Result of hemiepiphysiodesis for idiopathic genu valgum by retrograde percutaneous transphyseal screw

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Background
Genu valgum is the most common reason for pediatric orthopedic consultations. Osteotomies are frequently unnecessary when hemiepiphysiodesis is performed on growing children with angular deformities.
Aim
To assess clinical and radiological outcomes of idiopathic genu valgum deformity treatment in the pediatric population with percutaneous retrograde transphyseal screw and evaluate its efficacy and safety.
Patients and methods
This prospective study involved 11 patients aged 8–14 years, encompassing both sexes, with genu valgum deformity of knee more than 20°. All patients were subjected to retrograde percutaneous transphyseal screw application.
Results
Mechanical lateral distal femoral angle was significantly higher after 3 months, after 6 months, after 9 months, and after 1 year than preoperative (P<0.001). The rate of correction was significantly higher after 6 months, after 9 months, and after 1 year than after 3 months (P<0.05). The rate of correction was significantly higher after 3 months and after 1 year in patients. The mean of improvement was 90.3±3.19%. The complication of this technique: rebound was defined after 6 months occurred in one (5%) patient. Flexion contraction occurred in two (10%) patients. Irritation of the medial collateral ligament occurred in two (10%) patients. Painful flexion occurred in one (5%) patient.
Conclusion
A safe and successful way for treating idiopathic genu valgum abnormalities in juvenile patients was the retrograde percutaneous transphyseal screw procedure. A faster rate of correction was seen in younger individuals, although the mechanical lateral distal femoral angle improved significantly and gradually with time in the research.

Keywords:
genu valgum, hemiepiphysiodesis, mechanical lateral distal femoral angle, retrograde percutaneous transphyseal screw

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Introduction

One of the most prevalent reasons children see pediatric orthopedics is for genu valgum deformities, even though some degree of valgus deformity is deemed typical up to the age of 7 [1].

The distal femur (DF) is the most common location of primary pathological genu valgum but can arise from the tibia [2].

Symptoms related to genu valgum include circumduction gait, difficulty in running, knee pain, and patellar instability. Selected and symptomatic patients may be subjected to corrective osteotomy or, more recently, guided growth.

Bilateral genu valgum could be caused by physiologic, renal osteodystrophy (renal rickets), skeletal dysplasia, or spondyloepiphyseal dysplasia. Idiopathic genu valgum occurs at an unknown real incidence. Undoubtedly, it ranks high among the most prevalent reasons why youngsters have anterior knee pain and patellar dislocation.

It is commonly acknowledged that children between the ages of 2 and 6 may experience physiologic genu valgum. Ligamentous laxity, symmetry, and pain absence or functional restrictions are common features for this age range [3].

General conservative treatment for genu valgum is observation and bracing when the deformity is less than 15° and the child is less than 7 years old. Early detection and adequate intervention are necessary for achieving optimal deformity correction [4].

In order to alleviate symptoms and prevent progression, aggressive treatment is necessary for pathologic genu valgum. Only surgical intervention has been effective in resolving the issue [5].

Osteotomies are frequently avoided when physeal-directed growth therapy (hemiepiphysiodesis) is used to treat angular abnormalities in growing youngsters [6].

Problems that could arise included infections of the skin around the wound, improper placement of the staples, extrusion, bending, breaking, and difficulty in removing the staples [7].

Orthofix of Verona, Italy developed an 8-plate system, and its results were published in 2008 by Burghardt *et al.* [8], marking the emergence of a new approach.

In order to accomplish a temporary hemiepiphysiodesis, the 8-plate is screwed into place using two holes. The tension band plate (TBP) was considered an improvement over the Blount staple since, unlike the stapling approach, it does not compress the growth plate [9].

This work aimed to evaluate the clinical and radiological outcomes of idiopathic genu valgum deformity treatment in the pediatric population with percutaneous retrograde transphyseal screws and evaluate its efficacy and safety.

Patients and methods

This prospective study involved 11 patients, aged 8–13 years, of both sexes, presenting with genu valgum deformity of the knee exceeding 20°. The research was conducted from August 2022 to May 2024, following approval from the Ethical Committee of Tanta University Hospitals, Tanta, Egypt. Informed written consent was acquired from the patient's relatives.

Exclusion criteria were patients with old surgery for correction deformity, secondary genu valgum due to irradiation, neuromuscular diseases, infection, and active rickets.

A thorough medical history, physical exam, and laboratory evaluation [serum (calcium and phosphate), alkaline phosphatase, urine analysis, and renal function tests] and radiological investigation (radiograph) were conducted on every single patient.

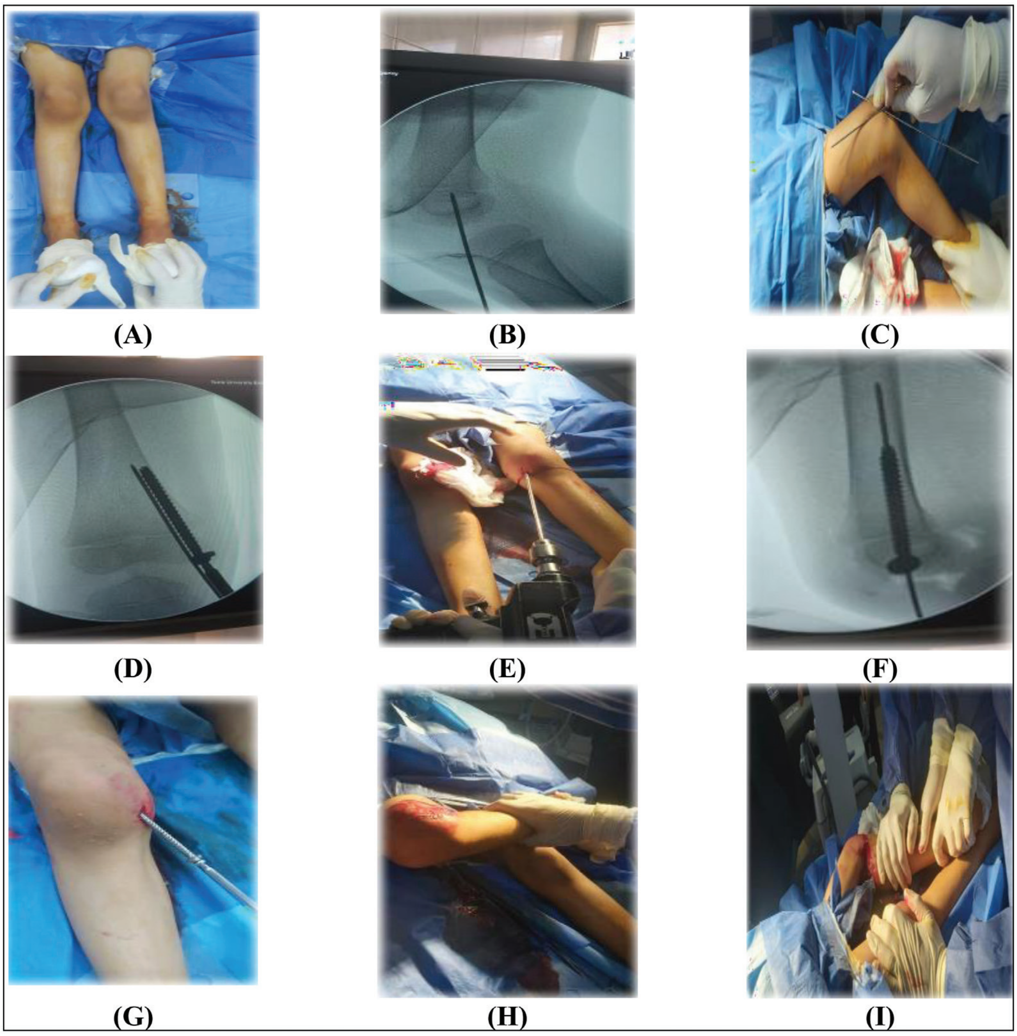
Surgical procedures

Patients were placed in a supine position on a radiolucent table while under general anesthesia; no tourniquet was utilized. After positioning the guide wire above the abnormal knee, the intended screw trajectory may be reproduced with the use of fluoroscopy. The afflicted knee needed accurate lateral and anteroposterior radiographs taken while the patient was in a 45° flexion posture. Dermal screw entrance was determined by drawing two perpendicular lines on the radiography projections and then intersecting them. This spot was cut using a 1 cm incision. A guide wire was introduced into the distal epiphysis through a small incision immediately below the femoral medial epicondyle using fluoroscopy. In order to accomplish the posterior translation, the collateral ligaments are moved away from the screw entrance by flexing the knee. Following that, the wire was angled at a 60–70° angle relative to the physeal plane and pressed obliquely across the physis. The midpoint of the medial femoral condylar physis, where the two halves meet, was the site of the guide wire's further advancement. We accomplished this because our view from the front and back did not extend beyond the junction of the diaphyseal and metaphyseal segments. The screws were carefully crafted to pass through the midline of the physis, as seen from the side. The procedure began at the cortex entry point and continued to the area right below the physis using a 5.2 mm cannulated drill. It was absolutely forbidden to drill into the physis. A properly threaded 7 mm screw with a cannula and a washer covered the wire. The screw was driven in by hand using a screwdriver. When the screw length was set to include 80% of the metaphysis and 20% of the epiphysis, it was possible to get a maximum bone grip on both physeal sides. By gently guiding the knee in a fully extended and flexed position, the soft tissue that had been trapped behind the screw washer was freed. Following the injection of local anesthesia at the surgical site, the skin was sutured shut using a single subcuticular stitch. There was no need to immobilize the patient after the procedure; they could start partial weight bearing right away. During the procedure and the subsequent follow-up, we painstakingly noted and documented any difficulties (Fig. 1).

Postoperative care and follow-up

For the first 24 months after surgery, we compared preoperative and postoperative measures of the mechanical lateral distal femoral angle (MLDFA). MLDFA measurements between 85 and 90° indicate the appropriate time to remove the screws. An ideal

Figure 1



(a) With the patient in a supine posture on a radiolucent table and under general anesthesia, without a tourniquet, step 1 was performed. (b) Step 2 involved placing the guide wire over the deformed knee and using fluoroscopy to replicate the screw's anticipated trajectory. The use of genuine lateral and anteroposterior images was essential. (c) Third step – with the afflicted knee bent at a 45° angle. The screw's dermal entrance location was determined by crossing the two perpendicular lines on the radiography projections. (d) Step 4, at the point where the medial femoral condylar physis's central two-thirds and peripheral thirds meet, the guide wire was moved farther. The reason for this came from the fact that the anteroposterior view terminates at the point where the metaphyseal and diaphyseal segments meet. (e) Fifth step: drilling the entrance point at the cortex up to the area just below the physis was done using a cannulated drill (5.2 mm). To avoid drilling across the physis, step 6 involved inserting a fully threaded 7 mm screw with a cannulated stainless steel end and a washer. The screw was designed to cover 20% of the length of the epiphysis and 80% of the metaphysis for maximum bone grip on both sides. (g) procedure number 7 – the use of a screwdriver in a hand-insertion technique, in order to free the soft tissue trapped under the screw washer, step 8 involved passive knee movement with complete flexion and extension. Step 9 involved infiltrating the surgical incision with local anesthetic and closing the skin with a single subcuticular stitch.

MLDFA for standard variables would fall within this range of angles. It was crucial to continue following up after the femoral screw was removed until the skeleton had fully matured. The effects of removing the screws were documented if the physis persisted in growing after complete repair.

Statistical analysis

We used SPSS, v26 (IBM Inc., Chicago, Illinois, USA) for our statistical analysis. Mean and SD were used as quantitative variables, and an unpaired Student's *t* test was employed to compare the two groups. When applicable, the χ^2 or Fisher's exact test was used to examine the qualitative variables, which were displayed as percentages and frequencies. Statistical significance was determined by a two-tailed P value less than 0.05.

Results

Demographic data, origin deformity, duration, and amount of correction were enumerated in Table 1.

MLDFA was significantly higher after 3 months, after 6 months, after 9 months, and after 1 year than preoperative (P<0.001). The rate of correction was

Table 1 Demographic data, origin deformity, duration, and amount of correction of the studied patients

	N=11
Age (years)	8.4±2.91
Sex	
Male	10 (90.91)
Female	1 (9.09)
Weight (kg)	33.5±11.63
Height (cm)	130.4±18.9
Limb deformity	
Unilateral	2 (18.18)
Bilateral	9 (81.82)
	N=20
Origin of deformity	
DF origin	20 (100.0)
Duration of correction (m)	7.5±1.79
Amount of correction (deg.)	8.9±2.99

Data are presented as mean±SD or frequency (%).
DF, distal femur.

Table 2 Mechanical lateral distal femoral angle, rate of correction and rate of correction according to the age of the studied patients

	N=20		*P*
MLDFA			
Preoperative	78±1.89		–
After 3 months	79.5±1.93		<0.001*
After 6 months	81.3±2.08		<0.001*
After 9 months	83.8±2.1		<0.001*
After 1 year	86.4±2.21		<0.001*
Rate of correction			
After 3 months	1.5±0.51		–
After 6 months	1.9±0.37		0.017*
After 9 months	2.5±0.51		<0.001*
After 1 year	2.6±0.5		<0.001*
Rate of correction according to age			
	<8 years (*n*=8)	≥8 years (*n*=12)	*P*
After 3 months	1.75±0.46	1.25±0.45	0.027*
After 6 months	1.88±0.35	1.83±0.39	0.811
After 9 months	2.63±0.52	2.33±0.49	0.220
After 1 year	2.88±0.35	2.42±0.51	0.042*

Data are presented as mean±SD.
MLDFA, mechanical lateral distal femoral angle.
*Significant *P* value less than 0.05.

significantly higher after 6 months, after 9 months, and after 1 year than after 3 months ($P<0.05$). The rate of correction according to age was insignificantly different after 6 months and after 9 months between both groups and was significantly higher after 3 months and after 1 year in patients with age less than 8 years than in patients with age more than or equal to 8 years ($P<0.05$) (Table 2).

The mean of progression was 90.3±3.19%. Rebound was defined after 6 months occurred in one (5%) patient. Flexion contraction occurred in two (10%) patients. Irritation of MCL occurred in two (10%) patients. Painful flexion occurred in one (5%) patient (Table 3).

Table 3 Progression and complications of the studied patients

	N=20
Improvement (%)	90.3±3.19
Rebound after 6 months	1 (5.0)
Flexion contraction	2 (10.0)
Irritation of MCL	2 (10.0)
Painful flexion	1 (5.0)

Data are presented as mean±SD or frequency (%).
MCL, medial collateral ligament.

Case 1: male child, 8 years old, right and left knee genu valgum (bilateral). Idiopathic cause. Normal laboratory investigation. Intraoperatively, general anesthesia. Supine position. Approach: bilateral retrograde transphyseal screw under C-arm. Postoperative radiograph. Follow up after 3, 6, 9, and 12 months of operation. After 12 months of screw removal radiograph. Preoperative and postoperative after 12 months (Fig. 2).

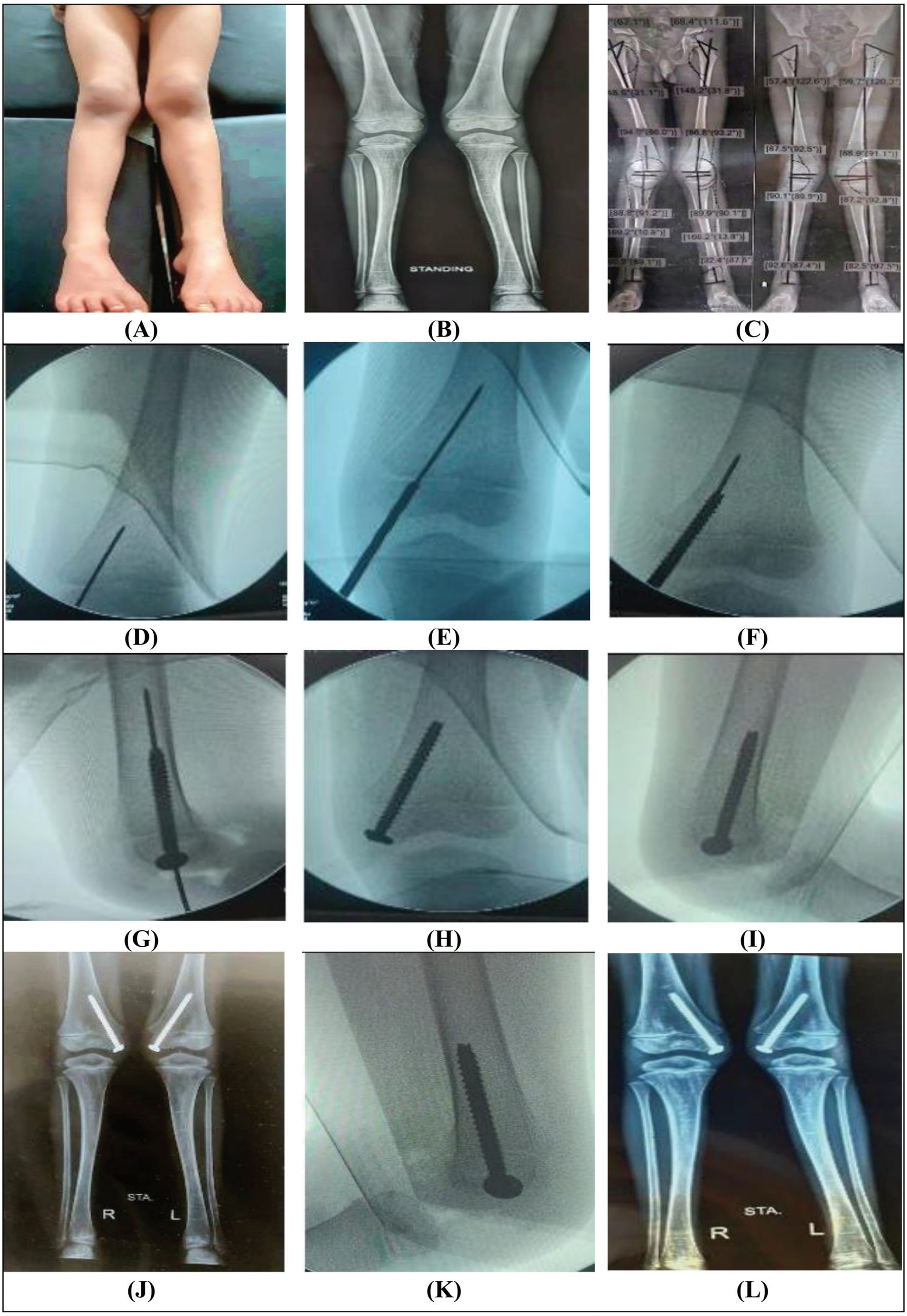
Discussion

Idiopathic genu valgum is a common teenage development condition, yet its severity, cause, and therapeutic significance vary greatly. Although mild valgus deformity ranging from 5 to 10° is common, particularly during the developmental years of 2–11, it might persist beyond this age depending on the person and their constitution [10].

Our study indicated that the mean MLDFA ranged from 75 to 81°, with a SD of 78°, prior to surgery. After 3 months, the MLDFA averaged 79.5°, with a range of 76–83°. After 6 months, the MLDFA averaged 81.3±2.08°, with a range of 78–85°. The average LDFA after 9 months was 83.8±2.1°, ranging from 80 to 87°. There was a significant increase in the MLDFA compared to before the procedure at 3, 6, 9 months, and 1 year. Park *et al.* [11] showed that femurs treated with percutaneous epiphysiodesis transphyseal screws (PETS) experienced overcorrection, with a mean MLDFA of 88.4° at the end of follow-up compared to 86.9° upon implant removal.

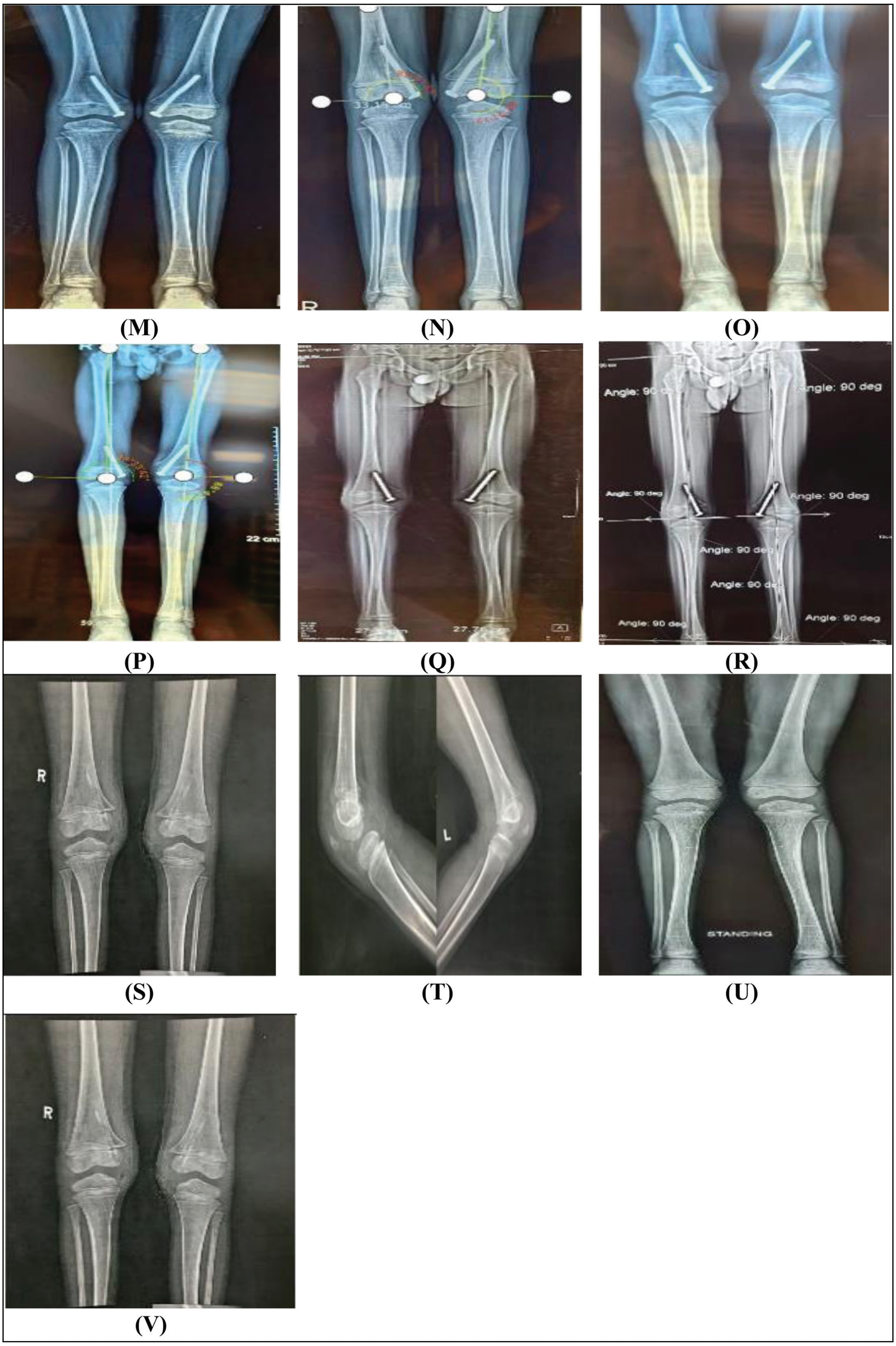
The rate of correction in our investigation varied between 1 and 2, with 1.5±0.51 after 3 months. After 6 min, the rate of correction was an average of 1.9±0.37. Following 9 min, the rate of correction was 2.5±0.51. This agrees with what was found by Abdelaziz *et al.* [12] found that an average of 1.25° per month was achieved in the correction of valgus deformities and 1.4° per month was achieved in the correction of

Figure 2



Preoperative (a) clinical picture, radiograph (b) anteroposterior view, (c) scanogram (mechanical lateral distal femoral angle), (d, e, f, g, h, and i) steps of operation under C-arm, postoperative (j) anteroposterior view, (k) lateral view, (l) follow up after 3 months, follow up after 6 months (m) scanogram (mechanical lateral distal femoral angle) (n), follow up after 9 months (o), scanogram (mechanical lateral distal femoral angle) (p), follow up after 12 months (q), scanogram (mechanical lateral distal femoral angle) (r), after screw removal radiograph after 12 months (s) anteroposterior view, (t) lateral view, (u) preoperative radiograph, and (v) postoperative radiograph after 12 months.

Figure 2



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varus abnormalities at the DF using the retrograde transphyseal guided growth screw approach. Park *et al.* [13] found that, even though both PETS and TBP could progressively fix genu valgum abnormalities in individuals with immature skeletons, PETS showed a much quicker rate of deformity reduction.

Compared to TBP, PETS resulted in a quicker rate of correction, according to one study [14]. Lee *et al.* [15] investigated that the rate of correction of idiopathic genu valgum following PETS. There was a total of 64 physes from 35 young, healthy participants in the research. Of them, 20 were proximal tibial joints, and 44 were DF joints. After 3 months, the average rate of correction was 1.75±0.46 in children less than 8 years old, and 1.25±0.45 in patients older than 8 years old. However, after 3 months, kids younger than 8 years old had a significantly higher rate compared to children 8 and older. According to research by Lee *et al.* [15] age plays a role in how quickly angular abnormalities heal. Using a linear mixed model, Sung *et al.* [16] reported that children of a younger age who exhibited valgus anomalies at the distal tibia, posterior tibia, and DF, respectively, experienced correction rates of 0.71°/month, 0.40°/month, and 0.48°/month.

Our research found a progression rate ranging from 83 to 95%, with 90.3±0.19%. In one (5%) patient, rebounding occurred after 6 months. The flexion contraction was felt by two (10%) individuals. In two (10%) individuals, MCL irritation was seen. Among the patients, one (or 5%) had painful flexion. In their study, Abdelaziz *et al.* [12] found that, on average, 15 physes showed rebound growth of 1.8°. Forty-two physes showed stability, and four physes showed progression of 1.6°.

On average, patients stayed stable for 53.4% of the time after having their guided growth implants removed, whereas 30.1% had rebound and 16.4% overcorrected [11]. With PETS, the incidence of rebound was 11.1% in the series, but with TBP, it was 48.6%.

After screw removal, the rate of rebound was 31%, and the rate of advancement of correction was 29% [17]. Shin *et al.* [18] found that there was no instance of physeal arrest with PETS. Murphy *et al.* [19] said that the transphyseal screws did not cause any problems or implant failures. Black *et al.* [20] found that comparing staples and PETS for the treatment of angular deformity showed that both implants were equally effective in correcting the deformity and had comparable or lower rates of rebound deformity after removal.

The study's limitation was a relatively limited sample size. The research was conducted at a single center. The follow-up of patients was constrained to a relatively short duration. There was no comparison group or control group. There was a chance that there may be selection bias or other confounding variables. Neither functional outcome measures nor outcomes reported by patients were included.

Conclusion

A safe and successful way for treating idiopathic genu valgum abnormalities in juvenile patients was the retrograde percutaneous transphyseal screw procedure. A faster rate of correction was seen in younger individuals, although the MLDFA improved significantly and gradually with time in the research. Over an average of 7.5 months, patients saw a mean correction of 8.9° and reported few problems. With a mean advancement rate of 90.3%, the approach was able to successfully cure deformities in most patients.

Acknowledgments

Data is available upon reasonable request from the corresponding author.

Authors' contribution

All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by M.A.E., M.E.A.F., and A.E.M.M. The first draft of the manuscript was written by O.A.E., and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Conflicts of interest

There are no conflicts of interest.

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