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ORIGINAL ARTICLE

Systematic triage and treatment of earthquake victims: Our experience in a tertiary hospital after the 2023 Kahramanmaras earthquake

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ABSTRACT

Objectives: The aim of this study was to evaluate the benefits of our triage system in acceleration of intervention for the musculoskeletal injuries and clinical follow-ups of trauma patients admitted to our center after the Kahramanmaras earthquake.

Patients and methods: Between February 6th, 2023 and February 20th, 2023, a total of 439 patients (207 males, 232 females; mean age: 37.1±19.1 years; range, 1 to 94 years) with earthquake-related musculoskeletal injuries after the Kahramanmaras earthquake were retrospectively analyzed. Data including age, sex, referral city information, removal time from the rubbles, physical examination findings, clinical photos, fasciotomy and amputation stumps and levels, and X-ray images and computed tomography images of all patients were shared and archived in the WhatsApp (Meta Platforms, Inc.® ATTN/CA, USA) group called 'Earthquake' created by orthopedic surgeons. To complete the patient interventions as soon as possible and to ensure order, the patients were distributed with the teams in order through this group by the consultant orthopedic surgeon. The treatments were applied and recorded according to the skin and soft tissue conditions, and fractures of the patients. All treatments were carried out with a multi-disciplinary approach.

Results: Of the patients, 16.2% were children. Lower limb injuries constituted 59.07% of musculoskeletal injuries. Upper limb, pelvic, and spinal cord injuries were observed in 21.9%, 12.7%, and 6.25%, respectively. Conservative treatment was applied to 183 (41.68%) patients. The most common surgical intervention was debridement (n=136, 53.1%). External fixation was applied in the first stage to 21 (8.2%) patients with open fractures. The mean removal time from the rubbles was 32.1±29.38 h. A total of 118 limb fasciotomy operations were applied to the patients. Fifty limb amputations were performed in 40 patients at the last follow-up due to vascular insufficiency and infection.

Conclusion: Based on our study results, we believe that a triage system using a good communication and organization strategy is beneficial to prevent treatment delay and possible adverse events in future disasters.

Keywords: Amputation, crush, earthquake, fasciotomy, Kahramanmaras earthquake, systematic triage.

Earthquakes are devastating natural disasters that cause many deaths and injuries in a short time. Earthquakes were responsible for an estimated 1.87 million deaths in the 20th century.[1] Previous studies have examined injury profiles and analyzed the effects of earthquakes on intracranial hemorrhage, fractures, dislocations and crush injuries, and these pathologies are the leading causes of earthquake-

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related deaths.[2] Many studies have discussed injury profiles after earthquakes, and most of them concluded that limb fractures are the most common earthquake-related injuries, representing more than half the recorded injuries.[3-5] Therefore, these natural disasters are challenging for orthopedic surgeons.

On February 6th, 2023, at 04:17 A.M. local time, an earthquake with 7.7 Richter scale occurred in Pazarcik district of Kahramanmaras, Türkiye. On the same day, at 01:24 P.M., another 7.6 earthquake occurred in the Elbistan district of Kahramanmaras. These earthquakes affected an area of 350 km and a total of 11 cities, causing more than 46,000 deaths and more than 110,000 injuries. The Kahramanmaras earthquake[6] is among the most destructive earthquakes in the 21st century, after the 2004 Indonesia earthquake (227,000 casualties),[7] 2010 Haiti earthquake (220,000 casualties),[8] 2008 Sichuan earthquake (87,000 casualties),[9] and 2005 Kashmir earthquake (87,000 casualties).[10] However, since the loss of life has not been finalized yet, this order may change.

Considering the increased urbanization and the number of high-rise buildings worldwide, the rescue efforts for future casualties in large urban areas may become more challenging.[2,11] Collapsed buildings prolong the removal time of victims and increase the severity of crush injuries, resulting in prolonged limb ischemia, rhabdomyolysis, and compartment syndrome.[2] This information is essential to get a better coordination of disaster management in the future.

After this devastating disaster, our center, as a tertiary care center (the largest-volume hospital in Türkiye, having 3,704 beds and 131 operating rooms), received many trauma patients collectively at the same time. To be sufficient for all applications, we used a systematical triage. In the present study, we hypothesized that such a rapid systematic evaluation and organized teamwork would positively affect the treatment outcomes and prognosis of patients in the next possible disaster. We, therefore, aimed to evaluate the benefits of our triage system in acceleration of patient intervention, musculoskeletal injuries, clinical follow-ups and treatments of trauma patients who were admitted to our center after the Kahramanmaras earthquake.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Ankara Bilkent City Hospital, Department of Orthopedics and Traumatology between February 6th, 2023 and February 20th, 2023. The clinical records of patients admitted with earthquake-related musculoskeletal injuries were reviewed. All patients with musculoskeletal injuries associated with the Kahramanmaras earthquake, regardless of age and sex, were included in the study. A total of 439 patients (207 males, 232 females; mean age: 37.1±19.1 years; range, 1 to 94 years) were enrolled. Soft tissue injuries, fractures, nerve injuries, vascular injuries, crush injuries, crush syndromes, compartment syndromes and need for intensive care unit (ICU) follow-ups were evaluated.

Removal time from the rubbles and demographic data of patients such as age and sex were recorded. Development of crush syndrome and subsequent need for dialysis were also evaluated. The presence and localization of fasciotomy at the time of admission to the Emergency Department (ED) and the time between injury and fasciotomy were noted. In addition, incomplete fasciotomies and amputation levels in the first intervention of the patients in the earthquake area were also investigated. The ICU follow-up and mortality rates were recorded.

From the moment of the earthquake, all trauma teams acted in coordination in our hospital and, first of all, all elective patients whose condition was stable were discharged and rooms were opened for patients who were expected to be referred from earthquake victims. Orthopedic and Traumatology surgeons were divided into six teams and each team was further divided into two and worked in shifts. Each team included orthopedics and traumatology specialists and senior residents. A WhatsApp (Meta Platforms, Inc., ATTN/CA, USA) group called 'Earthquake' was created by orthopedic surgeons. To complete the patient interventions as soon as possible and to ensure order, the patients were distributed with the teams in order through this WhatsApp group by the consultant orthopedic surgeon. The team that accepted the patient continued the follow-up from the initial evaluation to the final treatment and discharge. Extra-operating tables were arranged in cooperation with the Anesthesia and Reanimation Department and ED cases were operated without delay. The operations of the patients were performed simultaneously on 12 to 18 operating tables during the day and on six to eight operating tables during night shifts. By informing the medical companies, the necessary implants for emergency treatment such as external fixator were provided to our hospital.

Data such as age, sex, referral city information, removal time from the rubbles, physical examination findings, clinical photos, fasciotomy and amputation

stumps and levels, X-ray images and computed tomography (CT) of all patients who applied were shared and archived in the WhatsApp group.

Patients with good soft tissue circulation, and closed, non-displaced fractures were treated conservatively. Definitive treatments were performed for patients whose soft tissue conditions were suitable for surgery. In patients with fractures whose soft tissue is not suitable, temporary fixation was performed with an external fixator at the first stage, and definitive treatment was performed in the follow-ups. To provide immediate circulation among the patients who were referred to us from the earthquake area, fasciotomy lengthening was performed for those with incomplete fasciotomy, and emergency fasciotomy was performed for those with compartment syndrome. The vacuum-assisted closure (VAC) application was performed every three days in the follow-ups of the patients who had open wounds and patients who underwent fasciotomy and had no sign of infection.[12] The wound sites of all patients were evaluated at daily visits. Serial debridement operations was performed every two to three days in patients with excessive amount of necrotic tissue in the wounds, signs of infection such as erythema and purulent material, and patients who had a large amount of material accumulated in the chamber due to negative pressure in patients who underwent VAC. Intraoperative culture was taken for the patients who developed wound infection during follow-up, and appropriate treatment was initiated with the cooperation of the Infectious Diseases Department. After serial debridement, the wounds of the patients deemed suitable were closed. Patients whose wounds could not be closed primarily were transferred to Aesthetic, Plastic and Reconstructive Surgery Department. Daily hyperbaric oxygen therapy was applied to patients with open wounds and no contraindications. Despite serial debridement and antibiotherapy, patients whose infection could not be eradicated or adequate vascular circulation could not be achieved were amputated at the appropriate level in cooperation with the Infectious Diseases and Cardiovascular Surgery Departments.

In addition to orthopedics and traumatology specialists and hospital administration officials, pediatricians and pediatric surgeons, general surgeons, neurosurgeons, cardiovascular surgeons, aesthetic, plastic and reconstructive surgeons and internal medicine specialists were included in this WhatsApp group. In this way, all internal specialists and surgeons were informed about all the patients at the same time and were able to be involved in the whole process pre- and intraoperatively.

All crush syndrome patients were followed by internal medicine specialists from the moment of admission to the ED until discharge. Daily visits were made to the patients hospitalized by one internal medicine specialist and two senior residents, and necessary medication was given for the prevention and treatment of rhabdomyolysis and acute renal failure. The patients with amputations and/or completed definitive treatments were

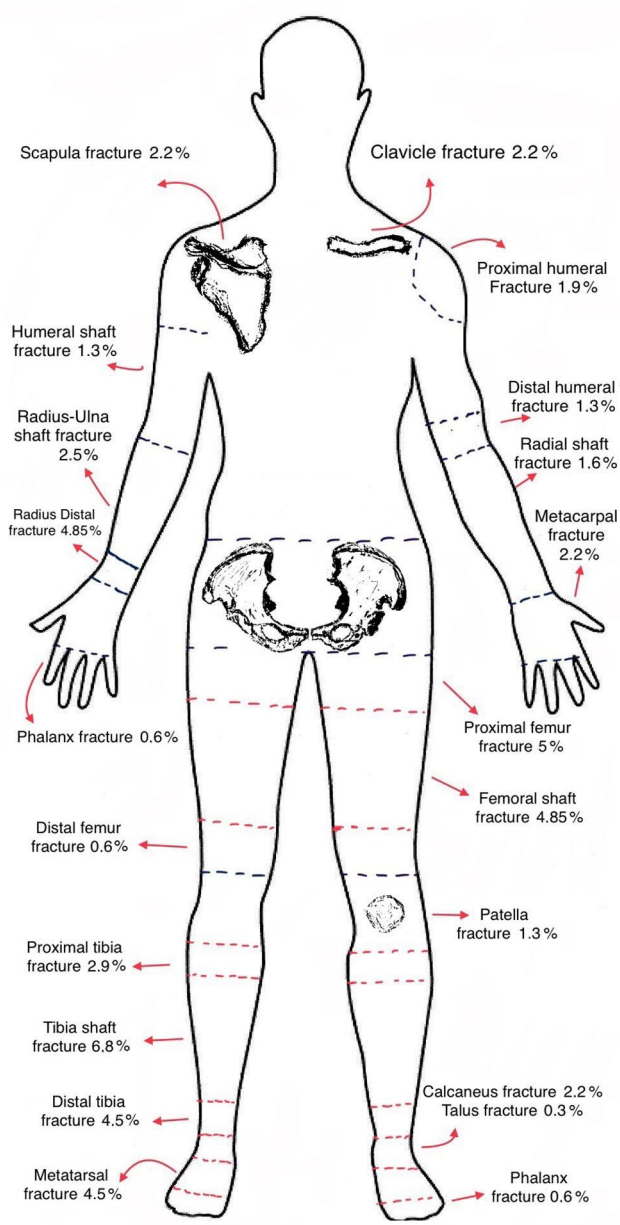


FIGURE 1. Fracture distribution of earthquake victims.

immediately transferred to our Physical Medicine and Rehabilitation Department. All observations and treatment decisions were handled with a multi-disciplinary approach. In addition, during this entire process, our psychiatry team administered therapy to all patients, particularly to those who lost their relatives and/or had limb amputations.

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. Since the quantitative values did not show normal distribution in the Shapiro-Wilk test, non-parametric test procedures were used. In this context, Mann-Whitney U test was used to determine the relationships between parameters.

RESULTS

Of a total of 439 patients included in the study, 16.2% were children. Lower limb injuries constituted 59.07% of all musculoskeletal injuries. Upper limb, pelvic, and spinal cord injuries were observed in 21.9%, 12.7%, and 6.25% of cases, respectively (Figure 1).

The rates of the fracture site of the patients are shown in Figure 1. The most common lower limb fractures were tibia shaft, femur shaft, and bimalleolar fractures (6.8%, 4.85%, and 4.85%, respectively). Distal radius fractures were the most common upper limb fractures (4.85%). Sacral fractures were the most common spinal injuries of the patients (4%).

Conservative treatment with cast immobilization was applied to 183 (41.68%) patients. Most common surgical intervention was debridement (n=136, 53.1%). A total of 99 (38.6%) patients with a good skin and soft tissue condition were applied definitive treatment in the first stage. Patients with open fractures were of all musculoskeletal injuries (4.78%). According to the Gustilo-Anderson classification, type 3 (61.9%) open fractures were the most common type, and type 1 (28.5%) and type 2 (9.52%) were the second and third, respectively. External fixation was applied in the first stage to 21 (8.2%) patients with open fractures (Table I).

According to the results of wound culture and intraoperative tissue culture, microorganisms were seen in culture in a total of 68 (15.48%) patients.

TABLE I
The number of procedures performed

Treatment method	n	%
Conservative	183	41.7
Internal fixation	99	21
External fixation	21	4.45
Debridement	189	40.1
Fasciotomy	118	23.77
Amputation	50	10.6

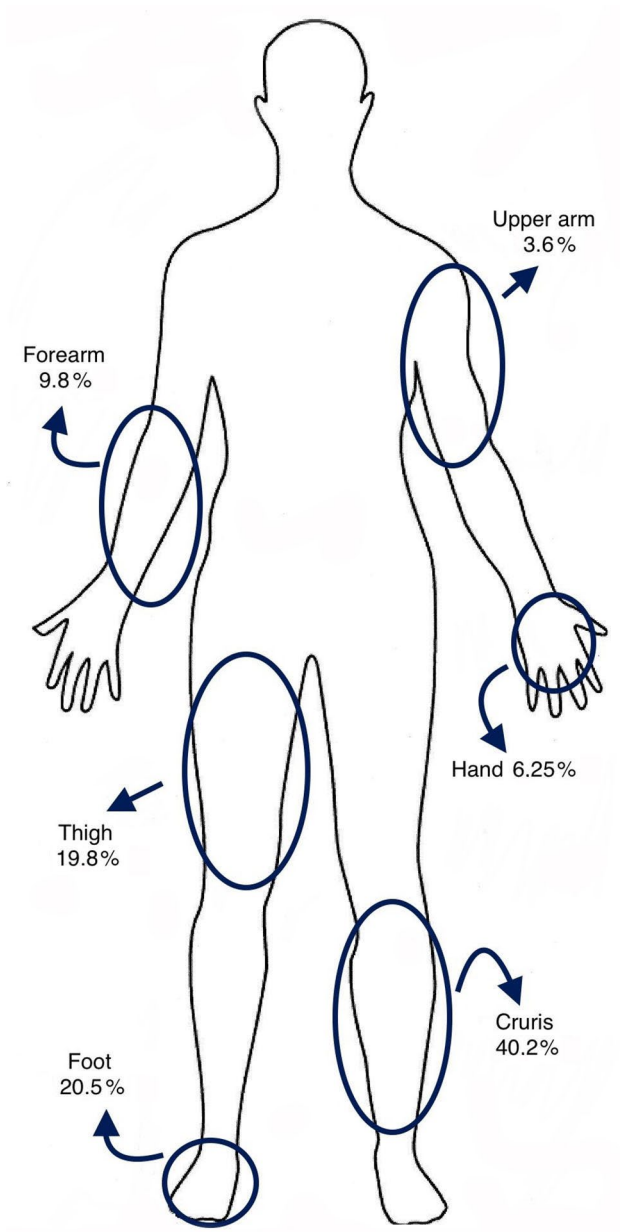


FIGURE 2. Distribution of fasciotomies applied to earthquake victims.

TABLE II
Distribution of renal condition, and vascular and nerve injuries

		n	%
Renal condition			
Acute kidney failure		72	16.4
Dialysis patient		56	12.75
Permanent dialysis patient		9	2
	Unilateral	Bilateral	Total
Vascular injury			
Upper extremity	22	3	25
Lower extremity	86	25	111
Total	108	28	136
Nerve injury			
Lower extremity			
Peroneal		78	83.8
Sciatic		15	16.2
Total		93	100
Upper extremity			
Radial		13	41.9
Ulnar		11	35.4
Median		3	9.6
Brachial		4	12.9
Total		31	100

Totally, 64.7% of the all infected patients were polymicrobial. Forty patients with microorganisms detected in their cultures were Gram-negative, four were Gram-positive and 24 were mixed type (Gram-negative + Gram-positive).

The mean removal time from the rubbles was 32.1±29.38 (range, 1 to 140) h. The fasciotomies of the patients, which were performed in another center and by our team, were examined and divided into upper and lower limbs (Figure 2). A total of 90 (80.3%) lower limb and 28 (19.7%) upper limb fasciotomy operations were applied. A total of 86 fasciotomies (70 lower limb and 16 upper limb) were performed during the first interventions in local hospitals in the earthquake zones. To avoid rhabdomyolysis, we performed a total of 32 fasciotomies (22 lower limb and 10 upper limb), considering the removal time from the rubbles and the time of admission. Crural fasciotomy (40.2%) was the most common fasciotomy performed in earthquake survivors. Forearm fasciotomy (9.8%) was found to be the most common type, when upper limb fasciotomy was examined in detail.

Acute renal failure due to crush syndrome developed in 72 (16.4%) patients during follow-up. A total of 56 (12.75%) patients underwent recurrent dialysis treatment, and nine of them (2%) became permanent dialysis patients (Table II). Follow-up of 160 patients was carried out in the ICU.

Vascular injury was detected in 130 (29.6%) patients (Table II). Vascular injuries were classified according to whether they were in the upper and lower limbs, and whether they were unilateral or bilateral. Accordingly, 111 (81.6%) lower limb (86 unilateral and 25 bilateral) and 25 (18.4%) upper limb (22 unilateral and 3 bilateral) vascular injuries were detected. Nerve injuries were detected in 114 (25.9%) patients. Nerve injuries were also classified according to their occurrence in the upper and lower limbs and the injured nerve. Accordingly, 93 (75%) of these injuries involved the lower limb (78 peroneal and 15 sciatic nerves) and 31 (25%) of these injuries involved the upper limbs (13 radial nerves, 11 ulnar nerves, 3 median nerve, 4 brachial plexus). Daily hyperbaric oxygen therapy was administered to 70 (15.9%) patients without contraindications during hospitalization.

A total of 50 (10.6%) limb amputations were performed in 40 patients at the last follow-up due to vascular insufficiency and infection. The rates of the amputations sites of the patients are shown in Figure 3. Transtibial amputation (47%) was the most

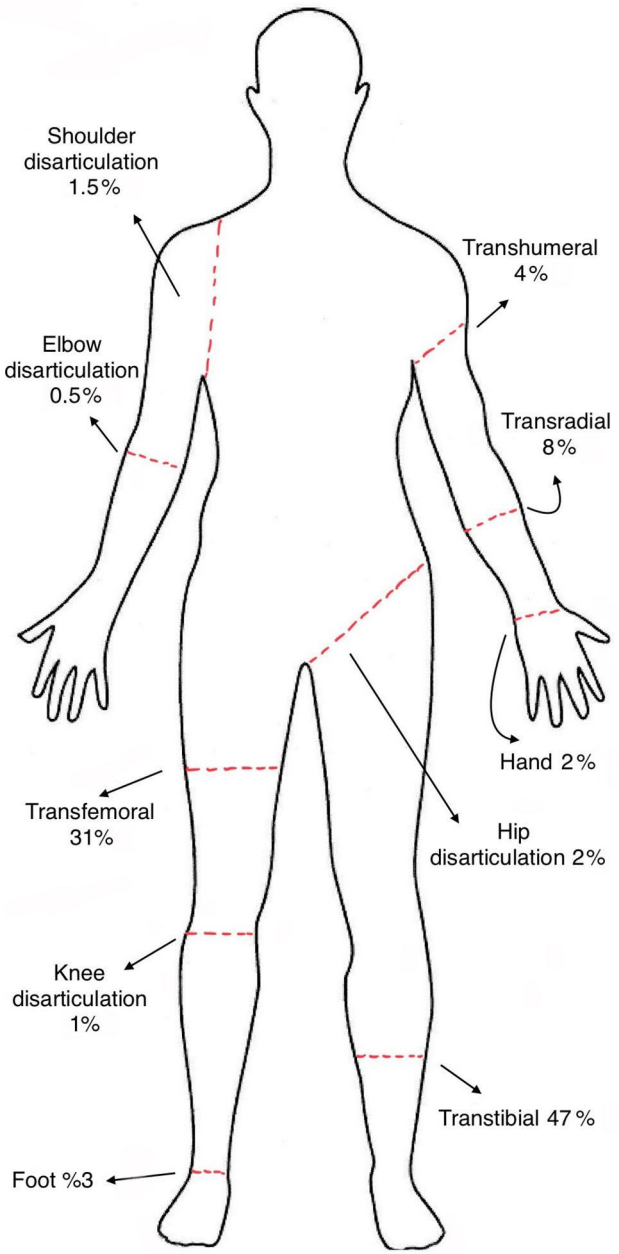


FIGURE 3. Distribution of amputations applied to earthquake victims.

common limb amputation type. The second and third most amputation types were transfemoral and transradial ones (31% and 8%, respectively). A total of eight patients died at the time of first arrival or during follow-up.

DISCUSSION

The main finding of this study is the successful results of the preparations and organizations we made in the process from hospitalization to the discharge of the patients, as well as the coordination and communication with other trauma teams. As a tertiary care center, we received many patients with advanced crush injuries and complex fractures, yet there was no delay in the treatment of patients or high mortality rates under our supervision.

In such a critical environment in the 2023 Kahramanmaras earthquake, overwhelming numbers of patients with musculoskeletal injuries were admitted in the initial few days. The patients were transferred collectively to our hospital from the earthquake zones by planes. All trauma teams were coordinated by us, and a successful triage was achieved. In this way, there was no delay in the evaluation and treatment of patients who were collectively referred to us in the ED.

Rigal[13] reported in a study about disaster situations that when a large number of injured transferred simultaneously, the treatments of patients could be delayed, and this decreased the success rate. We used a social networking platform (WhatsApp) as in other studies, and these new technologies played a critical role facilitating communication.[14] There are several advantages of using social network in such cases. In our study, we achieved faster treatment of patients, preoperative, intraoperative communication of different trauma teams and easy documentation of patients' information. Moreover, there was no delay in the arrival of patients requiring urgent intervention to the operating rooms or ICUs.

Hadary et al.[15] reported that the majority of the General Surgery Department workload shifted from the ED to the operating room, whereas orthopedic procedures and ICU beds became bottlenecks to patient flow during war. In our practice, most injured body regions were limbs; therefore, the Orthopedics and Traumatology Department workload was very high. Our center is the largest volume center in this region, and most of the surgical procedures were done by our clinic.

Awais et al.[16] reported a male-to-female ratio of 0.92 in 2005 Pakistan earthquake. Guner et al.[17] investigated 3,965 patients and reported a male-to-female ratio of 1.66 in 2011 Van earthquake. Zang et al.[18] also reported a male-to-female ratio of 1.26 in 2008 Wenchuan earthquake. In the current study, the male-to-female ratio was 0.89. Mulvey et al.[19] investigated 468 patients and the mean age was 28 in 2005 Kashmir earthquake. In this study, the mean age was 37.06±19.10 years, and 16.2% patients were pediatric population. Possibly, young age of earthquake survivors is associated to certain

factors, such as the time of the earthquake which was early in the morning and the most victims were asleep and the schools were suspended due to heavy snowfall.

Mulvey et al.[19] reported that 59.9% of all injuries affected lower limbs in 2005 Kashmir earthquake. Awais et al.[16] investigated 19,700 patients and found that most musculoskeletal injuries affected the lower limbs (50%) in 2005 Pakistan earthquake. The number of lower limb fractures was greater than upper limb fractures in Western Sumatra earthquake.[20] We found that lower limb injuries (59.07%) were greater than upper limb injuries in our study. Tahmasebi et al.[21] also reported that the time of the event might cause differences in the injury site and that the disaster could mostly affect the proximal bones (femur, humerus), since it was early in the morning. Guner et al.[17] also evaluated the injury sites and found distal bones (tibia, radius) mostly involved in the 2011 Van earthquake occurred in the afternoon. In the current study, unlike other studies in the literature,[20] we found a higher rate of injury to the distal bones, although the earthquake occurred early in the morning.

Considering all the patients included in the study, we evaluated the infection rate as 15.48% (n=68). The majority of these were polymicrobial agents (n=44). There was a predominance of Gram-negative (58.8%) microorganisms. Bozkurt et al.[22] reported that 276 patients had soft tissue infections and total of 25 patients with open fractures suffered from infections in 2005 Pakistan earthquake. The authors attributed the high prevalence of polymicrobial and Gram-negative agents in the spectrum of microorganisms to dirty injuries under the rubbles.

Pang et al.[20] reported that the most common procedure was debridement in 2009 Western Sumatra earthquake. Awais et al.[16] reported that most musculoskeletal injuries were managed with conservative treatment, and 79.5% were applied internal fixations and 20.4% were applied external fixations in 2005 Pakistan earthquake. Guner et al.[17] found that the most frequently surgical intervention was debridement, and 18.2% of the patients were applied conservative treatment, 32.8% internal fixation and 7.4% external fixation in 2011 Van earthquake. In the current study, we treated 41.7% of the patients conservatively. The most common surgical procedure was debridement (40.1%). Of all surgical procedures performed, 21% (n=99) consisted of internal fixation and 4.45% (n=21) external fixation.

Liu et al.[23] reported that 7.5% of all patients had vascular injury in 2008 Wenchuan earthquake. In the current study, we found a total of 136 vascular injuries in 130 (29.6%) patients. Guner et al.[17] also reported that the most common peripheral nerve injury was sciatic nerve. Liu et al.[23] found that 9.6% of all patients had nerve injury in their study. In this study, 124 nerve injuries in 114 patients were recorded and the peroneal nerve injury was the most common type of injury.

In their study, Duman et al.[24] reported that nearly half of the patient required fasciotomy and 25% of the patients required amputation. In our study, a total of 118 (26.9%) patients underwent fasciotomy operation and lower limb fasciotomy accounted for 80.3% of all fasciotomies. Amputation is a radical and life-saving intervention. Even under this disaster situation, amputation is always a difficult decision, but often the most appropriate one.[13] Awais et al.[16] reported that 112 patients underwent limb amputations, and below-knee amputation was the most frequent procedure in 2005 Pakistan earthquake. We had 50 limb amputations in 40 patients at the final follow-up. Transtibial amputation was the most common procedure in the current study.

There are some limitations to our study. First, it has a single-center, retrospective design. Second, despite such a large-scale disaster and thousands of injuries, the number of patients included in the study is relatively small. Third, the treatment methods applied to the patients were recorded; however, the results of the treatments could not be evaluated. Therefore, further studies should be conducted in the mid-term. On the other hand, the main strength of this study is that we received many patients with advanced crush syndrome and complex fractures as a tertiary care center.

In conclusion, earthquakes are devastating disasters that are impossible to prevent or to estimate the time, location and severity of damage and injury precisely. Investigation of the injury profiles and demographic data of patients affected by the earthquake is essential for effective rescue attempts. We believe that using a good communication and organization strategy, as in this study, is necessary to prevent treatment delay and possible adverse events in future disasters.

Ethics Committee Approval: The study protocol was approved by the Ankara Bilkent City Hospital Ethics Committee (date: 08.03.2023, no: E1-23-3333). 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 each patient and/or parents or legal guardians of the patient.

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

Author Contributions: Idea/consept, design, supervision, data collection and processing, analysis and interpretation, literature review, writing the article, critical review, references: G.Ö., T.K., O.B., B.S.; Supervision, data collection and processing, analysis and interpretation, literature review, critical review, references: C.Ç., İ.B., M.O.A., N.M., B.G., V.B., Ş.Ç., C.C.K., Ö.D., F.İ., E.C., İ.A.Y., M.G., H.A., S.T., K.K., M.D., B.Ö., O.T., A.Ş.S., E.U., H.İ.Ö., M.B., Ş.G., E.E., N.K.Ü., T.A., A.M.G., Ö.H.K.

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