

The Epidemiology of Operative Pediatric Hand Trauma: A Retrospective Chart Review

HAND
2021, Vol. 16(6) 827–831
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DOI: 10.1177/1558944719893037
hand.sagepub.com

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Abstract

Background: Hand injuries are common in the pediatric population with a wide spectrum of morbidity that can occur. Simple injuries are distinguished from complex injuries by the number of fingers/systems that are involved. The epidemiology of simple and complex operative hand trauma in the pediatric population has not yet been defined. **Methods:** A retrospective review was performed of all pediatric patients requiring operative intervention for hand trauma at a major children's hospital over a 3-year period (2015-2017). Data pertaining to demographics, mechanism, severity, type of surgery, and other factors related to hand trauma were then analyzed and interpreted. **Results:** Three hundred seventy-one pediatric hand injuries over a 3-year period required surgical intervention, with 19.2% being classified as complex. The average patient age was 11.0 years. A total of 68.7% of patients were men. Bony injuries made up 86.3% of simple injuries, with the proximal phalanx being the most commonly fractured bone. Complex injuries occurred more frequently in men and required a greater number of surgeries (1.6 vs 1.0). Of the complex injuries, only major injuries (severity score >100) required a significantly greater number of surgeries. Major hand injuries were mostly caused by motorized vehicles and required a significantly greater number of surgeries (3.8), compared with other causes of injuries. **Conclusions:** Operative hand injuries occur along a spectrum of morbidity in the pediatric population. While most of the injuries are simple and require only 1 procedure, more complex injuries can also occur and deserve a higher level of care and attention.

Keywords: pediatric, hand, trauma, epidemiology

Introduction

Traumatic hand injuries in the pediatric population are very common. An epidemiologic study looking at emergency department (ED) visits in the United States from 1990 to 2009 demonstrated that there were 818688 pediatric hand injuries per year.¹ This was equivalent to 2243 children sustaining a hand injury per day or 1 child every 38 seconds. A separate study found that pediatric hand trauma accounted for 1.7% of ED visits.² Most of these cases are minor injuries which do not require intervention, but the operative burden can vary, especially at tertiary centers where up to 30% of cases can require operative intervention.³

Traumatic hand injuries in the pediatric population are not well studied. Most pediatric focused studies examine the frequency of hand injuries as they present to the ED or look at hand trauma specifically pertaining to fractures.^{2,4-7} Less is published regarding the nature of operative pediatric hand trauma. The purpose of this study was to examine all cases of operative pediatric hand trauma that presented to a major children's hospital. We specifically sought to delineate the

demographic, injury, and operative characteristics related to the cases and correlate them with severity of injury.

Materials and Methods

In this retrospective review, we examined the demographics and management characteristics of operative hand trauma seen at Texas Children's Hospital over a 3-year period. Institutional review board approval was obtained from Texas Children's Hospital/Baylor College of Medicine. All cases of operative hand trauma occurring from January 2015 through October 2017 were queried for *Current Procedural Terminology* codes pertaining to operative hand

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Table 1. Characteristics of Simple and Complex Injury.

Characteristics	All	Simple	Complex	P value
Injuries (n)	371	299	72	
Average age of patient, y	11.0 (SD 4.4)	11.1 (SD 4.2)	10.4 (SD 5.4)	.23
Male vs female	116 (31.3%) female	101 (33.8%) female	15 (20.8%) female	.03
Time between injury and surgery, d	9.1 (SD 5.5)	9.7 (SD 5.3)	6.6 (SD 5.6)	<.001
No. of surgeries	1.1 (SD 0.8)	1.0 (SD 0.1)	1.6 (SD 1.7)	<.001

Table 2. Mechanism and Complexity of Injuries.

Cause of injury	All, No. (%)	Simple, No. (%)	Complex, No. (%)
1 Fall	35 (9.4)	30 (10)	5 (6.9)
2 Laceration	33 (8.9)	14 (4.7)	19 (26.4)
3 Sports/play	171 (46.1)	161 (53.8)	10 (13.9)
4 Punch/fight	44 (11.9)	32 (10.75)	12 (16.75)
5 Door/drawer slam	21 (5.7)	19 (6.4)	2 (2.8)
6 GSW/BB	5 (1.3)	2 (0.7)	3 (4.2)
7 Crush (other)	33 (8.9)	23 (7.7)	10 (13.9)
8 MVC/ATV	9 (2.4)	3 (1.0)	6 (8.3)
9 Finger caught in something	8 (2.2)	6 (2.0)	2 (2.8)
10 Foreign body removal	2 (0.5)	2 (0.7)	0
11 Industrial ^{a,b}	10 (2.7)	7 (2.3)	3 (4.2)

Note. ATV = all-terrain vehicle; MVC = motor vehicle crash; GSW = gunshot wound; BB = B-B air pistols.

^aHand saw, fan, blender, and grinder.

^bIndustrial injuries tended to occur very distally or do not result in significant injuries.

trauma, including fractures, dislocations, tendon, nerve, and arterial injury. Inclusion criteria included patients aged 18 years or younger, who had undergone surgery related to acute hand trauma. Hand trauma was defined as structural injury distal to the radiocarpal joint and transverse wrist crease. Patients were excluded if the inciting hand trauma occurred more than 3 weeks prior to presentation or if there was any type of operative intervention at an outside hospital prior to their presentation.

Charts were reviewed for basic demographic information, injury-related data, and operative information. Demographics included age, sex, date of injury, and date of initial surgery. Injury-related data included the mechanism of injury and whether this leads to a closed versus open injury. Operative information included the structures involved in the injury and the number and type of operations.

Patients were then classified into either simple or complex hand injuries based on the structures involved. Complex injuries were defined as patients who had 2 or more of the following structures involved: bone, ligament, tendon, nerve, artery, and a soft tissue injury requiring tissue transfer or skin graft. Fractures and dislocations were generally considered to be simple injuries, along with soft tissue injuries on multiple digits that did not require skin grafts or flaps. Adjacent tendon injuries in isolation, such as with flexor digitorum profundus/flexor digitorum superficialis repairs, were not considered complex injuries. Amputations

were only considered to be complex if they underwent an attempted replantation. Complex injuries were then characterized based on the degree of injury using the Modified Hand Injury Severity Scale.⁸ Complex cases were then grouped into minor (≤ 20), moderate (21-50), severe (51-100), and major (> 100) categories based on their severity score. Independent sample *t* tests were used to compare nominal/ordinal data, and Pearson χ^2 tests to compare categorical data. Finally, analysis of variance tests were used to compare groups of means.

Results

A total of 371 cases who met all inclusion and exclusion criteria were identified over the study period. After reviewing injury characteristics, 299 (80.6%) cases were identified as simple injuries, and 72 (19.4%) were categorized as complex. Most of the injuries were closed (70.9%), with a higher proportion of complex cases having open injuries (62.5%). Simple injuries were found to have a higher proportion of female patients (34%), longer time between injury and surgical intervention, and a lower number of average surgeries (Table 1). Simple injuries occurred most often as a result of sports or play (53.8%), a punch or fight (10.7%), or fall (10.0%). Complex injuries most frequently resulted from a laceration (26.4%) and punch or fight (16.7%) (Table 2).

Table 3. Bony Injuries.

Location of injury		No. (%)
1	Metacarpal	50 (19.4)
2	Proximal phalanx	133 (51.6)
3	Middle phalanx	42 (16.3)
4	Distal phalanx	25 (9.7)
5	Metacarpophalangeal joint	2 (0.8)
6	Carpus	6 (2.3)

Most of the simple injuries involved bony structures (86.3%). Of these injuries, the most commonly injured bone was the proximal phalanx (51.6%), with the metacarpal and middle phalanx being affected roughly from 15% to 20% of the time (Table 3). Tendons were the second most common structure to be injured, accounting for 4.7% of injuries, with extensor tendons accounting for most of these injuries (69.2%).

Complex injuries occurred along a spectrum, but the majority (91.7%) could be classified as nonmajor injuries. These nonmajor injuries required, on average, 1.27 surgeries, compared with the 4.17 surgeries required for major injuries, and this difference was statistically significant ($P = .001$) (Table 4). Certain injuries, which were categorized as “Other” injuries, were excluded from this analysis as they involved amputations that had undergone failed replantations, and in these cases, the injury severity score was difficult to quantify based on the nature of the injury, and the number of surgeries was not felt to correlate with a return to function. Of the 6 major injuries, half of them were due to motorized vehicles. Motorized vehicles were the cause of 9 complex injuries, and this was the only group to require a significantly greater number of surgeries compared with other causes (Table 5). More than half of the motorized vehicle injuries were due to all-terrain vehicles (ATVs) (55.6%), with the remaining cases being due to jet skiing, lawnmower-related injuries, and automobile accidents. The types of surgical procedures performed are outlined in Table 6.

Discussion

Pediatric hand trauma remains a unique area of hand surgery that deserves special attention. The primary differences in physiology of growing bone and soft tissue, as well as the distinctive characteristics of their injuries, make this population unique. Knowledge of the epidemiology of pediatric hand trauma can help with identifying high-risk injuries, as well as guide implementation of preventive measures.⁹ Despite the need for special attention, the field remains relatively understudied compared with the adult population, especially when concerning complex hand injuries. Previous studies have focused on all pediatric hand

injuries presenting to the ED or hand fracture epidemiology.^{1,9-11} Our study is unique in that it examines the epidemiology of all operative pediatric hand injuries.

In this study, we specifically looked at all operative cases of pediatric hand trauma over a 3-year period at Texas Children’s Hospital. We identified 371 operative cases, with about 20% of these being characterized as complex. Most of the simple cases occurred during sports or play. This finding is supported by another study which also found sports as the most common cause of pediatric hand trauma.² Fortunately, simple injuries required only 1 surgical intervention on average, whereas complex cases required a significantly higher number of operations (1.6 vs 1.0, P value = .001). The etiology of complex injuries tended to be more varied but included lacerations, sports/play, punching/fighting, and crush injuries as the most common causes. Previous studies have demonstrated that boys experience hand trauma more commonly than girls, which is similar to our findings.^{1,2,9} In our study, we found that for all injuries, men accounted for close to 70% of injuries and that number significantly increased to roughly 80% when considering complex hand injuries alone.

Major complex injuries accounted for just 8.3% of complex injuries but were the only grouping of complex injuries that distinguished itself by requiring a greater number of surgical interventions. The most common cause for these major injuries was motorized vehicles, which as a category included ATVs, jet skis, lawn mower–related injuries, and automobile accidents. More than 50% of this group of injuries were caused by ATV accidents, which may be a characteristic that is unique to certain parts of the nation. Between 1982 and 2013, Texas had the highest number of deaths related to ATV accidents, compared with the rest of the nation.¹² The American Academy of Pediatrics has recommended that children younger than 16 years should not ride an ATV of any size¹³; however, these recommendations have only been incorporated into safety bills in a subset of the country. Texas guidelines allow anyone older than 14 years to operate an ATV independently, and children younger than 14 years can ride an ATV as long as they are under the direct supervision of a parent or guardian. In 2015, ATV injuries resulted in at least 58 deaths and 26 700 serious injuries in children younger than 16 years.¹³ In our study, of the patients with 5 ATV injuries, only 1 patient was older than 16 years. The dangers of ATVs are largely related to vehicular weight (adult ATVs can be up to 270kg), high center of gravity, narrow wheelbase, and low-pressure tires. In addition, these vehicles are driven over areas of rugged terrain. Nonetheless, year after year, this continues to be an area of discussion for consumer product safety. Given the findings of this study, it appears that Texas guidelines for operating ATVs are inadequate to quell the mutilating hand injuries that are seen in the pediatric population. A transition toward more strict guidelines, such as those offered by

Table 4. Complex Injury Severity Score vs Frequency and Number of Surgeries.

Severity of injury		Frequency	Percentage	Mean no. of surgeries (SD)
1	Minor (<20)	28	38.89	1.14 (0.36)
2	Moderate (21-50)	23	31.94	1.35 (0.71)
3	Severe (51-100)	12	16.67	1.417 (0.90)
4	Major (>101)	6	8.33	4.167 (5.00)*
5	Other (0)	3	4.17	2.67 (2.08)
6	Total	72	100.00	

Note. A 1-way ANOVA was performed showing a statistically significant difference in the number of surgeries performed for complex major injuries compared with other injuries. Average of nonmajor surgeries excluding other: 1.27. ANOVA = analysis of variance.

*Statistically significant at $P = .001$.

Table 5. Mechanism of Injury vs Mean Number of Surgeries.

Cause of injury		Patients (n)	Mean no. of surgeries (SD)
1	Fall	35	1.0 (0.2)
2	Laceration	33	1.1 (0.2)
3	Sports/play	171	1.0 (0.2)
4	Punch/fight	44	1.1 (0.3)
5	Door/drawer slam	21	1.1 (0.4)
6	GSW/BB	5	1.6 (1.3)
7	Crush (other)	33	1.2 (0.6)
8	MVC/ATV	9	3.8 (4.1)*
9	Finger caught in something	8	1 (0)
10	Foreign body removal	2	1 (0)
11	Industrial ^{a,b}	10	1.2 (0.4)

Note. A 1-way ANOVA post hoc analysis showed that MVC/ATV accidents required significantly more surgeries than other causes of injury.

ANOVA = analysis of variance; ATV = all-terrain vehicle; MVC = motor vehicle crash; GSW = gunshot wound, BB = B-B air pistol.

^aHand saw, fan, blender, and grinder.

^bIndustrial injuries tended to occur very distally or do not result in significant injuries.

*Statistically significant at $P = .05$.

Table 6. Types of Surgery Performed.

Surgery classification		Number performed
1	CRPP	167
2	ORPP	98
3	ORIF	33
4	Tendon repair	41
5	Nerve repair	20
6	Artery repair	4
7	Amputation	6
8	Replantation	3
9	Other ^a	31

CRPP = closed reduction percutaneous pinning; ORPP = open reduction percutaneous pinning; ORIF = open reduction percutaneous pinning.

^aDebridement, foreign body removal, skin graft, and nail bed repair.

the American Academy of Pediatrics, may help to reduce the incidence of these injuries.

This study is unique in its objectives, but its findings parallel results of other studies. Soft tissue lacerations and bony injuries tend to be the most common injuries that

result in presentation to EDs.^{1,2} This does not necessarily reflect which cases require operative intervention. At Texas Children's Hospital, there are many fingertip injuries and lacerations, among others, that are effectively managed with local anesthetic or conscious sedation in the ED. The most commonly injured bone tends to vary with age, as the distal phalangeal and tuft fractures tend to be the most common in younger age groups, whereas the proximal phalanx and metacarpal fractures are more common in older patients.⁵ Tendon injuries account for between 5% and 15% of hand injuries, with extensor tendons being the most commonly injured¹⁴; this is consistent with our data.

The strengths of this study are that this is the first retrospective review that looks at operative pediatric hand trauma as a whole and provides epidemiologic and operative information regarding those cases. Three years of data provide a sufficient cross section of information to characterize the field. Texas Children's Hospital is a tertiary referral center that sees both common hand injuries funneled to it via affiliated pediatricians within the city and complex hand injuries as a result of its trauma hospital designation.

While the numbers and the unique objectives of this study provide a valuable piece of epidemiologic information, there are limitations to address. Although Texas Children's Hospital is the largest free-standing children's hospital in Houston, there is undoubtedly a diffusion of the pediatric hand trauma to other children's hospitals and/or other hand surgeon's practices. This does make it so that our sample does not represent the complete picture of hand trauma in Houston but likely represents a sufficient cross section. The number of operative interventions for each case has some margin of error associated with it. This does not account for patients who were lost to follow-up or patients who had injuries at the end of the study period and may require additional surgeries outside of the study time range.

Future studies should examine national trauma databases for more epidemiologic information regarding pediatric hand trauma. In addition, a specific injury severity score for pediatric hand should be developed to more accurately capture the spectrum and complexities of their injuries. It would be important to identify thresholds for injury complexity that required multiple surgical interventions and establish protocols for managing them. In addition, integration of care with physical and occupational therapy to examine methods for optimized outcomes in this complex population would be beneficial.

Conclusions

Pediatric hand trauma remains an understudied area of hand trauma. Most of the pediatric hand injuries requiring operative intervention are simple injuries that occur while children are playing or participating in sports and generally require only 1 surgery. Complex injuries requiring operative intervention have a different epidemiology, but for the most part, require only 2 surgeries. Major injuries represent the highest level of pediatric hand trauma and generally require a significantly greater number of surgeries.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Statement of Informed Consent

Institutional review board approval was obtained. All patient information has been de-identified, and informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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