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Results of open reduction and plate osteosynthesis in comminuted fracture of the olecranon

Ramazan Erden Erturer, MD[a], Cem Sever, MD[a], Mehmet Mesut Sonmez, MD[a,*], Ismail Bulent Ozcelik, MD[b], Senol Akman, MD[c], Irfan Ozturk, MD[c]

[a]*Sisli Etfal Training and Research Hospital, Istanbul, Turkey*
[b]*Ist-El Hand Center, Istanbul, Turkey*
[c]*Sisli Etfal Training and Research Hospital, Istanbul, Turkey*

Hypothesis: Using radiologic and clinical results, we studied the outcome of patients who underwent open reduction and plate osteosynthesis for comminuted olecranon fractures.
Materials and methods: We retrospectively studied 18 patients (5 women [27.8%] and 13 men [72.2%]; mean age, 41 years [range, 19-67 years]) with comminuted fractures of the olecranon who underwent locking-plate osteosynthesis after open reduction between March 2005 and August 2009. According to the Mayo classification, 11 cases were classified as type IIB (61.11%) and 7 cases were classified as type IIIB (38.88%). In 7 cases, additional injuries were present in the olecranon area. We evaluated results with respect to clinical and radiologic findings. The mean follow-up duration was 22.6 months (range, 7-42 months).
Results: Complete union was achieved in all cases. Mean union time was 4.4 months (range, 4-6 months). According to the Morrey scale, 4 cases were considered very good; 8, good; 5, fair; and 1, poor. The mean QuickDASH (Disabilities of the Arm, Shoulder, and Hand) score was 17 (range, 0-75). There were no statistically significant differences between the Mayo type IIB and type IIIB cases in terms of elbow range of motion, QuickDASH score, and Morrey score. On long-term follow-up, elbow stiffness developed in 1 patient, who underwent surgical release with simultaneous removal of the hardware. The cases with fair and poor scores were cases with open fractures and additional elbow injuries.
Conclusions: Locking-plate osteosynthesis is an effective and safe treatment option for comminuted olecranon fractures, allowing early joint motion and yielding satisfactory radiologic and clinical results. In cases with concomitant injuries, the risk of limited elbow motion is high.
Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Olecranon fractures; surgical treatment; plate osteosynthesis

Olecranon fractures constitute 10% of all upper extremity fractures. In addition to direct trauma, overloading of the triceps muscle may also cause a fracture.[20,23] Fractures due to direct trauma are usually comminuted fractures that impact into the interior of the distal humerus.[20] Articular surface irregularity, degree of comminution, and stability of the joint help determine treatment. Fractures displaced less than 2 mm, and without further separation when the elbow is flexed to 90°, they are usually considered stable and can be treated with

*Reprint requests: Mehmet Mesut Sonmez, MD, Kalipci sok, No 40/6 34357, Istanbul, Turkey.
E-mail address: mdmesutsonmez@yahoo.com (M.M. Sonmez).

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a conservative approach. Surgical treatment should be considered in more severe fractures.[8,23]

In the surgical treatment of olecranon fractures, the primary goals are anatomic reconstruction of the joint surface, stable fixation that allows early mobilization, and achieving painless and functional elbow range of motion. Tension-band wiring with Kirschner wires is a well-considered standard, especially in non-comminuted fractures.[21,24] Application of tension-band wires with screws or intramedullary pins, plate-and-screw osteosynthesis, and excision of the proximal fragment are other available surgical methods.[8,23] In this study, we evaluated the results of locking-plate osteosynthesis in patients with comminuted olecranon fractures.

Materials and methods

We retrospectively studied 18 patients (5 women [27.8%] and 13 men [72.2%]; mean age, 41 years [range, 19-67 years]) with comminuted fractures of the olecranon who underwent locking-plate osteosynthesis after open reduction between March 2005 and August 2009. The injury was in the right arm in 12 patients and the left in 6, with the injury being on the dominant side in 13 patients. The cause of the fracture was a motor vehicle accident in 7 cases (38.9%), fall from a height in 7 (38.9%), and a simple fall in 4 (22.2%). According to the Mayo classification system, 11 cases were classified as type IIB (61.1%) and 7 as type IIIB (38.88%) (Fig. 1). Four patients had open fractures (Gustilo-Anderson type I in three and type II in one). Seven patients had concomitant osseous injuries of the elbow (radial head fracture in four and coronoid fracture in three) (Table I).

All operations were performed with the patient under general anesthesia and in a lateral decubitus position via a pneumatic tourniquet. The fracture was exposed through a posterior midline incision with the proximal end curving to the lateral aspect of the olecranon. Temporary fixation was made with Kirschner wires after reduction and controlled with a fluoroscope. Four patients who were seen to have bone defects after reduction were treated with cancellous bone grafts from the iliac crest to restore bony congruence. Osteosynthesis was performed with a 3.5-mm low-contact locking olecranon plate (with 8-10 holes). Locking 3.5-mm screws were preferred in the proximal part, and 3.5-mm cortical screws were used to achieve compression at the fracture line, with locking screws placed in the shaft region. Additional cortical screws or Kirschner wires were used as needed (Fig. 2). In the 4 cases with radial head fractures, headless compression screws were used in 3 and plate-and-screw osteosynthesis was used in 1. In these cases, the radial head was accessed by laterally extending the dissection, with no additional incisions. In 3 patients with coronoid fractures, fixation was achieved with 3.5-mm cortical screws. In the 1 case with residual instability, a medial collateral ligament repair was performed. Range of motion of the elbow and stability of the osteosynthesis were assessed at the end of the procedure.

For antimicrobial prophylaxis, a first-generation cephalosporin (cefazolin sodium [Sefazol; Mustafa Nevzat, Istanbul, Turkey]) was used intravenously, with 2 g injected 30 minutes before surgery and 1 g injected every 6 hours for the first 2 postoperative days in all patients.

Figure 1 Preoperative radiograph of type IIIB olecranon fracture.

In cases with no additional injuries, an adjustable elbow brace was used after the operation, and active elbow exercises were initiated on the second day. During the first 3 weeks, the brace was locked in extension at night. In 7 cases with additional injuries to the elbow, posterior bracing with only passive motion being allowed was used for 2 weeks, followed by a controlled exercise program including active elbow exercises.

The results were evaluated with respect to clinical and radiologic findings. We used the Broberg-Morrey scoring system, consisting of 4 sections—mobility (40 points), grasping ability (20 points), stability (5 points), and pain (35 points)—for clinical assessment.[5] In this classification, 95 to 100 points indicates an excellent outcome; 80 to 94 points, a good outcome; 60 to 79 points, a fair outcome; and less than 60 points, a poor outcome. We evaluated upper extremity symptoms and function with the QuickDASH (Disabilities of the Arm, Shoulder, and Hand) rating scale.[15] We measured bilateral elbow range of motion with a goniometer. Affected and unaffected extremities were statistically compared, and statistical evaluation was performed with the use of a paired t test, by use of 2-armed paired P values.

During the follow-up period, radiologic union and implant failure or reduction loss were evaluated with elbow radiographs on anterior-posterior and lateral views. The mean follow-up time was 23 months (range, 7-42 months).

Results

An anatomic reduction was achieved in all patients excluding 3 cases in whom gaps greater than 2 mm were detected on radiographs taken after surgery. The mean tourniquet time was 42 minutes (range, 34-75 minutes). Complete union was achieved in all cases during the follow-up period. The mean elbow range-of-motion values

Table I Patient data

No	Age (y)	Sex	Fracture type (Mayo)	Additional injury	Broberg-Morrey score	Quick-DASH score	Extension-flexion arc (°)	Pronation-supination arc (°)	Open fracture	Reoperation
1	38	M	IIB		84	11.36	130	145		
2	41	M	IIIB	Radial head fracture	84	47.72	100	120		
3	19	F	IIB		90	2.27	140	145		
4	52	F	IIB	Coronoid fracture + MCL	68	13.63	125	140	+	
5	59	F	IIIB	Coronoid fracture	68	59.09	120	135		Hardware removal
6	24	M	IIB		95	6.81	140	150		
7	35	M	IIIB		90	9.09	130	135		
8	32	M	IIIB	Radial head fracture	65	27.2	120	120	+	
9	67	M	IIIB	Coronoid fracture	70	4.54	125	130		
10	50	F	IIB		95	0	134	130		
11	46	M	IIIB		88	4.54	120	128		
12	57	M	IIIB	Radial head fracture	50	75	25	30	+	Hardware removal plus capsular release
13	41	M	IIB		95	4.54	120	140		
14	35	F	IIB		82	2.27	125	142		
15	29	M	IIB		85	9.09	100	130	+	
16	22	M	IIB		92	2.27	130	145		
17	39	M	IIB	Radial head fracture	68	20.45	82	75		
18	53	M	IIB		95	4.54	125	134		

MCL, Medial collateral ligament.

Figure 2 Osteosynthesis with locking plate and additional screw and Kirschner wire.

measured 116° in flexion-extension and 126° in pronation-supination. A statistically significant difference in range of motion was found when the results were compared with the unaffected elbow (P = .003 and P = .013, respectively) (Table II). The mean Broberg-Morrey score was 81. According to this scoring system, 4 cases were considered very good; 8 cases, good; 5 cases, fair; and 1 case, poor. The mean QuickDASH score was 17 (range, 0-75). When Mayo type IIB and IIIB fractures were compared, the differences in Morrey elbow score, QuickDASH score, and elbow range of motion were not statistically significant; however, the Morrey elbow score and QuickDASH score were found to be slightly better in cases with type II fractures (P = .1019 and P = .0562, respectively) (Table III). There were no infections or nerve palsies in the early postoperative period. During follow-up, the reduction obtained during surgery was maintained in all cases, and there were no implant failures. During long-term follow-up, elbow stiffness along with heterotopic ossification developed in 1 case with open fracture and concomitant radial head fracture. This patient underwent a release procedure with hardware removal after union. In 1 case, plate exposure occurred 8 months after surgery due to material irritation. Patients with open fractures and additional injuries in the elbow were observed to be mostly in the fair and poor result groups.

Discussion

The Mayo system used in the classification of olecranon fractures is based on stability, displacement, and the quantity

Table II Statistical comparison of elbow joint range of motion between intact and affected sides regarding arcs of flexion-extension and pronation-supination

	Flexion-extension		Pronation-supination	
	Affected	Intact	Affected	Intact
Mean	116.166°	145.833°	126.388°	154.055°
SD	27.008°	4.287°	29.216°	4.696°
SEM	6.366°	1.011°	6.886°	1.107°
P	.003		.013	

Table III Statistical comparison between type IIB and type IIIB cases regarding Morrey score, QuickDASH score, and elbow joint range of motion

Fracture type	Morrey score		QuickDASH score		Flexion-extension		Pronation-supination	
	IIB	IIIB	IIB	IIIB	IIB	IIIB	IIB	IIIB
Mean	86.636	70.5	7.020	32.454	122.818°	105.714°	134.272°	114°
SD	9.553	13.620	6.136	28.532	17.400°	36.791°	20.713°	37.554°
SEM	2.880	5.560	1.850	10.784	5.246°	13.906°	6.245°	14.194°
P	.1019		.0562		.1118		.1046	

of comminution. Accordingly, nondisplaced fractures are classified as type I, fractures displaced over 3 mm with a stable elbow joint are classified as type II, and fractures that are unstable in relation to the humerus along with displacement are classified as type III fractures. In addition, the presence and absence of comminution in the fracture constitute subgroups A and B, respectively.[3] All cases in our study group were patients with type IIB and type IIIB injuries. Patients with type IIIB injuries had instability in the ulnohumeral joint that could be diagnosed radiographically.

All olecranon fractures are intra-articular injuries. The aims of treatment are to provide absolute stability of the fracture and to restore the joint surface to allow range-of-motion exercises in the early postoperative period.[20] A satisfactory range of motion with postoperative rehabilitation is critically important for successful clinical outcomes. It has been shown that stable fixation allowing early-term rehabilitation has a positive impact on elbow range of motion and improves clinical outcomes.[7,8] Olecranon fracture patterns may vary from simple transverse fractures to comminuted and unstable fractures. Reduction quality obtained at surgery affects clinical outcomes independent of the fracture type.[3]

Tension-band wiring with Kirschner wires is widely used in the surgical treatment of olecranon fractures, especially non-comminuted transverse fractures, and may provide a stable construct to allow early joint motion.[11,23,24] However, in comminuted fractures, particularly in cases with bone loss, initiating early movements after tension-band wiring osteosynthesis may cause problems.[2] Subchondral bone comminution opposite the tension-band construct may cause failure in compression.[3] The use of tension-band wiring in comminuted fractures may also cause contractions in the sigmoid notch.[4] In the biomechanical study by Fyfe et al,[9] whereas adequate rigidity was ensured by the use of tension-band wiring in models with transverse osteotomies, a significantly more stable fixation was achieved by plate fixation in comminuted osteotomies.

In the study by Gordon et al,[11] it was shown that posterior plate osteosynthesis along with an intramedullary screw was the most stable fixation approach for comminuted fractures. Hume and Wiss[16] conducted a comparative study in patients with displaced fractures: the percentage of clinically good results was 37% and that of radiologically good results was 47% in the tension-band wire group, versus 63% and 86%, respectively, in the plate group. Akman et al[1] reported good and excellent results in 75.6% of patients; however, it was found that these results varied according to fracture type and with associated injuries. Murphy elbow scores obtained in comminuted fractures were mostly fair and poor in their study. Anderson et al[2] reported their experience with plate treatment of olecranon fractures and found no significant difference between comminuted and simple fractures. Previous reports in the literature found no significant relationship between elbow range of motion and fracture pattern in patients undergoing plate treatment of olecranon fractures.[3,16] Although the results of treatment with tension-band wires in comminuted fractures were poor, the lack of a difference between fracture types when using a plate can be explained by the stability of plate osteosynthesis.

We believe that plate fixation should predominantly be used in comminuted olecranon fractures where tension-band wiring cannot be applied successfully. Other indications include oblique fractures in the distal aspect of the middle part of the trochlear notch, concurrent coronoid fractures, and joint subluxation with an associated Monteggia fracture.[20] Plate choices include one-third tubular plates, 3.5-mm limited-contact dynamic compression plates or reconstruction plates, hook-like plates, and locking anatomic plates.[3,6,19,20] In a cadaveric study by Buijze and Kloen,[6] there were no differences between locking compression plates and one-third tubular plates regarding fixation rigidity and strength. Locking compression plates provide superior mechanical stability at the fracture line because they provide angular stability. The locking-plate technique combines the direct healing of osteon bridging seen with lag screw compression and the axial and angular stability provided by a locking-plate construct. It avoids the need for a friction force at the bone-implant interface for fixation stability and therefore allows tensioning through the plate via the fixed-angle locking screws. Furthermore, the normal anatomy of the proximal olecranon process accommodates unicortical screw purchase only, because of the trochlear notch articular surface; hence, a locking screw becomes mandatory. Locking screws have been shown to provide excellent stability even with unicortical purchase. This proves to be important when dealing with small fracture fragments.[6,10,12] Although the results in our series in cases with type IIB fractures were slightly better compared with cases with type IIIB fractures, the difference was not statistically significant. Although this study supports the success of locking plates, further studies in larger patient populations are necessary.

Plates are usually placed on the dorsal face of the ulna because of the creation of a tension-band effect and to achieve high biomechanical stability.[20] Posterior plating is considered to be biomechanically superior to dual plating applied from the medial and lateral aspects.[11] In our study, the plates were applied from the posterior aspect in all patients.

In recent years, an increasing number of published studies have reported successful results with locking-plate osteosynthesis in comminuted olecranon fractures. Buijze and Kloen[6] reported good and excellent results with locking compression plates in combination with axial intramedullary screws in 15 of 16 patients. In their series, there were 10 comminuted fractures. Siebenlist et al[22] applied anatomically pre-shaped locking compression plates in comminuted proximal ulnar fractures and reported good and excellent results in 14 of 15 patients. Of the 15 patients in their study, 11 had comminuted olecranon fractures. In our study group, the percentage of good and excellent results was 67%, and this percentage appears to be low compared with similar studies. However, our study differs from other studies in that it included only patients with comminuted intra-articular fractures.

The most frequent complication reported after internal fixation of olecranon fractures is hardware irritation.[8,13] Subcutaneous placement of the plates is a risk factor for the development of such symptoms. However, painful hardware is more frequent in tension-band wiring than plate fixation.[14,16,17,24] For plate osteosynthesis, hardware removal rates are reported to be 0% to 20% in the literature. This percentage was reported to be 9.3% in the series of Anderson et al[2] and 56% in that of Buijze and Kloen.[6] In the study by Buijze and Kloen, impingement during elbow extension caused by the plate was another indication for hardware removal. In our study, we did not observe any impingement in the olecranon fossa due to the plate, and this situation has been attributed to the use of plates designed specifically for use on the olecranon. Two patients in our series underwent plate removal, one for irritation and the other for the development of elbow stiffness. This low rate of removal could be because of the use of anatomically matching plate systems and the relatively short duration of follow-up. Loss of reduction and articular surface incongruity is also reported to be higher with the use of tension-band wires than with plate fixation.[16] During follow-up, loss of reduction did not develop in any of our patients.

Limitation in joint movement is common after elbow surgery; however, it is mostly limited to a 10° to 15° loss in extension with olecranon fractures.[20] The mean elbow joint range of motion in our series was found to be 116° in flexion-extension and 126° in pronation-supination. These values are within the functional limits of elbow joint range of motion.[18] Previous reports have shown worse elbow ranges of motion than our study, especially in patients with radial head, capitellum, and Monteggia fractures.[13] In our study, the mean elbow range of motion in cases with additional injuries was 100° in flexion-extension and 107° in pronation-supination.

Conclusion

The clinical results of olecranon fractures frequently differ because of fracture type and concomitant injuries and are independent of the type of fixation. Accurate repair of the joint surface and absolute stability that allows initiation of early joint motion are necessary for successful outcomes.[8,20,23] Although our study is not a comparative study, it is significant because it included only comminuted fractures and used a locking plate in all cases. We recommend plate-and-screw osteosynthesis for comminuted fractures to ensure more stable fixation, to provide accurate joint restoration, and to prevent loss of elbow range of motion.

Disclaimer

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