

Long bone fractures in children and adolescents treated surgically in West Pomeranian Voivodeship in 2005-2014

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ABSTRACT

Introduction: Methods of surgical treatment of long bone fractures in children is a problem that has been recently addressed with growing attention. The unique specifics of fractures in the developmental age compared with fractures in adult patients requires an appropriate approach. Disregarding the issue may lead to long-lasting complications, including severe skeletal deformities.

Methods: The analysis included 821 children (575 boys, 246 girls) admitted to the hospital with long bone fractures. Data were obtained from medical records from between 2005 and 2014.

Results: Long bone fractures were the cause of hospitalizations in 64.9% of cases during the spring-summer period. The average age was 12 years old. Fractures occurred more often in boys. The main cause of fractures in the test group was indirect trauma during sports activities (32%). Fractures of the distal meta and epiphysis of the radius bone were the most common result of trauma in children and adolescents (12.4 % of all fractures). A total of 32.1% of fractures of the upper limbs concerned the

radius bone and 12% concerned the supracondylar humeral bone fractures. In lower limb fractures, the most common site was the distal part of the tibia bone (8.9% of all fractures). In surgical treatment, 399 (43.3%) K-wires were used. Plate stabilization was performed 225 times (24.5%), screw fixations 119 times (12.9%), FIN/ESIN fixations 141 times (15.3%), tension bands 11 times (1.2%), intramedullary nailing 19 times (2.1%), and external stabilizations 4 times (0.5%). Fracture healing complications were observed in 3 cases in patients with polytrauma.

Conclusions: Risk of a long bone fracture grows with a child's age. Fractures are more frequent in boys. We observed triple the number of fractures that needed surgery yearly from 2005 to 2014. The increase was linear. The choice of surgical treatment method depends on the fracture type, dislocation size, and the patient's age.

Keywords: Epidemiology, children's fractures, long bones, surgical treatment, case report Level of evidence: IV, case series

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INTRODUCTION

Within the epidemiology of children's long bone fractures, it is very vital to understand the mechanisms of the trauma and to select the method of treatment correctly. Currently in the literature there are many articles about trauma epidemiology [1,4, 6,10,12,13,16,20]. Much of the information is similar, but at this time no information can combine sex, age, mechanism of trauma, etc. with methods of treatment. In our study, we excluded conservative treatment and focused on surgical treatments. In our study, CRIF (closed reduction internal fixation) was the predominant method of treatment, and we feel it is the best choice for bones with open physis, as well as for older patients if possible. We only carry out ORIF (open reduction internal fixation) in particular indications when the specifications and pattern of the fractures, and the patient condition requires it, e.g., an urgent trauma situation.

According to the current literature, the following risk factors of long bone fractures in children are mentioned: age, sex, season, risk-taking behaviors, sports, bone mineral density (BMD) [1-4,6,13,16,20]. Obesity or overweight are also sometimes added to the list of fracture risk factors. However, the literature assessing coincidence of higher BMI and fractures is incoherent [1,8,12,21]. In this study, we considered age, sex, the seasonal cause of injury, and risk-taking behavior. We decided to exclude ethnicity and race as the Pomeranian population is ethnically homogenous. Due to a lack of information in our materials regarding patient height and weight, we could not determine the prevalence of fractures in obese children. We also did not include BMD data for the same reason. Regarding age, we grouped children into three categories (a preschool group 2-5 years; school group 6-10 years; adolescents 11-18 years). No children under two years were treated operatively. In our study, particular years were extracted to gauge whether there were any tendencies in growing prevalence of injuries in the last few years.

The aim of this study was to confirm the epidemiology of child fractures, including risk factors that have been widely presented in the professional literature over the last few years. One marked difference that makes our publications stand out and of particular value are the ORIF and CRIF treated inpatients (excluding outpatients) and a more refined and precise analysis of the implants used for each fracture stabilization. All surgical interventions that were performed were carried out to avoid complications in the fracture healing process and lower the danger of infection. Indications that we include for "surgical only" treatment were generally:

1. Open fractures;
2. Neurovascular deficits;

3. Failure of conservative treatment.

It should be noted that each type of fracture has its own indications for internal fixation treatment.

We collected data from the Pediatric Orthopedic and Traumatology Clinic of the Pomeranian Medical University in Szczecin between 2005 and 2014. The analysis was done on the basis of 852 children (571 boys, 271 girls) treated surgically because of long bone fractures. The Pediatric Orthopedic and Traumatology Clinic is the only reference center for pediatric traumatology in the Zachodniopomorskie Voivodeship (West Pomeranian Voivodeship) and also for part of the Lubuskie Voivodeship. The estimated pediatric population under the care of the clinic is around 400,000 children.

MATERIALS AND METHODS

This publication is a retrospective study with data obtained from a database at the Pediatric Orthopedic and Traumatology Clinic of the Pomeranian Medical University Hospital in Szczecin, Poland. The patient charts included in this material consist of a child population from 2 – 18 years old with long bone fractures, who were admitted to our department between January 2005 and December 2014, all of whom were only treated surgically. Procedures were performed by four orthopedic surgeons. Conservative treatment and outpatients were both excluded. We classified children into three age groups.

- 1) Preschool children, 2-5 years old.
- 2) School children, 6-10 years old.
- 3) Adolescents, 11-18 years old.

No child under 2 years old was treated surgically, and the 0-2 year-old group was not included. We also divided the patients according to age, sex, seasonal fracture prevalence, and the mechanism of injury. The mechanisms of injury were classified into 8 groups

- 1) Sport activities
- 2) Home injuries
- 3) Trampoline
- 4) Playground injuries
- 5) Suicide attempts
- 6) Road traffic accidents
- 7) Falls onto outstretched hands while on the street
- 8) Unknown

Furthermore, we made specific classifications of upper and lower limb fractures, and the particular bones that were treated surgically. Every bone was divided into its parts; so for example, we could divide the radius into:

- 1) Proximal radius
- 2) Diaphysis
- 3) Distal radius

The exceptions that were found included the clavicle bone, foot, hand and fibula bones, as proximal fibula fractures are extremely rare and we did not have any relevant data within our materials. We decided to extend the three part classifications mentioned above to specific classifications of the humerus, as it was felt that these are very important fractures in pediatric orthopedic surgery:

- 1) Proximal humerus
- 2) Diaphysis
- 3) Distal humerus
 - Supracondylar fracture
 - Medial epicondyle fracture
 - Lateral condyle fracture

The treatment methods of long bone fractures and the implants that were used to stabilize the fracture were closely monitored. Treatment between ORIF and CRIF and implant were divided into 7 groups:

- 1) K-wires
- 2) FIN/ESIN
- 3) Plates
- 4) Screws (only screws without plates)
- 5) Intramedullary nails (UHN,UTN,UFN)
- 6) External fixation
- 7) Sutures

The difference between particular parts of the fractured bones was combined with every type of implant currently used to stabilize fractures. It was not possible to discern the trends of a particular fracture within our department and to assess if it was similar to any worldwide recommendations that have been fully described, for example in *Tachdjian's Pediatric Orthopaedics* or *Rockwood and Wilkin's Fractures in Children*. Injury frequency was also specified, depending on the season, winter including October to March and summer comprising the remaining months from April to September.

RESULTS

821 children between 2 and 18 years of age were included in our study. They collectively suffered from 920 fractures of the long bones (99 patients had fractures of two long bones concurrently). The average age of the children for surgical treatment was 12 years old, with a total of 521 (63.5%) boys and 246 (36.5 %) girls (Table 1).

Table 1. Sex of children with long bone fractures treated surgically

Boys	Girls	Total
575	246	821
70.0%	30.0%	100.0%

The most eventful season was summer with 533 (64.9%) incidents that required surgical treatment, with only 283 (35.1%) in winter. This situation is probably the result of our geographic

position, as Szczecin is located in the northwest of Poland, about 100 km from the Baltic Sea, with its crowded beaches in the summer time. The rather long distance to the mountains results in a small amount of winter sport injuries. Fractures were found to be more common in adolescents with 554 (67.7%) patients (Table 2), second were school children 212 (25.8%) and third preschool children at 53 (6.5 %).

Table 2. Number of long bone fractures within the studied age groups

Preschool (2-6)	n	53
	%	6.5%
School (6-11)	n	212
	%	25.8
Adolescent (11-18)	n	554
	%	67.7
Total	821	
Median Age	12.2	
Standard Deviation	3.8	

The most common injury mechanism was sport activities with 190 fractures within this group of children (23.14%), with soccer at the top (31.6% of all sport activities), and the second falling onto an outstretched arm at 161(19.6%), trampoline injuries were seen 72 times (8.76%), home injuries 52 (6.33%), road traffic injuries 42(5.11%), we also had 4 suicide attempts - jumps from a height of more than 5 meters (0.48%). Unfortunately, 235 (28.6%) mechanisms are unknown due to missing patient chart information. The most common fracture was of the distal radius with 114 (12.4%) (Table 3) of all fractures treated in the main with K-wire stabilization 102 times, meaning 11% of all implants.

The second most common fracture was of the distal tibia with 82 cases (8.9%), and with the third being the clavicle bone at 80 cases (8.69%). Supracondylar fractures were found to be 4th within our study, with 74 cases (8.04%). The general number of distal humerus fractures was 112 cases. Differences between the second and fourth most common fractures were small, but as mentioned this study did not include conservative treatment. One result of particular interest was the stabilizations of the distal ulna, as well as fibula shaft fractures. This showed that these kinds of fractures needed only stabilization in patients that had fractures of two bones concurrently, so in the first example it was a forearm with a radius fracture and in the second it was a shank with a tibia fracture. We did not have any isolated fractures of the fibula shaft and distal ulna. The most common stabilizations were K-wire implants at 399 (43.36% of all fractures) with 205 stabilizations in children under 12 years old and 194 stabilizations in children over 11 years old (Table 4).

Table 3. Fracture locations

Fracture location	Number	Percent
proximal femur	11	1.20%
femur shaft	66	7.17%
distal femur	13	1.41%
proximal tibia	29	3.15%
tibal shaft	62	6.74%
distal tibia	82	8.91%
distal fibula	32	3.48%
metatarsal bone	9	0.98%
total lower extremity	304	33.04%
clavicle	80	8.70%
proximal humerus	31	3.37%
humeral shaft	36	3.91%
distal humerus lateral condyle	16	1.74%
distal humerus medial epicondyle	22	2.39%
distal humerus supracondylar	74	8.04%
ulnar shaft	46	5.00%
proximal ulna	14	1.52%
distal ulna	29	3.15%
proximal radius	22	2.39%
radial shaft	62	6.74%
distal radius	114	12.39%
metacarpal bone	37	4.02%
finger	33	3.59%
total upper extremity	616	66.96%
total	920	100.00%

Table 4. Types of stabilization compared with age

Type of stabilization	FIN/ESIN	screws	plate	K - wire	tension band	intermedullary nail	total
amount of stabilization in patients up to 11 y. o.	87	14	42	205	1	0	349
amount of stabilization in children of 12 y. o. and older	54	105	183	194	10	19	565
amount of stabilization in children of any age	141	119	225	399	11	19	914
percentage of stabilization in children of any age	15.43%	13.02%	24.62%	43.65%	1.20%	2.08%	100%

The next was plate stabilizations with 225 cases (24.45%), with 42 stabilizations in children under 12 years old and 183 stabilizations in children over 11 years old. The third was FIN/ESIN 141 (15.3%), with 87 stabilizations in children under 12 y. o. and 54 stabilizations in children over 11 y. o. We performed CRIF in 562 (68.45 %) of all surgically-treated children. ORIF was done in 258 cases (31.55% of total) - in situations when it was impossible to achieve proper repositioning in a closed manner, as well as the most popular indications in all open fractures and fractures with neurovascular or pleura damage complications. K-wire was used mostly in distal radius fractures, at 102 times (11% of all fracture stabilizations);

FIN/ESIN occurred primarily in femur diaphysis fractures, at 35 times (3.8 %); plates were mostly used in clavicle fractures, at 66 times (7.17%); “screws only” were used mostly in the distal tibia, at 40 times (4.34 %); a tension band, with proximal ulna, at 7 times (0.76%); intramedullary nails with tibia diaphysis was found 11 times (1.20%); external stabilizations in femur diaphysis was seen 2 times (0.21%); and sutures were used 2 times to stabilize intercondylar eminence (0.21%). In the last few years, we have also observed a growing tendency in injuries that need to be treated surgically. From 36 (4.38%) children in 2005 to 117 (14.25%) in 2013 and 146 (17,7 %) in 2014 (Figure 1).

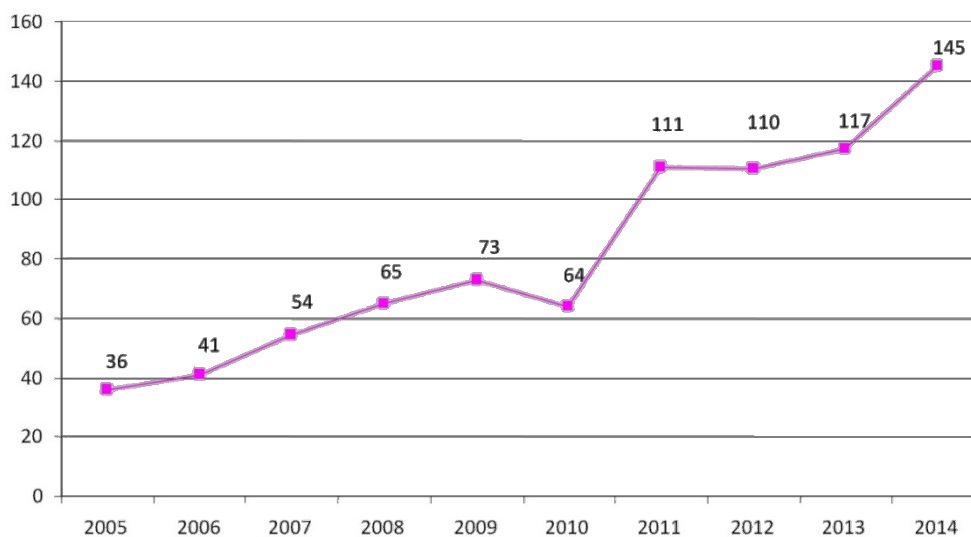


Figure 1. Number of long bone fractures treated surgically

DISCUSSION

This study describes the epidemiology of long bone fractures requiring surgical treatment, performed at the Pediatric Orthopedic Surgery and Traumatology Clinic in Szczecin from January 2005 to December 2014. After the analysis of 920 fractures in 821 children, we observed that boys have a greater risk of suffering from a fracture [1,2,4,10]. The number of fractures increased with the age up to adolescence. The most common fracture location was found to be the distal section of the radial bone. These observations are similar to the recent literature [1,2,6,9]. The second most common fracture was the distal tibia, and the third the clavicle. Frequency varies in comparison with other publications, not including the most common injury which was found to be the first place both in our work and in the literature. We had a large amount of ORIF clavicle fractures. In the literature, there are many publications that discuss operative vs. non-operative treatment [14,15,17]. In our materials, we had four children under 11 years old treated surgically due to clavicle fractures with additional indications, the rest were near adulthood with an average age of 15 with the same indications for open reduction described in the literature: open fracture, neurological or vascular injury, > 2 cm shortening, full displacement, and skin tenting over the fracture location [15,17]. These patients were treated as adults, which we found to be similar to a large number of publications [15,19]. We also avoided any non-unions and tried to allow our patients to return to full activity as quickly as possible. Supracondylar fractures were the fourth most common fracture within our selected population. In our report, distal humeral bone fracture was divided into three types of fracture:

Supracondylar, lateral condyle and medial epicondyle. After noting some fractures, we found that a total of 112 cases made this type of fracture the second most common. We observed a fourfold increase in the number of fractures operated on year by year, from 2005 to 2014. This result probably needs attention. This trend could be associated with the growing obesity among children. However, there is still not enough evidence to support this opinion [1,8,12,21]. A possible cause could be the increasing possibilities for Pomeranian adolescents to enjoy sporting activities due to the improvement and wider availability of sports facilities in our region over the last five years. We observed a peak of fractures in the summer months in the whole considered population. These fractures were caused by the growing availability and popularity of trampoline usage over the last few years due to the improving socio-economic status of the population.

The most popular stabilization was the K-wire implant – this stabilization was the most commonly used without regard to patient age. This is due to the type of fracture (distal radius, distal humerus, and distal tibia). The second most popular type of stabilization was a plate being common among 12 y. o. and older children. The third implant was FIN/ESIN, used in children of all age groups, however with dominance among children under 12 years old. A prevalent type of stabilization and fixation method was CRIF, confirmed in recent trends in pediatric orthopedic surgery, with the aim to perform a minimally invasive procedure and avoid tissue damage as much as possible.

Within the limitations of this study, we would like to indicate that our department is a reference center in the region, but child fractures can also be treated in three pediatric surgery

departments. However, it was impossible to obtain any data from these centers.

CONCLUSIONS

This study demonstrates the epidemiology of pediatric long-bone fractures managed surgically in the West Pomeranian Voivodeship and neighboring region over a 9-year period. This work supports the evidence of a growing number of fractures with the indication for surgical treatment – the growth was linear and some operations due to fractures performed each year tripled through the observation period. The type of internal fixation should be chosen after considering the patient's age, fracture pattern and dislocation.

Conflicts of interest

The authors declare no conflicts of interest.

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