Proximal tibial osteotomy osteoclasis in infantile genu-varum: improving the technique and managing potential complications

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Purpose
Genu-varum is a common problem encountered in pediatric orthopedic. Correction of pathological deformity is mandatory to ensure normal load transfer through the knee. In this study, we describe a new technique of osteotomy osteoclasis in order to evaluate if it is an effective and reliable method in management of infantile genu varum.
Methods
70 children with 122 legs suffering significant infantile genu-varum were treated by percutaneous osteotomy-osteoclasis technique. The mean age was 46 months. Genu-varum was bilateral in 52 children and unilateral in 18 with a mean preoperative proximal medial tibial angle 66.67 ± 2.67°. Under general anesthesia, transverse osteotomy osteoclasis was performed below the tibial tuberosity. Follow-up radiograph was done immediate postoperative, eight weeks postsurgery and at time of the final follow-up to assess alignment and consolidation.
Results
All children were evaluated clinically and radiologically. The mean follow-up was 28.60 ± 4.01 months. The mean operative time was 20 ± 3.96 min. All cases (100%) reported complete consolidation and the cast was removed within 8.69 ± 1.0 weeks (range: 7-11 weeks). The average proximal medial tibial angle improved from a mean 66.67 ± 2.67° (range 60 – 70) preoperatively to 90.15 ± 1.16° (range 88–92) postoperative ($P < 0.05$) and this was maintained till the end of follow-up. All patients' caregivers reported their satisfaction by the final end results.
Conclusion
Osteotomy osteoclasis is an effective reliable method in the management of infantile genu-varum.

Keywords:
genu varum, mini-invasive, osteoclasis, osteotomy

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Introduction

Genu-varum is one of the commonest problems encountered in pediatric orthopedic. Main causes are physiological bowing, Blount disease, rickets and skeletal dysplasia. Physiological genu-varum is common in children younger than two years and is usually self-limiting. On the other hand, pathological variant is evident in older children. It is typically severe, progressive and necessitates surgical intervention [1,2]. There is abnormal overload at the medial knee compartment, which hinders the normal ossification of the epiphysis. The problem may be unilateral with functional limb-length discrepancy or bilateral with the characteristic waddling gait [2,3]. Conservative treatment is the keystone for treatment of physiological genu-varum. Surgical correction is reserved for severe resistant cases. Options of treatment include bracing, osteoclasis with casting, osteotomy fixed by Kirshner wires and cast, and growth modulation procedures [4–8].

This prospective study was conducted to evaluate the efficacy of percutaneous osteotomy-osteoclasis as a less-invasive modality in the management of infantile genu-varum. Theoretically, this provides inherent stability of the osteotomy with good healing potentials. Furthermore, this procedure facilitates postoperative adjustment of any mal-alignment in the absence of hardware.

Materials and methods

In the period between January 2022 and April 2023, 122 limbs in 70 children (44 males and 26 females) with infantile genu-varum were treated by percutaneous high tibial osteotomy-osteoclasis technique at the authors' institution. All procedures were in accordance with the ethical standards of the responsible local institutional committee on human experimentation under license number 32358 and have been performed in accordance

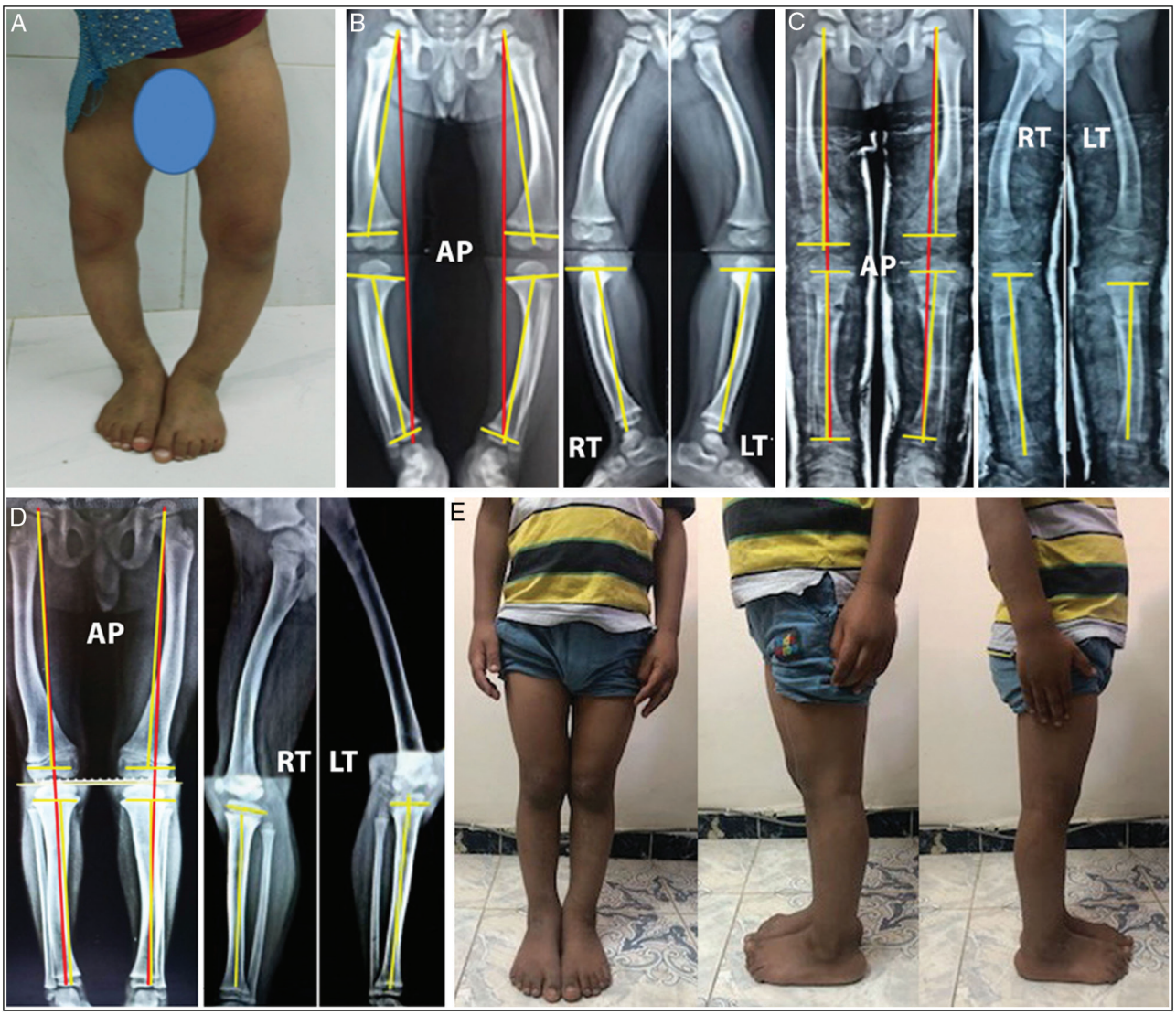
with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consents were taken from the caregivers. All children were evaluated clinically including the limb alignment and limb length discrepancy. In addition, radiological evaluation by long-standing radiographs of lower limbs were routinely done to ensure that tibia is the main component of the varus deformity and to calculate the proximal medial tibial angle (PMTA) (normal value = 87 ± 2° degrees) (Fig. 1a & b). This angle was used for assessment of degree of deformity correction and to follow the presence of under- or over-correction. All cases were subjected to laboratory investigations in the form of renal functions, serum calcium, phosphorus and alkaline phosphatase levels to exclude cases with metabolic disorders. The overall satisfaction of the parents was reported at the final follow-up.

Our inclusion criteria were infantile genu-varum with PMTA less than or equal to 70° not spontaneously corrected. Cases with active rickets, Blount disease, epiphyseal dysplasia, posttraumatic and postinfection cases were excluded from this study. Patients in whom the femur or the joint is the main site of the deformity were also excluded. The patients' demographic and radiological data are presented in Table 1.

Surgical procedure

Under general anesthesia, a one-cm vertical skin incision was done at the medial subcutaneous border of the tibia, one fingerbreadth below the tibial tuberosity. This was confirmed by intraoperative C-arm images. Longitudinal periosteal incision was done with minimal dissection. Incomplete medial transverse osteotomy including both anterior and posterior cortex was performed using drill bit or

Figure 1



(a). A three years old girl with bilateral genu varum. (b) Full length antero-posterior and lateral radiographs showing the PMTA 68 and 70 degrees on the right and left side respectively. (c) Three weeks postoperative radiographs showing ongoing consolidation of the osteotomy site with correction of the PMTA to 90 and 88 degrees on the right and left side respectively. The PPTA was 85 degrees on the right side and 80 degrees on the left side. (d). Radiological picture of the same child three months postoperatively showing complete consolidation of the osteotomy site with no changes in the corrected angles. (e). Clinical follow up of the same child three months postoperatively.

small thin osteotome. Osteotomy was completed manually by osteoclasis of the lateral cortex to provide postoperative stability by the preserved lateral periosteum. No fibular osteotomy was needed in the present study. The mechanical axis was checked by using a cautery cable technique i.e., the cable centered on the femoral head and center of the ankle passing just lateral to the center of the knee. After suturing the wound and under control of C-arm image, cast was applied in the correct alignment taking care to avoid over-correction or recurvatum. The usually existing internal rotation was simultaneously corrected during casting by keeping the axis of the second toe on line with the axis of the patella. The child was discharged 24h postoperatively after confirming good peripheral circulation. Full limb antero-posterior and lateral radiographs (Fig. 1c) were done immediate postoperative to confirm final position, check lower limb alignment and to measure the amount of correction. At this step, it was important to measure the posterior proximal tibial angle (PPTA) to confirm the absence of any sagittal pro or recurvatum deformities (normal=81±2°). Protected partial weight bearing in cast was allowed four weeks after surgery. At nearly eight weeks postoperative, full limb antero-posterior and lateral radiographs were done to confirm bony consolidation and to check limb-alignment, the cast was then removed, and the child was encouraged to bear weight gradually. All children were regularly clinically evaluated by the improvement of the clinical picture, and gait pattern. Radiographs were done at the time of the final follow-up to assess limb-alignment and to detect any recurrence of the deformity by measuring the MPTA (Fig. 1d & e).

Statistical analysis

Our data analysis was done with the program (SPSS; SPSS Inc., Chicago, Illinois, USA) version 20.0. We have to types of data; quantitative which were presented as range and mean ±SD. and qualitative which were presented as a percentage. Sample paired *t*-test was used to analyze the results and significance of data. P value less than 0.05 was considered statistically significant.

Table 1 Patients' demographic and radiological data

Variable	
Age (months)	
Range	36–52
Mean±SD	44.46±4.53
Sex: *n* (%)	
Male	47 (67.1%)
Female	23 (32.9%)
Side affected: *n* (%)	
Bilateral	52 (74.3%)
Unilateral	18 (25.7%)
Preoperative PMTA (°)	
Range	60–70
Mean±SD	66.67±2.67

PMTA, proximal medial tibial angle.

Results

A minimum 24 months follow-up was a must in the present study. The results were summarized in Tables 2 and 3. All cases (100%) reported complete consolidation within average 8.69±1.0 weeks (7-11). During the first postoperative visit, residual varus deformity was noticed in eight limbs (6.6%) among four children. Wedging of the cast (Fig. 2) was enough to gain the optimal correction with satisfactory clinical and radiological results. The PMTA improved significantly from a mean 66.67±2.67°(range 60–70) preoperatively to 90.15±1.16°(range 88–92) postoperatively ($P < 0.05$). All patients' caregivers reported their satisfaction by the results. We found no statistically significant relation between patients' variables (age, gender, affected side and preoperative PMTA angle) and time of union and the degree of correction ($P > 0.05$). During the follow-up, Cozen's phenomenon [9] was developed in ten (8.2%) limbs among eight children (Fig. 3). Analysis the incidence of this phenomenon in our study revealed that all the cases with Cozen's phenomenon were younger than 40 months ($P < 0.05$). Those cases were followed for one year during which four of the 10 limbs improved spontaneously, while the other six needed further management using medial guided growth plate which was removed after average one year after completing correction. Those patients who needed a second surgical procedure, though being

Table 2 The results of the study

Variable	
Operative time (minutes)	
Range	15–30
Mean±SD	20±3.96
Follow-up period (months)	
Range	24–36
Mean±SD	28.60±4.01
Time to consolidation (weeks)	
Range	7–11
Mean±SD	8.69±1.0
Post-operative PMTA (°)	
Range	88–92
Mean±SD	90.15±1.16
Complications: number of limbs (%)	
Cozen phenomenon	10 (8.2%)

PMTA, proximal medial tibial angle.

Table 3 The difference in PMTA between preoperative and final postoperative follow-up

Measured PMTA (°)	Preoperative		Postoperative
Range	60–70		88–92
Mean±SD	66.67±2.67		90.15±1.16
T. test		85.123	
P. value		0.001*	

PMTA, proximal medial tibial angle.
T, paired *t*-test.
* Significant at *P*-value < 0.05.

Figure 2

Wedging of the cast may be needed to readjust any relapsed deformity during follow up of the consolidation.

Figure 3

Cozen's phenomenon.

not fully satisfied by the index surgery, were satisfied by the final results after the second stage procedure.

Discussion

Genu-varum is a common pediatric problem. The maximum varus degree is between the age of 6 and 12 months. Later on, it improves toward neutral knee angles at the age of 18 months. Additionally, it is reported that the greatest mean knock knee (genu valgum) was observed by the age of 4 years, followed by a gradual decrease to the normal variables at 11 years. The persistence of genu varum after age of four years is abnormal and may needs surgical intervention Arazi and colleagues [10].

The goal of treatment of severe infantile genu varum is to correct mechanical axis deviation and to restore normal biomechanics to achieve stable, aligned extremity with normal gait pattern and prevention of potential late complications. Adherence to the basic principles of preoperative planning, meticulous handling of soft-tissue and achievement of durable correction are paramount in minimizing complications and yielding good functional outcomes Rab, Destieux and colleagues [1–5].

Corrective tibial osteotomy is the keystones of surgical treatment of pathological infantile genu-varum. Although satisfactory clinical results have been reported by many authors Gilbody and colleagues, Jackson and Cozen [6–9], the traditionally used osteotomies are relatively invasive, unstable and need fixation by K-wires. Major concerns are failure of fixation, unfeasibility to readjust correction in the presence of wires, physeal damage by the traversing wires, infection and joint stiffness Pinkowski and Weiner, Stuart and colleagues[11,12].

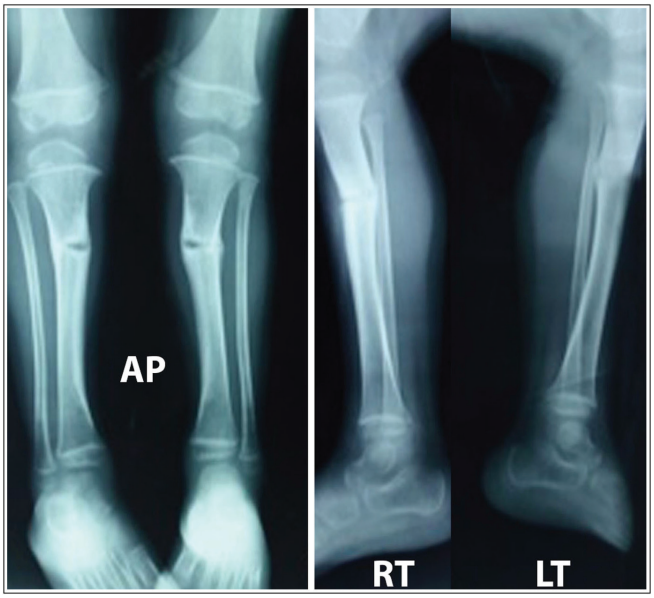
Guided epiphyseal growth modulation is a reproduction of the above-mentioned permanent physis arrest techniques but with temporary characteristics (temporary hemi-epiphysiodesis). The period for correction ranges from 6 to 24 months of insertion. The hardware used in this technique ranged from staples to percutaneous transphyseal screw fixation and finally the guided growth plate Blount, Goldman and Green [13–16]. Despite being minimally invasive, inherently stable, allowing postoperative fine-tuning and leaving minimal scar, they have some limitations. The need of learning curve, the use of hardware which may be prone to migration or breakage and the need for second surgery to remove the implants are among the disadvantages. According to Kemppainen and colleagues [17] guided growth procedure may be a cause of reversed deformity if patient delayed in implant removal. Additionally, the procedure is still susceptible to unexpected permanent physeal damage. Furthermore, these growth modulation techniques are unable to correct the associated internal tibial torsion which is a common finding in genu-varum Shin and colleagues, Danino and colleagues [18,19].

The technique used in the present study is a reproduction of the original closed osteoclasis maneuver with some modifications. Through a

minimal percutaneous incision, the anteromedial and posterior borders of the proximal tibial metaphysis were initially osteotomized. Then, the lateral cortex was manually broken (osteoclasis). Weakening of the anteromedial and posterior cortices determines the site of osteoclasis (guided osteoclasis). The preliminary preserved lateral cortex is used as a hinge for sound correction avoiding major displacement while allowing controlled correction of rotational component of the deformity. This is with the study of Miller and colleagues [20] who demonstrated the importance of intact lateral cortex and periosteum on the stability of the osteotomy. The preserved lateral periosteum and the intact fibula added significant stability with no need for hardware fixation and provided good intrinsic healing potentials. Special concern was taken to correct the rotational component of the deformity. This was simply achieved during casting by keeping the axis of the second toe aligned with that of the patella. The mean operative time of the present technique was 20 ± 3.96 min Intraoperative radiography was frequent at the beginning of the study and decreased dramatically with increased learning curve. It is essential to make follow-up full limb antero-posterior and lateral radiographs one week postoperatively to detect any residual or recurrent varus deformity. In the present study, residual varus deformity was noticed in eight limbs (6.5%) among four children. This was managed simply in the outpatient clinic by making appropriate wedging of the cast and this was enough to gain the optimal correction with satisfactory end results.

Cozen and Jackson's, Dorman and colleagues phenomenon [9,21] is a valgus angulation of the proximal tibia which occurs as a complication of proximal metaphyseal fracture in children. One of the suggested causes of this phenomenon is the loss of resistance of the destroyed medial periosteum which is important in control of the rate of growth of the proximal tibia. In the presented technique, the used percutaneous vertical periosteal incision with the minimal dissection is crucial to minimize damaging of the medial periosteum. Cozen's phenomenon was encountered in 10 limbs (8.2%) after a mean of 6 months after solid consolidation. Four of these 10 limbs improved spontaneously during the follow-up period, while the other six necessitated further intervention using medial guided growth plate procedure. Interestingly, it was noticed that all the cases with Cozen's phenomenon in the current study were younger than 40 months. Accordingly, we recommended delaying the time of surgery to ages older than 40 months and making the osteotomy somewhat lower at the upper fourth of the tibia (Fig. 4) to avoid physical irritation in younger children.

Figure 4



Lower-level osteotomy is recommended in younger children in attempt to avoid Cozen phenomenon.

An ideal procedure to correct a bony deformity should meet the following criteria; simple, reproducible, quick to perform, least invasive, inherently stable, needs no internal fixation, allows easy postoperative fine-tuning of correction, needs no secondary procedures to remove implants and leaves a cosmetically acceptable scar. The various methods of treatment of infantile genu varum could not fulfill all of these criteria. Remarkably, the technique presented in our study of percutaneous osteotomy-osteoclasis meets all the above-mentioned criteria.

One of the shortcomings of this study is the absence of comparison with other alternative techniques. So future studies including long-term comparison of this technique with other forms of osteotomy or other treatment modality in a larger sample of children is highly recommended.

In conclusion, percutaneous high tibial osteotomy-osteoclasis without internal fixation is a safe, simple, and reproducible procedure that could correct severe infantile varus deformity with its associated rotational component. Close observation of the children in the early postoperative week is important to adjust any residual mal-alignment which can be addressed easily by wedging the cast in an outpatient basis. Additionally, it is crucial to follow the child for appropriate period after full consolidation, even if normal alignment is achieved, to detect the development of the troublesome Cozen's phenomenon in the younger children.

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Nil.

Ethical Approval

All procedures performed in the study were in accordance with the ethical standards of our department and with the 1964 Helsinki declaration and its later amendments.

Consent to participate: A written consent from all of the participants after discussion about the aim of the research and the confidentiality of their data.

Consent to publish: Additional informed consent was obtained from all participants for whom identifying information is included in this article.

Authors' contributions

Ahmed M. Shafik and Ahmed Helal contributed to the study conception and design, material preparation, data collection and analysis. The first draft of the manuscript was written by Ahmed M. Shafik and both authors commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

Availability of data and materials

The data sets generated during and analyzed during current study are available from the corresponding author on reasonable request.

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Conflicts of interest

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

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