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Growth Modulation Using an Eight-Plate in the Management of Lower Limb Angular Deformities in Children: An Effective and Accessible Technique

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ABSTRACT

Introduction: *Angular deformities of the lower limbs in children, particularly genu valgum and genu varum, are common conditions in pediatric orthopedics. When they persist or worsen, they can lead to functional impairment, pain, gait abnormalities, and early osteoarthritis. Growth modulation using an eight-plate currently represents a minimally invasive alternative to conventional corrective techniques. The general objective of this study was to evaluate the efficacy and safety of eight-plate growth modulation in correcting lower limb angular deformities in children. The specific objectives were: to analyze the clinical and radiological outcomes obtained after treatment; to identify factors associated with therapeutic success or failure; to evaluate the complications related to this surgical technique; and to compare our results with data from the international literature.*

Material and Methods: *We conducted a descriptive retrospective study between January 2017 and December 2024 at the Department of Pediatric Orthopedics and Traumatology of the Abderrahim Harouchi Mother-Child Hospital in Casablanca. Children presenting with genu valgum or genu varum treated by growth modulation using an eight-plate were included. Data collected included epidemiological characteristics, etiology of the deformities, radiological parameters, duration of correction, and postoperative complications. Therapeutic success was defined as a satisfactory correction of the mechanical axis without the need for additional osteotomy.*

Results: *Eleven patients, corresponding to 13 knees, were included. The mean age was 7 years (range: 3.5 to 11 years). Genu valgum accounted for 7 cases and genu varum for 4 cases. The mean preoperative femorotibial angle was 16.6°. The mean duration of plate retention was 18 months. A satisfactory correction of the mechanical axis was achieved in 82% of cases. The two observed failures occurred in patients with Blount's disease. No deep infections or mechanical hardware failures were reported. Localized pain at the plate site was reported by four patients.*

Conclusion: *Growth modulation using an eight-plate is a reliable, effective, and minimally invasive technique for correcting lower limb angular deformities in children. It allows for progressive and physiological correction with low postoperative morbidity. This technique should be considered as a first-line treatment in children with sufficient residual growth potential.*

Keywords

Growth modulation, Eight-plate, Genu valgum, Genu varum, Hemiepiphysiodesis, Blount's disease, Pediatric orthopedics.

Introduction

Angular deformities of the lower limbs in children, primarily genu valgum and genu varum, represent a frequent reason for consultation in pediatric orthopedics. Although a portion of

these deformities is physiological during growth, some persist or progress into pathological forms that can cause gait disturbances, pain, functional limitations, aesthetic concerns, and early osteoarthritis in adulthood [1,2]. The therapeutic management of these anomalies depends on several factors, including the child's age, the severity of the deformity, its etiology, and the remaining residual growth potential.

For a long time, corrective osteotomies were the gold standard treatment. However, these techniques remain invasive and are associated with significant postoperative morbidity, a risk of neurovascular complications, prolonged hospital stays, and sometimes recurrence [3]. The advent of growth modulation using an eight-plate, described by Stevens in 2007, has profoundly altered the therapeutic strategy for angular deformities in children [4]. This technique is based on the principle of temporary hemiepiphysiodesis, using a plate that acts as a tension band across the physis to reversibly slow growth on one side of the physis (growth plate). Continued growth on the opposite side thus allows for progressive and physiological correction of the mechanical axis [5].

Several studies have demonstrated the efficacy of this method in treating idiopathic genu valgum, post-traumatic and post-infectious deformities, as well as certain constitutional bone diseases [6,7]. It offers several advantages over osteotomies, notably minimally invasive surgery, rapid recovery, reduced complications, and relatively low cost, making it particularly valuable in resource-limited settings [8].

However, the outcomes of growth modulation can vary according to the etiology of the deformity, the child's age, the severity of the initial angulation, and the remaining growth potential. Certain pathologies, such as Blount's disease, remain associated with higher failure rates and may require additional interventions [9].

In the Moroccan and African context, data regarding this technique remain limited. It is therefore necessary to evaluate the results obtained in our daily practice to assess its efficacy and safety within our hospital environment. The general objective of this study was to evaluate the efficacy and safety of growth modulation using an eight-plate in the correction of lower limb angular deformities in children. The specific objectives were: to analyze the clinical and radiological outcomes after treatment; to identify factors influencing therapeutic success or failure; to evaluate postoperative complications related to this technique; and to compare our results with data from the international literature.

Material and Methods

Study Type and Setting

This was a descriptive retrospective study conducted in the Department of Pediatric Orthopedics and Traumatology at the Abderrahim Harouchi Mother-Child Hospital, part of the Ibn Rochd UHC in Casablanca, Morocco. The study spanned an eight-year period, from January 2017 to December 2024.

Study Population

The study included children presenting with an angular deformity of the lower limbs, either genu valgum or genu varum, who underwent growth modulation using an eight-plate (Stevens plate). The etiologies encountered were:

- Idiopathic genu valgum
- Post-traumatic deformities
- Post-infectious deformities
- Constitutional bone diseases
- Blount's disease

Inclusion Criteria

The inclusion criteria were as follows:

- Patients aged under 16 years
- Children with an actively growing physis
- Patients who underwent growth modulation via an eight-plate
- Complete medical records with usable radiological follow-up

Exclusion Criteria

The exclusion criteria were as follows:

- Patients with incomplete medical records
- Patients lost to follow-up before the end of treatment
- Children who had undergone a prior corrective osteotomy

Variables Studied

Data collected from medical and radiological records included: age, sex, affected side, etiology of the deformity, femoral or tibial location of the deformity, radiological parameters, duration of plate retention, postoperative complications, and therapeutic outcomes.

Surgical Technique

All interventions were performed under general anesthesia and fluoroscopic guidance. A 2 to 3 cm skin incision was made over the target physis, taking care to preserve the periosteum. A guide pin was then inserted into the center of the physis under fluoroscopic control. The eight-plate was slid over this guide pin, and two self-tapping cannulated screws were placed following cortical drilling. Depending on the site of the deformity, the plate was positioned at the distal medial femur or proximal medial tibia.

Radiological Evaluation

Evaluation was based on full-length, weight-bearing lower limb radiographs (telemetry) obtained preoperatively and during postoperative follow-up. The radiological parameters analyzed were:

- Femorotibial (FT) angle
- Lateral Distal Femoral Angle (LDFA)
- Medial Proximal Tibial Angle (MPTA)

Measurements were performed using the Bone Ninja® application, developed by the pediatric orthopedics team at Johns Hopkins University in Baltimore, USA.

Criteria for Therapeutic Success

Treatment was considered successful when:

- The mechanical axis passed through Zone 1 according to the Stevens classification.
- No additional secondary corrective osteotomy was required.

Statistical Analysis
Data were entered and analyzed using Microsoft Excel 2019 software. Quantitative variables were expressed as means with ranges, while qualitative variables were expressed as frequencies and percentages.

Ethical Considerations
Patient data confidentiality was maintained throughout the study. Collected information was anonymized and utilized solely for scientific and academic purposes.

Results
General Population Characteristics
Our series consisted of 11 patients, corresponding to 13 knees treated with growth modulation using an eight-plate. The mean age at the time of surgery was 7 years, ranging from 3.5 to 11 years. The cohort comprised 6 boys and 5 girls, yielding a sex ratio of 1.2.

Regarding the distribution of deformities, genu valgum accounted for 7 cases (63.6%), while genu varum accounted for 4 cases (36.4%). Among the genu valgum cases, 5 were of femoral origin. For the genu varum cases, 3 were of tibial origin. The left side was affected in 7 cases, the right side in 2 cases, and bilateral involvement was observed in 2 cases.

Deformity Etiologies
The main etiologies identified were: idiopathic genu valgum, post-traumatic deformities, post-infectious deformities, constitutional bone diseases, and Blount's disease. Blount's disease was the underlying etiology in both cases that resulted in therapeutic failure.

Preoperative Radiological Data
The mean preoperative femorotibial angle was 16.6°, with values ranging from 6° to 42°. LDFA and MPTA measurements allowed for the precise determination of the femoral or tibial origin of the deformities, guiding the choice of the plate implantation site.

Therapeutic Outcomes
The mean duration of plate retention was 18 months, ranging from 9 to 40 months. A satisfactory correction of the mechanical axis, defined as the axis passing through Zone 1 of the Stevens classification, was achieved in 82% of cases. The best results were observed in idiopathic genu valgum and moderate deformities of femoral origin.
Two cases of therapeutic failure were recorded in patients with Blount's disease. These patients subsequently required a corrective osteotomy.

Complications
No cases of hardware loosening or deep infection were observed in our series. Localized pain at the implant site was reported by 4 patients, without major functional impact or the need for early hardware removal. One case involving difficulty during the removal of an epiphyseal screw required surgical revision under radiological guidance. No cases of overcorrection, rebound effect, or reverse effect were observed at the final follow-up.

Clinical and Radiological Illustrations
Clinical Case 1
A patient presenting with post-traumatic genu valgum secondary to a proximal tibial metaphyseal fracture (Kozin phenomenon), treated via temporary temporary medial hemiepiphysiodesis of the proximal tibia with an eight-plate, achieving progressive and satisfactory correction.

Clinical Case 2
A 4-year-old patient presenting with bilateral Blount's disease. Despite growth modulation, progress was marked by incomplete correction, leading to a secondary indication for osteotomy.

Clinical Case 3
A patient presenting with syndromic genu valgum treated with double growth modulation (distal femoral and proximal tibial), showing progressive improvement of the mechanical axis.

Discussion
In recent years, growth modulation using an eight-plate has emerged as a reference technique in the management of lower limb angular deformities in children. Its principle relies on temporary hemiepiphysiodesis, allowing for a progressive and physiological correction of the mechanical axis by utilizing residual growth potential [1]. Compared to corrective osteotomies, this technique offers the advantages of being minimally invasive, reversible, and associated with reduced postoperative morbidity [2].

In our study, the overall therapeutic success rate was 82%, which aligns with the results reported in several international series. Stevens, in his pioneering series, reported satisfactory results in most cases treated with the tension band plate [3]. Ballal et al. as well as Boero et al. also found high correction rates, often exceeding 80% [4,5]. These findings confirm the effectiveness of growth modulation in progressively correcting genu valgum and genu varum in children with an actively growing physis.

In our series, the best results were observed in patients with idiopathic genu valgum, particularly when the deformity was of femoral origin. Several authors have shown that the distal femur achieves a faster correction rate than the proximal tibia due to its greater growth potential [6]. Andersen and Gordon estimated the mean rate of correction to be approximately 0.7° per month, with variations depending on age and etiology [7].

Age at the time of intervention constitutes a major prognostic

factor. The younger the child, the greater the residual growth potential, resulting in a faster and more complete correction [8]. In our study, the mean age was 7 years, which may explain the good results achieved in the majority of cases. Conversely, children approaching skeletal maturity carry a higher risk of insufficient correction.

The two cases of failure observed in our series occurred in patients with Blount's disease. This pathology remains a therapeutic challenge in pediatric orthopedics. It is characterized by an asymmetric growth disturbance of the medial proximal tibia, leading to progressive genu varum [9]. Several studies have shown that severe forms, significant deformities (>20°), advanced age, and obesity constitute poor prognostic factors for guided growth [10,11]. Murphy and Mooney reported a higher failure rate for hemiepiphysiodesis in Blount's disease compared to idiopathic genu varum [12]. In these scenarios, some authors recommend an early corrective osteotomy or a combination of osteotomy and growth modulation [13]. Our results corroborate these observations, as both patients with Blount's disease eventually required a secondary osteotomy.

Regarding complications, our series confirms the excellent tolerance of this technique. No cases of deep infection, hardware breakage, or loosening were observed. Localized pain at the implant site was the most frequent minor complication. These results are comparable to those reported in the literature [14].

The rebound phenomenon after hardware removal represents a potential complication of growth modulation. It corresponds to a partial recurrence of the deformity after initial correction, particularly in young children with high residual growth potential [15]. No such cases were found in our series, likely due to regular radiological monitoring and appropriate timing of hardware removal.

Nevertheless, this study has certain limitations. Its retrospective nature exposes it to selection and information biases. The small sample size and the heterogeneity of etiologies prevent an in-depth statistical analysis of prognostic factors. Furthermore, the lack of a standardized functional evaluation represents another methodological limitation.

Despite these limitations, our work holds a specific interest as it reports the experience of a pediatric orthopedic reference center within an African and Maghreb context, where data on growth modulation remain sparse. Our results confirm that the eight-plate constitutes a reliable, effective, and accessible therapeutic option for correcting lower limb angular deformities in children.

Conclusion

Growth modulation using an eight-plate currently represents a reliable, effective, and minimally invasive therapeutic method in the management of lower limb angular deformities in children. This technique allows for a progressive and physiological correction of the mechanical axis while reducing the morbidity associated with corrective osteotomies. In our series, the outcomes obtained were globally satisfactory, with a success rate of 82%. The best results were observed in patients presenting with idiopathic genu valgum and significant residual growth potential. The technique demonstrated a low rate of complications, thereby confirming its safety and excellent tolerance.

However, certain pathologies, such as Blount's disease, remain associated with an increased risk of therapeutic failure, particularly in severe or late-diagnosed forms. In these situations, a tailored therapeutic strategy, which may include a corrective osteotomy, must be considered. Consequently, growth modulation via an eight-plate should be considered a first-line treatment in children presenting with moderate angular deformities and an actively growing physis. Early diagnosis, rigorous indication selection, and regular radiological follow-up remain essential to optimize therapeutic outcomes.

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