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Fixation of Distal Ulna Fractures by Distal Ulnar Locked Hook Plate

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ABSTRACT

Background: Distal ulna fractures are often found in conjunction with distal radius fractures, and the complexity of the interaction of the distal ulna with the radio-ulnar joint and triangular fibrocartilage complex makes understanding and treatment of distal ulna fractures challenging.

Objective: To determine the efficacy and analyze the results of Locking Compression Distal Ulna Hook Plate (LC-DUP) in patients suffering from distal ulnar fracture (either isolated or associated with distal radius fractures).

Patients and methods: This prospective clinical trial study included 18 patients. The age of the studied group ranged from 22 to 58 years; half of the group had age ranged from 30 to 40 years. They were suffering from distal ulna fractures and were treated by locked compression distal ulnar hook plates during the period from November 2019 to July 2020.

Results: All patients eventually achieved full union. Only two of them had delayed union. The radiological and clinical assessment of fracture site and DRUJ was promising. More than three quarters of patients had excellent outcome, while the rest quarter; half of them had good, and the other half had satisfactory outcome according to the Modified MAYO Score, which had mean of 90.5 ± 14.6. While, the mean of the Quick DASH score was 9.8 ± 5.8.

Conclusion: The good outcomes achieved in this study suggest that the use of the distal ulna hook plate could be an alternative treatment method for intra-articular ulna neck or head fractures, as well as basal oblique ulnar styloid fractures.

Keywords: Distal Ulna Fractures, Distal Ulnar Locked Hook Plate.

INTRODUCTION

Most fractures of the distal ulna, which are associated with fracture distal radius, are well aligned and stable once the distal radius has been realigned and secured. At that time, there is no benefit from the internal fixation of the ulnar fracture. Unstable and displaced fractures require open reduction and surgical stabilization, usually with a mini-fragment plate to avoid derangement of the load-bearing surface [(1)].

Locking Compression Distal Ulnar Plate (LC-DUP), recently designed for use in distal ulna fractures**.** Its anatomically precontoured design reduces soft-tissue dissection and the need for hardware removal [(2)]. The section of the implant applied to the ulnar head accepts fixed-angle locking screws for angular stability, while the shaft component accepts both locking and non-locking cortical screws for dynamic compression and improved length adjustment [(3)]. Distally, an undercut allows plate bending for further adjustment. Distally the plate has two pointed hooks designed to hold the styloid securely and to provide a reference point for plate application [(4)]. The gap between the hook arms can be used to house a lag screw, which is necessary to stabilize the ulnar styloid. In total, the plate has seven holes: (a) three 2.0-mm locking coaxial screw holes for ulnar head fixation, which are divergent in direction to enhance stability and pullout strength in cancellous bone and to prevent screws interfering with each other. (b) Four or more proximal Combi holes, which allow both locking and non-locking screws to be inserted into the ulnar shaft. One of these holes is oval in shape to allow minor adjustments during initial positioning of the plate. These holes also allow screw placement in an eccentric fashion to apply axial compression when indicated by the fracture pattern [(5)].

Although designed for distal ulna fractures, the indications for the plate have now been extended to the treatment of distal ulna nonunion, including ulnar styloid nonunion, providing improved security in osteopenic bone [(6)]. A publication further extends its use for a novel ulnar shortening osteotomy technique performed at the metaphysis for the treatment of ulnocarpal abutment syndrome (UCAS), offering benefits over diaphyseal osteotomy [(7)]. However, the major benefit of the plate brings is angularly stable fixation of unstable and/ or displaced distal ulna fractures including comminuted head fractures, which frequently present a challenge to the surgeon [(2)].

The aim of this study was to determine the efficacy and analyze the results of Locking Compression Distal Ulna Hook Plate (LC-DUP) in patients suffering from distal ulnar fracture (either isolated or associated with distal radius fractures).

PATIENTS AND METHODS

This prospective clinical trial study included 18 patients. The age of the studied group ranged from 22 to 58 years, half of the group had age ranged from 30 to 40 years. They were suffering from distal ulna fractures and were treated by Locked compression

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distal ulnar hook plates. The study was conducted during the period from November 2019 to July 2020. The fractures were classified according to Q modifier classification at Orthopedic Department Zagazig University Hospitals, and Sabha Medical Center.

Inclusion criteria:

1. Intra-articular distal ulnar fracture.
2. Extra-articular distal ulnar fracture.
3. Unstable ulnar neck or head fracture with angulation more than 10 degrees.
4. Ulnar styloid process fracture.
5. Skeletal maturity.

Exclusion criteria:

1. Stable distal ulna fracture after distal radius fixation.
2. Pathological fracture.
3. Previous surgery on the affected wrist.
4. Open fractures.

Ethical Considerations:

An approval was obtained from Institutional Review Board (IRB) of Zagazig University and written informed consents were obtained from all patients.

All patients were subjected to:

Preoperative assessment:

1. History taking to assure functional activity.
2. Demographic data collection.
3. Clinical examination.
4. Laboratory investigations.
5. Radiographic evaluation.

Preoperative radiological assessment and classification:

PA and lateral views of the fractured wrist joint and distal ulna were taken for each patient to allow for preoperative assessment and classification of fractures. According to X-rays done, fracture patterns were classified according to a O Comprehensive Classification of fracture distal ulna (Q modifier Classification).

Method of fixation: Eighteen patients with distal ulnar fracture were managed with open reduction and internal fixation using the distal ulnar locking compression hook plate (Titanium). Amoxicillin/clavulinic acid was giving to our patients prior their general anesthesia.

Post-operative care and follow up:

Post operatively, all patients received parenteral antibiotics in the form of cefotaxime Na during their hospital stay in a dose of 1 gram every 12 hours and continued postoperatively for 1 day.

- All patients were encouraged to start active flexion and extension of finger one day postoperative within limits according to pain tolerance, quality of reduction, stability of fixation and the age of the patient.
- Patients were discharged 24 hours postoperative when the primary complications had been excluded.
- Instructions about movement of the wrist were taught to the patients.
- Two weeks post discharge the wound was examined and stitches were removed.

The following was done:

1. Postoperative radiographs (PA and lateral X-ray) were done to assess fracture reduction and plate position was scheduled for 2, 4 and 6 weeks postoperatively and at monthly intervals thereafter as needed until final follow-up to assess union.
2. Alignment was assessed by measurement of the angulation of the ulna metaphysis on postero-anterior radiographs with anatomical position (coronal plane) and lateral radiographs with 90° pronation (sagittal plane)**,** as well as evaluation of ulnar variance.
3. Wrist function was evaluated with wrist range of motion (ROM), modified Mayo wrist score and disabilities of the arm, shoulder and hand (DASH) score.
4. Range of motion of the wrist and forearm (extension, flexion, supination, and pronation) was measured using a goniometer.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA).

Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value ≤ 0.05 was considered significant.

RESULTS

Table (1): Age and sex of the studied group

Variable	The studied group (18)	
Age (years)		
Mean ± SD	35.9 ± 9.7	
Range	(22-58)	
Median	34.5	
Variable	**NO (18)**	**%**
Age grouping		
20-30 years	5	27.8%
30-40 years	9	50.0%
40-50 years	2	11.1%
50-60 years	2	11.1%
Sex		
Male	10	55.6%
Female	8	44.4%

This table showed that the mean age of the studied group was 35.9 ± 9.7 years ranged from 22 to 58 years; half of the group (50.0%) had age ranged from 30 to 40 years. In addition, this table showed that 55.6% of the studied group were males and 44.4% of them were females (Table 1).

Table (2): Smoking, mechanism of injury, associated injury and modified Q classification among the studied group

		NO (18)	%
Smoking	**Yes**	4	22.2%
	No	14	77.8%
Mechanism of injury	**Fall from height (FFH)**	9	50.0%
	Direct trauma	5	27.8%
	Road traffic accident (RTA)	4	22.2%
Associated injury	**Absent**	8	44.4%
	Present		
	Ipsi-Lateral distal Radius	9	50.0%
	Ipsi-Lateral Shaft Radius	1	5.6%
Modified Q classification	**Q1**	8	44.4%
	Q2	5	27.8%
	Q3	0.0	0.0%
	Q4	0.0	0.0%
	Q5	0.0	0.0%
	Q6	5	27.8%

Table (2) showed that 22.2% of the studied group were smokers while 77.8% of them were non-smokers. The commonest mechanism of injury was FFH among 50.0% of the studied group followed by direct trauma (27.8%) of the studied group, then RTA among 22.2% of the studied group. The commonest associated injury was Ipsi-lateral distal radius among 50.0% of the studied group, 5.6% of them had ipsi-lateral shaft radius while 44.4% of the studied group did not have any associated injury. Q1 was the commonest classification (44.4%) followed by Q2 and Q6 each of them were among 27.8% of the studied group.

Table (3): Time of union among the studied group

Variable	The studied group (18)	
ime of union (Weeks):		
Mean ± SD	**13.4 ± 3.2**	
(Range)	**(9-25)**	
Median	**12.5**	
Variable	**NO (18)**	**%**
Time of union		
9-15 weeks	**15**	**83.3%**
15-20 weeks	**2**	**11.1%**
20-25 weeks	**1**	**5.6%**

Table (3) showed that the union duration of the studied group was 13.4 ± 3.2 weeks ranging from 9 to 25 weeks. Most of the studied group (83.3%) had healing time ranged from 9 to 15 weeks.

Table (4): Modified MAYO score (pain intensity & activity) among the studied group

Modified MAYO Score	Variables	NO (18)	%
Pain intensity	**No**	**14**	**77.7%**
	Mild	**3**	**16.7%**
	Moderate	**1**	**5.6%**
Activity	**Without protection**	**5**	**27.8%**
	Limited	**3**	**16.7%**
	With protection	**8**	**44.4%**
	Unable to Return	**2**	**11.1%**

Regarding pain intensity, table (4) showed that about two-thirds (77.7%) of the studied group did not have pain, 16.7% had mild pain and only 5.6% had moderate pain. Concerning activity, 44.4% of the studied group could do their activity with protection followed by 27.8% did their activity without protection, 16.7% had limited activity and 11.1% were unable to return.

Table (5): Modified MAYO Score (range of motion & grip strength) among the studied group

Modified MAYO Score	Variables	The studied group (18) Mean ± SD
Range of motion	**Flexion**	**75.6 ± 6.7**
	Extension	**74.1 ± 4.9**
	Supination	**80.5 ± 7.9**
	Pronation	**74.2 ± 9.5**
	Ulnar deviation	**34.1±8.5**
	Radial deviation	**20.9 ± 4.6**
Grip strength	**Dominant injury**	**26.5 ± 3.3**
	% to the opposite side	**80.0%**
	Non-dominant injury	**24.5 ±1.3**
	% to the opposite side	**93.0%**

Regarding range of motion, table (5) showed that the range of flexion motion among the studied group had average of 75.6 ranging from 60 to 85. The range of extension motion among the studied group had average of 74.1 ranging from 60 to 80. The range of supination motion had average of 80.5 ranged from 65 to 90. The range of pronation motion had average of 74.2 ranged from 55 to 80. The range of ulnar deviation motion had average of 34.1 ranged from 15 to 40. Finally, the range of radial deviation motion had average of 20.9 ranged from 10 to 25.

Concerning grip strength, 80.0% of the dominant injury was to the opposite side and 93.0% of the non-dominant one was to the opposite side.

Table (6): Outcome by Modified MAYO score and the Quick DASH score among the studied group

Final outcome	The studied group(18) Mean ± SD		
Modified MAYO Score	**90.5 ± 14.6**		
The Quick DASH score	**9.8 ± 5.8**		
Final outcome	**Variables**	**NO(18)**	**%**
Modified MAYO Score	**Excellent**	**14**	**77.8%**
	Good	**2**	**11.1%**
	Satisfactory	**2**	**11.1%**
the Quick DASH score	**0-11 (No difficulty)**	**15**	**83.3%**
	12-22(mild difficulty)	**2**	**11.1%**
	23-33(moderate difficulty)	**1**	**5.6%**

Table (6) showed that **Modified MAYO score was** 90.5 ± 14.6 ranged from 52 to 100. Most of the studied group (77.8%) had excellent functional outcome, 11.1% had good functional outcome and 11.1% had satisfactory functional outcome. Regarding **the Quick DASH score,** it was 9.8 ± 5.8 ranged from 0.0 to 24. Most of the studied group (83.3%) had no difficulty, 11.1% had mild difficulty and moderate difficulty and 5.6% had satisfactory functional outcome.

Table (7): Complications distribution among the studied group

Complications	NO(18)	%
No	**14**	**77.8%**
Delayed Union	**2**	**11.1%**
Infection	**1**	**5.6%**
Prominent implant	**1**	**5.6%**

Table (7) showed that most of the studied group (77.8%) did not have any complications, 11.1% of them had delayed union, 5.6% had infection and 5.6% had prominent implant.

Case presentation

29 years old male patient with left isolated distal ulnar neck fracture, Q2 according to Q modifier classification and the fracture was fixed after 1 week. Union time = 13 weeks. ROM = 170°. Grip strength, 96% of contralateral side. Excellent outcome according to modified **Mayo score.**

Figure (1): Preoperative X-ray.

Figure (2): Postoperative X-ray

Figure (3): 13 weeks post-operative X-ray

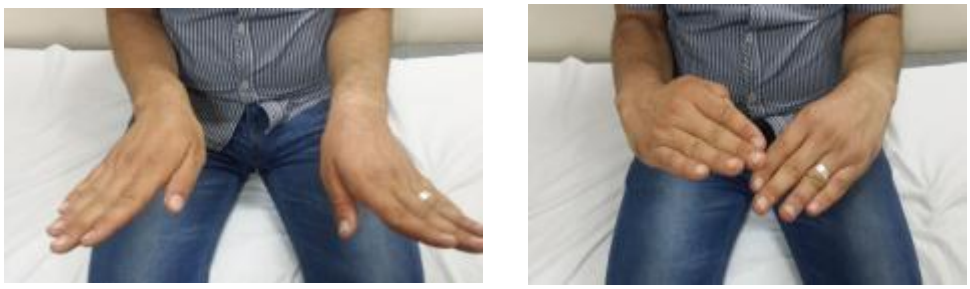

Figure (4): Range of motion

DISCUSSION

This clinical trial study included 18 participants underwent open reduction and internal fixation by LC-DUP for treating fracture distal ulna with or without distal radius fracture at Orthopedic Department, Zagazig University Hospitals and Sabha Medical Center. The mean age of the patient was 35.9 ± 9.7 years ranged from 22 to 58 years. 10 patients were males and 8 were females. Less than one quarter of the patients, (22.2%) were smokers and 78.8% were non-smokers participants, with one participant (11.1%) suffered from diabetes. Several mechanisms of injuries were reported in this series, with fall from height represented the most common cause of injury (50%), while direct trauma followed by road traffic accident (RTA) represented 27.8% and 22.2% respectively.

Half of the group (50.0%) had age ranged from 30 to 40 years. This is in agreement with **Lee *et al.*** [8] in their retrospective analysis of patients with DRF associated with ulnar styloid fracture where the mean age was 49.1 ± 11.6 years. Functional outcome of **Lee *et al.*** [8] had mean 90.0 ± 12.2 for MAYO wrist score and 9.2 ± 12.7 for DASH score, which was close to the functional outcome of our study. A positive correlation was found between functional outcome and complication rate regarding the age variability, the more the age the worst the outcome and the higher the complication rate. This is might be due to decrease bone quality, union rate and wrist functions with increased the age, and vice versa. Our results meet with **Tabl** [9] results who had age close to our study (34 ± 6.2). He reported a mean mayo score of 83.5. The excellent group was 15 patients (75%), good was three patients (15%), satisfactory was two patients (10%), while complications occurred only in two patients (10%).

Cha *et al.* [10] compared between open reduction internal fixation (ORIF) and conservative treatments of distal ulnar fractures (DUF) associated with distal radius fracture (DRF). The total mean of age in his study was 67.5 years, which was older age group of patients. He reported a DASH score of 13 ± 4 for the patients treated operatively and 14 ± 3 for conservative treatment group. This is high DASH score comparing with the Quick DASH score of current study (9.8±5.8) and may be due to the older age of his patients.

Concerning the effect of smoking on fracture healing, which is multifactorial as it causes changes at the fracture site including hypoxia and modification of cellular metabolic activity. Nicotine is a powerful vasoconstrictor causing reduction in peripheral blood flow and carbon monoxide reduces the oxygen-carrying capacity of the blood through the formation of carboxyhemoglobin [11].

A systemic review done by **Patel *et al.*** [12] where 39 patients underwent to ulna-shortening osteotomies, smokers had a longer time to union and higher incidence of delayed union or nonunion. The mean time to union was 7.1 months in smokers and 4.1 months in nonsmokers, and 30% of smokers experienced delayed union or nonunion compared to zero% of the non-smokers. In addition, **Hall *et al.*** [13] studied the impact of obesity and smoking on outcomes after volar plate fixation of distal radius fractures. They observed significant effect on the functional outcomes at 12 months follow-up. They found a significant higher Quick DASH score (18 + 23) in the smoker group compared to the non-smokers (9 + 14). Four patients included in studied cases (22.2%) were smokers, while 14 patients (77.8%) were non-smokers. Three patients of the smokers were complicated two with delayed union and one with superficial infection with only one patient reporting an excellent functional outcome, while 92.8% of non-smokers had excellent outcomes according to modified Mayo score.

The distal ulna anatomy is peculiar with most of the distal shaft covered by tendons and ligaments. Also, the cortical bone is predominant in the fine architecture of this area compared to the distal radius. These factors with the distal ulnar fracture configuration, comminution, age of patient and stability affect the rate of union of DUF. The surgical management can hinder the union if poor stability was achieved and if extensive sub-periosteal dissection was encountered during the surgery.

All studied fractures achieved union and good radiological results. Functional outcomes were promising, including wide wrist ROM and no DRUJ instability. The reported union time in the studied patients was 13.4 ± 3.2 weeks ranged from 9 to 25 weeks, where most of them (83.3%) healed in less than 15 weeks. In the study conducted by **Lee *et al.*** [4], the mean time of union for DUF fixed with DULP was 12.5 weeks (range, 9-18 weeks). **Manjappa *et al.*** [14] reported in the study of surgical management of forearm

bone fractures in adults using limited contact dynamic compression plate that the average time for union was 17 weeks. **Tabl** [9] achieved radiographic union at an average of 8.6 ± 0.73 weeks ranged from 6 to15 weeks post-operative.

Delayed union in our study occurred in 2 patients (11.1%), whereas one patient (4%) in **Lee, *et al.*** [4] study who also used the DULP for DUF. **Cha *et al.*** [10] divided his study group into two groups, first group treated surgically and showed one patient (3.4%) with delayed union while the second group, which was treated conservatively showed two (6.25%) delayed union patients.

This higher percentage in our study maybe due to small sample size, and the associated risk factors that affect the bone healing process, as both of delayed union patients were diabetic, smokers and aged above 50 years. This explanation meets with results published by **Gaspar *et al.*** [15], which revealed that time of union was significantly increased in smokers (6 ± 3 months) versus nonsmokers (3 ± 1 months). In addition, D.M increase the incidence of nonunion or delayed union, which reach 38% comparing to 14% of non-diabetics patients.

Although the majority of patients in our study were non-complicated (77.8%), some complications occurred with significant P value as delayed union in 2 patients (P value 0.001) who were treated by observation and calcium supplement till full union achieved, and superficial infection in one patient, treated by cover antibiotic (p value 0.01). In complicated patients variables as sex, mechanism of injury, associated injuries and Modified Q classification, had no statistically significant effect. Only age (especially above 50 years age group), smoking and diabetes mellitus variables were affecting the complication rate as they had P values 0.005, 0.03, and 0.01 respectively. Two cases suffered from DM and both of them were complicated. **Gaspar *et al.*** [15] observed that the time of union in ulnar shortening osteotomy reported delay in the union time in the diabetic patients. He concluded that diabetes with its peripheral vascular effect decreases the blood flow to the fracture site, the number along with activity of osteoblast, increases osteoclastic activity at fracture site, which affects the fracture healing process and increases risk of complications [16].

CONCLUSION

The distal ulna hook plate is an anatomic plate contoured to fit to the distal ulna. The good outcomes achieved in this study suggest that use of the distal ulna hook plate could be an alternative treatment method for intra-articular ulna neck or head fractures, as well as basal oblique ulnar styloid fractures. All DUFs achieved good results; functional outcomes were promising, including wide wrist ROM and no DRUJ instability. An approach including fixation for DRFs and non-intervention for DUFs is a good option for elderly patients.

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