

## Outcomes of the distal intraarticular humeral fractures treated by olecranon osteotomy

### *Distal humerus eklem içi kırıklarının olekranon osteotomisi ile tedavi sonuçları*

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#### ABSTRACT

**Objectives:** To evaluate the management and outcome of intraarticular fractures of the distal humerus treated by open reduction and internal fixation using the olecranon osteotomy technique.

**Materials and methods:** Twenty-one patients with intraarticular fractures of the distal humerus were treated by open reduction and internal fixation. The mean age of the patients was 41.6 years and the mean follow-up period was 25.3 months. All fractures were type C according to the AO/ASIF fracture classification system. Chevron type olecranon osteotomy was performed within 12-24 h after the injury in all cases but 4 of them. Physical and radiological examination of patients with the appropriate range checks were made.

**Results:** All fractures united within average duration of 3.2 months. Excellent or good results were found in patients less than 50 years-old, in women, when passing time from injury to surgery was within 12 hours and when early mobilization was achieved. The complications were seen as 2 (9.6%) transient neuropraxia of the ulnar nerve, 2 (9.6%) failure of fixation, 1 (4.8%) heterotopic ossification and 1 (4.8%) olecranon non-union. Fracture type (C1) and time from occurrence of injury to surgery (<12 hours) are the main prognostic factors for achieving the excellent/ good functional results.

**Conclusions:** The critical factors for a successful outcome of intraarticular fractures of the distal humerus included meticulous surgical technique, stable internal fixation, surgical experimentation and early controlled postoperative mobilization.

**Key words:** Distal humerus, intraarticular fracture, surgical treatment, olecranon osteotomy, early mobilization.

#### INTRODUCTION

Distal humerus fractures are difficult to manage successfully because of the local anatomic constraints, the frequent presence of communication, displacement and osteopenia<sup>1-6</sup>. Standard treatment

#### ÖZET

**Amaç:** Distal humerusun eklem içi kırıklarında olekranon osteotomisi yöntemiyle açık redüksiyon ve internal tesbit yapılan hastalarda tedavi sonuçlarının değerlendirilmesi.

**Gereç ve yöntem:** Distal humerusta eklem içi kırığı olan 21 hastaya olekranon osteotomisi yapılarak açık redüksiyon ve internal tesbit uygulandı. Hastaların ortalama yaşı 41.6 yıl ortalama takip süresi 25.3 ay idi. Kırıkların tamamı AO/ASIF kırık sınıflandırma sistemine göre tip-C idi. Chevron tipi olekranon osteotomisi yapılan hastaların dördü hariç diğerleri yaralanmadan sonraki ilk 12-24 saat içerisinde ameliyata alındı. Uygun aralıklarla hastaların fizik muayene ve radyolojik kontrolleri yapıldı.

**Bulgular:** Kırıkların tamamı ortalama 3.2 ayda kaynadı. Bayanlarda, 50 yaşın altında, yaralanmayla ameliyata alınma arasındaki süre 12 saatin altında olan ve erken hareket başlanan hastalarda mükemmel ve iyi sonuçlar elde edildi. Komplikasyon olarak 2 (9.6%) hastada geçici unlar sinir nöropatisi, 2 (9.6%) hastada tesbit yetersizliği, 1 (4.8%) hastada heterotopik ossifikasyon, 1 (4.8%) hastada da olekranonda kaynamama görüldü. Kırığın tipi (C1) ve yaralanmayla ameliyata alınma arasında geçen zaman (12 saat) mükemmel ve iyi fonksiyonel sonuçlar elde etmede ana belirleyici faktörlerdi.

**Sonuçlar:** Dikkatli ve titiz cerrahi teknik, stabil internal tesbit, cerrahi tecrübe ve ameliyat sonrası erken kontrollü hareket distal humerusun eklem içi kırıklarının başarılı sonuçları için kritik faktörlerdir.

**Anahtar kelimeler:** Distal humerus, eklem içi kırık, cerrahi tedavi, olekranon osteotomisi, erken hareket

and protocols for these fractures have not been developed. Although reasonable results were reported after conservative treatment in the past, it usually results in loss of elbow movement and permanent disability<sup>1,7,8</sup>. Moreover, accurate reconstruction of the articular surface is not always possible by

Tarihi / Received: 21.08.2009, Kabul Tarihi / Accepted: 05.10.2009

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closed manipulation<sup>1</sup>. The recent trend for displaced, intra-articular fractures of the distal humerus is open reduction and stable osteosynthesis with early rehabilitation<sup>2,9,10,11,12,5,13</sup>.

Adequate exposure is critical for visualisation of the fracture fragments during reduction and fixation, and it is generally agreed that the best exposure of both columns of the distal part of the humerus and articular surface is achieved through a posterior approach<sup>14,9,11,15</sup>. Various approaches that mobilize the triceps tendon (triceps-sparing approaches) have been described, but have limitations in exposure and extensibility. The triceps split has been used as a standard approach for distal diaphyseal fractures. Its use for periarticular fractures has not been well described<sup>9</sup>. The most recent studies have showed that the articular surface can be exposed via an olecranon osteotomy more than the other approaches<sup>16,17,9,3,18,19</sup>.

The purpose of this study was to retrospectively review the effect of fracture type, sex, age, time from injury to surgery and immobilization period on the results of distal intra-articular humerus fractures treated with stable internal fixation followed by early active movement.

## PATIENTS AND METHODS

A total of 21 patients with comminuted intra-articular fractures of the distal humerus were treated by open reduction and internal fixation. There were 13 men and 8 women with an average age of 41.6 years (range, 17-62). Left elbow involvement was found in 12 and right in 9. Average follow-up duration was 25.3 months (range 9-48).

By using the classification system of AO/ASIF, six fractures were type C1, 11 were type C2, and four were type C3. Two cases had grade 1 open fracture (case numbers 7 and 20). The cause of the fractures were traffic accident in 11, fall in 9, and sport injury in one.

Seventeen fractures were treated early within 24 hours. Four fractures (surgery was postponed until swelling had subsided in three cases and the severity of associated injuries made early operation impossible in one case) had delayed treatment (>24 hrs).

One of the patients had multiple fractures elsewhere in the body. Two patients had associated fractures in the forearm area and one required fas-

ciotomy of the forearm due to compartment syndrome.

## Operative Techniques

The patient was either placed supine with the affected arm placed across the chest or prone with the involved extremity flexed and hanging off the operating table. The pneumatic tourniquet was used. A straight posterior incision with radial deviation across the tip of the olecranon was made. The ulnar nerve was then identified and carefully protected (at the end of the procedure, the nerve was found in place in 8 patients and transposed anteriorly in 13 patients). Intra-articular chevron osteotomy was performed approximately two centimetres from the tip of the olecranon with a high-speed micro-oscillating saw to cut up to the subchondral bone. The osteotomy was completed with an osteotome used as a lever to crack through the articular surface. The proximal part of the olecranon was elevated with the triceps, which provides excellent exposure as far as seven centimetres proximal to the joint line before the radial nerve is threatened. The elbow capsule was incised and the fracture fragments were identified by carefully dissecting soft tissue and muscular attachments, as necessary. The articular fragments were inspected, and then carefully irrigated, and clots are removed with gentle curettage, taking care not to remove any bone.

The first step in the osteosynthesis was to reduction of the condyles and reconstruction of the joint surface. Medial and lateral condyles were fixed together with a cancellous lag screw. The next step was to anatomically reattach the condyles to the humeral shaft. Stable fixation was achieved by using two plates in 10 cases. Implants should not be placed in the coronoid or olecranon fossa. To avoid fixation failure before bone healing, a cancellous bone graft was used for bone defects and comminution. At the end of the procedure, the olecranon was reduced and then fixed with two longitudinal 2.0 mm K-wires and an 18-gauge tension band wire or 6.5 mm. cancellous screw.

The tourniquet was deflated, and hemostasis was obtained. A hemovac drain was placed and a meticulous wound closure was completed.

Usually by the second postoperative day, active or active-assisted range of elbow motion exercises as pain permitted was started in patients with good bone quality and rigid osteosynthesis. Longer

immobilization (>3 weeks) was used when the bone quality was poor and the stability of the osteosynthesis was questionable. No continuous passive motion machines were used. After the postoperative 6th week, resisted exercises were started and normal daily activities resumed. Strenuous physical exercise was only allowed after radiological evidence of union. For prophylaxis of heterotopic bone formation, patients received a six-week course of indomethacin (25 mg three times a day) beginning within twenty-four hours after surgery.

Pearson-Spearman correlation analysis was performed for statistical analyses. SPSS vs. 11.5 was used for statistical analyses. P less than 0.05 was accepted significant.

## RESULTS

All patients treated in our series had anatomic reconstitution of the joint surface in the early postoperative radiograph. All fractures united in average 3.2 months (range 7-19 weeks). Non-union was not determined in humerus. The clinical results were evaluated according to the criteria of Jupiter<sup>9</sup> (Table 1). These criteria consist of range of elbow motion (ROM) and subjective findings. When the re-

sults were graded according to the range of motion, excellent postoperative results were observed in 7 patients (33%) and good results were observed in 7 patients (33%) at final follow-up. Four patients (19%) had fair results, and three patients (14%) had poor results (Table 2).

Backing of one K-wire in olecranon were observed one patient (4.8%) (Case number: 5), but this did not make severe loss of elbow function and olecranon osteotomy united without complication.

Fixation failure depends on screw loosening were determined in two case (9.6%) (Case number: 10-18) with type C1 and C2 fracture. In these cases, fracture side was strengthened with lateral plate by using lateral longitudinal humeral exposure.

**Table 1.** Criteria for grading results<sup>12</sup>.

	Range of motion (degrees)		Subjective evaluation	
	Loss of extension	Flexion	Pain	Disability
Excellent	<15	130	None	None
Good	<30	120	Occasional	Minimum
Fair	<40	90-120	With activity	Moderate
Poor	<40	<90	Variable	Severe

**Table 2.** Overview of clinical data

Case	Age/ sex	Inj. limb	A.O. class.	Time from injury to surgery (hrs)	Immobilization (weeks)	Length of follow-up (mos.)	Range of motion	Subjective evaluation	Postop. Complications
1	58-F	L	C <sub>1</sub>	16	< 3	27	Excellent	Excellent	
2	38-F	R	C <sub>3</sub>	5	< 3	32	Good	Good	
3	56-M	L	C <sub>2</sub>	4	> 3	14	Fair	Good	Paraesthesias
4	19-M	R	C <sub>2</sub>	7 days	< 3	42	Poor	Fair	
5	29-M	L	C <sub>1</sub>	14	> 3	22	Good	Excellent	K-wire backing
6	22-M	R	C <sub>2</sub>	4	< 3	17	Excellent	Good	
7	43-M	L	C <sub>3</sub>	7	< 3	31	Fair	Good	
8	42-M	L	C <sub>2</sub>	8	< 3	25	Excellent	Excellent	Paraesthesias
9	56-M	L	C <sub>2</sub>	6 days	> 3	29	Fair	Fair	
10	27-F	L	C <sub>1</sub>	8	< 3	39	Excellent	Excellent	Fix.failure
11	24-M	L	C <sub>2</sub>	2 days	< 3	28	Fair	Poor	
12	17-M	R	C <sub>1</sub>	12	> 3	19	Good	Good	
13	43-M	L	C <sub>2</sub>	9	< 3	26	Excellent	Excellent	
14	47-F	R	C <sub>2</sub>	14	< 3	20	Good	Excellent	Olecranon nonunion
15	59-M	R	C <sub>3</sub>	11 days	> 3	44	Poor	Fair	Heterotopic ossification
16	62-F	L	C <sub>2</sub>	5	> 3	48	Good	Excellent	
17	51-M	L	C <sub>1</sub>	9	< 3	18	Excellent	Good	

**Table 3.** Excellent and good results rate according to the fracture types, sex, age, and time from injury to surgery and immobilization period

Characteristic	Excellent Good rating	or P
Fracture type		
C1 (n=6)	6 (100 %)	0.017
C2 (n=11)	6 (55 %)	
C3 (n=4)	2 (50 %)	
Sex		
Male (n=13)	7 (54 %)	NS
Female (n= 8)	7 (88 %)	
Age		
<50 y (n= 13)	10 (77 %)	NS
>50 y (n=8)	4 (50 %)	
Time from injury to surgery		
<24 hrs (n=17)	14 (82 %)	0.004
>24 hrs (n=4)	0 (0 %)	
Immobilization period		
<3 wk (n=13)	10 (77 %)	NS
>3 wk (n=8)	4 (50 %)	

NS: not significant

Primary bone grafting was performed in two cases (9.6%) (Case number: 15-20). Both of them were type C3 fracture. One patient had only pain with activity, but a “poor” result due to elbow stiffness.

Heterotopic ossification was seen in only one patient (4.8%) (Case number: 15) whose operation had been delayed for 11 days because of multiple injuries. This patient required a second procedure to excise it. A fair over-all result was achieved.

Transient neuropraxia of the ulnar nerve due to its mobilization before the olecranon osteotomy was found in two cases (9.6%) (Case number: 3-8) and recovered completely with only observation.

According to the functional results; 6 patients (100 %) in the C1 fracture type group, 6 (55 %) of 11 patients in C2 fracture type group and 2 (50 %) of 4 patients in C3 fracture type group had excellent and good results ( $p=0.017$ ). Seven (54 %) of 13 men and 7 (82 %) of 8 women had excellent and good results ( $p=0.378$ ). Ten (77%) of 13 patients with early mobilization (<3 weeks; average 11.9 days; SD, 4.2 days) of the elbow had excellent or good results, whereas only 4 (50 %) of 8 patients who were mobilized later (>3 weeks; aver-

age 26.1 days; SD, 2.8 days) achieved the same excellent and good level ( $p=0.097$ ).

According to the subjective criterions, the results were found to be excellent in 8 (38%), good in 8 (38%), fair in 3 (14%) and poor in 2 (10%) (Table II). There were no statistical correlation between the age, sex, immobilization period and subjective results.

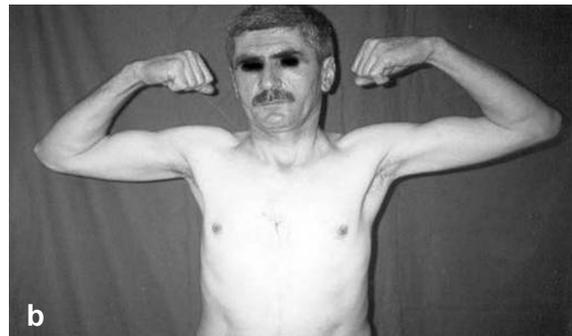
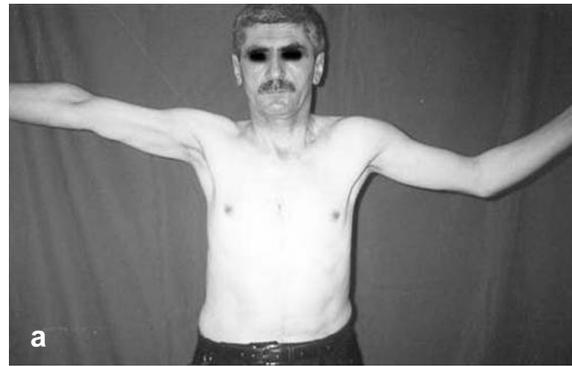
We used two plates for rigid fixation of fracture and continuity the fracture alignment in 6 cases with type C2 fracture and in 4 cases with type C3 fracture. Usually, one was lateral condyl plate and other was reconstruction plate (Scherman plate) (Fig 1-2-3).



**Figure 1 a - b.** Preoperative roentgenogram of the left elbow of a C<sub>3</sub> type fracture (Case 7).



**Figure 2 a - b.** Six weeks after the operation.



**Figure 3 a - b.** Functional result at 14 months

## DISCUSSION

Fractures of the distal humerus are difficult to treat both by the nature of injury and most surgeons do not have a great deal of experience with them<sup>20,1,5</sup>. Most intra-articular fractures of the distal humerus are displaced, and the successful treatment of any articular fracture demands an anatomic reduction, stable fixation and the ability to allow early elbow motion<sup>21,17,12</sup>.

There are numerous surgical exposures of the elbow joint<sup>14,22,4</sup>. The posterior approach through an olecranon osteotomy is the most widely used<sup>16,9,3,4</sup>. This approach provides excellent visualization, particularly of the distal articular fragments and excellent exposure for plate application<sup>9,4</sup>. An anatomic comparison in cadavers demonstrated only 35% of the articular surface is adequately exposed with a standard triceps splitting approach. In comparison, a triceps reflecting approach allowed access to approximately 46% of the articular surface. Employing the most extensive exposure, the olecranon osteotomy, only 57% of the articular anatomy is fully exposed<sup>23,19</sup>.

The elbow joint tolerates immobilization poorly and the functional outcome after surgical treatment is unavoidably worsened by prolonged im-

mobilization<sup>5</sup>. Therefore, early mobilization of the elbow has been recommended, but this requires stable fixation of the fracture<sup>1,24,18,13</sup>. However, patient-related factors, such as poor bone quality or extensive comminution of the fracture, may necessitate prolonged immobilization in order to avoid non-union of the fracture. In our series, 10 of 13 patients in early active elbow mobilization group showed excellent or good postoperative results, 4 of 8 patients in late mobilization group had excellent and good results.

Fair and poor results were reported in advanced-age and male cases<sup>25,7,18</sup>. In our study, we found fair and poor functional results especially in > 50 years-old cases and in male cases. This may be possibly because of inferior bone quality and longer immobilization in older patients and high C2 – C3 fracture frequency in male cases.

There is a correlation between the late surgery and heterotopic ossification<sup>17</sup>. We found one heterotopic ossification in a case with poor functional result and fair subjective evaluation that had operated after 11 days from trauma.

Dual plates are necessary to maintain the anatomic alignment of the fracture, while buttressing the fragments and preventing loss of reduction under torsion or bending loads. This is especially true in type C3 fractures<sup>26</sup>. It should be noted that double plating appears to be superior to single plating or to the use of screws and K-wires alone<sup>26,9,4,8</sup>. We used two plates in 10 cases with type C2 and C3 fracture for rigid fixation. Usually, one plate was lateral condyl plate and other was medial reconstruction plate.

Three different types of olecranon osteotomy can be used, intra-articular tranverse, extra-articular oblique and intraarticular chevron<sup>2</sup>. We believe that chevron osteotomy was enhanced stability and union, for this reason, we used chevron osteotomy. Non-union of the olecranon osteotomy has been reported to occur between 2-5 %<sup>20,26,17,9</sup>. In this study, 1 (4.8%) olecranon non-union was observed and reosteosynthesis with 6.5 mm long cancellous screw and tension band wiring was performed.

Ulnar nerve is at obvious risk both from the injury and subsequent surgery to the distal humerus. Ulnar nerve injury has been reported as %5-20<sup>20,1,27</sup>. Two (9.6%) transient ulnar nerve paraesthesias in cases with not anteriorly transposed were

encountered in the present study. We agree with Jupiter et al.<sup>9</sup> that, anterior transposition of the ulnar nerve should be done whenever the nerve is retraction or when a metal implant is likely to cause mechanical irritation.

Mechanical failure of fixation is common in patients with severe comminution and displacement (type C2, C3 according to AO/ASIF classification)<sup>8</sup>. Henley<sup>2</sup> reported 5 cases of implant breakage in a group of 33 patients. Sodergard et al.<sup>5</sup> reported 29.5% mechanical failure rate in 18 cases and advised a nonsurgical approach when the bone is osteoporotic. We observed 2 (9.6%) fixation failures due to the screw loosening. Our rate was lower than the literature.

Pajarinen and Bjorkenheim<sup>18</sup> did not find any correlation between the type of fracture and postoperative result. In this study, C1 fracture type had excellent and good functional result than other fracture types.

In conclusion, the successful treatment of comminuted intra-articular distal humerus fractures demands stable osteosynthesis with anatomic reduction of the joint surface and early mobilisation.

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