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Original Article

Cranial trauma patterns after the 2023 Kahramanmaraş earthquakes: A retrospective CT-based analysis

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Abstract

Aim: This study aimed to analyze the patterns of cranial trauma detected on computed tomography (CT) scans obtained following the 2023 Kahramanmaraş earthquakes and to evaluate neurotrauma management under disaster conditions.
Materials and Methods: A retrospective review was conducted on cranial CT scans performed between February 6 and 13, 2023, at a state hospital in Hatay that remained operational throughout the disaster. Patients with poor-quality CT scans or pre-existing neurological conditions were excluded. Two neurosurgeons independently evaluated the images for skull fractures, intracranial hemorrhages, and pneumocephalus, resolving discrepancies by consensus. Surgical indications and outcomes were also recorded.
Results: Of 576 patients evaluated, 544 met inclusion criteria (280 males, 264 females). No acute traumatic cranial pathology was detected in 497 patients (91.4%). The most frequent lesion was a linear skull fracture (4.2%), followed by subdural, epidural, and parenchymal hematomas (each 1.7%) and subarachnoid hemorrhage (1.4%). Five patients (0.9%) required surgical intervention, and one postoperative death occurred. Patient admissions peaked within the first three days post-earthquake. Most head injuries were minor, with severe neurotrauma being uncommon.
Conclusion: The majority of post-earthquake cranial CT scans revealed no significant pathology, suggesting that most head injuries were mild. Efficient triage systems, rational CT utilization, and prompt multidisciplinary coordination are crucial for optimizing neurotrauma care in disaster settings.

Keywords: Earthquake, head injury, cranial trauma, computed tomography, neurotrauma, disaster medicine

INTRODUCTION

Türkiye is geographically prone to various natural disasters such as floods, forest fires, and earthquakes. Among these, earthquakes impose the greatest burden on public health and the healthcare system. Head injuries of varying severity frequently occur during earthquakes as a result of blunt cranial trauma. Traumatic brain injury (TBI) encompasses a wide clinical spectrum ranging from minor contusions to life-threatening intracranial hemorrhages. Due to their high potential for morbidity and mortality, head injuries during earthquakes require rapid and systematic management.

The earthquakes centered in Kahramanmaraş on February 6, 2023, resulted in more than 50.000 deaths and over 107.000 injuries across Türkiye (1,2). According to a systematic review, head trauma accounts for approximately 16.6% of all earthquake-related injuries, with superficial lacerations and contusions being the most frequent types. Among intracranial hematomas, epidural hematoma (EDH) was reported in 9.5% of cases, intraparenchymal hematoma in 7.0%, and subdural hematoma (SDH) in 6.8% (3). In a study evaluating 768 adult patients after the 2023 earthquakes, 14.2% had head injuries (4). Similarly, a single-center study from Mersin reported that among 2.155 trauma victims, soft-tissue injuries and scalp lacerations were the most common head-related pathologies (5).

Because many hospitals were damaged during the earthquake, imaging and data recording processes were significantly disrupted. Therefore, this study retrospectively evaluated

cranial CT scans obtained from a state hospital located near the earthquake's epicenter that continued to provide uninterrupted service. The aim of this study is to identify cranial trauma patterns in patients presenting under disaster conditions, to assess CT indications, and to contribute to the development of an algorithm for neurotrauma management during disasters.

MATERIALS AND METHODS

This study was approved by the Mustafa Kemal University Non-Interventional Clinical Research Ethics Committee on 09.07.2025, with the protocol number 10/28. In addition, institutional approval for academic data use was obtained from the Provincial Health Directorate.

The study was conducted in the radiology archive of a state hospital in Hatay, located near the epicenter of the February 6, 2023, Kahramanmaraş earthquakes. This hospital sustained no structural damage and continued to operate without interruption during the disaster. The study population consisted of patients who underwent cranial computed tomography (CT) for suspected head trauma following the earthquake. Most of the patients had a history of being rescued from under the rubble and of head injury.

During the acute post-earthquake period, patients were admitted under mass-casualty conditions, frequently without identification documents. Due to the chaotic environment and urgent triage demands, detailed demographic data—including age and clinical severity scores—were not systematically recorded in the hospital information system. Patient registration was primarily based on self-reported name and surname. In unconscious or non-communicative patients, provisional identifiers such as "adult male" or "adult female" were used. While chronological age could not be reliably retrieved, sex information was available through radiology archive metadata associated with CT examinations.

All cranial CT scans were retrospectively reviewed. Exclusion criteria included scans with poor image quality due to artifacts, infants with open fontanelles, three patients with sequelae of previous cerebrovascular accidents, and one patient with a cranial defect secondary to prior craniectomy. Infants with open fontanelles were excluded based on radiological identification on bone window CT images rather than chronological age.

CT imaging was performed based on emergency physician assessment under disaster conditions. Indications included reported or suspected head trauma, loss or alteration of consciousness, persistent headache, vomiting, focal neurological deficit, high-risk mechanisms (such as entrapment under debris), and clinical uncertainty due to limited or unreliable patient history. In the disaster context, a precautionary imaging approach prioritizing sensitivity was adopted to minimize missed intracranial injuries.

Following authorization from the Provincial Health Directorate, CT images were analyzed in axial, sagittal, and coronal multiplanar reconstructions by two experienced neurosurgeons independently. Any discrepancies were resolved by consensus.

The following pathologies were assessed: linear and displaced skull fractures, subarachnoid hemorrhage (SAH), subdural hematoma (SDH), epidural hematoma (EDH), parenchymal hematoma, and pneumocephalus. Surgical indications were also recorded, and postoperative follow-ups of the five operated patients were reviewed.

All data were tabulated in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). A total of 576 patients underwent cranial CT; after applying exclusion criteria, 544 patients were included in the final analysis. The study covered the first week following the February 6, 2023 earthquakes. The number of patients and distribution of cranial pathologies by day were analyzed (Figure 1).

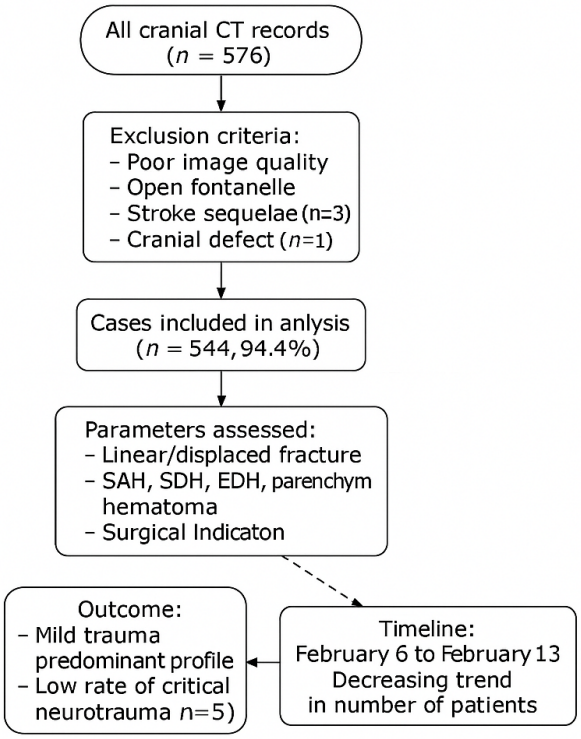

Figure 1. Flow diagram of the study methodology

RESULTS

Of the 576 patients evaluated, 544 met the inclusion criteria. Among these, 280 were male and 264 were female. No acute traumatic cranial pathology was identified in 497 patients (91.4%). The most common lesion was a linear skull fracture, detected in 24 patients (4.2%). Displaced skull fractures were observed in 5 patients (0.9%) and pneumocephalus in 7 patients (1.2%). Regarding intracranial hemorrhages, SAH occurred in 8 patients (1.4%), SDH in 10 (1.7%), EDH in 10 (1.7%), and parenchymal hematoma in 10 (1.7%) (Table 1).

Table 1. Summarizes demographic distribution, CT findings, surgical interventions, and mortality

Variable	n	%
Total patients	544	100
Male	280	51.5
Female	264	48.5
Normal CT	497	91.4
Linear fracture	24	4.2
Displaced fracture	5	0.9
SAH	8	1.4
SDH	10	1.7
EDH	10	1.7
Parenchymal hematoma	10	1.7
Surgery	5	0.9

Five patients (0.9%) required surgical intervention. Two underwent emergent craniotomy for acute EDH, one for extensive SDH, one for parenchymal hematoma associated with a displaced fracture, and one for EDH developing over a linear fracture. One patient with diffuse SAH and acute SDH died postoperatively.

Patient volume peaked between February 6 and 8, 2023. The highest number of admissions occurred on February 7 (155 patients), followed by February 6 (118), February 8 (106), and February 9 (61). By February 13, daily admissions had declined to approximately 20 patients.

These findings indicate that most earthquake-related head injuries in the acute phase were mild, and severe neurotraumatic lesions were relatively rare.

DISCUSSION

Earthquake-related injuries typically result from mechanisms such as falls, collapsing structures, and entrapment beneath debris. The magnitude and duration of seismic motion, as well as the type of buildings affected, directly influence the injury spectrum. Among these injuries, head trauma is relatively common due to the vulnerability of the cranial region to falling objects and structural impacts. However, most earthquake-associated head injuries are mild, while severe intracranial lesions remain infrequent compared with limb and thoracic injuries reported in previous disasters (6,7).

In the present study, 91.4% of cranial CT scans demonstrated no pathological findings. This high rate of normal CT findings should not necessarily be interpreted as inappropriate imaging. In mass-casualty disasters, triage strategies typically prioritize sensitivity over specificity to avoid missing potentially life-threatening intracranial lesions. Therefore, the elevated normal CT rate likely reflects precautionary, safety-oriented triage rather than unnecessary imaging alone. Similar to our findings, Igarashi et al. emphasized that most earthquake-related head injuries are minor and rarely require surgical intervention (3,8). The predominance of linear skull fractures in our cohort further supports the low-energy nature of the trauma mechanisms involved, likely resulting from secondary impacts such as falling debris rather than direct high-velocity forces.

The temporal distribution of cases—peaking within the first three days after the earthquake—reflects the chaotic nature of the initial emergency response period. During this phase, hospital overcrowding and limited resources may have led to an increased rate of non-indicated CT scans performed due to anxiety or medico-legal concerns. This overutilization of imaging during disasters has been highlighted in prior studies as an expected phenomenon when diagnostic uncertainty is high and triage protocols are not yet fully operational.

The relatively low incidence of intracranial hemorrhages, including subarachnoid, subdural, epidural, and parenchymal hematomas, aligns with international data. Chu et al. reported that most head injuries following the 2008 Sichuan earthquake were mild and infrequently associated with significant intracranial bleeding (6). In contrast, tertiary trauma centers—where severely injured or transferred patients are concentrated—have reported higher rates of life-threatening intracranial lesions and surgical interventions (7). The markedly lower surgical rate observed in our series (0.9%) may be partially attributable to referral patterns, with more severe cases managed at higher-level neurosurgical facilities, as well as potential prehospital mortality among catastrophic injuries.

Beyond the descriptive epidemiology, this study underscores several critical aspects of neurotrauma management during large-scale disasters. First, early imaging and triage efficiency are essential for identifying life-threatening conditions while conserving limited radiological capacity. Establishing portable CT systems or mobile diagnostic units in disaster-prone regions may facilitate earlier diagnosis and reduce interhospital transfers. Second, multidisciplinary coordination between emergency physicians, neurosurgeons, and radiologists plays a decisive role in preventing delays in life-saving interventions. The observed clustering of mild injuries within the first week suggests that healthcare systems must be prepared for a surge of low-acuity patients, requiring well-structured screening and triage protocols to maintain capacity for critically ill cases.

Our findings also have implications for disaster preparedness and policy-making. The ability of the studied hospital to continue uninterrupted operation despite regional devastation highlights the importance of structural resilience and pre-disaster planning. Future disaster management frameworks should integrate radiology-based surveillance systems to track trauma trends in real time, providing valuable epidemiological data for subsequent response optimization.

However, several limitations should be acknowledged. The retrospective design and lack of access to detailed clinical

records, including Glasgow Coma Scale (GCS) scores or long-term outcomes, limit the correlation between radiological and clinical severity. Additionally, the study only included patients who underwent CT imaging; therefore, individuals with mild head injuries who did not receive CT may have been underrepresented. Another limitation is the inability to assess the prehospital mortality burden, which might have resulted in an underestimation of severe neurotrauma cases. Despite these constraints, the current work remains one of the few studies to document neurotrauma patterns and CT findings under real-world disaster conditions in Türkiye.

CONCLUSION

Among 544 patients who underwent cranial CT after the 2023 Kahramanmaraş earthquakes, the majority (91.4%) had no pathological findings. Linear skull fracture was the most common lesion, while intracranial hemorrhage and surgical intervention rates were low.

Post-earthquake neurotrauma was predominantly limited to mild head injuries. Effective triage, rapid imaging protocols, and rational allocation of neurosurgical resources are crucial components of disaster-period neurotrauma management.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that there is no financial support.

Ethical Approval
The study protocol received approval from the Ethics Committee for Non-Interventional Clinical Research of Hatay Mustafa Kemal University. Approval date: 09/07/2025, Decision Number: 28.

Patient Consent
Not necessary for this manuscript.

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