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Corrections of Leg Deformities Using an External Fixator in an Adolescent with Severe Deficiency Rickets in Kisangani, DRC

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Abstract

This case report describes surgical management of severe bilateral lower-limb deformities attributed to nutritional rickets in a 15-year-old adolescent. Treatment involved staged tibial and fibular osteotomies, FESSA external fixation, subsequent casting, and rehabilitation. The authors report eventual bone consolidation and substantial improvements in mobility and self-care. Despite limited technical resources at our hospital, surgical management was undertaken. The procedure involved bifocal osteotomies with resection of the curved midsegments of the tibias and fibulas, followed by reduction and fixation of the tibial fragments using the French Armed Forces Health Service External Fixator (FESSA) in a simple articulated frame. Subsequent immobilization with thigh-to-foot casts was maintained until complete consolidation of the fracture sites. Postoperative recovery was marked by significant functional improvement, enabling the patient to wear shoes, sit, and walk independently without assistance. This case highlights the potential for functional autonomy restoration in severe rickets through adapted surgical techniques, even in resource-limited settings.

Keywords

Rickets, Skeletal Deformities, Osteotomy, External Fixator

1. Introduction

Rickets is the most widespread metabolic bone disorder in children worldwide. Two major forms are recognized. The first, nutritional rickets, is the most com-

mon and primarily results from vitamin D deficiency. Prevention is simple and inexpensive through adequate vitamin D supplementation and regular sun exposure. The second, vitamin D-resistant rickets, is rare and arises from genetic abnormalities affecting phosphocalcic metabolism [1]-[4].

Over the past 15 years, several studies conducted in African countries—including Gambia, Kenya, Nigeria, and South Africa—have identified low dietary calcium intake (less than 15 mg/day) as the leading cause of rickets in African children. In this context, rickets is largely a consequence of insufficient bone mineralization due to inadequate calcium reserves. These reserves may be depleted by diets poor in calcium-rich foods, excessive consumption of vegetables or cereals containing antinutrients and mineral-chelating agents (such as phytates, tannins, and oxalates), or disturbances in vitamin D intake, metabolism, or function [3] [5].

In contrast, in developed countries, rickets is most often linked to vitamin D deficiency caused by limited sunlight exposure and inadequate dietary intake. Dietary sources of vitamin D include dairy products, eggs, and certain fish. Preventive strategies therefore emphasize supplementation for pregnant women and children from birth through adolescence. During pregnancy, particularly in the third trimester, maternal vitamin D requirements increase to support fetal growth and establish neonatal vitamin D reserves essential for skeletal development and immune function. Supplementation of 80,000 - 100,000 IU at the beginning of pregnancy is recommended, with continued vitamin D administration during infancy and childhood. Vitamin D is prescribed in the form of natural vitamin D3 (cholecalciferol) or vitamin D2 (ergocalciferol), both of which are effective in preventing and treating rickets [6]-[13].

The symptoms of vitamin D deficiency are variable and often nonspecific. Their presentation depends both on the severity of the deficiency and on the age at which the disease develops. In some cases, manifestations may be subtle, while in younger children, they frequently appear as the characteristic skeletal signs of rickets [4] [6] [7].

The skeletal involvement is primarily expressed through bone deformities. Typical curvatures include *rachitic coxa vara* affecting the femoral necks, *genu varum* and *genu valgum* involving the knees, as well as deformities of the diaphyses of long bones, particularly the femur and tibia. These changes reflect the underlying defect in mineralization and highlight the clinical burden of rickets in growing children [1] [6].

In terms of management of Rickets-Related to Bone Deformities, the treatment of bone deformities associated with rickets encompasses several approaches. These include the use of plaster casts, corrective orthopedic devices, and positioning strategies such as maintaining the child in a supine posture to reduce the mechanical effects of gravity during standing and walking. In older children, surgical intervention through osteotomies may be required to achieve proper axis correction [14] [15].

The case presented here concerns a rare adolescent patient with rickets, exhibiting multiple skeletal deformities throughout the body. The most severe manifestations were the pronounced curvatures of both lower limbs, which prevented standing and walking and rendered the patient bedridden. Thanks to financial support from the Rotary Club of Kisangani and GoFundMe, the patient was able to undergo surgical treatment in the Department of Traumatology and Orthopedics, University Clinics of Kisangani, highlighting the importance of community and institutional collaboration in managing complex cases of rickets.

2. Observation

Patient X, a 15-year-old adolescent, was admitted to the Department of Surgery at the University Clinics of Kisangani on April 5, 2021, for evaluation of multiple skeletal deformities, predominantly affecting both lower limbs. The deformities developed spontaneously, with no reported history of trauma.

The onset of the condition dates back approximately 12 years, when the patient was only 3 years old. At that time, progressive deformities of the left thigh and leg were noted, gradually worsening over the years and significantly impairing ambulation (Figure 1). Prior to admission, the patient had received no medical treatment and relied solely on the use of a cane to facilitate walking.



Figure 1. Deformity of left leg.

A few months after the initial presentation, similar deformities developed in the contralateral lower limb, ultimately making walking impossible. To move around, the patient was compelled to drag himself along the ground, relying on both upper limbs for support (Figure 2). Over time, the deformities extended beyond the lower limbs, progressively involving the upper limbs and the spine, further compromising mobility and overall functional autonomy.



Figure 2. Deformity of two lower limbs.

Due to limited financial resources, the family resorted to traditional home massages in an attempt to alleviate the condition. These measures proved ineffective, and instead the deformities progressively worsened, ultimately leaving the patient completely bedridden (**Figure 3**). This outcome underscores the consequences of inadequate access to appropriate medical care and highlights the need for timely intervention in cases of severe rickets.



Figure 3. Bedridden patient mobilizing with the assistance of a wheelchair.

Through the humanitarian support program of *Go Fund*, in collaboration with the Rotary Club of Kisangani, the patient was referred to the University Clinics of Kisangani. There, he was able to receive comprehensive medical and surgical care (Figure 4). This intervention underscores the vital role of community and institutional partnerships in facilitating access to specialized treatment for patients with complex conditions such as severe rickets.



Figure 4. Patient welcomed at the University Clinics of Kisangani by the surgical team.

The obstetric and neonatal history was unremarkable; the patient was born naturally without any apparent malformations. It is noteworthy, however, that he was raised by his uncle, who lived in conditions of low socioeconomic status.

The additional medical history revealed no significant findings. On general physical examination, the patient's overall condition was compromised by his bedridden posture. Despite this, his nutritional status was satisfactory, and his height measured 1.26 meters. No psychomotor deficits or other systemic abnormalities were detected.

Vital signs were within normal physiological ranges: blood pressure 120/80 mmHg, heart rate 83 beats per minute, respiratory rate 24 cycles per minute, and temperature 36.1˚C.

2.1. Loco-Regional Examination

- **Upper limbs**: Both forearms exhibited incurvature with external convexity.
- **Right lower limb**: The thigh showed an outward convex curvature at the junction of the middle and distal thirds. The leg presented a pronounced anterior convex curvature in the middle third (Figure 2). The right foot demonstrated a moderate valgus deformity.

- In the left lower limb, deformities identical to those observed in the right were present. These included outward curvature of the thigh, pronounced anterior convexity of the leg, and valgus deviation of the foot, reflecting symmetrical skeletal involvement. pronounced only on the right (Figure 5).



Figure 5. Bilateral thigh deformities, more pronounced on the right.

Based on the patient's history—marked by a difficult childhood under limited socioeconomic conditions—and the clinical findings of multiple deformities predominantly affecting the long bones of the limbs, the diagnosis of nutritional rickets was suggested, with osteogenesis imperfecta considered as a differential diagnosis.

2.2. Paraclinical Assessment

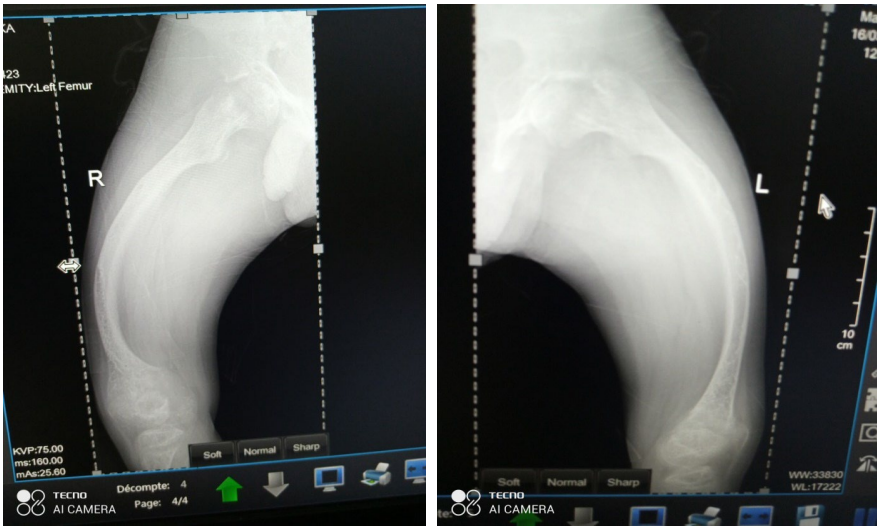
Laboratory investigations were requested and revealed the following:

- Complete blood count: Hemoglobin 12 g/L; white blood cell count 6800/mm^3.
- ESR: 43 mm/h.
- VDRL: Negative.
- HIV test: Negative.
- Serum calcium: 8.36 mg/dL.
- Serum phosphate: 42 ng/L.
- Alkaline phosphatase: 256 U/L.
- 25-OH Vitamin D level: 62.4 ng/mL.
- Blood glucose: within normal limits.
- Blood group: O positive.
- Coagulation profile: TS = 1 min 30 sec; TC = 3 min 58 sec.

Imaging studies revealed mild demineralization of the vertebrae without collapse of the vertebral bodies. A significant kyphoscoliosis was observed, along with marked curvature of both femurs and both tibial shafts (Figures 6-8). Despite these deformities, the density of the affected long bones appeared preserved, with evidence of cortical thickening.



Figure 6. Kyphoscoliosis of the spine with mild vertebral demineralization, without evidence of vertebral body collapse.



(a) (b)

Figure 7. External convex deformity of both femurs, more pronounced on the right, with preservation of bone density and cortical thickening.



(a) (b)

Figure 8. Anterior convex deformity of both tibiae, with radiographs showing normal bone density and preserved cortical appearance.

On April 8, 2021, the patient was admitted to the operating theater for his first surgical procedure, performed on the right leg. The operation consisted of a bifocal osteotomy resecting about 8 cm of the mid-curved segments of the tibia and fibula (**Figure 9(b)** and **Figure 10(a)**). Following resection, the tibial fragments were reduced and stabilized using a pediatric-type French Armed Forces Health Service External Fixator (FESSA), applied in a simple articulated frame (**Figures 9-12**).



(a) (b)

Figure 9. Bifocal osteotomy of the right tibia and fibula, with resection of the curved mid-segments. Fixation was achieved using two Steinmann pins (3 mm in diameter) placed on either side of the osteotomy site, connected by two 25 mm bars positioned parallel to the fracture fragments and secured with universal collars. The fibular osteotomy was left unfixed, as stabilization was deemed unnecessary.



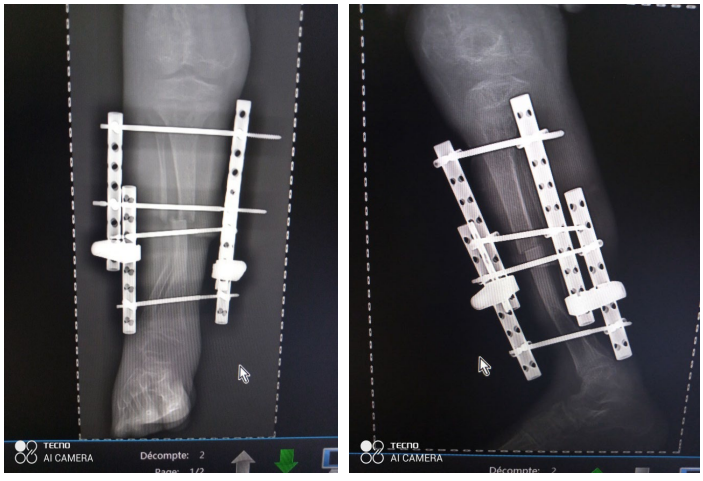
(a) (b)

Figure 10. Fixation of the right tibia using a pediatric-type French Armed Forces Health Service External Fixator (FESSA), applied in a simple articulated frame.



(a) (b)

Figure 11. Postoperative sequence demonstrating appropriate positioning of the external fixation device. Immediate postoperative radiographs confirmed satisfactory reduction and stable fixation at the tibial osteotomy site.



(a) (b)

Figure 12. Radiographs demonstrating bone fixation using the pediatric-type French Armed Forces Health Service External Fixator (FESSA), applied in a simple articulated frame.

No intraoperative complications were reported, and the postoperative recovery was uneventful. Wound healing progressed satisfactorily and was achieved by primary intention (Figure 11).

On April 28, 2021, twenty days after the initial procedure, the patient was returned to the operating theater for a second intervention, this time on the left leg (Figure 13 and Figure 14). The surgical technique mirrored that used on the right side. However, correction was less successful due to the severity of the deformity in the left femur and knee, which markedly deviated the axis of the leg outward.



Figure 13. Bifocal osteotomy of the left leg with resection of the curved mid-portion of the tibia and fibula.



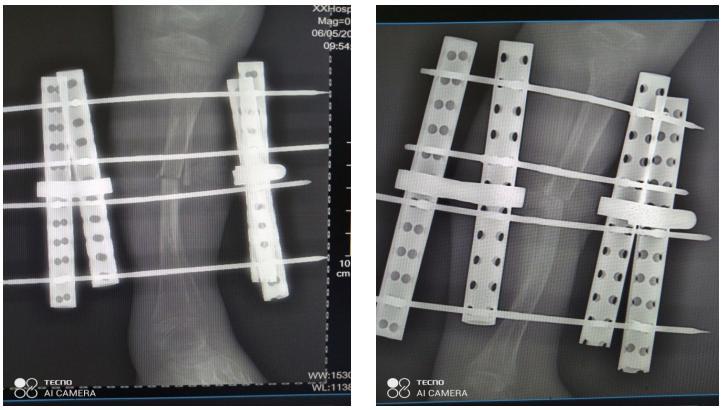
Figure 14. Fixation of the left tibia using the adult model of the French Armed Forces Health Service External Fixator (FESSA), applied in a simple articulated frame.

For technical reasons, Schanz pins from the AO fixator were employed during this procedure, as their length was more suitable. These were combined with union bars from the adult model of the French Armed Forces Health Service External Fixator (FESSA), which adapted appropriately to the pins (Figure 15, Figure 16(a) and Figure 17(a)).



(a) (b)

Figure 15. Post-operative follow-up and good arrangement of the assembly.



(a) (b)

Figure 16. Radiographs demonstrating bone fixation using the French Armed Forces Health Service External Fixator (FESSA), applied in a simple articulated frame with Schanz pins.



(a) (b)

Figure 17. Removal of the external fixator from the right leg, followed by application of a plaster cast. The same approach was subsequently recommended for the left leg one week later (**Figure 18**).



(a) (b)

Figure 18. Removal of the external fixator from the left leg, followed by application of a plaster cast.

The postoperative course was as uneventful as the first intervention, with wound healing achieved by primary intention (**Figure 15**). An important observation during surgery was the unexpected strength of the patient's bones: the cortical bone was thick and hard, comparable to that of a normal individual.

On July 13, 2021, three months after the initial surgery, radiographic evaluation revealed early callus formation at the osteotomy sites (**Figure 16**). Consequently, removal of the external fixator was undertaken—first on the right leg, followed one week later by removal on the left. At that time, slight residual mobility persisted.

Abnormality at the level of the right leg justified the application of a thigh-to-foot cast to complete bone consolidation.

The abnormality of the right leg warranted the application of a thigh-to-leg external fixation device to achieve proper alignment and stabilization (**Figure 17**).

One month after application of the plaster cast on the left leg, partial weight-bearing was authorized. The patient was initially mobilized by using the wheelchair as a tripod support, before progressing to ambulation with two crutches (**Figure 19** and **Figure 20**).



(a) (b)

Figure 19. Postoperative rehabilitation sequence showing partial weight-bearing on the plaster cast, with the wheelchair used as a tripod support.



(a) (b)

Figure 20. Contact support on plaster without tripod.

Three months after cast application, radiographic evaluation demonstrated complete consolidation of the left leg, while persistence of the fracture line was noted on the right. This finding was confirmed clinically by slight mobility during mobilization. Accordingly, the cast was removed from the left leg, while the right leg remained immobilized under plaster with weight-bearing permitted (**Figure 21**).



(a) (b)

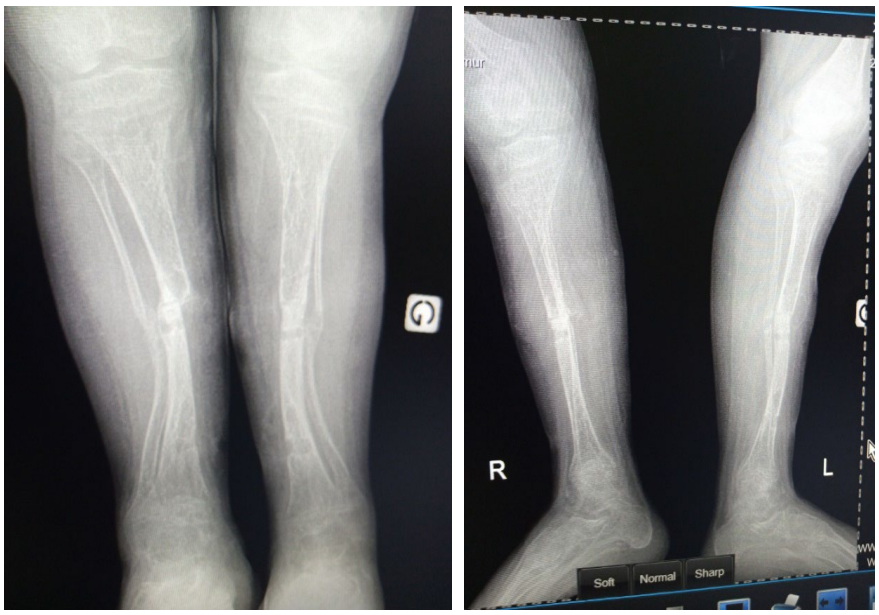
Figure 21. Control radiographs, lateral view, after removal of the casts.

One month later, the cast on the right side was removed, and the patient was allowed to ambulate with the aid of two crutches (**Figure 22**). Subsequent follow-up radiographs confirmed complete consolidation of the right leg (**Figure 23**).



(a) (b)

Figure 22. Removal of the final plaster cast from the right leg, followed by initiation of ambulation with the aid of two crutches.



(a) (b)

Figure 23. Control radiographs obtained after removal of the final plaster cast from the right leg.

The patient was discharged from hospital on July 10, 2021, after a total stay of 127 days. His general condition had markedly improved, with significant weight gain. Functionally, he regained independence, being able to put on his shoes, sit down, and walk unaided (**Figure 24**).



(a) (b)

Figure 24. Patient ambulating independently, without the need for human assistance.

3. Discussion

Vitamin D and calcium deficiency represent a major global health problem, affecting more than one billion children and adults worldwide. Several authors have described this situation as a true pandemic. Rickets, the clinical consequence of such deficiencies, must therefore be regarded as a priority public health issue, given its increasing prevalence across diverse regions [1]-[3] [6] [8] [16]-[19].

In Europe and other industrialized countries, rickets had largely disappeared following systematic vitamin D supplementation. However, since the beginning of the 21st century, a resurgence has been observed not only in developing countries but also in certain industrialized nations [4] [6] [10] [14] [17] [20].

Current estimates place the incidence of nutritional rickets in Europe and North America at approximately 3 per 100,000 children annually. Infants remain the most vulnerable group, with studies reporting incidences as high as 5.8 per 100,000 in children under three years in Denmark, and 7.5 per 100,000 in children under five years in England [6] [10] [14] [17] [20]-[22], corresponding to the age of onset in our patient.

Africa continues to report the highest prevalence of nutritional rickets, particularly calcium-deficiency rickets. Yet, migration flows from Africa, the Middle East, and Asia have contributed to a resurgence of cases in Europe and North America. Contributing factors include unfavorable socioeconomic conditions, diets deficient in vitamin D and calcium, and the absence of preventive health policies for pregnant women and breastfeeding mothers [3] [5] [7]-[13]. All of these conditions were present in our patient.

Despite numerous prevention programs, chronic malnutrition persists in many developing countries, fueling the rise of calcium and/or vitamin D deficiency rickets over the past two decades [3] [5] [7] [9] [16] [17]. Left untreated, rickets leads to lasting disabilities, impaired bone growth, reduced quality of life, and increased

susceptibility to fractures and deformities [11] [16] [17] [21].

Diagnosis requires radiographic evaluation—ideally of the knees and wrists to visualize multiple growth plates—combined with biochemical profiling to determine etiology and guide treatment strategies, whether dietary, pharmacological, or surgical [1] [3] [4] [19] [23].

Clinical manifestations vary with age: 1) cranial anomalies such as thinning of the vault and delayed suture ossification; 2) limb deformities including varus or valgus curvature in young children; and diaphyseal involvement in adolescents, characterized by cortical thinning, demineralization, curvature, and spontaneous fractures. 3) Other rarer manifestations include scoliosis, coxa vara, and pelvic deformities with obstetric implications [1] [3] [10] [16] [18].

In our patient, symptoms began at age three and worsened with growth. Most of the deformities described in the literature were present, attributable to gravity and muscular traction on excessively malleable bones [11] [18] [24] [25].

Interestingly, unlike typical cases of rickets, our patient exhibited paradoxically thick and hard cortical bone, comparable to that of a healthy individual. Biochemical parameters also remained within normal limits, in contrast to the usual disturbances in calcium, phosphate, and alkaline phosphatase levels [1] [2] [26] [27].

Management of rickets is both medical and surgical.

From a medical perspective, there are two aspects: 1) the preventive aspect and 2) the curative aspect.

Preventive strategies rely on sun exposure and systematic vitamin D supplementation in infants: 1) for infants (0 - 12 months), a systemic supplementation of 400 IU/day vitamin D is essential fro birth regardless of the feeding method (sein or preparation); 2) Over 12 months and a pregnant woman, a miniun intake of 600 IU/day of vitamin D is recommanded along with sufficient age-apropriate calcium intake (calcium defficiency being defined by an intake less than 300 ng/day) [28]-[31].

When the family environment does not allow for this regularity, periodic quarterly supplementation with a dose of 100,000 IU every 3 months or 200,000 IU every 6 months appears preferable during the first 2 years of life. Beyond the age of 2 and up to the age of 5, supplementation with a dose of 200,000 IU is administered at the beginning of each year [4] [28]-[31].

In the case of proven rickets, treatment requires joint administration of vitamin D and calcium for at least 12 weeks. 1) Vitamin D: a minimum dose of 2000 IU/day (adjusted according to the child's age); 2) Oral calcium: a minimum of 5000 IU/day is essential to avoid the hungry bone syndrome and ensure the restoration of the skeletal structure [28]-[34].

Administration is by infusion of calcium gluconate at a dose of 1000 mg/m^2/24h depending on the severity for approximately 2 months [4] [35].

Surgical management of rickets-like deformities of the lower limbs is achieved through axial correction osteotomy, primarily recommended for large children. However, for cases seen early, orthopedic treatment with plaster casts and succes-

sive corrections may prove sufficient [14] [15] [24] [25] [35].

Given that, in most of our resource-limited African communities, where there is no good health policy for the care of the sick, these children with rickets, often from poor families, are seen late in a very advanced stage of illness. Hence the need for surgical correction, the cost of which is not within everyone's reach.

This is the situation our patient found himself in, and thanks to the intervention of a philanthropic organization like the Rotary Club, he was able to benefit from complete medical and social care.

Regarding the surgical technique used in our patient, we performed a bifocal osteotomy with resection of about 8 cm of the mid-tibias and fibulas where the curvatures had reached their maximum. It is on the basis of this last reason that we justify the surgical strategy adopted for our patient. Reduction of the fracture fragments resulted in the straightening of the axis of both legs and the realignment of the lower limbs. The fibular osteotomy was not fixed, as it was deemed unnecessary. Only the tibial fragments were fixed using a pediatric FESSA External Fixator in a simple, hinged frame. On the right side, we used 3 mm pins, which corresponded to the fixator model, while on the left side, due to the significant associated deformities of the ipsilateral femur and knee, we used Shantz pins of the same diameter but greater length, with the same mounting configuration as on the right side.

In the literature, several other techniques are recommended for the surgical correction of rickets; among others, the Ilizarov technique uses several osteotomies performed at one time to straighten the mechanical axis, followed by fixation of the bone fragments by the Ilizarov fixator bearing his name [24] [35]-[38].

Others resort to elastic intramedullary nailing after axis correction osteotomy [14].

All these techniques have their advantages and disadvantages and depend more on the availability of equipment and the surgeon's experience.

Regarding postoperative results and patient progress, immediate postoperative radiographs showed satisfactory anatomical reduction and fixation of the bone fragments, better achieved on the right than on the left. However, from a technical standpoint, both legs regained their normal alignment.

The patient's postoperative progress was satisfactory, with the surgical wounds healing by primary intention. As for the osteotomy sites, bone consolidation was achieved within the usual timeframe (3 months) on the left and slightly delayed on the right (4 months).

To accelerate consolidation, we had to replace the external fixation assembly with leg-to-leg casts with immediate weight-bearing.

Our approach is based on the principle of dynamization, which consists of replacing our simple frame mounting, which is static, with a dynamic plaster, which allows support and promotes the corticalization of the callus.

Functionally, walking was permitted as soon as, even before full consolidation

was achieved, we noticed the chalk draft on the calcification. First with the aid of a wheelchair used as a tripod, then with the aid of two crutches, which allowed the patient to regain his independence. He was able to stand and sit down, put on his shoes and dress himself without needing human assistance.

Overall, thanks to comprehensive care (diet and calcium and vitamin D supplementation), the patient was able to recover considerable height and weight gain, as evidenced by **Figure 24**.

4. Conclusions

Nutritional rickets remains a frequent condition worldwide, with rising prevalence linked primarily to vitamin D deficiency and, in Africa, to inadequate calcium reserves. Prevention is straightforward and inexpensive, relying on vitamin D supplementation and sun exposure.

Despite disease control programs, chronic malnutrition continues to affect children in developing countries, driving the incidence of rickets upward. The diagnosis rests on characteristic bone deformities—bowing of the lower limbs, genu varum or valgum, coxa vara, flat feet, and exaggerated kyphosis—all of which were present in our patient.

Early detection allows correction through orthopedic methods such as successive casting. However, in advanced cases, particularly in older children, surgical intervention becomes necessary. Axial correction osteotomy remains the cornerstone of surgical management, with fixation methods adapted to available resources and surgical expertise.

Let's say that we have received verbal approval over the phone, from the patient himself and his uncle for the publication of this clinical case and also the work was authorized by the Ethics Committee of Kisangani.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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