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Hand injuries in children and adolescents

Повреде шаке код деце и адолесцената

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SUMMARY

Introduction/Objective The objective of the study was to determinate which groups in the population of children are most prone to hand injuries and to identify the causes of the injuries with the aim of further developing better means of prevention of severe injuries that can lead to invalidity.

Methods A retrospective epidemiological study was carried out, and included all children with hand injuries admitted to our hospital between January 1, 2010 and December 31, 2017; The data were collected and analyzed statistically using SPSS®. Significance was defined as $p < 0.05$.

Results The total number of patients was 254, 202 boys and 52 girls, with a mean age for both genders 10,13 years (range 1–17). The majority of patients were from an urban population 56,7% and 43,3% were from a rural area. Regarding the month in the year when the injury occurred, there were two peaks, in January and in May. The right hand was more affected, 53,2%, than the left, 45,6%, and both hands were affected in 1,8% of cases. Isolated soft tissue injuries (skin, muscles, tendons) were present in 59% of cases, isolated bone injuries (phalangeal and metacarpal bone fractures) in 15,3%, and both soft tissue and bone injuries in 25,7% of cases. The little finger was the most affected, followed by the long finger and thumb, index and ring finger, respectively. The most serious injuries were from explosive wounds caused by firecrackers and handling agricultural tools and engines.

Conclusion Hand injuries in childhood are common and can have devastating consequences. Developing prevention program by raising awareness about this issue is of vital importance.

Keywords: hand injuries; children; adolescents; prevention

САЖЕТАК

Увод/Циљ Циљ овог рада је да детерминише које групе унутар дечје популације су највише склоне повредама шака као и да идентификује узроке повреда у циљу будуће превенције повреда које могу довести до инвалидитета.

Метод Спроведена је ретроспективна епидемиолошка студија на основу медицинске документације све деце лечене у нашој установи од 1. јануара 2010 до 31. децембра 2017; подаци су сакупљени и анализирани статистички коришћењем SPSS® програма. Значајност је дефинисана као p вредност < 0.05 .

Резултати Укупан број пацијената је био 254, од тога 202 дечака и 52 девојчице, просечног узраста за оба пола 10,13 година (распон година 1–17). Већина пацијената је била из урбаног подручја. Већина пацијената је била из урбаног подручја. У односу на месец у години када су се повреде дешавале идентификују се два пика, у јануару и мају. Десна шака је повређивана чешће 53,2% у односу на леву која је била повређена у 45,6%, док су обе шаке биле повређене у 1,8% случајева. Изоловане повреде меких ткива (кожа, мишићи, тетиве) забележени су код 59% повређене деце, изолована коштан траума (преломи фаланги и метакарпалних костију) у 15,3%, док су мекоткивне и коштане повреде заједно чиниле 25,7%. Најчешће је повређиван мали прст, затим средњи прст и палац, а потом домали прст и кажипрст. Најтеже повреде, експлозивне ране, проузроковане су петардама и ватрометима као и руковањем пољопривредним алатима и машинама.

Закључак Повреде шака у дечјем узрасту су честе и могу имати девастирајуће последице. Развој бољег превентивног програма подизањем свести о овом питању је од изузетног значаја.

Кључне речи: повреде шаке; деца; адолесценти; превенција

INTRODUCTION

Active children often injure themselves in everyday activities such as sports or playing with toys and with each other. They suffer lacerations, fractures, or crushing injuries of the hand which can result in nerve, vessel and tendon lesions. [1] Injury is the cause of nearly 950 000 non-fatal hospitalizations among children each year worldwide, and the hand is the second most frequently injured region of the body among children. [2, 3] Almost 75%

of all hand and finger injuries among children admitted to the emergency room are minor injuries; however, 25% are major injuries, most frequently fractures of the hand and the fingers. Furthermore, 15.5% of all the hand injuries had to be surgically treated. [3] The most significant are severe mutilated hand injuries, where an injured child faces physical limitations but also the experience of chronic pain and psychological issues, such as post-traumatic stress disorder. These types of injuries also have an impact on the children's parents, family and their community networks. [2, 4] Therefore, prevention of such injuries, if possible, should become a necessity.

The objective of this epidemiological study was to determinate which groups in the population of children are most prone to hand injuries, and to identify the causes of injuries in the aim of further developing better means of prevention of severe injuries that can lead to invalidity.

METHODS

After institutional review board approval, medical documentation was retrospectively reviewed on all children with hand injuries admitted to our hospital between January 1, 2010 and December 31, 2017. The hospital itself is a tertiary level institution that covers a region of about 2 million people, and the only hospital within this region that treats hand injuries in children. Children with burn injuries and minor injuries treated in our outpatient clinic were excluded from the study. The following data were collected and entered into a Microsoft Excel[®] spreadsheet database: age, gender, place of residence, affected hands and fingers, and type of injury. The data were analyzed statistically using SPSS[®] version 23.0 (SPSS, Chicago, IL, USA), and mean, range, minimum, maximum values, and standard deviation (SD) were calculated. The variables were analyzed by a parametric Student's t test. Significance was defined as $p < 0.05$.

RESULTS

Over an eight-year period, the total number of patients was 254; there were 202 (79.5%) boys and 52 (20.5%) girls, with a mean age for both genders (mean [M]= 10.13 years; SD 5.16) and range of age (range [R], 1–17 years; Min=1; Max=17). The Student's t test showed a statistically significant difference (p value = 0.002) in age between the boys (mean [M]=10.58 years; SD 5.20) and girls (mean [M]= 8.38 years; SD 4,65). Based on a division into different age groups, there were 65 patients in the 1–6 years-old age group, 77 patients in the 6–12-years-old age group, and 112 in adolescents the 12-17 year-old age group with no statistically significant difference between the age groups ($p>0,05$). The distribution of patients by age is presented in Figure 1.

The majority of patients were from an urban population 144 (56,69%) and 110 (43,3%) were from a rural area. Regarding the month in the year when the injury occurred, there were two peaks: in May, 29 injuries, and in January, 27 hand injuries, while the smallest number of injuries occurred in February, 13. (Figure 2)

The right hand was affected in 135 (53,2%) patients, the left in 116 (45,6%) and both hands in 3 (1,2%). The difference was not found to be statistically significant between the affected hand (left or right) between different age groups. Except for the hands, other regions of the body were affected in 7 patients: the face in 3, the abdomen in 2, and the legs in 2 patients.

Isolated soft tissue injuries (skin, muscles, tendons) were present in 150 (59%) patients, isolated bone injuries (phalangeal and metacarpal bone fractures) in 39 (15,3%), and both soft tissue and bone injuries in 65 (25,7%) children with hand injuries. It should be pointed out that no carpal bone fractures were diagnosed. However, metacarpal bone fractures occurred in 30 patients, and in 23 only one metacarpal bone was fractured: the first metacarpal bone was affected in seven patients, the second in two, the third in one, the fourth

in one, and the fifth was the most affected one in 12 patients. Multiple metacarpal fractures occurred in seven patients: fracture of all five metacarpal bones was found in only one child, four fractured metacarpal bones (II-V) were present in three patients, and fractures of both II and III metacarpal bones were found in three children. All metacarpal bone fractures were treated with cast immobilization, and in 19 patients, after closed or open reduction, fixation was performed with 'K' wires. Due to the association of metacarpal bone fractures with extensor injury, tenorrhaphy was required in four patients.

Fingers were injured in 221 (87,07%) patients and the palm in 33 (12,92%). Injury of one finger only was present in 164, two fingers in 39, three fingers in 14, and four fingers in four patients. In this study there were no children with an injury of all five fingers. The most affected finger was the little finger, 42, followed by the long finger and thumb, index and ring finger, respectively (Figure 3).

Sections of extensor and flexor tendons were present in 116 patients. In 31 they were associated with bone fractures, and in seven of those patients traumatic arthrotomy was present as well. Isolated sections of extensors occurred in 35, and in 25 patients an extensor section was associated with fractures. On the other hand, isolated injury of the flexor tendons was present in 50 patients, and bone fractures were associated only in three. In three patients both extensors and flexors were affected, accompanied with bone fractures. Sections of flexor tendons were associated with lesions of the median nerve in five and ulnar nerve in two patients; sections of the ulnar nerve associated with ulnar artery injury were present in two children. Repair was performed in all cases. Injury of the radial artery occurred in one patient with the section of flexor tendons of both hands, and ligation of the radial artery was performed.

Fracture stabilization with 'K' wires was performed in 70, and cast immobilization in 176 patients. Stabilization with 'K' wires was performed in all isolated bone fractures (39),

but also in injuries that include bone fractures, traumatic arthrotomy, and extensor tendon ruptures. Cast immobilization was used in all cases which included bone fractures and both extensor and flexor tendon injuries.

Traumatic partial amputation was present in 39 patients (at the level of distal phalanges 36, middle phalanges one, and proximal phalanges two). Partial amputation of two fingers was present in six, and of three fingers in two patients. Fingertip partial amputations were caused by door slamming in 20 younger children, and in 15 were caused by different tools and machine handling among older children.

Traumatic amputation occurred in 21 patients (at the level of distal phalanges 15, middle phalanges four, and proximal phalanges 2). In five patients, traumatic amputation was present on three fingers (in four patients on the right hand, and in one on the left hand), and in one patient there was a traumatic amputation of the third and fourth fingers at the level of the proximal phalanges. These most serious injuries were caused by explosive wounds and handling of agricultural tools and engines (an ax, saw, circular saw, lawnmower, etc.). An explosive wound injury in a 10-year-old boy, including preoperative findings, X-ray and postoperative appearance, is presented in Figures 4, 5, and 6. In 15 patients, amputations were caused by handling of agricultural tools and machines, in four they were caused by explosive wounds, and in two by door slamming. Boys accounted for almost all of these amputations, except one which occurred in an eight-year-old girl and was caused by door slamming.

DISCUSSION

Bearing in mind that children are the most vulnerable population and that complex and massive hand injuries can result in lifelong disability, we carried out a study of hand injuries.

Our study showed that accidents cause soft tissue injuries of the fingers in most patients with or without bone fractures, resulting in temporary or permanent disability of the fingers. Injury prevention, and explaining mechanisms of injury during schooltime could be very important for the school-age population.

Ljungberg et al. reported a male predominance of 61% in hand injured children, almost the same as Yorlets et al. who reported a rate of 59% of males in their study. [5, 6] In our study the per cent of boys, 79.5%, was much higher than that of girls, 20.25%, with an accompanying significant difference in age (10.51 years for the boys compared to 7.84 years for the girls). Vadivelu et al. published that the incidence of hand injury was low in toddlers (34/100,000), that it more than doubled in preschool children (73/100,000), and steeply increased after the age of 10 (663/100,000). [7] The incidence increased with age in our analysis: it was 25.5% in the 1–6 age group, 30.3% in the 6–12 age group, and 44.2% in the oldest group, 12–17 years old.

Isolated bone injuries accounted for 15.3% of all injuries, and combined with soft tissue injuries such as tendon lesions, the number reached nearly 59%, which correlates with the findings in Vadivelu's study of 65.5%. [7] Fingertip injuries are the most common hand injuries among children with an incidence rate in the literature 37–46%. Distal phalanx fractures in childhood are very common and mostly caused by slamming a child's finger in a door. [5, 6, 8] Door slamming was the cause of fingertip amputation and partial amputations in 57% of cases included in this analysis, while partial amputations and amputations at the level of distal phalanges occurred in 71.15% of the amputation/partial amputation hand injuries. Tendons of both flexors and extensors were injured in 45.6% of all patients. Injury of the flexors was associated with nerve lesions and extensors with traumatic arthrotomies and bone fractures. Extensors were more affected in this study, which correlates with the findings of Kim et al. who also reported a higher incidence of extensor injury. [9] Pediatric

tendon injuries are no less severe than injuries in adults, and an excellent and good outcome could be achieved in 41% and 48% of the patients, respectively. [9, 10]

The majority of injuries were caused by a simple fall or glass cuts; however, the most severe ones were caused by firecrackers and fireworks, or handling of agricultural tools and machines, which correlates with the highest incidence in January around New Year's Eve and in the spring months with the start of the agricultural season. Children's patterns of injury change with age, and priorities for injury prevention alter according to stages of development. [2] Sandvall et al. reported in their study that more rocket injuries were noted among children (44%), homemade firework injuries among teens (34%), and more shell/mortar injuries among adults (86%), while 37% of all hand-injured patients had at least one partial or whole finger/hand amputation. [11] Although selling of any kind of fireworks and explosive items is strictly prohibited, these items are unfortunately sold illegally and 35.30% of finger amputations were caused by firecrackers, fireworks and explosive.

Despite the fact that child labor is against the law in our country, in rural areas it is a practice among low-income families for children to help their parents with agricultural work, which is also the cause of numerous injuries that can lead to invalidity. In our study, 64.70% of finger amputations occurred in older children handling agricultural tools and machines. Youths and young adults who work in the agricultural sector experience high rates of injury, and risk of this type of injury relates directly to the amount and types of farm work exposure. [12] Children can sustain significant injuries with unsafe lawnmower use such as mutilating injuries of the foot, legs, hands, and arms. The 'ride-on' mower injuries were more likely to involve amputations and longer hospitalization when compared to 'walk-behind' mower injuries. Garay et al. have published that at least 69% of accidents might have been prevented if children younger than six had not been near a lawnmower, and those younger than 12 had not been operating one. [13, 14] Stögner et al. have reported that ball sports, cycling, and

equestrian sports were the predominant cause of their recorded hand injuries, mostly fractures [15], while Gesslein et al. report a high incidence of acute hand and wrist injuries in elite taekwondo athletes despite the use of protective hand gear. Interestingly, in this study there were no hand fractures requiring surgical management among child athletes. [16]

Orthopedic hand injuries in children are very demanding, bearing in mind that the growing skeleton poses a different diagnostic and therapeutic challenge than the mature skeleton, as its unossified cartilaginous sections are still more susceptible to injury than bone. Although remodeling can correct for even moderate deformities if sufficient growth potential exists, remodeling cannot return the child to normal anatomy in many cases. [17] Also, 30% of peripheral nerve injuries involve the hand which adds to the complexity of orthopedic management in this type of injury. [18]

Most of the injuries were caused by accidents. Thus, the truth is that some of them could be prevented. With the aim of providing protection against and preventing future injuries, our hospital has formed a team dedicated to working with abused and neglected children. When suspicion of abuse or neglect regarding a child arises, a questionnaire which includes 30 questions about the social-economic conditions of the child's environment and mechanism of injury is used. A social worker is actively involved in all suspicious cases. The role of the social worker is to interview parents, assess the circumstances under which the injury happened, exclude the possibility of alcohol or drug abuse in the family, and give them advice on how to prevent injuries in the future if the injuries were accidental. The social worker has a crucial role in linking a multidisciplinary team consisting of pediatric surgeons, psychologists, and lawyers in cases of non-accidental injuries. Kendrick et al. reported that evidence-based resources for preventing thermal injuries, falls and scalding at home have been developed, and that they could increase injury prevention activity and some parental safety behaviors. [19]

The social media are a dynamic and interactive computer-mediated communication tool with a high impact in high-economy and middle-economy countries, and using social media in the health care context is gaining more and more popularity. [20] Social media websites, such as YouTube, Facebook, Twitter, etc. are popular sources of health information, especially for teens and young adults. [21] This made us take into consideration posting public messages on different social media in the future in order to raise awareness among adolescents and parents about potential risky behavior that can result in hand injuries with lifelong consequences.

CONCLUSION

Hand injuries in childhood are very common and can have devastating long-term consequences. As a result, it is of vital importance to develop better methods of prevention. These methods, which include not only raising awareness about this issue among parents and teenagers through social media and direct interaction with medical staff, but also the active involvement of teams of professionals, including social workers. These steps are of vital importance for the reduction of severe hand injuries in the pediatric population.

Conflict of interest: None declared.

REFERENCES

1. Davis JL, Crick JC. Pediatric Hand Injuries: Types and general treatment considerations. *AORN Journal*. 1988; 48:237-49.
2. Mitchell RJ, Curtis K, Foster K. A 10-year review of child injury hospitalizations, health outcomes and treatment costs in Australia. *Inj Prev*. 2017; 0:1-7.
3. Voth M, Lustenberger T, Frank J, Marzi I. Pediatric finger and hand injuries: An epidemiological study. *Chirurg* 2017 Aug 17. doi: 10.1007/s00104-017-0499-8. [Epub ahead of print]
4. Thirkannad SM. Mutilating Hand Injuries in Children. *Hand Clin* 2016;32:477-89.
5. Ljungberg E, Rosberg HE, Dahlin LB. Hand injuries in young children. *J Hand Surg Br*. 2003; 28:376-80.
6. Yorlets RR, Busa K, Eberlin KR, Raisolsadat MA, Bae DS, Waters PM, Labow BI, Taghinia AH. Fingertip Injuries in Children: Epidemiology, Financial Burden, and Implications for Prevention. *Hand*. 2017;12:342-7.
7. Vadivelu R, Dias JJ, Burke FD, Stanton J. Hand injuries in children: a prospective study. *J Pediatr Orthop* 2006;26:29-35.
8. Yaeger SK, Bhende SM. Pediatric Hand Injuries. *Clinical Pediatric Emergency Medicine* 2016;17:29-37.
9. Kim JS, Sung SJ, Kim YJ, Choi YW. Analysis of Pediatric Tendon Injuries in the Hand in Comparison with Adults. *Archives of Plastic Surgery* 2017;2:144-9.
10. Singer G, Zwetti T, Amann R, Castellani C, Till H, Schmidt B. Long-term outcome of paediatric flexor tendon injuries of the hand. *J Plast Reconstr Aesthet Surg*. 2017;70:908-913.
11. Sandvall BK, Jacobson L, Miller EA, Dodge RE 3rd, Alex Quistberg D, Rowhani-Rahbar A et al. Fireworks type, injury pattern, and permanent impairment following severe fireworks-related injuries. *Am J Emerg Med* 2017 Apr 25. pii: S0735-6757(17)30317-0. doi: 10.1016/j.ajem.2017.04.053. [Epub ahead of print]
12. DeWit Y, Pickett W, Lawson J, Dosman J. Farm Activities and Agricultural Injuries in Youth and Young Adult Workers. *J Agromedicine*. 2015; 20(3):318-26.
13. Garay M, Hennrikus WL, Hess J, Lehman EB, Armstrong DG. Lawnmowers Versus Children: The Devastation Continues. *Clin Orthop Relat Res* 2017;475:950-6.
14. Laing T.A., O'Sullivan J.B, Nugent N, O'Shaughnessy M, O'Sullivan S.T. Paediatric ride-on mower related injuries and plastic surgical management. *Journal of Plastic, Reconstructive & Aesthetic Surgery* 2011 64(5):638-642.
15. Stögner VA, Kaltenborn A, Laser H, Vogt PM. Hand injuries in sports - a retrospective analysis of 364 cases. *BMC Musculoskelet Disord*. 2020;21(1):826. Published 2020 Dec 8. doi:10.1186/s12891-020-03807-z
16. Gesslein M, Rütther J, Millrose M, Bail HJ, Martin R, Schuster P. High Incidence of Hand Injuries From Blocking in Elite Taekwondo Despite the Use of Protective Gear: A 5-Year Descriptive Epidemiology Study. *Orthop J Sports Med*. 2021;9(1):2325967120973996. Published 2021 Jan 25. doi:10.1177/2325967120973996
17. Zlotolow DA, Kozin SH. Hand and Wrist Injuries in the Pediatric Athlete. *Clin Sports Med*. 2020;39:457-479.
18. Andjelkovic S, Lesic A, Vuckovic C, Sudjic V, Bumbasirevic M. Relevant Factors in the Treatment of Digital Nerve Injury of the Hand. *Srp Arh Celok Lek*. 2011;139:780-783
19. Kendrick D, Ablewhite J, Achana F, Benford P, Clacy R, Coffey F et al. Keeping Children Safe: a multicentre programme of research to increase the evidence base for preventing unintentional injuries in the home in the under-fives. Southampton (UK): NIHR Journals Library; 2017 Jul. Programme Grants for Applied Research.
20. Grajales III FJ, Sheps S, Ho K, Novak-Lauscher H, Eysenbach G. Social Media: A Review and Tutorial of Applications in Medicine and Health Care. *J Med Internet Res*. 2014;16(2):e13 URL: <http://www.jmir.org/2014/2/e13/> doi:10.2196/jmir.2912 PMID:24518354
21. Vance K, Howe W, Dellavalle RP. Social internet sites as a source of public health information. *Dermatol Clin* 2009;27:133-6.

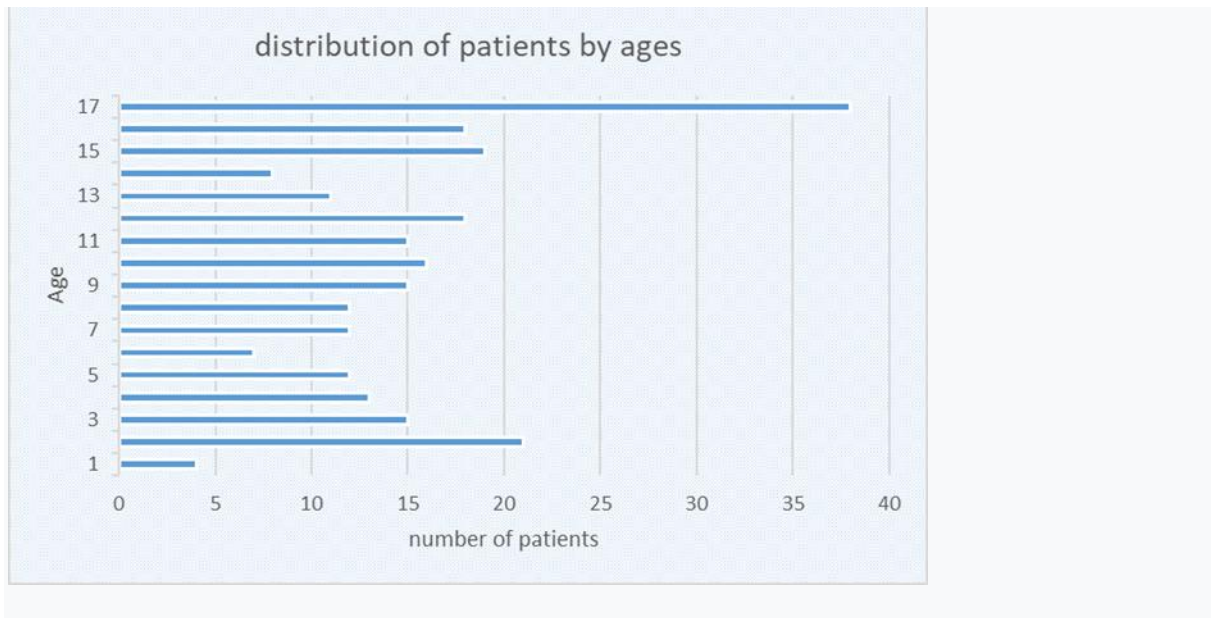


Figure 1. Representing a different incidence of hand injuries in age groups with the highest incidence in 17 years old

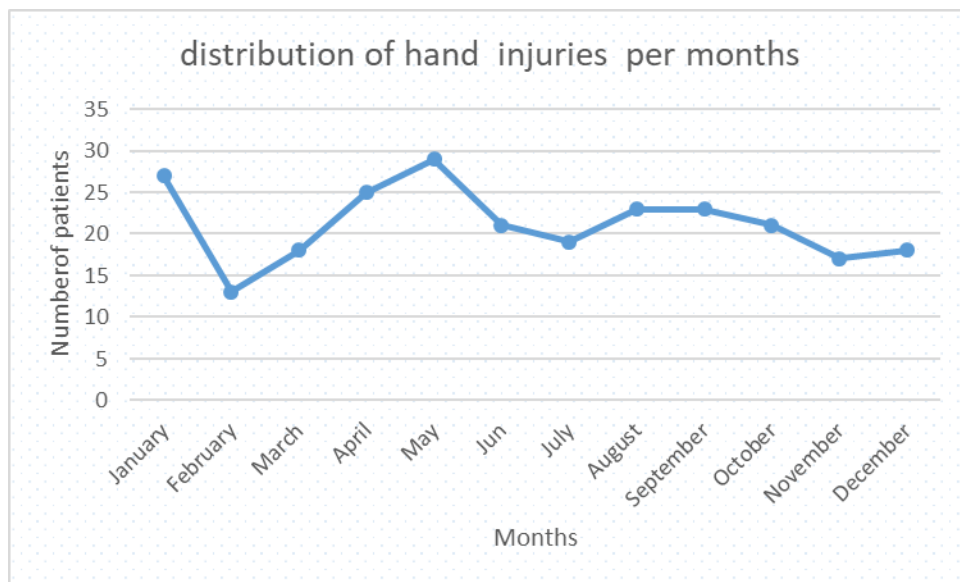


Figure 2. Graph presenting a bimodal distribution of hand injuries per months

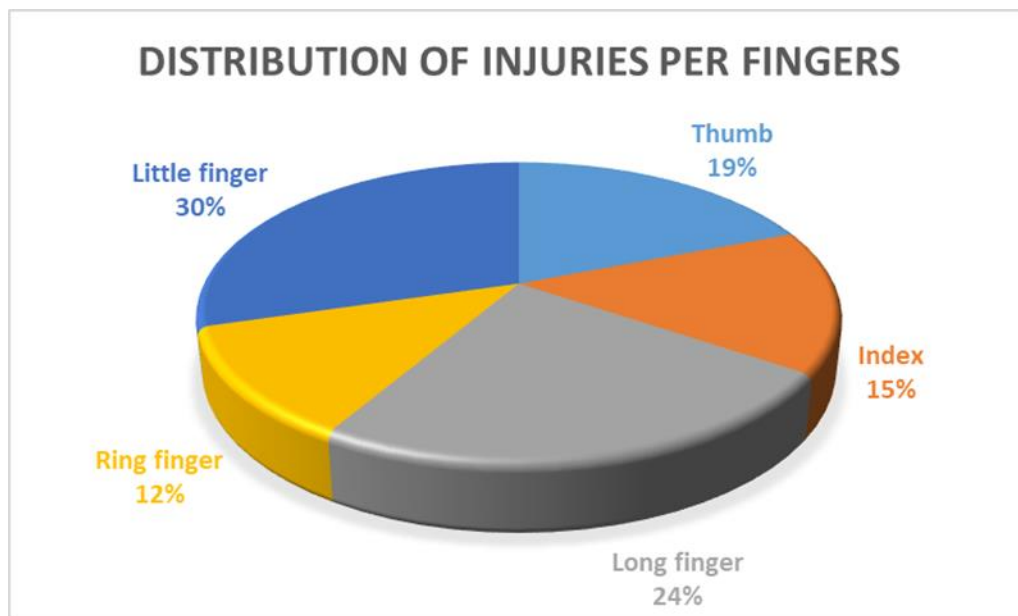


Figure 3. Representing number of injuries per each finger



Figure 4. Initial finding of explosive wound in a 10-year-old boy

Paper
accepted



Figure 5. X-Ray of the injured hand

Paper
accepted



Figure 6. Appearance of the hand after reconstructive surgery was performed

Paper
accepted