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ORIGINAL RESEARCH

Postoperative complications of open lower limb fractures in pediatric patients. A single-center observational study.

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Abstract

Introduction: Open lower limb fractures in children are serious injuries that require immediate surgical treatment to prevent further complications. This study aimed to determine the main postoperative complications of open lower limb fractures in pediatric patients in the Traumatology Department of a regional pediatric referral hospital.

Methodology: This retrospective observational study was conducted at Francisco de Icaza Bustamante Hospital in Guayaquil from January 2018 to December 2022. Patients aged 1 to 12 with open fractures of the lower limb who underwent surgical treatment were included. The variables examined included age, sex, fracture type and location, degree of bone exposure, presence and timing of complications, types of complications, types of surgical treatment, and factors leading to complications. The sample was probabilistic, and descriptive statistics along with odds ratios were utilized.

Results: There were 220 open fracture cases (29.3% [95% CI 26.1–32.6%]). At the population level, this represents 1.45% of fractures in children (95% CI 1.30–1.60%). There were 165 (75%) fractures with postoperative complications and 55 without complications (25%). The average age was 6.6 ± 1.62 years. The most prevalent fracture was diaphyseal fracture of the tibia and fibula, with 96 cases (43.6%). Right tibial fractures are also common, accounting for 24.1% of cases, followed by right femur fractures, accounting for 10.9% of cases.

Conclusions: Different types of complications were identified, with infections, wound healing complications, and fracture malposition being the most common.

Keywords:

Open fractures, lower limbs, children, consolidation, edema, infection, secondary osteoarthritis, nonunion, femur, tibia, fibula.

Abbreviations

CEM: intramedullary nail.
Fx: fracture.

Additional information

No supplementary materials are declared.

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Authors' contributions

Maria Georgina Pazmiño Beltran: Conceptualization, research, writing—original draft, resources, software, supervision.

Gema Priscilla Proaño Jarro: Conceptualization, research, writing—original draft, resources, software, supervision.

Inés Jacqueline Arboleda Enriquez: Methodology, Data curation, Formal analysis, Funding acquisition, Project management, Validation, Visualization, Writing – review and editing.
All the authors read and approved the final version of the manuscript.

Financing

The authors funded the costs of this research.

Availability of data and materials

The datasets used and analyzed during the present study are available from the corresponding author upon reasonable request.

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Introduction

Open fractures of the lower limbs in children are serious injuries that require immediate surgical treatment to prevent further complications. These fractures can result from various factors, such as sports injuries, traffic accidents, or falls [1].

Open fractures of the lower extremity are classified as medical emergencies and necessitate immediate medical attention, as the broken bone may be exposed to the environment and bacteria, increasing the risk of infection and other complications [2].

After surgery, pediatric patients with open lower limb fractures are at risk of developing several postoperative complications, which may include infection, delayed bone healing, deformities, chronic pain, gait disorders, and nonunion. [3]. In addition, other complications, such as vascular injuries, nerve injuries, bone necrosis, thromboembolism, and compartment syndrome, can occur [4].

This research is essential because it contributes to the understanding of the postoperative complications of open lower limb fractures in pediatric patients. Such injuries can seriously affect a patient's health, so understanding the main complications that may arise after surgery is essential for early and effective care [5].

Open fractures of the lower extremities in pediatric patients are considered emergencies because of their increased risk of complications, necessitating timely and effective treatment, including an appropriate antibiotic regimen and surgical plan. These fractures can lead to complications linked to trauma and treatment, such as infections, joint stiffness, malunion, delayed union, pseudoarthrosis, and secondary osteoarthritis. Extended hospital stays are a consequence of these postoperative complications, which can result in increased costs and sequelae that may later contribute to the development of a more advanced chronic condition associated with significant clinical complications that, in some instances, can culminate in patient death. Given this issue, it is crucial to categorize these injuries, as prompt action is necessary from when the patient arrives in the emergency room. This differentiation requires considering the mechanism of injury, the state of the soft tissues, the degree of contamination, the characteristics of the fracture, and its respective surgical treatment plan. This study aimed to determine the main postoperative complications of open lower extremity fractures in pediatric patients in the Traumatology Department of a regional pediatric referral hospital. The study hypothesis is that postoperative complications are related to the bone exposure level at the time.

Materials and methods

Study design

This study is observational. The source is retrospective.

Scenery

The study was conducted at Francisco de Icaza Bustamante Hospital, part of the Ministry of Public Health of Ecuador in Guayaquil, Guayas Province, from January 2018 to December 2022.

Participants

Patients aged 1–12 years with an open lower limb fracture who underwent surgical treatment were included. Patients with previous or concurrent infections in the affected limb, polytrauma patients with other fractures in different areas of the body, and those with preexisting medical conditions that could affect the recovery of the open fracture were excluded.

Variables

The variables included age, sex, type and location of the fracture, degree of bone exposure, presence of complications, timing of the onset of complications, type of complication, type of surgical treatment, and causes.

Data sources/measurements

The source was indirect; an electronic form was completed using institutional medical record data. A screening was conducted for the following ICD-10 root codes for inclusion in the study: S92: Fracture of the foot and toe, except the ankle. S82: Fracture of the lower leg, including the ankle. S72: Fracture of the femur. S82.10: Unspecified fracture of the upper end of the tibia. S52.312D: Greenstick fracture of the radial shaft. S92.155B: Nondisplaced avulsion fracture (chip fracture) of the left talus. S720: Fracture of the neck of the femur. S721: Intertrochanteric fracture. S722: Subtrochanteric fracture.

To stage the degree of exposure, the Gustilo–Anderson classification was used, which includes the following:

I: Open fracture (Fx) with a clean wound < 1 cm long.

II: Open Fx with a laceration > 1 cm long, without extensive soft tissue injury, flaps or avulsions.

III: Open injury with laceration, extensive soft tissue damage or loss, or segmental injury or traumatic amputation. High-velocity firearm injuries, injuries caused by deforming wounds, injuries requiring vascular repair, and injuries lasting more than eight hours were also included.

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IIIa: Adequate periosteal coverage of the fractured bone, despite laceration or extensive soft tissue injury. High-energy trauma is also present, regardless of the wound size, given the extensive injury to the underlying soft tissues.
IIIb: Extensive soft tissue loss with periosteal detachment and bone exposure. It is usually associated with extensive contamination.
IIIc: Associated with arterial injury requiring repair, regardless of the degree of soft tissue injury.

Biases

The application of the participant selection criteria avoided observation and selection bias. The principal investigator always maintained the data via a guide and records approved in the research protocol to prevent potential interviewer, information, and recall bias. Two researchers independently analyzed each record in duplicate, and the variables were entered into the database after verifying their concordance.

Study size

The sample was probabilistic. In a pediatric population of 758,290 children aged 1- 12 years in Guayaquil, the worldwide incidence of fractures is 20 per 1000 children [6], which means 15,166 possible fractures. EPI info ™ (Stat Calc, Epi Info, CDC, Atlanta. Version 7.2.6 [October, 2023]); with an expected frequency of patients with open fractures of up to 2.0% in children [7], with a confidence limit of 5% and a confidence level of 99%, the sample size was 52 cases.

Quantitative variables

Descriptive statistics were used. The results are expressed as frequencies and percentages. Scale variables were not converted to categorical variables.

Statistical analysis

Qualitative variables are presented as frequencies and percentages. Proportions were compared via the chi-square test. Odds ratios were calculated to assess the associations among variables, taking into account previously published statistical studies [8 - 10]. The statistical package used was IBM Corp. released from 2018). IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.

Results

Participants

A total of 750 fractures were reported in children, of which 220 (29.3% [95% CI 26.1–32.6%]) were classified as exposed. At the population level, this represents 1.45% of all fractures in children (95% CI 1.30–1.60%). There were 165 (75%) fractures with postoperative complications, and 55 (25%) were uncomplicated.

Main characteristics of the study group

The mean age of the 220 patients with open fractures was 6.6 ± 1.62 years. The most common fracture was diaphyseal fracture of the tibia and fibula, with 96 cases (43.6%). Right tibial fractures are also common, accounting for 24.1% of cases, followed by right femur fractures, accounting for 10.9% (Table 1).

Table 1. Frequency of open fracture types in children.

Type of fracture	Frequency n=220	%
Fracture diaphyseal of tibia and fibula	96	43.6%
Fracture right tibial shaft	53	24.1%
Middle third fracture tibia left	27	12.3%
Fracture diaphyseal right femur	24	10.9%
Distal third fracture tibia and fibula	14	6.4%
Fracture proximal metaphysis of the right tibia	4	1.8%
Distal third fracture tibia right	2	0.9%

Postsurgical complications

The prevalence of postoperative complications was 165 cases (75%) (Table 2). Infectious causes were the most common (18.2%), as were edema (18.2%) and pseudoarthrosis (14.1%). The length of stay was equal between complicated and uncomplicated patients, with a higher prevalence of 1-9 days (Table 3 and Figure 1). Among the mechanisms responsible for open fractures, collisions were the most common in 151 cases (68.6%), and the second most common cause was traffic accidents in 34 cases (15.5%) (Table 4).

Table 2. Complications of open fractures.

	Frequency n=220	%
Infection of surgical site	40	18.2%
Edema	40	18.2%
Pseudoarthrosis	31	14.1%
Osteomyelitis	26	11.8%
Limitation functional gait	16	7.3%
Rigidity articulate	4	1.8%
Delayed consolidation	4	1.8%
Pathological consolidation	4	1.8%
No complications	55	25.0%

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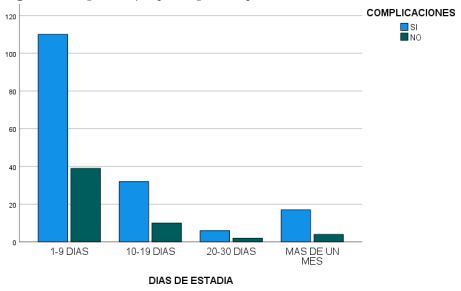
Table 3. Length of stay depending on complications.

	Open fractures with complications n=165	Open fractures without complications n=55	*P*
1-9 days	110 (66.7%)	39 (70.9%)	0.954
10 to 19 days	32 (19.4%)	10 (18.2%)	
20-30 days	6 (3.6%)	2 (3.6%)	
>30 days	17 (10.3%)	4 (7.3%)	

Figure 1. Length of stay depending on complications.



According to the degree of bone exposure, Gustilo-Anderson classification Grade II fractures, with a laceration of length > 1 cm and without extensive soft tissue injury, flaps or avulsions, were the most common, with 65 cases (29.5%). The grade I, IIIA, and IIIB classifications had a similar prevalence of 14.5%. The most severe bone exposure IIIC, associated with an arterial injury requiring repair, regardless of the degree of soft tissue injury, was the least prevalent in 5 patients (2.2%). The degree of exposure was most closely associated with the type of complication, infection and edema (Figure 2).

Types of treatment

The cross-tabulation table shows the distribution of complications from surgical treatment in the pediatric patient sample. Among the 220 patients, 22 were treated with external fixation, of whom only 2 had no complications, and 198 were treated with intramedullary nailing, of whom 51 did not develop secondary complications.

Among the 22 patients who presented with complications secondary to fixation with external tutors, 2 (9.09%) did not, whereas 20 (90.9%) did, including osteomyelitis (30%) and pseudoarthrosis (70%).

Among the 198 patients, 51 (25.75%) did not develop secondary complications, 46 (23.23%) developed edema as a complication of the surgical process, 40 (20.2%) had surgical site infections, 14 (7.07%) had osteomyelitis, 4 (2.02%) had pathological consolidation, 4 (2.02%) had delayed consolidation, 4 (2.02%) had joint stiffness, and 16 (8.08%) had gait disturbances (Table 5). Treatment with external tutors tends to lead to postoperative complications; however, this difference is not statistically significant because of the number of cases recorded in the external tutor treatment group (Table 6).

Table 4. Mechanism responsible for open fracture.

	Collision n=151	Fall from own height n=10	Slip fall n=15	Hit n=8	Traffic accident n=34	By traction n=2
Fx. Diaphyseal of tibia and fibula	65	7	5	4	15	0
Fx. Middle third of left tibia	20	0	3	0	3	1
Fx. Proximal metaphysis of the right tibia	4	0	0	0	0	0
Fx Diaphyseal of right femur	20	0	0	0	4	0
Fx. Right tibial diaphyseal	33	1	7	4	8	0
Fx. Distal third of the right tibia	2	0	0	0	0	0
Fx. Distal third of tibia and fibula	7	2	0	0	4	1

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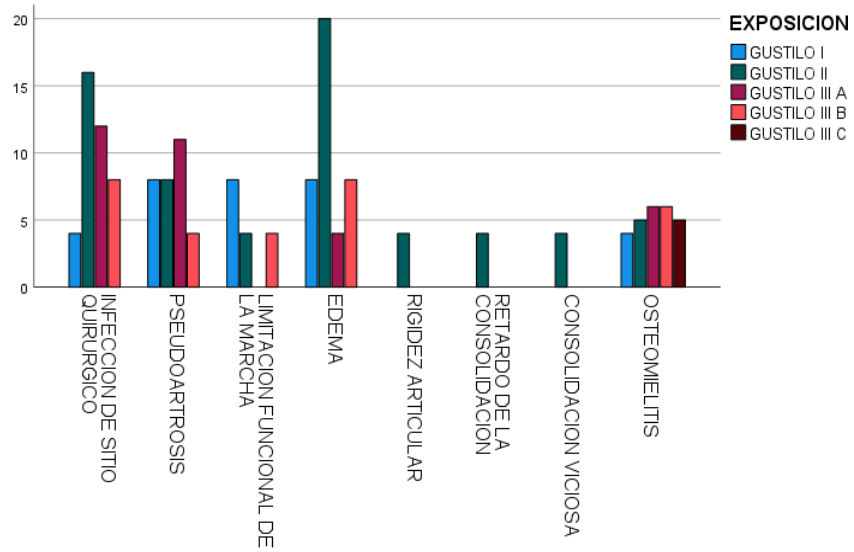
Table 5. Type of complications due to surgical treatment.

	External tutors n=22	Intramedullary nail n=198	*P*
No complications	2	53	
Pseudoarthrosis	14	19	
Osteomyelitis	6	14	
Edema	0	44	
Surgical site infection	0	40	0.074
Gait limitation	0	16	
Joint stiffness	0	4	
Delayed consolidation	0	4	
Pathological consolidation	0	4	

Figure 2. Complications according to the type of fracture exposure.



Gustilo-Anderson classification

I: open fracture with a clean wound < 1 cm long.

II: open fracture with a laceration > 1 cm long, without extensive soft tissue injury, flaps or avulsions.

III: Open fracture with laceration, extensive soft tissue damage or loss, or segmental AF or traumatic amputation. Also includes: High-velocity firearm injuries, AF caused by deforming wounds, AF requiring vascular repair, AF lasting more than eight hours.

IIIa: Adequate periosteal coverage of the fractured bone despite laceration or extensive soft tissue injury.

IIIb Extensive soft tissue loss with detachment of the periosteum and exposure of bone. It is usually associated with extensive contamination.

IIIc Associated with an arterial injury requiring repair, regardless of the degree of soft tissue injury.

Table 6. Association of the risk of complications by the treatment method.

	Complications n=167	No complications n=55	OR	95% CI	Z	P
External tutors	22	2	4.0207	0.9140-17.6865	1,841	0.0656
Intramedullary nail	145	53				

OR: Odds ratio. 95%CI: 95% confidence interval.

Discussion

The analysis revealed that the incidence of postoperative complications in pediatric patients was 59.45 per 100 patients from 2018 to 2022. Diaphyseal fractures of the tibia and fibula are the most common type of fracture among pediatric patients with open lower limb fractures at Francisco de Icaza Bustamante Hospital. Furthermore, collisions represent the leading cause of fractures, followed by falls from heights and accidents.

Regarding postoperative complications, the majority of patients experienced significant issues after surgery. Furthermore, the risk of complications increases with a longer hospital stay, with a higher percentage of patients encountering complications in the groups with extended hospitalizations.

In a related study, patients with diaphyseal fractures of the femur or tibia were evaluated. Of the 144 patients, 48 presented with open diaphyseal fractures of the femur or tibia, and 19 developed complications (39.5%). Compared to those in the present study, the number of patients who developed postoperative complications was lower than in the population discussed here, with an incidence of 4.7 versus 3.95 per 10 patients with postsurgical complications from open diaphyseal fractures of the tibia or femur [11]. Another study in Peru reported 1,643 lower limb fractures, of which 202 were open fractures, particularly affecting the tibia and fibula (49%). Within the same study, the most frequent postoperative complications (20.9%) included pseudoarthrosis (4.9%), superficial infections (3%), vascular sections (2%), osteomyelitis (1.5%), compartment syndrome (1.5%), lack of consolidation (0.9%), and arterial thrombosis (0.5%). In our study, the findings from the current investigation indicated that open fractures of the tibia and fibula were the most common (79%). Based on postoperative complications (59.45%), notable issues included surgical site infections (18.2%), pseudoarthrosis (14.1%), osteomyelitis (11.8%), delayed consolidation (1.8%), and malconsolidation (1.8%). These results closely align with, but are slightly more significant than, those of related studies. [12].

In another Argentine study, the stabilization of Gustilo grades I and II open leg fractures was examined in the acute stage, during which the use of external fixators was considered a viable option for stabilization. However, this method has the drawback of elevated infection rates associated with the Schanz nail, as well as complications such as loosening, poor adherence, misalignment, and lack of consolidation. Furthermore, there is a risk of infection after placing intramedullary nails following the use of an external fixator. When comparing our results with those of this study, a clear relationship emerges between infection rates and treatment with external fixators. Among our 22 patients, 20 (90.9%) experienced osteomyelitis, pseudoarthrosis, and a lack of consolidation, with only 2 (9.09%) patients free from secondary complications. [13].

The same study published in 2021 revealed that intramedullary nailing (CEM), both reamed and unreamed, resulted in fewer complications than fixation with external tutors. For instance, it led to a reduced risk of reoperation, poor consolidation, and superficial infection. Additionally, based on its findings, there were no cases of infectious processes, and the duration of hospitalization decreased. In comparison with our findings, among the 198 patients treated with CEM, 58 (29.29%) did not develop complications, while 46 (23.23%) experienced only edema or secondary blisters. This resulted in a total of 104 patients (52.5%) who encountered no more than local edema. Among these patients, 40 (20.20%) developed surgical site infections, a finding that slightly differs from published studies [13- 15].

In a related study published in 2019, pediatric patients with open lower extremity fractures who underwent external fixation were evaluated for postoperative complications. The findings revealed that infections were the most common postoperative complication, at a rate of 27.5%. These results align with the current study, which identified infections as one of the most prevalent postoperative complications [16].

Considering other studies, a study compared bone grafts and bone substitutes in open fractures, revealing a significantly lower infection rate [17].

These findings have significant implications for pediatric patients with open lower extremity fractures. Understanding postoperative complications may help reduce their occurrence, and identifying the most common causes of these injuries may aid in their prevention. Pathologic fractures, as well as those related to metabolic diseases, such as renal failure in children, which can cause fractures due to abnormal bone resulting from hyperparathyroidism, have been excluded [18].

The study has limitations due to its observational nature and the small number of patients receiving treatment with external tutors. Future studies should evaluate these aspects.

Conclusions

The most common fractures were diaphyseal fractures of the tibia and fibula, followed by fractures of the right femur and right tibia. The leading cause of fractures was collision, followed by accidents and falls. Various types of complications were identified, the most frequent being infections, wound healing complications, and fracture complications malposition.

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Statements

Ethics committee approval and consent to participate

The Bioethics Committee of the Faculty of Medical Sciences, University of Guayaquil, Guayaquil, Ecuador, approved the study.

Consent to publication

This information was not needed because the present study did not publish images, radiographs, or specific patient studies.

Conflicts of interest

The research has no financial interests or conflicts of interest.

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