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Dr. Pradeep A Sangnod
Orthopaedic Resident, HBT Medical College & Dr. RN Cooper Hospital, Mumbai, Maharashtra, India

Dr. Harish U
Resident, HBT Medical College & Dr. RN Cooper Hospital, Mumbai, Maharashtra, India

Dr. Ashish Assudani
Resident, HBT Medical College & Dr. RN Cooper Hospital, Mumbai, Maharashtra, India

Dr. Atul Bhaskar
Assistant Honorary, HBT Medical College & Dr. RN Cooper Hospital, Mumbai, Maharashtra, India

Dr. Satish P Kale
Honorary, HBT Medical College & Dr. RN Cooper Hospital, Mumbai, Maharashtra, India

Correspondence
Dr. Pradeep A Sangnod
Orthopaedic Resident, HBT Medical College & Dr. RN Cooper Hospital, Mumbai, Maharashtra, India

Effectiveness of eight plate in correcting angular deformity around knee: A study at tertiary care hospital

Dr. Pradeep A Sangnod, Dr. Harish U, Dr. Ashish Assudani, Dr. Atul Bhaskar and Dr. Satish P Kale

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Abstract
Background: Angular deformity around the knee is the common problem in growing childs. Genu valgum & Genu varum causes short term & long term effects on knees like Patellar maltracking, Osteoarthritis, ligament laxity & instability.so the study was done to evaluate effictiveness of temporary hemiepiphysiodesis using eight plate in the Indian population at tertiary care centre.
Method and Materials: Retro-prospective study was carried out in Orthopaedic dept at Dr R N Cooper hospital, Mumbai over the period of 2 yrs from June 2014 to May 2016. The study includes 31 patients i.e. 58 knees between the age group 4 yrs to 13.5yrs which were operated with Eight plate fixation for angular deformity correction. Every 3 month followup with clinical & radiological assessment for the period of 1 yr or till implant removal was done. The results were tabulated & analysed statistically using test of significance (chi square, ANOVA & Student t test) whenever necessary.
Result: In our study we found average rate of correction of a) IMD/ICD was 1.17cm/month, b) mLDFA was 0.58 degrees / month, c) mPTA was 0.52 degrees / month, d) Mechanical axis was 1.17mm/ month, e) Tibiofemoral angle was 0.30 gegrees / month. We also had two complications i.e. overcorrection in one case & found no correction in one patient.
Conclusion: Guided growth for angular deformity around knee using eight plate provides faster correction rate as compared to staples and transphyseal screws. It does not cause physeal arrest. It provides reversible growth. Minimal implant related complications like plate migration, plate bending and Breakage. Guided Growth using Eight plate is a safe and effective method for surgical correction of angular deformities around Knee Joint.

Keywords: Angular deformity, Genu valgum, genu varum, eight plate, hemiepiphysiodesis, guided growth

Introduction
The presence of angular deformity about the knee in children is a common finding; both genu varum and genu valgum are frequent causes of parental concern [1]. A general understanding of angular deformities in the paediatric population, including the cause, diagnostic imaging techniques, consequences of such deformities in a growing child and treatment options is essential knowledge for paediatric orthopaedicians and primary care providers [2].
Angular deformities have both short and long term effects on knee joint. Genu valgum can significantly affect knee function, leading to patellar maltracking, overload of the lateral compartment of the knee and medial collateral ligament stress. Similarly, knee varus can cause medial compartment overload with lateral collateral ligament laxity with a lateral thrust, subsequent knee instability and eventually pain and pathological gait. Varus deformity of the knee is typically associated with medial meniscal tears, whereas the valgus knee deformity is shown to have either side meniscal tear or both. Longstanding deformity during early childhood (either varus or valgus) of knees can lead to growth plate damage [2-4].
Treatment options to treat these angular deformities include nonoperative treatment options like observation, parent and patient education, counselling for weight reduction in obese kids and use of knee braces [5] to operative treatment like acute correction by osteotomy, physeal manipulation including physeal bridge resection (epiphysiolysis), physeal distraction

(chondrodiastasis) using external fixator and partial growth arrest (hemiepiphysiodesis) of growth plate for moderate to severe deformities.

Corrective osteotomy once considered the gold standard has several disadvantages with operative site morbidity, postoperative pain and prolonged treatment that requires internal or external fixation and restricted weight-bearing with complications like compartment syndrome, neurovascular injury, overcorrection or undercorrection, delayed union or nonunion [6].

This led to development of hemiepiphysiodesis, an attractive option of treating these angular deformities. Historically, permanent hemiepiphysiodesis, using open or percutaneous techniques, was effective in treating angular deformities, but relied on careful preoperative evaluation and postoperative follow-up to avoid overcorrection, undercorrection or both [7,8]. Temporary hemiepiphysiodesis has been shown to provide gradual deformity correction, yet may allow resumption of growth with implant removal. Epiphyseal staples work primarily as a compression device, preventing growth on the index side of the physis. The problems with staples have included implant failure, extrusion and physeal arrest resulting in permanent closure of the growth plate [9, 10, 11].

Use of eight plate technique has shown faster deformity correction, less complication rate and recurrence rate [12, 13].

Various other studies in past had also presented successful results in such a wide range of age group of Skeletally Immature children. However, there are very few studies published which could provide a comprehensive data on application of Guided Growth using Eight plate for correction of angular deformities of knee in Indian children. The lack of this knowledge remained the major lacuna which we tried to fill by our study.

Materials and Method

This study is retro-prospective series. During study period, all the patients who required hemiepiphysiodesis using eight plates, were screened using the inclusion and exclusion criteria mentioned below and included in the study after taking an informed consent & approval from ethics committee. The patients who were operated in past but followed up in OPD were also included. Their preoperative and follow up data collected from Medical Records office and OPD papers. We studied total of 58 knees i.e. 31 patients.

Inclusion Criteria

Several months up to one year

1. Children with angular deformity around knee
2. Skeletally immature children with at least one year of growth remaining. (Open Physis)

Exclusion Criteria

1. Physiologic varus or valgus.
2. Closed epiphysis due to trauma, infection, maturity
3. Physeal bar.
4. Childs with skeletal dysplasia.

A total of 58 Knee Joints were included in the study in 31 Skeletally immature children. The ratio of male to female patients was 16:15.

We found that 70.96% cases (22 patients) had Bilateral Genu Valgum, 6.45% cases (2 patients) had Unilateral Genu Valgum, 16.12% cases (5 patients) had Bilateral Genu Varum, 6.45% cases (2 patients) had unilateral genu valgum deformity.

We studied childrens between 4 year to 13 year 5 months who were operated with eight plate fixation for angular deformity around knee.

Surgical treatment was given to patients with age more than 4 years, with intermalleolar / intercondylar distance (IMD/ICD) more than 10 cm and / or mechanical axis more than 3^0 (valgum / varum) to that age.

Standing lower limb scanogram with patella facing anteriorly was taken preoperatively and at every 3 monthly intervals till 1 year or implant removal to look for mechanical axis and joint orientation angles (mechanical lateral distal femoral angle and mechanical proximal tibial angle).

Clinically, intermalleolar and intercondylar distance were measured with patient in standing position with both patella facing forward and medial malleolus / medial condyles just touching each other both preoperatively and at every 3 monthly interval till 1 year or implant removal (IR). Range of movement was assessed both preoperatively and postoperatively. All patents with rickets were treated with appropriate medical management

Radiologically, Mechanical axis of lower limb was measured as angle between mechanical axis of femur (centre of femoral head to centre of knee joint) and mechanical axis of tibia (centre of knee joint to centre of ankle mortise). The centre of knee joint was used to determine the mechanical axis. The normal mechanical axis was considered as 0 +/- 3^0.The mechanical lateral distal femoral angle (mLDFA) is measured at the intersection of a line extending from the center of the hip to the center of the Knee (mechanical axis of Femur) and a line parallel to the distal femur articular surfaces in the transverse plan. mLDFA is increased in Genu Varum contributed by femoral deviation and decreased in Genu Valgum contributed by femoral deviation. The mechanical medial proximal tibial angle (mPTA) is measured as the intersection of a line from the center of the knee to the centre of the ankle (mechanical axis of tibia) and a line parallel to the proximal tibia articular surface in transverse plane. mPTA is increased in Genu Valgum contributed by Tibial deviation and decreased in Genu varum contributed by tibial deviation.Each angle normally measures 87°+/-3. Mechanical axis deviation (MAD) line stretches from head of femur through the knee joint (the intercondylar eminence of the tibia), and down to the centre of the ankle (the ankle mortise, the fork-like grip between the medial and lateral malleoli). Usually, MAD > 15mm medially signifies Genu valgum while MAD >10mm laterally signifies Genu Varum. The Tibiofemoral angle (TFA) has been described as the angle defined by the mechanical axis of the femur intersecting the mechanical axis of the tibia. Radiologic, and clinical techniques have been used to assess the normal limits of the TFA.

After rouling out metabolic disorder the routine anesthetic evaluation is done.

Surgical procedure

Under general anaesthesia, patient in supine position over radiolucent table the affected limb scrubbed, painted & draped under all aseptic precautions. The single dose of appropriate antibiotic given before 30 minutes of incision time. Tourniquet inflated with adequate pressure. Knee Joint line and middle of femoral condyle marking done. Physeal region marked under C-Arm guidance. Skin incision taken 2cm above and 2 cm beloe the physis Superficial fascia & soft tissue dissected. Synovial sheath cut and physeal vessels

exposed. Needle or K wire passed in physis under C- arm guidance and plate is put below the physeal vessels.Plate position checked under C-arm in both AP and lateral views. Plates fixed in Middle 1/3rd of femoral condyle. Plate position checked under lateral view of knee. After drilling 3.5 mm screws inserted. Fixation checked under C-arm. Wash given and wound closed layer by layer. Aseptic sterile dressing done.

Postoperatively, Patient were encouraged for early joint mobilization, weight bearing and return to normal activities as tolerated. The suture removal done on day 14.

Follow up protocol

Every 3 months postoperatively patient clinical and radiological assessment done till implant removal. In case of genu valgum deformity intermalleolar distance measured and in case of genu varum intercondylar distance was measured. Full length x ray / scanogram of both lower limbs with patella facing anteriorly was done to measure radiological outcome. MLDFA, MPTA, mechanical axis deviation,tibiofemoral angle were assessed.

Once the patient achieved normal values of these parameters implant removal as done.

Results/ Our study Analysis

The mean age of surgical intervention in our study was 8.1 year

At the end of our study we found the results as tabulated below:

	at the time of presentation	at time of final correction/Implant removal	rate of correction
Intercondylar /Intermalleolar distance	15.49cm	0.79cm	1.17cm/month
Mean Mechanical Lateral Distal Femoral Angle	84.73 degrees	89.92 degrees	0.58degree/month
mean Mechanical proximal tibial angle	93.59 degrees	89.28 Degrees	0.52 degrees
Mean Mechanical axis	27.39 mm	5.1 mm	1.70mm/month
mean tibiofemoral angle	10.52 degrees	6.51 Degrees	0.30 degrees

As we have studied total 58 knee joints, complicatios occurred in 2 knee joints. Hence complication rate in our study found to be 3.44% which is comparable with previous studies of eight plate

Discussion

Angular deformities around knee joint are commonly presented in pediatric population who are attending the outpatient departments. Most of these patients comes to hospital because they or their parents/ guardian find it unsighty to look at the angulations at the affected joint. Majority of these patients passes through the normal stages of development with Physiological Genu Varum and Physiological Genu Valgum. For these patients no intervention is needed. Only counselling and reassurance to the parents and follow-up at appropriate intervals is sufficient. It is necessary to differentiate between physiological causes of angular knee deformity and others in order to prevent unnecessary and avoidable subjection of child to a surgical procedure which was not required at all. Pathological causes of angular deformities around knee joint are usually associated with abnormal gait, pain and later on risk of development of osteoarthritis of the affected joint.

In the past techniques like corrective osteotomies, corticotomy and external or internal fixation were used for correction of angular knee deformities. As these techniques were more invasive nowadays less invasive techniques used for correcting deformity in immature children. Temporary Hemiepiphysiodesis or Guided Growth Technique is an emerging technique which can correct angular deformities around knee joint with least invasiveness in such children. Properly planned Temporary Hemiepiphysiodesis using eight plate have been shown to excellent results.

Eight plate functions as flexible device which produces sustained compression / tension at physis. Compression is not constant as the screws diverge with correction and with maximum divergence the plate tends to bends, hence it is also called as tension band plate [15] Eight plate serves as non-rigid implant with lateralization of fulcrum for deformity correction. Thus, leading to faster rates of correction [12]. Staples and transphyseal screws are rigid implants with centralized fulcrum for deformity correction [14]. They produce constant compression at physis. Thus they take longer time for deformity correction [13]

Staples and transphyseal screws are rigid implants which may cause physeal arrest if used for longer duration [19]. In contrast

to this eight plates are relatively flexible implants as it allows for screw separation. Hence, physeal arrest incidences decreased.

Age and sex distribution

Ballal MS *et al*. [15] studied 37 knee joints in 25 childrens of age between 5 year 5 months to 14 years 9 months**.**

Burghardt RD *et al*. [16] studied 51 knee joints in 43 patients between the age group of 4yr- 14.3 yr.

Patwardhan *et al*. [18] studied 37 knee joints in 19 childrens. Age group was between 2 year 4 months to 11 year 2 months.

In our study, we included children of age between 3 years to 13 year 5 months. A total of 58 knee joints were studied in 31 patients, with 12 joints with Varus deformity and 46 with Valgus deformity. The Ratio of Male to Female cases was 16:15

Intercondylar Distance and Intermalleolar Distance

Patwardhan *et al*. [18] showed that average rate of correction in IMD/ICD in childrens operated with eight plate for angular deformity around knee was 1.14 cm / month. In our study we found average rate of correction 1.17 cm/ month.

Although, almost all the major studies on Guided Growth Application have documented fall in Intercondylar and Intermalleolar distances during follow ups, their role is just for documentation of correction. A vast variation occurs in intercondylar and intermalleolar distances depending of various factors including age, region, height etc. This makes Intercondylar distance and intermalleolar distance unfavorable parameters to define final correction.

Mechanical Lateral Distal Femoral angle (mLDFA) and Mechanical Proximal Tibial angle (mPTA)

In 2010, Burghardt RD *et al*. [34] studied that rate of correction of mLDFA was 0.65 degrees / month (Range 0.05-1.22 degrees/month) and Rate of correction of mPTA was 0.58 degrees / month (range 0.13-1.67 degrees/month). We observed Rate of correction of mLDFA of 0.58 degrees /month. (Range 0.08^0-1.86/ month) and of mPTA of 0.52^0 / month (Range 0.15^0-0.74^0/month)

Mechanial axis

In 2009, Wiemann *et al*. [9] in retrospective study showed that mechanical axis rate of correction was 11.1 degrees per year.

In 2015,Patwardhan *et al*. [18] in his study found that mechanical axis rate of correction was 0.76 degrees / month (Range 0.43^0-1^0). In our study we found the rate of correction of mechanical axis as 0.78^0 / month (Range 0.44^0-1^0)

Mechanical axis deviation

Burghardt RD *et al*. [16] showed that mechanical axis deviation rate of correction as 1.73 mm/ month (range 0- 6.4 mm/ month) In our study, we found the rate of correction of mechanical axis deviation as 1.70 mm/ month (Range 1.55 – 1.94mm /month)

Tibiofemoral angle

In 2011, Silvio Boero *et al*. [17] studied the anatomical tibio-femoral angle correction rate in idiopathic angular deformity around knee childrens and showed that rate of correction was 0.6 degrees/ month. In our study we found the average rate of correction of Tibio-femoral angle as 0.3 degrees / month. (Range 0.11 – 0.54 degrees / month).

Complications

As we have studied total 58 knee joints, complications occurred in 2 knee joints (Overcorrection of deformity in one patient & Uncorrected deformity at the end of 1 yr followup in another patient). Hence complication rate in our study found to be 3.44% which is comparable with previous studies of eight plate.

Limitations

As our study end point was follow up till correction or implant removal, we were not able to study the rebound phenomenon of deformity which may occur after implant removal.

Preoperative clinical & radiological photo

Postoperative 1 yr follow up photos

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