



Closed reduction and percutaneous pinning with three Kirschner wires in children with type III displaced supracondylar fractures of the humerus

Çocuklarda deplase suprakondiler humerus kırıklarında kapalı redüksiyon ve üç adet Kirschner teli ile perkütan çivileme

Levent KARAPINAR,¹ Hasan OZTURK,¹ Taskin ALTAY,¹ Bayram KOSE²

¹İzmir Tepecik Teaching Hospital, Department of Orthopedics and Traumatology; ²Turkish Airforce Academy Hospital

Amaç: Çocuklarda deplase suprakondiler humerus kırıklarının tedavisinde kapalı redüksiyon ve perkütan çivileme ile tedavi sonuçları değerlendirildi.

Çalışma planı: Altmış bir çocuk (41 erkek, 20 kız; ort. yaş 7.6; dağılım 2-13) deplase suprakondiler tip III humerus kırığı nedeniyle tedavi edildi. Tüm olgulara başvuru anından itibaren ilk altı saat içinde müdahale edildi. Hastaların nörolojik bakımında patoloji saptanmadı. Tüm olgularda kapalı redüksiyondan sonra, lateralden iki, medialden bir olmak üzere üç adet K-teliyle perkütan çivileme uygulandı. Medialdeki çivi dirsek fleksiyonu azaltılarak (80-90°) uygulandı. Ulnar sinir değerlendirmesi ameliyat sonrasında, taburcu olurken, ikinci haftanın sonunda, 3 ve 6. aylarda yapıldı. Son kontrolde her iki dirsekte hareket açıklığı ve taşıma açısı goniometreyle ölçüldü; etkilenen dirseğin ön-arka ve yan radyografileri incelendi. Sonuçlar, Flynn ve ark.nın klinik skorlama sistemine göre değerlendirildi. Hastanede kalma süresi ortalama 3.4 gün (dağılım 1-10) izlem süresi 28.9 ay (dağılım 17-53) idi.

Sonuçlar: Ameliyattan sonra iki olguda (%3.3) iyatrojenik ulnar sinir hasarı saptandı. Her iki olguda da üç ay içinde klinik olarak tam düzelmeye görüldü. Tüm kırıklar kaynadı. Dört olguda (%6.6) yüzeysel çivi yolu enfeksiyonu, bir olguda (%1.6) kubitus varus, bir olguda miyositis ossifikans görüldü. Derin enfeksiyon ve kompartman sendromu görülmedi. Tedavi sonuçları 49 hastada (%80.3) mükemmel, yedisinde (%11.5) iyi, ikisinde (%3.3) orta, üçünde (%5) kötü olarak değerlendirildi.

Çıkarımlar: Tip III deplase suprakondiler humerus kırıklarının tedavisinde üç adet K-teliyle uygulanan kapalı redüksiyon ve perkütan çivileme başarısı yüksek, komplikasyonları en az olan etkin ve güvenli bir yöntemdir.

Anahtar sözcükler: Kemik teli; çocuk; kırık fiksasyonu, internal/yöntem; humerus kırığı/televizyon/radyografi; ulnar sinir/yaralanma.

Objectives: We evaluated the results of closed reduction and percutaneous pinning in the treatment of displaced supracondylar fractures of the humerus in children.

Methods: Sixty-one children (41 boys, 20 girls; mean age 7.6 years; range 2 to 13 years) were treated for type III displaced supracondylar fractures of the humerus within the first six hours after trauma. Initial neurologic examinations were normal. Treatment included closed reduction followed by percutaneous pinning with two lateral and one medial K-wires, the last being placed during decreased (80 to 90 degrees) elbow flexion. The ulnar nerve was examined intraoperatively, at the time of discharge, at the end of two weeks, and in the third and six months. On final examinations, the range of motion and carrying angles of both elbows were measured with a goniometer and anteroposterior and lateral radiograms of the affected elbows were examined. The results were evaluated using the clinical scoring system developed by Flynn et al. The mean hospital stay was 3.4 days (range 1 to 10 days) and the mean follow-up was 28.9 months (range 17 to 53 months).

Results: Iatrogenic ulnar nerve injury occurred in two patients (3.3%), which showed complete clinical improvement in three months. Union was achieved in all the patients. Superficial pin tract infections were seen in four patients (6.6%); and cubitus varus (1.6%) and myositis ossificans in two patients, respectively. Deep infection or compartment syndrome were not encountered. The results were excellent in 49 (80.3%), good in seven (11.5%), fair in two (3.3%), and poor in three patients (5%).

Conclusion: Closed reduction and percutaneous pinning with three K-wires is an efficacious and safe procedure with a low complication rate in the treatment of type III displaced supracondylar fractures of the humerus.

Key words: Bone wires; child; fracture fixation, internal/methods; humeral fractures/therapy/radiography; ulnar nerve/injuries.

Supracondylar fracture of the humerus is the most common injury of the elbow in children,^[1-8] which results in apparent morbidity due to malunion, neurovascular injury and compartment syndrome.^[1,3,5,6,9,10] Stable fractures can be usually treated with closed reduction and cast. Percutaneous pin fixation is used in order to maintain the closed reduction of the type II and type III unstable fractures.^[6-7] Closed reduction and percutaneous pinning (CRPP) became the first line choice for the treatment of displaced supracondylar fractures of the humerus.^[2,3,11-13] Success was reported by several studies using the CRPP method with cross Kirschner wires (K-wire).^[11-13] Among those studies, there exists no prospective randomized clinical trial demonstrating that the fixation by cross K-wire is clinically the most stable method. However, cadaver and animal models have shown that cross K-wires are superior in terms of biomechanics.^[14,15] Placement of the medial K-wire while using the cross K-wire carry a risk for iatrogenic ulnar nerve injury.^[13,16,17] Successful results were obtained by CRPP method using two or three wires from the lateral side of the elbow in order to avoid such injury.^[18-21] It was indicated that the ulnar nerve slid away from the ulnar channel toward the anterior when the elbow is at hyperflexion in 6-18% of the children.^[22] Iatrogenic ulnar nerve injury can be prevented by maintaining the elbow flexion under 90 degrees in children with ulnar nerve hypermobility.

The present study aimed to achieve an effective and reliable fixation, avoiding any potential complications by decreasing the robust elbow flexion after placing two K-wires from the lateral side and before inserting the medial K-wire.

Patients and method

Sixty-one children (41 boys, 20 girls; mean age 7.6 years; range 2 to 13 years) were treated between October 1998 and October 2001 for type III displaced supracondylar fracture of the humerus. Of fractures, 44 were on the left and 17 on the right sides; 59 had extension (35 displaced to posterolateral, 24 to posteromedial), and two had distal flexion with diaphyseal involvement. All patients underwent closed reduction under scopy control followed by percutaneous pinning via three K-wires, two from the lateral and one from the medial sides.

Surgical technique

Medial or lateral displacement of the distal part was fixed with respect to the shaft of the humerus following the traction under general anesthesia and scopy control. Then, reduction was achieved by the thumb-pressing the olecranon when the elbow was at 120° flexion and the forearm at pronation. The reduction was confirmed using fluoroscopy by antero-posterior and lateral radiographs. The new moon image at the lateral scopy and also antero-posterior status of the distal part at the Jones position were evaluated. After stable anatomic reduction was achieved, firstly two lateral K-wires engaged to the medial cortex were inserted passing through the lateral epicondyle, using the C-arm fluoroscopy sheltered by sterile covers when the elbow was at robust flexion and the forearm at pronation. The position of the Kirschner wires was controlled by anteroposterior and lateral radiographs under scopy. As excessive elbow flexion causes the ulnar nerve to displace toward the pathway of the medial K-wire, the medial K-wire was advanced without any incision over the medial epicondyle, not passing through the ulnar channel after the elbow was flexed at 80-90°, and placed as engaged to the lateral cortex. Robust flexion was not required since the lateral K-wire achieved efficient stability. Reduction and position of the K-wires were rechecked by scopy. Kirschner wires were bent and left out of the skin to remove three weeks later. Long-arm splint was placed when the elbow was at 90° flexion and forearm at supination.

At early postoperative period, clinical neurological evaluations were carried out during discharge, and at end of week 2, and months 3 and 6. Cases with iatrogenic ulnar nerve lesion were followed up without any treatment. Splint was removed at the end of the week two, and the arm was suspended from the neck; and active elbow motions were initiated. K-wires were removed at postoperative week 3-4 without anesthesia following the healing of the fracture. At final examination, range of motion at the elbow and its carrying angle were assessed by goniometer at both elbows; anteroposterior and lateral radiographs of the affected elbows were taken (Figure 1, 2, 3).

The functional and esthetic assessment of the cases was based on the Flynn criteria (Table 1).^[23]

Table 1. The Flynn Criteria

Outcome	Esthetic	Functional
	Loss of carrying angle (°)	Loss of motion range (°)
Excellent	0-5	0-5
Good	6-10	6-10
Moderate	11-15	11-15
Poor	>15	>15

Mean follow-up period was 28.9±11.3 months (range 17 to 53 months).

Results

No pathology was found in the preoperative neurological evaluation of 61 cases. All patients were intervened within the first six hours upon admit-

tance. Mean hospital stay was 3.4±1.9 days (range 1 to 10 days).

Two patients (3.3%) had iatrogenic ulnar nerve lesion after the operation. Both cases had complete clinical recovery within three months. All fractures were united. None of the patients had complaint for pain at the elbow. Four patients (6.6%) had superficial pin tract infection, one (1.6%) had cubitus varus, and another had myositis ossificans. No deep infection and compartment syndrome were observed.

The results were excellent in forty-nine (80.3%), good in seven (11.5%), moderate (3.3%) in two, and poor (5%) in three patients according to the Flynn criteria. As poor results, two patients had 20° limited extension and one had 12° cubitus varus. The result was satisfactory in fifty-eight cases (95%).



Figure 1. Supracondylar fracture of the right humerus in a ten-year old boy. Preoperative (a) anteroposterior, and (b) lateral; and postoperative (c) anteroposterior, and (d) lateral; and (e) anteroposterior, and (f) lateral radiographs at the postoperative month 31.

Discussion

Closed reduction and percutaneous pinning is the most widely used method in the treatment of supracondylar fractures of the humerus in children.^[2,3,11-13] However, the configuration of the most convenient K-wire to be used after the closed reduction is controversial.^[11-21] The disadvantages of closed reduction and percutaneous pinning include risk for iatrogenic ulnar nerve injury during the fixation of the medial K-wire, potential pin tract infection, and loss of reduction leading to cubitus varus, cubitus valgus or hyperextension deformity.^[2,3,13,24] Therefore, the most convenient configuration for K-wire should provide a stability that can maintain the fracture reduction until sufficient union is achieved; and eliminate the risk for

neurovascular injury.^[2,4]

The fixation techniques of the K-wires in the CRPP method for supracondylar fractures in children have been compared by biomechanical and retrospective studies; however, there is no prospective and randomized study comparing these techniques. Olcay et al.^[25] compared the fixation techniques used in the supracondylar fractures of the humerus anatomically and biomechanically by using the torsional strength in an adult cadaver model; and found out that the most severe resistance against the rotation strengths was obtained by fixation via a third cross K-wire from the medial in addition to the two K-wires parallel from the lateral side; while the least resistance was through the fixation with two K-wires from the lat-



Figure 2. Supracondylar fracture of the left humerus in a two-year old boy. Preoperative (a) anteroposterior, and (b) lateral; postoperative (c) anteroposterior, and (d) lateral; and (e) anteroposterior, and (f) lateral radiographs at the postoperative month 24.

eral side; and finally the fixation with a cross K-wire each from the medial and lateral sides was less resistant than the fixation with three K-wires.

Herzenberg et al.^[15] have shown that the best outcome was obtained in cases with cross fixations both from the medial and lateral sides among all rigid fixations they implemented during the trials for the supracondylar fracture of the humerus in a dog model. In a study with 35 cases, Eralp et al.^[26] reported that the three K-wire configuration provided a more stable osteosynthesis and didn't lead to any additional morbidity in the closed percutaneous osteosynthesis of the displaced supracondylar fractures in children.

Cross K-wire fixation requires medial K-wire fixation after placing one or two K-wire from the lateral side, which, in turn, may lead to iatrogenic

injury of the ulnar nerve.^[13,16,17] Several methods have been tested in order to eliminate the risk for nerve injury.^[18-21,27,28] Wind et al.^[28] suggested to stimulate the nerve either by a small needle before placing the medial K-wire or by the K-wire itself before placing the K-wire in order to see if the K-wire touches the ulnar nerve and to determine the location of the ulnar nerve; and they proposed that this method can minimize the nerve injury.

Lee et al.^[24] reported that not parallel, but divergently placed K-wires from the lateral side provided sufficient stability to avoid ulnar nerve lesions in a biomechanical study they carried out with an artificial bone model of the children; however they indicated that it had a lower stability against the axial rotational strengths compared to the cross K-wires placed from the medial and lateral sides.



Figure 3. Supracondylar fracture of the left humerus in a nine-year old girl. Preoperative (a) anteroposterior, and (b) lateral; postoperative (c) anteroposterior, and (d) lateral; anteroposterior and lateral radiographs at the postoperative month 35.

Fixation should be stable enough in order to prevent any rotational deformity that may lead to cubitus varus.^[29]

In a previous study carried out in our clinic, iatrogenic ulnar nerve injury was observed in 27 of 258 patients (11%) who underwent CRPP with K-wire insertion from the medial when the elbow was at hyperflexion.^[13] In this study, iatrogenic ulnar nerve injury was observed in 61 patients after two K-wires were placed from the lateral side, and in two patients when medial K-wire was inserted by decreasing the elbow flexion. Although this decrease was important in clinical terms, it was not found significant in accordance with the statistical analysis by Fisher's accuracy test ($p>0.05$). In spite of decreased elbow flexion, iatrogenic ulnar nerve injury may occur. Divergent fixation with two or three K-wires from the lateral side seems to be the most convenient option as it decreases the risk for ulnar nerve injury.^[20,21] According to the Flynn criteria, the clinical results were 95% satisfactory in both studies including 258 cases and 61 cases, and there was no significant difference between them ($p>0.05$).

In cases where ulnar nerve injury occurs when the medial K-wire is fixated by decreasing the elbow flexion after placing two lateral K-wires, removal of the medial K-wire may be an option if the stability of the fracture with two lateral K-wires is well established. However, it may lead to loss in reduction and malunion.^[14,15,24,25] We removed the medial K-wire immediately after the union of the fracture, considering the instability of the fracture and recovery of the iatrogenic ulnar nerve lesions almost all the time in two patients with ulnar nerve lesions.^[16,30] Another option is the insertion of a third pin from the medial for the patients who are considered to be instable during the operation, following the two K-wire fixation from the lateral side.^[31] In conclusion, CRPP with three K-wires is an effective and reliable method with higher success and least complication rates in the treatment of type III displaced fractures.

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