acta medica

ORIGINAL ARTICLE

# The role of reconstructive plastic surgery in the treatment of victims of the 2023 Kahramanmaraş earthquake

Dicle Aksöyler[1]
ORCID: 0000-0002-3692-8893

Ömer Faruk Akpınar[1]
ORCID: 0009-0008-3311-107X

Erol Kozanoğlu[1]
ORCID: 0000-0003-1192-9520

Bora Edim Akalın[1]
ORCID: 0000-0002-5654-2082

Emre Sertaç Bingül[2]
ORCID: 0000-0002-8662-5380

Bengüsu Mirasoğlu[3]
ORCID: 0000-0002-2062-0229

Ömer Berköz[1]
ORCID: 0000-0001-8063-9995

Rıfat Atilla Arıncı[1]
ORCID: 0000-0002-3255-0184

[1] Department of Plastic Reconstructive and Aesthetic Surgery, Faculty of Medicine, Istanbul University, İstanbul Türkiye

[2] Department of Anaesthesiology, Faculty of Medicine, Istanbul University, İstanbul Türkiye

[3] Department of Underwater Hyperbaric Medicine Department of Medicine, Faculty of Medicine, Istanbul University, İstanbul Türkiye

Corresponding Author: Dicle Aksöyler
E-mail: drdicleaksoyler@yahoo.com

*Received: 4 April 2023, Accepted: 22 May 2024,*
*Published online: 29 June 2024*

ABSTRACT

Objective: As a result of the 2023 Kahramanmaraş earthquake, medical institutions experienced a large influx of patients requiring acute multidisciplinary surgical and medical care. This study aimed to evaluate the patient demographics and treatment management of survivors admitted to our reconstructive plastic surgery department.

Materials and Methods: We retrospectively analyzed the age, sex, time under the wreckage, time of admission, types and locations of injuries, treatment modalities, receipt of hyperbaric oxygen therapy, and receipt of vacuum-assisted closure therapy of the earthquake victims referred to our department.

Results: The definitive management of all 42 earthquake survivors admitted to our department was reviewed. This included five free flaps, four regional flaps, 18 split-thickness skin grafts, and one maxillofacial fracture repair. Eight patients were treated conservatively including two with non-displaced maxillofacial fractures. Of the 26 patients treated for lower extremity injuries, four were already amputees. Among the remaining 22 patients with such injuries, one underwent Charcot amputation plus free flap reconstruction to preserve extremity length and one underwent below-the-knee amputation. Of the 16 upper extremity injuries, two patients referred with extensive forearm necrosis underwent forearm amputation. To preserve extremity length and ensure the limbs were suitable for biomechanical orthoses, free transverse upper gracilis musculocutaneous flaps and free chimeric Anterolateral- Vastus Lateralis musculocutaneous flaps were performed.

Conclusion: This study illustrates the value of multi-modal reconstructive plastic surgery in the treatment of disaster survivors, particularly in the management of multi-trauma.

Keywords: amputation, earthquake, fasciotomy, flap, skin graft.

## INTRODUCTION

As a country spread over three major fault lines, Turkey is particularly vulnerable to earthquakes, with 61% of the damage caused by natural disasters in Turkey over the last 60 years attributable to earthquakes [1].

The injuries caused by earthquakes are most often due to victims being hit by or buried under parts of collapsed or collapsing buildings. This can result in compartment syndrome, soft tissue damage, fractures, and crush injuries, with the upper and lower extremities the most frequently affected areas [2]. These are important causes of morbidity and such injuries can be life-threatening. Most require fasciotomies under emergency conditions. However, the majority of fasciotomies opened under emergency conditions are inadequate, while others fail because metabolites produced as a result of crush injuries cause acute renal failure, increasing the mortality rate [3, 4]. Therefore, the appropriate and effective management of survivors is critical, beginning with the first intervention.

On February 6, 2023, two major earthquakes occurred in the Southeastern Anatolia region of Turkey. The first occurred at 04.17 local time in the Pazarcık district (37.288N–37.043E), with a depth of 8.6 km and a magnitude of 7.7 Mw. The second hit at 13.24 local time in the Elbistan district (38.089N–37.239E) at a depth of 7 km and a magnitude of 7.6 Mw. Together, they affected 11 provinces with a total population of over 16 million, killing over 50,000 people in the region [1, 5].

However, the emergency and advanced examination and treatment of earthquake survivors was hindered by damage to healthcare facilities and injured healthcare workers. For this reason, most of the seriously injured survivors had to be transferred to higher-level centers in other cities, including Istanbul, Ankara, Izmir, Adana, and Konya.

Our facility is one of the largest tertiary-level hospitals in Turkey. Eligible wards were converted into intensive care units, which were filled only with earthquake survivors. In our department, all non-urgent elective surgical operations were postponed. Patients awaiting surgery and those eligible for discharge were released from the hospital.

In this study, we aim to share the demographic data of the survivors admitted to the plastic surgery department of our center after the 2023 Kahramanmaraş earthquake, to describe the treatment and management protocols utilized, and to demonstrate the importance of a multidisciplinary approach in overcoming various obstacles while managing a large influx of patients following a disaster.

## MATERIALS and METHODS

This study was approved by our institutional ethics committee (Istanbul Faculty of Medicine Clinical Research Ethics Committee) on the 9th February 2024 (approval no. 255).

We performed a retrospective analysis of the medical records of earthquake survivors treated in the Plastic Reconstructive and Aesthetic Surgery Clinic of Istanbul University Faculty of Medicine between the 8th of February 2023 and the 1st of March 2023.

Earthquake victims with the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) diagnostic code X34 (victim of cataclysmic earth movements caused by earthquake) or X39 (exposure to forces of nature) admitted with open wounds, neural deficits, hand or wrist fractures, or maxillofacial fractures were referred to our clinic from the Orthopedics and Traumatology Clinic, the Emergency Medicine Department, the Intensive Care Unit, the Department Of Pediatrics, the Internal Medicine Department, the Undersea And Hyperbaric Medicine Department, and the General Surgery Clinic. The data of these patients were retrospectively reviewed.

The age, sex, time of admission, time under the wreckage, hyperbaric oxygen therapy (HBOT) application, vacuum-assisted closure (VAC) therapy, length of hospital stay, injury type and location, preferred treatment approach, and comorbidities of the patients were analyzed.

Statistical analysis was performed using SPSS v.26.0 (IBM Corp., Armonk, NY, USA). Categorical measurements were expressed as numbers and percentages, means ± standard deviations (SDs), and medians (min-max) as applicable.

## RESULTS

A total of 42 (54.8% [n=23] female, 45.2% [n=19] male) patients were included. Patient ages ranged from 2–86 (mean 25.9) years and 45.2% (n=19) were under 18 years old. Time under the wreckage ranged from 1–261 (mean 19.55) h (Table 1).

While 13.95% (n=6) of the patients were directly admitted to the plastic surgery clinic from the Emergency Medicine Department, 16.3% (n=7) were referred from the pediatric ICU and 4.65% (n=2) were referred from the adult ICU.

Three (7.1%) of the patients were referred due to isolated maxillofacial trauma, one of whom underwent naso-orbito-ethmoidal fracture correction by open reduction and internal fixation. One patient had a non-displaced lateral orbital wall fracture and one had a non-displaced condylar fracture. The latter two patients were treated conservatively.

There were 11 (26.2%) patients with isolated upper extremity trauma. One of these (70 h under the wreckage) underwent forearm amputation and the stump was reconstructed with a free anterolateral vastus lateralis chimeric flap (Fig. 1). Three presented with traumatic upper brachial plexus palsy, for which electromyography (EMG) was ordered for 3 weeks later. Three patients underwent split-thickness skin grafting for defect closure. Other three patients were treated conservatively because of presenting with simple abrasions.

**Table 1.** Demographic characteristic of the patients

| | N (count) | % (percentage) | Mean |
|---|---|---|---|
| Female | 23 | 54.8 | |
| Male | 19 | 45.2 | |
| Age Classification (year) | | | |
| 0-10 | 11 | 26.2 | |
| 11-20 | 12 | 28.6 | |
| 21-30 | 3 | 7.1 | |
| 31-40 | 6 | 14.3 | |
| 41-50 | 3 | 7.1 | |
| 51-60 | 4 | 9.5 | |
| 61-70 | 1 | 2.4 | |
| 70 up | 2 | 4.8 | |
| Length of the stay under the rubble (h) | | | |
| 0-6 | 8 | | 1.81 h |
| 6-12 | 6 | | 8.66 h |
| 24-48 | 7 | | 35.71 h |
| 72 up | 4 | | 135 h |

Of those admitted to our clinic, 52.4% (n=22) were referred due to isolated lower extremity trauma. One of these (12 h under the wreckage) was already a transfemoral amputee and a pedicled tensor fascia lata musculocutaneous flap was used on the contralateral side for a stage 4 ischial decubitus ulcer reconstruction. One pediatric patient presented with a transmetatarsal amputation (12 h under the wreckage) and was treated with a free vastus lateralis musculocutaneous flap. Another pediatric patient who presented with an open forefoot defect (1 h under the wreckage) underwent a free anterolateral thigh flap reconstruction for defect closure. A free vastus lateralis muscle flap was lost due to venous insufficiency and split-thickness skin grafting was performed for the final reconstruction with this patient. One patient (262 h under the wreckage) underwent a Charcot amputation and a free chimeric suprafascial anterolateral vastus lateralis thigh muscle flap was used to protect limb length. (Fig. 2) One patient underwent heel reconstruction using a reverse sural flap. Ten patients underwent STSG for defect closure. Other patients treated conservatively without requiring any surgical intervention.

Multiple significant side injuries were seen in 27.2% (n=6) of the patients, necessitating a multidisciplinary approach. One patient had lacerations to the intraoral mucosa and a non-displaced thoracolumbar vertebral fracture. A conservative approach was deemed preferable for this patient. One pediatric patient (40 h under the wreckage) was admitted to the facility with a humerus fracture, lung injury, and upper and lower extremity open fasciotomy defects. STSG for defect closure was performed. The humerus fracture was non-operative and a cast was applied. A temporary chest tube was considered for the pneumothorax injury. One patient (112 h under the wreckage) presented with a necrotic forearm and grade 4 sacral decubitus. The forearm stump was reconstructed with a free transverse upper gracilis musculocutaneous flap to preserve limb length and a gluteal musculocutaneous rotation flap was used for defect closure. Two patients (8 h and 112 h under the wreckage) had multiple open wounds and fasciotomy defects of the upper and lower extremities. Both underwent STSGs for closure of


**Figure 1. a.** An earthquake survivor with extensive dry necrosis on the volar side of the forearm and hand after 70 h under the wreckage. **b.** The appearance of the patient's limb and remaining humeral length after adequate debridement, HBOT, VAC therapy, and broad-spectrum antibiotics. **c.** An ALT-VL musculocutaneous flap with two skin perforators, before the ligation of the main pedicle. **d.** The flap was inset for final closure and the skin-grafted VL muscle, remnant radial artery and its concomitant veins, and cephalic vein were anastomosed to the lateral circumflex femoral artery and its concomitant veins. **e.** The patient with a biomechanical prosthetic following successful treatment.

ALT-VL, Anterolateral Thigh- Vastus lateralis; HBOT, Hyperbaric Oxygen Theraphy; VAC, Vacuum-Assisted Closure; VL, Vastus Lateralis

the defects and were treated with hemodialysis in the ICU for acute kidney injury. One patient (96 h under the wreckage) already had a below-the-knee amputation and a skin-grafted traumatic ear amputation but was referred for grade 4 sacral decubitus and peripheric facial paralysis. A tensor fascia lata static sling was used for facial palsy reconstruction and a gluteal fasciocutaneous rotation flap for grade 4 sacral decubitus reconstruction.

Negative pressure wound therapy (NPWT) was performed on 14.2% (n=6) of the patients with fasciotomy defects and 50% (n=21) of those with soft tissue infections and open wounds that could not be controlled by simple debridement. The treatment was repeated every 3 days and final wound closure was performed after 2–8 sessions of NPWT. To prevent the separation of wound edges in those patients with fasciotomy defects, either rubber bands or sutures were applied to the wound edges during the NPWT. This reduced lateral strain around the suture lines and decreased the need for skin grafts during final closure.

Cases requiring hyperbaric oxygen therapy (HBOT) underwent the treatment daily for 30 min to 2 h in a chamber pressurized at 1.5–3.0 atmospheres with 100% oxygen. This was received by 23 of the 42 patients (54.8%) with open wounds. Two


**Figure 2. a.** An earthquake survivor referred with foot necrosis after 262 h under the wreckage. **b.** The appearance of the patient's foot and lower limb after multiple debridements, VAC treatment, HBOT, and broad-spectrum antibiotics. **c.** A chimeric suprafascial ALT flap with the VL muscle.

patients with isolated upper extremity trauma, 16 patients with isolated lower extremity trauma, and five patients with lower and upper extremity fasciotomy defects underwent this treatment for 4–16 days (Table 2).

**Table 2.** The reconstruction types of the defects

| Treatments | N (count) | % (percentage) |
|---|---|---|
| Non surgical intervention | 8 | 19 |
| Primary wound closure | 4 | 9.5 |
| STSG+NPWT | 18 | 42.8 |
| HBOT | 23 | 54.7 |
| Regional flap | 4 | 9.52 |
| Free flap | 5 | 11.9 |
| Maxillofacial fracture repair | 1 | 2.38 |
| Amputation | 6 | 14.2 |

STSG: Split thickness skin grafting NPWT: Negative pressure wound theraphy HBOT: Hyperbaric oxygen theraphy

## DISCUSSION

As our facility was some distance from the incident area, we primarily treated patients presenting with multiple injuries and those in critical condition requiring collaboration between different medical and surgical disciplines. The majority of the patients had already undergone acute-urgent procedures such as fasciotomies or amputations before they were seen at our clinic.

We observed that the level of injury, the incidence of compartment syndrome, and the amputation and reconstruction requirements were related to the time spent under the wreckage. This could not be proven statistically as the reconstructions required became more complex as the time spent under the rubble increased.

Overall, the definitive management of all 42 patients was comprehensive and included five free flaps, four regional flaps, 18 split-thickness skin grafts, and one maxillofacial fracture repair. Among the 26 lower extremity injuries treated, four patients were already amputees (one below-the-knee amputation, one transfemoral amputation, and two metatarsophalangeal amputations), one patient underwent Charcot amputation plus a free ALT-VL flap to preserve extremity length and one underwent a below-the-knee amputation. Of the 16 upper extremity injuries treated, two patients who had already been referred with extensive forearm necrosis underwent forearm amputation. To preserve extremity length and ensure the limbs were suitable for biomechanical orthoses, free transverse upper gracilis flap and free chimeric ALT-VL musculocutaneous flaps were performed. Additional nerve coaptations were also performed to preserve muscle volume (Table 3).

Only one free flap was lost. This was in a patient (40 h under the wreckage) with a forefoot defect and transmetatarsal amputation. The patient was mobilized on the fifth day after defect reconstruction using a free vastus lateralis muscle flap but, the next day, the flap failed due to venous insufficiency. A venous Doppler ultrasound examination showed that the patient had suffered superficial and deep vein reflux during the Valsalva maneuver, suggesting that the flap failure was due to deep and superficial venous insufficiency resulting from the patient's crush injury. Subsequently, other patients with lower extremity injuries who required free flap reconstruction underwent venous Doppler ultrasound preoperatively and mobilization was initiated eight days after the reconstruction, beginning with the dangling procedure.

The optimal method of trauma management in patients presenting with dirty or contaminated soft tissue and bone infections is multiple debridements followed by vacuum-assisted wound closure, broad-spectrum antibiotics, and hyperbaric oxygen treatment if required. These procedures prepare the patient for proper functional anatomical and aesthetic reconstruction [6].

VAC narrows wound edges; removes exudate, including inflammatory and infectious material; and increases angiogenesis, all of which help to reduce the wound area and facilitate the formation of granulation tissue [7]. Previous research has found that, after 4 days of vacuum-assisted therapy, tissue bacterial counts are significantly decreased [8]. Therefore, vacuum-assisted therapy was repeated every 3 days 6–8 times as part of our wound management protocol.

Among the interventions used with these patients, HBOT has the unique ability to improve tissue oxygenation, decrease pathological inflammation, and repair ischemia-reperfusion injury. Although there is a lack of high-quality evidence for the efficacy of HBOT in acute wound management, it is thought to increase various growth factors, mobilize bone marrow-derived stem/progenitor cells, and induce changes in the synthesis of monocyte chemokines, hemoxygenase-1, heat shock proteins, and hypoxia-inducible factor-1, leading to the inhibition of inflammation [9, 10]. Not all tertiary centers have access to a hyperbaric chamber. Our facility has one chamber and 24/7 access was provided for the treatment of these patients. It is contraindicated in patients with pneumothorax, restrictive lung diseases, pregnancy, concomitant topical mafenide use, viremia, and concomitant chemotherapy [10,11].

**Table 3.** The distribution of the injury area and preffered reconstruction option, amputation levels

| | STSG | Regional Flaps | Free Flaps | Amputation levels |
|---|---|---|---|---|
| Upper Extremity | 6 patients | | Chimeric ALT-VL flap | Forearm |
| | | | Transverse upper gracilis flap | Forearm |
| Lower Extremity | 12 patients | Gluteal rotation flap | Chimeric suprafascial ALT-VL flap | Transfemoral amputation |
| | | Gluteal rotation flap | VL muscle flap | Below knee amputation |
| | | Sural flap | ALT fasciocutaneous flap | Transmetatarsal amputation |
| | | Tensor fascia lata flap | | Transmetatarsal amputation |
| | | | | Below knee amputation |
| | | | | Charcot amputation |

ALT: Anterolateral thigh flap. VL: Vastus lateralis muscle flap

Therefore, one pediatric patient with multiple side injuries and forearm fasciotomy defects was unable to undergo this treatment due to additional lung injury.

There were some limitations in this study. Firstly, although the medical records were double-checked, due to the retrospective nature of the study and the chaotic conditions following the disaster, some medical records might have been compromised. Secondly, we focused on the musculoskeletal and maxillofacial injuries of those earthquake survivors referred to our plastic surgery clinic. The details of injuries to major organs or other forms of trauma were not assessed. Thirdly, due to the remote location of the facility in relation to the disaster site, we were only able to treat 42 of the thousands of survivors.

Essentially, the role of reconstructive plastic surgeons is to make critical treatment decisions, to provide open wound reconstruction, and to determine how much of a damaged extremity can be saved and to leave a healthy stump that is long enough for the use of orthoses and prostheses.

## CONCLUSION

We believe that after the first intervention in the disaster area, ongoing management of earthquake victims in critical condition should be conducted in tertiary health centers with adequate intensive care support and orthopedic, general surgery, plastic surgery, cardiovascular surgery, hyperbaric and underwater medicine, internal medicine, infectious disease, pediatric, and psychiatric departments.

Collaboration between medical and surgical disciplines is crucial for the comprehensive and effective management of disaster survivor care.

### Author contribution

Study conception and design: DA, EK, BM, RAA; data collection: DA, ÖFA BEA, ESB, ÖB; analysis and interpretation of results: DA, ESB, BM, ÖB; draft manuscript preparation: DA, EK, BEA, ÖFA, RAA. All authors reviewed the results and approved the final version of the manuscript.

### Ethical approval

The study was approved by the Clinical Research Ethics Committee of Istanbul Faculty of Medicine (Protocol no. 255).

### Funding

The authors declare that the study received no funding.

### Conflict of interest

The authors declare that there is no conflict of interest.

## REFERENCES

[1] Gökmen MY, Uluöz M. The experience of a tertiary level hospital in the 2023 Turkey double earthquake zone; management of 1,092 musculoskeletal injuries in the first week. Eur Rev Med Pharmacol Sci 2023;27(19):9111-20. https://doi.org/10.26355/eurrev_202310_33937

[2] Ergani HM, Özmut Ö, Yıldırım F, Çit R, Yaşar B, Ünlü RE. Evaluation of the 2023 Kahramanmaras earthquake from the perspective of Plastic Surgery Department: A single-center experience. Jt Dis Relat Surg 2023;34(2):523-9. https://doi.org/10.52312/jdrs.2023.1107

[3] Clover AJP, Jemec B, Redmond AD. The extent of soft tissue and musculoskeletal injuries after earthquakes; describing a role for reconstructive surgeons in an emergency response. World J Surg 2014;38(10):2543-50. https://doi.org/10.1007/s00268-014-2607-y

[4] Gonzalez D. Crush syndrome. Crit Care Med 2005;33(1 Suppl):S34-41. https://doi.org/10.1097/01.ccm.0000151065.13564.6f

[5] Uluöz M, Gökmen MY. The 2023 Turkey Earthquake: Management of 627 Pediatric Musculoskeletal Injuries in the First Month. Children (Basel) 2023;10(11):1733. https://doi.org/10.3390/children10111733

[6] Clover AJP, Rannan-Eliya S, Saeed W, et al. Experience of an orthoplastic limb salvage team after the Haiti earthquake: analysis of caseload and early outcomes. Plast Reconstr Surg 2011;127(6):2373-80. https://doi.org/10.1097/PRS.0b013e3182131cde

[7] Singh D, Chopra K, Sabino J, Brown E. Practical Things You Should Know about Wound Healing and Vacuum-Assisted Closure Management. Plast Reconstr Surg 2020;145(4):839e-54e. https://doi.org/10.1097/PRS.0000000000006652

[8] Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. Ann Plast Surg 1997;38(6):563-76; discussion 577.

[9] Thom SR. Hyperbaric oxygen: its mechanisms and efficacy. Plast Reconstr Surg 2011;127(Suppl 1):131S-41S. https://doi.org/10.1097/PRS.0b013e3181fbe2bf

[10] Fife CE, Eckert KA, Carter MJ. An Update on the Appropriate Role for Hyperbaric Oxygen: Indications and Evidence. Plast Reconstr Surg 2016;138(3 Suppl):107S-16S. https://doi.org/10.1097/PRS.0000000000002714

[11] Dauwe PB, Pulikkottil BJ, Lavery L, Stuzin JM, Rohrich RJ. Does hyperbaric oxygen therapy work in facilitating acute wound healing: a systematic review. Plast Reconstr Surg 2014;133(2):208e-15e. https://doi.org/10.1097/01.prs.0000436849.79161.a4