Correction of multiplanar deformities around the knee with monolateral external fixator

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Introduction
Angular deformities around the knee are common during childhood and most cases are a variation in the normal growth pattern. Uncorrected deformities change the biomechanics by disturbing stress distribution on the knee joint weight-bearing surface. Monolateral external fixator with osteotomy has shown better results being simple, and offers accurate correction, a low complication rate, the ability to correct valgus, varus, and rotational deformities, with early mobilization of the patient.

Patient and methods
A multicenter study case series prospective study was conducted from January 2020 to January 2021. A total of 30 patients with coronal plane deformities were included in the study. Of them, 15 patients (all cases were unilateral, 9 left limbs and 6 right limbs) presented with genu valgum with an age range between 10 and 16 years, and mean age was 10.5 years. Eight patients presented with genu varum only and six cases presented with genu varum and internal tibial torsion (all cases were unilateral, seven right limbs and eight left limbs) with an age range between 10 and 16 years and a mean of was 12.4 years.

Results
There is a statistically significant decrease of tibiofemoral angle (TFA) and mechanical axis deviation (MAD) after surgical correction of genu valgum among the included children with *P* value=0.001, and there is a statistically significant increase of lateral distal femoral angle (LDFA) after surgical correction of genu valgum with *P* value=0.001. There is a statistically significant increase of TFA, medial proximal tibial angle (MPTA), and MAD after surgical correction of genu varum among the included children with *P* value=0.001.

Conclusion
Correction of multiplanar deformities around knee using monolateral external fixator has good results in genu valgus with the improvement of LDFA and TFA, and with the improvement of MPTA and TFA in genu varum and with correction of MAD in both of the deformity after surgical correction, with rotation correction using the ability of direction of Schanz placement.

Keywords:
deformities, knee, monolateral external fixator

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Introduction

Angular deformities around the knee are common during childhood and most cases are a variation in the normal growth pattern. Uncorrected deformities change the biomechanics by disturbing stress distribution on the knee joint weight-bearing surface [1,2]. Pediatric lower extremity angular deformity arises in any of the three planes (coronal, sagittal, and transverse). These deformities can lead to gait abnormalities, pain, or the development of future arthritis and disability [3]. Correction of deformity around the knee depends on the position of center of rotation of angulation and the degree of deformity. Correction varies according to the age of the patient and the position of deformity. Osteotomy is still considered the "gold standard" by some, but it is associated with increased expenses and morbidities including overcorrection or undercorrection, neurovascular risk, hardware healing problems, and recurrent deformity with growth [2]. Osteotomy and internal fixation have many hazards including a longer operative time, more intraoperative bleeding, a higher risk of infection, delayed mobilization of the patient, and a long skin scar [4].

Monolateral external fixator with osteotomy has shown better results being simple, and offers accurate correction, a low complication rate, the ability to

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correct both valgus and varus deformities, and early mobilization of the patient [5].

Patient and methods

A multicenter study case series prospective study was conducted from January 2020 to January 2021. A total of 30 patients with coronal plane deformities were included in the study.

Of them, 15 patients (all cases were unilateral, 9 left limbs and 6 right limbs) presented with genu valgum with female predominance at 53.3% and male 46.7%, with female to male ratio 1.14:1, with age range between 10 and 16 years, and mean age 10.5 years.

Eight patients presented with genu varum only and six cases presented with genu varum and internal tibial torsion (all cases were unilateral, seven right limbs and eight left limbs) with male predominance at 60.0% and female 40.0%, with male to female ratio 1.5:1, with age range between 10 and 16 years and mean 12.4 years (Table 1).

Table 1 Demographic data

Patient number	Sex	Side	Age	Deformity type
1	M	LF	14	Valgum
2	F	RT	11	Valgum
3	M	RT	10	Valgum
4	F	LF	12	Valgum
5	M	LF	10	Valgum
6	F	RT	10	Valgum
7	F	RT	12	Valgum
8	F	LF	10	Valgum
9	M	LF	11	Valgum
10	M	LF	12	Valgum
11	M	RT	11	Valgum
12	M	RT	10	Valgum
13	F	LF	10	Valgum
14	F	LF	11	Valgum
15	F	LF	16	Valgum
16	M	RT	11	Varum
17	M	RT	10	Varum
18	F	RT	12	Varum
19	M	LF	10	Varum
20	F	LF	10	Varum
21	M	RT	10	Varum
22	M	RT	12	Varum
23	M	LF	11	Varum
24	M	LF	12	Varum
25	F	LF	11	Varum
26	M	RT	10	Varum
27	M	RT	10	Varum
28	F	LF	11	Varum
29	F	LF	10	Varum
30	F	LF	16	Varum

LF, left; RT, right.

All cases meet inclusion criteria and were corrected with the monolateral external fixator (Hoffmann external fixator).

Inclusion criteria

(1) Genu valgus having a tibiofemoral angle (TFA) of more than 15 degrees.
(2) Genu varum having a metaphyseal-diaphyseal angle of more than 11 degrees.
(3) Presence of deformity causing functional disability of the patient.

Exclusion criteria

(1) Genu recurvatum.
(2) Flexion deformity.
(3) Pathological conditions (bone softening diseases).
(4) Severe deformities of more than 40 degrees when acute correction may lead to knee instability and nerve injury.

All children were assessed using plain x-rays (weight-bearing anteroposterior, lateral), computarized tomography (CT) scanogram, serum levels of parathyroid hormone, and calcium to exclude any parathyroid gland pathology that may contribute to the deformity.

Surgical technique

All cases were positioned supine, general anesthesia was given, and C-arm device was used.

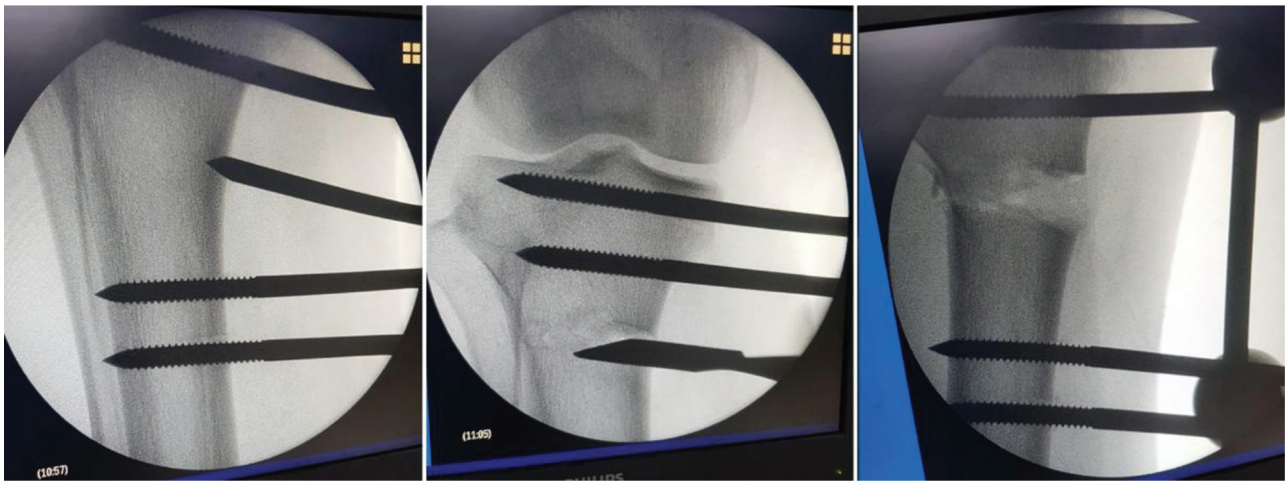
Genu varum

Fibular osteotomy was done with a skin incision about 1 cm at the junction between the middle and distal one-third of the fibula followed by the monolateral frame.

Through two minimal skin incisions on the medial side of the proximal tibia under C-arm guide, the first Schanz proximal tibial epiphysis parallel to the joint line was placed. The second Schanz was of the same diameter and placed just below the physeal growth plate over the clamp. The third and fourth Schanz were placed in the tibial shaft from the medial side. In cases with internal tibial torsion, the direction of the third and fourth Schanz in the tibial shaft was from the medial side with posterior inclination to correct tibial torsion (Fig. 1).

Tibial osteotomy with skin incision about 1 length is done 1 cm distal to tibial tuberosity and by the aid of C-arm drill bit, 4.5 mm incision is made for tibial

Figure 1



X-ray after corrective high tibial osteotomy.

Figure 2

Clinical photo of postcorrection and fixation of fixator in genu varum case.

osteotomy site, and then we introduced an osteotome to complete the osteotomy.

After osteotomy, translation was done to correct the mechanical axis followed by gradual correction followed by rod placement between proximal and distal clamps. Osteotomy site wound closure was performed by simple interrupted sutures (Fig. 2).

Genu valgus

Monolateral frame was placed with distal two Schanz. The first one was applied in the distal femoral epiphysis from lateral to the medial side and the second Schanz was applied parallel to the 1 s just proximal to the distal tibial growth plate through a clamp under C-arm guide.

Then the proximal two Schanz screws were placed through two minimal skin incisions about four-finger breadth proximal to the distal clamp into the femoral shaft through a single clamp.

Femoral osteotomy is done with the aid of a C-arm and using a 5-mm Schanz screw, and the osteotomy is carried out one-to-two finger breadth above and parallel to the physis through lateral, anterior, and with caution the posterior cortices, and then we introduced an osteotome to complete osteotomy (Fig. 3).

After osteotomy, translation was done to correct the mechanical axis followed by gradual correction to allow impaction of the distal segment into the proximal one followed by rod placement between proximal and distal clamps. Osteotomy site wound closure was performed by simple interrupted sutures (Fig. 4).

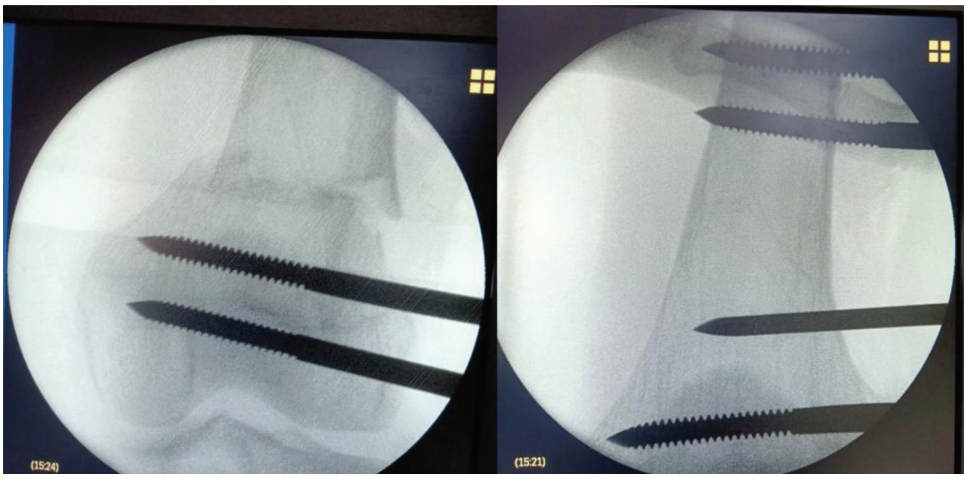
Postoperative follow-up

(1) After x-rays [Anteroposterior (AP), lateral views] 2, 6, and 8 weeks.
(2) Before fixator removal, 3, 9, and 12 months (after fixator removal).

Results

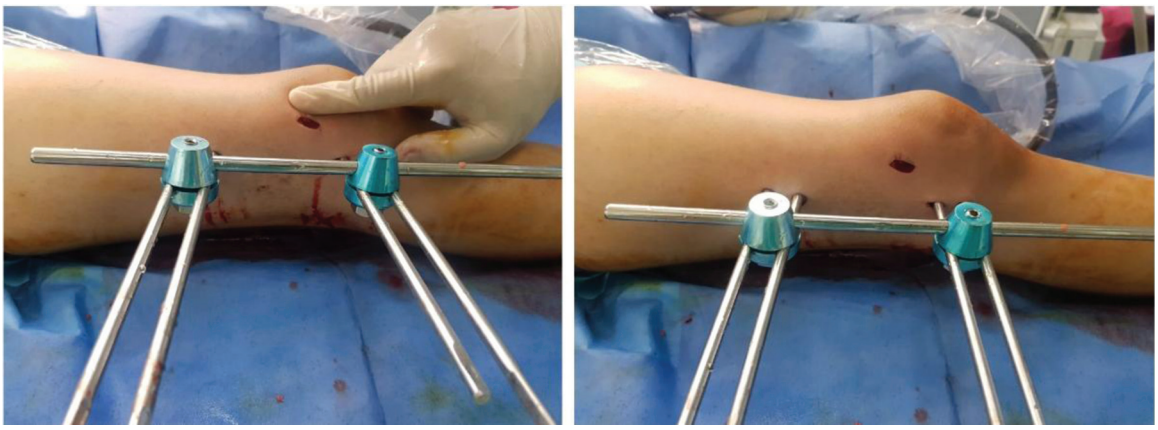
This was a prospective study that was performed on 30 children with angular knee deformities; 50% of the included patients had genu valgum and 50% of them had genu varum.

Figure 3



X-ray after corrective supracondylar osteotomy.

Figure 4



Clinical photo of postcorrection and fixation of fixator in genu valgus case.

There is a statistically significant decrease of TFA and mechanical axis deviation (MAD) after surgical correction of genu valgum among the included children with *P* value=0.001, and there is a statistically significant increase of lateral distal femoral angle (LDFA) after surgical correction of genu valgum with *P* value=0.001. There is a statistically significant increase of TFA, medial proximal tibial angle (MPTA), and MAD after surgical correction of genu varum among the included children with *P* value=0.001 (Tables 2 and 3).

The average time needed for full weight-bearing was 8 weeks and the average time needed for the complete radiological union was 7 weeks in genu varum cases. The average time needed for full weight-bearing was 9 weeks and the average time for the complete radiological union was 8 weeks for genu valgus cases.

Two patients had pin tract infection, both were suffering from genu valgum and were treated with oral antibiotics and followed up until improved; one patient with genu varum had lost correction of the deformity 2 weeks after surgery. This was discovered during the first follow-up visit, he was readmitted and the correction was done again.

Discussion

Angular deformities of the knee alter the biomechanics of the knee by causing a distorted stress distribution on the weight-bearing surface of the knee joint. The deformities of the tibia or femur in the frontal plane led to MAD of the lower limb and malorientation of the joints above and below the level of deformity [6].

Mostafa *et al.* [7] is an Egyptian study that was conducted to evaluate the degree of corrections and

Table 2 The median and range values of TFA, LDFA, and MAD in patients with genu valgum

Variable	Preoperative		Postoperative		Wilcoxon test	*P* value	Sig.
	Median	Range	Median	Range			
TFA	19	14 to 26	6	0 to 10	–3.41	0.001	S
LDFA	77	65 to 80	91	82 to 93	–3.42	0.001	S
MAD	3	2 to 5	0	–5 to 0	–3.43	0.001	S

LDFA, lateral distal femoral angle; MAD, mechanical axis deviation; TFA, tibiofemoral angle.

Table 3 The median and range values of TFA, MPTA, and MAD in patients with genu varum

Variable	Preoperative		Postoperative		Wilcoxon test	*P* value	Sig.
	Median	Range	Median	Range			
TFA	–15	–20 to –11	0	–5 to 10	–3.42	0.001	S
MPTA	80	70 to 84	90	85 to 95	–3.41	0.001	S
MAD	–5	–8 to –3	0	–6 to 3	-3.35	0.001	S

MAD, mechanical axis deviation; MPTA, medial proximal tibial angle; TFA, tibiofemoral angle.

complications done by osteotomy and hemiepiphysiodesis and found female predominance among genu valgum patients (67%), with a mean age of 8.4±3.1 years. There is a statistically significant decrease of TFA and MAD after surgical correction of genu valgum among the included children with *P* value=0.001, and there is a statistically significant increase of LDFA after surgical correction of genu valgum with *P* value=0.001.

Lim *et al.* [8] previously evaluated surgical correction of proximal tibia deformity in small children using monolateral external fixator and found a statistically significant increase of MPTA from 73° to 90° in varus tibia and from 104° to 89° in the valgus tibia, also MDA improved from 19° to 0° in varus tibia and from –25° to 2° in the valgus tibia.

In the present study, characteristics of patients with genu varum was studied, with male predominance at 60.0%, and male 40.0%, with male to female ratio 1.5:1, and age range between 7 and 12 years with median age 10 years.

There is a statistically significant increase of TFA, MPTA, and MAD after surgical correction of genu varum among the included children with a *P* value=0.001.

This goes in run with Pandya *et al.*'s [9] study that was performed on 17 consecutive patients with surgically corrected Blount disease using multiple axial corrections with a statistically significant decrease of MAD and TFA, and an increase of MPTA with *P* value=0.001.Another study by Özkul *et al.* [10] was conducted on 25 patients with genu varum with male predominance at 60%, which revealed a statistically significant decrease of MAD from 37.6 to 8.4 mm with *P* value <0.05, and statistically significant increase of MPTA from 76° to 89° with *P* value <0.05.

Ghasemi *et al.* [11] studied 43 patients with plates and 36 patients with external fixators with moderate uniplanar varus deformities and revealed statistically significant correction of MPTA from 83.9° to 90.9° with *P* value 0.001 and significant improvement of MAD from 23.6 mm medial to the midline to 6.9 mm lateral to midline with *P* value <0.001 that was similar to our study.

The limitation of the study is in the number of cases included, so more studies are needed.

Very few studies in using monoplaner fixator in acute correction of frontal plane and rotation deformities are available.

Conclusion

Correction of multiplanar deformities around knee using monolateral external fixator has good results in genu valgus with the improvement of LDFA and TFA, and with the improvement of MPTA and TFA in genu varum, and with correction of MAD in both of the deformity after surgical correction, with rotation correction using the ability of direction of Schanz placement.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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