Correction of Coronal Deformities in Pediatric Knees : Guided Growth by 8 plate Versus Corrective Osteotomy

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Abstract

Background: Coronal deformities around the knee are most commonly presented in paediatric orthopaedic. Physiological deformities are most often managed conservatively, but severe deformities that cause pain and dysfunction require surgical intervention with acute correction (osteotomy), or gradually by hemiepiphyseodesis.

Objectives: The main objective of this prospective study is to assess and compare short term results following correction by osteotomy versus 8-plate hemiepiphyseodesis.

Patients and Methods: 30 skeletally immature patient, aged (3-14 years); presented with angular deformities, 15 patient undergone corrective osteotomy for acute correction of the deformity, 15 patients had 8 plate hemiepiphyseodesis.

Results: The follow-up of both groups was every 3 months till 1 year post-operative. At 12-month follow-up, no statistically significant differences were observed between groups in radiographic parameters in patients with varus and valgus deformities (Independent sample t test, $P > .05$). At last follow-up, both groups showed statistically significant improvement in all radiographic parameters in patients with varus and valgus deformities (Repeated Measure ANOVA, $P < .05$).

Conclusion: This study showed no statistically significant difference in radiographic parameters between acute correction by osteotomies , and gradual correction by guided growth at 1 year follow up.

Keywords: Genu varum ; Genu valgum; Corrective osteotomy; Guided growth; 8 plate; epiphyseodesis.

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Introduction

Coronal deformities around the knee are most common in pediatric orthopedics. Physiological deformities are managed conservatively, but surgical intervention is required for severe deformities that cause pain, functional, and cosmetic problems. In skeletally immature patient major surgery, including osteotomy and internal or external fixation, can be avoided using guided growth (hemiepiphysiodesis) using 8-plate **(Celestre et al. ,2009)**, However, due to the risk of causing permanent growth arrest, these techniques must be timed considering the size of the deformity and remaining available growth. **(Kumar et al. ,2018)**

Since first described by Blount and Clarke in 1949, hemi-epiphyseodesis has become the gold standard, especially as an alternative to osteotomy for correcting the leg in adolescents. Various techniques of epiphyseodesis using screws, staples, and wires have been tried and described. Although the success rate is high, complications such as material failure, implant loosening, and growth plate damage are frequently reported.**(Zajonzet al. ,2017)**.

The 8-plate, first described by Stevens, is an easy one to use. Additionally, flexible screw-plate connections are expected to result in fewer complications related to implant loosening and fractures. Favorable outcomes and low rebound and complication rates were documented in the first case series **(Zajonz et al., 2017)**. Correction of pediatric knee deformities could also be achieved acutely using various lower limb osteotomies. For the growing child with mild to moderate deformity, hemi-epiphyseodesis has had some success in arresting or correcting deformities. Tibial osteotomy is generally required in those with severe deformity or those nearing skeletal maturity. Tibial osteotomy can achieve acute correction with internal or external fixation, or gradually with external fixation.**(Griswold et al. ,2018)**
Therefore, this study was conducted to assess and compare short term results after acute corrective osteotomy versus gradual 8 plate guided growth.

Patients and methods

A prospective comparative study was conducted to evaluate short term results following correction by either method. Informed consent was obtained from all participants. The study was approved by the Research Ethics Committee of our institution, ethical approval code (SVU-MED-ORT017-1-21-10-254).

We consecutively recruited patients presenting to the outpatient clinic of our university hospital. Patients were eligible for surgical intervention if conservative treatment failed with persistent angular knee deformity over 5º varus , or 10º valgus in children over 3 years old. Patients were excluded if they met any of the following exclusion criteria:

- physeal closure due to damage or skeletal maturity.
- Physeological deformity in younger ages that could be managed conservatively .

Surgical Technique

As for corrective osteotomy, The operation is done under general or spinal anaethesia according to patients age and anaethesiologist preference, tourniquet is applied to minimize bleeding.
Two Schanz pins are placed on either side of the planned osteotomy. The pin orientation is adjusted to match the post-

correction osteotomy position, taking into account all levels of planned correction.
There are multiple types of osteotomy: open wedge, closed wedge, reverse wedge or dome osteotomy with each technique having its own advantages and disadvantages.

An opening wedge osteotomy requires a single bone cut that leaves the contralateral cortex intact, followed by a widening osteotomy. This gives you more control over your fragments, making the procedure easier and more precise. Disadvantages include simultaneous limb lengthening, increased likelihood of non-union at the osteotomy site, and need for bone grafting at the osteotomy site when used in acute correction mode.**(Gupta et al. ,2020)**

In closing wedge osteotomy, a pre-calculated wedge of bone is removed at the CORA and bone ends are opposed and fixed. Closing wedge osteotomy does not require additional bone grafting, and is more stable. Disadvantages include shortening of the limb,and though the osteotomy is technically simple, difficulties arise from accidental miscalculation of the removed wedges, which may result in suboptimal correction of the deformity. It is important to prevent a secondary deformity in sagittal plane by keeping a hinge of bone intact.
Then using the shanz pins we tune the mechanical axis and preserve the correction done, we apply above knee plaster cast..

As for 8 plate insertion technique The surgery is performed under general anesthesia. Patient lie in supine position , Tourniquet is applied to minimize bleeding. The level of the physis on the target side and segment (distal femur or proximal tibia) is identified using intra-operative fluoroscopy.

The center of the physis is estimated by palpating the anterior and posterior margins of the femur or tibia and making a 2 cm skin incision at this location. The fascia is incised longitudinally.

Expose the periosteal surface by blunt dissection, being careful not to damage this layer and the perichondrial ring. The plate is placed in the center of the epiphyseal plate and temporarily secured with a fine wire or needle through a small central hole in the plate. Satisfactory positioning was confirmed by fluoroscopy. The cortices were drilled and fitted with self-tapping titanium screws, the screw should not pass the anatomical axis of the affected segment. Proper wound closue is done afterwards.**(Khaled et al. ,2018).**

Outcome measurement

Standardized AP and lateral radiographs of the knee as well as weight-bearing AP full-length radiographs were obtained. Radiological evaluation of hip-knee-ankle angle (HKA), medial proximal tibial angle (mMPTA),lateral distal femoral angle (mLDFA) was performed preoperatively, and 3,6 and 12 months postoperatively.
Fig.1(Marques et al. , 2021) shows normal mechanical and anatomical axes of the lower limb.

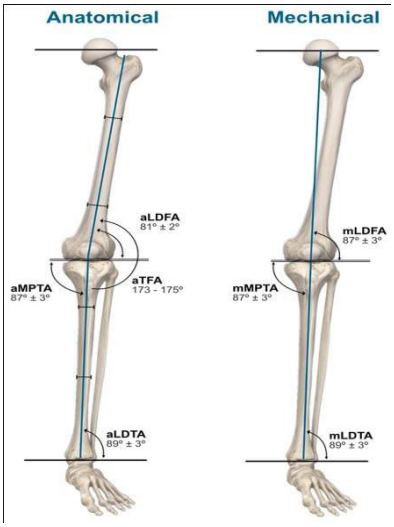

Fig. 1 .Mechanical and anatomical axes of lower limb

Statistical analysis

Description of means and standard deviation for quantitative variables and frequencies and percentage for qualitative variables were calculated using SPSS Version 22.0 (IBM Corp, Armonk, NY). Preoperative, postoperative and follow-up results of both groups were compared using paired sample-t-test. The level of significance was set at $P < 0.05$.

Results

Demographic data including age, gender, laterality, angular deformity, underlying disorder are summarized in **Table 1**.

Group 1 (hemiepiphyseodesis group), Group 2 (corrective osteotomy group).

Table 1. Patient Demographic Data (N = 30)

Variables	**Group I (N = 15)**	**Group II (N = 15)**	***P* value**
Age (years)			.017*
Mean ± SD	6.7 ± 3.2	9.8 ± 3.7	
Range	3 – 14	4 – 15	
Gender			.464**
Female	6 (40%)	8 (53%)	
Male	9 (60%)	7 (47%)	
Laterality			.881**
Right	3 (20%)	3 (20%)	
Left	2 (13%)	3 (20%)	
Bilateral	10 (67%)	9 (60%)	
Angular Deformity			.464**
Genu Varum	8 (53%)	6 (40%)	
Genu Valgum	7 (47%)	9 (60%)	
Underlying Disorder			.721**
None	12 (80%)	12 (80%)	
Achondroplasia	1 (6.7%)	1 (6.7%)	
Blount's Disease	1 (6.7%)	2 (13.3%)	
Cerebral Palsy	1 (6.7%)	0 (0%)	

* Independent sample t test; ** Chi-square test.

Radiological Results

No statistically significant difference was observed between groups regarding preoperative radiographic parameters, including HKA, mLDFA, and MPTA (Independent sample t test, P > .05). At 6-month follow-up, a statistically significant difference was observed between groups in radiographic parameters in patients with varus and valgus deformities, where osteotomy group had significantly better angular measurements compared to hemiepiphyseodesis group (Independent sample t test, P < .05). At 12-month follow-up, no statistically significant

difference was observed between groups in radiographic parameters in patients with varus and valgus deformities (Independent sample t test, P > .05).

At last follow-up, both groups showed statistically significant improvement in all radiographic parameters in patients with varus and valgus deformities (Repeated Measure ANOVA, P < .05).

Table 2. Radiological Results of Patients with Varus Deformity (N = 14)

Variables	Group I (N = 8)		Group II (N = 6)		*P* value**
	Mean	SD	Mean	SD	
HKA Angle					
Preoperative	20.8	4.4	20.4	3.6	.564
6 months	12.6	4.5	6.1	1.8	.000
12 months	6.7	6.7	6.2	1.8	.074
P value*	.000		.000		
mLDFA					
Preoperative	100.7	7.7	100.5	3.6	.312
6 months	95.7	4.9	90.2	3.1	.001
12 months	90.2	4.5	90.1	3.2	.875
P value*	.000		.000		
MPTA					
Preoperative	80.6	3.3	79.8	2.5	.081
6 months	84.6	2.0	89.3	3.5	.000
12 months	88.9	1.5	89.1	3.4	.062
P value*	.000			.000	

*Repeated measure ANOVA; ** independent sample t test.

Table 3. Radiological Results of Patients with Valgus Deformity (N = 16)

Variables	Group I (N = 7)		Group II (N = 9)		*P* value**
	Mean	SD	Mean	SD	
HKA Angle					
Preoperative	-15.3	9.5	15.4	4.8	.652
6 months	-8.2	2.6	4.1	3.7	.000
12 months	-3.1	1.3	4.1	3.7	.064
P value*	.000		.000		
mLDFA					
Preoperative	82.5	2.2	81.3	3.1	.613
6 months	87.1	1.1	87.5	4.4	.001
12 months	91.4	0.9	87.3	4.4	.816
P value*	.000		.000		
MPTA					
Preoperative	98.3	5.5	96.1	6.9	.092

6 months	93.9	3.8	89.3	2.2	.000
12 months	89.3	3.8	89.1	2.2	.072
P value*	.000		.000		

*Repeated measure ANOVA; ** independent sample t test.

Table 2 and **3** demonstrate preoperative, 6-months and 12-months follow-up radiographic parameters, including HKA, MPTA, and mLDFA, in patients with varus and valgus deformities.

Post-operative protocol

The average length of hospital stay was 1.5 ± 0.3 days (range, 1 – 1.9) in group I and 2.4 ± 0.3 days (range, 2.1 – 3) in group II. Patients undergoing epiphysiodesis required significantly shorter hospital stay compared to patients undergoing corrective osteotomy (Independent sample t test, P = .000).

All patients in group I were allowed full weight-bearing and full range of motion postoperatively. However, group II was not allowed to fully weight bear postoperatively. Eight (53.3%) patients in group II had full knee range of motion immediately postoperatively. A statistically significant difference was observed between groups regarding postoperative protocol (Chi-square test, P < .05).

Complications

Superficial infection developed in one patient in group I and two patients in group II. The infection resolved entirely with antibiotic therapy and dressing. Overcorrection was observed in one patient in group II, while no patients in group I showed overcorrection. None reported neurovascular injuries, growth arrest or recurrence of deformity.

Discussion:

In our study , No statistically significant difference was observed between groups regarding gender, laterality, type of angular deformity, and underlying disorder. However, a statistically significant difference was found between groups in terms of age distribution.

The mean age of patients was 6.7 ± 3.2 years (range, 3 – 14) in group I, and 9.8 ± 3.7 years (range, 4 – 15) in group II. Patients of group I were significantly younger compared to patients in group II.

Unlike corrective osteotomies , 8 plate hemiepiphyseodesis can only be used in younger patients before physeal closure , to gradually guide the growth of bone, it can also be used in severe degrees of angular deformity to gain some correction before maturity , as the screws in the 8-plate are free to diverge up to 30°; and that covers approximately 95% of the deformities encountered.

But, it is recommended that 8-plates to be removed after a maximum time of 24 months due to the risk of premature closure of the physis. **(Wiemannet al., 2009)** , in their retrospective study of 38 patients (24 extremities treated with 8-plate and 39 with Blount staple temporary hemiepiphyseodesis); found a statistically significant difference (p=0.04) with regard to age, i.e. having younger patients treated with the 8- plate technique.

In this study , the average length of hospital stay was 1.5 ± 0.3 days (range, 1 – 1.9) in the hemiepiphyseodesis group and 2.4 ± 0.3 days (range, 2.1 – 3) in the osteotomy group. Patients undergoing epiphysiodesis required significantly shorter hospital stay compared to patients undergoing corrective osteotomy.

Patients undergoing knee osteotomy should be hospitalized for at least 2 days. Because the bone was intentionally fractured, the patient must be on crutches for several weeks after surgery and devoted to months of physical therapy and exercise.

In our study, all patients in hemiepiphyseodesis group were allowed full weight bearing and full range of motion postoperatively. However, osteotomy group was not allowed to fully weight bear postoperatively. Eight (53.3%) patients in group II had full knee range of motion immediately postoperatively.

Patients who underwent 8- plate hemiepiphyseodesis were encouraged weight bearing immediately post-operative and early return to school.

Ding J. , in their retrospective study of 27 patients who underwent temporary hemiepiphyseodesis stated that No immobilization is required, early weight-bearing is encouraged 2 days after surgery, and patients can return to school 2 weeks after surgery without restriction of movement.**(Ding et al. , 2019).**

At 6-month follow-up, a statistically significant difference was observed between groups in radiographic parameters (including HKA, mLDFA, and MPTA) in patients with varus and valgus deformities, where osteotomy group had significantly better angular measurements compared to epiphysiodesis group . At 12-month follow-up, no statistically significant difference was observed between groups in radiographic parameters in patients with varus and valgus deformities .

At last follow-up, both groups showed statistically significant improvement in all radiographic parameters in patients with varus and valgus deformities. **(Beaudelaireet al. , 2021)**, in a retrospective comparative study between guided growth and tibial osteotomy in children with blount's disease, found out regarding rate of correction and incidence of recurrence that , The rate of correction was 78% in the hemi-epiphyseodesis group with no rebound at a median follow-up after removal of the material of 10 ± 2.4 months. Within osteotomy group, the rate of correction was 10% with a recurrence rate of 60%. **(Feldman et al. , 2006) ,** in their comparative study between Acute and gradual correction of tibia vara , found out that gradual deformity correction is a moreaccurate treatment for tibia vara than acute correction.

(McCarthy et al. , 2007) , in a retrospective review of 25 tibial osteotomies performed in 19 patients and performed with either acute or progressive correction found that Patients undergoing gradual correction had less neurovascular complications and better correction than those undergoing acute correction , and concluded that gradual correction was a safer technique for treating tibial deformity, allowing for greater correction.

On the other hand, our study had many limitations such as small sample size and short follow-up time.

Conclusion

This prospective comparative study has demonstrated that, at short-term follow-up, no statistically significant difference was observed between groups in radiographic parameters in patients with varus and valgus deformities and both groups showed statistically significant improvement in all radiographic parameters in patients with varus and valgus deformities.

Conflict of interest

The authors of the study have no conflict of interest related to this publication.

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