

The feature assessment of the bone fractures in 1020 children and review of the literature

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ABSTRACT

OBJECTIVE: This study aims to collect data, which is a risk factor on bone fractures in children.

METHODS: The study group consisted of 1020 children (n=282; 28% girls and n=738; 72% boys, with a mean age of 8.3 years) with a bone fracture. The age, gender, the month and the time of the day the fracture was sustained, mechanism of injury, feature of the fracture, the presence of coexisting injuries, and the method of treatment were recorded.

RESULTS: Boys had approximately three times more fractures than girls. The fractures were found to be more prevalent in upper extremities (76.6%) and on its left side (56.0%), and the most commonly fractured bone was isolated radius (n=304; 32.1%); most frequently distal radius). The most prevalent lower-extremity fractures were to the femur (n=92; 31.7%). It was found that fractures occurred most frequently between the ages 3 and 6 (23.6%), and fractures in boys were most common among 13 to 15-year-old patients (n=216; 23.9%), whereas girls aged 3–6 years suffered the most fractures (n=103; 30.8%). The fractures were more common in spring (n=384; 31.0%) and summer (n=365; 29.5%). The time slot bone fractures occurred the most was from 12:00 pm to 5:00 pm (n=824; 66.6%). The most common reasons for fractures were outdoor falls (n=705; 57.0%), and indoor falls (n=239; 19.3%), respectively. Bone fractures co-occurred with head trauma the most (n=30; 42.3%). Fifty-nine patients (5.8%) had epiphysis fracture. 51 patients (5.0%) had open fractures. Five hundred ninety-two patients (58.0%) were given outpatient treatment.

CONCLUSION: Child bone fractures are most frequently seen in the left upper extremity in 10–15-year-old boys, occurring as a result of outdoor falls in the afternoon in the spring and summer months. Bones located in the wrist, hand, and elbow have been found to be much more vulnerable to fractures. Many of the fractures were treated by conservative methods. Creating a safe environment for children is the most effective method of injury control. Necessary arrangements should be made for the safety of children in the environment and at home. Continuing education and legal regulations play an active role in injury control.

Keywords: Children; bone fracture; risk.

Cite this article as: Aygun U. The feature assessment of the bone fractures in 1020 children and review of the literature. *North Clin Istanbul* 2020;7(5):460–466.

Deaths due to trauma are among the top reasons for child health problems. In addition to deaths, a great many injuries occur, and most of these injuries require medical care. Severe injuries may result in disability, which shortens their healthy life period. The best way to prevent injuries is to carry out field research to determine

the risks related to trauma, to develop educational methods that would eliminate the harm that arises from the environment and family, and to help implement a safer environment plan [1].

The musculoskeletal system of children has anatomical, physiological, and biomechanical variations among

Received: November 14, 2018 *Accepted:* April 10, 2020 *Online:* August 12, 2020

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different age groups, and is different from that of adults [2–6]. Due to the properties of bone structure in children, skeletal injuries have complications that are different from adults, and thus require different methods of treatment. The prevalence of bone fractures in children varies significantly due to many factors, such as age, season, culture, climate, and the time of the day. Current efforts for child bone fractures are aimed to set up preventive programmes and collecting data to decrease the prevalence of such fractures [2, 6]. The prevalence of bone fractures in children, who are already vulnerable to experiencing trauma due to changing environmental conditions, rapidly advancing technology, and difficulties in social life, has gradually increased over the last three decades [7].

In this study, we assessed the data of our hospital, including age, gender, time and mechanism of injury, the feature of bone fractures (fractured bone, bone zone, side, open fracture, epiphyseal fracture, multiple fractures), associated injuries and type of the treatment in children diagnosed with bone fractures. In this way, it was aimed to collect information on bone fractures in children in our region and contribute to efforts for the prevention of childhood trauma.

MATERIALS AND METHODS

The design and content of this study were initially approved by the Institutional Ethical Committee (PR-10-02-23-05/23 February 2010). The age, gender, the month and the time of the day the fracture was sustained, mechanism of injury, feature of the fracture, the presence of coexisting injuries, and the method of treatment was recorded on a child bone fracture form by assistant physicians at the department of orthopedics for each of the child patients. The data were compiled by noting down the information immediately as each patient applied to the department and by checking hospital records. Detailed information on the trauma was attained from the patient, relatives of the patient, health workers of 112 (national emergency telephone number and department), and emergency physicians. Criteria for non-admission were set as follows: patients who had been diagnosed with bone fracture and treated at other health centers, visiting our health center for follow-up check purposes were not included in the study group.

The patients' ages were provided on the form in years and months. Age ranges were set as 0–2, 3–6, 7–9, 10–12, and 13–15 for analysis. Four-time slots (6.00 am–

11.00 am, 12.00 pm–5.00 pm, 6.00 pm–11.00 pm, and 12.00 am–5.00 am) for the time the injury was sustained were determined. The mechanisms by which the injuries were sustained were categorized under nine categories as follows: fall indoors/outdoors, in/out vehicle traffic accidents, battery, sprain, crush, minor trauma, and other. The type of fracture was described in detail and was recorded according to the side of the body the fracture was sustained, in which part of the bone the fracture occurred, whether it was an open fracture, and whether it was a fracture particular to children. Accompanying injuries were determined as head, chest, abdomen, nerve-vascular, and other. The method of treatment was recorded accordingly as outpatient/inpatient treatment (e.g., surgery, follow-up, or others [plaster, antibiotic treatment and forensic issues]). All data were computerized and organized together with the biostatistics department of the hospital.

Statistical Analyses

The chi-square test was used to compare the relationship between categorical variables where at least one of the variables was nominal and the gamma statistic was used when both variables were ordinal. To test if a specific category contained more or less than the expected number of observations, standardized residuals were used to make inferences. A *p*-value less than 0.05 was considered significant, and residuals greater than 1.96 or less than -1.96 were considered significant. SPSS (Statistical Package for Social Sciences) version 20.0 was used for all statistical analyses.

RESULTS

The study group consisted of 1020 children aged between two months and 15 years and 11 months who applied to and were diagnosed with a bone fracture in a university faculty of medicine, which serves nearly one million inhabitants in a three-year period (1 January 2008–31 December 2010). Seven patients had dislocated joints in addition to bone fractures. There were 282; 28% girls and 738; 72% boys, with a mean age of 8.3 years.

Bone fractures were more common in upper extremities (*n*=947; 76.6%) when compared to lower extremities (*n*=290; 23.4%). The most frequently fractured bones were found to be isolated radius, humerus and femur, respectively. Upper extremity bone fractures occurred most frequently in isolated radius and humerus, whereas in lower extremities, femur and tibia were the most frequently fractured bones (Table 1, 2). Isolated ra-

TABLE 1. Distribution of the upper extremity fractures

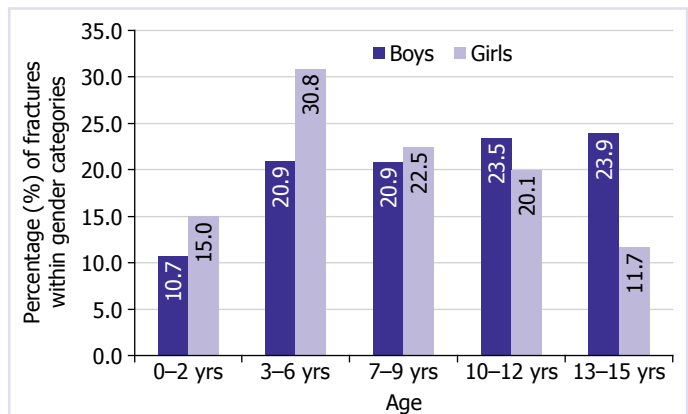
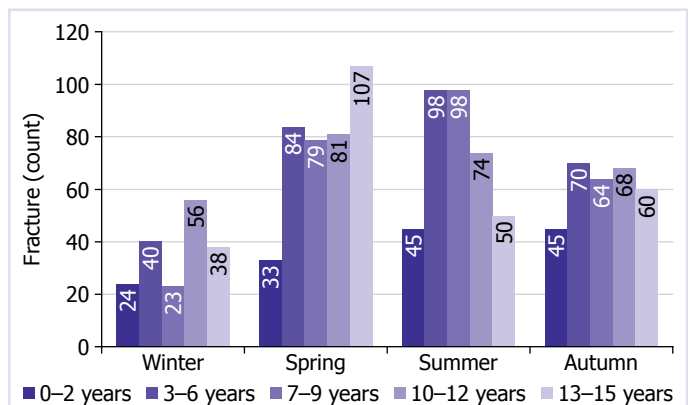
Bone	Total, %
Isolated radius	35.1
Humerus	25.2
Forearm	9.3
Phalanx	7.5
Isolated ulna	7.3
Clavicle	6.8
Metacarpal	5.5
Olecranon	2.7
Carpal	0.4
Scapula	0.2
	100

TABLE 2. Distribution of the lower extremity fractures

Bone	Total, %
Femur	31.7
Tibia	28.9
Metatarsal	12.6
Fibula	10.5
Phalanx	10
Pelvic	4.1
Tarsal	1
Calcaneus	0.6
Patella	0.3
Vertebral	0.3
	100

dius fractures were found to be most common in distal 1/3 zone ($n=275$; 90.5%), and humerus fractures were most common in supracondylar zone ($n=111$; 50.7%). Femur fractures were mostly concentrated around diaphysis ($n=52$; 56.5%), whereas tibia fractures occurred most frequently in distal 1/3 zone ($n=40$; 47.6%). Upper extremity fractures were predominantly sustained on the left side (56.0%), whereas in lower extremities, fractures on the right side were found to be more common (53.1%). One hundred ninety-four patients (19.0%) were diagnosed with multiple bone fractures.

3–6 year-olds sustained the highest number of fractures (23.6%), whereas bone fractures were the least

**FIGURE 1.** The correlation between fractures and gender, age.**FIGURE 2.** The correlation between fractures and injury season, age.

common among 0–2 year-olds (11.9%) (Fig. 1). The prevalence of bone fractures was approximately three times higher in boys than girls. When the figure is examined in detail, it is seen that the prevalence of fractures was significantly higher in 3–6-year-old girls (std. residual 2.8), and in 13–15-year-old boys (std. residual 2.2). The prevalence of fractures was found to decrease after the age of six in girls, whereas it increased significantly in boys after the age of 2. 30.8% of fractures in girls occurred among 3–6-year-old range, but this percentage decreased to 11.7% in girls between the ages of 13 and 15. Only 10.7% of fractures in boys were sustained by 0–2-year-old range, whereas other age groups constituted around 20%. Distribution of fractures according to age groups was significantly different between boys and girls ($p<0.001$).

Bone fractures were found to be most prevalent in spring ($n=384$; 31.0%) and summer ($n=365$; 29.5%), and least prevalent in winter ($n=181$; 14.6%) (Fig. 2).

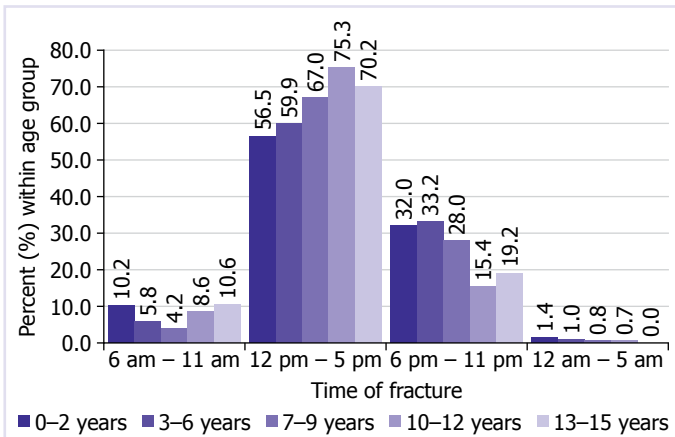


FIGURE 3. The correlation between fractures and injury hour, age.

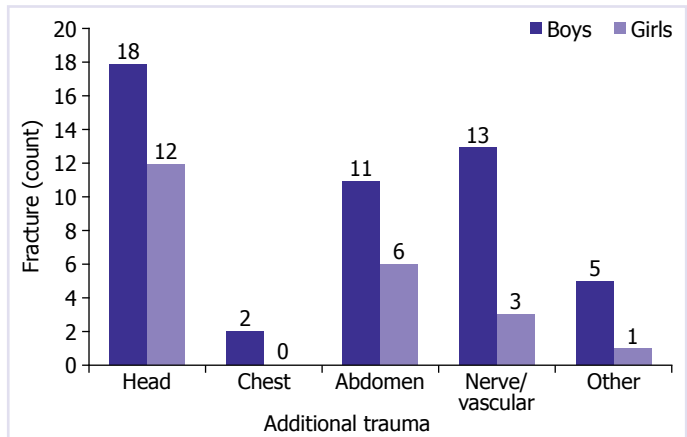


FIGURE 5. The correlation between fractures and associated injury, gender.

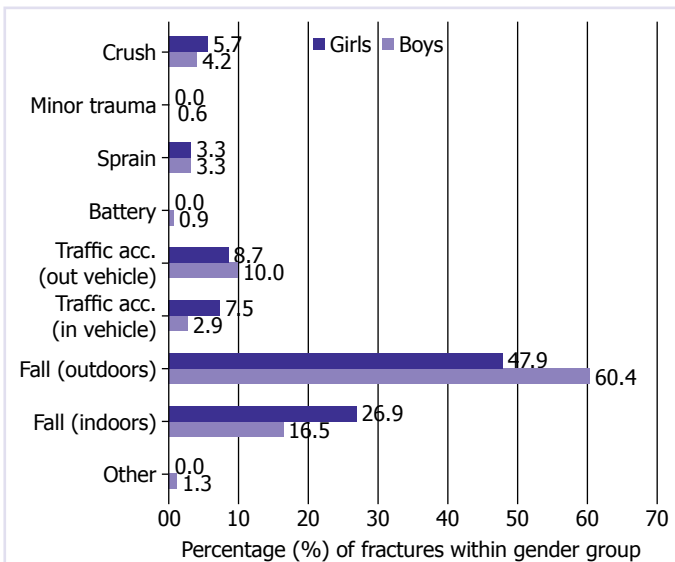


FIGURE 4. The correlation between fractures and injury mechanism, gender.

Fractures were most common in May (12.6%) and August (12.1%). A significant difference among seasons concerning number of fractures was observed ($p < 0.001$). The fractures were most frequently sustained between 12.00 pm and 5.00 pm in all age groups ($n = 824$; 66.6%) (Fig. 3). A statistically significant difference was found between time slots ($\gamma = .204$, $p < 0.001$).

Regarding the mechanism by which the fractures occurred, the most common cause was fall outdoors ($n = 705$; 57.0%), followed by fall indoors ($n = 239$; 19.3%) and out-vehicle traffic accidents ($n = 119$; 9.6%) (Fig. 4). The most prevalent cause of fractures for both genders was outdoor falls. A statistically significant dif-

ference was found between girls and boys regarding falls ($p < 0.001$). The prevalence of outdoor falls was higher in boys, whereas girls sustained more fractures due to fall indoors (std. residual 2.25). In other categories, no significant difference was found between genders. In 71 cases, bone fractures were accompanied by an additional injury, and there was a significant difference in the distribution of additional injury as regards gender ($p < 0.001$) (Fig. 5). Thirty (18 boys and 12 girls) child patients had head trauma in addition to bone fracture. The only significant difference in the category of additional injuries between boys and girls was in nerve-vascular damage (std. residual = 2.12).

Fifty nine patients (5.8%) had single epiphysis fracture, and this kind of fracture was more common in boys ($n = 35$). While the number of epiphysis fractures in upper extremities was 40 (67.8%; most frequently in radius distal and phalanx), there were 19 in lower extremities (32.2%; most frequently in tibia distal). The most frequent type of fracture was Salter Harris (SH) Type 2 (71.2%). A total of 51 patients (5.0%) had open fractures; 31 (60.8%) of these were located in upper extremities, and 20 (39.2%) of these were in lower extremities. Open fractures were more common in upper extremities (60.7%). Open fractures in upper extremities were commonly found to be associated with phalanges ($n = 16$), whereas tibia fractures were the most frequent open fractures in lower extremities ($n = 14$).

While 592 patients (58.0%) were provided with an outpatient treatment, 428 patients (42.0%) required inpatient treatment. 327 (76.4%) of these inmates were provided with surgery, whereas 67 (15.7%) patients

were administered to follow-up, and another 34 patients (7.9%) were hospitalized for other reasons. When we considered all fractures, in upper extremities, the types of fractures most frequently provided with outpatient treatment were radius ($n=275$; 22.2%); most commonly in distal 1/3) and humerus ($n=87$; 7.0%); most commonly in proximal 1/3), whereas fractures that most frequently required surgery were in humerus ($n=120$; 9.7%); most commonly in supracondylar) followed by radius ($n=71$; 5.7%); most frequently distal 1/3). In lower extremities, metatarsus ($n=31$; 2.5%) and phalanx ($n=23$; 1.9%) fractures were ones that were provided with outpatient treatment, whereas fractures that most frequently required surgery were femur ($n=58$; 4.7%); most commonly shaft and distal 1/3), followed by tibia ($n=34$; 2.7%); most commonly distal 1/3).

DISCUSSION

The prevalence of childhood fractures varies considerably due to many factors, such as age, geographical properties, and social and cultural structure [2, 6]. In children, fractures in upper extremities are more common than lower extremity fractures [2–5, 8]. Radius is the most frequently fractured long bone, followed by humerus and tibia. In lower extremities, tibia fractures are more prevalent compared to the femur. The second most frequently fractured region was found to be the hand [3, 5, 9], while some studies detected that it was the elbow (mainly supracondylar fractures) [10–12]. In the present study, bone fractures were observed mainly in the upper extremities. The most frequently fractured bones were found to be isolated radius, humerus, and femur, respectively. Regarding the fracture region, hand fractures ranked third. The parts with most fractures were distal 1/3 in isolated radius fractures and supracondylar in humerus fractures. The results of the present study are consistent with previous findings [3, 8] concerning the zone and the bones with most fractures.

Fractures were found to occur more frequently in upper extremities [3, 10, 11]. Left/right side ratio is 1.3;1. In lower extremities, bone fractures are more prevalent on the right side [3, 4]. In the present study, fractures in upper extremities were more common on the left side, whereas in lower extremities, right was the side where most fractures were sustained. That most fractures were sustained in the left upper extremities may be due to frequent use of upper extremities during trauma. Especially while tripping, and as right upper extremities are more

actively used, the left side takes on a protective role, thus making it more vulnerable to trauma.

In all age groups, the ratio of boys/girls having sustained only one fracture is 2.7:1 [11]. The likelihood of sustaining a fracture peak before puberty in girls and decreases throughout adolescent years, whereas in boys, the number of fractures tends to increase during adolescence [3, 4, 11, 13]. In the present study, it was observed that boys are three times more likely to sustain fractures than girls. 10–15-year-old boys and 3–6-year-old girls had the most fractures. The prevalence of fractures was found to decrease after the age of six in girls, whereas it increased after the age of two in boys. This may be due to age-related differences between genders in playing activities. While girls tend to choose less active games, boys prefer games in which they will have a more active role as they become older.

There were more cases of fracture during summer months, which can be attributed to that the children are on vacation, and carry out more physically demanding activities [10, 11, 14]. Masterson et al. [15] found a strong correlation between monthly daylight hours and the number of fractures sustained. Waltzman et al. [16] have shown that, during summer months, there is an increased tendency to suffer from injuries as people become older. In our study, fractures were most common in May and August. Our findings are consistent with the relevant literature in that fractures were the most common in spring and summer, and least common in winter. Bone fractures are reported to be most prevalent between 2:00 pm and 3:00 pm in the afternoon [2, 8]. The time children are most active during the day and the time when most fractures are sustained seem to be correlated. In the present study, fractures were found to occur most common between 12:00 pm and 5:00 pm, and the least common between 12:00 am and 05:00 am in all age groups.

Most fractures are known to occur due to falls. Studies found that 1% of the children sustained some kind of injury in public playgrounds [17, 18]. A study has reported that 2.8% to 9.2% of children suffers from injuries occurring in schools each year [19]. Only 5–10% of these injuries involve fractures [20, 21]. The prevalence of injuries occurring in schools is mainly due to athleticism and sports activities (53%) [22]. Approximately 29% of the patients injured in vehicle-pedestrian accidents are children. The main causes of children's injuries due to motor vehicle accidents are vehicle-pedestrian accidents (56.4%) and vehicle-bicycle crashes (19.6%) [3, 23, 24].

Head is the first body part in the falling tendency, and children use upper extremities to prevent falling. This explains the higher prevalence of skull and radius fractures in children [25].

In the present study, fall outdoors was the reason for most fractures and the most prevalent cause of fractures for both genders. Fall indoors was more meaningful in girls, whereas boys suffered from fall outdoors more. Regarding other causes of injury, there was no significant difference between genders. The most prevalent additional injury was head trauma in fractures. We believe that the increased risk of fractures outdoors is due to the presence of more risks associated with injuries outdoors, uncontrolled playgrounds, lack of precautions in traffic and an insufficient number of playgrounds away from areas with heavy traffic, lack of bicycle lanes and that children can ride on roads without any safety measures, and that girls spend more time playing indoors, whereas boys spend more time playing outdoors.

In child skeletal injuries, epiphysis injuries are frequent, as well as unique [2]. The total frequency of epiphysis injuries varies from 18% [26] to 27.6% [27]. It is reported that the most frequently injured areas are phalanges, distal radius, and distal tibia, respectively [28]. The fractures have been identified as follows: 71% of fractures occurred in upper extremities, whereas another 21% were sustained in lower extremities. Boys suffer from nearly twice as many epiphysis fractures as girls, and they are most prevalent during the prepubertal period. SH type 2 fractures are reported to be the most common kind of fracture [6, 12, 28, 29]. In the present study, the prevalence of epiphysis fractures was 5.8%, and the number of these fractures was bigger in upper extremities and in boys. The areas where epiphysis fractures were sustained most often were radius distal and phalanges in upper extremities, and tibia distal in lower extremities. SH Type 2 fractures were the most prevalent of all. The lower incidence of epiphysis fractures when compared to similar studies may be related to folk differences.

The most common open fractures in children are that of upper extremities, especially the hand. Most of these injuries are caused by falling [30–32]. The prevalence of open fractures in children varies from 1.5% to 2.6% [11, 14]. Our findings revealed a higher incidence (5.0%) of the open fractures. There were more open fractures in upper extremities. Open fractures in upper extremities were most frequent in phalanges, whereas tibia sustained the most fractures in lower extremities.

Multiple fractures are not common in children, varying between 1.7% and 9.7% [11, 14]. In our study, we found a compound fracture rate of 19%. We believe that the higher incidence of open and compound fractures in our study is because the traumas suffered by children in our region are more severe.

Because of the unique properties of bone structure in children, it is possible to successfully treat fractures in children without surgical procedures [2, 6, 8]. Accordingly, in the present study, the number of children receiving outpatient treatment was greater (58.0%). 76.4% of inpatients were hospitalized for surgery. Considering all fractures, the one that most frequently required surgery was humerus ($n=120$; 9.7%); most commonly in supracondylar in upper extremities, and femur ($n=58$; 4.7%); most frequently in the diaphysis and distal 1/3) in lower extremities like some studies [5, 8]. Based on the results of our study, we can assert that non-surgical treatment procedures for child bone fractures have not been abandoned, and advances in modern technology and the increased awareness of families have increased the applicability of surgery in lower extremity fractures. Furthermore, we believe that some patients, especially children with humerus supracondylar zone fractures, were referred to our hospital for surgery.

In conclusion, child bone fractures are most frequently seen in the left upper extremity in 10–15-year-old boys, occurring as a result of outdoor falls in the afternoon in the spring and summer months. Bones located in the wrist, hand, and elbow have been found to be much more vulnerable to fractures. Many of the fractures were treated by conservative methods. Contrary to previous findings in the literature, epiphysis fractures were found to occur less frequently, there was a higher incidence of the compound and open fractures. Building a safe environment for children is the most effective method of injury control.

Necessary arrangements should be made for the safety of children in the environment and at home. Continuing education, legal regulations play an active role in injury control.

Ethics Committee Approval: The design and content of this study were initially approved by the Institutional Ethical Committee (date: 23 February 2010, date: PR-10-02-23-05).

Conflict of Interest: No conflict of interest was declared by the author.

Financial Disclosure: The author declared that this study has received no financial support.

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