

Evaluation of Rate of Correction of Angular Deformity of Knee Using Tension Band Plate

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ABSTRACT

Introduction: Angular deformities of the knee are commonly encountered in pediatric orthopedics. Deformities around knee joint are Genu varum, Genu valgum, Genu recurvatum. In these conditions temporary hemiepiphyodesis gives good result with eight plate. The aim of this study was to show the efficacy and rate of correction of angular deformity using Tension band plate.

Material and Methods: We studied 15 patients with knee angular deformities like Genu Varum and Genu Valgus managed with eight-Plate guided growth. Correction of deformity was measured in terms of the following radiological criteria: Tibiofemoral Angle, Mechanical Axis Deviation, Lateral Distal Femoral Angle and Medial Proximal Tibial Angle (MPTA) Each patient was under appropriate medical management during the entire duration of treatment and after plate removal.

Results: The average age of intervention was 6.4±2.96 years (range 2.4 -13 years). After treatment, TFA (145.6%), MAD (100.0%) and LDFA (9.9%) decreases while MPTA (11.5%) increases gradually in Genu Varum while TFA (61.4%), MAD (79.9%) and MPTA (9.9%) decreases and LDFA (14.9%), increases gradually in case of Genu Valgum. Rate of change or correction in angular deformity was increased in all cases.

Conclusion: Reversible hemiepiphyodesis using eight plate is effective method with minimal complications and faster rates of correction. Physeal growth arrest is not seen with eight plate application. Larger data and long term follow up is required to assess the rebound deformity after eight plate removal.

Keywords: Genu Varum, Genu valgum, hemiepiphyodesis, angular deformity, Tension band plate.

INTRODUCTION

Pathological angular deformities of knee are commonly found childhood deformities. these may arise due to local or systemic cause or may be idiopathic.¹ Cosmetic deformity, Knee pain, discomfort, circumduction gait, and occasionally patellafemoral instability and joint instability are the presenting features. During growth from birth to adulthood child's knee alignment varies from varum of 15° at birth to valgum of adult value ie. 6-7° at 7 years via neutral alignment at 18-20 months. Maximum valgus is at 3-4 years of age which is 12°.²

Incidence of pediatric knee deformity is around 2% of general population. Various causes of angular deformity are Developmental, Physiological, Blount disease, Rickets, Hypophosphatemic Ricket, MED, Achondroplasia, Skeletal Dysplasia, Pseudochondroplasia, Post-traumatic, Hereditary Exostosis, Mucopolysaccharidosis.³ An important fact is that they predispose to early arthritic changes in the knee joint and secondary changes in hip and ankle joint.^{4,5}

Therefore it is important to identify them early and treat

accordingly. Treatment depends mainly on cause of disease, age of child and amount of deformity. Corrective osteotomies were once considered gold standard⁵ is no longer advised in skeletally immature child, unless acute correction is required.⁶ Distraction osteogenesis and Stapling method has decreased in recent times due to disadvantages like poor compliance, unpredictability of permanent iatrogenic physeal arrest.^{7,8}

Deformities around knee joint are Genu varum, Genu valgum, Genu recurvatum. In these conditions temporary hemiepiphyodesis gives good result. It can be done either by stapling or by eight plate (tension band plate).^{9,10} We have considered the correction of Genu varum and valgum by hemiepiphyodesis with eight plate.

Eight plate acts on principle of tension band and hence called tension band plate. It is applied on convex surface of deformity so it compresses the physes on convex side thereby reducing the growth on that surface without affecting the concave surface. Thus, it acts as guided growth system.⁹ One plate is applied to one physes of bone which is giving rise to deformity (ie. either femur or tibia) pertaining that physes has growth potential otherwise it is applied to other bone. In severe deformity plate is applied to both bones.⁴

In this study we evaluated the role of eight plate in correction of angular deformity around knee joint by measuring change in different orientation angles, MAD, tibio femoral angle.

MATERIAL AND METHODS

This study was conducted in KGMU Lucknow, UP India and follow up was done for 1 year. Total 15 patients were undertaken - out of these 5 were having genu varum deformity and 10 were having genu valgum deformity. Out of 5 of genu varum deformity 1 had his both limbs involved and 4 were unilateral cases, 4 were male 1 was female. Out of 10 patients of genu valgum deformity 6 were having unilateral deformity and 4 were having bilateral deformity, 7 were males 3 were females. We included the patients with the above mentioned deformity open physes age between 2 to 14/16 years (14 for female and

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16 for male), potential growth on opposite side of physes and MAD in zone 2 or 3 with gait disturbance, knee pain, medial or lateral thrust.¹¹ We excluded the patients with closed physes, skeletal maturity and physiological deformity. Sample was selected based on inclusion and exclusion criteria. Informed consent and ethical clearance was taken from the patient and the Institutional Ethical Board before beginning the study. We measured correction of deformity in terms of the following radiological criteria:

1. Tibiofemoral Angle (TFA)
2. Mechanical Axis Deviation (MAD)
3. Lateral Distal Femoral Angle (LDFA)
4. Medial Proximal Tibial Angle (MPTA)

All angles were measured manually by goniometer on scanogram and MAD and tibio-femoral angle was measured by computer software. Medical treatment was started at the time of admission and was continued post operatively which included calcium and Vitamin D3 supplementation.

Post operatively patients were not immobilized and were allowed to walk whenever they felt comfortable. Clinico-radiological Follow-up was done every second month till deformity was fully corrected and 8 plate was removed only when MAD came 0° (We also had the follow-up for more time after the implant removal but we did not mention in the study). Imaging was done by patients by making them stand comfortably with patella facing forward and the X ray beam parallel to the ground and towards the knee.¹¹ Due to unavailability of large X ray films we made the scanogram by joining 2 or 3 films together by computer software and then we measured different parameters on it.

STATISTICAL ANALYSIS

Data were summarized as Mean ± SD. Groups (periods) were compared by one way repeated measures analysis of variance (ANOVA) using general linear models and the significance of mean difference between the groups was done by Bonferroni post hoc test for contrasts/comparisons. Pearson correlation method was used to assess association between the variables. Simple linear regression was done to assess relative association between time and response, considering time the independent variable and response of the variable the dependent variable. A two-sided (α=2) p<0.05 was considered statistically significant.

RESULTS

Genu varum: The mean age of all patients ranged from 3-10 years with mean (± SD) 6.50 ± 2.66.

Effect of Eight plate on angles: The effect of eight plate treatment in angular deformity around knee joint of genu varum patients are summarized in Table-1. After treatment, TFA (145.6%), MAD (100.0%) and LDFA (9.9%) decreases while MPTA (11.5%) increases gradually. Comparing the levels over the periods, ANOVA revealed significant (p<0.01 or p<0.001) improvement in all angular deformity. Further, the significant (p<0.05 or p<0.01 or p<0.001) improvements in TFA, MAD and LDFA were evident after 2 months. After 8 month of treatment, 3 patients improved completely and after 10 month, all 5 patients improved (100.0%) completely.

Assessment of the rate of change of correction in angular deformity: The regression analysis was done to assess the rate

Table-1: Pre and post treatment changes in angular deformity around knee joint in patients with genu varum

Variables	Pre Op At 0 month (n=6)	Post Op					% change	p value
		After 2 month (n=6)	After 4 month (n=6)	After 6 month (n=6)	After 8 month (n=6)	After 10 month (n=3)		
TFA	13.17 ± 1.42	9.33 ± 1.50 ^{ns}	5.83 ± 1.89*	2.50 ± 1.75**	-2.33 ± 1.74***	-6.00 ± 0.58***	145.6%	p<0.001
MAD	3.22 ± 0.16	2.63 ± 0.25 ^{ns}	1.80 ± 0.35**	1.07 ± 0.29***	0.40 ± 0.19***	0.00 ± 0.00***	100.0%	p<0.001
LDFA	100.83 ± 0.98	98.33 ± 0.95 ^{ns}	96.67 ± 0.67*	94.00 ± 0.63***	92.17 ± 0.70***	91.00 ± 1.15***	9.9%	p<0.001
MPTA	76.67 ± 1.43	78.33 ± 1.96 ^{ns}	81.33 ± 1.91 ^{ns}	84.50 ± 2.16 ^{ns}	86.17 ± 1.68*	86.67 ± 2.40*	11.5%	0.004

^{ns}p>0.05 or *p<0.05 or **p<0.01 or ***p<0.001- as compared to PreOp, **TFA:** Tibio Femoral Angle, **MAD:** Mechanical Axis Deviation, **LDFA:** Lateral Distal Femoral Angle, **MPTA:** Medial Proximal Tibial Angle

Table-2: Pre and post treatment changes in angular deformity around knee joint in patients with genu valgum

Variables	PreOp At 0 month (n=14)	PostOp					% change	p value
		After 2 month (n=14)	After 4 month (n=14)	After 6 month (n=14)	After 8 month (n=14)	After 10 month (n=14)		
TFA	22.21 ± 2.39	20.00 ± 2.19 ^{ns}	16.79 ± 1.96 ^{ns}	13.71 ± 1.89 ^{ns}	10.57 ± 1.65**	7.50 ± 1.58***	61.4%	p<0.001
MAD	3.63 ± 0.35	3.09 ± 0.37 ^{ns}	2.39 ± 0.37 ^{ns}	1.66 ± 0.33**	0.97 ± 0.32***	0.55 ± 0.29***	79.9%	p<0.001
LDFA	74.79 ± 1.02	77.14 ± 1.14 ^{ns}	79.57 ± 0.96*	82.14 ± 0.92***	85.14 ± 0.97***	87.93 ± 1.01***	14.9%	p<0.001
MPTA	98.93 ± 1.50	97.43 ± 1.32 ^{ns}	94.93 ± 0.89 ^{ns}	93.21 ± 0.75**	91.14 ± 0.66***	89.71 ± 0.54***	9.9%	p<0.001

^{ns}p>0.05 or *p<0.05 or **p<0.01 or ***p<0.001- as compared to PreOp, **TFA:** Tibio Femoral Angle, **MAD:** Mechanical Axis Deviation, **LDFA:** Lateral Distal Femoral Angle, **MPTA:** Medial Proximal Tibial Angle

of change or improvement in angular deformity and summarized graphically in Figure-1. The regression coefficient (b or slope) which express the rate of change, revealed significant ($p < 0.001$) decrease (improvement) of 1.92 degree/month in TFA ($b = -1.92$, $t_b = 39.28$; $p < 0.001$), 0.34 cm/month in MAD ($b = -0.34$, $t_b = 21.81$; $p < 0.001$) and 0.83 degree/month in LDFA ($b = -0.83$, $t_b = 15.28$; $p < 0.001$) while significant ($p < 0.01$) increase (improvement) of 1.10 degree/month in MPTA ($b = 1.10$, $t_b = 10.10$; $p = 0.001$), 1.99 degree/month was seen.

Genu valgum: The present study also evaluated the effect of hemiepiphysiodesis by eight plates in angular deformity around knee joints in patients with genu valgum. The mean age of all patients ranged from 2-13 years with mean (\pm SD) 9.43 ± 3.20 .

Effect of Eight plate on angles: The effect of eight plates treatment in angular deformity around knee joint of genu valgum patients are summarized in Table-2. After treatment, TFA (61.4%), MAD (79.9%) and MPTA (9.9%) decreases while LDFA (14.9%), increases; gradually. Comparing the levels over the periods, ANOVA revealed significant ($p < 0.001$) improvement in all angular deformity. Further, the significant ($p < 0.05$ or $p < 0.01$ or $p < 0.001$) improvements in LDFA were evident as early after 2 months while MAD and MPTA showed improvement after 6 months and TFA after 8 months. After 10 month of treatment, 7 patients (50.0%) improved completely 10 months and after 12 months total 11 patients (78.6%) improved completely.

Assessment of the rate of change of correction in angular deformity: The regression analysis was done to assess the rate of change or improvement in angular deformity and summarized graphically in Figure-2. The regression coefficient (b or slope) which expresses the rate of change, revealed significant ($p < 0.001$) decrease (improvement) of 1.29 degree/month in TFA ($b = -1.29$, $t_b = 10.37$; $p < 0.001$), 0.27 cm/month in MAD ($b = -0.27$, $t_b = 9.13$; $p < 0.001$) and 0.87 degree/month in MPTA ($b = -0.87$, $t_b = 16.02$; $p < 0.001$) while significant ($p < 0.001$) increase (improvement) of 1.18 degree/month in LDFA ($b = 1.18$, $t_b = 14.82$; $p < 0.001$) was observed.

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, so various methods have been proposed to address this problem.¹³

Osteotomy, is still considered as the definitive solution for angular corrections, but is associated with frequent and severe complications. Another less invasive method of hemiepiphysiodesis is done in order to restore alignment with lower cost and the fewer complications. This most recent technique involves guided growth with an eight-Plate, and we have employed this technique in patients exhibiting deformities. All plates were applied to femoral side of deformity. All patients had MAD in zone 3. Most patients were of nutritional rickets, one was of multiple epiphyseal dysplasia, one was of renal rickets, and one was traumatic in nature. Due to deformity patients develop pressure in single compartment of knee, pain, gait disturbance and lateral/medial thrust. After 8 plate application, deformity got corrected MAD came to center of the knee joint, pain was relieved, Child started to play with his peers as he

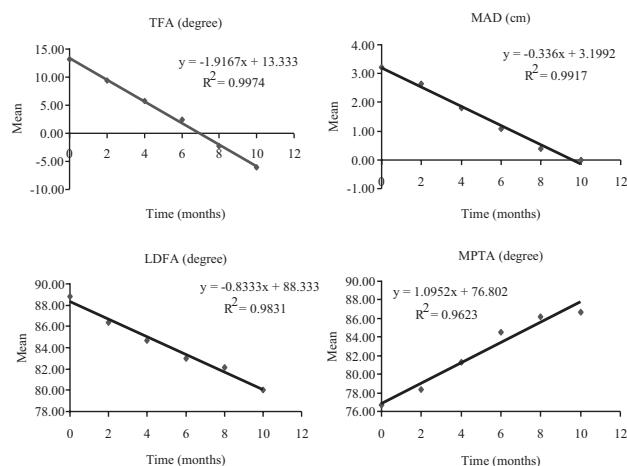


Figure-1: Best fit regression between mean response of variables and time in patients with genu varum.

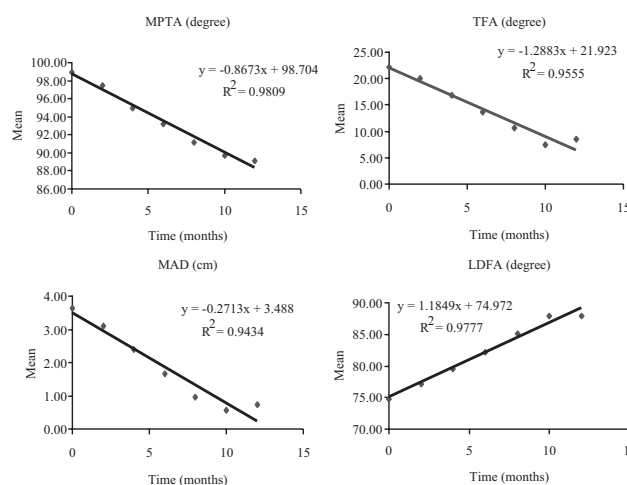


Figure-2: Best fit regression between mean response of variables and time in patients with genu valgum

could run or walk normally without any gait disturbance. Two of the patients did not show response as good as others because one was 13 years old female and her physes were approaching to close. Another patient was suffering from resistant rickets variety of renal rickets and his parents were also not complaint to the medical treatment and so did not show good response to treatment. Although response was not good in these patients but they also showed improvement in clinical symptoms. Rest of the patients had good clinico radiological improvement. We measured the deformity correction by evaluating the changes in following criteria:-

1. TFA improved for valgum deformity from 22.210 ± 2.390 to 6.340 ± 2.620 with the rate of 0.6450 per month. For varum deformity it changed from 13.170 ± 1.420 to 6.000 ± 0.580 of valgus with the rate of 0.9580 per month. Guzman and Boero (2011) also showed the similar results.^{14,15} The rate of TFA correction in study of Ballal MS, Bruce CE, Nayagam S. (2010) was 0.70 per month.⁹
2. MAD improved for valgum deformity from 3.63 ± 0.35 cm to 0.73 ± 0.43 cm with the rate of 0.135 cm per month. The total correction for varum deformity was from 3.22 ± 0.16 cm to 0 with the rate of 0.168 cm per month. In the study of Rolf D. Burghardt, John E. Herzenberg, Shawn C. Standard(2008)¹² the total correction of valgus and varus deformity was 3.07 cm and

3.88 cm respectively with rate of 0.174 cm per month.

3. Lateral Distal Femoral Angle (LDFA) corrected from 74.790 ± 1.020 to 87.860 ± 1.970 with the rate of 0.5920 per month. Same LDFA for varum deformity improved from 100.830 ± 0.980 to 91.000 ± 1.50 with the rate of 0.4150 per month. In the study of Rolf D. Burghardt, John E. Herzenberg, Shawn C. Standard (2008)¹² the total correction for valgus and varus deformity was from 820, 1030 to 910 and 930 respectively with the rate of 0.650 per month.

4. Medial Proximal Tibial Angle (MPTA) for valgus deformity changed from 98.930 ± 1.500 to 89.140 ± 0.800 with the rate of 0.480 per month. For varus deformity it improved from 76.670 ± 1.430 to 100.830 ± 0.980 rate of 0.5480 per month. Similar results were found by Bughart R D et al. Rate of correction of MPTA in his study was 0.580 per month.

Patient did not require second surgery as deformity was corrected early with time. Patients were mobilized as soon as they became comfortable with post operative pain. No post operative POP cast was given.

CONCLUSION

We did not notice the recurrence of deformity even after the plate was removed, so eight palte application can be considered as a definitive treatment in the management of genu valgum and genu varum deformity. So conclusively we can say that deformity correction around knee joint by eight plate application is not only very effective but also a very safe method giving early and good results.

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