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# Distribution of fractured bones among children: Experience with the Comprehensive Pediatric AO classification in a children's orthopedic hospital in Bogotá-Colombia☆

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A B S T R A C T

*Introduction:* Fractures in children and adolescents are a public health issue. However, reliable epidemiological descriptions of the South American population must be improved. This study aims to present epidemiological data on fractures from a children's orthopedic hospital in one of the five largest cities in Latin America.
*Patients and methods:* Descriptive epidemiological data from 2015 to 2019 were used to characterize children's fractures. Demographic variables, the number of fractured bones, high-energy trauma findings, fracture characteristics, fingertip injuries, and associated complications discriminated by the type of treatment are presented. Long bone fractures were classified according to the AO classification. All children less than 18 years of age were included.
*Results:* In a population of 3,616 children, 4,596 fractures were identified. More boys than girls sustain a fractured bone, with ratios as high as 6:1 around 15 years old. Distal forearm fractures were the most common (31.9%), followed by distal humerus (20.2%). Most of the complications were related to these two sites of fractures. The OR of complications between surgical and conservative management was 2.86.
*Conclusion:* Epidemiological data of fractures from the authors' institution display the usual trending reported in most populations. Gender-related and age-related differences were relevant. Most fractures and complications are related to upper limb low-energy trauma. The most frequent are loss of ROM and loss of reduction.
*Level of evidence:* Level III – retrospective cohort study.

## Introduction

Fractures in children are a public health issue [1]. Following general pediatric surgery, fractures are the second most common cause of inpatient surgery in the pediatric population in the U.S. [2] Incidence rates are variable, numbers as low as 12/1000 in Greece and Norway to high incidences of 36.1/1000 person-year in Wales have been published [3–5]. Trends over time are also variable. While the age-adjusted incidence rate decreased by 9.6% from 1990 to 2019, incident cases increased by 33.4% worldwide, throughout all age groups, as a result of population growth [1].

Demographic characteristics, as well as the affected skeletal site, define the incidence of fractures. Differences related to age and gender are well established: while fractures are more common in boys, girls usually sustain fractures at younger ages [6]. Data from the single emergency department in Malmö-Sweden, from 2005 to 2006, inform an

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**Table 1**
Patient characteristics and the distribution of fractures.

| *Characteristics* | *N* = 3616 |
|---|---|
| Age in years – mean (SD) [range] | 8.9 (4.1) [0 – 18] |
| Female/Male – frequency (%) | 1129 (31.2) / 2487 (68.8) |
| Polytrauma Yes/No – frequency (%) | 62 (1.7) / 3554 (98.3) |
| Fractured bones – mean (SD) [range] | 1.3 (0.5) [1 – 4] |
| *Fractured bone* – frequency (%) | *N* = 4596 |
| 1 Humerus | 1013 (22) |
| 15 Clavicle | 78 (1.7) |
| 2R Radius | 1669 (36.3) |
| 2 U Ulna | 838 (18.2) |
| 3 Femur | 181 (2.9) |
| 34 Patella | 4 (0.1) |
| 4 Tibia | 324 (7) |
| 4F Fibula | 120 (2.6) |
| 5 Spine | 3 (0.1) |
| 6 Pelvis | 8 (0.2) |
| 7.8 Hand phalanx | 224 (4.9) |
| 71 – 76 Carpus | 9 (0.2) |
| 77 Metacarpus | 63 (1.4) |
| 81 – 85 Tarsus | 4 (0.1) |
| 87 Metatarsus | 27 (0.6) |
| 88 Foot phalanx | 32 (0.7) |

The comprehensive pediatric AO classification was used to allocate fractured bones. Number of patients or fractured bone(N) with percentages in parenthesis.

incidence rate of 12.8/1000 and 23.6/1000 person-year for girls and boys, respectively. Parallel rates until the age of 10 are reported for girls and boys, thereafter, rates increase to peak at 12 and 14 years, respectively [7]. While in Sweden distal forearm is the most commonly affected site representing 26% of all fractures, in China distal humerus account for 28% [7,8]. Regardless, upper limb fractures account for 65% of all fractures in children [5]. Lower limb fractures represent 20% of all fractures in children with relevant rates of associated morbidity and mortality [7,9]. The femur and the tibia represent about 80% of the affected sites [10].

In the pediatric population, characterizing fractures beyond the affected bone is confusing due to the different classifications that authors use in publications, along with the scarce implementation of the pediatric AO classification system, which is more popular in the literature that refers to fractures in the adult population. Consequently, comparisons between publications are problematic [11].

Scarce data regarding the epidemiological profile of fractures in Latin American children are available in the medical literature [1]. The most complete data, that may be similar to our population, is the work of Clark et al. that describes the behavior of fractures in Mexican children and adolescents, however, data are presented in accordance to the ICD-10, which lacks a detailed description of fracture patterns [12]. Reliable data from South American population is lacking. This study aims to present epidemiological data on fractures from a single children's orthopedic center that attends kids in a large city in Colombia, South America.

## Methods

Data available in the authors' institution from 2015 to 2019 were used to characterize children's fractures descriptive epidemiology. The subject's data were included given age less than 18 years, one or more fractures of the extremities, institutional images and complete medical records obtained during attention. Pathological fractures, skull, facial bone and rib fractures, periprosthetic or peri-implant fractures, and fractures after osteosynthesis removal were not considered for the analysis. Data from 2020 to 2021 were not included as it corresponds to the social emergency due to COVID-19 in our country, the authors deem this period as non-representative of epidemiological trends.

Demographic variables, number of fractured bones, findings related

**Table 2**
Fractures related to high energy trauma.

| | *N* = 4565 |
|---|---|
| ***Multiple fragments*** – frequency (%) | |
| No | 4446 (97.4) |
| Wedge or segment | 18 (0.4) |
| Comminution | 101 (2.2) |
| ***Open fracture*** – frequency (%) | |
| No | 4415 (96.7) |
| GA I | 109 (2.4) |
| GA II | 26 (0.6) |
| GA III A | 9 (0.2) |
| GA III B | 4 (0.1) |
| GA III C | 2 (0) |

The degree of comminution and associated soft tissue injury were considered markers of high-energy trauma. Number of fractured bone(N) with percentages in parenthesis. Pelvic and spine fractures were not included. GA=Gustilo Anderson.

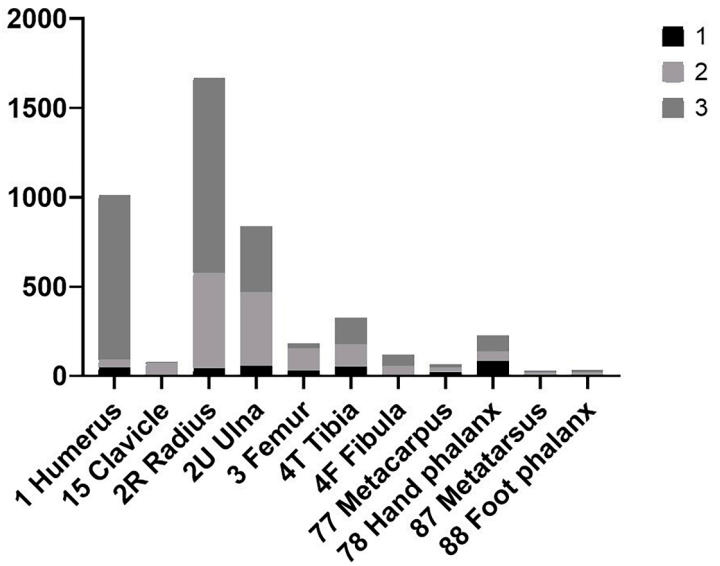


**Fig. 1.** Distribution of fractures by bone and segments.
The comprehensive pediatric AO classification was used to allocate the fractured bone segment. Pelvis and spine were not included.

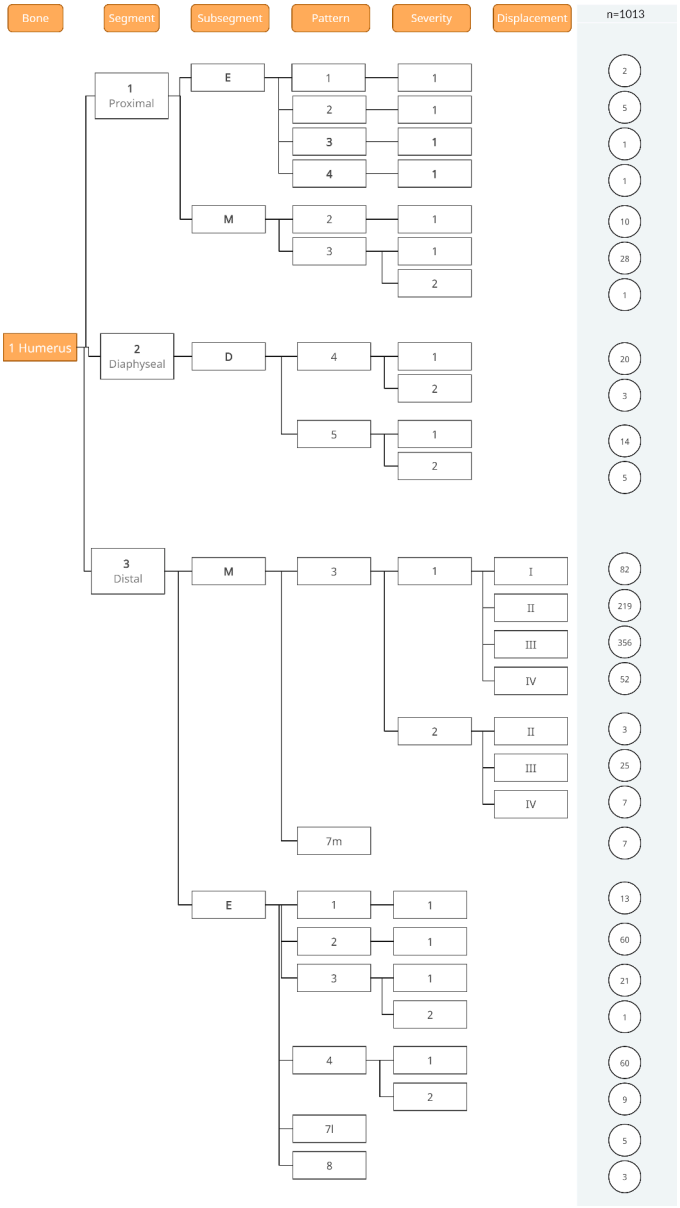


**Fig. 2.** Distribution of humeral fractures according to the AO Pediatric Comprehensive Classification system.

to high energy trauma, namely comminution and open fractures, characteristics of the fracture, and fingertip injuries were collected. Long bone fractures were classified according to the AO classification [13]. REDCap was used for registering while R and R Studio were used for analyzing data. The Institutional Review Board approved the study under the number 2,021,020,906–002. As data were anonymized, consent nor ascent, were required.

## Results

In a population of 3616 children, 4596 fractures were identified throughout the period. Most (4144 – 90.2%) were of long bones. Population characteristics and the distribution of the fractured bone are presented in Table 1. Each bone's absolute fracture frequency, as well as bone segment proportion of fractures are depicted in Fig. 1. Distal forearm fractures peaked differently for girls and boys: at age 10, girls reached the highest prevalence while boys had a high frequency of forearm fractures from 12 to 15. High energy related characteristics are presented in Table 2. Long bone fractures, sorted according to the AO Pediatric Comprehensive Classification system are presented in Figs. 2-5.

Complications are presented in Tables 3 and 4. About three fourths of neurologic complications were ulnar and radial nerves lesions associated with fractures of the distal humerus and radius. The majority of the peripheral nerve lesions were recognized during the initial clinical assessment, thus considered unrelated to surgical treatment. However, 96% of fractures associated with nerve lesions received surgical treatment.

Rigid elbow was a frequent complication after surgical treatment of distal humeral fractures, the 50% of patients with loss of movement. In our population, loss of ROM was less than 10°, except in children who sought attention three weeks past the fracture, those with prolonged immobilization (>6 weeks), and fractures of the humeral condyle that required open reduction. Loss of ROM was also associated with fractures of the distal radius (25%), phalanges of the hand (9%), and tibia (8%).

Vascular complications comprised the radial artery and digital arteries associated with fractures of the radius, metacarpal long bones and hand phalanges. Pressure ulcers due to immobilization were located in

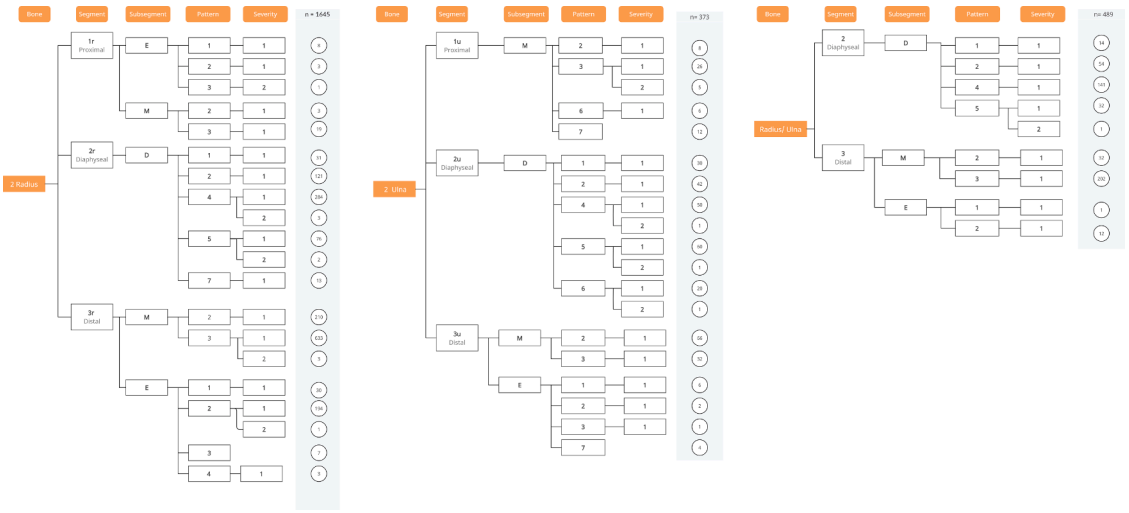

**Fig. 3.** Distribution of forearm fractures according to the AO Pediatric Comprehensive Classification system.
2R and 2 U and the fracture of both bones are included.

the distal humerus (38%), middle and distal radius (25%), and middle and distal tibia (25%). Infections were more frequent in the distal humerus (39%) and middle and distal radius (27%). Half of the reduction losses were related to fractures of the radius, 17% of the tibia, 14% of the humerus, and 13% of the femoral shaft. Loosening of the osteosynthesis implant was more frequent in the distal radius (55%). Although nonunion is rare, it was more frequent in the radius (36%) and the distal humerus (27%). The few instances of chronic pain were related to fractures of the distal tibia and foot phalanges. A single compartment syndrome was related to a GA II open and infected distal radius fracture, treated with percutaneous fixation, in a child who sustained a 3 m fall.

The most frequent hand/foot injury was the phalanx fracture (68.6%). An associated soft tissue injury occurred in 69 subjects (28.5%) and just 7 children (2.9%) had a total or partial amputation of the finger.

## Discussion

This research aims to present the distribution of fractures in children in an orthopedic center in a large Latin American city. The population of Bogota is about 7.9 million people, of which a quarter are under 19 years of age [14]. Unfortunately, accurate epidemiological data is challenging since medical attention is independent of the distribution of the population in city districts. Further, as Colombia's only institution focused on children's orthopedics, some patients receiving attention in our institution proceed from different regions. Nevertheless, gender and age-related data, the distribution of the affected bone and other characteristics related to the fractures, from 2015 to 2019, are presented.

Gender-related differences are a common trend in the distribution of fractures in the population: more boys than girls receive attention for a fractured bone. Customarily, global epidemiologic data of fractures is depicted in terms of gender due to different risk factors between males and females [1]. Overall, a 2:1 proportion, among all ages, was found in our data. Data from two Latin American countries report the same gender-related difference [12,15]. An Italian survey and a Sweden single hospital retrospective data, reports the same boy-to-girl proportion; the former relates this difference to behaviors and lifestyle factors [16,17]. Despite the merely descriptive nature of this study, without any attempts to establish relationships to risk factors, the authors believe that there is not any reason to support different determinants of fractures among Latin American children.

An age-related trend is also evident in our population: a steady increase in the occurrence of fractures, that peaks around 10 to 15 years for both genders, is apparent in our data. Once more, gender differences are noted. For girls, fractures tend to be stable between 7 and 12 with a peak at 10, while for boys, high rates are reported from 12 to 15, which suddenly drops to about a third at age 17. The boy-to-girl proportion at ages 14 and 15, which corresponds to the highest incidence of fractures in boys, is close to 6:1. Clark et al. divide their data into 0 to 9 and 10 to 19 years as behaviors differ between these two groups [12].

Distal fractures of the forearm, followed by distal humeral fractures are our population's most common sites. This finding corresponds with most epidemiological data reported elsewhere [18]. In our series, the radius is the bone that sustains most fractures. For girls, it peaks at ten and for boys at 12 and 13 years, as in Clark et al. publication [12]. Therefore, a relative weakness of distal radius during the last growing period is hypothesized.

In our population, fractures of the tibia are more common than fractures of the phalanxes of the hand. Age distribution is similar to distal fractures of the radius and the fracture frequency is proportional in the proximal and medial thirds of the bone. Contrarily, femur fractures have a bimodal presentation: in toddlers a gender difference is not identified while in adolescents, a male preference is evident. Authors suspect non-accidental trauma for the former with non-differential distribution between genders [19]. The latter is usually related to lifestyle activities [17].

Fingers fractures came in fourth place, of which the most frequent are closed phalanx fractures, followed by fingertips lesions. Most were closed factures (68.6%) and a minimal percentage required amputation (2.9%). Unlike others, the incidence in our population is relatively low for toddlers and preschoolers who usually sustain crushed injuries of the fingertips [17].

Most fractures are generally related to low-energy trauma as illustrated by the high prevalence of simple traces and absence of comminution (>97%). Even more, merely 1.7% of the fractures were related to polytrauma, and from our numbers on open fractures, most (77%) were GA I. Being a trauma referral hospital, the distribution of fractures is biased. Many of the attended children are referred from primary care for surgical stabilization. Transverse and oblique traces along the diaphysis of long bones, complete metaphyseal fractures and type 2 Salter Harris fractures are more prevalent in our population than, for instance, greenstick fractures which are very common among children.

Despite bone remodeling capability, coupled with a global trend toward conservative management of fractures in children, surgical treatment was somewhat more frequent than conservative in our population (54 *vs.* 46%) [20]. Authors justify this behavior in two singularities of the population: complexity of the fractures and the proportion of teenagers with limited remaining growth and tolerance to residual deformity.

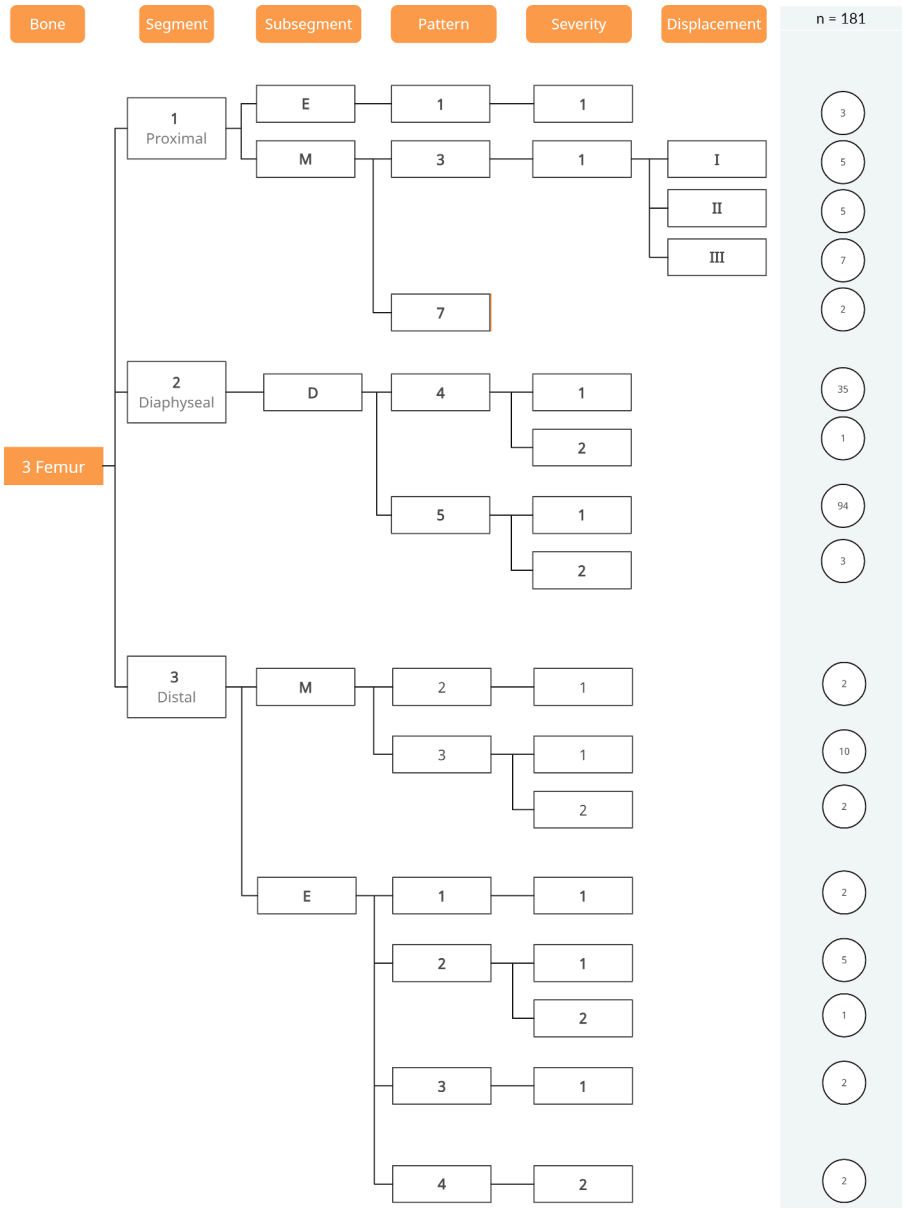


**Fig. 4.** Distribution of femoral fractures according to the AO Pediatric Comprehensive Classification system.

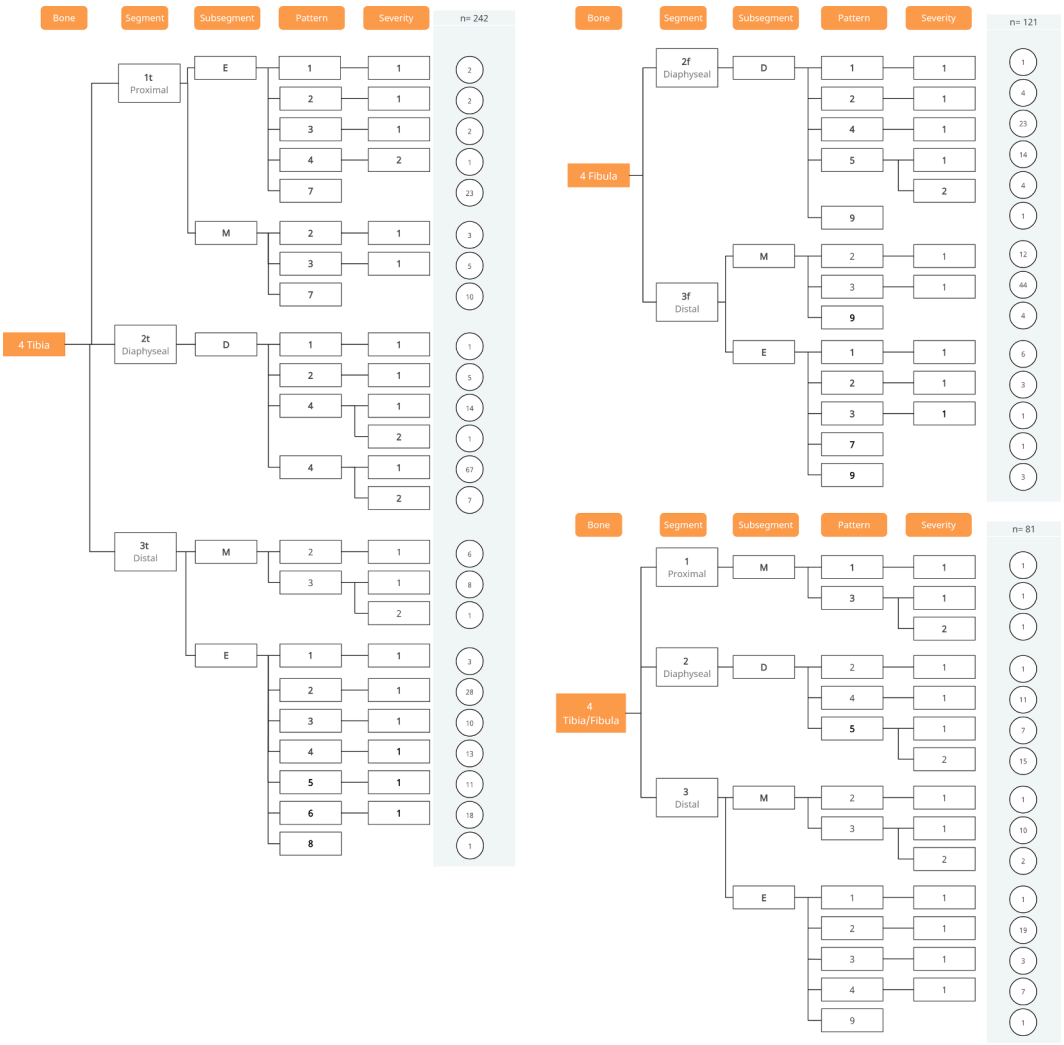


**Fig. 5.** Distribution of leg fractures according to the AO Pediatric Comprehensive Classification system. 4T and 4F and the fracture of both bones are included.

**Table 3**
Reported complications.

| *Complications* – frequency (%) | $N = 3616$ |
|---|---|
| No | 3132 (86.6) |
| Neurologic | 50 (1.4) |
| Vascular | 7 (0.2) |
| Pressure ulcers | 16 (0.4) |
| Infection | 33 (0.9) |
| Loss of reduction | 78 (2.2) |
| Loss of ROM | 230 (6.4) |
| Non-union | 11 (0.3) |
| Chronic pain | 2 (0) |
| Compartment syndrome | 1 (0) |
| Other | 56 (1.5) |

Other complications include refracture, depression, falls, joint instability, osteoarthritis, avascular necrosis, and longitudinal discrepancy.
Number of patients (N) with percentages in parenthesis.

Similar to other publications, vascular lesions were very infrequent. Most (86%) were related to upper extremity fractures, a higher rate than the reported by Kirkilas et al. [21]. However, vascular lesions were not related to supracondylar fractures despite publications that report a frequency of 12 to 20% of associated vascular lesions in these fractures [22].

Functional ROM of the elbow in children ranges from 30 to 130°. Similarly, functional pronation-supination includes 50° each [23]. In our population, loss of ROM was evident comparatively, without hampering functionality in most children. Loss of ROM is expected in 8% of children with a supracondylar humerus fracture treated with closed reduction and percutaneous fixation; similarly, when the humeral condyle is affected, loss of elbow's flexion and extension may be anticipated [24]. Concerning loss of reduction in distal radius fractures treated conservatively, the remodeling capability of the distal physis should be noted: angulations up to 15° may be remodeled even in adolescents [25]. On view of these, the most frequent complications, namely neurologic, loss of ROM, and loss of reduction, typically resolve spontaneously without hindering functionality.

Limitations must be mentioned. Our population is not representative of the Colombian population. As a specialized institution, inveterate, displaced and complex fractures, with peripheral nerve lesions, are overrepresented. Also, loss to follow up is common; this may overestimate loss of ROM, which may resolve over time. Finally, functional assessment was not systematically used to establish the effect of the fracture on functional ability.

## Conclusions

Fractures in the pediatric population are a frequent pathology. The

**Table 4**
Distribution of complications according to location and type of treatment.

| Fracture location $N = 4596$ | Orthopedic treatment $N = 2119$ (46.1) | Complications $N = 105$ (5) | Surgical treatment $N = 2477$ (53.9) | Complications $N = 352$ (14) |
|---|---|---|---|---|
| 11 | 27(56) | 2 | 21(44) | 3 |
| 12 | 20 (48) | 2 | 22 (52) | 3 |
| 13 | 179 (19) | 17 | 744 (81) | 162 |
| 151 | 1(100) | 0 | 0(0) | 0 |
| 152 | 56 (78) | 0 | 16 (22) | 2 |
| 153 | 2 (40) | 0 | 3 (60) | 0 |
| 2R1 | 22 (51) | 0 | 21 (49) | 9 |
| 2R2 | 309 (58) | 13 | 226 (42) | 22 |
| 2R3 | 525 (48) | 34 | 566 (52) | 57 |
| 2U1 | 30 (54) | 0 | 26 (46) | 3 |
| 2U2 | 241 (58) | 2 | 172 (42) | 6 |
| 2U3 | 260 (70) | 1 | 109 (30) | 1 |
| 31 | 5 (18) | 0 | 23 (82) | 1 |
| 32 | 86 (68) | 12 | 40 (32) | 5 |
| 33 | 14 (52) | 2 | 13 (48) | 1 |
| 34 | 2 (50) | 1 | 2 (50) | 1 |
| 4T1 | 19 (38) | 3 | 31 (62) | 8 |
| 4T2 | 91 (72) | 4 | 35 (28) | 11 |
| 4T3 | 38 (26) | 5 | 110 (74) | 11 |
| 4F1 | 7 (100) | 0 | 0 (0) | 0 |
| 4F2 | 27 (59) | 0 | 19 (41) | 0 |
| 4F3 | 30 (45) | 1 | 37 (55) | 1 |
| 5 | 3 (100) | 0 | 0 (0) | 0 |
| 6 | 6 (75) | 1 | 2 (25) | 1 |
| 71–76 | 8 (89) | 0 | 1 (11) | 0 |
| 771 | 4 (21) | 0 | 15 (79) | 2 |
| 772 | 10 (36) | 0 | 18 (64) | 6 |
| 773 | 7 (44) | 0 | 5 (56) | 0 |
| 781 | 35 (42) | 1 | 48 (58) | 9 |
| 782 | 16 (31) | 2 | 35 (69) | 5 |
| 783 | 15 (17) | 0 | 75 (83) | 13 |
| 81–85 | 2 (50) | 0 | 2 (50) | 2 |
| 871 | 4 (80) | 0 | 1 (20) | 0 |
| 872 | 5 (38) | 0 | 8 (62) | 0 |
| 873 | 4 (44) | 0 | 5 (56) | 0 |
| 881 | 1 (17) | 0 | 5 (83) | 0 |
| 882 | 2 (13) | 0 | 13 (87) | 2 |
| 883 | 7 (64) | 2 | 4(36) | 0 |

Number of fractures (N) with percentages in parenthesis. Complications percentages are based on total fractures treated orthopedically or surgically respectively.

location of the fracture and the risk of presenting it is related to the age and sex of the child. Low-energy fractures of the distal segments in the upper extremities, are definitively more common. Also, given its prevalence, complications are related to distal fractures. The most frequent are the loss of ROM of the elbow in surgically treated distal humerus fractures, and loss of reduction in the distal radius treated conservatively.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

## References


[1] GBD 2019 Fracture Collaborators. Global, regional, and national burden of bone fractures in 204 countries and territories, 1990-2019: a systematic analysis from the Global Burden of Disease Study 2019. Lancet Healthy Longev 2021;2(9):e580–92.

[2] Abdullah F, Gabre-Kidan A, Zhang Y, Sharpe L, Chang DC. Report of 2,087,915 surgical admissions in U.S. children: inpatient mortality rates by procedure and specialty. World J Surg 2009;33(12):2714–21.

[3] Kopjar B, Wickizer T. Fractures among children: incidence and impact on daily activities. Inj Prev 1998;4(3):194–7.

[4] Moustaki M, Lariou M, Petridou E. Cross country variation of fractures in the childhood population. Is the origin biological or "accidental"? Inj Prev J Int Soc Child Adolesc Inj Prev 2001;7(1):77.

[5] Lyons RA, Delahunty AM, Kraus D, Heaven M, McCabe M, Allen H, et al. Children's fractures: a population based study. Inj Prev J Int Soc Child Adolesc Inj Prev 1999;5(2):129–32.

[6] Clark EM. The epidemiology of fractures in otherwise healthy children. Curr Osteoporos Rep 2014;12(3):272–8.

[7] Lempesis V, Rosengren BE, Nilsson JÅ, Landin L, Tiderius CJ, Karlsson MK. Time trends in pediatric fracture incidence in Sweden during the period 1950-2006. Acta Orthop 2017;88(4):440–5.

[8] Qiu X, Deng H, Su Q, Zeng S, Han S, Li S, et al. Epidemiology and management of 10,486 pediatric fractures in Shenzhen: experience and lessons to be learnt. BMC Pediatr 2022;22(1):161.

[9] Joeris A, Lutz N, Blumenthal A, Slongo T, Audigé L. The AO pediatric comprehensive classification of long bone fractures (PCCF). Acta Orthop 2017;88(2):123–8.

[10] Liu H, Wang H, Shao B, Lu H, Zhang S, Ou L, et al. Epidemiological evaluation of traumatic lower limb fractures in children: variation with age, gender, time, and etiology. Medicine (Baltimore) 2019;98(38):e17123.

[11] Handoll HH, Elliott J, Iheozor-Ejiofor Z, Hunter J, Karantana A. Interventions for treating wrist fractures in children. Cochrane Database Syst Rev 2018;12:CD012470.

[12] Clark P, Montiel-Ojeda D, Rascón-Pacheco RA, Guagnelli MA, Lopez-Gonzalez D, Bremer A, et al. Fracture incidence in children and adolescents 0-19 years old in Mexico: a 12-year cross-sectional analysis. Arch Osteoporos 2022;17(1):127.

[13] Slongo TF, Audigé L. AO Pediatric Classification Group. Fracture and dislocation classification compendium for children: the AO pediatric comprehensive classification of long bone fractures (PCCF). J Orthop Trauma 2007;21(10 Suppl):S135–60.

[14] Home [Internet]. [cited 2023 Feb 23]. Available from: https://www.dane.gov.co/index.php/en/.

[15] Ortiz-Fullana JL, Valentín P, Ramírez N. Epidemiology of pediatric bone fractures across age groups: analysis of a pediatric population at an outpatient clinic in the Southwest region of Puerto Rico. Boletin Asoc Medica P R 2016 [Internet] [cited 2023 Feb 21]; Available from: https://www.semanticscholar.org/paper/Epidemiology-of-pediatric-bone-fractures-across-age-Ortiz-Fullana-Valent%C3%ADn/d132947ae3982402d25c27f932b7d3e5bc12feb7.

[16] Valerio G, Gallè F, Mancusi C, Di Onofrio V, Colapietro M, Guida P, et al. Pattern of fractures across pediatric age groups: analysis of individual and lifestyle factors. BMC Public Health 2010;10:656.

[17] Hedström EM, Svensson O, Bergström U, Michno P. Epidemiology of fractures in children and adolescents. Acta Orthop 2010;81(1):148–53.

[18] Mamoowala N, Johnson NA, Dias JJ. Trends in paediatric distal radius fractures: an eight-year review from a large UK trauma unit. Ann R Coll Surg Engl 2019;101(4):297–303.

[19] Ranade SC, Allen AK, Deutsch SA. The Role of the Orthopaedic Surgeon in the Identification and Management of Nonaccidental Trauma. J Am Acad Orthop Surg 2020;28(2):53–65.

[20] Ömeroğlu H. Basic principles of fracture treatment in children. Eklem Hast Ve Cerrahisi Jt Dis Relat Surg. 2018;29(1):52–7.

[21] Kirkilas M, Notrica DM, Langlais CS, Muenzer JT, Zoldos J, Graziano K. Outcomes of arterial vascular extremity trauma in pediatric patients. J Pediatr Surg 2016;51(11):1885–90.

[22] Kropelnicki A, Ali AM, Popat R, Sarraf KM. Paediatric supracondylar humerus fractures. Br J Hosp Med Lond Engl 2005;80(6):312–6. 2019 Jun 2.

[23] Valone LC, Waites C, Tartarilla AB, Whited A, Sugimoto D, Bae DS, et al. Functional Elbow Range of Motion in Children and Adolescents. J Pediatr Orthop 2020;40(6):304–9.

[24] Shaerf DA, Vanhegan IS, Dattani R. Diagnosis, management and complications of distal humerus lateral condyle fractures in children. Shoulder Elb 2018;10(2):114–20.

[25] Greig D, Silva M. Management of Distal Radius Fractures in Adolescent Patients. J Pediatr Orthop 2021;41(Suppl 1):S1–5.