Anteroposterior inverted-U proximal tibial osteotomy without internal fixation for correction of angular and torsional deformities in children with infantile tibia vara

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Background

An anteroposterior inverted-U proximal tibial osteotomy is a modification of the classical dome-shaped osteotomy. It improves the stability at the osteotomy site without losing the positive attributes of the dome osteotomy. There is no need for internal or external fixation when using this technique in children.

Aim of work

The primary objective of this study is to evaluate the efficiency of anteroposterior inverted-U proximal tibial osteotomy in achieving correction of the varus and internal tibial torsion in children with tibia vara and without the need of internal fixation.

Patients and methods

A total of 17 patients (24 legs) diagnosed as having infantile tibia vara were enrolled in this study. Their age ranged from 3 to 6 years, with a mean age of 4.02±0.84 years. Fourteen (58.3%) were male. The right side was affected in six (35.3%), whereas the left side was affected in four (16.7%), and seven (41.2%) were bilaterally affected. The patients were presented in different grades: nine (37.5%) grade I, 11 (45.8%) grade II, and four (16.7%) grade III. The anteroposterior inverted-U osteotomy was done in the form of two unicortical arcs. The first unicortical arc of perforations was made over the medial surface of the proximal tibia with its apex below the epiphysis and its base toward the shaft from posterior to anterior. Similar arc was performed over the lateral surface of the proximal tibia. The lowest parts of the medial and lateral arcs were connected to each other across the anterior border in front and across the posterior surface behind. The shape of the osteotomy with the downward projection of both posterior and anterior limbs prevents displacement of the osteotomy during the manual correction and the casting. Therefore, there was no need for any internal fixation of the osteotomy side.

Results

At the end of the follow-up period of 49.9±7.07 (36–60) months, a significant varus correction evidenced by a reduction in the mean intercondylar distance was noted postoperatively. The mean thigh-foot angle was much improved from −7.83±2.84° (5–15 in internal rotation) preoperatively to a postoperative value of 2.08±1.74° (0–5 in external rotation), indicating correction of the internal tibial torsion; this relation was statistically highly significant as well. The radiological parameters (tibiofemoral angle, mechanical axis deviation, and metaphyseal-diaphyseal angle) showed a significant improvement in the postoperative mean values when compared with the preoperative mean values. The tibia was well aligned in all the cases in the lateral view radiographs, and the cast was maintained in all the cases without change till the time of union.

Conclusion

From this study, it could be concluded that anteroposterior inverted-U osteotomy has a good safety profile and should recommend this technique to correct the varus and internal tibial torsion in children with tibia vara.

Keywords:
Blount; deformity, inverted-U, tibia vara, tibial osteotomy

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Introduction

Proximal tibial osteotomy has been the most frequently used form of surgical management in pediatric genu varum deformity. In the skeletally mature individuals, the osteotomy can be carried out through the old line of the upper tibial physeal scar. However, it is important to remember that in children, the osteotomy must be carried out while sparing both the proximal tibial physis and apophysis of the tibial tubercle [1,2].

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Many types of valgus osteotomies have been described for correction of genu varum, such as lateral closing wedge osteotomy, medial opening wedge, dome-shaped osteotomy, oblique tibial osteotomy, and the intraepiphyseal or transepiphyseal tibial osteotomy for severe deformity. Fixation methods can be quite achieved with cast, internal fixation devices, or the use of monolateral or circular frame external fixators according to the type of osteotomy [3–5].

On reviewing the literature, little relevant articles about tibial osteotomy in tibia vara were found; most of them were case reports or retrospective studies, and this may be attributed to the rarity of the incidence of Blount disease [6].

New techniques of angular deformity correction may offer decreased complications with increased safety and precision of correction. An anteroposterior inverted-U proximal tibial osteotomy is a modification of the classical dome-shaped osteotomy. It improves the stability at the osteotomy site without losing the positive attributes of the dome osteotomy. There is no need for internal or external fixation when using this technique in children [7].

The primary objective of this study is to evaluate the efficiency of inverted-U proximal tibial osteotomy in achieving correction of the varus and internal tibial torsion in children with tibia vara and without the need of internal fixation.

Patients and methods

This prospective study was approved by the local ethical committee of Alexandria Main University Hospital and was performed in accordance with the pertinent ethical guidelines (i.e. Declaration of Helsinki, as laid down in 1964 and revised in 2008). Written informed consent was obtained from all the participants. Seventeen patients (24 legs) diagnosed as having infantile tibia vara were enrolled in this study. Their age ranged from 3 to 6 years, with a mean age of 4.02±0.84 years. Fourteen (58.3%) were male. The right side was affected in six (35.3%), whereas the left side was affected in four (16.7%), and seven (41.2%) were bilaterally affected. The patients were presented in different grades: nine (37.5%) grade I, 11 (45.8%) grade II, and four (16.7%) grade III (Table 1). All the patients were subjected to thorough clinical examination after taking a written consent of their parents to be included in the study. The intercondylar distance (ICD) and the thigh-foot angle were measured to verify the degree of genu varum and internal tibial torsion, respectively. Preoperative radiological measurements were performed on long-standing anteroposterior radiograph and included the degree of mechanical axis deviation (MAD), the tibiofemoral angle (TFA), and the metaphyseal-diaphyseal angle (MDA). All these parameters were re-evaluated at the most recent visit, and these values were statistically compared with the preoperative figures. A statistical description of the case series is depicted in Table 1.

Table 1 Statistical description of the case series

Variables	Mean±SD (range) or *n* (%)
Age (years)	4.02±0.84 (3–6)
Sex	
Male	14 (58.3)
Female	10 (41.7)
Grade	
I	9 (37.5)
II	11 (45.8)
III	4 (16.7)
Side	
Right	6 (35.3)
Left	4 (23.5)
Bilateral	7 (41.2)
Follow up period (months)	49.9±7.07 (36–60)

Operative procedure

The operative technique that we employed entailed an anteroposterior inverted-U high tibial osteotomy through a 5-cm anteromedial vertical incision starting 1 cm distal to the joint line. All patients were operated under general anesthesia starting by excision of approximately 1 cm of the fibula through an incision over the junction between the distal and middle thirds.

The anteroposterior inverted-U osteotomy was done in the form of two unicortical arcs. The first unicortical arc of perforations was made over the medial surface of the proximal tibia with its apex below the epiphysis and its base toward the shaft from posterior to anterior. 2.7-mm drill holes 2–3 mm apart from each other were used for cortical perforations and connected together using a 0.5-mm osteotome. Similar arc was performed over the lateral surface of the proximal tibia. The lowest parts of the medial and lateral arcs were connected to each other across the anterior border in front and across the posterior surface behind. The anterior limb of the osteotomy was extended about one-quarter longer than the posterior limb. This is the most important surgical tip we used to ensure a sagittal stability of the osteotomy during elevation of the limb. Manual valgus manipulation was used for simultaneous correction of both varus and rotational deformity.

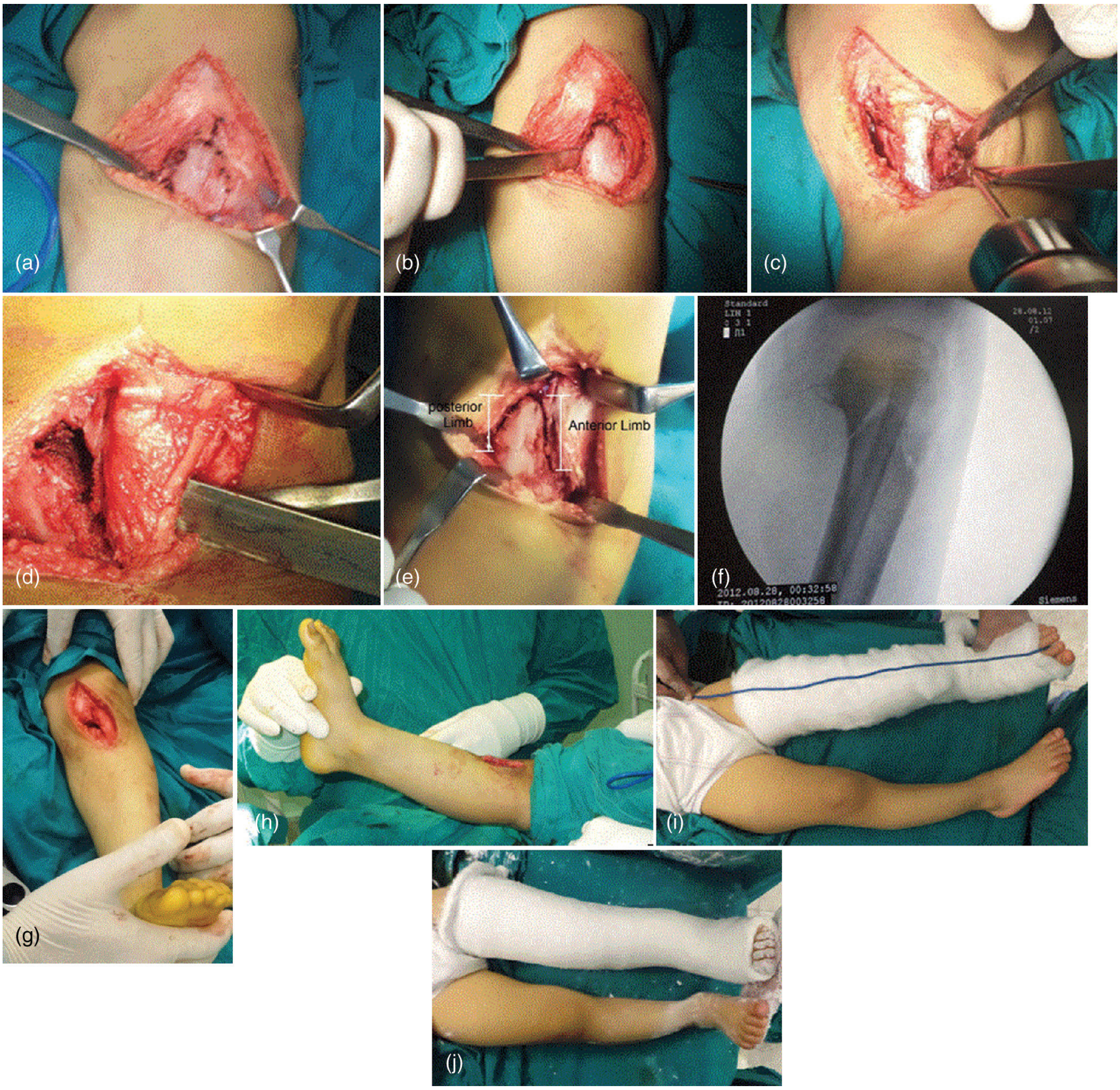
Mechanical axis correction was assured using the diathermy cord technique and the correction was maintained by a long leg cast.

The shape of the osteotomy with the downward projection of both posterior and anterior limbs prevents displacement of the osteotomy during the manual correction and the casting. Therefore, there was no need for any internal fixation of the osteotomy side (Fig. 1).

Follow-up methodology

The patients were followed up after 2 weeks, and another radiogram was taken to check for any early loss of correction. The patients were followed up again after 6 weeks by another radiogram to check the union of the osteotomy site. When the union achieved, the cast was removed with commencement of the exercise for knee and ankle for 2 weeks. All the patients were evaluated at the end of follow-up clinically for signs of residual varus deformities (measured ICD) or internal

Figure 1



The operative technique: (a) medial arc using a drill bit (2.7 mm). (b) The osteotome was used to connect the holes. (c) Lateral arc using a drill bit. (d) The osteotome connects the medial and lateral arcs. (e) The anterior limb of the osteotomy is extending about one-quarter longer than the posterior limb to ensure that the anterior end of the osteotomy does not encroach on the region of the tuberosity. (f) An intraoperative lateral view demonstrates anterior–posterior inverted-U osteotomy before application of cast. (g) Manual correction of both varus and rotational deformities. (h) Elevation of the limb after osteotomy demonstrating stability. (i) Use of diathermy cord technique as an intraoperative guide to represent the mechanical axis of the lower limb under C-arm guidance. (j) Application of long leg cast to maintain corrected position.

tibial torsion deformities (by measuring the thigh-foot angle). Range of motion of ankle and knee joints was measured using a goniometer and included flexion and extension of the knee, dorsiflexion, and plantar flexion of the ankle. Long-standing anteroposterior view of both lower extremities from the hip to the ankle at the end of follow-up was taken to assess the bone consolidation, and radiological measurements (MAD, TFA, and MDA) and compared with the preoperative values.

Method of statistical analysis

Data were analyzed by using SPSS software, version 20 (statistical package for social science for personal computers). Qualitative data were described using number and percentage (%) and were compared using χ^2. However, normally quantitative data were expressed in mean±SD and were compared using paired *t* tests. The *P* value was considered statistically significant if less than 0.05.

Results

Clinical assessment of correction of the deformities

At the end of the follow-up period of 49.9±7.07 (36–60) months, a significant varus correction evidenced by a reduction in the mean ICD was noted postoperatively, as it was decreased from a mean of 11.79±3.04 (8–19) preoperatively to 0.96 ±0.95 (0–3) after surgery. This relation was proved to be statistically highly significant ($P\leq0.001$). The mean thigh-foot angle was much improved from −7.83 ±2.84° (5–15 in internal rotation) preoperatively to a postoperative value of 2.08±1.74° (0–5 in external rotation), indicating correction of the internal tibial torsion, and this relation was statistically highly significant as well ($P\leq0.001$) (Table 2).

Radiological assessment

The radiological parameters (TFA, MAD, and MDA) showed a significant improvement in the postoperative mean values when compared with the preoperative mean values. The preoperative TFA was ranged from 13 to 48 in varus with a mean of 26.88±8.42°. However, at the end of the follow-up period, it ranged from 4° in varus to 5° in valgus with a mean 0.33±2.44°. This change in the mean TFA showed a statistically highly significant difference ($P\leq0.001$). Preoperative means of MAD and MDA were 48.79±11.93 mm and 20.25±3.46°, respectively, whereas their postoperative mean values were 3.75±4.00 mm and 3.04±2.28°, respectively. These relations were proved to be statistically highly significant ($P\leq0.001$). There were no statistically significant correlations between the stage of Blount and the postoperative changes in the means of MDA and TFA (P=0.18 and 0.09, respectively) (Table 2).

Table 2 Statistical comparison of the patients' data before and after surgery

Measurement	Preoperative	Postoperative	*P* value
Intercondylar distance (cm)			
Mean±SD	11.79±3.04	0.96±0.95	<0.001*
Range	8–19	0–3	
Thigh-foot angle (deg.)			
Mean±SD	−7.83±2.84	2.08±1.74	<0.001*
Range	−5 to −15	0–5	
Tibiofemoral angle (deg.)			
Mean±SD	26.88±8.42	0.33±2.44	<0.001*
Range	13–38	−5 to 4	
Mechanical axis deviation (mm)			
Mean±SD	48.79±11.93	3.75±4.00	<0.001*
Range	30–70	−1 to −14	
Metaphyseal-diaphyseal angle (deg.)			
Mean±SD	20.25±3.46	3.04±2.28	<0.001*
Range	16–28	0–8	

P, *P* value for paired *t* test for comparing between preoperative and postoperative clinical measures. *Statistically significant at *P* value less than equal to 0.05.

The tibia was well aligned in all the cases in the lateral view radiographs, and the cast was maintained in all the cases without change till the time of union. In this series, neither neurological nor vascular complications were encountered without reporting a recurrence of the deformity till the end of follow-up.

Case series

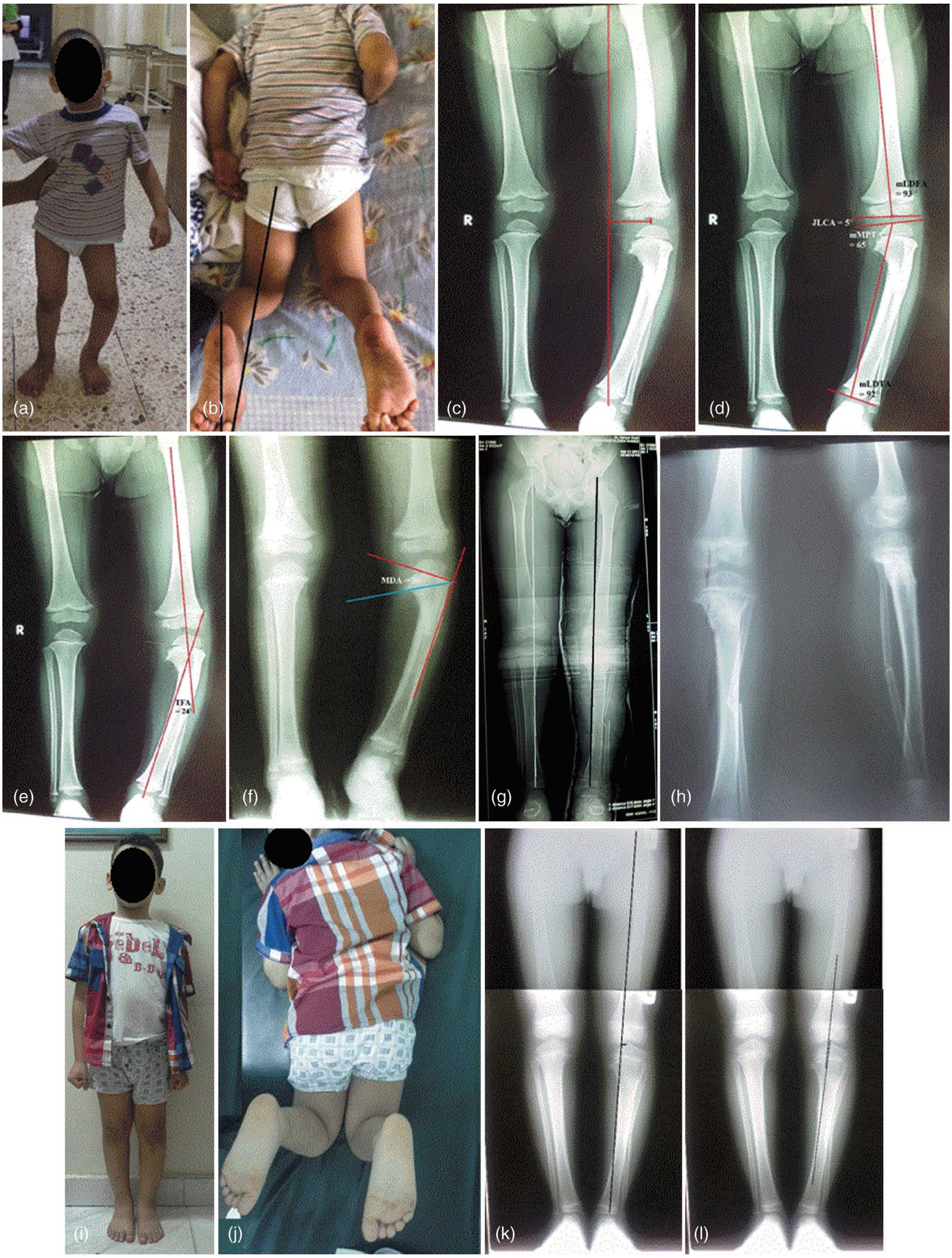
A case is shown in Fig. 2.

Discussion

The level of the apex of deformity was always considered very important in deformity correction, and the level of osteotomy relative to the apex depends on the location of the physis and the space needed for the hardware [8,9].

Reviewing the literature, many surgeons have recommended surgical correction of Blount cases before the age of four years, as longer the duration of deformity, the more depression of the medial aspect of the upper tibial epiphysis, consequently a high rate of postoperative recurrence [3,10]. Givon and colleagues, believed that once the physis is placed in normal alignment to the mechanical axis of the bone, mechanical forces prevent recurrences of the deformity in accordance with the Heuter-Volkmann law. The physis continues to function normally, and the limb alignment continues to improve after union of the osteotomy site [10].

Figure 2



A 4.5-year-old male patient was diagnosed as left Blount disease, Langenskiold stage III. Clinical examination showed: the ICD was 10 cm (a) and the thigh-foot angle was –12° (internal tibial torsion) (b). Preoperative radiology shows the MAD was 45 mm (c); the mechanical lateral distal femoral angle (mLDFA) was 90°, the mechanical medial proximal tibial angle (mMPTA) was 65°, the mechanical lateral distal tibial angle (mLDTA) was 95°, and the joint line convergence angle (JLCA) was 5° on both sides (d); the TFA was 24° in varus (e); and the MDA was 30° (f). Postoperative radiographs in cast of the patient: Scout view shows the proximal tibial osteotomy was done on the left side without any fixation. The decrease in the degree of MAD indicates correction of varus deformity. Scout AP view shows the angles on the radiograph (mLDFA, mMPTA, mLDTA, and JLCA) are within normal range on left side. (g). Radiographs of patient after radiological union and removal of the cast: AP view and lateral views of the LT side showing radiological union (h). Photographs of the patient at the end of follow-up with good alignment of the lower extremities (i) and correction of internal tibial torsion deformity (j). Stitch radiographs of the patient at the end of follow-up period shows the MAD (k), and TFA (l), which are within normal range with good bone consolidation and good alignment of the lower extremities. AP, anteroposterior; MAD, mechanical axis deviation; MDA, metaphyseal-diaphyseal angle; TFA, tibiofemoral angle.

Phedy and Siregar [6] reviewed the literature and they found little relevant articles about tibial osteotomy, most of them were case reports or retrospective studies, and they attributed this to the rarity of the incidence of Blount disease.

All patients enrolled in this study were diagnosed as infantile Blount disease and managed using the same protocol by inverted-U proximal tibial osteotomy to correct varus and internal tibial torsion and without internal fixation. In this series, we achieved a significant correction of both varus and internal tibial torsion as evidenced by a postoperative reduction in the mean ICD, and improvement of the mean thigh-foot angle, correspondingly. The radiological parameters (TFA, MAD, and MDA) showed a significant improvement in the postoperative mean values when compared with the preoperative mean values.

The main advantage of this technique is the sufficient anteroposterior stability at the osteotomy site which overcomes the anterior or posterior angulation that may occur at the osteotomy site, without the need for internal or external fixation. In comparison when open wedge, closed wedge, or oblique proximal tibial osteotomies were used in Blount disease, the osteotomy is not usually stable without internal fixation to maintain the correct position.

Loder *et al.* [11] reported fewer satisfactory results in patients in whom internal fixation was used after proximal tibial osteotomy for tibia vara. They concluded that these patients were probably fixed in a position of malalignment intraoperatively. Dietz and Weinstein [12] pointed out that internal fixation carries an increased risk of fracture after removal of the implant, and a slightly increased risk of infection. In growing children, epiphyseal arrest may follow rigid internal fixation if interfered with the epiphysis [13].

This technique also avoids the disadvantages of external fixation including frequent pin-tract infections, occasional poor patient tolerance of the device, and stress concentration at pin sites.

The advantage of anteroposterior orientation of osteotomy in this study over the different types of dome osteotomy is the stability achieved at the osteotomy site, which allows early active exercise of the knee that prevents stiffness. In addition, it does not interfere with patellar tendon during surgery. However, in both inverted and upright arcuates, to protect the tubercle apophysis, infrapatellar tendon, and proximal physis, the most central, midline point of the arcuate must be positioned below the tubercle. In an upright arcuate, this point becomes the apex, as the remainder of the arcuate proceeds toward the diaphysis. In a reverse arcuate, however, this point becomes the lowest part as the remainder of the arcuate proceeds toward the metaphysis [13].

Accordingly, this osteotomy takes benefit in being more proximal that incorporates greater cancellous surface and may promote more rapid union. Moreover, it produces a longer moment arm, so that less angulation at the osteotomy is necessary to restore the mechanical axis.

Ogbemudia *et al.* [7] described the anteroposterior inverted-U proximal tibial osteotomy technique to correct genu varum and internal tibial torsion in the treatment of Blount's disease in a series of 31 children with 47 limb deformity in a follow-up period for a minimum of 2 years. They reported 30 (64%) limbs with good outcome, whereas 17 (36%) had fair outcome. The better results achieved in this study in comparison with Ogbemudia's study may be owing to the older age of their series (4–15 years) in comparison with our series (3–6 years), which might increase the rate of deformity undercorrection, as casting method may not only be enough to hold and maintain correction in adolescents. Moreover, most of the patients in Ogbemudia's series (43 out of 47) were Blount stage VI, whereas in our series were in stages I–III with subsequently better results.

Van Huyssteen *et al.* [14] used the double-elevating osteotomy for late-presenting infantile Blount's disease, in 34 knees in 24 children, and they reported one (3%) tibia with anterior tibial angulation, which required an extension osteotomy 15 months after the first operation. Two (6%) patients had wound sepsis, one causing a wound breakdown necessitating a split skin graft. Three Kirschner wires and four Steinmann pins migrated after union, becoming prominent subcutaneously, and were removed under local anesthesia.

Hayek *et al.* [5] used serrated W/M corrective osteotomy to correct infantile tibia vara in 15 knees of 11 patients without the use of internal fixation. At the last follow-up, the mean angular correction had reduced to 1.3±4.9° of valgus without compromising the rotational correction and the overall good clinical results. They concluded that this procedure has the advantage of allowing both angular and rotational correction with a high degree of success without the need for internal fixation.

Dilawaiz-Nadeem *et al.* [4] described focal dome osteotomy for the correction of tibial deformity in children. They performed osteotomy, proximally, or distally in 39 tibiae (31 patients). In 33 limbs, the deformity was varus (with internal torsion), and the osteotomy was held with Kirschner wires and a plaster cast. All osteotomies united, and no compartment syndrome happened. Postoperatively, two (5%) patients developed temporary neurological deficits. They explained this as the fibular osteotomy was performed too proximal outside the 'safe zone.'

The anteroposterior inverted-U HTO is common with the lateral closing wedge osteotomy in offering the advantage of producing apposition of two broad native metaphyseal surfaces, thus optimizing relative stability and healing potential. However, it avoids the problems associated with lateral closing wedge including patella baja, inability to precisely achieve the desired amount of correction, and the possibility of exaggeration of leg-length inequality if the involved leg is initially shorter [15,16].

The anteroposterior inverted-U HTO is common with medial opening wedge technique in being easier for the surgeon to achieve the precise desired amount of angular correction than with lateral closing wedge HTO. However, medial opening wedge HTO has several disadvantages compared with anteroposterior inverted-U HTO. Medial opening wedge constructs are relatively unstable; hence, loss of fixation, nonunion, and delayed union are likely to be more frequent after medial opening wedge osteotomy and increased height of the patella [16–18].

In oblique and wedge osteotomies, the angle of each cut not only must be determined preoperatively but also executed precisely intraoperatively. Both of these steps possess a margin of error not encountered in the anteroposterior inverted-U HTO, the technique of which is constant, irrespective of the deformity and desired correction. Once the oblique or wedge osteotomy is complete, an adjustment of the position intraoperatively or postoperatively could sacrifice osseous contact [13].Gradual distraction osteogenesis using circular or unilateral external fixators for the correction of tibia vara was described by Price *et al.* [19]. This procedure has the advantage of adjustability, early weight bearing, and the ability to correct leg-length inequality. Its disadvantages are a longer consolidation period, unsightly scars, the need for compliant parents, and the need for expensive and complex devices. Complications of this method include pin-tract infections, and postoperative neuropraxia. This technique appears to be more suitable for the adolescent patients with Blount's disease.

The findings showed absence of skin necrosis, wound dehiscence, vascular insufficiency, peroneal nerve palsy, and compartment syndrome. There was no evidence of recurrence of the deformity in the studied patients in the early follow-up period, but longer follow-up till skeletal maturity is recommended to confirm this evidence.

Petje *et al.* [20] evaluated the ability to correct racketic genu varum deformities and assessed complications and recurrence rates in 10 children followed from early childhood to skeletal maturity. They performed 37 corrective operations in 10 children with different methods of internal and external fixations according to the patient's age. Deviation of the mechanical axis and knee orientation lines was increased at the follow-ups conducted during a period of 5–12 months. Longer follow-ups revealed a recurrence rate of 90% after the first corrective procedure and 60% after a second procedure.

Conclusion and recommendations

The high rate of good outcome, the reasonable stability arising from the anteroposterior orientation of the osteotomy and greater surface area for early union, and early weight bearing and active knee exercise indicate that this osteotomy has a good safety profile and should be recommended to correct the varus and internal tibial torsion in children with tibia vara.

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Conflicts of interest

There are no conflicts of interest.

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