

# Open reduction and internal fixation in AO type C distal humeral fractures using olecranon osteotomy: Functional and clinical results

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## ABSTRACT

**BACKGROUND:** To investigate the outcomes of patients undergoing open reduction and internal fixation with olecranon osteotomy due to AO type I3C fractures of the distal humerus.

**METHODS:** Data of 39 patients (mean age, 44.7 years; males, 56.4%) undergoing surgery with the diagnosis of AO type I3C distal humeral fractures were retrospectively evaluated. Patients' demographic characteristics, medical history, and radiological and functional outcomes were recorded. The patients were evaluated at the final follow-up according to the Mayo Elbow Performance Index (MEPI).

**RESULTS:** The mean degrees of flexion and extension loss were 102.2 degrees (range, 60–120 degrees) and 11.4 degrees (range, 0–25 degrees), respectively, at the final follow-up. According to the MEPI score, outcomes were excellent in seven, good in 12, fair in 13, and poor in seven patients. All patients achieved a radiological union of the fracture site within the first postoperative six months. It was found that the loss of extension was more severe, the range of flexion was decreased, and the mean MEPI score was lower in the patients with type C3 fractures than in those with type C1 and type C2 fractures. No significant difference was determined between fixation techniques (tension band vs. cannulated screw) regarding the functional outcomes.

**CONCLUSION:** Our results revealed better prognosis in AO type C1 and type C2 fractures than in AO type C3 fractures and no different effects of two fixation techniques in olecranon osteotomy on the outcomes.

**Keywords:** Comminuted fractures; elbow joint; osteotomy.

## INTRODUCTION

Fractures of the elbow, 30% of which include fractures of the humerus, account for 7% of all fractures in adults.<sup>[1]</sup> The elbow joint has the highest contribution to the functional movement of the upper extremity. Treatment of elbow fractures is challenging due to the complex anatomic structure of the elbow joint.<sup>[2]</sup> Correction of an insufficient or unstable surgical fixation is always more difficult than the initial operation. It is important to provide an appropriate means of therapy to restore upper extremity functions.<sup>[3]</sup>

Management of the distal humerus fractures has long been a problem for orthopedic surgeons. Restricted movement and pain occurring after treatment negatively affect the treatment outcomes. Currently, the utility of conservative methods is limited due to the advancements in implant technology and developments of new techniques. Therefore, surgery is the mostly preferred treatment for the management of the distal humerus fractures.<sup>[4]</sup>

The present study aimed to investigate the outcomes of patients who underwent open reduction and internal

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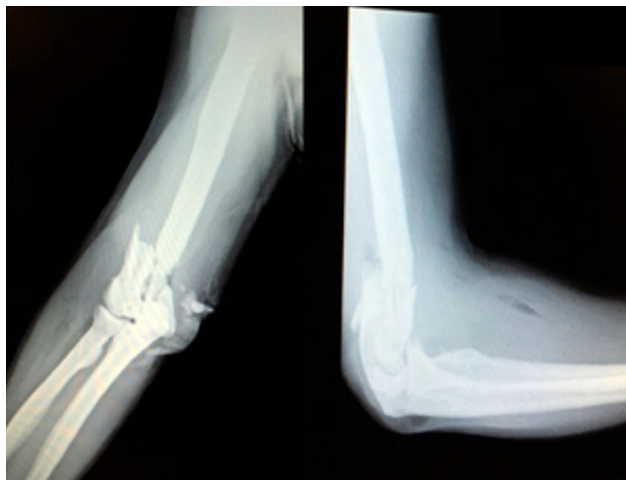


fixation with olecranon osteotomy due to AO type I3C fractures.

## MATERIALS AND METHODS

The present study was designed as a retrospective comparative study. Data of 39 adult patients who underwent surgical treatment with the diagnosis of AO type I3C fractures of the distal humerus (Fig. 1), according to the AO principles,<sup>[5]</sup> were retrospectively evaluated. In addition to the demographic characteristics of the patients, data regarding cause of injury, type of fracture according to the Gustilo–Anderson classification,<sup>[6]</sup> the surgical approach and the technique used, fixation technique, duration of follow-up, and radiological and functional outcomes were recorded.

The patients were operated on for a mean duration of 3.8 days (range, 1–16 days) after sustaining trauma. All patients underwent open reduction and internal fixation with olecranon osteotomy. Fixation of the osteotomy site was per-



**Figure 1.** Anteroposterior and lateral X-rays of a type C3 distal intra-articular humeral fracture.



**Figure 2.** Anteroposterior and lateral views at the postoperative 5th month of a 27-year-old female patient in whom fixation was performed using medial and posterolateral plates and transcondylar screw was used.

formed using cannulated screws in 21 patients and using tension bands in 18 patients. The fixation technique was chosen depending on the preference of the responsible surgeon. The medial and lateral columns were fixed using plates in 19 patients, and transcondylar screws were used to strengthen the fixation in eight of these 19 patients. The fixation was performed using medial and posterolateral plates in 20 patients, and transcondylar screws were used to strengthen the fixation in 12 of these 20 patients (Fig. 2).

After the operation, the operated extremities of all patients were immobilized in a long arm splint, with the elbow flexed at 90 degrees and with the forearm held in the neutral position; the cast was removed after resolution of edema at 15-day checkup. Prophylaxis with intravenous cefazolin (3 g/day) was administered for the first 48 h until removal of the drain. After removal of the splint, all patients participated in an exercise program supervised by a physiotherapist. The mean length of hospital stay was 5 days (range, 3–15 days). The patients were evaluated at the final follow-up visit according to the Mayo Elbow Performance Index (MEPI).<sup>[7]</sup> A MEPI score of <60 was evaluated as poor, a MEPI score of 60–74 was evaluated as fair, a MEPI score of 75–89 was evaluated as good, and a MEPI score of ≥90 was evaluated as excellent.

## Statistical Analysis

Data analysis was performed using the IBM SPSS Statistics for

**Table 1.** General characteristics of the study patients

Characteristics	Patients (n=39)
Age (year), Mean±SD,	44.7±12.3
Median (minimum-maximum)	44 (20–69)
Gender, n (%)	
Males	22 (56.4)
Females	17 (43.6)
Cause of injury, n (%)	
Traffic accidents	26 (66.7)
Fall	13 (33.3)
Type of fracture according to the AO principles, n (%)	
C1	10 (25.6)
C2	14 (35.9)
C3	15 (38.5)
Presence of multiple fractures, n (%)	24 (61.5)
Presence of open fracture*, n (%)	7 (17.9)
Duration of follow-up, months	36.7±19.4
Mean±SD, median (minimum-maximum)	30 (10–83)

\*All open fractures were type I open fractures according to the Gustilo–Anderson classification. SD: Standard deviation.

**Table 2.** Findings of the patients at the postoperative and follow-up periods

Characteristics	Patients (n=39)
Postoperative complications, n (%)	
Superficial wound site infection	3 (7.7)
Ulnar nerve problem	3 (7.7)
Heterotrophic ossification	2 (5.1)
According to the MEPI score, n (%)	
Excellent	7 (17.9)
Good	12 (30.8)
Fair	13 (33.3)
Poor	7 (17.9)
Functionality at the last follow-up	
Mean±SD, Median (Minimum-Maximum)	
Elbow joint flexion, degree	102.2±12.3 105 (60–120)
Loss of extension, degree	11.4±6.97 10 (0–25)

MEPI: Mayo Elbow Performance Index; SD: Standard deviation.

Windows, version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as number and percentage for categorical variables and as mean, median, standard deviation, and minimum and maximum for numerical variables. Comparison of two independent groups was performed using independent t-test for normally distributed variables and using Mann–Whitney U-test with the Monte Carlo simulation technique for non-normally distributed variables. For multiple group comparisons, one-way analysis of variance was performed, and the least significant difference was used for

post-hoc analysis of normally distributed variables, whereas for non-normally distributed variables, Kruskal–Wallis H tests were tested using the Monte Carlo simulation technique, and non-parametric post-hoc test was performed for post-hoc analysis. Comparison of categorical variables was performed using Pearson's chi square test with the Monte Carlo simulation technique. A p-value of <0.05 was considered statistically significant.

## RESULTS

The mean age of the patients (n=39) at the time of admission was 44.7±12.3 years, and 56.4% of them were males. The general characteristics of the patients are summarized in Table 1.

Superficial wound-site infections were observed in the early postoperative period in three patients. These patients were treated with appropriate intravenous antibiotics and healed without any sequelae. Three patients developed ulnar nerve palsy in the postoperative period. Implant removal was planned in the early period after observing the evidence of union, and ulnar nerve transposition was performed in all patients. Recovery of the ulnar nerve palsy was not achieved in one patient. Heterotrophic ossification was observed in two patients at 12 months during the follow-up period. A radiological union of the fracture site was achieved within the first postoperative six months in all patients. None of the patients experienced nonunion of the olecranon osteotomy site. The findings of the patients at the postoperative and follow-up periods are presented in Table 2.

Evaluation of the patients according to the type of fractures determined based on AO principles revealed that the loss of extension was more severe, the range of flexion was decreased, and the MEPI score was lower in the patients with

**Table 3.** Characteristics of the patients according to the type of fractures based on the AO principles

	Fracture type			p
	Type C1 (n=10)	Type C2 (n=14)	Type C3 (n=15)	
Mayo Elbow Performance Index score, Mean±SD	81.0±12.2 <sup>a</sup>	77.1±10.7 <sup>a</sup>	62.0±13.2	0.001
Flexion, degree, Mean±SD	111.5±6.7 <sup>a</sup>	106.4±6.6 <sup>a</sup>	92.0±12.2	<0.001
Presence of loss of extension, n (%)	5 (50.0)	13 (92.9)	15 (100.0)	0.001
Loss of extension, degree				
Median (Minimum-Maximum)	2.5 (0–20) <sup>a</sup>	10 (0–20) <sup>a</sup>	20 (10–25)	<0.001
Presence of complication, n (%)	1 (10.0)	3 (21.4)	1 (6.7)	0.508
Osteotomy fixation type, n (%)				
Cannulated screw	3 (30.0)	9 (64.3)	9 (60.0)	0.243
Tension band	7 (70.0)	5 (35.7)	6 (40.0)	

<sup>a</sup>Significantly different from the patients with type C3 fracture at p<0.001. SD: Standard deviation.

**Table 4.** Characteristics of the patients according to the osteotomy fixation type

	Osteotomy fixation with		p
	Cannulated screw n=21	Tension band n=18	
Mayo Elbow Performance Index score, Median (Minimum-Maximum)	80 (35–90)	72.5 (45–90)	0.995
Flexion, degree, Mean±SD	101.0±14.5	103.6±9.4	0.508
Presence of loss of extension, n (%)	18 (85.7)	15 (83.3)	1.000
Loss of extension, degree, Median (Minimum-Maximum)	10 (0–25)	10 (0–20)	0.854
Presence of complication, n (%)	3 (14.3)	2 (11.1)	1.000

SD: Standard deviation.

type 13C3 fractures compared with the patients with type 13C1 and type 13C2 fractures (Table 3).

In the present study, no significant difference was determined between the two fixation techniques (tension band vs. cannulated screw) with respect to the functional outcomes and complications (Table 4).

## DISCUSSION

Management of the distal humerus fractures is challenging due to its complex anatomic structure and poor bone reserve. The main goal of treatment is to provide a complete range of joint motion and a painless and stable joint.<sup>[8]</sup>

The optimal treatment for the distal humerus fractures is surgery, and the surgical technique to be selected in these fractures is related to the fracture type.<sup>[9,10]</sup> A medial or lateral incision can be preferred in single-column fractures involving the joint. A posterior incision can provide better visibility of the surgical site in bicolumnar fractures affecting both columns and involving the joint. An olecranon osteotomy is a technique used in posterior incisions. This technique provides better surgical visibility than other techniques such as triceps incision and separation.<sup>[9]</sup> In the present study, all patients underwent olecranon osteotomy.

Different fixation techniques have been used in previous studies. Flinkkilä et al.<sup>[11]</sup> reported parallel plate fixation as an effective method for the treatment of comminuted fractures of the distal humerus. Sanchez-Sotelo et al.<sup>[12]</sup> suggested that using 2.7-mm locking screws in addition to medial and lateral plates would increase the stability in comminuted fractures. Babhulkar and Babhulkar<sup>[13]</sup> reported successful outcomes using posterior transolecranon approach, dual fixation of both columns, and restoration of the continuity of articular surface. In the present study, double plates were used in all patients; we believe this is important in the treatment of such complex fractures. Moreover, in the present study, fixation of the osteotomy site was performed using cannulated screws in 21 patients and tension bands in 18 patients; no significant

difference was determined between the two fixation techniques in terms of functional outcomes and complications.

Complications may occur in distal humeral fractures either due to the injury itself or due to treatment. It has been reported that complications are more frequently observed in open fractures than in closed fractures.<sup>[14]</sup> Majority of the patients (82.1%) in the present study had closed fractures. Evaluation of the patients according to the fracture types determined based on AO principles revealed a more severe loss of extension, a decreased range of flexion, a lower MEPI score in the patients with type 13C3 fractures than in those with type 13C1 and type 13C2 fractures.

One of the complications encountered in distal humeral fractures is infection. The rate of surgical site infections has been reported to range between 3% and 12% in the distal humerus fractures.<sup>[15,16]</sup> In the present study, a superficial infection was observed in three patients. The patients did not require debridement, and all recovered with the administration of an appropriate anti-biotherapy recommended by infectious disease specialists and with the use of wound dressing.

The rate of ulnar nerve injury has been reported to be 0%–12% in fractures of the elbow joint.<sup>[11,15,17]</sup> Protection of the ulnar nerve is recommended in posterior approaches. However, there is a debate over the necessity of anterior transposition of the ulnar nerve. Wang et al.<sup>[18]</sup> recommended that anterior transposition of the ulnar nerve should be routinely performed. In the present study, the ulnar nerve was identified in all patients; however, transposition was not performed. Ulnar nerve palsy was observed in three patients, and ulnar nerve transposition was performed in the postoperative 6th month. However, we do not perform a routine ulnar nerve transposition during our surgical treatments in such cases.

Another important complication following the treatment of elbow fractures is the presence of heterotrophic ossification that results in a limited range of motion.<sup>[19]</sup> Anti-inflammatory drugs (such as indomethacin) and radiation therapy have been suggested as a part of the surgical treatment of heterotrophic

ossification.<sup>[19]</sup> In distal humerus fractures, the rate of heterotrophic ossification as a complication has been reported to be 0%–15%.<sup>[15,17,20]</sup> In the present study, none of the patients were administered prophylactic indomethacin; two patients, who had a type 13C3 fracture at the initial presentation, developed heterotrophic ossification and were monitored.

Nonunions are encountered as unwanted complications for orthopedists after surgical treatment of the elbow joint.<sup>[21]</sup> The complication of nonunion of the olecranon has been reported at a rate of 3%–7% after the treatment of type 13C fractures of the distal humerus.<sup>[15,20]</sup> In the present study, none of the patients experienced a complication related to the union of the olecranon.

Rehabilitation after surgery is of major importance in distal humerus fractures. Appropriate rehabilitation techniques improve patient outcomes.<sup>[22]</sup> In the present study, the mean duration of follow-up was 36.7 months. After the treatment, the mean degrees of flexion and loss of extension were found to be 102.2 and 11.4 degrees, respectively. In their study, Ozdemir et al.<sup>[15]</sup> reported the mean degree of flexion in the elbow joint as 115.1 degrees and the mean degree of loss of extension as 26.3 degrees. In studies evaluating functional outcomes of surgical treatment of elbow fractures, the rate of patients with excellent and good outcomes after the treatment were reported as 62% by Ozdemir et al.,<sup>[15]</sup> as 81% by Flinkkilä et al.,<sup>[11]</sup> as 72% and 86% in their two different groups by Babhulkar and Babhulkar,<sup>[13]</sup> and 92% by Schmidt-Horlohé et al.<sup>[20]</sup> In the present study, excellent and good outcomes were obtained in 48.7% (n=19) of the patients.

The main limitation of the present study was the absence of a control group including patients treated using a different surgical procedure. Another limitation was the absence of a patient group including patients treated with plate-screw fixation technique for olecranon fixation.

In conclusion, complex fractures of the distal humerus are difficult to treat. Functional outcomes worsen when the fracture type becomes more complex. The results of the present study revealed that the prognosis in type C1 and type C2 fractures was better than in type C3 fractures and that the type of fixation (tension band or cannulated screw) in olecranon osteotomy did not influence the outcome.

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## REFERENCES

- Pollock JW, Faber KJ, Athwal GS. Distal humerus fractures. *Orthop Clin North Am* 2008;39:187–200. [\[CrossRef\]](#)
- Kocaoglu M, Şener N, Şar C, Hamzaoglu A, Tuncay İ. Intraarticular fractures of the distal humerus in the adult: Surgical treatment and results. *Joint Dis Rel Surg* 1999;10:149–54.
- Chan K, King GJ, Faber KJ. Treatment of complex elbow fracture-dislocations. *Curr Rev Musculoskelet Med* 2016;9:185–9. [\[CrossRef\]](#)
- Nauth A, McKee MD, Ristevski B, Hall J, Schemitsch EH. Distal humeral fractures in adults. *J Bone Joint Surg Am* 2011;93:686–700.
- Holdsworth BJ. Humerus: distal. In: Ruedi TP, Murphy WM, editors. *AO Principles of Fracture Management*. Stuttgart New York: Thieme; 2000. p. 307–21.
- Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *J Bone Joint Surg Am* 1976;58:453–8. [\[CrossRef\]](#)
- Morrey BF, An KN. Functional evaluation of the elbow. In: Morrey BF, editor. *The Elbow and Its Disorders*. 3rd ed. Philadelphia: WB Saunders; 2000. p. 82.
- O'Driscoll SW. Optimizing stability in distal humeral fracture fixation. *J Shoulder Elbow Surg* 2005;14:186S–94S. [\[CrossRef\]](#)
- Bégué T. Articular fractures of the distal humerus. *Orthop Traumatol Surg Res* 2014;100:S55–63. [\[CrossRef\]](#)
- Lee DH. Treatment options for complex elbow fracture dislocations. *Injury* 2001;32 Suppl 4:SD41–69. [\[CrossRef\]](#)
- Flinkkilä T, Toimela J, Sirmiö K, Leppilähti J. Results of parallel plate fixation of comminuted intra-articular distal humeral fractures. *J Shoulder Elbow Surg* 2014;23:701–7. [\[CrossRef\]](#)
- Sanchez-Sotelo J, Torchia ME, O'Driscoll SW. Principle-based internal fixation of distal humerus fractures. *Tech Hand Up Extrem Surg* 2001;5:179–87. [\[CrossRef\]](#)
- Babhulkar S, Babhulkar S. Controversies in the management of intra-articular fractures of distal humerus in adults. *Indian J Orthop* 2011;45:216–25. [\[CrossRef\]](#)
- Min W, Ding BC, Tejwani NC. Comparative functional outcome of AO/OTA type C distal humerus fractures: open injuries do worse than closed fractures. *J Trauma Acute Care Surg* 2012;72:E27–32. [\[CrossRef\]](#)
- Ozdemir H, Urgüden M, Söyüncü Y, Aslan T. Long-term functional results of adult intra-articular distal humeral fractures treated by open reduction and plate osteosynthesis. *Acta Orthop Traumatol Turc* 2002;36:328–35.
- Claessen FM, Braun Y, van Leeuwen WF, Dyer GS, van den Bekerom MP, Ring D. What Factors are Associated With a Surgical Site Infection After Operative Treatment of an Elbow Fracture? *Clin Orthop Relat Res* 2016;474:562–70. [\[CrossRef\]](#)
- Mardanpour K, Rahbar M. Open reduction and internal fixation of intraarticular fractures of the humerus: evaluation of 33 cases. *Trauma Mon* 2013;17:396–400. [\[CrossRef\]](#)
- Wang KC, Shih HN, Hsu KY, Shih CH. Intercondylar fractures of the distal humerus: routine anterior subcutaneous transposition of the ulnar nerve in a posterior operative approach. *J Trauma* 1994;36:770–3.
- Englert C, Zellner J, Koller M, Nerlich M, Lenich A. Elbow dislocations: a review ranging from soft tissue injuries to complex elbow fracture dislocations. *Adv Orthop* 2013;2013:951397. [\[CrossRef\]](#)
- Schmidt-Horlohé KH, Bonk A, Wilde P, Becker L, Hoffmann R. Promising results after the treatment of simple and complex distal humerus type C fractures by angular-stable double-plate osteosynthesis. *Orthop Traumatol Surg Res* 2013;99:531–41. [\[CrossRef\]](#)
- Gallay SH, McKee MD. Operative treatment of nonunions about the elbow. *Clin Orthop Relat Res* 2000:87–101. [\[CrossRef\]](#)
- Wong AS, Baratz ME. Elbow fractures: distal humerus. *J Hand Surg Am* 2009;34:176–90. [\[CrossRef\]](#)

ORİJİNAL ÇALIŞMA - ÖZET

## AO Tip C humerus distal kırıklarında olekranon osteotomisi ile açık redüksiyon ve internal tespit: Fonksiyonel ve klinik sonuçlar

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**AMAÇ:** Çalışmada AO tip I3C humerus distal kırıklarında olekranon osteotomisi ile birlikte açık redüksiyon ve internal tespit yapılan hastaların fonksiyonel ve klinik sonuçlarını ortaya koymaktır.

**GEREÇ VE YÖNTEM:** AO Tip I3C distal humerus kırığı tanısı mevcut olan ve cerrahisi yapılan 39 hasta (ortalama yaş, 44.7; Erkek, %56.4) geriye dönük olarak değerlendirildi. Hastaların demografik verileri, tıbbi öyküleri, radyolojik ve fonksiyonel sonuçları kayıt altına alındı. Hastaların fonksiyonel sonuçları Mayo Dirsek Performans Puanlama Sistemi'ne (MEPI) göre değerlendirildi.

**BULGULAR:** Ortalama dirsek fleksiyon derecesi 102.2 (60–120 derece) ve ortalama ekstansiyon kaybı derecesi 11.4 (0–25 derece) olarak hesaplandı. Mayo Dirsek Performans Puanlama skorlama sistemine göre yedi hastada mükemmel, 12 hastada iyi, 13 hastada orta ve 7 hastada kötü sonuç elde edildi. Tüm hastalarda ameliyat sonrası altıncı ayda radyolojik olarak kaynama görüldü. Tip I3C3 kırıklarda tip I3C1 ve I3C2'ye göre daha fazla ekstansiyon kaybı, daha düşük fleksiyon derecesi ve daha düşük ortalama MEPI skoru tespit edildi. Fonksiyonel sonuçlara bakıldığında olekranon fiksasyon yönteminin (tansiyon bant ve kanüle vida) anlamlı farklılık yaratmadığı tespit edildi.

**TARTIŞMA:** AO tip I3C1 ve tip I3C2 kırıklarının klinik ve fonksiyonel sonuçlarının AO tip I3C3 kırıklara göre daha iyi olduğu ve iki farklı olekranon fiksasyon yönteminde fonksiyonel sonuçların değişmediği görüldü.

**Anahtar sözcükler:** Dirsek eklemi; osteotomi; parçalı kırıklar.

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