ORIGINAL ARTICLE

Open fractures associated with earthquakes and high-energy trauma: Clinical outcomes and management strategies

İsmail Güzel,[1] Bünyamin Arı,[1] Tarık Altunkılıç,[1] İbrahim Ulusoy,[2] Mehmet Boz[1]

[1]Department of Orthopedic Surgery, Malatya Turgut Özal University, Malatya-*Türkiye*
[2]Department of Orthopedic Surgery, Selahaddin Eyyubi State Hospital, Diyarbakır-*Türkiye*

ABSTRACT

BACKGROUND: This study aimed to evaluate the epidemiological characteristics, infection rates, complication risks, and clinical management strategies of open fractures resulting from high-energy traumas. Special attention was given to the effects of the 2023 major earthquake on the incidence of open fractures and patient management, comparing different trauma mechanisms retrospectively.

METHODS: This retrospective study included 512 patients admitted to a tertiary trauma center between 2019 and 2024. Patients were classified according to five different trauma mechanisms: traffic accidents, falls from height, occupational injuries, gunshot wounds, and earthquake-related traumas. Open fractures were assessed and classified using the Gustilo-Anderson classification to determine the severity of the injuries. Treatment protocols included early antibiotic administration, surgical debridement, wound management protocols, and surgical fixation methods. Statistical analyses were performed to compare differences between early surgical intervention (within 24 hours) and delayed surgical intervention (after 24 hours). Statistical tests used included T-test, Mann-Whitney U test, Chi-square test, and logistic regression analysis. A p-value of <0.05 was considered statistically significant.

RESULTS: The mean age of the 512 patients was 37.4±12.6 years, with 68% males and 32% females. The most common trauma mechanism was traffic accidents (54.2%), followed by falls from height (27.8%), occupational injuries (12.5%), gunshot wounds (5.5%), and earthquake-related traumas (11.3%). A significant proportion of earthquake-related injuries were classified as Gustilo-Anderson Type III fractures (42.8%), which was notably higher than that of other trauma mechanisms (p<0.001). In earthquake-related cases, multiple fractures were present in 63.2% of patients, and bilateral extremity fractures were observed in 21.4% of cases. The infection rate was 11.4% in patients who received early antibiotic administration, compared to 27.8% in those with delayed administration (p<0.005). Early surgical intervention resulted in an infection rate of 15.2%, whereas delayed intervention showed an infection rate of 31.4% (p=0.002). Amputation rates were found to be 6.4% for the entire patient group, but 41.2% in the Gustilo-Anderson Type IIIC fracture group. Osteomyelitis rate was 18.6% in patients who underwent delayed wound closure, and 35% of these patients required prolonged intravenous antibiotic therapy.

CONCLUSION: This study demonstrates that early antibiotic administration, early surgical intervention, and appropriate wound management strategies significantly reduce infection rates in open fractures resulting from high-energy traumas. Particularly, the high complication rates observed in earthquake-related cases highlight the need for systematic and carefully planned approaches in disaster-related patient management. The findings emphasize the importance of optimal surgical timing and proper antibiotic protocols in reducing infection risks and improving clinical outcomes. Further prospective studies are needed to validate these findings.

Keywords: Antibiotic therapy; complications; Gustilo-Anderson classification; high-energy trauma; infection rates; open fractures; retrospective analysis; surgical intervention; 2023 earthquake.

Cite this article as: Güzel İ, Arı B, Altunkılıç T, Ulusoy İ, Boz M. Open fractures associated with earthquakes and high-energy trauma: Clinical outcomes and management strategies. Ulus Travma Acil Cerrahi Derg 2025;31:995-1002.

Address for correspondence: İsmail Güzel
Department of Orthopedic Surgery, Malatya Turgut Özal University, Malatya, Türkiye
E-mail: dr.ismailguzel@gmail.com

Ulus Travma Acil Cerrahi Derg 2025;31(10):995-1002 DOI: 10.14744/tjtes.2025.54617
Submitted: 10.05.2025 Revised: 15.05.2025 Accepted: 20.09.2025 Published: 07.10.2025

INTRODUCTION

Traumatic fractures, especially those that occur as a result of high-energy trauma, are among the major health problems with serious clinical and socioeconomic consequences.[1] Open fractures are injuries in which the risk of infection is high, the recovery process is long, and the risk of complications is high due to the contact of bone tissue with the external environment.[2] High-energy trauma occurs in traffic accidents, falls from heights, occupational injuries, and gunshot wounds, and markedly increases the incidence of open fractures.[3]

Especially the lower extremity is the most common site of open fractures. According to epidemiologic data, open tibial fractures comprise approximately 40% of all open fractures, and the infection rate in these fractures ranges between 23% and 50%.[4] Open femur fractures, on the other hand, are associated with high mortality and morbidity, especially in multiple trauma patients.[5]

Treatment of open fractures differs depending on the anatomical site of the fracture, the severity of the wound, and the accompanying soft tissue damage. According to the Gustilo-Anderson classification, the risk of infection in Type I open fractures is 0-2%, whereas this rate can be as high as 25–50% in Type III open fractures.[6] Early antibiotic treatment, surgical debridement, wound management protocols, and surgical fixation methods have critical roles in the management of infection risk.[7] Early surgical fixation has been shown to significantly reduce infection rates and shorten the length of hospital stay.[8]

Nevertheless, not only local complications but also systemic complications represent a major problem in open fractures after high-energy trauma. Fat embolism syndrome (FES), a complication seen in multiple trauma patients, can increase mortality and has been extensively reported, especially in femur and tibia fractures.[9,10] Systemic complications such as thromboembolic events, sepsis, and acute respiratory distress syndrome (ARDS) also need to be considered in open fractures.[11,12]

In recent studies, the importance of understanding the mechanisms of high-energy trauma and multidisciplinary approaches in patient management has been highlighted.[13] Early intervention, surgical strategies, antibiotic treatment, and optimization of rehabilitation are among the key factors that improve patient outcomes in open fracture cases.[14,15]

In this study, the epidemiologic distribution of open fractures that develop after high-energy trauma, the affected patient profile, complication risks, and clinical management strategies were evaluated. Within the scope of the study, the last 5 years' hospital records were retrospectively analyzed: the incidence of open fractures, fracture distribution according to the Gustilo-Anderson classification, effects of early antibiotic treatment and wound management protocols on infection rates, surgical fixation methods and their clinical outcomes, and systemic complication rates were analyzed. In line with the findings, early surgical intervention, methods of infection prevention, and strategies to improve long-term patient prognosis were discussed.

MATERIALS AND METHODS

Study Design

This study was designed as a retrospective cohort analysis to evaluate the epidemiologic characteristics of open fractures after high-energy trauma, complication rates, and patient management strategies. The data were obtained from the records of open fracture cases admitted to a tertiary trauma center between 2019 and 2024. Especially after the large-scale earthquake in 2023, the change in patient distribution was analyzed, and earthquake-related open fracture cases were compared with cases of open fractures due to other causes of trauma. Post-earthquake patient load, its effect on the incidence of open fractures, and patients' demographic characteristics were analyzed.

Study Group and Inclusion Criteria

Adult patients (aged ≥18 years) diagnosed with open fractures as a result of high-energy trauma (traffic accidents, falls from height, occupational injuries, gunshot wounds, earthquake-related injuries, etc.) were included in this study. Inclusion criteria were a diagnosis of Type I, II, or III open fracture according to the Gustilo-Anderson classification, availability of complete clinical data, and a follow-up of at least 6 months.[2] Patients with insufficient clinical data, patients who could not undergo primary orthopedic follow-up due to accompanying severe head or spinal trauma, and individuals aged below 18 were excluded.

Power Analysis

A power analysis was performed using the G*Power 3.1 software to determine whether the study had sufficient statistical power. In line with the data from previous literature, it was determined that the incidence of infection in open fractures was between 25% and 30% and that the effect of surgical timing on the infection risk showed a moderate effect (effect size=0.30). As a result of a priori power analysis, it was calculated that a minimum sample size of 350 patients was sufficient, considering α=0.05, 1-β (power)=0.80, and effect size (Cohen's d)=0.30.[16] However, the aim was to include at least 500 patients in the sample to increase the statistical power of the study.

Data Collection and Evaluation

In the study, patients' data were obtained retrospectively from the hospital automation system and patient registration files. Demographic data, trauma mechanisms, fracture localizations, and types of open fractures according to the Gustilo-Anderson classification were examined in detail. The

Table 1. Distribution of Patients' Demographic Characteristics and Trauma Mechanisms

Characteristics	Value (n=512)
Mean age (years, mean ± SD)	37.4±12.6
Gender – Male	348 (68.0%)
Gender – Female	164 (32.0%)
Trauma Mechanism	
└Traffic accident	278 (54.2%)
└Fall from height	142 (27.8%)
└Occupational injuries	64 (12.5%)
└Gunshot wounds	28 (5.5%)
└Earthquake	58 (11.3%)*

*Includes patients admitted after the large-scale earthquake in 2023.

treatment process, surgical methods, fixation methods, differences between early surgical intervention and late surgical intervention, and the effect of wound management protocols on patient outcomes were assessed. Complication rates, one of the most important variables of the study, were also thoroughly evaluated, and factors such as infection incidence, delayed union, nonunion, fat embolism syndrome, sepsis, and thromboembolic events were particularly analyzed.

Statistical analyses were performed in SPSS 26.0 (IBM, Armonk, NY, USA) software. Continuous variables were presented as mean ± standard deviation (SD) and median (minimum–maximum) values, and categorical variables were presented as frequencies and percentages. For intergroup comparisons, the Student's t-test was used for normally distributed data, and the Mann-Whitney U test was employed for non-normally distributed data. The Chi-square test was used to examine the relationships between categorical variables, and multivariate logistic regression analysis was performed to identify the risk factors for complications such as the development of infection, delayed union, and fat embolism. Statistical significance was taken as $p<0.05$.[17]

Ethics committee approval and institutional permissions were received from the Clinical Research Ethics Committee of Malatya Turgut Özal University (Approval Number: 2025/123). The study was carried out according to the human rights principles of the Declaration of Helsinki (2013). The data were anonymized and analyzed in accordance with the principle of confidentiality. Due to the retrospective design of the study, special attention was given to protecting patient confidentiality.

With this methodology, the epidemiologic profile of open fractures after high-energy trauma between 2019 and 2024 and patient outcomes were analyzed in detail. In particular, changes in patient distribution, incidence of open fractures, and infection risk factors after the 2023 earthquake were assessed. The effect of patient density after the earthquake on the incidence of fractures was evaluated, and the clinical management processes of these patients were compared with other causes of trauma.

RESULTS

In this study, a total of 512 patients who applied to a tertiary trauma center between 2019 and 2024 were retrospectively evaluated. The mean age of the patients was 37.4±12.6. Of the patients, 68% were male and 32% were female. Among the causes of trauma, traffic accidents were the most frequent cause, and 54.2% of all patients were injured due to traffic accidents. This was followed by falls from height (27.8%), occupational injuries (12.5%), gunshot wounds (5.5%), and open fracture cases resulting from the 2023 earthquake (11.3%). These findings are presented in Table 1.

Distribution of Open Fractures According to Trauma Mechanisms

Traffic-accident-related open fractures occurred most in the tibia (42.1%) and femur (31.4%). Open fractures due to falls from height occurred most in the tibia (34.3%), radius-ulna (28.7%), and humerus (21.5%). Fractures due to occupational injuries were localized in the extremities in 70.2% and in the wrist and ankle in 29.8%. Gunshot wound-related open fractures were most commonly seen in the femur (43.7%) and humerus (28.4%). After the 2023 earthquake, the most common open fractures in multiple trauma cases were identified in the tibia (39.6%) and femur (33.1%). These rates are shown in Table 2 and Figure 1.

Table 2. Distribution of open fractures and fracture localizations according to trauma mechanisms

Trauma Mechanisms	Number of Patients (n)	Percentage (%)	Most Common Fracture Localizations
Traffic accident	278	54.2	Tibia (42.1%), Femur (31.4%)
Fall from height	142	27.8	Tibia (34.3%), Radius/Ulna (28.7%), Humerus (21.5%)
Occupational injury	64	12.5	Hand-wrist (29.8%), Alt Extremity (70.2%)
Gunshot wound	28	5.5	Femur (43.7%), Humerus (28.4%)
Earthquake-related trauma	58	11.3	Tibia (39.6%), Femur (33.1%)
Total	512	100.0	

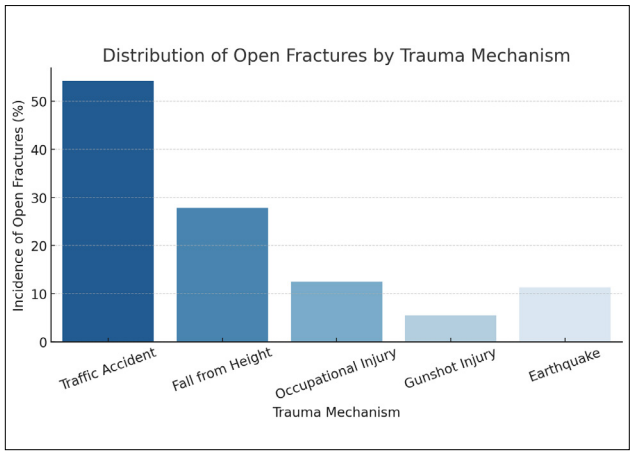

Figure 1. Distribution of open fractures by trauma mechanism.

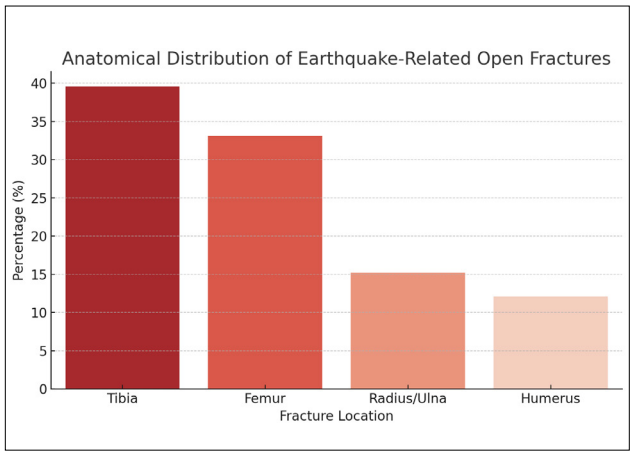

Figure 2. Open fracture distribution after the 2023 earthquake.

Patient Distribution and Incidence of Open Fractures After the 2023 Earthquake

The 2023 earthquake caused a significant increase in the incidence of open fractures throughout the study. Within three months after the earthquake, open fractures accounted for 24.7% of the total cases and the majority of serious injuries requiring hospitalization.

The characteristics of open fracture cases after the earthquake were as follows:

- Of the cases, 58.3% were male and 41.7% were female.
- The rate of multiple fractures was 63.2%, and 21.4% of the patients had bilateral extremity fractures.
- The most common fracture sites were the tibia (39.6%) and femur (33.1%).
- The rate of Gustilo-Anderson Type III fracture was 42.8% in earthquake-related trauma, which was significantly higher compared to open fractures due to other causes of trauma ($p<0.001$).

Infection rates were higher in patients with earthquake trauma. The rate of early surgical intervention was 52.1% in patients injured after the earthquake, while this rate was 69.2% in the other groups. The infection rate in patients who underwent delayed surgery was 31.4%, which was significantly higher than the rates in open fractures after trauma such as traffic accidents and falls from height ($p = 0.002$) (Figure 2).

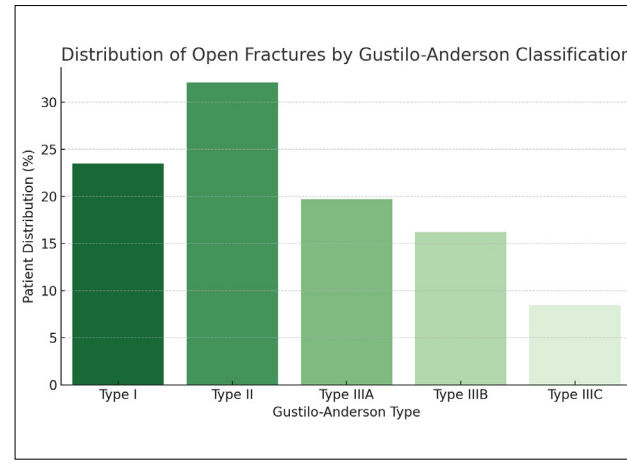

Figure 3. Distribution of open fractures according to the Gustilo-Anderson classification

Fracture Localization and Severity

Lower extremity fractures constituted 71.6% of open fracture cases. The most common fractures were as follows:

- Tibia (39.3%)
- Femur (26.5%)
- Humerus (18.1%)
- Radius/Ulna (12.4%)

The distribution of open fractures according to the Gustilo-Anderson classification was as follows:

- Type I: 23.5% (n=120)
- Type II: 32.1% (n=164)
- Type IIIA: 19.7% (n=101)
- Type IIIB: 16.2% (n=83)
- Type IIIC: 8.5% (n=44)

In particular, Type IIIB and IIIC fracture rates were significantly higher in patients with multiple trauma ($p<0.001$). Type III fractures were identified in 42.8% of cases of earthquake-related open fractures, while this rate was 28.3% in cases of open fractures due to traffic accidents and falls from height (Figure 3).

Treatment Approaches and Surgical Process

Surgical fixation was performed in 87% of the patients, and the remaining patients were followed conservatively. Patients who underwent surgery within the first 24 hours (69.2%) had lower complication rates compared to those who received delayed intervention ($p=0.002$). Patients who underwent external fixation (21.3%) usually had Type III fractures, and their

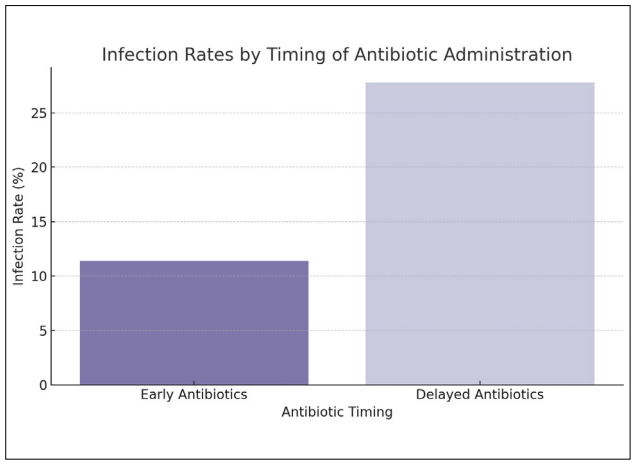

Figure 4. Infection rates according to antibiotic administration time.

mean length of hospital stay was significantly longer compared to the other groups (p=0.01).

The infection rate was 11.4% in patients receiving early antibiotic treatment and 27.8% in patients receiving late antibiotic treatment (p<0.005) (Figure 4).

Late antibiotic administration was more common in earthquake-related open fracture cases, and the infection rate was 30.2% in this group (p=0.008).

Cases requiring delayed closure and plastic reconstruction were most common in Type IIIB and Type IIIC fractures, and the mean recovery time was 14.3±3.6 weeks.

Complications and Clinical Outcomes

When a total of 512 patients were evaluated within the scope of the study, the infection rate was 18.7% in the general patient group. While the infection rate was 41.3% in Type III fractures, this rate was 4.8% in Type I fractures (p<0.001).

The nonunion rate was 9.6%, and the nonunion risk was 23.2% in Type III fractures.

The rate of cases requiring amputation was 6.4%, and the highest amputation rate was recorded in the Type IIIC fracture group.

Early surgical intervention (≤24 hours) reduced the risk of infection by 40% and significantly shortened the length of hospital stay (p=0.003).

The rate of osteomyelitis in earthquake-related open fracture cases who underwent late wound closure was 18.6%, and 35% of these patients required prolonged intravenous antibiotic treatment.

DISCUSSION

In this study, the epidemiologic data of 512 open fracture patients who applied to tertiary trauma centers between 2019 and 2024 were retrospectively analyzed, and patient distribution according to trauma mechanisms, infection rates, and clinical outcomes was assessed in detail. While traffic accidents were the most common cause of trauma, there was a significant increase in the incidence of open fractures after the 2023 earthquake. In particular, multiple trauma and Gustilo-Anderson Type III fracture rates were found to be significantly higher in patients injured after the earthquake compared to other types of trauma. Infection, delayed union, and amputation rates were higher in these patients.

In the present study, traffic accidents were the most common cause of open fractures (54.2%), followed by falls from height (27.8%) and occupational injuries (12.5%). In a large-scale epidemiologic analysis conducted by Court-Brown and Caesar, it was reported that open fractures due to high-energy trauma were most seen in the lower extremities and that tibial fractures accounted for more than 40% of all open fractures.[1] Similar results were reported in the study conducted by Rennie et al.[3] In the present study, tibia fractures were found to be the most common, constituting 39.3% of all open fractures.

It was determined that fracture patterns varied especially in specific trauma mechanisms such as gunshot wounds and post-earthquake traumas. In studies conducted by Rupp and Caudle, it was reported that soft tissue damage was more severe in open fractures due to gunshot wounds and that Gustilo-Anderson Type III fractures were more common.[18,19] In this study, 43.7% of the fractures due to gunshot wounds were found to be in the femur and 28.4% in the humerus, and these fractures included a high rate of Type III fractures.

The incidence of multiple fractures (63.2%) and bilateral extremity fractures (21.4%) was significantly higher in cases of earthquake-related open fractures. In the epidemiologic analysis conducted by Temel et al.[20] after the Kahramanmaraş earthquakes in 2023, it was reported that earthquake-related open fracture cases had a high rate of Type III fractures and that the infection risk was higher in these patients compared to other causes of trauma. Similar findings were reported in the study conducted by Ergen et al.[21] after the 2020 Elazığ earthquake. In the current study, the rate of Type III fracture among earthquake-related open fracture cases was determined as 42.8% and was significantly higher compared to other causes of trauma (p<0.001).

Patient Management and Infection Rates After the 2023 Earthquake

A significant increase was observed in the incidence of trauma-related open fractures after the earthquake. Type III fractures were detected in 42.8% of earthquake-related traumas, while this rate was calculated as 28.3% in other types of trauma (p<0.001). It was determined that open fractures due to earthquake trauma were more likely to be complicated by infection.[22-24] The main reasons for this include delayed medical intervention, inadequate wound cleaning, inappropriate wound closure strategies, delays in antibiotic treatment, prolonged hospitalization, and inadequate sterilization conditions.

In particular, late antibiotic administration was relatively more common in post-earthquake open fracture cases, and the infection rate was 30.2% in these patients. In contrast, the infection rate was 11.4% in patients who underwent early antibiotic administration, and the difference between the groups was statistically significant (p=0.008). These findings are consistent with the reference study by Gustilo and Anderson, which demonstrated that initiation of antibiotic administration within the first 6 hours reduced infection rates by up to 50%.[25] In the study conducted by Kamat, it was reported that the first basic interventions—such as wound irrigation, sterile antiseptic wound dressings, and most importantly, intravenous administration of broad-spectrum antibiotics, especially in the emergency room—play an important role in the prevention of infections in open fractures.[26] In the systematic review by Marchiori et al.,[27] it was emphasized that early antibiotic administration is very important.

Surgical Intervention Time and Clinical Outcomes

In the present study, infection rates were found to be significantly lower in patients who underwent early surgical intervention. The infection rate was 15.2% in patients who underwent surgery within the first 24 hours and 31.4% in patients who underwent delayed surgery (p=0.002). These results are consistent with findings reported in the study by Nicolaides et al.,[28] which showed that delayed surgery increased infection rates by up to 50%. This finding is consistent with the data reported in different studies by Singh and Gopal.[29,30]

It was observed that delayed surgical interventions increased the complication rates, especially in Type IIIB and Type IIIC fractures. In this group, the rate of osteomyelitis was found to be 18.6% in patients who underwent delayed wound closure, whereas this rate dropped to 8.2% in patients who underwent early closure (p=0.002). In particular, it was determined that early implementation of surgical reconstruction methods such as free flap closure reduced infection rates. In the large-scale study conducted by Weitz-Marshall et al.,[31] it was demonstrated that early plastic surgery interventions in severe open fractures reduced infection rates by 40%.

Infection Management and Clinical Recommendations

In our study, it was observed that patients who developed infection mostly had Type III fractures and that these patients had a significantly higher risk of osteomyelitis. Prolonged intravenous antibiotic use and the need for additional surgical debridement were more common in infected patients. Early antibiotic administration and optimal timing of surgical debridement were found to reduce infection rates. In their study, Riechelmann et al.[32] reported that immediate debridement and primary wound closure in Gustilo-Anderson Grade I, II, and IIIA open fractures reduced infection rates and eliminated the need for secondary surgery.

In this respect, according to our study data, early antibiotic administration reduces the risk of infection in Gustilo-Anderson Type III fractures, and optimal wound closure strategies reduce osteomyelitis rates. Acceleration of surgical reconstruction processes in Type IIIB and Type IIIC fractures may shorten the length of hospital stay and reduce complication rates. These results are consistent with the data reported by Stahel et al.[33]

Amputation Rates and Long-Term Functional Outcomes

In our study, the amputation rate was determined as 6.4% in the general patient population. In addition, the amputation rate in Type IIIC fractures was 41.2%. These findings are consistent with the high amputation rates (35-50%) in Type IIIC fractures reported in the study of MacKenzie et al.[34] Functional rehabilitation was found to be successful in 74% of patients who underwent lower extremity reconstruction, whereas 26% had long-term mobility restrictions.

Study Limitations and Future Research

This study has some limitations. Primarily, the study has a retrospective design and was carried out based on patient records; thus, it may have some missing data. Moreover, it was conducted in a single center, so the generalizability of the results is limited. Future multicenter and prospective studies may be helpful to better understand the long-term outcomes, especially in post-earthquake open fracture patients.

CONCLUSION

In conclusion, in this study, the epidemiologic characteristics, infection risks, and optimal treatment strategies in open fractures after high-energy traumas were evaluated in detail. In particular, the findings on patient management after the 2023 earthquake provide important clinical implications for post-disaster medical approaches. Early antibiotic administration, surgical interventions on time, and optimal wound management strategies are critical to reduce complication rates and improve long-term patient prognoses.

Recommendations

• In open fracture patients, early antibiotic administration needs to be integrated into standard protocols to reduce infection rates.

• Especially in Type III fractures, osteomyelitis rates should be minimized through early surgical intervention and appropriate wound closure methods.

• In the management of post-earthquake open fracture cases, the first post-traumatic intervention process should be accelerated, and multidisciplinary teams should have an active role in the field.

• Prospective studies should be performed to determine optimal treatment algorithms for Gustilo-Anderson Type III fractures.

• Long-term outcomes of infection management and extremity reconstruction strategies should be examined in more detail in multicenter studies.

Ethics Committee Approval: This study was approved by the Malatya Turgut Özal University Ethics Committee (Date: 05.05.2025, Decision No: 2025/123).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: İ.G., B.A.; Design: T.A., M.B.; Supervision: İ.G., İ.U.; Resource: B.A., M.B.; Materials: T.A., M.B.; Data collection and/or processing: İ.G., B.A.; Analysis and/or interpretation: T.A., İ.U.; Literature review: İ.G.; Writing: İ.U., M.B.; Critical review: İ.G., B.A.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

REFERENCES

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury 2006;37:691–7. [CrossRef]
2. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am 1976;58:453–8. [CrossRef]
3. Rennie L, Court-Brown CM, Mok JY, Beattie TF. The epidemiology of fractures in children. Injury 2007;38:913–22. [CrossRef]
4. Alıç T, Hassa E. Open Fractures from Gustilo and Anderson to the Present: A Bibliometric Analysis with Global Productivity and Research Trends. Indian J Orthop 2022;56:2119–32. [CrossRef]
5. Halawi MJ, Morwood MP. Acute Management of Open Fractures: An Evidence-Based Review. Orthopedics 2015;38:e1025-33. [CrossRef]
6. Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. J Trauma 1984;24:742–6. [CrossRef]
7. Patzakis MJ, Wilkins J. Factors influencing infection rate in open fracture wounds. Clin Orthop Relat Res 1989;(243):36–40. [CrossRef]
8. Court-Brown CM, Bugler KE, Clement ND, Duckworth AD, McQueen MM. The epidemiology of open fractures in adults. A 15-year review. Injury 2012;43:891–7. [CrossRef]
9. Lempert M, Halvachizadeh S, Ellanti P, Pfeifer R, Hax J, Jensen KO, et al. Incidence of Fat Embolism Syndrome in Femur Fractures and Its Associated Risk Factors over Time-A Systematic Review. J Clin Med 2021;10:2733. [CrossRef]
10. Blokhuis TJ, Pape HC, Frölke JP. Timing of definitive fixation of major long bone fractures: Can fat embolism syndrome be prevented? Injury 2017;48 Suppl 1:S3–S6. [CrossRef]
11. Dionyssiotis Y, Dontas IA, Economopoulos D, Lyritis GP. Rehabilitation after falls and fractures. J Musculoskelet Neuronal Interact 2008;8:244–50.
12. Greising SM, Corona BT, Call JA. Musculoskeletal Regeneration, Rehabilitation, and Plasticity Following Traumatic Injury. Int J Sports Med 2020;41:495–504. [CrossRef]
13. Bonatus T, Olson SA, Lee S, Chapman MW. Nonreamed locking intramedullary nailing for open fractures of the tibia. Clin Orthop Relat Res 1997;(339):58–64. [CrossRef]
14. Templeman DC, Gulli B, Tsukayama DT, Gustilo RB. Update on the management of open fractures of the tibial shaft. Clin Orthop Relat Res 1998;(350):18–25. [CrossRef]
15. Hundal RS, Weick J, Hake M. Management of Open Segmental Tibial Fractures. J Orthop Trauma 2021;35(Suppl 2):S50–1. [CrossRef]
16. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175–91. [CrossRef]
17. Schober P, Vetter TR. Logistic Regression in Medical Research. Anesth Analg 2021;132:365–6. [CrossRef]
18. Rupp M, Popp D, Alt V. Prevention of infection in open fractures: Where are the pendulums now? Injury 2020;51 Suppl 2:S57–63. [CrossRef]
19. Caudle RJ, Stern PJ. Severe open fractures of the tibia. J Bone Joint Surg Am 1987;69:801–7. [CrossRef]
20. Temel S, Yuksel RC, Kaynar AS, Caliskan M, Demir B, Alkan M, et al. Retrospective analysis of earthquake related crush injurie patients in ICU: 6-February earthquake in Türkiye. Eur J Trauma Emerg Surg 2025;51:116. [CrossRef]
21. Ergen E, Kaya O, Yılmaz Ö, Özdeş HU, Batur ÖC, Karaman S, et al. Which is more dangerous, earthquake, or the panic?Evaluation of the 24 January 2020 Elazig/Türkiye earthquake related musculoskeletal injuries. Ulus Travma Acil Cerrahi Derg 2022;28:1335–9. [CrossRef]
22. Clover AJ, Jemec B, Redmond AD. The extent of soft tissue and musculoskeletal injuries after earthquakes; describing a role for reconstructive surgeons in an emergency response. World J Surg 2014;38:2543–50. [CrossRef]
23. Missair A, Pretto EA, Visan A, Lobo L, Paula F, Castillo-Pedraza C, et al. A matter of life or limb? A review of traumatic injury patterns and anesthesia techniques for disaster relief after major earthquakes. Anesth Analg 2013;117:934–41. [CrossRef]
24. Ramirez M, Peek-Asa C. Epidemiology of traumatic injuries from earthquakes. Epidemiol Rev 2005;27:47–55. [CrossRef]
25. Gustilo RB. Use of antimicrobials in the management of open fractures. Arch Surg 1979;114:805–8. [CrossRef]
26. Kamat AS. Infection rates in open fractures of the tibia: is the 6-hour rule fact or fiction? Adv Orthop 2011;2011:943495. [CrossRef]
27. Marchiori JGT, Nunes APF. Time until the start of antibiotic prophylaxis and the risk of open fracture infection: a systematic review. Acta Ortop Bras 2024;32:e263176. [CrossRef]
28. Nicolaides M, Vris A, Heidari N, Bates P, Pafitanis G. The Effect of Delayed Surgical Debridement in the Management of Open Tibial Fractures: A Systematic Review and Meta-Analysis. Diagnostics (Basel) 2021;11:1017. [CrossRef]
29. Singh A, Agarwal A, Mohan R, Singh S, Tewari P, Srivastava S. The Effect of Timing of Debridement and Surgical Intervention in Open Fractures on the Rate of Infection and Surgical Outcomes: A Prospective Study in a Tertiary Care Setup. Cureus 2023;15:e37204. [CrossRef]
30. Gopal S, Majumder S, Batchelor AG, Knight SL, De Boer P, Smith RM. Fix and flap: the radical orthopaedic and plastic treatment of severe open fractures of the tibia. J Bone Joint Surg Br 2000;82:959–66. [CrossRef]
31. Weitz-Marshall AD, Bosse MJ. Timing of closure of open fractures. J Am Acad Orthop Surg 2002;10:379–84. [CrossRef]
32. Riechelmann F, Kaiser P, Arora R. Primary soft tissue management in open fracture. Oper Orthop Traumatol 2018;30:294–308. [CrossRef]
33. Stahel PF, Kaufman AM. Contemporary management of open extremity fractures: What you need to know. J Trauma Acute Care Surg 2024;97:11–22. [CrossRef]
34. MacKenzie EJ, Bosse MJ, Kellam JF, Burgess AR, Webb LX, Swiontkowski MF, et al; LEAP Study Group. Factors influencing the decision to amputate or reconstruct after high-energy lower extremity trauma. J Trauma 2002;52:641–9. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Deprem ve yüksek enerji travmalarına bağlı açık kırıklar: Klinik sonuçlar ve yönetim yaklaşımları

AMAÇ: Bu çalışma, yüksek enerjili travmalar sonrası gelişen açık kırıkların epidemiyolojik özelliklerini, enfeksiyon oranlarını, komplikasyon risklerini ve klinik yönetim stratejilerini değerlendirmek amacıyla retrospektif olarak yapılmıştır. Özellikle 2023 yılında meydana gelen büyük ölçekli depremin, açık kırık insidansı ve hasta yönetimi üzerindeki etkilerini incelemek amacıyla farklı travma mekanizmaları karşılaştırılmıştır.

GEREÇ VE YÖNTEM: Bu retrospektif çalışma, 2019-2024 yılları arasında üçüncü basamak bir travma merkezine başvuran 512 hastayı kapsamaktadır. Hastalar; trafik kazaları, yüksekten düşmeler, iş kazaları, ateşli silah yaralanmaları ve 2023 depremi kaynaklı açık kırıklar olmak üzere beş farklı travma mekanizmasına göre sınıflandırıldı. Açık kırıklar, Gustilo-Anderson sınıflamasına göre değerlendirildi ve kırık şiddetine göre gruplandırıldı. Tedavi süreçleri; erken antibiyotik uygulaması, cerrahi debridman, yara kapama protokolleri ve cerrahi fiksasyon yöntemleri açısından incelendi. Erken cerrahi müdahale (24 saat içinde) ve geç cerrahi müdahale (24 saatten sonra) arasındaki farklar istatistiksel olarak karşılaştırıldı. İstatistiksel analizler için T-testi, Mann-Whitney U testi, Ki-kare testi ve lojistik regresyon analizi kullanıldı. İstatistiksel anlamlılık düzeyi $p<0.05$ olarak kabul edildi.

BULGULAR: Toplam 512 hastanın ortalama yaşı 37.4±12.6 yıl olup, hastaların %68'i erkek, %32'si kadın idi. Travma mekanizmaları arasında en sık neden trafik kazaları (%54.2) olarak bulunurken, bunu yüksekten düşmeler (%27.8), iş kazaları (%12.5), ateşli silah yaralanmaları (%5.5) ve deprem kaynaklı travmalar (%11.3) takip etti. Deprem sonrası gelişen açık kırık vakalarının %42.8'inde Gustilo-Anderson Tip III kırıklar saptanmış olup, bu oran diğer travma mekanizmalarına göre anlamlı derecede yüksek bulundu ($p<0.001$). Özellikle deprem sonrası vakalarda, multipl kırık oranı %63.2 ve bilateral ekstremite kırıkları %21.4 olarak belirlenmiştir. Erken antibiyotik uygulaması yapılan hastalarda enfeksiyon oranı %11.4, geç antibiyotik uygulananlarda ise %27.8 olarak hesaplandı ($p<0.005$). Erken cerrahi girişim yapılan hastalarda enfeksiyon oranı %15.2, geç cerrahi yapılanlarda ise %31.4 olarak bulundu ($p=0.002$). Amputasyon oranları, tüm hasta grubunda %6.4, ancak Gustilo-Anderson Tip IIIC kırık grubunda %41.2 olarak saptandı. Geç yara kapama yapılan hastalarda osteomiyelit oranı %18.6 olup, bu hastaların %35'inde uzun süreli intravenöz antibiyotik tedavisi gerekti.

SONUÇ: Bu çalışma, yüksek enerjili travmalar sonrası gelişen açık kırıklarda erken antibiyotik uygulaması, erken cerrahi müdahale ve uygun yara yönetimi stratejilerinin enfeksiyon oranlarını anlamlı derecede azalttığını göstermektedir. Özellikle 2023 depremi sonrası hastalarda görülen yüksek komplikasyon oranları, bu tür afetler sonrası hasta yönetimi konusunda daha dikkatli ve sistematik yaklaşımların gerekli olduğunu ortaya koymaktadır. Çalışmamızda elde edilen bulgular, açık kırıkların tedavisinde optimum cerrahi zamanlamanın ve doğru antibiyotik protokollerinin uygulanmasının önemini vurgulamaktadır. İleriye dönük prospektif çalışmalar, bu sonuçların daha net değerlendirilmesini sağlayabilir.

Anahtar sözcükler: Açık kırıklar; antibiyotik tedavisi; cerrahi müdahale; enfeksiyon oranları; Gustilo-Anderson sınıflaması; komplikasyonlar; retrospektif analiz; yüksek enerjili travmala; 2023 depremi.

Ulus Travma Acil Cerrahi Derg 2025;31(10):995-1002 DOI: 10.14744/tjtes.2025.54617