

Osteosynthesis in Children at the University Hospital of Brazzaville: About 154 Cases and Review of the Literature

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How to cite this paper: Mboutol-Mandavo, C., Service Yanguedet, M., Bosséba Missengui, R., Akobande, E.N. and Miérét, J.-C. (2026) Osteosynthesis in Children at the University Hospital of Brazzaville: About 154 Cases and Review of the Literature. *Open Journal of Orthopedics*, **16**, 480-491.

<https://doi.org/10.4236/ojo.2026.169045>

Received: August 23, 2026

Accepted: September 26, 2026

Published: September 29, 2026

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Abstract

Introduction: Fractures in children are most often treated orthopedically; however, when surgical treatment is necessary, the choice of material must be adapted. The aim of this study was to report on the different methods of osteosynthesis used in children in our setting and to review the literature. **Patients and Methods:** This was a cross-sectional study with retrospective data collection carried out from January 2022 to December 2024 in the pediatric surgery department of the University Hospital of Brazzaville. All children under 18 years of age who had undergone osteosynthesis for a traumatic injury (fracture or epiphyseal detachment) were included. **Results:** We recorded 154 cases of osteosynthesis performed for fractures, representing 6.1% of the surgical procedures performed in the department. The cases were predominantly male, with a sex ratio of 2.4. The average age was 9.6 years (extremes 4 and 18 years). Play accidents (47.2%), road accidents (29.1%) and sports-related accidents (16.7%) were the most common. The injuries concerned the thoracic limb in 56.3% of cases and the pelvic limb in 43.7%, and were represented by fractures in 135 cases (87.7%) and epiphyseal detachments in 19 cases (12.3%). These occurred mainly on the humerus and femur, with 45.8% and 28.5% respectively. Fractures of the femoral shaft (48.1%) and supracondylar fractures of the humerus (43%) were the most frequently treated by osteosynthesis. The average time taken to perform osteosynthesis was 10.7 days (range 1 to 62 days). Pinning (59.8%) and intramedullary nailing (26.6%) was most frequently performed. The average hospital stay was 13.2 days (range 2 to 60 days). **Conclusion:** Fractures in children may require surgical treatment, and the choice of osteosynthesis material is essential.

Keywords

Bone, Child, Fractures, Osteosynthesis, Pinning, Brazzaville

1. Introduction

According to the WHO and UNICEF, child trauma is a serious public health problem that needs to be tackled as a matter of urgency [1]. In fact, child trauma is the leading cause of death and the leading cause of sequelae and compensation for physical injury in children, as well as being the main reason for hospitalization of children in Europe [2]. The rate of unintentional injuries among children in sub-Saharan Africa reached 53.1 per 100,000 per year, the highest rate of any region, regardless of income level [3]. These injuries can result in multiple lesions, including fractures. In Africa, fractures in children are the most common injury resulting from accidents in everyday life [4], with an average incidence of 75 per year in hospital [5]. The treatment of fractures in children is very often orthopedic; when surgical treatment is necessary (major displacement, joint fracture), it must respect the anatomy of the growing skeleton (growth plate and periosteum) as far as possible in order to limit the risk of iatrogenic growth problems [6]. The surgical methods used in children are therefore the subject of controversy [6]. We therefore conducted this study with the aim of reporting on the main methods of osteosynthesis performed in children in our setting and reviewing the literature.

2. Patients and Methods

We conducted an analytical study with retrospective data collection over a 3-year period from January 2022 to December 2024. We excluded cases of pelvic girdle, spinal column or pathological fractures, and cases of osteosynthesis performed for orthopedic pathology. Medical records that provided little information were also excluded. The sample was exhaustive and non-random. We included in our study children aged between 3 and 18 operated on for a limb fracture. The parameters studied were:

- epidemiological: frequency, sex, age divided into 4 groups (0 - 5 years, 6 - 10 years, 11 - 15 years, 16 - 18 years), fracture etiologies;
- diagnostic: the topography, site of diaphyseal or epiphyseal fractures, type open or no, X-ray results;
- therapeutic: time required for osteosynthesis, the type of osteosynthesis (pinning, nailing, external screw fixation, screw plate, stapling).

The data were collected in Excel and analyzed using Epi Info 6.04 software.

3. Results

3.1. Epidemiological Aspects

We compiled 144 cases of children with 154 fractures treated by osteosynthesis, representing a frequency of 6.1% of surgical procedures performed in the depart-

ment. There were 102 boys and 42 girls, giving a sex ratio of 2.4. The mean age was 9.6 years, with extremes of 4 and 18 years, with 2 frequency peaks between 5 and 9 years and 10 and 14 years (**Table 1**).

Table 1. Distribution of patients by age.

Age (Years)	N	%
0 - 5	15	10.4
5 - 10	57	39.6
10 - 15	51	35.4
15 - 18	21	14.6
Total	144	100

Playful accidents were the most common etiology (**Figure 1**).

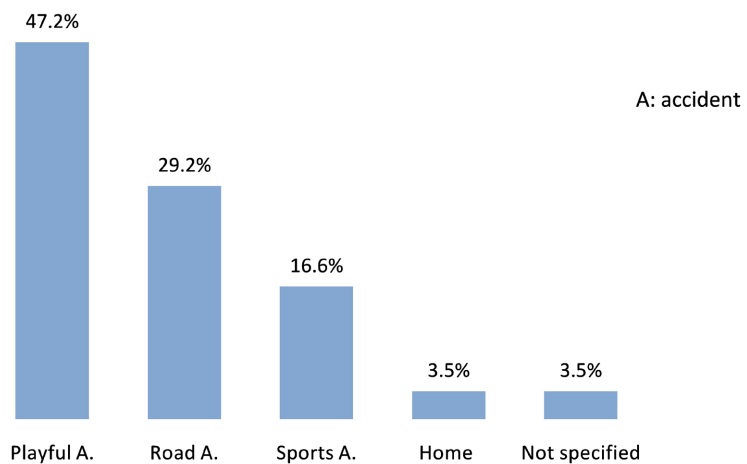


Figure 1. Distribution of patients by fracture etiology.

3.2. Diagnostic Aspects

The average consultation time was 2.6 days (extremes 1 hour and 34 days). The majority (83.3%) of children had consulted within 72 hours following the trauma.

Injuries were predominantly to the thoracic limb, particularly the elbow (**Table 2**).

Table 2. Distribution of patients by topography of trauma.

Topography	N = 144	%
Thoracic member	81	56.3
Humerus	66	45.8
Forearm	6	4.2
Hand	3	2.1
Wrist	3	2.1
Arm	2	1.4
shoulder	1	0.7

Continued

Pelvic member	63	43.7
Thigh	43	29.8
Knee	13	9
Lower leg	4	2.8
Hip	2	1.4
Ankle	1	0.7

All the children treated with osteosynthesis presented with pain, absolute functional impotence and deformity. All patients had a standard X-ray of the traumatized limb. The 144 patients presented with a total of 154 lesions, 135 (87.7%) fractures and 19 (12.3%) epiphyseal detachments.

Eleven patients (7.6%) had suffered 14 Cauchoix stage IIb (5 cases) and stage III (9 cases) open fractures.

The fractures most frequently involved the long bones and were commonly located in the diaphysis (**Table 3**).

Table 3. Distribution of patients by fracture site.

Fracture site	N	%
Diaphyseal	65	48.1
Supracondylar of the humerus	58	43
Epicondyle	6	4.4
Supracondylar femur	4	3
Phalanges	2	1.5
Total	135	100

3.3. Therapeutic Aspects

The average time to surgery was 10.7 days, with extremes of 1 and 62 days (**Figure 2**).

Pinning (59.8%) was the most common type of osteosynthesis (**Figure 3**).

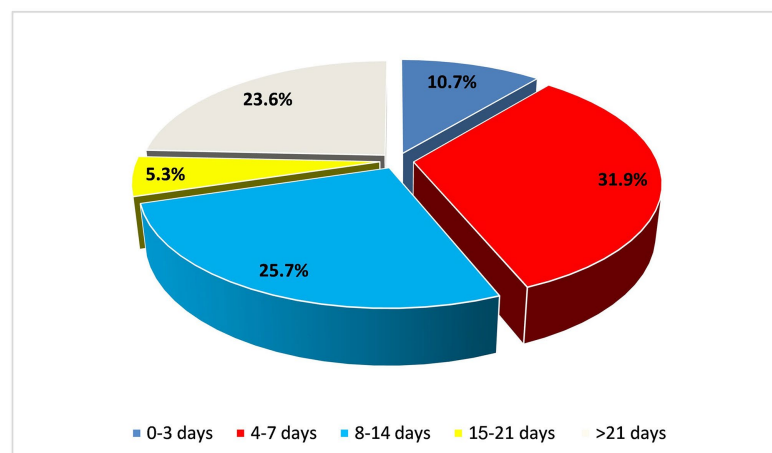


Figure 2. Distribution according to time to realization of osteosynthesis.

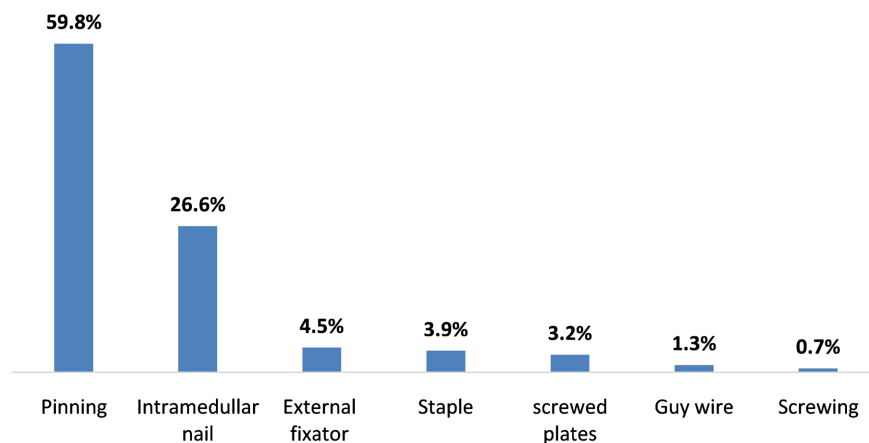


Figure 3. Distribution of patients according to type of osteosynthesis.

Outcome

The average hospital stay was 13.2 days, with extremes of 2 and 60 days. We did not observe any complications during the period of hospitalization.

4. Discussion

The search for therapeutic strategies for optimal management of limb fractures in children requiring osteosynthesis is controversial and still the subject of debate [6]. However, it is accepted that fractures of the growing bone require fixation techniques that prevent damage to the growth plate. All surgical techniques can be used, provided that the size of the implants is appropriate and that the technique used respects the growth zones of the bone [6]. Knowledge of each type of fracture, its location and consolidation, specific to age and each bone, is necessary for safe and effective treatment of pediatric fractures.

The treatment of fractures by osteosynthesis accounts for 6.1% of our surgical activity. The predominance of males in osteosynthesis reflects the more frequent exposure of boys to violent games and therefore to traumatic injuries, as already reported in the literature [7]-[9]. Chatelus and Th  lot [7] reported a sex ratio of 1.2 for everyday accidents in France; Kraus *et al.* [8] reported a sex ratio of 1.3 in a multicenter study of long bone fractures. In our series, osteosynthesis is most frequently performed in the 6 - 10 and 11 - 15 age groups. The indications for osteosynthesis depend mainly on the age of the child and the location of the fracture. In fact, osteosynthesis is less indicated in young children because the younger the child, the greater the capacity for bone remodeling; but also because orthopedic treatment of fractures is recommended in children under 6 - 8 years of age [8], as it is less aggressive because it respects two elements that are essential for bone growth: the physal and the periosteum. This rule does not apply [10] to:

- children with polytrauma, severe associated head trauma, pathological fractures, certain serious pathologies such as neurological damage or congenital bone fragility;
- joint fractures or epiphyseal detachments, which must be reduced anatomically;

- school-age children who will be able to write more quickly (fracture of the two bones of the forearm) or walk (fracture of the femur) with internal osteosynthesis.

Osteosynthesis is therefore less common in young children, because an iatrogenic lesion of the physal region can lead to epiphysiodesis, the consequences of which are all the more serious when the lesion occurs early in growth, *i.e.* in a young child with a high growth potential [11].

Preservation of the periosteum and the peri-fracture hematoma contribute to rapid consolidation of the bone. The periosteum also plays a part in the bone remodeling process, notably the correction of residual axial defects. Bone remodeling depends not only on age, but also on the site of the fracture and the plane of the deformity. Gamble and Vohries [12] reported that all supra condylar fractures in children under 5 years of age will have complete correction of excessive anteversion of the humeral pallet, and that this will be less important in children over 8 years of age.

Although growth easily corrects many cases of vicious calluses, it does not solve all the problems. Osteosynthesis is indicated from a certain age when the fracture callus does not have sufficient remodeling capacity [12].

Trauma is essentially accidental, due to play, road and sports accidents, which are the main causes of fractures treated by osteosynthesis in children in our series. Although domestic accidents are the most frequent type of everyday accident in children, they most often involve children under 5 years of age [4] [10] and the resulting fractures are often treated orthopedically [6], which may explain why they are not very common in our series.

The majority of children operated on (83.3%) are brought in within 72 hours of the trauma, and osteosynthesis is often carried out within the first week. This relatively long delay in the surgical management of fractures can be explained by a number of factors, including the high cost of surgical treatment, the availability of suitable implants and lack of social security cover. Wendling-Keim *et al.* [13] have highlighted the impact of delayed surgical treatment of fractures in children on the occurrence of complications. In fact, they reported that the delay between the trauma and the operation, the duration of the operation and the mode of transport to emergency had a significant impact on the occurrence of complications. However, the results of the study by Hidalgo Perea *et al.* [14] confirm that the time to surgery for femoral shaft fractures in children is not correlated with the time to bone healing and final function. They concluded that early surgical treatment of femoral shaft fractures in children should not replace medical resuscitation methods, as it is unlikely to affect outcome.

Fractures treated by osteosynthesis in children most often involve the metaphysis, in particular supracondylar fractures of the humerus (SCHF), and the diaphysis of the long bones, dominated by fractures of the diaphysis femur. This corresponds to the two peaks in frequency that we report, *i.e.* 5 - 10 years for supracondylar fractures of the humerus and 10 - 15 years for fractures of the diaphysis femur and leg bones. We note that fractures of the humerus and femur are the

most frequently treated surgically in children.

The frequency of supracondylar fractures of the humerus between 5 and 9 years of age is widely reported in the literature [15] [16]. Poor bone growth in the elbow region limits the possibility of spontaneous correction of residual defects after treatment, often necessitating surgical treatment. Bone remodeling is low in the elbow region, so the correction of displacements must be rigorous, especially when the child is older [15] [16].

Fractures of the femoral shaft can occur at any age, but before the age of 6, treatment is often orthopedic. It is from the age of 6 onwards that surgical treatment is indicated.

The majority of fractures operated on are closed fractures, but there is a significant proportion of open fractures (9.1%), half of which involve the leg.

5. Different Types of Osteosynthesis Material

As already emphasized, the literature agrees that the different methods of osteosynthesis must respect the growth plate, the periosteum and the fracture hematoma. All surgical techniques can be used, provided that the size of the implants is appropriate and that the technique used respects the growth zones of the bone [6]. In this respect, screw plates and locked nailing are reserved for older adolescents, while the gold standard in osteosynthesis, which has been recognized for around 3 decades, is pinning [17].

In our study, pinning was the most common type of osteosynthesis used in almost 60% of cases. There is general agreement in the literature that pinning should be the most commonly used method of osteosynthesis in children [17]-[20], due to the fact that the pins have little deleterious effect on the growth plate and respect the periosteum. There are two main types of pin osteosynthesis: stable elastic centromedullary pinning, especially for fractures of the diaphysis long bones in children aged between 6 and 12 years. Moreover, fine Kirschner wires are used for fractures of the bony extremities, such as fractures of the distal end of the humerus or epiphyseal detachments of the proximal humerus or distal radius, the medial malleolus or the short bones of the hand or foot [18].

Métaizeau's technique of stable elastic centromedullary embolization (ECMES) [17] is now the gold standard in the treatment of fractures in children. It meets the biological requirements of the bone consolidation process. In addition to preserving the hematoma (and its growth factors) and respecting the periosteum, the flexibility of the device allows the micromovements required to stimulate the periosteum and bone consolidation. The wires do not completely occupy the medullary canal, which does not interfere with the formation of an endosteal callus [17]-[19]. The assembly is stable in all three planes (frontal, sagittal and rotational) due to the curvature in opposite directions, which creates three stable support points; rotational movements are controlled by the medullary anchorage of the curved ends of the wire. This technique, initially developed for fixation of femoral shaft fractures, is tending to be applied to all long bone fractures, as well as those of the

hand and foot [9] [17]-[19]. It can also be used to fix certain fractures of the extremities, such as supracondylar fractures of the humerus or the radial head. Although the technique is demanding, the fixation is stable [10]. Some teams also use the ECMES technique in young children under 3 years of age for femoral shaft fractures [20]. This is despite the recommendations of the American Academy of Orthopedic Surgeons (AAOS), which states that the majority of fracture of the diaphysis femoral occurring between the ages of 5 and 11 - 12 years should be treated with ECMES, whereas before the age of 5, ECMES is only justified in children with polytrauma and poly fractures [21]. For treatment of the femoral diaphysis after the age of 11 - 12 years and/or if the patient weighs more than 50 kg, alternatives to ECMES such as pediatric medullary centric nails are more suitable [19]-[22].

In our study, most of the staple fractures were performed using Kirschner wires, particularly for supracondylar fractures, which are the second most common lesion treated by osteosynthesis. In fact, bi-cortical osteosynthesis using Kirschner wires is often indicated for fractures involving the metaphyseal and epiphyseal ends of long bones, particularly the distal and proximal ends of the humerus, the distal end of the radius and the medial malleolus, as well as fractures of the hand and foot [23].

Kapandji intrafocal pinning is also used in our indications, particularly for fractures of the distal quarter of the radius [24]. The technique is simple in principle, but meticulous in application, and because there is no need for immobilization, it offers a significant improvement in the outcome of these fractures. Another method of pinning is also recommended for these injuries: Py pinning [25].

Some teams are currently using the Minimally Invasive Reduction and Osteosynthesis System (MIROS). This system combines the advantages of external fixation and centromedullary pinning with those of a minimally invasive approach and adequate fracture stability, thus eliminating the need for a postoperative cast [26] [27].

Osteosynthesis using an adjustable stop pin (BBR) allows the use of a small-diameter fixation device with a screw less compression system, so as not to damage the growth plate [28] [29].

However, some authors believe that all surgical techniques can be used, if the size of the implants is appropriate and that the technique used respects the growth zones of the child's bone [6].

In our study, intramedullary nailing came 2nd with 26.6%, and is often indicated for fracture of the diaphysis femoral in adolescents. The external fixator was the 3rd most common means of stabilization (4.5%); external fixation is necessary for open fractures or fractures with significant soft tissue loss in order to facilitate treatment. Screw plates were used in 3.9% of cases. These osteosyntheses are used in adolescents. Rigid osteosyntheses such as screw plates and locked intramedullary nailing are reserved for older adolescents. The rigid osteosynthesis methods used in adults (nails, screw osteosynthesis) can be used in adolescents as soon as the growth plate has matured [10] [30], particularly in fractures of the diaphysis

femoral when the nucleus of the greater trochanter is ossified, or of the tibia after closure of the anterior tibial tuberosity. Some teams use minimally invasive screw-retained plates in both children and adolescents [31].

In children, locked polyaxial screw-plates are also used for bone fixation, particularly in the treatment of fractures, providing more stable and biological fixation [32]. They offer greater stability than conventional fixation systems, which is particularly important in children, where bone remodeling is rapid. Fixation is biological, as they promote bone healing by allowing controlled movement at the fracture site. They are used to consolidate fractures, particularly complex or unstable fractures. Fixation must be sufficiently stable not to disrupt bone growth, and polyaxial systems allow better adaptation to growth. Children can return to activity more quickly after surgery with stable fixation [33].

The absence of complications observed in our study may be because our study focused solely on the outcome during hospitalization; this constitutes a limitation, as complications might have been observed over a longer follow-up period.

6. Conclusion

Osteosynthesis plays a significant role in our surgical practice. Despite limited resources, we adhere to evidence-based guidelines when selecting osteosynthesis hardware, basing our choices on indications related to age, the specific bone involved, and the fracture type. Our study highlights the pivotal role of pinning in treating pediatric fractures; because osteosynthesis in children must preserve bone growth zones, implant selection must take into account the patient's age, the fractured bone, the fracture site, and the remaining potential for bone remodeling. Pinning is the preferred method as it best meets these requirements; however, rigid osteosynthesis remains an important treatment option for older adolescents.

Author Contributions

Conceptualization: Caryne Mboutol-Mandavo, Moïse Service Yanguedet; Methodology: Moïse Service Yanguedet; Software: Jean-Claude Miérét; Validation: Caryne Mboutol-Mandavo, Rhodia Bosséba Missengué, and Erica Nuptia Akobande; Formal analysis: Erica Nuptia Akobande; Investigation: Moïse Service Yanguedet, Rhodia Bosséba Missengué; Resources: Caryne Mboutol-Mandavo; Data curation: Caryne Mboutol-Mandavo; Writing—original draft preparation: Moïse Service Yanguedet; Writing—review and editing: Caryne Mboutol-Mandavo; Visualization: Caryne Mboutol-Mandavo; Supervision: Caryne Mboutol-Mandavo; Project administration: Caryne Mboutol-Mandavo; Funding acquisition: Rhodia Bosséba Missengué; All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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