

Original Research Article

Blount's disease treatment outcome with Taylor spatial frame in low resource settings

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ABSTRACT

Background: Blount's disease is a developmental condition defined by abnormal growth of the proximal posteromedial tibial physis, which causes progressive lower limb deformity. The deformity is primarily characterized by tibia vara, procurvatum, internal tibial torsion and limb shortening. To evaluate the outcome of treatment of Blount's disease using circular external fixation Taylor spatial frame (TSF).

Methods: The limb deformity correction unit of the Orthopaedics and Trauma Department of University College Hospital, Ibadan conducted a 5-year retrospective assessment of patients who had Blount's disease correction using the TSF device between January 2019 and July 2023. The data was analyzed using the Social Sciences Statistical Package, Version 19.

Results: 42 patients were recruited with 68 limbs. 26 patients (62%) had both right and left lower limb deformities. The majority were young adolescent in the age group of 11–15 years. And a male-to-female ratio of 1:2.81. They all had TSF frame application, fibulotomy and metaphyseal (proximal tibia) corticotomy and subsequently had graduated adjustment of the frame until correction is achieved, following the prescription generated from the TSF software. The highest complication observed was pin site infection in 10 patients (23.8%).

Conclusions: The TSF device is considered one of the most reliable methods of achieving safe and accurate correction of the multi-planar deformities associated with severe and recurrent Blount's disease.

Keywords: Blount's disease, Limb deformity correction, Proximal tibia osteotomy, Taylor spatial frame

INTRODUCTION

Blount's disease is a developmental condition defined by abnormal growth of the proximal posteromedial tibial physis, which causes progressive lower limb deformity. Blount's disease is an unequal proximal tibial growth condition distinguished by a three-dimensional deformity. The deformity is primarily characterized by tibia vara, procurvatum, internal tibial torsion and limb shortening. It has a prevalence of less than 1% in the United States and around 0.03% in South Africa. Negroid race is a risk

factor. It is frequent in males, obese individuals, early walkers (<1 year) and anyone with a family history of Blount's disease. Approximately 80% of infantile Blount's disease affects both limbs, whereas 50% of late-onset tibia vara disease is bilateral.¹ Blount's disease has two clinical types: infantile or early-onset and adolescent or late-onset, which are defined by whether the first symptoms appear before or after the age of ten. Blount's disease is frequently referred to as infantile tibia vara and osteochondrosis deformans. It is the second most prevalent cause of bowing (genu varum) immediately after physiologic genu varum.

The radiography results serve as the primary guide for therapy. Typically, with a metaphyseal diaphyseal angle $>11^\circ$. There is more growing time left in infantile tibia vara, hence, the degree of deformity is higher.² The etiology of Blount's disease is uncertain. However, several causes have been identified as contributing to the malformation. The proximal medial tibial metaphysis experiences altered endochondral bone development as well as asymmetric compressive pressures. Mechanical considerations include body weight, age at walking, considerable physiologic varus deformity with ligament stretching and developmental retardation at the medial tibial physis, consistent with the Hueter-Volkman principle.³ The dynamic component of the deformity in the obese coupled with varus movement of the knee and stretching of the ligament. The resulting varus deformity further increases the loading of the medial tibial physis, setting up a vicious circle. This causes medial deviation of the limb's mechanical axis, resulting in a multiplanar deformity varus, procurvatum, internal tibial torsion and shortening.²

Histologic examination of the damaged physis reveals islands of tightly packed cartilage cells with more hypertrophy than predicted for their location in the physis, islands of practically acellular fibrocartilage and unusually large clusters of capillaries. The physeal cell columns become uneven and haphazard in the organization, disrupting normal endochondral ossification. Both in the medial portion of the metaphysis and in the equivalent section of the physis. The varus deformity progresses as long as ossification fails and development proceeds laterally. In the latter stages of deformity, a bone bridge may bind medial development and the medial tibial plateau may appear to be deficient posteromedially. The lacuna is most likely unossified aberrant fibrocartilage, whose delay in ossification results in the appearance of a defect and is directly connected to the underlying histology. Joint laxity on the lateral side of the knee is common in untreated or recurring abnormalities.⁴

Physiological bowing, unlike Blount's disease, may persist for up to 2 years and may resolve. The deformity develops via the proximal tibia and may extend to the distal femur and tibia. There is no lateral thrust or knee joint laxity in Physiological bowing, as observed in Blount's disease. Usually, the metaphyseal-diaphyseal angle is smaller than 110° . Blount's disease often has a higher threshold than 150° . The Langenskiöld classification is the radiological staging of disease progression based on different degrees of epiphyseal depression and metaphyseal fragmentation. The Langenskiöld publication in 1952 also included general prognostic guidelines. Restoration to normal was prevalent in disease stages I and II and achievable in stages III and IV, while disease stages V and VI were linked with recurrence and lasting sequelae following mechanical realignment surgery (osteotomy).¹ The natural history is that of the progression and worsening of bowing when not treated. Significant improvements have been achieved in recent years, notably in terms of identifying disease

phases, understanding the three-dimensional structure of the deformity and developing therapeutic alternatives. Nevertheless, the specific etiology of Blount's disease remains unknown. The condition is commonly seen as a complication of childhood obesity, particularly among Afro-Caribbean populations. Earlier stages are more amenable to management, which includes active surveillance and bracing, but later stages may require surgical treatment. Recurrence is a common complication and is more frequent for osteotomies done at an earlier age (80% recurrence rate) than for osteotomies done at an older age (20% recurrence rate).²

The diagnosis is obtained after a clinical evaluation of the patient. The aim of the investigation is to confirm the diagnosis, rule out possible differentials (such as physiologic genu varum, Rickets, trauma to proximal tibial physis, metaphyseal chondrodysplasia, focal fibrocartilagenous dysplasia, osteomyelitis of proximal tibial metaphysis) and assess the patient's fitness for surgery. The main investigation tool is a scanogram (standing x-ray) of both lower limbs to estimate mechanical axis deviation (MAD) and the magnitudes of the deformities in three views, Anteroposterior, Lateral and axial views (six axis assessments). Patients with unilateral Blounts disease always present with leg length disparity with the affected side shorter than the normal side. The best treatment for this category is therefore a gradual correction using the Ilizarov circular external fixator or the computer assisted circular external fixator (hexapod) to simultaneously correct the multiaxial deformities including the length disparity. An MRI scan characterizes the extent of the ossified and cartilaginous epiphysis along with any physeal anatomic disruption. An MRI scan may help with preoperative planning by determining the size of the physeal bridge and the presence or absence of a genuine intraarticular deformity. A CT scan (with 3D reconstruction) may better determine the severity of the accompanying bone deformities. Other tests include a complete blood count, serum electrolytes and urea, total protein albumin, alkaline phosphatase, serum calcium and phosphate, vitamin D testing and viral indicators.²

The existence of Genu Varum after two years of age is considered abnormal. Blount's disease has a better prognosis with definitive therapy starting at the age of four. The possibility of recurrence should be explained to parents and caregivers at the start of treatment. Additional iatrogenic physeal injury should be avoided during operative treatment to preserve the growth plate as much as possible. Surveillance and bracing for non-operative care could be used in the management of Langenskiöld stages I and II and patients <3 years with an MDA of $11-150^\circ$ and a high level of compliance. While more advanced stages (III to VI) can be managed either using the acute correction approach with corrective osteotomies followed by cast immobilization or the gradual correction approach with growth modulation surgeries (physeal curettage or hemi-epiphysiodesis with 8-plate, staples and pinning) or

the use of proximal tibial osteotomies or corticotomies and the application of circular external fixation for deformity correction. However, acute correction seems faster, easier and more immediate deformity correction, while the advantage of gradual correction is reduced complications like neurovascular injuries.⁴ Treatment should begin promptly by restoring the structure of the epiphysis, the knee's anatomical axis and merging all growth cartilage while projecting the leg length disparity. A tibial lengthening is performed to meet the expected limb length disparity up to the patient's growth limit, as well as plateau elevation, varus correction and internal rotation deformity repair. Using a Taylor spatial frame, this surgery is conducted in the metaphyseal region of the growth cartilage closest to the major location of the defect (Figure 1).⁵ The objective of the study is to evaluate the outcome of treatment of Blount's disease using Circular external fixation (TSF).

METHODS

The limb deformity correction unit of the Orthopaedics and Trauma Department of University College Hospital, Ibadan conducted a 5-year retrospective cross-sectional observational study of patients who had Blount's disease correction using the Taylor Spatial Frame device between January 2019 and July 2023. A total of 42 patients were retrieved during this period. The patients were referred from various private and general hospitals within the south west and other geographical zones of Nigeria. The cases were traced using clinic, ward and theatre medical records as well as the TSF software application (software version 5.4).

The Ethical Review Committee of the University/University of Ibadan Hospital provided ethical approval.

The clinical and operative details of these patients were retrieved and analyzed. Clinical information extracted from the records included patients' demography, such as; age, sex, weight, height, BMI, presenting complaints, affected limb (unilateral or bilateral), primary disease or recurrence, clinical and radiological preoperative and post-operative features of the patients including Langenskiold stage, deformity parameters (medial proximal tibia, angle for degree of varus deformity, proximal posterior tibia angle for degree of procurvatum/recurvatum, internal tibia torsion using the thigh-foot angles and the degree of the limb length discrepancies. Other clinical data retrieved were procedures performed (proximal Tibia osteotomy, physeal bar excision, medial hemiplateau elevation and distal femoral osteotomy), post-operative complications, post-operative management and outcome of treatment.

Inclusion criteria

All patients who had a metaphyseal corticotomy and fibulotomy, with skeletal stabilization using the TSF a type of Computer-Assisted Circular External Fixation (CACEF) for correction of Blount's disease.

Exclusion criteria

All patients who had acute correction of Blount's disease were excluded from this study and also patients who had other devices application besides the computer-assisted circular external fixation (CACEF) for correction of Blount's disease.

A post-operative wound review was done on the 3rd day following surgery and after it was satisfactory, the pin site wound dressings were commenced and measurements of parameters (deformity, frame, mount and strut parameters) were taken and inputted into the TSF software. The duration of treatment was determined and a prescription was generated by the TSF software application. Then strut adjustment is commenced from day 7-10. The patients were discharged home to continue strut adjustment and followed up in the clinic as soon as they are judged compliant with strut adjustment.

Struts changes were done as required during follow up visits. After the correction of deformities, an x-ray was done to evaluate the radiological correction. Residual deformities were corrected in patients whose initial deformities were not fully corrected after the end of the initial TSF prescriptions or sometimes second or third as the case may be. Prescriptions were generated and followed through till deformities are fully corrected and adjusted by clinical and radiological parameters. The TSF device was left in situ and removed after about twice the duration of the adjustment of the strut for deformity correction.

The end of treatment is ultimately determined by the presence of clinical and radiological evidence of union. After removing the TSF device, an above-knee POP cast was applied to support the limb for two weeks. Then the patient was followed up in the clinic for the removal of the cast and the limb was examined to compare the parameters with pre-operative deformity parameters.

Statistical analysis

The data was analyzed using the Social Sciences Statistical Package, Version 19. The results were presented in simple proportions using tables and charts.

RESULTS

In our study, 42 patients were recruited with 68 limbs. 26 patients (62%) had both right and left lower limb deformities. The left lower limb was more affected than the right lower limb for those with unilateral limb deformities (Table 1). For the unilateral cases, the mean pre-op LLD was 6.24 cm (range: 2–12 cm). The majority were in the adolescent age group of 11–15 years (Table 1). And a male-to-female ratio of 1:2.8 (Table 1). 72% were obese with a BMI > 95% percentile (Table 1). Thirty (30) cases had primary surgery, while 12 cases were recurrent (Table 1). 5 patients have had 2 or more surgeries prior to

their presentations. For the skeletally immature (37 limbs), Langenskiold stage was III in 3 (7%), IV in 10 (24%), V in 17 (40%) and VI in 12 (29%) (Figure 1).

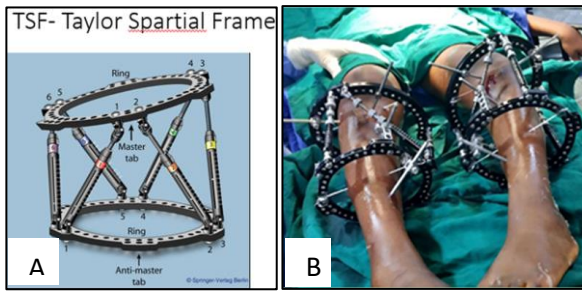


Figure 1: (A & B) The (TSF-Smith and Nephew Richards, Memphis, Tenn) is a circular external fixator with two rings or partial rings joined by six telescopic struts. It employs computer-based 6-axis deformity correction.

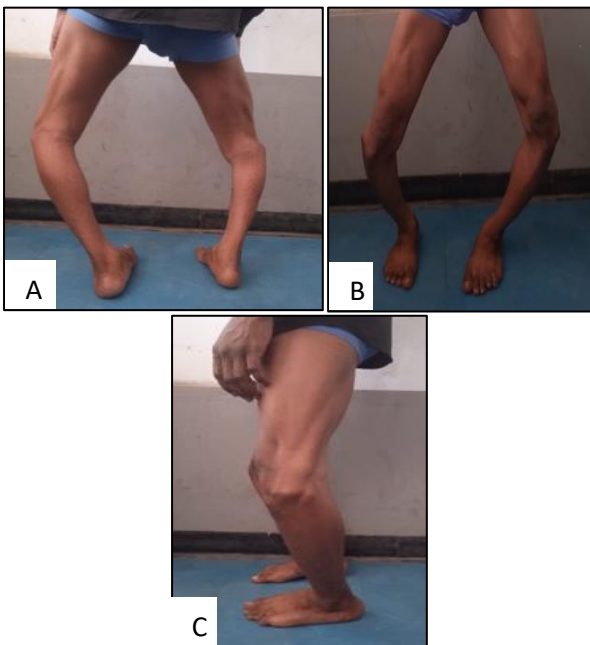


Figure 2: (A-C) 15 years old Boy with bilateral Blount's disease before correction with TSF device.

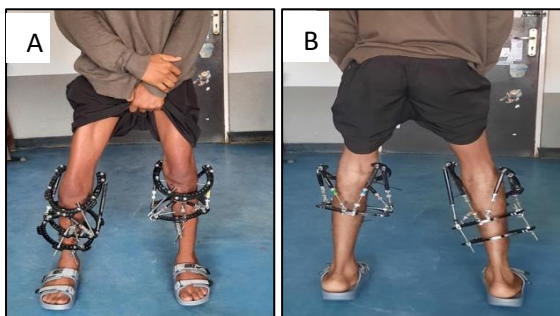


Figure 3: (A & B) After correction of deformity with TSF device.



Figure 4 (A and B): 5-year-old girl with bilateral Blount's disease.

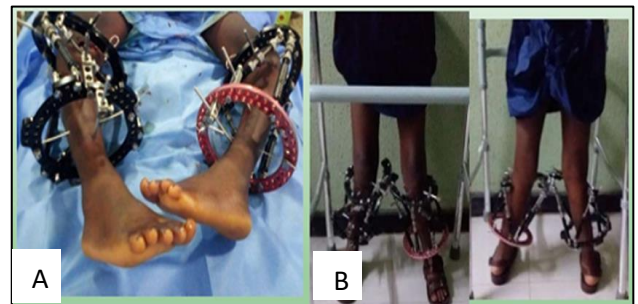


Figure 5 (A and B): Before TSF strut adjustment and after TSF strut adjustment.

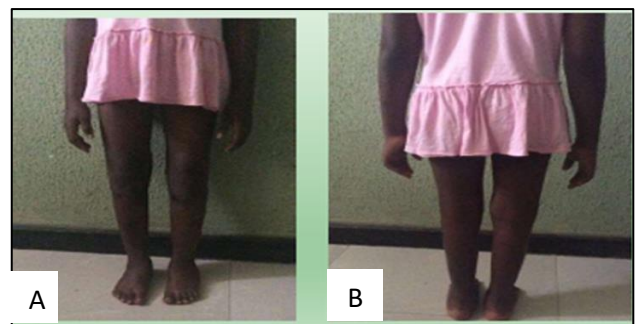


Figure 6 (A and B): After deformity correction and removal of TSF Device.

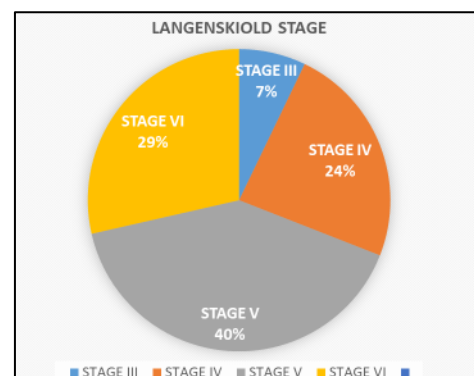


Figure 7: For the skeletally immature (37 limbs), Langenskiold stage was III in 3 (7%), IV in 10 (24%), V in 17 (40%) and VI in 12 (29%).

The pre-operative mean varus angle in this study was 38° (range: 20°-90°) (MPTA of 51.4°, range: 0°-70°). Post-operative mean varus angle was 2.45° (range: 12°-8° valgus).

Mean MPTA 87.55° (range: 78°-98°). The mean post-intervention thigh foot angle was 1.36° (0°-10° ext rotation). The mean pre-op procurvatum was 35.08° (range: 10°-75°). Mean post-treatment procurvatum was 3.8° (range: 0°-20°). They all had TSF frame application, fibulotomy and Proximal Tibia metaphyseal corticotomy (Table 2).

There was residual shortening of 2 cm in 1 patient who inadvertently stopped distraction after achieving angular deformity correction and this was later corrected by another prescription.

A patient over-lengthened his limb by 3 cm and had to be compressed with the frame. Others achieved equal limb lengths. The highest complication observed was pin site infection in 10 patients (23.81%) (Table 3).

Blount's disease affected majority within the early adolescent age group. Blount's disease affects both limbs more than a single limb. 42 patients with 68 limbs were analyzed. And for the unilateral cases, Mean Pre-Op LLD was 6.24 (range: 2 -12).

Most of the patients are Obese with more than 95% percentile of Body mass index. Thirty (30) cases were primary surgery while 12 were recurrent cases. 5 patients have had 2 or more surgeries previously.

Table 1: Sociodemographic data.

Variables	Frequency	%
Age (In years)		
<5	0	0
6-10	14	33
11-15	22	52
16-20	3	7
21-25	1	2
26-30	0	0
>30	2	5
Sex		
Male	11	26
Female	31	74
Affected limb		
Right limb	6	14
Left limb	10	24
Both limbs	26	62
Body mass index		
<95%	12	28
>95%	30	72
Blount's disease at time of presentation		
Primary cases	30	71
Recurrent cases	12	29

Table 2: Some adjunctive procedures are often required to prevent or minimize recurrence especially in the growing child.

Procedure	Frequency	%
Physal bar excision	2	4.76
Medial hemiplateau elevation	8	19.05
Distal femoral osteotomy	7	16.67
TSF frame+fibulotomy+Metaphyseal Corticotomy	42	100

Table 3: Complications following the application of the TSF for treatment of blount's disease.

Complication	Frequency	%
Pin Track infection	10	23.81
Wound dehiscence	1	2.38
Ankle equinus during treatment	2	4.76
Knee stiffness	4	9.52
Compartment syndrome	0	0
Stress fracture post treatment	0	0
Peroneal nerve palsy	0	0
Delayed regenerate consolidation	5	11.90
Premature regenerate consolidation	1	2.38
Regenerate bending post treatment	1	2.38
Skin blistering	3	7.14

DISCUSSION

The Taylor-Spatial Frame (TSF-Smith and Nephew Richards, Memphis, Tenn.) is a circular external fixator with two rings or partial rings joined by six telescopic struts. It employs computer-based 6-axis deformity correction.⁶ Since its conception, the TSF has mostly been utilized to treat fractures and deformities in adults. The frame has recently been characterized as being used exclusively to repair infantile and adolescent tibia vara and other pediatric limb abnormalities.^{5,7} Acute correction with internal fixation precludes partial weight bearing postoperatively and may necessitate the use of a long-leg cast. This is especially troublesome in adolescent tibia vara since mobility is strongly valued in these fat children. Gradual correction also has an advantage of less complication rate of neurovascular injuries and compartment syndrome.

Feldman et al, conducted a direct comparison of acute and progressive correction in 14 and 18 juvenile patients with Blount disease, respectively. They discovered that individuals who underwent progressive correction were more likely to achieve correction to within 3 degrees of the normal mechanical axis. All of our patients were gradually corrected using TSF, with a mean post-correction variation of 2.45 degrees.⁷ Stanitski and colleagues studied 17 individuals (25 tibias) with teenage tibia vara who were

treated with the Ilizarov procedure. Tibia varus improved from 27 degrees before surgery to within 5 degrees of normal thereafter. In our series, the mean pre-operative varus was corrected from MPTA of 51.40 to 87.55°. In contrast to the study conducted by Ying Li et al, whose patients remained in hospitals (15 to 33 days) until correction was achieved because they were unable to follow through on the prescription. Our patient's hospitalization period ranged from 10 to 14 days.⁸

Van Olm identified a peroneal nerve palsy in 15% of 100 cases and a compartment syndrome in 6%. Steel et al, discovered an 18% overall rate of neurovascular problems. Pinkowski and Weiner reported 11 percent of problems, including one delayed union and three superficial infections. There were no neurovascular problems in the 37 proximal tibial osteotomies done for deformity correction in our study. Furthermore, none of the participants in our research experienced compartment syndrome.⁹

The natural history of severe Blount's disease is characterized by increasing medial proximal tibial physeal development disruption, which finally leads to the production of a bony bar that generates a complicated 3D deformity with continued growth. Any varus repair that fails to address this medial physeal arrest will result in under-correction and recurrence. Because of the grotesque character of emerging abnormalities in their extreme forms, basic osteotomies with internal fixation are frequently ineffective and dangerous. As a result, the TSF device offers a safe and effective therapeutic option for gradually correcting congenital malformations.^{5,8}

The TSF enables for the simultaneous treatment of varus, torsion, procurvatum and limb length anomalies with few incisions as was achieved in the patients in our study. It may allow for complete weight-bearing during therapy. In a growing child with severe Blount's disease, the goal is to overcorrect the deformity to moderate valgus and equalize the limb to a magnitude established by predicting the remaining development. The age and severity of the disease have a significant impact on treatment outcomes (Doyle et al). Infantile tibia vara has a favorable prognosis and minimal recurrence incidence. Late-onset has a severe varus deformity, which influences the severity and extent of physeal injury.¹⁰⁻¹²

The majority of the patients have not reached skeletal maturity; thus, it is vital to follow them up until growth completion. The peculiarity of patients seen in our environment has made the advent of TSF useful as they present late, as they initially present to quacks and also present with recurrence and fibrosis. Patients should be followed up and monitored for wound healing, knee joint movement, deformity correction, limb length of the growing child and recurrence. Late patient presentation, high cost of frame or out-of-pocket spending for care, lack of an image intensifier and poor imaging by radiographers, lack of facility for long leg cast, technical difficulty/steep

learning curve, long-term follow-up and overcorrection/adjustment of struts are some of the challenges in managing Blount's disease using the TSF device in our environment.

CONCLUSION

Caregiver education improves the prognosis of individuals with Blount's disease. Before diagnosing Blount's illness, other possibilities should be examined. The TSF device is considered one of the most reliable methods of achieving safe and accurate correction of the multi-planar deformities associated with severe and recurrent Blount's disease.

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