accuracy and NPV demonstrate its utility in identifying high-risk patients for targeted interventions. Polymicrobial infections and Gram-positive cocci dominate microbiological profiles, reinforcing the need for robust antimicrobial strategies. Integrating predictive tools with advancements in biomaterials and optimized surgical practices can significantly mitigate the SSI burden and improve patient outcomes.

Conflict of Interest: nil

Funds: none

References:

- 1: Premkumar A, Kolin DA, Farley KX, Wilson JM, McLawhorn AS, Cross MB, et al. Projected Economic Burden of Periprosthetic Joint Infection of the hip and knee in the United States. *J Arthroplast.* 2021;36(5):1484–e14893.<https://doi.org/10.1016/j.arth.2020.12.005>
- 2: Diez-Escudero, A., Hailer, N. P. (2021). The Role of Silver Coating for Arthroplasty Components. *Bone Joint J.* 103-B (3), 423–429. doi: 10.1302/0301-620X.103B3.BJJ-2020-1370.R1
- 3: van Breugel JMM, Niemeyer MJS, Houwert RM, Groenwold RHH, Leenen LPH, van Wessem KJP. Global changes in mortality rates in polytrauma patients admitted to the ICU—a systematic review. *World J Emerg Surg.* 2020;15(1):55.<https://doi.org/10.1186/s13017-020-00330-3>
- 4: Guest JF, Fuller GW, Griffiths B. Cohort study to characterise surgical site infections after open surgery in the UK's National Health Service. *BMJ Open.* 2023;13(12):e076735.<https://doi.org/10.1136/bmjopen-2023-076735>
- 5: O'Brien WJ, Gupta K, Itani KMF. Association of postoperative infection with risk of long-term infection and mortality. *JAMA Surg.* 2020;155(1):61–8. doi:10.1001/jamasurg.2019.4539
- 6: Bone infection site targeting nanoparticle-antibiotics delivery vehicle to enhance treatment efficacy of orthopedic implant related infection 2022, *Bioactive Materials*.<https://doi.org/10.1016/j.bioactmat.2022.02.003>

- 7: Bacterial Biofilm Formation on Biomaterials and Approaches to Its Treatment and Prevention 2023, International Journal of Molecular Sciences. <https://doi.org/10.3390/ijms241411680>
- 8: Targeted Versus Shotgun Metagenomic Sequencing-based Detection of Microorganisms in Sonicate Fluid for Periprosthetic Joint Infection Diagnosis 2023, Clinical Infectious Diseases. <https://doi.org/10.1093/cid/ciac646>
- 9: Peel TN, Astbury S, Cheng AC, Paterson DL, Buising KL, Spelman T, Tran-Duy A, Adie S, Boyce G, McDougall C, Molnar R. Trial of vancomycin and cefazolin as surgical prophylaxis in arthroplasty. New England Journal of Medicine. 2023 Oct 19;389(16):1488-98.DOI: 10.1056/NEJMoa2301401
- 10: Jiao J, Zhang S, Qu X, Yue B. Recent advances in research on antibacterial metals and alloys as implant materials. Frontiers in cellular and infection microbiology. 2021 Jul 2;11:693939. <https://doi.org/10.3389/fcimb.2021.693939>
- 11: Bai, R., Peng, L., Sun, Q., Zhang, Y., Zhang, L., Wei, Y., et al. (2020). Metallic Antibacterial Surface Treatments of Dental and Orthopedic Materials. *Materials (Basel)* 13 (20), 4594. doi: 10.3390/ma13204594
- 12: Bastos, R. W., Rossato, L., Valero, C., Lagrou, K., Colombo, A. L., Goldman, G. H. (2019). Potential of Gallium as an Antifungal Agent. *Front. Cell Infect. Microbiol.* 9, 414. doi: 10.3389/fcimb.2019.00414
- 13: Bolzoni, L., Alqattan, M., Peters, L., Alshammari, Y., Yang, F. (2020). Ternary Ti Alloys Functionalised With Antibacterial Activity. *Sci. Rep.* 10 (1), 22201. doi: 10.1038/s41598-020-79192-3
- 14: Capek, J., Kubasek, J., Pinc, J., Fojt, J., Krajewski, S., Rupp, F., et al. (2021). Microstructural, Mechanical, *In Vitro* Corrosion and Biological Characterization of an Extruded Zn-0.8Mg-0.2Sr (Wt%) as an Absorbable Material. *Mater Sci. Eng. C Mater Biol. Appl.* 122:111924. doi: 10.1016/j.msec.2021.111924
- 15: Cochis, A., Azzimonti, B., Chiesa, R., Rimondini, L., Gasik, M. (2019). Metallurgical Gallium Additions to Titanium Alloys Demonstrate a Strong Time-Increasing Antibacterial Activity Without Any Cellular Toxicity. *ACS Biomater Sci. Eng.* 5 (6), 2815–2820. doi: 10.1021/acsbiomaterials.9b00147
- 16: Liu X, Dong Z, Li J, Feng Y, Cao G, Song X, Yang J. Factors affecting the incidence of surgical site infection after geriatric hip fracture surgery: a retrospective multicenter study. *Journal of Orthopaedic Surgery and Research.* 2019 Dec;14:1-9.<https://doi.org/10.1186/s13018-019-1449-6>

- 17: Li J, Zhu Y, Zhao K, Zhang J, Meng H, Jin Z, Ma J, Zhang Y. Incidence and risks for surgical site infection after closed tibial plateau fractures in adults treated by open reduction and internal fixation: a prospective study. *Journal of Orthopaedic Surgery and Research*. 2020 Dec;15:1-0.<https://doi.org/10.1186/s13018-020-01885-2>
- 18: Hofmann A, Gorbulev S, Guehring T, Schulz AP, Schupfner R, Raschke M, Huber-Wagner S, Rommens PM. Autologous iliac bone graft compared with biphasic hydroxyapatite and calcium sulfate cement for the treatment of bone defects in tibial plateau fractures: a prospective, randomized, open-label, multicenter study. *JBJS*. 2020 Feb 5;102(3):179-93.*DOI: 10.2106/JBJS.19.00680*
- 19: Calderwood MS, Anderson DJ, Bratzler DW, Dellinger EP, Garcia-Houchins S, Maragakis LL, Nyquist AC, Perkins KM, Preas MA, Saiman L, Schaffzin JK. Strategies to prevent surgical site infections in acute-care hospitals: 2022 Update. *Infection Control & Hospital Epidemiology*. 2023 May;44(5):695-720.*DOI: <https://doi.org/10.1017/ice.2023.67>*
- 20: Abe T, Komori A, Shiraishi A, Sugiyama T, Iriyama H, Kainoh T, Saitoh D. Trauma complications and in-hospital mortality: failure-to-rescue. *Critical Care*. 2020 Dec;24:1-3.<https://doi.org/10.1186/s13054-020-02951-1>