ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Author's translation
Acta Orthop Traumatol Turc 2005;39(3):193-198

Functional results of displaced lateral condyle fractures of the humerus with four-week K-wire fixation in children

Çocuklarda yer değiştirmiş humerus lateral kondil kırıklarında dört haftalık K-teli ile tespit sonuçlarımız

Unal BOZ,[1] Ali Engin ULUSAL,[1] Hakan VURUSKANER,[2] Yavuz AYDINOGLU[1]

Izmir Ataturk Education Hospital,2.Department of Orthopaedics and Traumatology
[2]Dr. Behçet Uz Children Hospetal Department of Orthopaedics and Traumatology

Amaç: Yer değiştirmiş humerus lateral kondil kırıklarının tedavisinde dört haftalık K-teli ile tespitin radyografik ve klinik fonksiyonel sonuçları değerlendirildi.

Çalışma planı: Yer değiştirmiş (>2 mm) humerus lateral kondil kırığı nedeniyle ameliyat edilen 69 çocuk hastanın (19 kız, 50 erkek; ort. yaş 6.1; dağılım 2-12) tedavi sonuçları klinik ve radyografik olarak değerlendirildi. Hastaların hepsi açık redüksiyon ve dört hafta süreyle K-teli ile tespit tekniği kullanılarak tedavi edildi. Kırıklar Milch ve Badelon sınıflamasına, klinik sonuçlar Hardacre ve ark.nın ölçütlerine göre değerlendirildi. İzlem süresi ortalama 39 ay (dağılım 26-89 ay) idi.

Sonuçlar: Hastalarda erken dönemde komplikasyon görülmedi. Geç dönem izlemde, 57 hastada (%82.6) iki dirsekteki taşıma açıları eşit bulundu; 11 hastada (%15.9) taşıma açıları arasında ortalama 5° fark görüldü. Elli dört hastada (%78.3) humeroulnar hareket açıklığı iki dirsekte de aynıydı. On beş hastada (%21.7) ise 5° fark vardı. Otuz üç hastada (%47.8) klinik ve radyografik olarak, yeni ve fazla kemik oluşumuna bağlı humerus lateral kondilde belirginleşme izlendi. Hardacre fonksiyonel değerlendirme ölçütlerine göre 54 hastada (78.3%) çok iyi, 15'inde (21.7%) iyi sonuç elde edildi. Kaynamama sorunuyla karşılaşılmadı.

Çıkarımlar: Yer değiştirmiş humerus lateral kondil kırıklarının tedavisinde açık redüksiyon ve K-teli ile dört haftalık tespitin fonksiyonel iyi sonuçlar elde etmek için yeterli olduğu görüldü.

Anahatar sözcükler: Kemik teli; çocuk; dirsek/yaralanma; kırık fiksasyonu, internal/yöntem; humerus kırığı/cerrahi/radyografi; zaman faktörü.

Objectives: We evaluated the radiographic and clinical functional results of four-week K-wire fixation in the treatment of displaced lateral condyle fractures of the humerus.

Methods: The study included 69 children (19 girls, 50 boys; mean age 6.1 years; range 2 to 12 years) with displaced (>2 mm) lateral condyle fractures of the humerus. All the patients were treated by open reduction and internal fixation with two K-wires for four weeks. The fractures were classified according to the criteria by Milch and Badelon and functional results were evaluated according to the criteria by Hardacre et al. The mean follow-up period was 39 months (range 26 to 89 months).

Results: No complications were seen in the early follow-up period. On final evaluations, the carrying angles of both elbows were equal in 57 patients (82.6%), with a mean difference of 5 degrees in 11 patients (15.9%). The range of motion of the humeroulnar joint on the affected side differed from that on the contralateral side in only 15 patients (21.7%) with a mean of 5 degrees. Radiographic evaluations showed overgrowth of the lateral condyle and new bone formation over the condyle in 33 patients (47.8%). Functional results were excellent in 54 patients (78.3%) and good in 15 patients (21.7%). Nonunion did not occur.

Conclusion: Treatment of displaced lateral condyle fractures of the humerus with open reduction and f o u r-week K-wire fixation proved to be efficient to achieve satisfactory functional results.

Key words: Bone wires; child; elbow/injuries; fracture fixation, internal/methods; humeral fractures/surgery/radiography; time factors.

Correspondence to: Dr. Unal Boz. 1359 Sok. No: 6/11, Kızılkanat Sağlık Sitesi, C Blok, 35220 Alsancak, İzmir.
Phone: +90232 - 463 44 57 Fax: +90232 - 421 61 01 e-mail: unalboz@yahoo.com

Received: 28.10.2004 **Accepted:** 18.01.2005

Lateral condyle fractures of the humerus account for 12% of the pediatric elbow fractures. Majority of them are injuries of growth plate with a Salter-Harris IV fracture pattern; and they are common in children between 2-14 years of age. These fractures may occur when a varus force is applied to the extended elbow. The fracture line extends toward the elbow joint, through the distal growth plate of the humerus. Various treatment methods are recommended according to the degree of displacement. Immobilization in a cast and weekly controls by graphs are common in the treatment of non-displaced fractures or for those which are displaced for less than 2 mm. The objective in the displaced fractures is to obtain and maintain the continuity of the growth plate and joint surface, which requires open reduction and fixation with K-wire in order to achieve it.[1-6] Misunion or malunion is common in patients who were untreated or failed to be treated, which may result in deformity in the elbow, loss of motion, degenerative arthrosis, and late ulnar neuritis.[7-11]

Several studies suggested immobilization of the elbow and fixation with K-wires for an average period of 6-8 weeks following the open reduction of the displaced fractures.[1-4] In our treatment protocol, the period for immobilization in a long-arm circular cast was three weeks, immediately followed by motion of joints and maintaining the fixation with K-wires for another week. In the present study, efficacy of a four-week K-wire fixation was evaluated in the treatment of displaced lateral condyle fractures of the humerus.

Patients and method

Eighty five patients were treated by open reduction and internal fixation in our clinic between 1995 and 2000 for lateral humeral condyle fractures. Of these patients, 69 patients (19 girls and 50 boys; mean age 6.1 years; range from 2 to 12 years) who were followed up were included in the study. The final clinical and radiographic examinations of cases were performed after three years in average.

All injuries were associated with low-energy traumas, resulting from falls. No primary neuro-vascular injury was observed following the fracture. Left elbow was involved in fifty five patients and right elbow in 14 patients. Other injuries were present in addition to the lateral humeral condyle in six patients.

For evaluation of fractures, Milch and Badelon classifications were used.[4-7] In the Milch classification, anatomical position of the fracture and its relation with capitello-trochlear groove are evaluated. A Milch type I fracture extends through the ossification center of the lateral condyle and exits at the radiocapitellar groove whereas a Milch type II fracture exits at the medial of the capitellotrochlear groove. In Type II fractures, angulation as well as lateral traslation of the olecranon and upper fragment of the radius are present (Figure 1). In the Badelon classification, degrees of displacement are evaluated. A Badelon type I fracture is undisplaced, and a type 2 fracture is displaced <2 mm, and a type 3 fracture is displaced > 2 mm. A type 4 fracture is completely disconnected, and mostly displaced, even the fragment may be rotated. Patients were evaluated after a two-year monitoring period since it has been reported that bone remodeling and improvement in motion of joints are completed in two years in the elbow injuries of children.[1-7]

During the final examinations, all patients were interviewed and a thorough examination was performed. Each patient was examined by the same physician. Clinical outcomes were evaluated according to the criteria by Hardacre et al.[1] for the lateral humeral condyle fractures (Table 1) as well as the radiographic criteria. The results were rated as excellent, good and poor. The mean follow-up period was 39 months (range from 26 to 89 months).

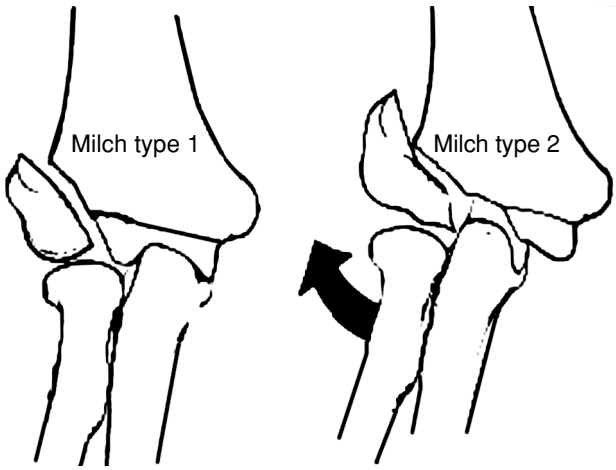

Figure 1. Milch classification for the lateral condyle fractures of the humerus .

Table 1. Evaluation of treatment outcomes in humeral lateral condyle injuries (Hardacre criteria)[1]

Excellent	Full range of motion
	Normal carrying angle and appearance
	No symptoms
	Complete healing of fracture
Good	Efficient range of motion
	Loss of extension less than 15 degrees
	Mild and subtle deformity
	No arthritic or neurological symptoms
	Complete healing of fracture
Fair	Loss of motion to the extent of disability
	Alterations in carrying angle and prominent deformity
	Presence of arthritic or neurological symptoms
	Presence of nonunion or avascular necrosis

Radiographically, full lateral and full anteroposterior images of both elbows were obtained for all patients. Healing of fracture and potential complications were evaluated. Radiographic indication of healing is the visualization of the callus tissue around the fracture on the anteroposterior and lateral views of the elbow. Avascular necrosis, presence of non-union and misunion, and status of the lateral condyle growth plate were also taken into consideration during the evaluation of functional results. Radiographs of the elbow were also evaluated in terms of rotational or angular deformities, and heterotopic ossification. Based on these observations, deformities of elbow were classified as normal, relatively cubitus varus, cubitus varus, pseudo cubitus varus and cubitus valgus. The carrying angle of the injured elbow is reduced in the relatively cubitus varus compared to the other elbow; but still above 0 degrees while in cubitus varus, the carrying angle is below 0 degrees. In pseudo cubitus varus, the lateral condyle is very prominent in the elbow and it is similar to cubitus varus; but the carrying angles are the same at both elbows. In cubitus valgus, the carrying angle is increased compared to the other elbow.

Results

According to the Milch classification, the fracture was of type 1 in two cases, and type 2 in 67 cases. According to the degree of displacement, 15 of fractures were Badelon type 3 and 54 were Badelon type 4.

Open reduction and internal fixation with K-wire were performed on the day of trauma in 47 patients, one day later in 12 patients, within 2 to 7 days in seven patients and after one week in three patients (Figure 2). Cases treated within 2 to 7 days were late referrals to our clinic. One of the patients who underwent surgery following the first week was treated by closed reduction and long-arm cast; he/she was operated at day 13 due to displacement determined in the fracture. The other two were late referrals.

Two K-wires were used for lateral humeral approach and fixation in all cases; placed percutaneously, and the fixation time was limited to four weeks. Percutaneous K-wires were removed without any need for clinical anesthesia at the end of the specified period.

No complication was observed during early period. The mean carrying angle in the fractured elbow was 8° (range from 0 to 15°), and 7.8° (range from 5 to11°) in the other elbow during the late monitoring period. These values had no significant difference. The carrying angles of both elbows were equal in 57 (82.6%) patients (Figure 2), with a mean difference of 5° in 11 patients (15.9%). Eight of these cases (11.6%) had relative cubitus varus, three (4.4%) had cubitus valgus. Only one patient (1.5%) had a difference of 11° in the carrying angle between the affected elbow and the other, who had cubitus varus. The intraoperative views showed that the reductions were anatomically performed and maintained. Following the removal of K-wires, no malunion or any arrest of growth in the lateral humeral growth plate was observed. According to Hardacre criteria, the functional results were excellent in 54 fractures (78.3%), good in 15 fractures (21.7%). No poor result was obtained (Figure 2).

Lateral humeral condyle was clinically and radiographically more prominent in 33 patients (47.8%) due to formation of new and extra bones. Review of early radiographs demonstrated that the bone spicules are elevated from the lateral condyle. The spicules were probably osteoperiosteal flaps, and the lateral prominence was depending on the formation of bone between spicule and lateral condyle, The lateral prominence was associated with deformity of pseudo cubitus in the elbow in 11 patients (%15.9).

The mean humeroulnar range of motion was 135° for both elbows. The humeroulnar range of motion was similar for both elbows in 54 patients (78.3%), with a difference of 5° in 15 patients (21.7%). A scar tissue wider than 2 mm was evident in 35 patients (50.7%); however, patients didn't have any complaints.

Discussion

Lateral condyle fractures of the humerus in children have a possible risk for complications such as misunion, non-union or angular deformities.[1-11] Therefore, most of the researchers recommend open or closed reduction and internal fixation in minimally displaced fractures. Even in undisplaced fractures, open reduction and internal fixation are indicated in order to prevent complications of any potential displacement.

Fractures can be classified by various methods. Among all, Milch and Badelon classifications are easy to use and simple. Diagnosis for lateral condyle fractures of the humerus is made by means of anteroposterior, lateral and oblique radiographs of the elbow as well as attentive clinical examination. Although arthrogram is helpful in more precise diagnosis, it may not be necessary in cases other than very young children as the lateral condyle of the humerus is ossified after two years of age. Sometimes intra-operative findings and radiographic images may be inconsistent. Radiographs and clinical evaluations were adequate to make diagnosis in our cases; and no unexpected finding was observed during the operation.

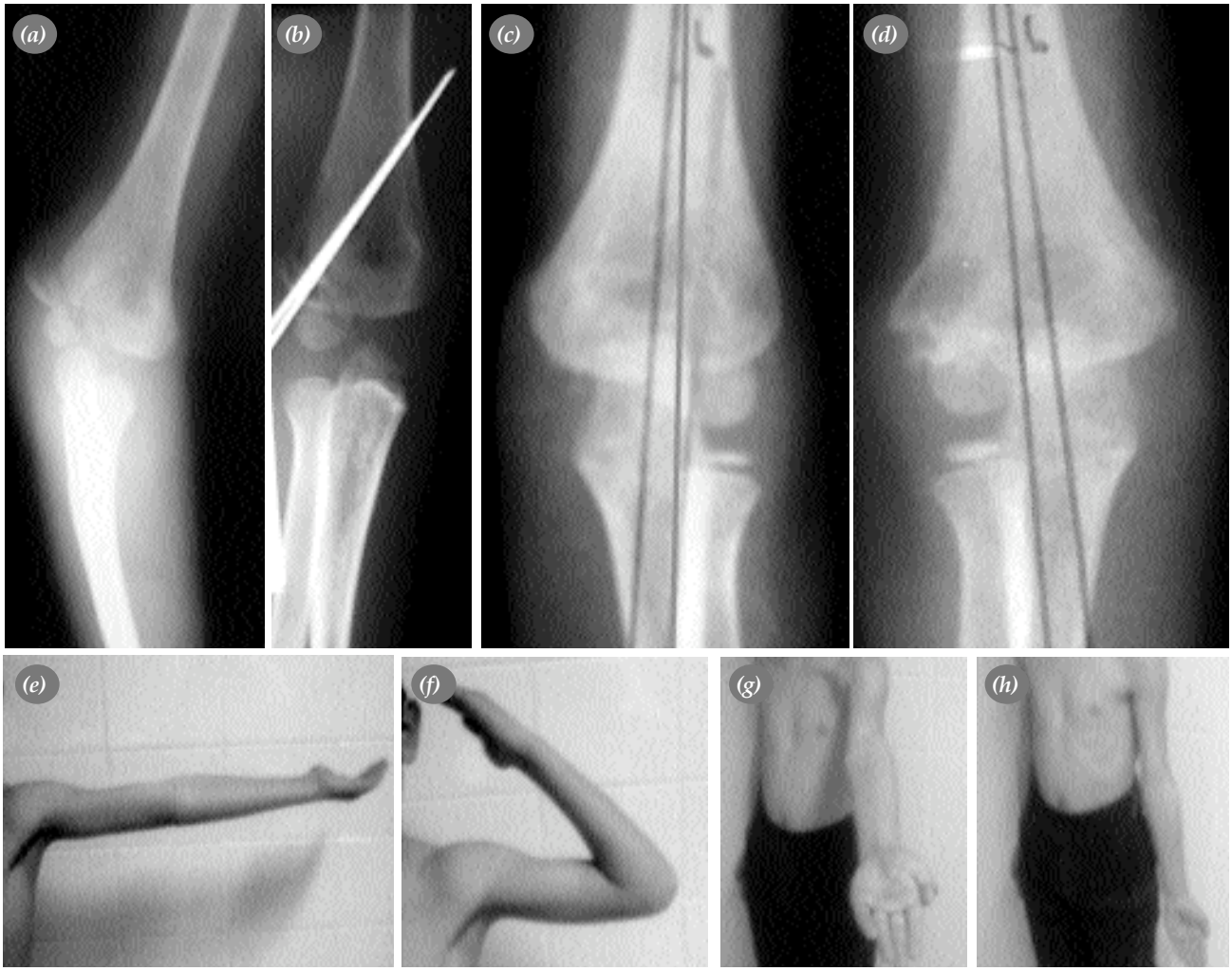

Figure 2. **(a, b)** Pre-operative and post-operative radiographs of a case. **(c, d)** Comparison of graphs with unaffected elbow after three years revealed equal carrying angles at both elbows. **(e-h)** Evaluation of functional results.

Two K-wires were used for fixation in our study for all patients; however, cancellous bone screws can be used in fragmented fractures and in elder children. It is already known that adequate fixation can be achieved with K-wire for such fractures even in adult patients. We achieved successful results with K-wires in all of our patients.

Time to remove the implant is very critical. Non-union was not observed in 69 patients who were treated by open reduction and internal fixation in the present study. However, non-union has been reported in cases with K-wires fixation for a period of 6-8 weeks.[4-7] Extension of the fixation period with K-wire up to 8 weeks does not decrease the incidence of non-union. During the removal of K-wires at week 4, we observed formation of callus tissue in all patients, which is a critical and sufficient parameter in indicating the healing of fracture. The mean removal time of screw was six weeks (3 to 7 weeks) in a study by Mintzer et al.[12] while other researchers reported a period of 3 to 8 weeks. Thomas et al.[13] removed the K-wires, which they used as fixation material, at postoperative week 3. However, their results were only based on non-union of the fracture, and no explanatory criteria or parameter was provided regarding the termination of the fixation, and no functional result was described. Küçükkaya et al.[14] suggested that fixation period should be determined by taking the age of patient into consideration, and they terminated the fixation within a range of 3 to 5 weeks. Our suggestion is that K-wires should be removed when callus tissue is displayed in the anteroposterior, lateral and oblique radiographs, where this period was four weeks in our study. We believe that such a period is adequate to achieve satisfactory results, and the effect of any extra period on the union and outcome of the treatment is controversial.

We used only K-wires for fixation purposes. While use of K-wires provides advantages of being easy and cheap, it has a disadvantage of requiring a second intervention in order to remove the wire.No pin tract infection associated with K-wire was observed in our patients. Some studies suggested alternative fixation methods in the treatment of lateral humeral condyle fractures, however their effect on reducing the risk for infection is not well known. One of the materials used for fixation is a screw of 1.5-2 mm with poliglicolic acid. Another fixation method is by short-grooved screws. Further studies are required to determine the superiority of current fixation methods. The advantage of fixation with screw over the K-wire is the continuation of fixation of the fracture during the mobilization of the elbow; but the power of fixation is decreased after three weeks in screws with poliglicolic acid because of the dissolution of the material. The surgical technique should not be too agressive to disturb the condylar vascularization. In order to control the intra-articular reduction, it may be necessary to cut some parts of the capsule and the synovia.[12-16] In our cases, we used soft tissue dissection as least as possible to reduce the risk for avascular necrosis of the condyle. We anatomically reduced the joint surfaces, fixating them with two K-wires.

During the final follow-up, deformity was seen at 23 elbows (33.3%), with relative cubitus varus and subsequent prominence in the lateral humeral condyle in eight patients (11.6%), and cubitus valgus deformity in three patients (4.4%) with a mean angulation of 5 degrees. Although reduction of fracture was observed to be completed at the intraoperative graphs, a difference of 11° was observed in the angle between two elbows, and deformity of cubitus varus was developed in this case. All deviations over 10 degrees in the varus or valgus deformity are dependent upon the incomplete reduction of the fracture fragments during the operation.[4-10] As proximal of the radius and olecranon frequently move to the lateral, particularly in Milch type 2 fractures, reduction and fixation of the fracture is of prime importance. The fact that the valgus deformity is a more common complication in the lateral condyle fractures of the humerus can be associated with the lateral traslation in type 2 fractures. But, varus deformity was relatively higher in our cases. It can be considered that the deformity resulted from the injury of condylar physis rather than complications related with reduction and fixation. In our study, 11 patients (15.9%) had pseudo cubitus varus, which develops secondary to the overgrowth of the lateral condyle of the humerus due to fracture, and it is not an angular deformity. Cause of the lateral prominence is the new bone formation under the osteoperiosteal flab. But, it cannot be correlated with the use of K-wire.[13,14]

In conclusion, satisfactory functional results can be achieved after a four-week open reduction and fixation with K-wire in the treatment of the displaced lateral condyle fractures of the humerus in children.

References

1. Hardacre JA, Nahigian SH, Froimson AI, Brown JE. Fractures of the lateral condyle of the humerus in children. J Bone Joint Surg [Am] 1971;53:1083-95.
2. Rutherford A. Fractures of the lateral humeral condyle in children. J Bone Joint Surg [Am] 1985;67:851-6.
3. Papavasiliou VA, Beslikas TA. Fractures of the lateral humeral condyle in children-an analysis of 39 cases. Injury 1985;16:364-6.
4. Foster DE, Sullivan JA, Gross RH. Lateral humeral condylar fractures in children. J Pediatr Orthop 1985;5:16-22.
5. Mirsky EC, Karas EH, Weiner LS. Lateral condyle fractures in children: evaluation of classification and treatment. J Orthop Trauma 1997;11:117-20.
6. Badelon O, Bensahel H, Mazda K, Vie P. Lateral humeral condylar fractures in children: a report of 47 cases. J Pediatr Orthop 1988;8:31-4.
7. Skak SV, Olsen SD, Smaabrekke A. Deformity after fracture of the lateral humeral condyle in children. J Pediatr Orthop B 2001;10:142-52.
8. So YC, Fang D, Leong JC, Bong SC. Varus deformity following lateral humeral condylar fractures in children. J Pediatr Orthop 1985;5:569-72.
9. Davids JR, Maguire MF, Mubarak SJ, Wenger DR. Lateral condylar fracture of the humerus following posttraumatic cubitus varus. J Pediatr Orthop 1994;14:466-70.
10. Hasler CC, von Laer L. Prevention of growth disturbances after fractures of the lateral humeral condyle in children. J Pediatr Orthop B 2001;10:123-30.
11. Bast SC, Hoffer MM, Aval S. Nonoperative treatment for minimally and nondisplaced lateral humeral condyle fractures in children. J Pediatr Orthop 1998;18:448-50.
12. Mintzer CM, Waters PM, Brown DJ, Kasser JR. Percutaneous pinning in the treatment of displaced lateral condyle fractures. J Pediatr Orthop 1994;14:462-5.
13. Thomas DP, Howard AW, Cole WG, Hedden DM. Three weeks of Kirschner wire fixation for displaced lateral condylar fractures of the humerus in children. J Pediatr Orthop 2001;21:565-9.
14. Küçükkaya M, Tezer M, Uludağ S, Kuzgun Ü. Surgical management of displaced fractures of the lateral humeral condyle in children: results of eight-year follow-up. [Article in Turkish] Acta Orthop Traumatol Turc 2001;35:16-20.
15. Dhillon KS, Sengupta S, Singh BJ. Delayed management of fracture of the lateral humeral condyle in children. Acta Orthop Scand 1988;59:419-24.
16. Horn BD, Herman MJ, Crisci K, Pizzutillo PD, MacEwen GD. Fractures of the lateral humeral condyle: role of the cartilage hinge in fracture stability. J Pediatr Orthop 2002;22:8-11.