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Outcome of Gradual Correction of Severe Genu varum more than 20 Degree by Ilizarov Fixator

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ABSTRACT

Background: Genu varum results in an abnormal mechanical stress that might potentially contribute to premature deterioration of the knee joint. Hence, it is important to correct the malformation to avert the occurrence of arthritis, which leads to impaired functionality.

Objectives: This work aimed to assess the clinical, radiological results and the complications in gradual correction of severe Genu varum greater than 20 degrees using Ilizarov fixator.

Patients & methods: This interventional study included 20 cases of genu varum greater than 20 degrees, which underwent gradual correction using the Ilizarov fixator at Menoufia University Hospital.

Results: There was a highly statistically significant variance between the pre-operative and post-operative measurements regarding range of motion, flexion deformity, mechanical axis deviation (MAD-C), joint congruence angle (JCA), proximal medial tibial angle (mMPTA), and total HSS knee score. However, no statistically significant differences were found regarding the mechanical lateral distal femoral angle (mLDFA), posterior proximal tibial angle (PPTA), and tibial slope (°). The number of cases with compartment syndrome in the study population was 2 (10%), while the number of cases with insufficient callus formation was 1 (5%).

Conclusion: Gradual correction using the Ilizarov fixator is a safe, accurate, and reliable method for correcting severe genu varum greater than 20 degrees. Clinically, the total HSS knee score, including pain, function, range of motion, muscle strength, flexion deformity, and instability, significantly improved postoperatively. Radiologically, mMPTA, MAD-C, ICA, and TFA significantly increase after surgery, without disturbing the posterior tibial slope.

Keywords: Genu varum, Ilizarov fixator, HSS knee score.

INTRODUCTION

Genu varum is a condition in which one or both legs curve outward, creating a wider space than normal between the knees and lower legs. This leads to pressure on the knee joints, resulting in early joint arthritis of the knee. Early treatment and correction of deformity are important to prevent arthritis [1].

Childhood diseases such as achondroplasia, rickets, skeletal dysplasia, and Blount's disease can lead to deformities in the tibia and genu varum. The objectives of surgical intervention are to correct the tibial deformity, maintain the mechanical axis, and elongate the extremities in cases of insufficient length [2, 3]. Surgical interventions for genu varum deformity in adolescents and adults include acute correction using internal or external fixation, as well as the use of an external fixator in severe cases [4, 5].

After correcting the deformity, some cases may require further correction if the position is not ideal. Additionally, possible complications include nerve paralysis, misalignment, loss of proper alignment, limb length discrepancy, compartment syndrome, fixation failure, deformity recurrence, issues related to autogenous bone grafts, and difficulties associated with allografts [6].

Different types of external fixators, such as unilateral fixators and the Taylor Spatial Frame (TSF), have been used for the correction of varus deformities. A viable approach is the use of the Ilizarov external fixator for progressive deformity repair through distraction osteogenesis. This method allows for the correction of severe deformities without the need for additional surgical procedures and can achieve ideal reduction [7, 8]. The Ilizarov technique provides simultaneous effective management of limb deformity and leg length discrepancy [9, 10].

The purpose of the present work was to assess the clinical and radiological results, as well as the complications, in the gradual correction of severe genu varum greater than 20 degrees using the Ilizarov fixator.

PATIENTS AND METHODS

This interventional study included a total of 20 individuals with genu varum greater than 20 degrees who underwent gradual correction using Ilizarov fixator, attending the Department of Orthopedic Surgery, Faculty of Medicine, Menoufia University Hospitals.

Inclusion criteria: Skeletally mature patients, aged 14 to 40 years, with medial knee pain secondary to genu varum and tibial deformity greater than 20 degrees.

Exclusion criteria: Skeletally immature patients, patients with vitamin D deficiency (vitamin D deficiency was corrected preoperatively, and correction was maintained till union of the osteotomy occurred), patients with renal failure, patients with the femur being the only source of the varum deformity and patients with post traumatic genu varum. Revise and correct these paragraphs grammatically.

Operative procedure:

Patients underwent preoperative imaging while standing and lying supine, with spinal anesthesia and a

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second-generation cephalosporin prophylactic dose. They were placed on a radiolucent operating table, and the position of the articular surface, tibial tuberosity, osteotomy, and anatomical axis were determined using an image intensifier.

Part of the tibia in the lateral view:

The image intensifier was introduced opposite to the target limb and perpendicular to its longitudinal axis to allow for imaging of the whole L.L. from the head of the femur to the talus. The procedure involved making a 5 cm incision on the fibula, elevating and retracting peroneal muscles, creating multiple holes in the fibula, breaking the bone, and removing 1 cm of it. A 3 cm skin incision was made on the tibial osteotomy level, and the underlying periosteum was incised. The osteotomy was done perpendicular to the metaphysis of the proximal tibia, and a curved artery was introduced into the distal segment to distract it from proximal knee.

Frames:

A 3 rings Ilizarov frame was utilized for gradual correction of deformities in the tibia. The frame was connected to a male post and twisted plate, with hinges on the lateral side. The proximal & distal rings were parallel to the articular surface & long axis of the shaft, respectively. The frame was fixed to a wire parallel to the articular surface and tensioned. The wounds were closed in layers with temporary 3 mm K wires removed.

Postoperative care and rehabilitation:
Patients underwent postoperative anticoagulation and antibiotics, followed by x-rays. Follow-up X-rays were monthly, and patients were instructed to clean the schanz screws and wires daily. After 2 weeks, stitches were removed, and pin tract infections were treated with amoxicillin- clavulanic acid antibiotics. Patients were encouraged to have full knee and ankle rehabilitation.

Our approach to complicated cases:
Delayed union: Dynamization of the frame in 3 cases was our approach to solve this problem. Instead of connecting the 3 rings by 6 rods we loosen the connection between the rods and the proximal ring. This allows for some micromotion which in all cases leaded to union. In other cases, the number of Schanz screws in each ring was reduced to only 3 Schanz screws in each ring.

In cases of poor regenerate in gradual correction:
We instructed 2 cases of our patients to distract gradually at a rate of one mm every day for 3 days followed by gradual compression at a rate of one mm every day for another 3 days. When thequality of the regenerate improves, we continued gradual distraction till reaching the desired correction.

Chronic osteomyelitis and persistent sinus following frame removal: Guttering and skin coverage was done for one patient.

CASE PRESENTATION
Male patient 23 y medically free with bilateral sever Genu varum.

Fig. (1): Pre-operative.

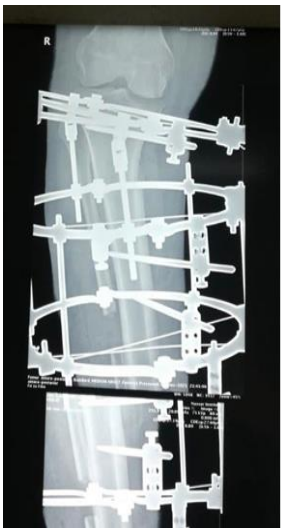

Fig. (2): Postoperative AP X-ray.

Fig. (3): Postoperative lateral view X-ray.

Fig. (4): After Removal.

Ethical approval:
This study was ethically approved by the Research Ethical Committee of Menoufia University. Written informed consent of all the participants or the participants' parents was obtained. The study protocol conformed to the Helsinki Declaration, the ethical norm of the World Medical Association for human testing.

Statistical Analysis:
The findings were tabulated and statistically analyzed using SPSS Version 24.0. The descriptive statistics used were mean± SD, and median. The X^2-test, standard student-t test (t), Mann-Whitney U test, and parried t test were all used in the analysis. A P value of ≤0.05 was judged statistically significant.

RESULTS

Table (1) reveals that there were 14(70%) male patients in the sample group. The age of participants varied from 14 to 40, with mean ± SD = 24.4 ± 7.35.

Table (1): Demographic characteristics among population of the research

Study population (n = 20)	
Male Female	14 (70%) 6 (30%)
Age (years) Mean ± SD. Median (IQR) Range (Min-Max)	 24.4 ± 7.35 23 (18.5 - 28.5) 26 (14 - 40)

SD: standard deviation, IQR: interquartile range

There was a highly statistically significant variance between the pre-operative and post-operative cases regarding range of motion, muscle strength,
and HSS knee score ($p < 0.001$) (Table 2).

Table (2): Range of Motion & Muscle Strength HSS Knee score among the study population

	Preoperative (n = 20)	**Postoperative (n = 20)**	**Test of Sig.**	**P**
Range of Motion Mean ± SD Median (IQR) Range (Min-Max)	 11.1 ± 1.37 11 (10 - 12) 6 (8 - 14)	 15.9 ± 1.97 16 (14 - 18) 7 (13 - 20)	 t = -8.938	 <0.001
Muscle Strength Mean ± SD Median (IQR) Range (Min-Max)	 6.15 ± 0.67 6 (6 - 7) 2 (5 - 7)	 8.8 ± 1.06 9 (8 - 9.25) 4 (7 - 11)	 t = -9.471	 <0.001

t: Independent T test, **p**: p value for comparing between the studied groups, P-value > 0.05: Non significant; P-value. < 0.05: Significant; P-value < 0.001: Highly significant.

There was highly statistically significant variance among studied individuals pre-operative & post- operative as regard flexion deformity and instability HSS knee score (p below 0.001). (Table 3)

Table (3): Flexion Deformity & Instability HSS Knee score among the study population

	Preoperative (n = 20)	**Postoperative (n = 20)**	**Test of Sig.**	**p**
Flexion Deformity Mean ± SD. Median (IQR) Range (Min-Max)	 6.1 ± 0.85 6 (6 - 7) 3 (4 - 7)	 8.8 ± 1.06 9 (8 - 10) 3 (7 - 10)	 t = -8.897	 <0.001
Instability Mean ± SD. Median (IQR) Range (Min-Max)	 6.25 ± 0.79 6 (6 - 7) 2 (5 - 7)	 8.8 ± 1.01 9 (8 - 10) 3 (7 - 10)	 t = -8.935	 <0.001

There was highly statistically significant variance among studied cases pre-operative & post- operative as regard mMPTA (°) and no statistically significant difference as reagard mLDFA (°) (Table 4).

Table (4): mMPTA (°) &mLDFA (°) Radiographical measurements among the study population

	Preoperative (n = 20)	**Postoperative (n = 20)**	**Test of Sig.**	**p**
mMPTA (°)				
Mean ± SD.	32.45 ± 8.36	48.4 ± 8.49	t = -5.986	<0.001
Median (IQR)	31.5 (26 - 40.25)	51.5 (41.5 - 55.25)		
Range (Min-Max)	26 (21 - 47)	26 (33 - 59)		
mLDFA (°)				
Mean ± SD.	88.2 ± 10.92	88.05 ± 10.8	t = 0.044	0.965
Median (IQR)	87 (81 - 91.25)	85.5 (81 - 95.25)		
Range (Min-Max)	45 (73 - 118)	41 (67 - 108)		

There was a highly statistically significant variance between the pre-operative and post-operative cases regarding MAD-C (mm), and no statistically significant difference was observed regarding PPTA (°) and tibial slope (°) (Table 5).

Table (5): MAD-C (mm), PPTA (°) & Tibial slope (°) Radiographical measurements among the study population

	Preoperative (n = 20)	**Postoperative (n = 20)**	**Test of Sig.**	**p**
MAD-C (mm)				
Mean ± SD.	28.2 ± 3.41	5.65 ± 0.67	t = 29.001	<0.001
Median (IQR)	28 (26.75 - 29.5)	6 (5 - 6)		
Range (Min-Max)	13 (21 - 34)	2 (5 - 7)		
PPTA (°)				
Mean ± SD.	79.1 ± 9.85	78.55 ± 9.69	t = 0.178	0.86
Median (IQR)	80 (70.5 - 86.25)	80.5 (75 - 85.5)		
Range (Min-Max)	31 (64 - 95)	39 (54 - 93)		
Tibial slope (°)				
Mean ± SD.	9.2 ± 1.06	9.8 ± 1.15	t = -1.717	0.094
Median (IQR)	9 (8.75 - 10)	10 (9 - 10)		
Range (Min-Max)	4 (7 - 11)	5 (8 - 13)		

There was highly statistically significant variance among studied cases pre-operative & post- operative as regard JCA (°) and TFA (°) (Table 6).

Table (6): JCA (°) & TFA (°) Radiographical measurements among the study population

	Preoperative (n = 20)	**Postoperative (n = 20)**	**Test of Sig.**	**p**
JCA (°)				
Mean ± SD.	1 ± 0	1 ± 0	t = 65535	<0.001
Median (IQR)	1 (1 - 1)	1 (1 - 1)		
Range (Min-Max)	0 (1 - 1)	0 (1 - 1)		
TFA (°)				
Mean ± SD.	8.8 ± 1.15	1.75 ± 0.44	t = 31.882	<0.001
Median (IQR)	9 (8 - 9.25)	2 (1.75 - 2)		
Range (Min-Max)	5 (6 - 11)	1 (1 - 2)		

There was highly statistical significant variance (p below or equals 001) among the both groups as regard total HSS Knee score (Figure 1).

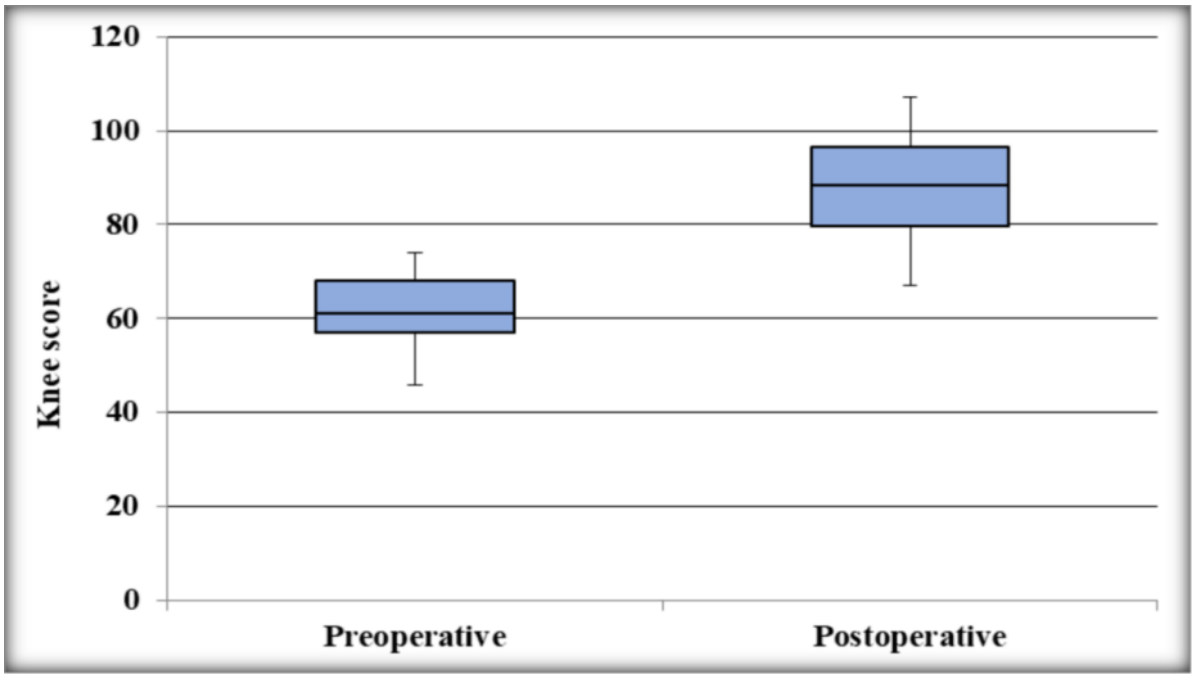

Figure (1): Box-plot revealing variance among the study groups concerning knee score.

Number of cases with Compartment syndrome in the study population was 2 (ten percent). Number of cases with insufficient callus formation in the study population was 1 (5.00%). (Figure 2)

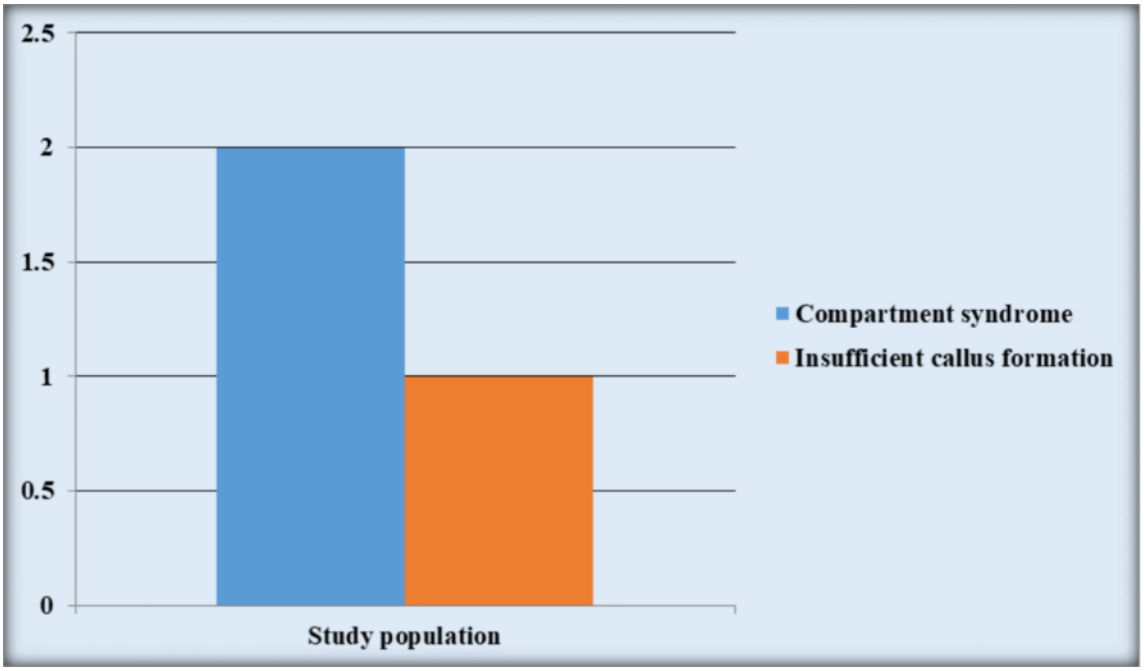

Figure (2): Bar chart revealing study population data concerning major complications.

DISCUSSION

Regarding the demographic characteristics among the studied groups, the present research indicated that the patients were predominantly male (14, 70%). The age of the examined individuals ranged from 14 to 40, with a mean ± SD of 24.4 ± 7.35.

Consistent with the present investigation, **Zayda *et al.*** [11] showed that patients with genu varum were predominantly male (68%). Additionally, **Mayer *et al.*** [12] reported that most patients were male (65%). Our investigation revealed a highly statistically significant variance among the studied patients pre-operative and post-operative regarding range of motion, muscle strength, and HSS knee score ($p < 0.001$).

In line with the current study, **El-Gafary *et al.*** [13] evaluated the findings of Ilizarov external fixator treatment in seven adolescent tibia varus cases and found that the average preoperative knee range of motion was 126.55º (range: 95º-148º), which subsequently decreased to 129.2º (range: 85º-145º).

Moreover, **Shiha *et al.*** [9] stated that all participants in this trial maintained nearly complete range of motion in the knee and ankle joints when the frame was applied. There was no decline in the knee's range of motion in any patient at the latest follow-up.

A highly statistically significant variance was found among the studied cases pre-operative and post-operative regarding flexion deformity and instability, with the HSS knee score showing significant improvement ($p < 0.001$).

Park *et al.* [14] showed that flexion deformity increased from 8.8 to 9.3, and instability increased from 8.3 to 9.5. However, this increase was non-significant for both range of motion and muscle strength, which contrasts with the current study and may be attributed to differences in sample size and severity.

There was a highly statistically significant variance ($p \leq 0.001$) between both groups regarding the total HSS knee score.

Consistent with the current investigation, **Salama *et al.*** [15] included 23 individuals (25 knees) with lower limb deformities who underwent progressive correction of their deformities using the Ilizarov device. The average age of the patients was 26.5 years, ranging from 10 to 45 years. Sixteen were male and nine were female. The study found that the average preoperative HSS score was 60 (range: 31-96), and the average HSS knee score after surgery was 93 (range: 67-100). The HSS score was rated as excellent in 15 limbs, good in 8 limbs, fair in 1 limb, and poor in 1 limb. 92% of cases yielded excellent or good results, while 8% yielded fair or poor results [11].

Also, in concordance with the current study, **Park *et al.*** [14] revealed that gradual correction using the Ilizarov fixator led to a substantial enhancement in the overall HSS score at the final evaluation. The average HSS score increased from 61.1 (SD 3.3) to 88.9 (SD 5.4) ($p < 0.001$).

A highly statistically significant variance was found among the studied cases pre-operative and post-operative regarding mMPTA (°), with no statistically significant difference observed regarding mLDFA (°).

Park *et al.* [14] showed that the mMPTA significantly improved from 72.4 (2.1) to 90.1 (2.8). However, the variances in mLDFA before and after surgery were not significant (88.1 (2.0) versus 88.2 (2.7), respectively).

A highly statistically significant variance was found among the studied cases pre-operative and post-operative regarding MAD-C (mm), with no statistically significant difference observed regarding PPTA (°) and tibial slope (°).

In concordance with the current study, **Mayer *et al.*** [12] found that the average preoperative MAD-C showed considerable improvement both at the time of frame removal and at the final follow-up. There were no significant changes in correction between the time of frame removal and the final follow-up, and no significant improvement was seen in PPTA.

Also, **Park *et al.*** [14] showed that MAD-C showed considerable improvement; however, there were no significant changes observed between the preoperative and postoperative PPTA, as well as tibial slope.

A highly statistically significant variance was found among the studied cases pre-operative and post-operative regarding JCA (°) and TFA (°).

Consistent with the current study, **Park *et al.*** [14] showed that the TFA significantly improved. However, in contrast to the current study, the variances in JCA before and after surgery were not significant.

Our study showed that major complications included compartment syndrome in 2 (10%) patients and insufficient callus formation in 1 (5%) patient.

With respect to the current research, **Salama *et al.*** [15] showed that complications consisted primarily of grade 1 and grade 2 pin tract infections (13 limbs and 7 limbs, respectively). Acute pin site infections exhibited favorable responses to both local pin site treatment and oral antibiotics. No instances of profound infection, persistent discharge, or infection after frame removal were reported. There were no instances of iatrogenic neurovascular injury or intraoperative complications in any case.

CONCLUSION

Gradual correction using the Ilizarov fixator is a safe, accurate, and reliable method for correcting severe genu varum greater than 20 degrees. Clinically, the total HSS knee score, including pain, function, range of motion, muscle strength, flexion deformity, and instability, significantly improved postoperatively. Radiologically, mMPTA, MAD-C, ICA, and TFA significantly increase after surgery, without disturbing the posterior tibial slope. Nevertheless, it is important to engage in thorough preoperative conversations with patients or their caregivers regarding potential consequences, since patients' willingness to accept and

adhere to the frame may provide challenges.

Conflict of interest: None.
Financial disclosures: None.

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