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Original Article

Comminuted olecranon fractures treated with anatomically preshaped locking and nonlocking plates: A retrospective comparative study

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ABSTRACT

Purpose: The purpose of this study was to investigate the clinical outcome of patients with comminuted olecranon fractures treated with anatomically preshaped locking and nonlocking plates.
Methods: From 2006 to 2010, 30 patients with comminuted olecranon fractures were treated with anatomically preshaped locking or nonlocking plates. Patients with a minimum follow-up of 12 months after surgery were evaluated for this analysis. Validated patient-oriented assessment scores including the Mayo Elbow Performance Index (MEPI), range of motion (ROM), and patient satisfaction were evaluated. All patients had follow-up radiographs.
Results: Ten patients treated with nonlocking plates (Group A) and 13 treated with locking plates (Group B) were included in this analysis. The average patient age was 36.5 years in Group A and 43.4 years in Group B. The mean MEPI (95 vs. 94), flexion/extension arc (124° vs. 120°), and time to union (3.1 months vs. 2.9 months) were not significantly different between Groups A and B, respectively. No infection occurred in either group. There were three complications in Group A, including one screw pullout, one case of elbow stiffness, and one case of residual valgus deformity. There were three patients in each group who received implant removal 11.3 months and 13 months, respectively, after surgery.
Conclusion: Both preshaped locking and nonlocking olecranon plates can achieve good results in the treatment of comminuted olecranon fractures.

1. Introduction

Olecranon fractures comprise 10% of all upper extremity fractures.[1] Traditionally, noncomminuted olecranon fractures can be effectively stabilized with tension band wiring and achieve good results.[2] Comminuted fractures of the olecranon, especially those involving the coronoid process and those associated with a transolecranon fracture-dislocation, however, often require plate fixation because tension band fixation cannot provide enough stability to allow early postoperative motion of the elbow.[2–7] In addition, plate fixation lowers the risk of fatigue failure caused by extreme bending stresses.[8] Plate fixation is the current gold standard for the treatment of comminuted olecranon fractures.[9–13]

Locking compression plates (LCPs) have become more popular in recent years and are believed to provide more stability and reduce complications such as screw pullout.[14–16] There are few studies regarding the results of LCPs in the treatment of comminuted olecranon fractures. Buijze and Kloen[8] reported excellent fracture union rates and good clinical outcomes using a titanium 3.5-mm LCP (Synthes, Zeist, Netherlands). Siebenlist et al[17] also reported excellent results and a low rate of symptomatic hardware removal using 3.5 mm anatomically preshaped olecranon locking plates.

To our knowledge, a comparison between anatomically preshaped LCP and nonlocking plates for the treatment of comminuted olecranon fractures has never been reported. The purpose of the study was to review the results of anatomically preshaped LCPs and nonlocking plates used for the treatment of comminuted olecranon fractures. We hypothesized that the LCP system provides equal or superior fixation and clinical results in the treatment of comminuted olecranon fractures as compared to the nonlocking system.

2. Materials and methods

This was a retrospective comparative cohort study approved by the Institutional Review Board of the authors' hospital. From 2006

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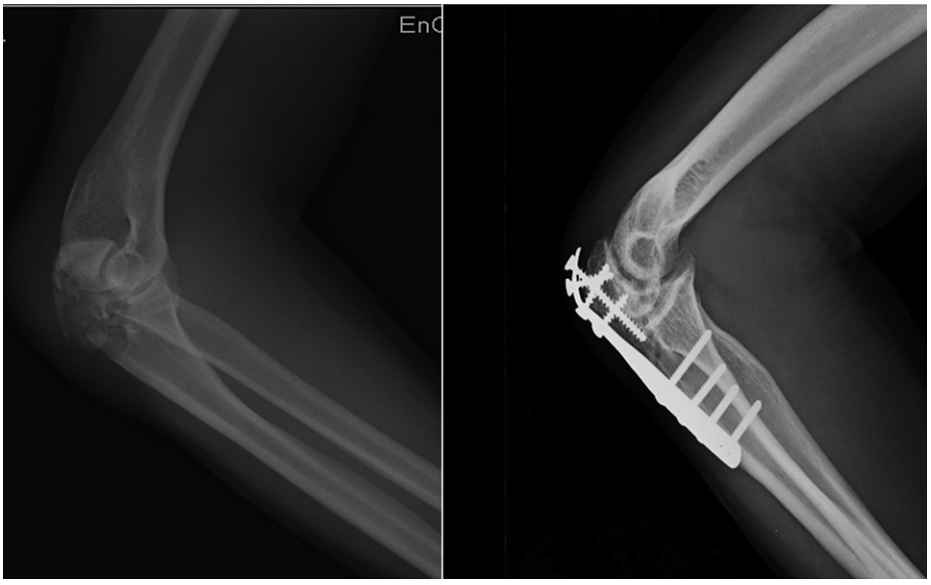

Fig. 1. Olecranon fracture fixed with preshaped nonlocking plate.

to 2010, patients in whom comminuted olecranon fractures (AO type 2.1-B3.3 B1.3, C2.3, and C3.3) were diagnosed that were managed with posterior plating with either anatomically preshaped nonlocking plates or olecranon locking plates were included in the study. The patients were invited for clinical examination after a minimum of 12 months of follow-up after surgery.

There were 23 patients who completed the evaluation. Ten patients were treated with an anatomically preshaped nonlocking plate in Group A (periarticular plates; Zimmer, Warsaw, IN, USA) (Fig. 1), and 13 patients with an olecranon locking plate in Group B (LCP) (Fig. 2). Patient demographic data are presented in Table 1. There were four males and six females in Group A and six males and seven females in Group B. The average patient age was 36.5 years in Group A and 43.4 years in Group B. All patients were right arm dominant. In Group A, the right elbow was involved in seven patients, and the left elbow in three patients. In Group B, the right elbow was involved in five patients and the left elbow in eight patients. There were four patients in Group A and six in Group B who had associated elbow injuries including radial head fracture, coronoid fracture, or elbow dislocation with instability.

All patients underwent surgery within 24 hours after injury by the senior author. After general anesthesia and a single dose of

Fig. 2. Olecranon fracture fixed with preshaped locking compression plate.

Table 1
Patient demographic data.

	Group A ($n = 10$)	Group B ($n = 13$)
Age (y), average	36.5	43.4
Male/female	4/6	6/7
Right/left	7/3	5/8
Associated elbow injury		
Radial head fracture	1	4
Coronoid fracture	1	1
Elbow dislocation	2	1
Collateral ligament rupture	0	4
Total	4	6

cephalosporin for prophylaxis, patients were placed in the decubitus position with the injured arm on a paddle, allowing elbow flexion beyond 90°. A midline incision was made under tourniquet control. The ulnar nerve was explored in cases in which there were associated injuries such as radial head fractures or coronoid fractures. The reduction was secured by clamps and temporarily by Kirschner wires after realigning the articulate surface. The plate was applied and fixed with the ulna in compression mode first. Next, bicortical compression screws were inserted in Group A and bicortical locking screws were inserted in Group B (Figs. 1 and 2).

Radial head fractures were fixed with wires and screws in three patients, and radial head replacement (Swanson Titanium Radial Head Implant; Wright Medical Technology, Arlington, TN, USA) was performed in two patients with comminuted radial head fractures (Mason type III or IV) (Fig. 4). The collateral ligament was repaired with suture anchors if instability was noted.

The elbow was fixed with long-arm splinting with 90° flexion and full supination after surgery. Active range of motion (ROM) was started 1 week after surgery. A custom-made progressive stretching static splint was made for each patient[18,19] (Fig. 3). Patients were encouraged to stretch the elbow joint in both flexion and extension within their tolerance of pain. Outpatient clinic visits were arranged every 2 weeks for the first month, and then monthly until fracture healing or full ROM was achieved. Outpatient physical therapy was arranged if the recovery of ROM was not satisfactory.

For outcome evaluation, patients who had undergone surgery at least 12 months previously were invited for clinical evaluation in January 2011. Validated patient-oriented assessment scores including the Mayo Elbow Performance Index (MEPI), flexion/extension arc, pronation/supination, and patient satisfaction were evaluated. All patients had follow-up radiographs. Fracture union was defined as healing of three of four cortices and absence of pain. The maximum score of the MEPI is 100 (45 for no pain, 25 for ability to perform functional activities, 10 for stability, and 20 for motion). A score >90 was considered excellent, 75 to 89 good, 60 to 74 fair, and <60 poor. Subjective satisfaction was divided into five grades (1: highly dissatisfied, 2: dissatisfied, 3: moderate, 4: satisfied, and 5: highly satisfied).

Statistical analyses were performed using SPSS statistical software for Windows, version 18 (SPSS, Somers, NY, USA). The Mann-Whitney U test was used for analysis of continuous variables and Fisher exact test for categorical variables. Statistical significance was defined as $p < 0.05$.

3. Results

There were 10 patients in Group A and 13 patients in Group B who completed the evaluation, with an average follow-up of 37 months in Group A and 14 months in Group B. The mean flexion and extension arc was 124° (range, 16°–140°) in Group A and 120° (range, 18°–138°) in Group B. The mean pronation/supination arc was 163° in Group A and 150° in Group B. The mean MEPI was 95 in Group A and 94 in Group B. The results in Group A were excellent in eight patients and good in two patients; the results in Group B were excellent in 10 patients, good in two patients, and fair in one patient. The mean time to union was 3.2 months in Group A and 2.9 months in Group B. There were eight patients in Group A (80%) and 10 patients in Group B (77%) who were satisfied or highly satisfied with the results.

A comparison of the clinical results between the two groups is shown in Table 2. There were no statistically significant differences in MEPI, union time, flexion/extension arc, pronation/supination arc, and satisfaction between Group A and Group B. All fractures had healed completely at the time of clinical evaluation.

Three patients in Group A had postoperative complications. One patient (Case 7) had residual valgus deformity after 48 months, but still had a good MEPI (85) and a 30–135° flexion/extension arc. She underwent elective implant removal 6 months after surgery due to implant irritation. Another patient (Case 1) experienced elbow stiffness and underwent implant removal and contracture release 9 months after surgery. At final evaluation, she had a good flexion/extension arc (30–135°) and excellent MEPI (100). The last patient

Fig. 3. Comminuted radial head fracture treated with radial head replacement.

Table 2
Comparison of clinical results between groups.

Clinical results (average)	Group A ($n = 10$)	Group B ($n = 13$)	p
MEPI			
Total	95	94	0.77
Excellent	8	10	
Good	2	2	
Fair	0	1	
Union (mo)	3.2	2.9	0.66
Flexion/extension arc (°)	124 (16–140)	120 (18–138)	0.72
Pronation/supination arc (°)	163	150	0.31
Satisfaction			
High	1/7/2	4/6/3	
Satisfied	8/10 (80%)	10/13 (77%)	
Moderate	1/10 (10%)	3/13 (23%)	
Complications	3 (valgus deformity, one screw back-out, stiffness)	0	
Infection	0	0	
Implant removal	3 (13 mo after surgery)	3 (11.3 mo after surgery)	

MEPI = Mayo Elbow Performance Index.

Table 3
Clinical results between different series.

	Locking (Synthes olecranon locking plate)	Nonlocking (Zimmer contoured periarticular plate)	Sienbelist[19] (Synthes olecranon locking plate)	Buijze et al[3] (Synthes LCP)	Anderson et al[1] (contoured nonlocking)
No. of patients	13	10	15	19	24
MEPI	94	95	97	93	89
Arc (°)	120	124	120	84–128	120
Union (mo)	2.9	3.2	3	4	4

MEPI = Mayo Elbow Performance Index.

(Case 5) had one screw backout 4 months after surgery, but the fracture healed completely (Fig. 5). Three patients in Group A and three patients in Group B underwent implant removal 11.3 months and 13 months, respectively, after surgery due to implant irritation. None of the patients had infection.

4. Discussion

The study revealed no significant difference between patients with comminuted olecranon fractures treated with either anatomic nonlocking or locking plates. This is the first comparative study between anatomic nonlocking and locking plates in the treatment of comminuted olecranon fractures.

The aims of surgical treatment for comminuted intra-articular olecranon fractures are realignment of the long axis, restoration of joint stability, articular congruity, normal strength, and a pain-free functional arc of motion of the elbow.[8] Postoperatively, immediate functional rehabilitation of the elbow is essential given that immobilization after an injury, even for a period as short as 3 weeks, has been shown to adversely affect the ROM of the elbow and the functional outcome.[18] Therefore, stable fixation is important. Furthermore, long-term reliability of plate fixation is crucial because extreme bending stresses at the proximal part of the ulna occasionally can lead to fatigue failure of internal fixation devices.[19,20]

By formation of a rigid, fixed-angle coupling, the locked plate and screws construct is more resistant to failure from sequential screw loosening and pullout.[14] Because all the screws in a single bone fragment are locked to the plate at fixed angles, they must fail (i.e., pull out) as a unit rather than individually and sequentially.[21] This feature may be of particular advantage in osteoporotic bone with thinner cortices; in this situation nonlocking screws cannot generate as much plate-to-bone compression, so the frictional forces resisting motion are less.[14] In our study, although the fracture healed completely, one patient in the nonlocking plate group did experience screw backout 4 months after surgery, although the fracture had united at that time. This complication may have been avoided if a locking plate construct had been used. One patient in the nonlocking plate group had a residual valgus deformity due to malunion of the radial head, but the functional result was good without any limitation.

Because of the mechanical strength advantages of the locking plate system, patients treated with locking plates should be able to participate in a more aggressive rehabilitation program. However, the clinical results of the two groups were not different in our study. The results, however, should be interpreted carefully because our study collected functional outcomes at more than 12 months after surgery and this study design might obscure the initial advantages of the locking plate system, despite the same final outcomes between two groups. Thus, further prospective studies with sequential evaluation of functional outcomes indicated that the entire process of fracture healing is necessary to truly evaluate the differences between the two systems. In addition, the patients in our series were relatively young (an average age of 36.5 years in Group A and 43.4 years in Group B), and osteoporosis was not so severe to obscure the advantages of locking plates.

Unlike traditional rehabilitation protocols that began active ROM exercise 2 or 3 weeks after surgery,[8,17] our rehabilitation program began passive, assisted ROM exercise at 1 week after surgery. By using a custom-made progressive stretching static splint, we are able to provide postoperative protection and ROM movement, thus advancing the rehabilitation program.[22,23] This splint also has a self-adjustable spiral rod (Fig. 3) so that patients can adjust the motion arc according to their own tolerance, which may reduce the possible iatrogenic injuries caused by the physical therapist's manipulation. This also reduces the use of postoperative nerve blocks and continuous passive motion. Patients can begin to increase the motion arc once the pain starts to decrease; this is the unique advantage of our design that previously used splints lack.

In 2007, Anderson et al[20] reviewed the results of olecranon fractures treated with a congruent elbow plating system. The authors emphasized the use of a proximal so-called home run screw for compression at the fracture site. There were 24 patients evaluated after a mean follow-up of 2.2 years. Among these, only six had a comminuted fracture type. A mean MEPI of 88 was reported, which is less than that reported in our study. In 2009, Buijze et al[8] reported 16 patients with comminuted olecranon fractures managed with contoured LCP fixation. They emphasized the advantage of positioning monocortical locking screws, which did not interfere with the placement of intramedullary screws. After a mean follow-up of 22 months, the average MEPI was 93. However, 56% of the patients (9 of 16) underwent implant removal after a mean of 12 months postoperatively due to symptomatic hardware. The author hypothesized that the LCP does not contour closely to the proximal ulna, causing prominence and soft tissue irrigation. In 2010, Siebenlist et al[17] reported 14 comminuted olecranon fractures, including three posterior Monteggia fractures, managed with

Fig. 4. The radial head fracture was fixed with screws and the lateral collateral ligament was repaired with suture anchor.

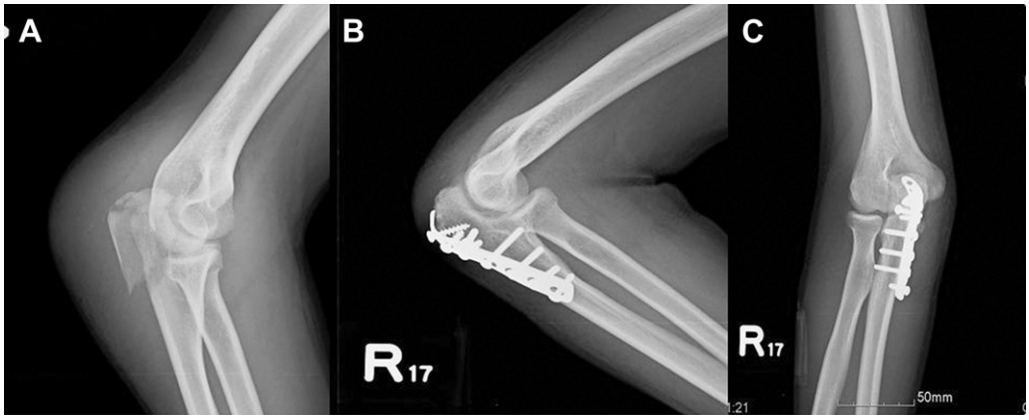

Fig. 5. (A) The olecranon fracture was fixed with (B) a preshaped non-locking plate. (C) One screw backed out after 4 months but the fracture healed.

preshaped olecranon LCPs. After a mean follow-up of 16 months (range, 8–29 months), an average MEPI of 97 was reported. The flexion/extension arc was 129° (range, 12–141°). Only one patient underwent implant removal due to symptomatic hardware. The author emphasized better patient compatibility of preshaped olecranon LCP.

In our series, union was achieved in all cases and the mean MEPI was 95 in Group A and 94 in Group B. However, there were six patients who underwent implant removal due to implant irritation. We believe that the triceps tendon over the olecranon tip should be split to allow the implant to fully fit with the olecranon to reduce the chance of implant irritation. Our results were at least comparable or better than those of other series (Table 3). We believe that stable fixation and good postoperative rehabilitation with a custom-made progressive stretching static splint were the key steps for successful treatment.

The limitations of the study are its retrospective nature and small number of cases. The follow-up periods were different between the two groups, and we did not calculate the power. However, because the incidence of comminuted olecranon fractures is low, our case numbers are the largest of which we are aware Figs. 4 and 5.

5. Conclusion

Comminuted olecranon fractures can be successfully treated with locked or nonlocked preshaped plating and an aggressive postoperative rehabilitation protocol. However, in older patients or those with osteoporosis, the possibility of screw backout using a nonlocked system should be taken into consideration. Further prospective studies are needed.

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