

Management of Distal Ulna Fractures by Distal Ulnar Hook Plate

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Abstract

Objective: To determine the efficacy and analyze the results of Locking Compression Distal Ulna Hook Plate (LC-DUP) in patients suffering 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 was ranged from 22 to 58 years; half of the group had age ranged from 30 to 40 years with distal ulna fractures treated by Locked compression distal ulnar hook plates during the period from November 2019 to July 2020.

Results: All patients eventually achieve 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 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) , where the mean of the Quick DASH score was (9.8 ± 5.8) .

Conclusion: 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.

Keywords: Distal Ulna Fractures, Distal Ulnar Locked Hook Plate

I. Introduction

Most fractures of the distal ulna which 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⁾.

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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 also to provide a reference point for plate application⁽⁴⁾.

The gap between the hook arms can be used to house a lag screw, should it be 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 distal ulnar fracture (either isolated or associated with distal radius fractures).

II. Patients and methods

This prospective clinical trial study included 18 patients, the age of the studied group was ranged from 22 to 58 years; half of the group had age ranged from 30 to 40 years with distal ulna fractures treated by Locked compression distal ulnar hook plates during the period from November 2019 to July 2020. The fractures were classified according to Q modefier classification, at Orthopedic Department Zagazig University Hospitals, and Sabha Medical Center.

Inclusion criteria: Intra-articular distal ulnar fracture. Extra-articular distal ulnar fracture. Unstable ulnar neck or head fracture with angulation more than 10 degree. Ulnar styloid process fracture. Skeletal maturity.

Exclusion criteria: Stable distal ulna fracture after distal radius fixation. Pathological fracture. Previous surgery on the affected wrist. Open fractures.

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

All patients were subjected to: history taking to assure functional activity, demographic data collection, clinical examination, laboratory investigations, 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 AO 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/clavulanic 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:

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. 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. Wrist function was evaluated with wrist range of motion (**ROM**), modified Mayo wrist score, Disabilities of the Arm, Shoulder and Hand (DASH) score. 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 Wilk test. Qualitative data were represented as frequencies and relative percentages. Chi square test (χ^2) to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean \pm 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.

III. Results

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

| Variable | The studied group (18) | |
|-----------------|-----------------------------------|-------|
| | mean \pm SD | |
| | (Range) | |
| | Median | |
| Age (years): | 35.9 \pm 9.7 (22-58) 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 study showed that the age of the studied group was (35.9 \pm 9.7) years ranged from 22 to 58 years, half of the group (50.0%) had age ranged from 30 to 40 years. This table shows that (55.6%) of the studied group were males and (44.4%) of them females.

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

| | | NO(18) | % |
|---------|-----|---------|-------|
| Smoking | Yes | 4 | 22.2% |
| | No | 14 | 77.8% |

| | | | |
|----------------------------------|---|--------|---------------|
| Mechanism of injury | FFH | 9 | 50.0% |
| | Direct trauma | 5 | 27.8% |
| | RTA | 4 | 22.2% |
| Associated injury | Absent | 8 | 44.4% |
| | Present | | |
| | Ipsi-Lateral distal Radius Ipsi-Lateral Shaft Radius | 9 1 | 50.0% 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% |

This study 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 didn't 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) | |
|-------------------------------|-------------------------------|----------|
| Time 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% |

This study showed that the union duration of the studied group was (13.4 ± 3.2) weeks ranged 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, this table shows that about two thirds (77.7%) of the studied group didn't have pain, (16.7%) of them had mild pain while only (5.6%) of them 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 \pm SD |
|---------------------|------------|---|
| Range of motion | Flexion | 75.6 \pm 6.7 |
| | Extension | 74.1 \pm 4.9 |
| | Supination | 80.5 \pm 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, this table shows that the range of flexion motion among the studied group had average (75.6) ranged from (60 to 85), the range of extension motion among the studied group had average(74.1) ranged from (60 to 80), the range of supination motion had average (80.5) ranged from (65 to 90), the range of pronation motion had average (74.2) ranged from (55 to 80), the range of ulnar deviation motion had average (34.1) ranged from (15 to 40) and finally the range of radial deviation motion had average (20.9) ranged from (10 to 25). In regard to 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): Final 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% |

This study 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%) of them 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%) of them had mild difficulty and moderate difficulty (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% |

This study showed that most of the studied group (77.8%) didn't have any complications, (11.1%) of them had delayed union, (5.6%) had infection and (5.6%) had prominent implant.

IV. 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 of them were males and 8 were females. Less than one quarter of the patients (22.2%) was smokers and (77.8%) were non-smoker participants, with one participant (11.1%) suffers from diabetes. Several mechanism of injuries were reported in this series, with fall from height represented the most common cause of injury (50%), while direct trauma followed by RTA represent (27.8%) and (22.2%) respectively.

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. The mean age detected in a study conducted by **Lee et al.**⁽⁸⁾ which was retrospective analysis of patients with DRF associated with ulnar styloid fracture, (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 this study.

A positive correlation was found between functional outcome and complication rate regarding to the age variability, the more the age the worst the outcome and the higher the complication rate. This 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 group close to our study (34 ± 6.2). He reported mean mayo score (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 ORIF and conservative treatments of DUF associated with 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 aged of his patients.

Concerning the effect of smoking on fracture healing which is multifactorial as it causes changes at the fracture site include 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 carboxy-haemoglobin⁽¹¹⁾.

A systemic review done by **Patel et al.⁽¹²⁾**, 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 with zero% of the non-smokers. Also **Hall et al.⁽¹³⁾** who studied the impact of obesity and smoking on outcomes after volar plate fixation of distal radius fractures, observe significant effect on the functional outcomes at 12 months follow-up. He found a significantly higher Quick DASH scores ($18 + 23$) in the smoker group compared to the never 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 the 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 as 17 weeks. **Tabl⁽⁹⁾** achieved radiographic union at an average of (8.6 ± 0.73) ranged from 6 to 15 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 use the DULP for DUF. **Cha et al.**⁽¹⁰⁾ divided his study group into two groups, first group treated surgically and was showed one patient (3.4%) with delayed union while the second group who 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 D.M, smokers and aged above 50 years. This explanation meet 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). Also 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) which 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 suffer from DM and both of them were complicated. **Gaspar et al.**⁽¹⁵⁾ who observed 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 decreasing the blood flow to the fracture site, also decreasing the number along with activity of osteoblast, increasing osteoclastic activity at fracture site lead to affection on fracture healing process and increase risk of complications⁽¹⁶⁾.

V. 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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