

Operative Pediatric Hand Trauma

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Abstract

This study aims to describe the epidemiology of hand injuries in pediatric patients undergoing surgical treatment. A retrospective analysis of patients with traumatic hand injuries surgically treated over a 7-year period. A total of 155 patients were included. Fracture was the most common injury type (74.8%), most of which were open (54.3%). Incidence of articular fractures increased with age. The predominant mechanism of injury before age 10 was crush. In toddlers, only central digits were affected. Good functional results were achieved (Quick-DASH 1.37 ± 4.90). The incidence of hand injuries requiring surgery increased with age. The mechanism and segment affected varied with age groups. Although good functional results are expected, complications may occur 33% and secondary surgical procedures in 7.7%.

Keywords

pediatric hand, trauma, surgery, complications, Quick-DASH

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Introduction

Hand injuries account for almost 20% of childhood injuries, with a wide spectrum of morbidity.^{1,2} Hand fractures are the second most common fracture in children,³ representing up to 25% of all limb fractures.²

Pediatric hand trauma can be challenging due to the differences in physiology of bone and soft tissue growth, as well as the distinctive characteristics of childhood injuries.

Even though most of hand injuries in children are minor, up to 30% of cases require a surgical procedure.^{2,4,5} Surgery should be considered in open fractures or fractures with substantial angulation or rotation, with extension into the joint that cannot be held in a reduced position only with splinting or casting.

The incidence, injury pattern and type of fracture may differ with the child's development and growth as they become more actively involved in outdoor and sport activities. Knowledge of the epidemiology can help to identify high-risk injuries and implement preventive measures.

This study aims to describe the epidemiology of hand injuries in children and determine their impact in terms of morbidity and function.

Material and Methods

We included in this retrospective study pediatric hand trauma patients, age <18 years old, undergoing surgical treatment in our tertiary Hospital, period 2012 to 2019. We have collected and analyzed demographic information, injury-related data, operative information and functional outcome of patients with pediatric hand injuries (fractures, dislocations, amputations, with or without associated tendon, nerve or arterial injuries), treated by surgery. Demographics included age at the time of injury, gender and hand dominance. Injury-related data included the mechanism of lesion, side and segment of injury, structures involved and definitive diagnosis. Operative information included surgery date, procedure, follow-up time, post-operative complications and the need of secondary surgical procedures.

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Table 1. Mechanism of Injury by Age Group.

	Toddlers	Preschool children	Younger schoolchildren	Senior schoolchildren
Car accident	0	0	0	7
Crush	5	11	21	17
Dog bite	0	0	1	0
Fall	0	1	3	22
Hit by a car	0	0	0	1
Laceration	2	4	11	19
Sport	0	1	2	27
Total	7	17	38	93

Table 2. Incidence of Fracture and Soft Tissue Injuries of the Hand in Children by Age Group.

	Fracture		Tendon injury
	Closed	Open	
Toddlers	0	5	2
Preschoolers	1	10	6
Young Schoolchildren	5	24	9
Senior Schoolchildren	47	24	26
Total	53	63	43

The patients were grouped according to their age: toddlers (<2 years), preschool (2-4 years), younger schoolchildren (5-10 years), and senior schoolchildren (11-17 years).

The hand injuries were classified based on the structures involved as simple (fracture, dislocation or soft tissue injuries in multiple digits that did not require skin grafts or flaps) or complex (≥ 2 of the following structures involved: bone, ligament, tendon, nerve, artery and a soft tissue injury requiring tissue transfer or skin graft).¹ The surgeries performed were classified as follows: amputation, closed reduction with cast immobilization/percutaneous pinning/internal fixation, open reduction with percutaneous pinning/internal fixation/transosseous suture, skin graft, skin suture, tenorrhaphy, neurorrhaphy, and replantation. A functional analysis was performed applying the *Quick-DASH score*⁶ to parents of patients older than 3 years old, over a telephone interview. Statistical analysis was performed with *SPSS® version 26.0* statistic software package. Continuous variables were compared using Mann-Whitney *U*-test and *t*-test, while categorical outcomes were compared using Chi-Square and Fisher Exact Test. Differences were considered statistically significant for $P < .05$.

Results

A total of 155 patients were included in this study, age 11 ± 5 years. We observed a male predominance ($n = 108$).

Dominance of right hand was verified in 138 patients (89.0%) and 79 patients were injured in the non-dominant hand (51.0%). Follow-up time was 6 ± 9 months.

Regarding age, toddlers accounted for 7 cases (4.5%), preschool children for 17 cases (11.0%), younger schoolchildren for 38 cases (24.5%) and senior schoolchildren for 93 cases (60.0%). The gender distribution was very similar among the age groups except for the group aged 11 years old or over, where a male predominance was seen ($P < .001$), with boys accounting for 76 cases (81.7%).

A wide variety of injury mechanisms were noted: crush ($n = 54$), laceration ($n = 36$), sports ($n = 30$), fall ($n = 26$), car accident ($n = 7$), dog bite ($n = 1$), and hit by a car ($n = 1$). The predominant mechanism of injury before 5 years of age was crush (66.6%) (Table 1). In younger schoolchildren, besides these mechanism (corresponding to 55.3%), the incidence of laceration injuries became more frequent (28.9%). In senior schoolchildren the most common mechanisms were sports-related (29.0%) and falls (23.7%).

Most of the injuries were bone fractures ($n = 116$; 74.8%) (Table 2), with higher incidence in boys (66.4%). Ten patients in our series (6.5%) sustained more than one fracture. Most of the fractures were simple ($n = 87$; 75%) and open ($n = 63$; 54.3%). Most of the complex injuries were associated with open fractures (69.2%). The most commonly fractured hand segment was the digit (85.9%), with the little finger being the most

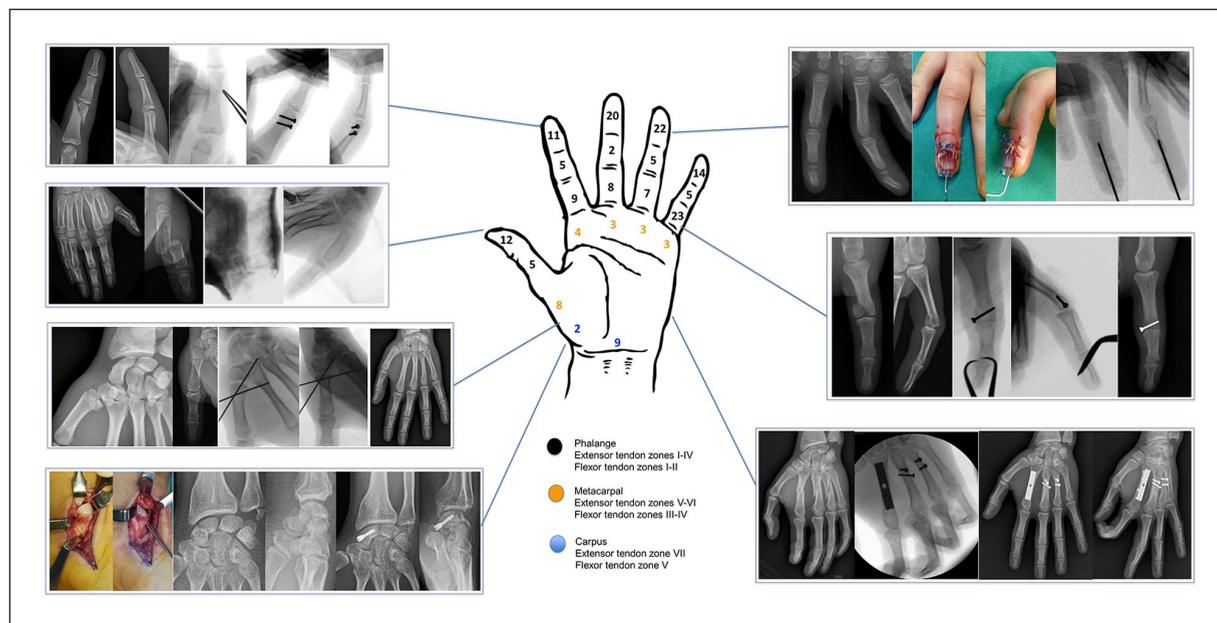


Figure 1. Distribution of injuries by anatomic hand segments and overview of different cases and surgical treatment options, carried out according to the type of injury.

frequently injured (28.4%), followed by the ring and middle finger (23.0% and 20.3%, respectively) (Figure 1). In toddlers only the central digits were affected, having all significant soft tissue damage associated with open fracture and/or tendon rupture. In preschool and younger schoolchildren the digits were affected uniformly and in patients with ≥ 11 years old a predominance of little finger injury was noted. Among the phalanges, the distal phalanx accounted for 53.4% of cases, being the most common bone fractured in all age groups.

Metacarpal fractures (6.9%) were noticed after 8 years of age, 46.2% of which were located in the first ray. The only carpal surgical injuries reported were 2 scaphoid fractures at the age of 17.

In 12.9% of the cases, a physal injury was present, secondary to crush ($n=11$), fall ($n=5$) and sports ($n=4$). The prevalence of articular fractures rises with age, being 16.9% ≤ 10 years of age and 41.7% in senior schoolchildren.

Reviewing injury complexity, 116 cases (74.8%) were identified as simple and 39 (25.2%) as complex, with the last ones occurring more frequently in males (69.2%). Simple injuries resulted from crush (30.2%), sport (23.2%), or fall (21.6%) and the complex injuries resulted more frequently from crush (48.7%) or laceration (38.5%).

Tendons were injured in 43 cases (27.7%), being the second most common structure to be damaged (Table 2),

without differences between age groups. Flexor tendon injury accounted for 60.5% of these injuries. Nerve injuries were identified in 10% of cases, while vascular injuries were present in 4%.

Osteosynthesis was performed in 81 patients (52.2%), of which 8 also underwent tenorrhaphy. Five patients (3.2%) were subjected to closed reduction and cast immobilization, 17 cases (11.0%) to skin suture being necessary skin graft in 5 of these. Tenorrhaphy with/without neurorrhaphy was performed in 35 patients (22.6%). Traumatic finger amputation was present in 17 cases (11.0%) (Table 3), being these predominantly in younger and senior schoolchildren, mainly resulting from crush and laceration injury mechanisms.

Complications were identified in 33% of the cases, with joint stiffness (49%), skin necrosis (16%), malunion fracture (12%), and nail dystrophy (10%) as the more commonly observed. These complications were present in 43.6% of the complex lesions and 25% of the simple injuries ($P=.028$).

A second surgery was needed in 12 cases, 7 simple and 5 complex injuries ($P=.109$). It was secondary to laceration in 50% of the patients, without relevant difference in gender (4 female and 8 male).

A functional evaluation using the *Quick-Dash Score* was performed at time of data revision, with an average Quick-Dash score of 1.37 ± 4.90 which denotes good functional results.

Table 3. Types of Surgery Performed.

Surgery	Number
Skin suture	12
Skin graft	5
Fracture: closed reduction (total)	42
Closed reduction and cast immobilization	5
Closed reduction and percutaneous pinning	35
Closed reduction and internal fixation	2
Fracture: open reduction (total)	36
Open reduction and percutaneous pinning	15
Open reduction and internal fixation	21
Tenorrhaphy (total)	43
<i>Tenorrhaphy solo</i>	26
Reduction and percutaneous pinning + tenorrhaphy	4
Reduction and percutaneous pinning + tenorrhaphy + vasculo/neurorrhaphy	2
Reduction and Internal fixation + tenorrhaphy	1
Reduction and internal fixation + tenorrhaphy + vasculo/neurorrhaphy	1
Tenorrhaphy + neurorrhaphy	9
Amputation	17

Discussion

In our study, the male-female ratio of 2.37:1, as we have observed that hand injuries were more common in males. The predominance of male gender is comparable to other studies,^{2,7,8} although some authors had an equal distribution between genders.^{1,9} We observed a changing pattern in the gender distribution with age: the incidence was similar until the age of 10, but after that age, boys had a higher incidence. This can be explained by older boys being more involved in contact sports.

Although most patients were right-handed, both hands were involved with similar rate, as previously observed by other authors.^{8,9}

As children grow and mature, the injury mechanism and pattern changes. Nearly 66.6% of the hand injuries in toddlers and preschool children were secondary to crush, always presenting soft tissue damage associated with open fracture and/or tendon rupture. This finding is also in line with the literature⁸⁻¹¹ and as referred by Liao and Chong,¹⁰ this can be related with the stage of development, when toddlers start to explore their environment with their hands making them susceptible to fingertip crush injuries. In this regard, toddlers presented a predominance of injury in central digits, which are longer and more susceptible to crush. In contrast, senior schoolchildren suffered more frequently from sport-related indirect injuries (29.0%) as comparable to that of other studies,^{2,9,10} which can be explained by the increased participation in sports and at a higher level in conjunction with heavier weight of the patients.

The number of fractures observed represents a significant value in childhood injuries, rising in number as

age increases. The little finger was the most commonly involved digit (28.4%), as noted by other authors.^{8,9} Phalangeal fractures were more common than metacarpal fractures (85.9% and 6.9%, respectively). However, the incidence of metacarpal fractures was expressively lower than reported in other studies.^{1,2,9} Among the phalanges, the distal phalanx was more vulnerable to fracture for all age groups (53.4%), in contrast to other studies who presented the proximal phalanx as the most commonly fractured bone.^{1,8,9,11}

In the pediatric population, fractures tend to occur through the physis because it is unmineralized and weaker than the surrounding bone and ligament. However, the majority of these can be treated non-surgically due to the remarkable potential of the physis to remodel.¹⁰ This explains the incidence of 12.9% of physeal injuries in our study, as we only included patients who underwent surgical treatment.

Tendons injuries were identified in 27.7% of the cases, a percentage superior to the 4.7% and 9.4% described by Koshy¹ and Voth² respectively. Besides, the flexor tendons were injured in 60.5%, differing from the literature.^{1,12}

Most of the pediatric hand injuries requiring operative intervention were simple injuries (74.8%) related to crush (30.2%). Patients with complex injuries were twice as likely to require a secondary surgical procedure (12.8%; 5 of 39) when compared with the likelihood in cases of a simple injury (6%; 7 of 116) ($P=.109$). The complexity of injuries correlates with the occurrence of complications. We acknowledge that this study has some limitations, related to its retrospective nature and to the fact that it does not present the incidence rate of hand

injuries in our population, since most children with contusion or closed undisplaced fractures are treated in the emergency department and do not require surgical intervention. However, we think that our data improves the understanding regarding the epidemiology and morbidity of traumatic hand injuries in children.

Conclusions

The incidence of hand injuries requiring operative intervention increases with age. The mechanism of injury and anatomic segment affected are variable with age groups, with nearly two-thirds of hand injuries in toddlers and preschool children having important associated soft tissue damage.

Although good functional results can be expected for children sustaining a hand injury, with most lesions being simple injuries and requiring single surgery, the complexity correlates with the incidence of complications, which can be expected in up to 33% of the patients, with need for a secondary surgical procedure in up to 7.7% of the cases.

Author's Contribution

All of the authors actively contribute to the work reported. Rita Lopes, first author, was the one who was involved in the acquisition of the data and wrote the first draft of the article. All of the authors were involved in the study design, analysis and interpretation of the data and substantially and critically reviewed the article.

Declaration of Conflicting Interests

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Submission Declaration

The work described has not been previously published nor is under consideration for publication elsewhere. The publication

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