ORIGINAL ARTICLE

Comparison of outcomes of open reduction and internal fixation versus closed reduction and percutaneous pinning in Song type 4-5 pediatric lateral condyle fractures

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ABSTRACT

BACKGROUND: Lateral condyle fractures are the second most common peri-elbow fractures in children aged 6-10 years, following supracondylar fractures. In treating these fractures, either open or closed reduction fixation can be performed. However, it is not yet completely clear which type of fracture should be treated and how. The Song classification has been increasingly used by orthopedic surgeons for these fractures in recent years. A review of the literature reveals few studies comparing closed reduction and percutaneous pinning (CRPP) and open reduction and internal fixation (ORIF) in lateral condyle fractures (LCFs) with displacements of 2 mm or more. Based on this, we compared Song stage 4 and 5 fractures operated with open or closed reduction methods in our clinic in terms of radiological and clinical aspects.

METHODS: Patients who underwent surgery in our clinic for Song type 4 and 5 lateral condyle fractures between 2011 and 2016 were included in the study. After obtaining approval from our ethics committee (ID: 0017137911 7), we retrospectively evaluated the medical records of the patients. Between 2011 and 2016, 213 patients underwent surgery for LCF in our hospital, 24 patients were lost to follow-up, and 78 patients had other types of Song fractures. Our study evaluated 111 patients, who were divided into two groups: the CRPP group and the ORIF group.

RESULTS: A total of 111 patients were included in our study, with 52 undergoing CRPP and 59 undergoing ORIF. There was no difference between the groups in terms of age, gender, side of injury, mechanism of trauma, and follow-up time (p=0.962, p=0.198, p=0.706, p=0.526, p=1.000, p=0.708, respectively). There was also no significant difference in the displacement amounts between the patients (p=0.233). In the postoperative radiological comparison, a lateral spur was observed in 12 patients (23%) in the CRPP group and 28 patients (47.5%) in the ORIF group. Hardacre's criteria were evaluated as excellent in 46 (88.4%) of the patients who underwent CRPP and 50 (84.7%) of the patients who underwent ORIF. No significant result was found between both groups (p=0.769). There was no difference in complications between the groups (p=1.000).

CONCLUSION: This study demonstrates that in pediatric patients with lateral condyle fractures displaced by 2 mm or more, the choice between open or closed reduction has minimal impact on medium and long-term outcomes. Since there are not many studies on this subject in the literature, we believe that our results will provide valuable guidance for treatment decisions.

Keywords: Lateral condyle fracture; open reduction; closed reduction; song classification.

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INTRODUCTION

Lateral condyle fractures (LCF) rank as the second most common elbow fractures in children, following supracondylar humerus fractures, and are the most common type of intra-articular fractures.[1] LCFs frequently occur between the ages of 6 and 10.[2] Major complications include avascular necrosis, nonunion, elbow stiffness, elbow deformity, and overgrowth of the lateral condyle.[3] Although the Milch classification is commonly utilized, it falls short in determining the appropriate treatment.[4,5] The Song classification, introduced in 2008, has become more frequently used in medical literature.[6] This classification is more comprehensive than others and provides greater guidance in treatment planning and prognosis determination.[7]

Generally, LCFs displaced more than 2 mm are treated with open reduction and internal fixation (ORIF) to ensure anatomical reduction of the intra-articular fracture.[8] However, for reasons such as less soft tissue dissection, shorter surgery duration, and avoidance of unesthetic wound incisions, some authors have recommended closed reduction and percutaneous pinning (CRPP) in fractures with a displacement of more than 2 mm.[9] Song defined a new classification in 2008 and treated patients with a total displacement of 4 mm or more with CRPP, reporting good results.[7,10]

When reviewing the literature, we recognize that there are few studies comparing CRPP and ORIF in LCFs with a displacement of 2 mm or more.[11] Based on this, we hypothesized that the CRPP method would yield similar or better results compared to the ORIF method in Song 4 and 5 lateral condyle fractures. Therefore, we planned our study to compare the radiologic and clinical results of these two methods.

MATERIALS AND METHODS

Patients included in the study were those operated on by our clinic for Song type 4 and 5 lateral condyle fractures between 2011 and 2016. After obtaining ethics committee approval, the medical records of these patients were evaluated retrospectively. (Date: August, 2022; Number: 00171379117). The study was conducted in accordance with the principles of human experimentation as defined in the Declaration of Helsinki. Informed consent was obtained from all parents of the individuals before surgery.

Inclusion criteria included being younger than 11 years of age, undergoing surgery within the first 24 hours after injury, and having no previous or concurrent injury to the same elbow. Patients with systemic bone disease, open fractures, and trauma-related neurovascular injury were excluded from the study.

Patients with a follow-up period of less than 6 years and Song type 1, 2, or 3 fractures were also excluded. Preoperative internal oblique radiographs were taken for all patients, and the amount of displacement was measured and recorded.[10]

The surgeries were performed by four different experienced orthopedic specialists (MD). Another experienced orthopedic specialist who was not involved in the surgical procedure performed radiologic measurements and all clinical assessments (Fig. 1).

Between 2011 and 2016, 213 patients underwent surgery for LCF at our hospital. Of these, 24 patients were lost to follow-up, and 78 were diagnosed with other types of Song. Our study focused on 111 patients, who were divided into two groups: the CRPP group and the ORIF group. The choice between open or closed reduction was at the discretion of the surgical team. After the patients presenting to our emergency department were diagnosed, a neurovascular examination was performed and documented.

Surgical Technique and Post-operative Follow-up

All patients were operated on within 24 hours of admission to the hospital. All surgeries were performed with the patient in the supine position, and C-arm scopy was utilized throughout the procedure. A tourniquet was applied to each patient but was only inflated if closed reduction could not be achieved. Closed reduction was attempted in all cases. If unsuccessful, the procedure continued with open reduction (Figures 2 and 3). For patients requiring open reduction, the reduction was achieved via a lateral incision, followed by percutaneous pinning performed laterally (Fig. 4). Post-operatively, a long arm splint was applied to the extremity in 80-90° flexion, and patients were maintained in the splint for four weeks. The follow-up appointments were scheduled as follows: the

Figure 1. Measurement of displacement on internal oblique radiograph.

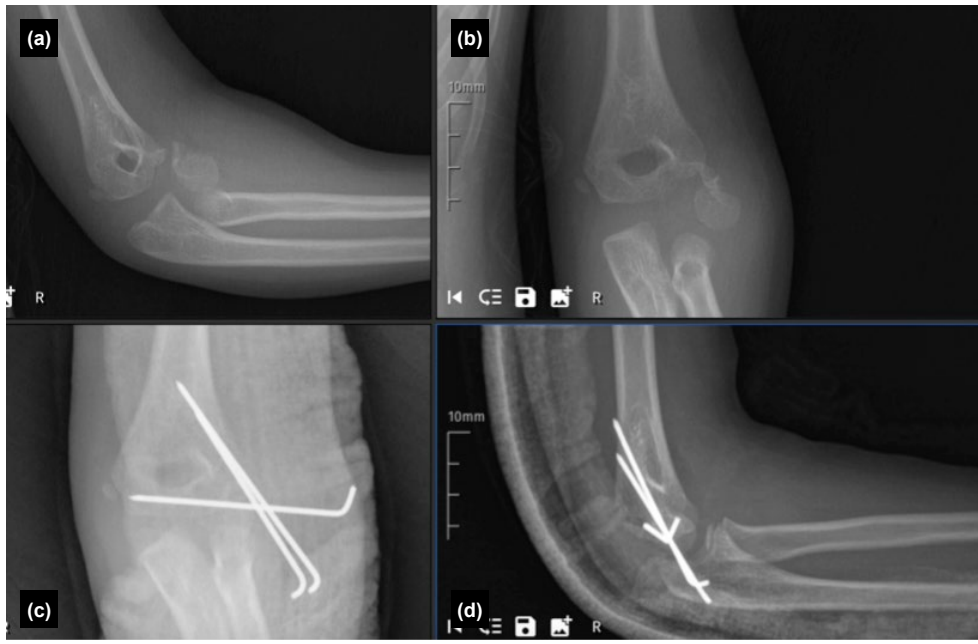

Figure 2. Treatment of Song type 5 lateral condyle fracture with CRPP. **(a,b)** Radiographs at the time of initial presentation **(c,d)** Early postoperative radiographs.

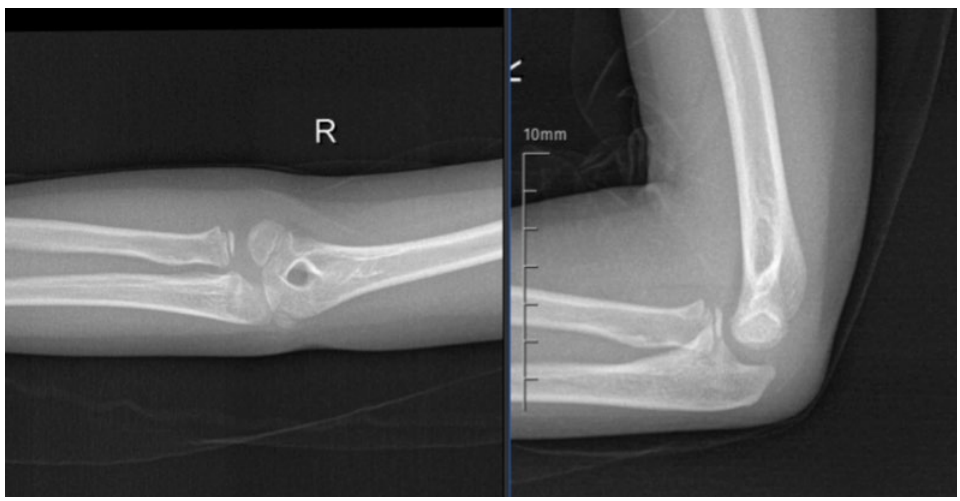

Figure 3. Post operative 2nd year ap and lateral images of the same patient.

first at 10 days post-surgery, the second at four weeks, and the third at six weeks. At the four-week mark, the splint was removed, and elbow range of motion (ROM) exercises were initiated. Patients returned for a follow-up check at six weeks. If callus formation was observed on the X-ray, the pins were removed, and ROM exercises continued. In cases where the appropriate range of motion could not be achieved, patients were referred to the physical therapy clinic, and rehabilitation was carried out under the supervision of a physiotherapist.[12]

Subsequently, patients were scheduled for check-ups every three to four months during the first year.

All patients were evaluated based on age, gender, Song and Milch classification, presence of a lateral spur, fishtail deformity, cubitus varus, cubitus valgus, amount of displacement, ulnohumeral angle, and Hardacre criteria.[1,2] Postoperative complications were also compared between groups. The first and last postoperative X-rays of the patients were assessed by a single author. Elbow joint functions were clinically evaluated using the Hardacre criteria, which categorize outcomes into three groups: poor, good, and excellent. According to these criteria, an excellent result is defined by full range of motion, a normal carrying angle, absence of symptoms, and complete well-being, while a good outcome is characterized by a slight decrease in range of motion, less than 15 degrees loss of extension, and an indeterminate deformity.[2]

Statistical Analysis

Statistical analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics for Windows,

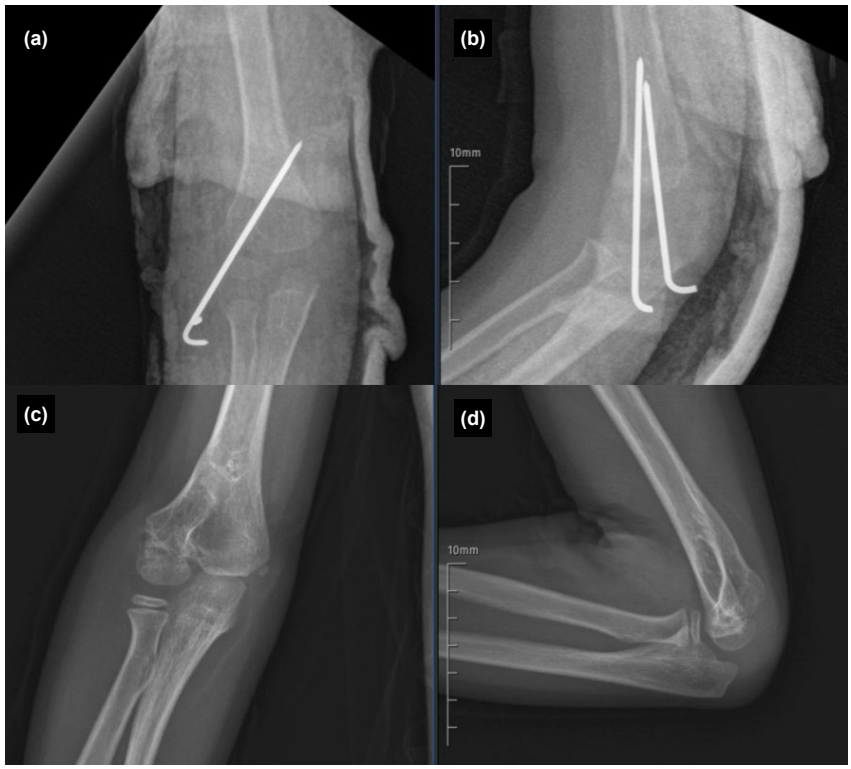

Figure 4. Treatment of Song type 5 lateral condyle fracture with CRPP. **(a,b)** Radiographs at the time of initial presentation **(c,d)** Early postoperative radiographs.

version 25.0 (IBM Corp., Armonk, NY, USA), and MedCalc Statistical Software, version 15.8 (MedCalc Software bvba, Ostend, Belgium). For quantitative data, independent samples t-tests were used, incorporating bootstrap results. The Mann-Whitney U test, with Monte Carlo simulation, was applied for comparing two independent groups. Categorical variables are presented as numbers with 95% confidence intervals (CIs). A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 111 patients were included in our study, with 52 treated using CRPP and 59 treated using ORIF. Radiologically successful union was achieved in all patients. There was no difference between the groups in terms of age, gender, side, trauma mechanism, and follow-up period (p=0.962, p=0.198, p=0.706, p=0.526, p=1.000, p=0.708, respectively) (Table 1).

Additionally, there was no significant difference in the amount of displacement between the patients (p=0.233). In the postoperative radiological comparison, a lateral spur was observed in 12 patients (23%) who underwent CRPP and in 28 patients (47.5%) who underwent ORIF. There was a statistically significant difference between the two groups (p=0.013), with the lateral spur being more common in patients who underwent open surgery. No significant difference was observed in the frequency of fishtail deformity or angular deformity between the groups (p=0.059 and p=0.160, respectively). The mean ulnohumeral angle was 10.73±4.02 in the CRPP group and 11.65±5.27 in the ORIF group (p=0.307). According to the Hardacre criteria, 46 patients (88.4%) in the CRPP group and 50 patients (84.7%) in the ORIF group achieved excellent results (Table 2), with no significant difference between the groups (p=0.769). Regarding Song classification, 71 patients (64%) were classified as stage 4, while 40 patients (36%) were classified as stage 5. No clinical difference was detected between patients with Song stage 4 and stage 5 (p=0.956).

Table 1. Preoperative patient demographics

	CRPP (n=52)	ORIF (n=59)	p
Age	5.07±2.2	5.09±2.4	0.962
Gender			
Female	22 (42.3%)	17 (28.8%)	0.198
Male	30 (57.6%)	42 (71.1%)	
Injured Side			
Left	35 (63.6%)	44 (72.5%)	0.526
Right	17 (36.4%)	15 (27.5%)	
Follow-up Period (months)	115.8±23.1	114.25±19.8	0.708
Milch Classification			
Type I	17 (32.6%)	10 (17%)	0.088
Type II	35 (67.3%)	49 (83%)	
Song Classification			
Type IV	32 (61.5%)	38 (64.4%)	0.083
Type V	20 (38.5%)	21 (35.6%)	

Table 2. Radiologic and clinical outcomes

	CRPP (n=52)	ORIF (n=59)	p
Postoperative Complications*			
No	51 (98.1%)	57 (96.7%)	1.000
Yes	1 (1.9%)	2 (3.3%)	
Lateral Spur			
No	40 (77%)	31 (52.5%)	0.013
Yes	12 (23%)	28 (47.5%)	
Fishtail Deformity			
No	52 (100%)	54 (91.5%)	0.059
Yes	0 (0%)	5 (8.5%)	
Deformity			
Varus	48 (92.3%)	48 (81.3%)	0.160
Valgus	4 (7.7%)	11 (18.7%)	
Hardacre Criteria			
Excellent	46 (88.4%)	50 (84.7%)	0.769
Good	6 (11.6%)	9 (15.3%)	
Displacement (mm)	3.19±0.93	3.44±1.19	0.233
Ulnohumeral Angle (mm)	10.73±4.02	11.65±5.27	0.307

*Complications include infection, avascular necrosis, nonunion, and premature physeal closure.

The mean operative time was 68.9 minutes for the CRPP group and 116.1 minutes for the ORIF group. There was a statistically significant difference between the two operative times (p=0.000).

Postoperative complications, including infection, avascular necrosis, nonunion, and premature physeal closure, were analyzed. Pin site infections developed in two patients who underwent ORIF and in one patient who underwent CRPP; all were managed with oral antibiotics. There was no difference in the incidence of complications between the groups (p=1.000).

In evaluating cubitus varus and valgus, valgus deformity was observed in 4 patients (7.7%) in the CRPP group and in 11 patients (18.7%) in the ORIF group. No cases of cubitus varus were observed (p=0.160).

Clinically, there was no statistically significant difference between fractures classified as Song stage 4 or 5 or Milch stage type 1 or 2 (p=0.956, p=0.822).

DISCUSSION

The primary aim of our study is to discuss the mid- to long-term outcomes of closed versus open surgery in lateral condyle fractures with displacement greater than 2 mm. Our findings indicate that ORIF is not superior to CRPP. In fact, CRPP offers advantages such as being less invasive, avoiding scarring, and reducing anesthesia time.[4] Lateral condyle fractures in pediatric patients are continually debated topics, concerning whether they require surgery, conservative follow-up, open reduction, or closed reduction. There is no consensus in the literature. Achieving anatomical restoration of the joint surface is the primary goal in surgical treatment, a goal universally accepted.[3,4]

Our study adds to the ongoing discussion about the most appropriate surgical approach for treating lateral condyle fractures in pediatric patients. There are studies suggesting that the Milch classification is inadequate for surgical decision-making and that intraoperative radiological findings often do not align with preoperative expectations.[5] Given the limitations of the Milch classification, we assessed our patients using the Song classification.[6] Typically, a review of the literature suggests that conservative follow-up is recommended for Song stage 1 and 2 fractures, while CRPP is the preferred treatment method for stage 3 fractures. While both closed and open reductions are viable for stage 4 fractures, open reduction is advocated for stage 5 fractures.[7,8] In our clinic, we operate on stage 4 and 5 fractures while adopting a conservative approach for patients with stage 1, 2, and 3 fractures.

The rate of complications following surgical treatment of lateral condyle fractures is high. Major complications include overgrowth of the lateral condyle, surgical site infection, discharge at the pin tract, development of cubitus varus or valgus, fishtail deformity, and nonunion. A delayed union or nonunion of a fracture is defined as a fracture that has not completely healed after three to nine months. Nonunion is frequently linked to poor functional outcomes in patients and a high need for additional surgery.[13,14] Although existing studies report a nonunion rate of approximately 5% in patients treated with Kirschner wires (K-wires), our study observed no cases of nonunion in either group.[15] We attribute this to the fact that all patients underwent surgery within the first 24 hours.

In our study, similar to the literature, we found that the most common complication was the development of lateral spurs.[16] Among all patients we operated on, 36% developed lateral spurs. The incidence of lateral spurs was significantly higher in patients who underwent open surgery (p=0.013). Although it was the most common complication, we observed during follow-up that there was no need for surgical intervention as it did not cause clinical functional limitations. Similarly, Pribaz et al. also reported in their study that this complication did not impact functional outcomes.[17]

Fishtail deformity, which can occur in all distal humerus fractures, is a rare complication. This complication may arise during both surgical treatment and conservative follow-up of the fracture.[18] Glotzbecker et al. reported that most of the 15 patients who presented with fishtail deformity experienced limitations in movement and pain. They reported that clinical outcomes were poor in patients with radial head dislocation

and that surgical correction was necessary.[19] Conversely, another study reported that this deformity did not cause any clinical or functional limitations.[20] Another article mentioned that while fishtail deformity does not pose a problem in the early period, it may lead to early arthrosis in the long term.[21] In our study, we observed fishtail deformity in 5 (4.5%) of our patients, all of whom were in the open surgery group. Although not statistically significant, we believe the higher incidence in the open surgery group is due to open surgery potentially causing avascular necrosis by disrupting the blood supply. According to the Hardacre criteria, four of these patients were evaluated as excellent and one as good. Clinically, we noted that they did not experience any significant loss of function and did not require surgical treatment.

When evaluating the carrying angles of the patients, we noticed that the averages were close to each other and there was no significant difference between the two groups (p=0.307). When evaluating the literature on this subject, we observe similar results.[22]

The preoperative displacement amounts of our patients were similar, and while 46 (88.4%) of the patients who underwent CRPP had excellent results, 50 (84.7%) of the patients operated on by open reduction had excellent results and 9 (15.3%) had good results. No significant differences were found in terms of displacement or deformity between these patient groups (p=0.233, p=0.160).

Our study had some limitations. The main limitations were that this study was not a prospective randomized trial, the number of individuals included was relatively small, and the surgeries were performed by different surgeons. However, one of our study's shortcomings in terms of patient standardization is that we initially tried closed reduction on the patients and initiated open reduction when it failed. Multicenter randomized controlled studies are needed to reach more definitive results.

CONCLUSION

The findings underscore the importance of anatomical restoration in determining treatment options. According to the results of our study, we should always consider the possibility of increased complications following open reduction in these patient groups.

Given that there is no clinical or radiological difference between the patients who underwent CRPP and those in the ORIF group, and considering the higher incidence of complications in the ORIF group, CRPP treatment appears to be more advantageous. Reflecting on the literature, the number of studies applying CRPP to Song stage 4 and 5 fractures is limited, and patient follow-up periods are generally short. We believe our findings will contribute to the literature on this subject.

Ethics Committee Approval: This study was approved by the Umraniye Training and Research Hospital Ethics Committee (Date: 11.08.2022, Decision No: 249).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: S.K.Ç.; Design: M.E.K.; Supervision: S.K.Ç., A.Ş.; Resource: F.B., S.B.; Materials: F.B., M.E.K.; Data collection and/or processing: A.Ş.; Analysis and/or interpretation: M.E.K.; Literature search: S.K.Ç., M.E.K.; Writing: M.E.K.; Critical reviews: F.B., S.B.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Song tip 4-5 pediatrik lateral kondil kırıklarında açık redüksiyon ve internal fiksasyon ile kapalı redüksiyon ve perkütan pinleme sonuçlarının karşılaştırılması

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AMAÇ: Lateral kondil kırıkları özellikle 6-10 yaş arası çocuklarda suprakondiler kırıklardan sonra en sık görülen dirsek çevresi kırıklardır. Bu kırıkların tedavisinde açık ya da kapalı redüksiyonla tespit yapılabilmektedir. Hangi kırık tipinin nasıl tedavi edileceği henüz tam olarak netlik kazanmamıştır. Ortopedik cerrahlar tarafından Song sınıflaması son yıllarda bu kırıklar için daha sık kullanılmaya başlanmıştır. Literatürü incelediğimizde 2 mm ve üzeri deplasmanı olan LKK'lerde KRPP ve ARİF'i karşılaştıran az sayıda çalışma olduğunu görüyoruz.Buradan yola çıkarak kliniğimizde açık veya kapalı redüksiyon yöntemleriyle ameliyat edilen Song evre 4,5 kırıklarını radyolojik ve klinik açıdan karşılaştırdık.

GEREÇ VE YÖNTEM: Çalışmaya 2011-2016 yılları arasında Song tip 4,5 lateral kondil kırığı nedeniyle kliniğimiz tarafından ameliyat edilen hastalar dahil edildi. Etik kurul onayı alındıktan sonra hastaların tıbbi kayıtları retrospektif olarak değerlendirildi (ID: 001713791 17). Hastanemizde 2011-2016 yılları arasında 213 hasta LKK nedeniyle ameliyat edilmiş, 24 hasta takip dışı bırakılmış ve 78 hasta diğer Song tiplerine sahip hastalardan oluşmuştur. Çalışmamız 111 hasta üzerinde değerlendirildi ve hastalar 2 gruba ayrıldı: KRPP ve ARİF grubu.

BULGULAR: Çalışmaya toplam 111 hasta alındı, 52 hastaya KRPP ve 59 hastaya ARİF uygulandı. Gruplar arasında yaş, cinsiyet, taraf, travma mekanizması ve takip süresi açısından fark yoktu (sırasıyla, p=0.962, p=0.198, p=0.706, p=0.526, p=1.000, p=0.708). Hastaların deplasman miktarları arasında anlamlı bir fark yoktu (p=0.233). Ameliyat sonrası radyolojik karşılaştırmada, KRPP uygulanan 12 hastada (%23) ve ARİF uygulanan 28 hastada (%47.5) lateral spur gözlendi. Hardacre kriterleri KRPP uygulanan hastaların 46'sında (%88.4) ve ARİF uygulanan hastaların 50'sinde (%84.7) mükemmel olarak değerlendirildi. Her iki grup arasında anlamlı bir sonuç bulunmadı (p=0.769). Gruplar arasında komplikasyon açısından fark yoktu (p=1.000).

SONUÇ: Çalışma bize deplasmanı 2 mm ve üzerinde olan çocuk hastalarda açık ya da kapalı redüksiyon yapılmasının orta ve uzun dönemde pek fark olmadığını sunmaktadır. Literatürde bu konuda çok fazla çalışma bulunmaması nedeniyle sonuçlarımızın tedaviyi yönlendirmede etkili olacağı kanaatindeyiz.

Anahtar sözcükler: Açık redüksiyon; kapalı redüksiyon; lateral kondil kırığı; Song sınıflandırması.

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