Comparative Study between Eight Plate and Staples in the Management of Angular Knee Deformities in Children Older Than 3 Years Attending Suez Canal University Hospital

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Abstract

Background: **Most of the angular deformities of pediatric knees are benign and disappear without any interventions by the age of eight years. The ones that don't resolve cause gait disturbance, pain, cosmetic problems and early joint degeneration so they need to be corrected.** ***Aim:*** **This study aimed to evaluate the correction rate of angular deformities around the knee by guided growth using eight-plate versus stapling.** ***Methods:*** **The design of this study is a randomized controlled clinical trial that included 20 patients, 16 bilateral and 4 unilateral, a total of 36 angular deformed knees with open physis presenting to Orthopedics clinic, Suez Canal University Teaching hospitals. The study participants were assigned to two groups: Group 1: deformed knees had been treated with eight-plate and Group B: deformed knees had been treated with staples.** ***Results:*** **The overall correction rate of the tibio-femoral angle (TFA) was 1.67 degrees per month for staples and 1.8 degrees per month for eight-plate (*p* = 0.70). The correction in medial proximal tibial angle (MPTA) was significantly better in the eight-plate group (*p*=0.539). Implant-related complications were identified as implant failure in one patient of the staples group and another patient with superficial infection in the eight-plate group.** ***Conclusion:*** **Eight-plate is as effective as staples in the correction of the tibio-femoral angle and provides better improvement of the medial proximal tibial angle. We recommend both eight-plate and staples as effective devices to be used in the correction of angular knee deformities in children.**

Keywords: Angular deformities around the knee; hemiepiphysiodesis, staples; eight-plate; guided growth; genu varum; genu valgum; tension band plate.

Introduction

Angular deformities around the knees in children are common, lower limb deformities represent 16.61% [(1)] . They may be physiological or pathological. Physiological deformities resolve usually as the child grows up by age of 3 and 6 years for genu varum and genu valgum, respectively [(2)(3)]. Pathological deformities result in abnormal mechanical load, which causes knee pain, disturbed gait, mal-tracking of the patella, cosmetic deformity and early arthritis [(3)(4)(5)].

For years, corrective osteotomy was the gold standard operation for the correction of deformity. Complications of osteotomy as bleeding, need for fixation, delayed weight-bear till union, joint stiffness due to prolonged immobilization, risk of infection, neurovascular injury, compartmental syndrome and physeal injury disturbing

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the growth, made us in need of other treatment options [6][7].

Using a device for a temporary closure of half of the physis allowing the other half to grow to correct the deformity is the idea behind what is called temporary hemiepiphysiodesis or guided growth [8][9]. It avoids all the complications of osteotomy and this made it a better option. The commonly used devices are eight-plate, staples and transphyseal screws [7][10,11]. Hemiepiphyseodesis is a simple technique, provide early weight bearing and it has the advantage of being cost effective and readily available [12]. Blount and Clark first introduced staples as a device of hemiepiphysiodesis in 1949. It was used by many surgeons showing good results in gradual correction of the deformities without any bone damage which allowed the children to fully bear weight from day one post-surgery. Staples breakage and migration were the commonest complications [13][14]. A tension band plate (known as an eight-plate) was made to avoid this complication. The eight-plate has two non-locking screws inserted one in the epiphysis and the other in the metaphysis acting as a tension band on the physis with fewer complications than staples [14][15][16].

Therefore, this study was dedicated to comparing the effectiveness of both devices in the correction of pediatric angular knee deformities.

Methods

A randomized clinical trial was conducted in the Orthopedics department, at Suez Canal University teaching hospital. The study was approved by the local ethical committee in our hospital (at 9 February, 2021 with number 4467), and consent from the parents or guardian(s) of the participants and affirmation from older children was taken.

Patients

Patients were recruited from the outpatient orthopedic clinic in our hospital. Children with open physis presented with angular knee deformities, older than 3 years for varus and older than 6 years for valgus were eligible for inclusion. Patients with physiological deformities, deformities due to metabolic disorders that improved with medical management, deformities as a result of infection or neoplasm, post-traumatic deformities, Blount disease, dynamic deformities as in neuromuscular disorders and contractures, non-ambulatory patients, multiple CORA were excluded.

Study Procedures

Children were diagnosed with angular knee deformities by the supervising orthopedic surgeon who performed standard physical examinations including measuring the intercondylar or intermalleolar distances (patients with distance > 3 cm were considered to had a deformity), lab including alkaline phosphatase, serum calcium, phosphorus, parathyroid hormone, and imaging including an x-ray of both lower limb long-standing film from hip to ankle to diagnose the pathology. When a child met the inclusion criteria, he or she was included in a list then the names in the list were randomly assigned to one of the two study groups. Group A is the eight-plate group and group B is the staples group. Randomization was based on the order of the candidate in the list, the odds were Group A and the evens were group B.

Interventions

The surgery was performed under general anesthesia. A pre-operative antibiotic was injected intravenously. The child was lying supine. We used a needle under C arm guidance to localize the growth plate. To be in the middle of the

growth plate in the sagittal we palpate the anterior and posterior margins of the bone and make a 2 cm vertical skin incision at this position. Using blunt dissection, we reached the bone avoiding any injury to the periosteum or the perichondrial ring. In the case of the eight-plate; the plate was placed extraperiosteal over the physis and kept in place with a thin k-wire (0.8cm) through the small central hole in the plate. Using the C-arm to confirm the plate position. In every hole of the plate, a self-tapping screw was introduced after drilling one in the metaphysis and the other in the epiphysis. One or two staples were inserted sub-muscular, extra-periosteal, their place was checked intraoperatively by the C-arm.

No need for post-operative immobilization. A full range of knee motion was allowed from day 2 to post-operative. Early weight-bearing as tolerable was allowed along with a rapid return to normal activities, Usually, full weight-bearing was achieved by 2 weeks after surgery. Sutures were removed after 2 weeks.

Outcome measures

The primary outcome measure was the correction of the deformity. This was measured clinically by the intermalleolar distance in cases of genu valgum and intercondylar distance in cases of genu varum every 3 months and confirmed radiologically after 1 year of follow-up or after clinical correction of deformity by a plain x-ray long-standing film of both lower limbs including hips, knees and ankles measuring mechanical tibiofemoral angle (mTFA), mechanical lateral distal femoral angle (mLDFA) and mechanical proximal tibial angle (mPTA).

Statistical analysis

Data were entered into a Microsoft Excel 2016, of the Microsoft Office Bundle of Microsoft Corporation, USA, then analysed using SPSS version 23 (Statistical Package for Social Sciences) Of IBM Corporation, USA. If $p < 0.05$ it was considered significant. Student t test and Mann Whitney test were used to calculate difference between quantitative variables in two groups for parametric and non-parametric variables. Log rank test compares the entire survival experience between groups.

Results

Enrollment

There were 30 ptients eligible for this study and those who met inclusion criteria were 20 patients, 16 bilateral and 4 unilateral, a total of 36 angular deformed knees with open physis presented to the Orthopedics clinic, Suez Canal University Teaching hospitals (Figure 1).

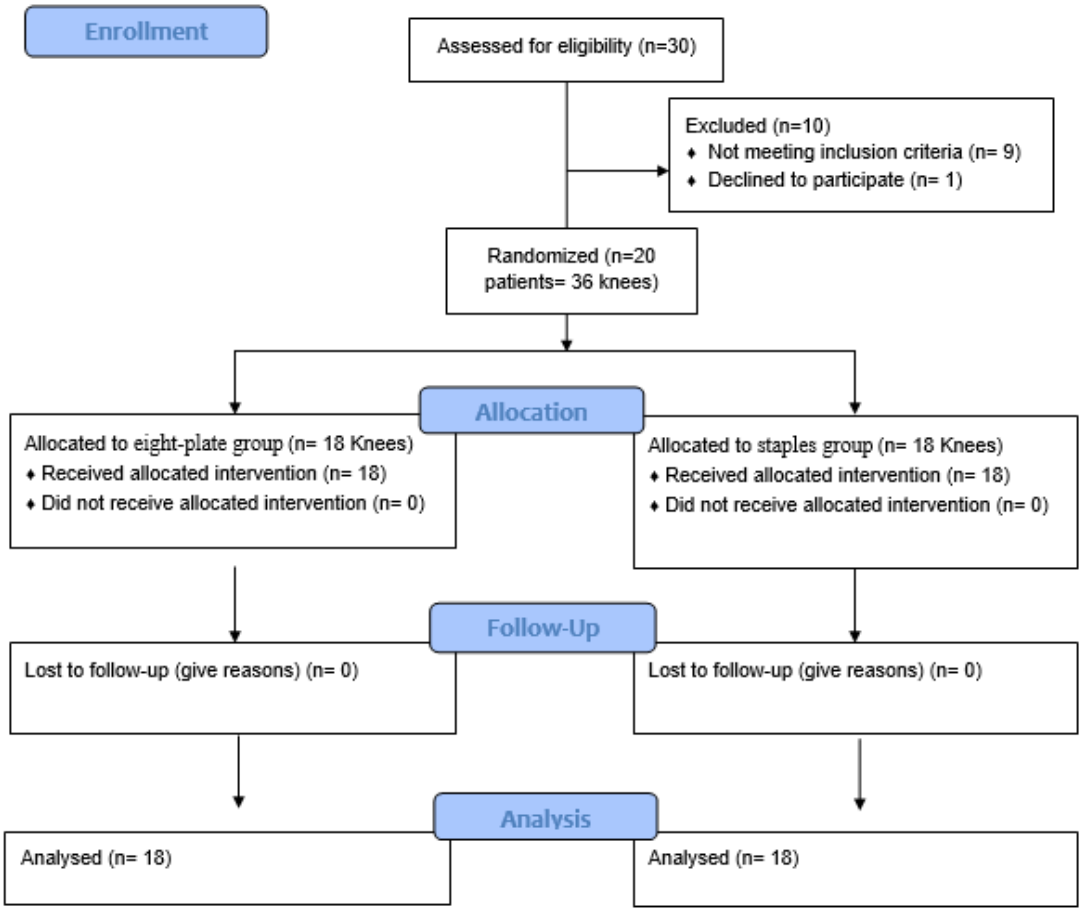

Figure 1. Flow chart of this study.

Patients Characteristics

Figure 2. A 7-year-old boy with bilateral genu valgum deformity, (A): Pre-operative (B): 12 months after surgery (C): pre-operative x-ray, (D): post-operative x-ray

The mean age of the patients was 5.30 ± 2.80 years with a range of age between 3.5 to 13 years. The mean age of the eight-plate group is 6 ± 3.2 years, while the mean age of the staples group is 4.5 ± 4.6 years. Males formed 52.8 % of the patients in the study while females formed 47.2 %. This percentage wasn't the same within each group. In group A males represented 38% while females were representing 62%, in group B 66.7%

were males while females were 33.3 only. Regarding the type of deformity, most of our patients had genu varum (83.3%). About 94.4% of group A had genu varum deformity, while 72.2% of group B were genu varum. About 52.8 % of the deformities were on the left side.

Figure 3. A 3.5-year-old boy, with bilateral genu varum deformity, (A): Pre-operative (B): 12 months after surgery (C): pre-operative x-ray (D): post-operative x-ray.

Outcomes

The rate of correction of MTFA in the 8-plate group was 2.0391 ° per month and 2.125 ° in the staples group with a p-value of 0.539. The mLDFA was corrected by a rate of 0.846° in the 8-plate group and 0.889° in the staples group per month with a p-value of 0.563. the mPTA showed a correction rate of 1.1° and 1.02° for 8-plate and staples, respectively per month with a p-value of 0.024. The correction rate of intercondylar distance is shown in table 1 and the intermalleolar distance correction rate in table 2.

Table 1: Change in the intercondylar distance (ICD).			
ICD	Staples group Mean (cm) ± SD	8 plate group Mean (cm) ± SD	p-value
Pre-operative	23.6 ± 9.9	24.6 ± 8.9	
Post-operative	1.5 ± 4.7	1.6 ± 4.2	0.482
Change in ICD	22.1 ± 6.6	23 ± 5.2	

Table 2: Change in intermaleolar distance (ICD).			
IMD	Staples group Mean (cm) ± SD	8 plate group Mean (cm) ± SD	p-value
Pre-operative	18.6 ± 7.2	19.5 ± 6.9	
Post-operative	2.8 ± 4.2	2.5 ± 4.1	0.482
Change in IMD	15.6 ± 6.6	17 ± 5.2	

The time of implant removal in the 8-plate group was 11.688 +/- 0.151monthes and 10.94+/- 0.473 months in the staples group as seen in table 3.

Table 3: Survival analysis on time to remove the implant in both groups				
Implant	Mean (months)	Standard error	95% CI	p-value
Staples	10.94	0.473	(10.013- 11.869)	0.289
Eight-plate	11.688	0.151	(11.392- 11.983)	

There was one patient in the staple group who had a failure of the proximal tibial staple after 6 months. Meanwhile, one patient in the 8-plate group had a superficial wound infection. No case showed overcorrection.

Discussion

Our study showed no statistically significant difference in deformity correction rate for both staples and eight-plate groups. We reviewed similar studies that were written during the last few years. A study by Jelinek et al 2012 compared 33 knees treated with eight-plate and 32 treated with staples. Jelinek et al found no statistically significant difference in the rate of correction of the deformity in both techniques; this is similar to our results. They mentioned 4 cases of overcorrection in the eight-plate group, and this was prevented in our study by close follow-up. They mentioned implant displacement with two cases of staples; it happened after sufficient correction of the deformity, so no re-insertion of the staples was needed, we also noticed this in one case, sufficient deformity correction was achieved so we didn't re-insert a staple. One of their patients in the staples group had a wound infection which needed debridement and vacuum as reported, we had only one case with eight-plate had a superficial wound infection treated by antibiotics [(15)].
Gottliebsen et al.in 2013 studied 20 knees with angular deformity treated by guided growth and reported no statistically significant difference in the rate of correction by both staples and eight-plate groups[(13)].
Kumar et al in 2016 after following up with 37 patients with 63 affected knees 31 of them were treated with eight-plate while 32 were managed by staples found no statistically significant difference in the rate of deformity correction between the two techniques used. Four knees (two in each group) hadn't been corrected after two years and required further operations, we had three knees (one in the staples group and two in the eight-plate group) not corrected after one year of follow up we are intending to follow them for one more year. This may be due to their old age (12, 13 and 14 years) and relatively short follow-up duration. Kumar et al also mentioned that they had two knees experienced staples extrusion before sufficient deformity correction and needed further operations to correct the deformity. And as mentioned above we had one knee with a staple extrusion that happened after sufficient correction of the deformities so no further operation was needed [(6)].

Recommendations

We recommend Temporary hemiepiphyseodesis in the correction of angular knee deformities in children. Either use of an eight-plate or staples is recommended. More studies with prolonged follow-up periods to see the result of both devices in form of deformities correction, rebound growth or growth arrest. Both staples and eight plates have similar potential for the correction of angular deformity around the knee in children older than 3 years.

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