Orthopaedics & Traumatology: Surgery & Research 105 (2019) 751–755

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Original article

Distal femoral hemiepiphysiodesis with screws and suture versus 8-plate for the treatment of genu valgum in children

Gino Martínez*, Alejandro Gündel, Pablo Ruiz, Ismael Cañete, Felipe Hodgson

Department of Traumatology and Orthopedics, Clinical Hospital of Pontificia Universidad Católica de Chile, Santiago, Chile

ARTICLE INFO

Article history:
Received 9 October 2018
Accepted 26 February 2019

Keywords:
Genu valgum
Child
Growth plate
Epiphysiodesis
Surgical procedures

ABSTRACT

Introduction: There are different techniques for gradual correction of angular deformities in lower limbs. The use of screws and non-absorbable filament have been described as an effective alternative for transitory hemiepiphysiodesis in pediatric population.
Hypothesis: In pediatric population with genu valgum there are no differences in outcome between hemiepiphysiodesis, using screws and non-absorbable filament (SNAF) versus 8-plate.
Methods: Retrospective evaluation, 44 knees in 22 patients younger than 15 years, with idiopathic genu valgum, were operated on. One group (20 knees) was operated on with 8-plate technique and another group (24 knees) was operated on with SNAF technique. Initial and final intermalleolar distance (IMD) and mechanical lateral distal femoral angle (mLDFA) were compared, registering complications for each group. Mann-Whitney test was used for statistics, with significance value < 0.05.
Results: All patients achieved the expected mechanical axis correction. IMD and mLDFA significatively improved. There were no significant differences in magnitude and speed of correction when comparing the two techniques. Only one SNAF patient had a minor perioperative complication.
Discussion: This report compares postoperative results between SNAF and 8-plate technique for correction of angular deformities in lower limbs. In this series of patients, significant clinical and radiological changes were observed between the initial and final values using both techniques, with no significant differences between them. Our group proposes the SNAF technique as an efficient, simple and cost-effective alternative to the traditional 8-plate technique, for the treatment of idiopathic genu valgum in children.
Level of evidence: III, retrospective comparative study.

1. Introduction

Angular deformities of lower limbs are a common finding in children [1]. Although most of these correspond to physiological conditions that resolve spontaneously without intervention [2–4], some deformities persist through preadolescence and will not correct spontaneously [5]. In these cases, surgical intervention may be necessary to restore the mechanical axis of the lower limbs. The current recommendation is to address lower limb angular deformities as early as possible to prevent consequences as an altered gait pattern, early degeneration of the articular cartilage and soft tissue changes [5–7].

There are different techniques for gradual correction of angular deformities of lower limbs [7–9]. One of them is hemiepiphysiodesis, which consists in partial growth arrest of one side of the physis in order to cause a secondary angular modification, gradually correcting the deformity [9,10]. The ideal method for hemiepiphysiodesis would be one that ensures a controlled rate of correction without causing permanent physeal damage, unless the objective is to cause a permanent physeal closure. These techniques include permanent methods such as ablation or physeal curettage [9,11] or potentially reversible techniques such as stapling [12], transphyseal screws [13] or tension band plates [14]. The most currently used technique is the tension band plate with two screws [14–16].

There are studies in New Zealand rabbit models that have shown that the use of screws and nonabsorbable suture is an effective way of angular correction [17,18]. Furthermore, they showed that removal of the sutures restored physeal growth, proving that is an alternative for transitory hemiepiphysiodesis in patients with angular deformity of lower limbs.

Recently Martínez et al. published the first experience using screws and nonabsorbable sutures in humans, demonstrating that it is an effective, safe, technically simple and reproducible

* Corresponding author. Pediatric Orthopedics, Pontificia Universidad Católica de Chile, School of Medicine, Orthopaedic Surgery, Diagonal Paraguay 362, Santiago de Chile, Chile.
E-mail addresses: ginomartinez@gmail.com, grmartin@puc.cl (G. Martínez).

https://doi.org/10.1016/j.otsr.2019.02.019
1877-0568/

alternative for the gradual correction of genu valgum in the pediatric population [19]. It should be noted, this technique also represents a much cost-effective alternative to traditional implants (approximately USD 30 vs. USD 800 in our center), what is a particularly important issue to consider in developing countries, where public health systems have a limited budget.

On the other hand, the correction of angular deformities of lower extremities in children has been widely performed by hemiepiphysiodesis with tension plates, obtaining satisfactory results [20,21]. As an alternative the use of screws and nonabsorbable suture has been described, being a more economical option. The objective is to compare the angular correction capacity of both techniques in the treatment of genu valgum. Our hypothesis is that in pediatric population with genu valgum there are no differences in outcome between hemiepiphysiodesis, using screws and non-absorbable filament (SNAF) versus 8-plate.

2. Patient and methods

A retrospective evaluation of patients under 15 years of age who underwent idiopathic genu valgum surgery by distal medial femoral hemiepiphysiodesis with screws and suture or 8-plate.

Boys and girls between 8 and 15 years old, with idiopathic genu valgum. Our diagnostic algorithm was the following: when patients older than 8 years came to our clinic because of discomfort associated to genu valgum, we measured the clinical intermalleolar distance (IMD), if it was more than 8 cm, then we requested anteroposterior X rays of lower extremities in standing position. If the mechanical axis of the limb was within zones 2 or 3, we measured the articular angles. If the deformity was categorized as driven by distal femur, with a mechanical lateral distal femoral angle (mLDFA) < 87°, the surgical option was medial hemiepiphysiodesis of distal femur. Surgical treatment was indicated when pathological genu valgum was persistent over time or worsens, or the probability of spontaneous correction was minimal according to the age of the patient (> 10 years). Patients with skeletal dysplasias, osteodystrophy, physeal injury or previous surgeries around the knee were excluded. Patients who were still in correcting process at the time of the study were also excluded (open physis with implants in situ). Data collection was approved by the Research Ethics Committee of our institution (ID 170620002). None of the authors have any conflict of interest.

The evolution of IMD, mechanical axis deviation and mLDFA in radiographs at the beginning and at the end of the treatment was recorded by two observers. In addition, the magnitude and speed of correction of the mLDFA was determined.

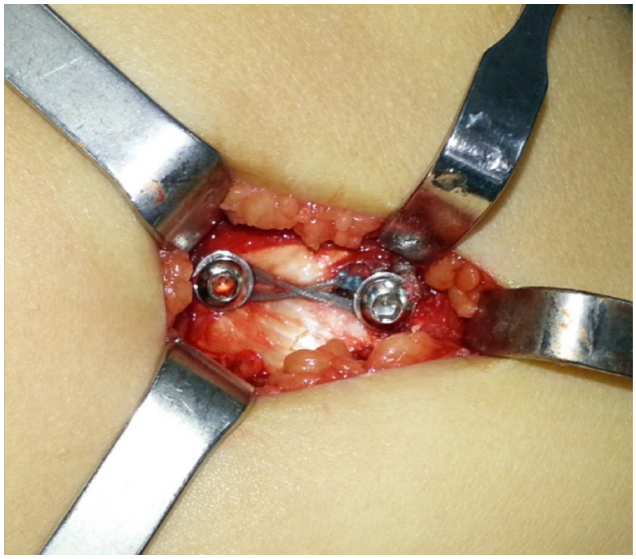

Fig. 1. Intraoperative image of hemiepiphysiodesis with screw and non-absorbable filament.

Surgery was performed in 22 patients, 44 operated knees, 20 with 8-plate technique and 24 with SNAF technique. There weren't any statistical differences between both groups characteristics, the sample was integrated by 55% of boys, the median age was 11.5 years (range 8–14 years), the initial IMD was 11 cm (range 10–17 cm) and the initial mLDFA was 85 degrees (range 77–88 degrees).

All the operated children had pathological genu valgum (IMD > 10 cm and load axis in zone 2 or 3). There was only one case less than 10 years operated (8 years and obese) who had a progression of genu valgum at follow up.

2.1. Surgical procedure

Group A. An anchoring system with two 4.0 mm cancellous screw and metal washer was used. The two monocortical screws were implanted on the medial aspect of the distal femur under radioscopic vision; one proximal to the physis and other distal to the physis. Screws were tied together using a non-absorbable filament (FiberWire #2.0), with 2 laps going under the washers and following a pattern in an eight figure (Figs. 1 and 2). These washers are used to prevent sliding of the filament over screw head. Periosteal damage was carefully avoided.

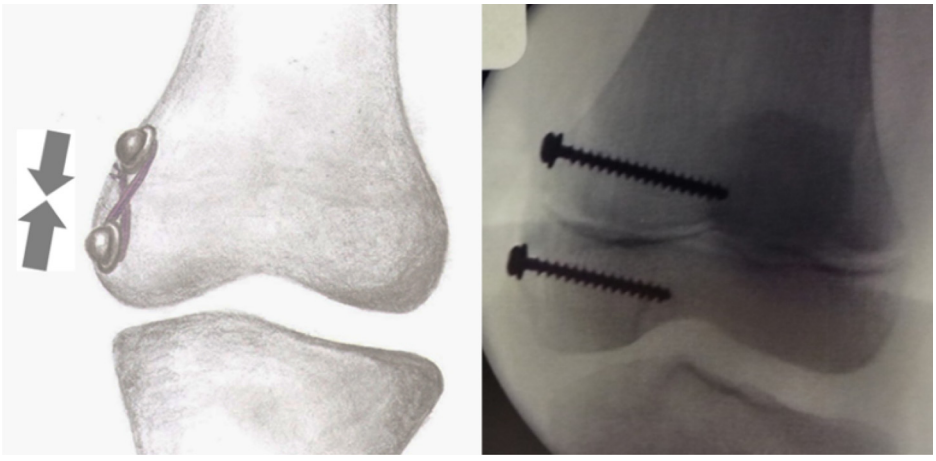

Fig. 2. Scheme and intraoperative X-rays of hemiepiphysiodesis with screws and non-absorbable filament.

Group B. An anchoring system with two 4.0 mm cancellous screw and 8-plate. The two monocortical screws were implanted on the medial aspect of the distal femur under radio-scopic vision: one proximal to the physis and other distal to the physis. Periosteal damage was carefully avoided.

2.2. Data collection

Clinical and radiographic collecting was performed. We analyzed the radiographs taken at the beginning, at the end of treatment (physeal closure or final angular correction) and posterior to fixation removal when necessary (Fig. 3). Data concerning gender, age at diagnosis and intervention were registered. Clinical IMD modification, mechanical axis correction and mLDFA were evaluated using long cassette standing radiographies. Angular measurements were performed by two physicians working blindly and independent to the main surgeon (a pediatric orthopedic surgeon and a trained orthopedic resident). Each of them performed two repeated measurements in different moments of time and then considering an average value of the data. Surgical time, operative and postoperative complications were recorded.

2.3. Statistical analysis

Statistical analysis was performed using the Wilcoxon test, chi squared and Mann-Whitney U according to the nature of the results with STATA v.13. A significance value < 0.05 was used. Intra- and interobserver variation of mLDFA measurements was analyzed with intra-class correlation test (ICC).

3. Results

The median time between surgery and the final angular correction in the SNAF group was 12.3 months (range 9.2–22.3 months) and in the 8-plate group was 16.5 months (range 11.6–25.2 months). There were no significant differences between the described characteristics of both groups.

All patients achieved the expected correction, with mechanical axis within zone 1 (axis between tibial spines) at the end of treatment. In this series of patients, significant changes were observed between the initial and final values of IMD for SNFA group ($p = 0.0022$) and 8-Plate group ($p = 0.0048$) (Fig. 4). When comparing techniques, no significant differences ($p = 0.34$) were observed between them in regard to the magnitude of the correction of IMD (Table 1).

When assessing mLDFA modification of each lower limb individually:

- the initial mLDFA of the 8-plate group was 85.3° versus 84.9° for the SNFA group;
- the final mLDFA of the 8-Plate group was 91.8° versus 95.9° for the SNFA group;
- there was a significant correction for SNAF group ($p = 0.0022$) and plate group ($p = 0.0048$) (Fig. 5). We found no significant differences in the magnitude of correction ($p = 0.48$) or the correction speed ($p = 0.33$) between the groups (Table 2);
- for mLDFA measurements, excellent interobserver correlation coefficient was found (ICC = 0.94), as well as excellent intraobserver correlation (ICC = 0.98).

Only one patient presented a minor perioperative complication in the SNAF group, corresponding to a small surgical wound dehiscence which evolved favorably toward closure with basic wound caring. In the plate group, there were no complications.

Ten knees in the SNAF group completed the desired correction while still having an open physis, so it was necessary to retire the fixation by removing the screws and suture or just cutting the filament (depends on the parent's choice), with two cases of further minimal valgus rebound (Fig. 6). In the 8-plate group, it was necessary to remove six plates, with no changes after that.

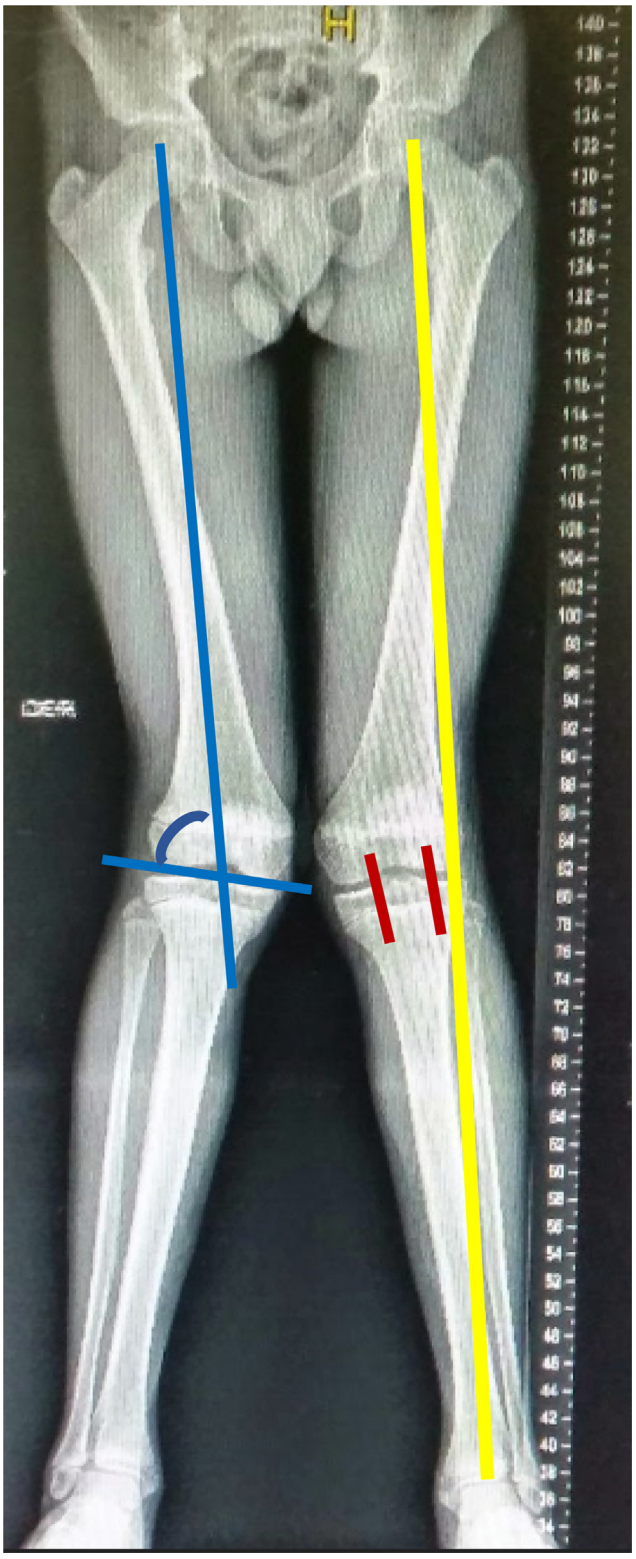

Fig. 3. Radiographic measurement: mechanical axis in zone 2 (yellow). mLDFA (blue).

Table 1
Correction of IMD according to the technique applied. IMD: intermalleolar distance.

Technique	Initial IMD	Final IMD Median (RCI)	Correction IMD Median (RCI)	*p*-value
SNAF	11 cm (10–11.75)	2.5 cm (1–3.75)	9 cm (6.25–10.5)	0.0022
8-plate	11 cm (10–11)	0.5 cm (0–1)	9 cm (8–11)	0.0048

RCI: range of confidence interval; SNAF: screws and non-absorbable filament.

Fig. 4. Clinical IMD correction example: initial (left) and final (right).

Table 2
Magnitude and speed of correction in both groups.

Technique	Median of mLDFA correction	Median of mLDFA speed correction
SNAF	11° (10–11.75)	0.45 degrees/month (1.0–3.75)
8-plate	6.5° (3–19)	0.54 degrees/month (0.21–1.48)
p-value	0.48	0.33

mLDFA mechanical lateral distal femoral angle; SNAF: screws and non-absorbable filament.

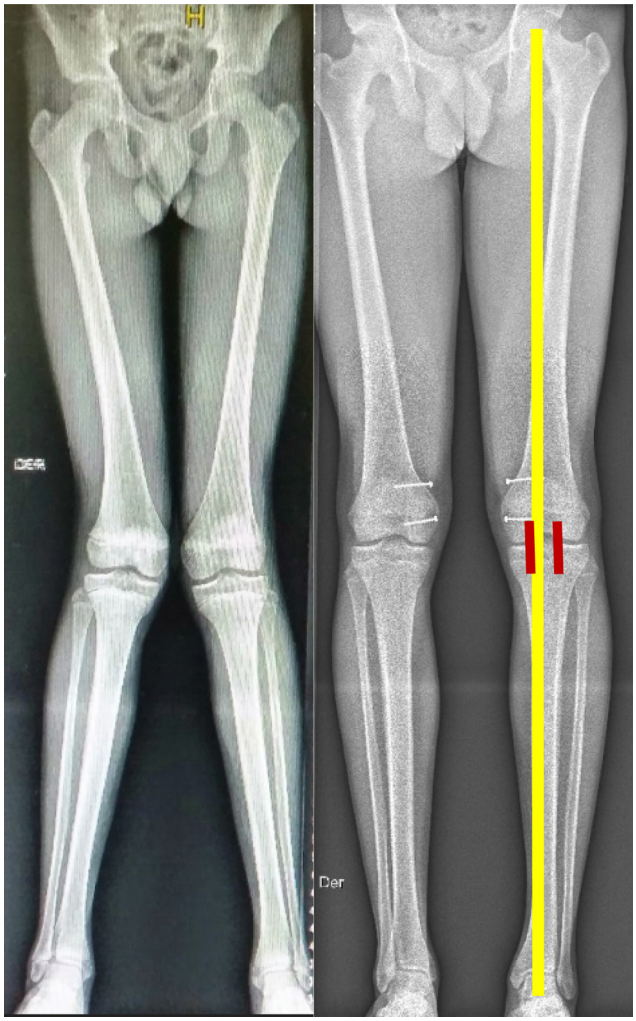

Fig. 5. Mechanical axis correction example: initial (left) and final (right).

Fig. 6. Example of SNAF removed after 13 months post-op.

4. Discussion

The management of angular deformities of lower extremities in patients with mature skeleton is commonly performed with osteotomies. Though, in patients with an immature skeleton modulating their growth and thus correcting the deformity is an option. Within the surgical alternatives initially arose irreversible techniques such as Bowen et al. [11] and Phemister [9] that have the potential inconvenience of overcorrecting or undercorrecting the deformity and the crucial choice of age to intervene a physis with enough growth remaining to achieve correction [7].

Therefore, it's an attractive alternative the possibility of having transient techniques to modulate growth. Among which emerges the use of staples outside of physis of Blount and Clarke [12], but with the disadvantage of the possible implant migration [7]. Also, the transphyseal screw of Métaizeau et al. [13] that manages to

correct on average 0.44 degrees/month but taking into account the risk of compromising the physis permanently. Finally, the real standard of extraperiostal tension plates proposed by Stevens [14] that corrects on average 0.77 degrees/month the mLDFA angle, without permanent growth plate damage [22].

The treatment of angular deformities of lower limbs is an active field of research. The use of absorbable and nonabsorbable filament as hemiepiphysiodesis fixation method has been studied in animal models, proving to be an effective technique for angular modification of the lower limbs and keeping the physeal function intact at the time of filament removal [19], proposing this technique as a possibility to perform transient hemiepiphysiodesis. There is a report of screws and suture use in human, but to our knowledge there are no studies comparing this technique with the standard 8-plate technique. Therefore our hypothesis was in pediatric population with genu valgum there are no differences in outcome between hemiepiphysiodesis, using screws and non-absorbable filament (SNAF) versus 8-plate.

In our report, both the medial distal hemiepiphysiodesis with SNAF and 8-plate techniques proved to be an effective and safe method for angular correction of genu valgum in pediatric patients. The angular correction capacity is similar for both techniques, there were no significant differences in the magnitude and speed of correction of the mLDFA. It is worth mentioning that the correction speed was estimated per month, however, no monthly radiographs were taken in the children to avoid unnecessary irradiation. Both procedures resulted in the expected correction in all patients, with no major perioperative complications, so they present as an efficient alternative for hemiepiphysiodesis in patients with angular deformity of the lower limbs.

The proposed model is a useful, effective and cost-effective alternative to the current standard of care (approximately USD 30 vs. USD 800 in our center), which is a particularly important issue to be consider in public health systems with limited budget or in developing countries. In addition, the versatility of the system can be adapted to different geometry and different sizes of physis, instead the 8-plates that are made for specific geometry and bone size. If fixation removal is needed, this can be done easily only by cutting the filament with a scalpel, which could be performed even under local anesthesia. Screws may eventually be left for sequential correction. This model has the limitation that the tension of the filament is not standardized because we do not have the tools to do this, thus, the tension can be variable.

Although this article has limitations being a retrospective study with a limited sample size, it has the strength to be the first report comparing SNAF versus 8-plate technique. In this series of patients, significant changes were observed between the initial and final values of IMD using both techniques. When comparing the techniques, no significant differences were observed between them.

5. Conclusion

Medial distal femoral hemiepiphysiodesis with screws and nonabsorbable filament is an effective and safe method for correction of mechanical axis and IMD in idiopathic genu valgum in pediatric patients and postoperative results do not differ with the standard 8-plate technique results. The proposed model is a cost-effective alternative to the current standard of care for the treatment of genu valgum.

Disclosure of interest

The authors declare that they have no competing interest.

Funding sources

None.

Authors' contribution

Gino Martinez: the conception and design of the study and final approval of the version to be submitted.
Felipe Hodgson: the conception and design of the study.
Pablo Ruiz: drafting the article and acquisition of data.
Ismael Cañete: drafting the article and acquisition of data.
Alejandro Gundel: analysis and interpretation of data.

Acknowledgments

The author thanks Dr. Hodgson and Dr. Gündel, as members of the surgical team for many of the surgeries, and for collaborating with data collection and statistical analysis. And grateful to Dr. Ruiz and Dr. Cañete, for their work in writing and editing this article.

References

[1] Talarico V, Baserga M, Fuiano L, Mattace F, Mastria G, Arcuri V. Evaluation of the varus-valgus knee in a group of calabrian children. Pediatr Med Chir 2011;33:80–4.
[2] Staheli LT, Corbett M, Wyss C, King H. Lower-extremity rotational problems in children. Normal values to guide management. J Bone Joint Surg Am 1985;67:39–47.
[3] Salenius P, Vankka E. The development of the tibiofemoral angle in children. J Bone Joint Surg Am 1975;57:259–61.
[4] Kling TF, Hensinger RN. Angular and torsional deformities of the lower limbs in children. Clin Orthop Relat Res 1983;176:136–47.
[5] Murphy SB. Tibial osteotomy for genu varum. Indications, preoperative planning, and technique. Orthop Clin North Am 1994;25:477–82.
[6] Castañeda P, Urquhart B, Sullivan E, Haynes RJ. Hemiepiphysiodesis for the correction of angular deformity about the knee. J Pediatr Orthop 2008;28:188–91.
[7] Saran N, Rathjen KE. Guided growth for the correction of pediatric lower limb angular deformity. J Am Acad Orthop Surg 2010;18:528–36.
[8] Ballal MS, Bruce CE, Nayagam S. Correcting genu varum and genu valgum in children by guided growth: temporary hemiepiphysiodesis using tension band plates. J Bone Joint Surg Br 2010;92:273–6.
[9] Phemister D. Operative arrestment of longitudinal growth of bones in the treatment of deformities. J Bone Jt Surg 1933;15:1–9.
[10] Haas S. Retardation of bone growth by a wire loop. J Bone Jt Surg Am 1945;27:25–36.
[11] Bowen JR, Torres RR, Forlin E. Partial epiphysiodesis to address genu varum or genu valgum. J Pediatr Orthop 1992;12:359–64.
[12] Blount WP, Clarke GR. Control of bone growth by epiphyseal stapling; a preliminary report. J Bone Joint Surg Am 1949;31A:464–78.
[13] Métaizeau JP, Wong-Chung J, Bertrand H, Pasquier P. Percutaneous epiphysiodesis using transphyseal screws (PETS). J Pediatr Orthop 1998;18:363–9.
[14] Stevens PM. Guided growth for angular correction. J Pediatr Orthop 2007;27:253–9.
[15] Burghardt RD, Herzenberg JE, Standard SC, Paley D. Temporary hemiepiphyseal arrest using a screw and plate device to treat knee and ankle deformities in children: a preliminary report. J Child Orthop 2008;2:187–97.
[16] Niethard M, Deja M, Rogalski M. Die kniegelenksnahe Achskorrektur im Wachstumsalter durch temporäre Hemiepiphyseodese mit der eight-Plate®. Z Orthop Unfall 2010;148:215–21.
[17] Albarova RGIL, Albarova JGIL. Hemiepifisiodesis femoral distal mediante biomateriales reabsorbibles. Rev Espan Cirug Osteo 2000;35:297–306.
[18] Martínez G, Baar A, Ibañez A, Vergara P, Carmona M, Drago S. Assessment of femoral physeal activity after transitory hemiepiphysiodesis using screws and nonabsorbable filament. J Pediatr Orthop 2014;34:208–12.
[19] Martínez G, Drago S, Avilés C, Ibañez A, Hodgson F, Ramírez C. Distal femoral hemiepiphysiodesis using screw and non-absorbable filament for the treatment of idiopathic genu valgum. Preliminary results of 12 knees. Orthop Traumatol Surg Res 2017;103:269–73.
[20] Zajonz D, Schumann E, Wojan M, Kübler FB, Josten C, Bühligen U, et al. Treatment of genu valgum in children by means of temporary hemiepiphysiodesis using eight-plates: short-term findings. BMC Musculoskelet Disord 2017;18:456.
[21] Kumar S, Sonanis SV. Growth modulation for coronal deformity correction by using Eight Plates—Systematic review. J Orthop 2018;15:168–72.
[22] Danino B, Rödl R, Herzenberg JE, et al. Guided growth: preliminary results of a multinational study of 967 physes in 537 patients. J Child Orthop 2018;12:91–6.