Treatment of genu valgum in children by percutaneous transverse metaphyseal osteotomy of the distal femur

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Purpose The aim was to measure and correct the angular deformity of 15 patients with genu valgum by a new percutaneous technique.

Materials and methods We conducted a prospective study to evaluate the results of using percutaneous supracondylar femoral osteotomy technique with casting as a minimally invasive surgical intervention for the treatment of genu valgum.

Results The youngest patient was 7 years and the oldest was 20 years with an average age of 14 years. The range of hospital stay is from 1 or 2 days, but it decreased with the late cases in the study, which can be explained by the improvement in the learning curve of the technique. The least time of follow-up is 6 weeks, but two cases have been followed for 57 weeks with a mean of 24.90 weeks.

Conclusion The percutaneous technique provides the privileges of acute correction without the need for dissection, minimizes the formation of ugly scar or keloid, minimizes the risk of infection, and allows for accurate correction. There is no need for plate fixation or a staged operation to remove hardware.On the other side, the percutaneous osteotomy has a learning curve and the compliant patient is crucial for a close assessment of the condition.
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Introduction

Angular deformities of the lower limbs are common during childhood. In most cases, this represents a variation in the normal growth pattern and is an entirely benign condition [1].

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 [2].

There are two surgical options for dealing with progressive angular deformities in children osteotomy or guided growth surgery. Osteotomy 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 [3].

Unfortunately, local complaints occurred mostly caused by the fixation methods (i.e. irritations of the tractus iliotibialis) and stability of fixation method (i.e. delayed bone healing). The medial closed varus osteotomy creates an unstable situation and relies much more on rigid internal fixation. Bone healing and length are often opposing considerations. In osteotomies stabilized by plating or nailing, an opening wedge risks nonunion and a closing wedge leads to shortening [4].

The percutaneous technique is a new modification of formal osteotomy that can avoid the above mentioned disadvantages.

Materials and methods

Our study was a prospective analysis, 11 patients (15 limbs) were included in our study. Six patients were men and five patients were women. Four patients had bilateral genu valgus and seven had unilateral genu valgus. The youngest was of 7 years and the oldest was 18 years with an average of 14 years. The Ethics Committee of our institute approved the study.

Patient characteristics

Our study population included all patients presented above the age of 7 years with genu valgus having a tibiofemoral angle of more than 15°.

All patients with any other associated deformity were excluded:

(1) Flexion deformity (fixed flexion deformity >15°).

(2) Genu recurvatum.
(3) Severe collateral ligament instability.
(4) Evidence of subluxation.

Evaluation included preoperative history taking, physical examination, laboratory investigation, and radiographic measurements. Postoperatively, the outcome was measured according to clinical improvements, radiographic measurements, and modified Bostman knee score.

Full laboratory investigation: complete blood count, prothrombin time, prothrombin concentration (PC), international normalized ratio, serum calcium, serum phosphorus, and serum alkaline phosphatase; in case of rickets: parathyroid hormone and vitamin D level.

Radiological evaluation: Scanogram both lower limbs (preoperative and after osteotomy consolidation).

Surgical technique

Position of the patient: the patient should be supine in a suitable position that the C-arm can give good pictures of the knee joint. A tourniquet is applied above the knee.

The surgeon positions himself on the contralateral side, whereas the C-arm sets on the ipsilateral side. A 2 cm transverse incision is made on the medial side at the level of the upper pole of the patella (Fig. 1).

Using a straight haemostat, a plane of dissection is created longitudinally between the subcutaneous tissue and the muscles so that haemostat can reach the cortex on C-arm images.

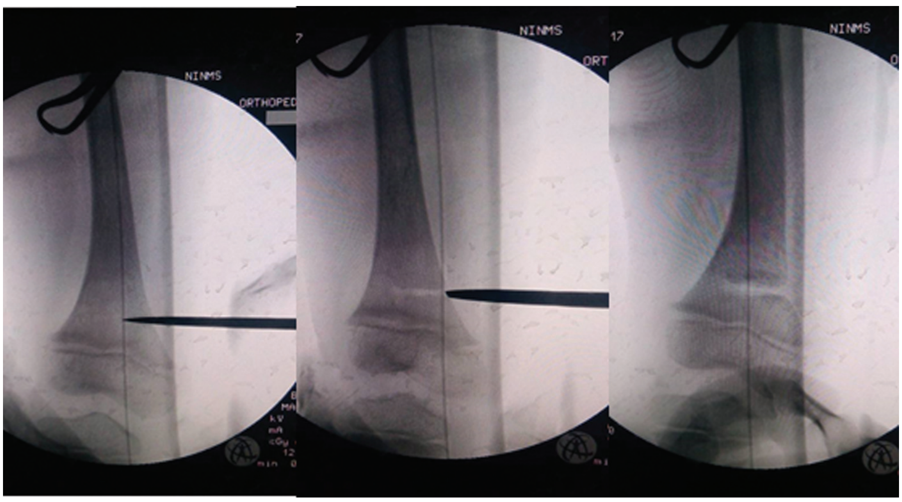
Place an osteotome in a horizontal way through the flap in the muscular layer above the level of the physis (Figs. 2–5). Make a window-shaped cortectomy on the medial side of the femur?and impaction of the cancellous bone proximally and distally using the osteotome. Start making cortectomy in a systematic manner through anteromedial, anterolateral, posteromedial, and through posterolateral cortex under the guidance of C-arm without the violation of the surrounding soft tissue. Drill the lateral cortex 2–3 drills to weaken the far cortex.

Gradual correction allows impaction of the distal segment into the proximal one with application of the cast while maintaining correction. Make an image to be sure that the desired correction is achieved.

Figure 1

Skin incision.

Figure 2



The osteotomy.

Case 2

(1) A 10-year-old male patient.
(2) Complaint: bilateral genu valgum.
(3) Cause: nutritional rickets.
(4) Intermalleolar distances: 11 cm.

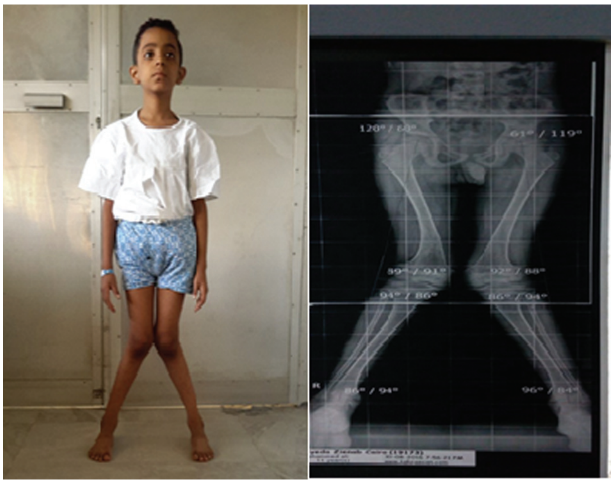
Intraoperative

(1) The surgical technique was done as described.
(2) Postoperative image.
(3) Follow-up for 5 months.

Statistical analysis

Data were analyzed using the statistical program for social science, version 20.0 (SPSS; SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean±SD. Qualitative data were expressed as frequency and percentage.

Figure 3



Preoperative scanogram.

The following tests were done: paired sample *t*-test of significance, χ^2-test, the confidence interval was set to 95%, and the margin of error accepted was set to 5%. So, the *P* value was considered significant as the following:

(1) *P* value less than 0.05 was considered significant.
(2) *P* value less than 0.001 was considered as highly significant.
(3) *P* value greater than 0.05 was considered insignificant.

Results

The youngest patient was 7 years and the oldest was 18 years with an average of 14 years. The range of hospital stay is from 1 to 2 days but it decreases with the late cases in the study that can be explained by the improvement in the learning curve of the technique. The least time of follow-up is 6 weeks, but some cases have been followed for 57 weeks with a mean of 24.90 weeks (Tables 1 and 2).

In the clinical assessment, intermalleolar distance is a critical element to decide if the condition is candidate for surgical intervention. There has been improvement from mean 15.93 to 5.87 cm with *P* value of less than 0.001 (HS).

Table 1 Clinical data of the study stratified according to cause and side

	N (%)
Cause	
Idiopathic	8 (53.3)
Post-traumatic	1 (6.7)
Rickets	6 (40)
Side	
Left	7 (46.7)
Right	8 (53.3)

Figure 4

Postoperative radiographies.

Figure 5

Scanogram after 5 months of operation.

Table 2 Clinical data of the patients stratified according to MDLFA, tibiofemoral angle and intermalleolar distance

	Preoperative	Postoperative	*t*-test	*P* value
Intermalleolar distance				
Range	8–35	0–15	9.482	<0.001 (HS)
Mean±SD	15.93±5.96	5.87±3.4		
Median	14	5		
Tibiofemoral angle				
Range	15–36	0–15	7.219	<0.001 (HS)
Mean±SD	22.6±5.84	8.0±3.5		
Median	22.5	8.5		
MDLFA				
Range	72–83	85–99	8.916	<0.001 (HS)
Mean±SD	79.13±3.03	90.97±3.87		
Median	80	89.5		

HS; highly significant; MDLFA, mechanical lateral distal femoral angle.

Tibiofemoral angle and mechanical lateral distal femoral angle (MDLFA) have been significantly improved from a mean of 22.6–8 and from a mean of 79.13–90.97, respectively.

There has been dramatic improvement from a mean of 22.6–8, although, two patients with bilateral affection have been overcorrected and one of them was recorrected a 2 weeks from surgery by changing cast under general anesthesia and C-arm guidance.

The improvement of MDLFA is statistically significant from a mean of 79.13–90.97; the range of correction postoperatively are 85–99, six (20%) patients are recorded to be in the range of 95–99, but only one patient with bilateral correction is categorized as unsatisfactory according to the modified Bostman knee score. The amount of correction in patients ranged from 4 to 19° (Table 3).

An accurate correction of malalignment and of joint orientation is important for function and to prevent joint degeneration. There has been statistical difference that 12 (80%) cases were within the range of +1 and −1 with *P* value of less than 0.001 (Table 4).

Table 3 The clinical outcome of the study according to mechanical axis deviation

Mechanical axis deviation	Preoperative [*n* (%)]	Postoperative [*n* (%)]	χ^2-test	*P*
3 plus	7 (46.7)	0 (0.0)	24.633	<0.001
2 plus	8 (53.3)	1 (6.7)		
1 plus	0 (0)	6 (40.0)		
1 min	0 (0)	6 (40.0)		
2 min	0 (0)	1 (6.7)		
3 min	0 (0)	1 (6.7)		

The Bostman knee score [5] is used to assess the results of the percutaneous technique. The modification in the score is using school in exchange for work to match the age of targeted cases. Throughout the questionnaire, a higher score means better results. Moreover, the total score is divided to categorize the results as unsatisfactory, good and the score is divided to categorize the results as unsatisfactory, good, and excellent.

The difference in pain is statistically significant. Its mean changes from 2.9 to 5.2 with *P* value of less than 0.001. It is noticed that the pain is more in patients with a lower level of osteotomy that affects patellofemoral articulation. These cases needed a longer period of follow-up and physiotherapy, but eventually all recover with excellent outcome.

Return to daily activities has been statistically improved from a mean of 2.87–3.87 with *P* value of less than 0.001. It is interesting to know that one case participates in regional and national team sports (100 m dash).

From the statistical point of view, the total score shows significant improvement from a mean of 21 to 30 with *P* value of less than 0.001 (Table 5).

Using the categorizing of the Bostman knee score, 11 (73.3%) cases are excellent and three (20%) cases are good. Only one patient with bilateral affection is overcorrected, so the result is unsatisfactory.

Discussion

There are three surgical options for the correction of knee deformity of femoral origin.

Acute correction by corrective osteotomy at distal femoral metaphysis has been the mainstay of pediatric orthopedics and is often considered the definitive treatment. However, dissection may result

Table 4 The results according to preoperative and postoperative Bostman knee score [5]

	Preoperative	Postoperative	Paired sample *t*-test	*P* value
Pain				
Range	0–6	0–6	7.112	<0.001 (HS)
Mean±SD	2.90±2.43	5.2±1.92		
Median	3	6		
Work/school				
Range	0–4	2–4	5.414	<0.001 (HS)
Mean±SD	2.87±1.25	3.87±0.51		
Median	3	4		
Assistance in walking				
Range	0–4	2–4	6.687	<0.001 (HS)
Mean±SD	3.07±1.14	3.87±0.51		
Median	4	4		
Stair climbing				
Range	0–2	1–2	6.851	<0.001 (HS)
Mean±SD	0.97±0.41	1.83±0.38		
Median	1	2		
Giving way				
Range	0–2	2–2	5.216	<0.001 (HS)
Mean±SD	1.73±0.58	2.0±0		
Median	2	2		
Difference in patella circumference				
Range	0–4	2–4	6.442	<0.001 (HS)
Mean±SD	2.67±1.42	3.87±0.51		
Median	2	4		
Effusion				
Range	0–2	1–2	1.433	0.223 (NS)
Mean±SD	1.5±0.68	1.77±0.43		
Median	2	2		
Range of motion				
Range	3–6	3–6	1.476	0.274 (NS)
Mean±SD	5.30±1.29	5.60±1.04		
Median	6	6		
Total				
Range	9–29	15–30	5.823	<0.001 (HS)
Mean±SD	21±6.14	28±3.97		
Median	21	30		

HS, highly significant.

Table 5 The clinical outcome of the study according to Bostman knee score

Total score postoperative	*n* (%)
Unsatisfactory	1 (6.7)
Good	3 (20)
Excellent	11 (73.3)
Total	15 (100)

in ugly scar, risk of infection, physeal injury, and neurovascular affection.

Physeal manipulations are managed using epiphysiodesis that could be permanent by ablation of one side of the physis or temporary using staple, transphyseal screw, or tension band plate.

Gradual correction using an external fixator and distraction osteogenesis offers the advantage of accurate coronal, sagittal, and axial plane correction without significant soft tissue dissection. However, its complications included intractable pin-site infection, superficial pin-site infection, delayed union, long duration of cumbersome fixation, and transfixation of soft tissues.

Corrective osteotomy is the gold standard for severe angular deformity, but is a major surgical intervention with operative site morbidity, postoperative pain, and prolonged therapy that requires internal or external fixation and restricted weight bearing that are the main drawbacks of this surgery. Osteotomies are high-risk surgeries with a small but significant incidence of compartment syndrome, neurovascular injury, and overcorrection or undercorrection, delayed union or nonunion [6].

Ballal *et al.* [7] had 25 consecutive children (51 physes, 12 bilateral procedures) with symptomatic varum or genu valgum treated by guided growth using a flexible two-hole titanium plate (eight plates). All the children were entered into a database and reviewed as outpatients at 4-monthly intervals until correction was complete.

The 25 children included in the study had a mean follow-up of 12.4 months (6–32 months) at the time of plate removal. Those who had not reached skeletal maturity at the time of the study would be followed up until maturity. There were 10 women and 15 men. The mean age was 11.6 years (5.5–14.9 years).

There were 12 bilateral and 13 unilateral deformities. The preoperative deformity ranged from 53° of genu varum to 17° of genu valgum. The mean deformity for genu varum was 28.8° (11.1–53.3°) and 8.4° (3–25°) for genu valgum. Owing to the large range in size and direction of deformity, there was a correspondingly large range in the time required for gradual correction; the mean was 16.1 months (7–37.3 months). The rate of correction was influenced by the physis treated and the age of the child. There was a mean rate of correction of 0.7° (0.3–1.5°) per month in the distal femur, of 0.5° (0.1–1.0°) per month in the proximal tibia, and of 1.2° (0.1–2.2°) per month if femur and tibia were treated concurrently.

When the sample was divided into two groups to reflect an approximate age of onset of puberty, the overall rate of correction for children under the age of 10 years was 1.4° per month, compared with 0.6° per month for the older children.

Conclusion

Corrective osteotomy is the gold standard for severe angular deformity, but is a major surgical intervention with operative site morbidity, post-operative pain, and prolonged therapy that requires internal or external fixation and restricted weight bearing which are the main drawbacks of this surgery. The use of percutaneous osteotomy can fulfill its role for correction without exposure to the hazards associated with the standard technique.

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Nil.

Conflicts of interests

There are no conflicts of interest.

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