ORIGINAL ARTICLE

# Neurosurgical and orthopedic outcomes of emergency patients admitted after the Pazarcık earthquake: Focus on crush syndrome incidence and associated morbidity

**Barış Erdoğan,[1] Atakan Besnek[2]**

[1]Department of Neurosurgery, Yeditepe University Faculty of Medicine, İstanbul-*Türkiye*
[2]Department of Neurosurgery, Şanlıurfa Training and Research Hospital, Şanlıurfa-*Türkiye*

## ABSTRACT

**BACKGROUND:** This study retrospectively evaluates the clinical outcomes of patients admitted to our hospital following the Pazarcık earthquake on February 6, 2023. It specifically focuses on patients requiring multidisciplinary follow-up care in orthopedics and neurosurgery clinics, assessing the nature and severity of their injuries.

**METHODS:** We included patients admitted under the International Classification of Diseases (ICD)-35 code as a result of the earthquake centered in the Pazarcık district of Kahramanmaraş province.

**RESULTS:** A total of 449 patients were admitted: 265 (59%) were discharged as outpatients, while 184 (41%) required hospitalization. Of the hospitalized patients, 45.7% required surgery, with 51.2% of procedures performed by orthopedic surgeons, 27.4% by neurosurgeons, and 19% involving both orthopedics and plastic, reconstructive, and aesthetic surgery. Compartment syndrome was documented in 14.7% of hospitalized patients, and crush syndrome in 46.7%. Additionally, 13% of patients required physical therapy. The overall mortality rate was 7.1%, significantly higher among patients with compartment syndrome ($p<0.001$) and crush syndrome ($p=0.001$), but lower in those who underwent surgery ($p=0.023$).

**CONCLUSION:** This evaluation reveals that the Pazarcık earthquake caused significant morbidity, with high incidences of crush and compartment syndromes requiring urgent surgical intervention. These findings underscore the need for improved disaster preparedness and effective treatment protocols to address the unique challenges posed by such catastrophic events.

**Keywords:** Crush syndrome; compartment syndrome; earthquakes.

## INTRODUCTION

Earthquakes are natural phenomena caused by fractures in the Earth's crust, resulting in vibrations and ground shaking in affected areas. These disasters can cause significant destruction, leading to extensive loss of life and property. Globally, approximately five million earthquakes occur each year, with around 3,000 perceptible to humans.[1] The duration and intensity of an earthquake are critical in determining the extent of the resulting damage. In addition, the population density and characteristics of the affected settlements greatly influence the level of destruction. The consequences of earthquakes extend beyond physical damage, encompassing profound economic, political, health, and psychological impacts. Between 1900 and 2014, our country endured 180 significant earthquakes, resulting in substantial casualties and damage, with reports indicating that 96,064 lives were lost and 778,759 buildings were severely impacted during this period.[2,3]

While it is impossible to prevent earthquakes, the adverse

Cite this article as: Erdoğan B, Besnek A. Neurosurgical and orthopedic outcomes of emergency patients admitted after the Pazarcık earthquake: Focus on crush syndrome incidence and associated morbidity. Ulus Travma Acil Cerrahi Derg 2025;31:1037-1046.

Address for correspondence: Barış Erdoğan
Department of Neurosurgery, Yeditepe University Faculty of Medicine, İstanbul, Türkiye
E-mail: dr.baris.erdogan@gmail.com

Ulus Travma Acil Cerrahi Derg 2025;31(10):1037-1049 DOI: 10.14744/tjtes.2025.88550
Submitted: 03.09.2024 Revised: 27.07.2025 Accepted: 29.07.2025 Published: 07.10.2025

effects of these disasters can be mitigated through effective preparedness and precautionary measures. Advance disaster planning is essential to ensure the rapid transport of earthquake victims to healthcare facilities, as prolonged entrapment under debris can significantly increase morbidity and mortality rates. Healthcare institutions must be equipped with the necessary tools and technical infrastructure to respond effectively to such emergencies. Regular drills should be conducted to identify and address any deficiencies in emergency preparedness.[1-6]

On February 6, 2023, a catastrophic earthquake with a moment magnitude (Mw) of 7.8 struck Kahramanmaraş, affecting 11 provinces and approximately 15 million people. Nine hours later, a secondary quake with a magnitude of 7.7 Mw occurred, centered in the Pazarcık district of Kahramanmaraş. The close timing of these two seismic events exacerbated the devastation, as structures already damaged during the first quake collapsed during the subsequent tremor. Official reports indicate that more than 50,000 people perished, and approximately 125,000 sustained injuries as a result of these earthquakes in Türkiye.

This study was conducted at Şanlıurfa Training and Research Hospital and aims to retrospectively examine the clinical outcomes of 449 patients admitted following the earthquake on February 6. The focus of this research is particularly significant because it centers on neurosurgical and orthopedic outcomes, which are crucial for understanding the range of injuries sustained during seismic events. By addressing these outcomes, we aim to illuminate the specific challenges and treatment considerations that arise in such contexts. Furthermore, this study contributes to filling a notable gap in the existing literature on disaster-related injuries, especially in light of previous major earthquakes such as those in Van and other regions worldwide.[7-9] By drawing parallels and insights from these past events, we hope to enhance the understanding of injury patterns and management strategies necessary to optimize patient care in future disaster scenarios.[10-14]

In the aftermath of significant seismic events, the severity of injuries can vary widely. Orthopedic injuries frequently include fractures and dislocations, which often necessitate immediate surgical intervention and comprehensive rehabilitation. These injuries not only affect physical mobility but may also result in long-term functional difficulties. Similarly, neurosurgical injuries, such as traumatic brain injuries caused by falls or blunt impacts, pose substantial risks. Rapid assessment and intervention for these types of injuries are essential to prevent permanent neurological damage. Analyzing injury patterns and their treatment outcomes is critical for developing effective disaster response protocols. By synthesizing insights from previous studies on orthopedic and neurosurgical care in various disaster contexts, this research aims to contribute to the enhancement of clinical practices for trauma management in catastrophic events. Moreover, the study underscores the importance of long-term follow-up and evaluation of treatment protocols to better understand the lasting effects of earthquake-related injuries on both physical and mental health. Ultimately, this research endeavors to contribute to the ongoing discourse on disaster management within healthcare, providing evidence-based recommendations to improve response strategies and patient outcomes in the aftermath of such devastating incidents.

## MATERIALS AND METHODS

This study included patients admitted to our hospital following the earthquake that occurred in the Pazarcık district of Kahramanmaraş Province on February 6, 2023, who were assigned the International Classification of Diseases (ICD) 35 code. The use of the ICD 35 code was mandated by our hospital for all patients presenting after the earthquake, ensuring systematic documentation of conditions related to the disaster. Ethical approval for the study was obtained from the Harran University Ethics Committee (Approval No: HRÜ/23.05.17). The study was conducted in accordance with the principles of the Declaration of Helsinki.

We collected demographic data, including age, sex, time of admission to the emergency department after the earthquake, initial neurological examination findings, and the presence of traumatic pathologies confirmed through radiological imaging and clinical assessment. Additionally, we documented any history of chronic kidney disease (CKD) and pregnancy status in female patients. Information regarding hospitalization, specific wards to which patients were admitted, details of surgical interventions, postoperative neurological examination findings, and specifics of surgeries performed on neurosurgical patients were also documented.

For all hospitalized patients, we retrospectively assessed the presence of compartment syndrome and crush syndrome, receipt of physical therapy, patient outcomes, and length of hospital stay.

### Statistical Analyses

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS; SPSS Inc., Chicago, IL), version 22. Descriptive data were presented as frequencies and percentages for categorical variables and as mean±standard deviation (Mean±SD) for continuous variables. The chi-square test (Pearson chi-square) was used to compare categorical variables across groups. The normality of continuous variables was assessed using the Kolmogorov-Smirnov test. For comparisons between paired groups, the Mann-Whitney U test was applied.

Overall survival was analyzed using Kaplan-Meier survival analysis for univariate assessments. The log-rank (Mantel-Cox) test was performed to compare survival times among categorical variables. The significance level for all statistical analyses was set at $p<0.05$.

## RESULTS

A total of 449 patients were included in the study. The mean age of the patients was 32.4±20.2 years, with a median age of 29 years (range: 0.3-86). Among these patients, 52.8% were female and 47.2% were male. The average time interval between the earthquake and hospital admission was 53.0±51.1 hours, with a median of 36 hours (range: 1-240 hours). This highlights a delay in care, similar to that observed in other disaster scenarios (Table 1).

**Table 1.** Characteristics of the patients enrolled in the study

| | Number | % |
|---|---|---|
| Age, Mean±SD | 32.4±20.2 | |
| Gender | | |
| Female | 237 | 52.8 |
| Male | 212 | 47.2 |
| Arrival time after earthquake, Mean±SD | 53.0±51.1 | |
| Hospitalization status | | |
| Outpatient discharge | 265 | 59.0 |
| Admission | 184 | 41.0 |
| Motor deficit | | |
| Yes | 22 | 5.0 |
| No | 414 | 95.0 |
| Patient consulted for neurosurgery | 99 | 22 |
| Patients admitted by neurosurgery | 33 | 7.3 |
| Patients operated on by neurosurgery | 23 | 5.1 |
| Number of spinal surgeries performed by neurosurgery | 19 | 4.2 |
| Number of cranial surgeries performed by neurosurgery | 4 | 0.8 |
| Presence of other systemic trauma in patients hospitalized in Neurosurgery | 11 | 33.3 |
| Degree of motor deficits in patients hospitalized in the neurosurgery department | | |
| Lower limb 1/5 | 1 | 11.1 |
| Lower limb 2/5 | 1 | 11.1 |
| Lower limb 4/5 | 1 | 11.1 |
| Limbs 2/5 | 1 | 11.1 |
| Paraplegia | 3 | 33.3 |
| Right lower extremity 3/5 | 1 | 11.1 |
| Drop hand (left) | 1 | 11.1 |
| Postoperative neurological examination | | |
| Normal | 3 | 33.3 |
| Paraplegia | 3 | 33.3 |
| Lower limb 4/5 | 2 | 22.2 |
| Upper limb 4/5 | 1 | 11.1 |
| CKD | | |
| Yes | 15 | 3.3 |
| No | 434 | 96.7 |
| Pregnant | | |
| Yes | 4 | 0.9 |
| No | 445 | 99.1 |
| Operation status | | |
| Yes | 84 | 45.7 |
| No | 100 | 54.3 |

| | | |
|---|---|---|
| Operating department | | |
| Orthopedics | 43 | 51.2 |
| Neurosurgery | 23 | 27.4 |
| Orthopedics+PREC | 16 | 19.0 |
| Orthopedics+PREC+CVS | 1 | 1.2 |
| General Surgery | 1 | 1.2 |
| Type of operation performed in neurosurgery | | |
| Spine stabilization | 15 | 65.2 |
| Kyphoplasty | 4 | 17.4 |
| Elevation of fracture | 2 | 8.7 |
| Evacuation of hematoma | 1 | 4.3 |
| Wound debridement | 1 | 4.3 |
| Compartment syndrome | | |
| Yes | 27 | 14.7 |
| No | 157 | 85.3 |
| Crush syndrome | | |
| Yes | 86 | 46.7 |
| No | 98 | 53.3 |
| Physiotherapy | | |
| Yes | 24 | 13.0 |
| No | 160 | 87.0 |
| Exitus | | |
| Yes | 13 | 7.1 |
| No | 171 | 92.9 |
| Length of stay, Mean±SD | 11.0±11.0 | |

PREC: Plastic, Reconstructive, and Aesthetic Surgery; CVS: Cardiovascular Surgery; CKD: Chronic Kidney Disease.

Of the total patients, 59% (265 patients) were discharged as outpatients, while 41% (184 patients) required hospitalization. Within the cohort, 11 patients (2.5%) had a Glasgow Coma Scale (GCS) score between 3 and 8, and five patients (1.1%) scored between 9 and 14, while the majority of 433 patients (96.4%) had a GCS score of 15. Motor deficits were identified in 5% of the patients, with 10 admitted to the neurosurgery department. Among them, presentations included lower extremity weakness (graded 1/5, 2/5, or 4/5), paraplegia, and upper extremity weakness (Table 1).

Postoperative neurological outcomes varied among hospitalized neurosurgery patients; some displayed normal neurological function, while others presented with paraplegia or varying degrees of extremity weakness. Chronic kidney disease was identified in 3.3% of patients, and 0.9% were pregnant (Table 1).

Among hospitalized patients, 7.3% were admitted for neurosurgical interventions, and 45.7% underwent surgical procedures. Orthopedic surgery accounted for 51.2% of the operations performed, followed by neurosurgery (27.4%), combined orthopedic and exploratory surgery (19%), and a combination of orthopedic, exploratory, and cardiovascular surgeries (1.2%). General surgery represented another 1.2% (Table 1).

Compartment syndrome was observed in 14.7% of hospitalized patients, while crush syndrome was present in 46.7%. Physical therapy was administered to 13% of patients. The inpatient mortality rate was 7.1%, and the mean duration of hospital stay was 11.0±11.0 days (median: 11; range: 1-62) (Table 1).

Trauma signs were documented in 157 patients (35%), with extremity fractures being the most common injury (66.2%). Less frequent injuries included T5 fractures, C5 fractures, and epidural hematomas (each 0.6%) (Fig. 1).

### Patient Disposition and Outcomes

In terms of patient disposition, 59% were discharged as outpatients, while 12.2% were hospitalized in orthopedic wards, 7.3% in neurosurgery departments, and 6.5% in internal medicine units. The time to hospital arrival was significantly longer for trauma patients compared with non-trauma patients. GCS scores for trauma patients were significantly

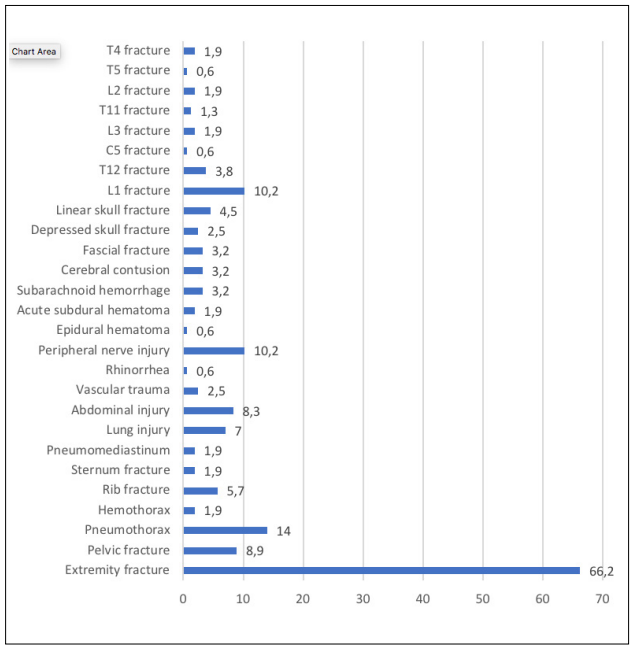


**Figure 1.** Trauma types observed in earthquake patients.

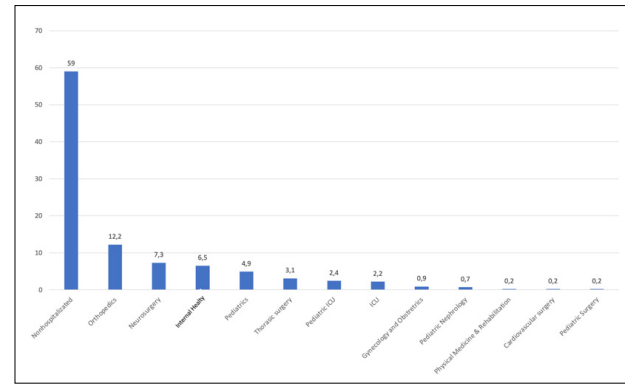


**Figure 2.** Hospitalization status of patients.

lower compared with those without trauma. Among trauma patients, 16.4% received physical therapy, with 27.3% of those hospitalized in neurosurgery departments receiving physical therapy compared to 9.9% of those not hospitalized in these departments (Table 2, Fig. 2).

Moreover, patients with compartment syndrome exhibited significantly lower mean GCS scores and were younger on average compared with those without compartment syndrome. The incidence of compartment syndrome was significantly higher among patients with trauma, those who underwent surgery, and those who received physical therapy (Table 3).

Patients with crush syndrome had significantly lower mean GCS scores and longer lengths of stay compared with patients without crush syndrome. The incidence of crush syndrome was significantly higher among male patients, those with motor deficits, those with CKD, and those who received physical therapy. Conversely, the occurrence of crush syndrome was significantly lower among patients with trauma, those admitted to neurosurgery departments, and those who underwent surgical procedures (Table 3).

Patients who did not survive had significantly lower mean GCS scores and longer hospital stays compared to survivors. The mortality rate was significantly higher among patients with compartment syndrome and crush syndrome, while those who underwent surgical interventions experienced notably lower mortality rates (Table 4).

Of the 449 patients included in the study, 265 were discharged as outpatients and 184 were hospitalized. Thirteen of the hospitalized patients died, resulting in an overall survival rate of 92.9%. The average survival time for all patients

**Table 2.** Comparison of trauma presence and neurosurgery hospitalization according to various parameters

| | Trauma | | | Neurosurgery Hospitalization | | |
|---|---|---|---|---|---|---|
| | Yes n (%) | No n (%) | p* | Yes n (%) | No n (%) | p* |
| Gender[a] | | | | | | |
| Female | 83 (35.0) | 154 (65.0) | 0.980 | 17 (7.2) | 220 (92.8) | 0.879 |
| Male | 74 (34.9) | 138 (65.1) | | 16 (7.5) | 196 (92.5) | |
| Age, Mean±SD | 33.6±22.3 | 31.7±18.9 | 0.617** | 39.0±24.9 | 31.9±19.7 | 0.111** |
| Arrival time, Mean±SD | 56.0±45.6 | 51.3±53.8 | 0.006** | 50.2±43.5 | 53.2±51.7 | 0.858** |
| GCS, Mean (Standard deviation) | 14.0 (3.0) | 15.0 (0) | <0.001** | 14.7 (1.5) | 14.7 (1.8) | 0.555** |
| Length of stay, Mean±SD | 10.7±10.8 | 12.1±12.2 | 0.971** | 6.0±2.7 | 12.0±11.9 | 0.107** |
| Physiotherapy | | | | | | |
| Yes | 24 (16.4) | 0 (0.0) | 0.018 | 9 (27.3) | 15 (9.9) | 0.005 |
| No | 122 (83.6) | 38 (100.0) | | 24 (72.7) | 136 (90.1) | |

*Chi-square analysis; **Mann-Whitney U test. [a]Row percentage; [b]Column percentage. GCS: Glasgow Coma Scale.

**Table 3.** Comparison of the presence of compartment syndrome and crush syndrome according to various parameters

| | Compartment Syndrome | | | Crush Syndrome | | |
|---|---|---|---|---|---|---|
| | Yes n (%) | No n (%) | p* | Yes n (%) | No n (%) | p* |
| Gender | | | | | | |
| Female | 16 (17.8) | 74 (82.2) | 0.299 | 35 (38.9) | 55 (61.1) | 0.037 |
| Male | 11 (11.7) | 83 (88.3) | | 51 (54.3) | 43 (45.7) | |
| Age, Mean±SD | 24.5±18.1 | 34.5±22.4 | 0.033** | 30.9±20.7 | 34.9±23.2 | 0.282** |
| Arrival time, Mean±SD | 46.8±38.7 | 60.4±47.7 | 0.227** | 49.1±35.8 | 66.6±53.2 | 0.121** |
| GCS, Mean (Standard deviation) | 10.7 (5.4) | 14.8 (1.3) | <0.001** | 13.3 (3.9) | 14.9 (4) | <0.001** |
| Length of stay, Mean±SD | 15.1±14.7 | 10.2±10.2 | 0.313** | 14.6±13.1 | 7.8±7.6 | <0.001** |
| Trauma | | | | | | |
| Yes | 27 (18.5) | 119 (81.5) | 0.004 | 57 (39.0) | 89 (61.0) | <0.001 |
| No | 0 (0.0) | 38 (100.0) | | 29 (76.3) | 9 (23.7) | |
| Motor deficit | | | | | | |
| Yes | 4 (18.2) | 18 (81.8) | 0.241 | 14 (63.6) | 8 (36.4) | 0.039 |
| No | 13 (8.7) | 136 (91.3) | | 60 (40.3) | 89 (59.7) | |
| CKD | | | | | | |
| Yes | 0 (0.0) | 15 (100.0) | 0.133 | 15 (100.0) | 0 (0.0) | <0.001 |
| No | 27 (16.0) | 142 (84.0) | | 71 (42.0) | 98 (58.0) | |
| Pregnant | | | | | | |
| Yes | 0 (0.0) | 4 (100.0) | 0.402 | 0 (0.0) | 4 (100.0) | 0.0124 |
| No | 27 (15.0) | 153 (85.0) | | 86 (47.8) | 94 (52.2) | |
| Neurosurgery hospitalization | | | | | | |
| Yes | 1 (3.0) | 32 (97.0) | 0.053 | 6 (18.2) | 27 (81.8) | <0.001 |
| No | 26 (17.2) | 125 (82.8) | | 80 (53.0) | 71 (47.0) | |
| Operation status | | | | | | |
| Yes | 18 (21.4) | 66 (78.6) | 0.018 | 22 (26.2) | 62 (73.8) | <0.001 |
| No | 9 (9.0) | 91 (91.0) | | 64 (64.0) | 36 (36.0) | |
| Physiotherapy | | | | | | |
| Yes | 8 (33.3) | 16 (66.7) | 0.011 | 16 (66.7) | 8 (33.3) | 0.036 |
| No | 19 (11.9) | 141 (88.1) | | 70 (43.8) | 90 (56.3) | |

*Chi-square analysis; **Mann-Whitney U test. GCS: Glasgow Coma Scale; CKD: Chronic Kidney Disease.

was 55.8 days. Notably, patients who underwent surgery had significantly longer survival times, while those with compartment syndrome experienced significantly shorter survival times (Table 5).

This comprehensive analysis demonstrates the significant impact of the earthquake on patient outcomes, highlighting the critical importance of effective emergency response and surgical interventions in reducing mortality and morbidity associated with such catastrophic events.

## DISCUSSION

On February 6, 2023, a sequence of powerful aftershocks measuring 7.8 and 7.7 on the Richter scale struck Pazarcık, impacting 11 provinces to varying degrees. This catastrophic event affected a vast population across a broad geographic area, resulting in thousands of fatalities and tens of thousands of injuries. The collapse of infrastructure and buildings, particularly those with inadequate stair designs, significantly contributed to the loss of life by obstructing escape routes. The severity of the impact was influenced by factors such as building design and geographical location.

Interestingly, there has been an observed increase in global earthquake frequency since 1980, which parallels a rise in earthquake-related fatalities. Between 1980 and 2009, one

**Table 4.** Comparison of the presence of exitus according to various parameters

| | Exitus | | p* |
|---|---|---|---|
| | Yes | No | |
| Gender | | | |
| Female | 6 (6.7) | 84 (93.3) | 0.836 |
| Male | 7 (7.4) | 87 (92.6) | |
| Age, Mean±SD | 25.7±21.7 | 33.6±22.1 | 0.216** |
| Arrival time, Mean±SD | 34.3±25.7 | 60.2±47.4 | 0.061** |
| GCS, Mean | | | |
| (Standard deviation) | 5.1 (3.0) | 14.9 (9) | <0.001** |
| Length of stay, Mean±SD | 4.7±4.4 | 11.4±11.3 | 0.007** |
| Trauma | | | |
| Yes | 13 (8.9) | 133 (91.1) | 0.074 |
| No | 0 (0.0) | 38 (100.0) | |
| Motor deficit | | | |
| Yes | 0 (0.0) | 22 (100.0) | 0.700 |
| No | 1 (0.7) | 148 (99.3) | |
| CKD | | | |
| Yes | 0 (0.0) | 15 (100.0) | 0.605 |
| No | 13 (7.7) | 156 (92.3) | |
| Pregnant | | | |
| Yes | 0 (0.0) | 4 (100.0) | 0.577 |
| No | 13 (7.2) | 167 (92.8) | |
| Neurosurgery hospitalization | | | |
| Yes | 2 (6.1) | 31 (93.9) | 0.804 |
| No | 11 (7.3) | 140 (92.7) | |
| Operation status | | | |
| Yes | 2 (2.4) | 82 (97.6) | 0.023 |
| No | 11 (11.0) | 89 (89.0) | |
| Operating department | | | |
| Orthopedics | 0 (0.0) | 43 (100.0) | 0.082 |
| Neurosurgery | 0 (0.0) | 23 (100.0) | |
| Orthopedics+PREC | 2 (12.5) | 14 (87.5) | |
| Orthopedics+PREC+CVS | 0 (0.0) | 1 (100.0) | |
| General Surgery | 0 (0.0) | 1 (100.0) | |
| Compartment syndrome | | | |
| Yes | 9 (33.3) | 18 (66.7) | <0.001 |
| No | 4 (2.5) | 153 (97.5) | |
| Crush syndrome | | | |
| Yes | 12 (14.0) | 74 (86.0) | 0.001 |
| No | 1 (1.0) | 97 (99.0) | |
| Physiotherapy | | | |
| Yes | 0 (0.0) | 24 (100.0) | 0.223 |
| No | 13 (8.1) | 147 (91.9) | |

*Chi-square analysis; **Mann-Whitney U test. GCS: Glasgow Coma Scale; CKD: Chronic Kidney Disease; CVS: Cardiovascular Surgery; PREC: Plastic, Reconstructive, and Aesthetic Surgery.

analysis reported 372,634 deaths and nearly one million injuries, with unrecorded injuries estimated between 29,392 and 1,267,864.[15] Factors such as the increasing global population, particularly the elderly, combined with the proliferation of high-rise buildings have contributed to this trend. In the aftermath of earthquakes, there is a notable surge in hospital admissions, often overwhelming healthcare personnel and infrastructure and leading to incomplete patient records. While systematic record-keeping for earthquake-related incidents began in California in 1989, earlier data were found to be insufficient.[16] However, advancements in technology now allow for more comprehensive record-keeping, facilitating future earthquake preparedness initiatives.[7,17] In our hospital, we documented a total of 449 patient admissions, all systematically recorded under the ICD 35 code.

Within our emergency department, 449 patients were evaluated, with 59% discharged as outpatients. A breakdown of admissions revealed that orthopedic cases accounted for 12.2%, followed by neurosurgery at 7.3%, thoracic surgery at 3.2%, general surgery at 0.2%, cardiovascular surgery (CVS) at 0.2%, and pediatric surgery at 0.2%. Gynecology and obstetrics accounted for 0.9%, internal medicine for 6.5%, the pediatric intensive care unit for 2.4%, and the adult intensive care unit for 2.2%. Trauma was identified in 157 patients (35%), with extremity fractures being the most prevalent at 66.6%. In a study by Tanaka et al.,[18] extremity fractures accounted for 54.8% of cases following the Hanshin-Awaji earthquake, while Peek-Asa et al.[19] identified them in 72.42% of hospitalized patients after the Northridge earthquake. Bulut et al.[16] reported a comparable extremity fracture incidence of 66.6% following the Marmara earthquake, closely aligning with our results. Notably, 51.2% of surgeries in our cohort were performed by the orthopedic department, underscoring the high prevalence of extremity fractures. While physical trauma predominated, crush syndrome-induced renal failure also resulted in hospital admissions. Following orthopedics and neurosurgery, internal medicine accounted for the highest number of hospitalizations in our study, reflecting the diverse medical implications of earthquakes.

Neurosurgical trauma, particularly in conjunction with orthopedic injuries, is a major concern in post-earthquake scenarios. Survival rates for neurosurgical cases depend on several factors, including earthquake intensity, duration, architectural integrity, and timeliness of hospital admission. The incidence of head trauma has been reported to range from 3.2% to 61%, while spinal trauma has been documented in 4.9% and 31.1% of cases.[20] Igarashi et al.[12] conducted a systematic review indicating that head injuries represent approximately 16.6% of earthquake-related trauma, ranking third after lower and upper extremity injuries. In our cohort of 449 patients, 99 sought neurosurgical consultation, and 33 were ultimately admitted. Surgical interventions were performed on 23 patients, while 10 were managed conservatively. Thirteen patients presented with cranial trauma, four of whom required

**Table 5.** Overall survival and comparison according to various parameters

| | Survival Rate | Average | Standard Error | 95% CI | p* |
|---|---|---|---|---|---|
| Operation status | | | | | |
| Yes | 97.6 | 59.7 | 1.7 | 56.4-63.0 | 0.013 |
| No | 89 | 29.9 | 1.5 | 26.9-32.9 | |
| Compartment syndrome | | | | | |
| Yes | 66.7 | 30.3 | 3.9 | 22.5-38.1 | <0.001 |
| No | 97.5 | 59.1 | 1.5 | 56.1-62.0 | |
| Total | 92.9 | 55.8 | 1.8 | 52.3-59.2 | |

*Log-rank (Mantel-Cox) analysis was performed.

surgical intervention. This is consistent with findings from Jia et al.,[21] who reported that 7.2% of head-injured patients required surgery following the 2008 Sichuan earthquake. Spinal trauma was observed in 20 patients, with 19 undergoing surgery. Decompression and stabilization procedures were performed in 15 spinal cases, while kyphoplasty was conducted in four. A study by Bortolin et al.[10] emphasized the importance of including neurosurgical expertise in disaster response teams, given the high incidence of spinal injuries requiring surgical intervention. Additionally, 11 patients presented with other systemic traumas (Table 1).

In the study by Miller et al.,[22] spinal traumas constituted 85% of cases, while cranial traumas accounted for 15%. In our findings, the distribution was 60% spinal and 40% cranial trauma; however, the surgical intervention rates for spinal trauma patients were consistent with Miller et al.'s analysis, which reported surgery rates of 10% for cranial trauma and 82% for spinal trauma. Conversely, Aycan et al.[7] noted that cranial trauma occurred in 72.7% of patients and spinal trauma in 18.7% following the 2011Van earthquake, demonstrating significant variance from our results. The absence of combined neurosurgical trauma in our study, compared to Aycan et al.'s[7] report, warrants further investigation. The higher incidence of patients transferred from neighboring provinces may elucidate the predominance of spinal trauma, as head trauma is often associated with higher mortality and longer delays in inter-provincial transfers. The literature reveals significant variability in reported rates of cranial and spinal trauma, complicating direct comparisons across studies.[16,21,23-25] While estimating trauma incidence among survivors is relatively straightforward, determining prevalence among deceased individuals remains challenging. Nonetheless, it is reasonable to infer a higher incidence of cranial injuries among fatalities.

Natural disasters, including earthquakes, pose unique medical challenges, with crush syndrome and compartment syndrome representing significant concerns. Crush syndrome is characterized by prolonged pressure on muscle tissue, leading to its destruction and subsequent systemic complications such as hyperkalemia, hyperphosphatemia, myoglobinuria, and acute renal failure. The pathogenesis of crush syndrome involves complex mechanisms, including ischemia-reperfusion injury and myopathy.[26] Estimating the incidence of crush syndrome can be difficult due to multiple factors, including earthquake severity, efficiency of transport to hospitals, and the condition of healthcare infrastructure. The duration of entrapment under debris critically influences the clinical course; timely and aggressive fluid therapy, along with dialysis, has been shown to reduce incidence rates.[27,28] Hang et al.[26] reported crush syndrome in 46.3% of cases; our study observed a slightly higher rate of 46.7% among hospitalized patients. Similarly, Kantarcı et al.[28] documented renal failure in 18.3% of crush syndrome cases, whereas our findings indicated an elevated incidence. Treatment strategies for crush syndrome vary: some recommend fasciotomy combined with fluid resuscitation and dialysis, while others advise caution due to the risk of infection.[29-31] The timing of fasciotomy should therefore be carefully considered in light of infection and organ necrosis risks.[29-31] Compartment syndrome, which can result from fractures, soft tissue damage, or vascular injuries, may occur independently or as a consequence of crush syndrome.[32] Notably, the incidence of compartment syndrome in our study was considerably higher than previously reported in our region following past earthquakes.[31] Additionally, we found a significantly lower average age among patients with compartment syndrome, a finding not previously documented in the literature. While this observation may be anecdotal, it suggests potential variations in disease manifestation across different age groups.

Overall, earthquakes cause substantial morbidity and mortality, influenced by various factors such as earthquake intensity, duration, construction standards, population density, proximity to healthcare facilities, and the speed of victim transport. Morbidity and mortality tend to be higher in densely populated regions, during nighttime events, and in areas with poorly constructed or tall buildings. Age and gender appear to have a limited impact compared with these other determinants, and comprehensive large-scale studies investigating their role remain scarce. Globally, significant earthquake-related casualties have been recorded, including over 240,000

deaths and 165,000 injuries from the Tangshan earthquake in China, 50,000 casualties in the 1990 Iran earthquake, and 17,480 deaths with 43,953 injuries during the Marmara earthquake[7,15,16] In the case of the Pazarcık earthquake, official statistics reported 50,783 fatalities and 122,000 injuries, along with 8,476 deaths in Syria, reflecting higher mortality rates compared to the Marmara earthquake. In our hospital, patients took an average of 53.0±51.1 hours to reach us, resulting in the hospitalization of 184 individuals and a mortality rate of 7.1%. Mortality rates were higher among patients with crush syndrome and compartment syndrome, whereas patients who underwent surgical procedures experienced lower mortality. Elevated Glasgow Coma Scale scores and extended hospital stays were also associated with reduced mortality, indicating that deceased patients often presented with poorer initial clinical conditions. The overall survival rate was 92.9%, with a mean survival duration of 55.8 days. Survival time was longer for operated patients and those with crush syndrome, whereas patients with compartment syndrome exhibited poorer clinical trajectories. Neurological deficits were documented in 22 patients, 10 of whom received neurosurgical interventions. Among these, three were diagnosed with paraplegia, five experienced lower limb paresis, one had combined upper and lower limb paresis, and one had predominant upper limb paresis. Nine patients underwent surgical procedures; postoperative neurological status remained unchanged in three paraplegic cases, while improvements were observed in the remaining six. Early physical therapy was initiated for all patients with deficits, and paraplegic patients were referred to specialized physical therapy centers for advanced care.

Despite these important insights, our study has limitations. The retrospective data collection may introduce biases, particularly regarding patient selection and the quality of medical records. Inherent variability in documentation practices across emergency departments can lead to incomplete or inaccurate patient data, which may affect the validity of our findings. Future research should adopt prospective designs to enhance data reliability and enable better measurement of outcomes in similar disaster contexts. Acknowledging these limitations is essential for grounding our conclusions in the study's complexities and provides a framework for future investigations to build upon these findings.

## CONCLUSION

Earthquakes are catastrophic natural disasters that are inherently unpredictable and cannot be prevented. Without effective precautions, they can lead to substantial mortality and morbidity. It is therefore imperative to prioritize engineering initiatives aimed at mitigating earthquake damage and to develop robust disaster response plans. Our study revealed that 46.7% of hospitalized patients presented with crush syndrome. Furthermore, specific data indicated that 30% of these patients required surgical intervention, while those with compartment syndrome had a mortality rate of 15%. These findings underscore the critical need for targeted medical protocols to manage such injuries effectively.

Although earthquakes cannot be prevented, proactive strategies can be implemented to reduce their adverse effects. Given our geographical vulnerability to seismic events, fostering comprehensive preparedness across all sectors is essential. This multifaceted approach will help minimize earthquake-related damage, enhance the resilience of the affected communities, ultimately reduce morbidity and mortality rates.

**Ethics Committee Approval:** This study was approved by the Harran University Ethics Committee (Date: 27.03.2023, Decision No: HRÜ/23.05.17).

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions:** Concept: B.E.; Design: B.E.; Supervision: B.E.; Resource: A.B.; Materials: A.B.; Data collection and/or processing: A.B.; Analysis and/or interpretation: B.E.; Literature review: B.E., A.B.; Writing: B.E.; Critical review: B.E., A.B.

**Conflict of Interest:** None declared.

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

## REFERENCES

1. Tsivelekas K, Pallis D, Ampadiotaki MM, Gourtzelidis G, Nikolaou S, Papadakis SA. Panic related injuries after the Athens earthquake in July 2019. Acta Orthop Traumatol Hell 2021;72:271–5.
2. Dağ M, Çakmak F, Köse Ş. Osmanlı döneminden günümüze Türkiye'de deprem ile bulaşıcı ve salgın hastalıklar arasındaki ilişki. Tarih İncelemeleri Derg 2023;38:459–95. [Article in Turkish] [CrossRef]
3. Gözükızıl CA, Tezcan S. Cumhuriyet'in yüzüncü yılında Türkiye'de afetler: 6 Şubat 2023 Kahramanmaraş depremi. Kent Akademisi 2023;16:97–114. [CrossRef]
4. Nieh JH, Hsu TH, Cheng HC, Chong KC, Lai PF. 2018 Taiwan hualien earthquake-disaster lessons we learned in the emergency department of a tertiary hospital. J Acute Med 2020;10:149–55.
5. Xu S, Shi B, Yuxian J, He M, Yang P, Xu W, et al. Comparative analysis of the wounded in patients and deaths in a hospital following the three major earthquakes in western China. Front Public Health 2022;10:775130. [CrossRef]
6. Yeşiloğlu Ö, Doğan S, Avci A. Approach to earthquake victims at emergency services: A review and analysis of current practices. Cam Sakura Med J 2023;3:4–13. [CrossRef]
7. Aycan A, Yener U, Aycan N, Gönüllü E, Dursun R, Gönüllü H. Neurosurgical injuries caused by the 2011 Van earthquake: The experience at the Van Regional Training and Research Hospital. J Emerg Med 2015;49:464–70. [CrossRef]
8. Lu-Ping Z, Rodriguez-Llanes JM, Qi W, van den Oever B, Westman L, Albela M, et al. Multiple injuries after earthquakes: A retrospective analysis on 1,871 injured patients from the 2008 Wenchuan earthquake. Crit Care 2012;16:R87. [CrossRef]
9. Matsuzawa G, Sano H, Ohnuma H, Tomiya A, Kuwahara Y, Hashimoto C, et al. Patient trends in orthopedic traumas and related disorders after tsunami caused by the Great East Japan Earthquake: An experience in the primary referral medical center. J Orthop Sci 2016;21:507–11. [CrossRef]
10. Bortolin M, Morelli I, Voskanyan A, Joyce NR, Ciottone GR. Earthquake-related orthopedic injuries in adult population: A systematic review. Prehosp Disaster Med 2017;32:201–8. [CrossRef]

11. Guner S, Guner SI, Isik Y, Gormeli G, Kalender AM, Turktas U, et al. Review of Van earthquakes form an orthopaedic perspective: A multicentre retrospective study. Int Orthop 2013;37:119–24. [CrossRef]
12. Igarashi Y, Matsumoto N, Kubo T, Yamaguchi M, Nakae R, Onda H, et al. Prevalence and characteristics of earthquake-related head injuries: A systematic review. Disaster Med Public Health Prep 2022;16:1253–8. [CrossRef]
13. MacKenzie JS, Banskota B, Sirisreetreerux N, Shafiq B, Hasenboehler EA. A review of the epidemiology and treatment of orthopaedic injuries after earthquakes in developing countries. World J Emerg Surg 2017;12:9. [CrossRef]
14. Xu J, You C, Zhou L, Wu B, Li X, Li Z, et al. Long-term results of patients with head injuries treated in different hospitals after the Wenchuan, China, earthquake. World Neurosurg 2011;75:390–6. [CrossRef]
15. Doocy S, Daniels A, Packer C, Dick A, Kirsch TD. The human impact of earthquakes: A historical review of events 1980-2009 and systematic literature review. PLoS Curr 2013;5:ecurrents.dis.67bd14fe457f1db0b5433a8ee20fb833. [CrossRef]
16. Bulut M, Fedakar R, Akkose S, Akgoz S, Ozguc H, Tokyay R. Medical experience of a university hospital in Turkey after the 1999 Marmara earthquake. Emerg Med J 2005;22:494–8. [CrossRef]
17. Armenian HK, Melkonian A, Noji EK, Hovanesian AP. Deaths and injuries due to the earthquake in Armenia: A cohort approach. Int J Epidemiol 1997;26:806–13. [CrossRef]
18. Tanaka H, Oda J, Iwai A, Kuwagata Y, Matsuoka T, Takaoka M, et al. Morbidity and mortality of hospitalized patients after the 1995 Hanshin-Awaji earthquake. Am J Emerg Med 1999;17:186–91. [CrossRef]
19. Peek-Asa C, Kraus JF, Bourque LB, Vimalachandra D, Yu J, Abrams J. Fatal and hospitalized injuries resulting from the 1994 Northridge earthquake. Int J Epidemiol 1998;27:459–65. [CrossRef]
20. Karmacharya BG, Sathian B. Study of traumatic brain injury due to recent earthquake in Manipal Teaching Hospital. Nepal J Neurosci 2015;12:63–6. [CrossRef]
21. Jia L, Li GP, You C, Li H, Huang SQ, Yang CH, et al. The epidemiology and clinical management of craniocerebral injury caused by the Sichuan earthquake. Neurol India 2010;58:85–9. [CrossRef]
22. Miller JH, Zywicke HA, Fleming JB, Griessenauer CJ, Whisenhunt TR, Okor MO, et al. Neurosurgical injuries resulting from the 2011 tornados in Alabama: The experience at the University of Alabama at Birmingham Medical Center. J Neurosurg 2013;118:1356–62. [CrossRef]
23. Chen R, Song Y, Kong Q, Zhou C, Liu L. Analysis of 78 patients with spinal injuries in the 2008 Sichuan, China, earthquake. Orthopedics 2009;32:322. [CrossRef]
24. Groves CC, Poudel MK, Baniya M, Rana C, House DR. Descriptive study of earthquake-related spinal cord injury in Nepal. Spinal Cord 2017;55:705–10. [CrossRef]
25. Tang B, Chen Q, Chen X, Glik D, Liu X, Liu Y, et al. Earthquake-related injuries among survivors: A systematic review and quantitative synthesis of the literature. Int J Disaster Risk Reduct 2017;21:159–67. [CrossRef]
26. Huang KC, Lee TS, Lin YM, Shu KH. Clinical features and outcome of crush syndrome caused by the Chi-Chi earthquake. J Formos Med Assoc 2002;10:249–56.
27. Demirkiran O, Dikmen Y, Utku T, Urkmez S. Crush syndrome patients after the Marmara earthquake. Emerg Med J 2003;20:247–50. [CrossRef]
28. Kantarci G, Vanholder R, Tuglular S, Akin H, Koç M, Ozener C, et al. Acute renal failure due to crush syndrome during Marmara earthquake. Am J Kidney Dis 2002;40:682–9. [CrossRef]
29. Frink M, Hildebrand F, Krettek C, Brand J, Hankemeier S. Compartment syndrome of the lower leg and foot. Clin Orthop Relat Res 2010;468:940–50. [CrossRef]
30. Görmeli G, Görmeli CA, Güner S, Ceylan MF, Dursun R. A clinical analysis of patients undergoing fasciotomy who experienced the 2011 Van earthquake. Eklem Hastalik Cerrahisi 2012;23:156–60. [Article in Turkish]
31. Guner SI, Oncu MR. Evaluation of crush syndrome patients with extremity injuries in the 2011 Van Earthquake in Turkey. J Clin Nurs 2014;23:243–9. [CrossRef]
32. Stella M, Santolini E, Sanguineti F, Felli L, Vicenti G, Bizzoca D, et al. Aetiology of trauma-related acute compartment syndrome of the leg: A systematic review. Injury 2019;50:S57–64. [CrossRef]


ORİJİNAL ÇALIŞMA - *ÖZ*

## Pazarcık depremi sonrası acil servise kabul edilen hastaların nöroşirurjikal ve ortopedik sonuçları: Crush sendromu insidansı ve morbiditeye dair retrospektif bir analiz


AMAÇ: Bu çalışma, 6 Şubat 2023 tarihinde meydana gelen Pazarcık merkezli depremin ardından hastanemize başvuran hastaların klinik sonuçlarını retrospektif olarak değerlendirmektedir. Çalışma, özellikle ortopedi ve nöroşirürji kliniklerinde multidisipliner takip gerektiren hastalara odaklanarak, yaralanmaların niteliği ve şiddetini analiz etmeyi amaçlamaktadır.

GEREÇ VE YÖNTEM: Çalışmaya, Kahramanmaraş ili Pazarcık ilçesi merkezli deprem nedeniyle ICD-35 kodu ile hastanemize kabul edilen hastalar dâhil edilmiştir.

BULGULAR: Toplam 449 hasta başvurmuş olup, 265'i (%59) ayaktan tedavi ile taburcu edilirken, 184'ü (%41) hastaneye yatırılmıştır. Yatan hastaların %45.7'si cerrahi müdahale gerektirmiştir; bu operasyonların %51.2'si ortopedik cerrahlar, %27.4'ü nöroşirürjiyenler tarafından gerçekleştirilmiştir; %19'u ise ortopedi ile plastik, rekonstrüktif ve estetik cerrahi iş birliğinde yapılmıştır. Yatan hastaların %14.7'sinde kompartman sendromu, %46.7'sinde ise crush sendromu saptanmıştır. Ayrıca hastaların %13'üne fizik tedavi uygulanmıştır. Genel mortalite oranı %7.1 olup, bu oran kompartman sendromu ($p<0.001$) ve crush sendromu ($p=0.001$) bulunan hastalarda anlamlı şekilde daha yüksek, cerrahi müdahale uygulanan hastalarda ise daha düşük bulunmuştur ($p=0.023$).

SONUÇ: Bu değerlendirme, Pazarcık depreminin ciddi morbiditeye yol açtığını ve acil cerrahi müdahaleleri gerekli kılan yüksek oranlarda crush ve kompartman sendromu vakalarının görüldüğünü ortaya koymaktadır. Bulgular, böyle felaketlerde karşılaşılan özgün zorluklara karşı daha etkili afet hazırlık planlarının ve tedavi protokollerinin geliştirilmesi gerekliliğini vurgulamaktadır.



Anahtar sözcükler: Crush sendromu; kompartman sendromu; deprem.

Ulus Travma Acil Cerrahi Derg 2025;31(10):1037-1046 DOI: 10.14744/tjtes.2025.88550