Original Article

Treatment of Late-Onset Blount's Disease using Linear Rail System and Double Corrective Osteotomies at the Intra-Articular and Metaphyseal Regions

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Abstract

Background: Blount's disease is a developmental anomaly that affects the posteromedial aspect of the proximal tibia physis with changes seen in the epiphysis, metaphysis, and sometimes, in severe cases, the distal femur as well. It results in a posteromedial deformity, internal tibial torsion, and shortening of the affected leg. **Aim:** The purpose of this study is to document the results of the treatment of the late form of this deformity using intra-articular and metaphyseal osteotomies of the proximal tibia and a linear rail system (LRS) device. **Patients and Methods:** Six patients were treated for late-onset unilateral Blount's disease. The procedure consisted of intra-articular osteotomy below the physis to elevate the depressed medial tibia plateau and a metaphyseal osteotomy below the tibia tubercle to address any residual varus deformity, tibial torsion, and leg shortening using a LRS device. **Results:** The mechanical axis deviation was corrected from a mean of 6.0 cm (range of 3.1–9.6 cm) to 1.4 cm (0–2.9 cm). The tibiofemoral angle was corrected from a mean of 23.2° varus (range of 16°–30°) to a mean of 1.8° varus (range of 5° valgus–7° varus). The limb length discrepancy was corrected. Operation time was 90 min on average. The device use time was three months on average. Schoenecker outcome criteria were good for all the patients. **Conclusion:** The use of double corrective osteotomies at the proximal tibia and the LRS device were found to be cheap, easy to use, and very effective in the treatment of Blount's disease deformity.

Keywords: Blount's disease, distraction osteogenesis, double osteotomies, linear rail system

Introduction

Blount's disease is a developmental anomaly that affects the posteromedial aspect of the proximal tibia physis with changes seen in epiphysis, metaphysis, and sometimes in severe cases, the distal femur as well.[1] It results in a multiplanar deformity of the proximal leg that is comprised of varus deformity, tibial internal torsion, and procurvatum.[1,2] Several methods are used to manage it. These include the use of braces, hemiepiphysiodesis, and corrective osteotomy.[1-6] These methods have their limitations when Blount's disease is unilateral and there is an associated limb length discrepancy (LLD) and ligamentous laxity. The introduction of the Ilizarov technique, which utilizes the principle of "tension stress," brings about "distraction osteogenesis."[2-8] This has been used in the gradual method of correction of LLD seen in Blount's disease. It has overcome the limitations mentioned above. It is considered as the gold standard in the treatment of severe Blount's disease with associated LLD.[2,5,6] The Ilizarov technique is achieved by the use of Ilizarov device. The device is complex and cumbersome for both the patients and the managing physician to operate. This led to the development of multi-axial correction (MAC) monolateral device in the USA, which is a noncircular device used to treat Blount's disease.[2] Although this is less complex than Ilizarov device in treating Blount's disease, it is expensive and not available in our environment. Taylor spatial frame (TSF) is a modified form of the Ilizarov device.

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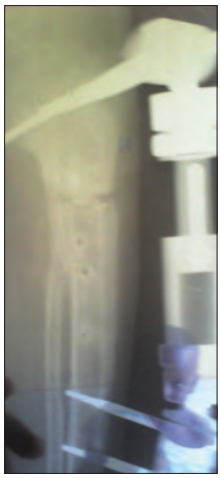

Figure 1: X-ray of patient 2 after operation

Figure 2: Clinical photo of patient 2 after operation

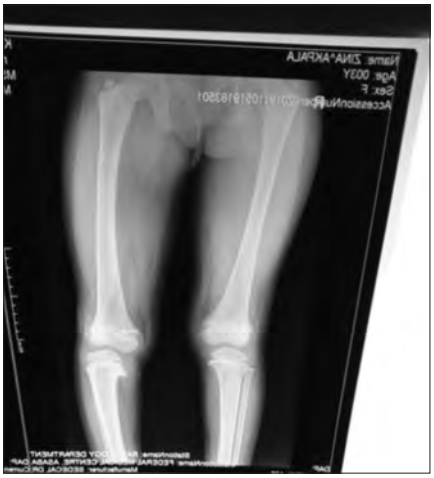

Figure 3: : Pre-operative x-ray of patient 1

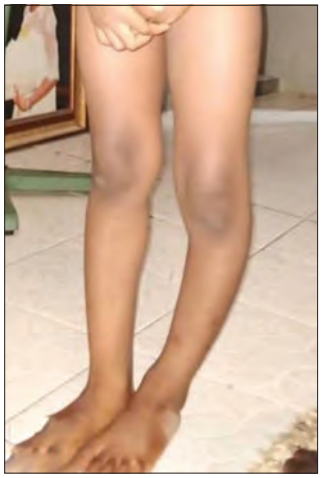

Figure 4: Pre-operative clinical photo of patient 1

It uses Internet-based computer-generated software to correct the deformity of Blount's disease. TSF is more expensive and difficult to get than the regular Ilizarov device.

In our literature search, Bar-on *et al*. used a TSF with two osteotomies, one at the intracapsular region to elevate the depressed medial tibial plateau via an intra-epiphyseal open-wedge osteotomy.[9] He obtained an iliac bone graft to support the open wedge. He made a second osteotomy at the proximal metaphysis below the tibial tubercle. With these double osteotomies and a TSF, they were able to treat severe Blount's disease successfully.[9] Using this model, we devised a similar treatment method where a linear rail system (LRS) was used instead of a TSF and the angular deformities were corrected acutely [Figures 1 and 2]. The LLD was corrected by a gradual method by the LRS. The LRS, which is a modification of the Wagner external fixator, is readily available in our environment and is cheaper than the TSF. Although LRS cannot correct angular deformity like the TSF, the angular deformities can be corrected acutely by corrective osteotomy at the centre of rotation of angulation at the proximal metaphysis.[3] At this point, the varus deformity, internal torsion and LLD are addressed. The depressed medial tibial plateau is addressed by an intracapsular corrective osteotomy done below the physis.

In this study, we present our experience in the use of LRS device and double corrective osteotomies in the proximal tibia to manage Blount's disease in Delta State University Teaching Hospital, Oghara, Nigeria.

Patients and Methods

This was a retrospective study of 6 patients carried out for three years from July 2018 to June 2021 in Delta State University Teaching Hospital, Oghara in Delta State, Nigeria. It is a tertiary hospital located in the South-South geopolitical zone of Nigeria. Inclusion criteria are children older than 4 years with the developmental anomaly of the proximal leg with varus deformity, with no associated history of trauma, rickets, infection, or neoplasia [Figures 3 and 4]. Exclusion criteria were varus deformity resulting from trauma, infection, neoplasm, or rickets. Information for the study was obtained from patient case notes using Dror Paley[3] criteria for assessing Blount's disease. These include social demograp (sex, age, and

Figure 5: Clinical photo of patient 1 after operation

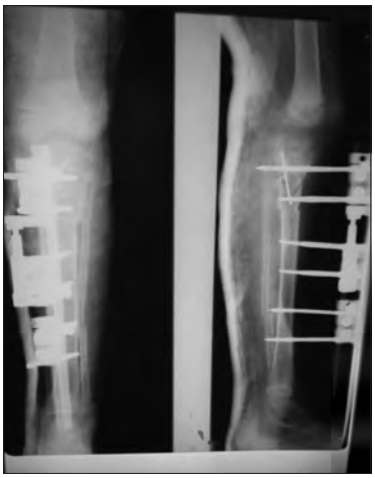

Figure 6: Post-operative x-ray of patient 1 with LRS

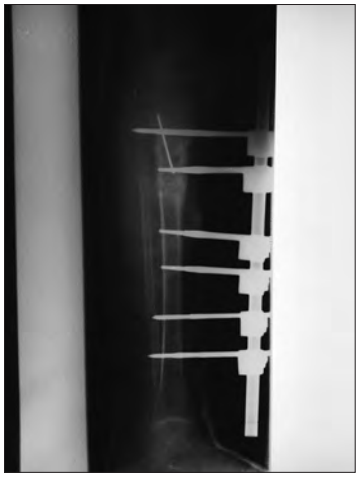

Figure 7: X-ray showing consolidation of regenerate in patient 1 before removal of device

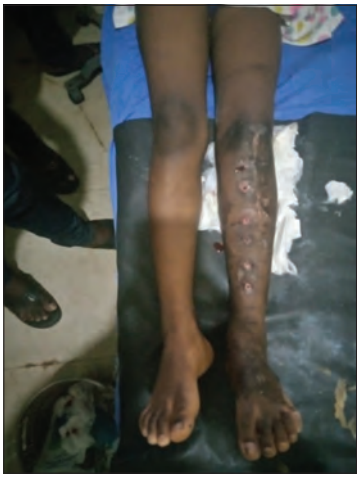

Figure 8: Clinical photo of patient 1 limbs after removal of device

occupation), Preoperative and postoperative measurements of the following angles; tibiofemoral angle (TFA), mechanical axis deviation (MAD), internal tibial torsion angle by measuring (thigh-foot angle). The knee joints were examined for ligamentous laxity before and after the procedure. Ethical clearance was obtained from the Institution Research Ethical Committee. Patients were followed up for one year period each. Results were analyzed using a simple statistical method. The outcome was assessed by Schoenecker *et al*.'s criteria (poor, fair, good, and excellent).[4]

Procedure

Patient was placed in supine position under general anaesthesia. A pneumatic tourniquet was applied on the ipsilateral thigh (the thigh was padded with a soft band) after elevating the limb for 20 min. Routine cleaning and draping of the affected limb from below the tourniquet to the toes was done. A longitudinal incision was made on the knee anteriorly and medial to the patella tendon and the tibial tubercle. The incision extended from the lower pole of the patella to 5 cm below the tibial tubercle. A lateral-based closing wedge osteotomy was made below the tibial tubercle to acutely correct the varus deformity of the Blount's limb. The depressed medial tibial plateau was elevated by an open-wedge osteotomy done below the physis and supported by the wedge of bone removed from the lateral closed wedge. The wedge of bone was stabilized by a k-wire. The transverse osteotomy space created after removing the triangular wedge of bone from the closing wedge was used for the purpose of distraction histogenesis to correct LLD and correction of the internal tibial torsion, when present, by derotation at this point. Osteotomy of the fibula was done at the middle. A small segment of bone was removed to prevent bone healing earlier than expected. This bone was added to the wedge of the tibia bone used to support the elevated medial tibial plateau if necessary. The tibia was, thereafter, held up in a LRS [Figure 5]. Two Schanz pins were inserted in the proximal tibial third in a horizontal T-clamp or vertical clamp and ensured that the joint line is oriented horizontally. Two Schanz pins were inserted in the middle third of the tibia and another two Schanz pins were inserted in the distal third of the tibia, both oriented vertically. A prophylactic fasciotomy was done. Tourniquet was monitored and removed after one and a half hours. The patient was, thereafter, placed on

broad-spectrum antibiotics, analgesics and muscle relaxants, Vitamin C, Vitamin D, and calcium tablets. The wound and pin sites were cleaned daily with normal saline and spirit and dressed with povidone-soaked gauze. A latency period of five days was observed and distraction commenced afterward at the rate of 1 mm/day achieved by turning the distractor device 180° 12 hourly. The patient's mother was taught how to distract the device and dress the wound. The patient was discharged home after two weeks postoperation after the mother had mastered the care of the device and wound. The process of distraction also stretched out the lateral lax collateral ligament and tightened medial collateral knee ligaments. Distraction was stopped when the LLD was corrected. An above-knee cast was applied to support the limb immediately distraction ended with the LRS still in place. The device was maintained till the regenerate consolidated and the elevated proximal tibia osteotomy site had healed. During the period of distraction, patient did not bear weight. The patient commenced partial weight-bearing at the end of the distraction. LRS device and cast were removed after the consolidation of regenerate and healing at intra-articular osteotomy site. Full weight-bearing started after the consolidation of the regenerate and healing of the intra-articular osteotomy site were achieved. Postoperation visits were initially two weekly for two months and later monthly till the end of treatment. The patient did X-ray monthly to monitor the state of the regenerate and the intra-articular osteotomy sites [Figures 1 and 6].

Results

A total of six patients were seen in this study. Three males and three females with an M: F ratio of 1:1. All had the unilateral type of Blount's disease. The age range was 5–15 years with a mean age of 11 years. The preoperation parameters of the patients were the range of TFA was 16°–30° varus with a mean of 23.7° varus and the range of MAD was 3.1–9.6 cm (mean was 6.0 cm). The range of LLD was 2–5 cm (mean was 3.7 cm). The range of tibial torsion was 35° of internal torsion to 20° of external torsion (mean was 7.5° internal torsion). Four patients had Lagenskiold grade IV, while two patients had grade V.

The postoperation parameters of the patients were; corrected TFA range was (5° valgus to 7° varus) with a mean of 1.8° varus. Corrected MAD range was 0–2.9 cm (mean = 1.4 cm), LLD was zero for all patients. The ligamentous laxity of medial and lateral collateral ligaments and LLD were resolved for all the patients.

The medial knee pain experienced before treatment disappeared following treatment in all the patients.

The duration of operation for all the patients was an average of 90 min.

The morbidities seen in this study were pains, tearing of the skin, and pin-tract infection in all the patients. Only one patient had two complications of numbness and inability to dorsiflex the big toe. The pains stopped at the end of the distraction, the skin wounds healed. The numbness and the inability to dorsiflex the big toe, however, persisted.

The outcome of treatment by Schoenecker *et al.*'s criteria[4] was good for all the patients.

Discussion

There is no study done in our literature search that showed where LRS was used to treat Blount's disease; hence, we intend to compare the outcome of treatment of Blount's disease using LRS and double corrective osteotomies with that of Ilizarov and MAC devices. Ilizarov device can correct deformities of multi-axial nature. The complex nature of the device is, however, its drawback. It is cumbersome for both patients and surgeons to manipulate. The LRS, when combined with appropriate corrective open- and closed-wedge osteotomy and derotation where internal tibia torsion is present, can correct the deformity associated with Blount's disease. The surgeon addresses the posteromedial varus, procurvatum and internal tibial torsion (if present) deformities acutely on table in the theater while the patient's relation corrects the residual LLD at the postoperative period gradually by distraction, if present with LRS. Both corrections are achieved with great ease when compared with Ilizarov device. In addition to correcting the LLD, the distraction also addresses the lateral collateral ligamentous laxity as it stretches out the contracted medial tissue structures (skin and ligament) and makes the lax lateral collateral ligament taut. The contracted medial structures and the lax lateral collateral ligament are often the cause of the failure of treatment of Blount's disease treated by only corrective osteotomy (acute method).[3] These are not addressed by the acute method of treatment. The depressed posteromedial tibial plateau is elevated and supported by the bone fragments obtained from the wedge of bone removed from the lateral-based closed wedge, the fibula fragment removed during fibula osteotomy, and the consolidated regenerate [Figures 6 and 7]. This helps to prevent relapse as it ensures the stability of the knee joint. This bone graft is a lot safer than the bone graft obtained from the iliac crest used by Bar-On *et al*.[9] in a growing child as this may affect the physis and growth of the ilium. The TSF used by Bar-On *et al*.[9] is an advanced form of the Ilizarov device. It is even more difficult to get and more expensive than the Ilizarov device itself. It has been observed by several authors that the acute method of correction of Blount's disease is only effective when patients present before four years old (Infantile type of Blount's disease), early type.[5,6] Those that present after four years old (late type of Blount's disease) tend to have the failure of treatment.[5,6] The lateral collateral ligament has been exposed to the long period of overstretch and the medial physis has suffered a lot of damage as well. These patients often present with Lagenskiold stages of IV, V, and VI of the disease.[5,6] In our study, the patients had grades IV and V of the disease. It, therefore, means combining acute and gradual methods of treatment of Blount's disease

in patients with late-type of Blount's disease is important to prevent failure. Ilizarov and LRS devices provide gradual method of treatment hence their successes in the treatment of Blount's disease.

In this study, all the patients treated had the unilateral type of late Blount's disease [Table 1]. We adopted intra-articular elevation of the depressed medial tibia plateau below the physis and proximal metaphyseal close-wedge osteotomy below the tibial tubercle. Subphyseal osteotomy was done in our study because the epiphysis at the depressed medial tibial plateau was flattened out against the physis. Attempting to carry out intra-epiphyseal would injure the physis. Bar-On *et al*. and other authors were able to carry out intra-epiphyseal osteotomy because the epiphysis at the medial end was big enough. Bar-On *et al*. treated four patients successfully.[9]

In this study, we were able to reduce the TFA from a mean varus of 24.8° (range of 16–30) to a mean varus of 1.8° (range of 5° valgus to 7° varus) [Tables 1 and 2]. Although 5°–7° valgus was the aim of treatment, 5°–7° varus was achieved in some patients in our study. This may be a consequence of recurrence that is characteristic of the disease. However, patients are still being monitored for recurrence and possible revision. We achieved a reduction of an average of 21° in the varus deformity and a 47 mm reduction in MAD. Pandya *et al*.[2] achieved a 40.2 mm reduction in MAD and 15.9° reduction in TFA with the use of the MAC device, while Gordon *et al*.[10] achieved a reduction of 107 mm in MAD with the use of Ilizarov device. With the Ilizarov device, Feldman *et al*.[11] corrected MAD from 55.8 mm (range of 44–77 mm) to 4.9 mm (range of 2–11 mm), Alekberov *et al*.[12] achieved a reduction in TFA from 28° varus (range of 20°–39°) to 7.5° valgus (range of 0–18), Hefny *et al*.[7] corrected TFA from 36° varus (20°–47°) to 4° valgus, and Eidelman[13] corrected TFA 16.2° (12°–19°) to normal values. Our results compared with Alekberov *et al*. and Eidelman *et al*. We could not assess the influence of LRS on MPTA and PPTA corrections because the X-ray was not clear enough to measure these angles.

The operation time for LRS in this study was an averagely 90 min. This is less than the operation time for MAC device in the study done by Pandya *et al*.[2] who recorded 120 min on the average while a time of 150–180 min was recorded for Ilizarov device in studies done by different authors.[2,8] The device use time for LRS was on average 90 days while that for MAC devices was 130 days[2] and 150 days for ilizarov device.[9] The reason for the shorter duration was because the varus and internal torsion deformities have been corrected in the theatre acutely by the surgeon while the MAC and Ilizarov devices spent time correcting these deformities during the postoperation period.

The morbidity seen in the use of LRS includes pain, pin site infection, and tearing of the skin. Pain was easily managed by analgesics and muscle relaxant while pin-tract infection was managed by antibiotics (determined by wound swab microscopy, culture, and sensitivity), daily cleaning of the wound with normal saline and methylated spirit and dressing with povidone-soaked gauze. These morbidities are also seen with Ilizarov device. The morbidity associated with Ilizarov device from multiple pin sites is much more than with the use of LRS and the risk of impaling neurovascular structures is almost nonexistent with the use of LRS when compared with Ilizarov device. This is because the pins in the LRS are much less and they are applied in a unidirectional way, well away from the neurovascular structures while that of the Ilizarov are more in number and they are applied in a multi-directional way and this increases

Table 1: Sociodemography and preoperation clinical findings

Age (years)	Sex	TFA (° varus)	IT (°)	MAD (cm)	LLD (cm)	Lax collateral ligament	Medial knee pains	Lagenskiold grade
5	Female	16	−10	3.1	2	Present	Present	IV
14	Male	30	−20	5	3	Present	Present	IV
12	Male	18	20	8	3	Present	Present	IV
8	Female	25	−35	6	4	Present	Present	IV
15	Female	30	10	9.6	5	Present	Present	V
12	Male	25	−10	6	4	Present	Present	V

The negative value of the IT indicates internal torsion while a positive indicates external torsion. TFA: Tibiofemoral angle, IT: Internal torsion, MAD: Mechanical axis deviation, LLD: Limb length discrepancy

Table 2: Treatment outcome, morbidity and complications

TFA	LLD	MAD	IT	Lax collateral ligament	Duration of stay (days)	MORBIDITY
5° valgus	0	0	−10	Absent	7	Pain and skin tearing
7° varus	0	2.7	−10	Absent	14	Pain, skin tearing numbness and inability to dorsiflex the big toe
7° varus	0	2.6	−10	Absent	14	Pain, pin site infection and skin tearing
5° varus	0	0	−10	Absent	14	Pain and skin tearing
5° valgus	0	2.9	−10	Absent	14	Pain and skin tearing
5 valgus	0	0	−10	absent	14	Pain, skin tearing, and pin site infection

TFA: Tibiofemoral angle, IT: Internal torsion, MAD: Mechanical axis deviation, LLD: Limb length discrepancy

the chances of impalement of neurovascular structures. The Schanz pins of LRS are safer to manage when compared to the bent sharp tips of Ilizarov wire, which can injure the caregiver if not properly bent. Acute compartment syndrome has been reported to occur with corrective osteotomies in the proximal tibia as a common complication.[8] This was the reason why a prophylactic fasciotomy was routinely done for all the cases. Recurrence of deformity and malunion has been observed by other authors with the use of the Ilizarov device.[2,8] In this study, numbness and weakness of the big toe were recorded in one patient only. This was also witnessed by other authors in their study also. Megahed observed that the peroneal nerve palsy is often seen in patients with severe varus angulation and posited that the correction of the marked deformity plus added correction of the internal torsion often resulted in the nerve palsy.[8] Megahed *et al*. advocated that prophylactic peroneal nerve release be done to overcome this problem.[2,8]

The learning curve for the LRS in both patients and doctors is much shorter and as such the duration of patient stay in the hospital is much less than when Ilizarov is used. The frequency of outpatient visits is also much less as the chance of making mistakes and patients' complaints are less when compared with Ilizarov device. It takes a shorter time to treat Blount's disease with LRS than with Ilizarov device. This is because the varus aspect of deformity has been corrected on the table during surgery for the LRS while with Ilizarov device; correction is achieved gradually with the device, which takes time to achieve. The LRS device is cheaper and more readily available than the Ilizarov device and TSF. It is, therefore, more cost-effective to use LRS than the Ilizarov device or the TSF.

The outcome of treatment was good for all the patients according to Schoenecker *et al*.'s[4] criteria. The patients and parents were very happy with the outcome [Figures 8, 9].

The LRS is less stable than ilizarov device over time; hence, the patient is not encouraged to bear weight with it like patients with ilizarov device. The pins undergo loosening from osteolysis over time. The patients are advised to bear no weight during the distraction process. It also has more stress riser effect than ilizarov because of the large diameter size of the pins and so easily predisposes the tibia to fracture at the pin sites. At the end of distraction, an above-knee fibercast is applied immediately on the limb bearing the LRS to protect the patient from this problem. The patient is then able to ambulate both with initial partial weight-bearing and later full weight-bearing as the regenerate consolidates.

Figure 9: 2 weeks after removing device (standing)

Conclusion

The combined use of the acute method and gradual method in the treatment of Blount disease has been made possible by double osteotomies in the proximal tibia and LRS device. This method of treatment is very easy for both patients and surgeons to carry out and also very cost-effective. Although the patient volume is small in this study, it is a preliminary study. We want to request other surgeons to apply it and share their experience in the use of this treatment method as well.

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Conflicts of interest

There are no conflicts of interest.

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