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Evaluation of post-earthquake fractures according to anatomical body parts: A retrospective study

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Abstract

Bone fractures that occur in earthquakes threaten human life. The study aims to localize the fractures in earthquake victims according to anatomical regions in the earthquake centered in Kahramanmaraş 2023. The study included 137 patients aged between 1-90 years diagnosed with fractures by an orthopedic physician. Radiographs were taken of patients admitted to the emergency department after the earthquake. The fractures diagnosed patients were evaluated and classified in anatomical regions and fracture type. The fractures were observed in females with high rates of fragmented (49.6%) and s ingle fractures (75.9%). The fractures also occurred on the right side (58.4%), in the upper extremities (37.2%) and long bones (38.7%). In the specific anatomic region evaluation of fractures; high rates were observed in manus (19%), antebrachi (15.3%), crus (13.9%) and pes fractures (12.4%). In the region of the most common fragmentary fracture type (48.9%); omos (3%), brachium (1%), thorax (15%), viscerocranium (7%) and neurocranium (3%), in oblique fractures (25.5%); pes (26%), in transverse fractures (20.4%); antebrachi (21%), manus (32%) and vertebral column (4%), in spiral fractures; pelvis (14%), femur (14%) and crus (57%) region. We determined that fractures frequently occur on the right-side extremities and, besides sequentially high rates at manus, antebrachii, crus, and pes. We recommend providing information about the protection of these anatomical parts in the training given to people during the earthquake closure and post-earthquake panic times to reduce earthquake-related fractures.

Keywords: Anatomical regions, earthquake injuries, fracture, natural disaster, trauma

Introduction

Earthquakes are major natural disasters that are difficult to predict [1]. Türkiye is located in the Alpine Himalayan orogenic belt and is one of the most active regions of the world in terms of earthquakes. Therefore, 98% of the population lives at risk of earthquakes. As a matter of fact, on February 6-7, 2023, two major earthquakes with a magnitude of 7.8 and 7.6, centered in Kahramanmaraş, killed over 50.000 people and injured over 100.000 people, with great destruction in the surrounding provinces, especially Kahramanmaraş, Malatya, Adana, Gaziantep, Hatay, Osmaniye, Adıyaman, Şanlıurfa, and Diyarbakır [2,3].

The trauma-related injury site of individuals rescued after a disaster is essential regarding the protection protocol. In the literature, it is found that orthopaedic injuries are in the first rank of injuries seen after earthquakes, and more than half of these injuries are extremity fractures [4,5].

Bone tissue is the passive element of the human body and contains the flexibility of the organic substances and the hardness of the inorganic substances. Bone fractures, commonly seen after earthquakes, are a condition in which bone integrity is disrupted due to trauma that exceeds bone flexibility. Besides, these fractures develop anywhere in the bone. Orthopaedists often classify bone fractures according to their location (proximal, middle, and

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distal), fracture shape (transverse, short, oblique, or spiral), and degree of fragmentation. Therefore, it may cause serious cost and morbidity with the disability of fracture [6-9].

This study aims to localize the fractures in earthquake victims according to anatomical regions in the earthquake centered in Kahramanmaraş and to contribute to the literature by creating awareness of how individuals can protect their bodies more effectively in case of disaster based on the localization frequency obtained.

Material and Methods

Permission for the study was obtained from Malatya Turgut Ozal University Non-Interventional Clinical Ethics Committee (2023/B.189). In this retrospective study, we evaluated the files with 'Kahramanmaraş earthquake' labels in the database between February 06-10/2023 were examined. The study included 137 patients aged between 1-90 years who were diagnosed with fractures by an orthopedic physician with radiographs, taken in patients admitted to the emergency department of Training and Education Hospital due to the earthquake or brought by health teams after the earthquake (Figure 1). The fractures diagnosed patients were evaluated and classified in terms of anatomical regions and fracture type (Table 1). The inclusion criteria were earthquake survivors who were diagnosed with fractures due to radiologic images in the records labeled 'Kahramanmaraş earthquake' in the system and who were between the ages of 1 and 90 years. Exclusion criteria were individuals outside the 1-90 age range and not labeled with the 'Kahramanmaraş earthquake' labels in the system.

Files of individuals in the study included age, gender, and demographic information. Radiological images were evaluated by orthopedic specialists, radiologists, and anatomy specialists. Fractures were classified according to assessment criteria, and data were recorded (Table 1).

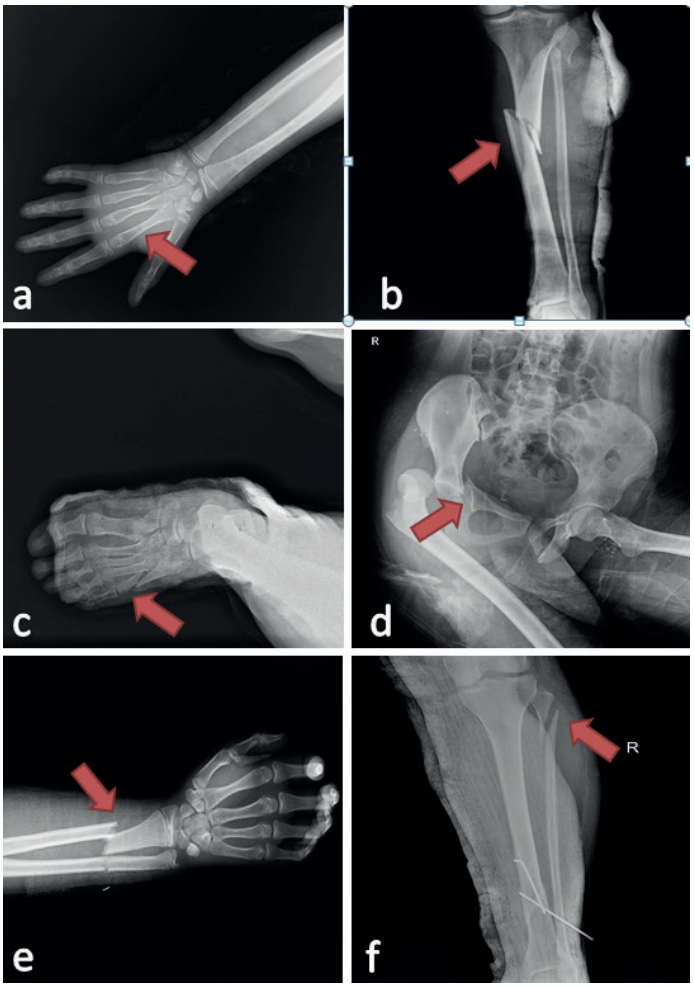

Figure 1. Examples of fractures in the study: **a.** A case with metacarpal bone fracture, **b.** A case with tibia fracture, **c.** A case with 5. metatarsal bone fracture, **d.** A case with coxa fracture, **e.** A case with ulna and radius fracture, **f.** A case with fibula fracture

Table 1. The classification of fractures

Classification criteria	Classification parameters
Gender	Female, male, unknown
Anatomical region	Head, neck, upper extremity, lower extremity, thorax, vertebral column, pelvis,
Fracture type	Transvers, oblique, fragmented, spiral
Multiple fractures	Single, multiple
Bone type	Long, short, flat, irregular
Side of the bone	Right, left, median
Specific region	Omos, brachium, antebrachii, manus, thorax, vertebral colon, pelvis, femur, crus, pes, viscerocranium, neurocranium

Statistical Analysis

The data included in the study were analyzed with the IBM SPSS (Statistical Program in Social Sciences) 25 software (New York, ABD). The significance level (p) was taken as 0.05 for comparison tests. Number, percentage, mean, standard deviation, minimum, and maximum values were used as descriptive statistics. In the analysis of categorical data, cross-tabulations were created, and Chi-square analysis was applied.

Results

137 patients were included in the study; 68 were female, 64 were male, and the gender of 5 patients was unknown due to lack of records. The patients' mean age and standard deviation was 43.25±27.86 years, and the age range was between 1 and 90 years.

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Distribution of Variables

The incidence of fractures was higher in female patients (49.6%). The highest rates were;

- Upper extremity fractures in the anatomical region of the fracture (37.2%),
- Fragmented fractures in the fracture type (48.9%),
- Single fracture (75.9%) in the fracture number,
- Long bone in the fractured bone type (38.7%), and right side in the direction of the fractured side (58.4%).

In the specific region evaluation of the patient's fractures, the highest rates were manus (19%), antebrachii (15.3%), crus (13.9%), and pes (12.4%), respectively (Table 2) (Figure 2).

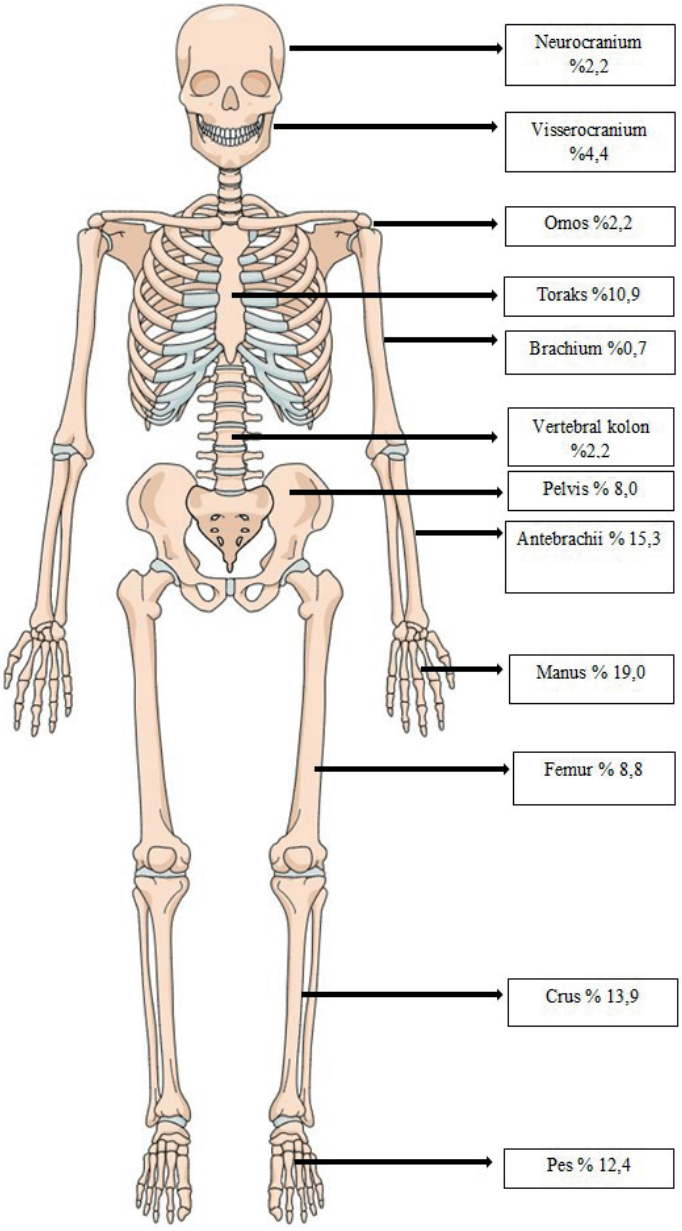

Figure 2. Percentages of fractures relative to anatomical sites [10]

Table 2. Distribution of variables

Variable	Parameters	Number (n)	Percantage (%)
Gender	Female	68	**49.6**
	Male	64	46.7
	Unknown	5	3.6
Anatomical region	Head	9	6.6
	Upper extremity	51	**37.2**
	Thorax	15	10.9
	Vertebral column	3	2.2
	Pelvis	10	7.3
	Lower extremity	49	**35.8**
Fracture type	Transvers	28	20.4
	Oblique	35	25.5
	Fragmented	67	**48.9**
	Spiral	7	5.1
Multiple fractures	Single	33	24.1
	Multiple	104	**75.9**
Bone type	Long	53	**38.7**
	Short	28	20.4
	Flat	20	14.6
	Irregular	36	26.3
Side of the bone	Dexter	80	**58.4**
	Sinister	42	30.7
	Corpus	15	10.9
Specific region	Omos	3	2.2
	Brachium	1	0.7
	Antebrachii	21	**15.3**
	Manus	26	**19.0**
	Thorax	15	10.9
	Vertebral column	3	2.2
	Pelvis	11	8.0
	Femur	12	8.8
	Crus	19	**13.9**
	Pes	17	**12.4**
	Viscerocranium	6	4.4
	Neurocranium	3	2.2
Total		**137**	**100.0**

Comparisons by Fracture Type

In the analysis of fracture types according to gender, there were a high rates of transverse fracture (54%) in females and high percentage of fragmented fracture (55%) in males.

In the analysis of the relationship between the general anatomical region of the fracture and the fracture types;

- Transverse fractures in the upper extremity (57%) and vertebral column (4%) regions,
- Oblique fractures in the caput region (6%),
- Fragmented fractures in the thorax region (15%), spiral

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fractures in the pelvis (14%) and lower extremity regions (71%),

were found to be high rates. A statistically significant correlation exists between these regions and fracture types (Table 3) (p=0.033).

In the analysis of the relationship between bone types and the most rated fracture type;

- Long bones with spiral fractures (71.4%),
- Short bones with transverse fractures (32.1%),
- Flat bones with oblique fractures (38.6%)
- Irregular bones with fragmented fractures (31.3%) were found at high rates (Table 3).

In the specific region evaluation;

- The most common fragmentary fracture type (48.9%) determined in omos (3%), brachium (1%), thorax (15%), viscerocranium (7%), and neurocranium (3%)
- Oblique fractures (25.5%) determined in pes (26%),
- Transverse fractures (20.4%) determined in antebrachi (21%), manus (32%), and vertebral column (4%),
- Spiral fractures were determined in the pelvis (14%), femur (14%) and crus (57%) region (Table 3).

In the correlation analysis, there was a statistically significant difference between fracture type with gender (p=0.003) and anatomical region of fracture (p=0.033) (Table 2).

Table 3. Comparisons by fracture type

Variable	Parameters, n (%)	Fracture type				Total, n (%)	Chi- square	p value
		Transverse	Oblique	Fragmented	Spiral			
Gender	**Female**	15 (54)	16 (46)	30 (45)	7 (1)	68 (5)	**20.097**	**0.003***
	Male	12 (43)	15 (43)	37 (55)	0 (0)	64 (47)		
	Unknown	1 (4)	4 (11)	0 (0)	0 (0)	5 (4)		
Anatomical region	**Head**	0 (0)	**2 (6)**	7 (1)	0 (0)	9 (7)	**26.481**	**0.033***
	Upper extremity	**16 (57)**	11 (31)	23 (34)	1 (14)	51 (37)		
	Thorax	3 (11)	2 (6)	**10 (15)**	0 (0)	15 (11)		
	Vertebral column	**1 (4)**	0 (0)	2 (3)	0 (0)	3 (2)		
	Pelvis	1 (4)	1 (3)	7 (1)	**1 (14)**	10 (7)		
	Lower extremity	7 (25)	19 (54)	18 (27)	**5 (71)**	49 (36)		
Bone type	**Long**	11 (39.3)	13 (37.1)	24 (35.8)	**5 (71.4)**	53 (38.7)	14.176	0.116
	Short	**9 (32.1)**	10 (28.6)	8 (11.9)	1 (14.3)	28 (20.4)		
	Flat	3 (10.7)	**3 (38.6)**	14 (20.9)	0 (0.0)	20 (14.6)		
	Irregular	5 (17.9)	9 (25.7)	21 (31.3)	1 (14.3)	36 (26.3)		
Specific region	**Omos**	1 (4)	0 (0)	**2 (3)**	0 (0)	3 (2)	44.334	0.090
	Brachium	0 (0)	0 (0)	**1 (1)**	0 (0)	1 (1)		
	Antebrachii	**6 (21)**	3 (9)	12 (18)	0 (0)	21 (15)		
	Manus	**9 (32)**	8 (23)	8 (12)	1 (14)	26 (19)		
	Thorax	3 (11)	2 (6)	**10 (15)**	0 (0)	15 (11)		
	Vertebral column	**1 (4)**	0 (0)	2 (3)	0 (0)	3 (2)		
	Pelvis	2 (7)	1 (3)	7 (1)	**1 (14)**	11 (8)		
	Femur	1 (4)	4 (11)	6 (9)	**1 (14)**	12 (9)		
	Crus	4 (14)	6 (17)	5 (7)	**4 (57)**	19 (14)		
	Pes	1 (4)	**9 (26)**	7 (1)	0 (0)	17 (12)		
	Visserocranium	0 (0)	1 (3)	**5 (7)**	0 (0)	6 (4)		
	Neurocranium	0 (0)	1 (3)	**2 (3)**	0 (0)	3 (2)		
Total		28 (1)	35 (1)	67 (1)	7 (1)	137 (1)		

n: number, %: percentage, *p<0.05: statistically significant difference between the groups

Comparisons by Specific Region

There was no statistically significant difference between the specific region and gender (p=0.324). In contrast, there was a statistically significant difference between the side of a fracture and the specific region, with fractures being more common on the right side (Table 4) (p=0.001).

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Table 4. Comparisons by spesific region

Variable	Parameters, n (%)	Spesific region												Total, n (%)	Ki square	p value
		Omos	Brachium	Antebrachii	Manus	Thorax	Vertebral column	Pelvis	Femur	Crus	Pes	Visserocranium	Neurocranium			
Gender	Female	-	-	**10 (48)**	12 (46)	7 (47)	3 (1)	6 (55)	7 (58)	10 (53)	8 (47)	4 (67)	1 (33)	68 (5)		
	Male	3 (1)	1 (1)	**11 (52)**	12 (46)	8 (53)	0	5 (45)	5 (42)	6 (32)	9 (53)	2 (33)	2 (67)	64 (47)	24.457	0.324
	Unknown	-	-	-	2 (8)	-	-	-	-	3 (16)	-	-	-	5 (4)		
Side of the fracture	Dexter	1 (33)	1 (1)	14 (67)	**17 (65)**	12 (8)	3 (1)	1 (9)	7 (58)	11 (58)	11 (65)	-	2 (67)	80 (58)		
	Sinister	2 (67)	-	7 (33)	9 (35)	3 (2)	-	-	5 (42)	8 (42)	6 (35)	1 (17)	1 (33)	42 (31)	**92.471**	**0.001***
	Corpus	-	-	-	-	-	-	10 (91)	-	-	-	5 (83)	-	15 (11)		

n: number, %: percentage, *p<0.05: there is a statistically significant difference between the groups

Discussion

In our study, we determined that the fractures that occurred in the Malatya region after the 2023 Kahramanmaraş earthquake were primarily female, fragmented, and single fractures, and these fractures were located in the right upper extremity and long bones. In the evaluation of the specific anatomical site of the fractures, manus, antebrachi, crus, and pes fractures were the most common fractures.

The literature reports that lower extremity fractures caused by earthquakes are predominantly seen [11–15]. Kang et al. [16] reported fractures as a result of the Lushan earthquake ratios in the lower extremities and pelvis (57.3%), thorax (55.6%), upper extremities (43.8%), and facial bones (39.2%). Çağıran et al. [17] reported that the most common fractures in the 2020 Aegean Sea earthquake were lower extremity fractures (11.8%), besides 5.2% of fractures were upper extremity fractures, 3.2% pelvic fractures, and 2.6% vertebral fractures. Teicher et al. [18] reported that 16.7% of fractures occurred in the upper extremities and 83.3% in the lower extremities. In our study, similar to the literature, we found that the highest rates of upper extremity fractures were 37.2% and lower extremity fractures were 35.8%. Similarly to the literature, we suggest that the reason for the high rate of limb fractures is due to the positioning away from the body of the extremities, and the extremities play a significant role in the formation of movement during the closure position (curling the floor like fetus) at the time of the earthquake and in panic situations after the earthquake.

Teicher et al. [18] reported that 204 of the 264 fractures after the Haiti 2010 earthquake were observed in the humerus, radius, femur, and tibia, which are long bones, while Bozkurt et al. [12] schematized that distal tibia, femur shaft, and lateral malleolus fractures were observed at a high rate after the 2005 Pakistan earthquake. In our study, we observed that there are high proportions of long bones in all types of fractures consisting of transverse (39.3%), oblique (37.1%), fragmentary (35.8%), and spiral (71.4%) fractures.

Following limb fractures in the literature, we realized that spine and cranial fractures are also present. Kang et al. [16] reported that fractures are the most frequently observed injury, with a rate of 41.5% in post-earthquake injuries, while the most common anatomical regions are the lower extremities and pelvis (34.2%), followed by the body surface (17.9%), cranium (14.0%), and spine (10%). Miller et al. [19] reported that 85% of patients had spinal and spinal cord injuries, 15% had intracranial injuries, and 7% had combined intracranial and spinal injuries, Aycan et al. [20] reported that 72.7% of the patients exposed to the 2011 Van earthquake had cranial injuries, 18.2% had spinal injuries, and 9.1% had combined cranial and spinal injuries. In our study, the rate of vertebral fractures was 2.2%, while the rate of caput fractures was 6.6%. As the reason for the difference between these studies, we consider that the data obtained for earthquake victims with such fractures are mainly due to the difference in the data obtained. We obtained the data from the emergency department unit and did not include the intensive care unit or other departments.

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Çakır et al. [21] reported that vertebral fractures caused by panic are generally caused by falls on the first day after the first main earthquake, and these fractures are together with other bones. Aycan et al. [20] state that since Türkiye is also in the first-degree seismic zone, injuries caused by falling from heights are highly common, which is due to people's lack of earthquake education and earthquake awareness. In our study, although we determined a high rate of limb fractures, unlike the Cakir et al. study, we have a similar opinion as to the cause of fracture. Besides this, fractures can be seen in terms of attitudes and behaviors during disasters and emergencies in general. We suggest that the frequent occurrence of limb fractures is caused by the panic caused by the earthquake and the fact that the extremities are not held close to the trunk in the closing position at the time of the earthquake. Therefore, the extremities become more prone to injury.

The first limitation of our study is that we could only evaluate some of the data due to the panic of the radiology unit after the earthquake and many distorted images. The second limitation of our study is that we could not evaluate the images of patients with severe diseases because we could not enter the intensive care unit system.

Our study has practical implications for earthquake preparedness and response. We found that fractures occur at a high rate in female earthquake victims, particularly on the right side, upper and lower extremities. Moreover, fractures occur at the highest regional rates in the manus, antebrachi, crus, and pes regions. This information is directly applicable to the training provided to people during earthquake closure and post-earthquake panic times, as it guides them on how to protect these anatomical parts and reduce earthquake-related fractures.

Conclusion

We determined that fractures frequently occur on the right-side extremities and, besides sequentially high rates at manus, antebrachii, crus, and pes. We recommend providing information about the protection of these anatomical parts in the training given to people during the earthquake closure and post-earthquake panic times to reduce earthquake-related fractures.

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

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
This work was implemented with the approval of the Non-Interventional Clinical Ethics Committee (2023/B.189).

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