

# Radiological comparison of parallel fixation and divergent fixation using K-wire in pediatric lateral condyle fractures

Pediatric humerus lateral kondil kırıklarında K-teli kullanılarak yapılan paralel tespit ile divergan tespitin radyolojik karşılaştırması

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## Abstract

**Aim:** Lateral condyle fractures (LCF) of the humerus are the second most common (10-20%) after supracondylar fractures in childhood. Many methods have been described in the literature for their treatment, but a gold standard method has not been proposed. In this study, we aimed to compare the radiological results and complications of 2 different fixation methods (parallel or divergent) with K-wire in treatment.

**Methods:** Patients under 18 years of age who were operated in our hospital due to humeral LCF between January 2014 and January 2020 were included in this retrospective cohort study. They were divided into Group 1 (fixed with parallel K-wire) and Group 2 (fixed with divergent K-wire). The age, and gender of the patients were noted, and side, type of fracture, type of treatment, radiological union times, nonunion or delayed union, fishtail deformity, excessive growth of the lateral condyle (spur) and avascular necrosis were evaluated using plain radiographs.

**Results:** The mean age of 41 patients included in the study were 4.69 years, there were 28 males and 13 females. The most common type of fracture was Weiss type 2 (n=23). The most common complication was lateral overgrowth (spur) (n=7). There was no significant difference between the radiological union times and the number of complications in both groups ( $P=0.079$ ,  $P=0.56$  respectively).

**Conclusion:** Both methods used in LCF fractures yielded satisfactory results. Avascular necrosis rates are high in the treatment of type 3 fractures, in which strict follow-up is important.

**Keywords:** Lateral condyle, Fracture, Humerus, Lateral spur, Child

## Öz

**Amaç:** Çocukluk çağında humerusun lateral kondil kırıkları (LKK), suprakondiler kırıklardan sonra en sık (%10-20) ikinci sıradadır. Literatürde bu kırıkların tedavisi için birçok yöntem tanımlanmıştır, ancak altın standart bir yöntem önerilmemiştir. Bu çalışmada, tedavide K-teli ile 2 farklı fiksasyon yönteminin (paralel veya diverjan) radyolojik sonuçlarını ve komplikasyonlarını karşılaştırmayı amaçladık

**Yöntemler:** Ocak 2014-Ocak 2020 tarihleri arasında hastanemize humerus LKK nedeniyle başvuran ve 18 yaş altı olan çocuk hastalar bu retrospektif kohort çalışmaya dahil edildi. Çalışmaya dahil edilen hastalarımızın tamamı LKK nedeniyle ameliyat edilen 18 yaş altı çocuklardan oluştu. Hastalar Grup 1; paralel K-teli ile sabitlenmiş ve Grup 2; diverjan K-teli ile sabitlendi. Her iki grupta yaş, cinsiyet, taraf, kırık tipi, tedavi tipi, radyolojik kaynama süreleri, kaynamama veya gecikmiş kaynama, fishtail deformitesi, lateral kondilde aşırı büyüme ve avasküler nekroz olan hastalar direk radyografiler kullanılarak değerlendirildi.

**Bulgular:** Çalışmaya dahil edilen 41 hastanın yaş ortalaması 4,69 yıl, 28'i erkek, 13'ü kadındı. En sık görülen kırık tipi Weiss tip 2 idi (23 hasta). En sık görülen komplikasyon 7 hastada lateral aşırı büyüme idi. Her iki grupta da radyolojik kaynama süreleri ile komplikasyon sayısı arasında istatistiksel olarak anlamlı bir fark yoktu (sırasıyla  $P=0,079$ ,  $P=0,56$ ).

**Sonuç:** LKK kırıklarında uygulanan 2 farklı yöntemin her ikisi de tatmin edicidir. Tip 3 kırıkların tedavisinde avasküler nekroz oranları yüksektir ve bu kırıklar da sıkı takip önemlidir.

**Anahtar kelimeler:** Lateral kondil, Kırık, Humerus, Lateral spur, Çocuk

## Introduction

Pediatric humerus LCFs are rare, and account for approximately 10-20% of all childhood elbow fractures. They usually occur because of forcing the extended arm to varus due to falling from height [1,2]. Displaced fractures require open reduction and internal fixation for anatomic reduction of the intra-articular component. While internal fixation is usually achieved with K-wires in young children, compression screws can be used in older children [3,4]. Although different treatment methods have been defined depending on the degree of fracture [5], the treatment of nondisplaced or minimally displaced fractures is still controversial [6,7]. The most widely used classification system for LCF is the Milch classification system. However, it has been reported that this classification does not predict the treatment results [8,9]. Weiss et al. described a new classification system for these fractures in 2009, in which, considering the displacement of the fracture, the complication rates of the treatment are specified in more detail [8]. In our study, the radiological union times, and complications of 2 different surgical methods (fixation with 2 parallel K-wires and divergent 2 K-wires) were compared using the Weiss classification.

## Materials and methods

The pediatric LCF patients, who applied to our clinic between January 2014 and January 2020, were included in the study. The study started after obtaining the approval of the local ethics committee of our university on 18/09/2020 with the number 2020 / 06-02. The data was collected from the automation recording system of our hospital. Pediatric patients under 18 years of age who were operated for lateral condyle fractures and whose latest data were available were included in the study. Patients with distal humerus fractures and open fractures were excluded. After the implementation of these criteria, 41 patients whose information were available and met the inclusion criteria were evaluated. Standard antero-posterior (AP), lateral and oblique radiographs of all patients were examined. All preoperative fractures were classified according to the Weiss classification (Figure 1).

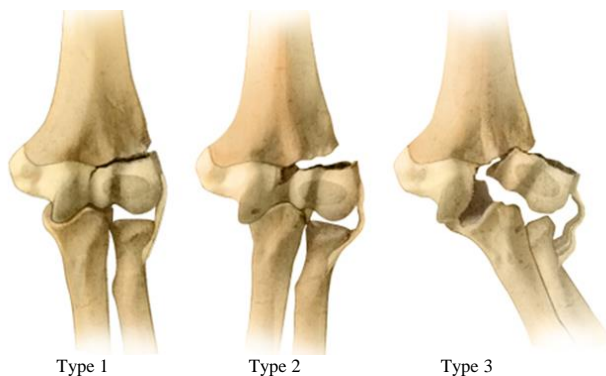


Figure 1: Weiss classification

The Weiss classification, used for lateral humeral condyle fractures, is based on the degree of displacement measured from the elbow:

- Type 1: <2 mm displacement
- Type 2: 2-4 mm displacement
- Type 3: >4 mm displacement

All patients were administered general anesthesia, and a tourniquet was placed above the elbow. The plane between the brachioradialis and the triceps was determined laterally. The extensor communis muscle was partially released to view the joint surface. After the joint surface was anatomically restored, it was fixed with parallel K-wires (Figure 2) and divergent K-wires (Figure 3). In both groups, K-wires were left exposed from the skin and the long arm was splinted. Patients were called for clinical and radiological controls once a week. K-wires were removed 4-6 weeks later in patients with radiographic union. Age, gender, side, type of fracture, treatment modality, duration of radiological union and complications of both groups were evaluated. Nonunion or delayed union, fishtail deformity, and excessive growth of the lateral condyle (spur) were evaluated as complications using direct radiographs. Patients whose treatment was completed with conservative methods and patients who were followed up were excluded from the study.



Figure 2: Postoperative radiographic image of a patient who underwent the parallel K-wire method  
 Figure 3: Postoperative radiographic image of a patient who underwent the divergent K-wire method

## Statistical analysis

SPSS 21 (IBM Corp., Armonk, NY, USA) package program was used to analyze the data obtained in the study. Differences and normal values between both groups were measured using Student's t-test. Numerical data were expressed as mean (SD) and categorical data were expressed as percentages. Chi-square test or Fisher's exact test was used in the analysis of categorical data. Values of  $P < 0.05$  were considered statistically significant.

## Results

Among 41 patients included in the study (Group 1,  $n=23$  and Group 2,  $n=18$ ), 28 were males and 13 were females. Their mean age was 4.69 years, 19 had right elbow fractures, and 22 patients had left elbow fractures. Detailed demographic data of our patients are presented in Table 1.

Lateral condyle fractures of the humerus were more common in males and more fractures occurred in the left extremity. Union occurred insignificantly earlier in the group who underwent parallel K-wire ( $P=0.79$ ). Radiologically, Weiss fracture classification was performed for all LCF patients, and the type of intervention for fractures is presented in Table 2.

Type 2 fractures are the most common ( $n=23$ , 56%), and the least common was type 1 fractures. The radiological complications of our study are given in Table 3.

Table 1: Demographic data of our patient

	Group 1 Fixation with parallel 2 K-wire	Group 2 Fixation with divergent 2 K-wire	P-value
Gender			
Male(%)	15 (53.6)	13 (46.4)	0.066
Female(%)	3 (23.1)	10 (76.9)	
Side			
Right (%)	7 (36.8)	12 (63.2)	0.298
Left(%)	11(50)	11(50)	
Complication developed (%)	5 (41.7)	7 (58.3)	0.566
Average Age (SD)	4.21 (1.9)	5.17 (1.8)	0.004
Radiological union time (weeks) (SD)	5.05 (1.5)	5.34 (0.9)	0.079

SD: Standard deviation

Table 2: Distribution of patients according to the Weiss classification

Weiss Type	Group 1 Fixation with parallel 2 K-wire	Group 2 Fixation with divergent 2 K-wire	Total
Type1	1	3	4
Type 2	10	13	23
Type 3	7	7	14

Table 3: Radiological complication

	Group 1 Fixation with parallel 2 K-wire	Group 2 Fixation with divergent 2 K-wire	Total
Lateral overgrowth (Spur)	3 (16.6%)	4 (17.3%)	7 (17.07%)
Non-union	1(5.5%)	1 (4.3%)	1 (2.4%)
Avascular necrosis	1(5.5%)	1 (4.3%)	2 (4.8%)
Fishtail deformity	0	1 (4.3%)	1 (2.4%)

Three (16.6%) of 18 patients in group 1 had lateral spur, 1 (5.5%) had nonunion and 1 (5.5%) patient had avascular necrosis. In group 2, 4 (17.3%) of 23 patients had lateral spur, 1 (4.3%) had nonunion, 1 (4.3%) developed fishtail deformity and 1 (4.3%) patient had avascular necrosis.

## Discussion

Although conservative treatment is recommended in pediatric humerus LCFs, the course of nondisplaced or minimally displaced fractures cannot be predicted. Later displacement of non-displaced fractures occurs in as many as 11-42%. Determining the fracture fragment by mobilizing the soft tissues in subsequent surgical procedures has been reported to cause necrosis. These are some researchers suggesting closed reduction with percutaneous nailing for minimally displaced fractures [10-12]. In the treatment of these fractures, surgical treatment is preferred in patients with a displacement of more than 2 mm to prevent significant complications such as malunion and nonunion [13]. In our clinic, surgical treatment is performed in all Type 2 and Type 3 fractures based on Weiss classification in pediatric LCFs, while Type 1 fractures are followed up closely for the reasons mentioned above. Weekly radiographic controls are performed, and the parents are informed that fracture displacement may occur. In our study, four patients with nondisplaced fractures (Weiss type 1) who were followed up with a long arm cast were provided surgical treatment in the early period and healed without complications. Three of these patients were fixed with divergent K-wires and 1 was fixed with parallel K-wires. In a study conducted by Pirker et al., displacement developed in the fracture line in 9.8% of the cases treated conservatively with plaster in minimally displaced condyle fractures [14].

After pediatric humerus LCF, complications such as lateral spur formation, nonunion, avascular necrosis of the capitellum, cessation of physis growth or excessive stimulation of physis can be observed [15]. Considering the complications that occurred at the end of our study, the most common was lateral spur in 7 cases. Lateral spur developed in 3 cases in group

1 and in 4 cases in group 2. The etiology of lateral spur formation after humerus lateral condyle fractures in children has not been fully elucidated. However, it has been stated that reasons such as insufficient reduction, physical stimulation of the lateral condyle and periosteal flap caused by the fracture fragment may play a role in the formation of lateral spur after these fractures [16,17].

In their study, Pribaz et al. [18] found that the initial fracture displacement degree was related to the degree of the spur, which did not affect the range of motion of the elbow joint. As a result of the study, we did not perform any additional surgical interventions in our 7 cases of lateral spur in both groups. One of the major complications of lateral humeral condyle fractures in children is avascular necrosis. It has been reported that the protection of the soft tissue in the lateral condyle fragment is important in reducing the possibility of avascular necrosis [19]. Both AVN cases we encountered in our study underwent traditional bonesetter intervention and presented 3 weeks after the fracture. Roye et al. [20] reported that they treated 4 LCF cases without AVN, who presented 8 weeks later. Gaur et al. [21] reported that in a study of 15 patients in which they performed open reduction and internal fixation, a more appropriate reduction was achieved with the Z-plasty they performed in the origin of the extensor communis muscle, and that these patients had almost complete union without AVN. In a study conducted by Shimada et al. [22] on 16 children with LCF, they reported AVN in only one child who had been operated twice before. In our study, the soft tissues of the posterior capitellum were preserved using a lateral approach, and thus the possibility of AVN development was reduced.

In a large-scale review in the literature, it was reported that nonunion is a rare complication in pediatric humeral LCFs and this rate is 1.4%. The absence of callus in the fracture fragment for 8 weeks can be considered nonunion. It has been reported that the most important risk factor for nonunion is type 3 fractures, and this complication has been overcome by fixing the fracture fragment with a threaded screw [23]. Nonunions were detected in 2 of 41 patients included in our study. There were cases of nonunion in 2 patients (4.8%), one in each group of 41 patients in both groups.

There are only a few studies in the literature about the superiority of parallel K-wire and divergent K-wire to one another. Although the clinical significance of joint surface reduction is well known, the ideal pinning technique has not been covered in the literature. Two or three K-wires placed parallelly or divergently were compared in terms of union and functional results in 2 previous studies on this subject [24, 25]. Bloom et al. proposed that 2 K-wires sent divergently at an angle of 60 degrees constitute the most effective method of fixation. In addition, in this biomechanical study, they reported loss of reduction in the fracture line because of the valgus test in fractures treated with 2 parallel K-wires [26]. Blasier [27] defined the potential for reduction loss in the fracture line of parallel 2 K-wire application.

## Limitations

The main limitations of our study include its retrospective nature and that the elbow joint range of motion was not measured. However, since our study was based on

radiological results, functional results were not considered. Failure to evaluate varus and valgus angulations in the elbow joint after LCF can be considered a limitation.

### Conclusion

In our study, no reduction loss was experienced in either method. In this study in which radiological results and complications in the treatment of pediatric LCF with 2 different methods were performed in a tertiary health center, one method was not superior to the other, and satisfactory results were obtained in both. In our clinic, it can be said that there is a tendency towards performing divergent two K-wires, at about 60 degrees to each other. Regardless of the treatment method, it is important to define the fracture well, to ensure fixation with percutaneous methods surgically, and to protect the posterior structures in incisions to be made. Avascular necrosis rates are high in the treatment of type 3 fractures, and strict follow-up, as well as informing the parents about these fractures are extremely important.

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