EIGHT - FIGURE PLATE SYSTEM FOR CORRECTION OF ANGULAR DEFORMITIES OF LOWER LIMBS IN CHILDREN. INITIAL RESULTS

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ABSTRACT

The aim of the study is to present results of our experience with 8-figure plate system for treatment of angular deformities of lower limbs. 19 patients underwent surgery using 8-plates for correction of angular deformities with diagnosis of genu valgum or genua valga. Clinical evaluation and X-ray documentation was performed on regular basis including clinical measurements of intermalleolar distance (IMD) and radiological assessment of lateral distal femoral angle (LDFA) and medial proximal tibial angle (MPTA). Average preoperative measurements were IMD=15.8 cm, LDFA=81° and MPTA=97°. At the time of hardware removal, average LDFA raised to 89° (87–92) and average MPTA lowered to 88° (86–89). The hardware was removed in 9.1 months after surgery in average. No complications were observed. 8-plates appeared to be optimal treatment option for correction of angular lower limb deformities showing advantages over the Blount´s staples. It also brings the possibility to intervene in children younger than 10 years of age.

Key Words: lower extremity deformities, angular deformity, genu valgum, hemiepiphyseodesis, 8-plate

INTRODUCTION

Angular upper limb deformities and, more often, deformities of the lower limb of various aetiologies are considered to be relatively common orthopaedic problems of the childhood. The surgical treatment of these deformities depends on the degree of deformity (**15**) and on the age of patients (**10, 18**). In skeletally immature patients, it is possible to correct mild limb deformities by performing both persistent (permanent) or temporary hemiepiphyseodesis.

Permanent epi- or hemiepiphyseodesis necessitates precise calculation of the remaining bone growth and good intervention timing due to irreversible stapling of the physis (**7, 9–11, 18**). On contrary, temporary hemiepiphyseodesis is, at least, partially reversible and may be used for deformity correction in patients before reaching skeletal maturity (**10**).

Several surgical treatment options had been already introduced. The method of the physis stapling was first mentioned by Blount and Clarke back in 1949. This technique was used for the treatment of axial deformities and other authors adopted Blount staples for the correction of leg length discrepancies (**4**). Another method was proposed by Mètaizeau (**13**) who used transphyseal screws to arrest physeal growth. Eidelman and D'Agostino described modification of Blount staples with grooves to allow more accurate targeting with K-wires guided insertion of staples over the physis (**6**). Based on the findings and recommendations from different authors, Blount staples could be left in a place no longer than 2 years because after this period permanent physeal growth arrest occurs due to excessive compression of the physis (**4, 14**). The risks of harming the physis and other complications observed during treatment with staples let to the effort to devise a new system in regard to overcome these pitfalls. In 2007, Peter M. Stevens introduced in Journal of Pediatric Orthopedics (JPO) their experience with the brand new original system called 8-figure plate for correction of angular deviations of the lower limbs in children (i.e. guided growth system, 8-plates), with the aim to eliminate complications accompanied with the methods mentioned above (**4, 18**). Furthermore, this physis preserving system based on so called "tension band" principle, could be applied in children younger than 10 years, which means under universally accepted age limit for using Blount staples (**18**). With progressive introduction of this new method in other institutions, 8-plates started to be used also for correction of mild length discrepancies of the lower limb. However, 8-plates have their supporters as well as the opponents (**12**).

The aim of this study is to present our first experience and outcomes of the treatment of angular deformities of the lower limb using 8-plates and to compare the results with the literature from abroad.

MATERIAL AND METHODS

Due to retrospective nature of the study, informed consent was reviewed and signed by the parents of the patients who were enrolled in the study.

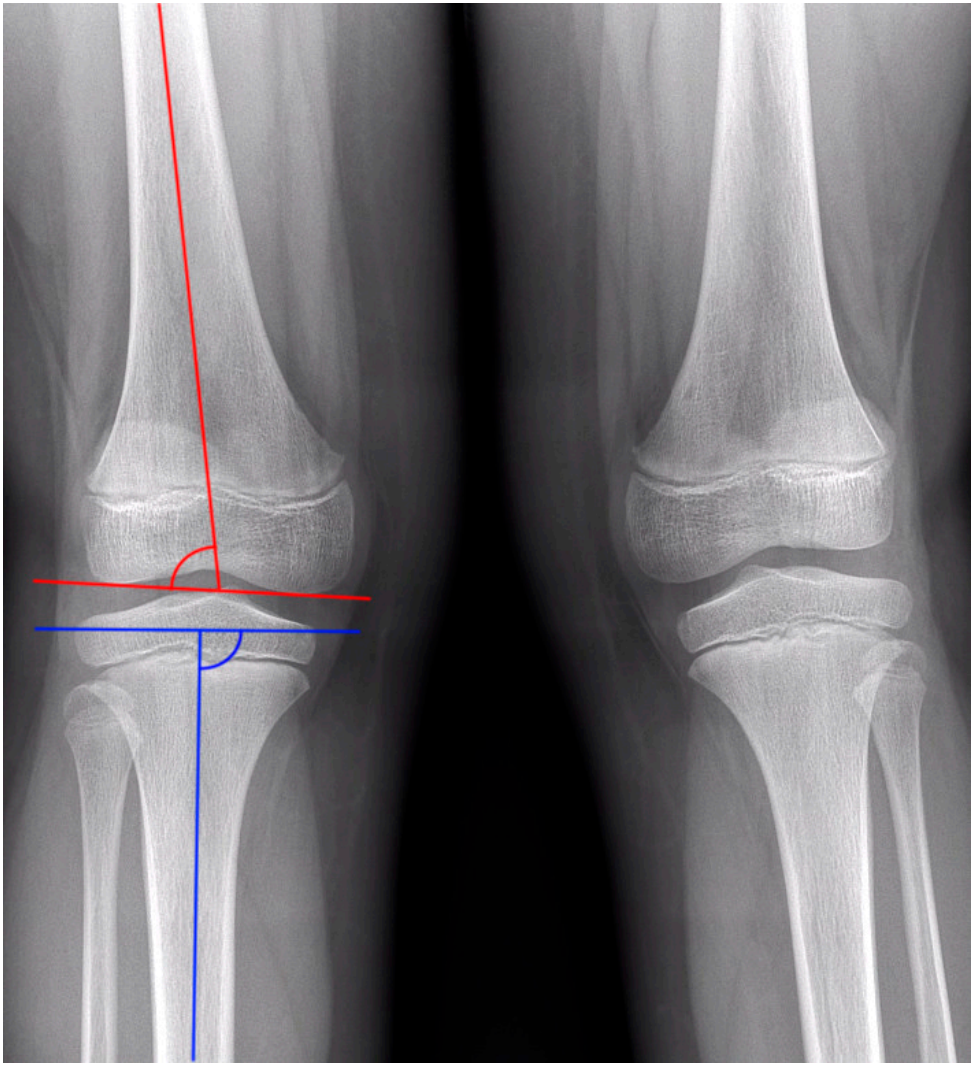

Figure 1. Radiograph of the knee joints in the vertical position (a part of the film of lower extremities of one patient from our group) obtained to measure angular relationships i.e. measurements of lateral distal femoral angle (LDFA, red colour) and medial proximal tibial angle (MPTA, blue colour).

From January 2014 to April 2015, 19 patients who underwent surgery to correct angular deformities of the lower limbs with 8-plate system were enrolled in our study. The group consisted of 13 boys (68.4%) and 6 girls (31.6%)

Inclusion criteria for this study were as follows: children aged 6-15 years with angular deformity of the lower limbs in terms of genu valgum (or genua valga), at least 6 months of estimated remaining growth (generally assessed based on the age of patient and based on pre-operative X-ray) and pre-operative intermalleolar distance (IMD) of 10 cm and more.

Patients with previous surgical correction of the angular deformity were not included.

Measurements

All patients were carefully examined preoperatively. Furthermore, the distance between medial ankles – IMD was assessed.

Additionally, routinely long radiographs of the lower extremities in the vertical position were obtained to measure angular relationships of the knee joints. Depending on the localization of the deformity, mechanical lateral distal femoral angle (LDFA) (normal values ranging from 85° to 90°) and medial proximal tibial angle (MPTA) (normal values ranging from 85° to 90°) were measured on preoperative standardized standing anteroposterior radiographs using Paley and Herzenberg method (**16**); in the case of bilateral deformity, LDFA and MPTA were measured for each knee separately (**Figure 1**).

All these measurements were repeated during next clinical and radiographic follow-ups in the interval of 3–4 months.

Eight figure plate system

The 8-figure plate system consists of the 2-holes plate and the 2 (self-tapping) screws. There could be one or two more holes for K-wire guided insertion of the plate (**Figure 2**). The screws are canalized or lockable, depending on the particular 8-figure plate system. There are currently available many 8-plates systems but the differences amongst them are minimal. The system we used (Normed, Tuttlingen, Germany) consisted of plates of 2 sizes – 3.5 and 4.0 mm. The 3.5 size was designed for the children up to 8 years or for the patient with the weight of up to 35 kg. The plates of the system could be used and applied at the area of knee, hip or ankle joints or to the area of the elbow and wrist. In our group of patients, 8-figure plate system was used only for the correction of genua valga deformity.

Surgical technique

8-figure plate is inserted using minimally invasive approach from a 3 cm short incision at the area of the knee right above the physis and under fluoroscopy control. This allows accurate targeting and

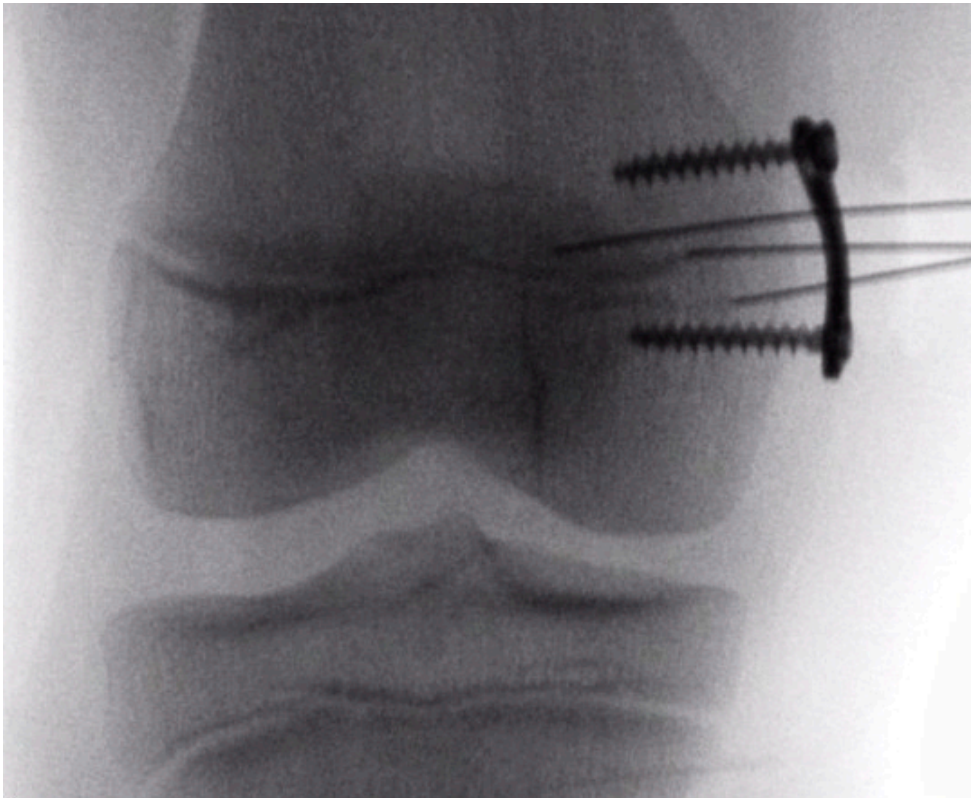

Figure 2. The implementation of the 8-plates using fixation with K-wires.

localization of the plate straddling the growth plate of the long bone. The penetration to the bone is performed under strict preservation of periosteum which minimizes the possibility of damaging the growth plate (**4,18**).Before the final plate anchoring to the bone by screws, pre-fixation with K-wires is performed for accurate targeting of the plate above the physis under fluoroscopy control. The plate must be placed exactly in the centre of the lateral diameter of the bone and always strictly parallel with the long axis of both of the bones. Therefore, the lateral radiograph projection is also necessary to avoid iatrogenic development of the angular deformity in the sagittal plane caused by wrong placement above the growth plate (genu recurvatum, procurvatum) (**4**). Pre-fixation with K-wires allows easier and safer centring of the screws for final plate fixation. After screws are inserted, it is necessary to check the movements of the knee joint before the suturing to avoid possible blockage of the movements caused by wrong plate placement.

Patients may burden limbs from the first postoperative day with partial relief using French crutches when walking. Crutches are used for the necessary time period of post-operative pain.

Simultaneously intensive rehabilitation procedures are initiated to restore the free movement range. In average, patients put away the crutches within 2 weeks after surgery, which equals to the healing time of surgical wounds and extracting stitches. Post-operative and clinical check-ups are performed in 3-4 months (**10, 18**). Plate extraction is planned after full correction of the lower limb deformity (**4, 10, 18**).

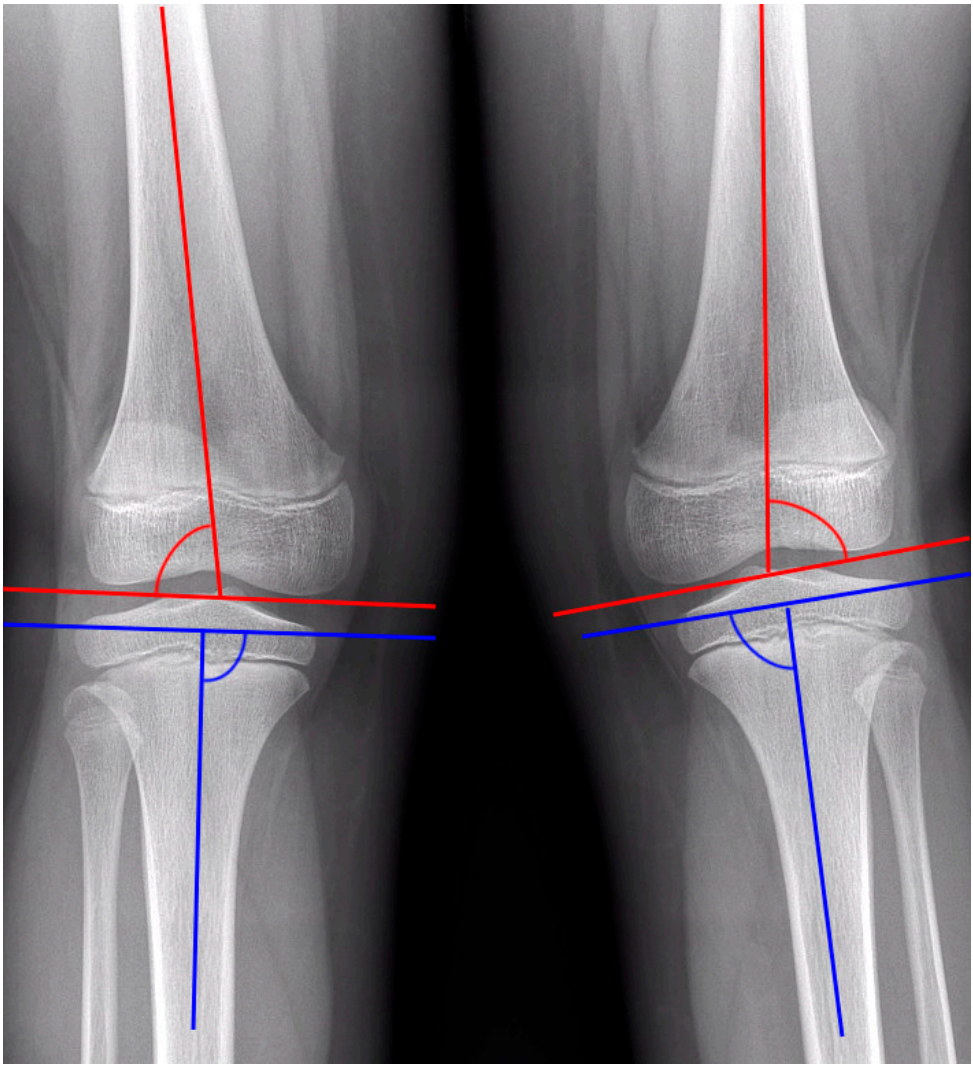

Figure 3 A. Genua valga correction by 8-figure plates. X-ray of the genua valga before treatment - the initial values for right leg were: LDFA=80.7°, MPTA=89.2°; for left leg LDFA=79.7°, MPTA=89.2°.

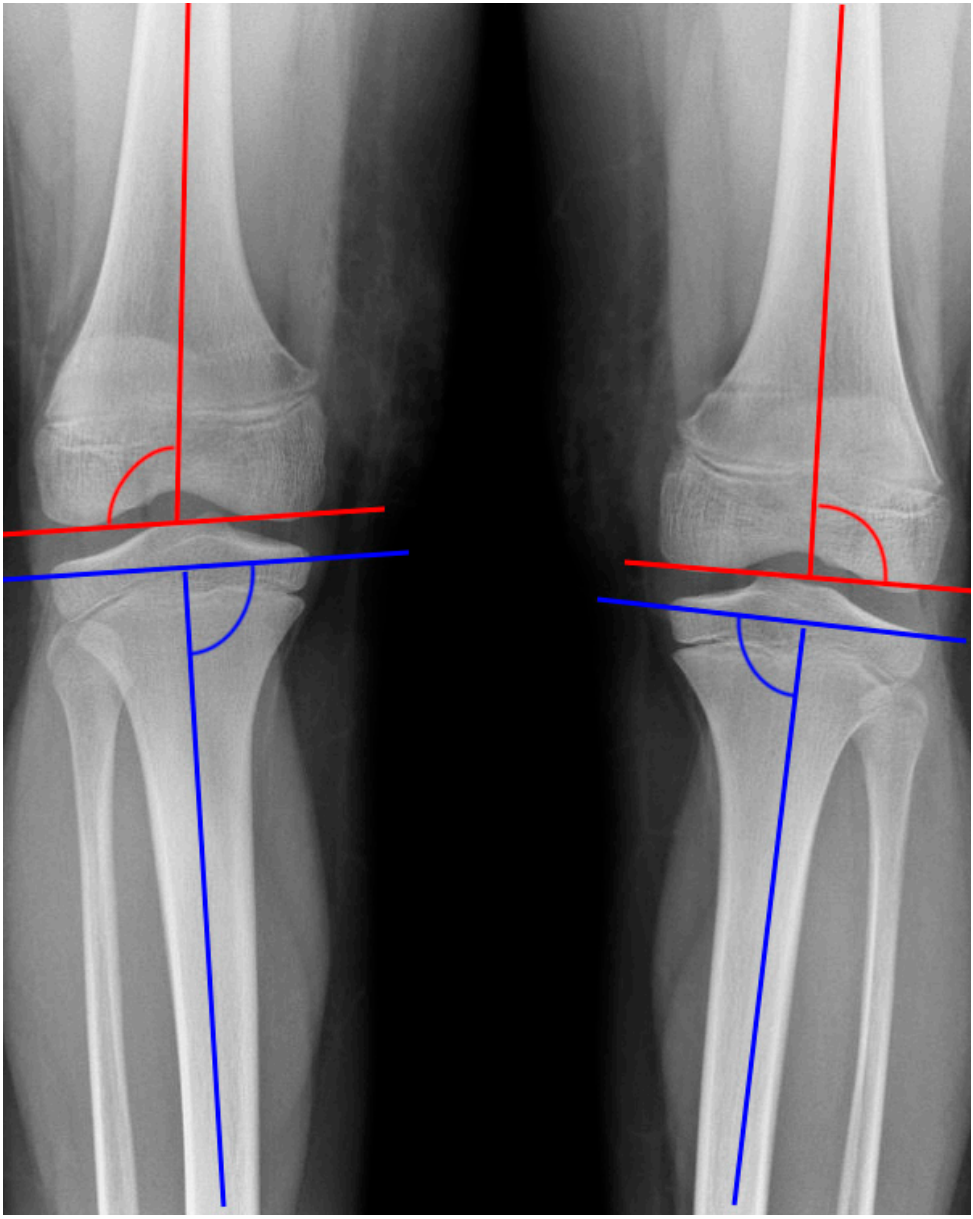

Figure 3 B. Genua valga correction by 8-figure plates. X-ray shows correction of the knee joints after surgery. Just after the hardware removal, the reach values were as follows: right leg: LDFA=91.9°, MPTA=90.4°; left leg LDFA=87.6°, MPTA=90.8°. Full correction was achieved in a clinical way as well.

RESULTS

Nineteen patients (13 male, 6 female) with a diagnosis of genu valgum (or genua valga) underwent temporary medial hemiepiphyseodesis; 3 patients (15.8%) only for unilateral genu valgum, two patients (10.5%) with the severe findings of the deformity of genua valga underwent medial hemiepiphyseodesis bilaterally at the area of distal femur as well as at the area of proximal tibia. The remaining 14 patients (73.7%) of the group underwent medial hemiepiphyseodesis of distal femurs bilaterally.

The most frequent diagnosis was idiopathic genu valgum (or genua valga), 2 patients suffered from epiphyseal dysplasia and 2 patients underwent surgery due to post-traumatic deformity.

Two patients with diagnosis of epiphyseal dysplasia were operated although they were diagnosed with the epiphyseal dysplasia. Average initial preoperative IMD in the standing position was 15.8 cm. The average preoperative LDFA was 81° and MPTA 97°, respectively.

At the time of the hardware removal, average preoperative value of LDFA measured by radiograph raised from 81° (79–84) to the average 89° (87–92), initial average preoperative value of MPTA decreased from 97° (92–98) to the average of 88° (86-89) and preoperative IMD in the standing position decreased to around 0 cm. Correction of genua valga by the 8-figure plates in one of our patients is demostrated at X-rays of his knee joints – see **Figures 3 A, B**.

Average difference of LDFA measure in 3-months interval of follow-up in these patients equals 2.1° (±0.9) and the difference of MPTA equals 1.5° (±0.6) (**Table 1**). Treatment was successfully completed in all patients and plates were extracted in 9.1 months (6.3–12.1) in average after the surgery.

The mean time of the surgery for unilateral genu valgum was 27 min (± 7), in patients with bilateral genua valga 43min (± 5). Patients stayed in the hospital for 5 days in average (3-8 days) and this time was directly dependent on the retreat of post-operative pain and the especially on the effectiveness of post-operative rehabilitation and ability to walk on crutches.

No complications in this patients´ group were observed.

	Before treatment	After treatment
Average IMD (cm) (vertical position)	15.8	0
Average LFDA (degrees)	81	89
Average MPTA (degrees)	97	88
	3 months after surgery	
Average change of LFDA (degrees)	2.1	
Average change of MPTA (degrees)	1.5	

Table 1. Measurements prior and after treatment of angular deformities of lower limbs using 8-plates (IMD – intermalleolar distance; LDFA - lateral distal femoral angle; MPTA – medial proximal tibial angle).

DISCUSSION

Blount staples are still the most commonly used device in our conditions especially for treatment of the angular deformities of the lower limbs. Besides some indisputable advantages, their implementation unfortunately brings along a number of complications, such as staples breakage, hardware migration or hypercorrection of the original deformity. The most serious observed complication was damage of the physis caused by excessive compression with subsequent formation of the physeal bar with all the consequences of its development (**1, 2, 4, 5, 10, 14, 18**).

In comparison to Blount staples providing compressive force on the physis, 8-plate system serves as a "tension band" (**18**) This allows careful conduction of the inner physiological growth process and thereby restoring the physiological axis or the length of the limb without the need of invasive intervention on the bone in the future. Due to fixation of the plate with screws, the risk of hardware extrusion is minimal (**4, 5, 10**) and so the failure of the system is significantly reduced compared to Blount staples in this respect. Not all the authors share this opinion. Gottliebsen et al. (**8**) and Jelinek et al. (**10**) published studies in which no differences between the 8-plates and staples were observed in terms of complication occurrence and effectiveness of these 2 methods. This could be explained by the small populations for comparison of 2 different methods consisting of 25 and 35 children, respectively.

The 8-plate could be applied in children under 10 years of age (generally accepted age for stapling) because of its protective effect on the physis (**10, 18**). Furthermore, the improved plate fixation with screws in bones which are not yet fully mature and consist of large portion of cartilage support the indication of 8-plates for younger patients. Screws firmly hold the plate in the cartilaginous bone due to threads and thus, in comparison to the smooth Blount staples, they prevent hardware migration in children of the same age (**4, 5, 10**). Therefore, it is no longer necessary to wait until the children patient with mild angular lower limb deformity reaches the certain bone maturity for appropriate application of the staples and so it is possible to prevent progression of the deformity by its correction in a younger age. Our findings support this theory because 6 patients with the age of less than 10 years were included and no complications such as extrusion of the hardware were observed in our patient population.

The optimal early planning of the surgery is advantageous not only in terms of rational limiting the progression of the deformities which is often seen in children. It also helps to avoid relatively difficult corrective osteotomy which is used in treatment of these deformities in adulthood (patients with terminated skeletal growth) or in patients with severe angular deformities (**2, 4, 10, 18**).

Furthermore, fast postoperative recovery and immediate burdening of the limb is feasible due to minimally invasive implementation of the plates as it is seen in stapling procedure (**3, 4, 18**).The extraction of the plates can be performed after reaching full correction of the deformity, which means after reaching physiological joint axis. Raab et al. (**17**) and other authors recommended the material extraction after slight overcorrection of the deformity to avoid the rebound phenomenon which can be sometimes observed after 8-figure plates or Blount staples extraction (**4, 10, 17, 19**).

We followed the recommendation of slight over-correction of the deformity and patients are further monitored to observe final axis of lower limbs.

The resumption of physeal growth physis occurs after hardware removal and deformity recurrence could be seen (**8, 19**). Other advantage of the 8-figure plate system compared to the Blount staples is lower occurrence of rebound phenomenon that was already described. It is explained by the tension effect on physis which doesn´t react by growth spurt after hardware removal as it is seen after compression of the Blount staples (**10, 17**). No rebound phenomenon was observed in our patients but further investigations need be done to be able to predict when this phenomenon will occur and in what extent.

According to today´s professionals' agreement, 8-figure plate system shouldn´t be used in children under 6 years of age, in severe axial deviation more than 30 degrees, in joint contractures more than 20-30 degrees, in severe epi- and metaepiphyseal dysplasia, at the area of malignity or severe osteoporosis or osteopenia. Although using 8-plates in children younger than 6 years of age is relatively contraindicated, Stevens (**18**) used this method in patient at the age of 2 years and he didn´t observed any complications. Our own experiences with 8-figure plate aren´t also in some ways in accordance with the recommended contraindications mentioned above. In 2 patients with the severe form of epiphyseal dysplasia, which was classified as acontraindication by some inventors of 8-figure plate systems due to the larger portion of cartilage in epiphysis in this condition, we successfully corrected the axis of lower extremities. We decided to apply the 8-plates in these 2 patients due to severe and progressing valgus deformity of the knee joints and due to young age of the patients. We reached very good results in terms of axis correction and we didn´t observed any complication during the therapy. Up to date, these patients are still under follow-up and no rebound phenomenon has been observed after the therapy.

Moreover, the operation with plates and screws fixation to the epiphysis went in a standard way, and postoperative correction underwent clinically and radiologically in a normal, standard way without any complications observed.

Stevens (**18**) described faster effect and axis correction using 8-plates, especially in treatment of genu valgum, compared to Blound staples. Correction of the pathological axis of the joint lasts approximately 5–13 months (in our study average time 9.1 months) based on the literature which is comparable to the Blount staple method (**5, 10**). Even in our study population our observations let to similar conclusion after first clinical and radiography check-ups.

The limitation of this study is relatively small amount of patients, which is, on the other way, comparable with patient's populations of different authors´ studies. The other important limitation is economical issue. We must agree with the general opinion that the main disadvantage of using 8-plates is their significantly higher price compared to the price of Blount staple.

CONCLUSIONS

Despite of our first, short-term experiences with this operative technique and short-term follow-up outcomes we can only confirm and conclude that introduction of this method to treat the angular deformities of the lower extremities enriches significantly our operating repertoire in this field of paediatric orthopaedics, especially in younger children. Thus, 8-figure plate system showed the potential to replace Blount staples in full extent of their indications.

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