

Our Experience with Correction of Angular Deformities of Knee by Flexible Figure of 8-plate Hemiepiphysiodesis

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Abstract

Background: Genu valgum and genu varum deformity in the lower limb in children results in cosmetic problem, gait disturbance, pain and early joint degeneration. Most of them are physiological and improve to the normal adult femorotibial angle before the age of eight years. Persistent deformities are corrected by osteotomy and internal fixation or gradual correction by external fixation. Osteotomy has got its complications. Gradual correction also can be achieved by stapling, percutaneous drill technique and transphyseal screw. Stapling has drawbacks related to implant failure including migration and breakage of implants. Drilling and screwing carries risk of permanent growth arrest. The timing of epiphysiodesis has to be perfect otherwise there may be under correction or overcorrection. 8-plate temporary hemi-epiphysiodesis is a new concept and producing good results with less complication. The objective of this study is to reduplicate the results of 8-plate hemiepiphysiodesis on angular deformities of knee joint.

Methods: We attempted gradual correction through 8-plate in 31 patients with 54 angular deformities around knee. Cases were followed for 38 months (range, 24 to 52 months) after removal of implants. Measurements were compared pre and postoperatively.

Results: There was statistically significant improvement in all the outcome measures measured. There was gross reduction of intermalleolar distance and reduction in angular deformity.

Conclusions: 8-plate hemiepiphysiodesis is an effective means for correcting angular deformity around the knee in skeletally immatured patients.

Key words : Hemiepiphysiodesis, angular deformity, 8-plate.

Introduction:

Most children are bow legged at birth, become knock-kneed by age 2. This knock-knee alignment usually peaks by age 4, and then improves by age 9.

Most improve spontaneously to the normal adult femorotibial angle before the age of eight years.¹ In normal skeletal growth, limbs are equal in length and are properly aligned from the hips to the ankles. Sometimes, due to reason that may be idiopathic in origin or growth plate or bone forming disorders can cause long bones of the leg (e.g., tibia, femur) to grow out of alignment. Pain and limitation of activity may occur in a significant number of children who do not spontaneously grow out of “bowed legs” or “knock knees.” Abnormal or injured physes, with or without pathologic loading, may result in a wide variety of problems that require orthopaedic reconstruction to correct angular problems and equalise limb lengths. For neglected cases, or upon reaching skeletal maturity, osteotomies may be required for correction.

However, in the skeletally immatured patient with angular deformity, reversible hemi-epiphysiodesis, or guided growth, may be used to correct the mechanical axis, limb length, and restore function. Correction using hemiepiphysiodesis is a much less invasive surgical method for correcting pathological angular deformities by

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restricting the growth on one side of the physis, while permitting continued growth on the opposite, non-instrumented side. The goal is to permit realignment through growth. Gradually, the bone realigns and the deformity is corrected. Since the bone is not cut (as with an osteotomy), there is no neurovascular risk, instability from the cut, or significant period of healing. Gradual correction by hemi-epiphyseal arrest is possible using techniques such as stapling,² percutaneous drill hemi-epiphysiodesis³ or transphyseal screws.⁴ But all these techniques carry a risk of permanent growth arrest if timing of surgery and available remaining growth is not calculated precisely.

8-plate hemi-epiphysiodesis is a well accepted method of correction for many deformities in children due to its tension band technique and less complications in comparison to staples.⁵⁻⁸ The observed rate of correction was more rapid than stapling without any permanent growth arrest. This technique has rapidly gained popularity and studies, show encouraging results.⁵⁻⁸ The eight-plate gently guides growth while allowing natural, safe and gradual correction of limb alignment.

The purpose of this study is to discuss the role 8-plate hemi-epiphysiodesis to correct angular deformities of the knee joint and to compare our results with Wiemann *et al*,⁸ Ballal *et al*⁵ in a prospective trial.

Materials and Methods:

A decision to offer surgical correction was based on symptoms and absence of spontaneous improvement after observation for at least 12 months. All the children with sufficient bone age⁹ remaining were included in the study. Those children within six months of skeletal maturity (14 years of bone age for females and 16 years for males), were excluded from the study¹⁰.

Thirtyone children, 20 boys and 11 girls (mean age of 11.6, range 5.5 – 14.9) with 54 symptomatic genu varum and valgum were included in this prospective trial. Bilateral deformity was noted in 8 cases. There were 14 valgus, 36 varus and 4 wind-swept deformity knees. Average follow-up was 38 months. Average operation time and hospital stay were similar for all subjects with an average correction time of 11 months. All the patients were reviewed as outpatients at 4 months interval till correction was complete (Fig. 1-8).

Informed consent was obtained from the primary caregiver of children and the procedure was approved by institutional ethical committee.

Outcome Measures: Full limb radiographs were obtained using a dedicated 51 by 14 inch graduated grid cassette, which included the full limb of tall subjects. The subject stood without footwear, with tibial tubercles facing forward with the x-ray beam centred at the knee at a distance of 8 ft. A setting of 100–300 mA-s and a kilo voltage of 80–90 were used depending on limb size and tissue characteristics.

The AP, weight-bearing, short knee x-ray was obtained with the patient standing with the back of their knees in contact with the vertical cassette, and the central beam centred 2.5 cm below the apex of the patella with a film to focus distance of 100 cm. Both knees were radiographed together. All radiographs were obtained with the same technique for each subject.

Tibio-femoral angle: Full-limb radiographs were obtained. Both knees were radiographed together. Angles were measured using a standard plastic 30 cm goniometer, and recorded in degrees. Angles greater than 180° represent a valgus alignment, and angles lesser than 180° a varus alignment.

Anatomical alignment is measured from the AP knee radiographs. A dot is placed at the midpoint of the tibial spines. The femoral anatomical axis is then found by drawing a line from the midpoint of the tibial spines to a point 10 cm above the tibial spines, midway between the medial and lateral femoral cortical bone surfaces. The tibial anatomical axis is found by drawing a line from the midpoint of the tibial spines to a point 10 cm below the tibial spines, midway between the medial and lateral cortical bone surfaces.

The angle of the intersection of the axes is then measured by goniometer.

Mechanical Axis: Stevens *et al*. believed that the knee can be divided into four radiographic quadrants, designating varus as negative and valgus as positive. Plus or minus zone I, the central quadrants, represent physiologic deformities. Plus or minus zone II often correlates with symptomatic deformities that may warrant surgical intervention. Plus or minus zone III is outside the confines of the knee and usually warrant surgical intervention. The mechanical axis measured on a full-length film can be readily correlated to any of these zones. The mechanical axis was defined as a line drawn between the centre of the femoral head and the centre of the tibial plafond. Zones of the mechanical axis have previously been described, and identification of these

zones has been reported to be reproducible with negligible interobserver error.¹¹ 'We considered the mechanical axis of the limb to be abnormal if it crossed the knee joint outside the centre of knee,¹² This outcome measure was not statistically computed but to ascertain the success of the surgery after follow-up.

Intermalleolar and intercondylar distance: The intermalleolar and condylar distance was measured using a measuring tape and calculated as the distance between the 2 malleoli with the medial condyles touching or both the malleoli touching for intercondylar distance.

For the 4 patients with wind swept deformity only tibio femoral angle was measured.

All the measurements were made twice: once before surgery and at the time of final follow-up.

Procedure: The level of the physis on the relevant side and segment (distal femur or proximal tibia) was identified using fluoroscopy. The centre of the physis was estimated by palpating the anterior and posterior margins of the femur or tibia and placing a 2 cm skin incision over this position. The fascia lata was divided longitudinally. The periosteal surface was exposed by blunt dissection, taking care not to injure this layer and the perichondrial ring. The plate was placed over the physis and provisionally secured with a hypodermic needle through a small central hole in the plate. Satisfactory positioning was confirmed by fluoroscopy. Threaded guide wires were then driven through the centres of the two main holes of the plate, aiming to keep the direction of these wires parallel to the physis. The cortex was broached using a cannulated drill and a self-tapping 4.5 mm titanium screw was passed over the guide wire. These wires were extracted before each screw was finally secured on to the plate and its position checked. A compression bandage was applied after wound closure.

Patients were discharged after three days of surgery. They were also safely mobilised partially weight-bearing on crutches. The compression bandage was reduced after three or four days and knee motion encouraged. Full weight-bearing was usually achieved in the second week. Patients were monitored clinically and radiologically at three monthly intervals. When clinical correction of the deformity was deemed satisfactory, a standing scanogram was obtained to confirm the clinical impression. The desired correction was restoration of the mechanical axis to within the inner two zones of a six-zone division of an

anteroposterior radiograph of the knee; when this occurs, there is improvement¹³ in the position of the ground reaction forces. Plate removal was undertaken as day surgery and the patients followed up until skeletal maturity to check for rebound deformity, limb-length discrepancy or premature physal closure.

Data collection and analysis: All data were collected and statistically analysed by paired t test. Pairwise all comparisons were set at 95% confidence interval.

Results:

The pre-operative deformity ranged from 53° of genu varum to 17° of genu valgum. The mean deformity for genu varum was 32° (11° to 53°) and 14° (11° to 23°) for genu valgum. Post operatively all patients showed improvement in parameters measured and all these parameters were found to be statistically significant. The mean varus angled improved from 32.47 to 5.39 degrees whereas the valgus improved from 17 to 9.56 degrees (Table-I & Chart I). Similarly the intercondylar distance and intermalleolar distance improved from 10.8 cm to 3.69 cm and 11.31cm to 2.5 cm respectively (Chart - II). Statistically all measurements were significant $p < 0.05$ as calculated by paired 't' test.

Table -1: Showing Pre and Postoperative outcome

Outcome measure	Pre-operative (mean)	Post-operative (mean)	t value	p value
Intercondylar distance	10.8 cm	3.6 cm	14.16	0.00
Intermalleolar distance	11.31 cm	2.5cm	13.48	0.00
Genu valgum	17.00	9.56	15.68	0.00
Genu varum	32.47	5.39	22.66	0.00

Chart -I: Outcome Pre and Postoperatively

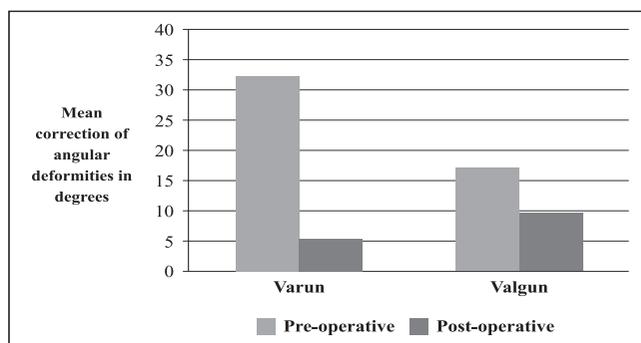
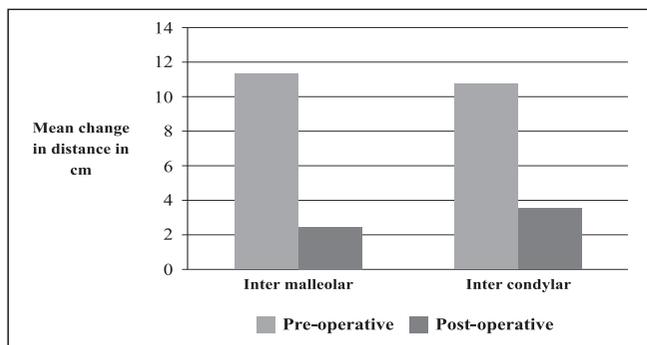


Chart -II: Outcome Pre and Postoperatively



There were complications in two patients, namely radiological evidence of plate and screw migration. The plate and screws were removed and replaced.

Discussion:

The eight-plate holds one side of the growth plate. As the opposite side of the physis continues to expand and grow, the screws diverge within the plate, effectively serving as a hinge. This hinge action also avoids compressing the growth plate that is being guided. And because of its flexibility, the chances of the plate or screws bending or breaking under the forces of bone growth are considered very low. Bony deformity may be treated by osteotomy, for which careful analysis of the deformity and detailed operative planning are essential. Analysis of the deformity has been formalised and clarified by the centre of rotation angulation method.¹⁴ However, in deformities around a joint, an open physis can make correction a technically difficult problem. Furthermore, osteotomy and acute correction of deformities carry a risk of complications such as compartment syndrome and non-union.^{15,16}

Bony deformity may also be corrected by manipulating the growth behaviour of an open physis.^{16,17} In experimental and clinical work, Haas^{17,18} demonstrated the resilience of the physis following surgical instrumentation. He documented growth inhibition by placing a wire loop around a canine distal femoral physis and noted that growth resumed when the wire broke. Based on this work and others,^{18,19} procedures have been introduced to manipulate the growth from a physis. The technique of hemi-epiphysiodesis is well established in children, in particular the use of staples and transphyseal screws. Both methods exert compression on the physis and, when placed eccentrically, can retard development on the side of application and thereby produce asymmetrical growth.^{2,4,19} Some concerns have been raised over the use of staples in younger children; the prolonged presence of rigid implants bracketing the physis has prompted worries over excessive compression leading to permanent physeal closure.^{20,21} Aykut *et al*²² demonstrated clinically and experimentally that transgression of the periosteum during staple insertion or removal poses a risk of producing a physeal bar. In contrast, a recent study²³ demonstrated that percutaneous epiphysiodesis using transphyseal screws in the correction of lower limb deformities in younger children can be a reversible method.

The flexible plate concept developed by Stevens differs from staple or screw compression across the physis.⁵ The placement of this non-rigid tension band device at the perimeter of the physis produces the effect of a focal hinge. While some compression is applied across the physis, it is not constant owing to the propensity of the screws to diverge as correction proceeds. Once the



Fig-1: Pre operative genu valgum X-ray



Fig-2: Post operative genu valgum X-ray after correction



Fig 3: Pre operative clinical



Fig 4: Post operative follow up one year after correction



**Fig-5: Pre operative X-ray
Genu valgum**



**Fig 6: Post operative follow
up X-ray after 16 months**



**Fig 7: Pre operative Clinical
photograph genu varum**



**Fig 8: Post operative
clinical after correction of
genu varum**

screws reach their maximum divergence, there is also the facility within the flexible plate to bend. Both of these features reduce the risk of creating a permanent physal tether through excessive and prolonged compression across the physis. Also, only one plate per physis is needed to produce correction, whereas three staples per physis are usually needed for the same effect. This clinical study also confirms the reversible nature of growth inhibition produced by the device. The speed of correction in hemiepiphysiodesis is determined by the nature of the growth modulation (staple, transphyseal screw or flexible plate), the age of the child and the physis treated. Burghardt *et al*²⁴ described the rate of correction using the flexible plate method in terms of mechanical axis deviation. In this case, the rate of improvement in the mechanical axis derived from the tibial segment was slower than from the femoral segment. Conversely, we can report on rates of correction as derived from each physis in terms of angular improvement per month, but also describe the influence of age on the process. The measurement of the rates of correction per month allows the surgeon to estimate the overall treatment time and provide parents with relevant information. Visual appreciation of the effect of gradual correction usually occurs towards the end of the treatment period. Providing counselling about the estimated time needed will allay any parental anxiety over what may appear initially to be a lack of progress. Implant migration was noted in two patients and this has also been documented with the use of staples.^{20,25} There were no instances of screw or implant back-out as can occur with staples.^{26,27}

The average age of the children in this study was 11.6 years with a 25% to 75% interquartile range of 10 to 13

years. Therefore, the majority were adolescents. This is similar to the study by Stevens.⁵ The ability to harness this technique for younger children, as in some of the cases in this study, is a major advantage and reduces the need for osteotomy for deformities around the knee joint. The only problem is that the physis itself must be normal and respond to growth guidance through the flexible plate. Finally, the ability to perform the implantation and removal of the device within a short span of time is an added advantage over correction by osteotomy. Most children were walking confidently without aids by the second post-operative week.

Conclusion:

This study has confirmed the reversible nature of growth inhibition on the physis produced by a bridging flexible titanium plate and has demonstrated its value in correcting deformities around the knee. The procedure is technically simple and has significant potential for treating genu varum and valgum for many children without the need for osteotomy.

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