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ORIGINAL ARTICLE

Evaluation of musculoskeletal injuries after the 2023 Kahramanmaras earthquake: A local hospital experience

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Earthquakes have caused more than 800,000 deaths and even more injuries since the year 2000.[1] Türkiye is one of the countries that is frequently and severely affected by earthquakes.

Many studies have shown that more than half of the injuries after earthquakes are caused by extremity fractures.[2-6] Earthquake-related injuries are typically caused by falling objects or tissue compression over a prolonged period.[7] This highlights the importance of multidisciplinary management by orthopedic and trauma physicians.[5,6,8-10]

On February 6th, 2023, two major earthquakes with magnitudes of 7.7 and 7.6 struck the districts of Pazarcık and Elbistan in Kahramanmaras, affecting a total of 11 provinces and 110,000 square kilometers with a 350-km long.[11] These earthquakes resulted in at least 50,500 deaths and more than 120,000 injuries.

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ABSTRACT

Objectives: The aim of this study was to evaluate musculoskeletal injuries, clinical follow-ups and treatments of trauma patients admitted to our hospital after the 2023 Kahramanmaras earthquake.

Patients and methods: Between February 6th, 2023 and February 16th, 2023, a total of 957 trauma patients (452 males, 505 females; mean age: 36.2±19.9 years; range, 0 to 97 years) who were affected by the earthquake were retrospectively analyzed. Age, sex, presence of orthopedic consultation, diagnosis of open/closed fracture, diagnosis of dislocation, presence and classification of soft tissue injury, additional system injury, preoperative and postoperative neurovascular examination status, presence of compartment syndrome, conservative/surgical applications, operation side, fasciotomy surgery and level, amputation surgery and level, length of stay in the hospital and intensive care unit (ICU), the Mangled Extremity Severity Score (MESS) score were collected.

Results: A total of 811 of the survivors were Turkish and 146 were Syrians. Of 957 earthquake victims, 40% had soft tissue injuries, 19% had closed fractures, 8.9% had other system injuries, 7.7% had crush injuries, 4.1% had nerve injuries, 2.1% had compartment syndrome, 2.1% had vascular injury, 1.8% had dislocation, and 1.7% had open fracture. Surgical or conservative treatments were applied to 574 patients with musculoskeletal injuries. Conservative treatment was applied to 322 of 574 patients and surgical procedure was applied to 252 patients.

Conclusion: The highest patient density is experienced within the first 24 h after a devastating earthquake. The most common injuries due to high-energy trauma are isolated soft tissue injuries and fractures. The definition of the demographic characteristics and clinical outcomes of earthquake patients is critical to the development of preparedness, response, and recovery policies for future disasters..

Keywords: Earthquake, epidemiology, local hospital, musculoskeletal injury.

The affected provinces include Kahramanmaras, Kilis, Diyarbakir, Adana, Osmaniye, Gaziantep, Sanliurfa, Adiyaman, Malatya, Hatay, and Elazig. Some hospitals in these provinces were also destroyed

by the earthquake. In a mass disaster situation, it is not possible to estimate the total number of patients who initially seek treatment at a hospital in the earthquake zone, and a fast and coordinated action is necessary to maximize the effectiveness of patient care.[12] As experienced in this devastating Kahramanmaras earthquake, in the first few days, it was nearly impossible to transfer patients to larger cities those were not affected by the earthquake, resulting in a significant increase in the number of patients seeking treatment at local hospitals that were not damaged by the earthquake.

The Kilis Prof. Dr. Alaeddin Yavaşça State Hospital, where this study was conducted, is in the earthquake zone and remained undamaged. Many trauma patients affected by the earthquake from the same province, neighboring provinces, and districts sought treatment at this hospital. In the present study, we aimed to evaluate musculoskeletal injuries, clinical follow-up, and treatments of trauma patients admitted to our hospital after the 2023 Kahramanmaras earthquake.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Kilis Prof. Dr. Alaeddin Yavaşça State Hospital, Department of Orthopedics and Traumatology between February 6th, 2023 and February 16th, 2023. Data of the earthquake victims who were admitted to our center were reviewed and all trauma patients were included. Trauma patients unrelated to the earthquake and patients without musculoskeletal injuries were excluded from the study. A total of 1,154 patients were admitted to our hospital. Of them, 197 who did not meet the inclusion criteria were excluded and a total of 957 trauma patients (452 males, 505 females; mean age: 36.2±19.9 years; range, 0 to 97 years) affected by the earthquake were recruited.

The initial care of all trauma patients affected by the earthquake was provided in the emergency department. Triage was applied to patients according to their urgency and all examination findings and lesions were recorded. Patients undergoing surgical treatment were administered appropriate doses of antibiotics in the pre- and postoperative periods. In the postoperative period, the wound and neurovascular examinations of all patients were recorded, and a standard postoperative follow-up protocol was applied.

Age, sex, presence of orthopedic consultation, diagnosis of open/closed fracture, diagnosis of dislocation, presence and classification of soft tissue injury, additional systemic injuries, pre- and postoperative neurovascular examination status, presence of compartment syndrome, conservative/surgical interventions, operative side, fasciotomy surgery and level, amputation surgery and level, length of stay in the hospital ward, length of stay in the intensive care unit (ICU), and the Mangled Extremity Severity Score (MESS) scores were collected. The MESS is a useful tool which takes into consideration the degree of soft tissue injury, limb ischemia, the presence of shock, and the age of the patient. According to the MESS scoring, a score of >7 indicates an absolute indication for amputation.[13]

All data and images included in the study were analyzed from the Sisoft Health Information Systems SisoHbys version 2.0.4.482 and SisoViewer version 3.1 databases (Sisoft Healthcare Information Systems, Türkiye).

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics for the numerical variables were expressed as the mean ± standard deviation, and minimum maximum values.

RESULTS

Out of 957 trauma patients who were included in our study, 811 were Turkish and 146 were Syrian. Baseline characteristics of the patients are given in Table I.

Hospital admission time

Within the first 24 h after the earthquake, 402 (42.0%) patients, within the second 24 h, 147 (15.4%) patients, within the third 24 h, 146 (15.3%) patients, and after 72 h, 262 (27.4%) patients were admitted to our center (Figure 1). Out of 402 trauma patients admitted to the hospital within the first 24 h, 259 (64.4%) were treated by orthopedists due to musculoskeletal injuries.

Clinical examination of injuries

At the initial examination, 1,154 patients were evaluated by emergency physicians and orthopedic surgeons. A total of 957 patients were considered earthquake trauma patients, all of whom had musculoskeletal injuries. Musculoskeletal injuries requiring conservative or surgical treatment were observed in 574 patients and were followed in the emergency room or ward. A total of 383 patients were discharged early after the initial treatment in the emergency room and were scheduled for orthopedic

TABLE I
Demographic data

	Nationality			
	n	%	Cumulative %	Mean±SD
Age (year)				36.2±19.9
Türkiye	811	84.7	84.7	
Syrian	146	15.3	100	
Total	957	100		
Sex				
Male	452	47.2	100	
Females	505	52.8	52.8	
Total	957	100		
Age group (year)				
0-10	86	9	9.0	
11-20	145	15.2	24.1	
21-30	175	18.3	42.4	
31-40	171	17.9	60.3	
41-50	139	14.5	74.8	
51-60	115	12	86.8	
61-70	68	7.1	93.9	
71-80	48	5	99.00	
81-90	8	0.8	99.8	
91-97	2	0.2	100	
Total	957	100		

SD: Standard deviation.

outpatient follow-up. Despite early intervention in the emergency department, a total of two patients died.

In 15 patients, musculoskeletal injuries with additional system injuries were observed and evaluated as multiple injuries. In seven patients, fractures were observed in more than one region and were evaluated as multi-trauma.

Of 957 earthquake victims, 40% had soft tissue injuries, 19.4% had closed fractures, 8.9% had other system injuries, 7.7% had crush injuries, 4.1% had nerve injuries, 2.1% had compartment syndrome, 2.1% had vascular injury, 1.8% had dislocation, and 1.7% had an open fracture (Figure 2).

Types of fractures and dislocations

A total of 212 fractures were observed, with 196 (92.4%) being closed fractures and 16 (7.5%) being open fractures. The distribution of fractures according to anatomical region were as follows: 62 (29.2%) in the upper extremities, 104 (49.0%) in the lower extremities, 22 (10.4%) in the spine, and 24 (11.3%) being pelvic ring fractures (Table II). The distribution of fractures according to anatomical region is shown in Figure 3.

Dislocations were observed in 17 patients, with 11 (64.7%) in the shoulder, one (5.8%) in the wrist, three (17.6%) in the hip, and two (11.7%) in the ankle. Of the 17 patients with dislocations, 14 were admitted to the hospital within the first 24 h.

Before and after the earthquake disaster, hospital operations

In the province where our hospital is located, the population is 238,000 in total. The hospital has a bed capacity of 75 in the emergency department, 550 in the inpatient wards, 50 in the ICU, and 10 active operating rooms in the surgical department. Before and immediately after the disaster, the occupancy rate of the operating rooms and emergency department increased from 0 to 50% and from 10 to 100%, respectively. In contrast, the occupancy rate of the inpatient wards decreased from 72.7 to 12%.

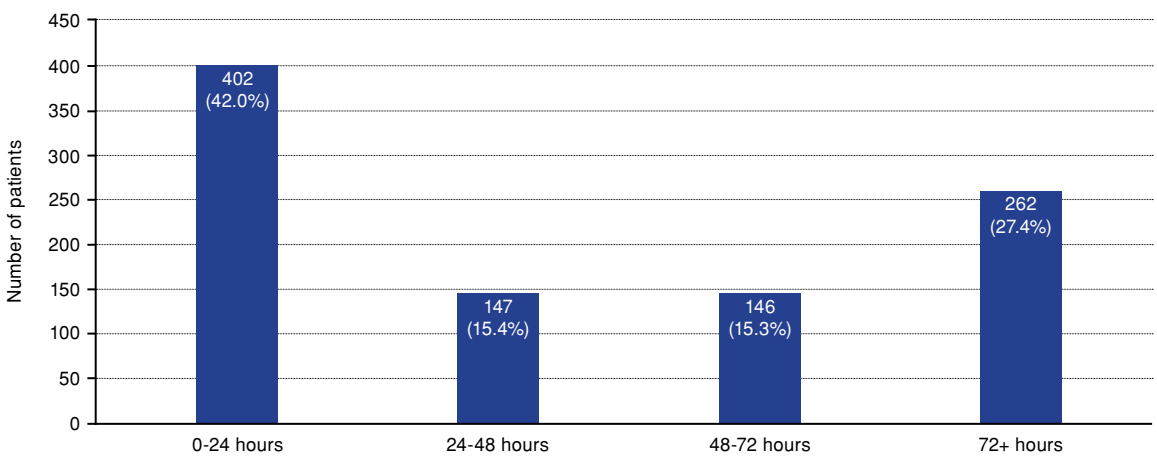


FIGURE 1. Time of hospital admission.

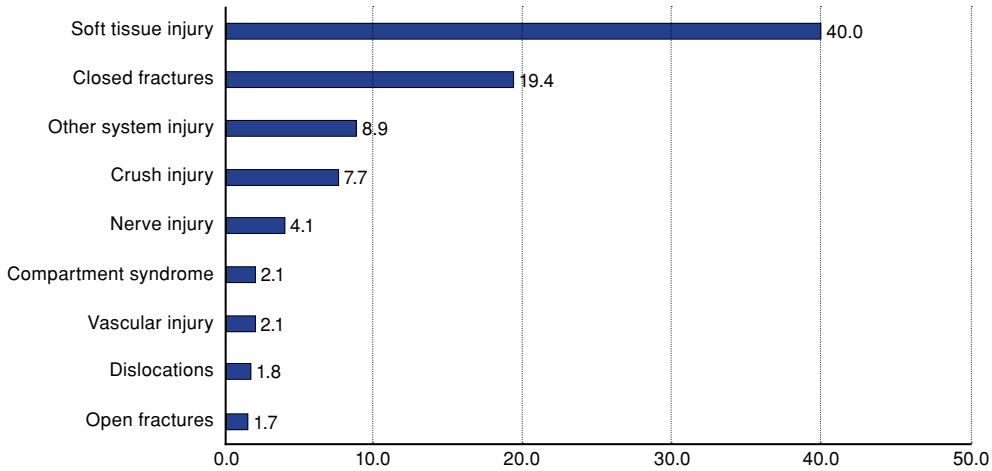


FIGURE 2. Clinical analysis of the injuries.

A total of 140 patients were admitted to the hospital ward, and 34 patients were admitted to the ICU. The mean length of hospital stay was 6.4 (range, 1 to 48) days, while the mean length of ICU stay was 8.5 (range, 1 to 27) days.

Treatments of patients

Surgical or conservative treatments were administered to 574 patients who had musculoskeletal injuries. Conservative treatment was provided to 322 out of 574 patients, while 252 patients underwent surgical procedures.

Among the 35 patients who underwent two-stage surgery, primary closure or grafting was performed during the first stage of fasciotomy in 22 patients, and external fixation was carried out during the first stage in 13 patients, followed by final treatment during the second stage. Out of the five patients who underwent fasciotomy, two were amputated, while three others were referred for further treatment after fasciotomy.

Debridement surgery was performed in 161 patients, post-fracture arthroplasty in four patients, open reduction internal fixation in 28 patients, and closed reduction internal fixation in 18 patients. In one patient, external fixation was performed as a one-stage permanent final treatment.

Fasciotomy was carried out in 27 patients in 34 different regions, with 50% of the regions located in the cruris, 14.7% in the thigh, 14.7% in the foot, 14.7% in the forearm, and 5.8% in the hand.

Grafting was applied to 22 regions, with eight undergoing primary closure, and two that failed to

TABLE II
Anatomical location of fractures

	Upper extremity				Lower extremity						
	Clavicle/ scapula	Humerus	Radius/ ulna	Hand	Femur	Tibia/ fibula	Foot	Patella	Spine	Pelvic girdle	Total
Open fractures	0	1	2	2	0	5	6	0			
Total		5				11			0	0	16
%	0.0	6.3	12.5	12.5	0.0	31.3	37.5	0.0	0.0	0.0	100.0
%											
Closed fractures	9	23	14	11	22	37	32	2			
Total		57				93			22	24	196
%	4.6	11.7	7.1	5.6	11.2	18.9	16.3	1.0	0.0	0.0	100.0
%		29.0				47.4			22.9	25.0	100.0
General total	9	24	16	13	22	42	38	2	22	24	212
%	4.2	11.3	7.5	6.1	10.4	19.8	17.9	0.9	10.4	11.3	100.0
%		29.2				49.0			10.3	11.3	100.0

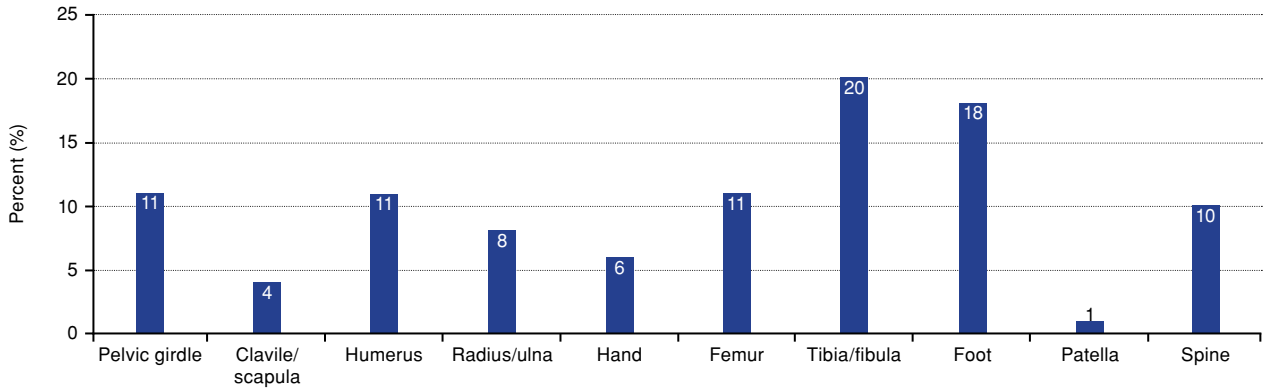


FIGURE 3. Types of fractures.

close, resulting in below-knee amputation in two patients.

The follow-up and treatment of patients who underwent fasciotomy surgery were tailored by plastic surgeons. Vacuum-assisted closure (VAC) was applied to 28 different areas in 23 patients. The wound site was primarily monitored by plastic surgeons and no infections were observed.

The MESS scores of 27 patients who underwent fasciotomy were evaluated, and it was found to be less than seven in 25 patients, eight in one patient, and nine in one patient. Amputation was performed in two patients with MESS scores of 8 and 9, respectively.

Neurovascular examination

In the preoperative period, vascular damage was observed in 20 patients. Of these, poor circulation was observed in 18 patients and complete deficit in two patients. Fasciotomy was performed in all patients with vascular damage. In the postoperative period, circulation was normal in one patient with complete deficit and 15 patients with poor circulation.

A total of 39 patients had neurological damage, of whom 10 received conservative treatment, eight received non-fasciotomy surgical treatments, and 21 patients received fasciotomy. Among the five patients who underwent neurological examination, four were treated conservatively and one was treated with fasciotomy and both returned to normal after treatment.

DISCUSSION

Our hospital, located in an earthquake-prone region, faced a significant increase in the patient load, particularly within the first few days following a major earthquake. The high volume of patients was due to both the severity of the disaster and the damage sustained by nearby hospitals.[1] As with any affected population, each earthquake presents unique challenges, underscoring the critical need for evidence-based prevention strategies.[2] The epidemiology of earthquake-related injuries and mortality is distinct from that of other disasters, emphasizing the importance of robust and readily available local health services capable of responding to such events.[3]

Many studies have reported that the rate of hospital admission in the immediate aftermath of an earthquake is the highest within the first 24 h, making it crucial to prepare and equip medical facilities rapidly.[4-7] In our study, the first peak of patient admissions (42.0%) occurred within the initial 24 h of the earthquake.

Understanding the patterns and frequencies of earthquake-related injuries is essential. In the orthopedic context, studies have shown that lower limb injuries are the most common, with pelvic and spinal cord injuries occurring at higher rates than expected.[8-10,14] In our study, 49.0% of all fractures involved the lower extremities, with tibia fractures being the most prevalent, followed by foot fractures. High-energy trauma resulting from the destructive force of earthquakes may explain the higher-than-expected incidence of pelvic ring and vertebral fractures. Among our study participants, 17 dislocations were observed, with 14 patients presenting within the first 24 h. Particularly in this early period, we noted a higher-than-expected incidence of anterior shoulder dislocation, suggesting a need for further studies of this issue.

Hospitalization rates are particularly high within the first two days following a major earthquake, with patient triage critical to ensure that those requiring

urgent care receive it promptly. Rapid transport of patients in need of urgent treatment is crucial, as is rapid discharge of patients not requiring emergency care to free up hospital capacity.[15] In our study, the occupancy rate of the inpatient service of the hospital was evaluated as 72.7% (n=400) before the earthquake disaster. Following a crisis meeting with all departments after the earthquake, triage was applied to the patients. As a result, the occupancy rate of the inpatient service of the hospital quickly dropped to 12% (n=66). Since 66 of 400 patients required urgent treatment, hospitalization continued. Of 256 patients who did not require urgent treatment, 113 left the hospital without permission. Treatment was arranged for 68 patients, and they were discharged after outpatient treatment. As 75 patients who did not require urgent treatment still needed inpatient follow-up and care, they were transferred to neighboring cities unaffected by the earthquake. The high number of patients leaving the hospital without permission can be attributed to the fear caused by the earthquake. The reason for the operating room to operate at 50% capacity after the earthquake is related to the fact that some of the existing staff were earthquake victims. In the earthquake zones, even if hospitals do not suffer from any damage, it should be taken into consideration that existing personnel may not be able to work at full capacity.

Mulvey et al.[16] reported that the most common earthquake-related injuries in the 2005 Kashmir earthquake were soft tissue injuries and fractures. In the early stages of earthquake response, urgent orthopedic surgeries typically involve external fixation, amputation, and debridement. In our study, the follow-up and treatment of patients who underwent fasciotomy surgery were tailored by plastic surgeons. The VAC system was applied to 28 different areas in 23 patients. The wound site was primarily followed by plastic surgeons and no infections were observed.[17] The most frequently performed surgery was debridement, which is a must to prevent infection and other complications.[10,17-21]

Two-stage surgery was required for 35 patients, with permanent surgery performed in the second stage following external fixation in the first. High-energy trauma, particularly in natural disasters such as earthquakes, can cause severe soft tissue injury, making external fixation surgery a crucial method for preserving limbs.[22,23] This surgery is also indicated for patients with critical medical conditions.[24] Rapid provision of external fixation materials is essential in local hospitals affected by earthquakes.

Severe crush injuries and compartment syndrome are the most common reasons for amputation.[17] Early fasciotomy can prevent amputation, and our study reported a low rate of amputations, attributable to easy accessibility of our hospital and prompt fasciotomy. Rapid extrication and transport of patients to the nearest hospital by search and rescue teams are critical for early treatment of compartment syndrome and crush injury.[25-27]

Plastic surgeons play an essential role in post-disaster patient management, including the assessment and triage of large numbers of patients with soft tissue injuries and the selection of appropriate operative options for severe trauma, such as skin grafting and flap transplantation.[28] Plastic surgeons play an important part in reducing the workload of orthopedic specialists who are most active after an earthquake disaster. In our study, volunteer plastic surgeons from different provinces played an active role in evaluating and following patients who underwent fasciotomy.

Despite the main strengths of the study including its ability to provide an early analysis of patients affected by the earthquake, as it was conducted in a local hospital located in the earthquake zone, there are some limitations. First, the study has a single-center, retrospective design which may have caused bias. Second, due to confusion and increased demand for health care during the time of the earthquake, there was a lack of record keeping or incomplete record keeping among the deceased.

In conclusion, after a devastating earthquake such as 2023 Kahramanmaras earthquake, the highest density of patients is typically seen within the first 24 h. Soft tissue injuries and fractures are the most common injuries resulting from high-energy trauma. The definition of the demographic characteristics and clinical outcomes of earthquake patients is critical to the development of preparedness, response, and recovery policies for future disasters.

Ethics Committee Approval: The study protocol was approved by the Ankara City Hospital Clinical Research Ethics Committee (date: 08.03.2023, no: E1-23-3368). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from the parents and/or legal guardians of the patients.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, analysis and/or interpretation, critical review, materials: B.K., Z.U.; Design, literature review: K.P., N.V.; Control/supervision: M.G.F.; Data collection and/or processing, writing the article, references and fundings: B.K, Z.U.

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