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ORIGINAL ARTICLE

Characterization and mapping of upper extremity fractures in children by a tertiary hospital quarantine and post-quarantine period

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ABSTRACT

Objectives: This study aims to categorize and map the incidence and patterns of upper extremity fractures in children during and after novel coronavirus disease 2019 (COVID-19) quarantine and to identify changes in the demographic characteristics and mechanisms of these fractures.

Patients and methods: Between April 2020 and April 2022, a total of 3,549 upper extremity fractures occurring in 1,028 pediatric patients (682 males, 346 females; median age: 7 years; range, 0 to 18 years) were retrospectively analyzed. Those who presented between the dates of April 1st, 2020 and April 1st, 2021 (quarantine) were included in Group 1, whereas those who presented between April 1st, 2021 and April 2nd, 2022 (post-quarantine) were included in Group 2. The fracture map also showed the fracture density and location.

Results: There were statistically significant differences in terms of age range between Groups 1 and 2 ($p<0.01$). The 6-11 age range was significantly higher in Group 1, and the 12-18 age range was significantly higher in Group 2.

Conclusion: Reducing physical activity during quarantine reduces fractures, particularly in adolescents. The removal of restrictions increases fractures in children in this age range. These findings highlight the importance of considering age ranges and physical activity levels while planning safety measures to prevent injuries in children.

Keywords: Children, COVID-19, fracture heat mapping, quarantine, upper extremity fracture.

The World Health Organization (WHO) classified novel coronavirus disease 2019 (COVID-19) as an epidemic on March 11th, 2020.[1] Similar to other countries worldwide, our nation has implemented certain steps. Examples of measures include practices such as social isolation, the utilization of masks in public spaces, the closure of schools, and the suspension of sporting activities and events. Changes in lifestyles have an impact on children. It is well known that the incidence of fractures is significantly high in individuals under the age of 18, with more than half of these fractures occurring in the upper extremities.[2,3]

During the quarantine and pre-quarantine phases in children, several studies assessed pediatric injuries, particularly fractures.[4-9] The majority of them were created by utilizing short intervals. Furthermore, it failed to provide information regarding the period post-lockdown. In the present study, we, therefore, aimed to evaluate the upper extremity fractures in pediatric patients during the interval following the post-quarantine measures and to assess fractures of the upper extremities in

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children whose daily lifestyles, sports activities, and social areas changed throughout the quarantine and post-quarantine periods.

PATIENTS AND METHODS

This single-center, retrospective cohort study was conducted at Bakırköy Dr. Sadi Konuk Training and Research Hospital, Department of Orthopedics and Traumatology between April 2020 and April 2022. Pediatric patients who presented to our center with fractures of the upper extremities during the COVID-19 quarantine (Group 1) and patients who presented post-quarantine (Group 2) at the same institution were included. Those who presented between the dates of April 1st, 2020 and April 1st, 2021 were included in Group 1, whereas those who presented between April 1st, 2021 and April 2nd, 2022 were included in Group 2. Patients aged above 18 years and who did not have the fractures of upper extremities and those with missing data were excluded from the study. Finally, a total of 3,549 fractures occurring in 1,028 patients (682 males, 346 females; median age: 7 years; range, 0 to 18 years) were included in the study (Figure 1).

Patient demographics included age (0-2 years old, 2-5 years old, 6-11 years old, 12-18 years old),[10] sex, fracture mechanism, type, re-reduction, complication, fracture region, and treatment.

Heat mapping

A technique that involves the identification and classification of fractures that occur within the skeletal system is referred to as bone fracture mapping. This method is frequently utilized in the field of medical imaging to assist in the diagnosis and treatment of fractures.[11,12] The pre-designed upper extremity model (including the clavicle, humerus, radius-ulna, carpal, metacarpal, and phalanx) was used to construct the fracture line density map, also known as heat mapping. This was done by employing Adobe Illustrator (Adobe Inc., CA, USA). A blue-red coloration was assigned to it in accordance with the rarity-frequency status (Figure 2).

Statistical analysis

Statistical analysis was performed using the NCSS version 2022 (NCSS LLC, Kaysville, UT, USA). Descriptive data were expressed in median (min-max) or number and frequency, where applicable. The Pearson chi-square test, Fisher exact test, and Fisher Freeman-Halton test were used to compare qualitative data. The fracture heat map illustrated the fracture location, while the frequency spectra illustrated the fracture line majorities. A p value of <0.05 was considered statistically significant.

RESULTS

Demographic data regarding the entire cohort and a comparison of the quarantine and post-quarantine periods are presented in Table I. There were statistically significant differences in age between Groups 1 and 2 ($p=0.001$; $p<0.01$). The 6-11 age range was found to be significantly higher in Group 1,

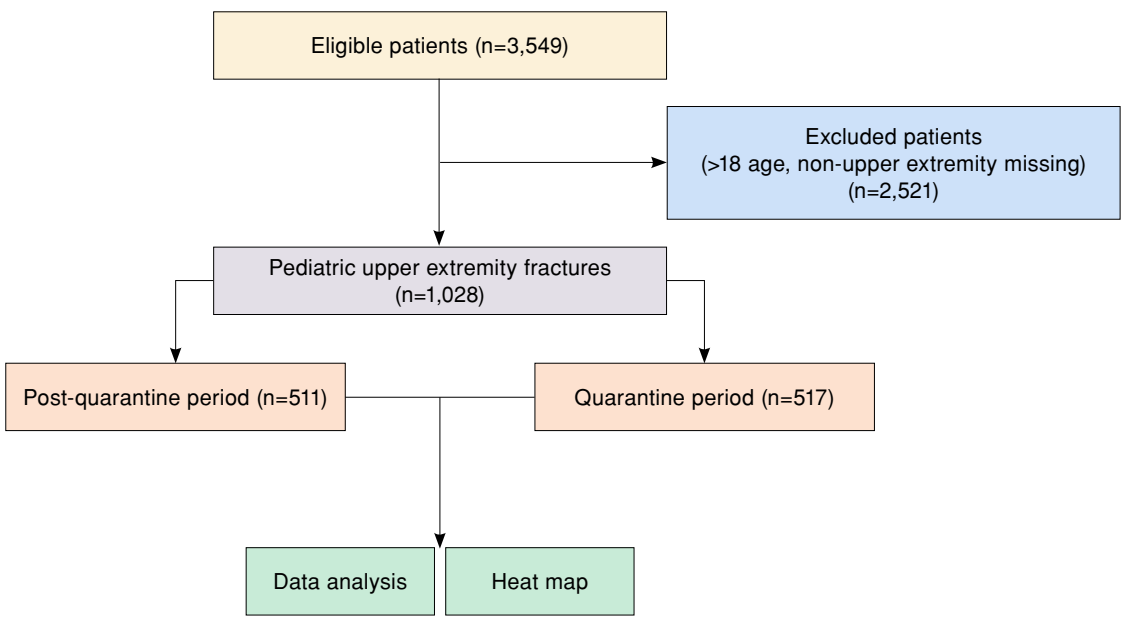


FIGURE 1. Study flowchart.

and the 12-18 age range was significantly higher in Group 2. There were no significant differences in sex (p>0.05) between the groups.

The descriptive characteristics of pediatric upper extremity fracture patients in Groups 1 and 2 are presented in Table II. No statistically significant difference was observed between the groups in terms of the trauma mechanism and fracture type (p>0.5). In addition, there was a higher prevalence of home/low-energy falls and close-type fractures in both groups. When the re-reduction rates compared in the subgroups, the need for re-reduction was frequently observed in distal radius ulna fractures. There was no statistically significant difference regarding complications or reductions between the groups and fracture subgroups (p>0.05).

The most common fracture regions were the distal part of the radius-ulna, supracondylar humerus fracture, and radius-ulna shaft (29.4%, 16.3%, and 11.5%, respectively). Although clavicula, humerus and carpal-metacarpal fractures were higher in Group 2, there was no statistically significant difference between the groups. There were no significant differences in the treatment. However, the patients were treated more with cast-brace in both groups.

DISCUSSION

As in the rest of the world, the restrictions imposed due to the COVID-19 pandemic in Türkiye have brought about important changes in many aspects of life. The narrowing of the living space, the decrease in mobilization, and a more sedentary lifestyle naturally led to a decrease in trauma exposure. After the end of the period of combating the pandemic, a mobilized and active period began with the removal of all social restrictions. All these changes have enabled individuals to be more active and to return to their profession, social, and sports activities.

The main finding of our study was that the frequency of fractures in the 6-11 age group was significantly higher in the quarantine period compared to the post-quarantine period. In the post-quarantine period, the frequency of fractures was more common in the 12-18 age group. Turgut et al.[8] reached a similar conclusion in their study. The incidence of fractures differs between age groups, as schools are closed and children are prevented from going out after the measures and restriction decisions taken during the quarantine period.[13] When the decrease in sports activities and the children's going out was limited, the frequency of trauma decreased and the possible fractures decreased. No significant difference was observed in fracture rates in the preschool age group.[14] It was thought that the fact that children in this age group continued their activities at home was effective. We observed that the frequency of fractures increased in the adolescent age group with the removal of restrictions (post-quarantine period). Therefore, trauma exposure was found to be relatively less in school-age children compare to do adolescents due to prolonged restrictions in sport activities, games, and social activities for those children.

Johnson et al.[5] and Bram et al.[9] did not observe a significant difference in sex distribution during quarantine and before the quarantine period. Similarly, no significant difference was observed in our study regarding sex distribution during and after the quarantine periods. More trauma injuries were observed in boys compared to girls in the post-quarantine and quarantine periods, consistent with the literature.[15] Daily activities, games, and

TABLE I
Demographics of pediatric upper extremity fracture patients in post-quarantine and quarantine periods

	Post-quarantine		Quarantine		Total		
	n	%	n	%	n	%	*p**
Age (year)	54	10.4	57	11.3	111	10.9	0.001**
0-2	187	36.2	187	36.5	374	36.3	
2-5	183	35.4	133	26.0	316	30.7	
6-11	93	18.0	134	26.2	227	22.1	
12-18	351	67.9	331	64.8	682	66.4	
Sex							0.301
Male	351	67.9	331	64.8	682	66.4	
Female	166	32.1	180	35.2	346	33.6	

* Pearson chi-square test; ** p<0,01.

TABLE II
Descriptive characteristics of pediatric upper extremity fracture patients in post-quarantine and quarantine period

	Post-quarantine period		Quarantine period		Total		
	n	%	n	%	n	%	*p*
Mechanism of fracture							1.000*
Home/low-energy fall	515	96.6	510	99.8	1025	99.7	
High-energy fall	1	0.2	0	0.0	1	0.1	
Direct blow	1	0.2	1	0.2	2	0.2	
Fracture type							0.545†
Close	513	99.2	505	98.8	1018	99.0	
Open	4	0.8	6	1.2	10	1.0	
Re-reduction							0.124‡
No	503	97.3	488	95.5	991	96.4	
Yes	14	2.7	23	4.5	37	3.6	
Complication							0.471*
No	508	98.3	506	99.0	1014		
Vascular	6	1.2	2	0.4	8		
Neurological	3	0.6	2	0.4	5		
Tendon	0	0.0	1	0.2	1		
Fracture region							0.312‡
Clavicula	53	10.3	38	7.4	91	8.9	
1/3 medial	3	0.6	1	0.2	4	0.4	
Shaft	48	9.3	34	6.6	81	7.9	
1/3 lateral	2	0.4	3	0.6	5	5	
Humerus	120	23.2	114	22.5	234	22.9	
1/3 proximal	32	6.2	26	5.1	58	5.7	
Shaft	4	0.7	6	1.2	10	1	
Supracondylar	84	16.3	82	16.2	166	16.2	
Radius-ulna	249	48.2	263	51.5	512	49.8	
1/3 proximal	38	7.3	41	8.1	79	7.7	
Shaft	59	11.5	64	12.5	123	11.9	
1/3 distal	152	29.4	158	30.9	310	30.2	
Carpal-metacarpal	39	7.5	30	5.9	69	6.7	
Phalanx	56	10.8	65	12.7	121	11.8	
Treatment							a0.871
Cast-brace	478	92.6	472	92.4	951	92.5	
Surgery	38	7.4	39	7.6	77	7.5	

* Fisher Freeman-Halton test; † Fisher exact test; ‡ Pearson chi-square test.

sports for men and women vary according to age groups. Although there are different opinions about the reasons for this, there is no consensus in the literature. There are differences between sexes in many areas, such as social environment, lifestyle, nutrition style, and participation in sports activities, which can lead to these conditions.[16,17] Although it is thought that boys take risks and increase in activity compared to girls, we do not have data to prove this in our study.

Gornick et al.[18] investigated the mechanism of injury in children in a recent study they published and stated that many of the cases occurred after low-energy traumas. In both periods, home or low-energy falls were observed more frequently in the present study. There is a decrease in high-energy traumas, since all age groups are restricted from going out during the quarantine period. Presentations with fractures in the quarantine period and post-quarantine period were mostly caused

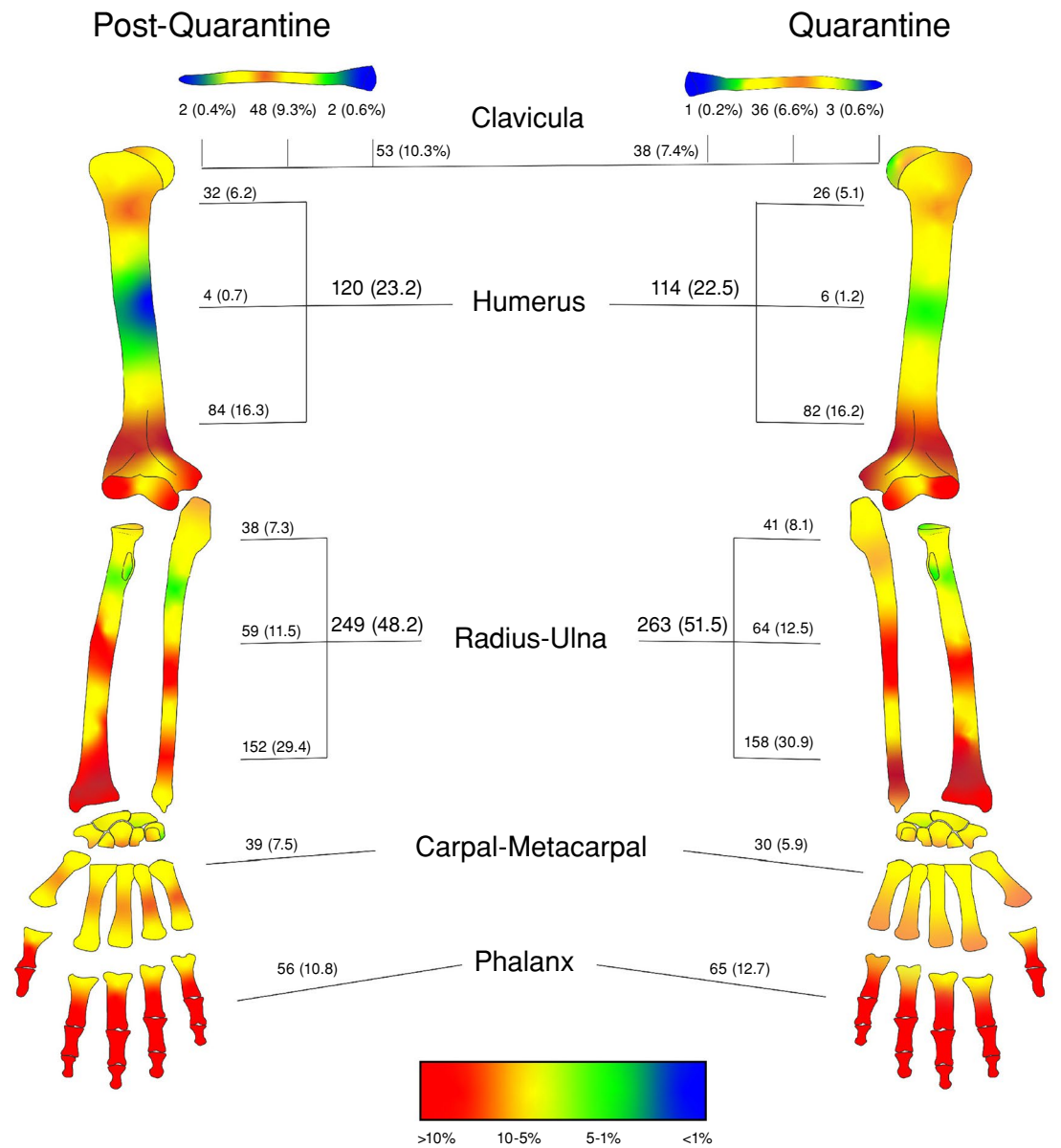


FIGURE 2. Heat map of pediatric upper extremity fractures (post-quarantine and quarantine periods).

by low-energy injuries in our study. This finding suggests that the life habits and protective measures gained during the quarantine period may have protected patients against high-energy trauma.

Although vascular injuries were higher in the post-quarantine period, no statistically significant difference was observed. However, the rate of reduction was observed to increase during the quarantine period.

Similar to many studies in the literature,[8,14,15] the most common fracture localization was radius ulna distal region fractures (30.2%) in our study. It is thought that there is a decrease in the frequency of fractures in adolescence due to the closure of schools, restrictions on going out, and a decrease in contact sports. However, in our study, these were followed by supracondylar humerus fractures (16.3%) and radius shaft fractures (11.5%), respectively. Although there are publications in the literature[19,20] showing that finger and clavicle fractures are the most common localizations after radius ulna distal fractures, there are also publications that give similar results to our study.

While 472 (92.2%) of 512 patients admitted during the quarantine period were followed conservatively, this rate was 92.6% (478/516) in the post-quarantine period. In this respect, no statistically significant difference was found between the two groups. Similarly, Bram et al.,[9] in their study, observed no significant difference in the rate of surgical or conservative follow-up during and before the quarantine. On the other hand, Turgut et al.[8] reported that the surgical/conservative ratio increased during the quarantine period. Therefore, they cited the fact that families were hesitant to apply to the hospital for minor traumas due to the fear of transmission of the COVID-19 infection and the relative increase in cases requiring surgery among admissions. During the quarantine period, the rotation of health teams and their assignments in COVID-19 services increased. In addition, it is thought that the frequency of surgery performed in central hospitals may increase during this period due to the increase in patient referrals from peripheral hospitals to central hospitals. In our study, surgical and conservative rates were found to be statistically similar in the quarantine and post-quarantine periods. We believe that most fractures result from straightforward injuries, which is the reason for the similar surgical and conservative rates.

With the return of life to its normal course after the quarantine, the risk of exposure to trauma has increased. This has led to a significant increase in orthopedic trauma cases. Although the opening of schools, parks, and living spaces, and the re-release of social activities, there has been no significant increase in the diversity of cases in the pediatric age group.

Using an upper extremity model, we calculated the patients' fracture densities in our investigation. As shown in Figure 2, we created a heat map to visually represent the locations of the fracture sites. The heat map has a color gradient ranging from blue to red. We believe that this recently acclaimed strategy, which has garnered attention in the literature,[21-23] would be beneficial for clinicians in both diagnosing and treating patients.

The main strengths of this study are that it includes a simultaneous one-year quarantine and post-quarantine period. In addition, the heat mapping of the fracture locations of the patients who came in both periods still, it has some limitations that should be acknowledged. The study has a single-center and retrospective design. Patient data were scanned retrospectively. Further multi-center, larger-scale, prospective studies may provide more reliable conclusions on this subject.

In conclusion, changing activity areas in pediatric patients also affect fracture rates and regions. Additionally, it is of utmost importance to consider the age and developmental stage of pediatric patients while implementing safety measures. Younger children may require more supervision and protective measures, whereas older children may benefit from education on safe play and proper use of equipment. By addressing these factors, we can further decrease the likelihood of fractures in pediatric patients.

Ethics Committee Approval: The study protocol was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (date: 20.12.2021, no: 2021-24-08). 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 the parents and/or legal guardians of the patients.

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

Author Contributions: Idea, study design, figures: M.Ç.; Data collection, materials: M.K., İ.E.S.; Control/supervision: V.Ö.; Analysis and/or interpretation: M.Ç., E.B.; Literature review, critical review: M.Ç., A.B., E.B.

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