Correction of adolescent blount deformity by external fixator: gradual versus acute correction

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Background
Treatment of adolescent Blount disease remains challenging. Correction of the deformity in the form of derotation, angulation, and translation is usually required. External fixator is the best fixation method for deformity correction in Blount disease.
The aim of this study is to compare the results of acute and gradual deformity correction with external fixator.
Methods
27 patients (38 knees) with adolescent Blount disease were divided into 2 groups and underwent either acute correction (19 limbs) or gradual correction (19 limbs). There were no significant differences in patient demographics or preoperative deformity parameters in either group. The external fixator used for acute correction was that described by Khanfour and El-Rosasy, and Ilizarov fixator was used for gradual correction group.
Results
There was a statistically significant improvement between the preoperative and postoperative parameters of deformity in each group. There was no statistically significant difference between postoperative deformity parameters in either group. Mean fixator time and median operative time were shorter in the acute correction group.
Conclusion
Both acute and gradual correction of Blount disease with an external fixator produce satisfactory results. The choice of correction method should depend on surgeon preference, patient compliance, and degree of deformity.

Keywords:
acute versus chronic, adolescent blount disease, external fixator

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Introduction

Blount disease is an asymmetric developmental disorder of the postero-medial part of the proximal tibial physeal plate that ends in a three-dimensional deformity [1].

Two clinical types of Blount disease exist, the infantile (early-onset) and adolescent (late-onset) types. This classification is based on whether the deformity started before or after 10 years of age. In contrast to the infantile Blount disease, the adolescent type is more common in obese male patients, tends to be unilateral, and the proximal tibial varus deformity is usually less than 30° [2,3].

Correction of Blount disease deformity includes the correction of varus angulation, rotation, and length discrepancy. The best strategy for correcting these deformities either by acute or gradual methods is still debatable. The mechanical axis can be corrected acutely and fixed by either plate and screws, external fixator, or intramedullary nail [4–6].

Proximal tibial osteotomy in adolescent Blount disease is performed distal to the center of rotation and angulation (CORA) to avoid injury to the proximal tibial physis (Osteotomy Rule II). Fixation of the osteotomy by either a plate and screws or nail is difficult because of the lateral translation of the distal tibial fragment. Therefore, questions have been raised about the safety of acute correction based on the concept of osteotomy rule II and fixation with an external fixator module [7].

Many authors have shown the advantages of gradual correction of the deformity with a circular external fixator, including fine-tuning of the deformity correction. However, this technique requires a high degree of patient compliance and carries an increased risk of pin tract infection [8–11].

To date, however, there has been insufficient discussion of the outcomes of gradual deformity correction of adolescent Blount disease compared with acute correction using external fixation.

Materials and methods

This is a retrospective clinical study of 27 patients (38 knees) who had adolescent Blount disease. It was conducted between January 2016 and March 2021. It was approved by the IRB of our institution and the legal guardians of each child signed an informed consent. Eligibility criteria included patients aged 10 years and older, with a varus tibial femoral angle (TFA) greater than 15° and a mechanical axis deviation (MAD) greater than 25 mm medial to the tibial spine. Patients with severe deformities with a tibiofemoral angle greater than 40 degrees and unilateral cases with an expected leg length discrepancy after deformity correction more than 1 cm were excluded.

In this study, there were two groups with two different treatment modalities. The first group (13 patients) received acute correction of the deformity by an external fixator consisting of components of the Ilizaorv device as described by Khanfour and El-rosasy [7]. The second group (14 patients) underwent gradual corrective surgery with Ilizarov fixator.

As for the demographic data of the patients in each group (Table 1). In the first group, there were 19 limbs in 13 patients (9 males and 4 females). These were 6 bilateral and 7 unilateral cases. In the second group, there were 19 limbs in 14 patients (9 males and 5 females). These were 5 bilateral and 9 unilateral cases. The mean follow-up time in the first and second groups was 3 and 2.9 years, respectively.

Preoperative evaluation

Patients were examined both clinically and radiologically. Clinical evaluation focused on the assessment of rotational deformity and the presence of lateral thrust. Long standing X-ray of both lower limbs were obtained for sagittal and coronal plane deformity analysis. Mechanical axis deviation (MAD), tibio–femoral angle (TFA), medial proximal tibial angle (MPTA), and posterior proximal tibial angle (PPTA) were measured and compared in each group.

Surgical technique

In the supine position and under general anesthesia, the affected limb was sterilized and draped. A tourniquet was not used.

Initially, fibular osteotomy was performed via the lateral approach in the middle third of the fibula in both groups.

The acute correction group

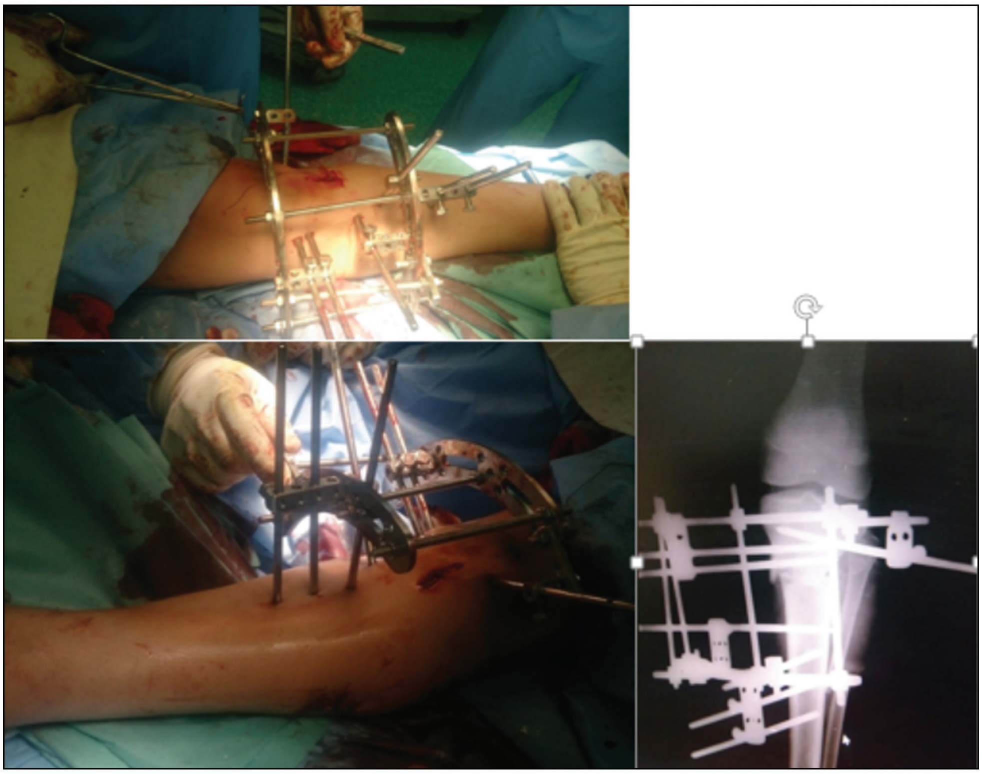
External fixator consisting of two symmetrical femoral arches connected by 4 connecting rods was prepared preoperatively. Under image intensifier control, two 6-mm Shanz screws were inserted just distal to the proximal tibial physeal plate parallel to the knee joint. The tibial osteotomy was then performed distal to the tibial tuberosity using an osteotome after multiple drilling with preservation of the periosteum. The deformity was then corrected sequentially, we began correction with derotation, translation, angulation, and finally extension if a procurvatum deformity was present. Tibial rotation was assessed by evaluating the relationship between the tibial tuberosity and the second toe of the plantigrade foot. The preassembled construct was then applied to the leg and secured to the proximal segment with the proximal 2 Shanz screws. An additional 2 Shanz screws were then inserted through the construct into the distal segment. Additional Shanz screws (1–2) were inserted at different planes in both the proximal and distal segments for more rigid fixation (Fig. 1). Intraoperative correction of the varus deformity was assessed by the diathermy cable that ran from the center of the hip joint to the center of the ankle joint, with the patella facing forward under the image intensifier. Simultaneous bilateral correction of both limbs was performed in only two of six bilateral cases.

Table 1 Patient demographics in both groups

	Age (years)		Side		Sex		Mean follow up period (in years)
	Mean (Range)	Std. deviation	Right	Left	Male	Female	
Gradual correction group (n 14 cases) (n 19 Limbs)	11.7857 (10-15)	1.52812	7 (36.8%)	12 (63.2%)	9 (64.3%)	5 (35.7%)	2.92 ± 0.73 3 (2–4)
Acute correction group (n 13 cases) (n 19 Limbs)	12.3077 (10-15)	1.75046	10 (52.6%)	9 (47.4%)	9 (69.2%)	4 (30.8%)	3 ± 1 3 (1–4)
P value	0.443		0.328[a]		1.000[b]		0.700[a]

[a]Pearson Chi-Square test.
[b]Fisher's Exact Test.

Figure 1



Clinical and radiological photos of the external fixator construct used in acute correction group.

The gradual correction group

A preassembled Ilizarov frame consisting of one or one and 5/8 rings proximally, depending on the patient's body weight, and a distal base frame consisting of two symmetrical rings were prepared preoperatively. The proximal and distal constructs were connected by two hinges and one or two distractors, depending on the body weight. A reference wire and two appropriately sized half-pins were usually attached to the proximal ring, and three half-pins were attached to the distal ring in different planes. Tibial osteotomy was the final step of the procedure, performed through a 2 to 3 cm anterior incision.

Postoperative care and follow-up

In both groups, active knee and ankle motion were allowed as tolerated from the 1st postoperative day. The patients were allowed to weight bearing as tolerated after the 2nd postoperative week at the time of stitches removal.

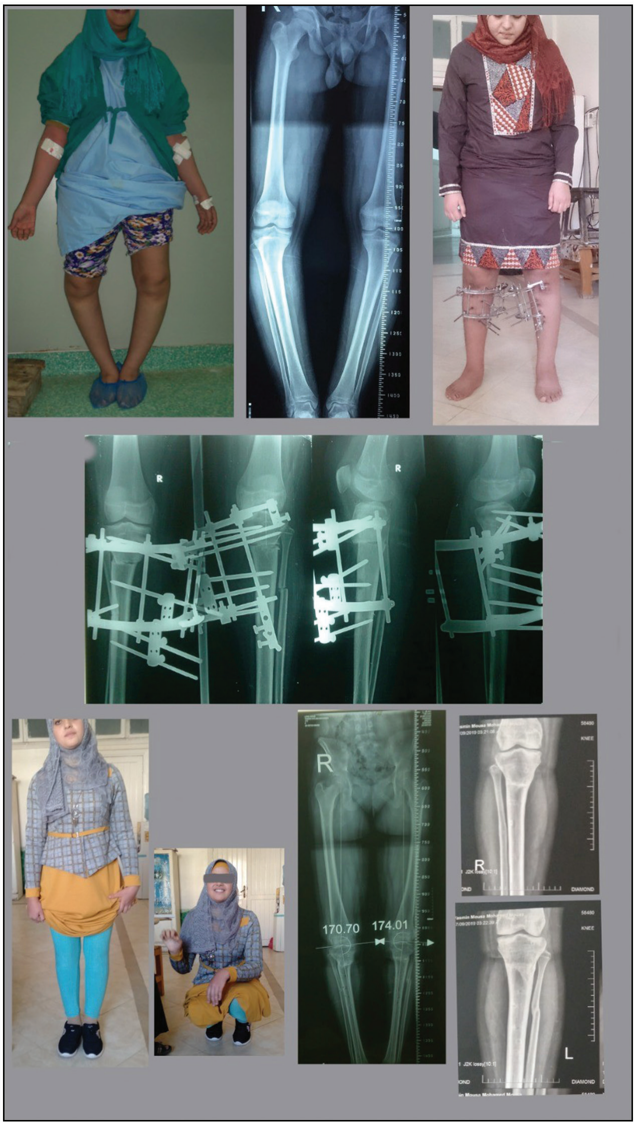
The patient or his parents in the second group were instructed to begin gradual correction of deformity at the 10th postoperative day at a rate of 1 mm per day.

Clinical and radiologic follow-up was every 2 weeks until union of the cortectomy and complete correction of the deformity (gradual group). The fixator was removed under anesthesia after a dynamization period of at least 2 weeks. Figures 2 and 3 shows serial clinical and radiologic follow-up of a case of acute correction and gradual correction respectively.

The clinical and radiographic deformity parameters of both groups were collected and compiled in tables. The tibial rotation was measured clinically using the foot thigh angle both preoperatively and at the final follow-up. While the patient was in the prone position and the knee was flexed 90 degrees, a clinical photo was captured and the angle between the long axis of the thigh and the foot was measured. Radiographically, patients underwent frontal plane analysis consisting of MAD, TFA, MPTA, and sagittal plane deformity analysis by measuring PPTA.

The results were evaluated in both groups according to the modification of the criteria of Schoenecker *et al.* [12]. One patient with a good outcome had no pain or instability of the knee. Also, the knee was perpendicular to the mechanical axis of the leg and had a deviation of less than 5° from normal values for age. Fair result was present if the patient had occasional pain in the knee that deviated 5° to 10° from perpendicular to the mechanical axis of the tibia. A poor outcome was assumed in patients with limited normal activity due to pain and joint space incongruence with osteophytes in the knee joint.

Figure 2



Fifteen years old female with bilateral Blount disease corrected simultaneously in acute manner with sequential clinical and radiological follow-up photos.

Figure 3

Fourteen years old boy with left sided Blount disease corrected gradually by Ilizarov fixator with sequential clinical and radiological follow-up photos.

Statistical analysis

Continuous variables were expressed as the mean±SD & range, and categorical variables were expressed as a number (percentage). Continuous data were checked for normality by using Shapiro Walk test. Mann-Whitney U test was used to compare two groups of non-normally distributed data. Percent of categorical variables were compared using Pearson's χ^2 test or Fisher's exact test when was appropriate. All tests were two sided. A P value <0.05 was considered significant. All statistics were performed using SPSS 22.0 for windows (IBM Inc., Chicago, IL, USA).

Results

There were no statistically significant differences between the two groups in age, sex, and side. Preoperatively, the magnitude of deformity, mean tibial rotation, tibiofemoral angle, MPTA, PPTA, and MAD were almost the same in both groups.

There was statistically significant improvement between the preoperative and postoperative parameters of deformity in each group (Table 2). Comparisons were made between the gradual and acute correction groups (Table 3). It was found that the total duration of external fixator was significantly longer in the gradual correction group (mean 15.78 ± 2.25 weeks) than in the acute correction group (mean 13.47 ± 1.57 weeks).

In the acute group, there was a statistically significant improvement in mean internal tibial torsion from 16.31 ± 7.23 degrees preoperatively to a mean external tibial rotation of 6.68 ± 4.53 degrees postoperatively at the last follow-up. The gradual correction group also experienced a statistically significant improvement in mean internal tibial torsion from 23.15 ± 11.92 degrees preoperatively to a mean external tibial rotation of 5.73 ± 3.75 degrees postoperatively. There were no significant differences in mean postoperative tibial rotation between the two groups (P=0.343).

As for MPTA, the mean angle in the acute group (89.05 ± 2.54) degrees was greater than the mean

Table 2 Comparison between preoperative and postoperative parameters in both groups by Wilcoxon signed ranks test

Parameters	Preoperative	Postoperative	*P* value
Gradual group			
Tibial torsion			
Mean±SD	-23.15±11.92	5.73±3.75	<0.001
Tibio-femoral angle			
Mean±SD	-28.31±6.64	5.78±5.15	<0.001
MPTA			
Mean±SD	65.94±7.73	87.57±1.26	<0.001
PPTA			
Mean±SD	77.26±7.78	81.68±4.28	0.001
MAD			
Mean±SD	-42.78±9.93	1±2.33	<0.001
Acute group			
Tibial torsion			
Mean±SD	-16.31±7.23	6.68±4.53	<0.001
Tibio-femoral angle			
Mean±SD	-24.21±7.12	6.47±4.24	<0.001
MPTA			
Mean±SD	67.42±5.16	89.05±2.54	<0.001
PPTA			
Mean±SD	81.78±3.45	84.10±3.54	0.004
MAD			
Mean±SD	-38.26±8.20	1.78±3.42	<0.001

angle in the gradual group (87.57±1.26) degrees at final follow-up. The mean tibio-femoral angle in the gradual group (5.78) was less than that in the acute correction group (6.47), but this was not statistically significant (P=0.905). The difference in mechanical axis deviation was also insignificant, with the mean MAD in the gradual correction group (1±2.33 mm) versus 1.78±3.42 mm in the acute group (P=0.235). The mean PPTA in the gradual group (81.68±4.28 degrees) was less than that of the acute correction group (84.10±3.54 degrees), but this was also not statistically significant.

As regards the operation time, the median operation time in the acute correction group was 80 [ranging from 60–90] minutes and the median operation time in the gradual correction group was 120 [ranging from 100–150] minutes.

As regards the complications, superficial pin-tract infection occurred in 6 cases in the gradual correction group and in 3 cases in the acute correction group. In all cases, the infection was cleared with a good dressing and antibiotics without the need for further intervention. Transient common peroneal nerve injury occurred in 1 case in each group, which improved spontaneously within 3 months. Recurrence was noted at follow-up in 2 cases in the gradual group and in one case in the acute group. The deformity was mild and accepted by the patients, who refused any further intervention.

Table 3 Comparison between gradual and acute group regarding study parameters

Parameters	Gradual group (*N*=19)	Acute group (*N*=19)	*P* value
Preoperative			
Tibial torsion			
Mean±SD	-23.15±11.92	-16.31±7.23	0.060[a]
Median (Range)	-20 (-45– -5)	-15 (-30– -5)	
Tibio-femoral angle			
Mean±SD	-28.31±6.64	-24.21±7.12	0.058[a]
Median (Range)	-25 (-39– -20)	-25 (-40– -15)	
MPTA			
Mean±SD	65.94±7.73	67.42±5.16	0.557[a]
Median (Range)	66 (50–78)	68 (60–75)	
PPTA			
Mean±SD	77.26±7.78	81.78±3.45	0.066[a]
Median (Range)	80 (62–85)	81 (75–87)	
MAD			
Mean±SD	-42.78±9.93	-38.26±8.20	0.159[a]
Median (Range)	-40 (-62– -30)	-37 (-53– -25)	
Postoperative			
Tibial torsion			
Mean±SD	5.73±3.75	6.68±4.53	0.343[a]
Median (Range)	6 (-4–10)	10 (-5–12)	
Tibio-femoral angle			
Mean±SD	5.78±5.15	6.47±4.24	0.905[a]
Median (Range)	7 (-5–12)	7 (-5–10)	
MPTA			
Mean±SD	87.57±1.26	89.05±2.54	0.007[a]
Median (Range)	88 (86–89)	90 (82–94)	
PPTA			
Mean±SD	81.68±4.28	84.10±3.54	0.130[a]
Median (Range)	81 (75–87)	85 (75–90)	
MAD			
Mean±SD	1±2.33	1.78±3.42	0.235[a]
Median (Range)	2 (-5–4)	3 (-5–5)	
Time in fixator (weeks)			
Mean±SD	15.78±2.25	13.47±1.57	0.002[a]
Median (Range)	16 (12–20)	13 (11–16)	
Schoenecker criteria			
Good	15/19 (78.9%)	15/19 (78.9%)	1.000[c]
Fair	4/19 (21.1%)	4/19 (21.1%)	
Recurrence			
Absent: No. (%)	17 (89.5%)	18 (94.7%)	1.000[b]
Present: No. (%)	2 (10.5)	1 (5.35)	

[a]Mann Whitney U test.
[b]Chi-square test.
[c]Fisher's Exact Test; *P* value<0.05 is significant.

Discussion

Treatment of Blount disease remains a therapeutic challenge [2]. There are many fixation methods after corrective tibial osteotomy in Blount disease, either by plate and screws, unipolar or circular fixators. As a method of fixation, the external fixator offers several advantages over internal fixation [7]. One of these advantages is the ability to adjust limb alignment in the postoperative period. The second is the rigid, secure fixation of the small proximal fragment. In addition to early weight bearing and feasibility of osteotomy site compression. Finally, the angulation and translation of the distal fragment that help the mechanical axis deviation correction can only be obtained and maintained using the external fixator [12–14].

The deformity of the adolescent Blount disease can be corrected either acutely or gradually using the external fixator. Many studies have been performed using the external fixator for either acute correction [5,7,9,15] or gradual correction [16–18] and little that compare between them [19,20].

In reviewing the literature comparing acute versus gradual correction, it was noted that most studies included small samples and mixed results of different types of Blount disease with different pathologies (infantile or adolescent). Gilbody and colleagues [19] recommended more prospective studies using the same fixation method for acute and gradual correction. To our knowledge this is the first study comparing the external fixator as a fixation method for acute versus gradual deformity correction in adolescent Blount disease.

In the current study, the mean degree of tibial torsion correction in the acute correction group was 22.9 degrees, the mean MPTA improved by 22 degrees, MAD changed by 40 mm, and the PPTA changed only slightly by 2.3 degrees. The results observed in this study mirror those of previous studies in which an external fixator was used for acute correction of Blount disease [7,9,15].

Khanfour and El-Rosasy [7], obtained a mean degree of acute angular correction of 33^0 which is consistent with our results (30 degrees). However, Price and colleagues [14], reported a lesser mean varus correction of 20 degrees, and Smith and colleagues [5], obtained a mean varus correction of 24.4 degrees. This may be attributed to using a monolateral fixators for acute correction.

Gradual correction of Blount disease with the Ilizarov external fixator is best for complex and severe deformities. Although the external fixator for gradual correction is more complicated than that for acute correction, some disadvantages of acute correction, such as common peroneal nerve paralysis, compartment syndrome, residual deformity, limb length inequality, and delayed union, are alleviated [16–18].

Stanitski and colleagues [11], performed a study on 25 tibias of obese patients with late-onset Blount disease and obtained axial alignment (within 5 degrees of normal) with the Ilizarov technique, which was similar to the results of the current study. In the study by Coogan and colleagues [8], the preoperative proximal tibial varus improved from an average of 18 degrees postoperatively to 2.5 degrees deviation from standard anatomic alignment. However, the results of the current study differ slightly from the previous studies by Gaudinez and Adar [21], whose series of 11 patients with adolescent Blount disease achieved a mean correction of the tibiofemoral angle of 16 degrees by monolateral gradual correction.

Our results show that there are no statistically significant differences in correction of the deformity parameters between the gradual and acute groups. We also found that the external fixator time was significantly shorter in the acute group than in the gradual group [P value = 0.002]. These results differ from those of some published studies (Gilbody *et al.* [19] and Feldman *et al.* [20]), which found that there was no significant difference in the external fixator time and also there was an evidence that gradual correction provided more accurate correction of the mechanical axis than acute correction. A possible explanation for this could be that these studies used Taylor Spatial Frame for gradual correction and monolateral fixators for acute correction.

The mean operative time in acute correction group [80 min] was shorter than that of the gradual correction group [120 min]. This allowed simultaneous correction of bilateral Blount disease in two cases in our series. It has the advantages of short treatment period with rapid recovery compared to the staged surgery. However, this causes loss of self-dependence of the patient with sleeping difficulties due to the presence of two external fixators. This represents a burden on the patient and the parents especially at the first two weeks after surgery.

We found that acute correction with a multiplanar external fixator is a simple well-tolerated option with shorter duration for the correction of mild to moderate deformities. Gradual correction with the Ilizarov external fixator should be used for complex severe deformities, especially in obese patients.

Limitations of this study include the relatively small sample size and short follow-up period.

Conclusion

Both acute and gradual correction of Blount disease with an external fixator gives satisfactory results. Mild to moderate deformities are better treated by acute correction with external fixator. However, complex severe deformities can only be treated by gradual correction.

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Conflicts of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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