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ORIGINAL ARTICLE

Gradual on top-of-acute correction of neglected adolescent tibia vara by percutaneous tibial osteotomy and two-ring Ilizarov frame

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ABSTRACT

Objectives: This study aims to assess the effect of gradual correction after acute translation of the tibia in tibia vara using a two-ring Ilizarov frame on the correction of mechanical axis deviation (MAD), union time, and the rate of complications.

Patients and methods: Between September 2018 and January 2021, a total of 30 patients (25 males, 5 females; mean age: 20±5 years; range, 15 to 25 years) with adolescent tibia vara were included. The patients had a transverse fibular ostectomy and percutaneous tibial osteotomy below the level of the tibial tuberosity. Acute correction of the rotation deformity combined with acute translation was done. A two-ring Ilizarov frame with a medial distractor and two lateral hinges were used to fix the osteotomy and the coronal plane deformity was gradually corrected.

Results: The mean follow-up was 24±4 months. All patients had improvement in the mechanical medial proximal tibial angle (mMPTA) and MAD postoperatively. There was an improvement in the Hospital for Special Surgery knee score at one year postoperatively. No neurovascular complications or union complications were observed.

Conclusion: Acute translation followed by gradual angulation of the proximal tibia in cases with adolescent tibia vara yields better correction of the mechanical axis with good functional and radiological outcomes.

Keywords: Acute correction, Ilizarov, tibia vara.

Adolescent tibia vara is a pathological angular deformity affecting the proximal tibia in adolescent patients.[1] It usually has a medially deviated mechanical axis which leads to later medial compartment arthritis. It can be acutely or gradually corrected.[2] Adolescent tibia vara is characterized by tibial varus, intoeing, and procurvatum.[3] It is caused by a disorder of the medial physis of the proximal tibia.[4]

Tibia vara is classified into juvenile onset at age four to 10 years and late onset at more than 11 years.[5] Adolescent tibia vara typically occurs in individuals with obesity. Increased pressure across the medial aspect of the proximal tibial physis leads to the inhibition of growth of the medial part of the physis.[6] Patients usually have a distal femur varus deformity.[7] Load is shifted medially, with an increase in the stress on the medial compartment, leading to medial compartment arthritis.[8,9]

Many lines of management are present for adolescent tibia vara. Hemiepiphysiodesis can correct deformity in adolescent tibia vara patients, if there is sufficient growth.[10] Acute correction of mild-to-moderate tibia vara can be performed with wedge creation, either lateral closing or medial opening wedge. Internal fixation can be also used.[11] Acute correction of severe deformities can be done

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by Ilizarov.[2] Some authors made a modified Rab osteotomy with fixation with screws only and they achieved good results.[12] However acute correction has a high risk of recurrence, particularly at a young age.[13] Other complications of acute correction are neurovascular affection, compartment syndrome, and limb length discrepancy.[14] Gradual correction of the coronal plane deformity by a tibial osteotomy below the level of the tibial tuberosity has a good outcome with minimal risks.[15] Gradual correction by a Taylor spatial frame (TSF) can accurately correct the coronal and sagittal deformities with accurate correction of the mechanical axis.[16] In developing countries, it is difficult to use a TSF for deformity correction due to financial problems; therefore, we use the Ilizarov frame.[17] In tibia vara, the center of rotation and angulation (CORA)is located near the proximal tibial joint line. This makes it difficult to adjust the hinges accurately at the level of the CORA, affecting the translation of the distal segment according to the rules of osteotomy,[18] with subsequent affection on the correction of the mechanical axis.

In the present study, we hypothesized that acute lateral translation of the distal segment could correct the mechanical axis accurately, followed by gradual correction of the coronal plane deformity which is a safe way of correction according to the literature.[15] We, therefore, aimed to assess the effect of gradual correction after acute translation of the tibia in tibia vara on the correction of mechanical axis deviation (MAD), union time, and the rate of complications.

PATIENTS AND METHODS

This single-center case series was conducted at Kasr Al Aini Faculty of Medicine, Department of Orthopedics between September 2018 and January 2021. A total of 30 patients (25 males, 5 females; mean age: 20±5 years; range, 15 to 25 years) with adolescent tibia vara who met the inclusion criteria were enrolled. All the cases were operated on by a single surgeon. Inclusion criteria were as follows: skeletally mature patients with a mechanical medial proximal tibial angle (mMPTA) of less than 75 degrees and medial joint line pain. Skeletally immature patients and patients with medial joint line depression were excluded. All the patients had preoperative bilateral lower limb standing X-ray scanogram and Hospital for Special Surgery (HSS) knee score.

Preoperative planning

Preoperative planning was done using the method, as previously described.[18] The mechanical axis of the lower limb was drawn from the center of the head of the femur to the center of the ankle joint. Mechanical axis deviation was measured in millimetres. The mechanical lateral distal femoral angle (mLDFA), tibiofemoral angle (TFA), and mMPTA were measured manually using a ruler and goniometer on the standing lower limb X-ray scanogram to identify the site of the deformity and its degree. The CORA was determined and, in tibia vara, it is near the proximal tibial joint line. Our goals were to correct the MAD with proper translation and angulation with an osteotomy below the level of the CORA.

Operative technique

All patients had spinal anesthesia and were operated in the supine position, and a thigh tourniquet was used. We made a 3-cm incision on the fibula between the middle and lower thirds. A transverse fibular ostectomy was done (Figure 1a). Then, a 2-cm incision was made at the anterolateral tibia at the level just below the tibial tuberosity. Multiple drill holes were created at the tibia followed by creating a transverse osteotomy by a sharp osteotome perpendicular to the long axis of the tibia. Lateral translation of the distal segment was done to correct the mechanical axis, and acute correction of the rotational component was done (Figure 1b). This was fixed by two 2-mm Kirschner wires (K-wires) and the frame was, then, applied to

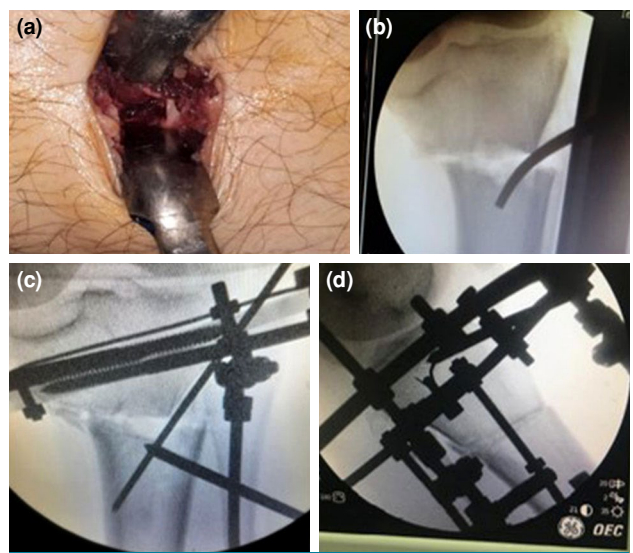

FIGURE 1. (a) Fibular ostectomy. **(b)** Lateral translation of the distal segment to correct the mechanical axis deviation. **(c)** Fixation of the osteotomy after translation. **(d)** lateral intraoperative X-ray showing the position of the motor along the sagital plane of the tibia.

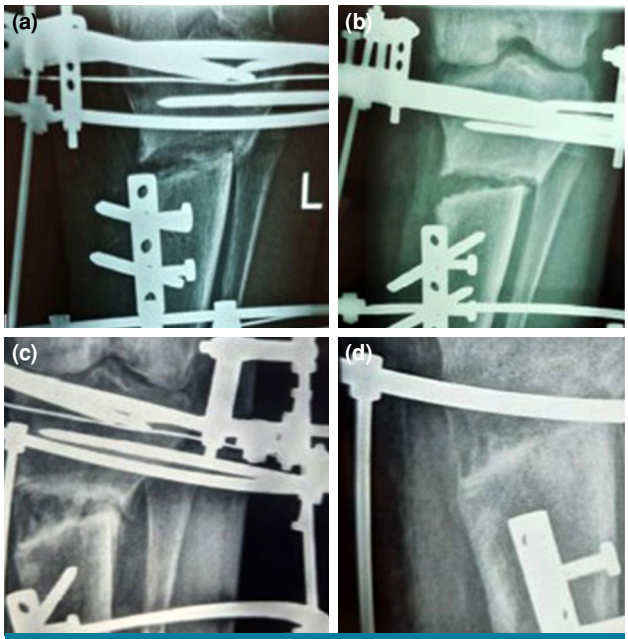

FIGURE 2. (a) Four weeks of follow-up. **(b)** Six weeks of follow-up. **(c)** Eight weeks of follow-up. **(d)** 10 weeks of follow-up.

fix the osteotomy. The frame used was a two-ring mini-frame with five points of fixation on each side of the osteotomy. Both rings were connected by a single medial distractor and two lateral hinges at the level of the CORA (Figures 1c, d).

Postoperative protocol

Patients started distraction one week after surgery at the rate of 0.25 turn every 6 h. Partial weight-bearing was allowed, until till full correction was reached and the frame was stabilized by more rods. The patient had an X-ray one month after surgery and, then, every two weeks to assess regenerate formation (Figures 2a-d). After the clinical correction was reached, a standing X-ray scanogram was done to fine-tune the correction (Figure 3a). The frame was removed, when consolidation occurred (Figure 3b). Patients were followed every three months following frame removal for 24 months. All the patients had a follow-up HSS knee score one year after surgery.

Statistical analysis

The sample size calculated was 30 lower limbs using a clinical sample size calculator, with 0.05 alpha error, a confidence interval of 0.95, and a power of the study of 0.80.

Statistical analysis was performed using the SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Quantitative data were presented in mean ± standard deviation (SD), while qualitative data were presented in number and frequency. The paired Student t-test was used to compare pre-and postoperative scores and angles, while the Student t-test was used for numeric parametric data.

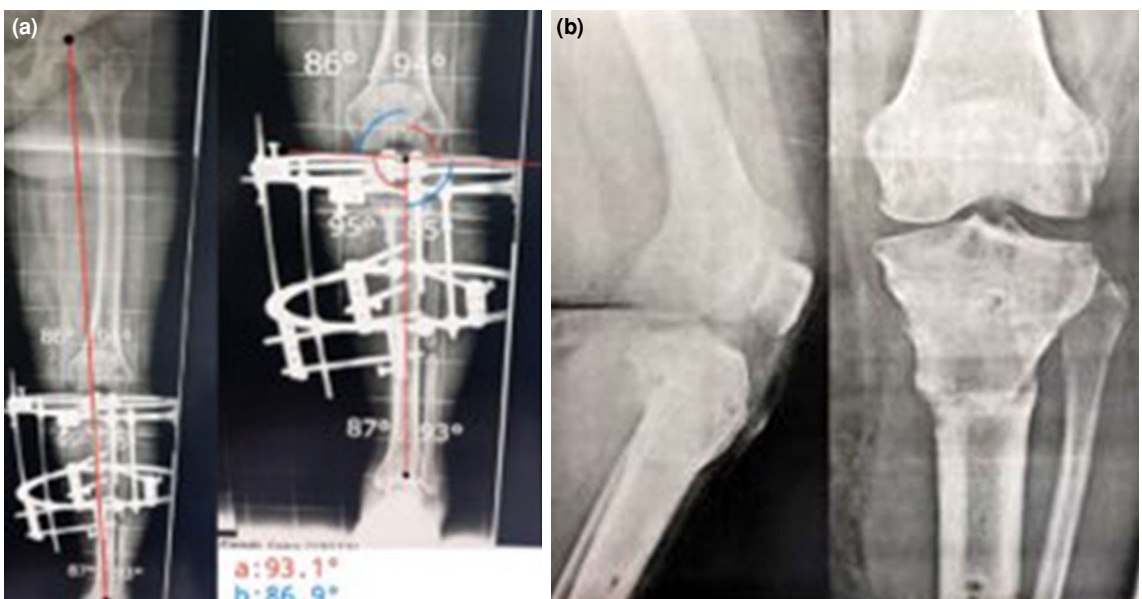

FIGURE 3. (a) Standing scanogram after correction of the limb alignment at four months for a 20-year-old patient. Angle (a): mMPTA=93 degrees. **(b)** X-rays after removal of the frame at five months for the same patient.
mMPTA: Mechanical medial proximal tibial angle.

The chi-square test and Fisher exact test were used to analyze qualitative data. A p value of <0.05 was considered statistically significant.

RESULTS

Baseline characteristics of the patients are shown in Table I.

Table II shows pre- and postoperative radiographic parameters. Accordingly, there was a statistically significant improvement in the mean MAD from 80 mm to 7 mm postoperatively (p=0.05). The mean TFA improved from 35 degrees to 5 degrees postoperatively. The mean mmPTA improved from 65 to 92 degrees postoperatively. The mean time to union was 5±1 months. One patient had delayed union (11 months). The mean preoperative HSS knee score was 70±10. The mean postoperative HSS knee score was 95±5. There was a statistically significant improvement in the HSS knee score (p=0.00). Regarding complications (Figure 4), 50% of the patients had pin tract infection which was treated successfully with antibiotics. A total of 5% of the patients had a superficial wound infection which was treated with antibiotics. No cases had non-union.

TABLE I
Showing the demographics of the cases (n=30)

Variables	n	%	Mean±SD
Age (year)			20±5
Sex			
Males	25	83.33	
Females	5	16.66	

SD: Standard deviation.

TABLE II
Showing mean pre- and postoperative MAD, TFA, mMPTA, and my LDFA

	Mean±SD	SE	p
MAD			0.05
Preoperative	80±2.943	0.658	
Postoperative	7±1.928	0.431	
TFA			0.258
Preoperative	35±8.949	2.001	
Postoperative	5±3.927	0.878	
mMPTA			0.204
Preoperative	65±8.239	1.842	
Postoperative	92±5.032	1.125	
mLDFA			0.000
Preoperative	95.60±5.986	1.338	
Postoperative	95.30±6.216	1.390	

MAD: Mechanical axis deviation; TFA: Tibiofemoral angle; mMPTA: Mechanical medial proximal tibial angle; mLDFA: Mean lateral distal femoral angle; SD: Standard deviation; SE: Standard error.

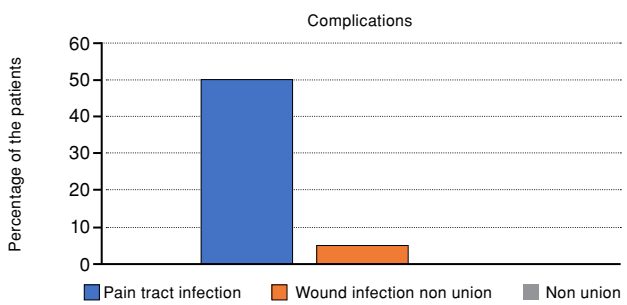

FIGURE 4. Chart showing the percentage of complications.

DISCUSSION

Adolescent tibia vara continues to be a profound problem facing orthopedic surgeons, as long as child obesity continues to be a prevalent public health concern. The main goal in the treatment is to correct the mechanical axis. Gradual correction of the deformity has been well studied in the literature.[8,15]

The technique described by Paley[18] relied on putting olive wires to allow lateral translation to happen. In our hands, jamming of the lateral cortex of the proximal and distal segments occurred occasionally and stopped lateral translation of the distal segment. Thus, we thought of doing an acute translation of the distal segment to able to control the amount of translation needed to correct the mechanical axis. This was followed by gradual correction of the coronal plane angulation by the Ilizarov fame. Although until date, we did not titrate the amount of translation needed according to the preoperative mMPTA angle, we believe that the step of acute translation helped to lower the residual MAD.

This technique allowed us to have less residual postoperative MAD compared to other studies. The mean preoperative MAD was 80±2.9 mm in our study, and it was corrected to 7±1.92 mm postoperatively. This was more than the correction obtained by Saw et al.[15] their study where they had a mean postoperative MAD of 9.0±37.7 mm. Also, it was more than the correction obtained by Kim et al.[19] who had a mean postoperative MAD of 10±15.8 mm and more than the correction obtained by Meselhy[20] who had a mean postoperative MAD of 12.18±11.36 mm. The mean postoperative MAD values were lower in our study than the results reported by Fahmy and Fathi[21] who had a mean postoperative correction of the

MAD of 0.88. This may be because we had a higher mean preoperative MAD of 80±2.9 mm compared to the mean preoperative MAD in the study of Fahmy and Fathi,[21] which was 35.5 mm.

The main finding of our study is that acute translation with gradual angulation can produce satisfactory radiological and clinical outcomes and, to the best of our knowledge, this is the first study to present this technique of acute translation followed by gradual angulation to correct the deformity components in adolescent tibia vara.[22]

In our cases, the mean TFA improved from 35 degrees to 5 degrees postoperatively. This is comparable to the study of Saw et al.[15] who had an improvement of the mean TFA from 31 to -2 degrees. Also, the mean mmPTA improved from 65 to 92 degrees postoperatively. This is comparable to the results of Fahmy and Fathi[21] who had improvement in the mMPTA from a value of 68 degrees to 87 degrees postoperatively. It is also comparable to the results of Li et al.[23] who had an improvement in the mMPTA from 66 degrees to 88 degrees postoperatively.

In our study, acute translation did not hinder the union process. The mean time to union was 5±1 months, which is shorter than the results of Saw et al.[15] who had a mean time to frame removal of 9.4 months. Our results are also comparable to the results of Li et al.[23] who had a mean time to union of 114 days.

Regarding complications, we had one patient with a delayed union which occurred at 11 months without the need of grafting. A total of 50% of our patients had pin tract infections successfully treated with antibiotics. None of the patients had neurovascular complications. Fahmy and Fathi[21] had one case with peroneal neuropraxia which resolved within six weeks. Saw et al.[15] had only two cases of pin tract infection, one case with delayed union that required grafting, and two patients with refracture at the osteotomy site.

The main limitations to this study are its small sample size, relatively short follow-up time, and the lack of a control group.

In conclusion, acute translation followed by gradual angulation using the Ilizarov frame in patients with adolescent tibia vara can yield a better correction of the MAD and it is a safe method for correction of the coronal plane deformity in these cases. Further large-scale, prospective studies including control groups are needed to confirm these findings.

Ethics Committee Approval: The study protocol was approved by the Cairo University Ethics Committee (date: 27.07.2020, no: MD-213-2020). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient and/or parents or legal guardians of the patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept: A.S.B., A.M.K., A.B.Z.M.; Design, analysis and/or interpretation, writing the article: A.M.K., A.S.B.; Control/supervision: A.M.K., A.B.Z.M.; Data collection and/or processing, literature review, references and fundings, materials: A.S.B.; Critical review: A.B.Z.M.

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