Submitted: 12 July, 2024 Accepted: 18 October, 2024 Published: 08 April, 2025 DOI:10.22514/sv.2025.049

Open Access
Signa Vitae

ORIGINAL RESEARCH

Frostbite fallout: analyzing cold burn injuries from the February 2023 twin earthquakes in Kahramanmaraş, Turkey

Mümin Karahan[1], Ramazan Kaya[2], Ersen Türkmen[3], Yunus Oklu[4], Mehmet Şah Sakçı[5], Levent Şahin[6,*]

[1]Orthopedics and Traumatology, Medical School, Kafkas University, 36000 Kars, Türkiye
[2]Orthopedics and Traumatology, Necip Fazıl City Hospital, 46000 Kahramanmaraş, Türkiye
[3]Orthopedics and Traumatology, Polatlı Duatepe State Hospital, 06000 Ankara, Türkiye
[4]Orthopedics and Traumatology, Van Erciş Şehit Rıdvan Çevik State Hospital, 65000 Van, Türkiye
[5]Orthopedics and Traumatology, Batman Training and Research Hospital, 72000 Batman, Türkiye
[6]Emergency Medicine, Medical School, Kafkas University, 36000 Kars, Türkiye

***Correspondence**
leventsahin@kafkas.edu.tr
(Levent Şahin)

Abstract

Background: Despite being rare in earthquakes with high morbidity rates, cold injuries to the extremities can progress to a wide variety of symptoms ranging from pain and loss of sensation to extremity necrosis and amputation. **Methods**: This study aimed to evaluate the location and depth of cold burns on the extremities of cases rescued from the rubble following the sequential earthquakes in Türkiye on 06 February 2023. Cases of earthquake victims presenting to the emergency department and orthopedic outpatient clinic one month after the earthquake were investigated for the times of extraction from the rubble, age, gender, cold burns on the extremities, initial presentation sites of patients, and treatment protocols. **Results**: Of the total 17 patients in the study, 11 were male and 6 were female. The earliest extraction time from the rubble was observed to be 49 hours, while the latest was 119 hours. Examination of the regions affected by patients' cold burns revealed that the upper extremity was the most affected region. Superficial cold burns were observed in 58.80% of patients, while deep cold burns were observed in 41.20%. **Conclusions**: Early heating, treatment and wound care for earthquake victims after disasters can prevent potential cold burns and frostbite.

Keywords

Earthquake; Cold injury; Frostbite; Extremity; Frozen

1. Introduction

Earthquakes are known to cause a significant proportion of orthopedic injuries, accounting for approximately 87% of all injuries [1]. Following earthquakes, common injuries include severe soft tissue injuries, crush injuries to the extremities, long bone fractures, open fractures and compartment syndrome [2]. Additionally, burns are frequently reported as a consequence of earthquakes, with cases documented in the literature [3]. However, thermal burns and scald burns are the predominant types reported. Despite the wealth of literature on earthquake-related injuries, data on hypothermia and cold injuries remain scarce. The Irpinia Earthquake (1980) reported only one case of hypothermia, while the Kashmir earthquake (2005) documented over 100 cases, and the Great East Japan Earthquake reported hypothermia as the cause of 0.2% of deaths [4]. However, there is a lack of literature on cold burns specifically affecting the extremities. Cold burns result from exposure to extreme cold, predominantly affecting the extremities, with initial symptoms including numbness, a sensation of heaviness resembling wood, and throbbing pain [5]. Long-term effects may include persistent pain, numbness and tingling. Assessing the extent of initial damage to the extremities is challenging. Pathophysiologically, cold burns occur through direct cellular freezing or ischemia progressing from the skin [6]. The progressive dermal ischemia is usually more harmful than the direct cell damage, and its cause is similar to the events that lead to reperfusion injury. Inflammatory mediators, such as prostaglandins, thromboxanes, bradykinin, and histamine, lead to edema formation, endothelial injury, and arrest of dermal blood flow. Thawing causes momentary and initial vasoconstriction of arterioles and venules, followed by resumption of capillary circulation and blood flow. Flow is soon disrupted by showers of emboli in microvessels. These emboli and the preexisting endothelial damage cause further tissue loss from progressive thrombosis and hypoxia [7, 8]. Clinically, cold burns are classified into four degrees and the classification is only done after rewarming: first-degree freezing presents with erythema resembling a white plaque; second-degree freezing exhibits erythema, moderate edema, and the formation of soft, clear fluid-filled blisters while maintaining skin perfusion; third-degree freezing is characterized by non-perfused skin, severe edema, and hemorrhagic blisters; and fourth-degree freezing manifests as hard black tissue [6]. Treatment priority involves providing supportive therapy based on the patient's condition, gradual rewarming to halt direct cellular and dermal damage and active wound care [6].

Türkiye stands out as one of the most earthquake-prone

This is an open access article under the CC BY 4.0 license (https://creativecommons.org/licenses/by/4.0/).
 ©2025 The Author(s). Published by MRE Press.

regions globally, with a significant portion of its population residing in areas prone to seismic activity. Consequently, earthquakes resulting in substantial loss of life are not uncommon. Recently, two major earthquakes occurred on the same day, centered in Kahramanmaraş. With the onset of winter and temperatures dropping below 0 degrees Celsius, the risk of cold burns and hypothermia escalates for individuals trapped under rubble. This study aims to assess cases of cold burns on extremities, either brought to our clinic from the rubble or presenting to the outpatient clinic following the earthquakes on 06 February 2023, centered in Kahramanmaraş, with magnitudes of 7.7 and 7.6. The scarcity of data on post-earthquake cold burns underscores the importance of this study.

2. Materials and methods

2.1 Patients and study design

Our study comprised a total of 17 patients, all of whom were affected by the cold following the earthquake that struck on 06 February 2023, centered in Kahramanmaraş and affecting 11 provinces. The evaluation of cold burns on the extremities of earthquake victims who presented to both the emergency department and orthopedic outpatient clinic spanned one month starting from 06 February 2024. Patients seen in the emergency department were assessed only once, and due to the unique circumstances of their examination, subsequent follow-up was not feasible. Consequently, our study retained a descriptive nature for these reasons.

2.2 Data collection

The hospital where the cases were brought and their information was received was very close to the epicenter of the earthquake. Data on patients were obtained from records kept in the field hospital in Kahramanmaraş, the earthquake's epicenter. Pictures of the cases were taken by doctors on duty with the patient's permission.

Frostbite injuries can be classified into grades 1 to 4 depending on the clinical presentation after rewarming [9, 10]. To facilitate the classification of patients in the field according to burn severity, the following classification system has been employed.

2.2.1 Grades 1 to 2 comprising superficial frostbite injuries

- Grade 1, cyanosis is absent, and the risk of amputation is minimal.
- Grade 2, frostbite presents with cyanosis on the distal phalanx of fingers or toes and is associated with a moderate risk of amputation.

2.2.2 Grades 3 to 4 deep frostbite injuries

- Grade 3 frostbite injury
  - Cyanosis up to the metacarpophalangeal joint (MCP; base of the fingers) or metatarsophalangeal joint (MTP; middle of the foot).
  - Bears a high risk of amputation.
- Grade 4 injuries
  - Cyanosis is seen proximal to the MCP or MTP joint.
  - The risk of amputation is almost 100% [2].

Normal skin blood flow is about 250 mL/min but during frostbite, the flow drops to less than 20–50 mL/min. As the temperature drops to below 0 degrees Centigrade, blood flow ceases. The slower venous system freezes before the arterial system [11].

Differentiating cold injuries (such as frostbite) from lesions due to ischemia from pressure or immobilization involves several key aspects:

- Cause: Cold injuries stem from environmental exposure, while ischemic lesions arise from mechanical pressure.
- Skin Color and Temperature: Cold injuries show cold, pale skin, whereas ischemic lesions may start warm and become cooler if blood flow is compromised.
- Sensation and Pain: Cold injuries may lead to numbness, while ischemic lesions are often painful due to pressure.
- Common Locations: Cold injuries affect exposed areas, while ischemic lesions are found over pressure points.

Understanding these distinctions is crucial for appropriate management and treatment of each condition.

In this study, data were collected about gender, age, extraction times from the rubble, cold burn areas, depth of cold burn, type of hospital admission (emergency room-outpatient clinic) and type of treatment application. Most of the earthquake victims were evacuated from reinforced concrete buildings. The number of injured people from wooden, steel-framed, and other adobe types of houses was minimal. Those whose hospital records were incomplete or inaccurate, those who had no data for the study, and those who froze to death under the rubble were excluded from the study.

3. Statistical analysis

Quantitative variables were examined by providing mean, standard deviation, median, 1st and 3rd quartiles, as well as minimum and maximum values. Meanwhile, qualitative variables were evaluated using frequency and percentage. Age and times of extraction from the rubble were considered qualitative variables, whereas gender, location, and depth of cold burns, initial presentation sites of patients, and treatment outcomes for those who could be followed up were considered as quantitative variables. Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 21 (SPSS Inc., Chicago, IL, USA).

4. Results

The study comprised a total of 17 patients, with 64.70% (n = 11) being male and 35.30% (n = 6) female. Patients had a mean age of 36.76 ± 18.65 years, with a median age [1st Quartile–3rd Quartile] of 37.00 [20.00–52.50] years, and ages ranging from 8.00 to 70.00 years (Table 1). Extraction times from the rubble had a mean and standard deviation of 85.00 ± 19.56 hours, a median extraction time [1st Quartile–3rd Quartile] of 84.00 [69.50–102.50] hours, and ranged from 49.00 to 119.00 hours (Table 1).

Examination of cold burn areas indicated the upper extremities were the most affected, with 64.70% of patients (n = 11) showing involvement, 29.4% (n = 5) affecting the lower

TABLE 1. Characteristics of patients.

Variables	n (%)
Gender	
Female	6 (35.30)
Male	11 (64.70)
Age	
Mean ± Standard Deviation	36.76 ± 18.65
Median [1st Quartile–3rd Quartile]	37.00 [20.00–52.50]
Minimum–Maximum	8.00–70.00
Estimated Extraction Times from Rubble	
Mean ± Standard Deviation	85.00 ± 19.56
Median [1st Quartile–3rd Quartile]	84.00 [69.50–102.50]
Minimum–Maximum	49.00–119.00

extremities, and 5.90% (n = 1) involving both extremities. Regarding the depth of cold burns, 58.80% of patients (n = 10) had superficial burns, while 41.20% (n = 7) had deep burns (Table 2).

TABLE 2. Location and depth of cold burns.

Variables	n (%)
Location of Cold Burns	
Upper Extremity	11 (64.70)
Lower Extremity	5 (29.40)
Both Upper and Lower Extremities	1 (5.90)
Depth of Cold Burns	
Superficial	7 (41.20)
Deep	10 (58.80)

Among the cold burn cases in earthquake victims brought to the hospital, there were burn degrees of all stages (Fig. 1). Out of the patients, 23.50% (n = 4) visited the outpatient clinic, while 76.50% (n = 13) went to the emergency department. In the emergency department, patients' vital signs were stabilized, and they received treatment for hypovolemia, hypothermia, rewarming and wound care. Subsequently, patients were transferred to different provincial centers. Unfortunately, due to exceptional circumstances, follow-up for these patients was not possible. Among those who visited the outpatient clinic (n = 4), all developed necrosis, leading to amputation.

5. Discussion

Natural disasters have plagued humankind since the beginning of our species, compelling early humans to seek protection against cold through shelter, clothing and fire as they migrated out of Africa 60,000–70,000 years ago. However, despite such measures, natural disasters can still obliterate personal belongings and infrastructure, leaving individuals vulnerable to harsh environments. One devastating consequence is death from accidental hypothermia [4]. Earthquakes, often accompanied by tsunamis, have historically caused more fatalities than any other disaster combined, with millions occurring annually, though most are minor and cause no harm [12]. However, over 80% of earthquake-related deaths have occurred in countries such as China, Japan, Pakistan, Türkiye and others. Earthquakes and tsunamis are rapid-onset disasters, and from 1994 to 2013, they resulted in an estimated 1.35 million deaths and displaced approximately 218 million people [13]. Türkiye is among the most seismically active regions globally, with the majority of its population residing in earthquake-prone areas. Notably, on 06 February 2023, two major earthquakes, with magnitudes of 7.7 and 7.6, struck Kahramanmaraş. Particularly in the aftermath of earthquakes and natural disasters during winter, frostbite injuries become a concern. Frostbite, akin to burn injuries but caused by cold [3], poses a significant risk, especially as temperatures drop below 0 degrees Celsius for those trapped under rubble. In this study, we aimed to assess cases of extremity frostbite in patients brought to our clinic following the aforementioned earthquakes or those presenting to the outpatient clinic thereafter.

The severity of symptoms typically corresponds with the severity of injury, with initial sensations of cold numbness and sensory loss often reported by patients [14]. The affected extremity may feel cold to the touch, accompanied by sensations of clumsiness, likened to a "block of wood". Thawing and reperfusion often trigger intense pain, followed by throbbing sensations days after rewarming, which may persist for weeks or months, even after tissue demarcation. Some patients report residual tingling sensations, likely due to ischemic neuritis [15, 16]. Initial frostbite appearances seen in emergency departments can be deceptively benign, with some degree of thawing typically occurring. Tissue may appear mottled blue, violaceous, yellowish-white, or waxy, with an initial hyperemia following rapid rewarming, even in severe cases [17]. Of the 17 patients in our study, seven exhibited superficial frostbite, characterized by partial/full-thickness skin freezing, erythema, edema, hyperemia, vesicles, blisters and desquamation. The remaining ten patients had deep frostbite, involving full-thickness skin and subcutaneous freezing, violaceous/hemorrhagic blisters, black eschar formation, skin necrosis and blue-grey discoloration.

Despite the availability of primary data on anatomic locations of orthopedic extremity injuries for individual major earthquakes, no review has compiled detailed epidemiological data from these studies. While several reviews broadly characterize injury patterns as "lower limb" or "upper limb" and "open" or "closed" [2, 18], they lack detailed epidemiological information. Notably, a report on the 2011 Van earthquake indicated a higher incidence and mortality rate of flame burns. Similarly, scald injuries were predominant in the lower extremities among 40 recorded cases in the 1999 Düzce earthquake [19]. Examination of cold burn areas in our study revealed that the upper extremities were most affected, with 64.70% exhibiting upper extremity involvement, 29.4% lower extremity involvement, and 5.90% involvement of both extremities. Most studies on frostbite among civilians have noted a significant proportion of patients exhibiting cognitive impairment due to alcohol, drugs or psychiatric issues. These individuals are more commonly male, tend to develop

FIGURE 1. Figures of frostbite cases of different degrees. (a) 3rd and 4th degree burns, necrotic tissue, (b) 3rd degree freezing is characterized by non-perfused skin, severe edema, (c) 2nd and 3rd degree burns, clear fluid-filled blisters, (d) 4th degree frostbite, hard & black texture, (e) 1st degree simple frostbite, (f) 3rd degree burn with multiple trauma.

frostbite on their extremities, and fall within the age group of 30 to 49 years [20, 21]. However, during natural disasters and earthquakes, there is no reported evidence regarding the involvement of specific age ranges or genders in these publications. In our study, out of the 17 patients examined, 64.70% were male and 35.30% were female. Frostbite cases should be transferred to the hospital without any attempt at unconscious rewarming [3]. Patients must be protected from the wind and any wet clothing should be removed, replacing it with dry garments. Vigorous rubbing must be avoided, as this can cause additional harm. Upon arrival at the emergency service, heating should be initiated as part of the treatment, but it must be done gradually [3]. To achieve this, the affected area should be slowly warmed by immersing it in warm water at approximately 40–42 degrees Celsius for 15–30 minutes. Rapid warming can lead to further damage due to secondary inflammation. For patients with systemic hypothermia, it's important to first raise the core temperature above 35 degrees Celsius using warm intravenous fluids before addressing the warming of affected extremities. However, once warming is administered, the patient may start to experience pain, necessitating pain management. Non-steroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen, are used to manage pain and prevent further inflammation, though stronger pain relief, including narcotics, may be necessary.

While some sources suggest draining or excising white or cloudy blisters, hemorrhagic blisters should generally be left untouched. As with burn injuries, preventing infections and dehydration is crucial [22, 23].

Additionally, gentle cleaning and debridement are recommended. Local wound care should be provided to the affected areas [3]. In the emergency department, patients' vital signs were stabilized, and hypovolemia and hypothermia were addressed. Reheating and wound care procedures were performed. Subsequently, the patients were referred to facilities in various provinces. Unfortunately, due to the exceptional circumstances, follow-up for these patients could not be conducted. Among all patients admitted to the outpatient clinic, amputation was necessary due to the development of necrosis. Thus, four patients who visited the outpatient clinic underwent amputation due to the progression of necrosis.

There are several limitations in our study. The first and most important of these is the chaotic healthcare system experienced in the hospital after the earthquake. In this confusion, the accuracy of patient record files may have been compromised. Another limitation is that our study is single-centered.

6. Conclusions

While frostbite injuries remain potentially disastrous and are associated with high morbidity, their risk during natural disasters in cold, temperate, and even subtropical regions can be mitigated through early warming, prompt medical treatment, and effective local wound care. Before a disaster occurs, it is vital to take preventive actions, such as conducting precise evaluations of disaster risks in particular regions and implementing hazard mapping and warning mechanisms. Additionally, safeguarding current structures within hazard zones to the maximum extent, erecting buildings outside these zones, and coordinating effective rescue efforts are imperative. Performing assessments after disasters to pinpoint shortcomings and apply remedies will aid in diminishing the likelihood of cold-related injuries in subsequent disasters.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

MK—made conception and design, analysis and interpretation of data, drafting the manuscript. ET and LŞ—made analysis and interpretation of data and revising it critically for important intellectual content. RK—drafting the manuscript. MŞS and YO—made acquisition of data. All of the authors approved the final version to be published.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Due to the extraordinary circumstances, we secured verbal consent from all patients, as written consent was not feasible. Our study, characterized by its retrospective observational-descriptive approach, received ethical approval from the Ethics Committee of the Faculty of Medicine, Kafkas University, under protocol number 80576354-050-99/433, dated 30 April 2024. We rigorously adhered to the ethical principles outlined in the Helsinki Declaration throughout the study.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] 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 Journal of Emergency Surgery. 2017; 12: 9.

[2] Missair A, Pretto EA, Visan A, Lobo L, Paula F, Castillo-Pedraza C, *et al*. A matter of life or limb? A review of traumatic injury patterns and anesthesia techniques for disaster relief after major earthquakes. Anesthesia & Analgesia. 2013; 117: 934–941.

[3] Sirkeci CB, Demiröz A. Burn and frostbite injuries in disaster and earthquake treatment. Cerrahpaşa Medical Journal. 2023; 47: 23–26.

[4] Oshiro K, Tanioka Y, Schweizer J, Zafren K, Brugger H, Paal P. Prevention of hypothermia in the aftermath of natural disasters in areas at risk of avalanches, earthquakes, tsunamis and floods. International Journal of Environmental Research and Public Health. 2022; 19: 1098.

[5] Imray C, Grieve A, Dhillon S. Cold damage to the extremities: frostbite and non-freezing cold injuries. Postgraduate Medical Journal. 2009; 85: 481–488.
[6] Hutchison RL. Frostbite of the hand. Journal of Hand Surgery. 2014; 39: 1863–1868.
[7] Zacarian SA, Stone D, Clater M. Effects of cryogenic temperatures on microcirculation in the golden hamster cheek pouch. Cryobiology. 1970; 7: 27–39.
[8] Bulkley GB. The role of oxygen free radicals in human disease processes. Surgery. 1983; 94: 407–411.
[9] Handford C, Buxton P, Russell K, Imray CE, McIntosh SE, Freer L, *et al*. Frostbite: a practical approach to hospital management. Extreme Physiology & Medicine. 2014; 3: 7.
[10] Cauchy E, Chetaille E, Marchand V, Marsigny B. Retrospective study of 70 cases of severe frostbite lesions: a proposed new classification scheme. Wilderness & Environmental Medicine. 2001; 12: 248–255.
[11] Basit H, Wallen TJ, Dudley C. Frostbite. StatPearls Publishing: Treasure Island (FL). 2024.
[12] Peleg K, Reuveni H, Stein M. Earthquake disasters–lessons to be learned. The Israel Medical Association Journal. 2002; 4: 361–365.
[13] Auerbach PS, Cushing TA, Harris NS. Auerbach's wilderness medicine. 7th edn. Elsevier Health Sciences: Philadelphia, PA, USA. 2016.
[14] Reamy BV. Frostbite: review and current concepts. Journal of the American Board of Family Medicine. 1998; 11: 34–40.
[15] Oakley EHN. Cold damage to the extremities: frostbite and non-freezing cold injuries. In Tooke JE, Lowe GD (eds.) A textbook of vascular medicine (pp. 353–370). 1st edn. Hodder Education Publishers: Arnold, UK. 1996.
[16] West JB, Schoene RB, Milledge JS. High altitude medicine and physiology. 4th edn. Hodder Education Publishers: London. 2007.
[17] McCauley RL, Smith DJ, Robson MC, Heggers JC. Frostbite. In Auerbach PS (ed.) Wilderness medicine: management of wilderness and environmental emergencies (pp. 129–145). 3th edn. Mosby: St. Louis. 1995.
[18] Morelli I, Sabbadini MG, Bortolin M. Orthopedic injuries and their treatment in children during earthquakes: a systematic review. Prehospital and Disaster Medicine. 2015; 30: 478–485.
[19] Ad-El DD, Engelhard D, Beer Y, Dudkevitz I, Benedeck P. Earthquake related scald injuries—experience from the IDF field hospital in Duzce, Turkey. Burns. 2001; 27: 401–403.
[20] Valnicek SM, Chasmar LR, Clapson JB. Frostbite in the prairies: a 12-year review. Plastic and Reconstructive Surgery. 1993; 92: 633–641.
[21] Pinzur MS, Weaver FM. Is urban frostbite a psychiatric disorder? Orthopedics. 1997; 20: 43–45.
[22] Hallam MJ, Cubison T, Dheansa B, Imray C. Managing frostbite. The BMJ. 2010; 341: c5864.
[23] Woo EK, Lee JW, Hur GY, Koh JH, Seo DK, Choi JK, *et al*. Proposed treatment protocol for frostbite: a retrospective analysis of 17 cases based on a 3-year single-institution experience. Archives of Plastic Surgery. 2013; 40: 510–516.

How to cite this article: Mümin Karahan, Ramazan Kaya, Ersen Türkmen, Yunus Oklu, Mehmet Şah Sakçı, Levent Şahin. Frostbite fallout: analyzing cold burn injuries from the February 2023 twin earthquakes in Kahramanmaraş, Turkey. Signa Vitae. 2025; 21(4): 32-37. doi: 10.22514/sv.2025.049.